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Reconstruction of Stress Fields in Tectonic Plates Based on Field Observations: Elastic and Plastic Models

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This paper theoretically investigates and shows the results of numerical analysis of stress identification in the Earth's crust. Solution domain is regarded as elastic or ideal plastic which gives the opportunity to compare different rheologies. Identification of stresses is based on use of experimental data on principal stress orientations as boundary conditions whereas no information is known regarding stress magnitudes on the boundary. This differs the research from conventional approaches.
Antarctic tectonic plate was chosen as the solution domain. This choice is justified by the character of the experimental data available for this region (The release 2005 of the World stress map) which are scattered around the margins of the tectonic plate and are mainly on stress orientations.
Analysis of tectonic plates regarded as elastic was already reported by Galybin at EGU General Assembly in 2005. Solution was based on formulation of a BVP with principal directions and curvatures of stresses as boundary conditions. This led to the non-uniqueness of the solution for the stress tensor. However it has been shown that the number of solutions is finite and can be fully determined.
This report focuses more on the case of ideal plastic rheology (maximum shear stress is a constant) and the formulation of the BVP for it. The concepts of stress trajectories and slip lines are employed here. The theoretical background is supplemented by results of numerical analysis. This is based on the methods developed earlier and assumes finite difference representation of the differential equations dealt with. An iterative procedure is than employed for the Cauchy's boundary value problem where a novel approach, based on the alternations of BVP for slip lines and stress trajectories, is introduced.
Results for elastic and plastic models are compared. In contrast with the elastic solution the pattern of stress trajectories can be reconstructed uniquely (by integrating differential equation of hyperbolic type found from the equations of equilibrium). Because of the fact that maximum shear stress is a constant, stress tensor may be found with accuracy of one additive constant.

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