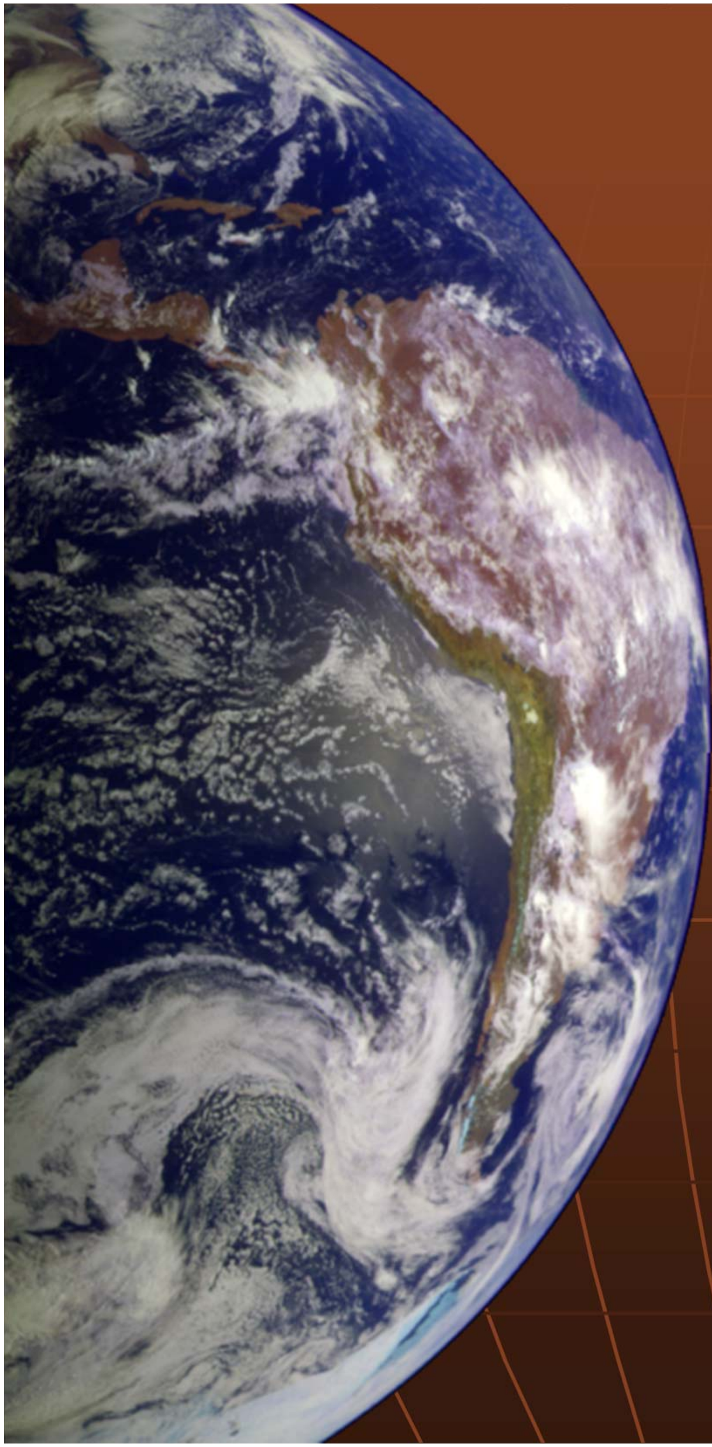
UT-AUSTIN EDGER FORUM



PP & PS wave velocity analysis and joint prestack inversion in the same PP timescale domain

Zhiwen Deng

Visiting scholar in the

Institute for Geophysics, University of

Texas at Austin, from BGP,CNPC

THE UNIVERSITY OF TEXAS AT AUSTIN

JACKSON

SCHOOL OF GEOSCIENCES

Outline

1 Introduction

2 Technical method

3 Conclusions

Introduction

Advantages in reservoir characterization by MC exploration

1, Much more information (P,P-S & S-S) acquired with multicomponent exploration comparing with p-wave exploration;

2, It's more reliable to predict lithology and fluid using multicomponent information;

3, It's more accurate to identify the orientation and intensity of fractures using shear wave splitting;

4, It's effective for true or false bright spots identification, improving gas chimney image,…….

More difficult problems exist in the MC application compared to P-wave, i.e., statics , resolution, velocity analysis, image , horizon calibration & joint inversion etc.

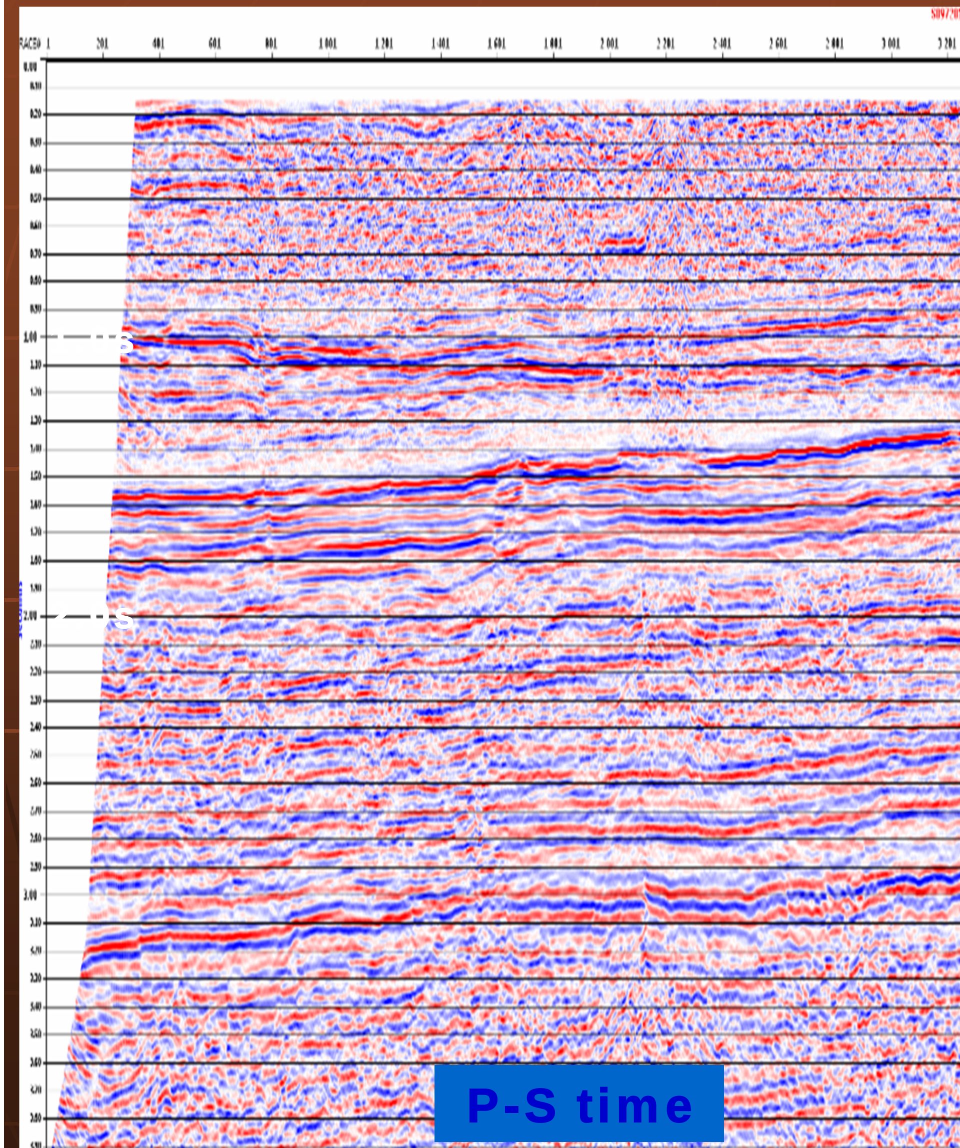
Data processing problems

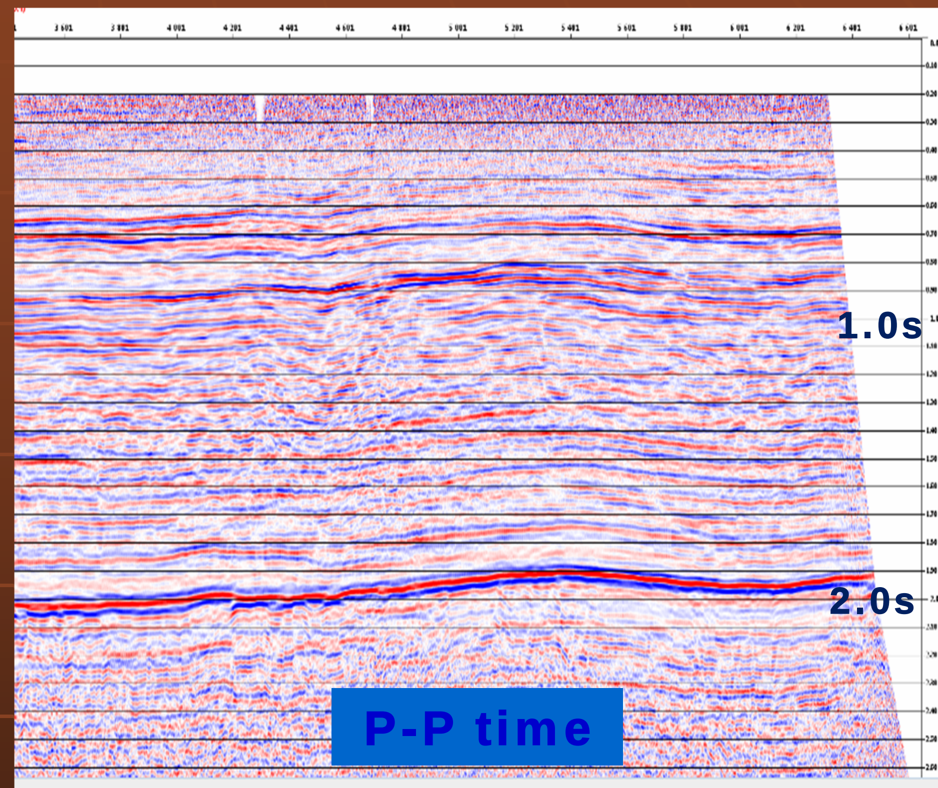
1, PP & PS wave velocity analysis and imaging done separately at different time scale domains

2, Final PP & PS wave data with different travel time for the same horizon

Introduction

Problems





P-wave and PS-wave sections processed by traditional method.

PSV-WAVE

P-WAVE

PP & PS wave
Horizon calibration or inversion problems

1, Registration is necessary for PP & PS wave horizon calibration and inversion

2, Exact horizons and velocity needed in PP & PS wave registration

Introduction

New PP & PS wave velocity analysis and inversion method

1, PP & PS wave velocity analysis and inversion completed at the same time scale domain

2, Final PP & PS wave data with the same travel time for the same horizon

3, Registration processing is not needed

Outline

1 Introduction

2 Technical method

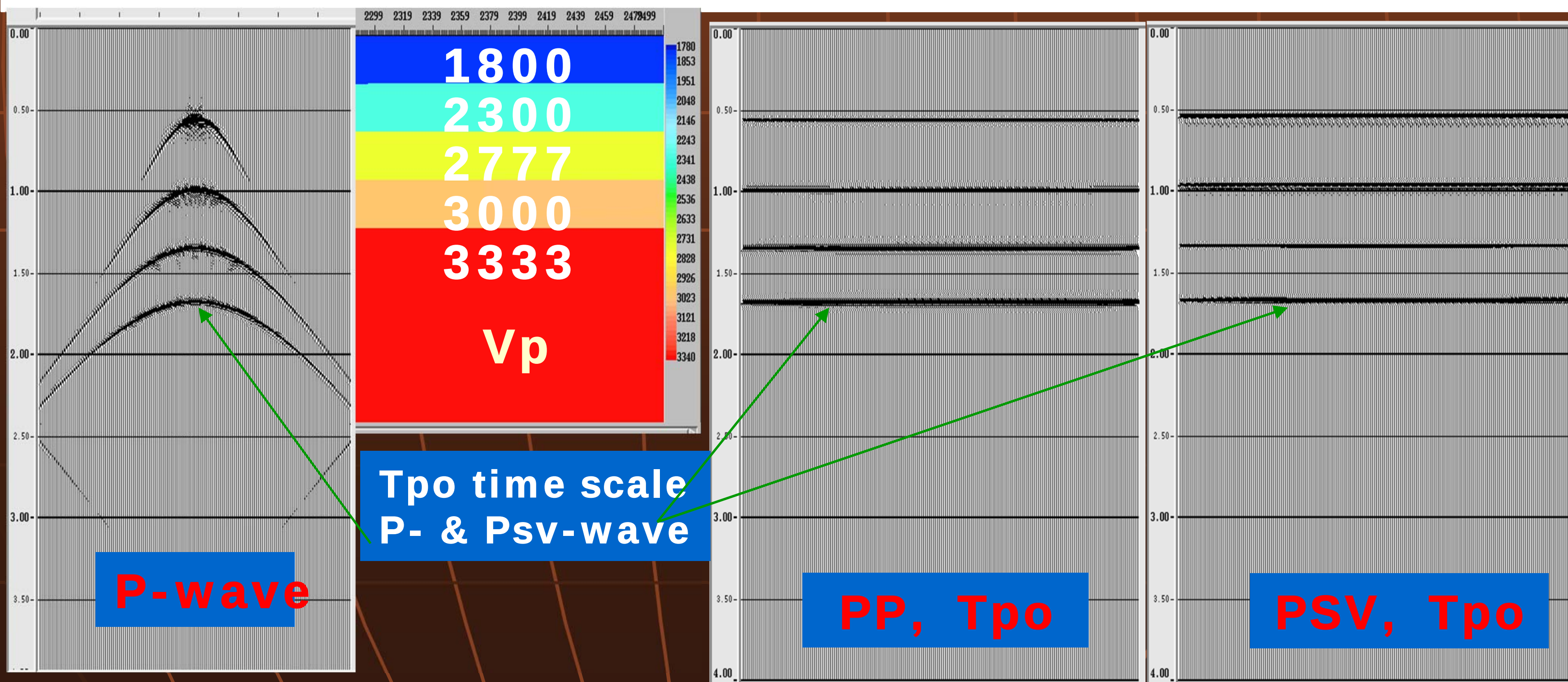
3 Conclusions

Time scale *①Sv wave velocity analysis*

$$H = T_{ppo} \cdot V_p(T_{ppo}) / 2$$

$$H = T_{sso} \cdot V_s(T_{sso}) / 2$$

$$H = T_{pso} \cdot V_p(T_{pso}) \cdot V_s(T_{pso}) / (V_p(T_{pso}) + V_s(T_{pso}))$$



①Sv wave velocity analysis

P-SV wave travel time-distance curve

Double square root equation

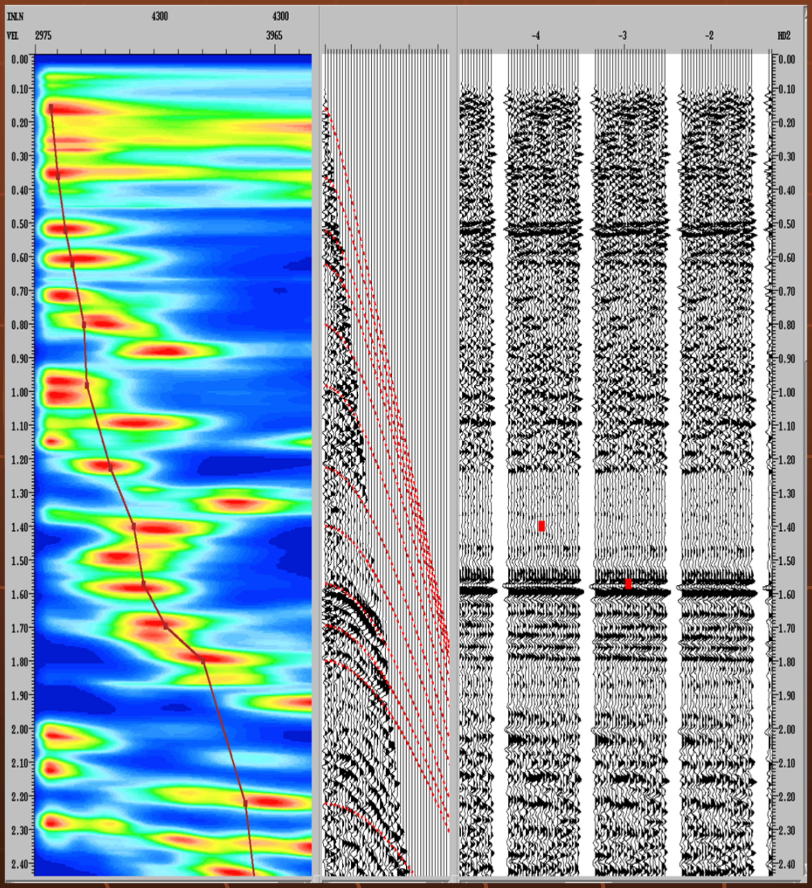
$$t = \sqrt{t_{0P}^2 + \frac{x_P^2}{v_P^2}} + \sqrt{t_{0S}^2 + \frac{x_S^2}{v_S^2}}$$

Taylor series expansion equation（Thomsen，1999）

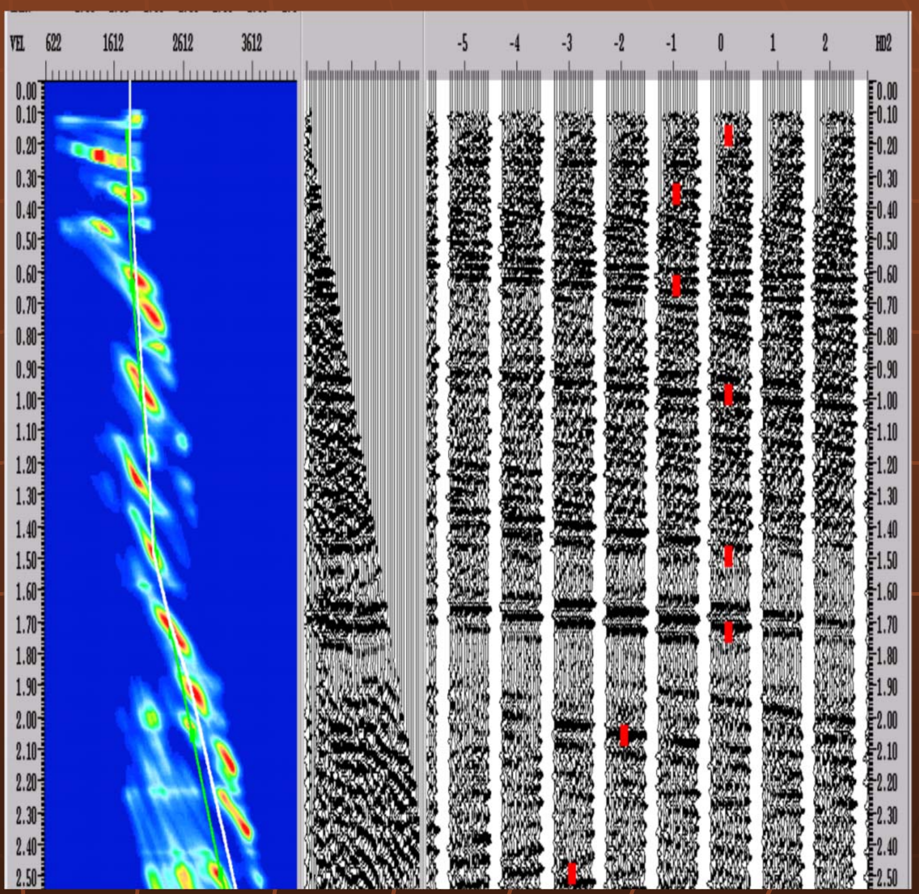
$$t_{PS}^2(x) = t_{0PS}^2 + \frac{x^2}{v_c^2} + \frac{A_4 x^4}{1 + A_5 x^2}$$

①Sv wave velocity analysis

P-wave and SV-wave velocity analysis in the same P-P time domain

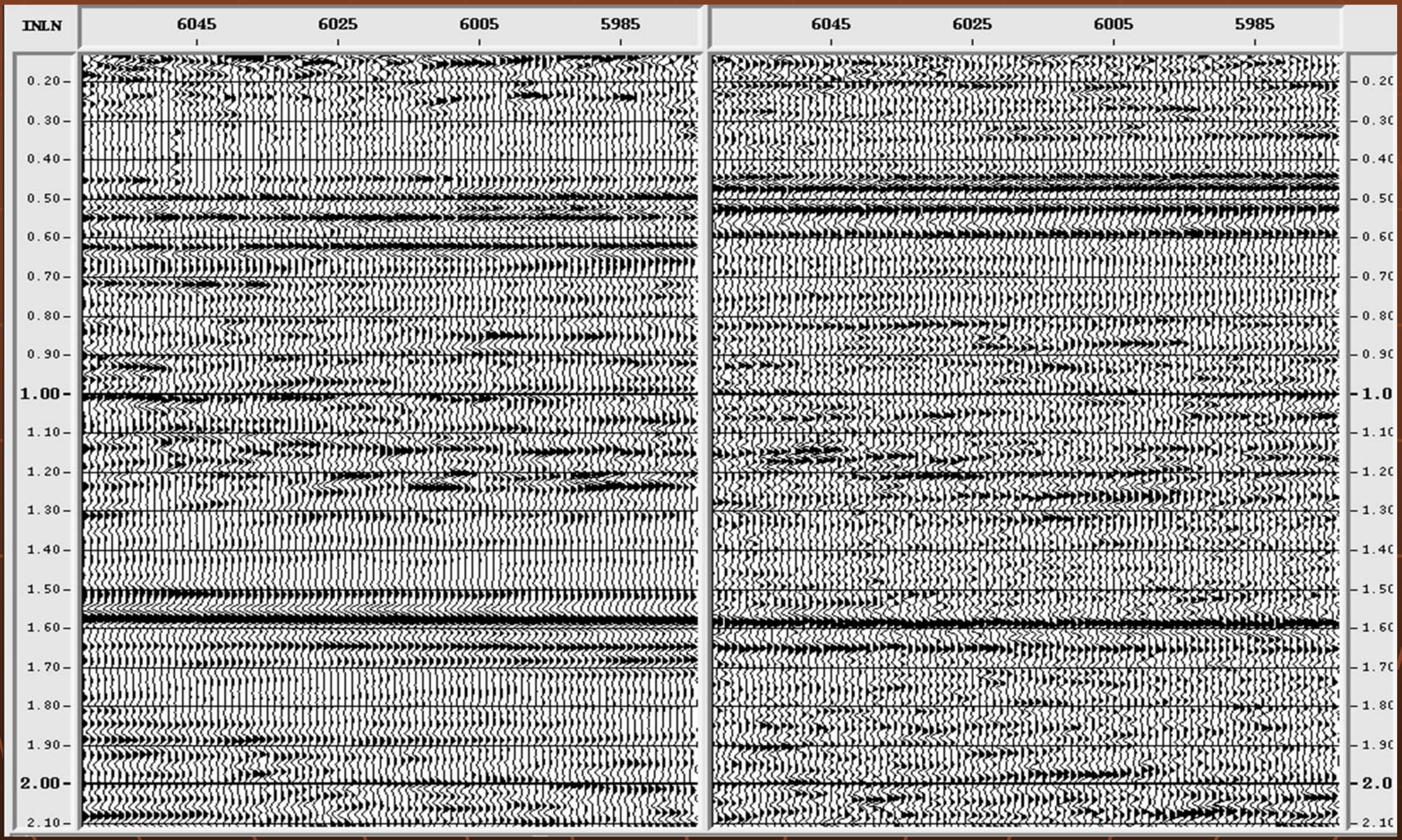


P-wave velocity spectrum



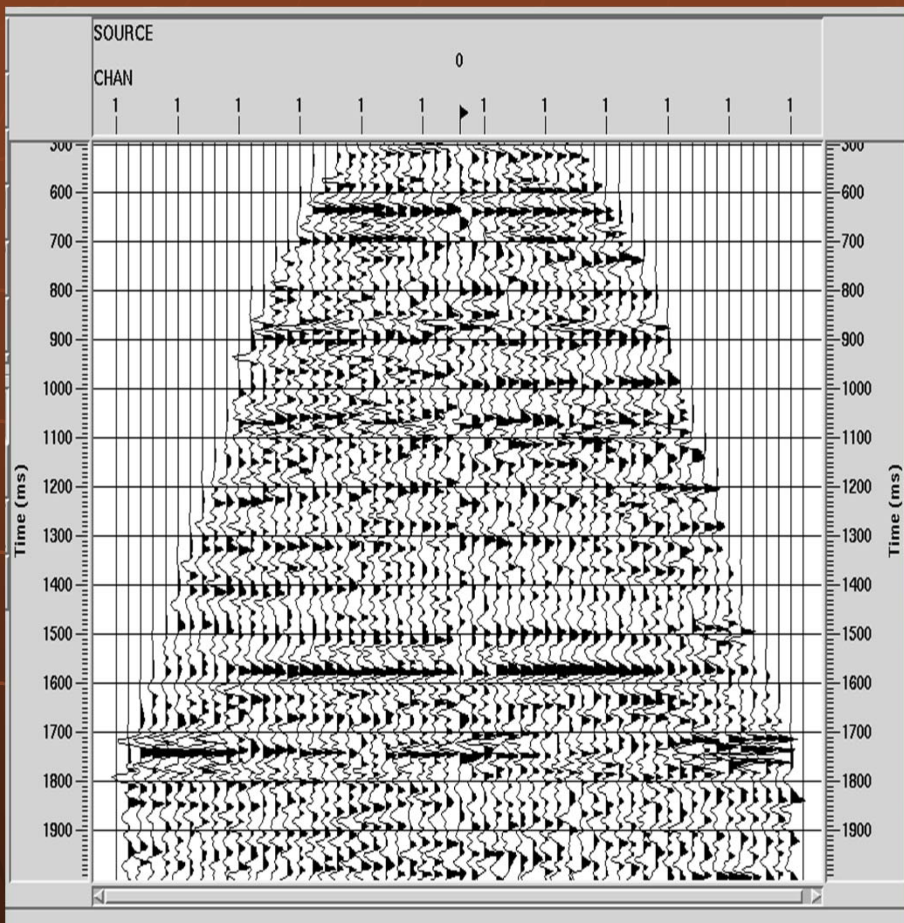
SV-wave velocity spectrum

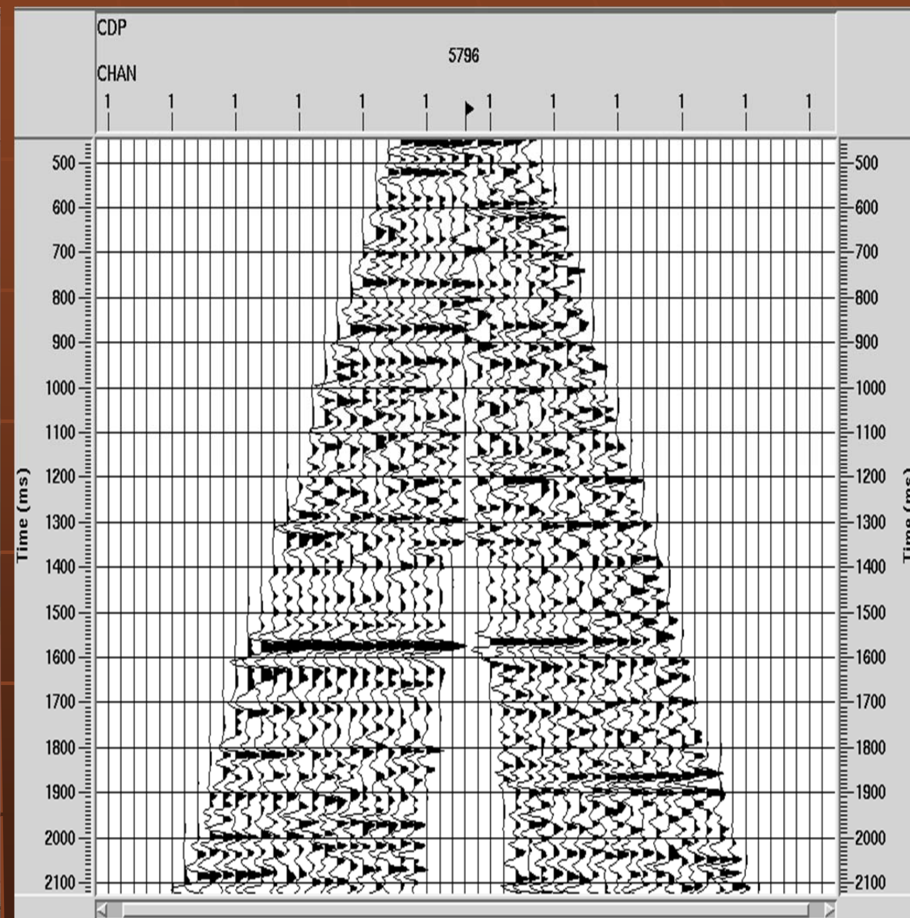
①Sv wave velocity analysis



P wave section(left) and SV-wave section (right) at the same T_{ppo} time domain

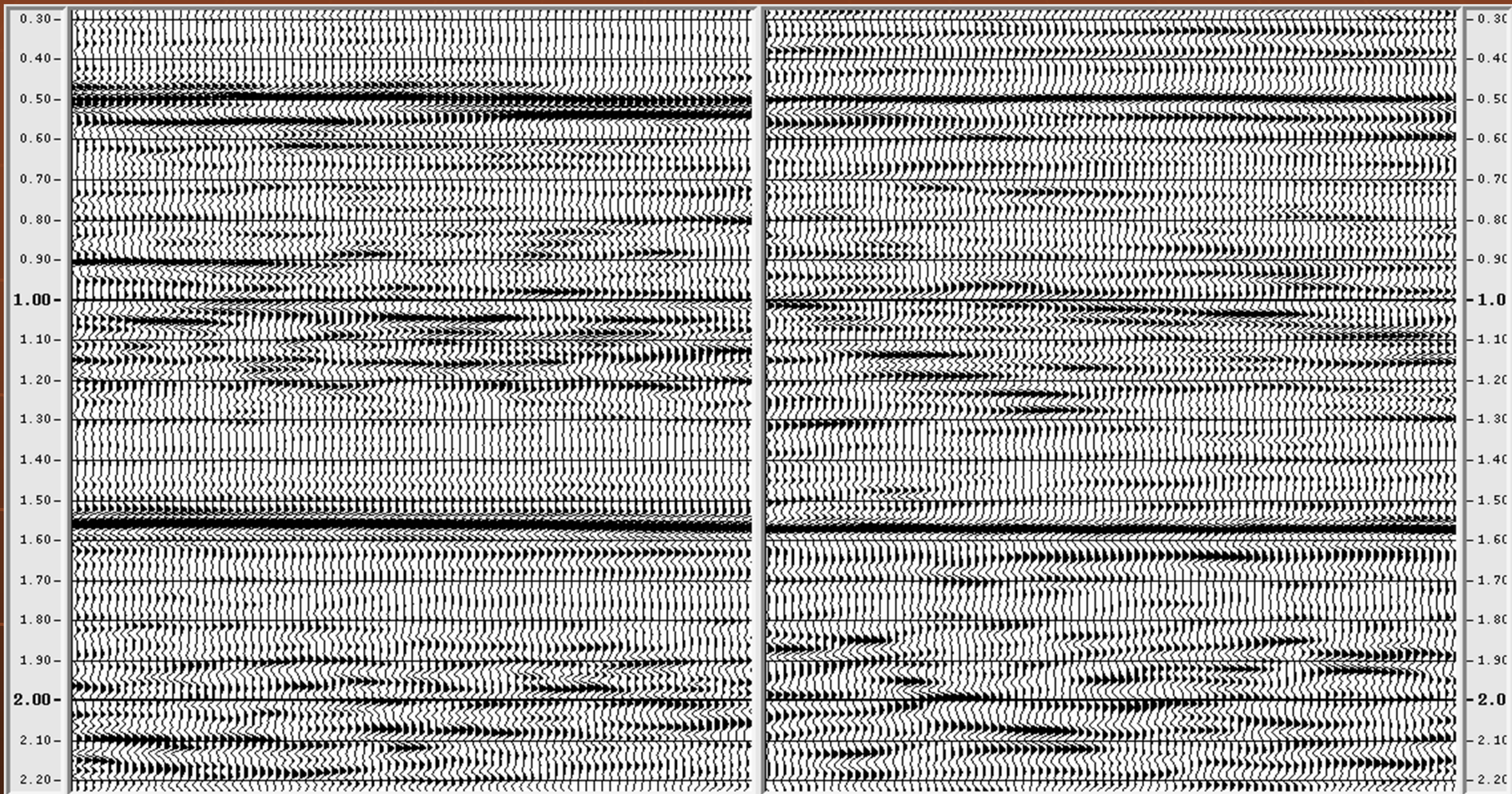
①Sv wave velocity analysis





CIP gather of P wave　　**CIP gather of PS wave**

①Sv wave velocity analysis



PP(left) & PS(right) wave Kirchhoff prestack time migration

VFSA prestack joint inversion

Use well log and seismic data to perform well tie at each well location and extract P-wave & PS-wave wavelets

↓

Pick horizons in seismic data (NMO-corrected angle gathers)

↓

Interpolate the well logs(Vp,Vs,Zp,Zs and density) between the picked horizons corresponding to each CMP(CCP) gather

↓

Select a CMP(CCP) gather to run the VFSA algorithm

↓

Obtain inverted acoustic and shear impedance

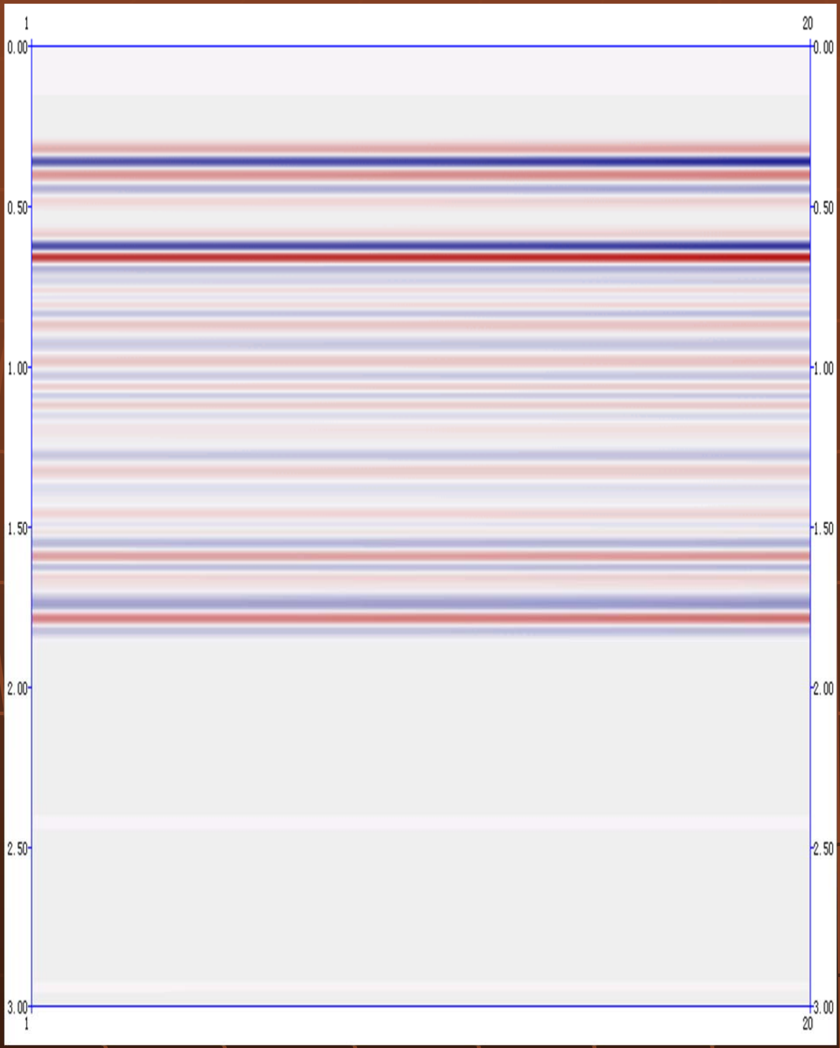
Flow chart of joint inversion algorithm

VFSA prestack joint inversion

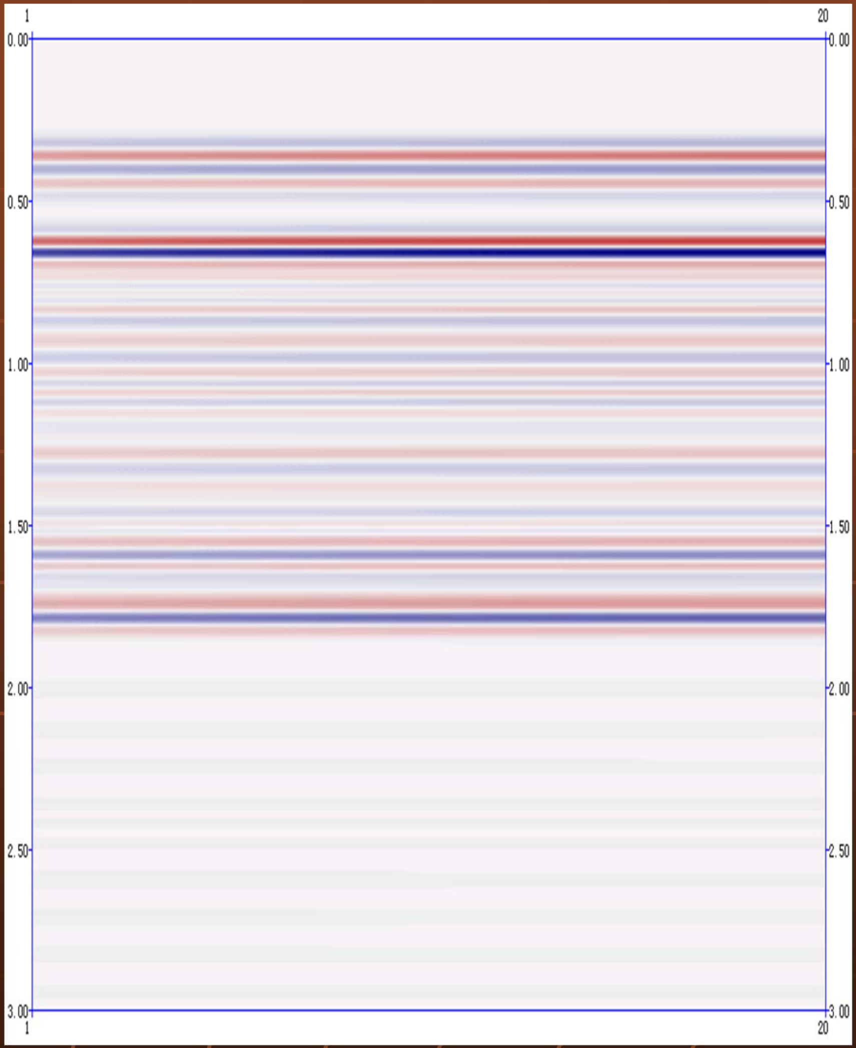
Objective function

$$E = 2\omega_p \frac{\sum (d_p^{obs} - d_p^{pre})^2}{\sum (d_p^{obs} + d_p^{pre})^2 + \sum (d_p^{obs} - d_p^{pre})^2} + 2\omega_{ps} \frac{\sum (d_{ps}^{obs} - d_{ps}^{pre})^2}{\sum (d_{ps}^{obs} + d_{ps}^{pre})^2 + \sum (d_{ps}^{obs} - d_{ps}^{pre})^2}$$

VFSA prestack joint inversion

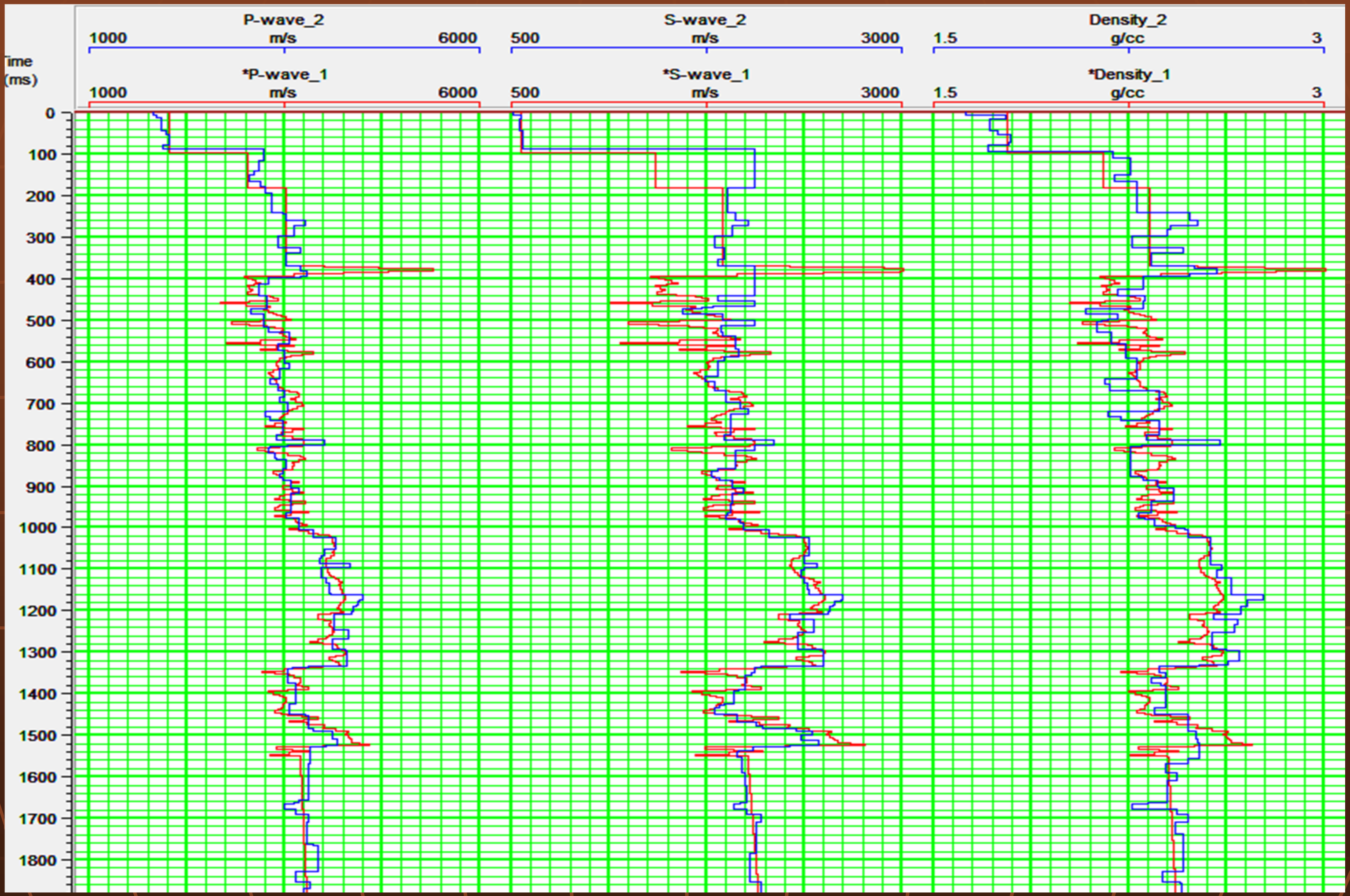


P-wave gather



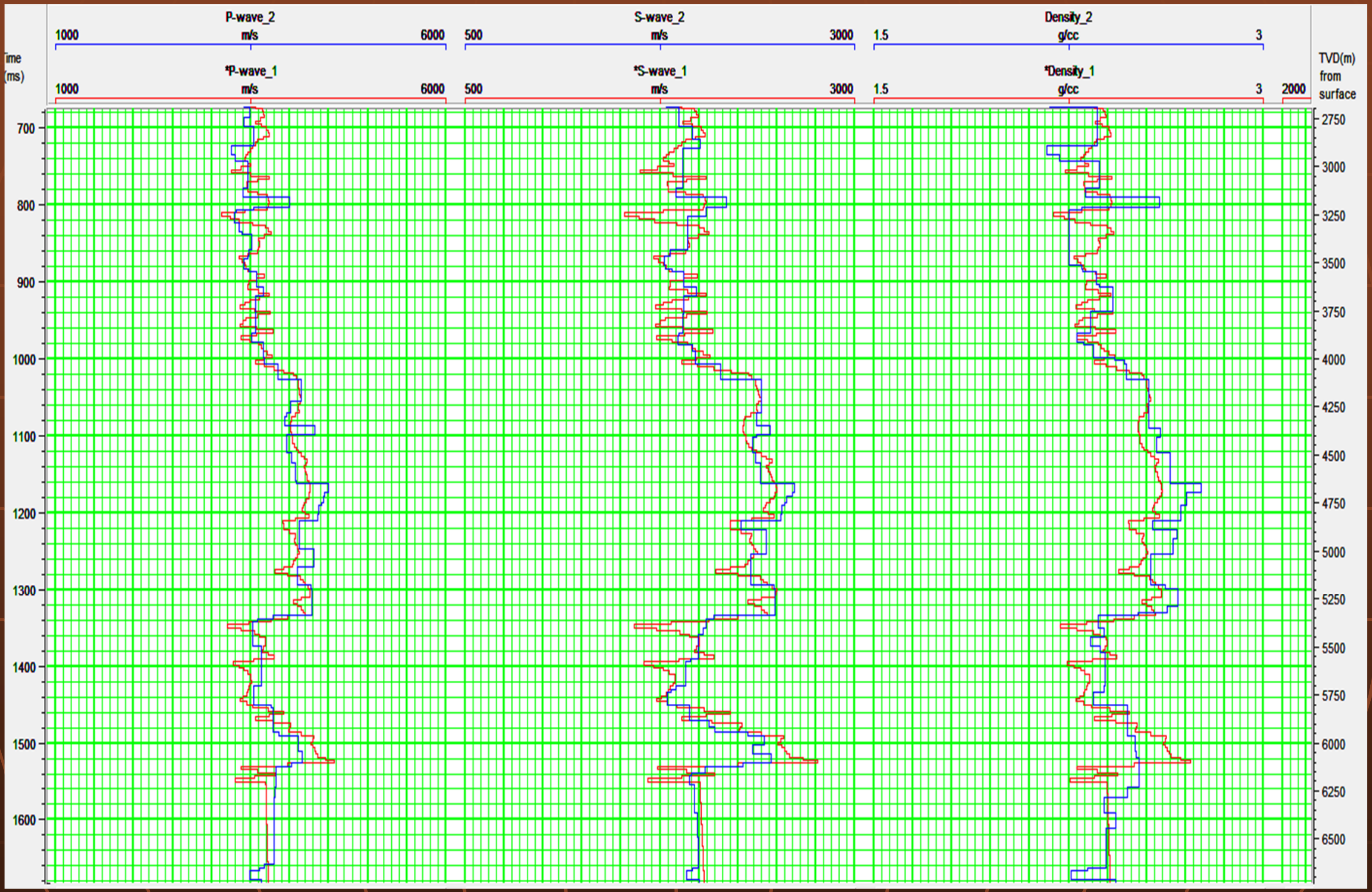
PS-wave gather

VFSA prestack joint inversion



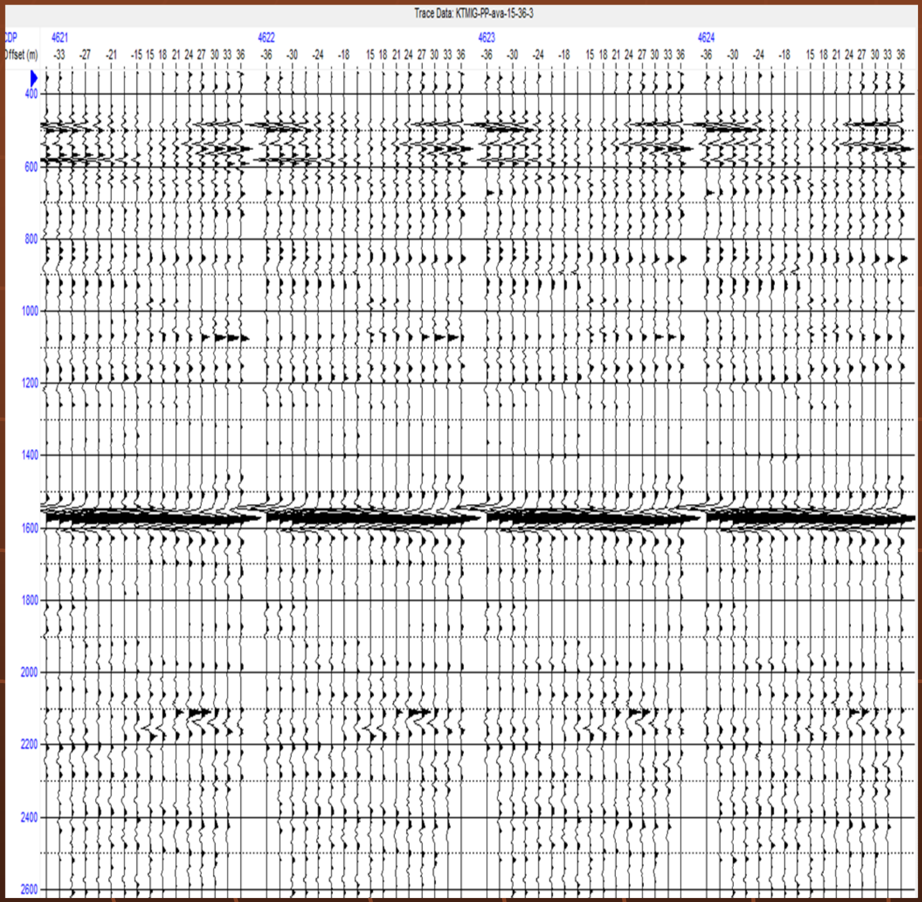
Comparison between raw velocity / density (red) and PP & psv joint inversion velocity / density(blue)

VFSA prestack joint inversion

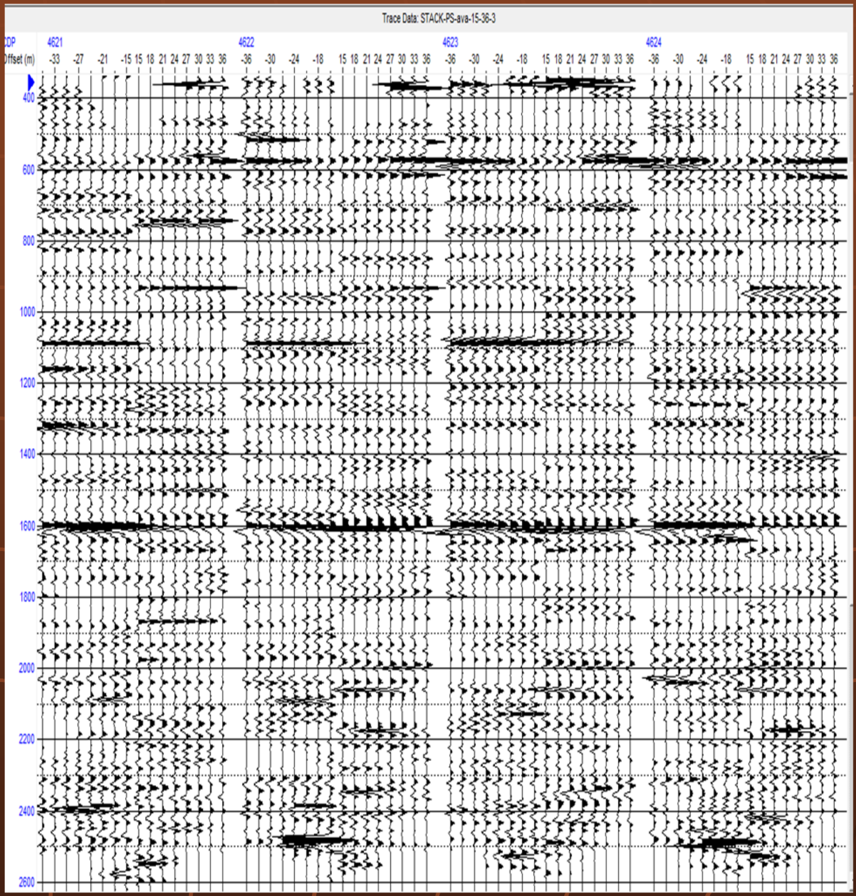


Comparison between raw velocity / density (red) and PP & psv joint inversion velocity / density (blue)

VFSA prestack joint inversion



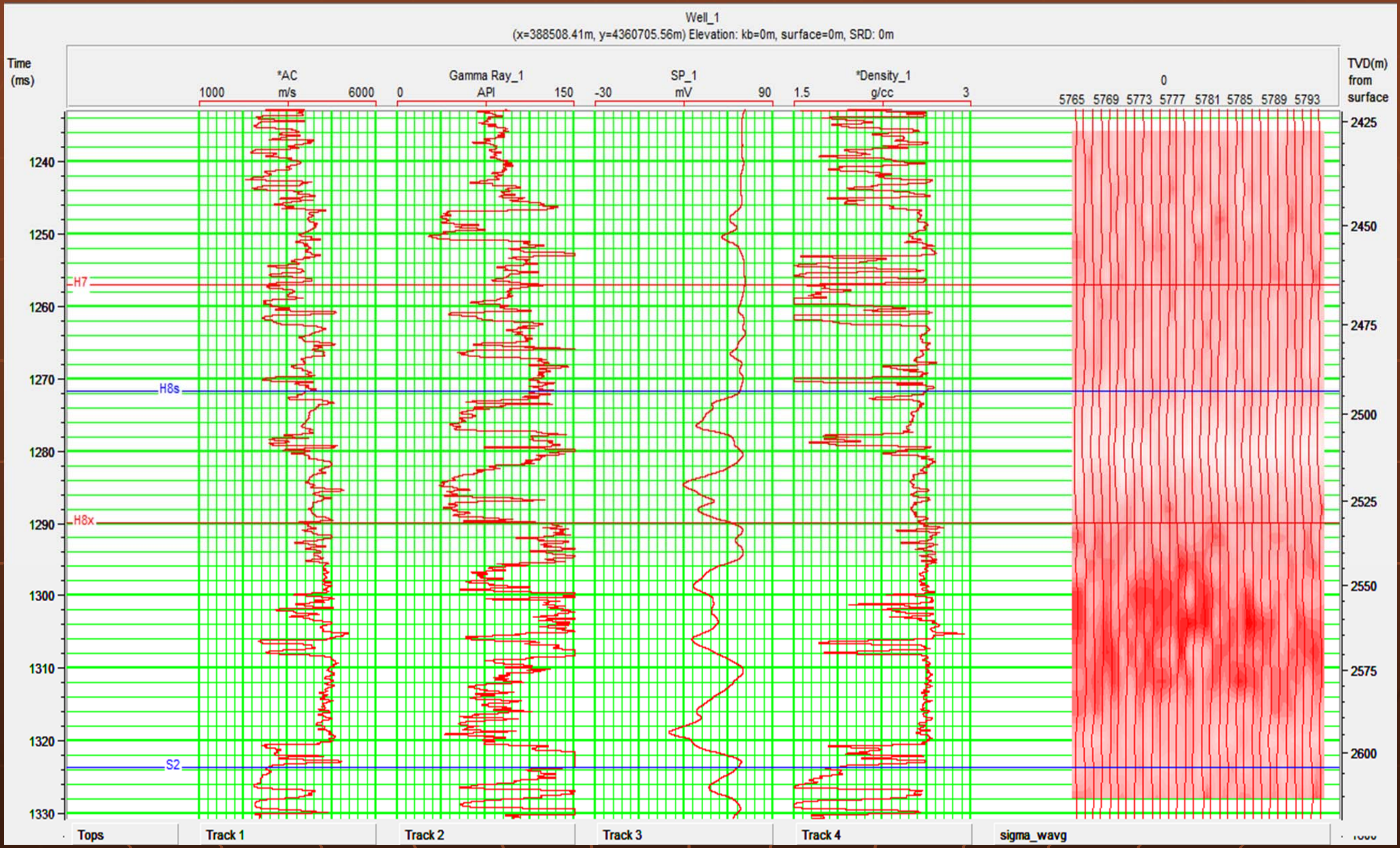
P-wave angle gathers



Ps-wave angle gathers

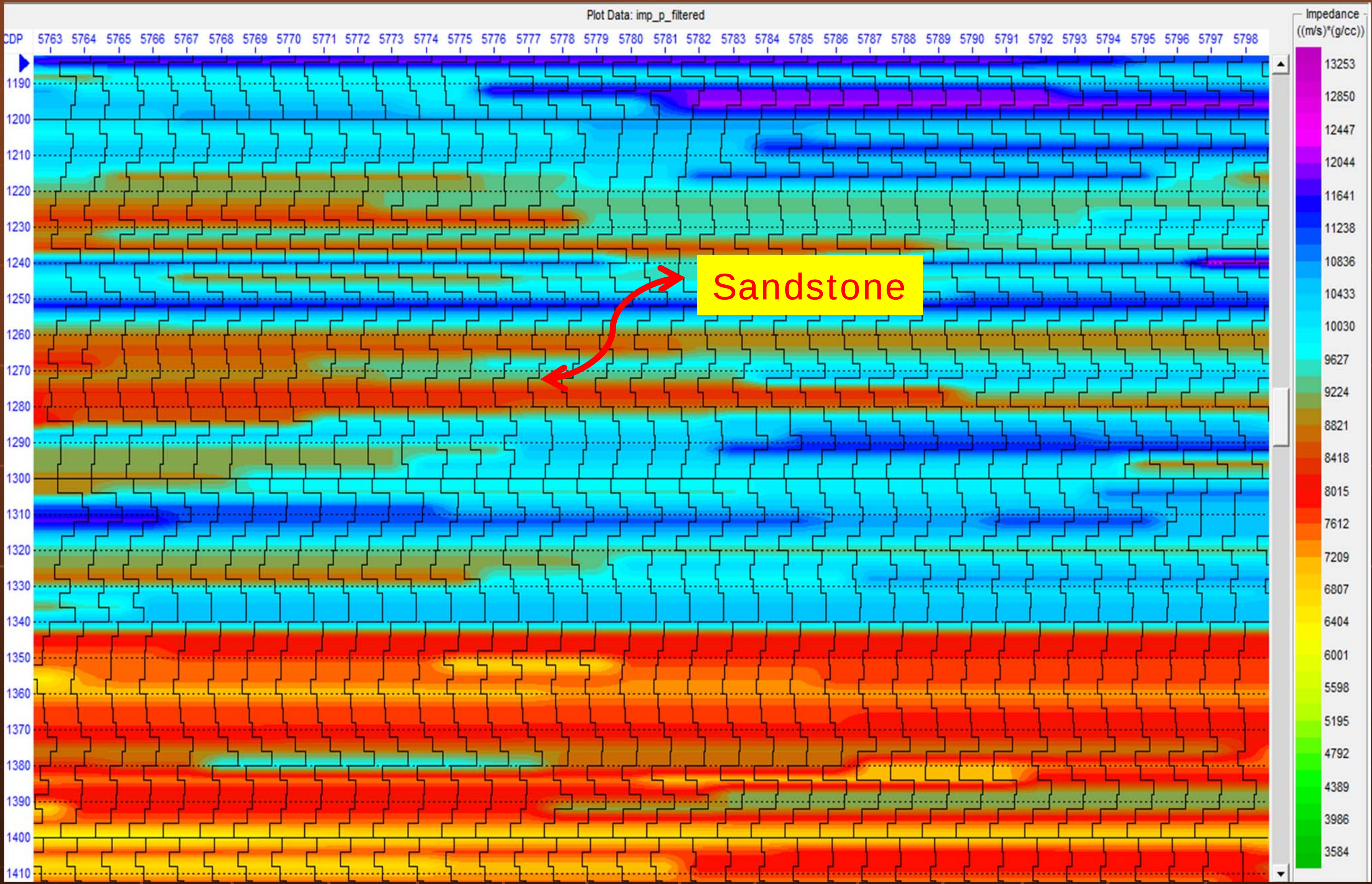
Example

VFSA prestack joint inversion



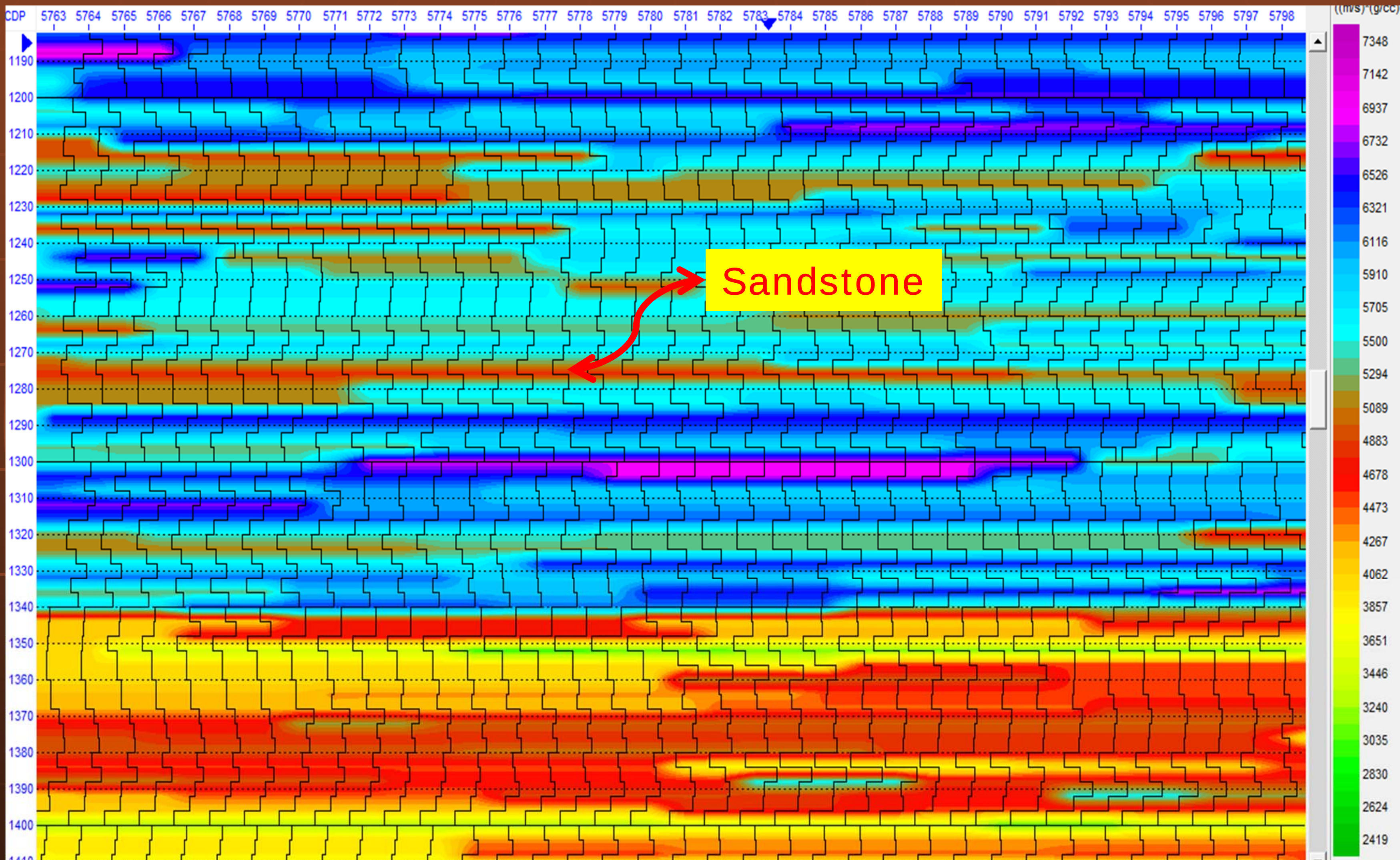
Horizon calibration

VFSA prestack joint inversion



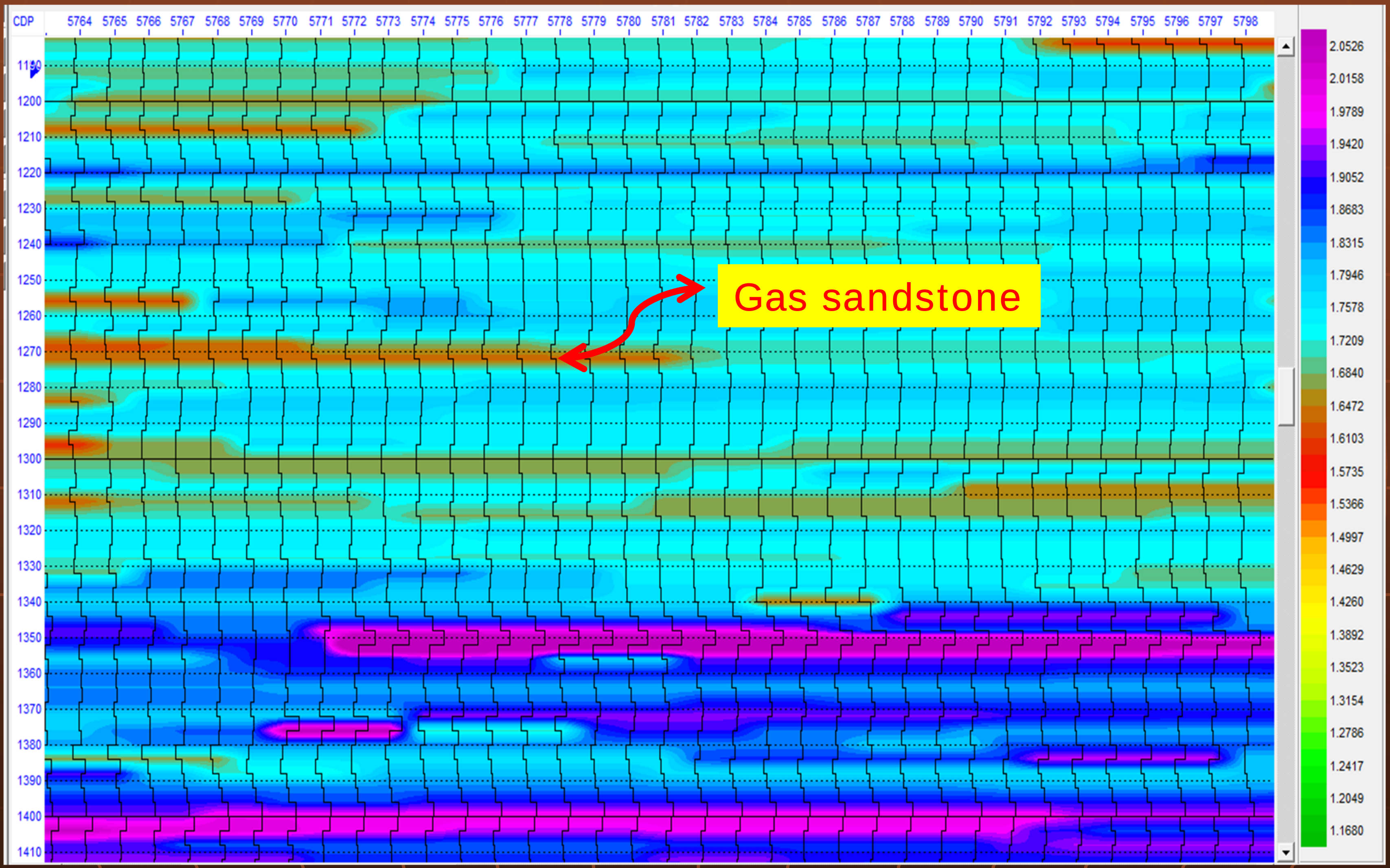
P-wave impedance

VFSA prestack joint inversion



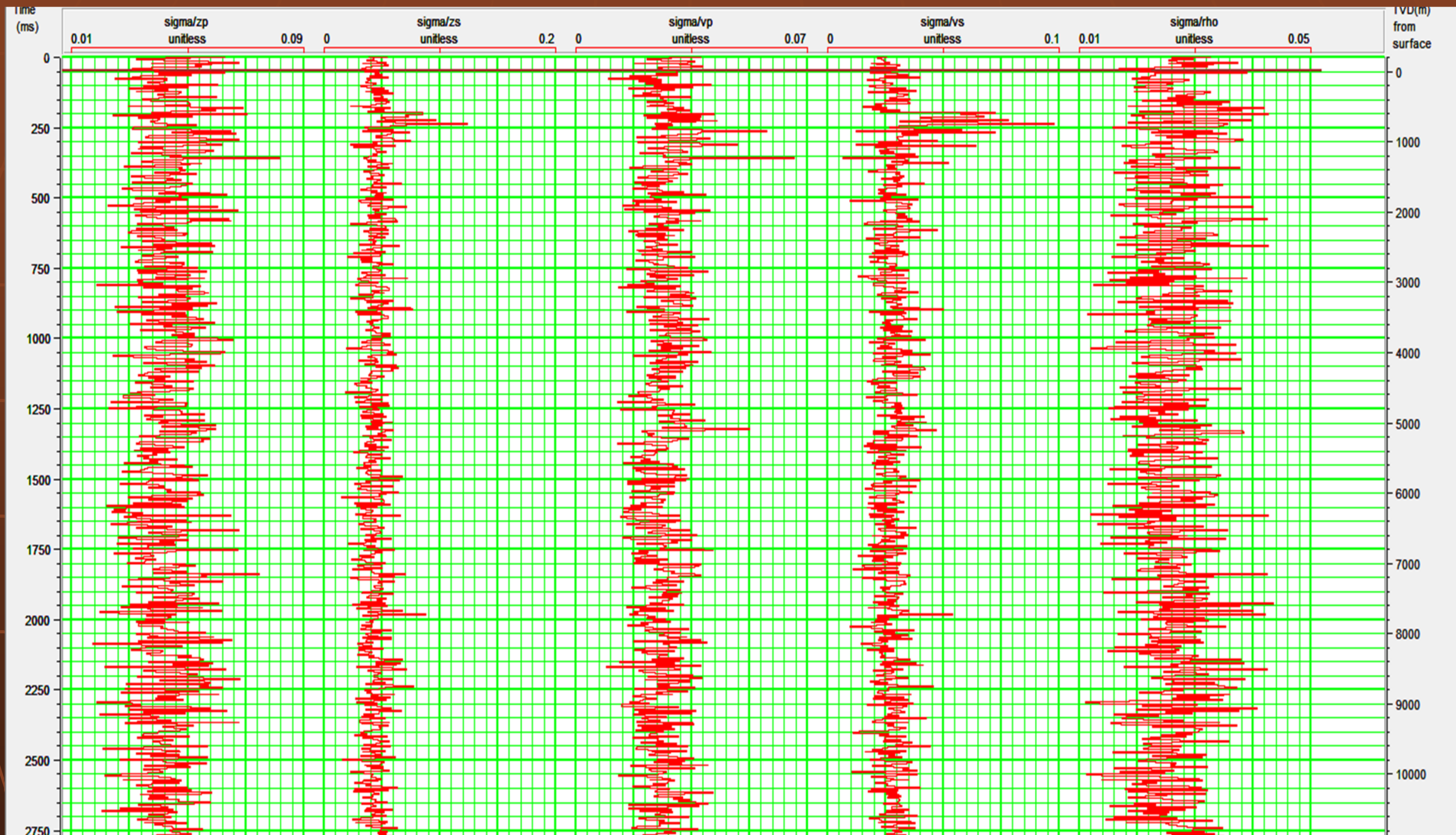
S-wave impedance

VFSA prestack joint inversion



Vp / Vs ratio

VFSA prestack joint inversion

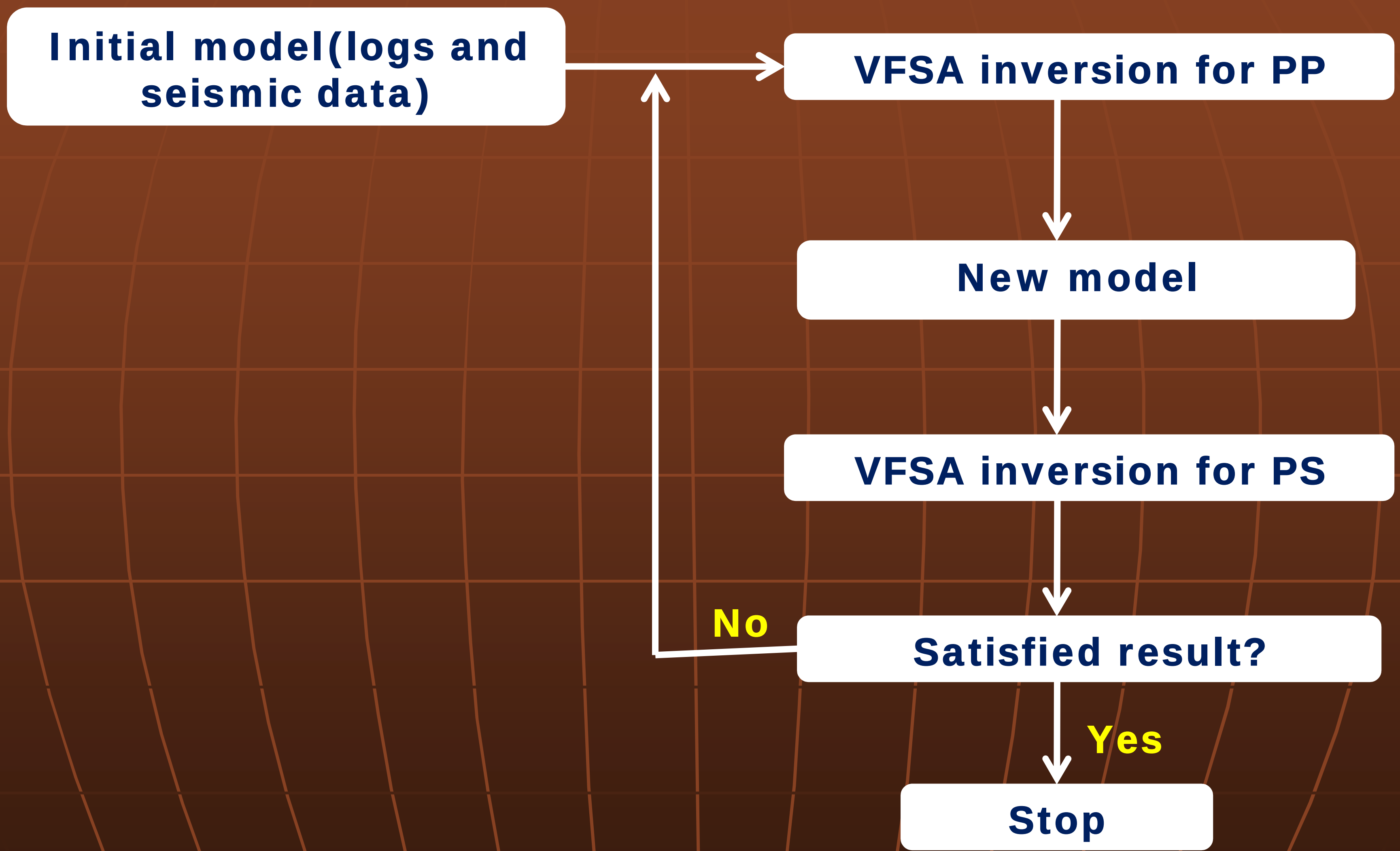


Standard Deviation / mean

Uncertainty Estimation

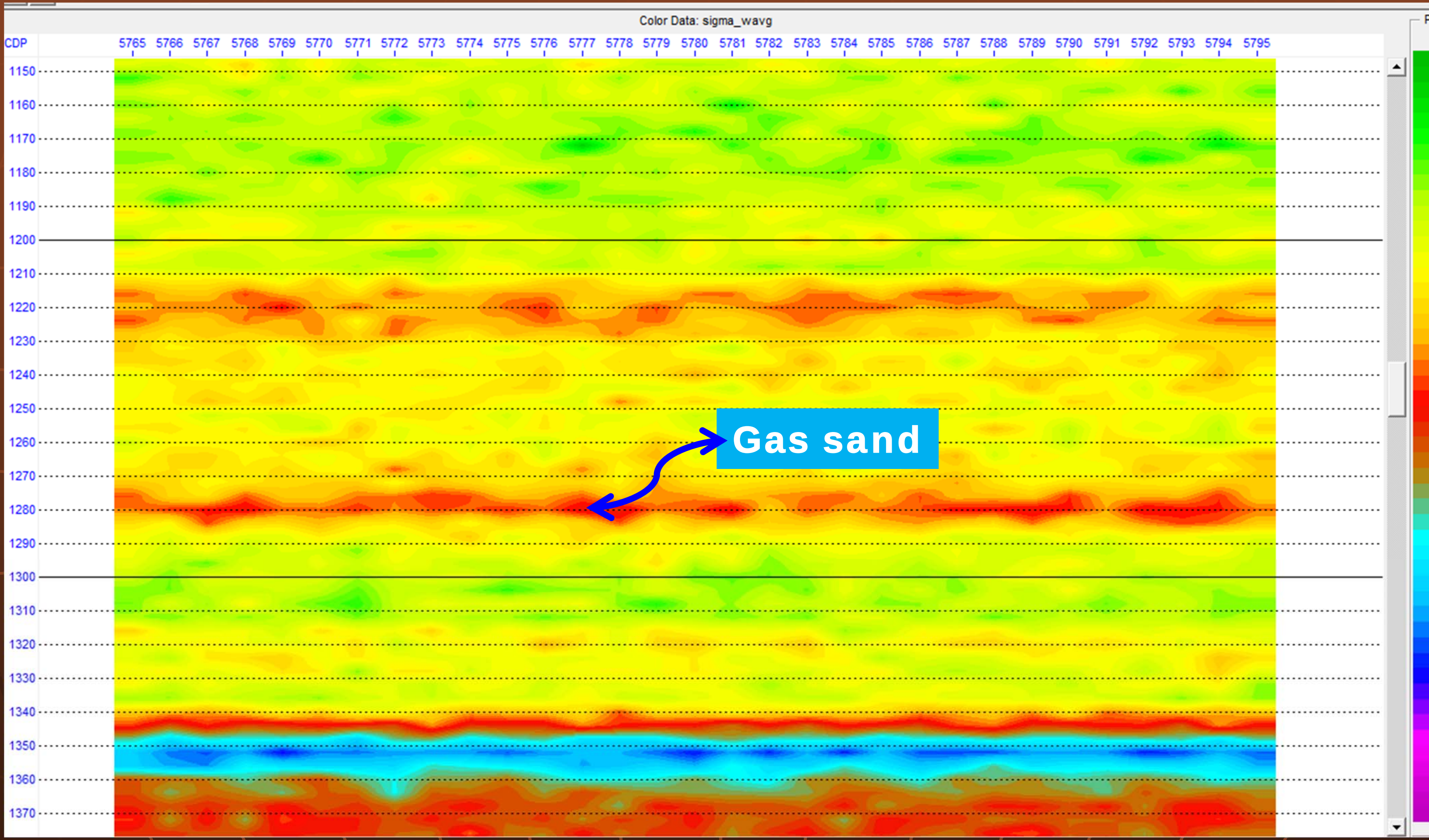
Future work

VFSA prestack joint inversion



Flow chart of two-step inversion algorithm

VFSA prestack joint inversion



Vp/Vs ratio

Outline

1 Introduction

2 Technical method

3 Conclusions

Conclusions

1, New velocity analysis method can get PP & SV wave velocity

2,Imaging PP and PS wave in the same time scale circumvents the registration problem in the data interpretation and joint inversion

3, VFSA prestack joint inversion has higher accuracy

Acknowledgement

Mrinal K. Sen

Youxin Wang

Xue Yang

Yi Tao

Robert Tatham

Kyle Spikes

Paul Stoffa

Rui Zhang

Special Thanks to our Sponsors

UT-AUSTIN EDGER FORUM

Anadarko

bp

BRIGHAM Exploration Company

CIMAREX

devon

ConocoPhillips

CNPC BGP

Chevron Human Energy

drillinginfo® Open To Explore™

HALLIBURTON | Landmark Software & Services

DAWSON® Dawson Geophysical Company

Thank you very