Model study of influence of internal stresses on deformation and seismic processes in convergent plate boundary zones by the example of Lake Baikal ice cover

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An important class of problems in mechanics of heterogeneous media (including geological ones) isstudying regularities of deformation and destruction of specific quasi-two-dimensional (plate) systems, whose structural elements are mainly located in one plane. A classical example of a natural plate medium is the lithosphere. Macroscopic geometry of the lithosphere and mechanic characteristics of substrate stimulate its fragmentation (breaking into ensemble of interacting plates) and appearance of specific deformation mechanisms, connected with removal of mature material from the plane of deformation (subduction) and formation of a new one (spreading). Studying zones of subduction and their influencing the stressed medium condition is one of the most urgent geotectonic and geodynamic problems, connected with understanding regularities of deformation processes in the lithosphere. Due to huge spatial and temporal scale of deformation pro-cesses in such zones, one of the perspective ways to analyze their peculiarities is physical modeling with the help of simplified model systems. As the results of previous researches have shown [Hamagu-chi, Goto,1978; Psakhie et al., 2009], a perspective model medium for studying tectonic processes (in particular, the conditions of subduction zone formation and development) is a plate ice cover of large water reservoirs. The present paper is devoted to evaluation of typical level of stress in plate medium and the role of underride/subduction as relaxation mechanism by the example of Lake Baikal ice cover. The conducted full-scale research have shown that regularities of localization of interplate defor-mations in the Lake Baikal ice cover are determined by distribution, value and sign of internal plate stres-ses. In particular, convergent interplate movements, leading to forming and developing underride zones (analogous to subduction zones in the lithosphere), are the results of increase in positive (stretching) stresses. Decrease in value and change of stress sign to negative result in partial consolidation of blocks consisting in "healing" some of previously active interfaces and localization of small, mainly divergent interblock movements on the rest of the interfaces. These regularities are consistent with modern conception on the connection between sign and value of regional tectonic stresses near inter-plate boundaries in the lithosphere and type of relative displacement of tectonic plates (convergent or divergent). It is important to mention that stress distribution inside the consolidated (i.e. not separated by through-thickness cracks) fragments of the ice cover is rather homogeneous and correlates mainly with the direction of movement of the fragments themselves. At the same time, stress state of neighbo-uring fragments can differ greatly. In accordance with traditional definition [Zoback,1992], stresses deter-mining deformation processes on the ice cover interplate boundaries can be regarded as "tectonic". Thus, measurement results prove the existence of "plate tectonics" in the ice cover of Lake Baikal and support its usage for the physical modeling of tectonic processes in the lithosphere being grounded.

On the basis of measurements of internal plate deformations the threshold stresses of activation of convergent processes in the underride zones as high-rank deformation-induced structures are estimated. The value of these stresses is connected with inner cohesion on the most solid parts of interplate boundaries and, as a rule, varies within the range 2—10 % of the compression strength of plate material. In case of "healed" boundaries (after ra-ther long "calm" periods of deformation activity) the activation threshold value can rise anomalously high (20—30 % of plate material strength). The recent research results show that high internal stresses can provoke changes of the character of deformation processes in a block-structured medium, in-cluding the appearance of "precursors" of dynamic convergent events and effects of fragmentation of consolidated blocks. It gives the ground to the supposition that anomalies of deformation regime of the Earth's crust, registered at various times before large earthquakes, seem to be connected with reaching a certain threshold level of stress in the area of registration. Basing on the data obtained on the ice cover we can suppose that a characteristic value of such strains can reach 20—30 % of rock strength.

It is important to mention that activation of inter-plate boundaries in the ice cover as a multiscale block-structured medium is preceded by the involve-ment of low-rank deformation mechanisms. As the seismic monitoring data show, the intensity of their involvement rises abruptly when the activation moment approaches. Alongside with it, immediately before the activation the number of relatively high-energetic seismic events increases, which reflects growing charac-teristic scale of the involved deformation mechanisms with the increase in internal stresses.

All said above indicates that both ice cover and the lithosphere are multiscale media with a hierarchical system of relaxation mechanisms. Each mechanism corresponds to a typical activation threshold (stress). Relaxation (and deformation) mechanisms with maximum involvement threshold are connected with the formation and functioning of interblock boundaries. Thereby, the ice cover of Lake Baikal gives a unique possibility to study the influ-ence of a strained state on the regularities of deformation accommodation processes in block-struc-tured (plate) media of different nature, particularly, in the lithosphere.

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