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*Abstracts of*

# *The Second Eurasian RISK-2020 Conference and Symposium*


*Editor*

- **Vugar Aliyev**


*"Innovations in Minimization of Natural and Technological Risks"*

*"Minimization of the Most Prevalent Project Risks in the Oil and Gas Industry"*

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***RISK-2020***

Vugar Aliyev
(Editor)

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*RISK-2020 (12th – 19th April 2020)*

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# High-Sensitivity Seismic Networks for Reservoir Geodynamic Processes Monitoring

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**ABSTRACT**

**Introduction.** The long-term hydrocarbon exploration process is often accompanied by induced seismic activity. This leads to various negative consequences on the territory of deposits. The consequences of induced local earthquakes are subsidence and horizontal shifts of the rock mass, casing-breaks of wells, damage to buildings, to communications, to pipelines and other infrastructure facilities of the field. All this causes significant economic damage. In addition to financial costs, possible environmental damage should be noted. It can be flooding of the field and nearby territories, landslide phenomena; environmental pollution associated with a possible spill of oil products, etc.

One of the main methods of remote control of the geodynamic situation is seismic monitoring [1]. It allows you to determine the parameters of seismic events within the oilfield from the seismic records, as well as to identify areas of increased seismicity and investigate the dynamics of their development. For example, in Canada, the UK, and US 'Traffic light systems' (TLS) [2] are used to mitigate strong induced seismicity.

In this paper, we will show how to create a relatively cheap and high sensitivity seismic network for reservoir geodynamic processes monitoring.

**Methods.** The best solution, of course, is downhole microseismic monitoring system consists of deep observation wells in oilfield territory. It makes a great signal-to-noise ratio of the signals from weak earthquakes. In this context, data processing can be almost fully automated. But seismic equipment installation and operation processes in the deep (several kilometers) are very expensive. Another way is to create a surface seismological network. However, a high level of industrial noise makes it difficult (and in some cases makes it practically impossible) to detect signals from weak local earthquakes. This is an especially big problem for surface observation systems. Because of the magnitude of induced earthquakes, as a rule, less than 3.5, and the catalog representability of surface networks start from magnitudes 1-1.5, it is not enough information to investigate seismic activity in the oilfield.

The intermediate solution between the above-mentioned is the shallow seismic network with a high number of sensors. Installation of the seismometers in the depth about 100 meters provides 10 times incensement in signal-to-noise ratio [3] and the number of recorded weak earthquakes will increase about 10 times too. We have experimental confirmation of this.

**The way to reduce the equipment cost**. The main parts of seismological equipment are digitizer and sensor. There are many fair offers of modern digitizers in the current market. But the situation with the sensors is different. There are two main classes of sensors in the industry: broadband seismometers for seismology and short-period geophones for seismic exploration works. First are very expensive, and the second is inappropriate by the technical specification for local earthquakes registration (high natural frequency and low sensitivity). But if we will use the modern low-frequency geophones with higher sensitivity (natural frequency 5 Hz, and sensitivity 100 V/m/s) with the special software for frequency correction of its records [4], it will be enough to recording all local earthquakes in magnitude range 0.5-4.5 (fig. 1).

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Moreover, in comparison with posthole seismometers, there is no need to cementing well bottom and providing the ability to remove the seismometer from the borehole. The figure 1 shows that even geophone with natural frequency about 5 Hz is not useful to record local earthquakes. After the frequency correction of the record, the low frequencies related to seismic process may be observed in the data.

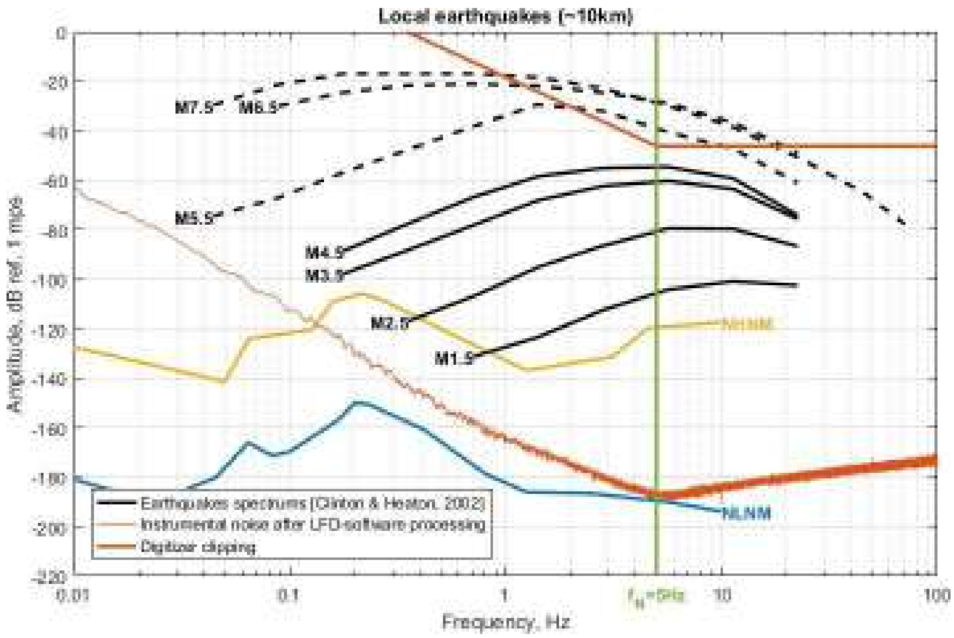


Figure 1. Shallow network with modern low-frequency geophones and its frequency correction software will provide registration of local earthquakes in magnitude range 0.5-4.5. Vertical green line – geophone natural frequency. The signals in frequency range lower natural frequency are not visible in seismic records before software processing.

**Conclusions and discussion.** In our experience, shallow network with equally spaced observation points with distances between neighboring seismic stations about 5-10 km, provides registration of weak earthquakes in magnitude range 0.5-4.5. In oilfields with increased seismicity level, it should be enough to analyze seismic activity and study its dynamics. For example, earthquake magnitude-frequency distribution can give you information about its nature (natural or induced). Instead of expensive posthole seismometers, you can use modern low-frequency geophones with the special software for the frequency correction of its records. This will help to significantly reduce equipment costs.

One more complication in comparison with downhole microseismic systems is to detect and to process (arrival times picking) signals from weak earthquakes. In this problem, neural networks can be very effective.

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