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Microseismic Monitor Technology

(MMT)

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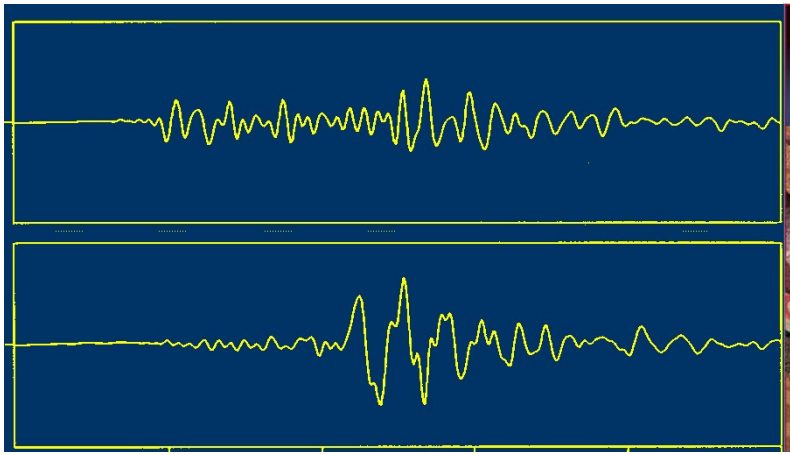
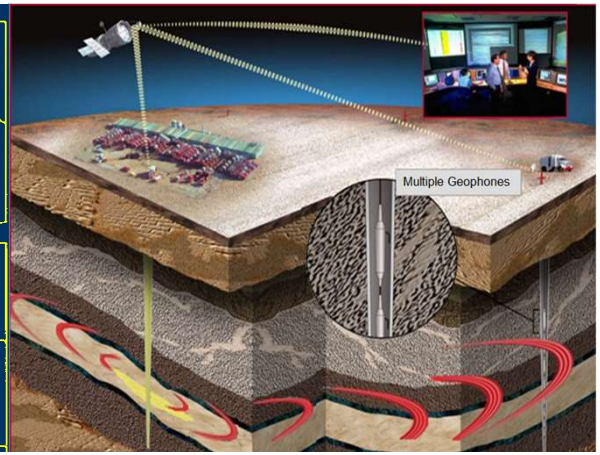
About Microseismic

- Microseismic means weak earthquake of energy releasing. It can be nature produced or artificial induced.
- Acoustic wave is the typical signal of microseismic. The compressional and shear wave can be detected by sensitive geophones.
- Microseismic signal can be induced by explosion of mining, hydraulic fracture, Oil and gas production, water injection, gas injection and production in underground gas storage, thermal recovery and etc.
- Hydraulic fracture in oilfield caused formation broken under overpressure and produced microseismic signal. The microseismic energy and location can be inverted by wave signal processing through proper modeling. The microseismic events provided fracture information for oil and gas development.

Compressional and Shear wave





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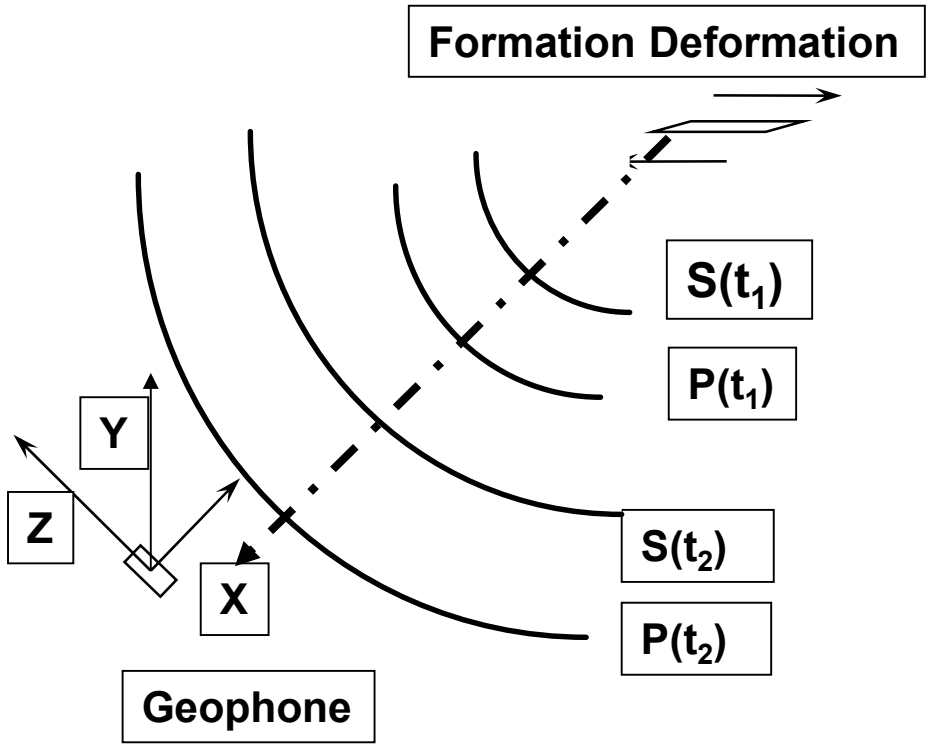
Microseismic Signal Acquisition

Microseismic signal can be acquired through geophones on surface or in downhole.

Due to the weak energy of microseismic the signal will attenuated through long distance travelling. Geophone located in downhole nearby microseismic occurring location will have higher signal-noise ratio.

A serials geophone with 3 components(X, Y, Z) can be used to locate microseismic in formation.

Pre-job proper design of geophones location is a key point of microseismic signal acquisition.



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Microseismic Signal Acquisition

Microseismic fracture monitoring is an essential technique in unconventional oilfield exploration and development of shale gas, tight formation hydrocarbon etc. Compare to surface microseismic monitoring the downhole monitoring provides more closer, more accurate and more clear reflecting the real-time change, extend of length, height and width of fractures during fracture job. It helps customer analysis the formation reformation and evaluate the results of fracture and thus for adjusting the plan of fracture procedure to reduce the cost and time of reservoirs reformation. It is the most accurate, on time and rich information of monitoring method.

- **Realtime monitor**：Check fracture results, analysis fracture structure real-time, adjust fracture parameters (pressure, sand volume, fluid volume, diverters etc), optimize fracture procedure.
- **Fracture evaluation**：Provides geometry of fracture grid. Evaluate the results of fracture job, Calculate moveable hydrocarbon volume(SRV) associated with information from logging and lithology of formation.
- **Application for field development**：Provide the structure of fracture and the major stress of formation and important information for development of oilfield in well distribution, distance, length of horizontal section, fracture interval etc.

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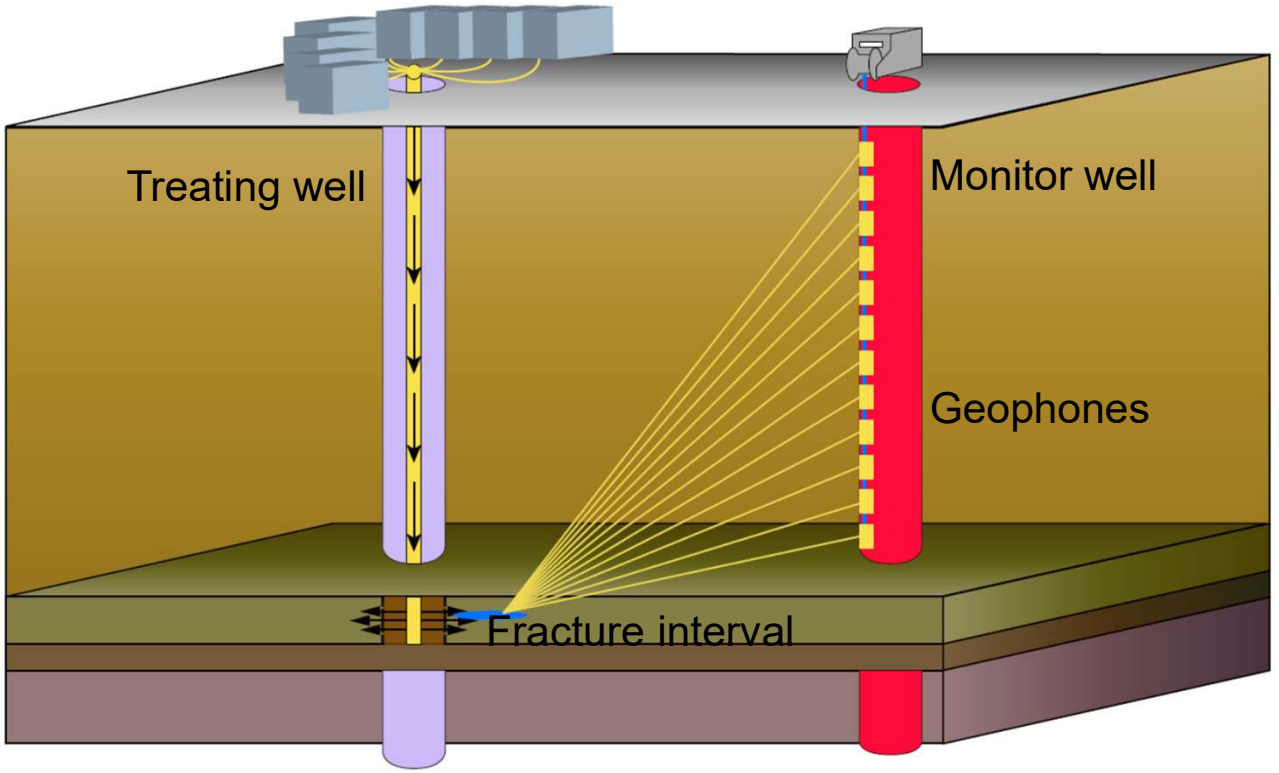
Microseismic Signal Acquisition

Microseismic monitor technology deploys a series 3-components downhole tools inside monitor well which is adjacent to the treating well(Fracture well) of fracture job and acquire microseismic signal continuously.

Interpretation software processes signals and provides the fractures information.



Illusion of Microseismic Monitor Technology

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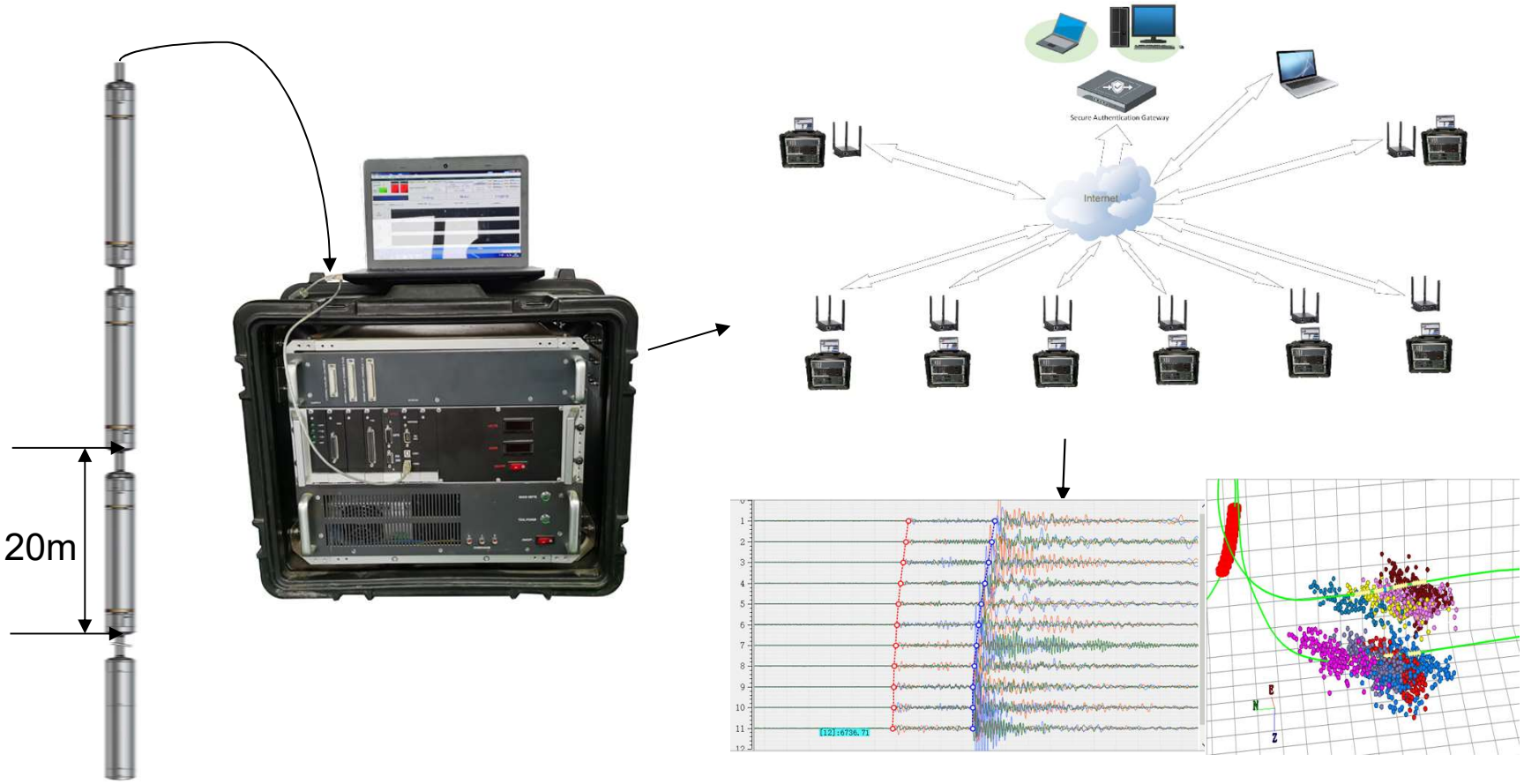
Equipment Introduction

The equipment for microseismic monitoring mainly includes: Data Acquisition System PIVSP (panels and acquisition software), Magnetic Vertical Seismic Profile Tool (MagnetVSP) or Slim Vertical Seismic Profile Tool (SlimVSP), Remote Transmission System, and Fracture Microseismic Monitor software (real-time processing and interpretation).

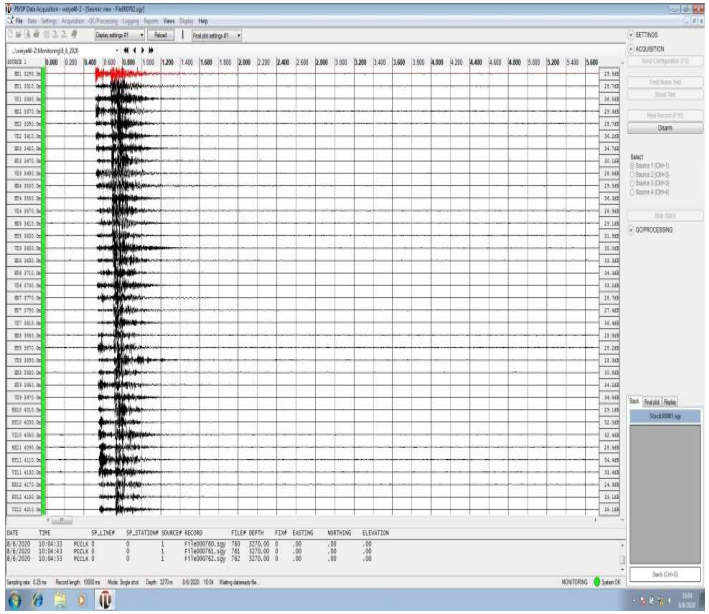


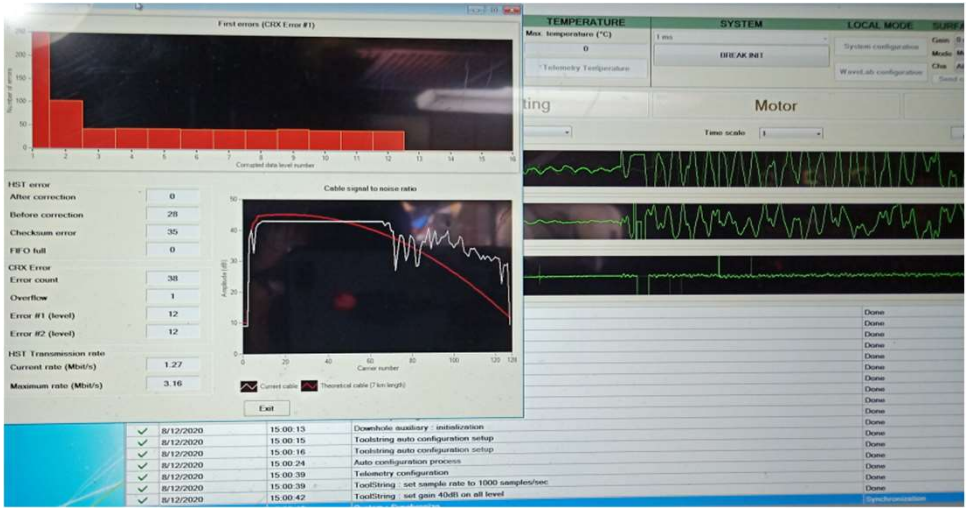
Surface System PIVSP

Surface acquisition system

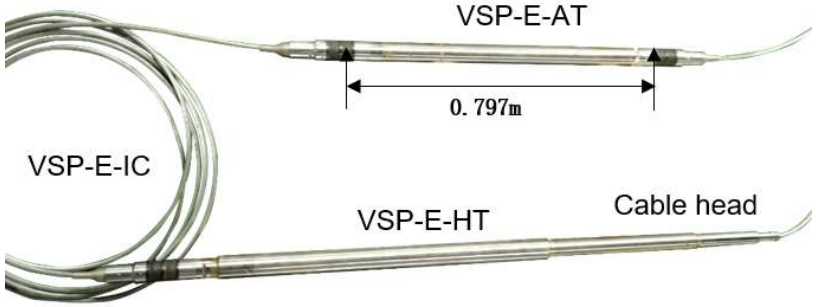
Surface acquisition system includes downhole tool control panel, signal acquisition panel and computers with acquisition software.

Realtime acquisition system continuous acquires data and interpretation software processes data real time.





DEoRC Downhole Instrument - MagnetVSP



Tool Specification

Maximum Pressure	**20000 psi (140 MPa)**
Maximum Temperature	**350℉ (175℃)**
Length	**VSP-E-AT: 0.797 m**
	VSP-E-HT: 1.05 m
Weight	**VSP-E-AT: 8 kg**
	VSP-E-HT: 3 kg
Diameter	**VSP-E-AT: 54 mm**
	VSP-E-HT: 63.5 mm
Sample rate	**0.25ms，0.5ms，1ms，**
	2ms，4ms
Gain	**20 dB,40 dB**
Dynamic Range	**20 dB) ＞121 dB**
	(40 dB) ＞105dB

MagnetVSP uses magnetic method to deploy tools to casing instead of conventional motor-arm which reduced tool weight and size significantly.

MagnetVSP can work with Downhole Hydraulic Tractor (DHT) and deploy in horizontal section closed to fracture intervals which provides higher Signal-Noise ratio.

■ Features & Benifits

- ✓ Ultra slim body allows a wide range of wells.
- ✓ Lower cost
- ✓ Unique bypass function can exclude a malfunction level and allows operation continued.
- ✓ Three-component geophone sensor
- ✓ Combined with Downhole Hydraulic Tractor (DHT) the microseismic monitor of well group can be acheived.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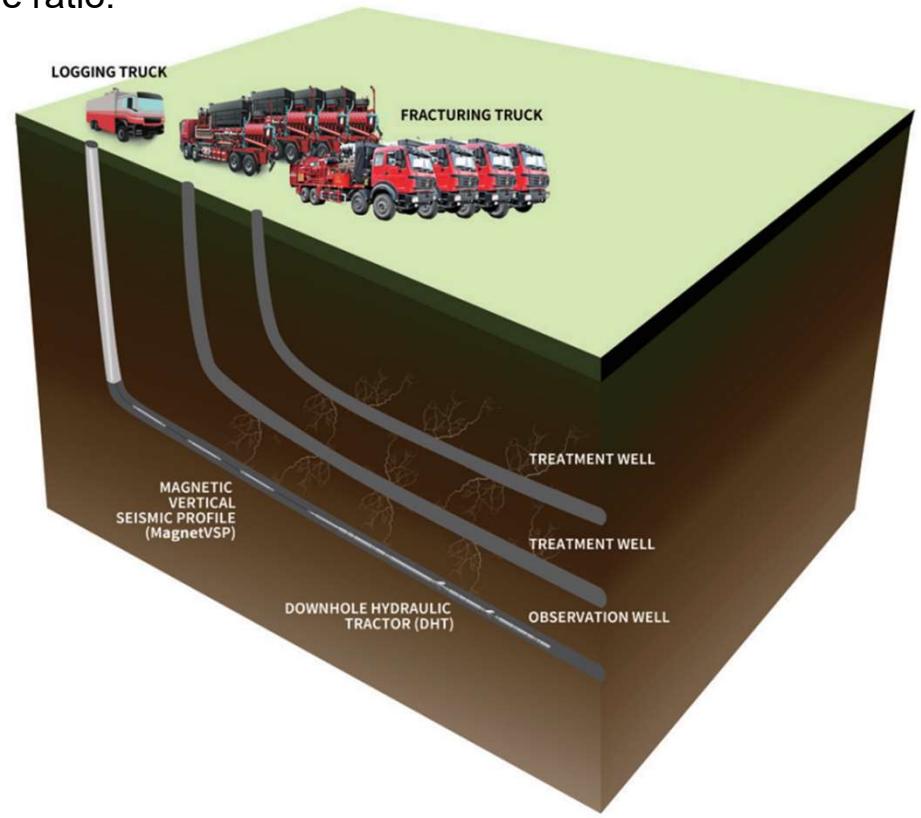
Auxiliary Equipment
Downhole Hydraulic Tractor (DHT)

The Downhole Hydraulic Tractor (DHT) is designed to convey logging tools, VSP tools and perforating gun in horizontal or high deviated wells.

Downhole Hydraulic Tractor (DHT) can convey MagnetVSP up to 30 levels in horizontal wells, which allows positioning receivers orientation of geophones with perforation signal one time for multi-stages fracture jobs and avoid moving geophones and positioning again. And receivers closer to fracture job section provide more clear signal and noise ratio.

■ Features & Benifits

- ✓ 12.0 feet length in the basic configuration
- ✓ Conform to diameter changes from 3.625 to 15.0 inches depending on drive wheel used.
- ✓ The traction control allows dynamic adjustment of the arm radial force which reduces amount of slippage and unnecessary wear.



DEoRC Downhole Instrument - SlimVSP

SlimVSP is the perfect choice for digital multi-level array seismic surveys in the mining borehole.

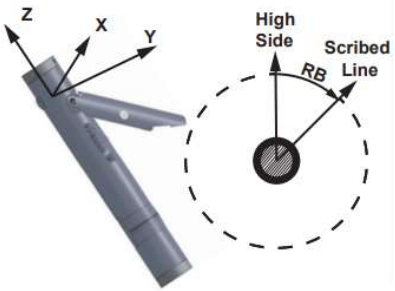
With 100-level digital 3-components, SlimVSP benefits from the most advanced developments in terms of real time telemetry and mechanical reliability, that makes system optimal solution to face to today's challenges: cost, effective, high volumes and high quality data.

■ Features & Benifits

- ✓ Ultra slim body allows a wide range of wells.
- ✓ Maximum up to 100-levels in one run
- ✓ Unique bypass function can exclude a malfunction level and allows operation continued.

Tool Specification

Maximum pressure	**20000 psi (137.9 MPa)**
Maximum temperature	**350℉ (175℃)**
Weight	**VSP-S-AT: 26.46 lbs. (12 kg)**
	VSP-S-HT: 19.8 lbs. (9 kg)
Tool diameter	**VSP-S-AT: 1.77 in. (45 mm)**
	VSP-S-HT: 2.5 in. (63.5 mm)
Minimum borehole size	**3in(76.2mm)**
Maximum borehole size	**8.5in(216mm)Standard Arm**
	13in (330mm)Long Arm
Sample rate	**0.25ms，0.5ms，1ms，**
	2ms，4ms
Gain	**20 dB, 40 dB**



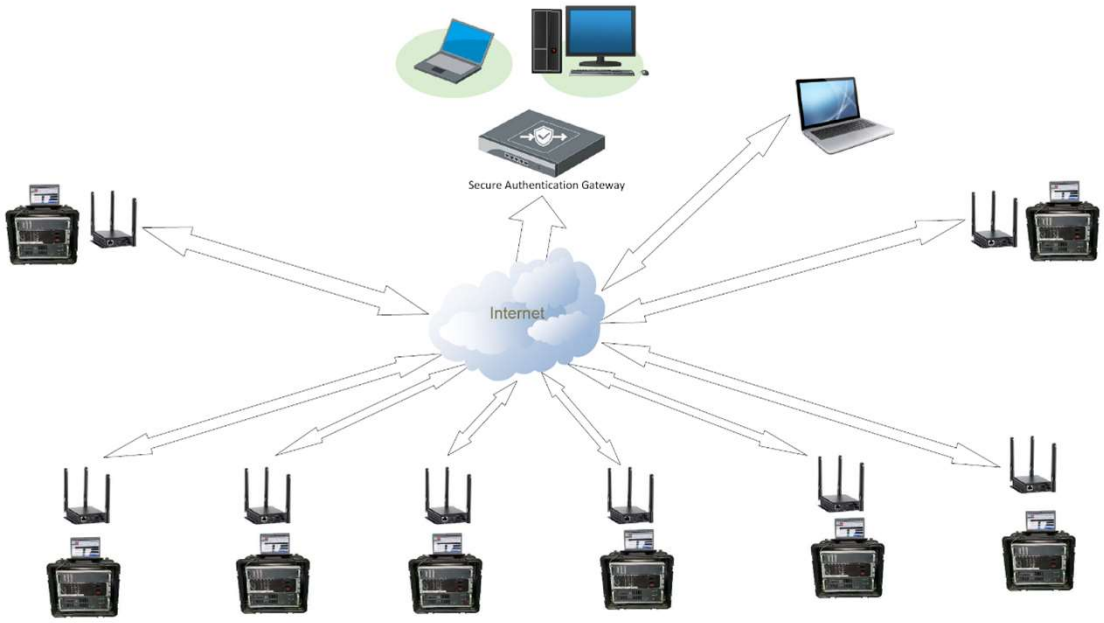
DEoRC Remote Data Transmission system

Remote data transmission system requires a stable wireless or wired network connection, router and storage server. On-site data is transmitted over the network to a storage server, where interpreters or engineers can access the data served over the network for processing and interpretation.

If the site network can reach home level (fiber optic), the raw data can be transferred in real time, if the site network is poor, can not meet the original data real-time transmission, you can set up once an hour to compress the original data and transfer to the server.

■ Features & Benifits

- ✓ GPS synchronization in time
- ✓ Wireless real-time transmission
- ✓ Optional hourly data compression and transmission
- ✓ Each acquisition system can transfer up to 50GB of data per day
- ✓ Server mass storage up to 20TB
- ✓ Monitor the working status of each well site computer



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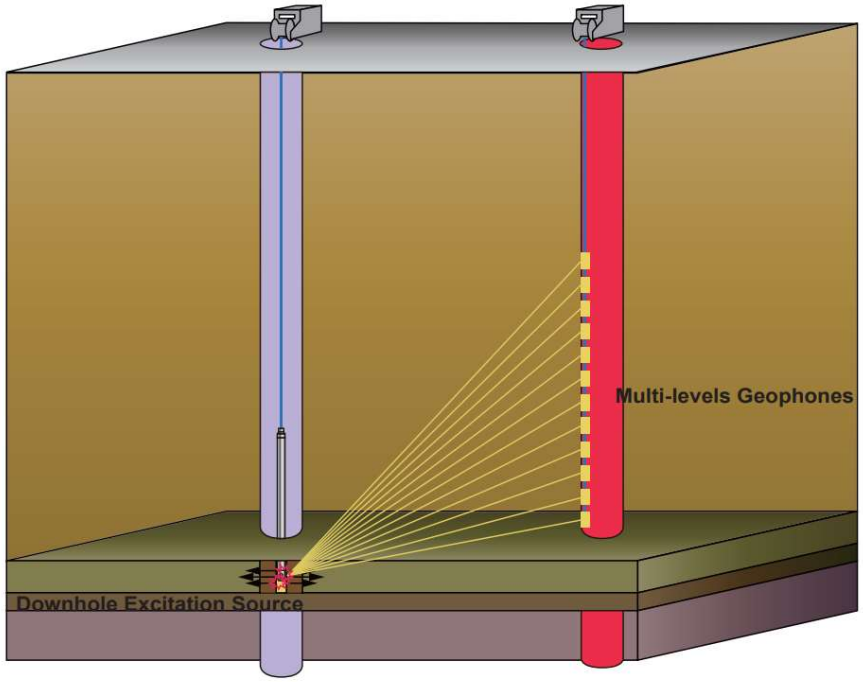
Auxiliary Equipment
Non-Explosive Implusive Source (NEIS)

Non-Explosive Implusive Source



Downhole Excitation to Position Receivers Orientation

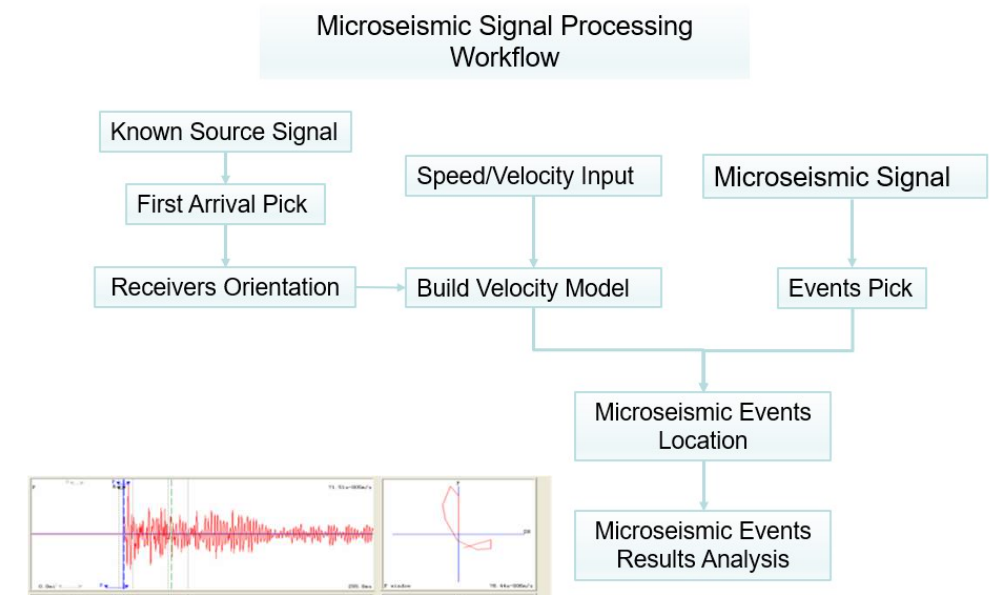
Applications

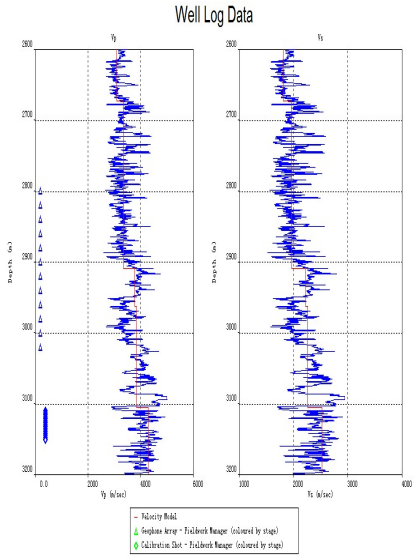
- ✓ Surface excition source for Vertical Seismic Profile.
- ✓ Downhole excition source for positioning receiver orient in microseismic monitoring jobs.
- ✓ Suitable for old perforated wells.

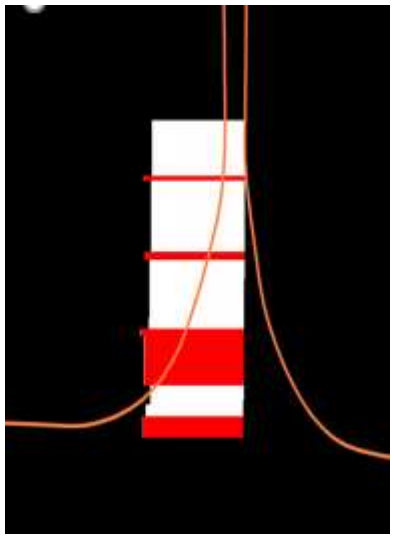
Features & Benifits

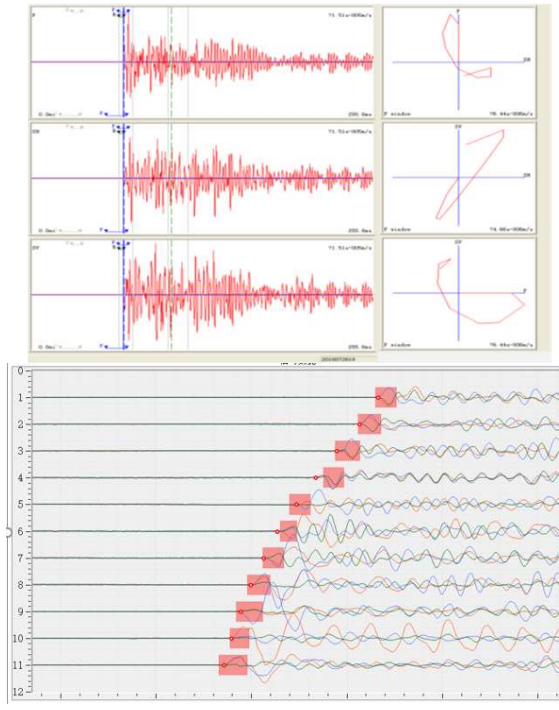
- ✓ The excitation energy is stronger than the perforation charge and first arrival is easier to identify.
- ✓ Compared with explosive source, it is more safe and more stable.
- ✓ Without special procedure for explosive materials and permissions.

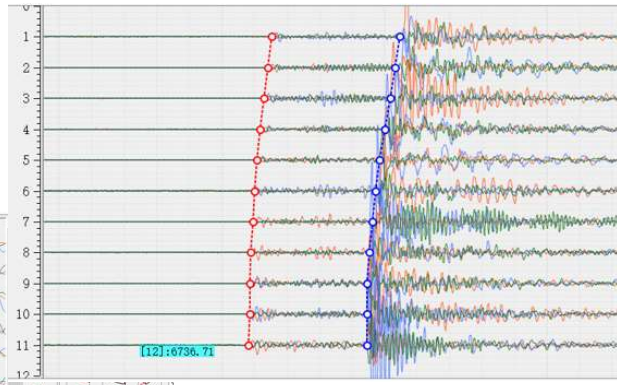
Microseismic Signal Processing and Interpretation

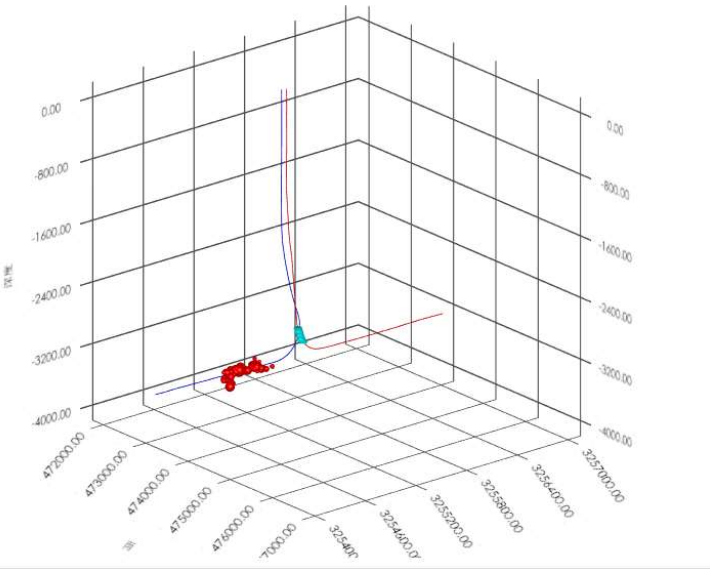










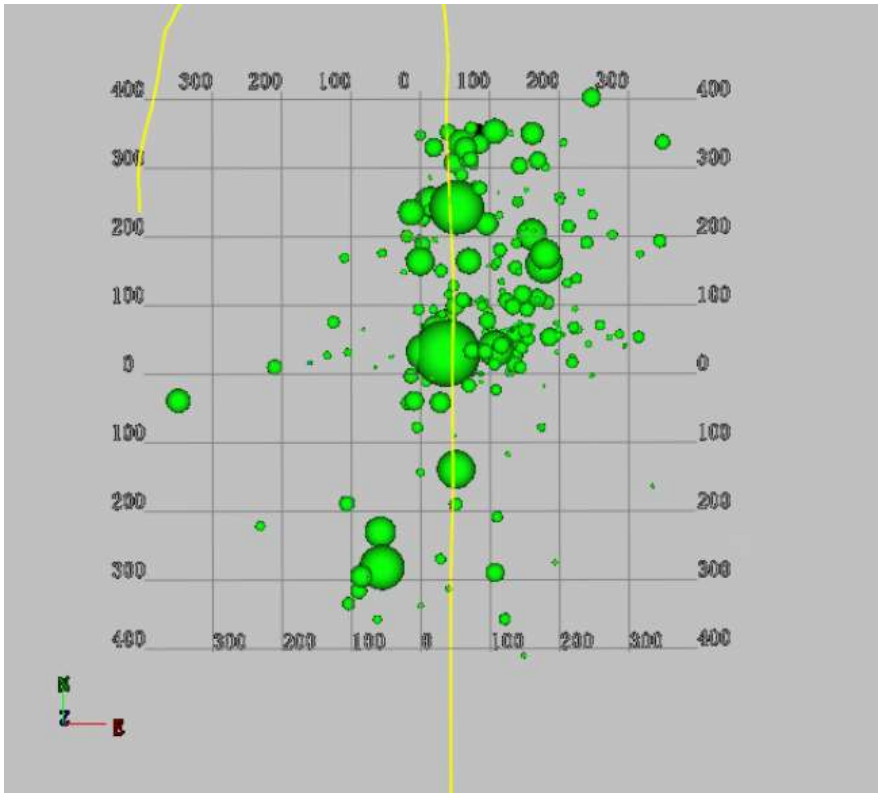


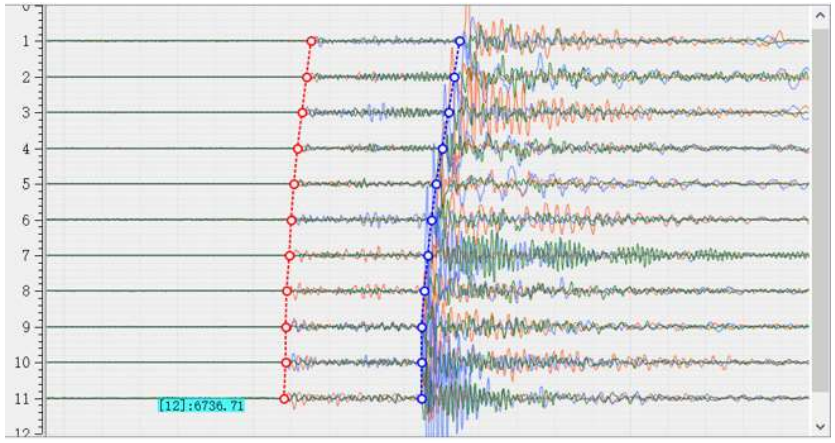
DEoRC Data Processing – Events Locating

The 3 dimension signals of first arrival picks can be invert to location information through pre-defined velocity model and receivers location.

Also software can calculate the degrees of microseismic energy level.

Software can display the microseismic events visually by the time sequence.





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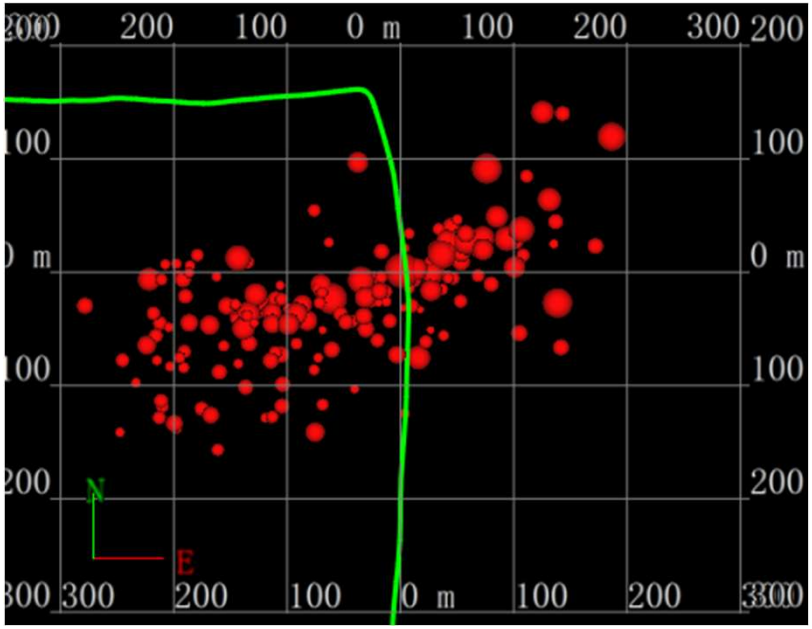
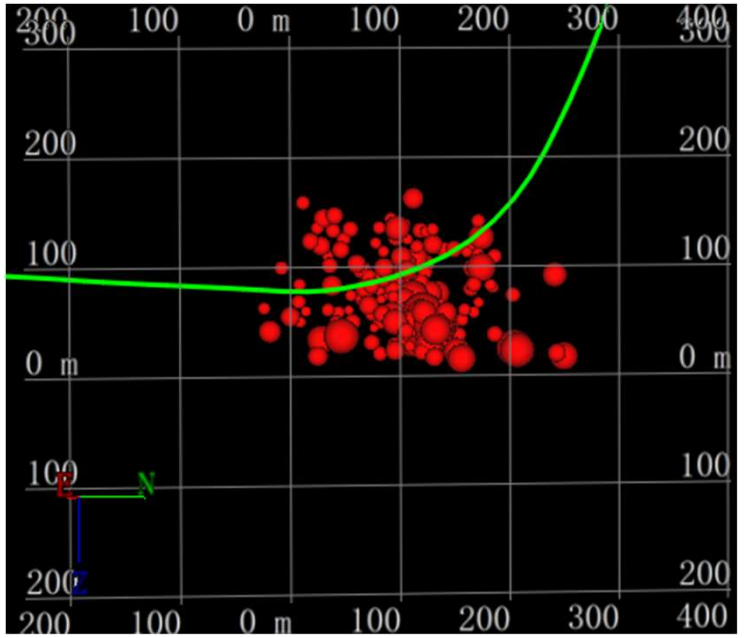
MMT – Events Inversion



Top View

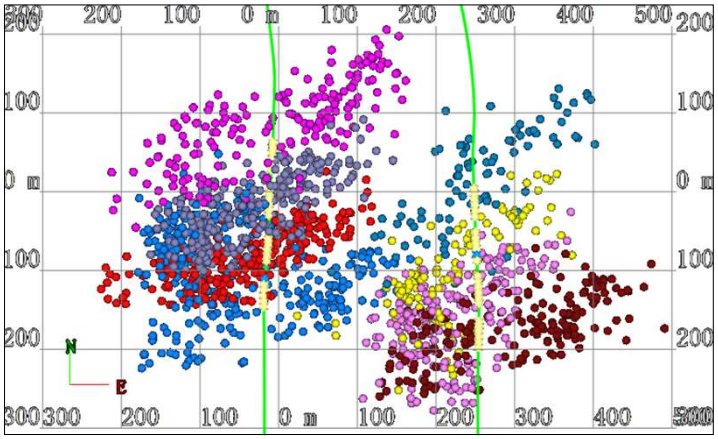


Side View

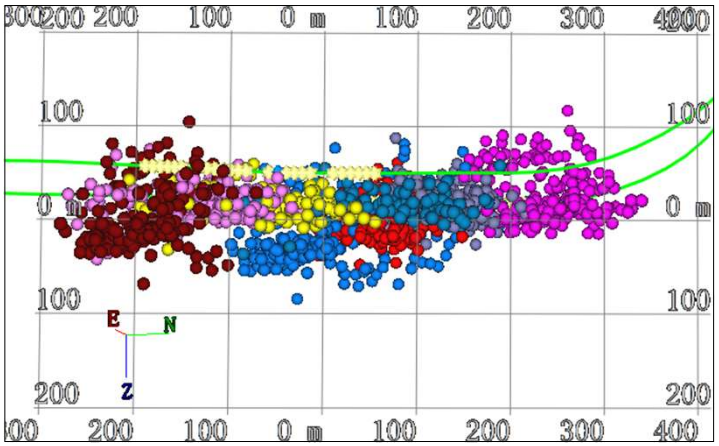
Monitor Range (m)	Length of Fracture Grid (m)	Width of Fracture Grid (m)	Height of Fracture Grid (m)	Direction of Fracture Grid	Microseismic Events
759	W:171 E:167	45	61	North-East 70 deg	177

The larger the color ball means the higher micro-seismic level and the stronger energy.

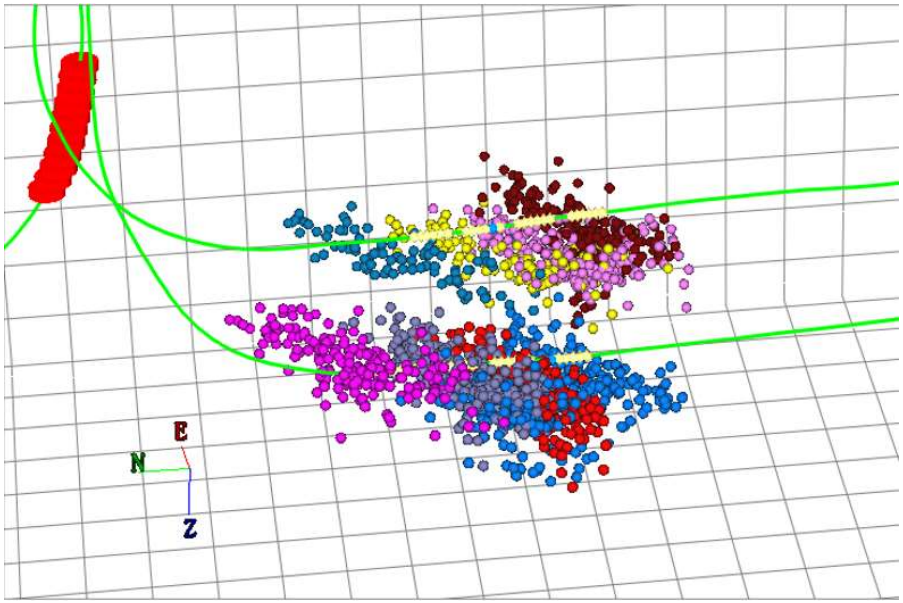
MMT–Dual Well Results Display



Top View



Side View



Dual wells multi-stage 3D results