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INVESTIGATION OF THE BOUNDARY AND INTERNAL FAULT ZONES OF TUNKA BASIN (BAIKAL RIFT SYSTEM) USING HVSR METHOD

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Introduction

This work is devoted to the study of the Tunka basin structure of south-western flank of the Baikal rift system. This basin is the central element of 160km long latitudinal chain of rift basins separated by low uplifts. Tunka is the largest and deepest basin (Fig. 1). The thickness of sedimentary cover is greater than 2000 meters (Logatchev, Zorin, 1978). The sedimentary cover of the basin is represented by rift lacustrine, alluvial, volcanoclastic sediments and basalt flows. In general the depression is a half-graben bounded from the north by the steeply dipping Tunka fault. The surface of the Khamar-Daban block from the south gently plunges under the sediments of the depression. It is assumed under sediments the depression is crossed by the seismically active Baikal-Mondy fault in a latitudinal direction. Several known historical and instrumentally recorded strong earthquakes are confined to this fault.

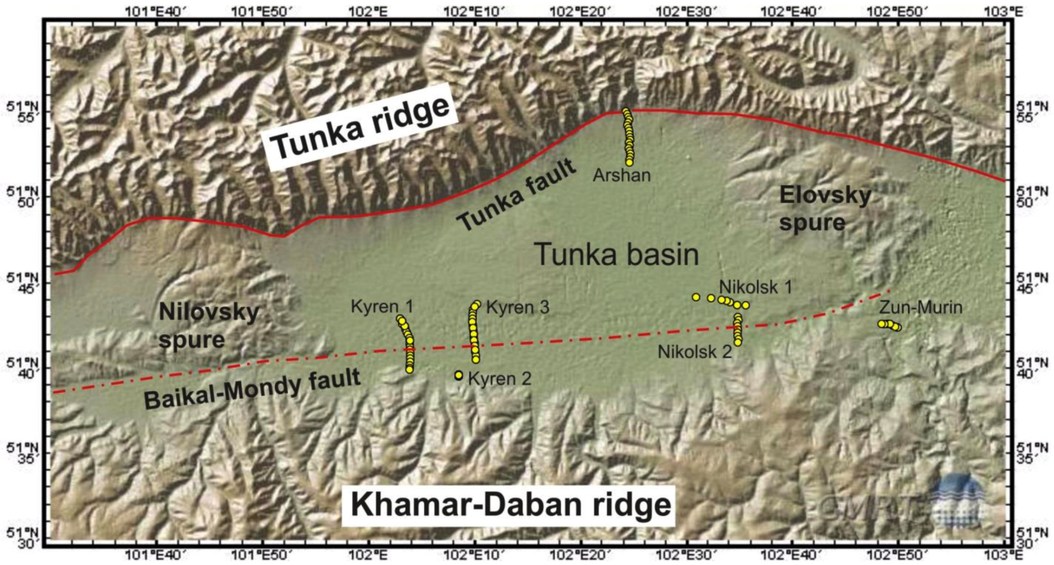

Figure 1: The topography of Tunka basin. The position of the HVSR profiles is shown by yellow circles.

Method

We used the data of microseismic sounding in comparison with the data of drilling and structural observations. The Horizontal-to-Vertical Spectral Ratio (HVSR) method, also called Nakamura's method (Nakamura, 1989), is a single-station approach using ambient noise measurements to estimate the fundamental frequency of a site. For site conditions where there is a strong contrast in velocity between the surface layer and a deeper material a peak will be observed in the HVSR plot that closely corresponds to the fundamental frequency of the site. This method has been used extensively in microzonation studies of cities around the world. At present the number of publications on the use of various modifications of microseismic sounding for the study of different parts of the earth's crust are known (Gorbatikov et al., 2008; Gosar, Lenart, 2010; Mulargia, Castellaro, 2016). The method allows to evaluate of the position of faults, forms the basement, to reveal heterogeneity of medium.

When studying the internal structure of rift basins and active fault zones, measurements of ambient noise were made for long profiles crossing the depressions, as well as for profiles oriented across the orientation of fault zones. The recording time of ambient noise in each point was from 30 minutes or more. The H/V-ratio curves were calculated in the frequency range from 0.5 to 20Hz. The velocity structure was estimated using dispersion curves calculated for single or two stations located in the same block.

Results

In the present study we consider several profiles (Fig. 1). Sounding profiles were traversed in the inner parts of basins, as well as across strike of boarder faults.

The submeridional profile of Nikolsk 2 in the southern side of the Tunka depression crossing the zone of the Baikal-Mondy fault is a good illustration of the HVSR method. (Fig. 1). The thickness of the sedimentary cover here increases in the north. At the same time the complexity of the section increases due to the appearance of dense inhomogeneities (Fig. 2, 3). It is reflected on H/V curves in the appearance of additional maxima of the H/V ratio values. The results obtained were compared with drilling data (Fig. 3). The zone of the Baikal-Mondy fault is represented by three faults in the basement that emerge into the sedimentary cover.

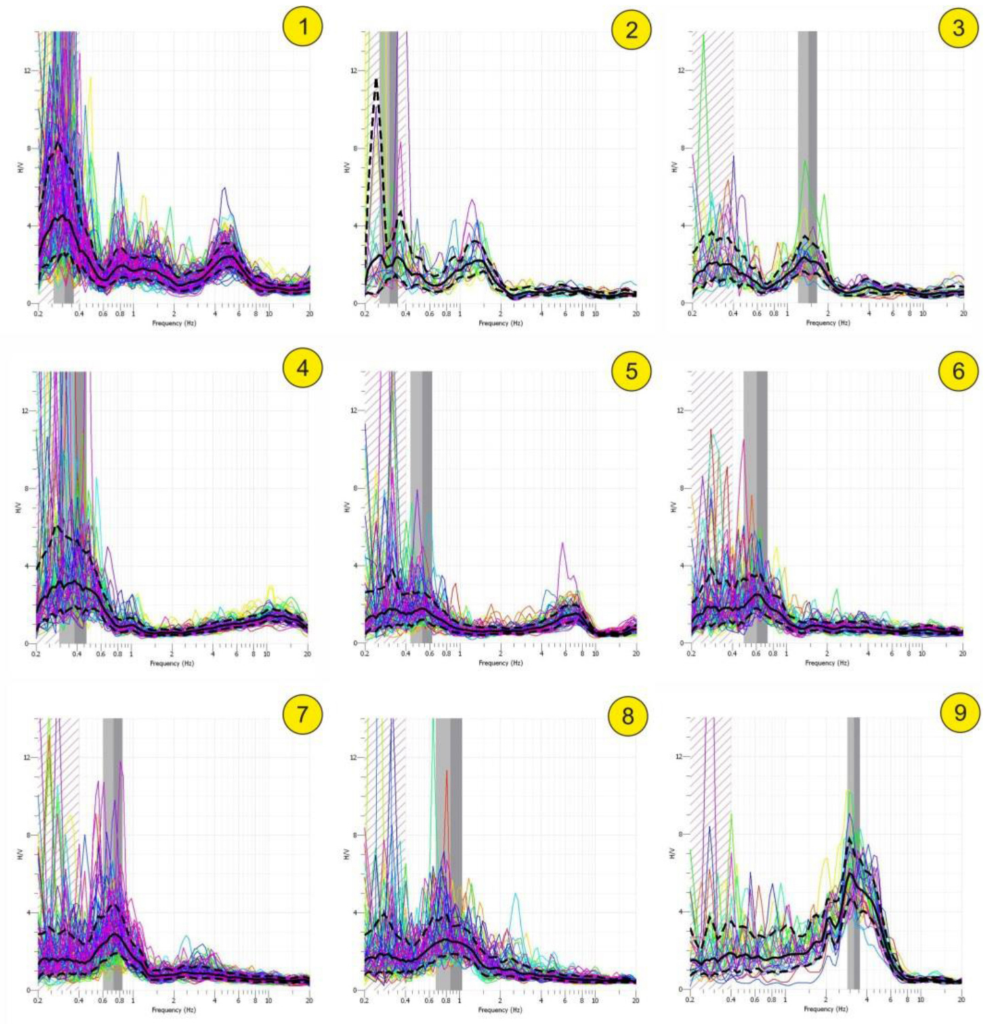

Figure 2: H/V curves for seismic stations of Nikolsk 2 profile.

Sublatitudinal cross-section along the left side of the Irkut river valley in the east of Tunka basin (Nikolsk 1, Fig. 1) shows large differences in the composition and the constitution of one in the eastern and western parts. West, the deepest part of the basin, is composed by mainly of soft, and at the bottom - denser sediments. Basement depth here is about 1000 meters. To the east an uplift of basement reveals along the fault of reverse or thrust type, or the existence of dense body of volcanic rocks in the lower part of the section. Still further to the east there is a gradual rise of the basement, which corresponds to the modern relief of the western slope Elovsky spur. Here, in the upper part of the section high density layers are allocated, which correspond to basalt flows established by drilling and geological observations.

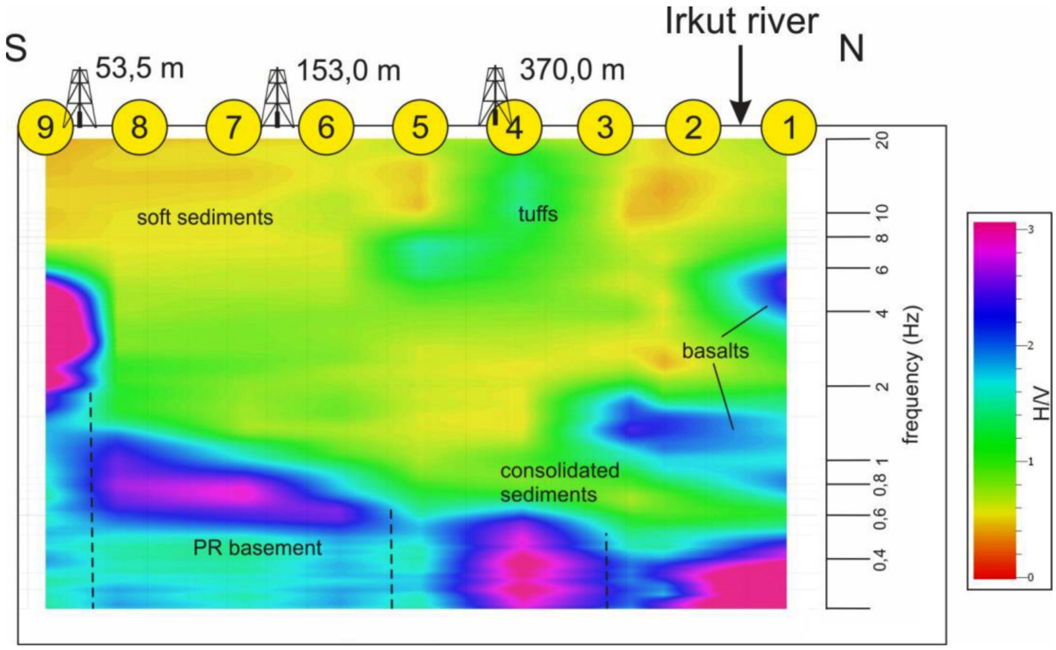

Figure 3: The HV cross-section along Nikolsk 2 profile. The position and depths of boreholes are shown. Dashed lines show the faults in the basement.

Two submeridional profiles in the western part of the basin (Fig. 1) made it possible to determine the position of individual faults in the zone of the Baikal-Mondy fault. According to our data, the general structure of this zone is a graben, the depth of which exceeds $1200m$. The graben is complicated by a longitudinal fault, along which vertical displacement of the surface of the PR basement of the depression is also noted.

The preliminary interpretation of submeridional $6km$ long section across Tunka fault (Arshan) shows the vertical displacement of basement surface with amplitude at about first tens meters along the fault plane. Further to the south on $5km$ the inclined step is traced. Obviously, the main displacement which forms a deep part of the basin is located to the south of the end of the profile.

Conclusions

As a result of the investigation, we came to the following conclusions:

1. The use of the method of microseismic profiling made it possible to establish the position of individual faults in the zone of the seismically active Baikal-Mondy fault under the KZ sediments of the Tunka rift basin. In addition, it allows to determine the thickness of the sediments.

2. There are the fundamental differences in the compositions of the section in the western and eastern parts of the Tunka basin. Western (the deepest part) of the basin obviously does not contain basalt flows.

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