Tomographic velocity analysis of PP- and PS-waves for VTI media: Field-data application

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Motivation

Parameters for P-wave depth imaging:

\[ V_{P0} \quad \epsilon \quad \delta \]

P-wave moveout:

\[ V_{nmo} \quad \eta \]
Motivation

PP reflections can be combined with:

• borehole data (VSP, check shots, well logs)
• pure SS reflections
• PS reflections
Velocity analysis of PS-waves

- moveout asymmetry
- polarity reversals
- conversion-point dispersal
Methodology

• registration of PP and PS reflections

• $PP + PS = SS$

• joint MVA of PP- and SS-waves imaging with Kirchhoff depth migration
Gridded model

$$\lambda = \begin{pmatrix} V_{P0} \\ V_{S0} \\ \epsilon \\ \delta \end{pmatrix}$$
Objective function

\[ F(\Delta \lambda) = \mu_1 \| A_P \Delta \lambda + b_P \|^2 \quad \text{(flattening PP CIGs)} \]
\[ + \mu_2 \| A_S \Delta \lambda + b_S \|^2 \quad \text{(flattening SS CIGs)} \]
\[ + \mu_3 \| D \Delta \lambda + y \|^2 \quad \text{(codepthing)} \]
\[ + \zeta \| L \Delta \lambda \|^2 \quad \text{(regularization)} \]
PP final image

SS final image
Image with gridded model

PP

SS
[Szydlik, T., P. Smith, S. Way, L. Aamodt, and C. Friedrich, 2007]
Statoil’s model
Statoil’s model

$V_{S0}$

$z$ (km)

$x$ (km)

$V_{S0}$ (km/s)
Initial model
Initial model
Initial model
PS image with initial model
PS image with initial model

reflector 1
reflector 2
reflector 3
reflector 4
reflector 5
PP image with initial model

- reflector 1
- reflector 2
- reflector 3
- reflector 4
- reflector 5
top of Cretaceous unit
Estimated model

\[ V_{P0} \]

\( x \) (km)

\( z \) (km)

\( (\text{km/s}) \)
Estimated model
Estimated model
Estimated model
PP image with estimated model
PP image with estimated model

reflector 1
reflector 2
reflector 3
reflector 4
reflector 5 (top of Cretaceous unit)
PS image with estimated model

reflector 1
reflector 2
reflector 3
reflector 4
reflector 5 (top of Cretaceous unit)
Conclusions

• MVA for multicomponent data
• PP+PS=SS to generate SS reflections
• update by flattening and codepthing
• well-focused PP and PS images for Volve field
• four Thomsen parameters from PP+SS inversion
• depth ties yield $V_{P0}/V_{S0}$ ratio
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