Paleostress orientation estimated from microcracks in quartz grains of the Toki Granite using mixed Bingham distribution method

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Healed microcrack (HC) is a fluid inclusion plane which was healed by the same mineral as the host mineral whereas sealed microcrack (SC) is a microcrack sealed by secondary material. These cracks are preferably formed perpendicular to the minimum principal stress ($\sigma 3$) axis. In the previous study, only $\sigma 3$ orientation has been estimated using HC, SC and mesocracks from the JAEA borehole core (DH-15) in the Late Cretaceous Toki Granite, central Japan (Takagi et al., 2008). The microthermometry analysis for fluid inclusions constituting HCs in the Toki Granite suggests that the HCs were formed around 60 Ma (Takagi et al., 2008).

Recently, a new analytical method that can estimate the orientation of all principal stress ($\sigma 1$, $\sigma 2$, $\sigma 3$) axes was developed (Yamaji et al., 2010; Yamaji and Sato, 2011). Kanai et al. (2014) proposed a precise calibration method to estimate an orientation distribution of microcracks applying that new analytical method. In this study, we re-examine the previous data after Takagi et al., (2008) and comprehensively estimate the paleostress orientation using those new methods. Twenty oriented granite pieces from 200–1000 m depth were used and three orthogonal thin sections prepared for previous study were re-used to measure the microcracks in each sample. The distributions of HC and SC display one to three concentrations and those are commonly orthogonal each other. Since several paleostresses were detected from each sample, the paleostress that has $\sigma 3$ axis closest to the orientation of maximum density address as prominent stress in the sample at the timing of microcrack formation. Most of the prominent stress of the HCs show $\sigma 3$ axis trending E-W, subhorizontal, whereas $\sigma 1$ and $\sigma 2$ axes form a single girdle parallel to N-S orientation, in which $\sigma 1$ tends to be more horizontal than $\sigma 2$. These results suggest that the HC is formed in NW-SE orientation before the rotation of the SW Japan together with the opening of the Japan Sea in 20-15Ma. This restored NW-SE compressive orientation is presumably because of the influence of the regional compression due to the Pacific plate subduction in early Paleogene. The paleostress orientations using SCs give quite different result from those using HCs. Most of the prominent stresses show N-S subhorizontal $\sigma 3$ axis, E-W subhorizontal and subvertical $\sigma 1$ axis, and E-W subhorizontal and vertical $\sigma 2$ axis. If the SCs were formed before the opening of Japan Sea, the results of $\sigma 1$ E-W axis trending should be NE-SW before the rotation of SW Japan. However, it seems difficult to consider that this orientation is related to orientation of the Oceanic plate subduction before the opening of Japan Sea (20-15Ma). This paleostress orientation using SCs is left as future’ s problem to be solved.

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