Velocity calibration and wavefield decomposition for walkover VSP data

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Overview

CRS approach for VSP geometry

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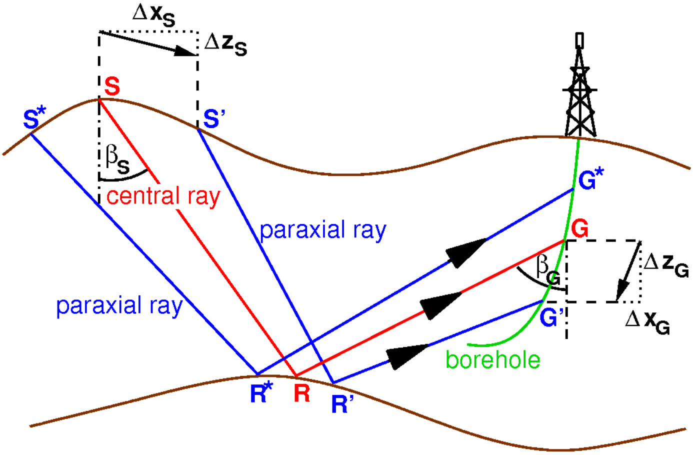
VSP measurement configuration



S and *G* are the positions of $\vec{x}_S$ and $\vec{x}_G$, respectively

CRS Operator for arbitrary geometry

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$$\begin{aligned}
\tau_{\text{hyp}}^2 &= \left(\tau_0 + \frac{\sin\beta_S}{v_S}\Delta x_S - \frac{\cos\beta_S}{v_S}\Delta z_S + \frac{\sin\beta_G}{v_G}\Delta x_G - \frac{\cos\beta_G}{v_G}\Delta z_G \right)^2 \\
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&+ \tau_0\, DB^{-1}\, (\Delta x_G - \Delta z_G \tan\beta_G)^2 \\
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- DB^{-1}, AB^{-1}, B^{-1} : composites of elements of ray-propagator matrix

A look at multi-coverage walkover data

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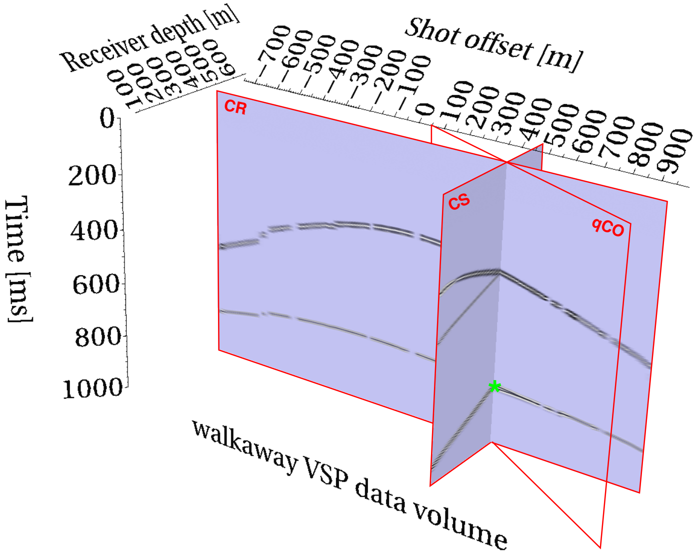

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  ➥ length of slowness vector $|\vec{p}|$ independent of incidence angle

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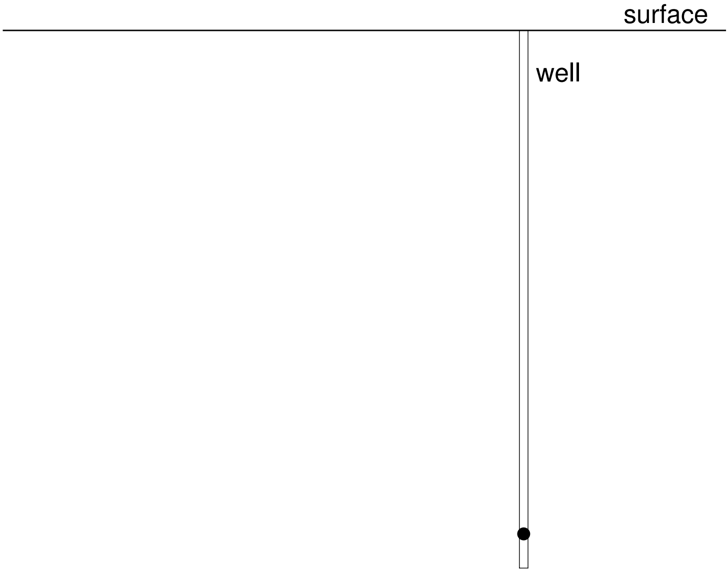
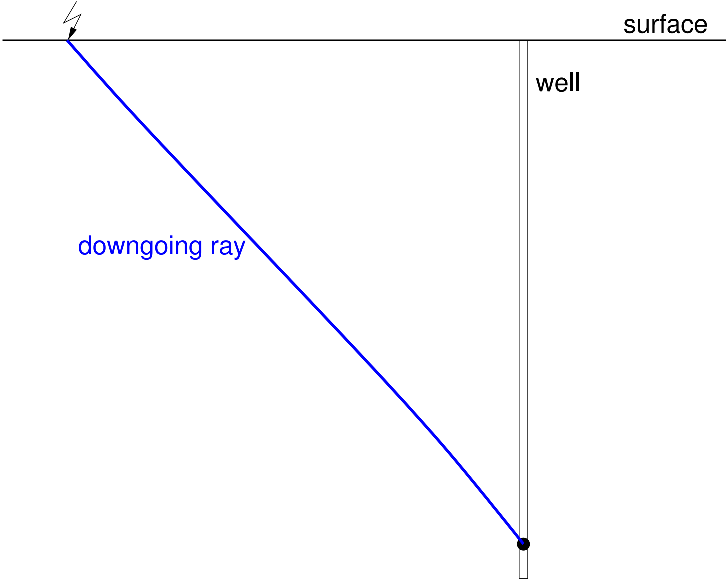
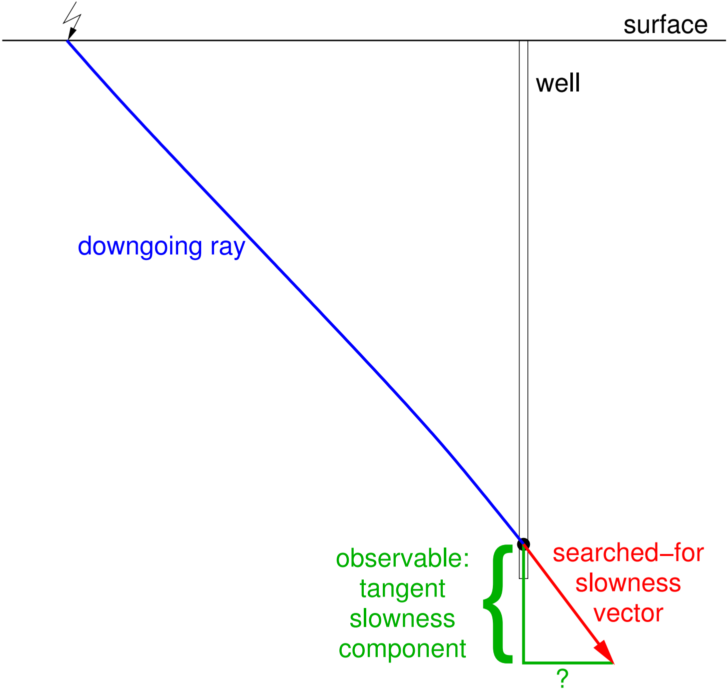
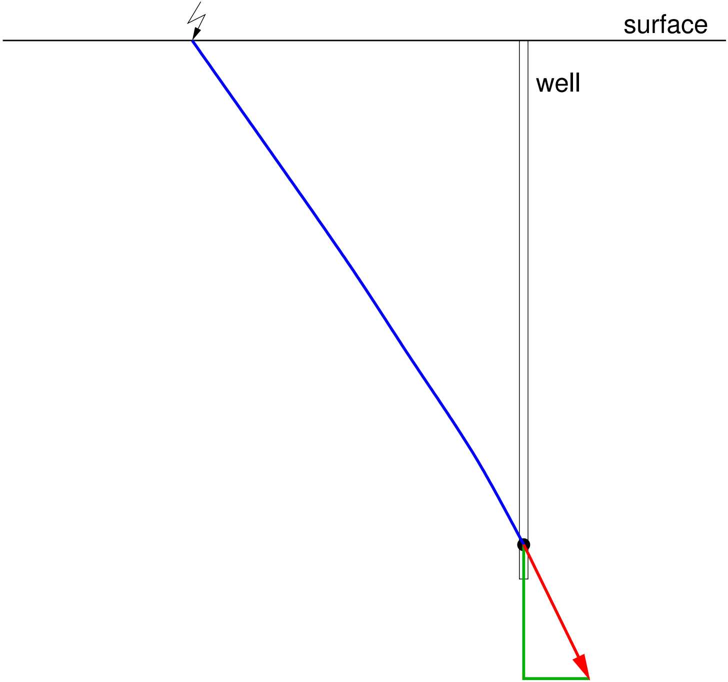
➥ searched-for velocity $v\left(\vec{x}_G\right) = \max\left\{p_t\left(\vec{x}_S; \vec{x}_G\right)\right\}^{-1}$


surface
well


surface
well
downgoing ray


surface
well
downgoing ray
observable:
tangent
slowness
component
searched–for
slowness
vector
?


surface
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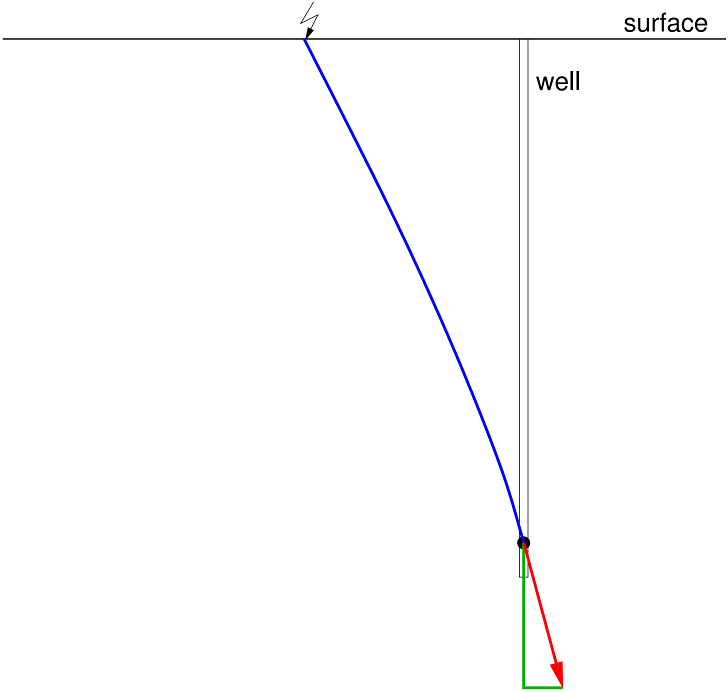
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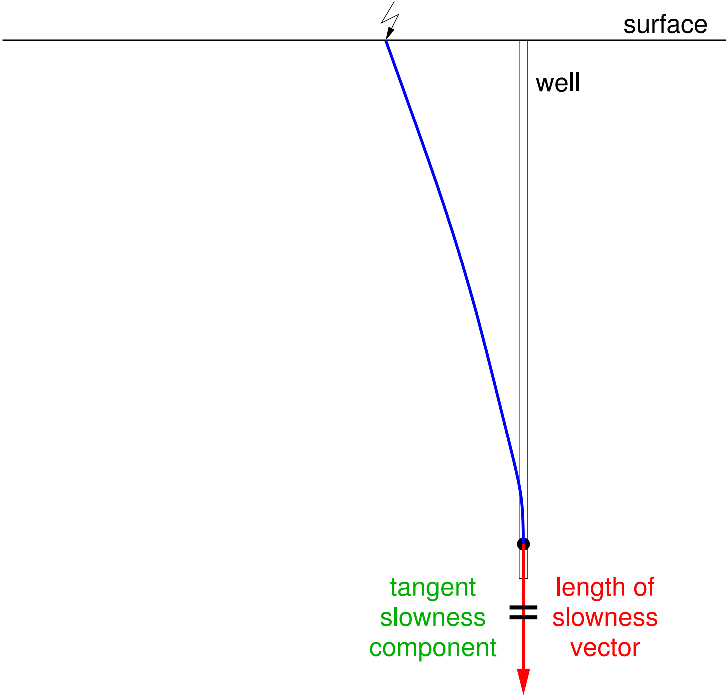
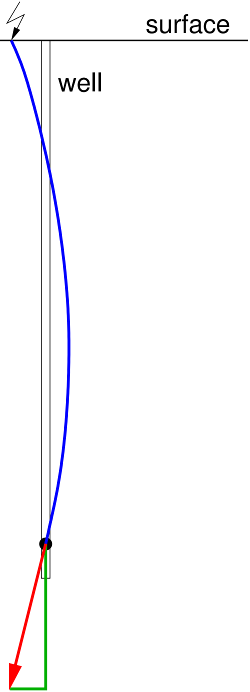

surface
well
tangent slowness component
=
length of slowness vector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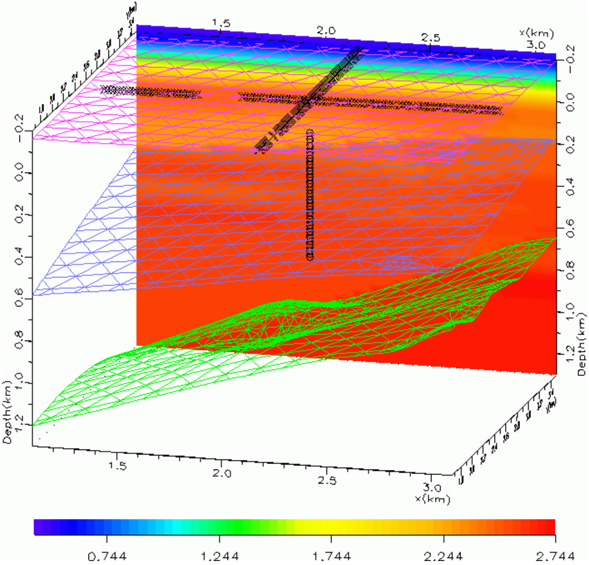

P-wave velocity [km/s]

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- 2D approach sufficiently accurate for calibration

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  well-localized minimum at zero angle

Calibration using checkshot inversion

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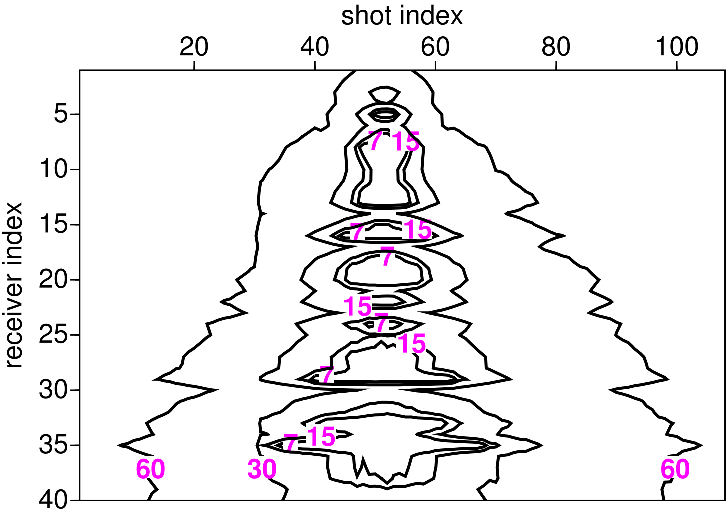
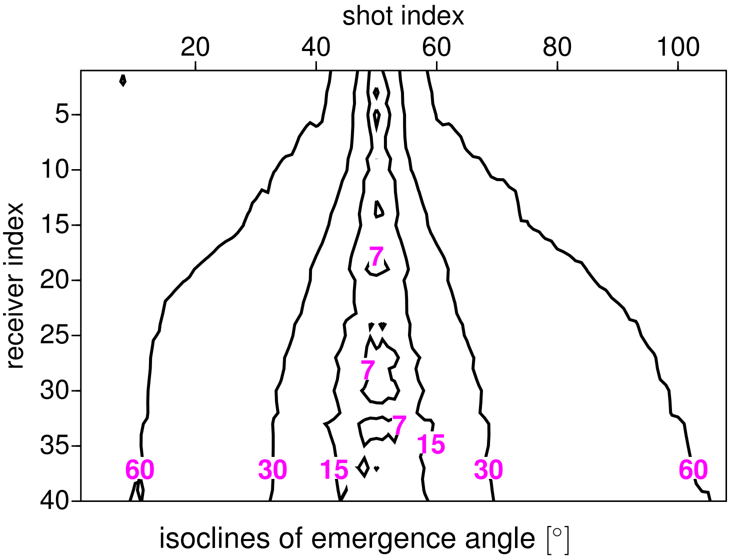
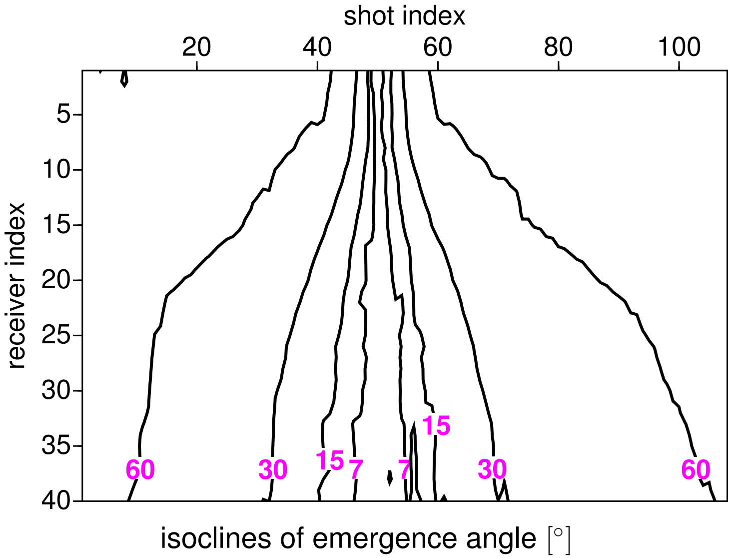


isoclines of emergence angle [°]

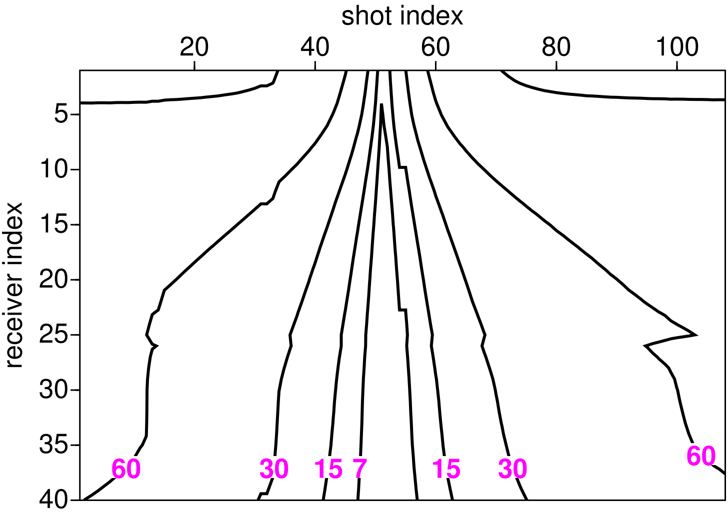
Calibration with initial model



Calibration with corrected model



Forward-modeled angles



isoclines of emergence angle [°]

1D velocity curves along well

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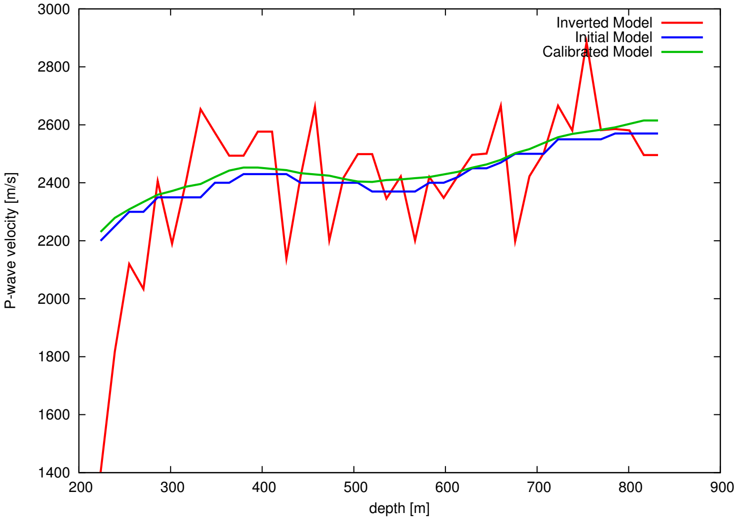

CRS-based wavefield decomposition

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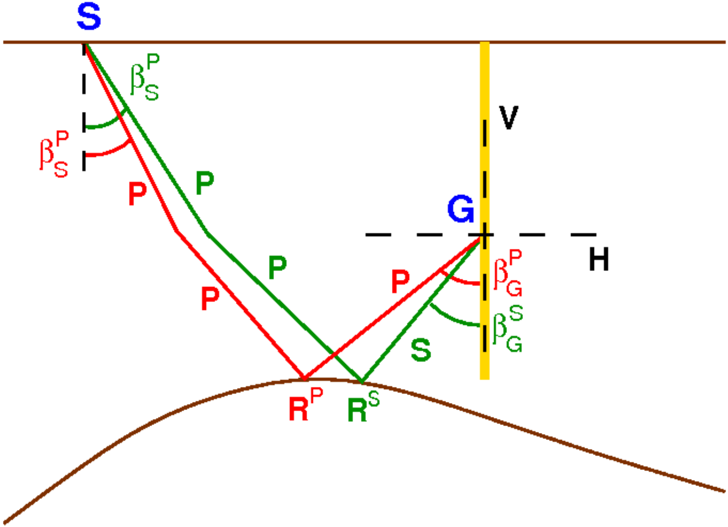
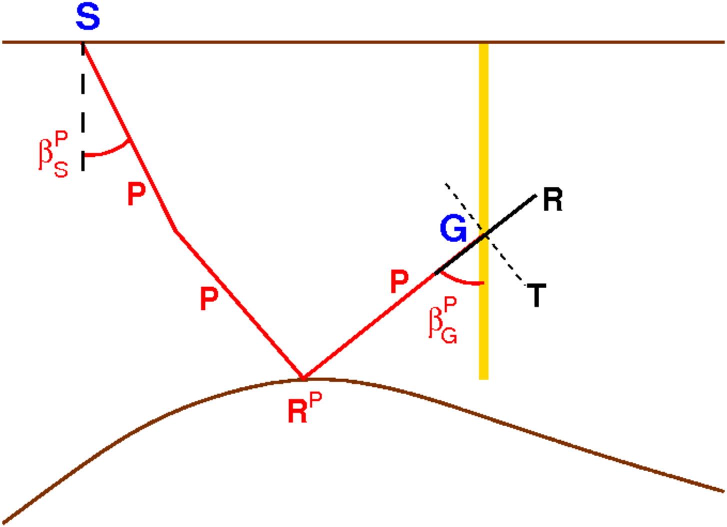


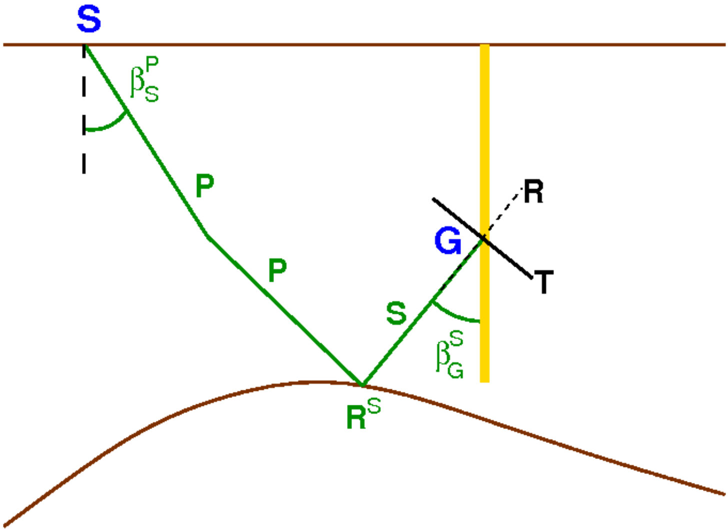
Components (V,H) prior to rotation

CRS-based wavefield decomposition



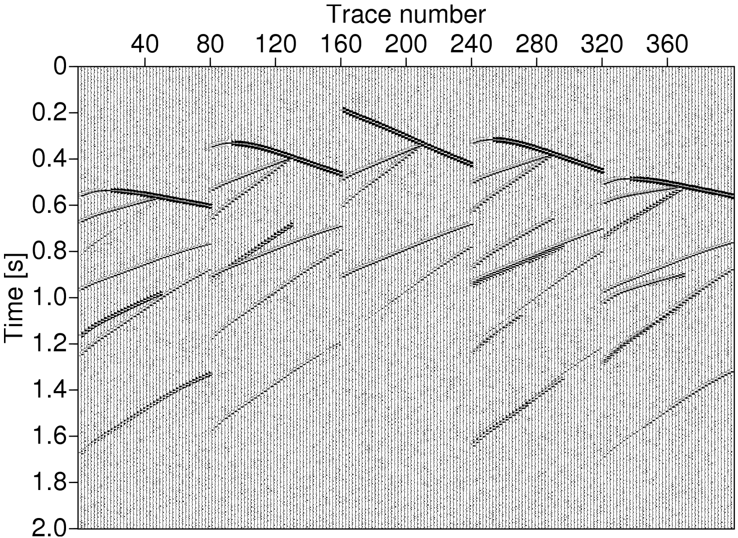
Components (R,T) after rotation by β_G^P – R is strong

CRS-based wavefield decomposition



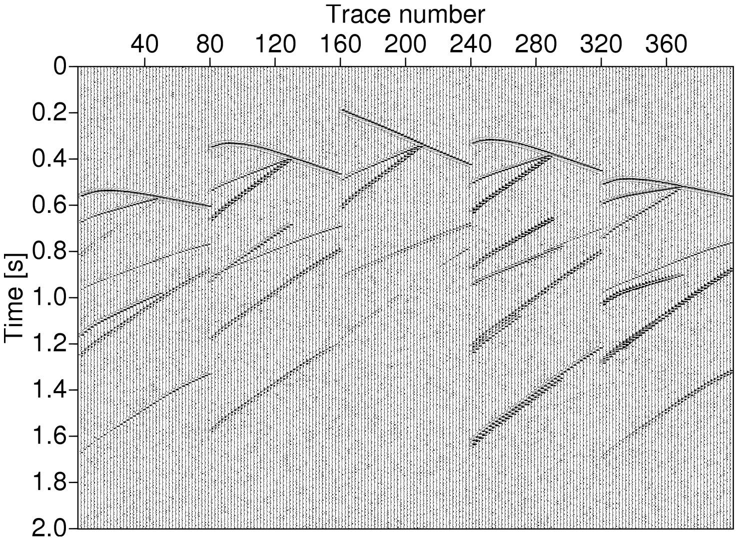
Components (R,T) after rotation by β_G^S – T is strong

Five CS gathers prior to rotation



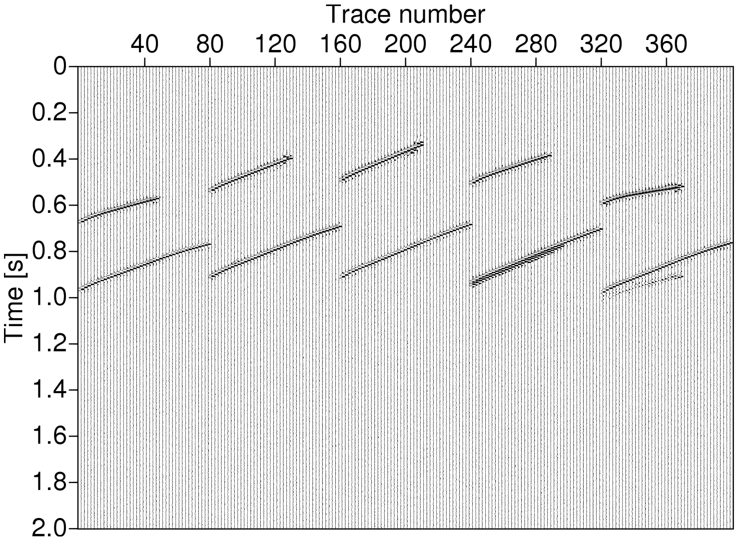
vertical component

Five CS gathers prior to rotation



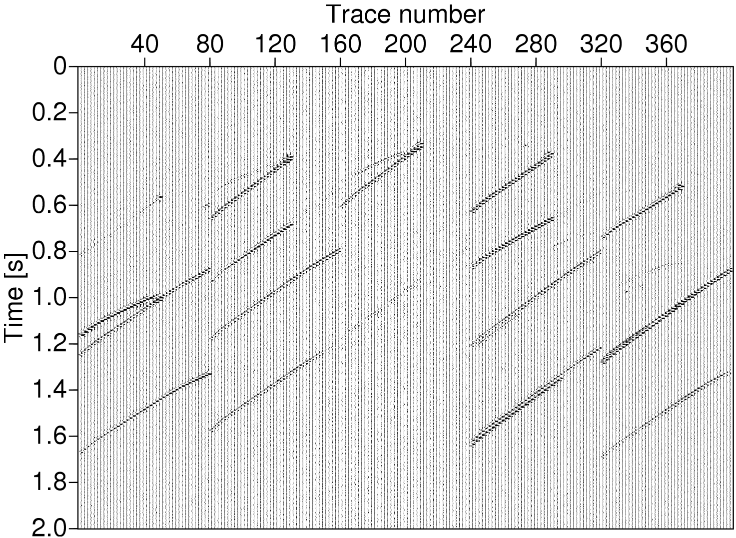
horizontal component

Five CS gathers after decomposition



radial orientation using β_G^P

Five CS gathers after decomposition



transverse orientation using β_G^S

Conclusions & outlook

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Acknowledgments

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- Paulsson Geophysical Services Inc. for providing synthetic data and tremendous assistance in questions of VSP imaging