Elastic Constant Inversion based on GPS velocity

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We constructed new inversion method named 'elastic constant inversion method' to estimate Poisson's ratio in the earth's crust based on GPS velocity field, and applied it to the Chugoku District, southwestern Japan.

The inversion method is formulated for two-dimensional plate in plane stress state, whose material has linear isotropic elasticity and heterogeneity of the elastic constants. We studied a case when Poisson's ratio is heterogeneous and Young's modulus is uniform as the simplest case. A number of small 'blocks' in which Poisson's ratio is constant are defined. Poisson's ratio in each block was estimated from the velocity vectors based on equilibrium of the stress. If we choose many blocks in the body such that they overlap determining Poisson's ratio of each block by each other, we can estimate the whole distribution of Poisson's ratio in the body.

An inverse problem of Poisson's ratio in a block is formulated by equilibrium equations of stress. We can obtain the simultaneous equation about Poisson's ratio with using spatial derivatives of velocity field as coefficients. The derivatives of velocity field can be calculated from GPS data, however, the observation error makes the straightforward estimation of the derivatives difficult. Thus, we adopt Taylor series expansion of the velocity field to estimate them. Velocities at nodes in a block, where GPS velocities are given, are expressed by the products vector of an expansion coefficients vector, whose components are equivalent to spatial derivatives of velocity at center of the block, and a matrix composed of polynomials of coordinates of the nodes. We applied singular value decomposition to this matrix to estimate the expansion coefficients. The number of nodes in a block is determined by prediction error of the equilibrium equations taking the spatial change of Poisson's ratio into account, and the cutoff order of the singular value decomposition and Taylor series decomposition are determined by comparison of the ratio between maximum and minimum singular value with the ratio of the error to the signal of GPS observation.

We performed some calculation examinations of the method comparing with the method in which the spatial derivatives of velocity field are calculated directly applying finite element method. The results of the examination exhibit good accuracy in reproducing the given Poisson's ratio distribution and its superiority to direct differential method.

The elastic constant inversion method derived above is applied to Chugoku district, southwestern Japan, in the periods before and after the 2000 Western Tottori earthquake. We used GPS data of GEONET observed from 1997 to 2002. Annual and biannual sinusoidal variations and jumps that have apparent origins are excluded from all GPS time series. The result shows significant change of the distribution of Poisson's ratio with the earthquake. It may indicate the movement of crustal fluid. The comparison with seismic study suggests that there is isolated area in the viewpoint of transmission of regional stress.