Increasing the sensitivity of surface seismic monitoring networks for the hydrocarbon deposits development: case study

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The process of long-term development of hydrocarbon deposits is often accompanied by the technogenic and induced seismicity, leading to various negative consequences on their territory. Among the most significant consequences are: destruction of wells and communications; damage to buildings, pipelines and other infrastructure facilities of the oilfield. All this causes significant economic damage. It is also necessary to note possible environmental damage, in particular environmental pollution associated with a possible spill of petroleum products, etc.

One of the methods of remote monitoring of the geodynamic situation is seismic monitoring, which allows using records of seismic vibrations to determine the coordinates and energy of seismic events within the field. There are two main types of surveillance systems: surface, consisting of separate seismological points located on the earth's surface, and borehole, consisting of receiving antennas installed at a depth of several kilometers, in close proximity to the seismically active zone. Recordings from ground stations are usually characterized by an extremely high level of industrial noise associated with the operation of equipment on the territory of the field. Borehole systems, on the contrary, are characterized by a high signal-to-noise ratio, due to the proximity of seismometers to the hypocenters of recorded earthquakes and remoteness from sources of industrial noise. However, an obstacle to their widespread use is the extremely high cost of drilling deep wells, as well as installation and maintenance of equipment.

This paper presents the results of theoretical studies of the dependence of the sensitivity of the surface network of seismological monitoring on the number and spatial distribution of observation points on the territory of the deposit, as well as field experiments on the deepening of seismometers to depths of up to 100 meters.

For theoretical studies, real recordings of a ground-based seismological network operating at an existing oil field were used. As part of the field experiment, seismometers from all observation points were installed at the bottom of wells up to 100 meters deep. The optimal depth was determined during reconnaissance work, in which recordings were made at various depths. For some time after installation, the recording was conducted in parallel by two systems: ground and buried.

As a result of theoretical research, a method was proposed for assessing the sensitivity of the network based on the spatial distribution of observation points with appropriate levels of seismic noise. As a result of the field experiment, it was demonstrated that the installation of seismometers in wells with a depth of about 80 meters provided an increase in sensitivity by magnitude of the order of 1 (Ml), and the number of recorded local earthquakes increased approximately 10 times. This result is in good agreement with the theory [1].

References

Aki K., Richards P.G. (1980). Quantitative Seismology: Theory and Methods.