Geophysical Research Abstracts
Vol. 15, EGU2013-1972-1, 2013
EGU General Assembly 2013

Stress tensor inversion from orientation distributions of dykes and veins with an attempt to constrain driving fluid pressure ratio

Katsushi Sato (1), Atsushi Yamaji (1), Satoshi Tonai (1,2)

(1) Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan (k_sato@kueps.kyoto-u.ac.jp), (2) Present address: Department of Applied Science, Faculty of Science, Kochi University, Kochi 780-8520, Japan

Orientaions of dykes and veins provide clues to tectonic stress conditions. A newly formed dilatant fracture in an intact rock mass is expected to be perpendicular to σ_3 (the minimum compressive principal stress) axis. Meanwhile, pre-existing fractures re-open when fluid pressure P_f exceeds normal stresses acting on them (Delaney et al., 1986). This criterion can explain a wide range of orientation distribution under a relatively high fluid pressure. Jolly and Sanderson (1997) employed this criterion and proposed a method to determine a reduced stress tensor which carries not only σ_3 axis but also σ_1 axis, σ_2 axis and a stress ratio $\Phi = (\sigma_2 - \sigma_3)/(\sigma_1 - \sigma_3)$, where σ_1, σ_2 and σ_3 are the magnitudes of compressive principal stresses in descending order. This method graphically determines the stress ratio from the range of orientation distribution of dykes or veins. However, the recognition of distribution ranges in stereograms by eyes is problematic because it can lead us to artificial and incorrect solutions.

We solved the problem by introducing stochastic models to the orientation distributions. Our assumption is that the frequency of poles to veins or dykes takes its maximum at σ_3 axis and monotonically decreases toward the margin of their distribution range. That means the frequency is a monotonic decreasing function of the magnitude of normal stress acting on fractures. The parameters of probability density functions includes the unknowns of a reduced stress tensor, which are optimised so as to fit the probability distribution to the observed orientation distribution of veins or dykes. There is no need to specify the range of distribution on stereograms since the optimised probability distribution has principal stress orientations as its symmetric axes and its anisotropy gives the stress ratio.

The new method has a few options of types of probability distribution. Bingham distribution, which is the simplest exponential distribution on the unit sphere, turned out useful to model a natural distribution with gradual decrease of vein poles from σ_3 axis to the margin. The stress condition which formed a swarm of Plio-Pleistocene epithermal quartz veins in SW Japan was successfully inferred (Yamaji et al., 2010). We recently proposed another flexible model using "shifted power-law" function, which has an advantage in determining the driving fluid pressure ratio $\lambda = (P_\mathrm{f} - \sigma_3)/(\sigma_1 - \sigma_3)$ (Sato et al., in press). This model was applied to a Miocene dyke swarm intruded into the back-arc basin and basement rocks in central Japan during the rifting of Japan Sea. As a result a normal-faulting stress regime with an arc-normal σ_3 axis and a relatively high magma pressure ($\lambda \approx 0.8$) were inferred.

References

Delaney, P.T., Pollard, D.D., Ziony, J.I. and Mckee, E.H., 1986, *Jour. Geophys. Res.*, 91, 4920-4938.
Jolly, R.J.H. and Sanderson, D.J., 1997, *Jour. Struct. Geol.*, 19, 887-892.
Sato, K., Yamaji, A. and Tonai, S., *Tectonophys.* in press, doi:10.1016/j.tecto.2012.12.008.
Yamaji, A., Sato, K. and Tonai, S., 2010, *Jour. Struct. Geol.*, 32, 1137-1146.