PRODUCTION PROFILES OF RADIONUCLIDES IN CHONDrites
AND THEIR SOLAR CYCLE VARIATION. N. Bhandari, S.K. Bhattacharya
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The activity of radioisotopes induced by cosmic rays in
meteorites depends, among other things, on the primary cosmic
ray flux and the energy spectrum of the secondaries inside the
body. The latter in turn depends upon the size and shape of the
meteorite and the shielding depth of the sample. Reedy and
Arnold (1) have developed a model for calculating radioisotope
production in the Moon which describes the secondary spectra in
terms of a single shape parameter $\alpha$. Here we make an attempt to
extend this model to the case of chondrites. For this purpose
we adopt the following approach.

We have measured the depth profile of $^{53}$Mn in the pallasite
Marjalahti whose preatmospheric size has been determined based
on extensive track measurements (2). This has been shown to
agree well with the expected activities in pallasites derived
from the calculations of Kohman and Bender (3) for iron meteo-
rites. Using similar thick-target approach, Trivedi and Goel (4)
have determined the production profiles of $^{22}$Na in chondrites.
Their calculations have been found to agree well with the obser-
vations in several meteorites. We have, therefore, used these
$^{22}$Na profiles (4) to deduce the Reedy-Arnold shape parameter $\alpha$
for chondrites of various sizes as a function of depth.

a) Cosmic ray flux in meteorite orbits and the shape parameter $\alpha$

The long term average flux, $J$, of GCR protons (>1 GeV)
taken by Reedy and Arnold (1) is 1.7 protons/cm$^2$.sec.4$\pi$ and this
also probably represents the observations made during solar cycle
19 near the earth (at 1 A.U.). However, observations of GCR spec-
tra during solar cycle 20 (1965-75) (5) yield an average value of
1.9 protons/cm$^2$.sec.4$\pi$. Allowing a maximum of +7% per A.U.
increase with aphelion distance (6) we can atmost expect a value
of 2.1 protons/cm$^2$.sec.4$\pi$ for the flux applicable to meteorite
orbits. We adopt the values of 1.7 and 2.1 protons to represent
the range of long term flux. The values of the shape parameter $\alpha$ were derived by fitting the $^{22}$Na profiles (4) for both these
fluxes and are given in Fig. 1 and 2 as function of depth for six
different sizes.

b) Production profiles

The flux of cosmic ray particles above 1 GeV was calculated
as a function of depth ($J(d)$) using the same approach as in (1)
and is shown in Fig. 3 for the case of free-space flux of 1.7
protons. Based on these values of $\alpha$ and flux (>1 GeV) and the
reaction cross-sections (1,7) the production rates of three low
energy radioisotopes $^{26}$Al, $^{53}$Mn and $^{54}$Mn were calculated for
Bronzite chondrites (adopted composition : Fe = 27.16%, Si=17.20%
Mg=14.20%, Al=1.13%, Na=0.62% and Mn=0.25%). These depth pro-
files are given in Fig.4 for the case of flux, $J = 1.7$ protons.
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Fig. 1 Shape parameter for $J=1.7$

Fig. 2 Shape parameter for $J = 2.1$

Fig. 3 $j(d)$

Fig. 4 Activity profiles for radius=10, 20, 30, 40, 50 and 100 cm.
c) Modulation effect

The proton fluxes during solar cycle 20 range from 1.3 in 1970 to 2.2 in 1975 (5). Based on these fluxes we show the expected variations of $^{54}$Mn and $^{22}$Na at different epochs during cycle 20 for a H group chondrite of 50 cm pre-atmospheric radius at a depth of 15 cm (Fig. 5). The profiles given in Fig. 4 apply to spherical bodies. Depth profiles of some isotopes are available in St Severin, Keyes and Dhajala meteorites. St Severin and Keyes are, however, known to have oblong shape, approximately of dimensions (cm) 75 x 46 x 40 and 66 x 67 x 37 (8) respectively. The effective radius for these meteorites for comparing the production in spherical geometry is around 15-20 cm for which the observed profiles (9) agree with Fig. 4.