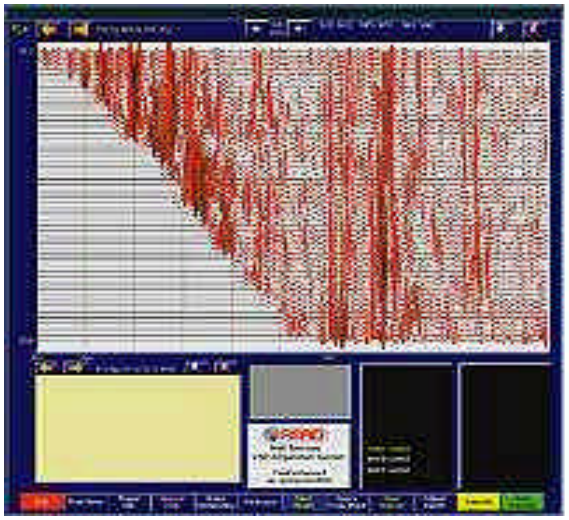
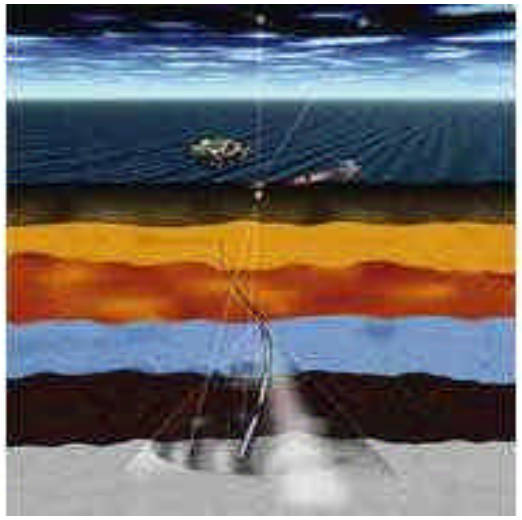
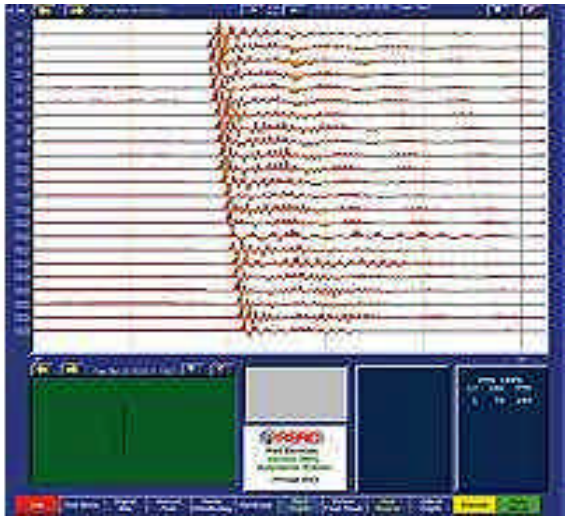
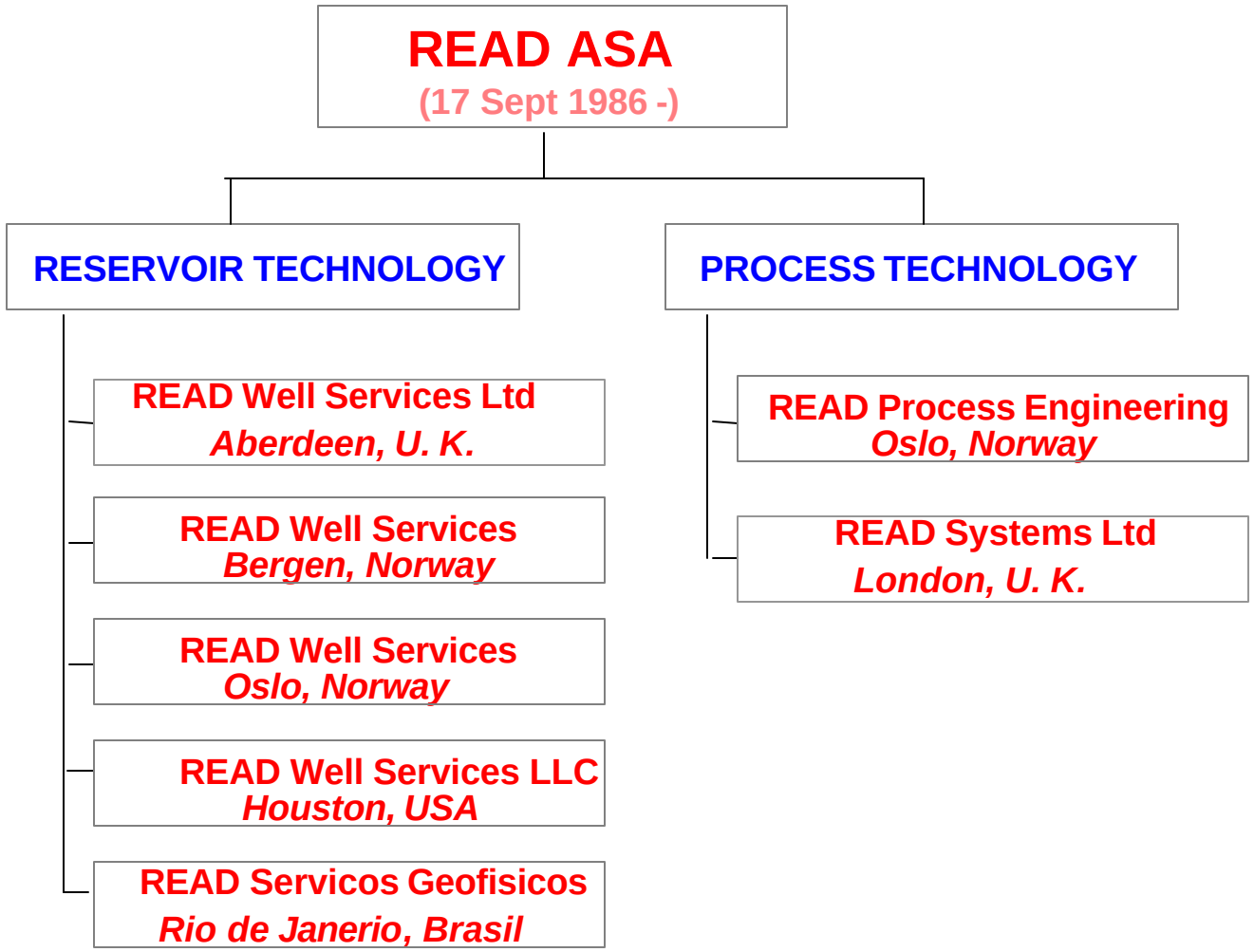
Presentation Outline

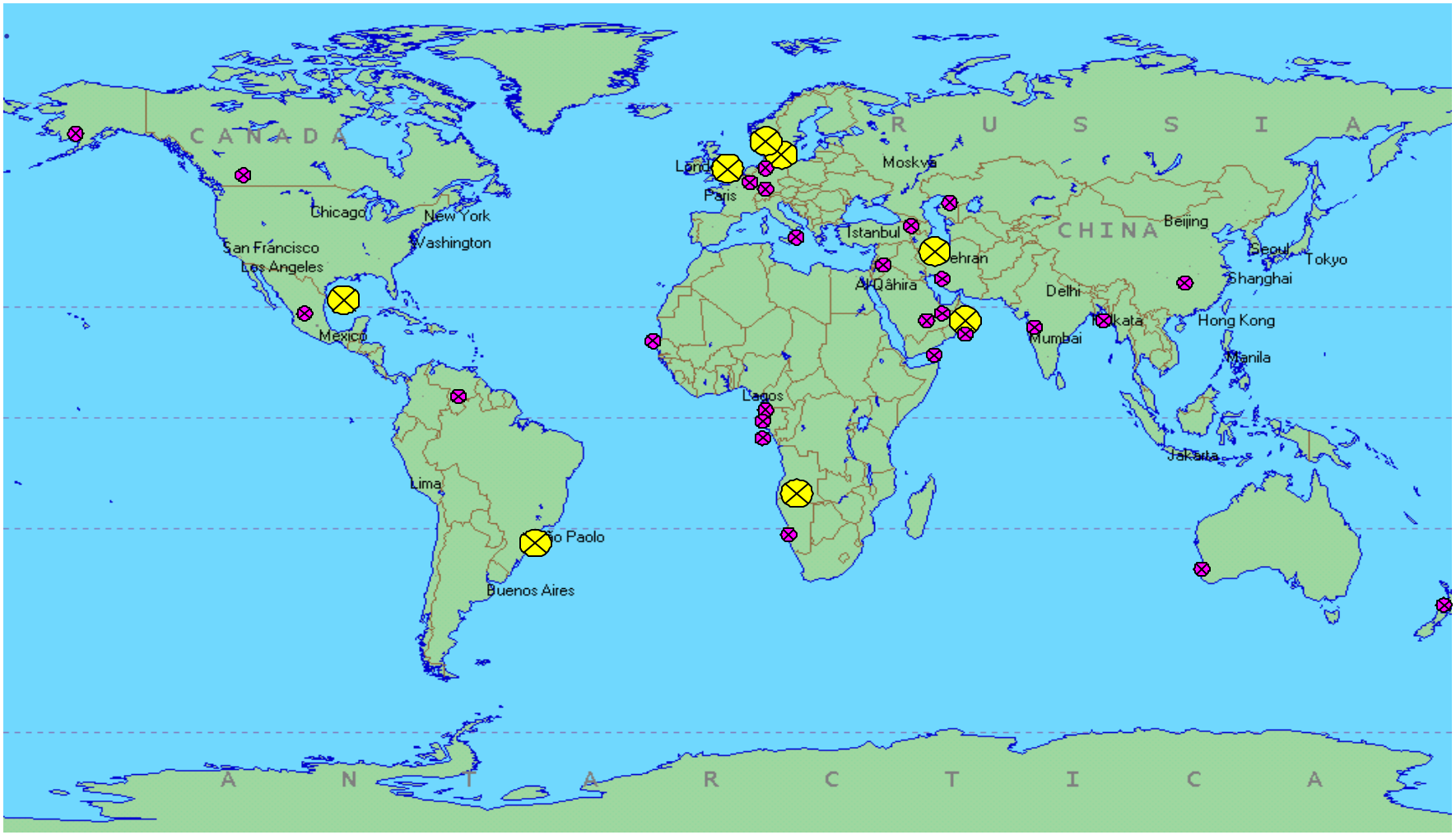
- Introduction to Read Well Services
- 3D VSP Acquisition and Processing Capabilities
- 3D VSP Case Examples and Benchmark Results
- Preliminary Proposal to CNOOC 3D VSP at Bohai Field

The READ Group of Companies



Operational Areas



(Total 1750 VSP Projects Worldwidely)

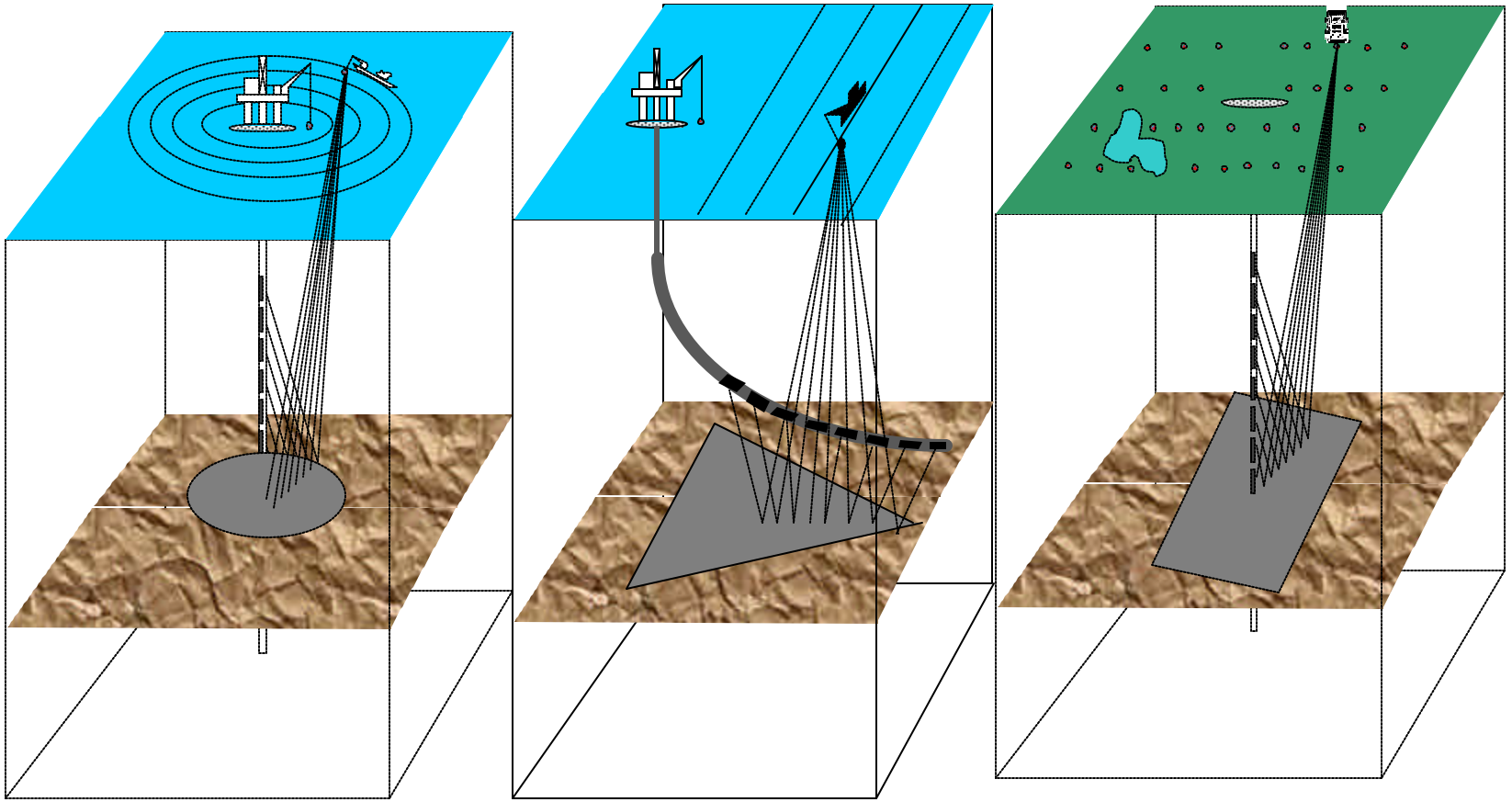
Highlights for 3D VSP

READ has acquired/processed ~ 50 3D VSP projects world-widely since it started business in 1987. READ has more experience than ANY contractors in acquiring larger VSPs and is continuously breaking new ground in advancing the technique.

READ was first to use multiple sources to reduce rig time and the

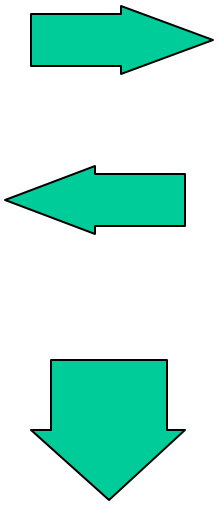
first to acquire 3DVSP “offline” while drilling. READ has deployed the longest wireline logging string ever (2,700ft or 845m), used more levels of Geochain tool than any other contractors on standard wireline (28 levels). In addition, READ has acquired the largest deepwater 3DVSP in the Gulf of Mexico with ever 40,000 shot points, and is the benchmark proven leader in both 3D and 2D borehole seismic processing.

3D VSP Survey Design & Acquisition



Pre Survey Planning Procedure

Discussion with client:
- Define target
- what information is wanted.
- Primary objectives
- Secondary objectives

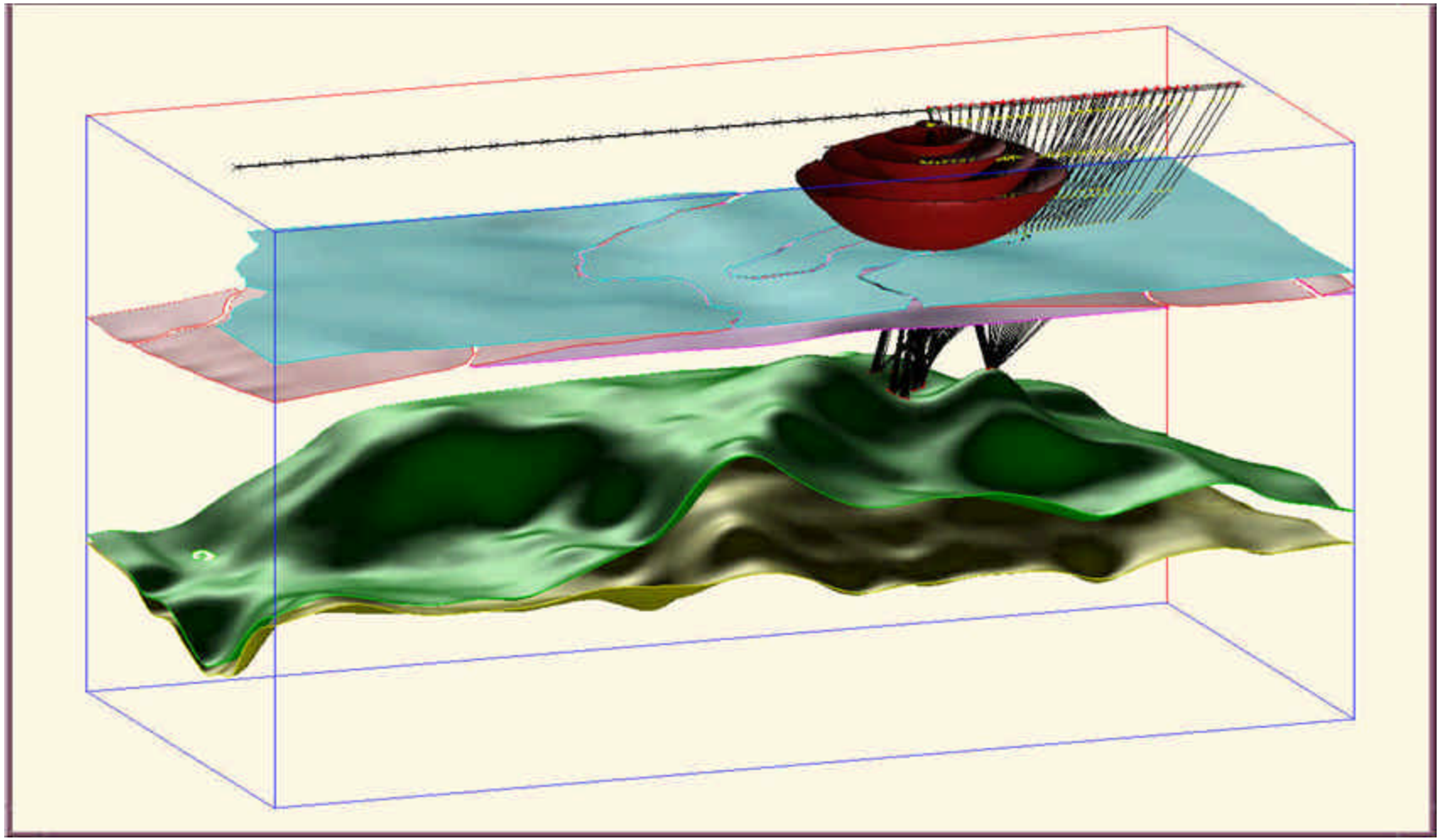


Modeling
- Ray tracing
- Synthetic data
- Processing data
- amplitudes
- coverage
- P-S

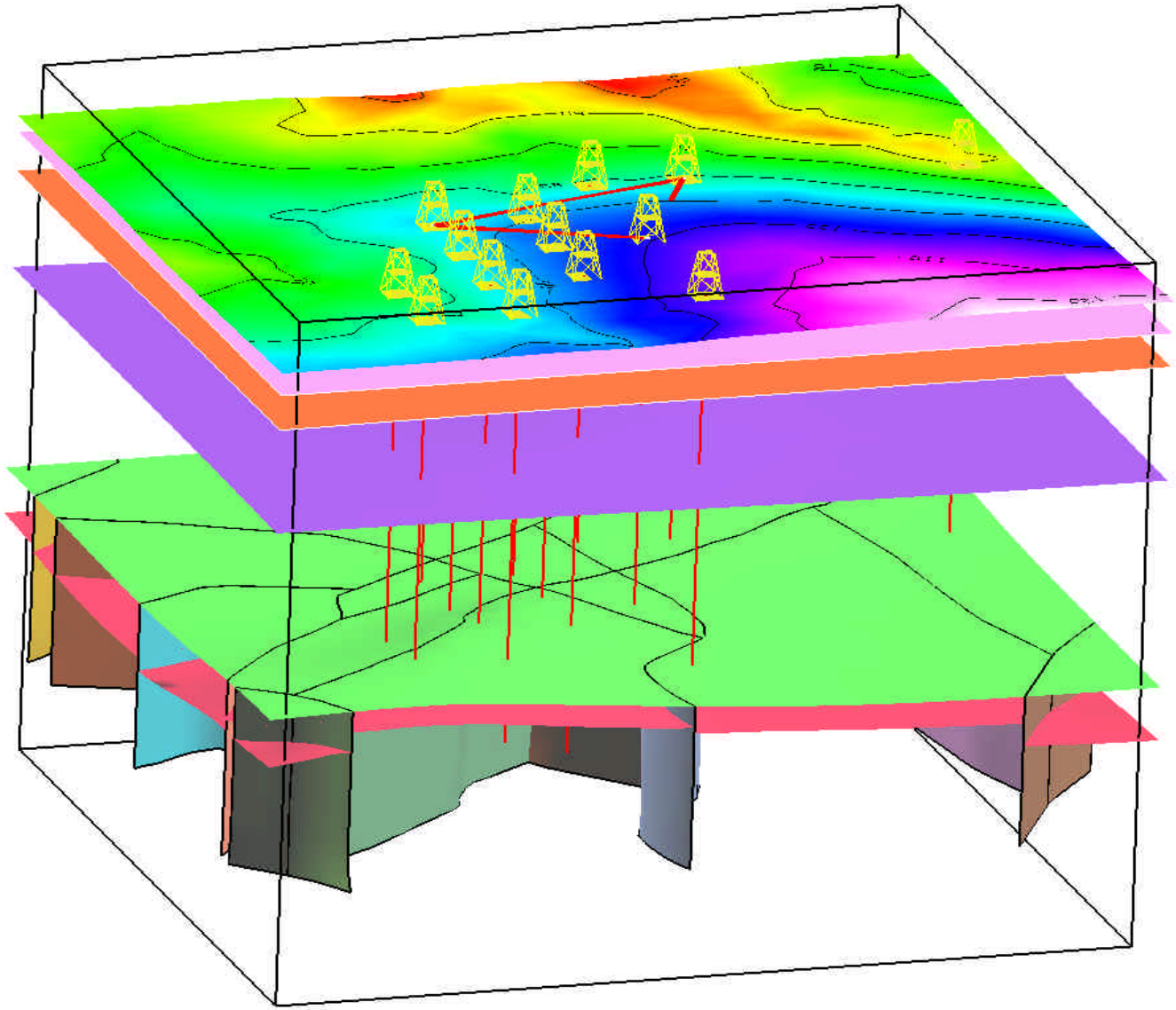
Reporting;

Recommendations for:	**Estimated:**	**Display of:**
-Geometries	- Seismic coverage	- Depth model
-Geophone positions	- Resolution	- Ray tracing results
- Shot Positions	- Noise Problems	- Synthetic data
- Sources	- P to S conversion	- Processing results of synthetic
	- Survey / Rig time	- Estimated refl. coeff. and AVO

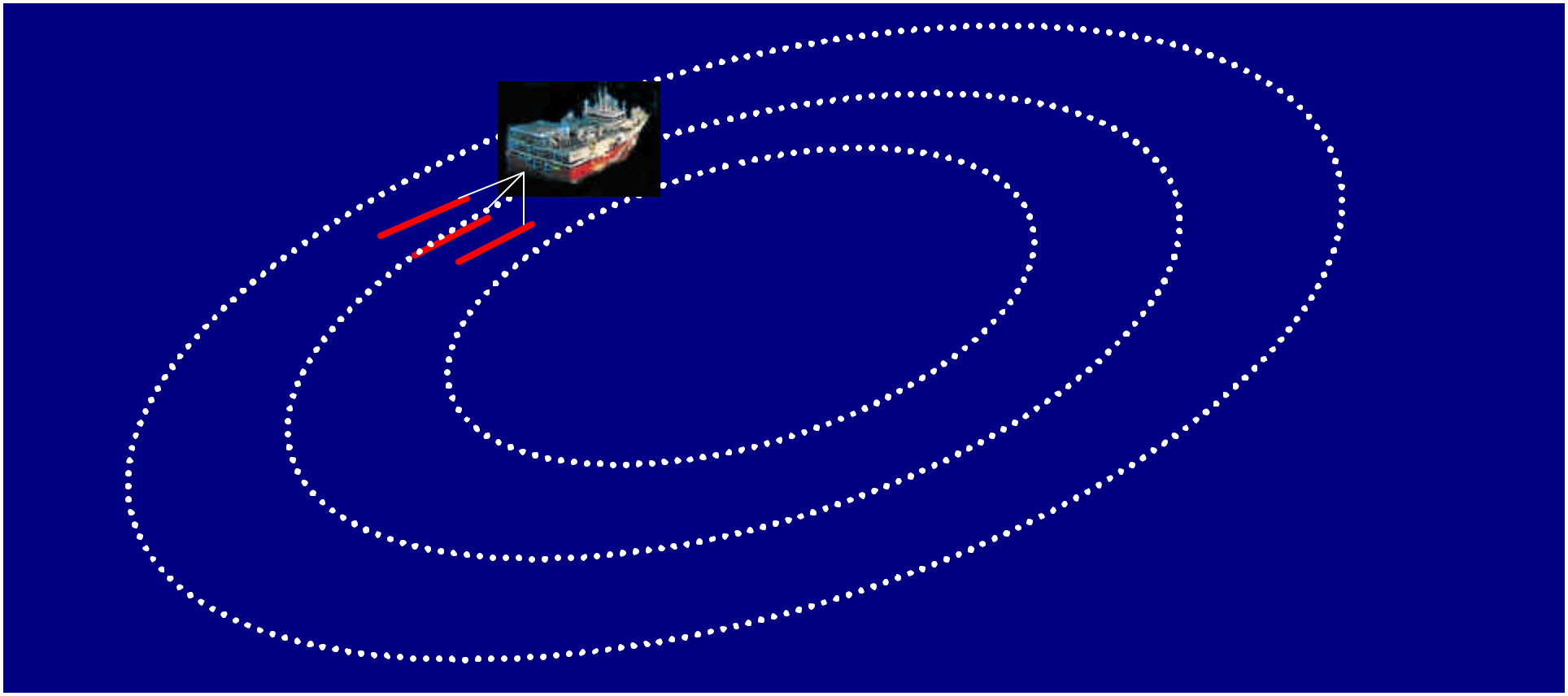
3D Advanced Modeling Tools for Survey Designs



Multi-wells Survey



Multi-source Shooting Pattern



- Cutting rig time to 1/3 (1/2) using continuous spiral shoot with 3 (2) sources fired consecutively
- Cutting rig time to 1/4 with more efficient tool strings

VSP Acquisition Borehole Tools

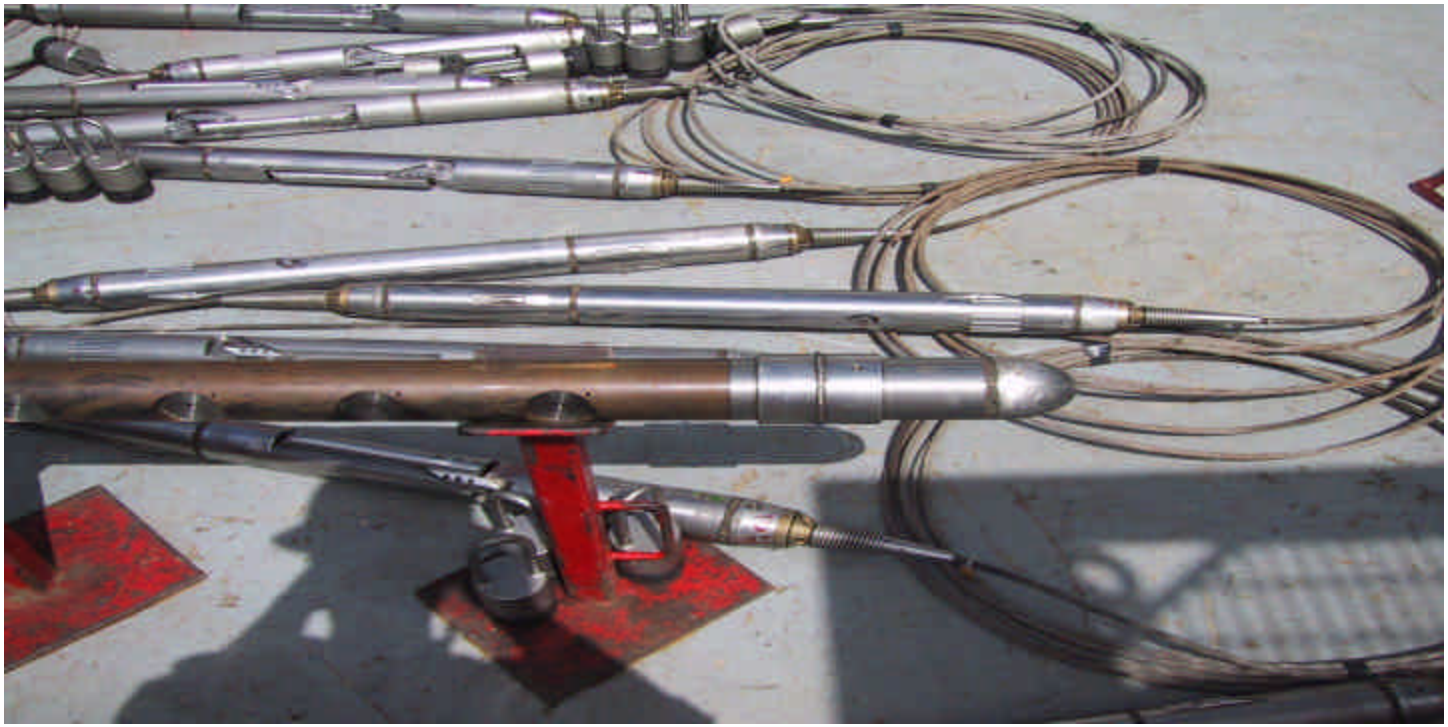
Special tools	Features
Geolock-S	Slim high temperature tool, drill pipe conveyance
Geolock	Large hole, drill pipe conveyance
ASR	Dual level high temperature, drill pipe conveyance

Multilevel tools	Features
DELTA	4 or 8 satellite drag and shoot system.
Slim DELTA	4 or 8 satellite drag and shoot system.
SYGMA	Up to 32 satellites.
HDSeis	Up to 40 satellites

Pump down tool	Features
ESR	1-11/16" Dual level gimballed

All tools are combinable with GR for depth correlation
Multilevel tools can be combined with hydrophone
Multilevel tools can be combined with tractor (VSPXpress)

SYGMA™



Gulf of Mexico – 7 Surveys - NO downhole failures – 300 hours continuous operation.

3D VSPs Acquired by READ in GOM During Past 3 Years

The Thunder Horse 3D VSP (2002)

Water depth: > 7000ft; No. of Shots: ~ 30,000;

No. of shutter levels: 16;

Source Vessel: two separate supply boats; dual source arrays; spiral survey

3D VSPs Acquired by READ in GOM During Past 3 Years

The Mad Dog 3D VSP (2003)

Water depth: > 7000ft; No. of Shots: ~ 40,000;

No. of shutter levels: 25;

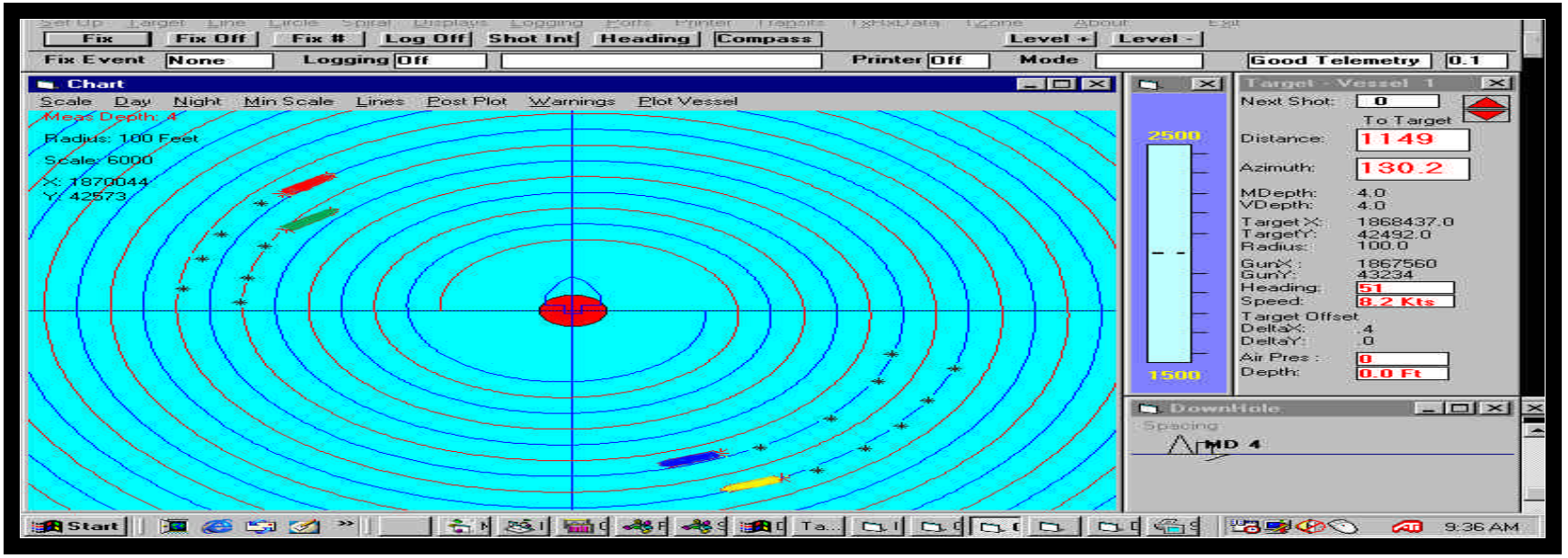
Source Vessel: Bai Hai 512 of CNOOCS, dual source arrays, spiral survey

Tubular Bells 3D VSP (2003)

Water depth: > 9600ft; No. of Shots: 12,300;

No. of shutter levels: 20;

Source Vessel: Condor Explorer of Seabird; dual source arrays; spiral survey



Stones 3D VSP (2005)

Water depth: > 9700ft; No. of Shots: ~ 14,400;

No. of shutter levels: 28;

Source Vessel: Polar Venture of Fugro; dual source arrays; spiral survey

READ's Strengths in 3D VSP Acquisition

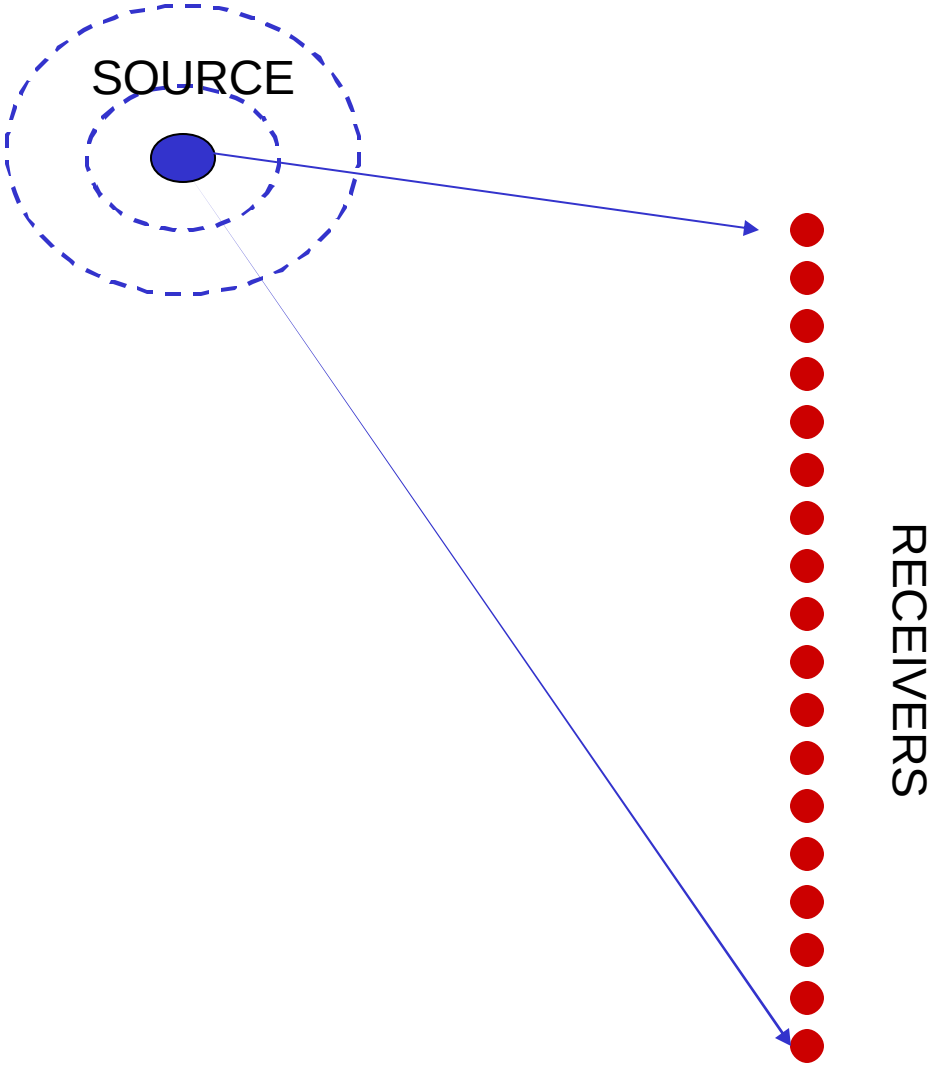
- The most experienced engineers
- Always well planned and tested before operations begin
- State of the art of equipment
- Plenty of backup personnel and equipment in field
- High efficiency and low cost
- READ always reached project objectives in any previous 3D VSP survey

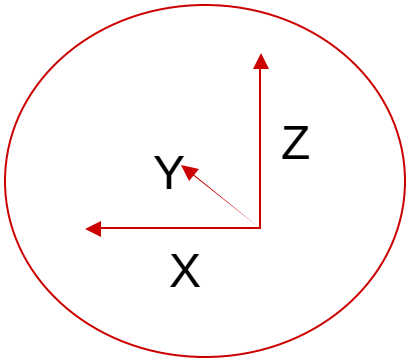
3D VSP Data Processing

GENERAL PROCESSING SEQUENCE:

1. Pre-processing (format conversion, geometry/navigation, Regularizing etc.)
2. First –Break Picking
3. Three-Component Rotation
4. Align data with first arrival time and extract down-going P wave
5. Remove down-going P and P-S waves
6. Deterministic deconvolution (design deconvolution operator from down-going P-wave)
7. Wave field separation and up-going P-P and/or P-S waves enhancement
8. Initial velocity model from surface, check shot and zero-offset VSP data etc
9. Initial forward FB modeling and prestack depth migration
10. Velocity model tomographic updated and anisotropic parameter estimation
11. Final pre-stack anisotropic depth migration (finite difference or Kirchhoff)

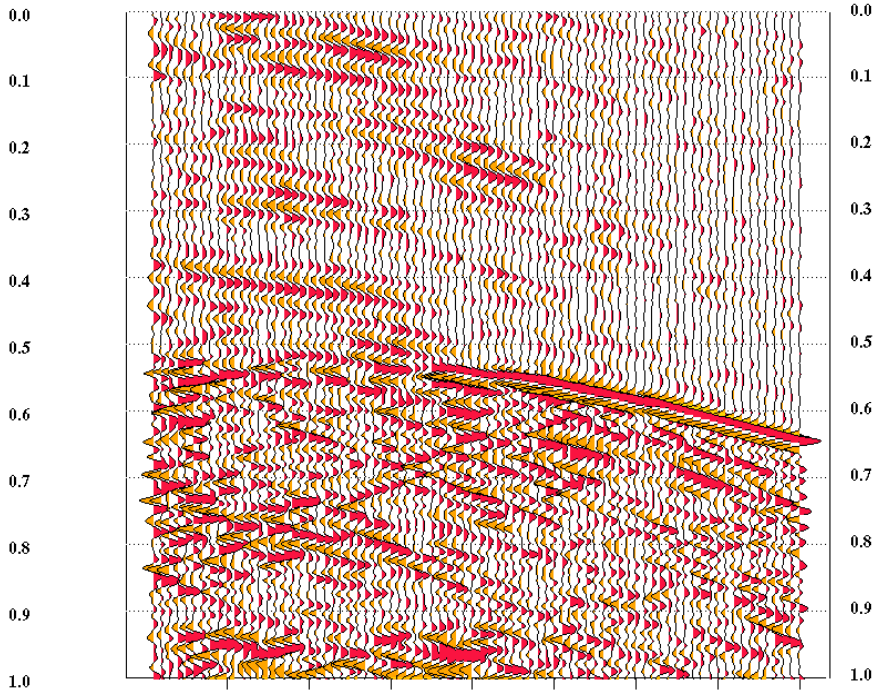
WHY 3 COMPONENT DATA?



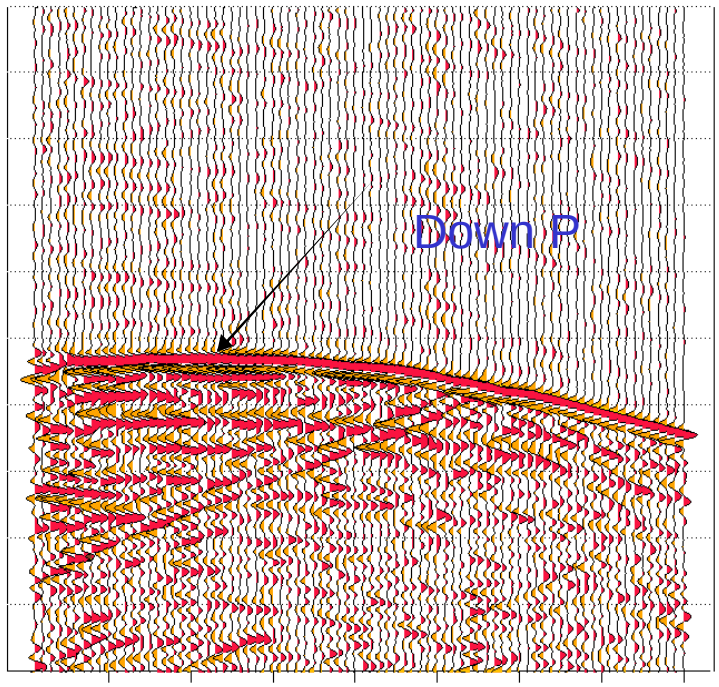


3-COMPONENT ROTATION

Vertical Component Data

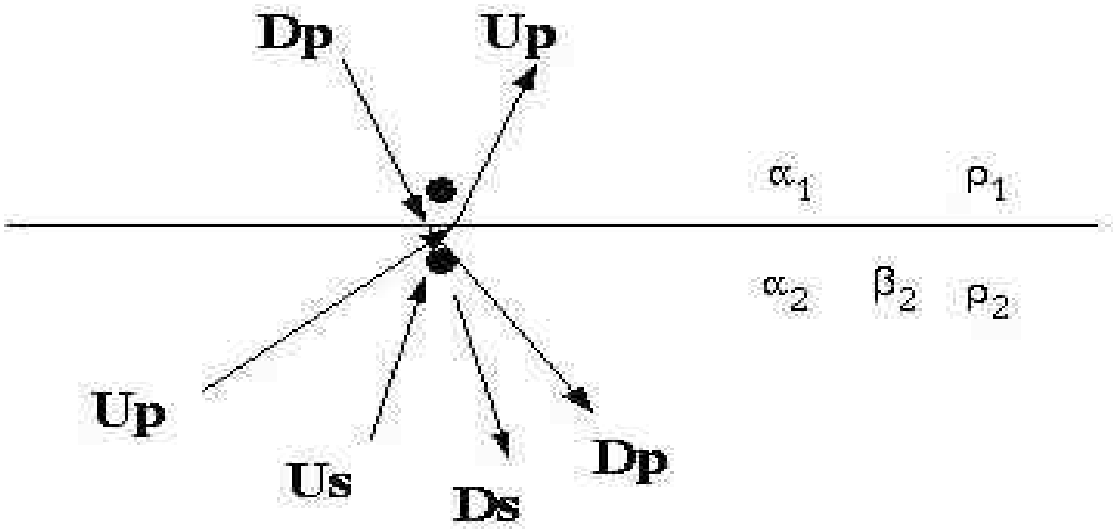


Scalar Wavefield



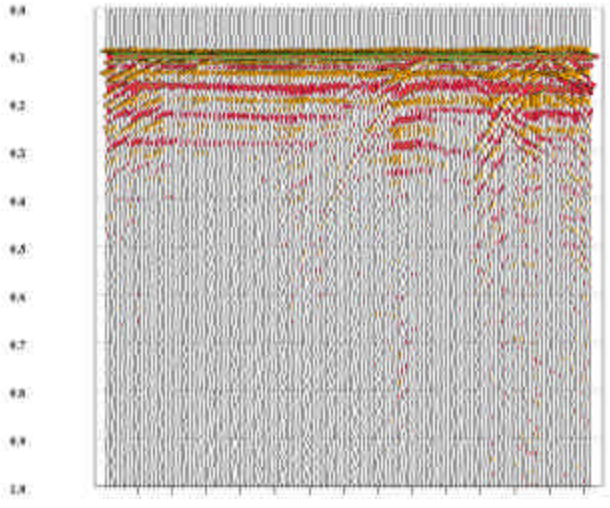
Common Shot Gather (80 Receivers)

FROM VECTOR TO SCALAR WAVEFIELDS

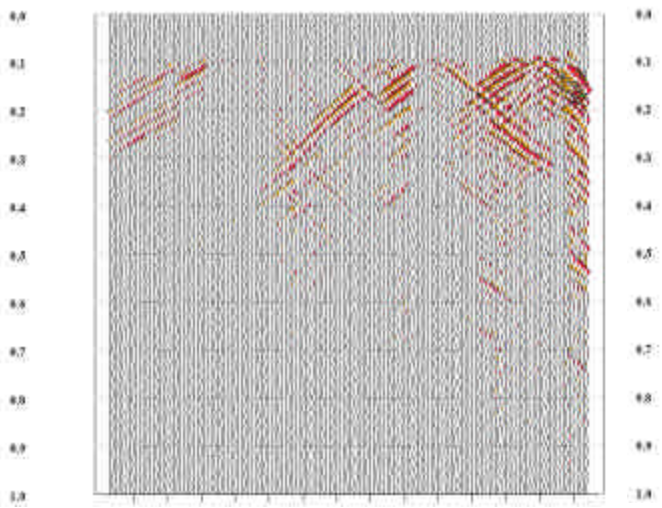


MEDIAN FILTERING TO REMOVE DOWN WAVEMODES

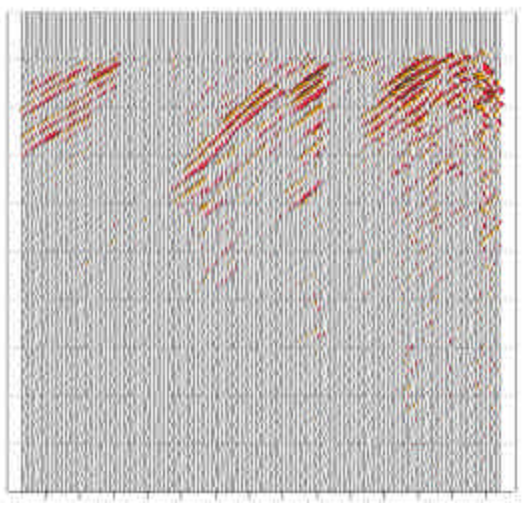
Aligned Raw Data



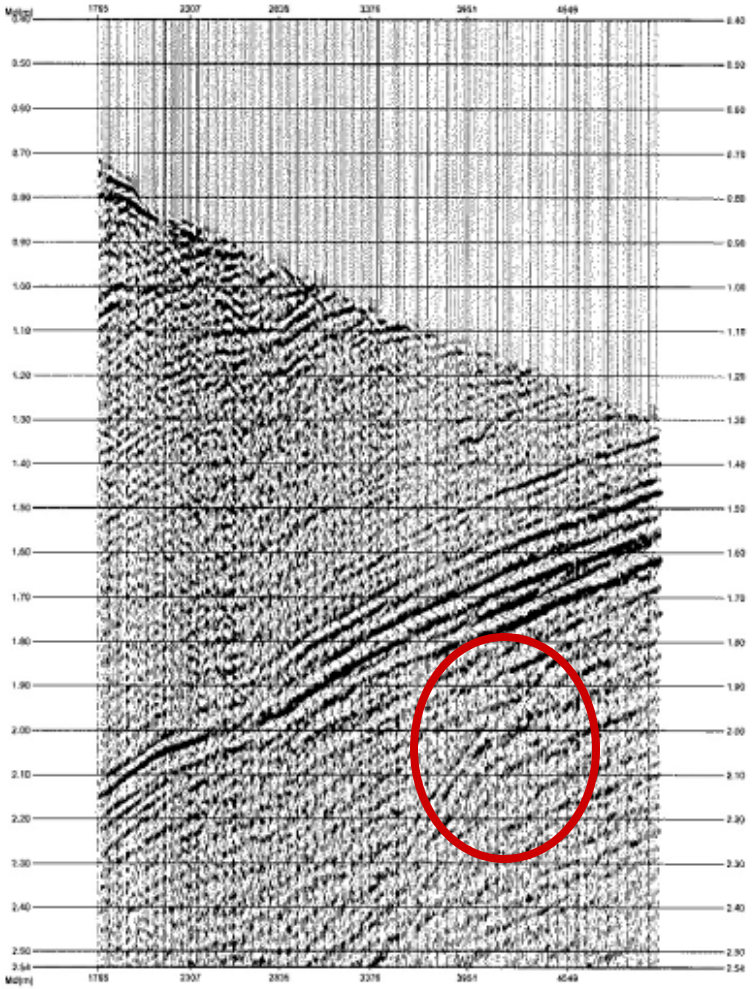
Remove Down P



Remove Down S



P-S SEPARATION, MODEL OR DATA BASED



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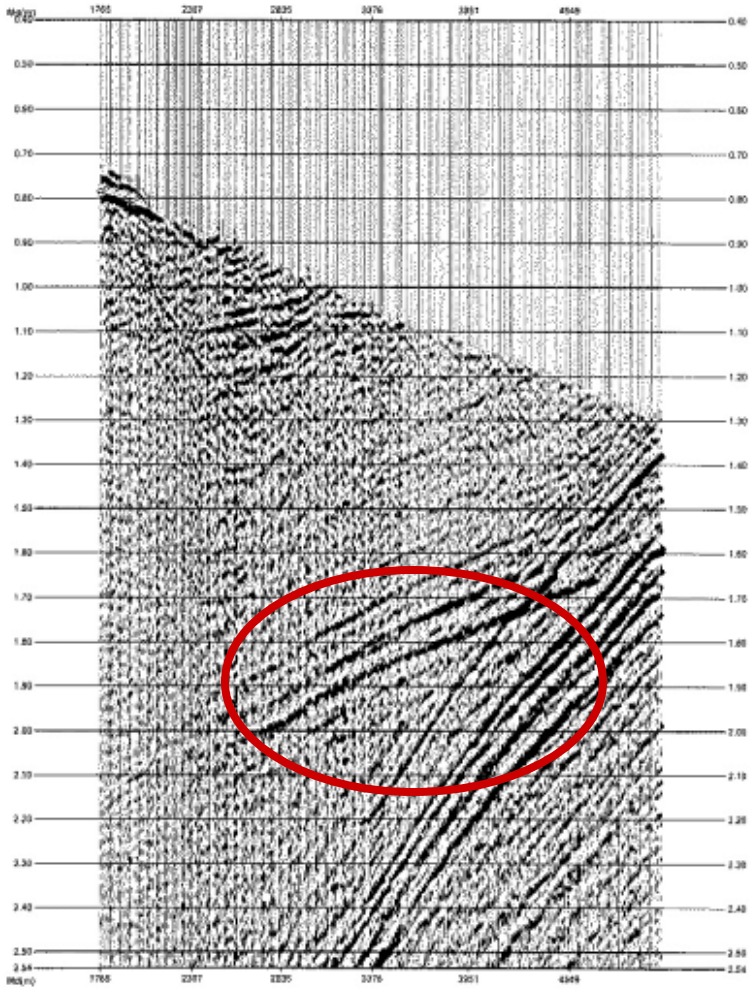

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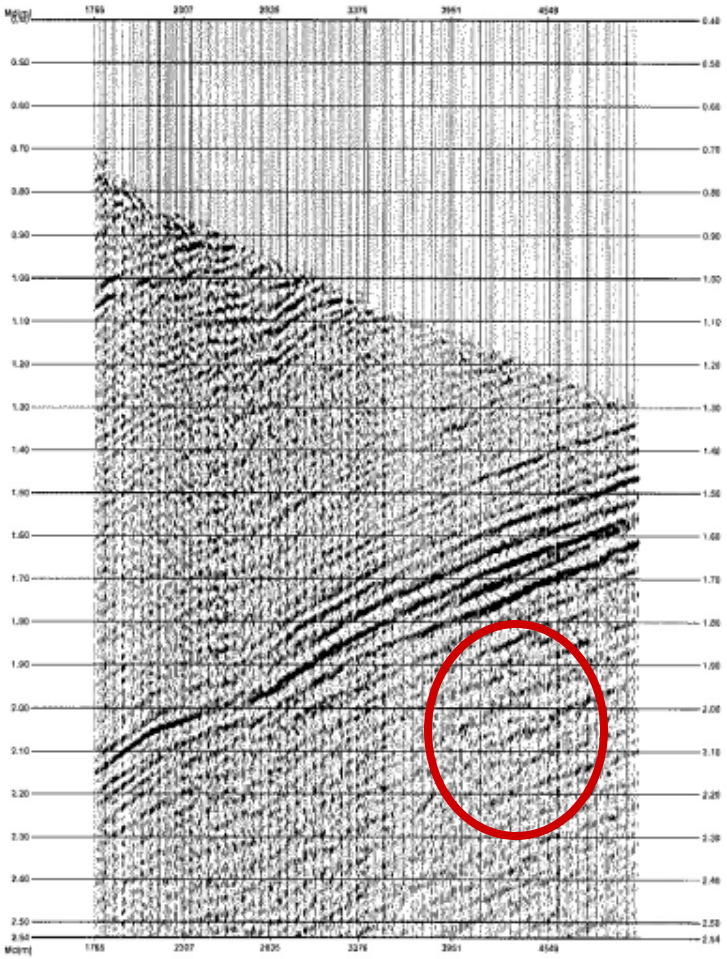
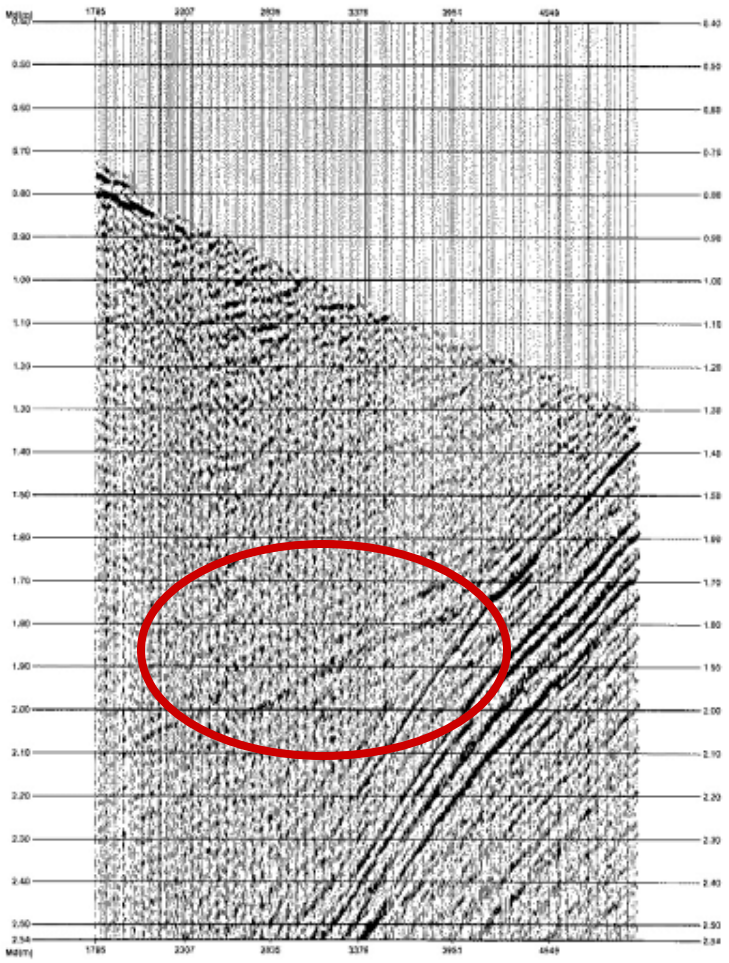
P-S SEPARATION, MODEL OR DATA BASED



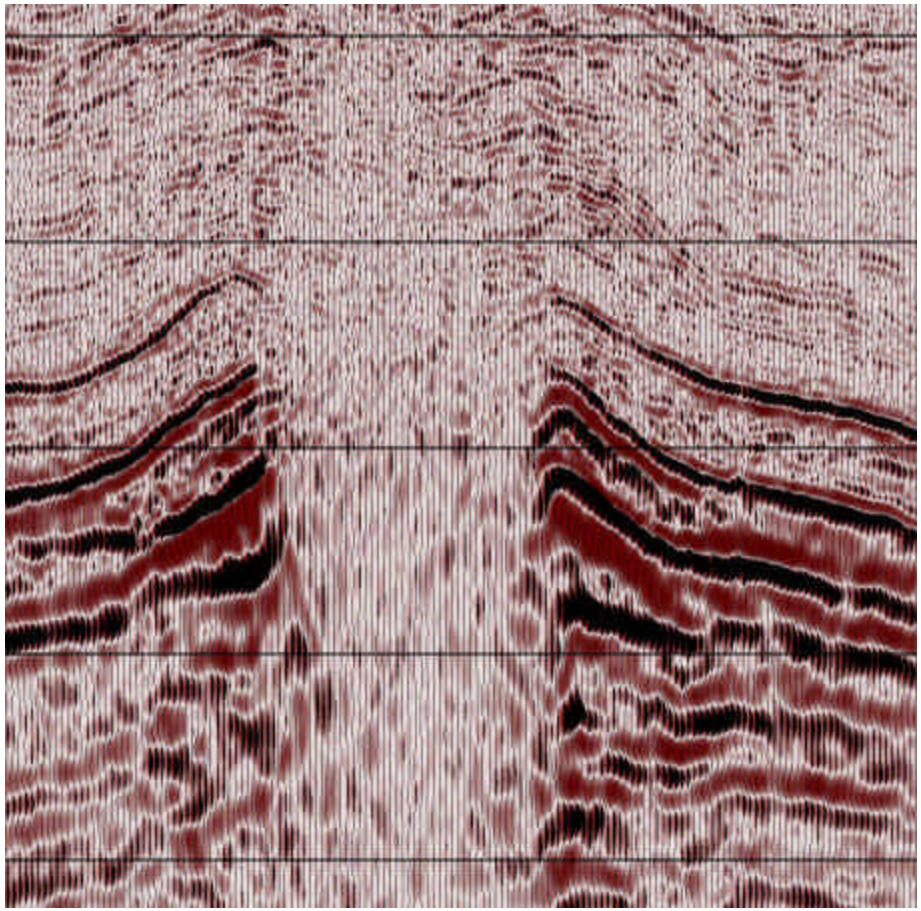
P-P



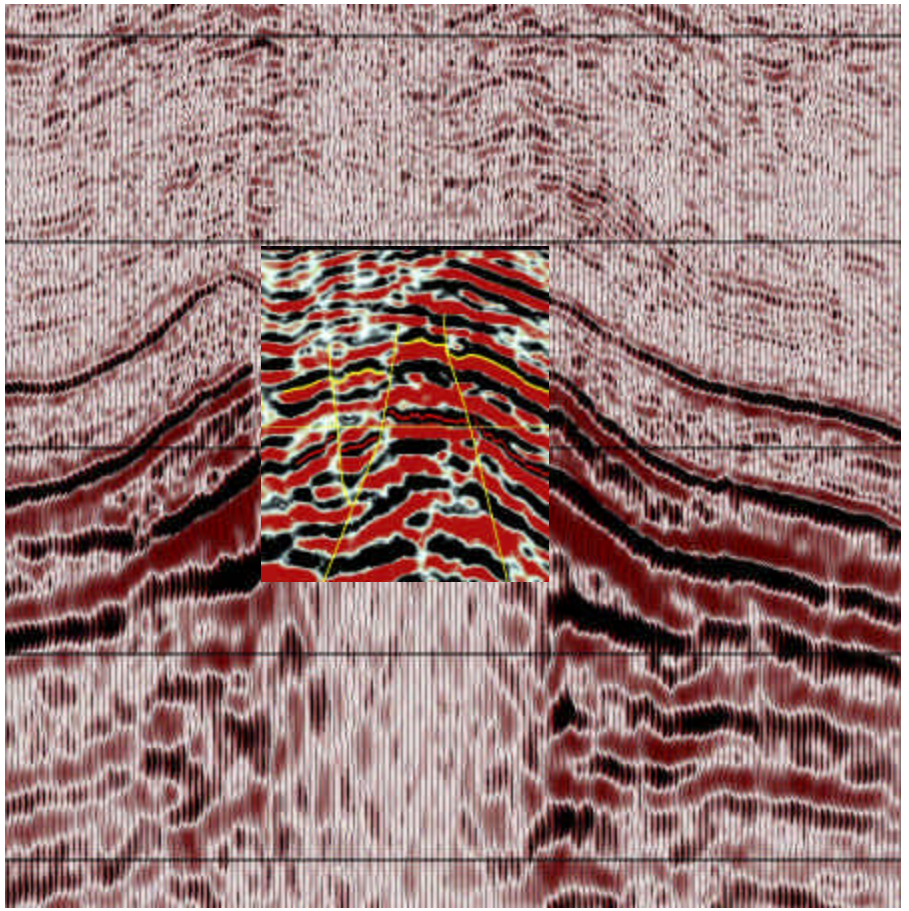
P-S

3D VSP Case Examples

THE EKOFISK FIELD 3D VSPs by READ

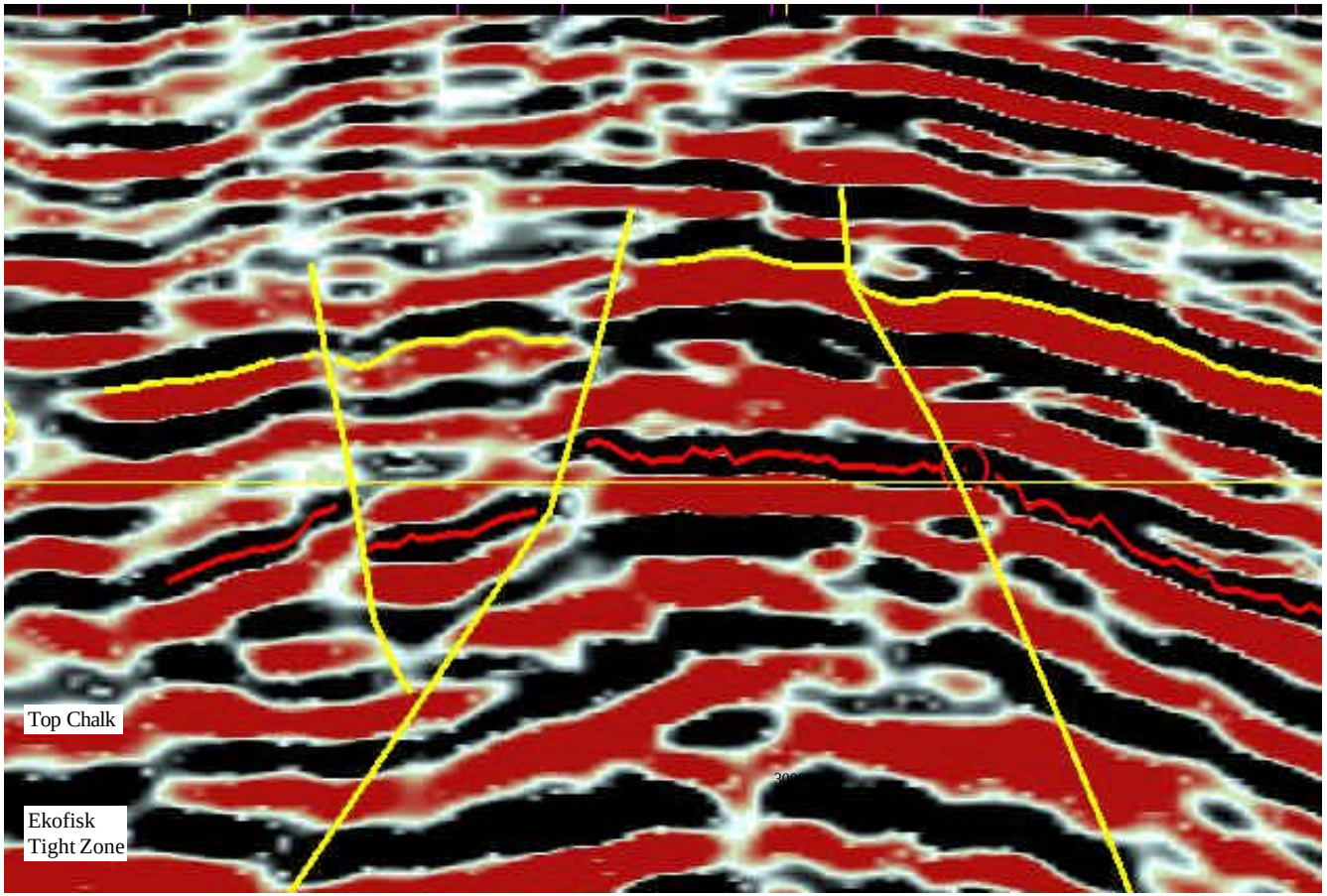


SURFACE SEISMIC

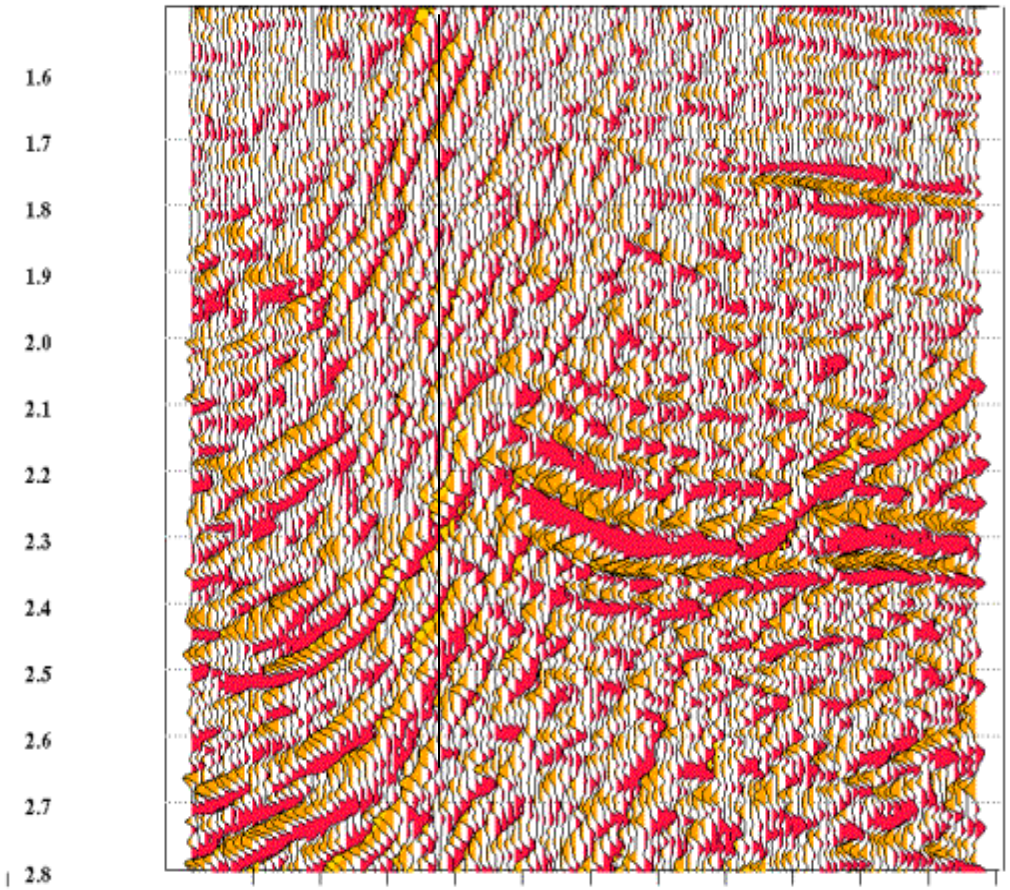


3D VSP DEPTH MIGRATION

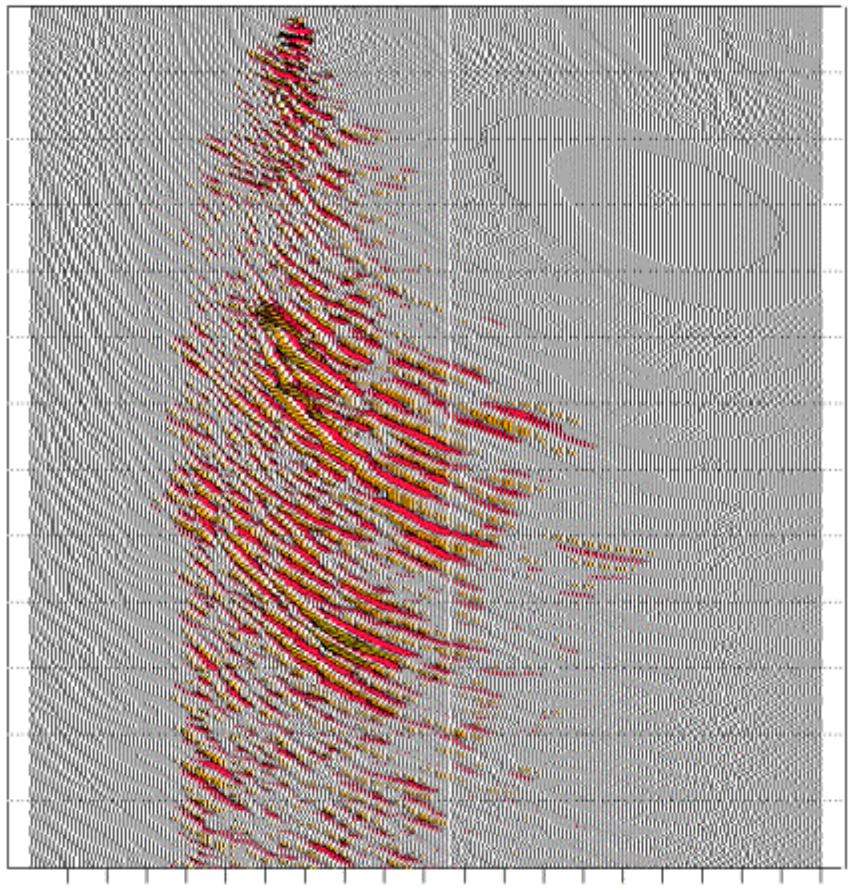
THE EKOFISK FIELD 3D VSPs by READ



SUBSALT VSP, GOM

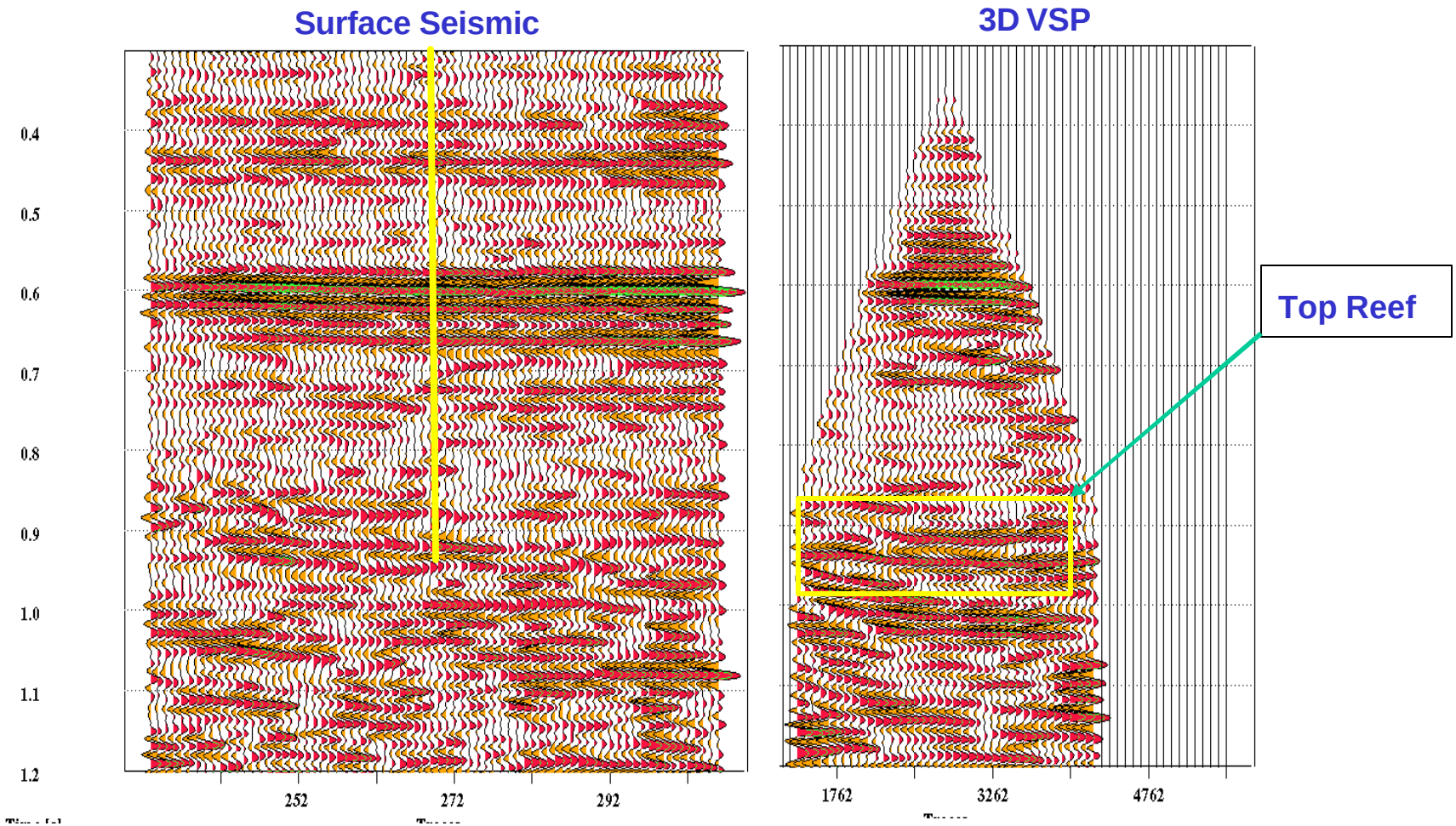


Surface seismic through walkaway profile



Anisotropic FD depth migration of VSP

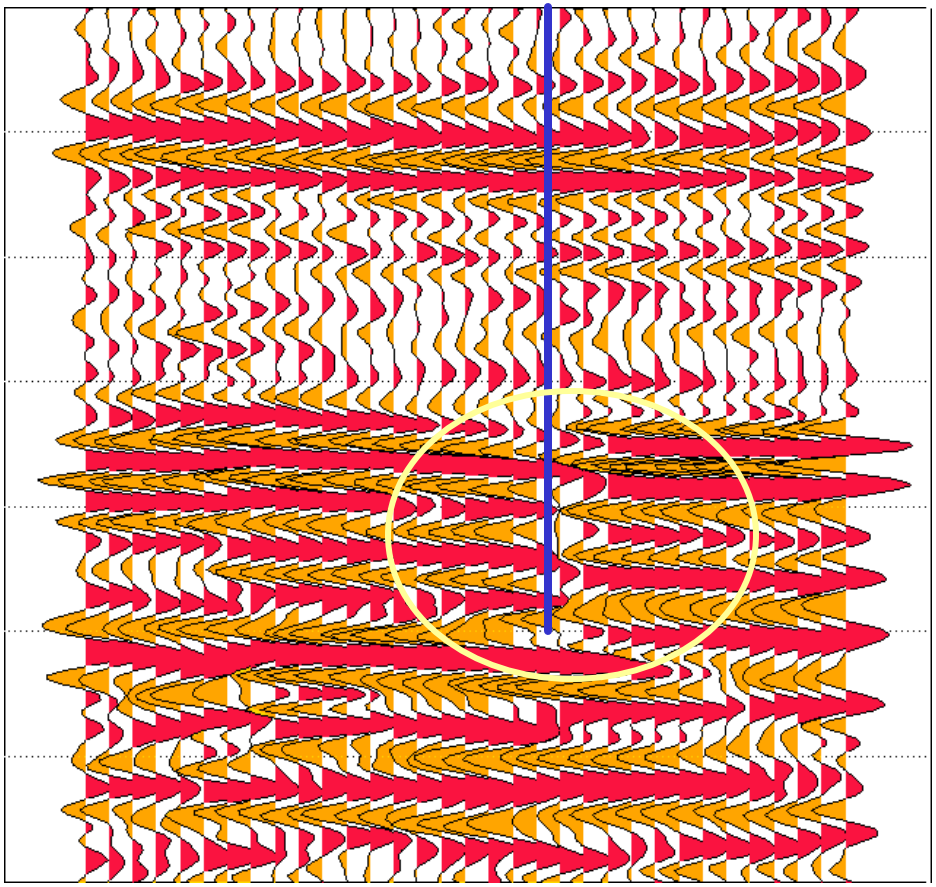
3D VSP MAP REEF STRUCTURE



Note: The 3D VSP section has been band-passing filtered to match the surface data.

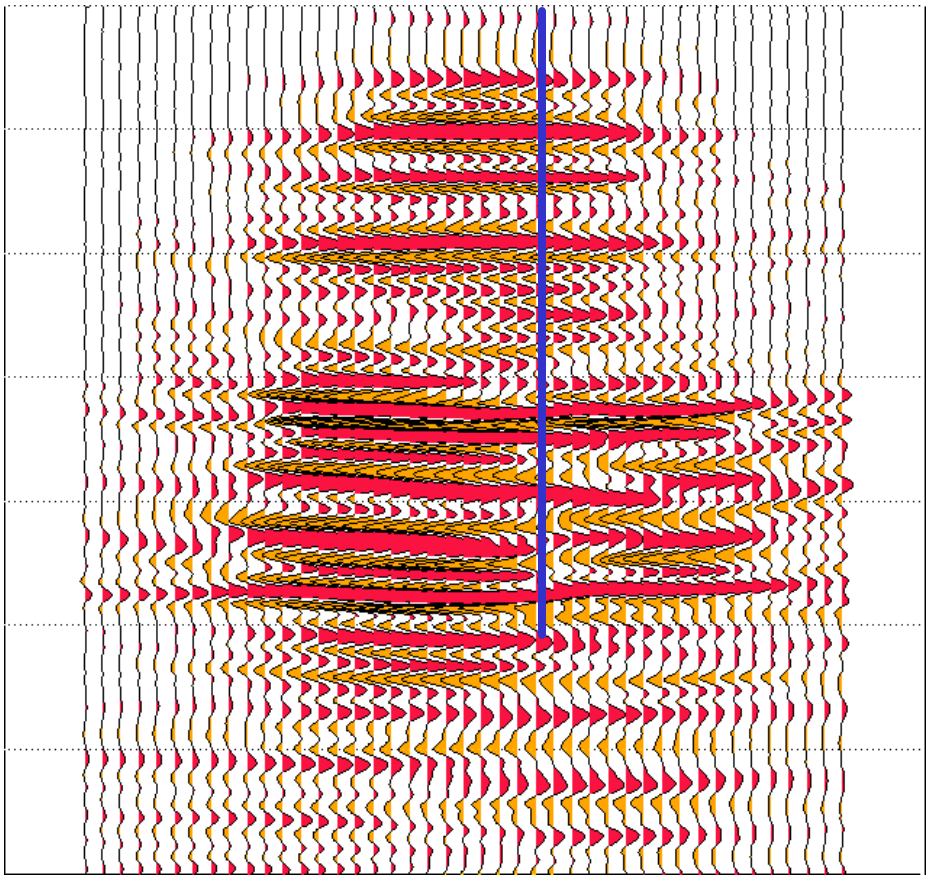
HIGH RESOLUTION 3D VSP

2D Surface Seismic



30 Hz dominant frequency

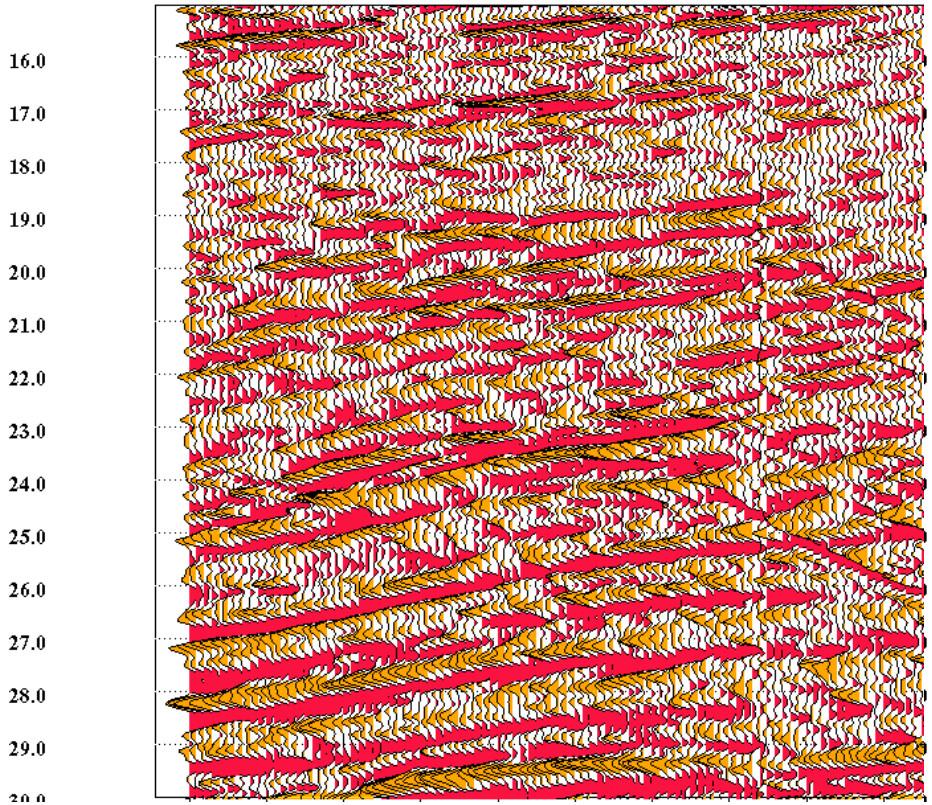
3D VSP profile along same line



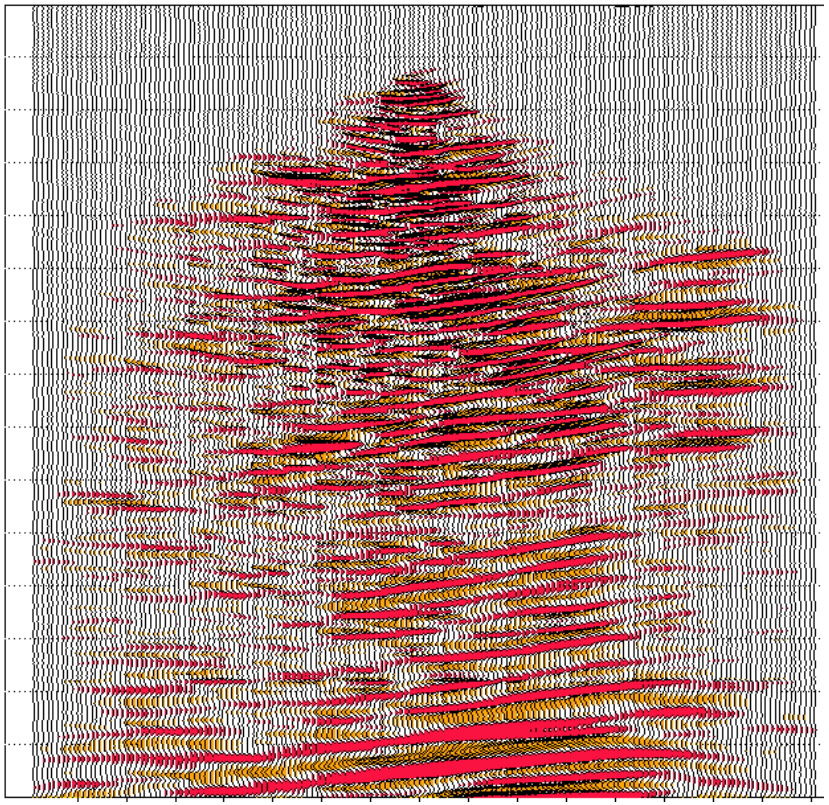
>50 Hz dominant frequency

HIGH RESOLUTION 3D VSP

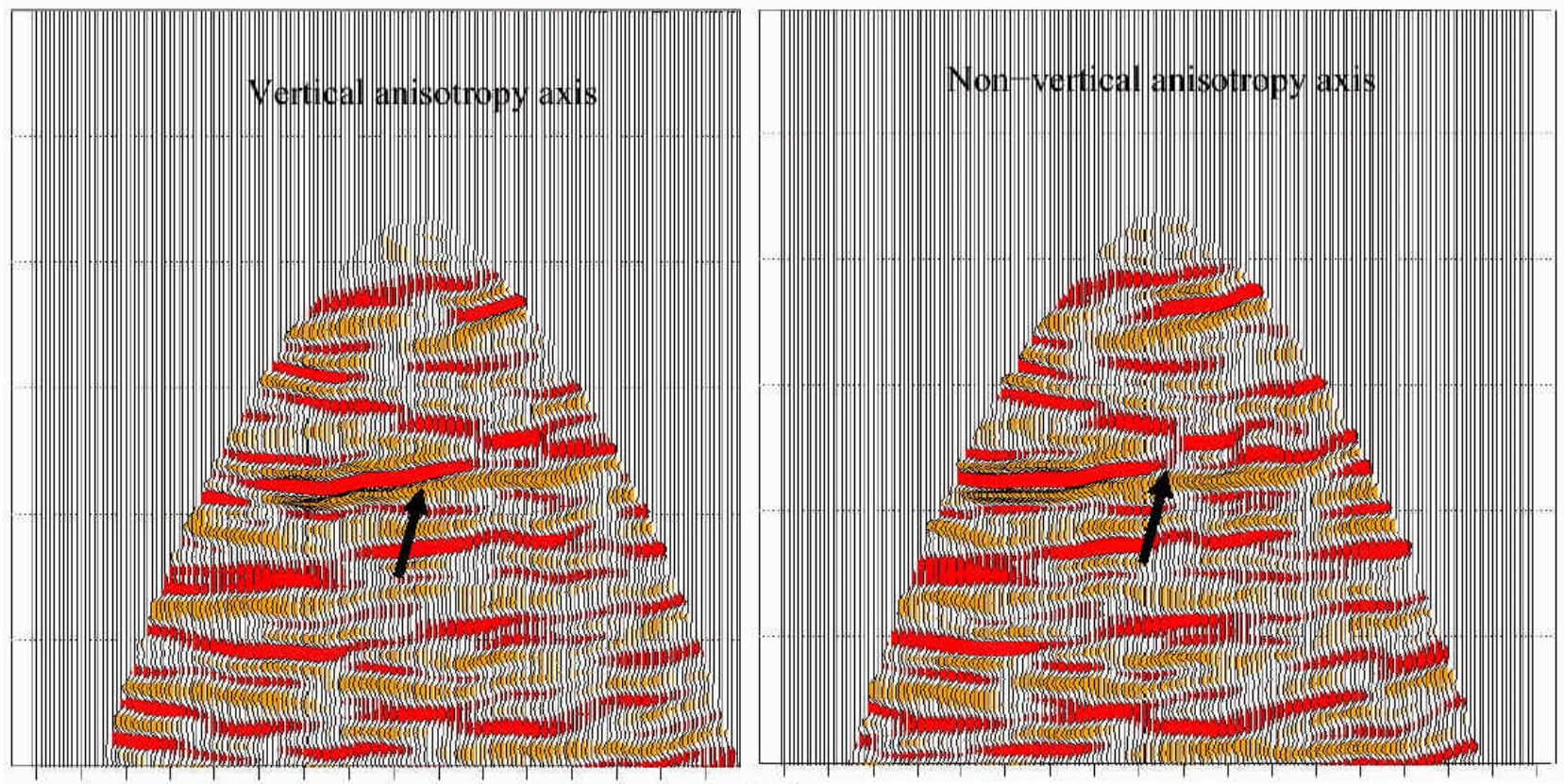
2D Surface Seismic



3D VSP Finite Difference Migration



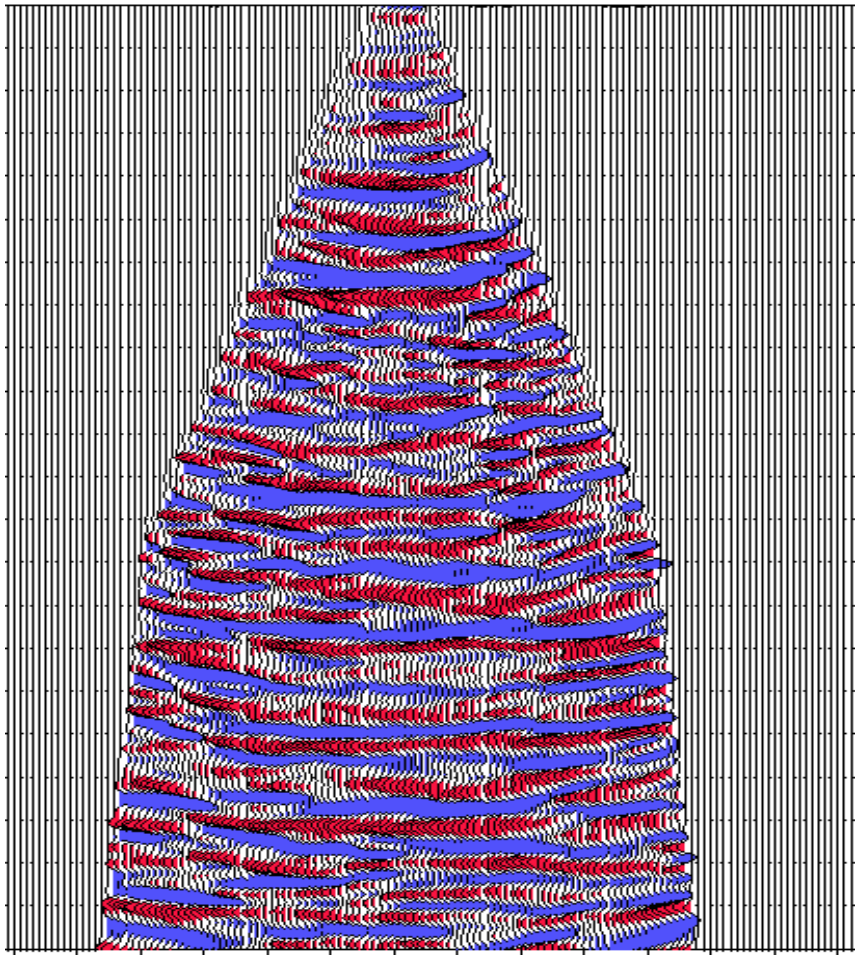
HIGH RESOLUTION 3D VSP



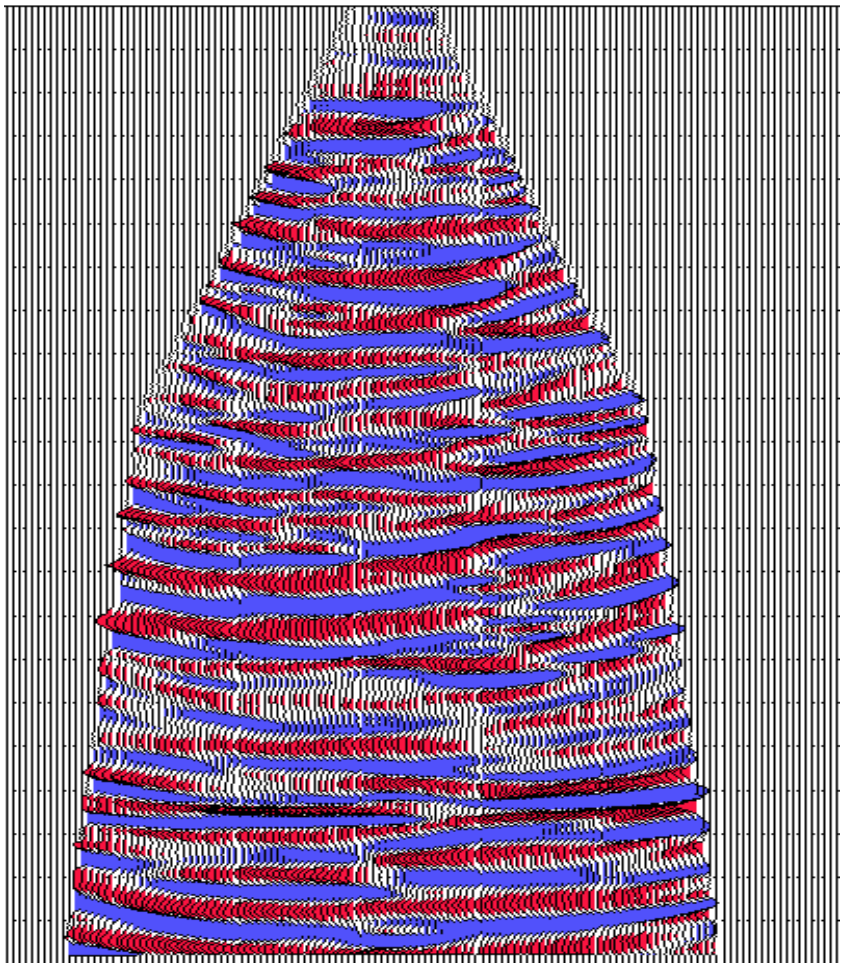
Anisotropy Effect on Small Faults Imaging - Small fault is mis-imaged approximately 50m by vertical anisotropy axis

HIGH RESOLUTION 3D VSP – PS Wave Imaging

PP



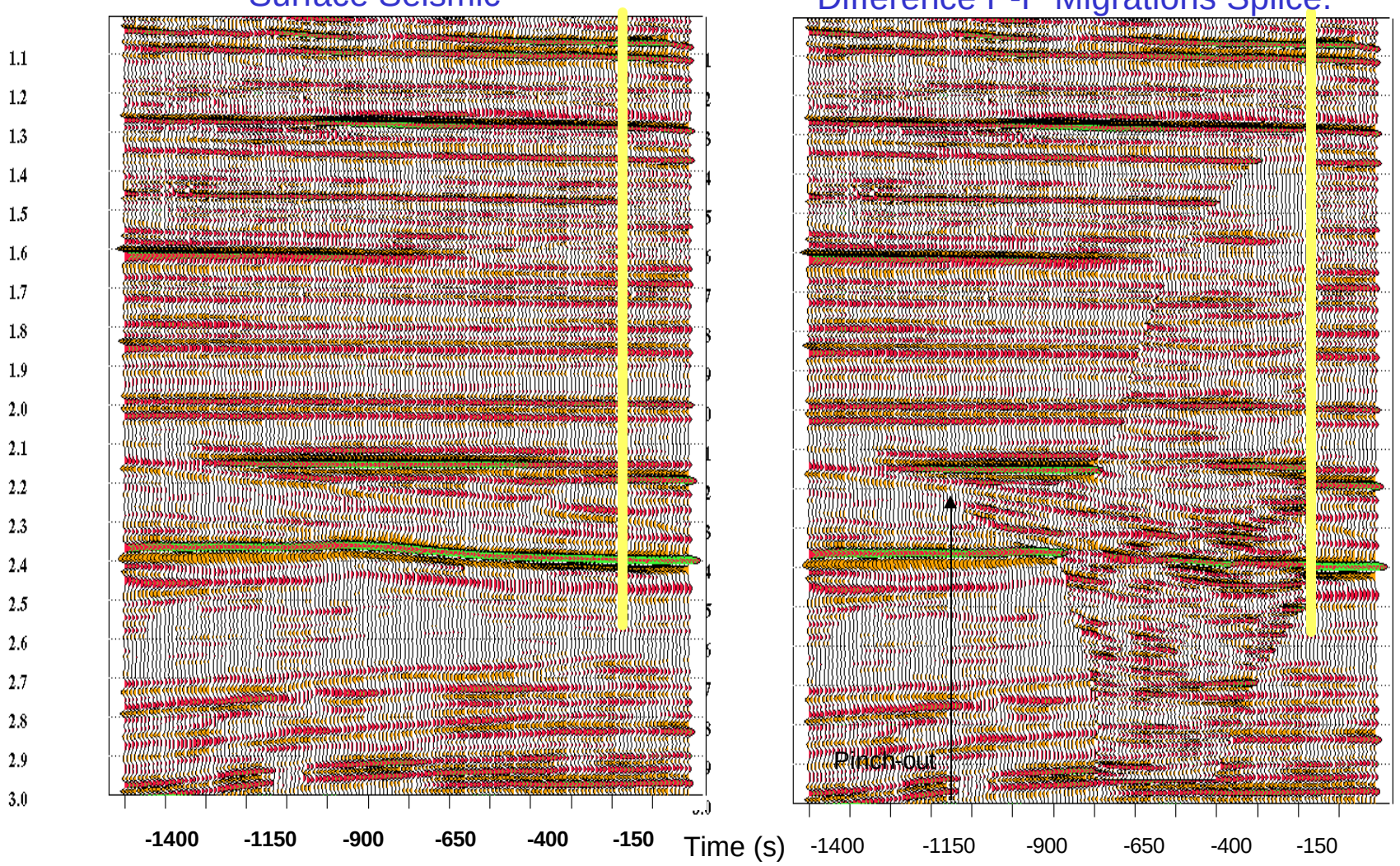
PS



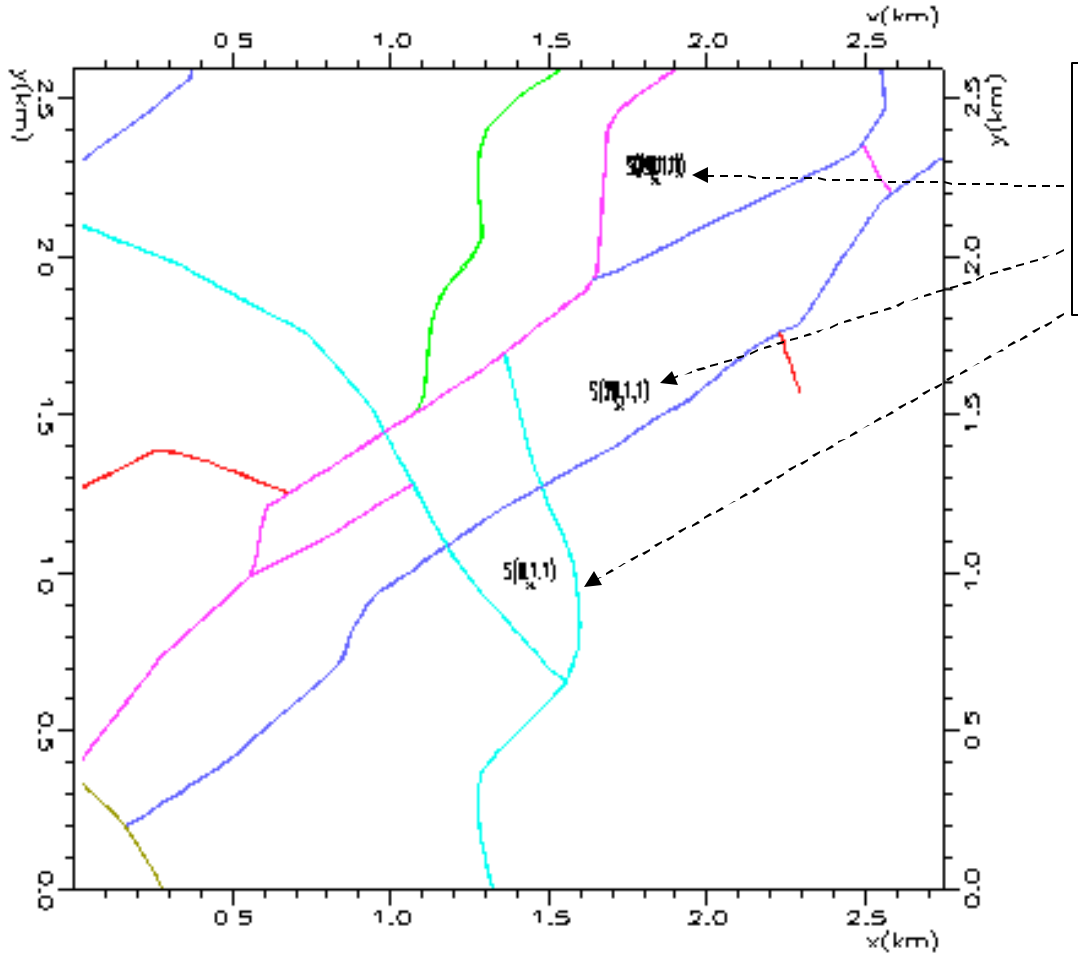
VSP MAP PINCH-OUT TOWARD UNCOMFORMLITY

Surface Seismic

Surface Seismic with VSP Finite Difference P-P Migrations Splice.



HIGH RESOLUTION 3D VSP - Petrobras Multiwell 3D VSP

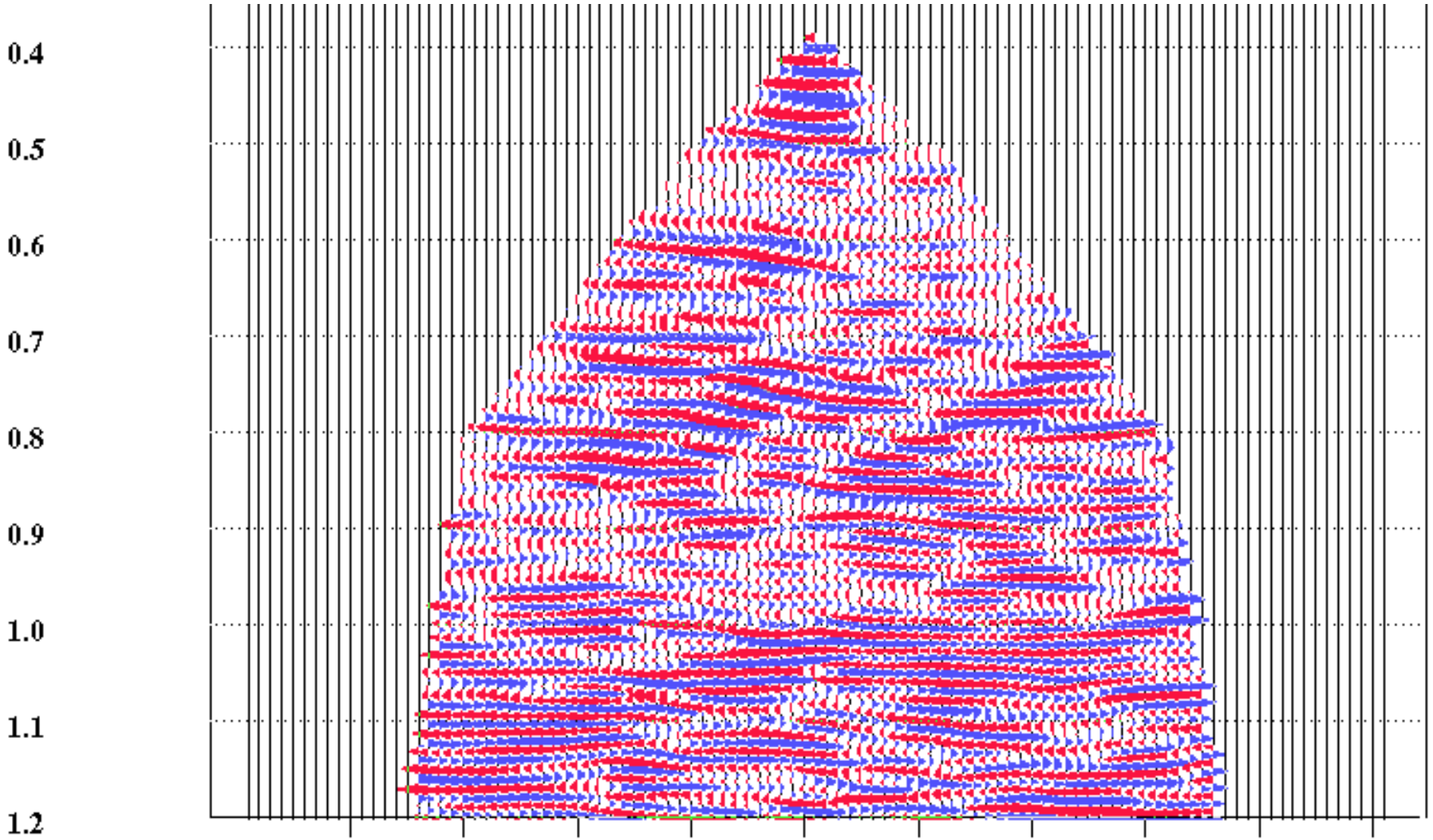


18 levels in 3 wells:
1LA-2 (8 levels)
CAM885 (8 levels)
CAM858 (2 levels)

Receiver Depths:
Below the Jandaira Fm.
Top geophone @ 560 m
(below MSL)

~1850 shots,
Elliptic pattern
60 by 60m grid

HIGH RESOLUTION 3D VSP - Petrobras Multiwell 3D VSP

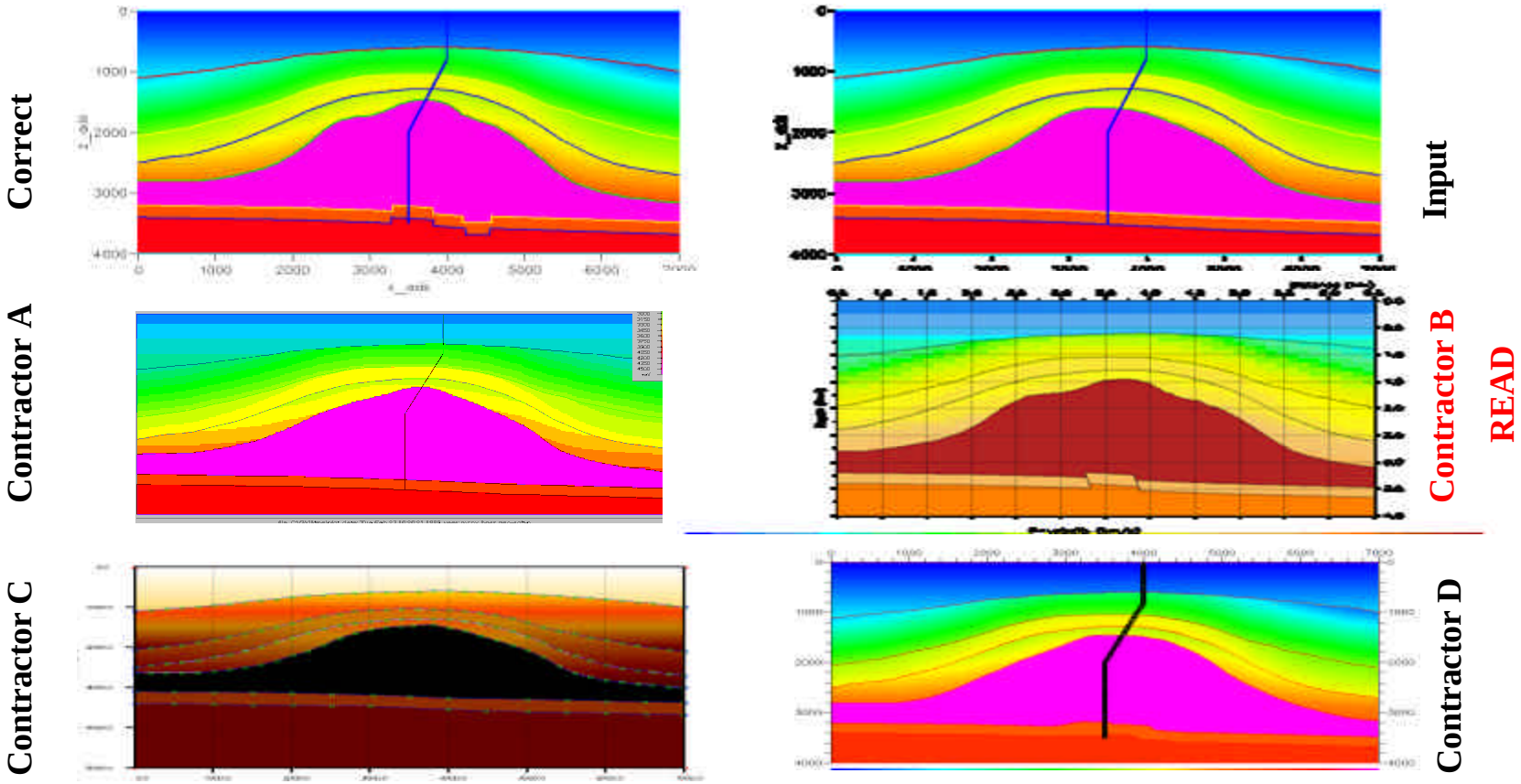


NOTE:

Petrobras Drilled New Wells Based on the 3D VSP Imaging Results, and They Gained More than 1000 Barrels/Day Increase in Oil Production!

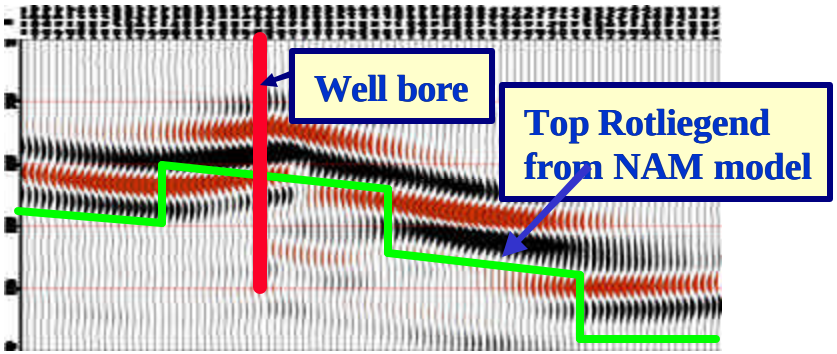
Data Processing Benchmark

Shell Benchmark - Tomography

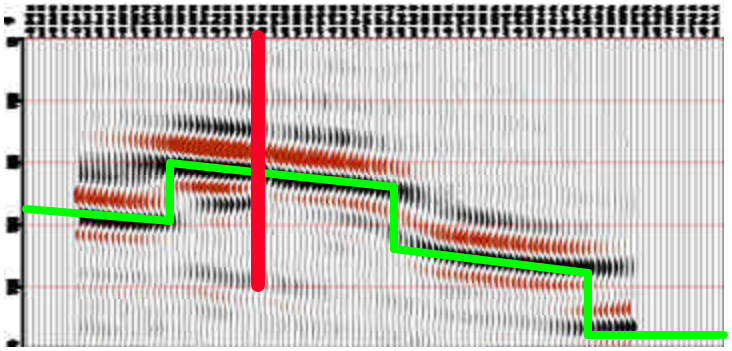


- "Correct" model - all data generated in this model (ZO, Offset VSP, WA)
- All Parties (Schlumberger, Baker, CGG and READ) is given the "Input" model for initial velocity model.
- **Contractor B (READ)** recreated the "Correct model" with less than 10 m error margin throughout the model.

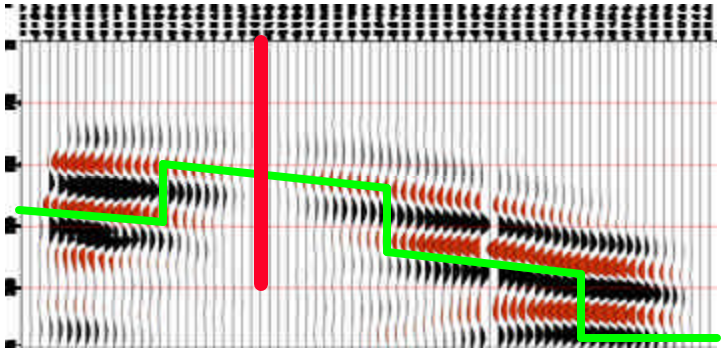
Shell Benchmark - Migration



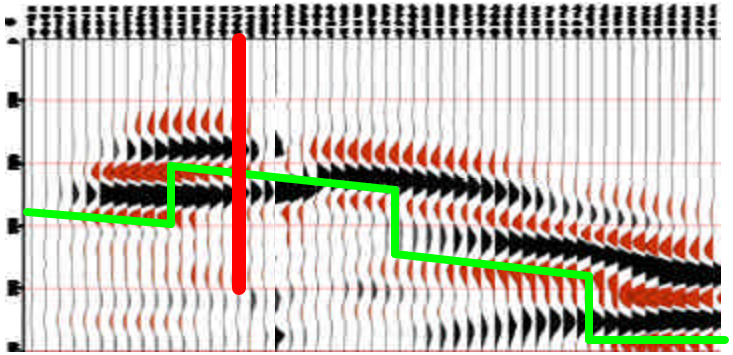
Contractor A



Contractor B - READ



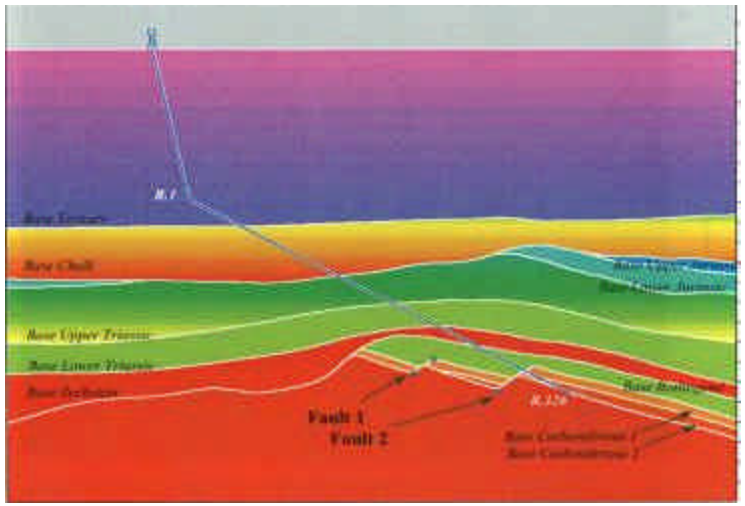
Contractor C



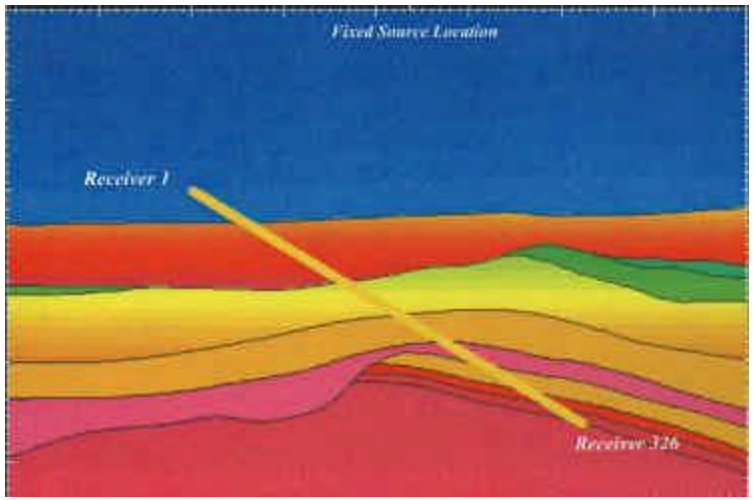
Contractor D

- **GREEN LINE is the correct fault position**
- **Migration results from READ Well services as *Contractor B***
- **Other results from Schlumberger, Baker and CGG.**

Other International Benchmarks



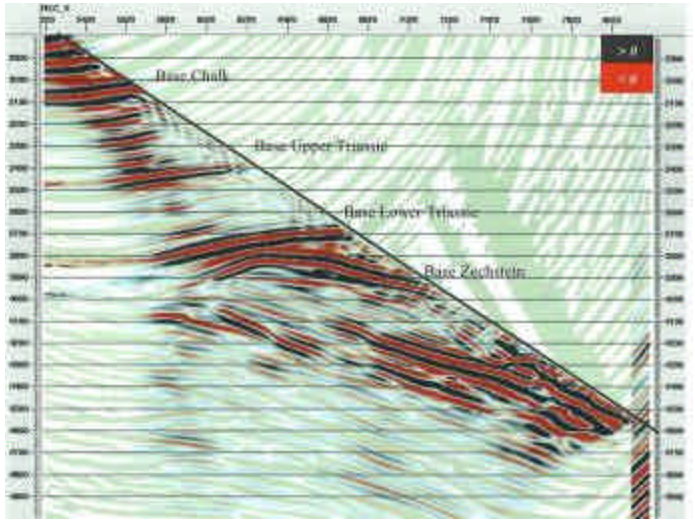
Correct model



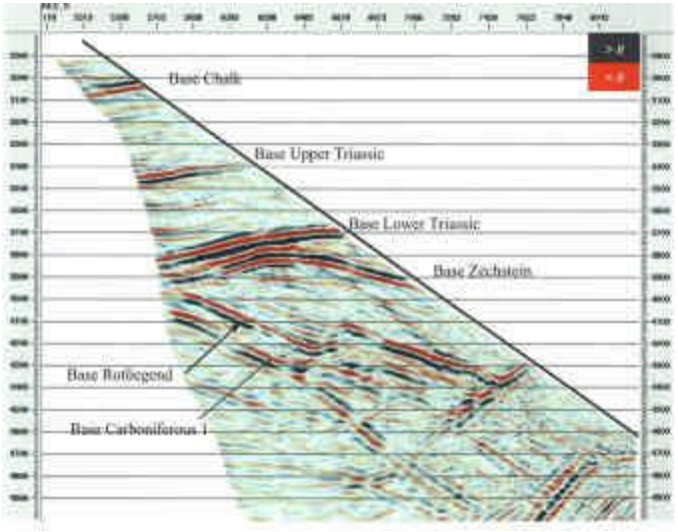
Input model

- READ Well Services benchmarked for BP (US) for 3D VSP processing (2001) and became top ranked contractor.
- READ Well Services benchmarked for an European Company (2004) and become top ranked.

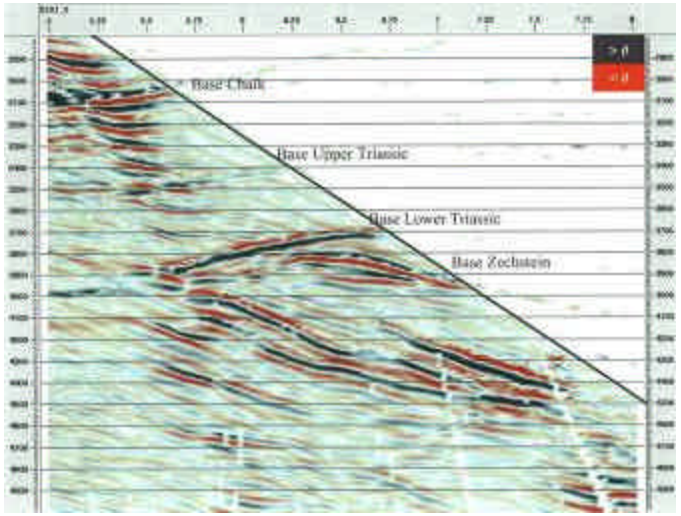
Other International Benchmarks 2004



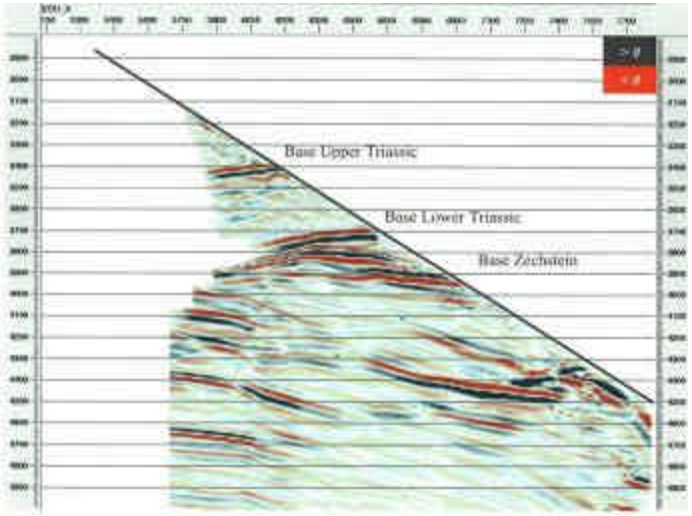
Contractor A



Contractor B - READ



Contractor C



Contractor D

Preliminary Proposal to 3D VSP at Bohai Field

Geological Background:

Target depth 1300-1600m, delta deposits with lake facies, sand and mud layering, and highly lateral inhomogeneity due to mini-faults and other mini-structures etc.

Typical Well:

1798m(TVD 1635m), casing 13”3/8 at 478m + 9”5/8 at 1798m

Water depth:

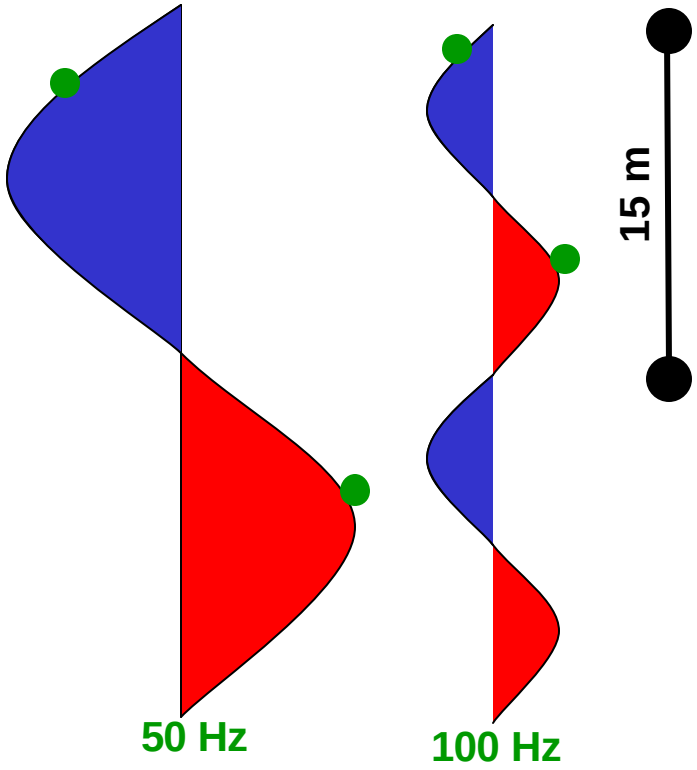
32m

Geological Objectives:

To resolve the sequences and those thin sand /mud interleave layers, to identify the mini-faults and other micro-structures through high resolution 3D VSP data, and therefore to increase oil production based on the new and more accurate geological model and its corresponding new development plan.

GEOPHONE SPACING - RULES OF THUMB

One wavelength must be sampled twice to avoid aliasing



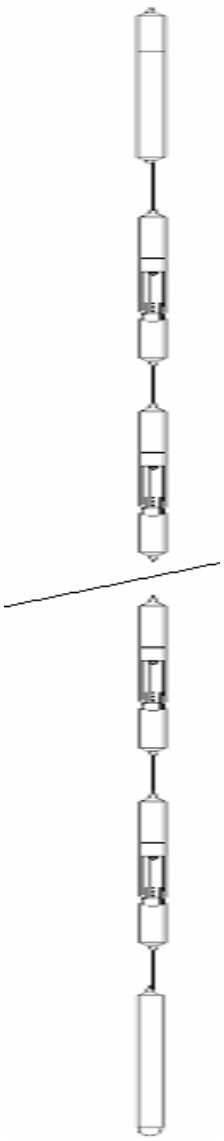
Example:

If Vp = 3000m/s, geophone spacing = 15 m, then

Highest Frequency

= 3000/(2X15) = 100Hz

16 Level SYGMA with 15m Spacing



Wireline Company Head, Adapter
Gamma ray Tool (GRT) 0.8 m, 51 lbs
Telemetry Adaptor Section, 0.96 m, 39 lbs
4.1m Interconnect Wireline Cable, 20 lbs

Satellite 1 0.9 m, 38 lbs

14.1m Interconnect Wireline Cable, 48 lbs

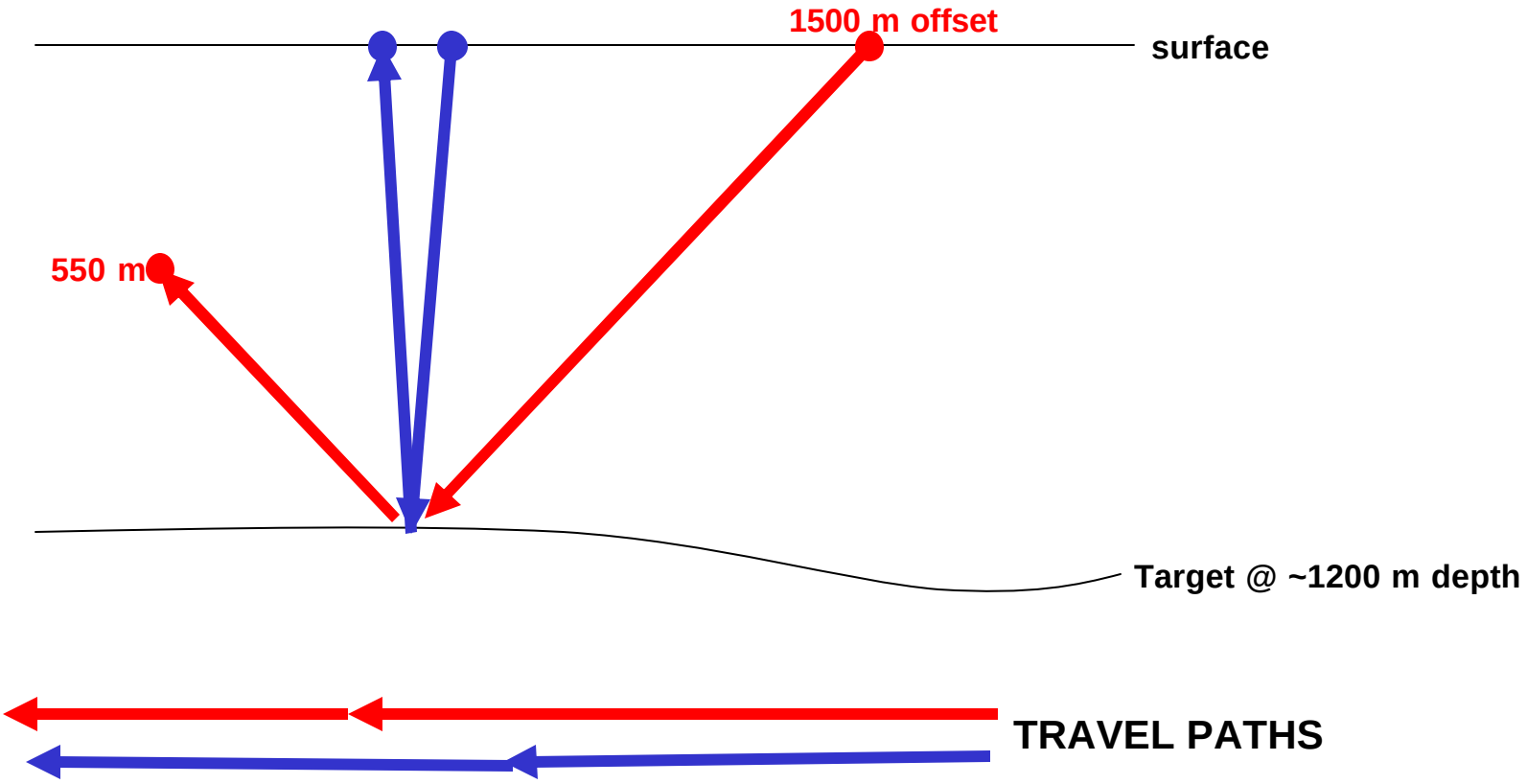
2ms sampling rate

Satellite 16 0.9 m, 38 lbs
4.1m Interconnect Wireline Cable, 20 lbs

Voltage Regulator Section (VRS) 4.22 m, 199 lbs, Includes VRS, Motion Detector, Bull Nose

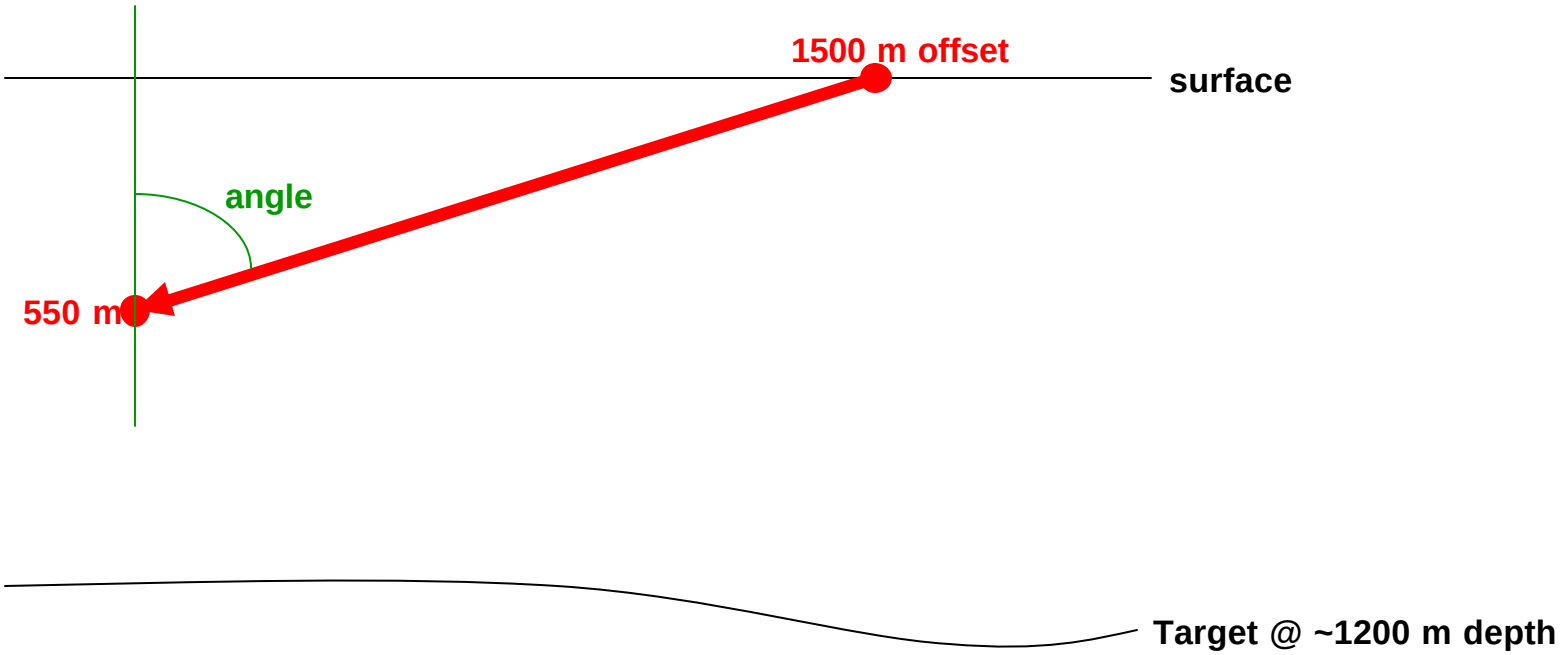
SOURCE –RECEIVER OFFSET - RULES OF THUMB

no more than ~ 2 times receiver depth



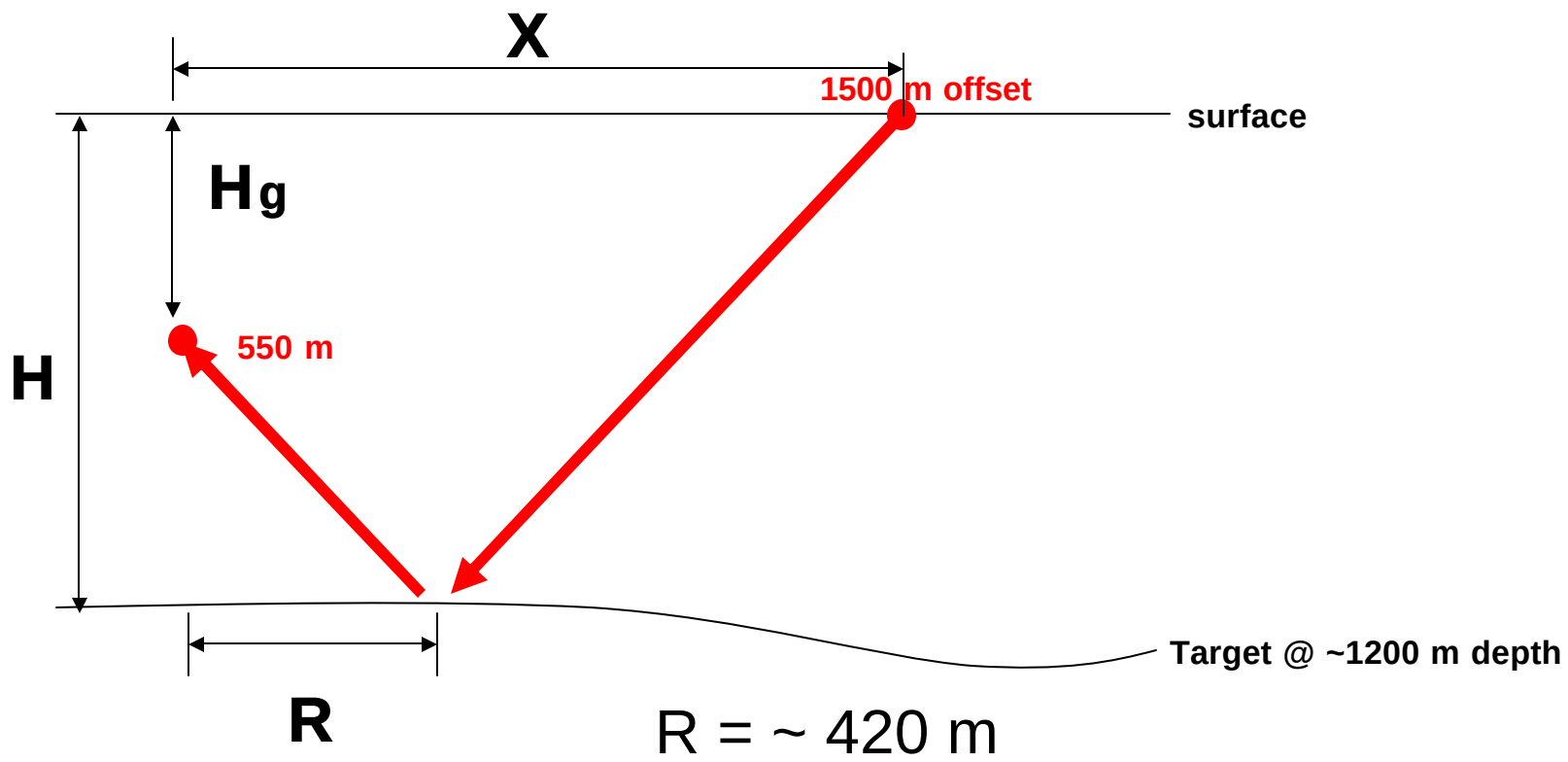
SOURCE –RECEIVER OFFSET - RULES OF THUMB

Direct arrival angle, no more than ~ 70-75 degrees



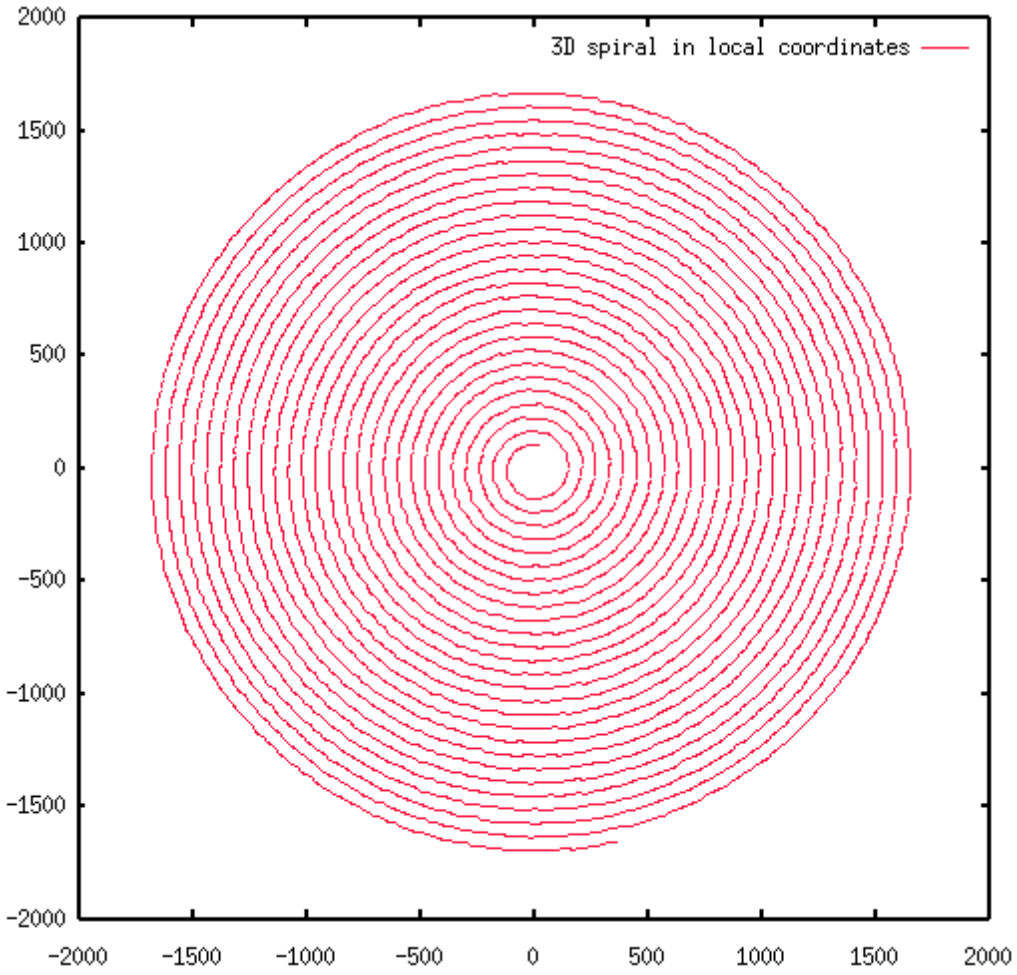
TARGET LAYER COVERAGE - RULES OF THUMB

$$R = X * (H - Hg)/(2H - Hg)$$



R = ~ 420 m

Spiral Survey with Dual Source Arrays



For 3km maximum offset

and 25m source spacing:

Total ~45,000 shots

Or 50m source spacing:

Total ~11,500 shots

If Shot of Survey with ~45,000 shot points:

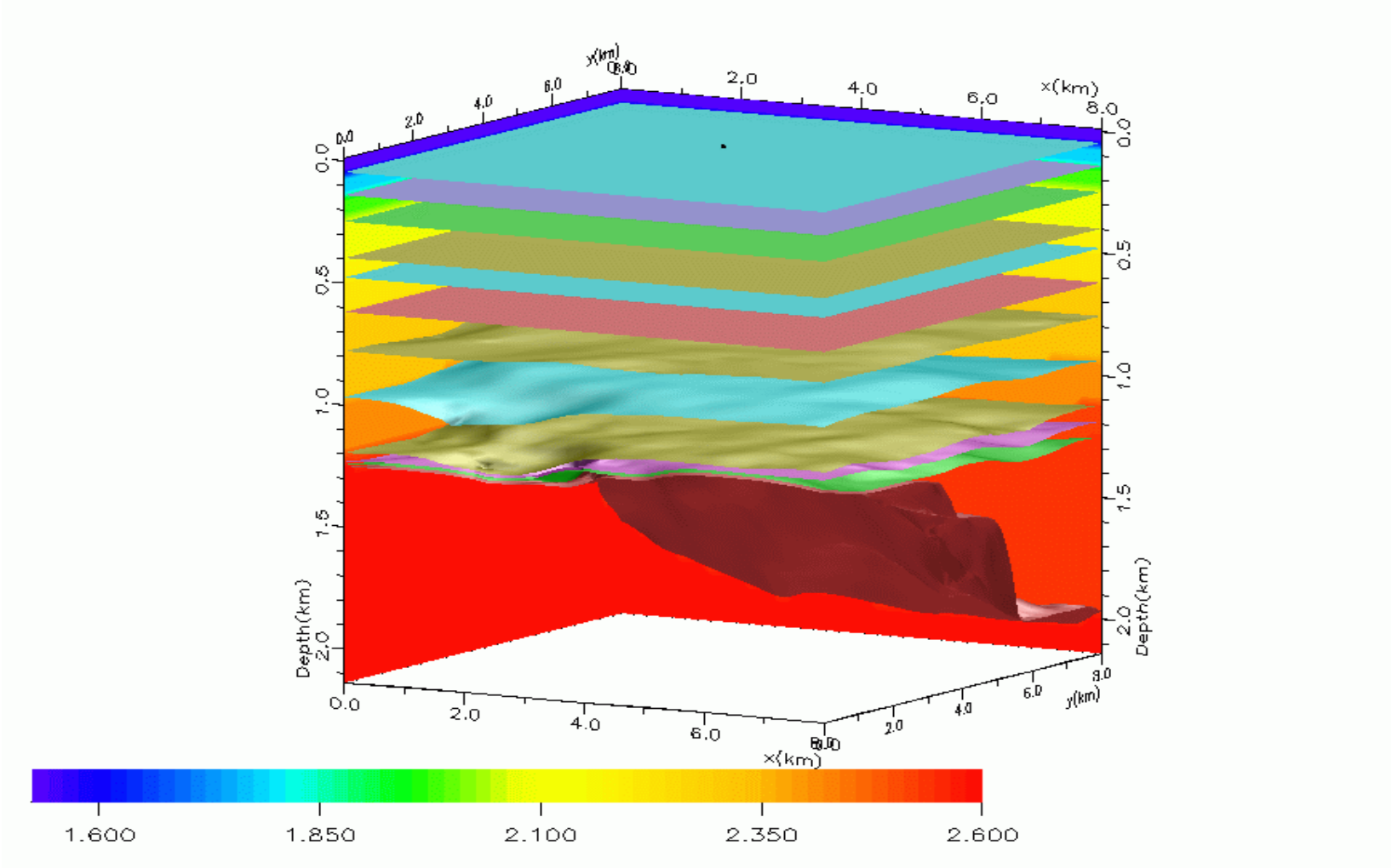
122 hours

If Shot of Survey with ~11,500 shot points:

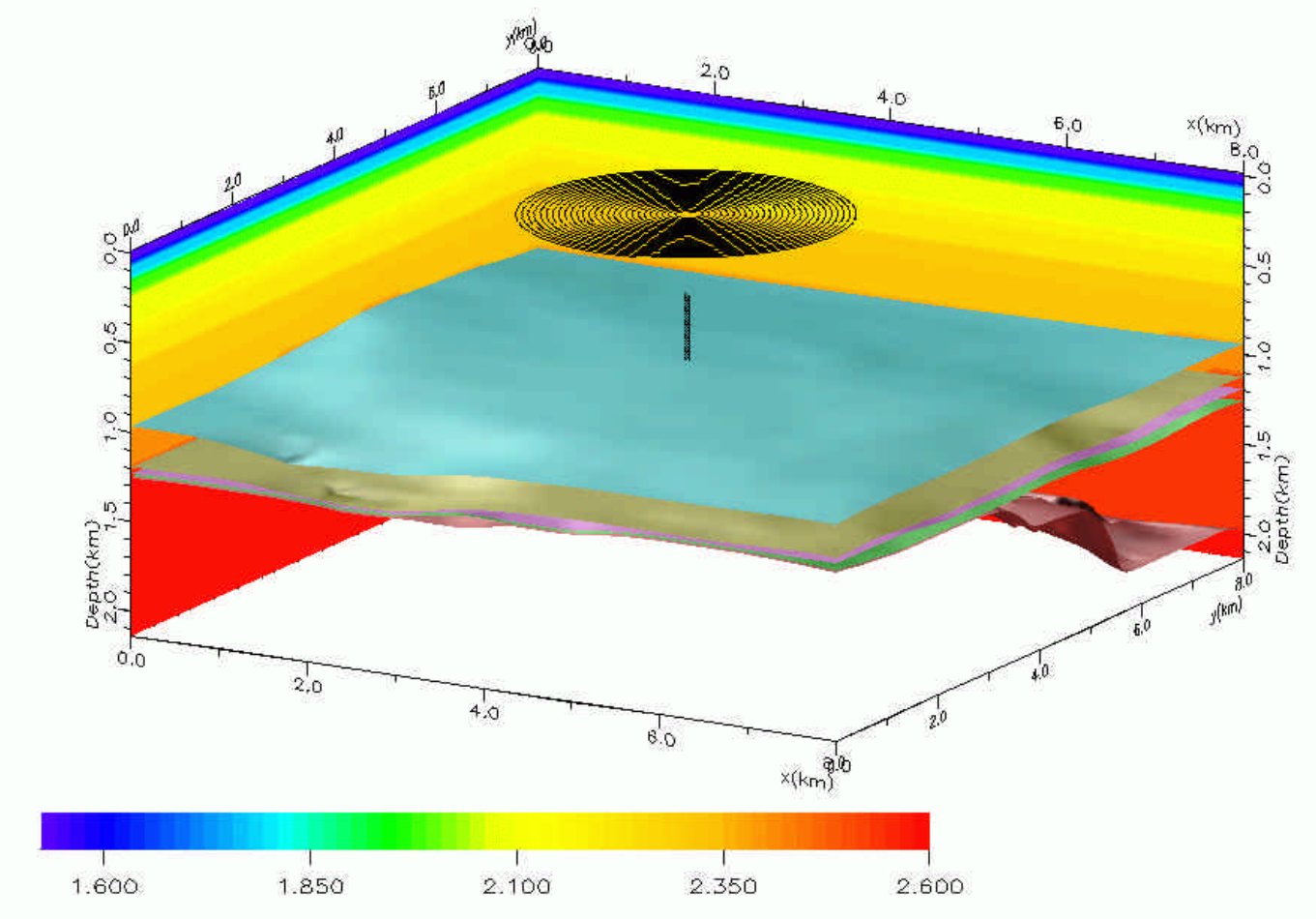
40 hours

Final Survey Parameters and Number of Shots should be Determined by Pre-survey Modeling Study!

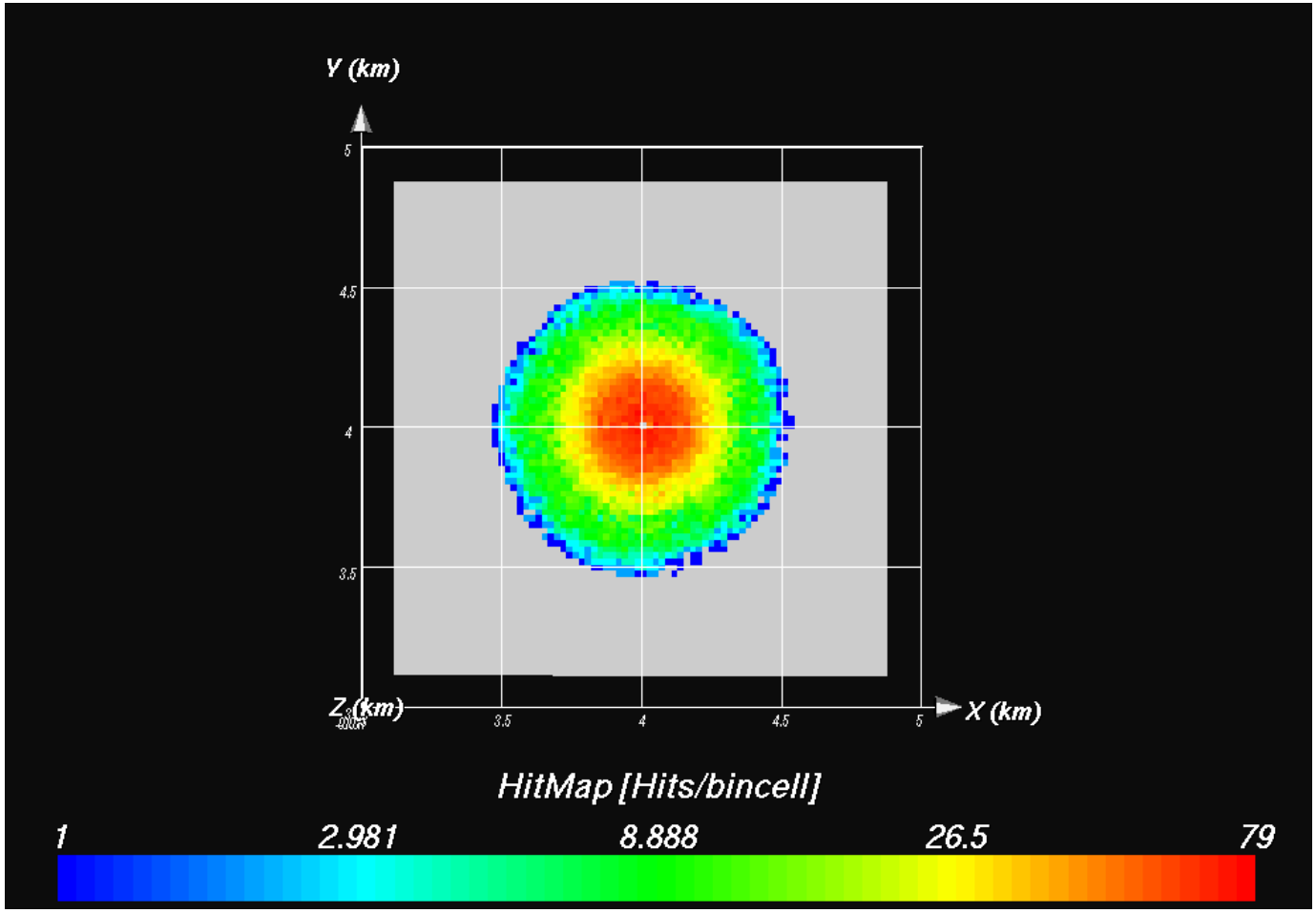
3D Geological Model Example for Survey Design



Survey Geometry



Imaging Coverage for Target Layer



Major Deliverables of 3D VSP Project at ShuaiZhong 36-1 Field:

(1) High-resolution P-P Anisotropic Migration Imaging Cube

(2) High-resolution P-S Anisotropic Migration Imaging Cube

(3) Final Velocity Model

READ IS A LEADER IN 3D VSP TECHNOLOGY!