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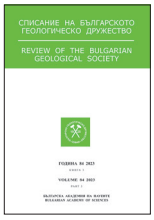

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First station from the Sofia University Seismic Network

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Първа станция от сеизмичната мрежа на Софийски университет

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Abstract. The first seismic station of the Seismic Network of Sofia University (SNSU) was built in 2023 with funding from the Scientific Research Fund of Sofia University “St. Kliment Ohridski”. The station is operating in the Faculty of Physics since September 2023. The equipment consists of a seismometer Geophone 4.5 Hz and a digitiser PSN-ADC24. A portable computer is used for data recording and archiving. During the month of station operation several earthquakes in Bulgaria and neighbouring countries were analysed. The spectrum of the seismic noise from the station was analysed for different periods. The characteristics of the terrain of station installation were also determined using the method H/V. Although the equipment has modest capabilities, it allows students and young scientists to work directly with the seismic equipment and to do scientific investigations. The possibility of scientific research will be expanded renewing the equipment (purchased in October 2023).

Keywords: seismic station, seismogram, spectrum, seismic noise, Sofia University.

Introduction

The Virtual Seismological Network of Sofia University was founded in 2015 with a project supported by the Scientific Research Fund of the Sofia University. Until 2021, in the frame of annual projects concerning the Virtual network, data from seismic stations located on the Balkan Peninsula (with free access in near real-time) were used for various scientific studies (Raykova et al., 2018; Dimova et al., 2019; Dragomirov et al., 2021). The access to real-time seismic records has been limited in recent years, mostly to the stations accessible by the European Integrated Data Archive (EIDA). The mechanisms for accessing data have also changed, making it impossible to employ the developed approach for data analysis.

Throughout the past few years, the need to build a seismic station in Faculty of Physics has been growing, filling a gap in the geophysical education of the students. The new seismic station will enable students in geophysics to work with seismic equipment, as well as to use seismic recordings for various scientific studies. In 2023, the Sofia University’s Scientific Research Fund provided funding for a project aimed at procuring equipment and establishing a seismic station within the Faculty of Physics. As a result, the first seismic station affiliated with Sofia University has become a reality.

Seismic station FzF (SU)

A space in the basement of building V of the Faculty of Physics was adapted to install the available

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seismic equipment. The first seismic station of the Seismic Network of Sofia University (SNSU) started to operate in September 11th 2023. The station's temporary code is FzF and the temporary network code is SU. Furtherly, the network and station will be registered in the international registries taking into account existing acronyms of other stations and networks. The equipment consists of a three-component Geophone 4.5 Hz seismometer, a digital system PSN-ADC24 of the Webtronics, a GPS antenna for receiving accurate time and portable computer with the software WinSDR (www.seismicnet.com) for registering and archiving data. The installed seismic equipment is shown in Figure 1a. The sampling rate of the digital data is 100 samples per second. The seismometer is oriented in a N–S, E–W and vertical Z directions. The geographic coordinates of the station are 42.67°N, 23.33°E and the altitude is 597 m. The station registers continuous records along with individual files of events (according to the used trigger rule for event detection). Soon, a continuous recording from the seismic station in real-time will be also available through the web page of the "Meteorology and geophysics" Department (www.mg.phys.uni-sofia.bg). Seismic set "Velbox" of the Sara Electronic Instruments S.R.L. was purchased in the end of September 2023. The set consists of a seismometer SS02 (with greater capabilities than Geophone 4.5 Hz) and a digitiser SL06 with internal memory. This equipment is going to be installed soon in the same location in Faculty of Physics. The now-working apparatus will be moved to the Astronomical Observatory of Sofia University in Sofia's Boris Garden after its renovation. If sufficient funding becomes accessible, it is planned to expand SNSU by installing seismic stations in the holiday bases of the Sofia University throughout the whole country.

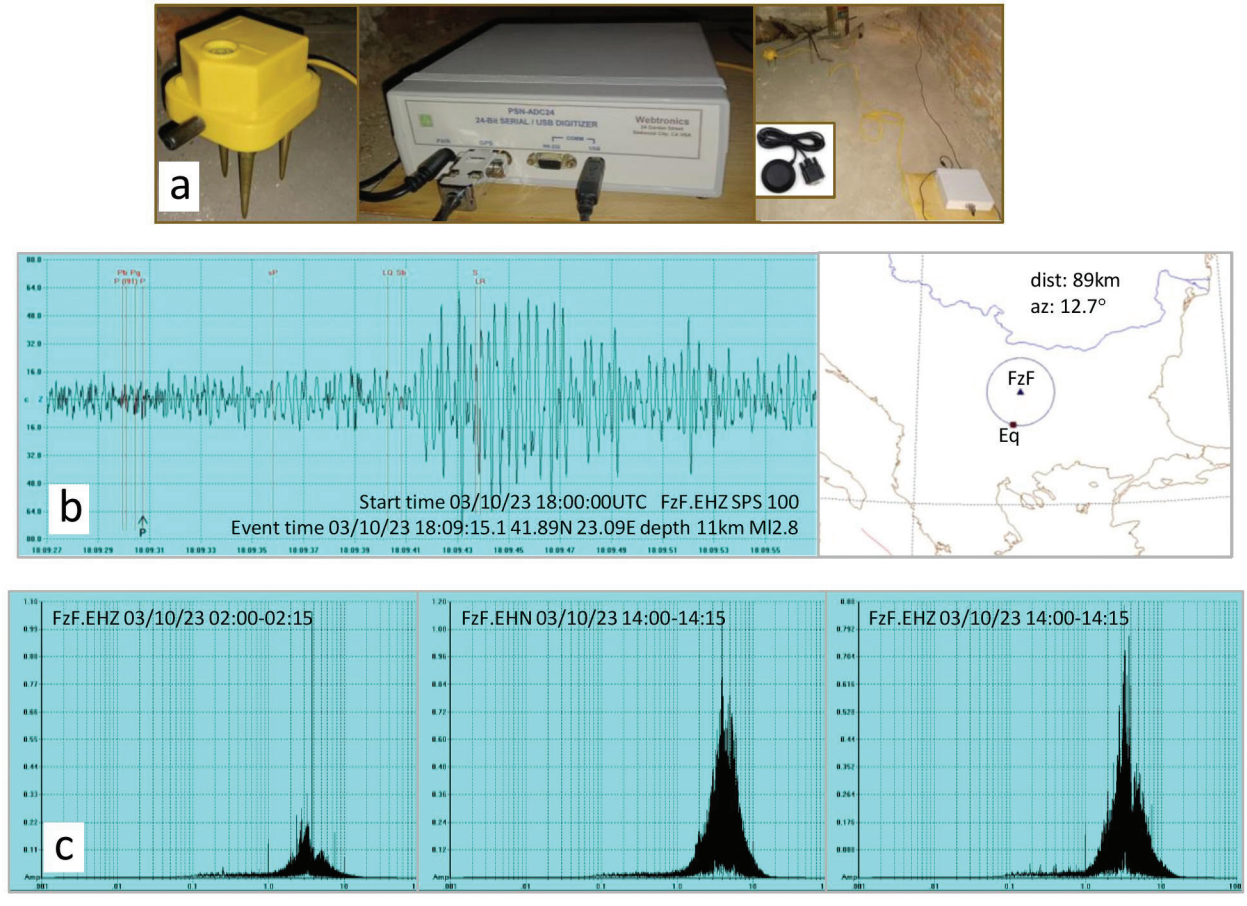

Fig. 1. Equipment installed in the basement of the Faculty of Physics: *a*, Geophone 4.5 Hz, digitiser PSN-ADC24, GPS antenna and adapted space. Registered event (03.10.2023 18:09:15.1, 41.89°N 23.09°E, Ml2.8, Bulgaria – www.emsc-csem.org); *b*, seismogram of component EHZ and theoretical seismic phase (left panel) and map with location of the event (Eq) and the station FzF (right panel). Amplitude spectrum of seismic noise; *c*, component EHZ night (left); component EHN day (middle); component EHZ day (right).

Seismic data analysis

Seismic data processing is carried out with WinQuake software (www.psn.quake.net/software.html), which has a large set of tools for seismic data analysis. No significant local earthquakes occurred in the month of September (according to the Euro-Mediterranean Seismological Centre www.emsc-csem.org) that were clearly recorded on the seismometer, but there were several earthquakes in Bulgaria and neighbouring countries that were identified on the continuous records. Figure 1a (right panel) shows the location map of the seismic station and one of the analysed earthquakes. This event is an M_l 2.8 aftershock (main shock in September 4th 2023, 07:31:52.6 UTC, M_l 3.9) in Simitli, in October 3rd 2023 at 18:09:15.1 UTC (earthquakes data are from www.emsc-csem.org). The epicentral distance is about 89 km. Figure 1b (left panel) shows the seismogram of this earthquake, registered on the vertical component. The record was filtered in the frequency interval 0.1–5 Hz. P-waves could not be identified due to the fact that their amplitudes and frequencies resemble the seismic noise registered by this type of seismometer. S- and LQ-waves were clearly identified.

The seismic noise from the station was also analysed for different periods: night, day, working and non-working days. Figure 1c shows examples of the seismic noise spectrum recorded on October 3rd: the spectrum of the vertical component for the time interval 02:00:00–02:15:00 UTC is shown in the left panel; the middle panel shows the spectrum of the horizontal N–S component for the time 14:00:00–14:15:00 UTC; the right panel shows the spectrum of the vertical component for the time 14:00:00–14:15:00 UTC. It is clearly seen that the amplitudes of the noise during the night are significantly smaller (about 5 times) than the amplitudes during the day. This difference is due to the intensive human activity during the day hours. In addition, daytime noise amplitudes of the vertical component are smaller than those of the horizontal component. This confirm the fact that usually the horizontal components are more noisy than vertical components.

The characteristics of the terrain on which the station is installed were also determined using the seismic noise analysis. The H/V spectra ratio method (Nakamura, 1987) was used. The maximum H/V amplitude ratio was identified at around 0.25 Hz. To determine the thickness of the sediments beneath the station, we used the equation for the fundamental mode of surface waves $f = V_S / 4h$, where f is the resonant frequency, V_S is the velocity of the S-waves, and h is the thickness of the shallow sedimentary layer. The velocity of P-waves in the shallow sedimentary layer in the Lozenets district of Sofia is between 300 m/s and 700 m/s (according to Ilieva et al., 2003). The values of V_S were estimated from the theoretical ratio between the velocities of P and S body waves, $V_P / V_S = 1.73$. The calculated values vary between 175 and 400 m/s. Accordingly, the shallow layer with such velocities extends to a depth between 175 and 400 m. This result is in accordance with the studies of Castellaro et al. (2016) held in the Faculty of Physics.

Conclusions

The first seismic station from the Seismic Network of Sofia University (SNSU) starts to operate in September 11th 2023 in the Faculty of Physics. It is assembled by a seismometer Geophone 4.5 Hz, a digitiser PSN-ADC24, GPS antenna and portable computer for data recording and archiving. Up to the present several earthquakes in Bulgaria and neighbouring countries were registered and analysed. The study of the spectrum of the seismic noise shows low amplitudes during the night hours in respect to the day hours. The amplitudes of the noise, registered on the horizontal components are bigger than the amplitudes of the vertical component. Using the method of H/V spectra ratio of the seismic noise, the thickness of the shallow sedimentary layer below the seismometer is estimated to be between 175 and 400 m. Although the equipment has modest capabilities, it is able to carry on numerous scientific investigations. The recently purchased equipment (seismometer SS02 and digitiser SL06 from SARA electronic instruments S.R.L.) with much better characteristics will increase possibilities for the scientific studies.

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