Review

of the PhD thesis

«Joint Detection, Location and Source Mechanism Determination of Microseismic Events»

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The PhD thesis presents a new method for joint detection and location of microearthquakes, the so-called microseismic events, and determination of their source function mechanisms. Microseismic events usually result from injection of liquid solutions into rock formations during hydraulic stimulation of shale gas reservoirs. Induced expansion of fractures improves productivity of wells. It can be monitored by corresponding acoustic emissions. Source locations of such emissions as well as focal mechanisms of fractures are important for evaluation of effectiveness of the well stimulation. The thesis addresses a very topical issue concerned with efficient passive seismic monitoring. It requires accurate and efficient imaging of weak microseismic events to be able to provide an extensive representation of the fracturing process.

The proposed imaging method is based on stacking of seismic amplitudes with corrected polarity. This aspect is important since it contributes to the signal-to-noise ratio and helps to obtain a clearer image of event. The imaging method also involves an original algorithm of event detection combined with an algorithm for verification of detected events based on semblance of amplitudes. These aspects enables application of the method to continuous data. This, in turn, has been successfully illustrated in the thesis by the extensive case study of hydraulic fracturing monitoring on a real shale gas reservoir.

Regarding the provided PhD thesis manuscript, I have the following questions:

1. The semblance estimation is usually used for extraction of weak signals from noisy records and simultaneous determination of their location. Why in the dissertation this estimation is not a principal criterion but it is used as an additional checking condition only? What is advantage of the proposed scheme (Figure 4)?
2. Directivity diagram of a seismic source can be naturally included in the semblance estimation, but it requires additional iteration by two angles, characterizing the space orientation of a source at semblance calculation in each point of a space grid. It is very expensive procedure. It is not quite clear from the presented description how the problem is overcoming with a weak signal extraction and simultaneous determination of its seismic momentum (directivity diagram)? Is it the same as for the semblance? By iteration?
3. It follows from eq. (4), (7) that the considered values do not include the usual summation by time window. What is the advantage of such approach?
4. May be the shear waves (sources of shear waves) were determined at experimental data processing? How they can be discriminated from the sources of longitudinal waves?

Overall, the thesis is an important contribution to the passive seismic monitoring technology. New theoretical and experimental results described in the PhD thesis represent clear evidence of enough high qualification of the author in the corresponding field of research. I strongly

recommend Denis Anikiev to be awarded with the PhD degree at Saint Petersburg State University.

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