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MICROSEISMIC SOUNDING IN THE SOURCE ZONE OF THE SKOVORODINO, 2011, EARTHQUAKE (M=6.0)

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The earthquake with Mw=6.0 occurred on October 14, 2011 in the southeastern Siberia (Russia) in the zone of junction of Kalatur and Tukuringra mountain ranges near the town of Skovorodino. This earthquake aroused a great interest among specialists due to its strength and location. The magnitude of the Skovorodino earthquake is the largest in the known seismic history of the region and is close to the maximum value expected for the region. Besides, presently this region is actively developed; including the construction of oil- and gas-pipelines. The exact knowledge of the source zone and the specific geologic structures is of primary importance for the correct seismic hazard assessment. Although the world and regional seismological networks adequately reflect the seismicity of the area, they do not provide the necessary quality of location of even strongest events.

The epicentral observations of the Skovorodino earthquake were carried out by the network of Institute of Physics of the Earth, RAS, during October-December 2011 and made it possible to monitor the aftershock activity. More than 1300 events were recorded. Map of epicenters together with the cross-sections by depth and the fault plane solution are shown in Fig.1. The analysis of more than 10000 waveforms led to the following conclusions (Bykova et al., 2014)

1. The Skovorodino, 2011, earthquake is an outstanding event in the region. Its magnitude exceeds previously known values by 2 – 2.5.

2. Two clusters of epicenters are clearly expressed in the aftershock cloud: west and east (Fig. 1). They differ in the recurrence plots, in the level and time variations of the energy released, and in the depths of hypocenters, which implies the complex structure of the source. Generally, the source can be represented as a strike-slip in a plane striking EW and dipping steeply to the North. Its sizes are about 17 km × 17 km, the mean value of the displacement is about 63 cm, exceeding the values characteristic for M=6.0 events by about 30%.

3. The aftershock sequence is anomalous: rather strong ($M \geq 3.5$) aftershocks are absent. It is consistent with the anomalously large displacement in the source and the rather large magnitude of the mainshock with respect to events previously recorded in the region.

The study of the source zone of the Skovorodino earthquake was continued in 2013 using the methods of microseismic sounding. The aim was to reveal 3D heterogeneities in the source zone and to construct the more precise model. The region studied is shown by the frame in Fig. 1.

In the method proposed the spatial properties of spectral characteristics of microseismic signal recorded by one or several stations along profiles within the specific site are used to identify the heterogeneities of the medium (Kalinina et al., 2009). The analytical solutions proved that in the Rayleigh fundamental mode the zone of maximum shear stresses is located at a depth equal to half of

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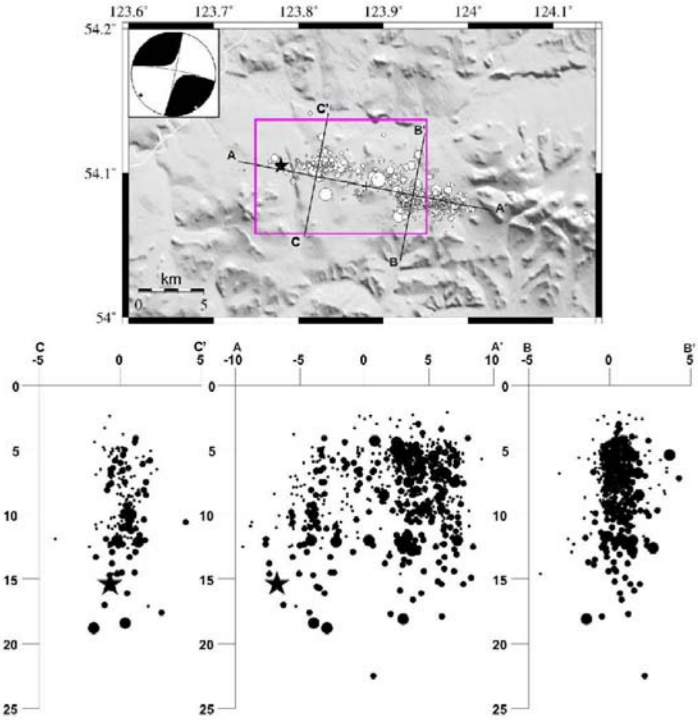

Figure 1. Map of aftershock epicentres (the star marks the mainshock), cross-sections by depth along the lines AA’, BB’ and CC’ and the CMT fault plane solution. The frame shows the region studied by microseismic sounding

their wavelength. The zones of maximum amplitudes are situated close to the surface. The local heterogeneities with different elastic modules lead to changes of the oscillation character in microseism amplitudes. If seismic wave velocities in the heterogeneities are higher than in the surrounding rocks the amplitude of the microseismic waves above the heterogeneities decreases, and vice versa.

The random component of microseisms is compensated during spectral analysis by averaging the signals over a significant time intervals. The correct interpretation of the data obtained required the record time should increase the interval of signal stationarity in the frequency range observed. The observations were carried out at 21 points along 3 profiles (nearly corresponding to the western and eastern clusters of the aftershock cloud and the striking direction). To study the identity of recording conditions, the instruments were disposed for simultaneous registration at the point of the base-station before and after the field observations. Besides, to take into account the influence of global and local microseism sources, one station (the base-station) operated in a continuous mode. The power spectra densities obtained were normalized by the corresponding PSD of the base-station and the maps of distribution of relative microseismic amplitudes were constructed in the frequency range studied. The results were converted the depth $H(f)$ distribution using the expression $H(f) \approx 0{,}5 \times \lambda(f)$ (where $\lambda(f)$ is the wavelength), i.e. to depths of ~15 km, taking into account the frequency range of the instruments used.

The results of the microseismic survey are illustrated in Fig.2 as the horizontal layer at a depth of 10 km. The zero depth corresponds to the level located at the absolute mark equal to 500 m. The color spectrum reflects the intensity of the relative amplitude of microseisms in decibels. The microseismic survey method allows us to distinguish rocks by their velocity properties. The base-station was installed within the studied zone on the Devonian sandstone deposits, so areas having similar elastic properties will give close to zero amplitude (green color). Figure 2 exhibits the following characteristic features of the investigated area:

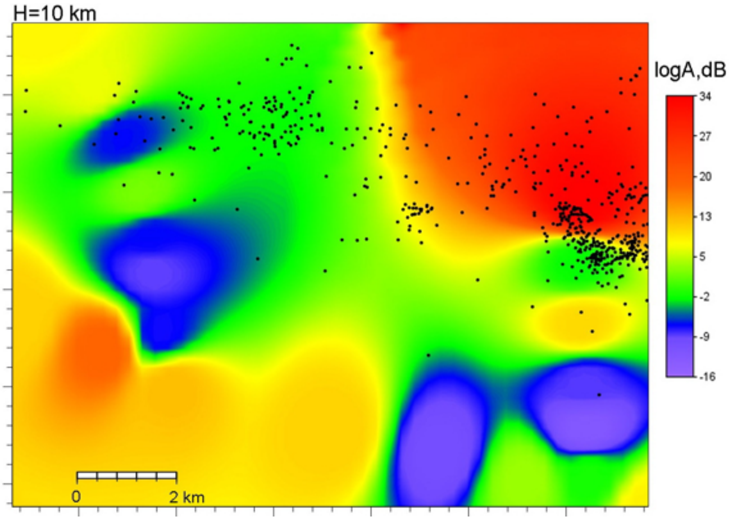

Figure 2. Results of the microseismic survey at a depth of 10 km

1. The zone of high amplitudes $\lg A > 10$ dB (red color) could be interpreted as the fractured sandstone and sandy shale deposits of Devonian. In the northeast, the large red zone agrees well with the location of the most intense east cluster of aftershocks.

2. The local zones of low amplitudes $\lg A < -5$ dB (blue color) have almost the equal size (about 2 km in diameter) and stand up to a depth of 2 km. These zones could be interpreted as an intrusion of Pz_3 volcanic rocks.

The complex investigation of the Skovorodino earthquake source zone is continued.

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