Full-Wave Location Method (FWL)

In 2011, CJSC “Gradient” company has developed the Full-Wave Location method (FWL) which has significant advantages over the world analogues. This method can be successfully used for microseismic monitoring, hydraulic fracture monitoring and natural fractures network mapping.

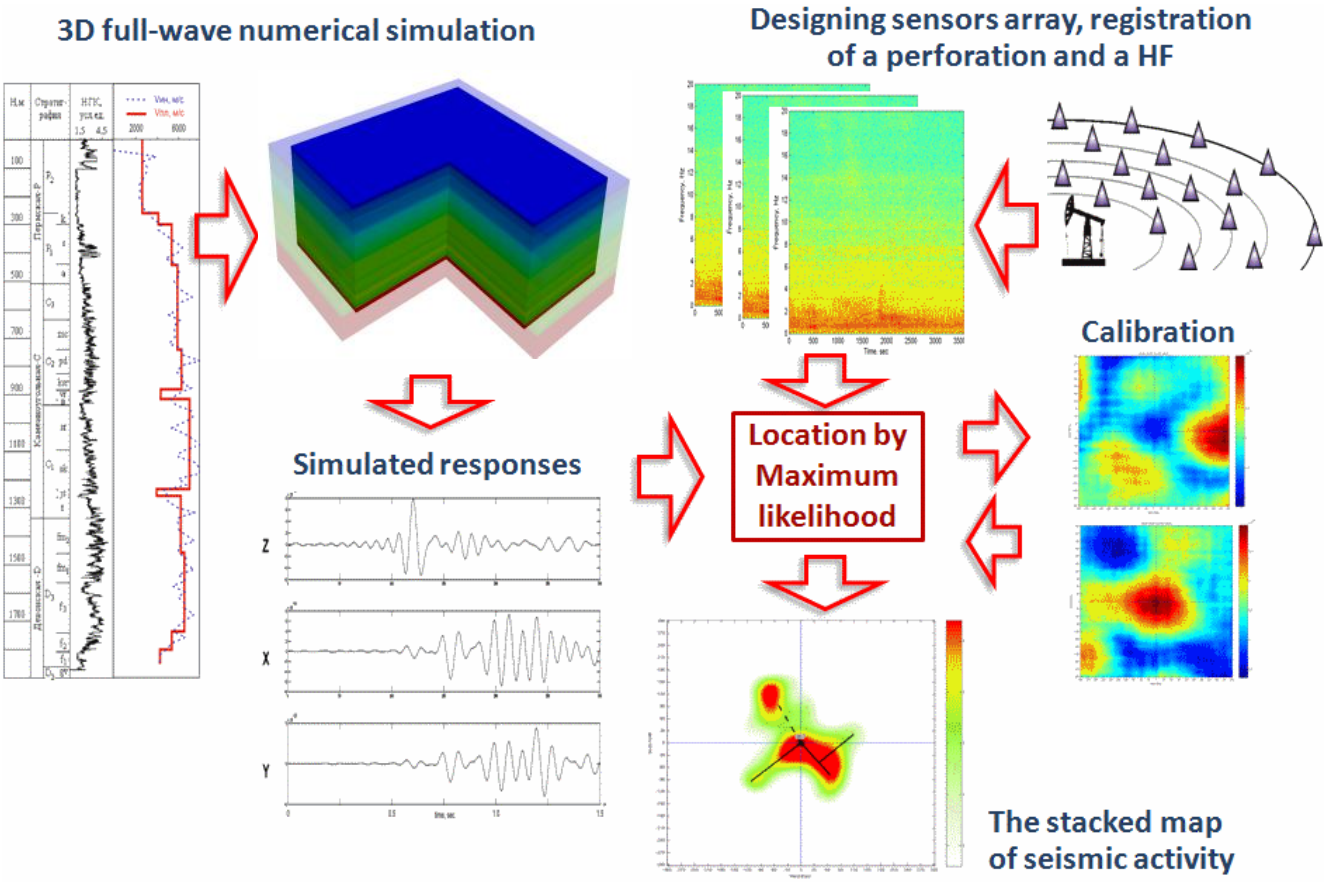
Application of FWL method

Our company provides a full cycle of microseismic emission monitoring surveys. The FWL technology can be used to solve both the geological and technological challenges. Range of solutions has been tested and is actual for implementation at oil and gas fields, some of solutions are unique.

Range of tasks to be solved:

- **Hydraulic fracture monitoring (HFM)**
  - to assess dynamics, dominant direction of fractures and estimate zones of proppant penetration. Field surveys are conducted from daylight surface, without lowering the equipment into neighboring wells
- **Natural fractures network mapping**
  - to identify zones of active natural fracturing and determine the orientation of faults and fractures
- **Identification of anomalous objects in geological media**
  - to improve the efficiency and safety of technological operations during the drilling, workover, well abandonment and monitoring of abandoned wells
- **Monitoring of fluid injection into reservoir**
  - to determine fluid migration paths

Processing



Equipment

Recorders

Baikal-ACH

SCOUT

Highly sensitive three component broadband seismometers

CME-4111-LT

LE-3Dlite

Name	Unit	Baikal-ACH88	SCOUT
Number of input channels		3	3
ADC resolution		24	24
Sampling frequency	Hz	100-4000	125-4000
Range of operating temperatures	°C	- 40… +60	- 40… +70

Name	Unit	CME-4111-LT	LE-3Dlite
Conversion ratio	V/(m/s)	4 000	400
Input signal		analog, differential	
Band frequency	Hz	0.1 - 20	1 - 80
Range of operating temperatures	°C	-40...+55	-15... +65

Physical theory

Full-Wave Location method is based on estimation of seismic tensor components, which maximize likelihood function. For this is necessary to know useful signal (simulated responses from deep source).

Useful signal is a full-wave process registered on three components on observation points located at the surface. The responses are calculated by 3D numerical simulation of wave processes in viscoelastic media. Numerical model is created using information from structural maps and VSP data.

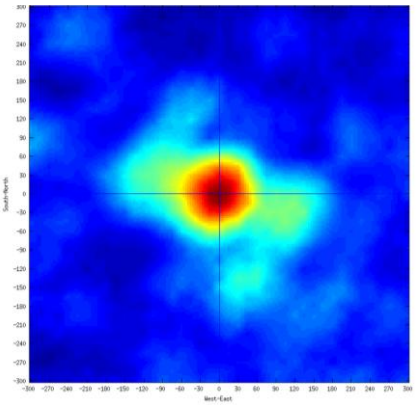
Source of the wave process is the force applied to nodes around the point of visualization in directions determined by components of the seismic moment tensor.

This approach allows the best way to locate, identify the type of event and its characteristics in case of low signal / noise ratio at the receiving channels.

Advantages

- Field surveys are conducted from daylight surface using highly sensitive broadband seismometers. Wells shut-in, plug setting and downhole sensors run in nearby wells isn't required
- 3-component event location using full form of wave process, containing all wave types.
- Location technology automatically exclude influence of correlated noise
- Retrieving of seismic moment tensor and location of seismic events. Implementation of maximum likelihood method allows locating seismic events even when the signal / noise ratio at the receiving channels equal to 1/100.

Results



As a result of FWL method processing interpreter receives:

- **Coordinates of seismic events**
- **Event's seismic moment tensor**
- **Type of seismic event (VOL, DC, CLVD)**
- **Event reliability estimation (S/N)**
- **Dynamics of events appearance**

Interpretation is based on comparison of event location results with different geological and geophysical information, depending on the task.