Chapter 10

FACTORS AFFECTING NEUTRON MEASUREMENTS AND CALCULATIONS

Part F. Water Content in Granite

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Introduction

As part of the DS02 studies to reevaluate neutrons from the atomic bomb, we cored rock samples from a pillar of Motoyasu Bridge, located at a distance of 128 m from the hypocenter in Hiroshima, and measured the depth profile of induced ^{152}Eu radioactivity in the rock (Hasai et al. 1987). By use of the MCNP neutron transport calculation code, the depth profile of ^{152}Eu in the rock was calculated, assuming a neutron distribution at the given location around the pillar based on the DS86 calculations. The depth profile was then compared with the distribution of measurements (Endo et al. 1999). For the calculation, it is necessary to know the major components of the rock. It is also necessary to estimate the water content correctly, since the cross section of hydrogen-neutron reactions is large, and neutron moderation effects of hydrogen are significant. For this purpose, the basic characteristics of water content in rock were studied, based on a few characteristic experiments to estimate the water content, which was then used in neutron transport calculations. The following describes our concepts and methods.

Estimation Methods

The concept and measurement methods for adsorbed water ($H_2O^{(-)}$) and combined water ($H_2O^{(+)}$) have already been established in the field of geochemistry. The former is water adsorbed in mineral particles, such as inter-layer water, and the latter is water structurally combined together in the form of OH^- and H^+ ions. Samples were ground into powder (100 mesh or less) for measurements of these two water components. What we need is water contained in the volume of the rock itself. Several experiments have revealed the existence of water (penetrated water), which rapidly penetrates via capillarity when the surfaces of rocks are dampened by rain or dew, and macro water (water adsorbed in coarse grains), which exists in boundaries of minerals or in volumes of coarse minerals. With these two, as well as adsorbed water and combined water, we learned that it is possible to evaluate four types of water components.

Results

Kawasaki Techno Research (Chiba City) was requested to measure adsorbed water ($H_2O^{(-)}$) and combined water ($H_2O^{(+)}$) via the Karl Fischer technique for three pieces of pillar samples (sample No. W3, W12, and W19 used in the study by Hasai et al. 1987). After averaging the data, 0.13 ± 0.01% was obtained for the former and 0.20 ± 0.01% for the latter. Water adsorbed in coarse grains was estimated to be 0.18 ± 0.10%. By adding the above data, 0.51 ± 0.10% was obtained for the water content, excluding penetrated water. The maximum value for penetrated water was 0.16 ± 0.10%, based on absorbed water determination experiments. When the upper limit and lower limit are set for the water content of the pillar at the time of atomic bombing, the lower limit is 0.51 ± 0.10% and the upper limit 0.67 ± 0.10%. For neutron transport calculations, 0.59%, the mean of these two values, was used as the water content.

Conclusions

For neutron transport calculations of exposed rock samples, a technique to estimate the water content, one of the major rock components influencing the neutron transport, was developed. Water content values obtained via this technique were used to calculate the depth profile of ^{152}Eu induced by neutrons (Hasai 1987).

References

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