

Seismic Full Waveform Inversion (FWI)

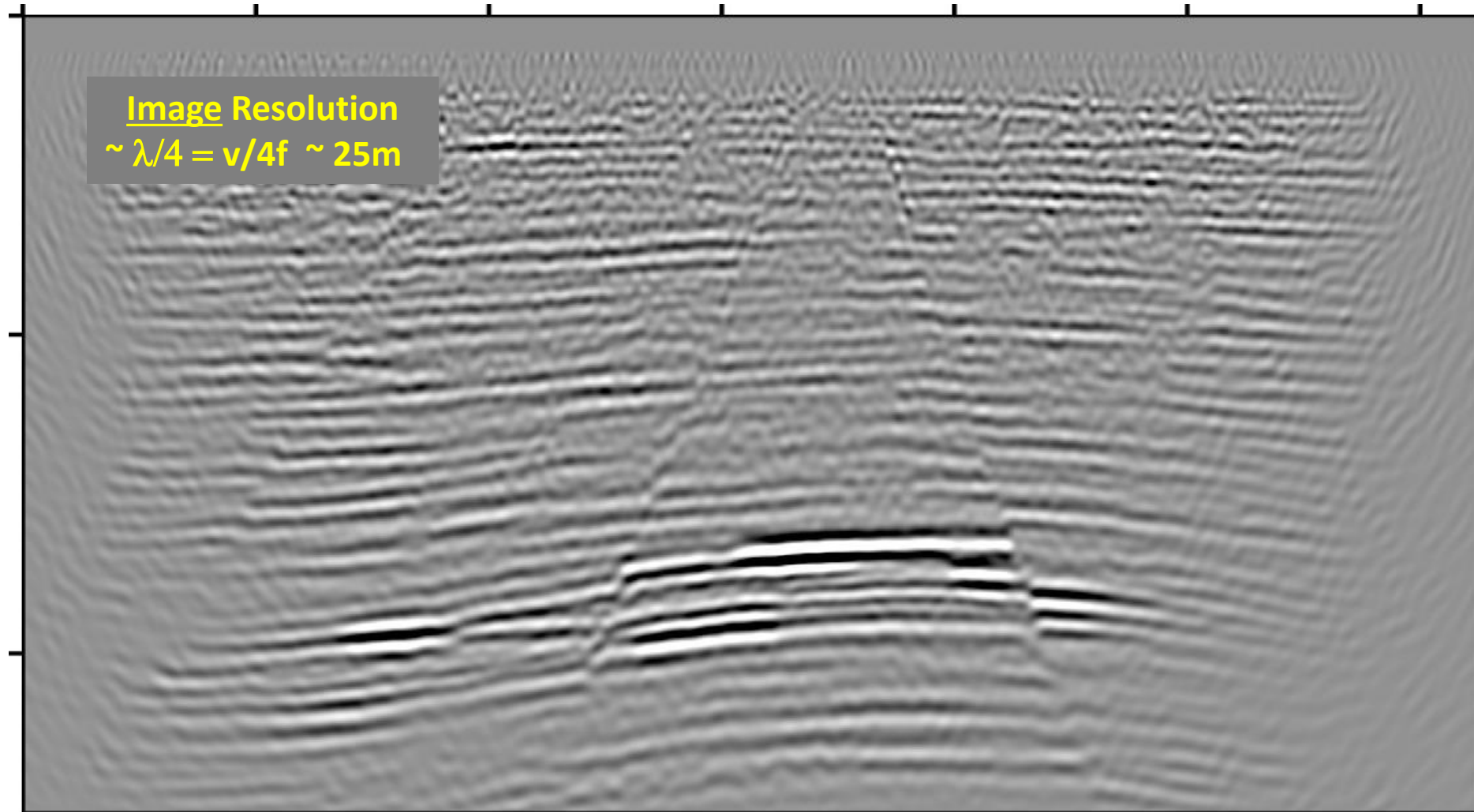
can help improve understanding of SZ geology, geophysics, fluid flow, geomechanics...

Prof. David Lumley et al.

*Cecil and Ida Green Endowed Chair in Geophysics
Dept Head, The University of Texas at Dallas*

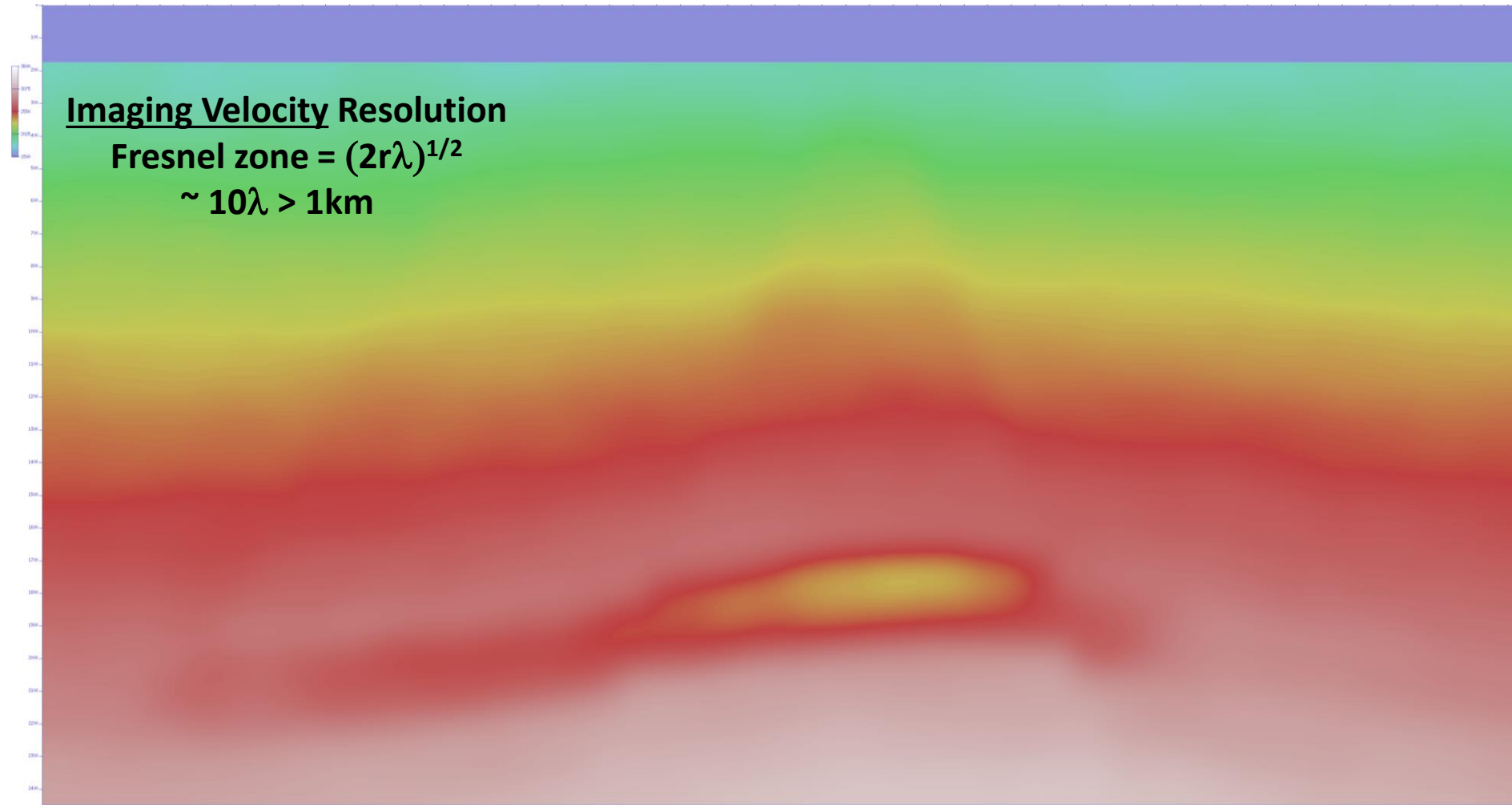
CRESCENT workshop Oct 27 2025

Seismic Image $\sim \lambda/4$

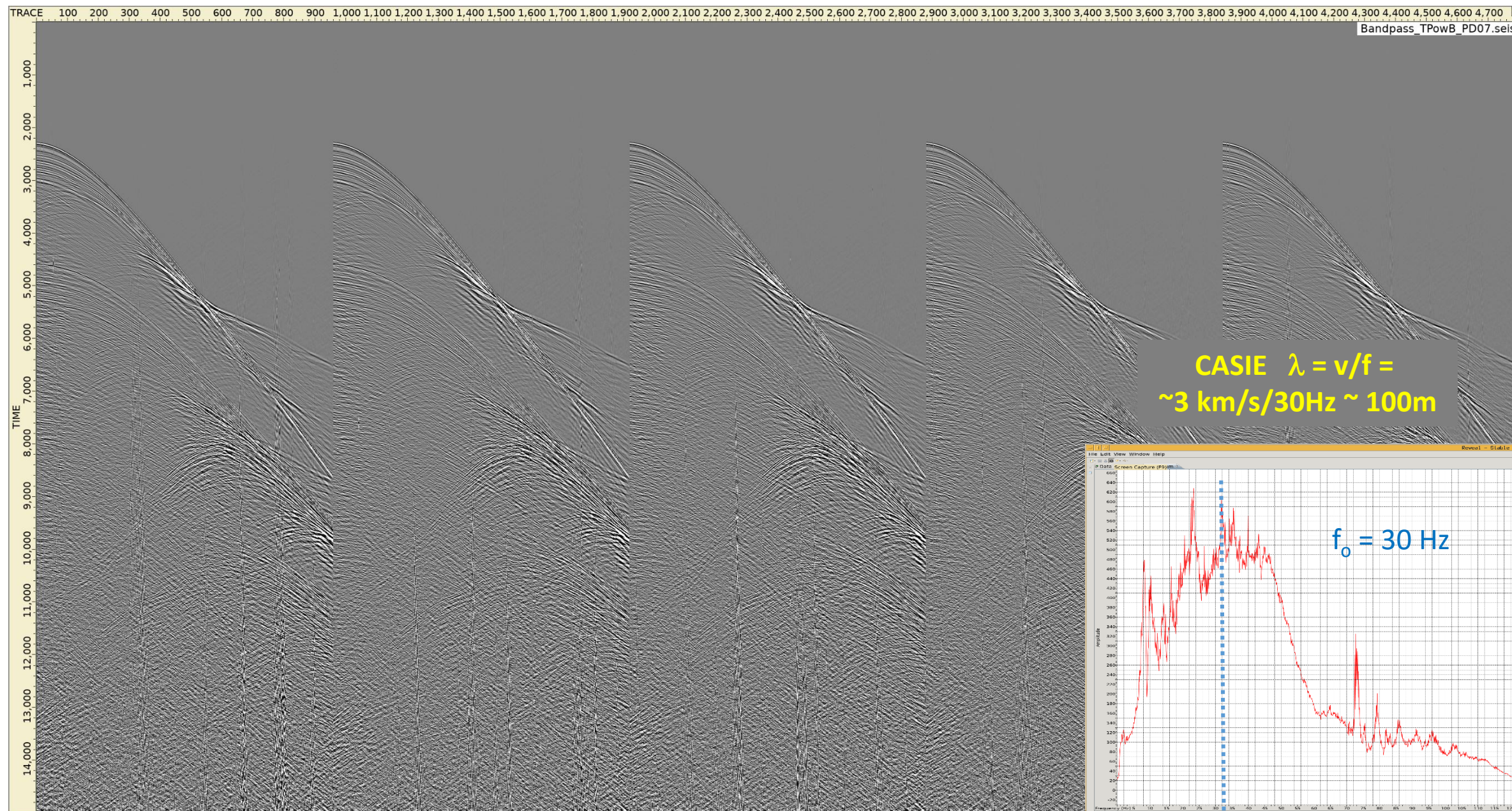


Zhou & Lumley, 2018

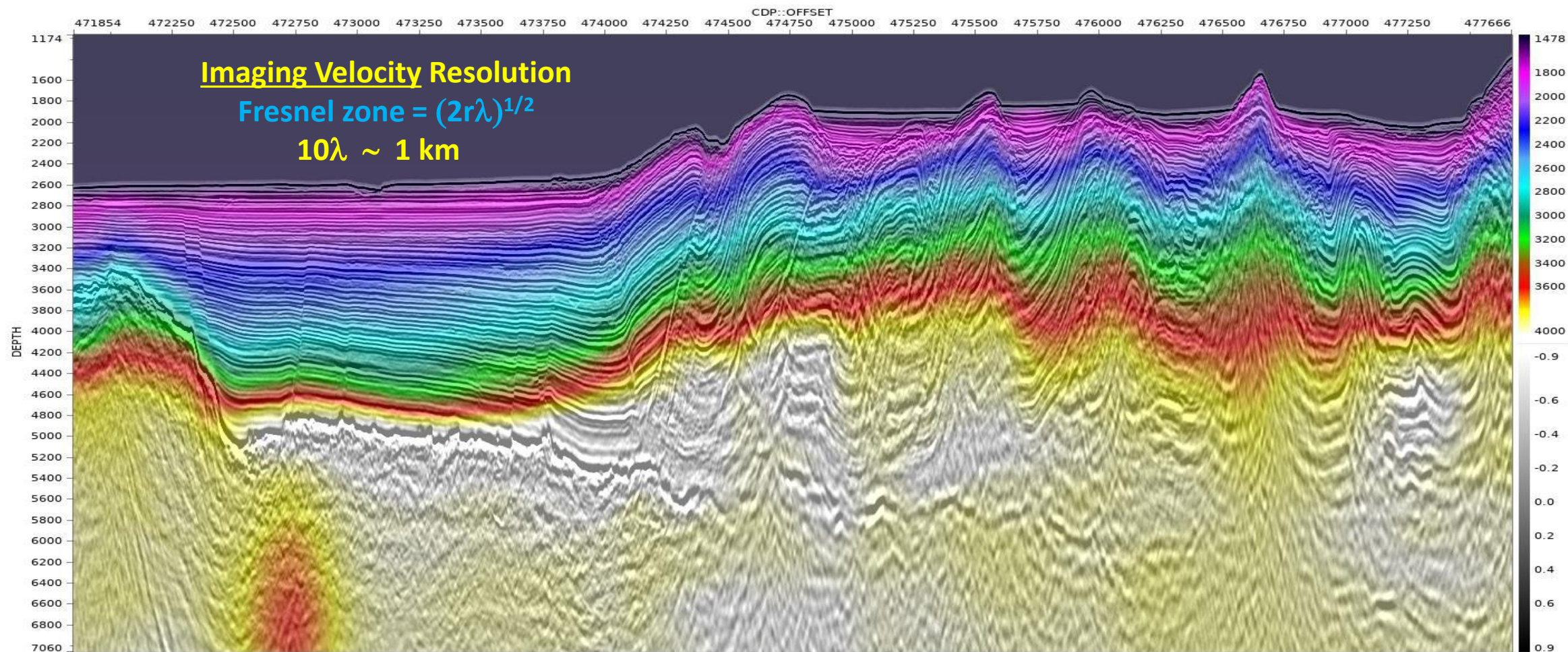
IMAGING Velocity Model $\sim 10\lambda$



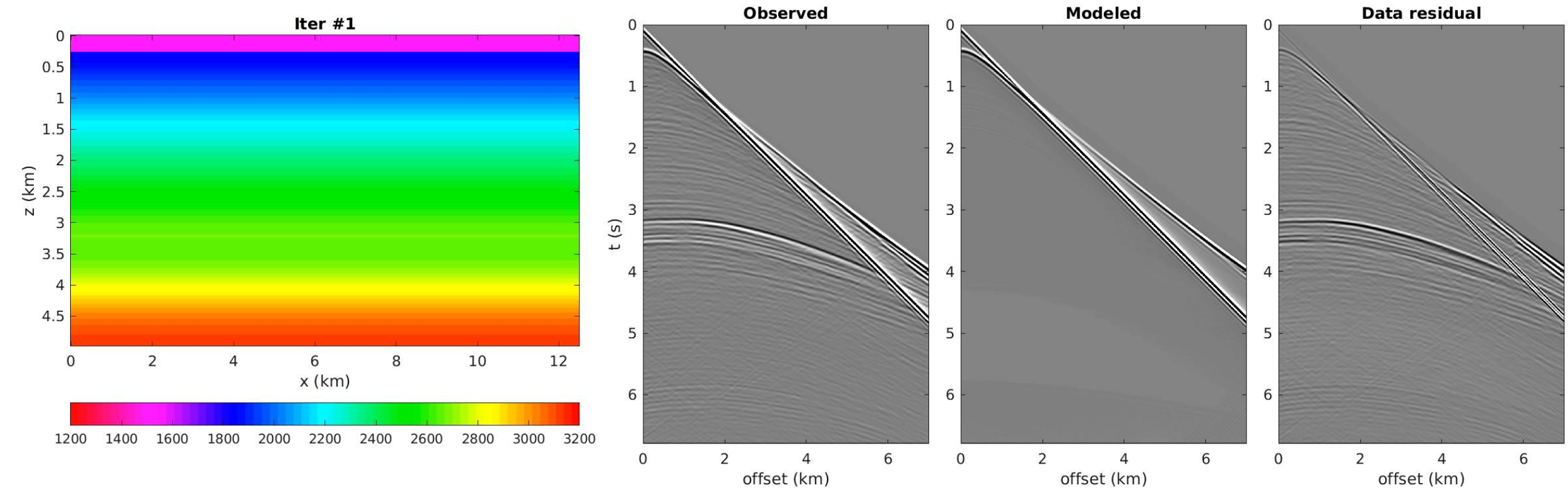
CASIE21 Line PD07 Shot Gathers



CASIE21 Line PD08

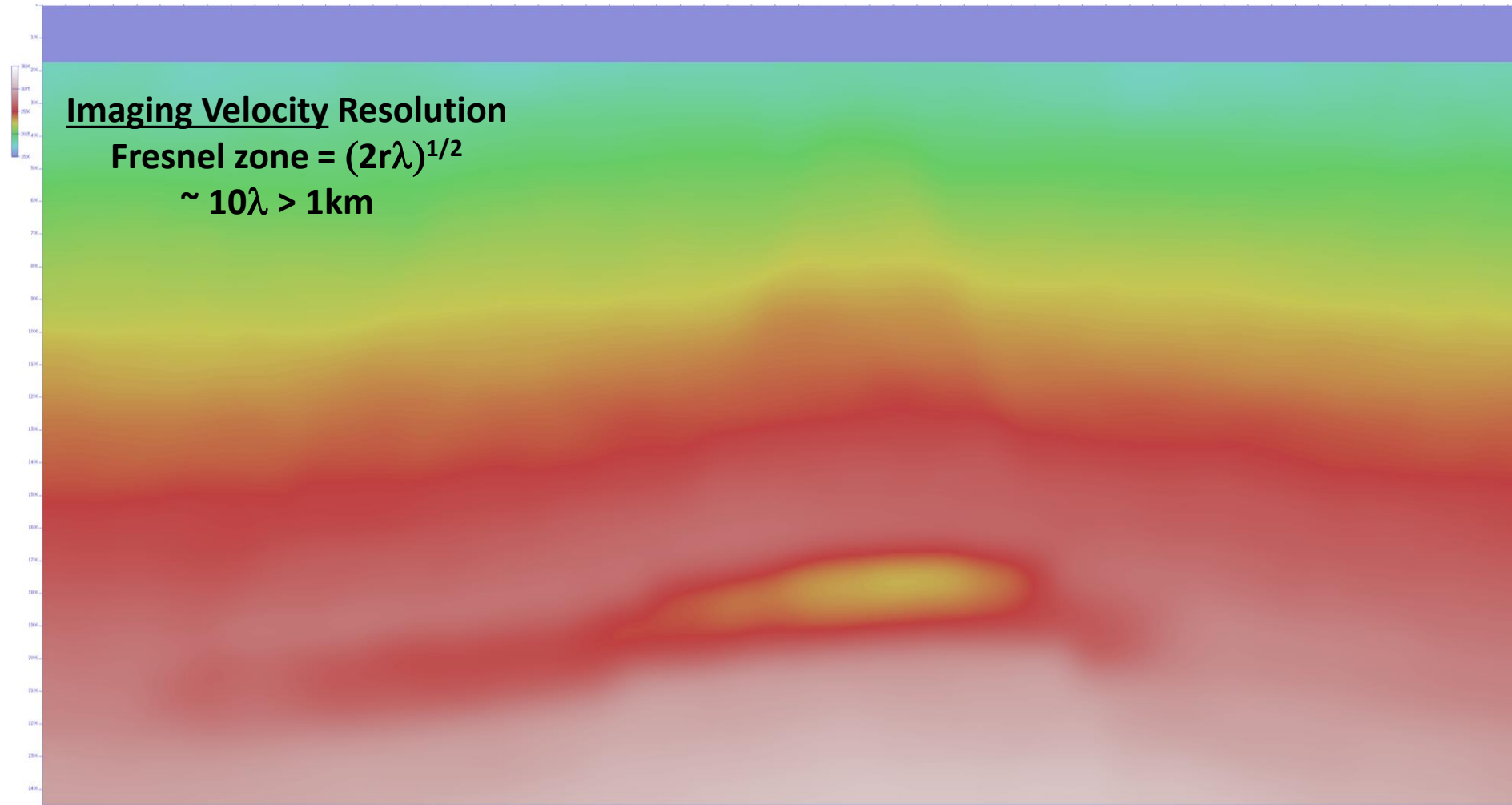


Full Waveform Inversion – FWI movie

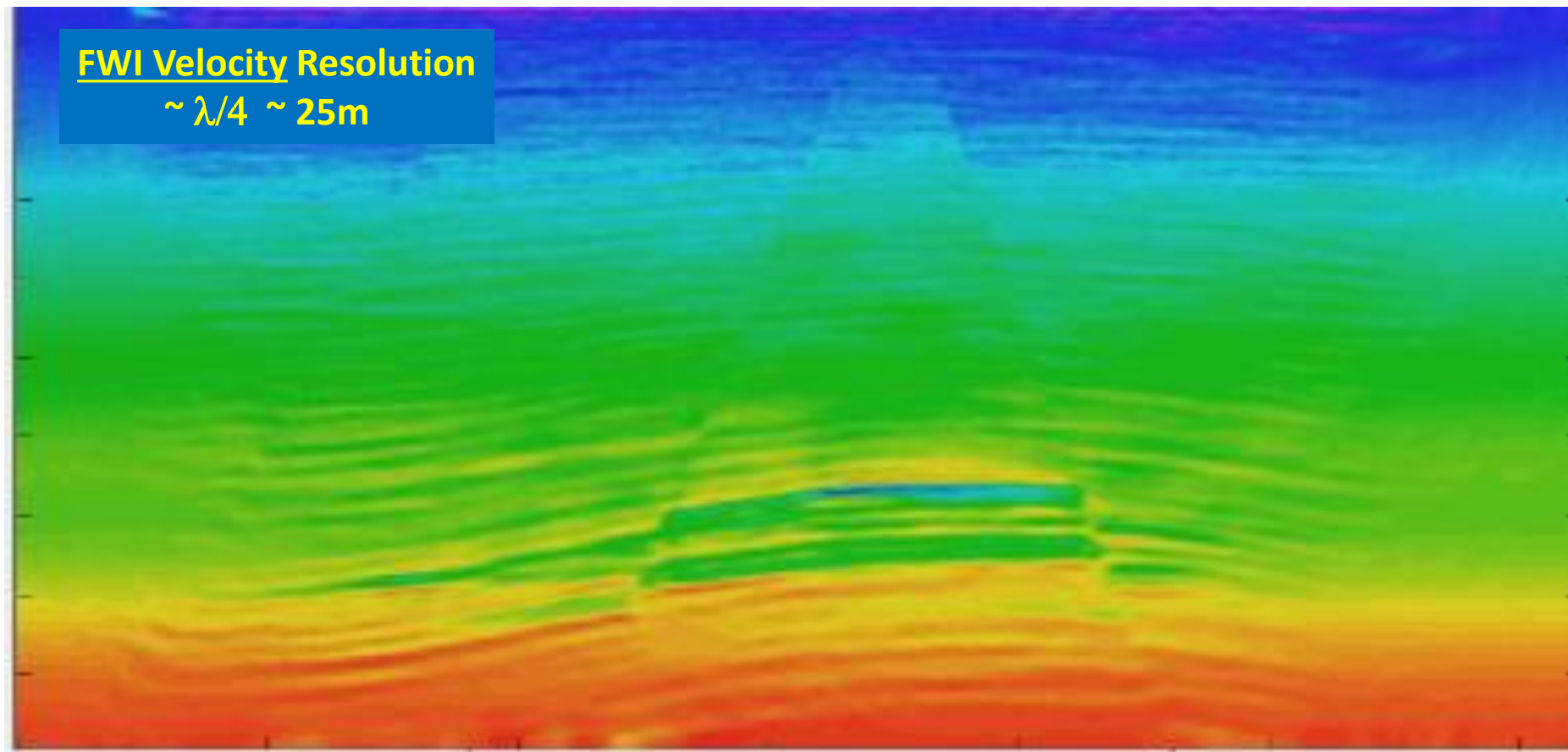


Zhou & Lumley, 2018

IMAGING Velocity Model $\sim 10\lambda$

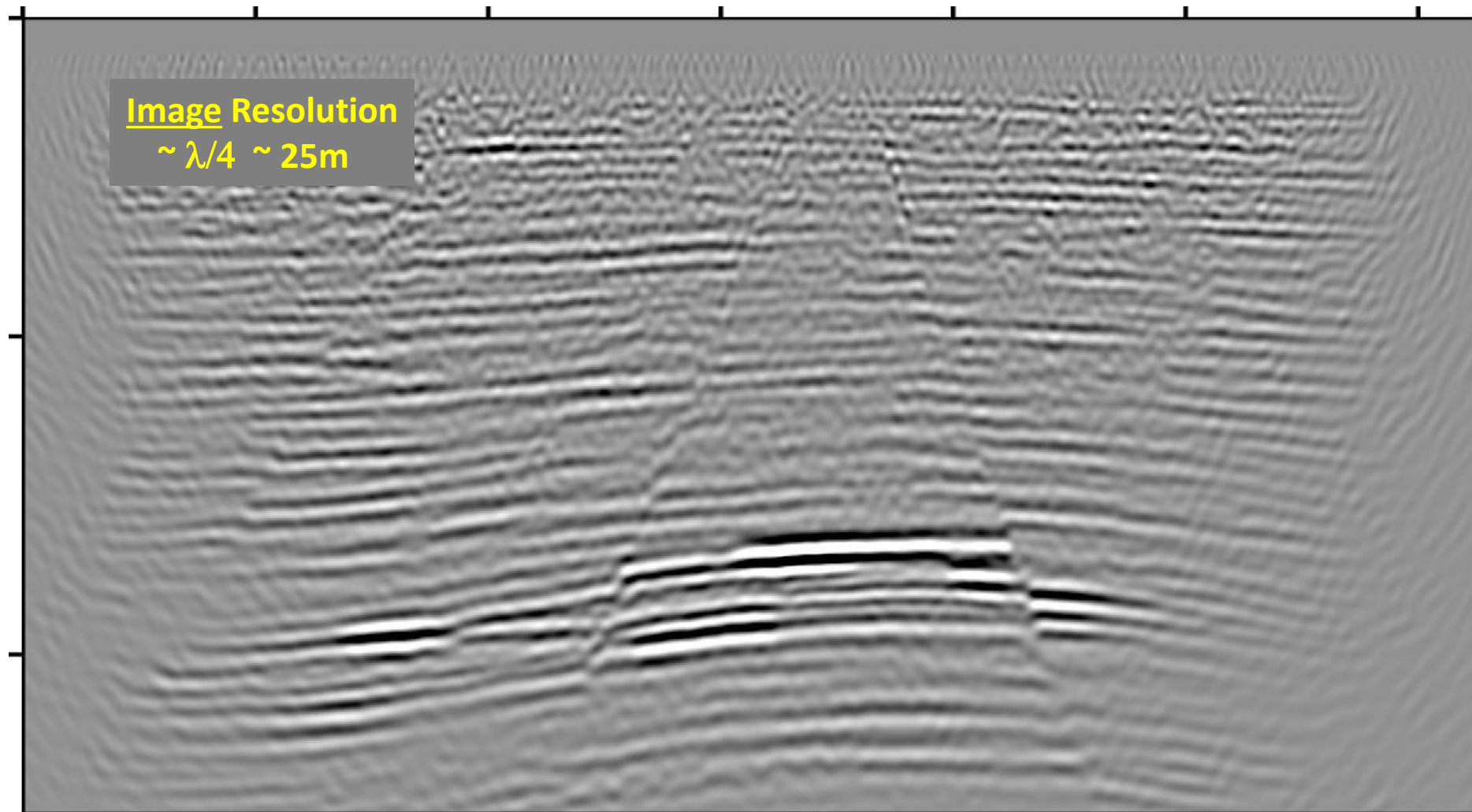


FWI Velocity Model $\sim \lambda/4$



Zhou & Lumley, 2018

Seismic Image $\sim \lambda/4$



Zhou & Lumley, 2018

Seismic wave equations

multi-parameter (MP) FWI

$$(\nabla^2 - v^2 \partial_{tt}) P(\underline{x}, t) = s(\underline{x}, t)$$

Acoustic v_p, ρ

anisotropy ϵ, δ ; viscoacoustic Q_p

1C hydrophone

3C geophone

$$\rho \ddot{\underline{u}} = \underline{f} + \rho v_p^2 \nabla (\nabla \cdot \underline{u}) - \rho v_s^2 \nabla \times (\nabla \times \underline{u})$$

Elastic v_p, v_s, ρ

linear isotropic

$$\rho \ddot{\underline{u}} - \nabla \cdot \underline{\underline{C}} : (\nabla \underline{u} + \nabla \underline{u}^T) / 2 = \underline{f}$$

$$\rho \ddot{u}_i - \partial_j C_{ijkl} e_{kl} = f_i$$

$$\rho \ddot{u}_i - \partial_j \sigma_{ij} = f_i$$

general Elastic v_p, v_s, ρ

anisotropy polar, azimuthal

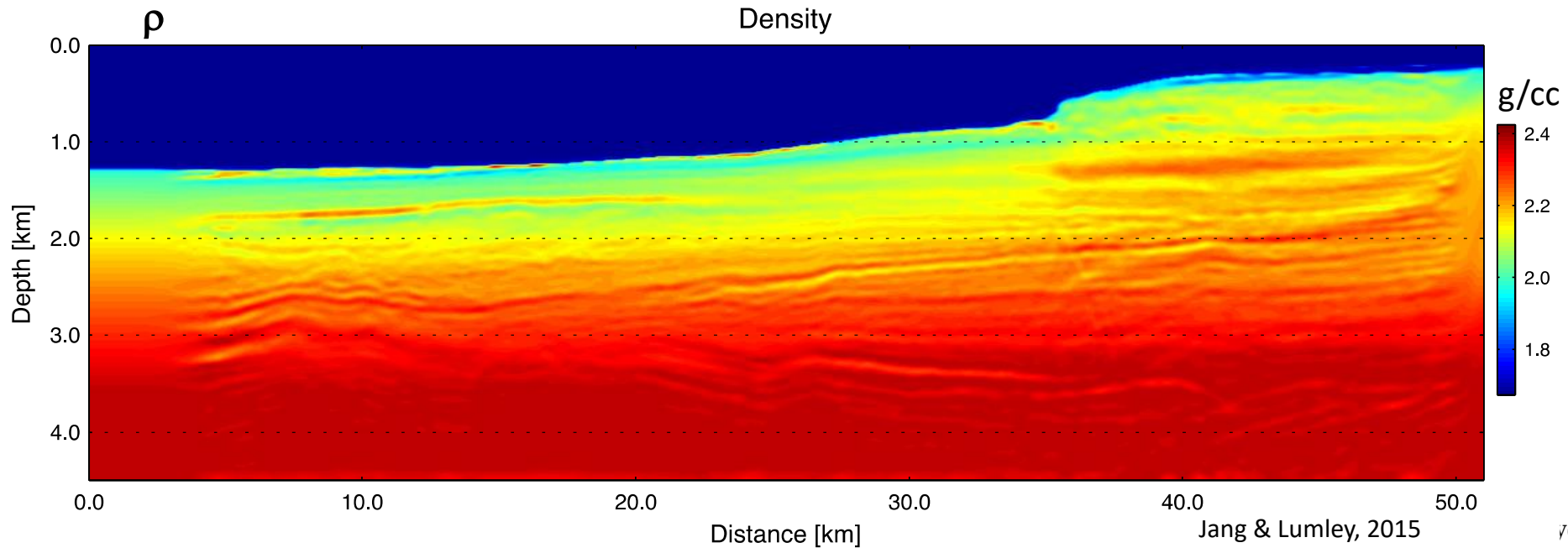
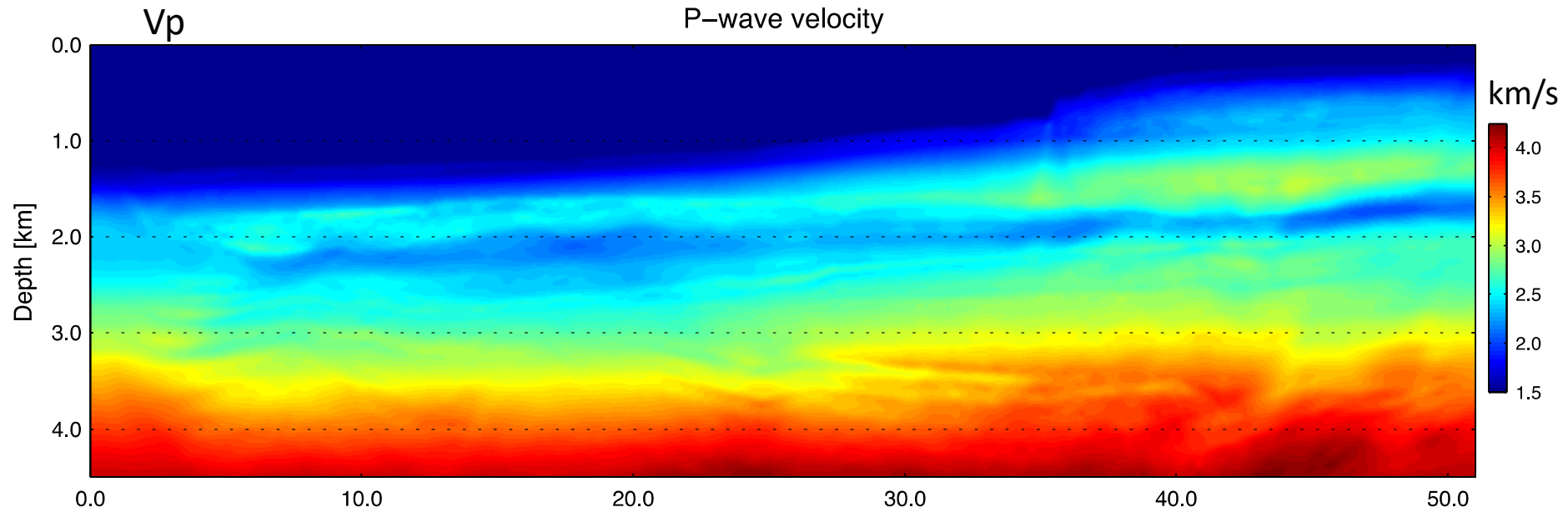
viscoelastic Q_p, Q_s

v = velocity; P = pressure; s = source fcn (pressure)

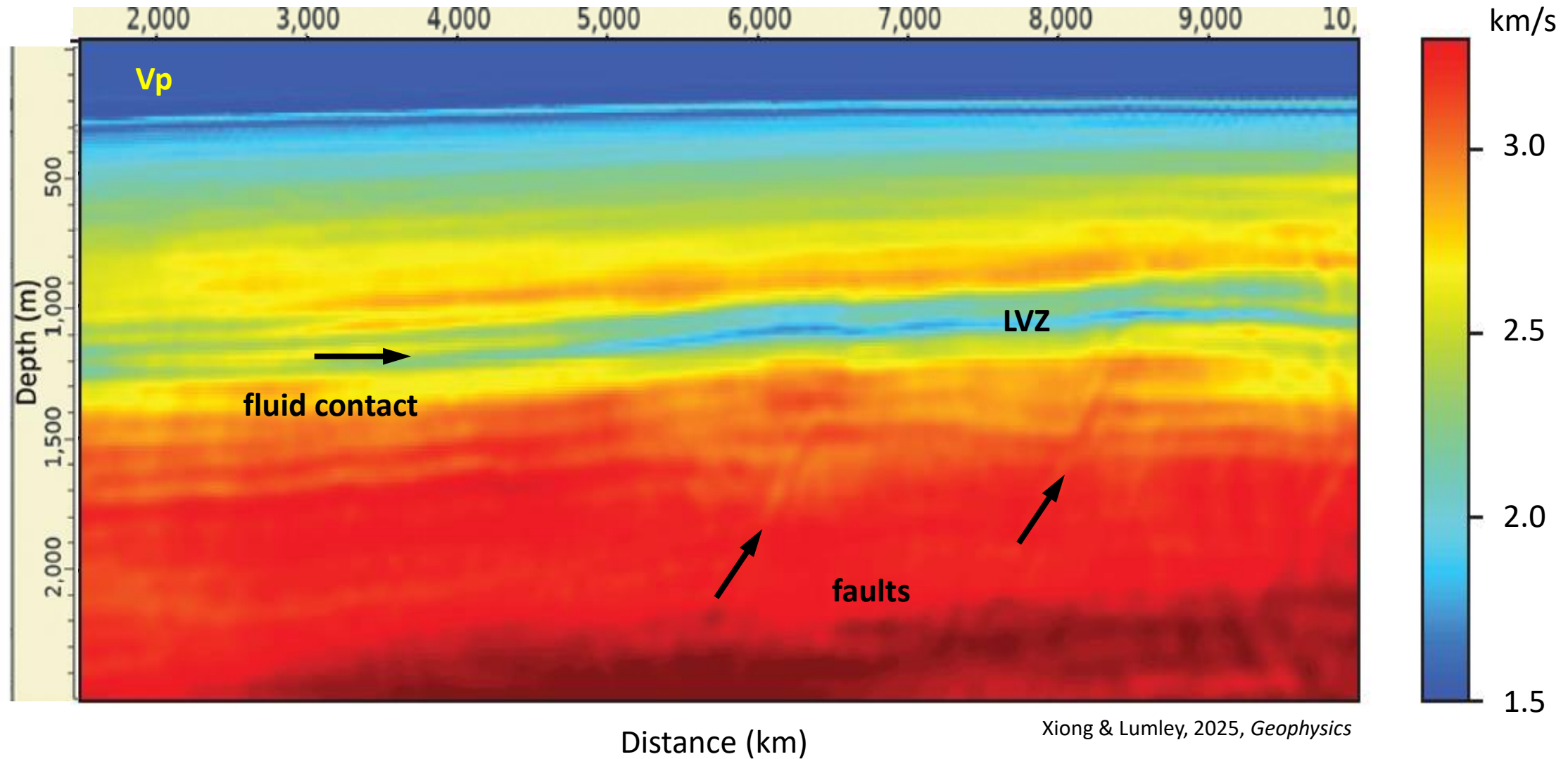
ρ = density; $\underline{u}$ = particle displacement; $\underline{f}$ = source fcn (force)

$\underline{\underline{C}}_{ijkl}$ = elastic stiffness tensor; σ_{ij}, e_{kl} = stress, strain tensors

Australia: MP FWI (v_p, ρ)

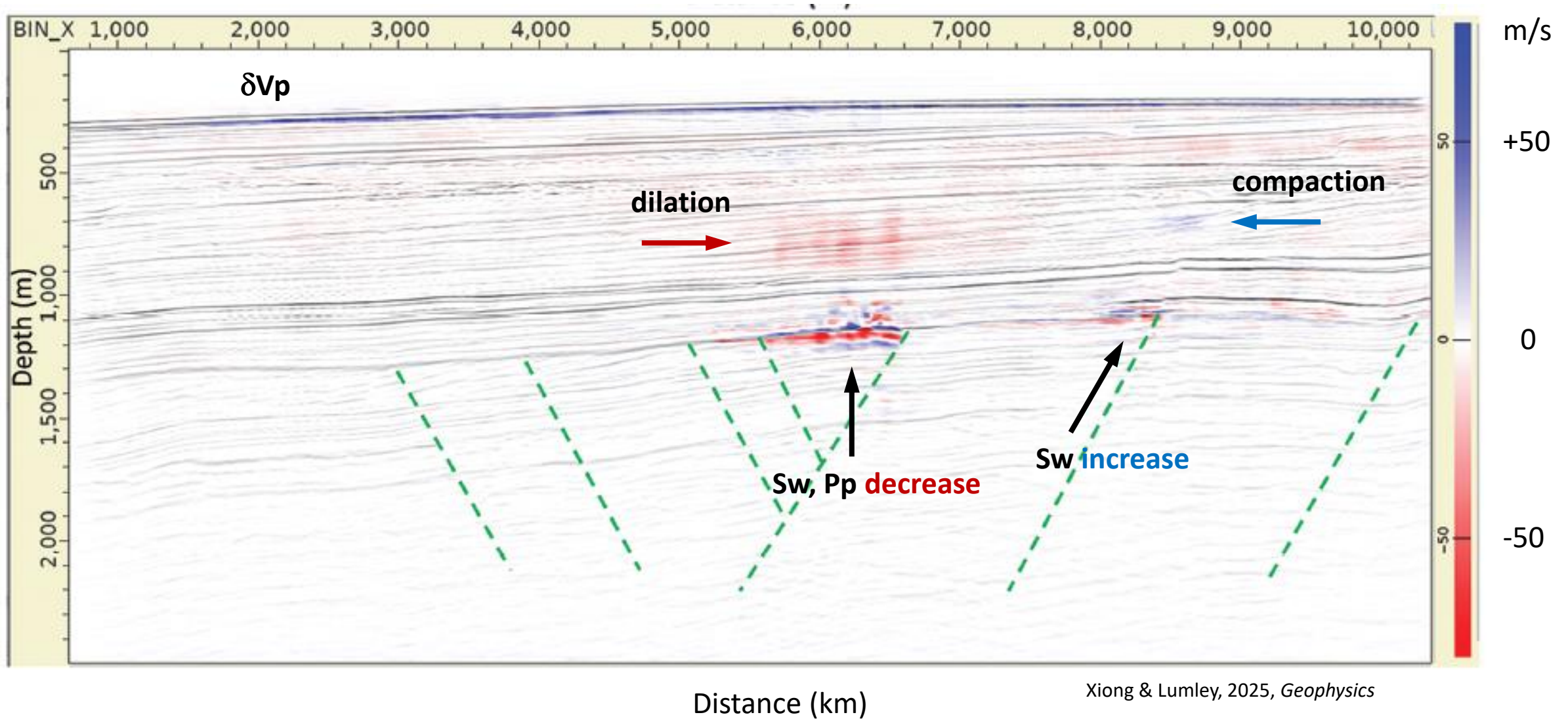


Australia FWI



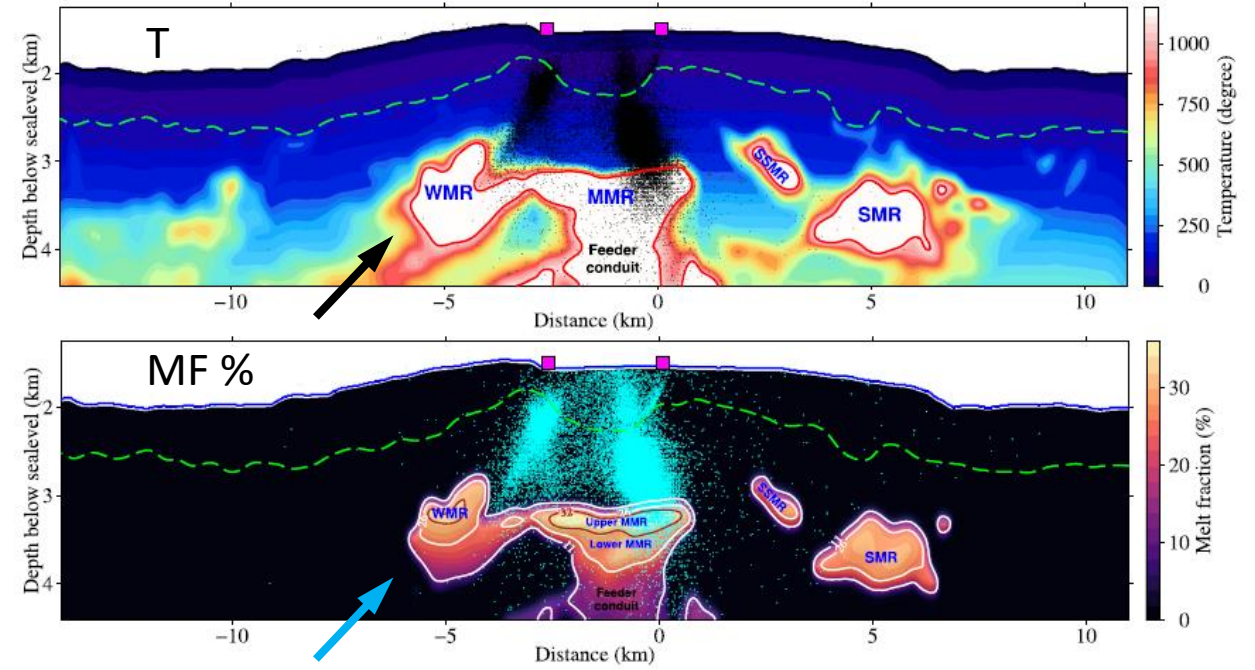
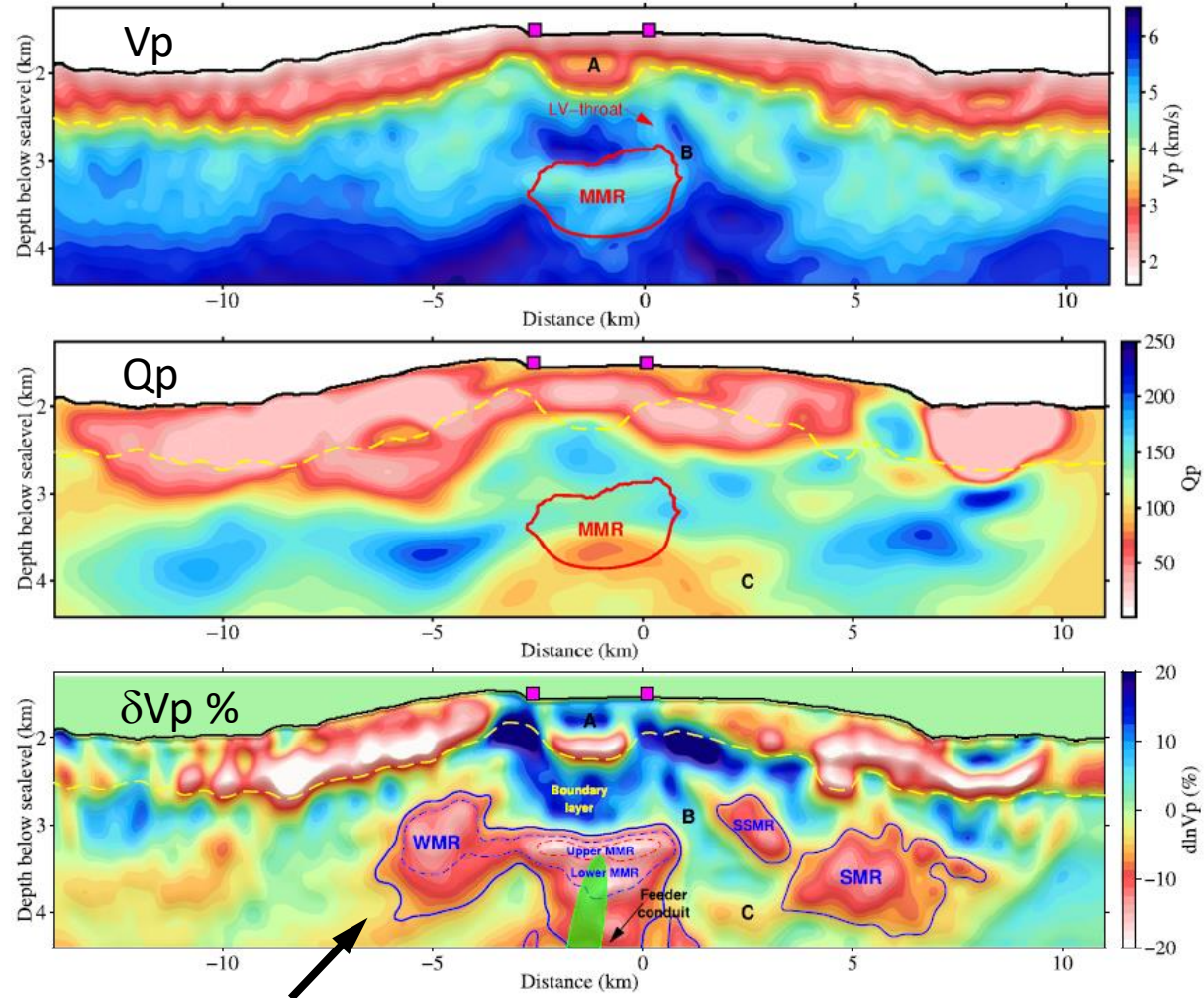
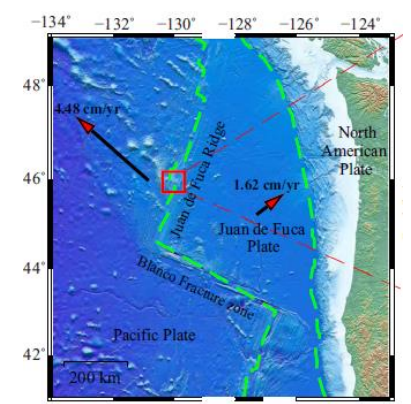
Xiong & Lumley, 2025, *Geophysics*

Australia 4D FWI



Xiong & Lumley, 2025, *Geophysics*

Axial Seamount: MP FWI (v_p, Q_p)



Yang et al., 2024, *Nature*

CASIE21 FWI Goals (Lumley et al., Tobin, other collaborators?)

- * increase V_p velocity resolution -> improve PSDM Imaging
- * MP FWI -> density, anisotropy, Q_p -attenuation...
- * FWI -> rock physics -> litho, fluids, P_p , T , geomech stress/strain, etc...

