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Application of Emission Tomography for Localization of Seismic Sources and Active Zones

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Algorithm of seismic emission tomography used in this study is based on the summation of observed seismic records along traveltime curves calculated for different positions of conjectural sources. It is supposed that velocity structure is known. Hypothetical sources are sequentially placed in regular grid points of investigated volume and for each source position semblance S (the ratio of cumulative signal energy to sum of individual signals energies) is calculated. If observed records contain signals from sources located in investigated volume, local maxima of S have to correspond to each real source position. Visualization of S gives an overview about spatial distribution of seismic sources.

The numerical experiments showed that random noise in the data influences on the contrast of source selection. In the absence of noise the maximum value S at the source point may exceed the background values iteratively, but for signal-to-noise ratio about unit the exceeding can be only several tens of percent. Incorrect velocity structure leads to source shift close to vertical direction. Sources move up for higher and down for lower velocities. Traveltime fluctuations within half of wave period (for example, owing to surface inhomogeneities) influence on the results appreciably smaller than random noise.

To investigate capabilities of seismic emission tomography for localization of single sources method was tested on the data of physical modeling and full-scale experiment. According to results of physical modeling, mean location errors for any coordinate did not exceed a few percents of collection system dimension. Results of full-scale experiment with areal data collection system (30*30 m2) showed the good accuracy of horizontal source localization (location error was less than 0.5 m), and slightly worse one for the depth. Algorithm of seismic emission tomography was also used for determination of small earthquakes epicenters in Altai Mountains from data of 5-6 seismic stations and shown quite good results.

The data of passive seismic observations in active zones were processed as well. In the first case passive seismic observations were carried out in the area of mud volcano in Taman Peninsula (Black Sea). Noisy zone was found under the volcano crater with maximum intensive noise at depth of about 150 m. In the second case the data of passive observations on linear seismic line across the surface rupture in epicentral zone of strong earthquake in Altai Mountains (27.10.2003, Ms=7.3) were processed. Here zones of anomalous S were found in the depth interval 400-800 m.

Thus, obtained in wide frequency range (from ultrasonic to seismological frequencies) results showed that seismic emission tomography is the effective tool for localization of seismic sources and for study of active zones.