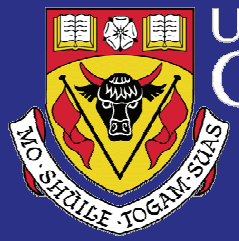


UNIVERSITY OF CALGARY

CREWES

FLUID SUBSTITUTION IN COALBEDS

by

Diane Lespinasse

Robert Ferguson

Outline

- Objective
- Introduction
- Theory
  - Palmer and Mansoori permeability model
  - Gassmann Fluid Substitution
- Area of study
- Methodology
- Results
- Conclusions

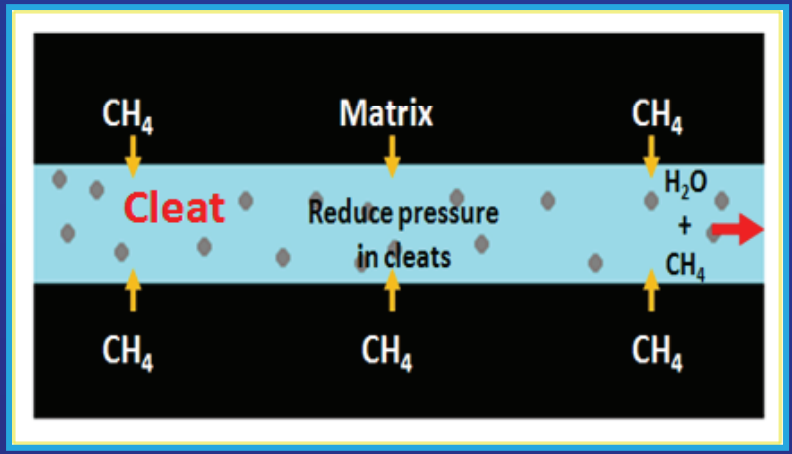
Objective

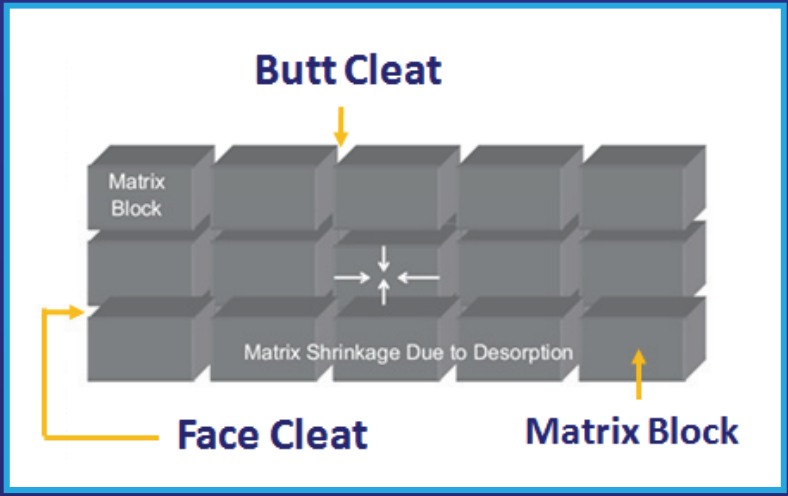
Evaluate the seismic response due to fluids in the pore space of coalbeds. We perform a fluid substitution in two coalbeds of the Mannville Group in the Corbett Field

Introduction

Coalbed Methane

- Unconventional resource
- Dual porosity system
- Methane production
- Coal matrix deformation





Permeability model

Changes in coal permeability:

- Increase of the effective stress
- Shrinkage of the matrix

Palmer and Mansoori (1998):

$$\frac{\phi}{\phi_i} = 1 + \frac{C_f}{\phi_i}(P - P_i) + \frac{\varepsilon_\infty}{\phi_i}\left(\frac{K}{M} - 1\right)\left(\frac{P}{P + P_\varepsilon} - \frac{P_i}{P_i + P_\varepsilon}\right)$$

$$\frac{k}{k_i} = \frac{\phi^3}{\phi_i^3}$$

ϕ= Porosity K= Bulk modulus C_f = Fracture Compresibility ε_∞= Volumetric strain at P_∞

P=Pressure k = permeability M= Constrained Axial Modulus P_ε = Pressure at ε_∞ /2

Gassmann fluid susbtitution

Gassmann´s equation (1951):

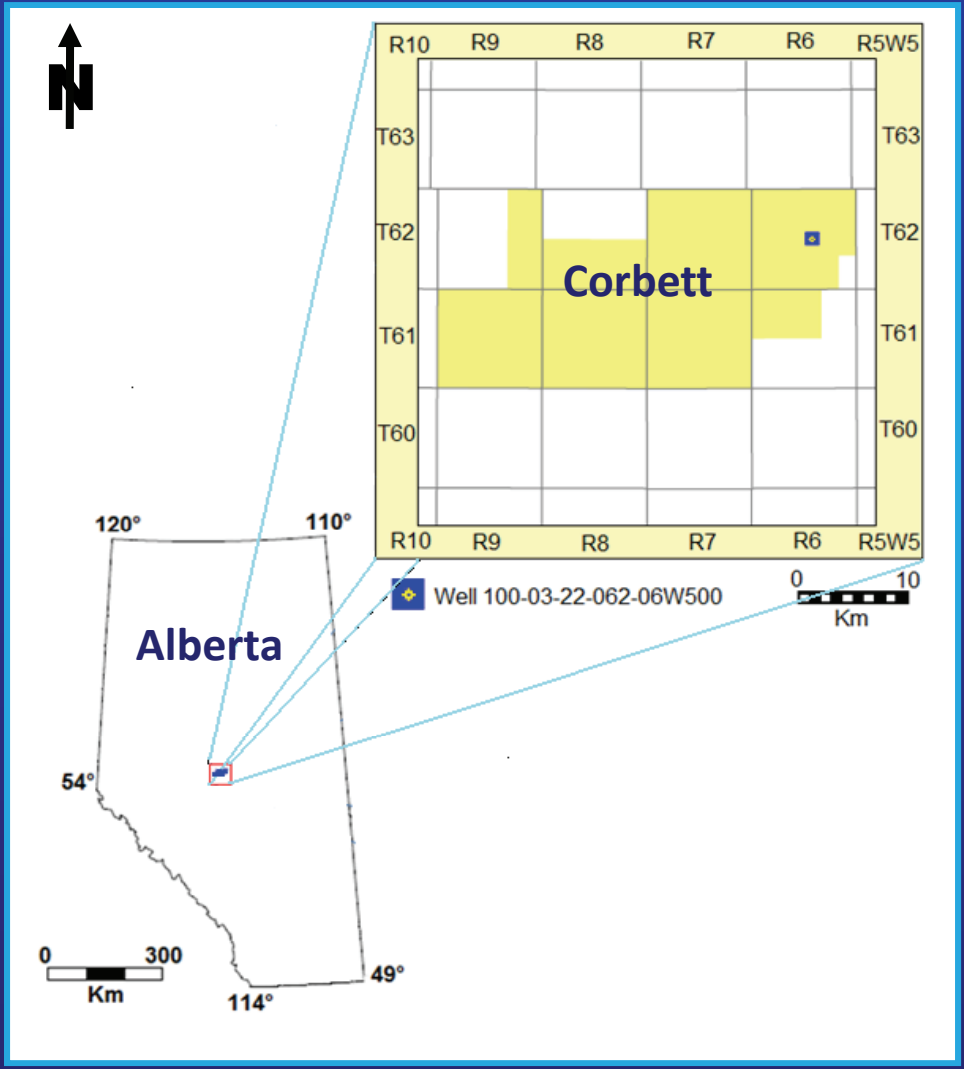
$$K_{sat} = K^* + \frac{\left(1 - \frac{K^*}{K_0}\right)^2}{\frac{\phi}{K_{fl}} + \frac{(1-\phi)}{K_0} - \frac{K^*}{K_0^2}}$$

Applications:

- Information for well data analysis
- AVO Response
- 4D surveys

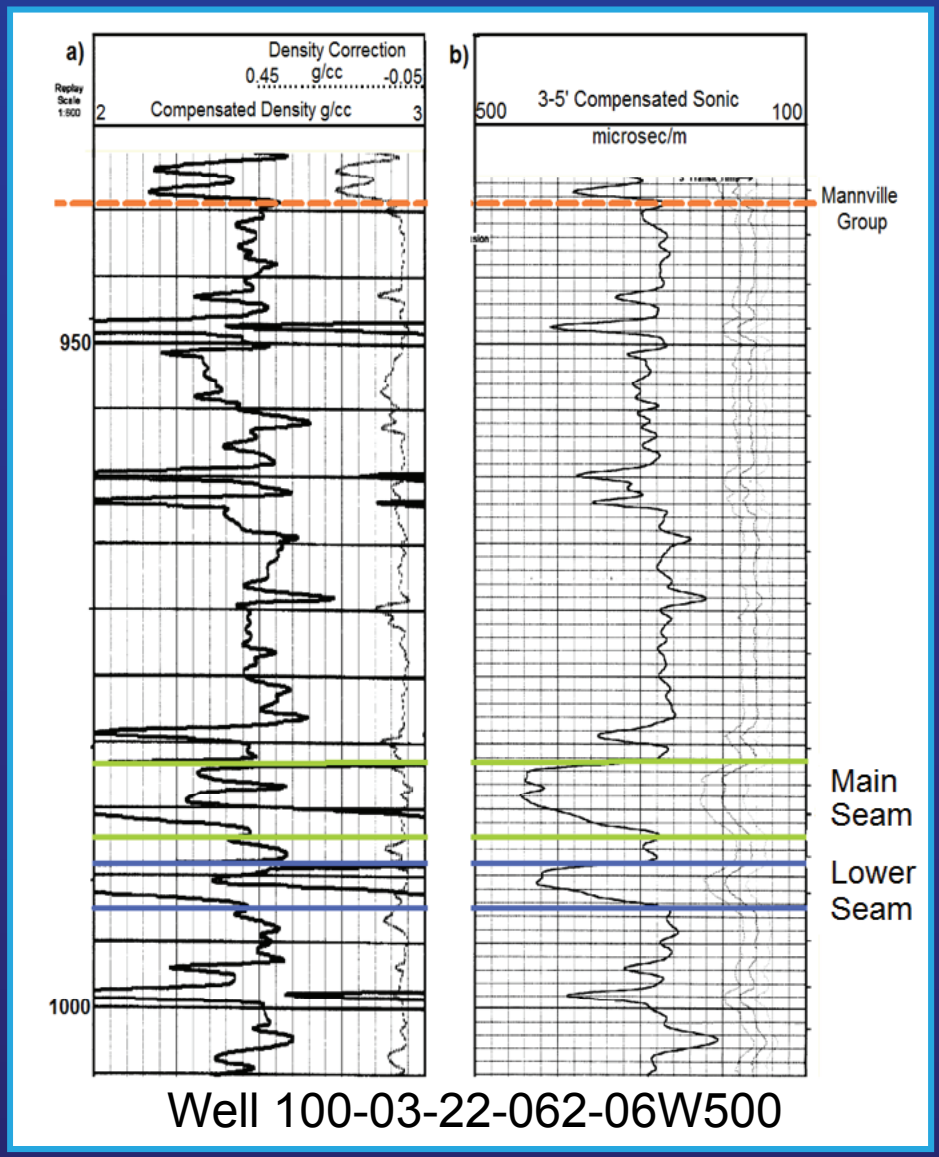
Area of study

- Corbett Field
- Corbett Creek area
- Central Alberta,
- 145Km NW of Edmonton
- Extension of 558 Km^2



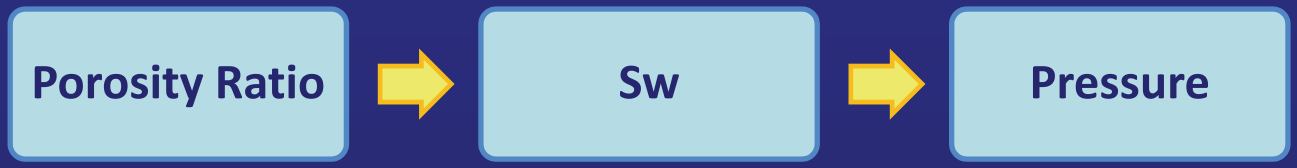
Area of study

- Low density and high sonic response
- Upper Mannville Group
- 825m (NE) - 1080m(SW)
- Main Seam : 3.6m
- Lower Seam: 1.5-2m



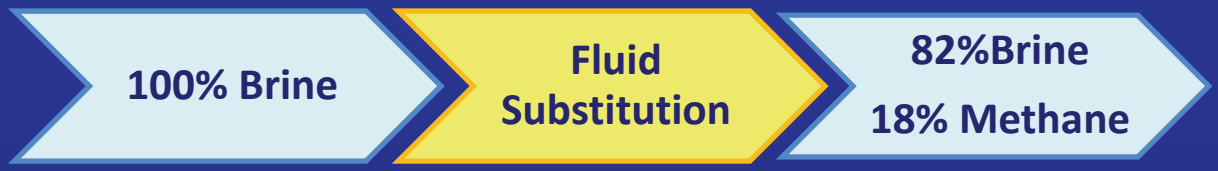
Methodology

- Data selection: Horseshoe Canyon vs Mannville Group
- Fluid Simulation (F.A.S.T Software)
  - Langmuir isotherm
  - Matrix shrinkage
  - Deliverability and production forecast



Methodology

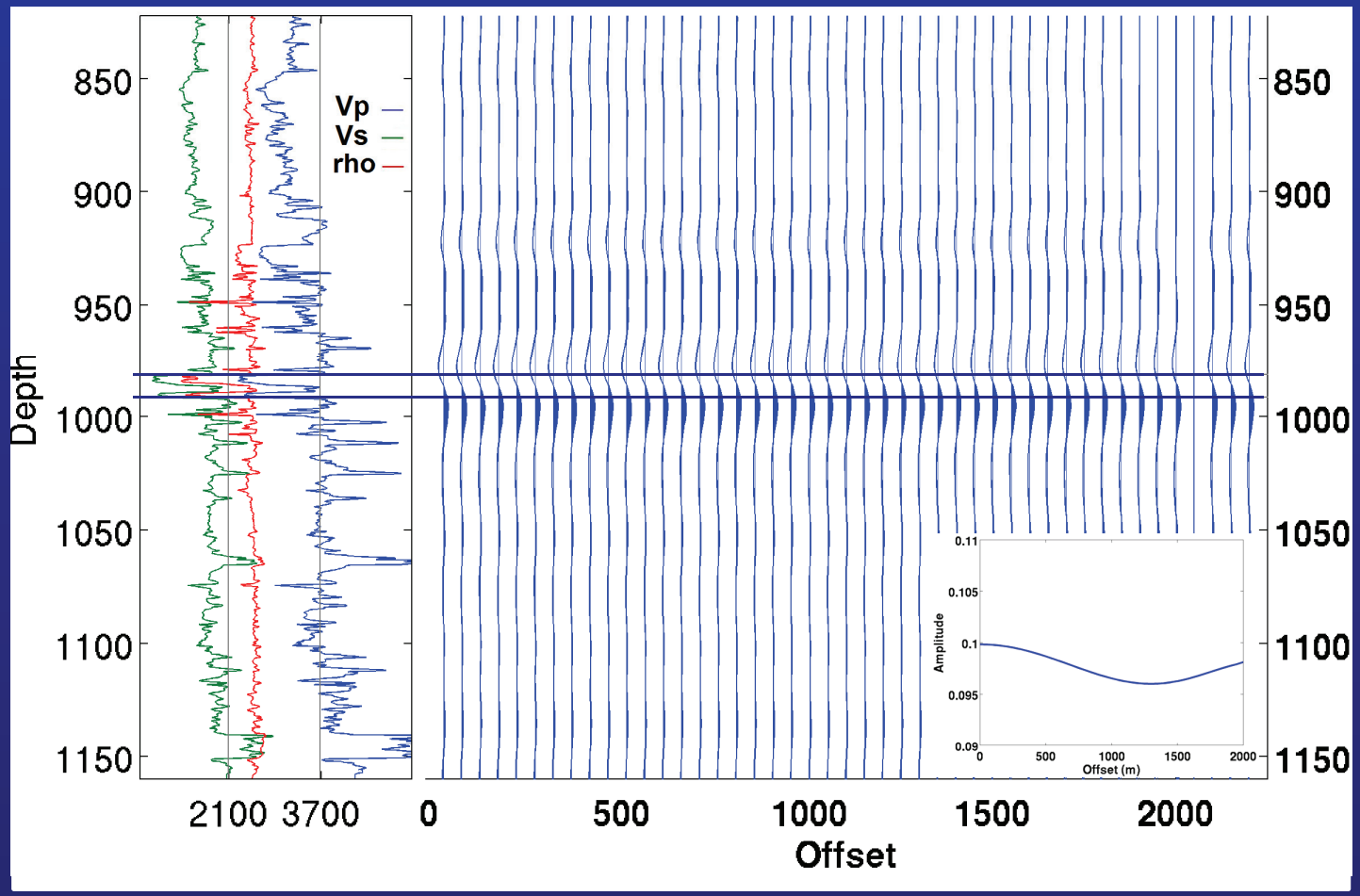
- Gassmann Fluid Substitution



- Synthetic Seismograms (Syngram)
  - Time and Depth domain
  - 30Hz and 60Hz Ricker
  - Different coal thickness

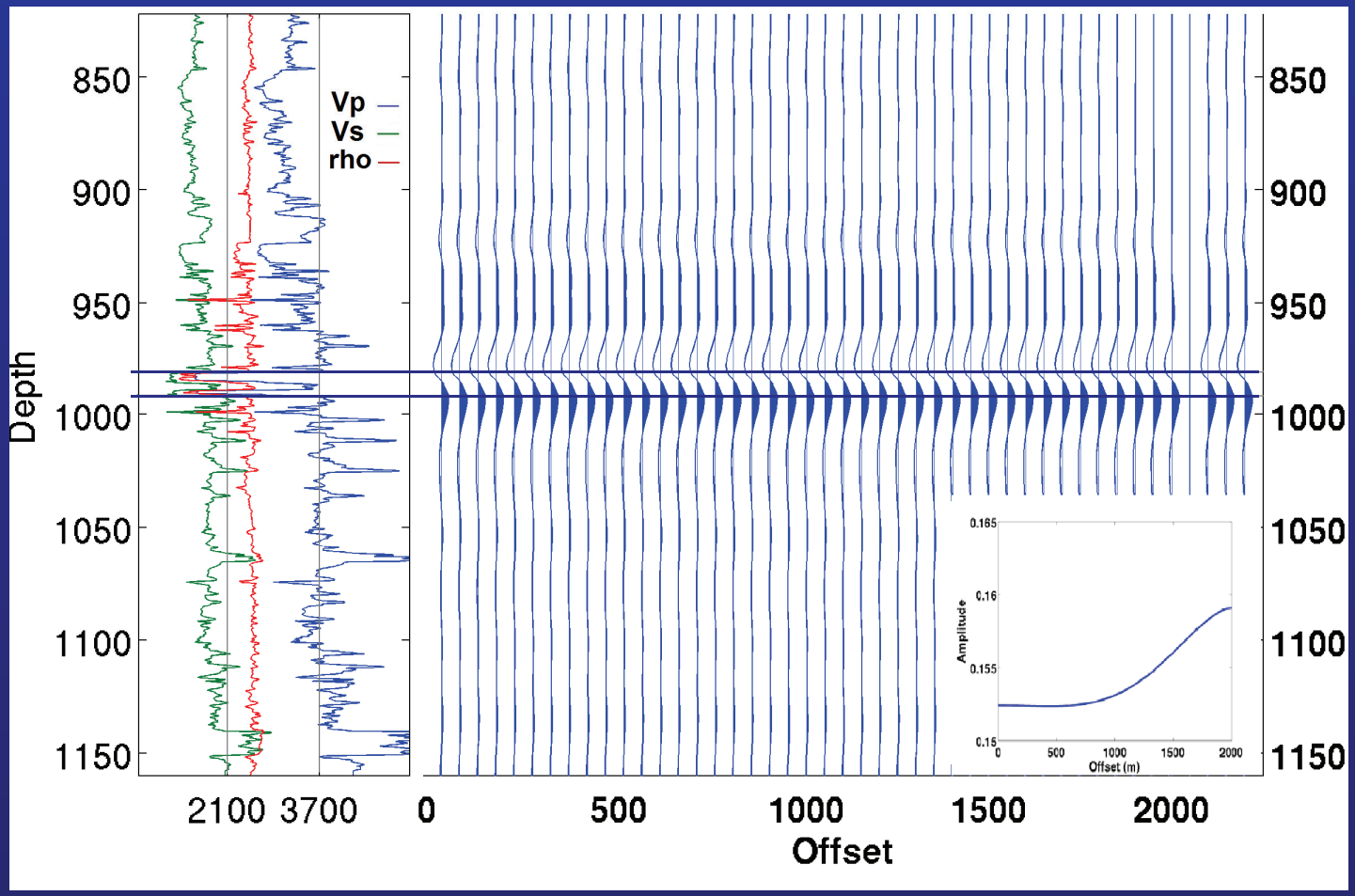
Results

Pore Fluids	Ricker Wavelet	Coal Thickness	Domain
Brine 100%	Freq 30 Hz Phase 0°	Main seam 3.65m Lower seam 1.67m	Depth



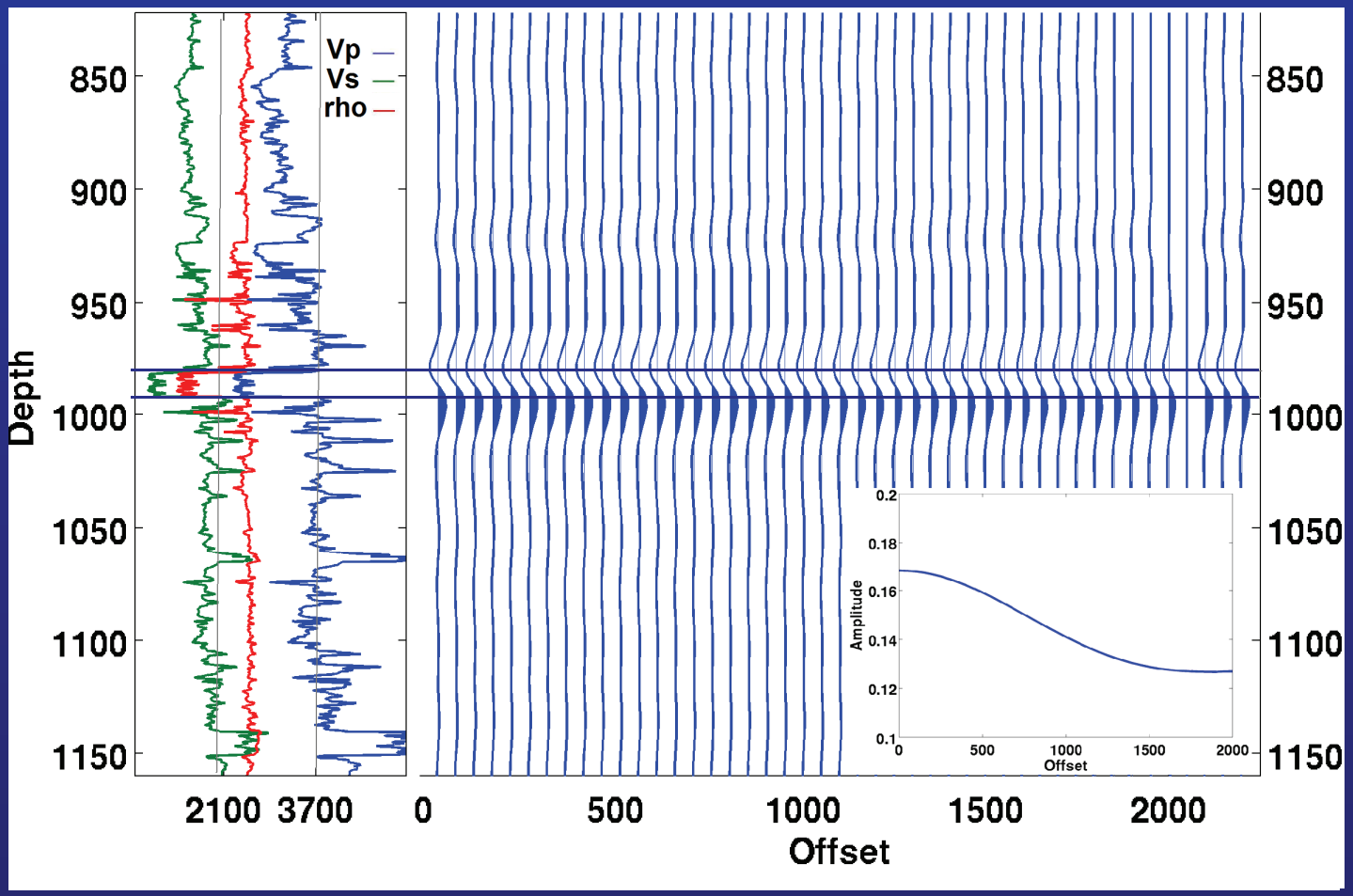
Results

Pore Fluids	Ricker Wavelet	Coal Thickness	Domain
Brine 82% CH_4 18%	Freq 30 Hz Phase 0°	Main seam 3.65m Lower seam 1.67m	Depth



Results

Pore Fluids	Ricker Wavelet	Coal Thickness	Domain
Brine 100%	Freq 30 Hz Phase 0°	Coal seam 10.6m	Depth



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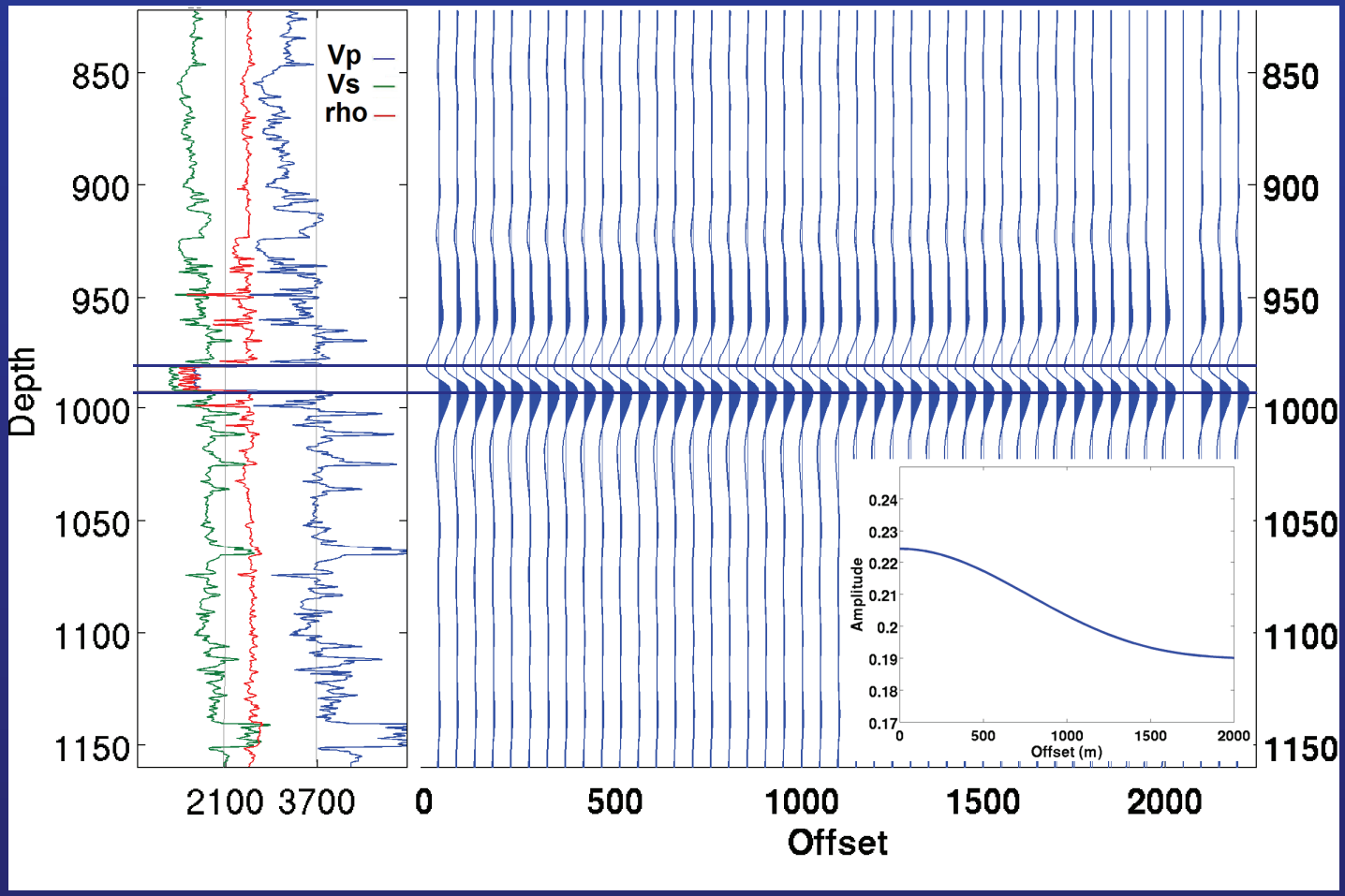
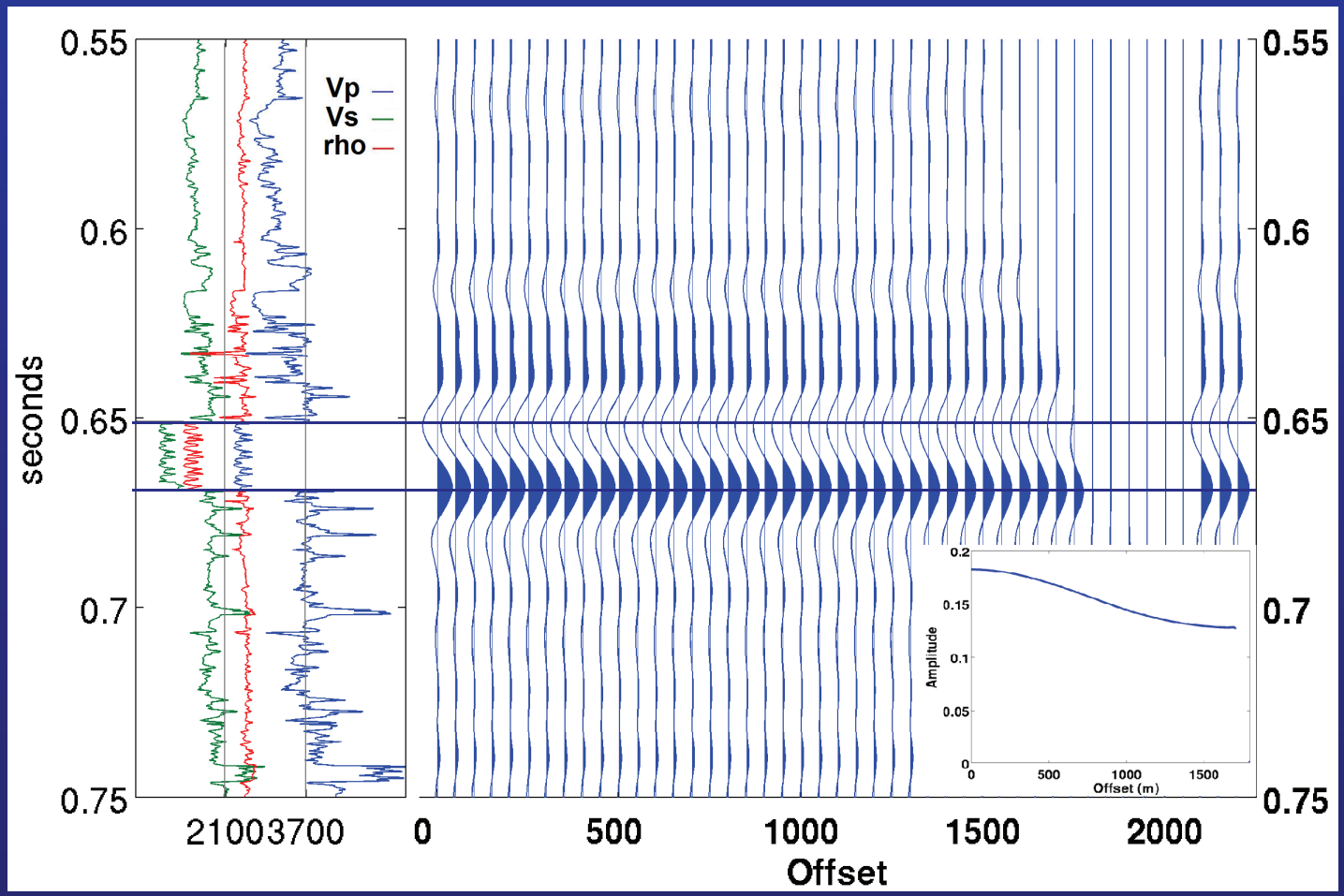


Results

Pore Fluids	Ricker Wavelet	Coal Thickness	Domain
Brine 100%	Freq 30 Hz Phase 0°	Coal seam 21m	Time



Results

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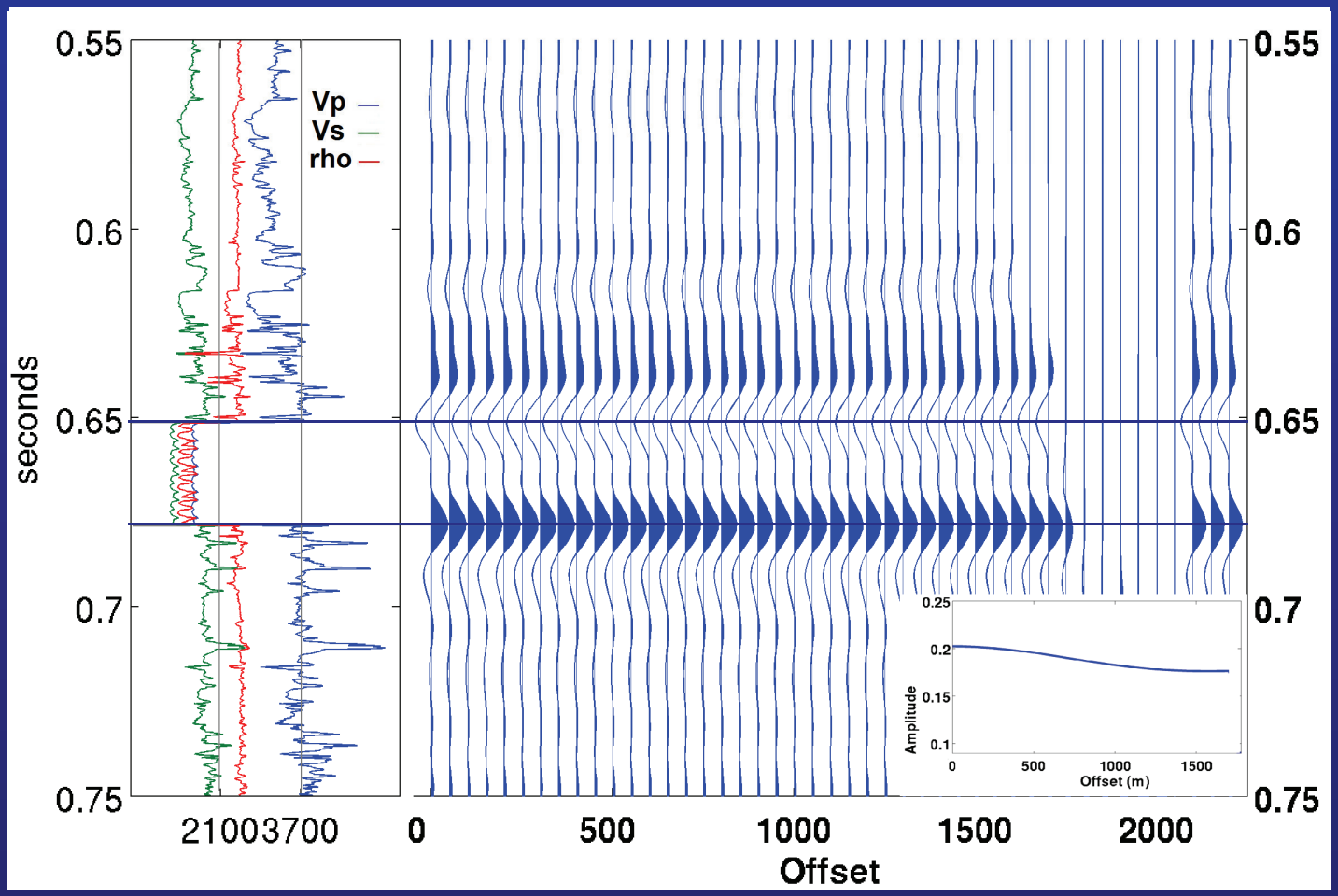
Brine 82% CH_4 18%	Freq 30 Hz Phase 0°	Coal seam 21m	Time



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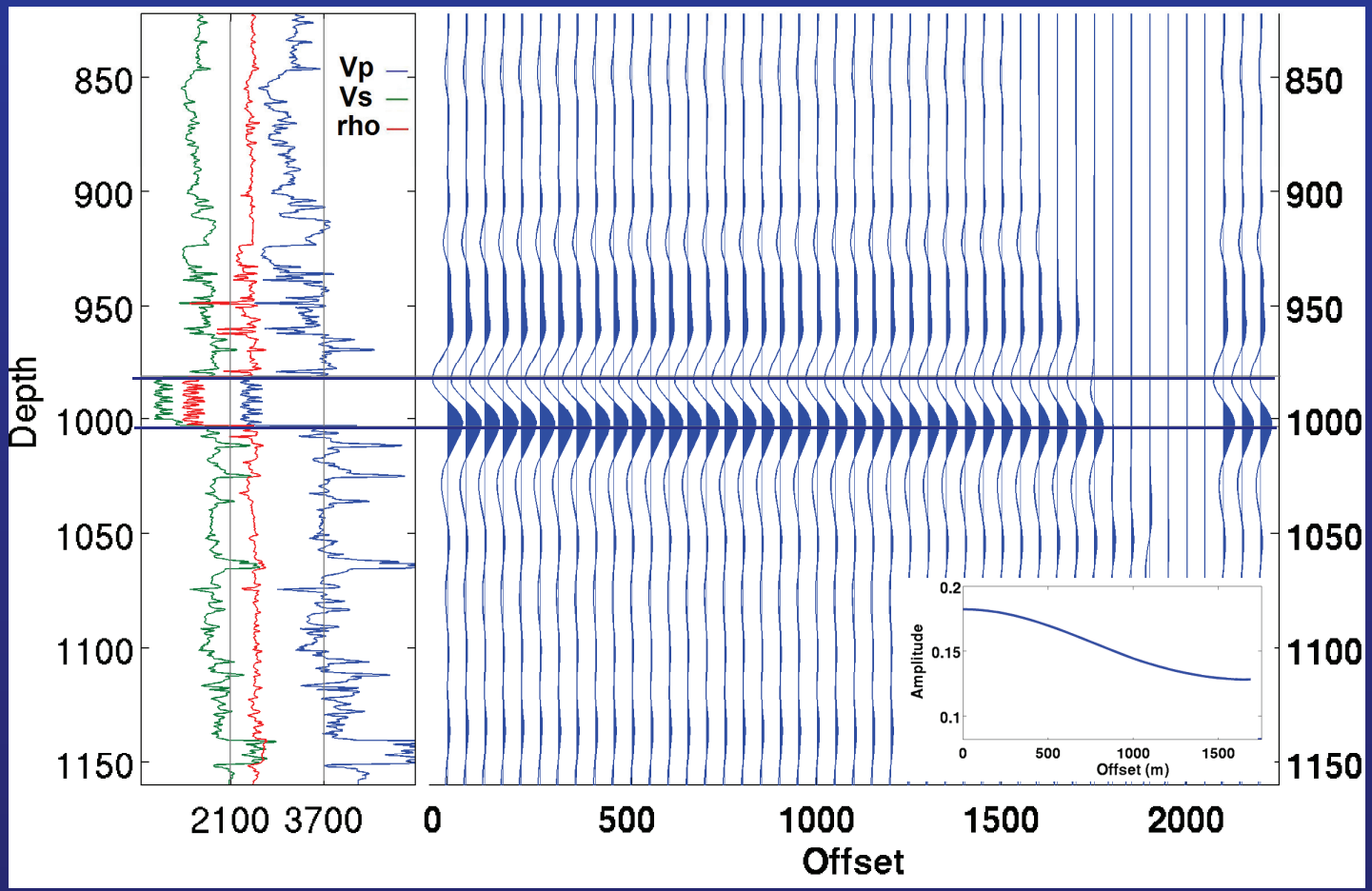

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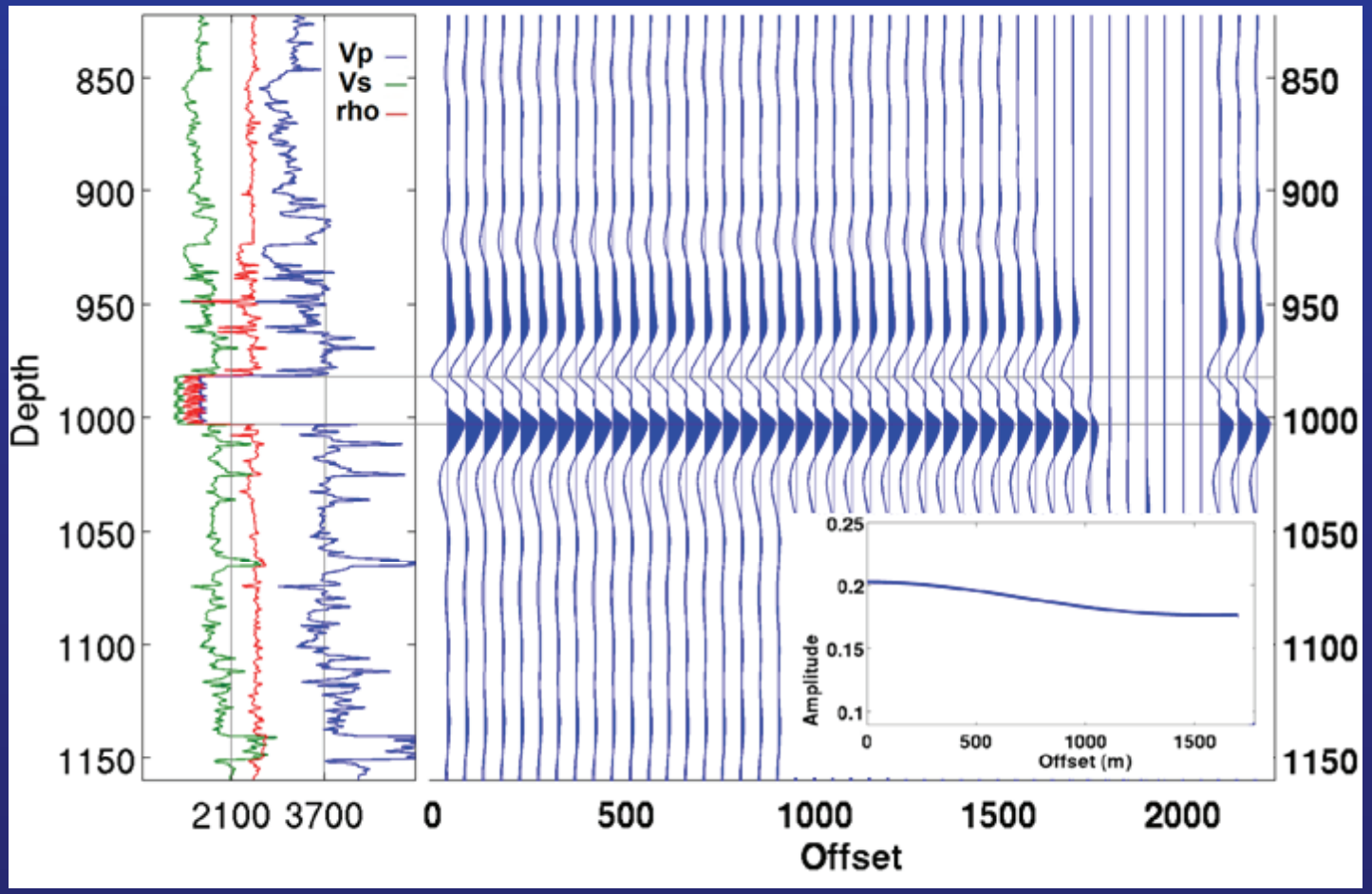
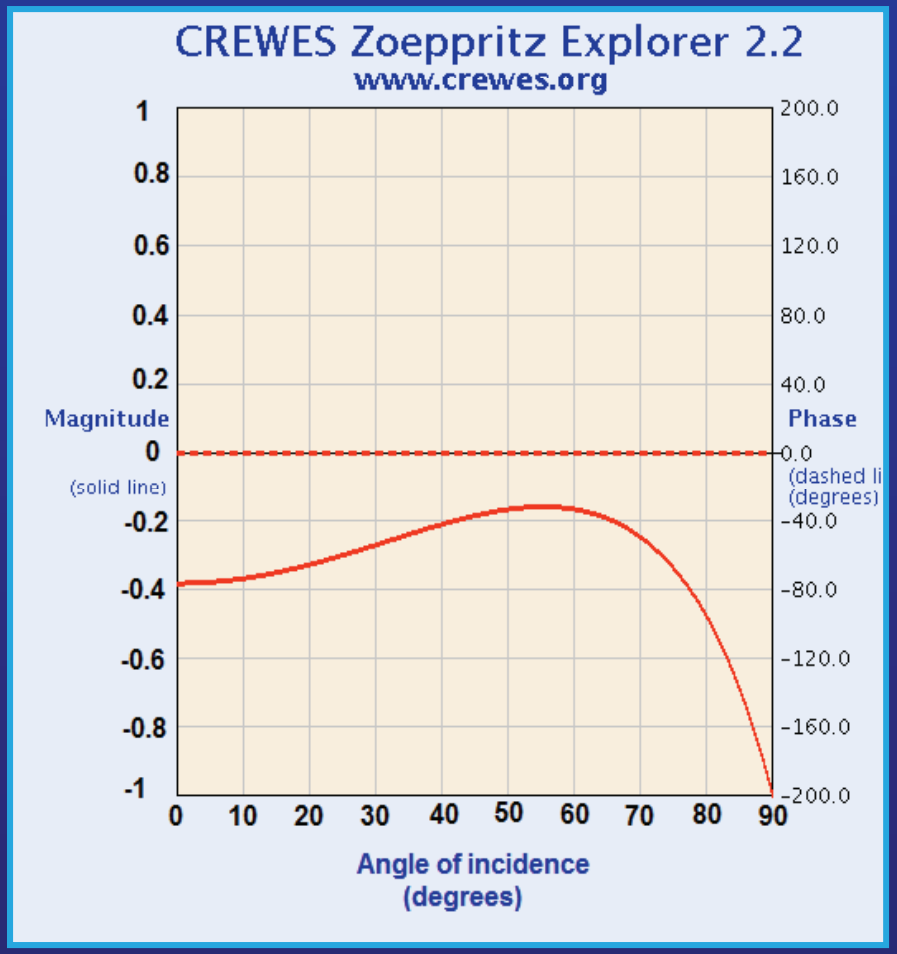
Brine 82% CH_4 18%	Freq 30 Hz Phase 0°	Coal seam 21m	Depth



Results

- CREWES Zoeppritz Explorer
- Average Vp, Vs and density
- Upper Layer: Overburden
- Lower Layer: Coal
- No critical angle



Conclusions

- Corbett Field: Not enough resolution to identify Main Seam and Lower Seam. Subtle changes after fluid substitution
- 10m coalbed: was resolved with the 30Hz Ricker wavelet. More evident changes in the wavelet character
- 21m coalbed: Accentuated changes in wavelet character
- 21m coalbed: The changes due to fluid substitution are more evident in seismograms in depth domain.

Conclusions

- Transmission Loss and Spherical Divergence were not considered

Future work:

- Reuss and Voight bounds to have a better control of the parameters used in the fluid substitution

- Fluid substitution with a San Juan basin data set

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