Vector Wave Energy Migratiom (VWEM)

new approach to a universal migration method

[in Tesseral]

$$U_l(M,t)=\frac{1}{4\pi}\int_{\Sigma}\left\{G\left[\frac{\partial u_l}{\partial n}\right]-[u_l]\frac{\partial G}{\partial n}+G\left[\frac{\partial u_l}{\partial t}\right]\frac{\partial \tau}{\partial n}\right\}d\Sigma+\frac{1}{4\pi}\int_{v}[u_l]\nabla^2 G dV$$

Kirchhoff-Sobolev Diffraction Integral

Where:

G – Green function, which respond to wave equation;

τ – time function, which respond to the equation;

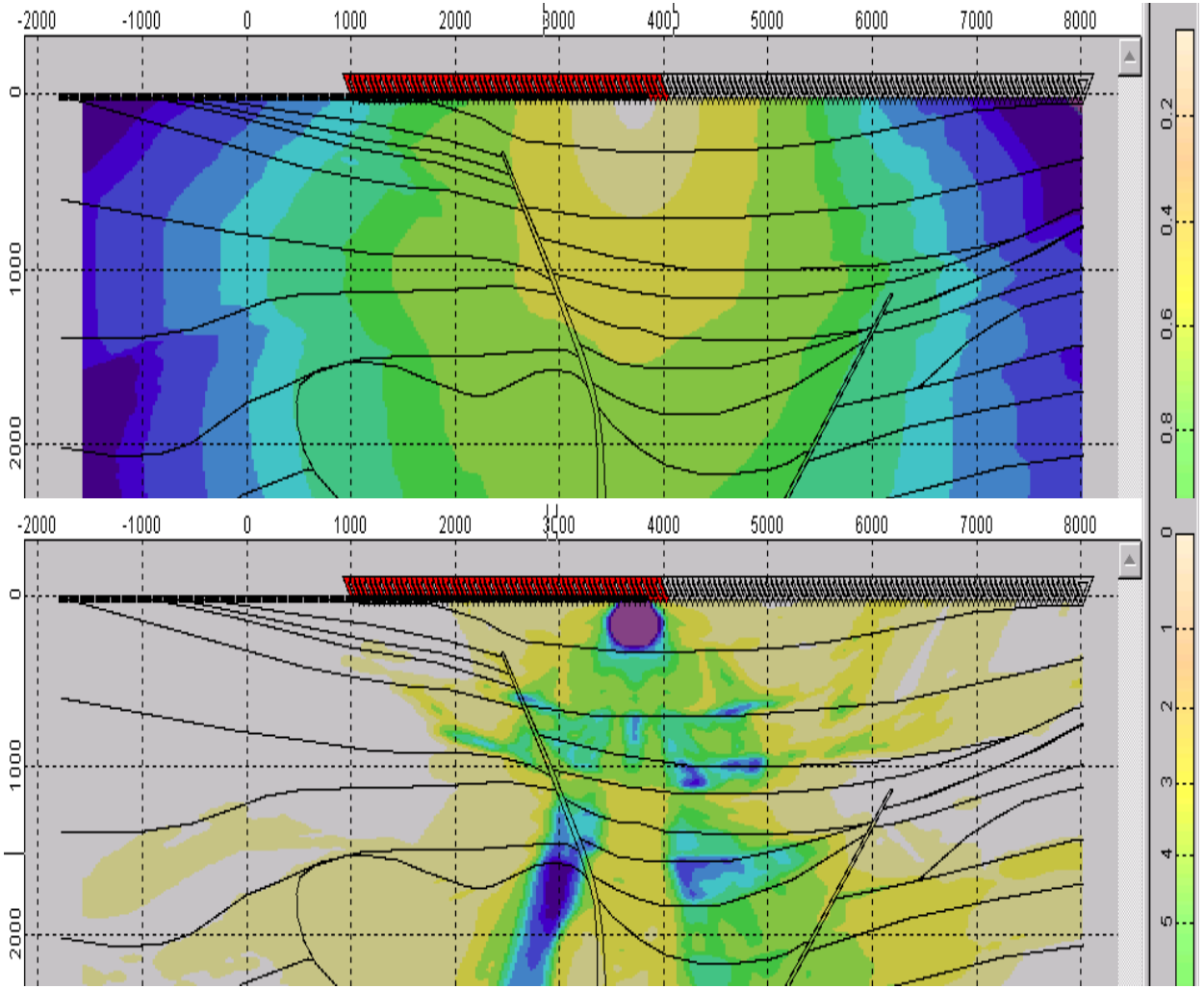
t – time;

n – normal to the integration surface **Σ**.

U_l - wave field component

www.tesseral-geo.com

Example of calculation of a time field and Green function



New capabilities of migration procedures

Hybrid algorithm of Kirchhoff migration based on vector wave equation (VWEM)

Not only P-wave migration operator tunings

First arrival

Maximum energy

Maximum divergence

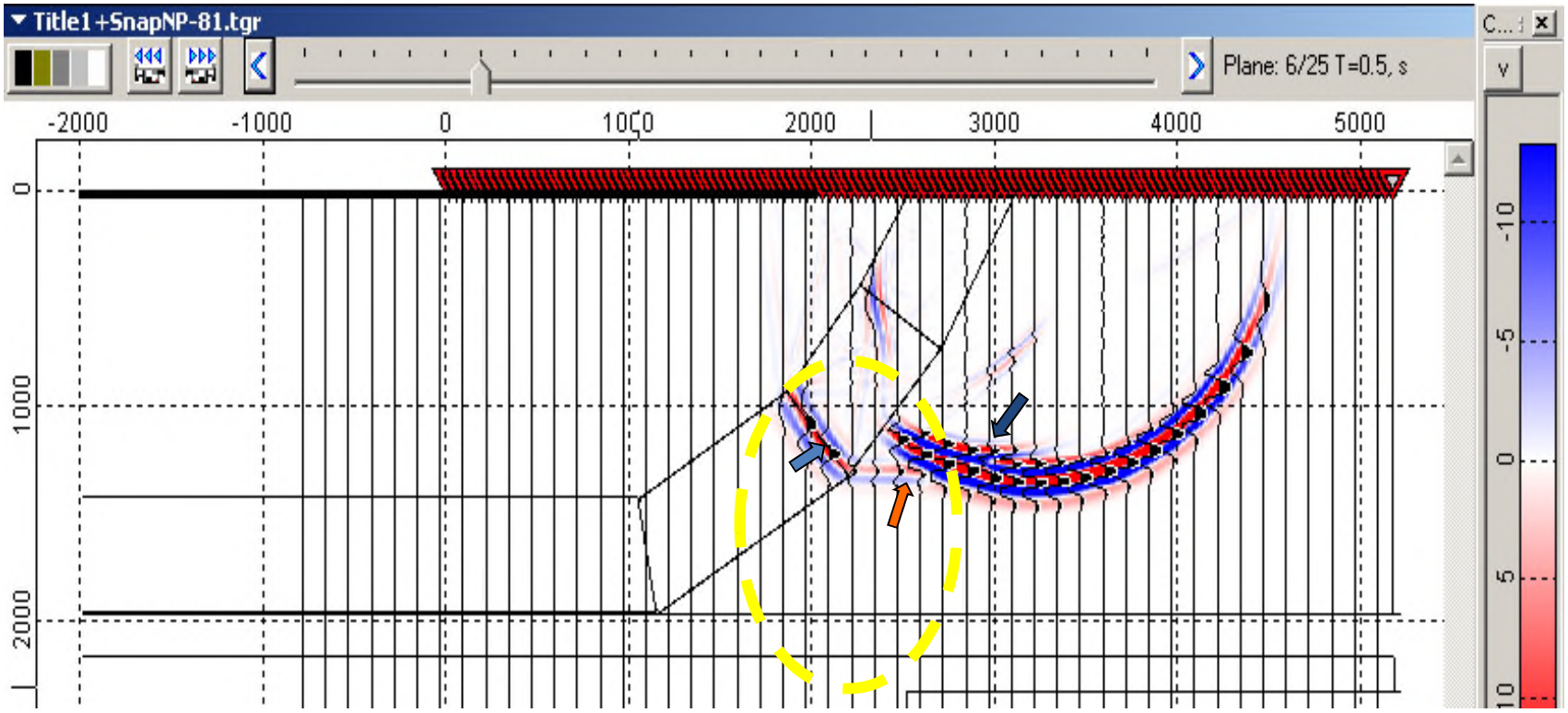
Maximum rotor

Maximum vertical component .. etc….

Macro ↔ micro model

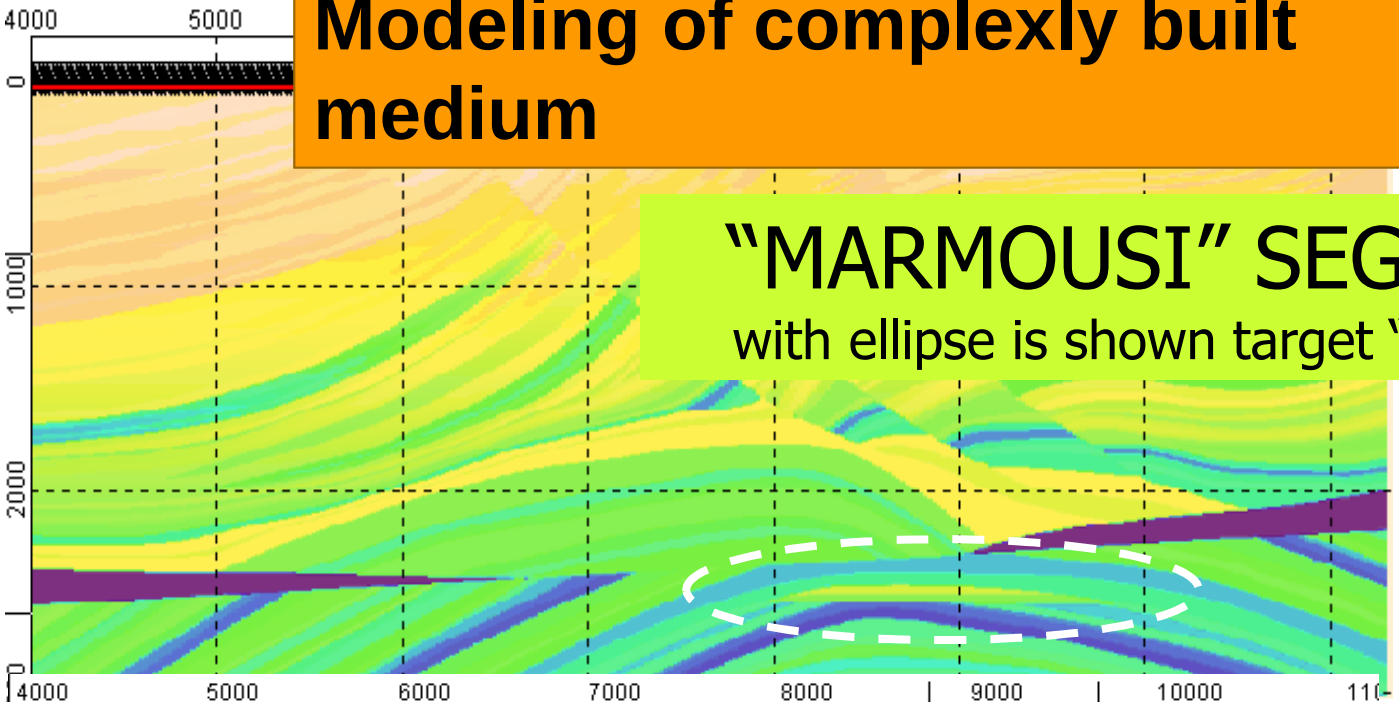
Highly complex anisotropy

Maximum Energy vs First Arrival – multipath problem solutions



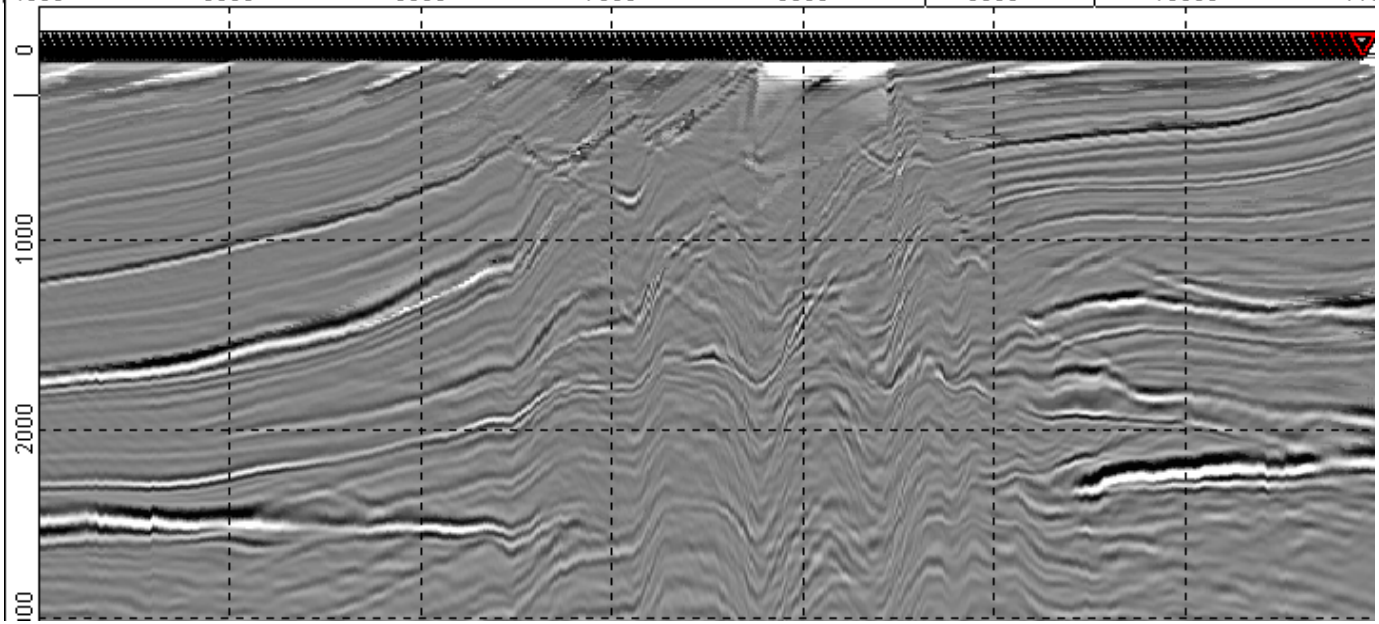
Example of ambiguity in determining time fields for pre-stack depth migration.
In shadow area under high velocity trust wave with much lower energy (red arrow) is coming in first arrivals. High energy wave (**black arrow**) in this area is coming in later arrivals. If this wave is not taken into account **signal/noise ratio** at migration summation is very low.

Modeling of complexly built medium

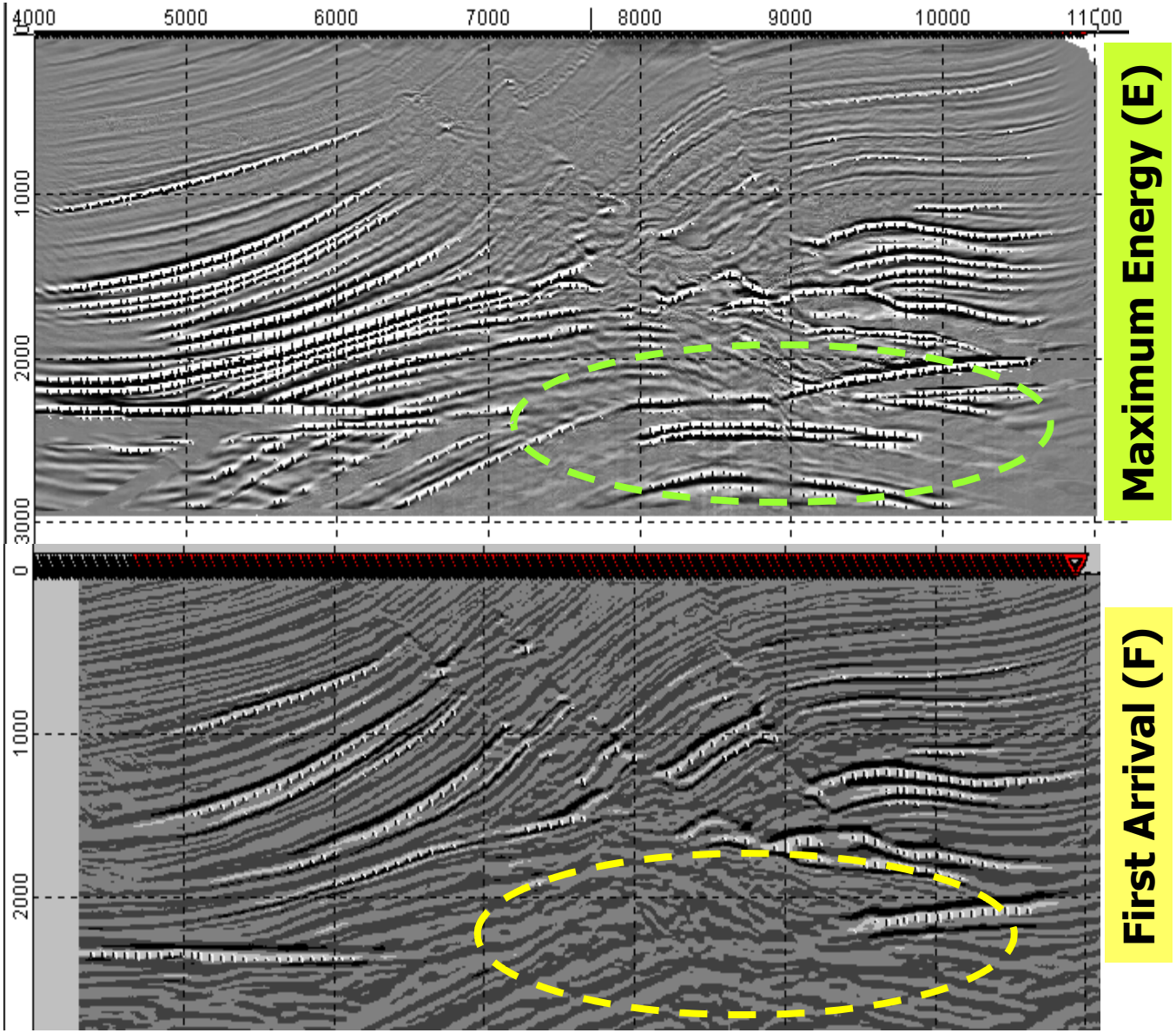


"MARMOUSI" SEGY-Model

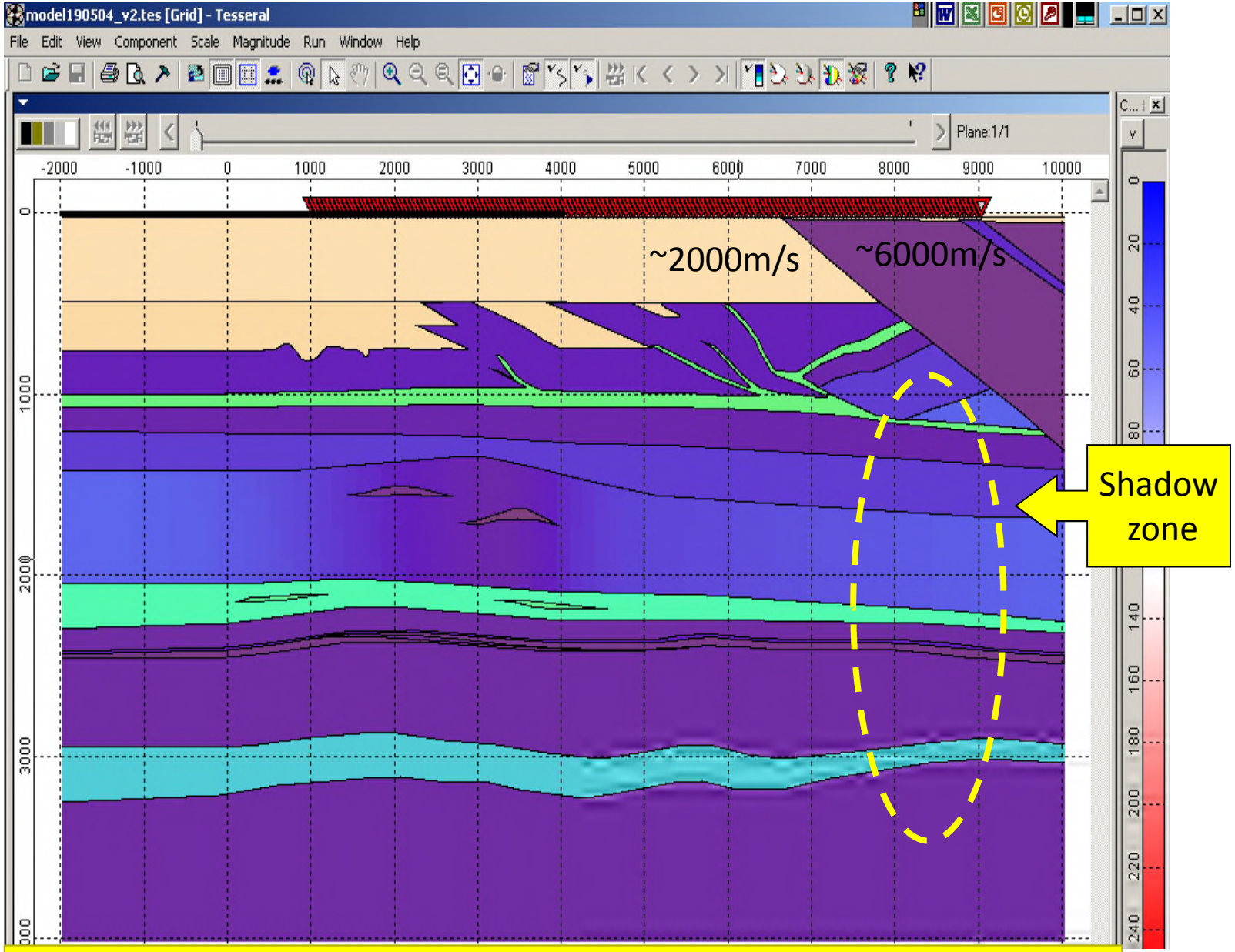
with ellipse is shown target "gas deposit"



Time Pre-stack migration



Migration procedures included in the package allow to check different processing sequence scenarios

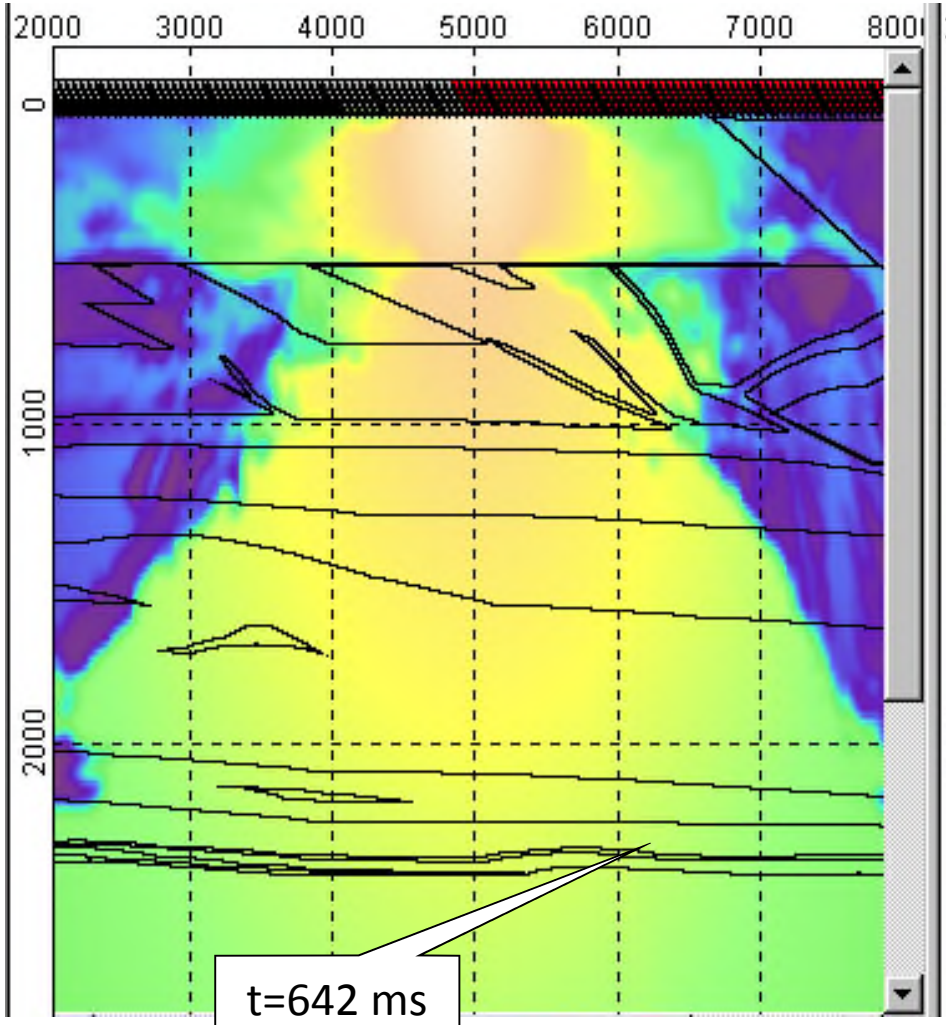


"Carbonate Trust" Velocity Model

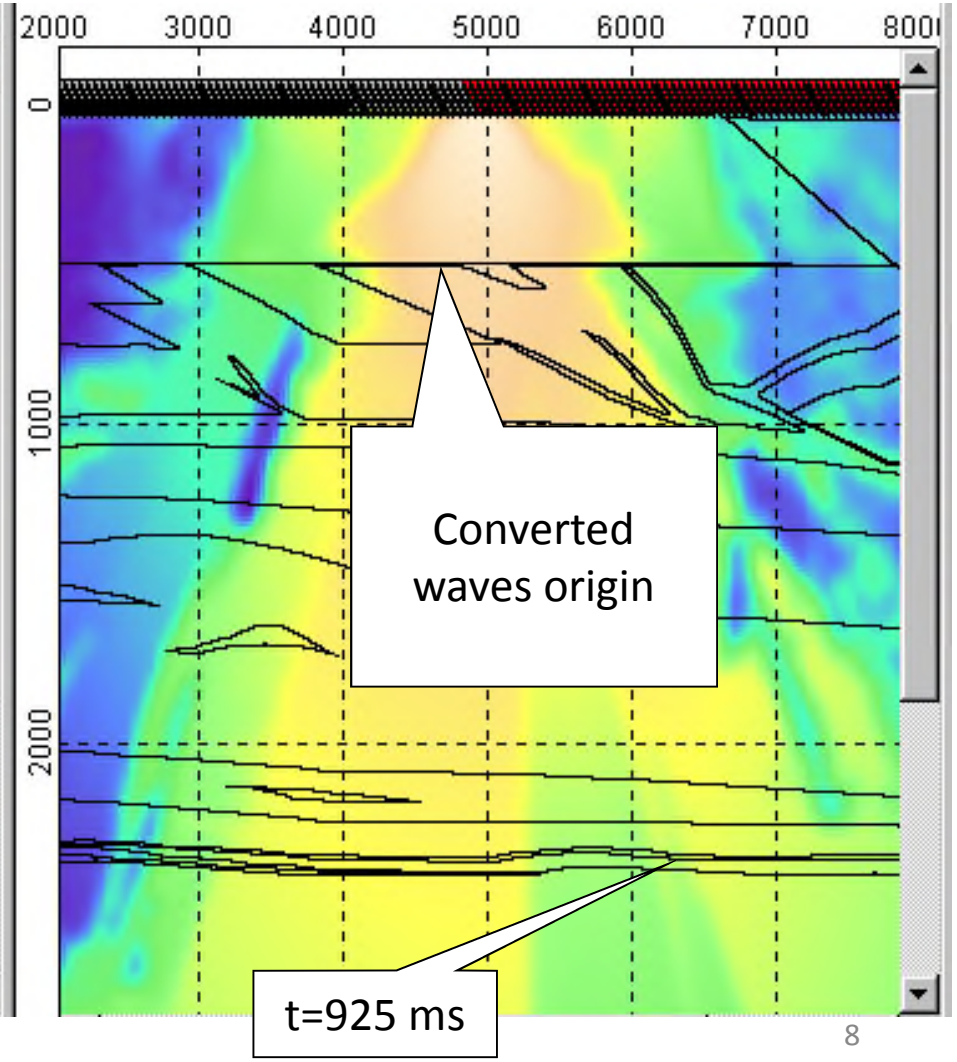
Incident wave timefields (*elastic wave equation*)

(Carbonate Trust) TIMEFIELDS: D^e-operator vs E^e-operator

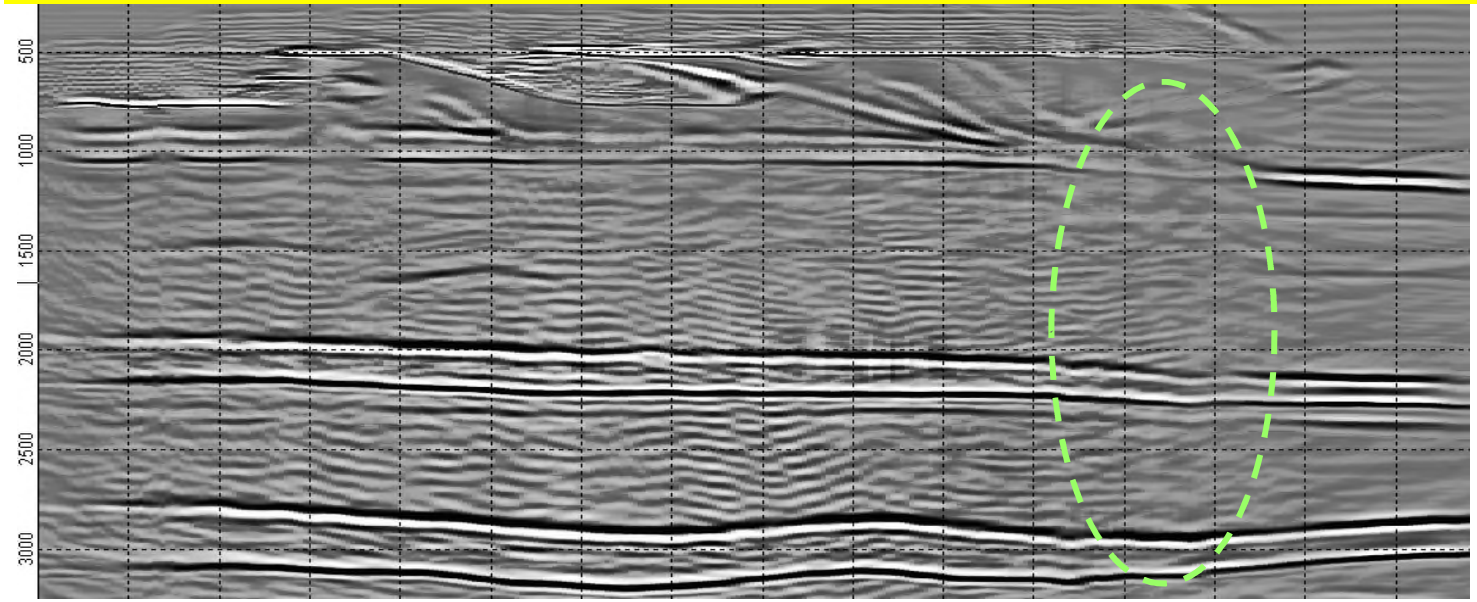
Maximum *Divergence* (D^e)



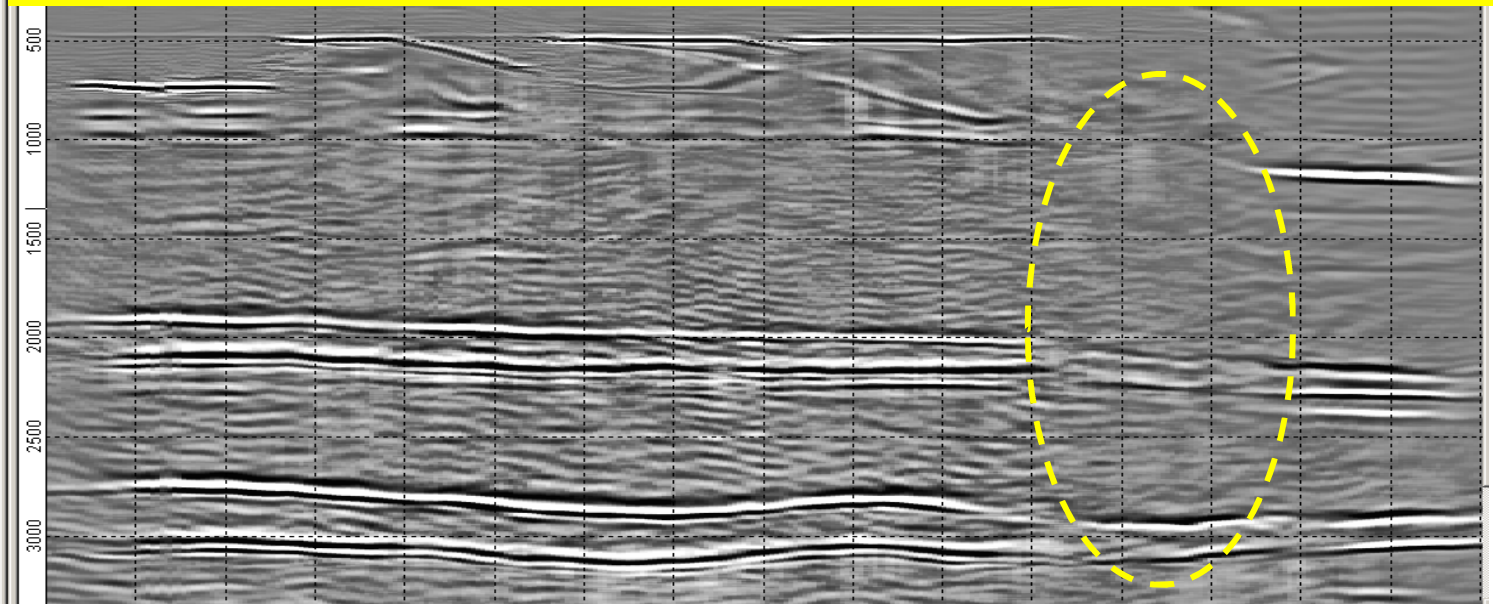
Maximum *Energy* (E^e)



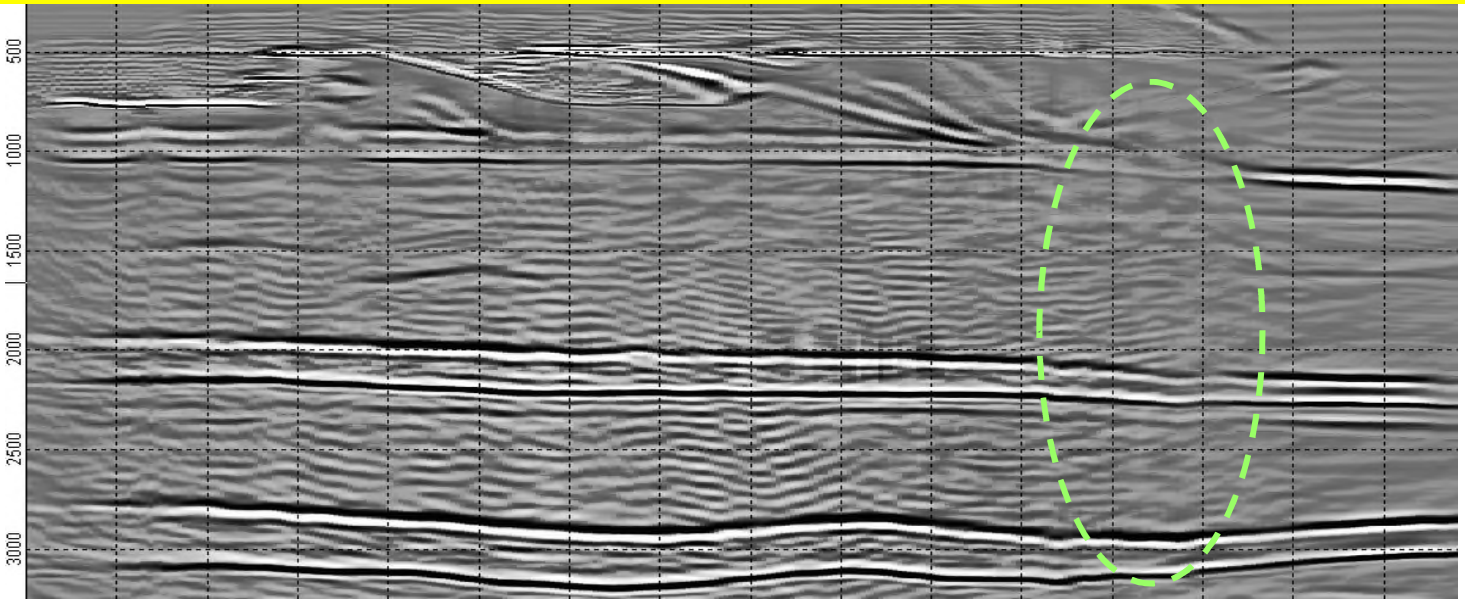
VWEM Maximum *Divergence elastic wave equation* (D^e)



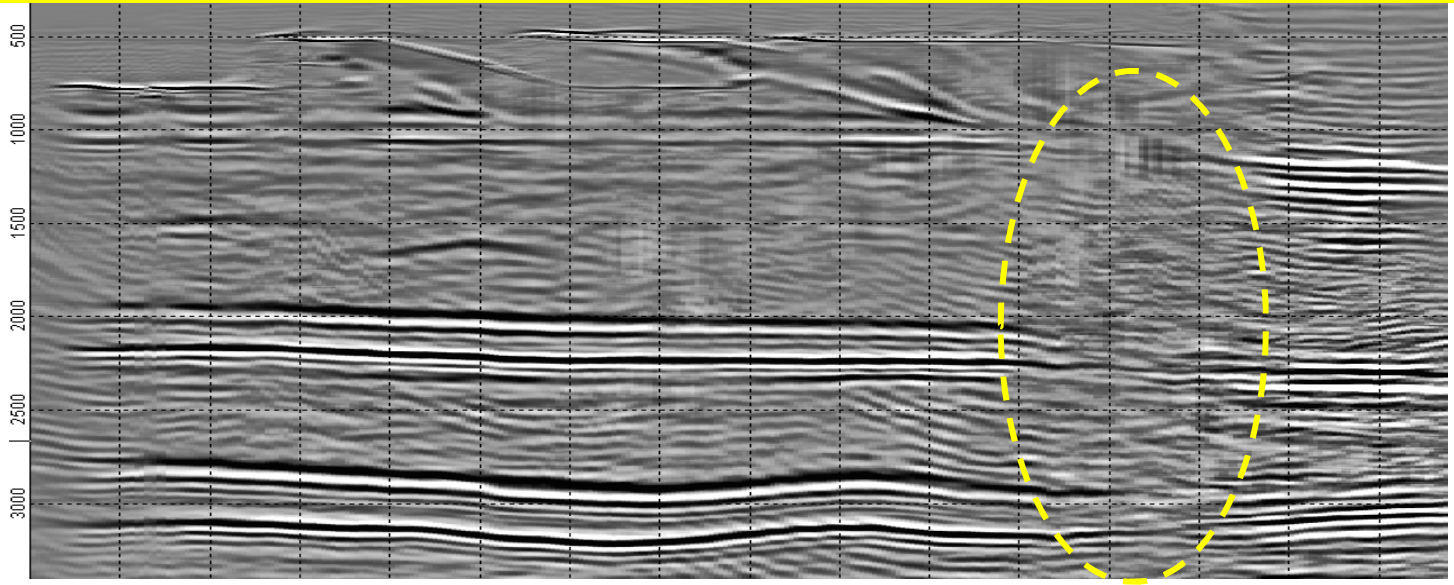
VWEM Maximum *Energy elastic wave equation* (E^e)



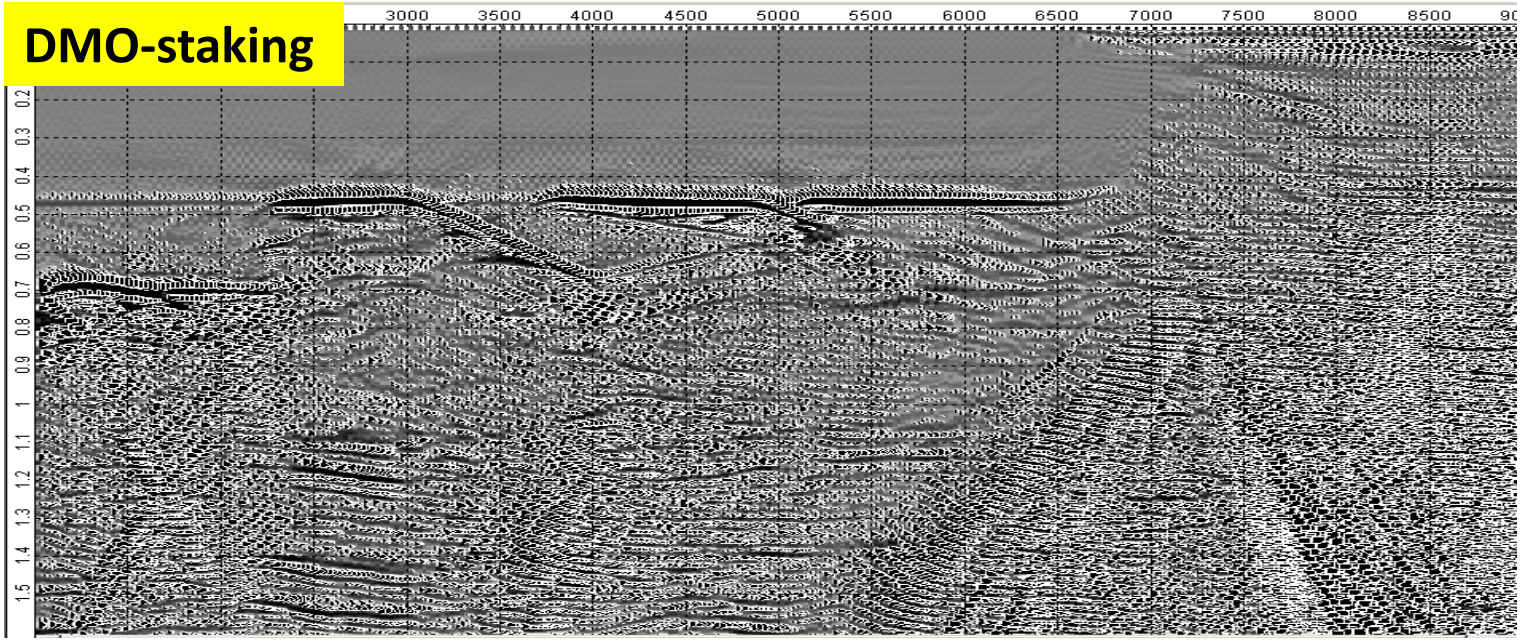
VWEM Maximum *Divergence elastic wave equation* (D^e)



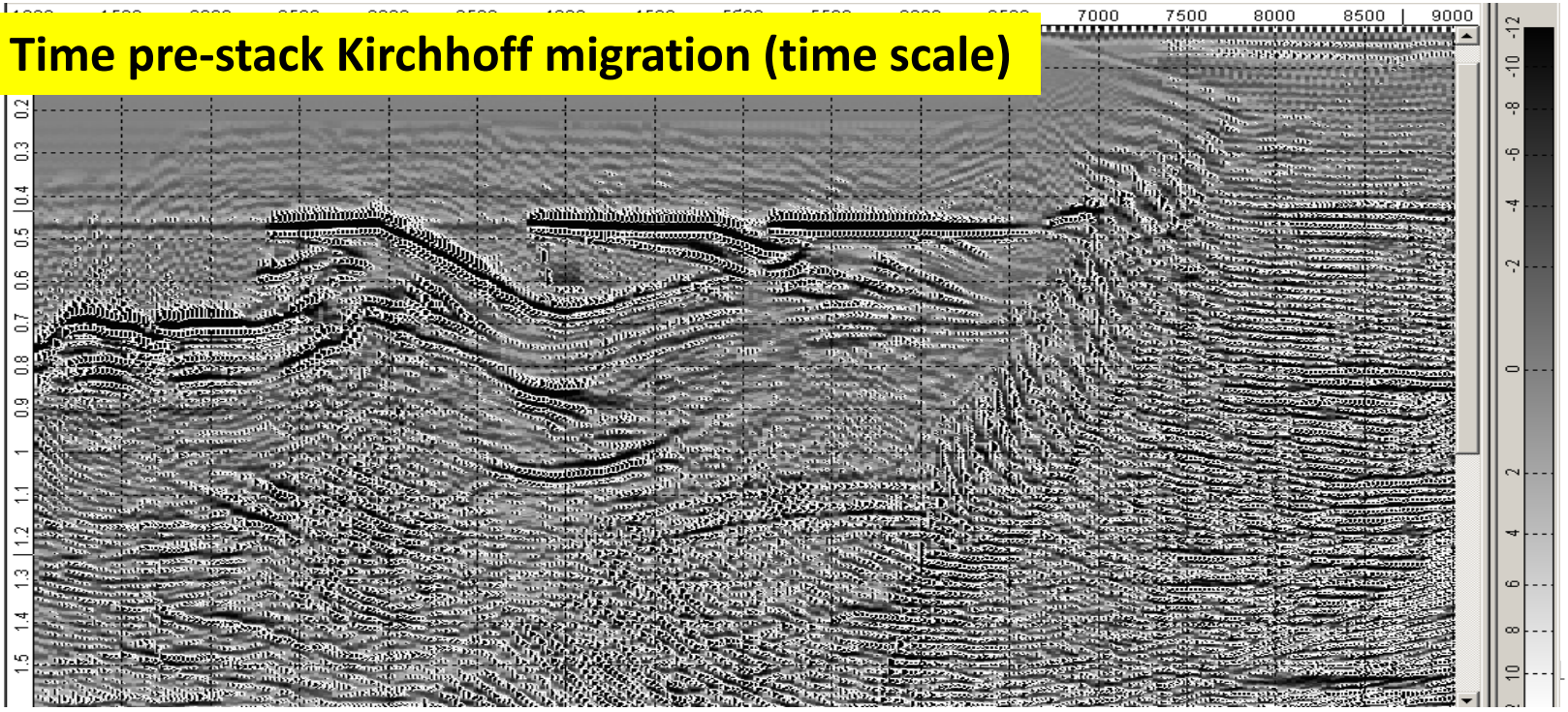
VWEM Maximum *Energy acoustic wave equation* (E^a)



DMO-staking

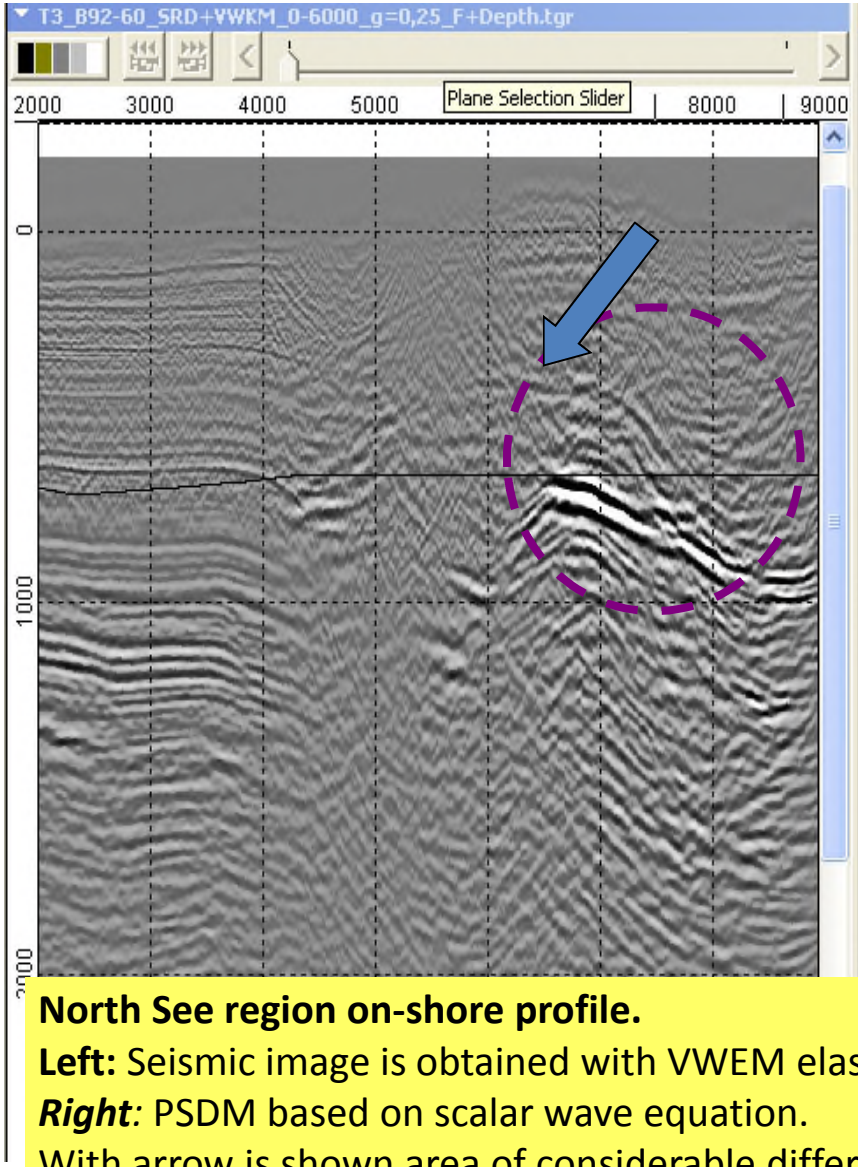


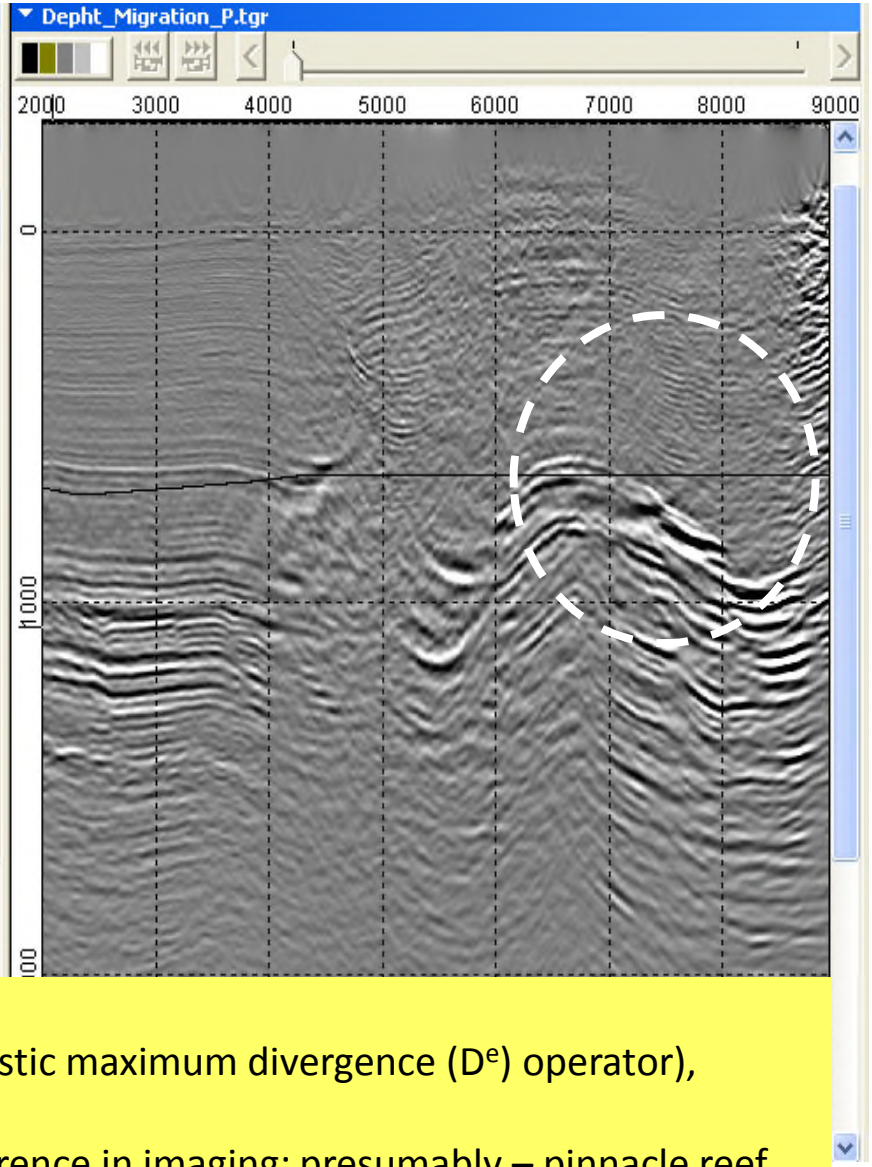
Time pre-stack Kirchhoff migration (time scale)



VWEM (D^E operator)

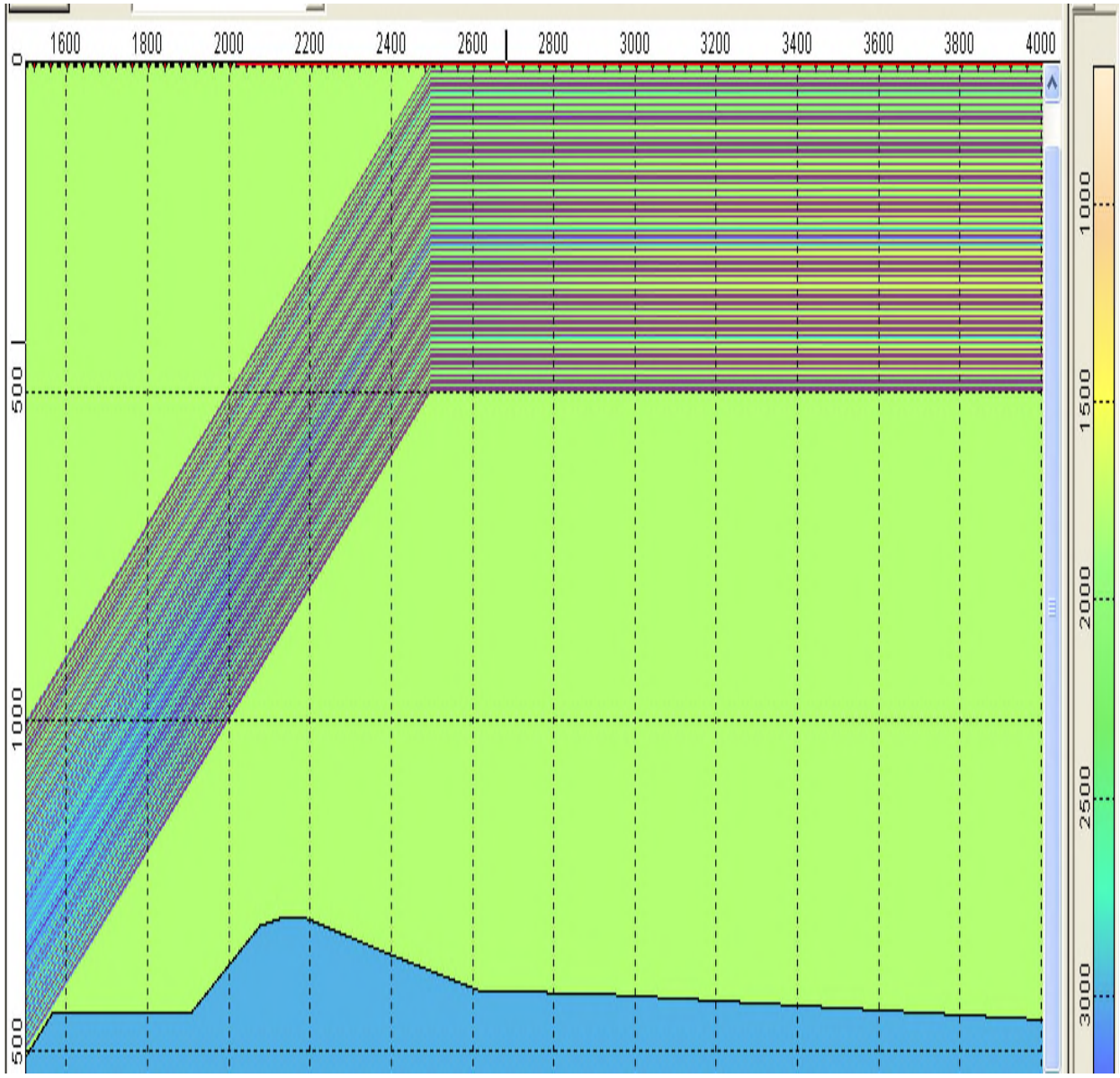
Wave PSDM





North See region on-shore profile.
Left: Seismic image is obtained with VWEM elastic maximum divergence (D^e) operator),
Right*:* PSDM based on scalar wave equation.
With arrow is shown area of considerable difference in imaging: presumably – pinnacle reef

“Where is the reef?” - thin layered variant



Parameters of the thin layers:

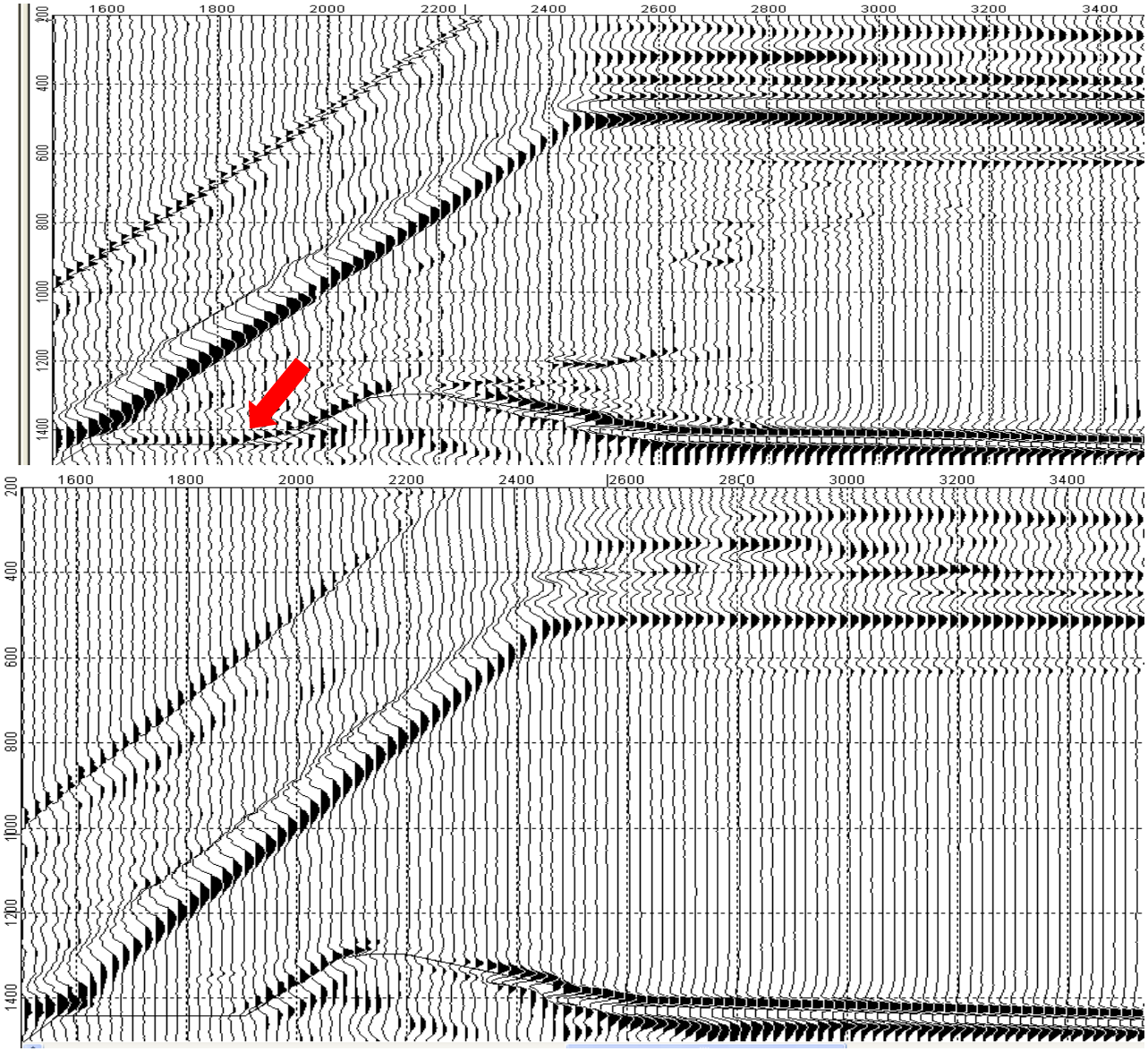
Δh=10 m, λ=60m

α_1=4000 m/s, β_1=2000 m/s, ρ_1=2350 kg/m^3, α_2=2000 m/s, β_2=1150 m/s, ρ_2=2010 kg/m^3, where α, β and ρ are P-wave, S-wave velocities and densities in carbonates and shale, respectively.

Backus’s average parameters are follows:

α_{B}=2470 m/s, β_{B}=1450 m/s, ε=0.32, δ=0.03.

Thin-layered «Where is the reef?» VWKM IMAGING (V^e-operator)

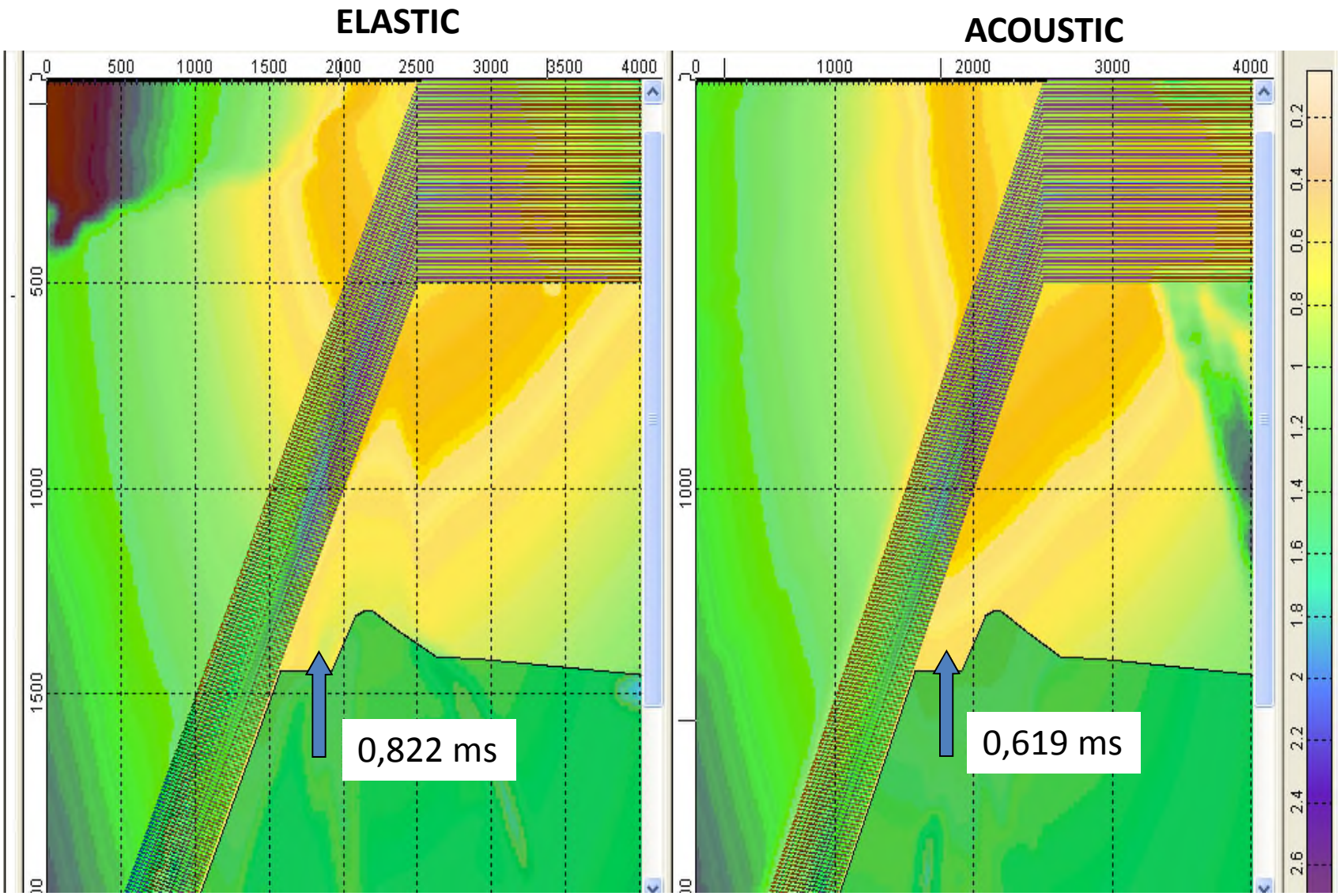


VWKM: Maximum *Vertical* Component (*elastic* wave equation)

VWKM: Maximum *Vertical* Component (*acoustic* wave equation)

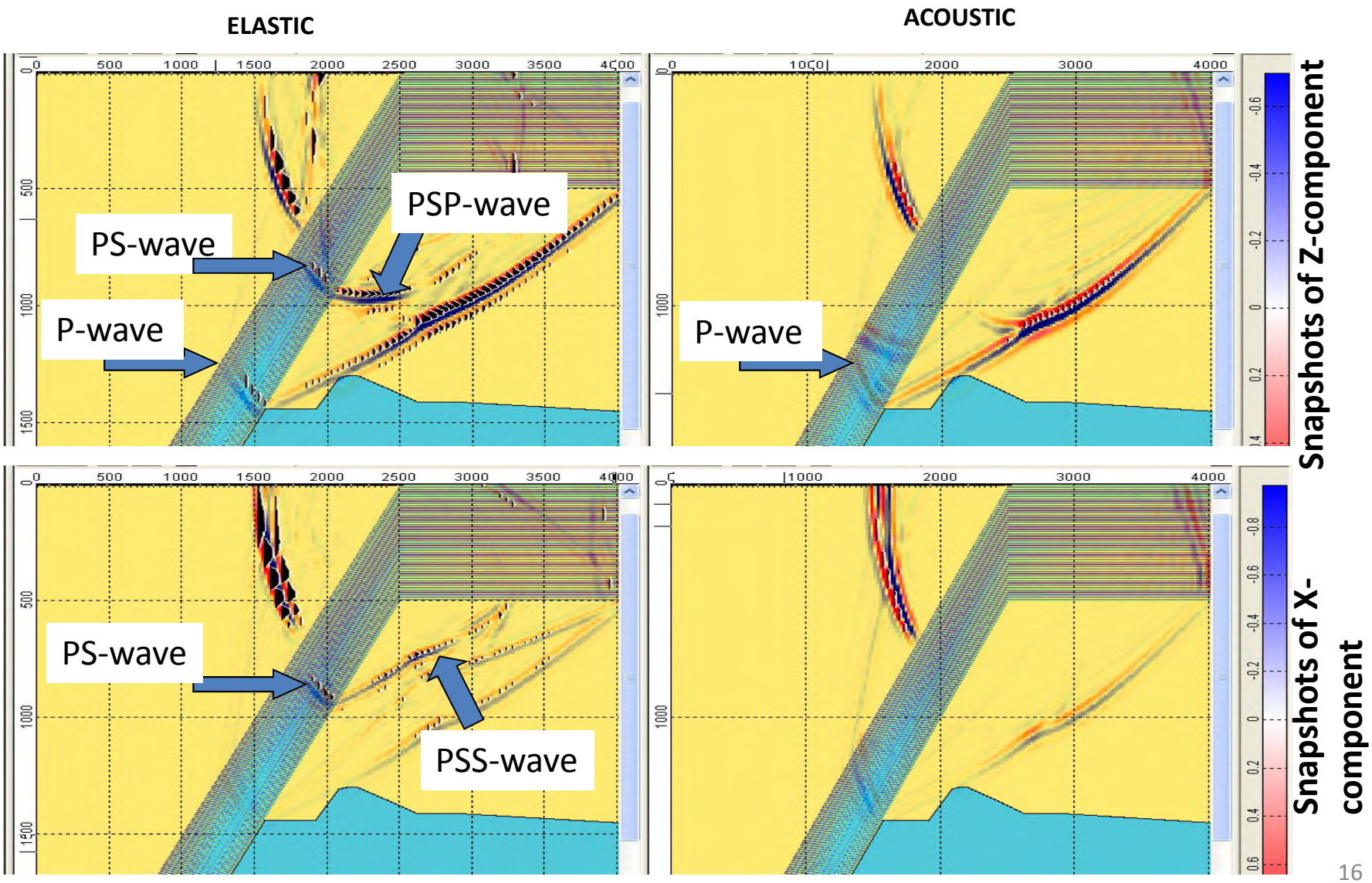
Thin-layered «Where is the reef?»

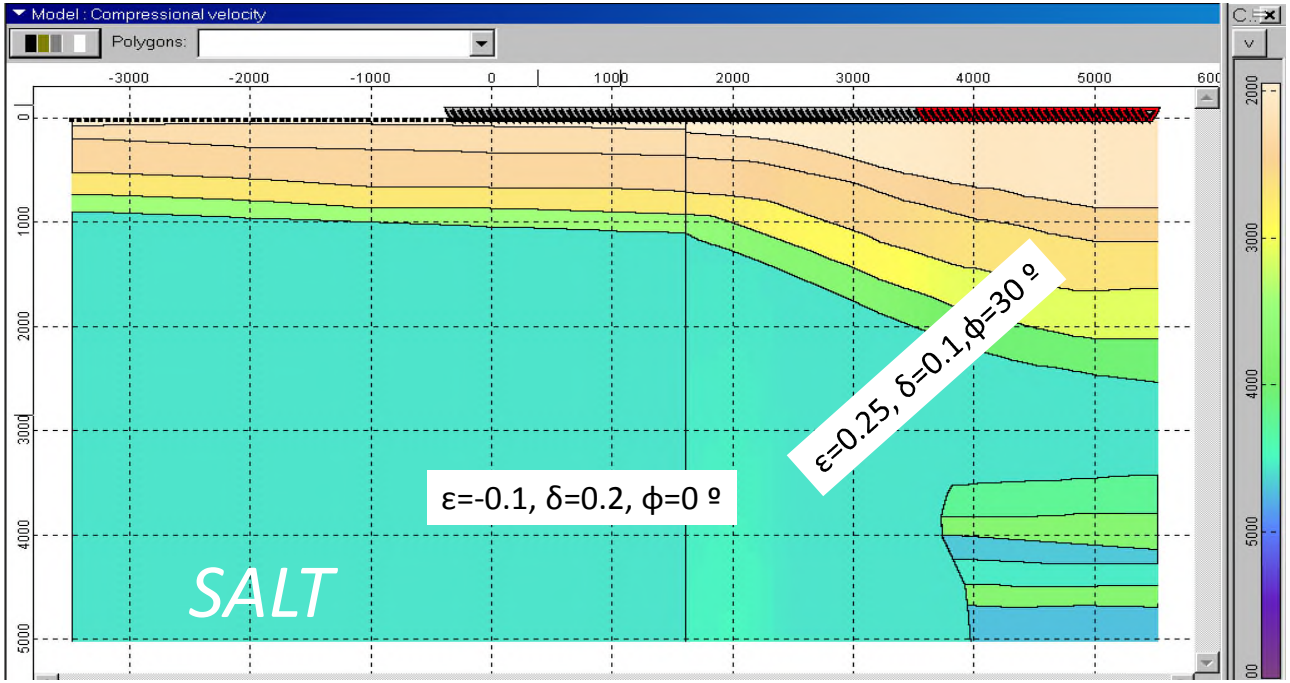
Time Fields for Maximum *Vertical* Component



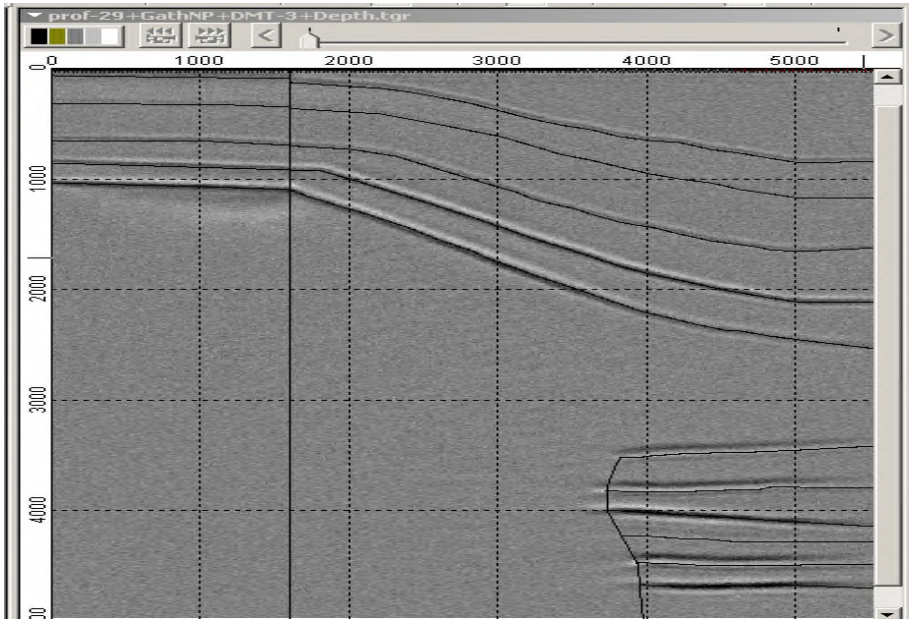
Thin-layered «Where is the reef?»

Snapshots of Elastic and Acoustic Waves

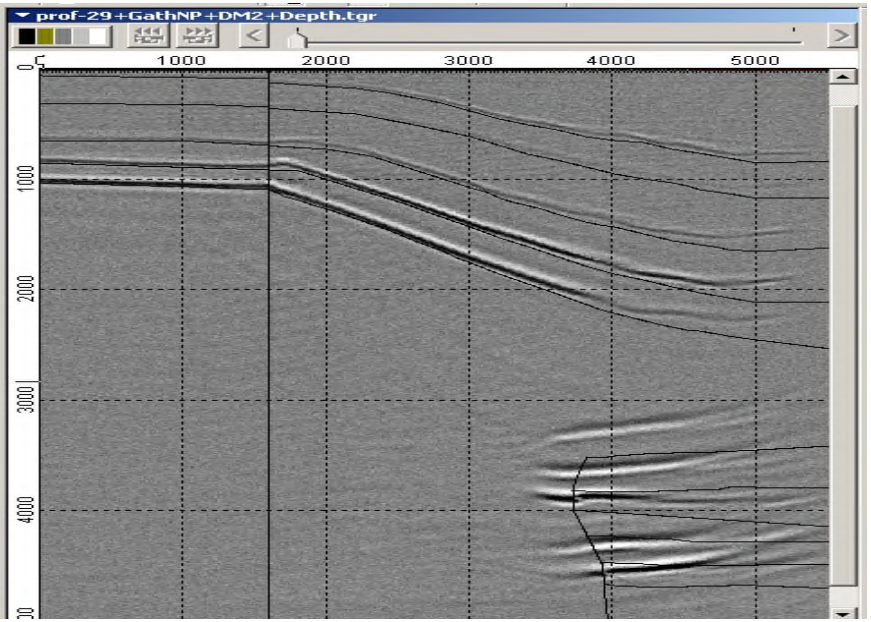




Velocity model along profile D29 (Ukraine)

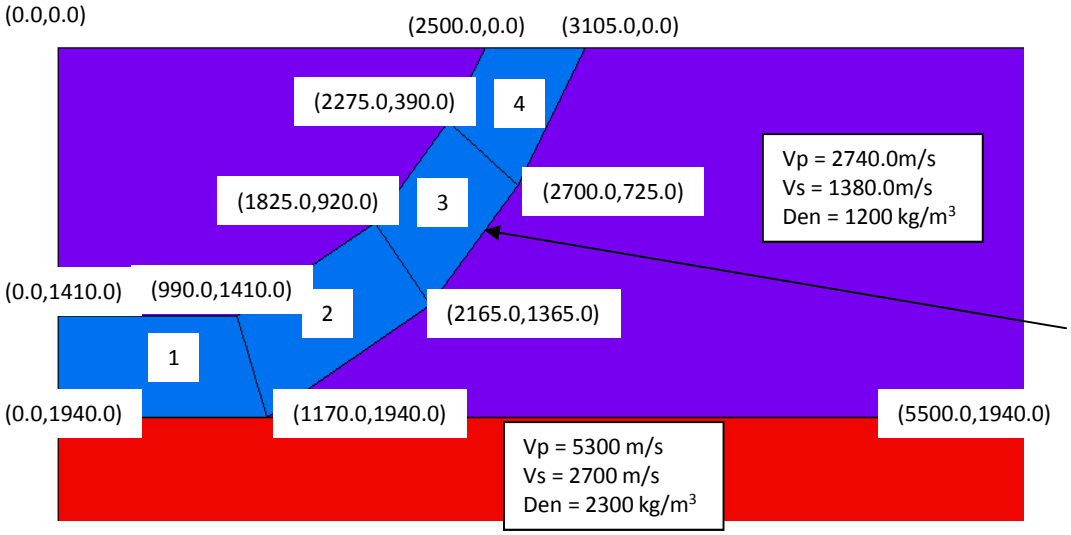


Taking anisotropy into account



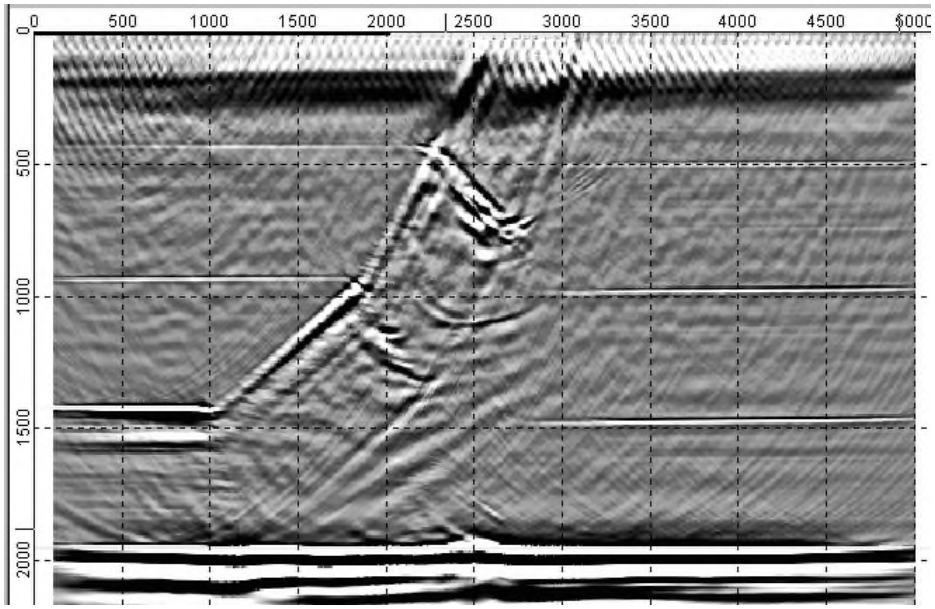
Not taking anisotropy into account

Physical model of anisotropic thrust by Lauton

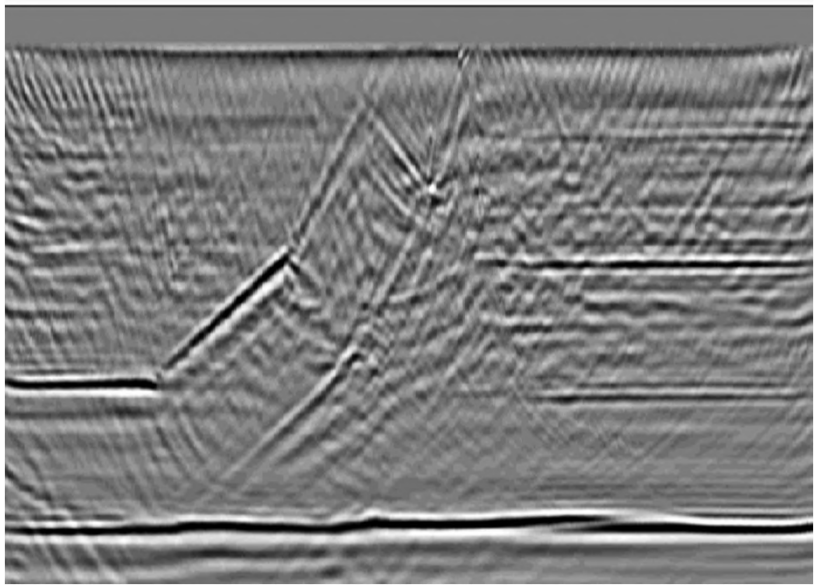


Anisotropic blocks: V_{p0} = 2875 m/s; V_{s0} = 1450m/s; Den = 1740 kg/m3
epsilon = 0.22; delta = 0.10

Dips: Block 1 = 0; Block2 = 30.43; Block3 = 49.67; Block4 = 60.10



VWKM



PSDM (Veritas)

SUMMARY

Review of current challenges in migration processing

migration algorithms	Steep boundary angles	Strong lateral velocity variations	Topography	Rough seismic boundaries	Non-uniform shot point / receiver intervals	True amplitudes	Multipath operator	Solid Earth model (P/S/PS waves, true X,Z,Y component)	Highly complex anisotropy	Macro/ micro model
VWEM	+	+	+	+	+	+	+	+	+	+
Two - Way Shot-Domain Prestack Imaging	+	+	+	-	-	+	-	-	-	-
One-Way Shot-Domain Prestack Imaging	-	+/-	-	-	-	+	-	-	+/-	-
One-Way Survey Sinking	-	+/-	-	-	-	+	+	-	+/-	-
Prestack Gaussian-beam depth migration	-	+	+	-	-	-	+	-	+/-	-

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EAGE 67th Conference and Exhibition, Madrid, 2005.

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