New ^{36}Cl Measurements and Interpretation of the Hiroshima Discrepancy

T.C. Huber, E. Nolte, W. Rühm [a], and K. Kato [b]
[a] Radiobiological Institute LMU [b] Hiroshima Prefectural College of Health Sciences

When measured yields of radionuclides produced by thermal neutrons from the A-bomb in Hiroshima were compared with calculations based on the actual dosimetry system DS86, a large discrepancy was observed for distances to the epicenter between 1000 and 2000 m (Fig. 1).

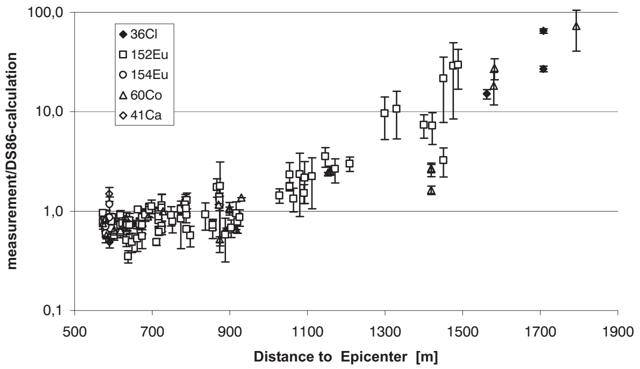

Fig. 1: Ratios of measured and calculated radionuclide yields in Hiroshima as function of distance to the epicenter; data from the literature, see [1] for references

To investigate this discrepancy, ^{36}Cl/Cl ratios were determined at the MLL in 46 granite and concrete samples from Hiroshima (Fig. 2), by means of AMS. In these samples, ^{36}Cl was produced via thermal neutron capture on stable ^{35}Cl.

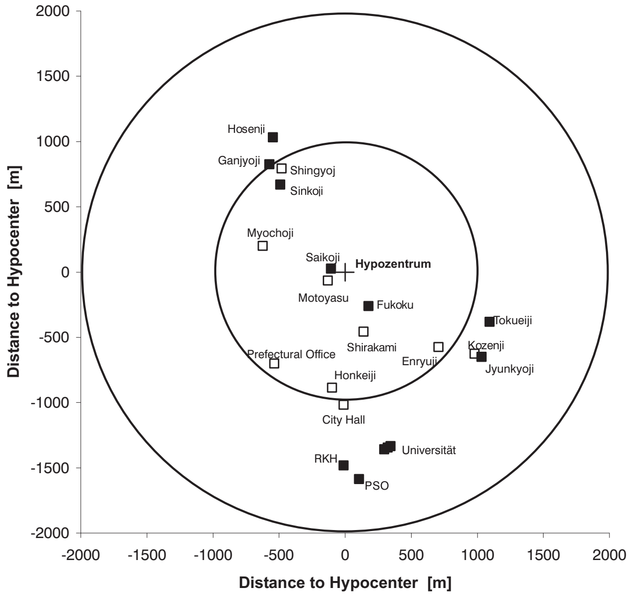

Fig. 2: Locations of the samples in which ^{36}Cl/Cl ratios were measured

For quality control, some of the samples were also measured for ^{36}Cl and ^{152}Eu by other laboratories. In parallel, the natural in-situ production of ^{36}Cl in those samples was calculated. In mineral samples, ^{36}Cl is produced in-situ by reactions of the nucleonic component, stopped negative muons and fast muons from cosmic rays with K and Ca, and by ^{35}Cl(n,γ) reactions where the neutrons originate from the above three reactions and from the decays of U and Th. For these calculations, the elemental composition, the original depth of the sample in the lithosphere and the local erosion rate have to be known. In Fig. 3, the ^{36}Cl/Cl ratios measured in the samples from Hiroshima are corrected for calculated cosmic-ray induced signals.

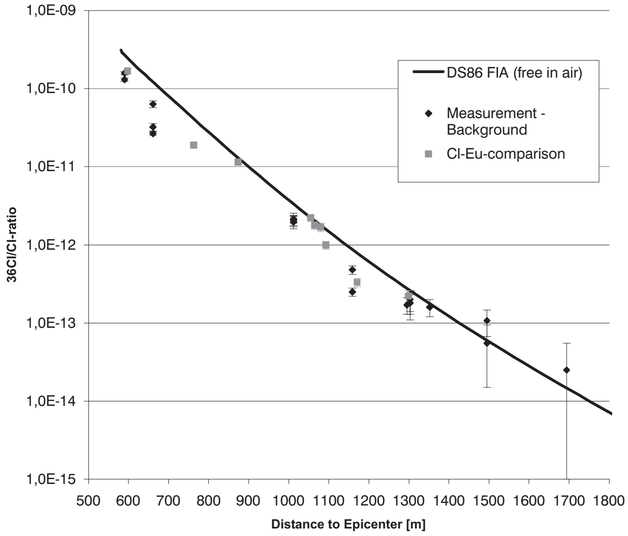

Fig. 3: Measured ^{36}Cl/Cl ratios as function of distance to the epicenter in comparison with DS86 calculations; data are corrected for cosmic-ray induced ^{36}Cl production.

It is evident that, after subtraction of the cosmic-ray induced signal, measured ^{36}Cl/Cl ratios fit within the experimental uncertainties to DS86 calculations, even for large distances to the epicenter. There is no evidence for a dicrepancy between measurements and calculations. In conclusion, the in-situ production by cosmic rays in samples from Hiroshima appears to be the reason for the discrepancy reported for ^{36}Cl. As can be seen from Fig. 3, for distances less than 1000 m the measured ^{36}Cl/Cl ratios are lower than those calculated. This observation is also made for all other radionuclides (Fig. 1) and for thermoluminescence data. This might indicate that the height of explosion was actually somewhat higher than the 580 m used in DS86. When the bomb height is for example increased to 600 m, the agreement between measurement and calculation is better for short distances to the epicenter.

References

[1] T.C. Huber, Ph.D. thesis, TU München, 2002