# Evaluation of relationship between fault displacement and ESR intensity using low-speed ring shear apparatus

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It is important to evaluate fault activity for mitigating risks of the disasters. In this study, we focus on fault dating by electron spin resonance (ESR) method. This method is explained easily in the following steps. First, number of electrons and halls trapped in defects in quartz are detected as ESR signals. Second, a total dose is calculated from the intensity of ESR signals. Third, the total dose is divided by an annual dose rate to obtain elapsed time from the latest earthquake on the fault, because the ESR intensity is reset to zero under a temperature of about 300 or 500 degrees to which the fault is heated by coseismic slip. Therefore, ESR dating is one of the appropriate techniques to assess fault activities. However, the hypothesis that numbers of electrons and halls trapped in defects are reset to zero by heating has not been tested thoroughly. Moreover, it is not clear whether zeroing of the ESR intensity can happen on shallow faults from which we can easily obtain samples, because frictional heat and terrestrial heat are negligible on such shallow faults.
There exist several studies on a relationship between fault displacement and ESR Intensity (Tanaka, 1987; Hataya and Tanaka, 1993; Fukuchi, 2004). However, they have the following issues: (1) Conditions of ESR measurement were inappropriate. (2) Specific ESR signal was only measured and other signals were not. (3) Relationship between displacement and ESR intensity was not clearly represented by either a table or a plot. (4) Effect of heat on ESR intensity was not considered. Therefore, we conducted shear tests with silica sand (JIS test powder) under the conditions of shallow depths where frictional heat is negligible to clarify a relationship between displacement and ESR intensity. The inner diameter and outer diameter and thickness of sample are 20 mm, 30 mm and 1.5 mm. We used low-speed ring shear apparatus in Tohoku University. Sliding rate and the normal stress were kept constant to 0.72 mm/s and 0.981 MPa, respectively. Final displacements were varied among test runs up to 1.7 m.
Temperature rise $\delta T$ on the shear surface was estimated to be a few degrees from Sibson (1975) under the conditions of this experiment. So, an effect of heating is negligible in this study. ESR measurement was conducted under appropriate conditions in which $E_1$’ center representing ≡Si ( means a lone electron and - means sheared electron pair, and ≡means one Si atom combined with three Si atoms by each electron pair) does not overlap with R signal (structure corresponding to this signal is not clarified yet) and the other ESR signals can be detected. The relationship between displacement and ESR intensity was investigated by ESR measurements before and after the shear displacement. Many ESR signals such as $E_1$’ center, OHC ($O^{3-}$), Peroxy center (≡Si-O-O) and so on decreased as displacement increases. This means that accumulation of displacement contributes to zeroing of ESR intensity under a low confining pressure corresponding to a sub-surface. Therefore, it is possible to reset the ESR intensity by fault activities at shallow depths.

Reference

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