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PASSIVE SEISMIC IMAGING OF POWERFUL VIBRATOR NEAR-ZONE

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The paper presents the results of experimental study of ground noise in near-zone of the powerful vibrator. Experiments were carried out on Bystrovka vibration seismic test site located on the East Bank of the big river reservoir (Ob' sea) about 50 km south-west of Novosibirsk (Russia). The powerful vibrator (Figure 1, left) located on this site can generate ground force 40-50 tons in the frequency range 5-15 Hz. Vibrator is used for active seismic monitoring, and it works once a week during several sessions each a few tens of minutes.

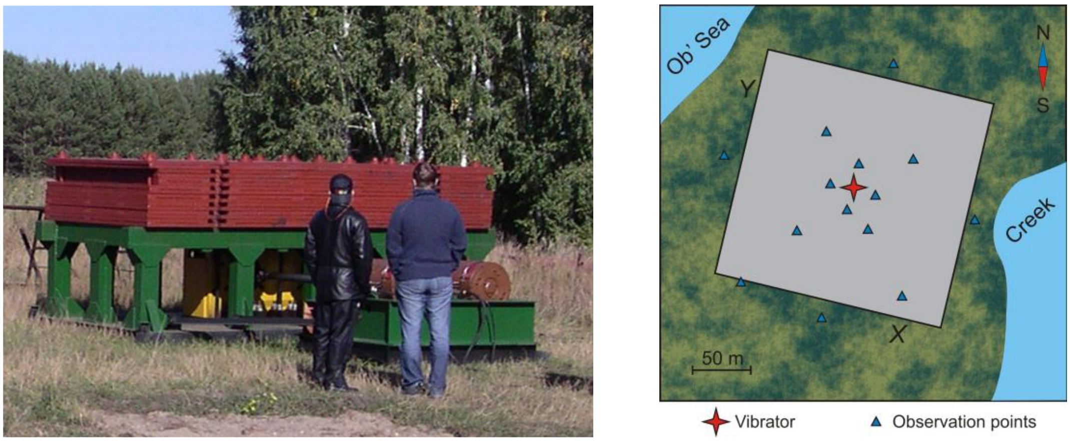

Figure 1. Powerfull vibrator (left) and observing system on Bystrovka test site (right); grey square shows projection of investigated volume

Near this vibrator, the network including 14 observation points was organized (Figure 1, right). At each observation point, the vertical geophone GS-20DX and the seismic recorder RefTek-125A were installed. Continuous recording at all observation points began one hour before the start of first vibration session and lasted about 22 hours. During this time, 7 sessions of vibrations were carried out. Session duration varied from 20 to 45 minutes with breaks between sessions about 2.5–3 hours.

We could not detect any regular changes in microseisms energy directly on the records obtained during breaks between the vibration sessions. However, after averaging microseisms energy estimates for each vibration break, we found out the clear regularity in microseisms energy changing. After subsequent sessions microseisms energy is growing, at first with increasing and then with decreasing gradient. After the last vibration session, the average energy of microseisms increased by almost an order of magnitude compared to background values.

In spite of the observed regular changes of microseisms energy after powerful vibrations, there is a question about the nature of the microseisms – whether they are exogenous or endogenous. We processed the noise records using algorithm of seismic emission tomography (e.g., Kugaenko, 2005),

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which allows detecting noisy zones in a medium with known velocity structure and has high interference immunity to incoherent noise. Algorithm is based on the summation of observed seismic records along traveltime curves calculated for different positions of supposed source. For example, sources can be sequentially placed in a regular grid of investigated volume. For each source position semblance S (Neidell and Taner, 1971) is calculated – the ratio of cumulative signal energy to sum of individual signal energies. If observed records contain signals from sources located in investigated volume, local maxima of S will correspond to each real source position.

For data processing we used not numerous a priori information about velocity structure in the Bystrovka site. It was assumed that longitudinal wave velocity in the top layer of 15 m is $V_p = 420$ m/s, farther to a depth of 50 m $V_p = 3500$ m/s and deeper $V_p = 4450$ m/s. Scanning on points of supposed sources was carried out for cubic volume of medium with edge of 200 m.

Processing of microseismic field before beginning of vibrations using algorithm of seismic emission tomography didn't show considerable anomalies of semblance S. However, during the breaks after vibrations the anomalies of S corresponding to noisy zones appear both near the surface and at the depths of up to 20-30 m (different cross-sections of S before vibrations and after sixth vibration session are shown in Figure 2).

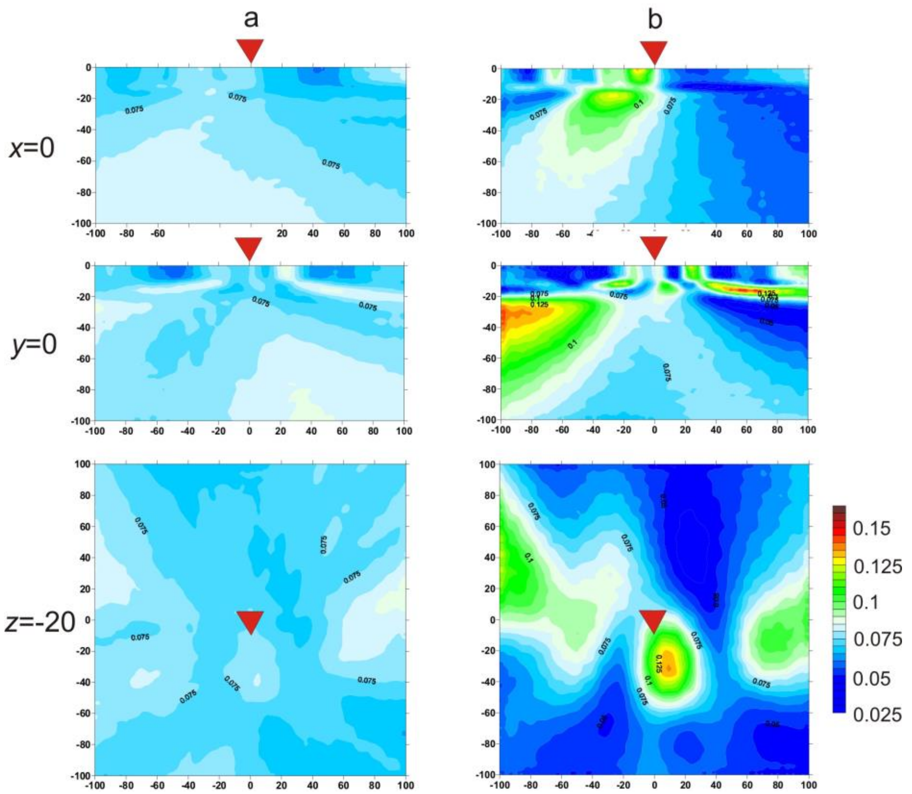

Figure 2. Cross-sections of averaged semblance S before vibrations (a) and after sixth vibration session (b); triangles indicate vibrator position

Thus, data processing using algorithm of seismic emission tomography allowed us to justify the endogenous nature of microseisms increasing on the ground surface after powerful vibrations. As it was shown by additional experiments, average ground noise energy decreases to background level for about half a day after the last vibration session.

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