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A model of elastic stress field in Antarctica

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This work is aimed at modelling of the stress field in Antarctica by using the data on modern stress orientations available through the World Stress Map project (www.world-stress-map.org). The following assumptions are used in modelling:

- Antarctic plate is considered as an elastic isotropic plane domain (curvature is neglected)
- One of three principal stresses is assumed to be vertical and normal to the domain

The main feature of data is that the information on stress orientations is mostly available in a relatively narrow region Ω associated with the boundary of the Antarctic plate, while few orientations are known within the plate. This necessitates combining two approaches recently suggested by Galybin and Mukhamediev (1999 *JMPS* 47, 2381-2409 and 2004 *IJSol&Struc*, 41, 5125-5142) for solving elastic problems in which stress orientations are known, though stress magnitudes remain unknown everywhere.

First approach deals with the boundary value problem (BVP) formulated in terms of stress orientations. This BVP has no unique solution in general case, however, the number of independent solutions can be identified from the distribution of stress orientations along the entire boundary. Then the total solution of the BVP is constructed as a linear combination of independent solutions and hence it contains several arbitrary real constants. Second approach is applied when stress orientations are known at discrete points located within the considered domain. In this case the problem does not belong to any type of BVPs and its solution is sough as a linear combination of basis functions with unknown coefficients. These coefficients are determined by matching the observed and predicted data.

Although two boundary conditions (BC) are required to obtain a solution of the BVP, only the BC shown below determines the number of arbitrary constants entering into the solution

Here σ_{ij} are in-plane stress components in a reference frame $Ox_1x_2$and φ is an angle that the major principal stress constitutes with the x_1-axes.

The angle φ is reconstructed from the data on the most of the boundary. Second BC involving the curvature of stress trajectories on the boundary cannot be derived from the data with satisfactory accuracy. Thus it has been proposed to use condition (1) not on the boundary but in the narrow region Ω, which is considered as a proper approximation of the second BC. This eventually leads to the mathematical formulation as in the second approach mentioned above.

The analysis of data (357 points of different quality) has shown that

- Solution for stress components contains two arbitrary real constants
- Maximum shear stress (acting in-plane) contains one unknown multiplicative constant
- Stress trajectories are unique

The arbitrary constants cannot be identified from stress orientations alone but they can be determined if stress magnitudes are known at some locations.

Computations have been performed for different systems of basis functions and the fields of stress trajectories and dimensionless maximum shear stresses are plotted. The analysis of the model shows that higher level of shear stresses can be expected in areas adjacent to Pacific, Nazca and South American plates.

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