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Separation of deviatoric stress tensors from heterogeneous calcite twin data using a statistical mixture model

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It is essential for the techniques of paleostress analysis to separate stresses from heterogeneous data (e.g., Tikoff et al., 2013). A statistical mixture model is shown in this paper to be effective for calcite twinning paleopiezometry: Given the orientations of twinned *e*-planes and their gliding directions, the present inverse method based on the mixture model determines not only deviatoric stress tensors, but also estimates the number of tensors that should be read from a data set using Bayesian information criterion.

The present method is based on the fact that mechanical twinning occurs on an *e*-plane if the resolved shear stress along its gliding direction, τ, is greater than a critical value, τ_c (e.g., Lacombe, 2010). The orientation data from *e*-planes corresponds to points on a 5-dimensional unit sphere, a spherical cap on which indicates a deviatoric stress tensor. The twinning condition, $\tau > \tau_c$, is identical with the condition that the points corresponding to the orientation data are distributed upon the spherical cap (Yamaji, 2015a). It means that the paleostress analysis of calcite twins comes down to the problem of fitting a spherical cap to data points on the sphere (Yamaji, 2015b). Given a heterogeneous data set, two or more spherical caps should be fitted to the data point on the sphere. A statistical mixture model is employed for this fitting in the present work. Such a statistical model enables us to evaluate the number of stresses recorded in the data set.

The present method was tested with artificial data sets and a natural data set obtained from a Miocene graben in central Japan. From the former type of data sets, the method determined the deviatoric stress tensors that were assumed to generate the data sets. The natural data were inverted to give two stresses that appeared appropriate for the tectonic setting of the area where the data were obtained.