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The Influence of Cosmic Ray Production on Extinct Nuclide Systems

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Excesses of the daughter products of short-lived nuclides in meteorites and lunar rocks are widely used to decipher early solar system processes. Recently, systems as Mn-53-Cr-53, Nb-92-Zr-92, Tc-99-Ru-99, and Hf-182-W-182 have been used to deduce, e.g., the age of the Earth's core, the formation interval of asteroidal cores, the accretion rate of the Earth, the age of the Moon and the rates of accretion and metal segregation in Mars and various meteorite parent bodies, (e.g. Sanloup et al., 2000; Lee and Halliday, 1995; Lee et al., 1997; Lugmair and Shukolyukov, 1998). Since the observed excesses are often on the order of a few epsilon-units (1 epsilon = 0.0001) only, isotopic shifts induced by galactic cosmic rays (GCR) may become a concern. We demonstrated that in lunar rocks the abundance of radiogenic W-182 as well other W isotopes used for instrumental mass fractionation correction are often significantly altered by cosmogenic production, mainly from Ta. We also showed, however, that observed W-182 excesses in Martian meteorites and eucrites are undoubtedly the result of early Hf-182 decay (Leya et al., 2000). Here we will present new calculations for the systems Mn-53-Cr-53, Nb-92-Zr-92 and Tc-99-Ru-99 for meteorites and lunar rocks. The GCR induced isotopic shifts on the extinct mother-daughter nuclide pairs as well as of the isotopes used for instrumental mass fractionation corrections will be given as a function of the meteoroid radius, the shielding depth of the sample and their received neutron dose. The latter are estimated via the Ne-21 and/or Ar-38 exposure age. Because we already showed that the measure of the neutron dose in lunar samples via the cosmic ray exposure age yields GCR induced shifts to high by up to factor of 10 for samples that were irradiated at the very top of the regolith (Leya et al., 2000), we will give the calculated cosmic ray shifts also as a function of the GCR shifted ratios in Sm and Gd isotopes. Because these ratios are also altered by thermal and epithermal neutrons - like most of the ratios in the Mn-53-Cr-53, Nb-92-Zr-92 and Tc-99-Ru-99 systems - Sm-149/Sm-150 and Gd-155/Gd-156 are very good proxies for the received neutron dose of the sample. Our model in its present form is based on the best knowledge of the particle spectra in meteoroids and lunar rocks and of the excitation functions of the underlying nuclear reactions. For further details of the model calculations see (Leya et al., 2000). The new results should therefore replace earlier estimates, (e.g. Lugmair and Shukolyukov, 1998). The new data for the cosmic ray produced Cr-53 and Cr-54 in the iron meteorite Grant are in reasonable agreement with the estimates used in (Lugmair and Shukolyukov, 1998) but besides the absolute value we also give the radius and shielding depth dependency of the GCR induced isotopic shifts and increase therefore the applicability of the data. For the Nb-92-Zr-92 and the Tc-99-Ru-99 systems our values are the first results discussed so far.

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