Activity evaluation of fracture zone in granitic rock -Case study on the survey of fracture zones at the “Monju” site

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Background: In the fast breeder prototype reactor Monju of the Japan Atomic Energy Agency (JAEA), geological survey of fracture zones has been carried out at the Monju site based on the instruction received from the Nuclear Regulation Authority (NRA). JAEA submitted a complete report to NRA on March 2014. Results of the investigation, it has shown that no clear evidence was observed to indicate that on-site fracture zones are active faults. In December 2015, the field survey by the Experts Committee of NRA was carried out.
Overview of geological survey: The basement rock of the northern Tsuruga peninsula where the Monju site is located is composed of the Late Cretaceous-Paleogene granite known as Kojyaku granite. In the on-site investigation, the stripping area was expanded in the northern direction of the longest fracture zone in the reactor building foundation rock. We examined cross-cutting relationships of fractures and displacement of markers and features of the fracture zone structure.
Activity evaluation of fracture zone: In the stripping area, the fracture zones were grouped into 2 systems called α-system (ENE-WSW) and β-system (NNE-SSW). We confirmed that the α-system was formed after the β-system from the cross-cutting relationships. The α-system fracture zones are left-lateral faults that have mesh-like clay veinlets, and the width of the α-system fracture zones is several centimeters. The latest shear zone with width of about 1cm less was identified by investigation of cross-cutting relationships focusing on α-system fracture zones. Minor right-lateral slip and biotite grains deformed plastically are observed on the thin-section of the latest shear zone. According to the existing experimental studies (Stesky, 1978; Lin, 1999, etc.), the temperature condition of plastic deformation of biotite grain is known to be exceeding 150 to 250 degrees centigrade. Also, biotite grains deformed plastically are universally observed along the fracture zones in the stripping area. Therefore, it can be considered that these fracture zones are older small-scale geological structure which was formed under the high-temperature environment of the deep part before exposure of the granitic body, and that these fracture zones are non-active in recent age.
In addition, the basalt dikes which have the K-Ar ages of about 19Ma are observed in the stripping area. It can be considered that basalt dikes partially intruded along the α-system fracture zones later from the distribution of the chilled margin of contact boundary between the granite. Calcite veins and irregular local deformation structures are observed into the basalt dikes. Also, the calcite veins often develop parallel to the boundary between the basalt and the granite along the fracture zones. Twins which indicated the deformation at a high temperature (150 ~ 300 C, typeII; Burkhard, 1993) are observed frequently in the calcite veins of the boundary portion under microscopic observation. However, there is no damage due to shear in the calcite vein itself. From this fact, it can be also considered that the boundary portion between the basalt and the granite along the fracture zone is not sheared after the calcite veins are formed in a high temperature environment.
In the activity evaluation of the fracture zone in the granite, it is possible in some cases to estimate the formation environment (temperature conditions, etc.) of the fracture zone from the feature of structure and minerals in the fracture zone or veins along/across the fracture zone. As a result, information of consideration concerning whether the fracture zone is active or not can be obtained.

[Reference]Stesky, R.M. (1978), Canadian Journal of Earth Sciences, 15, 361-375; Lin, A. (1999), Tectonophysics, 304, 257-273; Burkhard, M. (1993), Journal of Structural Geology, 15, 351-368

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