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Advanced Numerical Modelling Of Stresses In Tsunamigenic Regions

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The analysis of several tsunamigenic zones by a newly developed computational method allows for identification of most possible stress regimes in these regions. The method uses only the data on stress orientations from the World Stress Map database, but not the data on stress regimes, depths, etc. containing in the database. Orientations serve as the input for the direct modelling of the stress fields, in particular, to obtain the maps of stress trajectories, maximum shear stresses and mean stresses in order to reveal most possible stress regimes.
The tectonic plates are modelled as elastic domains on the basis of complex potentials in the Kolosov-Muskhelishvili's formulation. Continuity of tractions is imposed on all plate boundaries as the transmission boundary condition to complement the WSM data on stress orientations. This formulation obeys the mechanical meaning and it is valid for all the configurations regardless of the possible types of inter-plate interaction. The numerical approach requires discretisation of the computational domain into elements, followed by introduction of the collocation points on the element interfaces. The complex potentials are approximated by polynomials within every element and the continuity of the potentials is imposed at the collocation points. The technique is inspired by the Trefftz method which provides low sensitivity to the choice of element shapes and sizes. This is an advantage that allows us to take into account real geometry of the tectonic plates. As the result, the fields of stress trajectories, maximum in-plate shear stresses and mean stresses have been determined. The former is a unique field while the field of maximum shear stress is normalised (therefore one positive multiplicative constant is an arbitrary parameter) and the field of the mean stress contains one extra additive parameter. Despite this non-uniqueness, conclusions regarding most likely stress regime can be drawn.
The regions under investigation included 3 areas where the recent 2009-10 tsunamis have occurred, namely, Tonga, Sumatra and Solomon Islands. Analysis has shown that the stress patterns of all of these areas are somewhat similar. The Zones of low maximum shear stresses have been revealed near the plate boundaries that correlate with the locations of the recent 2009-10 tsunamis. Therefore the low values of maximum shear stress can be associated with the potentially "tsunamigenic stress regimes" (namely with either normal or thrust faulting). This complements the WSM data on stress regimes in these regions.
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