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Do mesoscale faults in a young fold belt indicate regional or local stress?

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The result of paleostress analyses of mesoscale faults is usually thought of as evidence of a regional stress. On the other hand, the recent advancement of the trishear modeling has enabled us to predict the deformation field around fault-propagation folds without the difficulty of assuming paleo mechanical properties of rocks and sediments. We combined the analysis of observed mesoscale faults and the trishear modeling to understand the significance of regional and local stresses for the formation of mesoscale faults. To this end, we conducted the 2D trishear inverse modeling with a curved thrust fault to predict the subsurface structure and strain field of an anticline, which has a more or less horizontal axis and shows a map-scale plane strain perpendicular to the axis, in the active fold belt of Niigata region, central Japan. The anticline is thought to have been formed by fault-propagation folding under WNW-ESE regional compression.

Based on the attitudes of strata and the positions of key tephra beds in Lower Pleistocene soft sediments cropping out at the surface, we obtained (1) a fault-propagation fold with the fault tip at a depth of ca. 4 km as the optimal subsurface structure, and (2) the temporal variation of deformation field during the folding. We assumed that mesoscale faults were activated along the direction of maximum shear strain on the faults to test whether the fault-slip data collected at the surface were consistent with the deformation in some stage(s) of folding. The Wallace-Bott hypothesis was used to estimate the consistence of faults with the regional stress.

As a result, the folding and the regional stress explained 27 and 33 of 45 observed faults, respectively, with the 11 faults being consistent with the both. Both the folding and regional one were inconsistent with the remaining 17 faults, which could be explained by transfer faulting and/or the gravitational spreading of the growing anticline. The lesson we learnt from this work was that we should pay attention not only to regional but also to local stresses to interpret the results of paleostress analysis in the shallow levels of young orogenic belts.