DETERMINATION OF LUNAR-SOLAR DEFORMATION PROCESSES IN THE GEOMEDIUM VOLUME IN THE CONDITIONS OF MEGAPOLIS

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Abstract. The paper describes a new borehole hardware-software complex designed for synchronous registration of geoacoustic emission signals, electromagnetic radiation, temperature and borehole device rotation angle. The results of regime measurements with the new equipment in megapolis conditions are shown. The analysis of the obtained data is performed. The spectral-time analysis of regime measurements of geoacoustic emission and electromagnetic radiation signals registered in the borehole at a depth of 274 m was carried out. In the spectra of signals of electromagnetic radiation and geoacoustic emission the main diurnal and semidiurnal deformation tidal processes of known physical nature were identified.

1. Introduction
As is known, as a result of relaxation of tectonic stresses in the mountain rock, geoacoustic and electromagnetic signals arise. In most cases, fractured and crushed rock zones undermine by a borehole are marked by increased values of geoacoustic emission (GAE). On the other hand, as a result of rock deformation and fracture, the resulting electric fields generate electromagnetic radiation in a wide range of frequencies. At the same time, taking into account the variety of mechanisms of conversion of mechanical energy into electric energy [1], as a result of borehole logging it is possible to encounter rock intervals where anomalies are recorded both in geoacoustic and electromagnetic parameters.

Spatial and temporal distribution of natural geoacoustic emission (GAE) and natural electromagnetic radiation (EMR) in boreholes carries significant information about deformation processes in the Earth's crust, directly reflecting both the current stresses and the structure of the studied rock mass [2]. GAE and EMR of rocks change over time. This is recorded by control measurements over days, weeks, months and years [3]. Identification of hidden periodicity in temporal variations gives an insight into the type of deformation processes and their physical nature.

2. Equipment for borehole measurements
The problem of studying the current dynamic state of rock massifs in their natural setting, gave rise to the need to create the appropriate equipment for measurements in boreholes. Earlier in the borehole geophysics laboratory of the Institute of Geophysics UB RAS already created a device (MESH-42) [4], which allows to conduct synchronous measurements of GAE signals from three mutually orthogonal sensors (X, Y, Z) in three frequency ranges (from 100 to 5000 Hz) and EMR at three frequencies (40, 80 and 120 kHz).
This year there was used a prototype of the complex device SHEST-4201 [5], that allows to conduct simultaneous measurements of GAE signals in three frequency ranges (from 100 to 5000 Hz), EMR at 8 frequencies in the frequency band 35-135 kHz, ambient temperature and inclination angle of the device body relative to the borehole inclination plane down to 2 km depth. Improvement of the new device characteristics is made by increasing the number of frequencies and stabilizing the ranges of received EMR signals in the whole received range of frequencies.

3. Research results.
All measurements were carried out in a borehole located on the territory of the Institute of Geophysics. The borehole was drilled in the gabbro strata of the Shirokorechensky massif. The geological section is represented by interbedded gabbro of different structure from fine-grained to coarse-grained. There are interlayers of amphibolites, tuffolavs, peridotites and quartz veins of low thickness. The depth of the borehole casing is 40 m.

In order to conduct long-term measurements, the borehole instrument was installed at the bottom hole at a depth of 274 m. The geological structure of this area is represented by medium-grained massive gabbro, with thin veins of quartz-carbonate composition. Continuous measurements lasted from October 15 to 29, 2020. Full record of GAE signals (H1, H2, H4, Z1, Z2, Z4), EMR (F1...F8) and borehole instrument rotation angle (αlf) are shown in Figure 1.

On the diagrams of horizontal H1 and vertical Z1 components of geoacoustic emission signals measured in the first frequency range, 8 local anomalies of different intensity were recorded during the measurements. The most significant anomaly stands out 22.10.20 from 10:00 to 14:00 local time on parameters H1 and Z1 with an increase in the amplitude level relative to the background values to 1.01 and 0.7 mm/s², respectively. By the same parameters, abnormal increases in amplitudes of lesser intensity were registered on 19.10.20 from 10:00 to 13:00, on 21.10.20 from 14:00 to 15:00, on 23.10.20 from 11:00 to 17:00, on 27.10.20 from 10:00 to 11:00, on 28.10.20 from 12:00 to 14:00 and on 29.10.20 from 9:00 local time. A characteristic feature of all selected anomalies is their manifestation in the daytime during the working week, which may suggest that their source is of technogenic origin. In particular, such a source may be blasting, carried out at the crushed stone quarry, located near Yekaterinburg. On the diagrams of all other parameters such local anomalies are not fixed. Background values of GAE components in all frequency ranges are within 0.4-0.7 mm/s², the amplitude level of EMR signals of geological environment at frequencies 40-120 kHz varies from 0.2 to 1.9 pTl that corresponds to the quiet geodynamic situation in the borehole area.
Since rocks are in a stressed state, changing under the influence of many factors, including lunar-solar tides, irregularity of the Earth's daily rotation, its own vibrations, etc., the result is the formation of a complex vibrational mode of stressed state. In order to highlight the known deformation processes [6], manifested in the fields of geoacoustic emission and electromagnetic radiation in conditions of constant technogenic impact on the geological environment (in a megapolis) performed spectral-time analysis of variations in the amplitudes of GAE and EMR signals. For this purpose, an hourly averaging of the obtained data was performed. Figures 2 and 3 shows the results of the analysis, where the periods of oscillatory movements of the geological environment, identical to the lunar-solar deformation processes, equal to 11-14 and 21-28 hours are mainly distinguished. These periodicities are close to the known diurnal, semidiurnal and long-period tides. The most intense anomalies in all periods are noted on the records of GAE signals in the frequency range 100-500 Hz (H1 and Z1), which is clearly associated with the effects of technogenic impacts, which are manifested in this frequency range.
Figure 2 - Spectral-time analysis of GAE signals and angle $\alpha$ of long-term monitoring in borehole № 1 IGF UB RAS

Figure 3 - Spectral-time analysis of EMR signals of long-term monitoring in borehole № 1 IGF UB RAS
4. Conclusion

Performed measurements showed that the response in the acoustic signals is noted only during the periods of impact on the array and is reflected by local maxima on the GAE curves in the frequency range of 100-500 Hz. Acoustic activity drops after the end of technological impacts on the rock massif and in the absence of external loads are observed background GAE values, and the absence of any noticeable changes in EMR parameters during the explosions and after them gives the right to conclude about the dynamic stability of the studied rock massif.

The principles of construction of equipment for regime observations and for the research stage of works are essentially different. If at the research stage it is necessary to obtain as general information about the phenomenon as possible, in regime observations the elements of concreteness in the choice of parameters prevail. Due to the fact that natural electromagnetic radiation has not yet left the stage of studying its characteristic features, the question about the spectral composition of emissions generated before earthquakes, and hence the question about the most rational choice of the frequency of receiving equipment for regime observations, the possible dependence of the spectral composition of EMR on the region and individual properties of the event remain open. This circumstance determines the necessity of conducting measurements in a sufficiently wide frequency band. Since the main problem in the study of EMR is the set of event statistics, it is most expedient to develop an inexpensive and reliable instrument for installing it on a wide network of stations in different seismically active regions of the country for conducting continuous observations [7]. Relevance of the obtained results is the possibility of creating on their basis a new method of control and assessment of the current dynamic state of the geological environment volume.

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