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Application of a distributed acoustic measurement system for active and passive seismic studies

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Solicited talk

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Recently, both in Russia and in the rest of the world, there are now several different types of optical devices for recording dynamic deformations in a medium based on the use of the Rayleigh backscattering effect. Such systems can record natural dynamic deformation from earthquakes in a wide frequency range from 100 seconds to hundreds of Hertz, as well as signals from artificial seismic sources for seismic exploration purposes. To select the optimal system for recording dynamic deformations and improve it, it is of great importance to test such systems and compare the obtained data of distributed dynamic deformations with records of traditional seismological instruments.[1],[2],[3] The presentation shows the application of a new innovative technology of seismic observations based on high precision recording of dynamic deformations to solve problems of bottom seismic exploration and seismology. The basis for the measuring system of dynamic deformations was taken from the development of the domestic company PetroFibre LLC - "Coherent Phase-sensitive Optical Reflectometer"-- VOSK-A. In 2020-22, numerous tests were carried out on the device for recording both active terrestrial and marine seismic, as well as for passive registration of earthquakes in marine on land conditions. According to the test results, the device was improved for optimal recording of seismic signals of a wide frequency range. In September 2021, an active experiment was conducted in the Blue Bay (Gelendzik) to record seismic energy from a 2.5-liter marine pneumatic source on a fiber-optic cable previously laid out on the bottom. The total length of the optical cable was 10,500 meters, the distance between the measuring channels was 1,02 m. The VOSK-A optical reflectometer was installed in the laboratory on the pier, which carried out continuous measurements of dynamic deformations during the work of a marine seismic source. Using a high density of channels, the position at the bottom of each of the 10,000 optical channels was very accurately restored (less than one tenth of a meter of RMS error) according to the travel times of water waves from the source. The time seismic section was obtained and interpreted up to 5 seconds of double travel time (or about 7 km in depth). This result is possible due to the high density and a large number of receiving channels, which allow increasing the effective fold during summation and thereby increasing the depth and resolution of the resulting section.

For the first time in the history of India, records of local and remote earthquakes were obtained on a distributed dynamic deformation system. Earthquake data records in the form of dynamic deformations were obtained along the entire laid fiber (35 km), every 6,25 m, i.e. 5,600 channels are recorded simultaneously, and these channels are broadband in the range from 100 sec to 100 Hz with a comparable dynamic range as with traditional broadband long-period seismographs. The length of the local deformation measurement base was chosen to be the same for all channels (20 m). Thus, the measuring system is equivalent to installing 5,600 long-period single-component seismographs along the entire 35 km line. The study was supported by program No. FMWE-2024-0026 (P.P. Shirshov Oceanology Institute)

References

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