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The evolution of glaciotectonic fault-propagation folds

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Glacial deposits may serve as important oil and gas reservoirs and they are often disrupted and deformed. This deformation contributes to glaciogenic reservoir heterogeneity. Therefore, we examined a range of Pleistocene outcrops as analogues to specify the styles of deformation that may be encountered within glaciogenic reservoirs. An interesting feature are fault-propagation folds. They are an important but only seldom recognised structural style within sediments affected by glacier induced deformation. Fault-propagation folds develop in the hanging wall of low angle thrust faults and compensate part of the slip along the fault. Field examples are recognised in northern Europe, formed by different ice advances in the Quaternary. The recognition of the fault-propagation fold mechanism in glaciotectonic deformation is extremely important because resultant structures are related to exactly the same phase of deformation (i.e. the same phase of ice advance), and thus may play a critical role in analyses of the temporal and spatial evolution of glacier induced deformation. Some of these examples are in good agreement with the predictions of the trishear kinematic theory. They show curved forelimbs and monoclinal geometries. The technique of tectonic forward modelling was used to quantify the controlling factors for the evolution of glacier induced fault-propagation folding. The geometry of folds and faults was examined and measured in the field. Special emphasis was placed on the assessment of the interplay of faulting and folding. For the tectonic forward modelling we used the program FaultFold 4.5.4©, which assumes trishear kinematics to simulate the evolution of fault-propagation folds (Allmendinger, 1998). Modelling focused on the geometry and position of thrusts, the displacement and the propagation-to-slip ratio. The simulations were carried out based on field data, to reconstruct the structural evolution of 2D sections from an undeformed to deformed state.

The modelling results show that trishear kinematics are absolutely valid for the description of glaciotectonic fault-propagation folds. The trishear approach is appropriate to model these structures and produces realistic structures that can be compared to natural examples. With respect to the modelling output, the most important factors for the structural evolution of the fault-propagation folds is the ramp angle of the thrust, the position of the tip line and the propagation-to-slip ratio along the fault. This fits to observation made by several previous studies at large scale fault-propagation folds in fold-and-thrust belts. Modelling results show that a P/S ratio of 1 creates a tight fold with a kink-like geometry, whereas P/S ratios of 2.5 result in open folds with well rounded forelimbs. The results of the study show that modelling can help to predict the structure of glaciotectonic products. In the past tectonic modelling was seldom applied to soft sediment deformation. The study presented here underlines the power of modelling techniques and their wide field of application.

References

Allmendinger, R.W. 1998: Inverse and forward numerical modeling of trishear fault-propagation folds. Tectonics 17, 620-656.