Bedtime stories from space:
History of meteorites and cosmic radiation told by cosmogenic nuclides

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While meteorites travel through space, they are exposed to cosmic rays, which induce nuclear reactions producing so-called cosmogenic nuclides (CNs). If meteorites land on Earth, production stops and radioactive nuclides start to decay. Thus, CNs, stable and radioactive, are archives of the exposure and terrestrial history of individual meteorites. Moreover, when looking at a larger number of meteorites, this may also give hints about the constancy of the cosmic radiation itself [1].

Data for the lighter cosmogenic radionuclides ^{10}Be, ^{26}Al, ^{36}Cl, and ^{41}Ca ($t_{1/2}$=0.1-1.4 Ma) are now attainable at the accelerator mass spectrometry facility DREAMS [2]. Accompanied by data for the heavier radionuclides ^{53}Mn ($t_{1/2}$=3.7 Ma) and ^{60}Fe ($t_{1/2}$=2.6 Ma), which are measured at the large tandems at Canberra and Munich, and stable noble gas nuclides from Mainz and Bern, complete exposure histories of extraterrestrial material can be reconstructed.

One of the first meteorites investigated by this team is Gebel Kamil, an ungrouped Ni-rich iron meteorite that produced an impact crater (Ø: 45 m) in southern Egypt. Two neighboured shrapnel (S) samples and two from the only individual (I) fragment (~83 kg) have been analysed. Concentrations of all CNs – stable and radioactive – are a factor ~4 x lower in S-samples than in I-samples. Comparison with Monte-Carlo calculations of production rates indicate that Gebel Kamil was exposed as a meteoroid body of 115-120 cm radius (50-60 tons). Samples I originate from a moderate shielding of ~20 cm, whereas samples S are from a deeper position of 50-80 cm. Most reliable ^{36}Cl-^{36}Ar ages of I and S are (366 ± 18) Ma [3].

Chemically and analytically more challenging are the analyses of corresponding pairs of chondrule and matrix to decipher the ancient and recent exposure history from two highly primitive meteorites [4]. Chondrules may have been irradiated for millions of years as free-floating particles in the solar nebula by the cosmic rays at that time. Despite sample masses of only 1.6-1.8 mg for single chondrules, radioactive CN results for two highly primitive Renazzo-type (CR3) chondrites from Antarctica (MET00426 & QUE99177) are clearly distinguishable from processing blank and can, thus, be used in combination with noble gas data.

Chemically and analytically demanding for both noble gases and ^{36}Cl are also the analyses of pairs of troilite (FeS) inclusions and metal fractions from the iron meteorite Mundrabilla. This work is struggling with mg-amounts of sulphur, where ^{36}S is a troublesome isobar of ^{36}Cl and also causes severe problems in noble gas spectrometry. It is aimed at improving determination of production rates for lighter nuclides such as ^{3,4}He, ^{10}Be, ^{21}Ne, ^{26}Al and ^{36}Cl.

Ackn.: L. Folco, J. Zipfel (meteorites) & accelerator crews and colleagues (support AMS).

[1] Smith et al. *contribution to 13th Int. Conf. on Accelerator Mass Spectrometry (AMS-13).*
[2] Akhmadaliev et al., *Nucl. Instr. Meth.B* **294**, 5 (2013) & Pavetich et al., *this meeting.*
[3] Ott et al., submitted to *Meteorit. Planet. Sci.*
[4] Ott et al., *contribution to 13th Int. Conf. on Accelerator Mass Spectrometry (AMS-13).*