Determination of the latest activity zone of the fault using medical X-ray CT scanners

*Akiyuki Iwamori[1], Hideo Takagi[2], Nobutaka Asahi[3], Tatsuji Sugimori[3], Eiji Nakata[4], Shintaro Nohara[4], Keiichi Ueta[4]

1. Kansai Electric Power. Co., 2. Waseda Univ., 3. DIA Consultants. Co., 4. Central Research Institute of Electric Power Industry

Abstract

Since X-ray CT was developed as a medical imaging technique by Hounsfield in 1972, a lot of reseach subjects have been published (e.g. Wellington and Vinegar, 1987). Medical X-ray computed tomography (CT) is a non-destructive technique that allows observation and analysis of the 3-D internal structure of fault rocks. The CT number which closely relate the contrast of the CT image caluculated by medical X-ray CT scanners can be represented as follows (Johns et al., 1993) :

$CT=1,000(\mu-\mu_w)/\mu_w$

where $\mu=\rho(a+bZ^{3.8}/E^{3.2})$ (Wellington and Vinegar, 1987)

(μ: X ray attenuation coefficient of the object, μ_w: X ray attenuation coefficient of water, ρ: electron density (bulk density), Z: effective atomic number, E: X-ray energy, a: nearly energy-independent coefficient called the Klein-Nishina coefficient, b: constant)

From the above, μ depends on ρ, Z and E and the CT number defined as the proportion of μ to μ_w also relies on these three parameters. Accordingly, when the composition of the host rock of fault rocks is invariable and X-ray tube voltage is maintained constantly, the CT number relies on the density of material heavily. However, X-ray sources of medical X-ray CT scanners delivers polychromatic X-ray and an artifact called beam hardening (henceforth called BH) occurs in the CT image, which causes the edges of an object to appear brighter than the center, even if the material is the same throughout (Nakano et al., 2000). We studied the method of reducing BH in order to calculate precise CT number and increased the accuracy of imaging CT pictures of the internal structure of fault rocks.

We collected fault rock samples at the Hiji outcrop of Median Tectonic Line (MTL) in Ina City, Nagano Prefecture. At the Hiji outcrop, an active fault displacing the gravel layer deposited in Late Pleistocene extends in Sanbagawa schist close to the MTL (Sugiyama, et al., 2017). We collected oriented samples approximately 15 cm in length which contained the latest activity zone and observed and analyzed CT pictures using medical X-ray CT scanner. As a result, the CT numbers in fault gouge of active fault domain are smaller than those of cataclasite. The effective method of reducing BH, which was based on the results of the relationships of CT number, effective atomic number and X-ray tube voltage using monocrystal minerals and hard rocks of pelitic schist, allow the detailed determination of the latest activity zone of the fault using CT numbers.

References

Nakano, T., Nakashima, Y., Nakashima, K. and Ikeda, S., 2000, *J. Geol. Soc. Japan*, **106**, 363-378.

Johns, R. A., Steude, J. S., Castanier, L. M., and Roberts, *P.V.*, 1993, *JGR*, **98 (B2)**, 1889–1900.

Wellington, S. L., and Vinegar, H. J., 1987, *J. Pet. Technol.*, **39**, 885-898

Sugiyama, K., et al., 2017, Abst. 124th Annual Meet. *Geol. Soc. Japan.*, R15-P-4.

Keywords: medical X-ray CT, X-ray linear absorption coefficient, CT number, beam hardening, the latest activity zone of the fault

