CREWES

# *Results from multi-azimuth numerical modelling over an Orthorhombic medium*

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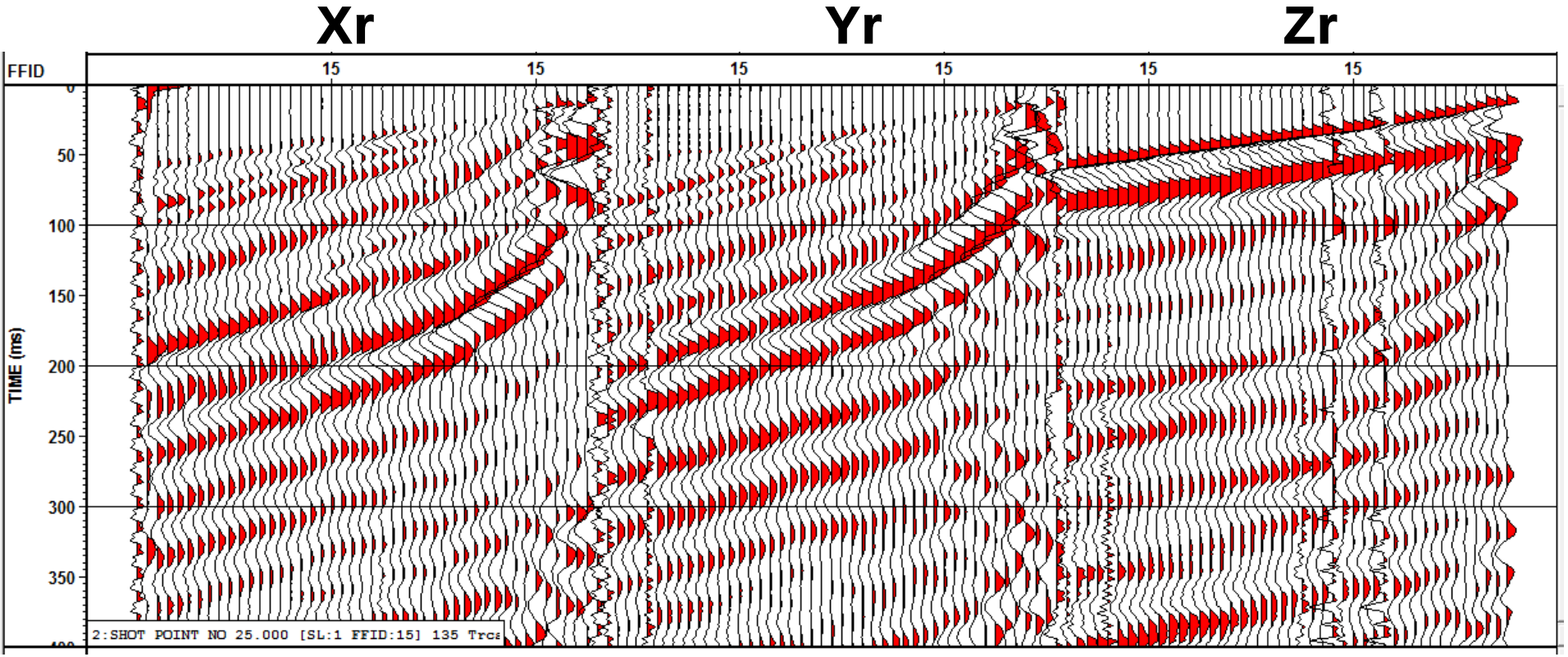
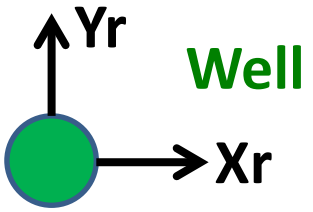
# Outline

- Motivation: CREWES S-wave hammer
- Design of the numerical experiment
- Numerical results


1202

# Zero offset VSP at Priddis well: source V




Well

Offset dx = 2.5 m W

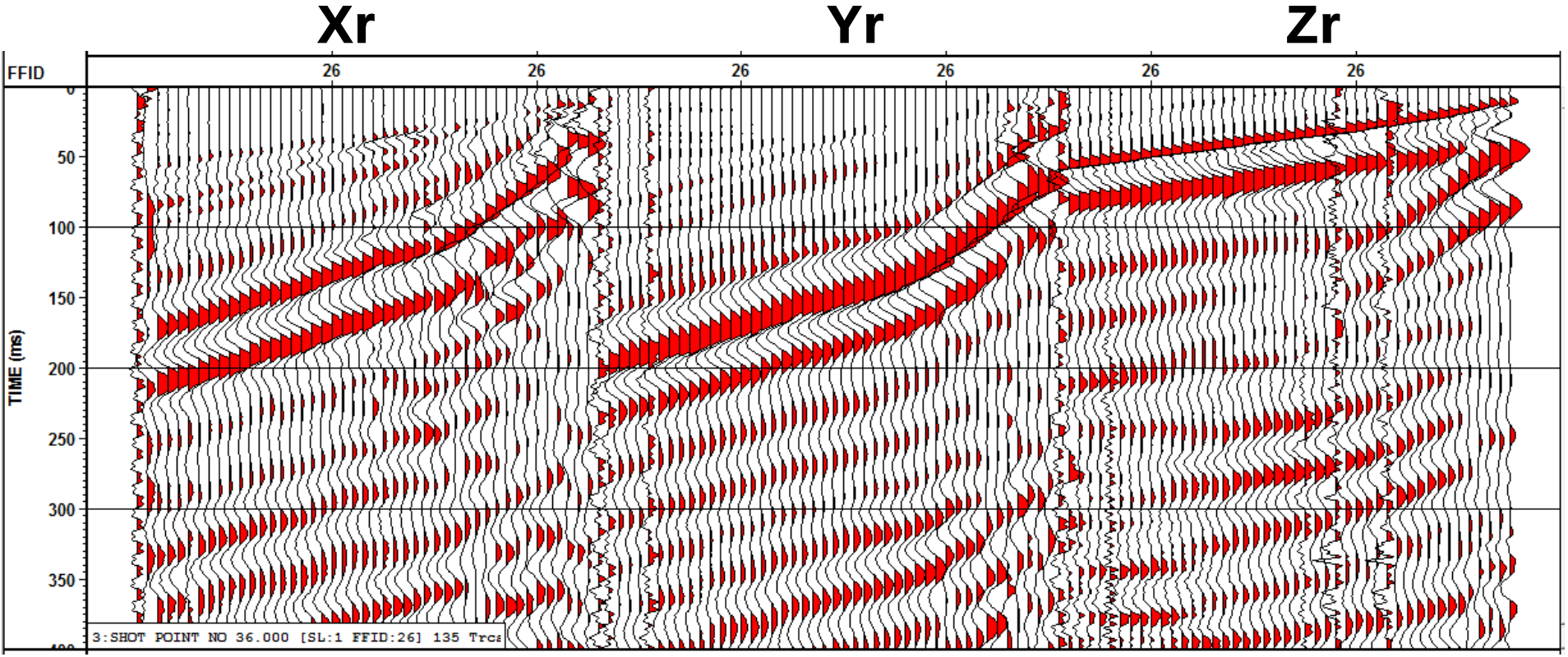
Offset dy = 3.7 m S

Vp1 = 2160 m/s

Vp2 = 3210 m/s

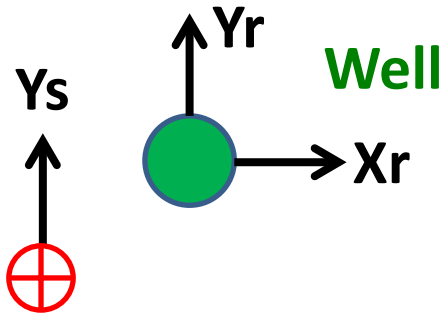
Source

# Zero offset VSP at Priddis well: source Ys




Offset dx = 2.5 m W

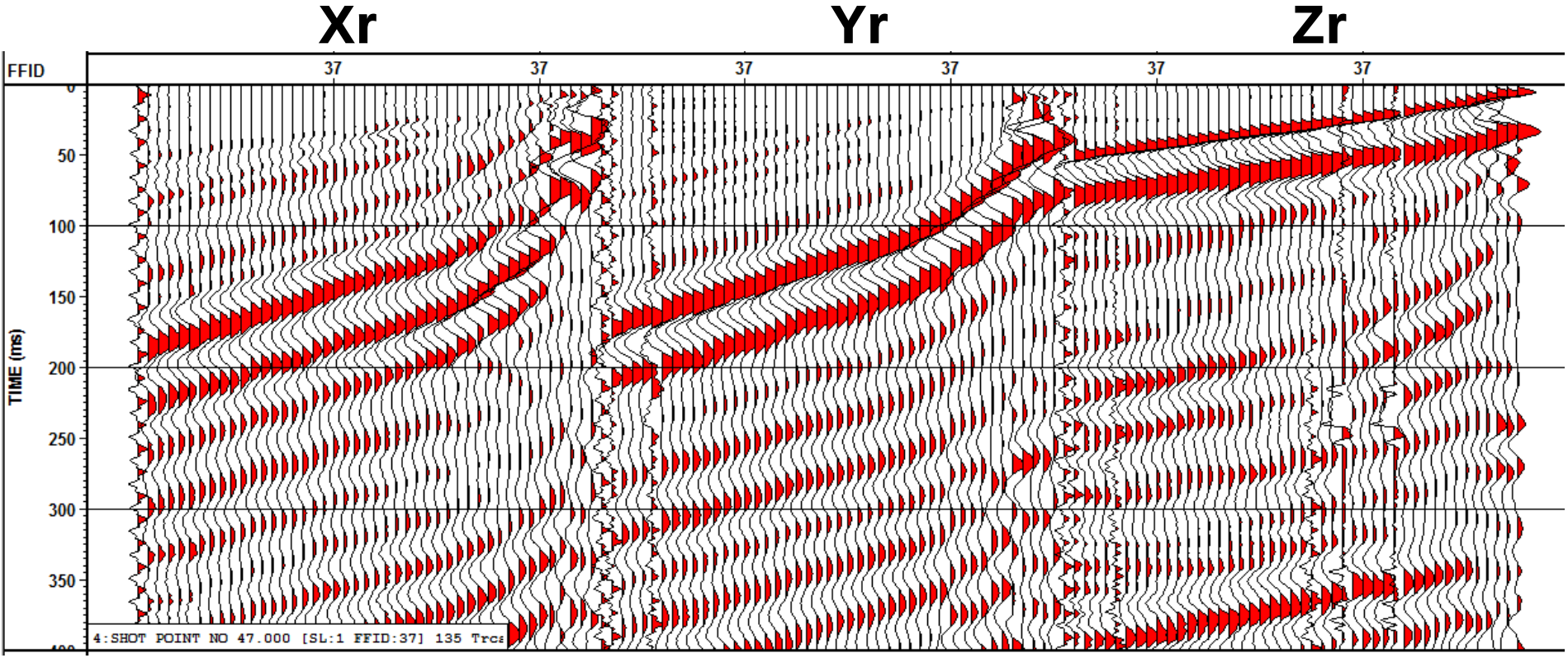
Offset dy = 3.7 m S

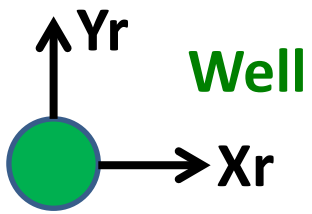



Vs1 = 520 m/s

Vs2 = 1400 m/s

# Zero offset VSP at Priddis well: source Y's

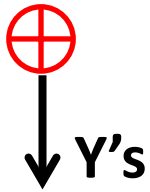



Well

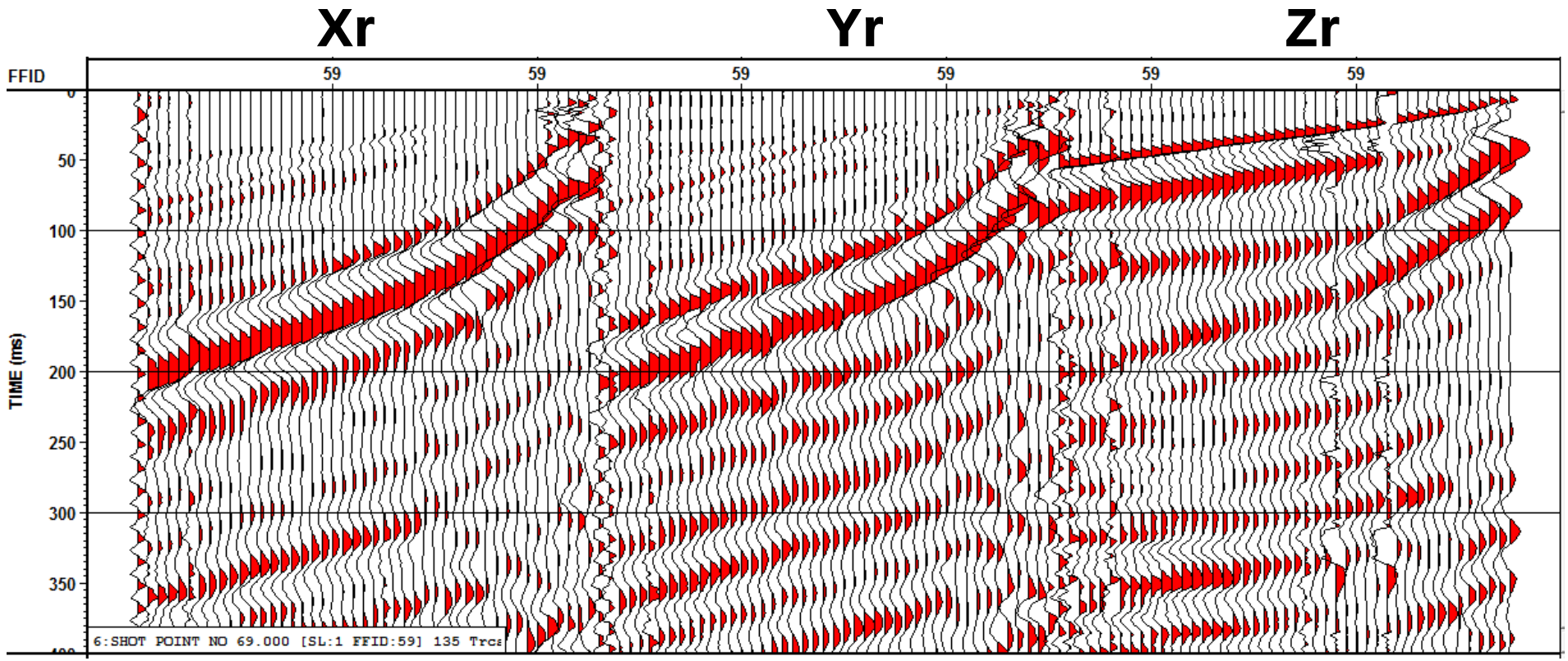
Offset dx = 2.5 m W

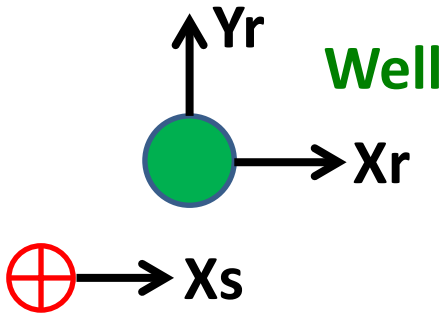
Offset dy = 3.7 m S




Source

# Zero offset VSP at Priddis well: source Xs



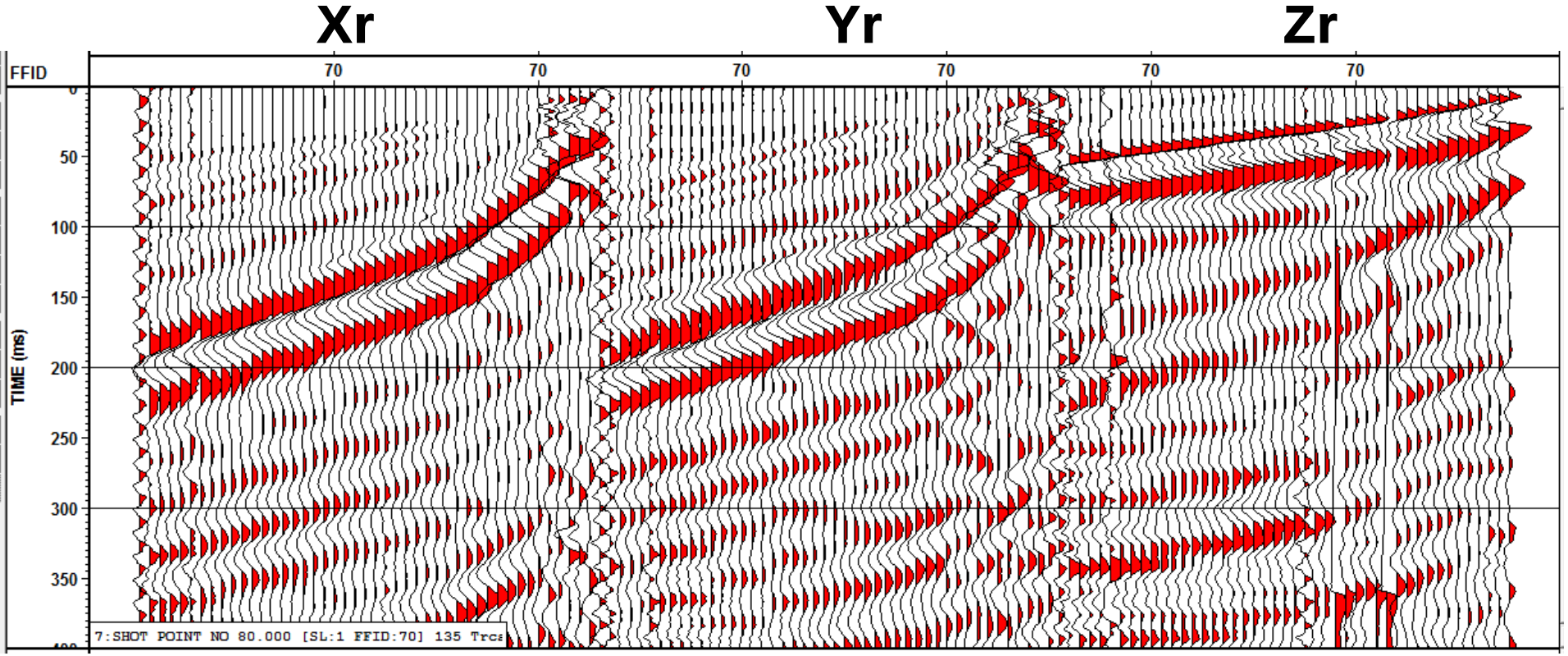



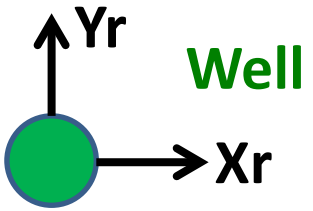

**Offset dx = 2.5 m W**

**Offset dy = 3.7 m S**

**Source**

# Zero offset VSP at Priddis well: source X's

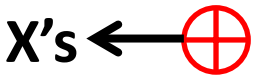



Well

Offset dx = 2.5 m W

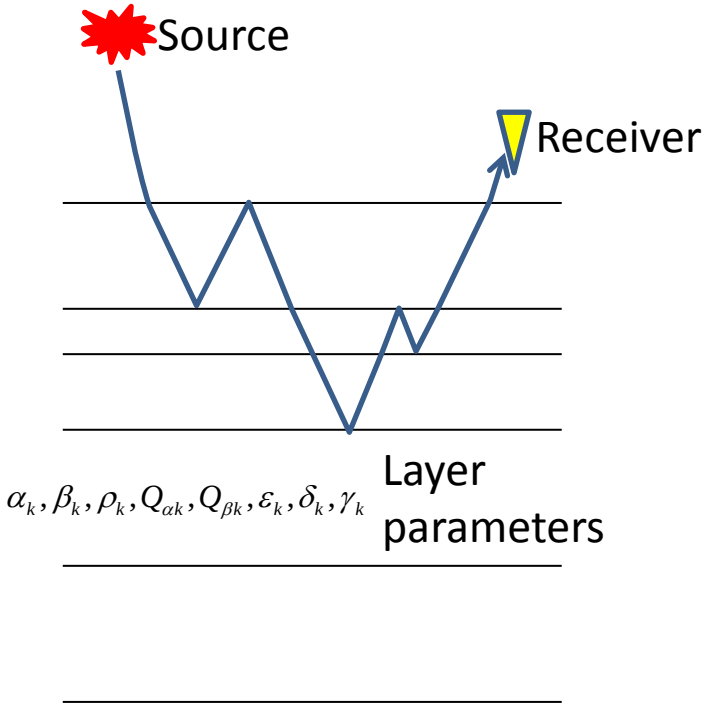
Offset dy = 3.7 m S




Source

# Reflectivity_fd method

## Mikhailenko (1970-present), Daley (1975-present)

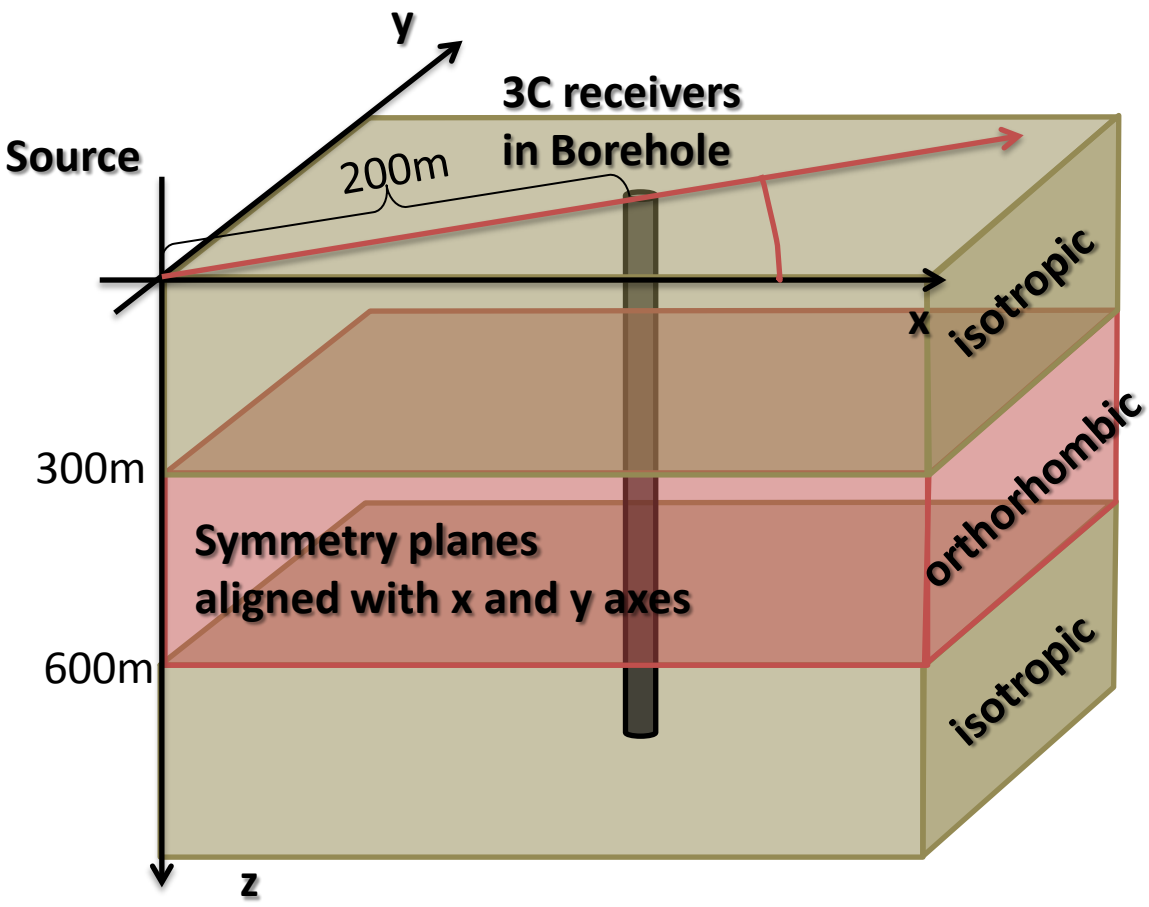



3D Layered medium
Structure varies only with z

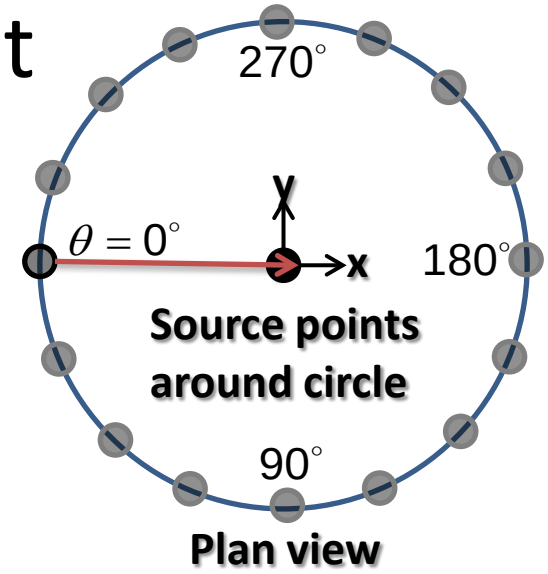
- **Uses finite-differences in $z$ and $t$ instead of frequency-domain propagator matrices.**
- **Integration over lateral wavenumbers by inverse Hankel transform.**
- **Includes all multiples and mode conversions.**
- **Has been extended to the anisotropic and visco-elastic cases.**
- **Model parameters can vary with depth at the finite-difference grid spacing.**
- **Run time is independent of the number of layers.**

*See especially: Daley, P. F., 2010, P-SV wave propagation in a radially symmetric vertically inhomogeneous TI medium: Finite difference hybrid method, CREWES Research Report.*

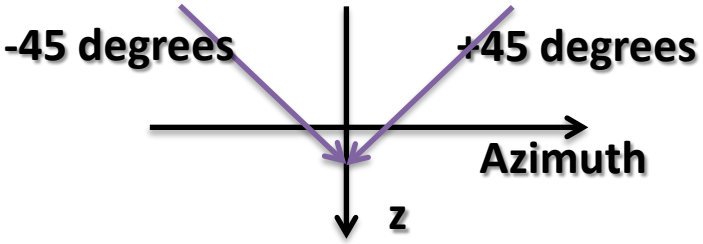
# The model and the experiment




Orthorhombic: Two orthogonal sets of vertical fractures



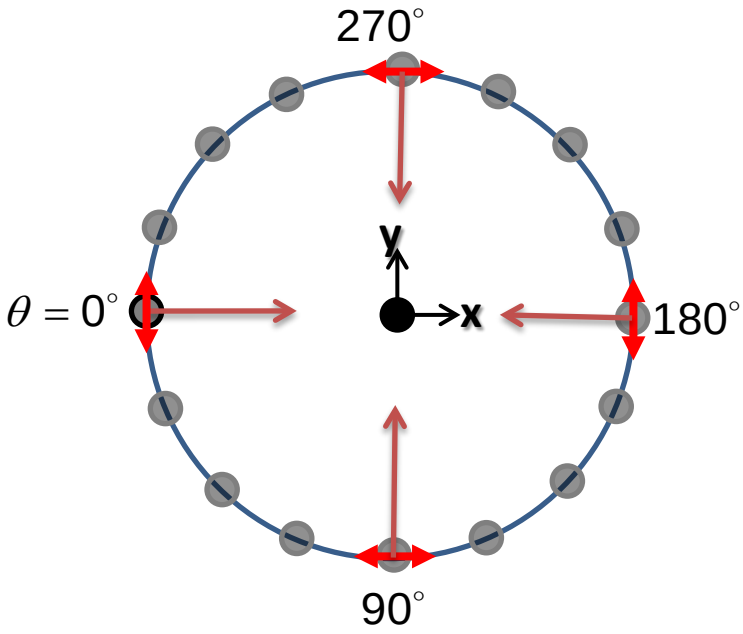

Plan view




Two point forces, just below the free surface, at each source location. Directed orthogonal to S-R azimuth. Shot separately.

# Vanishing components

| Azimuth | X component | Y component | Z component |
|---|---|---|---|
| 0 | vanish | | |
| 90 | | vanish | |
| 180 | vanish | | |
| 270 | | vanish | |



# Density normalized Voigt coefficients

Orthorhombic Layer (Phenolic)

$$\begin{bmatrix} 8.70 & 4.68 & 5.07 & 0 & 0 & 0 \\ & 13.25 & 5.13 & 0 & 0 & 0 \\ & & 12.25 & 0 & 0 & 0 \\ & & & 2.89 & 0 & 0 \\ & & & & 2.34 & 0 \\ & & & & & 2.28 \end{bmatrix}$$

# Isotropic layers

| | Surface | Isotropic | Layer | | |
|---|---|---|---|---|---|
| $2.745^2$ | $1.931^2$ | $1.931^2$ | 0 | 0 | 0 |
| | $2.745^2$ | $1.931^2$ | 0 | 0 | 0 |
| | | $2.745^2$ | 0 | 0 | 0 |
| | | | $1.38^2$ | 0 | 0 |
| | | | | $1.38^2$ | 0 |
| | | | | | $1.38^2$ |

# Examine results

- 16 azimuths
- 2 sources per azimuth plus source subtraction =3 effective sources
- 3 components
- 16*3*3 = 144 Gathers

Yikes!!

# New Matlab Display tool: *plotgathers*

Facilitates comparison of many similar trace gathers.

Download a fresh toolbox to get a copy.

The remainder of this talk is an interactive Matlab demo. This demo, and the associated data is available to CREWES and Sponsors upon request.

# Interesting Data Comparisons

1. Observe expected null planes
   a) $0^o$ and $180^o$ x component
   b) $90^o$ and $270^o$ y component

2. Compare plus-minus and subtraction
   a) Compare P45, M45, and diff for $0^o$ y component
   b) Compare P45, M45, and diff for $0^o$ z component

3. Shear-wave splitting
   a) diff, y component, $0^o$
   b) diff, x component, $90^o$

4. Weak Z component $135^o$ and $315^o$

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