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Clustering of dike orientations for paleostress analysis

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We propose a clustering method for dike orientations to infer paleostresses from the groups of dike orientations. Such inference has been done with the assumption that the orientations make a cluster or a girdle on a stereogram, which can be recognized on a stereogram by eyes. It was also assumed that all dikes were formed under a state of stress. Therefore, it was difficult to apply this method to dikes formed under polyphase stress history.

To solve this problem, we developed a numerical method of adapting a mixed Bingham distribution to the orientations of the dikes that could be affected by different stress states. Given a set of orientations, a mixture distribution is determined by the EM algorithm, and stress axes and stress ratios are obtained from each of the optimal Bingham components. The method determines the number of the components as well via Bayesian information criterion.

We tested the method using the artificial data sets that were generated with assumed stress states. The method successfully detected the stress states and the number of groups. Applying the method to the dikes at the western flank of the Miocene Ishizuchi Cauldron in Shikoku, Japan, we obtained two stress states. One of the stresses was consistent with the extensional tectonics accompanied by the Japan Sea opening. The other one was consistent with the volcano-tectonics of the area at the time of the dike formation.

Keywords: dike, orientation statistics, cluster analysis, stress, Japan Sea opening