WS10-B02

Small Microseismic Surface Acquisition System Case Study

G.N. Erokhin* (Immanuel Kant Baltic Federal University), V.D. Baranov (TINP Ltd.), A.N. Kremlev (Immanuel Kant Baltic Federal University), D.N. Gapeev (Immanuel Kant Baltic Federal University), I.I. Smirnov (Immanuel Kant Baltic Federal University) & S.V. Rodin (Anteloil Ltd.)

SUMMARY

Small Microseismic Surface Acquisition System for oilfield monitoring is presented. Algorithms for data processing are based on the mathematical theory of inverse problems and the using of the supercomputer calculations. A distinctive feature of the suggested system is high mobility, compactness and universality. The technology based on the this acquisition system is intended not only for hydraulic fracturing monitoring but also for long-duration passive monitoring of fluid injection, for hydrocarbon drainage area estimation and for oilfield block structure mapping. Case Study has more than 50 examples.

Introduction

Recently, passive seismic monitoring has become an effective instrument for the control of hydraulic fracturing. The traditional acquisition system uses the downhole arrays of receivers, but the surface arrays has been applied also (Duncan and Laking, 2006). Eisner et al., (2010) consider the advantages and disadvantages either surface or downhole acquisition systems. The precision, provided by these two types of acquisition system is closely connected to the mathematical algorithm used for data processing. For the vertical downhole arrays usually the delays between the time of arriving the P-wave and the S-wave are used for calculation the coordinates of events. For the surface arrays of receivers the algorithms similar to Passive Seismic Emission Tomography (Duncan and Laking, 2006) are used traditionally. For the proposed Small Microseismic Surface Acquisition System the original algorithms based on solution of the kinematic inverse problems and on the supercomputing are designed by Erokhin et al., (2008). Joint the Small Microseismic Surface Acquisition Systems and the original inverse problem algorithm provide stable results for microseismic monitoring of multistage hydraulic fracturing and for long-duration passive oilfield monitoring.

Description of acquisition system

The Small Microseismic Surface Acquisition System consists of the surface arrays of receivers usually covering not more than 0.4 sq.km. The vertical geophones GS-11D or similar are located on 3-5 m depth. Aperture diameter is about 800 m. The number of sensors equals 30-60 units (Figure 1). Coordinates of each sensor in the aperture are calculated with high precision on the basis of GPS. Data sampling is not more than 2 ms. Optimum depths for monitoring in this case are in the range of 2-4 km and the accuracy of a location of events in the horizontal plane isn't worse than 10 meters. Methods of the solution of the dynamic inverse problem (seismic moment tensor) are given in the papers Erokhin *et al.*(1987) and Anikonov *et al.* (1997)

Figure 1 Scheme of Small Microseismic Surface Acquisition System.

Figure 2 Results of microseismic monitoring the multistage hydraulic fracturing.

Case Study

Example 1. Multistage hydraulic fracturing. The results of microseismic monitoring of the multistage hydraulic fracturing for the Vientoy oilfield (West Siberia, 2013) are presented (Figure 2). The events are located on the depth of 2960 meters. The number of surface array receivers is 42.

Example 2. Hydrocarbon drainage area estimation based on the long-duration passive microseismic monitoring. The results of long-duration passive microseismic monitoring for the oilfield Lebiashe (West Siberia, 2005) are presented (Figure 3). Wells № 311,1007 and 1009 produce oil without pumping units. The events are located on the depth of 2680 meters. The number of surface array receivers is 36. The duration of the observation is 21 days.

Example 3. Oilfield block structure mapping on the base of the long-duration passive microseismic monitoring. The results of block structure mapping, based on long-duration passive microseismic

monitoring for the Alatube oilfield (Kazakhstan, 2012) are presented (Figure 4). The duration of the observation is 14 days. The events are located on a depth of 3870 meters. The number of surface array receivers is 48. Development of the oilfield - with oilwell pumping unit.

Figure 3 Image of the seismic emission in horizontal plane on the base of the long-duration passive microseismic monitoring.

Figure 4 The oilfield block structure on the base of the long-duration passive microseismic monitoring. Red line is well.

Conclusions

Presented results prove the efficiency and stability of the Small Microseismic Surface Acquisition System applied to oilfield development monitoring. This efficiency is provided by original data processing algorithm based on solutions of inverse problems. Suggested technology enable monitoring not only hydraulic fracturing but front propagation of fluid injection, hydrocarbon drainage area and oilfield block structure mapping as well. Case study has more than 50 tests of the technology.

Acknowledgments

The authors thank Pavel Bortnikov and Fyodor Shmakov for participation in the research and Anteloil Ltd. for the experimental data.

References

- Anikonov, U.E., Bubnov, B.A. and Erokhin, G.N. (1997) *Inverse and Ill-Posed Sources Problems, VSP*, ISBN 90-6764-273-8.
- Duncan, P. and Laking, J. (2006) Microseismic Monitoring with a Surface Array: Passive Seismic: Exploration and Monitoring Applications Dubai, *EAGE Annual Conference & Exhibition*, Extended abstract, A29.
- Eisner, L., Hulsey, B.J., Duncan, P., Jurick, D., Werner, H. and Keller, W. (2010) Comparison of surface and borehole locations of induced seismicity. *Geophysical Prospecting*, **58**, 809–820. doi:10.1111/j.1365-2478.2010.00867.x
- Erokhin, G.N. and Bortnikov, P.B. (1987) Inverse problem of determination of the earthquake source seismic moment tensor. *Geology and Geophysics*, **4**, 115-123.
- Erokhin, G.N., Mynagashev, S.M., Bortnikov, P.B., Kuzmenko, A.P. and Rodin, S.V. (2008) *The technique of hydrocarbons deposit hydraulic fracturing monitoring*. RU No. 2319177. Published 2008.10.09., bulletin 7.