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Application of the stress orientation concept to some problems of geodynamics and palaeogeodynamics

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In situ stress orientations are usually found by inverting data on natural stress indicators and used as constraints on the sought solution when modeling tectonic stress field by using conventional methods. The latter are based on solving boundary value problems formulated in terms of boundary stresses and assume specific constitutive equations for the lithosphere. A solution that fits the data is further considered as a possible stress tensor field (T-field) realised in the region. However, diverse boundary conditions may produce the same stress orientations, which (due to the large scatter of the plate-driving force estimations) indicates non-uniqueness and unreliability of the results obtained by this approach.

The alternative direct approach uses the data on stress orientations as input information, which leads to new types of problems possessing relaxed conditions on constitutive equations and/or boundary conditions. Spatially discrete experimental data on stress orientations are used to compile trajectories of principal stresses (TPS). In this case, there is no need to assume any constitutive model for the region under study: the equilibrium conditions present a closed system of partial differential equations of the hyperbolic type with the characteristics that coincide with the TPS. If an elastic model for the region is introduced, then there is no need to know the boundary stress magnitudes because the T-field is determined by the TPS field with an accuracy of finite number of arbitrary constants. For the elastic lithosphere the numerical method has been developed, which recovers the T-field directly from the discrete stress orientations without preliminary compiling the TPS field. Only a positive multiplier is

unidentified in the determined deviatoric 2D stresses. This multiplier represents itself by a constant or a second-degree polynomial of coordinates (if inclination of the TPS is a harmonic function).

The above methods have been applied for investigation of the contemporary 2D T-fields in some stable blocks of the lithosphere (e.g., West European and Australian platforms) including reconstruction of stress magnitudes and constraining plate-driving forces. One of the main results is the revelation of a singular point of the TPS pattern within continental Australia.

The direct approach is most advantageous for reconstructing continuous palaeostress fields because in that case one has no information on the boundary stresses in principle. As a proper stress indicator, we considered rock joint patterns in sedimentary rocks of various ages. Both field observations and theoretical considerations show that the primary joint sets are formed at the stage of diagenesis of sediments at horizontal bedding. Most likely, it happens due to internal instability of sediments manifested in localized form. During lithification, regularly spaced thin zones of localized plastic deformation evolve into the observed rock joint sets. The maximum compressive palaeostress is directed along the bisector of the acute angle between conjugate joint sets. Since the age of primary joint sets is associated with the time of sedimentation, the data related to different tectonic phases can be subdivided into monophase subsets. The approach has been applied to reconstruct the evolution of palaeostress fields in some elastic regions adjoining to the zone of convergence of Arabian and Eurasian plates.

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