Clear Evidence for A-bomb Induced ^{41}Ca-Signals in Biological Material

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The health data from the atomic-bomb survivors serve as the prime basis for risk estimates of late effects induced by ionizing radiation. Dose estimates have been performed by means of the dosimetry system DS86 [1] which allows the calculation of individual organ doses. Up to now, a variety of long-lived radionuclides such as ^{32}P, ^{60}Co, ^{52}Eu, ^{36}Cl, ^{41}Ca, and ^{63}Ni have been used for valididation of DS86 neutron fluences (see Ref. [2] for a review, and see also this report). Without exception, these radionuclides were extracted from inorganic materials such as concrete, granite, and copper. However, extensive and sophisticated calculations are required, to determine organ doses to the survivors from those measurements. To improve the situation, we propose the detection of ^{41}Ca ($T_{1/2} = 103$ kyr) in tooth enamel of individuals exposed to A-bomb neutrons [3]. In Hiroshima and Nagasaki, ^{41}Ca was predominately produced via thermal neutron capture on ^{40}Ca. Since enamel had already been used as a dosemeter for γ–radiation from the A-bomb explosion [4], the detection of ^{41}Ca would allow, for the first time, reconstruction of both, γ–ray and neutron exposures in the same biological material.

Some years ago, it had already been demonstrated at the MLL that a-bomb induced ^{41}Ca can be detected in samples from Hiroshima, by means of accelerator mass spectrometry (AMS) ([5], [6]). Today, the combination of the MP tandem and the GAMS set-up [7], and the use of negative CaH_3^-–ions allows a much lower detection limit and higher reproducibility than achieved in the earlier measurements, and values for the ^{41}Ca/^{40}Ca isotope ratio of about '10^{-15}' can be measured [3]. For our measurements, less than 50 mg enamel material was enough, which corresponds to about 15 mg Calcium. In order to avoid possible contamination of the chemistry equipment from standard samples, we produced Ca standard material as hydrides directly. Standards with isotope ratios covering a range between $2{\cdot}10^{-10}$ and $1{\cdot}10^{-12}$ were produced by irradiation of CaH_2 powder with thermal neutrons at 'The Research Reactor' of the Hahn Meitner Institute in Berlin. This Ca standard-material is used directly without any further treatment.

Remarkable site-dependent fluctuations of the natural ^{41}Ca/^{40}Ca isotope ratio have been reported recently, for environmental samples [8]. However, this may not rule out the application of this method for a retrospective determination of a-bomb neutrons, since our study is restricted to a comparably small geographic area with expected low natural ratios. In order to quantify these natural ^{41}Ca/^{40}Ca isotope ratios, enamel samples from the Hiroshima area had to be investigated thoroughly. Six tooth samples from unexposed survivors of the A-bomb explosion in Hiroshima have been examined, and the overall ^{41}Ca/^{40}Ca background level of the applied method has been quantified. The measured ^{41}Ca/Ca ratios are indeed low which confirms our original expectations of a low background level. For these control samples, between 0 and 5 counts per sample were identified as ^{41}Ca events, and a mean ^{41}Ca/Ca isotope ratio of $(1.9 \pm 0.5){\cdot}10^{-15}$ was obtained (see Fig. 1).

A comparison of the measured ^{41}Ca/^{40}Ca isotope ratios obtained for the control samples with those calculated, based on DS86, suggests that ^{41}Ca might be detectable in enamel from survivors which where exposed up to about 1200 m from the hypocenter (see [9]).

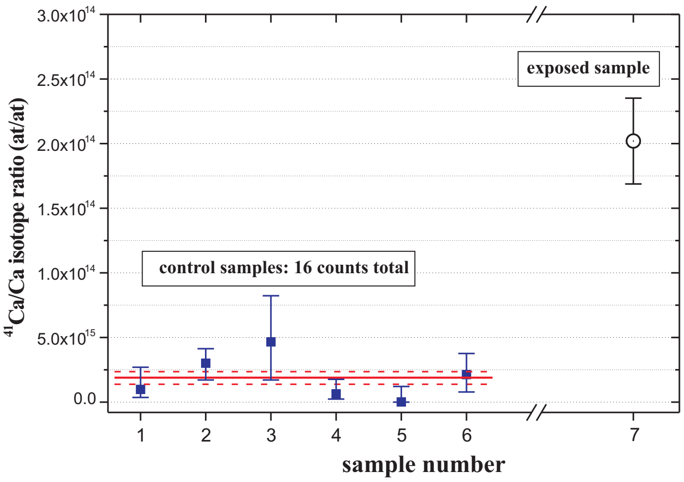

Fig. 1: ^{41}Ca/^{40}Ca isotope ratios for unexposed samples from Hiroshima and a preliminary result for an exposed survivor.

Indeed, first results obtained on a tooth sample from an exposed survivor suggest a ^{41}Ca/^{40}Ca isotope ratio of $2{\cdot}10^{-14}$ which is significantly above the ratios measured in the control samples (see Fig. 1) [3]. A systematic study of tooth enamel of exposed survivors from Hiroshima is presently under way.

References

[1] W.C. Roesch (ed.), U.S.-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki, Final Report. Radiation Effects Research Foundation, Hiroshima (1987) .
[2] W. Rühm *et al.*, Radiation Environ. Biophys. **37** (1998) 293.
[3] A. Wallner *et al.*, submitted to Nucl. Instr. Meth.
[4] N. Nakamura and C. Miyazawa, J. Radiat. Res. **38** (1997) 173.
[5] G. Korschinek *et al.*, Nucl. Instr. Meth. **B29** (1987) 67.
[6] W. Rühm *et al.*, Z. Physik **A341** (1992) 235.
[7] K. Knie *et al.*, Nucl. Instr. Meth. **B172** (2000) 717.
[8] D. Fink *et al.*, jbPaperRefNucl. Instr. Meth.B47199079.
[9] A. Wallner *et al.*, Annual report 2001, p. 22.