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Research Article

Measurement of Tremors for the Seismic Station of Gllogovc-Kosovo

Nazmi HASI[1], Latif HASI[2]*, Besire CENA[3]

[1]University of Mitrovica, PIM-Trepça, KS-40000 Mitrovica, Kosovo
Email: nazmi.hasi@umib.net - **ORCID:**0000-0002-8915-3788

[2]International Learning Group School, Prishtina, Kosovo
* **Corresponding Author Email:** latti99_hasi@hotmail.com - **ORCID:** 0009-0000-2781-3720

[3]University of Mitrovica, PIM-Trepça, KS-40000 Mitrovica, Kosovo
Email: bessirecena@gmail.com - **ORCID:** 0000-0001-6267-6362

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Abstract:

To select a potential location for a future seismological station properly, it is of crucial importance to explore the existing local seismic tremor recorded by seismographs. This tremor/noise is referred to as seismic tremor, whereas it is necessary to define as precisely as possible its spectral characteristics. It is very important that the station location be as quiet as possible because the seismic noise can obscure the records at the selected location for seismic station. Therefore, in addition to other geophysical methods, it is of particular importance to define the spectral characteristics of the local tremor at the investigated sites. Seismic noise measurements were made at seismic station of Gllogovc - Kosovo. It is very important that the station location be as quiet as possible because the seismic noise can obscure the records at the selected 8 locations for seismic stations.Seismologists are necessary for such investigations. Considering the requirement regarding their sensitivity and resolution, geophones are not recommended to be used. Still, geophones were also used in these measurements for the purpose of comparing the obtained results. The most important requirement that should be fulfilled is that the instrumental noise of the seismometers be much lower than the level of the natural seismic noise at the location.

1. Introduction

Generally, the two frequency ranges of the spectral content of the seismic noise (hereinafter referred to as tremor) are of seismological importance. These are the short-periodic and the long-periodic tremor [1-9]. Since their nature and sources are different, a different approach to measuring these tremors and interpretation of the obtained results from the measurements is imposed. In these measurements, corresponding and statistically consistent ground velocity power density spectra are to be obtained. The limits of the frequencies within which measurements will be made are also to be selected: up to 0.1 Hz in the low-frequency (long-periodic) part of the spectrum and up to 10 Hz in the high-frequency (short-periodic) range of the tremor spectrum. The following are the frequencies at which individual geological layers below the location would be in resonance conditions: It should be mentioned however that there is also the effect of the so-called artificial tremor that could interfere with the real seismic tremor at the site. The artificial tremor is generated by the motion of vehicles, industrial activities and motion of persons in the immediate vicinity of the site and also the motion of the persons that perform the measurements. These effects are in the frequency interval of 10 to 30 Hz [10-14]. Practically, these are beyond the frequencies of interest, but if their effect is too strong, the frequencies of interest will be contaminated due to the limitations of the procedures that are used in spectral analyses. In recording a contaminated tremor, the motion (motion of pedestrians or traffic) is mostly presented as a set of strong vibrations, while the industrial tremor is mostly stationary and occurs in the form of peaks. One of the greatest problems in measuring seismic tremors is the wind effect. Unfortunately, the wind can generate such a noise whose spectrum can overlap with the spectrum of the seismic tremor which is of concern. The seismological practice has seen that natural seismic tremor is generally non-stationary, with frequencies ranging from 0.2 to 0.5 Hz. It changes with the passing of time and depends on the regional climatic/weather changes, i.e., conditions, with amplitudes that could be increased even ten times within a short period of time. In conclusion, it can be stated that the investigations of the characteristics of tremors are mainly based on the assumption that the natural tremor of a certain location could have the same or similar spectral characteristics as in the case of an earthquake effect. The main assumption is that the occurrence of certain spectral peaks in the spectrum of the measured tremors, their frequency and amplitude could result from the existence of certain geological layers below the site. The existence of such resonant spectral peaks, i.e., frequencies, which on the other hand, point out the possibility for local amplification of ground motion during earthquakes, is of direct importance also for the investigation of the seismic risk both at the location itself and its immediate surroundings. Special attention should be paid to the validity of the obtained results that depends on the selected measuring equipment, the instrumental noise, and the effect of external excitations, i.e., the sources producing an artificial seismic noise that has an effect upon the measuring of the real seismic tremor.

2. Material and Methods

To measure the tremors, it is necessary to have corresponding equipment and software support for processing the obtained data. The equipment used for these measurements represented field and laboratory equipment. The field equipment consisted of the following:

1. Digital seismograph composed of:
2. Seismologists (SS1-Ranger, Kinemetrics Inc.);
3. Digital recorder (SSR-1, Kinemetrics Inc.);
4. Portable computer is necessary for immediate control of the digital recorder and archiving of data (HP Laptop + SW software, Kinemetric Inc.).

The laboratory processing was done by use of a powerful computer with corresponding software (Matlab based, TSOFT, Dadisp2002 and own software) necessary for the processing of the seismological data. Seismometers are necessary for such investigations. Considering the requirement regarding their sensitivity and resolution, geophones are not recommended to be used. Still, geophones were also used in these measurements for the purpose of comparing the obtained results. The most important requirement that should be fulfilled is that the instrumental noise of the seismometers be much lower than the level of the natural seismic noise at the location. To define the effect, i.e., separate the record of the high-frequency artificially created noise from the low-frequency tremor, a sufficiently high resolution of the acquisition system is necessary. To distinguish these ranges clearly on the spectrum, it is also necessary to have sufficiently high sampling in order to encompass as greater as possible frequency range during the measurement. For our measurements, it was sufficient to select a short-periodic seismometer, with a critical damping and 16 bit analog-digital acquisition system that provides 90 decibels resolution in measuring tremors. To provide as better as possible conditions for the measurements and hence data of a better quality, sufficiently high sampling of 200 Hz, i.e., 0.005 milliseconds between two adjacent values in the digital signal was used. This enables that the Noykvist frequency be at 100 Hz, or the most consistent values of frequency be up to 50 Hz. The selected filter in the acquisition system was 6 pole low-pass Batter fort filter of DC-50 Hz.

3. Results and Discussions

The graphic presentations, the time histories of the recorded seismic tremor at the location as well as their spectral characteristics are presented in the appendices for location. The measurement was performed during calm weather without presence of wind. The location is situated on a bare mild slope. In the vicinity, there is a low frequency road (macadam). At a distance of 300 m, excavation of gravel is carried out by use of mechanical equipment. There were no excavations during the measurements. A number of recordings were made on two locations: functional tests on the equipment and the seismometers and recording of tremors. A characteristic record from the location was selected, while the results from the analysis are given in Appendix 1. The two seismometers were installed on a soil composed of loose ultrabasalts with a distance of 7 – 8 m between them and on approximately the same base. Individual sets of peaks are observed on the uncorrected time record on channel 1 and channel 2 (Fig.1, Fig.2 and Fig. 3). It is interesting to note that although both seismometers were very close, in addition to the different size of the peaks that occur at the same time on both the channels, occurrence of noise that is absent on the first channel can be observed on the second channel. On the

SS1_2238 spectrogram (Fig. 4), spectral components can be observed in the advances up to frequencies of 55 Hz. On the spectrogram of the SS1_2251 record **(**Fig.5), the participation of clearly separated vibrations is much greater in respect to those in the SS1_2238 record, but these are also almost limited up to frequencies of about 55 Hz. On the power spectra (PSD), the picture is not much different for both the records. The low-frequency part is good for both the channels, with a high level of spectral components for frequencies of up to approximately 0.1 Hz. In the case of channel 1, the low-frequency noise (0.1-1.2 Hz) is with a much larger amplitude (Fig. 6) in respect to the PSD spectrum for the SSS1_2251 record. The sets of dominant frequencies are within the intervals of 0.15 – 1.5 Hz in the case of both the uncorrected records. On channel 1, pronounced peaks are observed for 2.2 Hz, whereas in the case of channel 2 (SS1_2251), the remaining components are with frequencies from 2.5 to 50 Hz. To avoid the effect of the sets of noises that are advancing and result from the local disturbances incurred during the measurements, three segments of a size of 8192 terms were selected per each measurement. It was not possible to eliminate the noise generated by the periodic traffic along the local earth road. In Fig. 7, sets of vibrations that do not belong to the natural seismic tremor are clearly distinguished on the uncorrected segments of the time histories of seismic noise. The signals were corrected through the amplitude spectrum of the response functions obtained for each of the seismometers. In the PSD power spectra, there dominates the noise of 0.1 to 0.3 Hz which gradually drops to 5 Hz. After this frequency, the spectral amplitudes are negligible, i.e., the noise is very low (Fig. 8,9.10,11.12.13). Due to traffic along the local road, there occur four sets of vibrations that cannot be eliminated. Their presence considerably changes the spectral picture of the corrected records of ground velocities and the shape is like that of the summary PSD spectrum (Fig.14) with much lower spectral amplitudes in the low-frequency part. These occur up to frequencies of 1 Hz and are relatively high in the frequency interval of 2 – 50 Hz. Singled out predominant frequencies are observed at 2.8 Hz and 6.8 Hz. The comparison of the average spectra of the records obtained by both seismometers (Fig.15) clearly shows that due to the low noise, the measuring point of seismometer SS1_2238 is acceptable for construction of a seismological station.

Appendix 1

Seismological Station LLAPUSHNIK-GLLOGOVC (LAP) Coordinates: 42.5644 N, 20.8756 N, h= 663 m

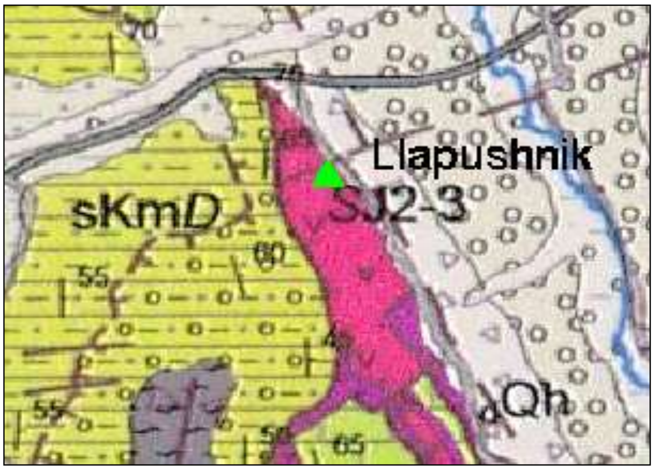

Fig.1. *LAP (1): SS1_2238 (recordings of microtremors on hard soil-rock seismometer location)*

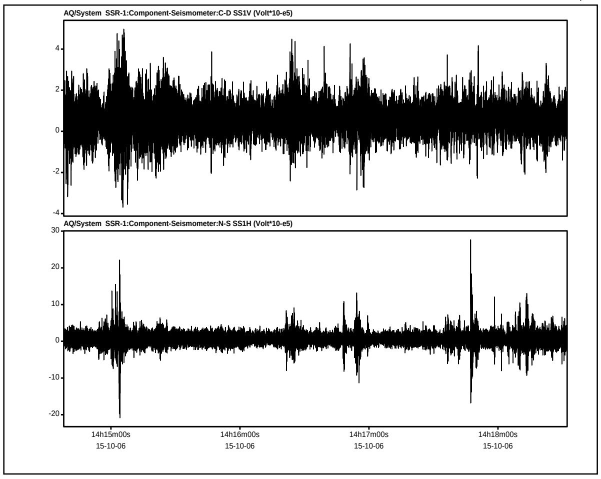

Fig.2. *LAP (1): SS1_2251 (recordings of microtremors on hard soil-rock seismometer location)*

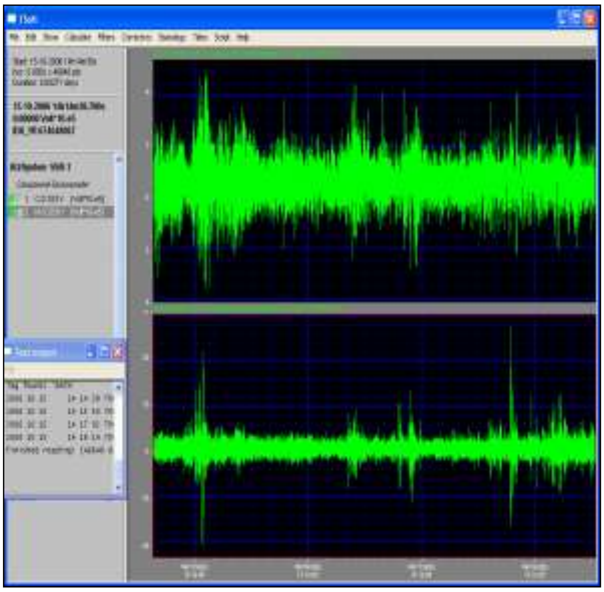

Fig.3. *TSOFT presentation of seismic tremor recordings at LAP location*

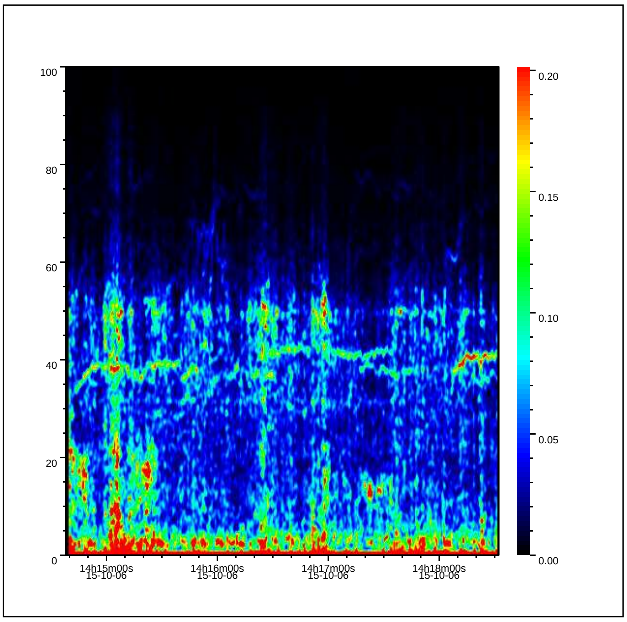

Fig.4. *LAP (1); Spectrogram of microtremors recording on hard soil location (seismometer SS1_2238)*

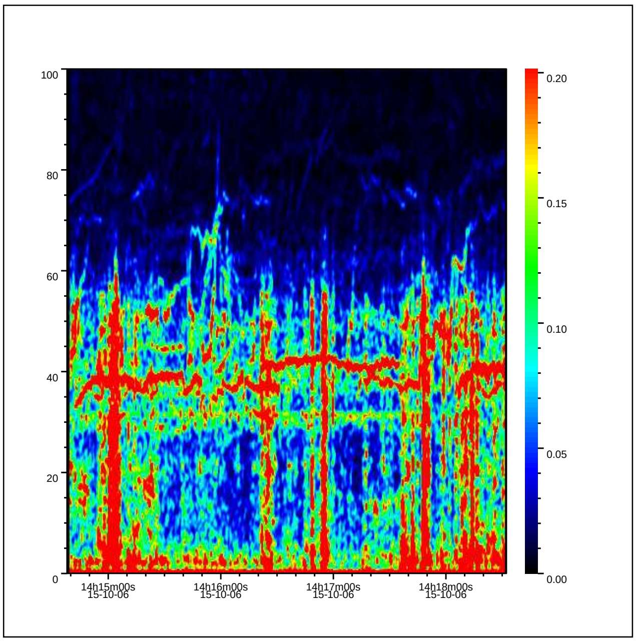

Fig.5. *LAP (2); Spectrogram of microtremors recording on medium soft soil location (seismometer SS1_2251)*

4. Conclusions

Seismic noise measurements were made at location in Gllogovc (Kosovo). It is very important that the station location be as quiet as possible because the seismic noise can obscure the records at the selected location for seismic station. Spectra were computed from the records and compared with the new low noise model. The performed microtremor investigations enabled selection of the most favorable microlocation for the anticipated seismological station from the aspect of minimal seismic noise and providing of high-quality earthquake records. The comparison of the average spectra of the records obtained by both seismometers (Fig15) clearly shows that due to the low noise, the measuring point of seismometer SS1_2238 is acceptable for construction of a seismological station.

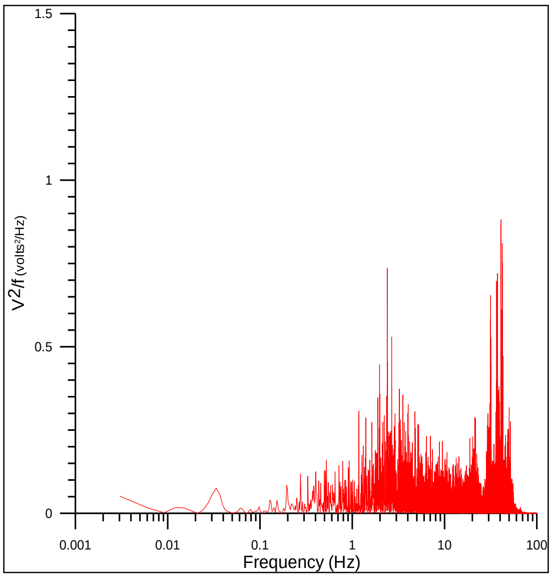

Fig. 6. *LAP (2): PSD spectrum of noncorrected recording of microtremors (SS1_2251)*

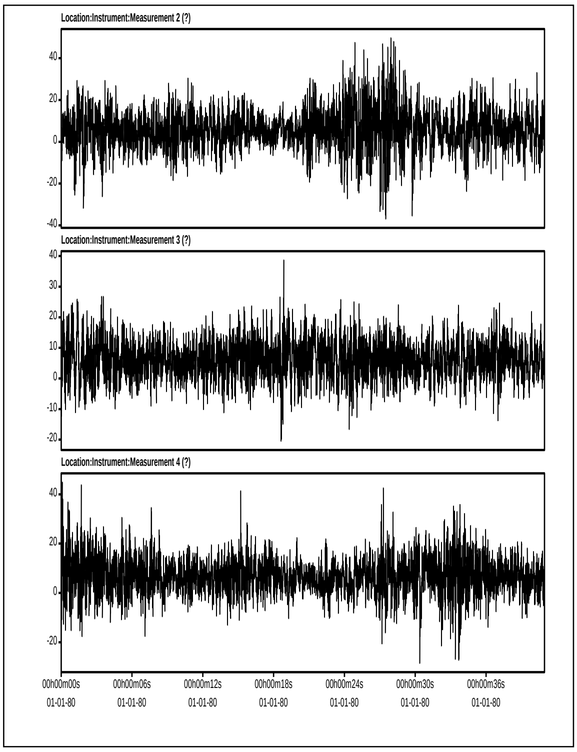

Fig. 7. *LAP (1): Segments (~40 s duration) of*

noncorrected recording of microtremors (SS1_2238)

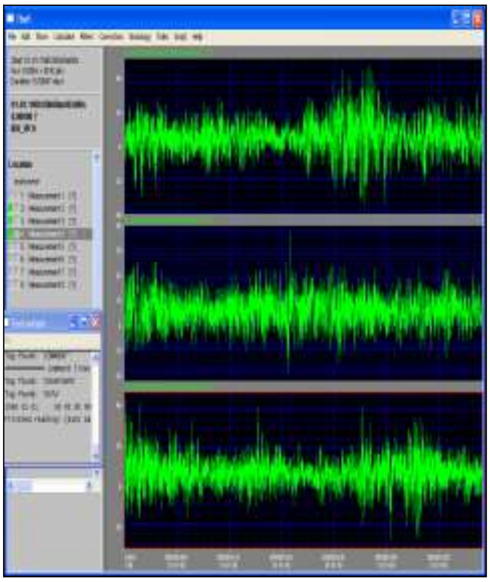

Fig. 8. *TSOFT presentation of separated segments of seismic tremor recordings at LAP location*

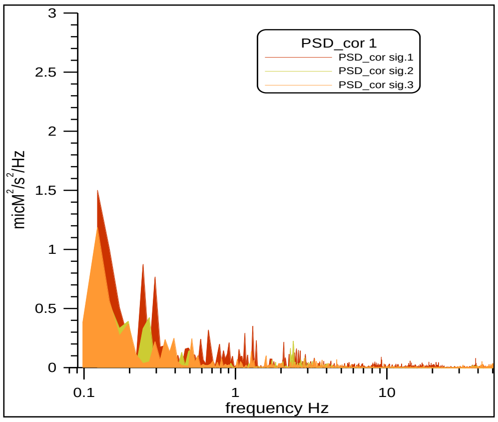

Fig.9.*LAP (1): PSD spectrum for 3 separated (8192 samples each) of corrected recording of microtremors (SS1_2238)*

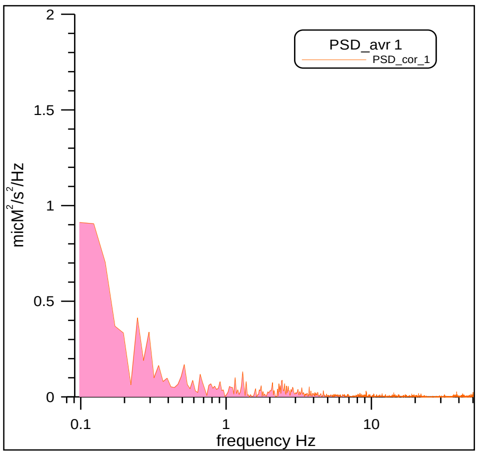

Fig.10. *LAP (1): PSD spectrum for 3 separated (8192 samples each) of corrected recording of microtremors (SS1_2238)*

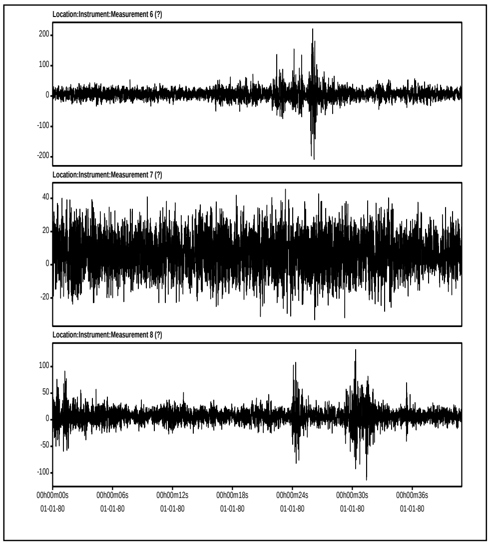

Fig.11. *LAP (2): Segments (~40 s duration) of noncorrected recording of microtremors (SS1_2251)*

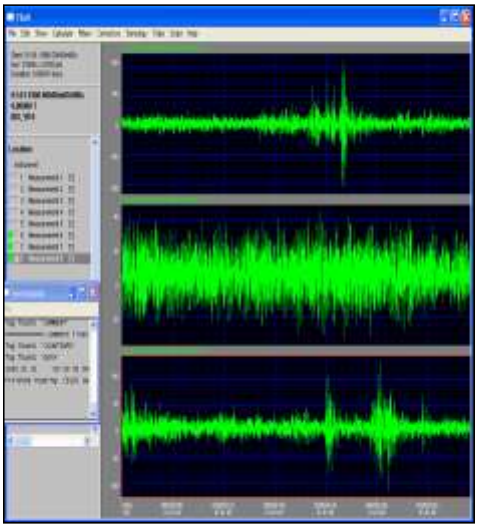

Fig.12. *TSOFT presentation of separated segments of seismic tremor recordings at LAP location*

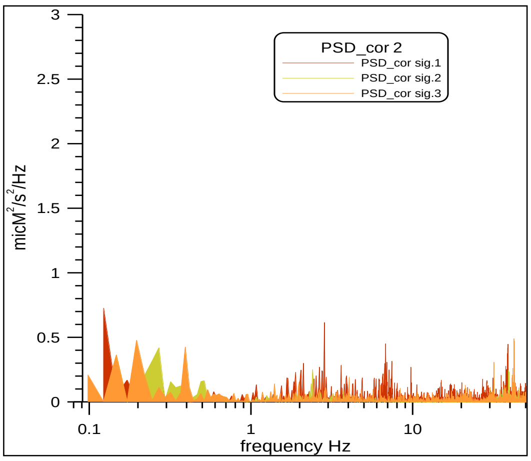

Fig.13. *LAP (2): PSD spectrum for 3 separated (8192 samples each) of corrected recording of microtremors (SS1_2251)*

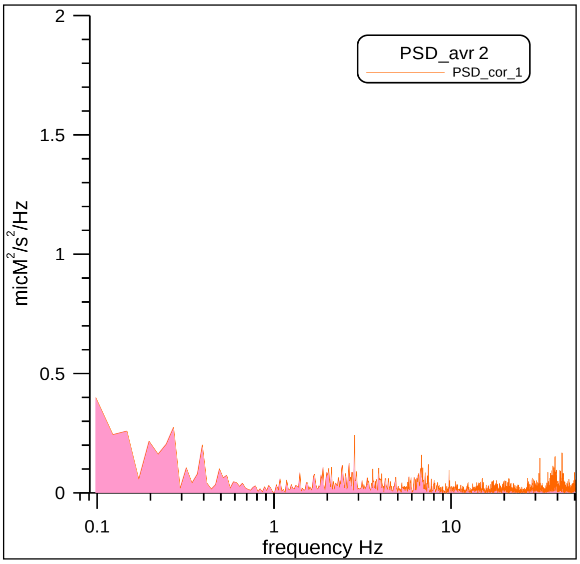

Fig.14. *LAP (2): Averaged PSD spectrum for 3 separated PSD spectrums (8192 samples each) of corrected microtremors recording (SS1_2251)*

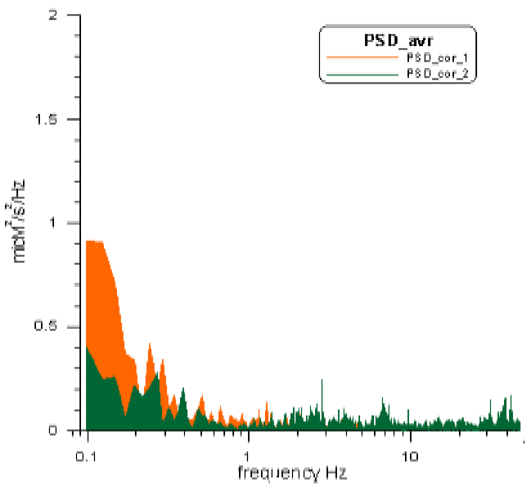

Fig.15. *PSD averaged spectrums (PSD_avr) for locations: LAP (1): PSD_cor_1; seismometer SS1_2238,LAP (2): PSD_cor_2; seismometer SS1_2251*

Author Statements:

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- **Data availability statement:** The data have been withdrawn by the measurements done using equipment of the Faculty of Geosciences, University of Mitrovica.

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