

Oceans cover more than 70% of our planet's surface. This means that a significant part of the geological structures that are part of complex geodynamic systems, such as subduction zones, rift zones, heat plumes, etc., are located deep underwater. In order to enable geophysical studies of these large-scale systems, in the mid-20th century, technology based on measurements of seismic waves from the ocean floor using the so-called OBS (ocean-bottom seismometers) was implemented. During seismic measurements, OBS are deployed on the ocean floor and record seismic waves penetrating the interior of the lithosphere. The recorded seismograms are then processed using seismic imaging methods to reconstruct geological models. With the development of these methods and easier access to significant computing power over the last 20 years, OBS technology has been significantly developed in the industry related to the hydrocarbon exploration. Thus, currently, industrial projects using OBS is conducted using thousands of receivers placed on the ocean floor at intervals of several hundred meters. This allows for relatively dense coverage of significant areas and obtaining multiple illumination of the geological medium with seismic waves sampling this medium from different perspectives. This type of high-quality data allows for full use of leading seismic imaging techniques for the most accurate reconstruction of geological models.

Unfortunately, academic experiments using OBS significantly deviate from industrial standards. Vast majority of experiments is carried out along two-dimensional profiles with a limited number of receivers, most often placed at a distance of several to even several dozen kilometers. Data measured in this way only allow for partial recognition of the medium being studied, leaving a large uncertainty of its geological interpretation. They also do not allow for the full use of the potential of innovative seismic imaging methods, and consequently limit our ability to better understand the processes occurring in the Earth's interior. The main limitation of these studies is the too sparse distribution of OBSs, which causes insufficient sampling of the medium being studied. The urgent need to develop this paradigm stems from the availability of well-established imaging algorithms that cannot be fully exploited in academic projects due to the lack of optimized OBS data.

In the context of seismic experiments, optimal OBS data acquisition should be understood as a set of key parameters that allow the best possible reconstruction of the intended target. These parameters, which may include the survey geometry, source/receiver configuration, and others, are closely related to the processing technique used. In addition, they also depend on the medium properties. Therefore, newly acquired OBS data should be tailored to the specific method, target, and available capabilities. On the other hand, we can consider optimizing archived OBS data during their processing. In this approach, we can adapt our imaging approach to efficiently use a given data set to reconstruct the target of interest, all within the available computational capabilities.

The scientific problem that we aim to address in this project is the need to change the standard approach to OBS data acquisition in academic projects, as well as the way they are routinely processed. We want to develop methods for analyzing the propagation of seismic waves and precisely recognizing their impact on the reconstruction of geological models. In the project, we will consider different imaging approaches based on seismic tomography and full-waveform inversion. We will analyze different, realistic scenarios of experiments using OBS, and different regularization techniques that can improve the quality of imaging. The final effect of the project is to achieve a balance between the potential of advanced processing techniques and academic OBS data, which will allow for the full use of this potential.