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Development of Software for Processing Microseismic Data with Application to Observation of Shear-wave Splitting

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SUMMARY

Nowadays microseismic monitoring technology is widely used for the field control of hydraulic fracturing used in the production of unconventional hydrocarbon and geothermal resources. In the paper I show my results on developing software with graphic-user interface for microseismic data processing. It allows interactive processing including trigger-files extraction, band pass filtering, arrival-time picking, polarization analysis. This software was applied to process real dataset with a particular focus on polarization analysis of shear waves. Polarization analysis revealed evidence of splitting (cross-type shape of polarization hodogram). It is an important observation as it proves anisotropic properties of rocks treated by hydrofrac.
Introduction

Microseismic monitoring technology became popular during the last decade in the US, and it is just emerging for Russian oil and gas industry. Its data processing techniques are still under active development everywhere in the world and almost non-existent in Russia. One of important trends worldwide is to account for anisotropic properties in microseismic data processing. Anisotropy is crucial for applications in unconventional resources production (i.e. shale gas and oil). It is of great interest for Russia as well in view of strategic interest to develop the Bazhen suit (anisotropic shale) which has enormous proven hydrocarbon reserves.

Microseismic data processing is becoming appreciated by geophysical community. S-wave splitting was observed in microseismic data (Wuestefeld, et al. 2010), and anisotropic velocity models were built and used for microseismic event location (e.g. Grechka and Yaskevich 2014). For my Bachelor thesis I will be working on developing methods of microseismic data processing accounting for seismic anisotropy. It turns out that there is no specialized software for microseismic data processing available for academia (and this type of processing is not a part of standard seismic processing packages like Promax, Geovector etc.).

Thus the goal of my research project is to develop software for microseismic data processing with convenient graphic-user interface enabling efficient interactive processing of real data (including extraction of trigger files, band-pass filtering, arrival-time picking, polarization analysis). Polarization analysis of 3-component seismic data will be one of crucial procedures aiming at detecting S-wave splitting (indicator of presence of anisotropy). In the paper show my progress in the software development which is already used for processing real data. I show an example of polarization analysis with evidence of S-wave splitting.

Methods and example

There are many details in microseismic monitoring data processing procedures. My software, as part of student project resulted in an interface for microseismic monitoring data processing realized in Matlab.

Now this interface can handle trigger files selection, filtering, arrivals picking and polarisation analysis and mostly I will describe the later one.

At first P-wave polarisation analysis is being made. The extraction of beneficial seismic signals from three-component data and polarization properties estimation is better to conduct with technique based on a singular value decomposition (SVD). This conclusion based on that one can handle linear and elliptically polarized signals and minimises the influence of polarized noise on the estimated signal properties (Meersman et al. 2006). Realized algorithm consist of: P-wave arrival picking, allocation of polarisation analysis window on each receiver, polarisation analysis with SVD.

The second part is analysis of shear-wave arrival, that allows to detect shear wave splitting. Most of microseismic events characterized with similar frequency spectrum and a small duration of arrival-times between ‘fast’ and ‘slow’ share-waves. The cause of this is source-receiver distance that usually no more than 1000 m (Meersman et al. 2006).

For the particular dataset with my interface a produced set of trigger files, filtered them and picked the arrival times. I here present an example of shear wave splitting analysis. The length of analysis window was chosen to include both S waves (Fig. 1 Trace).

On the Fig. 1 (Hodogram of Particle Motion), I show trajectory of particle motion in the chosen window of 3C-data. The filtered 3C trace is presented below. Band pass filtering was applied (Filter parameters 0-100-200-400 Hz). One can clearly on the Fig. 1, trajectory of participle forms conventional crosses, with first arrival of horizontally polarized wave.
Figure 1 Screenshot of S-wave polarization analysis as part of microseismic data processing interface; on top— hodograms of participle motion; bottom— corresponding 3C-data; Green—start time of the allocated window, blue— end time of allocated window.

Conclusions

As a part of my BSc thesis project I have realized a GUI interface for microseismic data processing in the Matlab environment. Functionality includes the following processing steps: trigger file extraction from continuous records, band-pass filtering, arrival-time picking, polarization analysis. This software will be freely available for using in academia. Plans for future extension include implementation of kinematic inversion algorithm for locating hypocenters of microseismic events. It was used for real data processing. Polarization analysis of S-wave revealed evidence of splitting (cross-type shape of polarization hodogram). It is an important observation as it proves anisotropic properties of rocks treated by hydrofrac. Thus it proves importance of accounting for anisotropy while microseismic data processing.

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References


