ESR technique for the assessment of fault activity; an approach from frictional tests using the Asano fault gouge collected by a trenching survey

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The ESR (electron spin resonance) dating method is a technique for the assessment of fault activity on the basis of the formation age of fault rocks (Fukuchi, 2004). In ESR dating, the age of the latest fault movement is determined by presupposing that ESR signals in fault rocks have been completely reset by frictional heating. When the ESR signals have been incompletely reset, the ESR ages obtained give older ones than the actual age of the latest fault movement. This problem on the incomplete resetting may be settled by collecting fault rocks from the depths under the ground where frictional heat temperature easily increases, however the deeper the drilling depth of borehole is, the higher the cost is. Therefore, it is important to reveal the depth where the complete resetting of ESR signals really happens. In this study, we carry out frictional tests using the Asano fault gouge collected by a trenching survey, and consider the necessary condition for the complete resetting of ESR signals on the basis of ESR analysis of the gouge samples after frictional tests. Moreover, we compare ESR spectra obtained from the gouge samples after frictional tests with those from the fault gouges collected from the Asano fault trenching and boring sites, and consider the resetting phenomenon of ESR signals by natural frictional heating.
The fault gouge sample used for frictional tests is grayish white gouge with a width of ~10mm distributed along the fault plane between granite and Osaka group on the north wall of the Asano fault trench. The grayish white gouge was dried under natural circumstances, ground with an agate mortar and set between a pair of columnar gabbro samples with a diameter of 24.98mm. In shearing, one columnar gabbro was fixed and another was rotated. Frictional tests were carried out at a normal stress of 2 MPa and a slip rate of 1.3 m/s under dry and wet conditions (Tsutsumi et al., 2016). When the total displacement was 30m, the maximum frictional heat temperature attained was estimated as 380 degree C under dry condition and 340 degree C under wet condition. The gouge samples after frictional tests under dry and wet conditions were divided into three parts of 0-9mm (central part), 9-16mm (intermediate part) and 16-25mm (circumference part), and ESR measurements of the three parts were carried out. As a result, a strong FMR (ferrimagnetic resonance) signal formed by frictional heat is detected from all the three parts under dry condition (Fukuchi, 2012), and the FMR signal intensity increases from the central part to the circumference part. Besides, E' center in quartz and quartet signals in montmorillonite available for ESR dating have been completely reset. On the other hand, a weak FMR signal is detected from the circumference part under wet condition, however the E' center and quartet signals have been hardly reset. These results mean that the FMR signal intensity is available for the judgement of resetting state of ESR signals. Moreover, as a result of ESR analysis of the fault gouge along a fault (fa-5) located at a depth of about 200m in the Asano fault 300m boring core sample, a similar FMR signal to that obtained from the circumference part under wet condition is detected. This suggests that frictional heat along the Asano fault may have been generated under wet condition.

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Keywords: ESR dating, Electron spin resonance, Asano fault, Fault gouge, Assessment of fault activity, Frictional test

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