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Automated Inverse Modelling of Extensional Basin Formation: Importance of Integrating Geophysical and Geological Data for Thermal History Reconstructions

Many basin stratigraphies are generated by extensional events characterized by geodynamic processes such as mineral phase transitions, ductile crustal flow and multiple rifting events. We perform inversions of extensional basin formation through automatically adjusting parameters, which control numerical forward models. The parameters are adjusted to generate a model stratigraphy, which is close to any real stratigraphy derived from geophysical and geological data. We use a synthetic stratigraphy generated by a forward model including mineral phase transitions, ductile crustal flow and multiple rifting events (referred to here as correct model) as real stratigraphy. For the synthetic stratigraphy the subsidence and thermal histories are known and errors generated by the inversions are evaluated. Our automated inversion algorithm is able to accurately reconstruct the synthetic stratigraphy with both correct and incorrect forward models. Incorrect models do not consider all processes (e.g., mineral phase transitions) that are considered in the correct model. Importantly, the only inversion that additionally reconstructs accurately the thermal history is the inversion using the correct forward model. Inversions using incorrect forward models fail to accurately reconstruct the thermal history, although they accurately reconstruct the basin stratigraphy. Results show that similar stratigraphies are generated under different thermal histories. Contrary, different stratigraphies are generated under similar thermal histories. The most promising approach for accurately reconstructing both the thermal history and the present day stratigraphy for real basins is to integrate all available geophysical and geological data into the inversion algorithm. The integrated geophysical (e.g., bore hole temperature or depth of Moho) and geological data (e.g., number and duration of rifting events) provide necessary constraints for the inversion algorithm and enable excluding incorrect solutions.