Seismic activity near Livingston and Snow Island, Antactica from Bulgarian broad band seismic station LIVV

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The Antarctic territory was considered to be a non-seismic zone for a long time. However, over time it was understood that this part of the globe is a very complex geodynamic system combining subduction zone, rifting and spreading zones, and magmatic activity. Any of these zones should be manifested with high seismicity.

Typical seismicity for Bransfield Strait consists of shallow, weak to moderate earthquakes. This type of seismicity is attributed to weak magmatic activity along the ridges and crustal movements during the extension of the strait and rift along its axis. Sporadic deep earthquakes (up to about 65 km), a result of residual subduction, are also detected north of the South Shetland Islands. One of the active areas in the Bransfield Strait is Deception Island with moderate to intense seismic activity.

The seismic activity in the Bransfield Strait has increased since August 2020, accompanied by the strong earthquake on 23 January 2021 (MW=6.9). A swarm of earthquakes is observed all throughout 2020 and the activity slowly increases over time. it reaches its peak on the 2 of October and 6 of November with a Mw 5.9 and a Mw 6.0 earthquakes respectively. In the first months of 2021, the seismic activity remains high, and on some days that more than 20 events/hour are recorded (Figure 2). Seismicity also in other areas near South Shetland Islands has also increased in 2021-2023.

The earthquake activity from the end of 2020 was detected by the global seismic networks. However, due to the low coverage of seismic stations in the area of Antarctic Peninsula and South Shetland Islands, the weak seismicity has not been studied. Many of the earthquakes in the region are recorded also on seismic station LIVV. Although due to technical problems in the station, the strongest earthquakes are not recorded.

In our study we use single station localization method to estimate the earthquake's epicenters. A Python code for localization was developed for this purpose (Dimitrova et al. 2019). It is based on the Golitsyn's method, based on the analysis of the seismic signals recorded at one three-component seismic station. The geographic coordinates of the epicenter are calculated using the epicentral distance and azimuth from the station to the event. The difference between arrival times of P and S-waves is used to calculate the distance to the epicenter defined by travel-time tables. The azimuth angle station – epicenter is defined by the sign of the amplitudes at the three components (Dimitrova et al. 2019). A local velocity model was constructed for the region of the seismic station. The geographyc coordinates are estimated with Vincenty formulae.

FIGURE 1. Seismic station LIVV on Livingston Island. Antarctica

Seismic station LIVV (Figure 1) is situated on Livingston Island close to the Bulgarian Antarctic Base. The station is located near the Balkan glacier and about a kilometer away from the Bulgarian Antarctic base. It was firstly installed in 2015 as a temporal station, recording only in astral summers. In 2020 the station was moved to a new more quiet place and become permanent.

The station is equipped with two seismometers – one broadband Guralp cmg 40T and one short-period Geospace, which cover the frequency range for the study of local, regional and global seismicity. The seismometers are placed on bedrock and oriented to the geographic north. There is thermal and hydro insulation around them in order to prevent external influences and noise. The sampling frequency is 100 Hz.

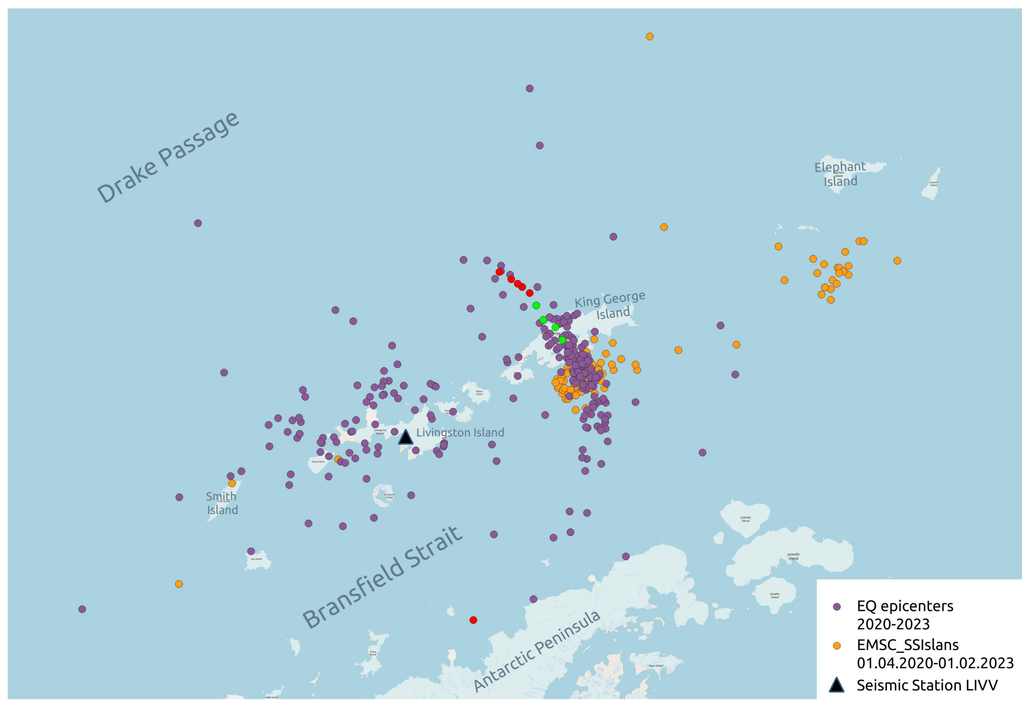

FIGURE 2. Map of the earthquakes in Bransfield Strait and near Livingston island in the studied period. Orange points show earthquakes taken from EMSC catalog, purple points show epicenters for events recorded on LIVV station and located using single station method. Red and green points show the possible epicenter of two earthquakes respectively or the error in epicenter estimation

In order to analyze the weak seismic activityin the studied region before and after the swarm near Orca Volcano from 2020, the data within the time period from the beginning of 2020 to March of 2023 recorded by the LIVV station are used*

Earthquakes are located using single station method and traveltime table computed for the region.

Most of the epicenters are located in Bransfield strait, but there are also many events with epicenters located near Snow and Smith Islands and also in Drake Passage (Figure 3).

*available data are:
- between 27TH and 140TH day of 2020;
- between 356TH day of 2020 and 142ND day of 2021;
- between 253TH adn 319TH day of 2021;
- between 028TH and 146TH day and 300 - 365TH of 2022;
- between 001TH and 149TH day and 212-273 of 2023;
- between 295TH of 2023 and 010TH day of 2024.

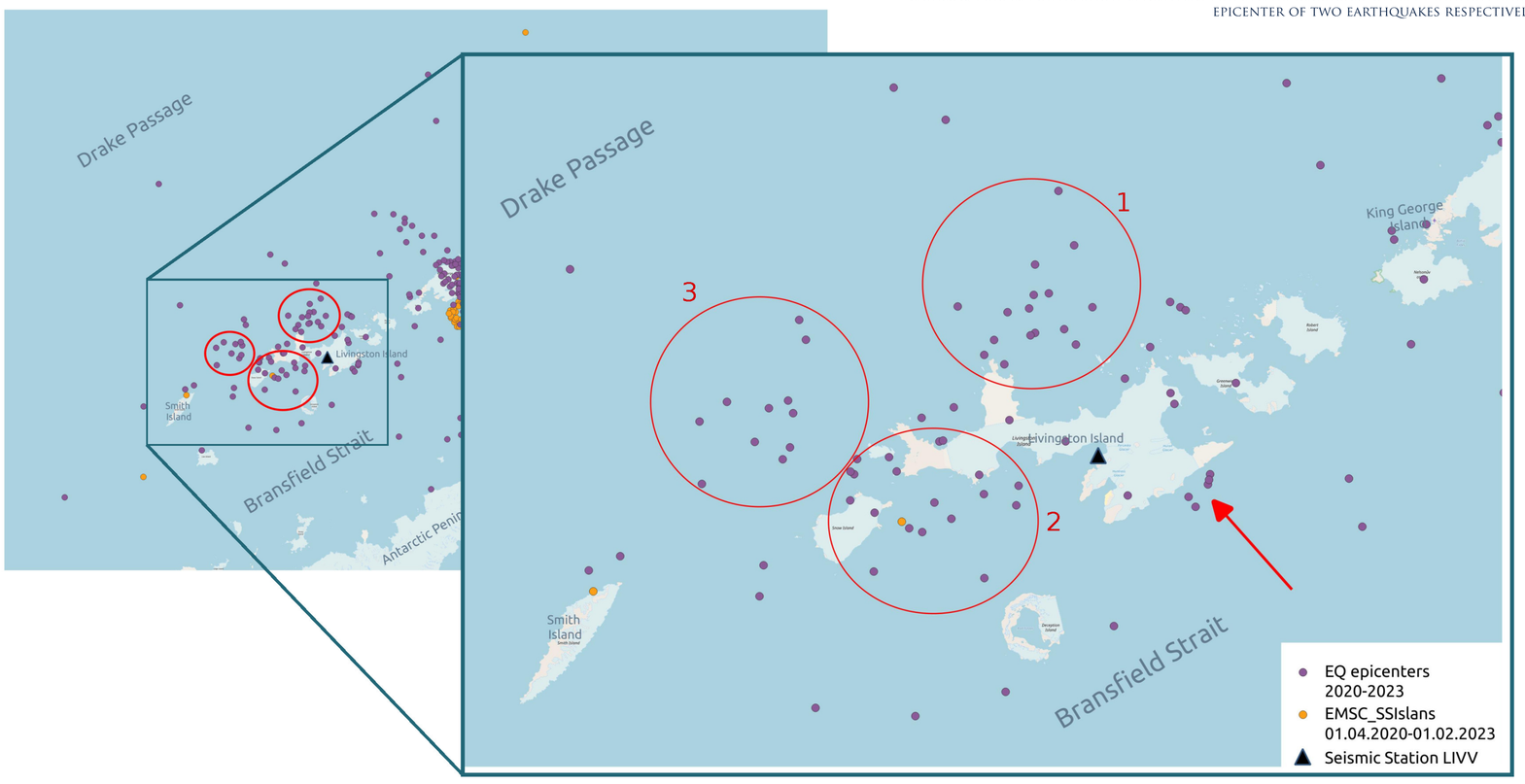

FIGURE 3. Seismicity near Livingston Island. Earthquakes' epicenters form three clusters.

More than 600 earthquakes were distinguished on the record of the seismic station LIVV betwen 2020 and 2023. For the events with clear onset, the time difference of P and S wave arrivals (S arrival time-P arrival time) and the amplitudes of the onset are measured. As a result, the number of the events to be localized by single-station method is reduced to 120 (Figure 2). Most of the recorded events have S-P time difference in the range between 12.5 and 14 s. They occurred in the region of Orca volcano.

In the studied period, about 40 events were localized near Livingston Island. The epicenters of those events form three clusters which are marked with red circles on Figure 3. One of the clusters is situated in the north-eastern direction from the Cape Shireff of the Livingston Island. The second cluster comprises the western part of the Livingston Island (Bayers Peninsula) and the Snow. The third cluster is in the north-western direction of the Snow Island. One event from EMSC catalog is presented in the second cluster. There, small number of events are also reported in previouse studies.

Red arrow on Figure 3 shows a group of earthquakes located near the south-eastern coast of Livingston Island. In this area, high seismic activity was observed in 2014-2016. Till the end of 2016 the activity decreased and in the period from 2017 to 2020 no one earthquakes was registered there. Between 2020 and 2022 five earthquakes are registered again.

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