Field acquisition, processing and interpretation of VSP data.

Five Day **VSP Training Course** and **Workshop**

Illustrated by processing of real VSP data

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Content

1. Vertical Seismic Prospecting – origination and development (E.I. Galperin)

1. History of VSP origination
2. VSP as bridge between logs and surface seismic
/Logging by downgoing waves, primary reflections, true signature for surface seismic, time to depth for surface seismic, anisotropy from VSP/
3. VSP as method of prospecting the near borehole space.
/Offset VSP, Walkaway VSP, 3D VSP/
4. VSP as third dimension in seismic prospecting (2D + VSP, 3D + VSP)

2. Field acquisition

1. Down hole geophones
/Pressure and temperature resistance clamping, resonances, inclination resistance, polarity, right hand configuration, frequency band, dynamic range, digitizing, transmission/.
2. Acquisition 1D, 2D, 3D and 2D + VSP, 3D + VSP geometries
/Downhole and auxiliary channels, stacking, visual control, operators report/
3. Signature, time and amplitude control.
/Reference geophone, geometry and special notes/.
4. Depth control.
/Cable depth, registration, control acquisition/.
5. Quality control .
/Signal to noise ratio in different frequency bands/.

3. Processing

1. Preprocessing
1.1. Description of well and acquisition geometry, headering
1.2. Editing of frequency resonances and amplitude spikes.
1.3. Static corrections from reference geophone
1.4. Signature and amplitude corrections from reference geophone.
2. First break peaking
2.1. Direct peaking and correlation.
2.2. Determination and subtraction of correlated noises before first breaks
2.3. First break peaking under complicated conditions
/Modules XYZ, Modules XY, Low frequencies/
3. Polarisation and orientation.
3.1. Local, geographic, PRT and SP-oriented XYZ coordinate system;
3.2. Polarization parameters.
3.3. Orientation;
4. Static corrections
4.1. Principles of static corrections
4.2. Static corrections for SP from model joint optimization;
4.3. Static corrections by smoothing of hodograph;
4.4. Static corrections from symmetry of downgoing and upgoing waves;

5. Velocity models

- Interval, layer and average velocities from VSP, vertical hodograph;
- Calibration of sonic log;
- Layering of logs;
- Combining of VSP and sonic log models;
- Anisotropy (TLA);
- Anisotropy : transversly isotropic media
- Geometries of models;
- Joint optimization for several SP;

6. Wave field analysis.

6.1. Elements of wavefields:

- P, S, PS down going and upgoing waves;
- Tube waves;
- Sideway waves;
- Vibrations of uncemented casing;
- Surface waves;
- Waveguide back dispersion;
- Frequency resonances;
- Amplitude spikes;
- Random noises;
- Gas discharges;

6.2. Principle of additive iterative subtraction analysis.

6.3. Polycor correlation of waves.

6.4. Determination and subtraction of waves

- 2D Fourier filtering;
- Polycor weighting;
- Sliding base determination and subtraction along hodograph combining Fourier filtering and Polycor weighting.

7. Deconvolution

7.1. Prediction error statistical deconvolution

7.2. Prediction error and spike signature deconvolution

7.3. Surface seismic to VSP deconvolution

8. Migration

8.1. Ray migration

8.2. Kinghoffer migration

8.3. Finite difference migration

9. Inversion

9.1. Inversion of reflectivity

9.2. Inversion of sections

9.3. Full vector inversion

10. Anisotropy study

10.1. Tranversal isotropic media with horizontal axis of symmetry

10.2. Tranversal isotropic media with vertical axis of symmetry

10.3. Splitting of shear waves

10.4. Study of fast to slow waves

4. Wavefield modeling

1. Reflectivity modeling
2. Wavefield equation
3. Mathematical modeling
4. Ray method
5. Finite difference modeling

5. Interpretation and presentation of results

1. VSP to log matching
2. VSP to surface seismic matching
3. Traditional interpretation of 2D and 3D VSP
4. Anisotropy estimates.

Training Schedule.

Monday

9.00 - 9.45	History of VSP origination. Prof.E.I. Galperin
10.00 - 10.45	VSP versus LOGs and Surface Seismic
11.00 - 11.45	Integration of VSP, LOGs and Surface Seismic
12.00 - 13.00	
13.00 - 13.45	Downhole geophones – special claims
14.00 - 14.45	1D, 2D, 3D, and 2D+VSP, 3+VSP geometries
15.00 -15.45	Signature, time and amplitude control
16.00 - 16.45	Quality control

Tuesday

9.00 - 9.45	Preprocessing : descriptions and headering
10.00 - 10.45	Preprocessing : correction by reference geophone
11.00 - 11.45	Preprocessing : frequency and amplitude edition
12.00 - 13.00	
13.00 - 13.45	First breaks determination and correction
14.00 - 14.45	Polarization and orientation
15.00 -15.45	Static corrections
16.00 - 16.45	Velocity models

Wednesday

9.00 - 9.45	Principles of additive iterative substraction analysis
10.00 - 10.45	Elements of wavefields
11.00 - 11.45	Polycor correlation of waves
12.00 - 13.00	
13.00 - 13.45	2D Fourier filtering
14.00 - 14.45	Polycor weighted stacking
15.00 -15.45	Weighted subtraction of waves
16.00 - 16.45	Automative model based selection

Thursday

9.00 - 9.45	Deconvolution : statistical approach
10.00 - 10.45	Deconvolution : signature approach
11.00 - 11.45	Migration
12.00 - 13.00	Inversion
13.00 - 14.00	
14.00 - 14.45	Anizotropy : TLA
15.00 -15.45	Anizotropy : vertical symmetry
16.00 - 16.45	Anizotropy : horizontal symmetry

Friday

9.00 - 9.45	VSP to LOG matching
10.00 - 10.45	VSP to Surface Seismic matching
11.00 - 11.45	Tieing up of surface reflections to depth section
12.00 - 13.00	
13.00 - 13.45	Wavefield equation and dispersion coefficients
14.00 - 14.45	Reflectivity modelling
15.00 -15.45	Mathematical modelling
16.00 - 16.45	Ray tracing modelling
17.00 - 17.45	Finite difference modelling