Trishear inverse modeling by using fault-slip data from meso-scale faults

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In this study, we improved the method of the trishear inverse modeling (e.g., Allmendinger, 1998; Cardozo, 2005), which is a method to infer subsurface geological structures quantitatively. The trishear model (e.g., Erslev, 1991; Hardy and Ford, 1997; Allmendinger, 1998) is a kinematic model of fault-propagation folds. In the conventional trishear inverse modeling, observed bedding data (positions of key beds and bedding dips) have been used to constrain the trishear model. However, observed bedding data are usually so limited in number and location that the inverse modeling usually gives several trishear models which have similar goodness of fit for the bedding data and nevertheless represent different geological structures (Cardozo et al., 2011). To deal with this problem, we incorporated fault-slip data of meso-scale faults as a constraint condition. In the new method, the trishear models concordant with the fault-slip data are selected from ones obtained by the modeling using bedding data. The goodness of fit of a model for a fault-slip datum is defined by the angular difference between the observed slip direction and the direction of the maximum shear strain on the fault plane calculated from the model. This new method was tested by the artificial trishear model prepared as an answer of the inverse modeling (answer model) and artificial bedding and fault-slip data simulated from the answer model. As the result of the test, it was found that the trishear models close to the answer model can be selected by using fault-slip data of meso-scale faults. In addition, we applied the trishear inverse modeling to the Matto Anticline in the central part of Niigata Prefecture, NE Japan. The anticline has been regarded as a fault-propagation fold which was formed by a concealed fault. There is a controversy in the dip direction of the concealed fault (Yamada et al., 1992; National Research Institute for Earth Science and Disaster Prevention, 2012). To infer the dip direction, we collected bedding data and fault-slip data from outcrops and carried out the inverse modeling by them. As a result, the east-dipping fault was found to be more concordant with the observed data than west-dipping one.

Keywords: Trishear, Fault-propagation fold, Fault-slip data, Inverse modeling, Uonuma Formation

