



PSS-GEO Subsurface — AI-Driven Platform

Integrated Technologies:

Full-Wavefield Modelling — Spectral Element Method (SEM)
— Finite-Difference Method (FDM)

Full-Waveform Migration (FWM)

Full-Waveform Inversion (FWI)

Joint Migration Inversion (JMI)

Rune Inversion — Pre-Stack and Post-Stack

From Data to Prospect with PSS-GEO Subsurface AI-driven Platform

Human-Guided Agentic AI for Autonomous Subsurface Exploration



INTEGRATED TECHNOLOGIES OVERVIEW

Full-Wavefield JMI and Quantitative Inversion

PSS-GEO Subsurface combines advanced full-wavefield modelling with PSS-GEO's implementation of **Joint Migration Inversion (JMI)** for 2-D and 3-D seismic data.

The workflow uses iterative forward modelling → residual calculation → adjoint backpropagation → model update → remigration, utilising primaries, converted and scattered waves, and multiples.

JMI separates the background propagation model from the high-wavenumber scattering/reflectivity response, allowing reconstruction of the velocity model together with R_{pp} and seismic imaging information. Elastic modelling incorporates P- and S-wave propagation and mode conversions, providing sensitivity to V_p , V_s and density.

A fundamental challenge of **elastic full-waveform inversion** is multiparameter non-uniqueness and cross-talk: changes in V_p , V_s and particularly density can produce similar seismic responses. Consequently, fitting the full waveform alone does not guarantee a unique or geologically reliable separation of these properties. To reduce elastic parameter crosstalk, the PSS-GEO JMI workflow can operate in a staged mode in which selected parameters are initially fixed or strongly constrained and progressively released as the background model converges. Unlike a conventional staged FWI parameterisation, JMI simultaneously provides explicit R_{pp}/R_{ps} updates within the internal loop. A final joint refinement can then update V_p , V_s , density and reflectivity using the complete elastic wavefield.

PSS-GEO utilises its JMI approach to produce the initial model parameters and reflectivity section, if needed, and combines the JMI full-wavefield solution with **Rune Inversion** to produce full-bandwidth properties. JMI provides the wave-equation-constrained propagation and scattering solution, while Rune Inversion provides independent quantitative estimation of **V_p , V_s and density**, removing parameter coupling and improving the stability of the final elastic-property reconstruction.

Advanced Full-Wavefield Modelling

PSS-GEO Subsurface incorporates two complementary modelling engines:

≈ **Elastic Spectral Element Method (SEM)** — the mathematical concept for accurate modelling of complex elastic wave propagation. The elastic solver represents P-waves, S-waves, reflected and transmitted waves, P-SV/SV-P converted waves, multiples and scattered waves, together with stress and particle-velocity components. SEM is particularly attractive for thin layers, complex interfaces and irregular geometry, because high-order spectral-element approximation can represent wavefields accurately with fewer numerical-dispersion errors than conventional low-order finite differences at comparable discretisation. It also provides a natural framework for elastic effects, mode conversion and complex boundaries. Surface-wave phenomena, including Rayleigh waves in 2-D P-SV modelling and, in a full 3-D elastic formulation, Love waves/SH energy, can be represented when the model, free-surface boundary conditions, source and acquisition geometry support them.

≈ **Finite-Difference Modelling (FDM)** — provides a simpler and computationally efficient alternative for regular grids, with acoustic and elastic implementations used for rapid forward modelling, testing, inversion development and cases where complex SEM geometry is not required.

WHY PSS-GEO JMI?

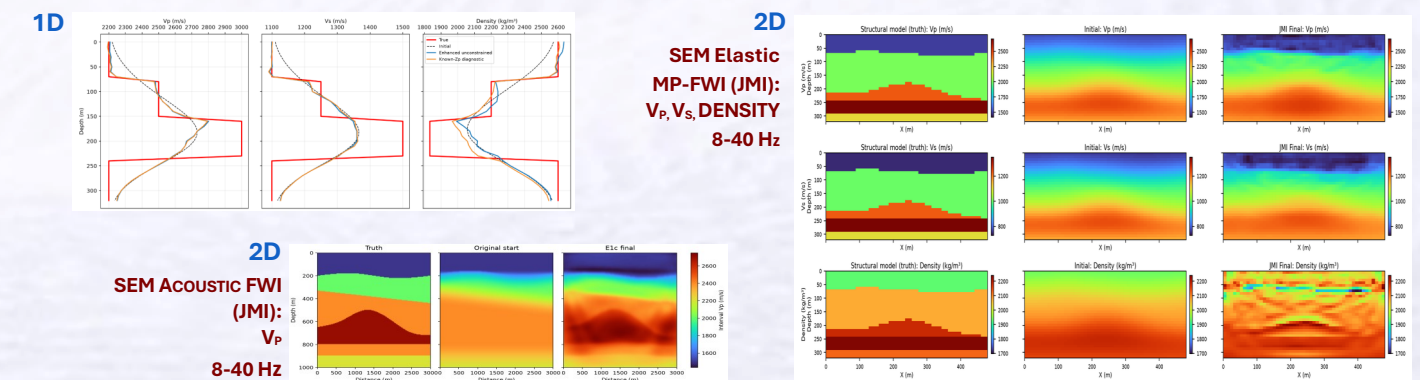
Conventional workflow: *multiple attenuation* → *velocity analysis* → *migration*

full-wavefield data → *iterative velocity and image reconstruction: FWI + R_{pp}/R_{ps} (where supported by converted-wave data) + V_s + Density*

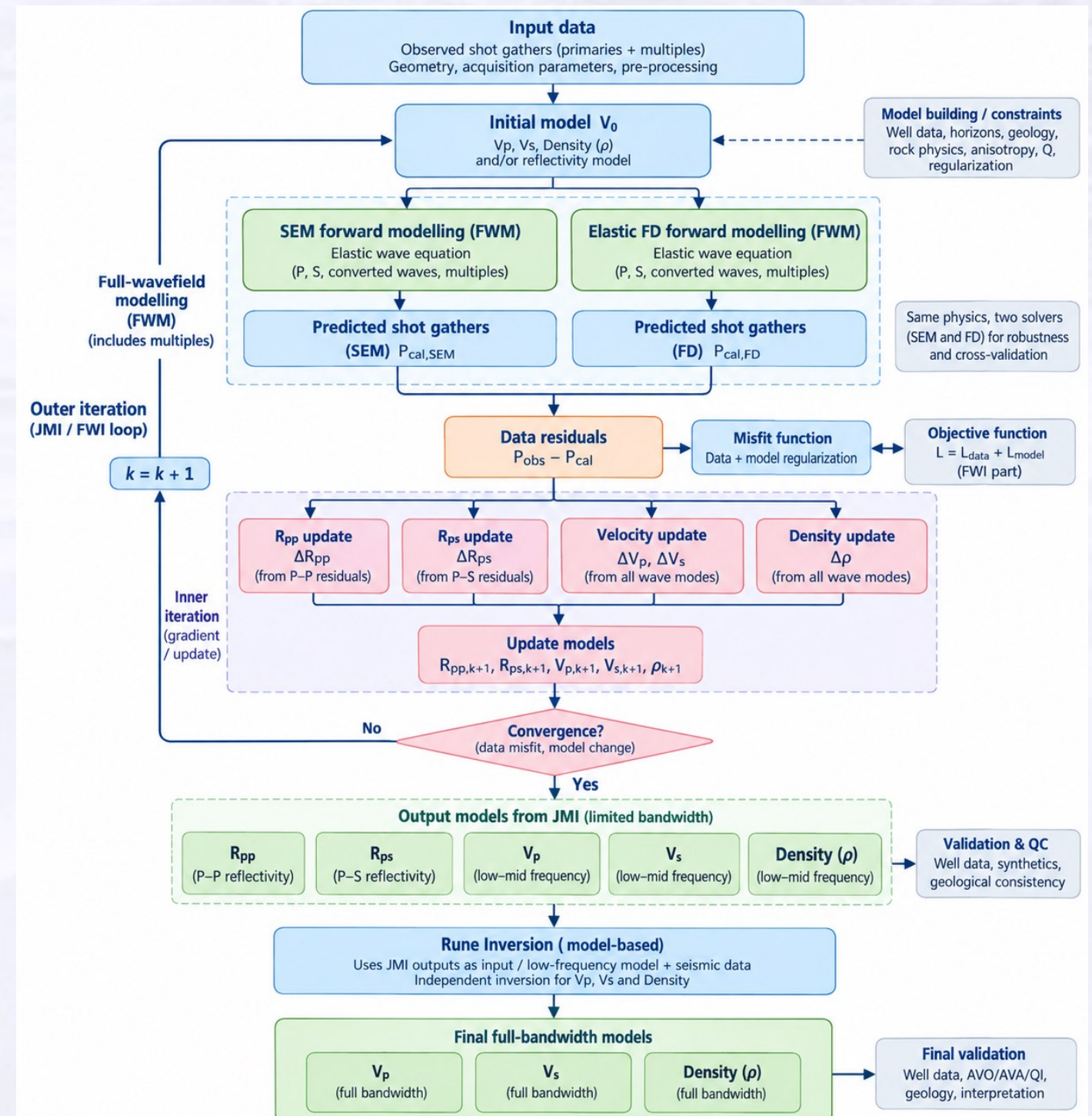
The objective is not simply to fit the seismic data, but to separate the propagation model from the scattering response, improving velocity reconstruction and imaging while retaining information contained in multiples and converted/scattered waves.

JMI SYNTHETIC TEST: INDEPENDENT MULTI-PARAMETER ESTIMATION WITH NO FIXED PARAMETERS IN INNER STAGES

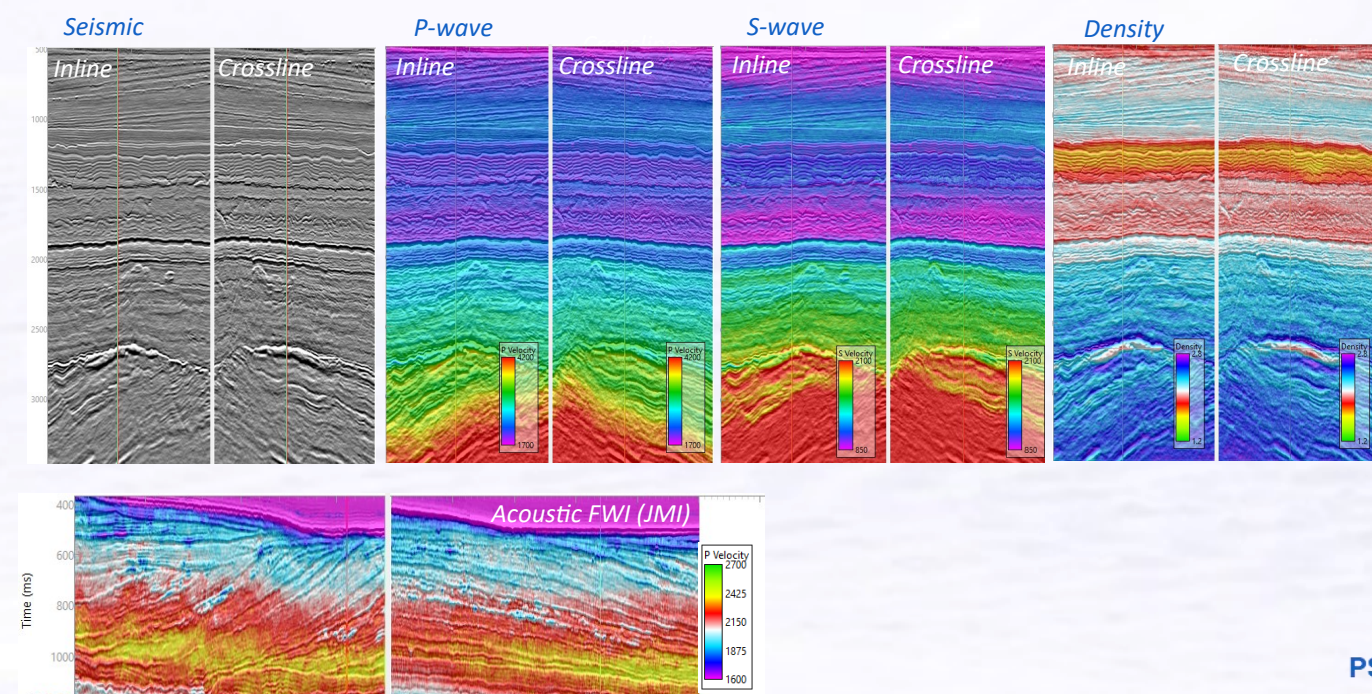
≈ 8→15→25→40 Hz, 5 source positions and 41 receivers, explosive and vertical-force sources, pressure, V_x , V_z , divergence and curl objectives, log- V_p , log- V_s , log- Z_p parameterisation, Huber total-variation regularisation, preconditioned Polak–Ribiere nonlinear conjugate gradient, 15 iterations, a separately labelled known- Z_p constrained diagnostic



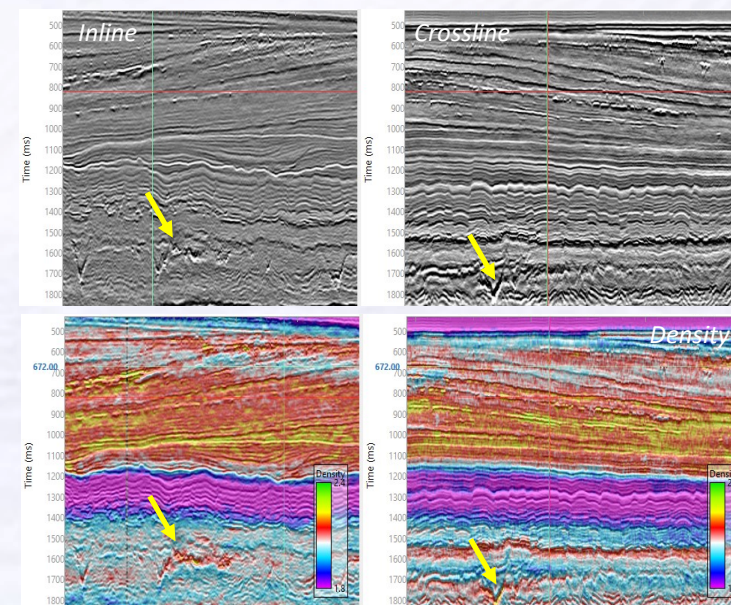
FULL PSS-GEO JMI AND RUNE INVERSION WORKFLOW



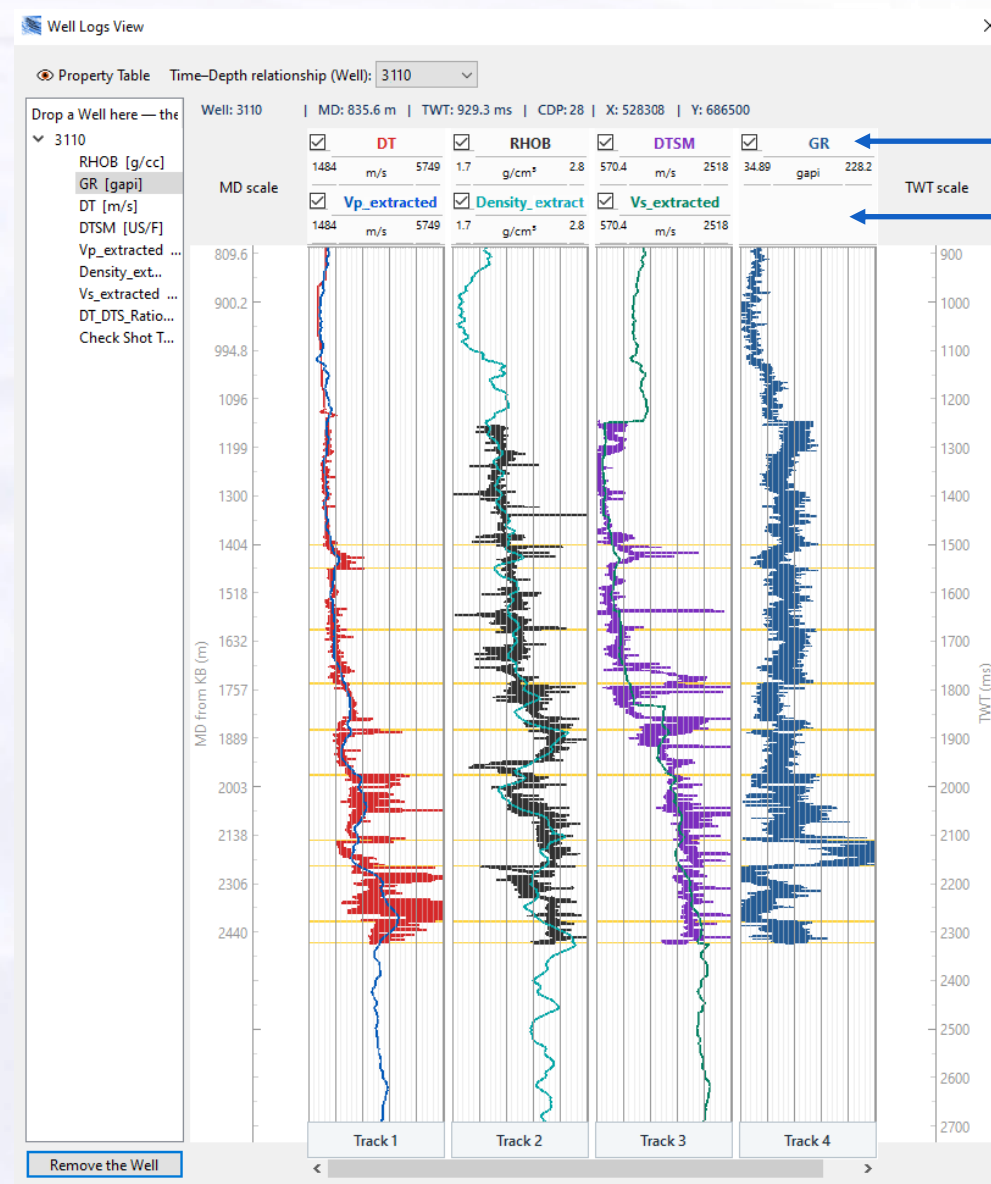
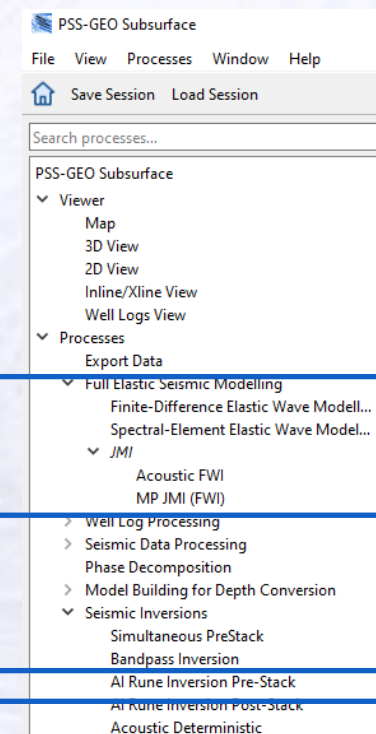
CASE STUDIES: FULL PSS-GEO JMI AND RUNE INVERSION WORKFLOW - FULL BANDWIDTH



Shallow Analysis of Seismic and PSS-GEO JMI & Rune Inversion Density Sections for Geohazards and Injectites



Demonstrated here:

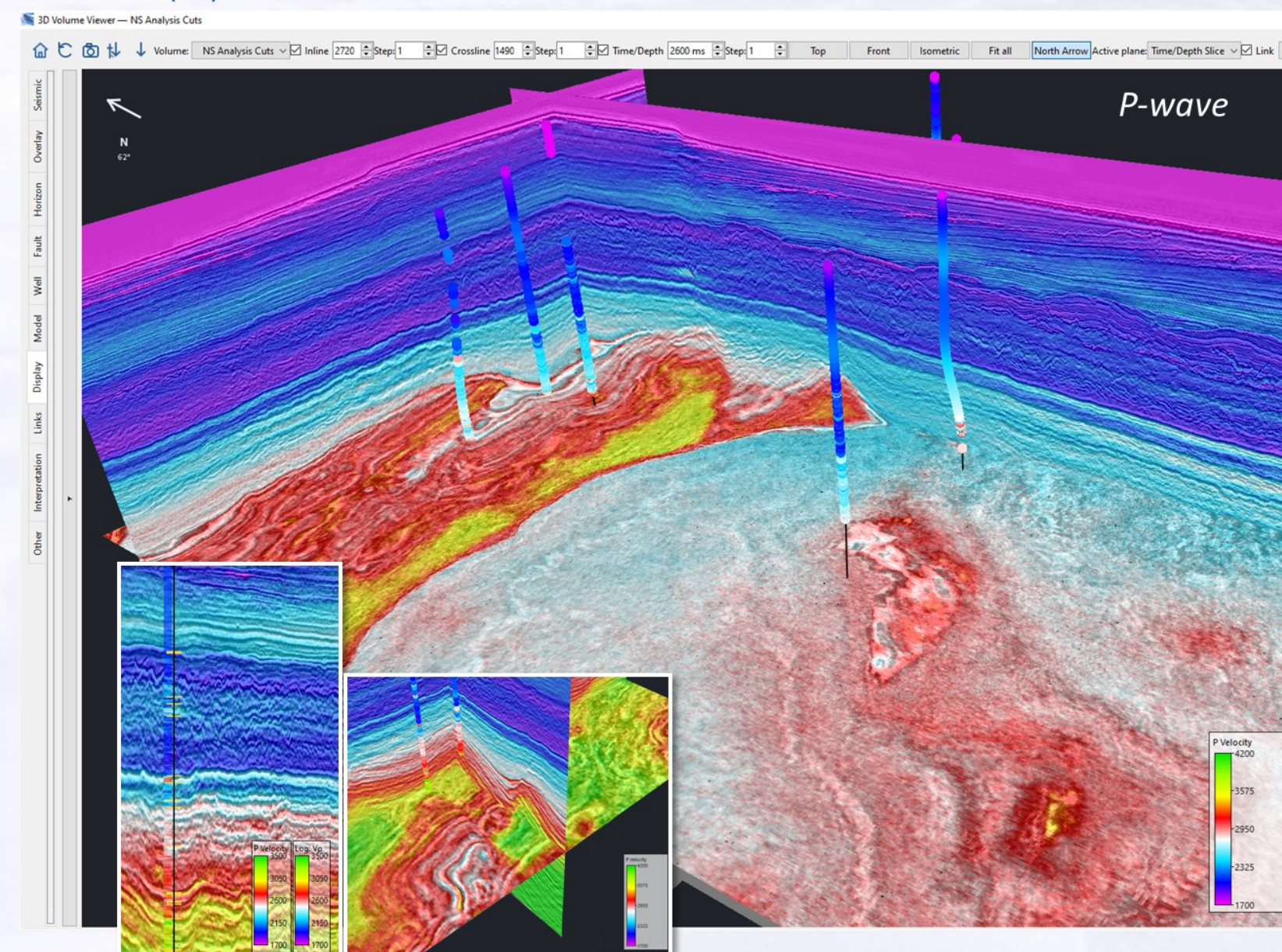


LOGS

PSS-GEO Elastic MP FWI (JMI)



PSS-GEO FWI (JMI)



Full-Wavefield Modelling — Elastic SEM & Acoustic/Elastic FDM

P- and S-waves, PP and PS/SP conversions, primaries, multiples and scattered wavefields.

Full-Wavefield Migration (FWM)

Full-wavefield imaging, including utilisation of multiple-scattered energy within the JMI framework.

JMI / Full-Waveform Inversion — V_p & R_{pp}

Coupled reconstruction of the propagation-velocity model and reflectivity/image.

Elastic JMI / Full-Waveform Inversion — V_p , V_s & Density

Elastic inversion using P-, S- and converted-wave information; extension of the JMI scattering framework to elastic PP/PS information.

PSS-GEO JMI approach: full-wavefield data → iterative reconstruction of propagation properties and reflectivity/image

Acoustic: V_p (FWI) + R_{pp}

Elastic: V_p (FWI) + V_s + ρ , exploiting P-, S- and converted-wave information

Advanced Elastic: V_p + V_s + ρ + R_{pp} + R_{ps}

Rune Inversion — Pre-Stack & Post-Stack

Independent quantitative inversion of full-bandwidth elastic and reservoir-related properties.

PSS~Geo

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