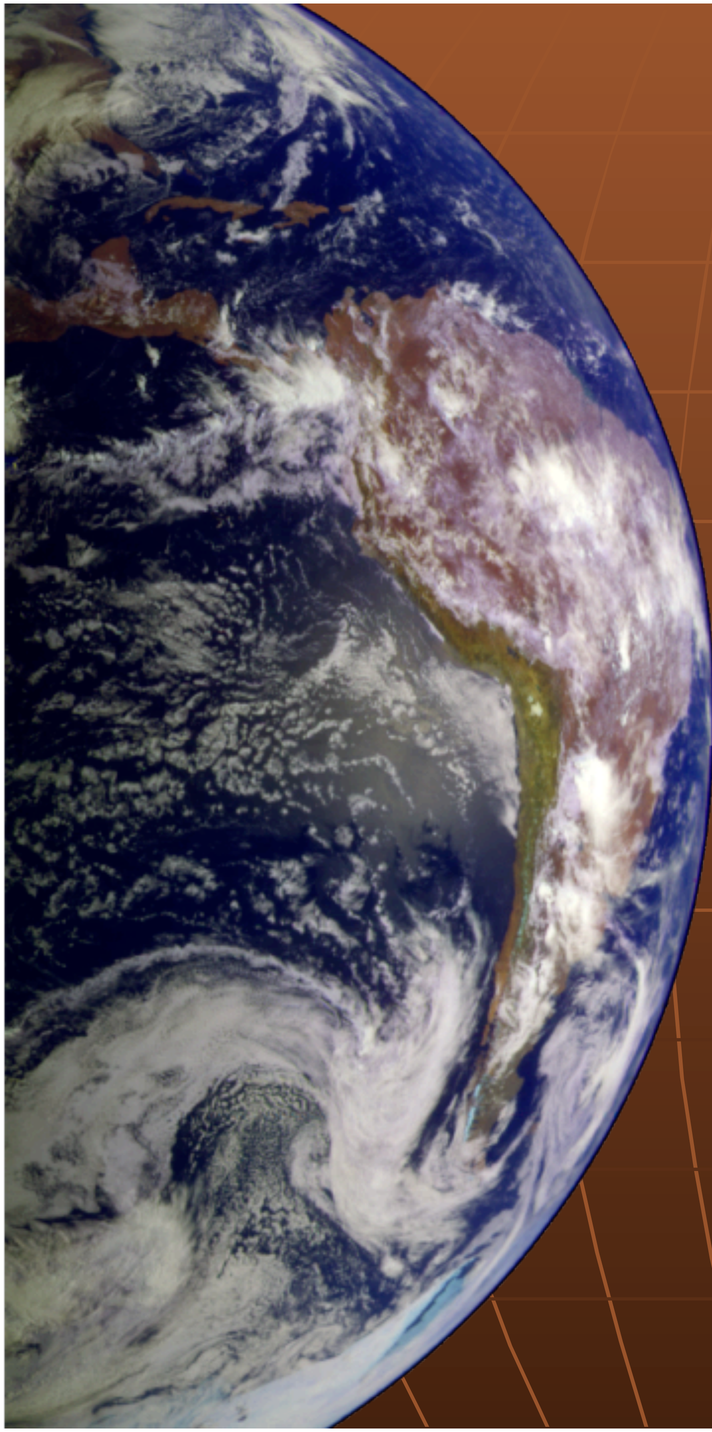

Time Lapse Seismic Response to Production

Presented by

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(PhD candidate)

Supervised by

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Institute for Geophysics
Jackson School of Geosciences
University of Texas at Austin

Date: February 22 , 2010

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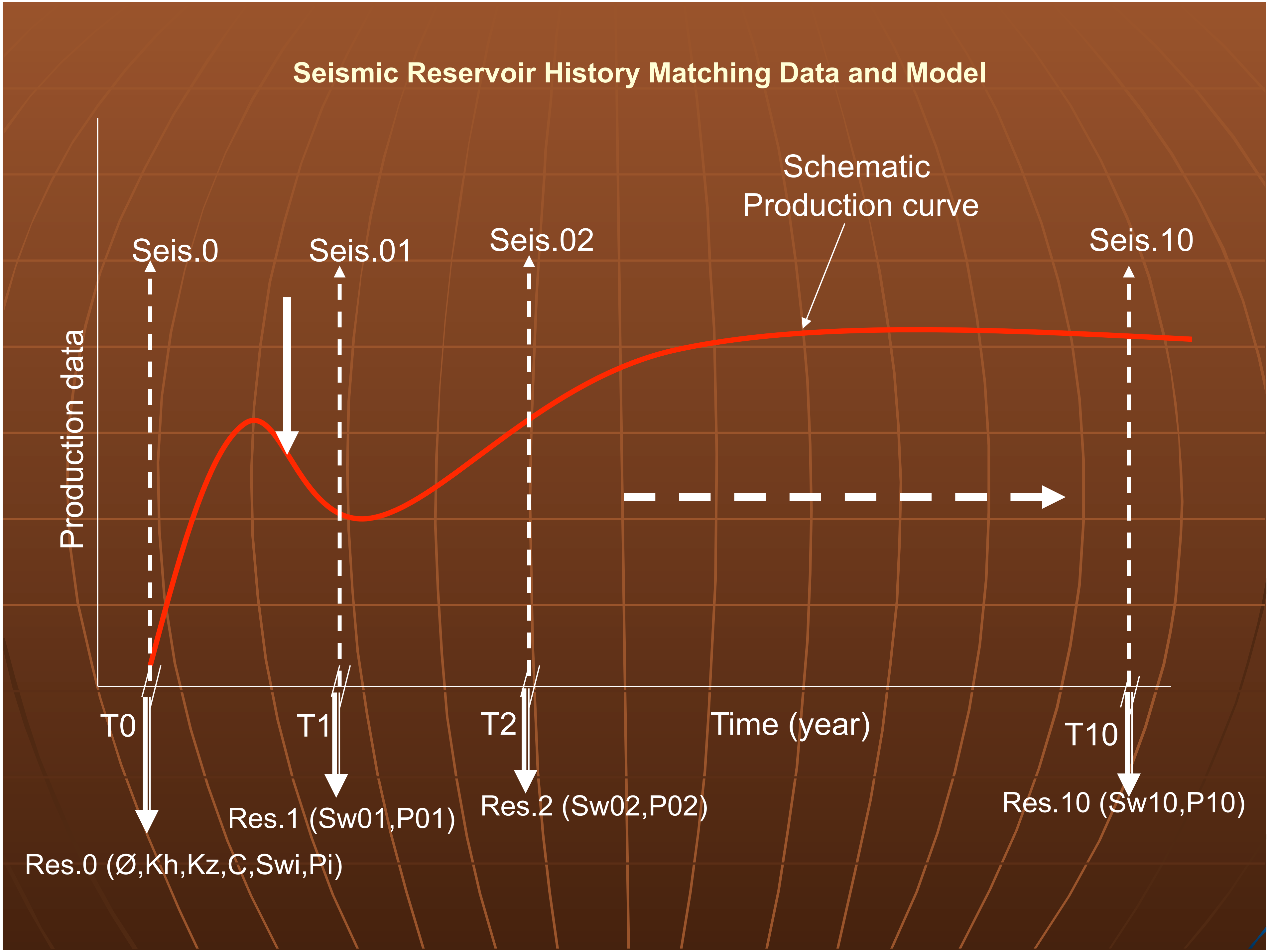

Seismic Reservoir History Matching Data and Model
Schematic
Production curve
Production data
Seis.0
Seis.01
Seis.02
Seis.10
T0
T1
T2
Time (year)
T10
Res.0 (Ø,Kh,Kz,C,Swi,Pi)
Res.1 (Sw01,P01)
Res.2 (Sw02,P02)
Res.10 (Sw10,P10)

Seismic Time-lapse analysis

- **Qualitative interpretation:**
  - Identifications of flood fronts, preferential pathways, thief zones, and flow barriers, i.e. seals, by-passed pay and infill target definition.
- **Quantitative interpretation:**
  - Discrimination of saturation and pressure changes from changes in seismic attributes
- **Seismic reservoir history matching:**
  - Updating of the reservoir flow model in order to have realistic reservoir production forecasts

Research outcomes

- **Previous work**
  - **Sensitivity analysis of multi-component seismic attributes to fluid content and pore pressure (SEG Abstract, presented in Las Vegas meeting 2008)**
  - **Multi-component seismic time-lapse cross-plot and its applications (SEG Abstract, presented in Houston meeting 2009)**
- **Current work**
  - **Time-lapse rock-fluid physics templates**
- **Future work**
  - **Global stochastic pre-stack seismic inversion to estimate petrophysical properties**
  - **Global reservoir history matching constrained by seismic and production data**

Contents

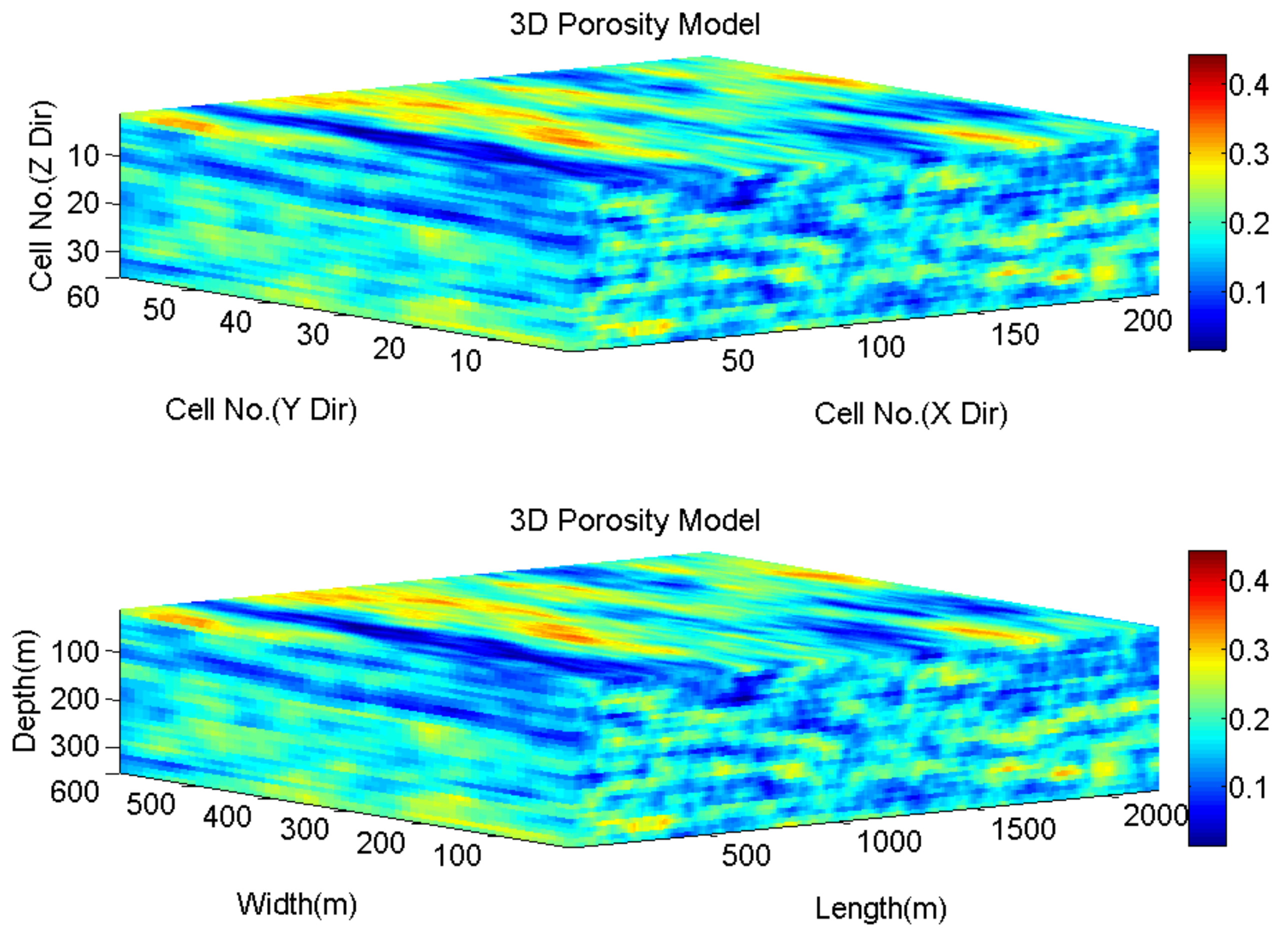
Reservoir model

- A generic reservoir model representing a prograding near shore zone environment (wave-dominated sandstone).

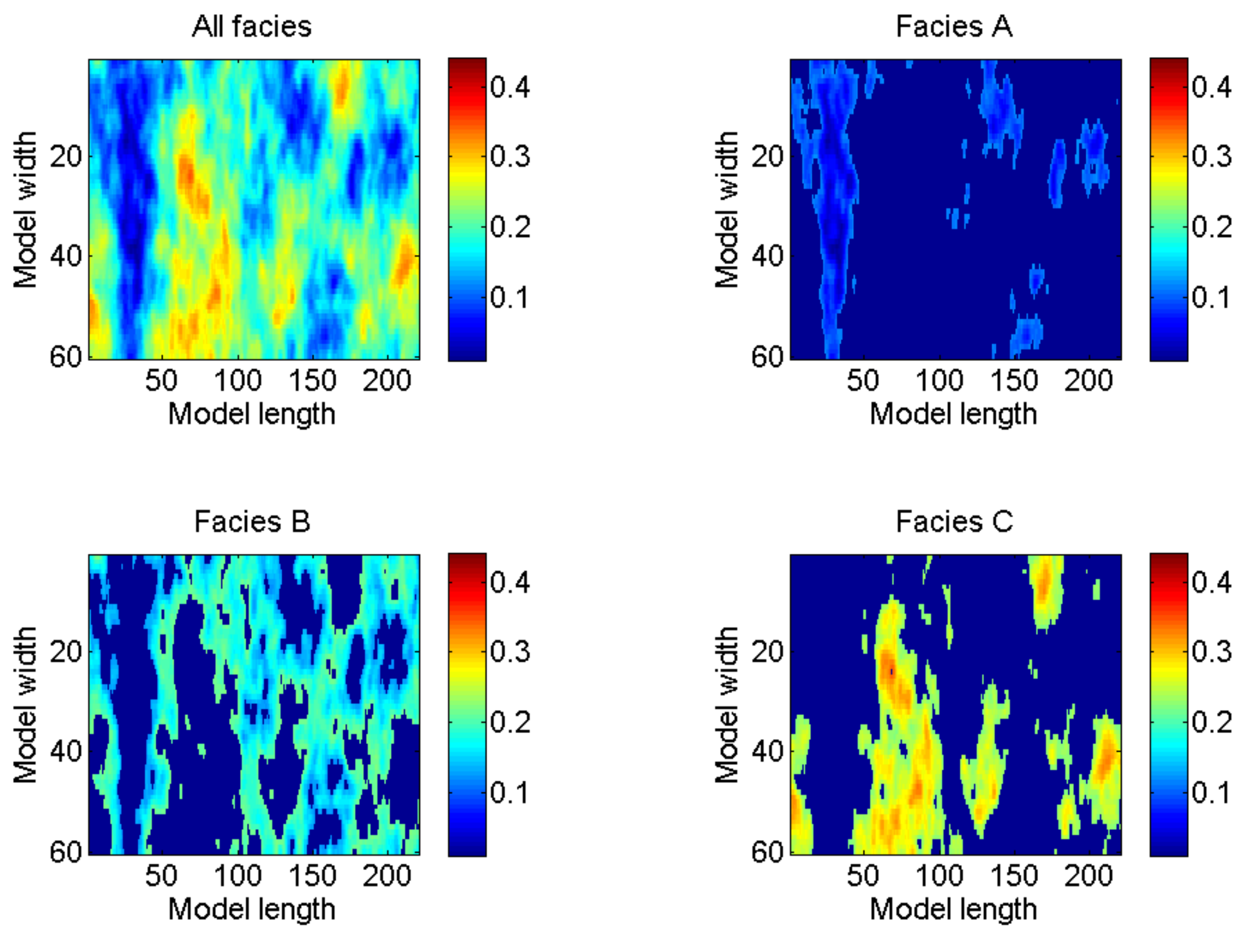
- It consists of three petrophysical facies:
  - Facies A: fine grained sandstone (mean grain size 80 um)
  - Facies B: medium grained sandstone (mean grain size 250 um)
  - Facies C: coarse grained sandstone (mean grain size 500 um)

- The model size: x=220, y=60,z=35 cells.
- The cell size: 10 x 10 x 10 (m).
- The model dimensions are x=2200, y=600, z=350 (m).

3D effective porosity model



Facies distribution in effective porosity domain
Map view



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  - Reservoir simulation
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- Summary and conclusions
- Future research
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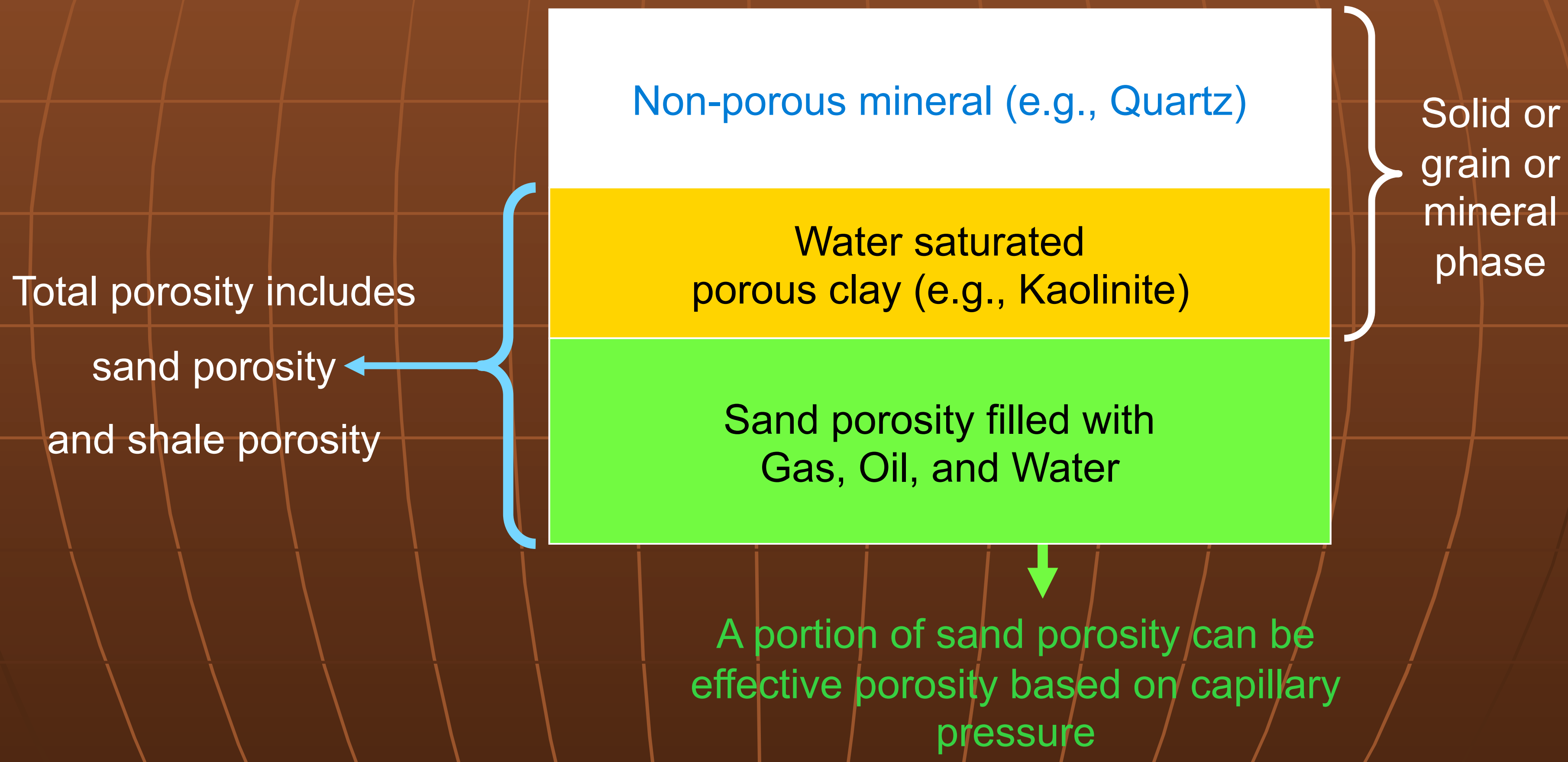
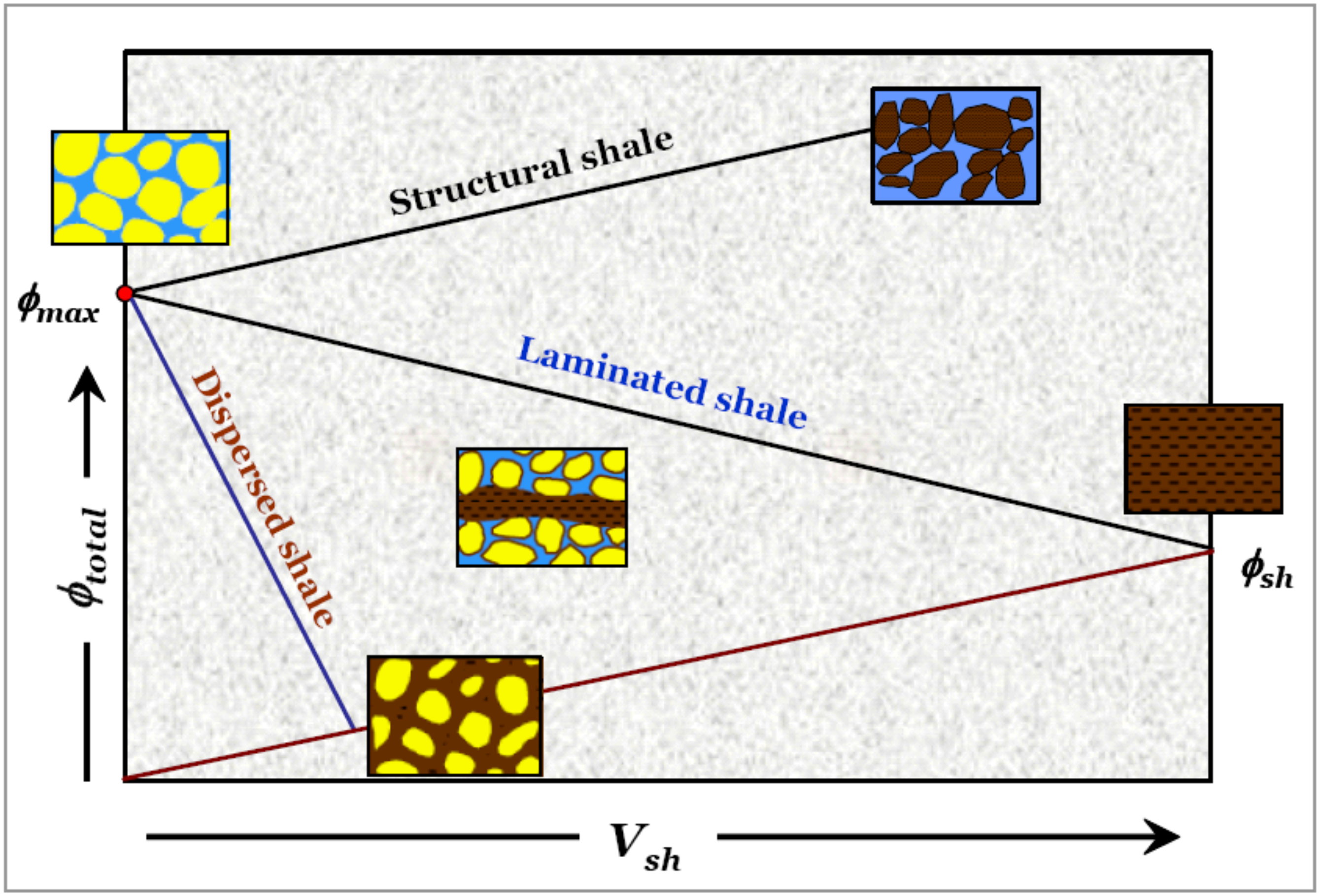
Schematic representation of reservoir rock

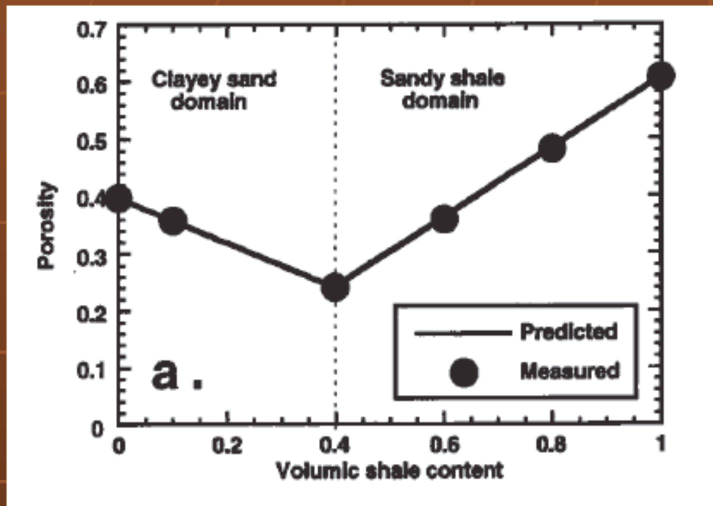


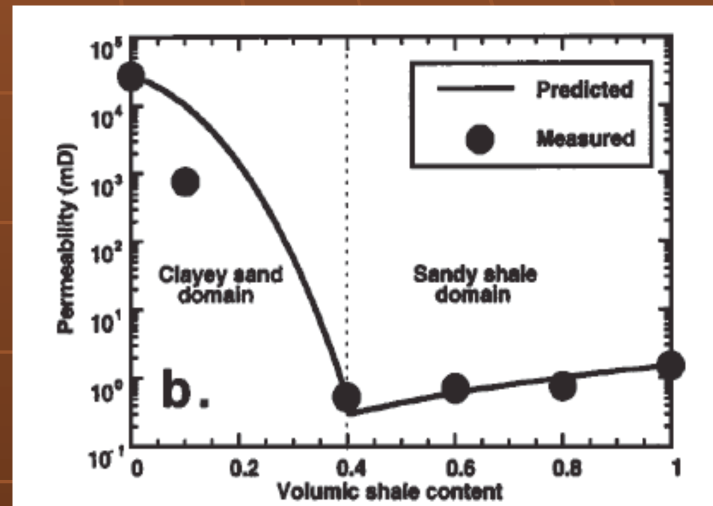
Clay distribution in clastic rocks

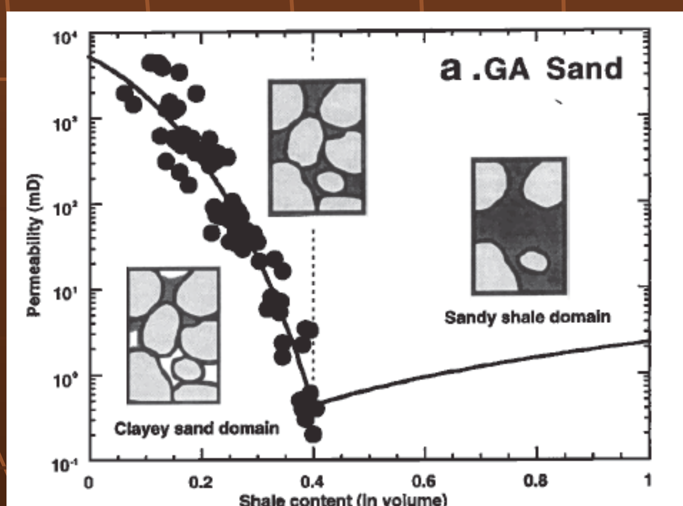


Thomas & Stieber model

Porosity/Permeability model for dispersed clay model (Lab and Real data from GOM)







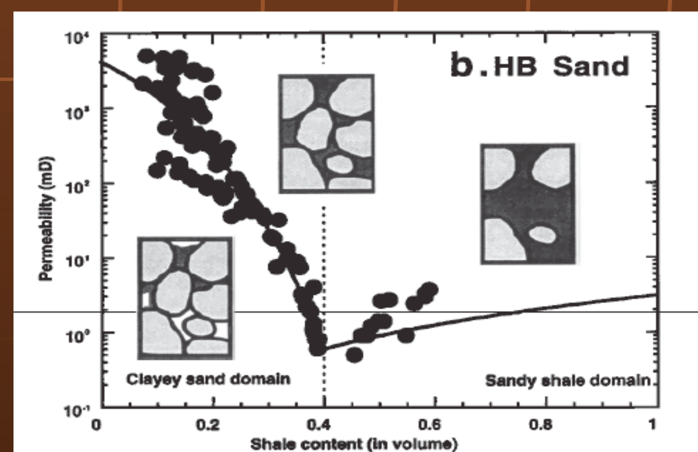


Figure 13. Permeability versus shale content (in volume) for GA and HB sands.

Revil and Cathies, water resources research, vol. 35, no. 3, March 1999

Porosity/water saturation model for dispersed clay model (Real data)

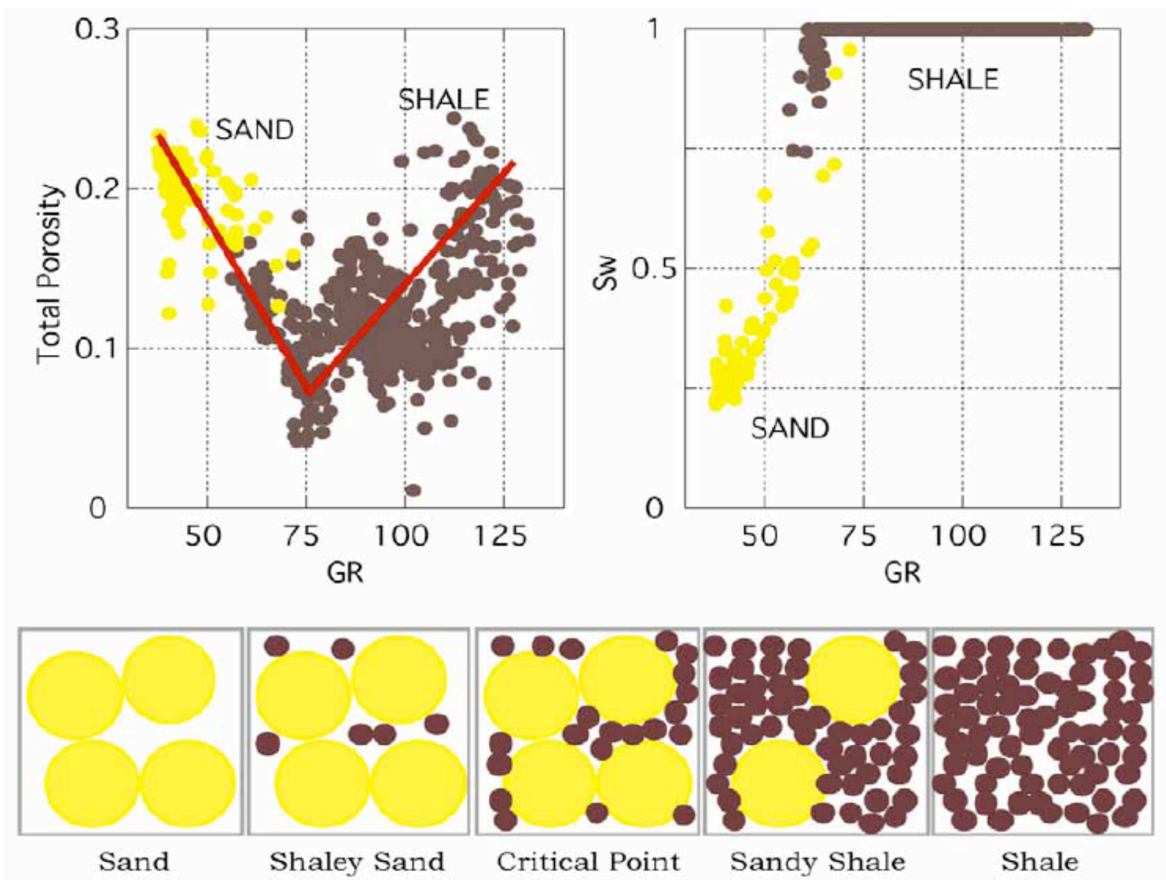
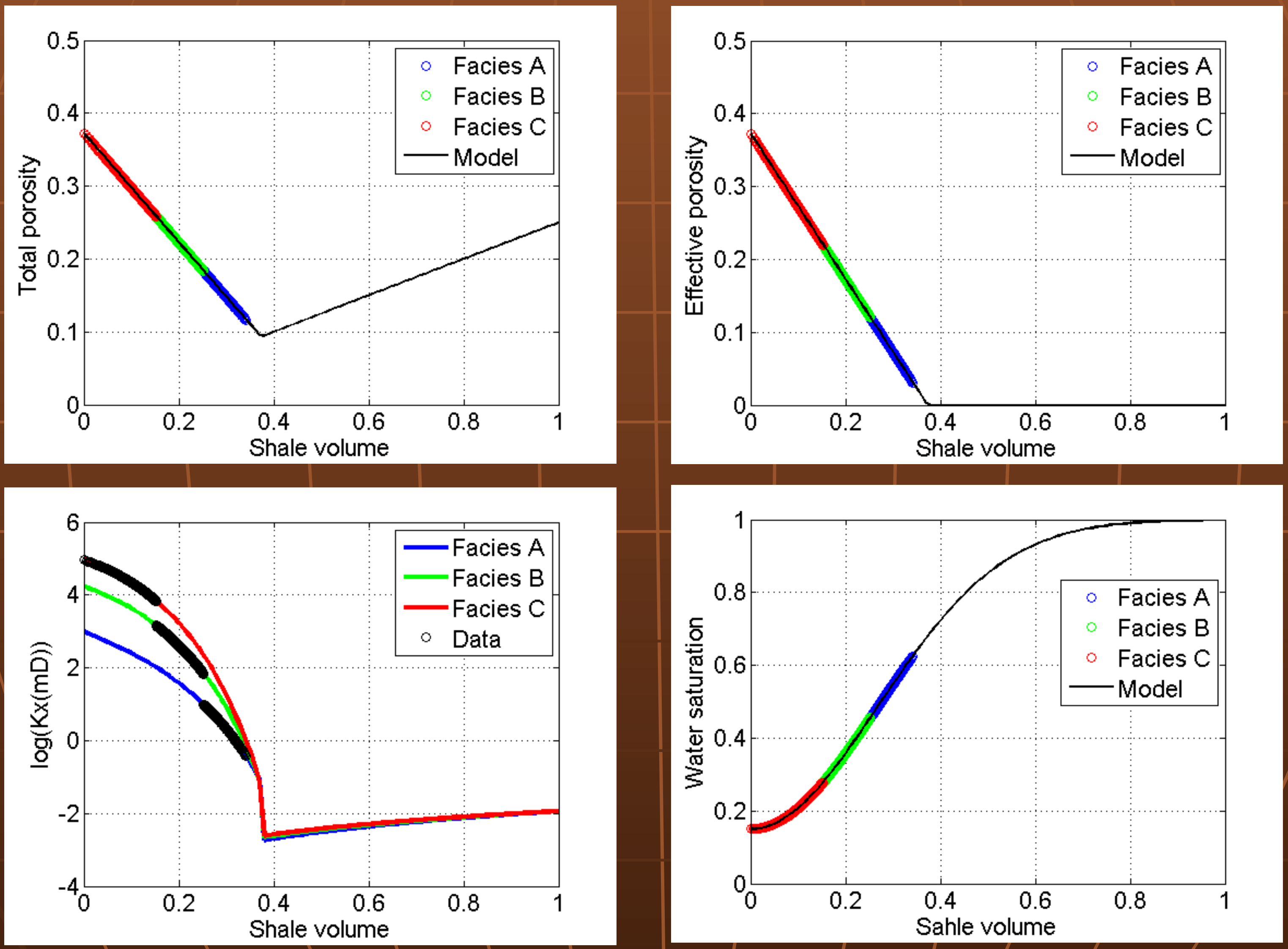


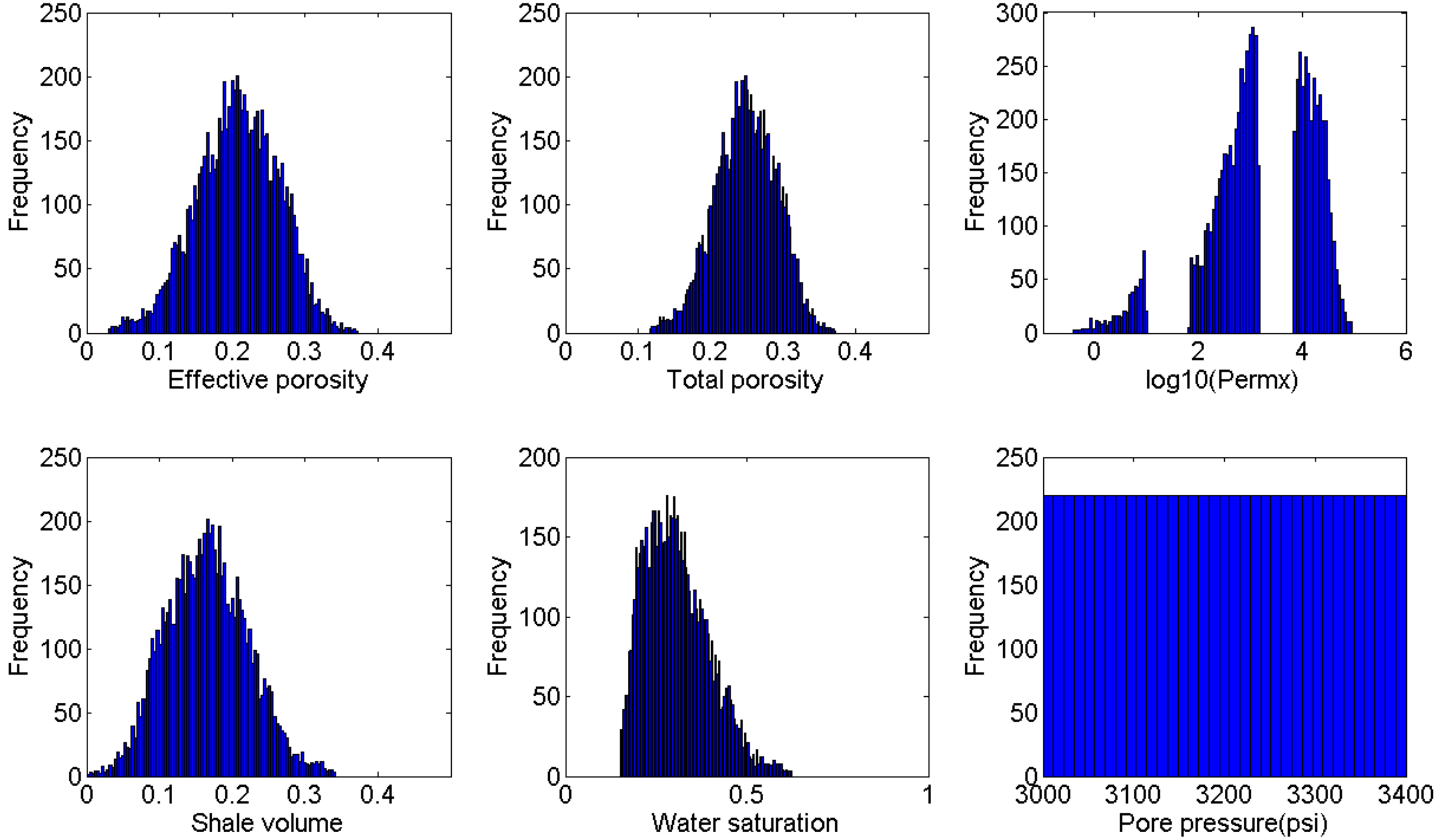
Figure 3: Top – total porosity and water saturation versus gamma ray (clay content measure), with the pay zone highlighted in yellow. Bottom – cartoon of the porosity change in the dispersed clay depositional model.

ASEG 17th Geophysical Conference and Exhibition, Sydney 2004.

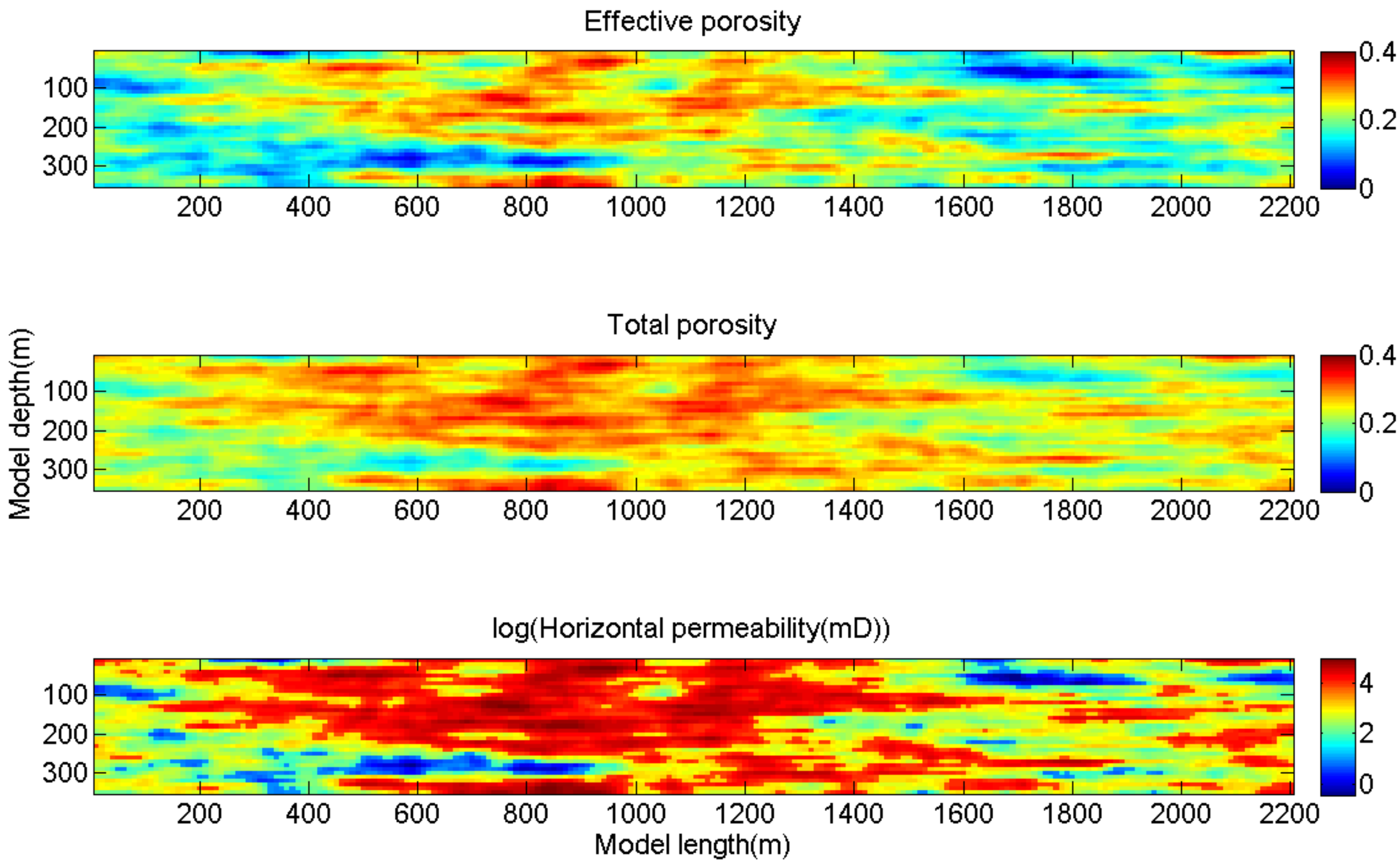
Petrophysics model



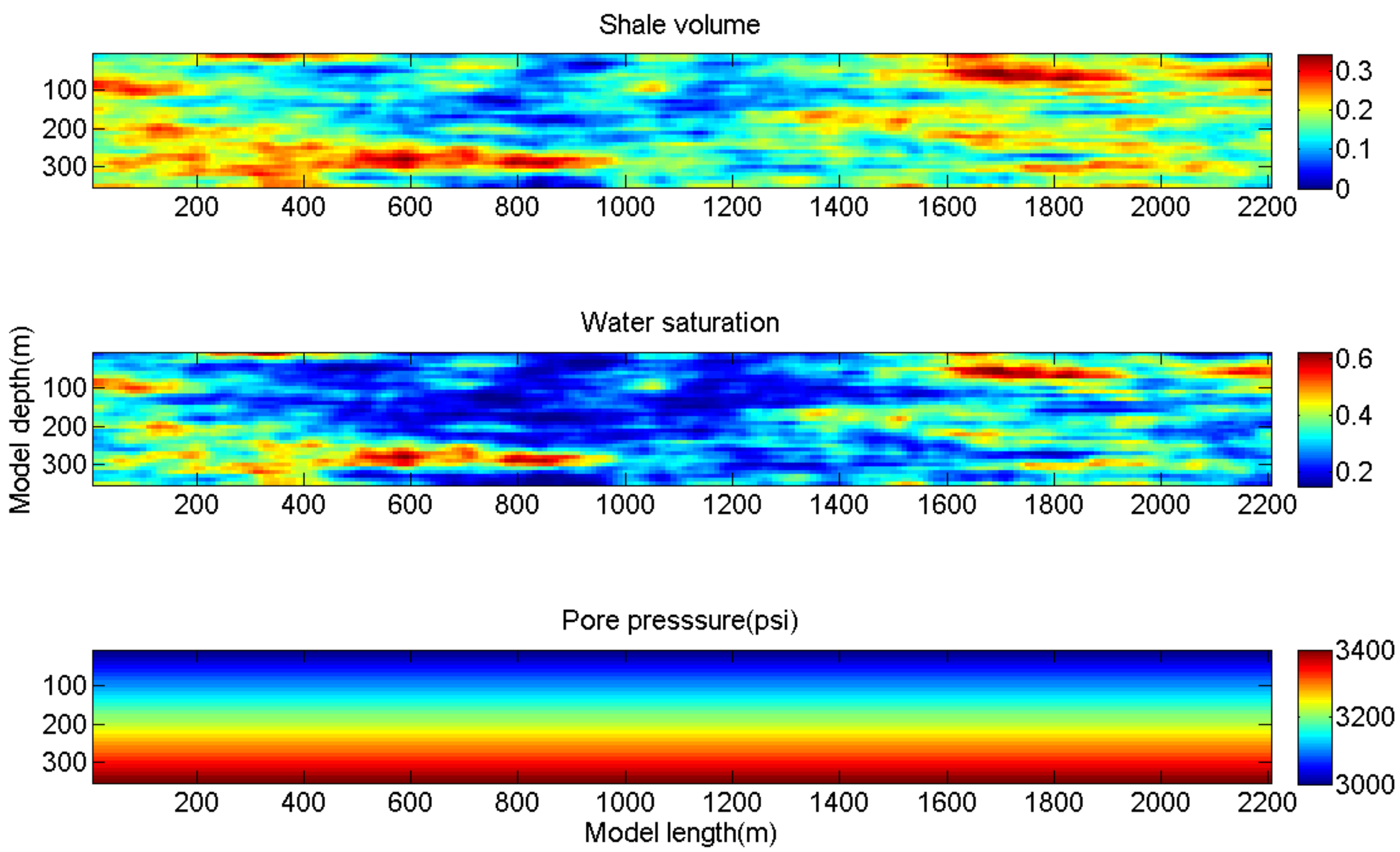
Histogram of reservoir properties



Distribution of petrophysics properties (Section view)



Distribution of petrophysics properties (Section view)



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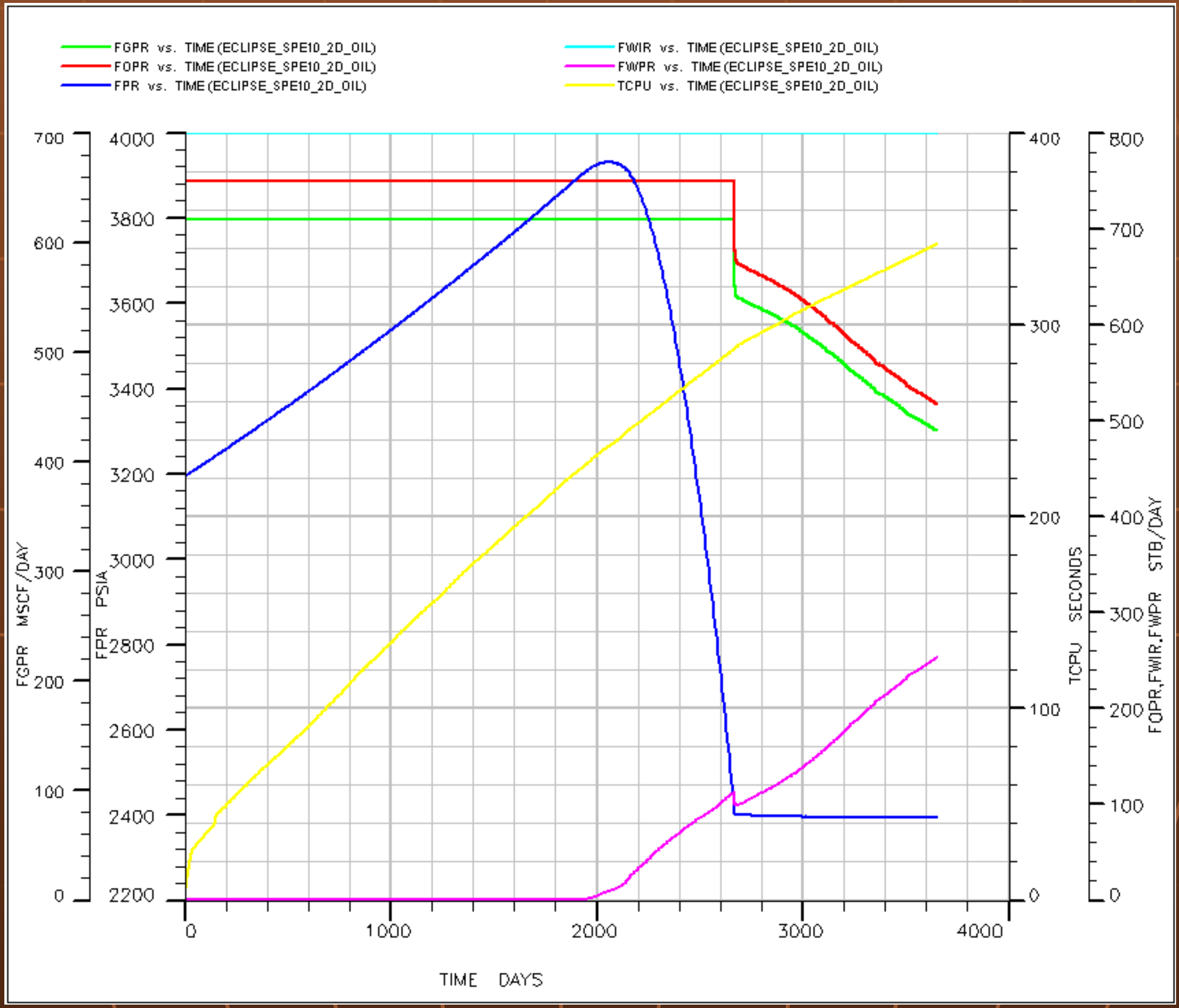
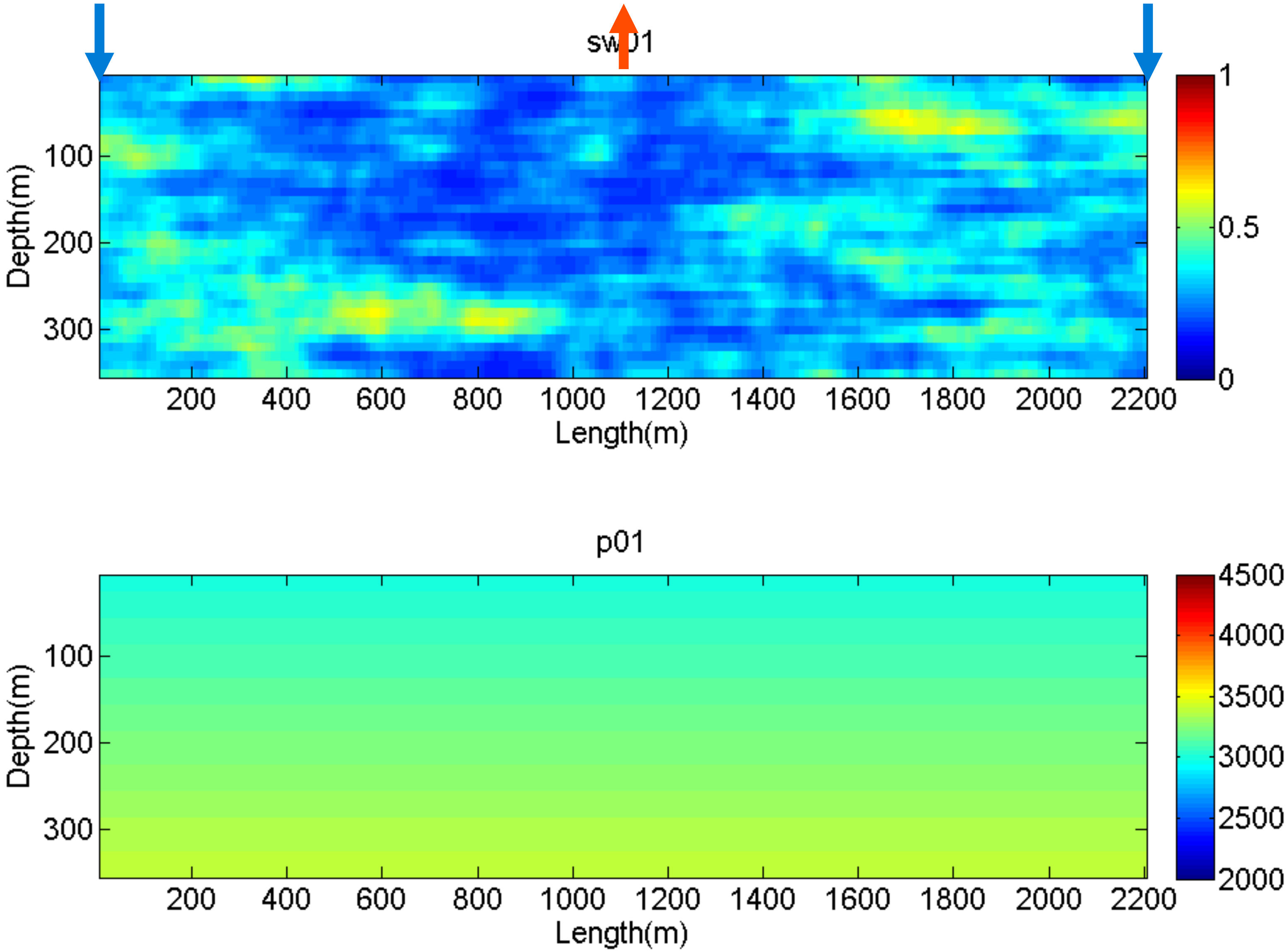
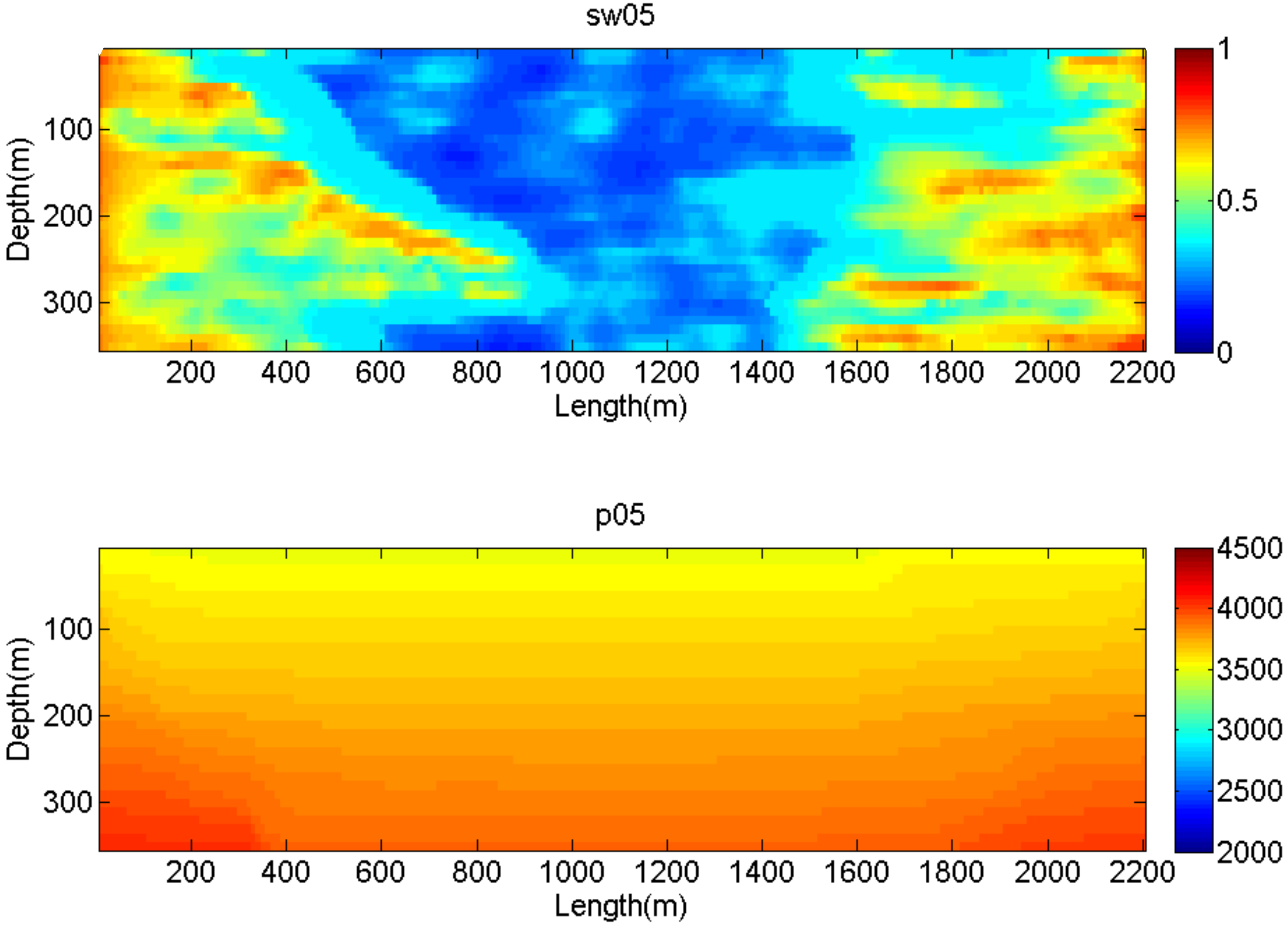
Production data



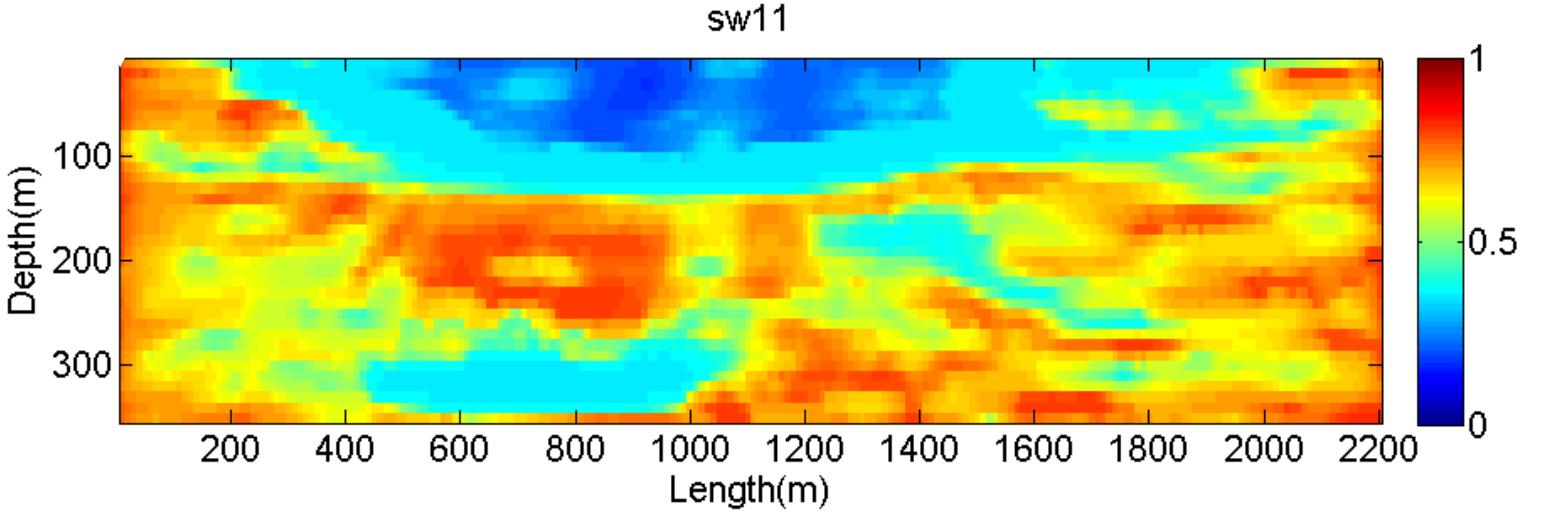
Production time step (1) : Initial reservoir state

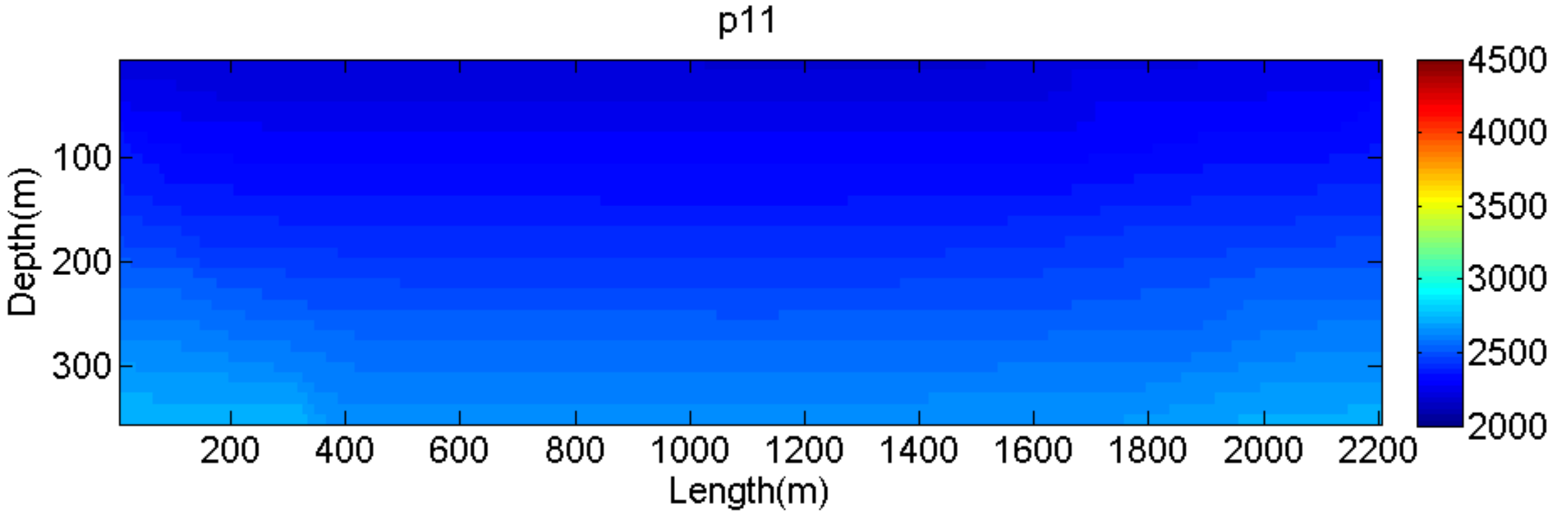


Production time step (5)



Production time step (11)





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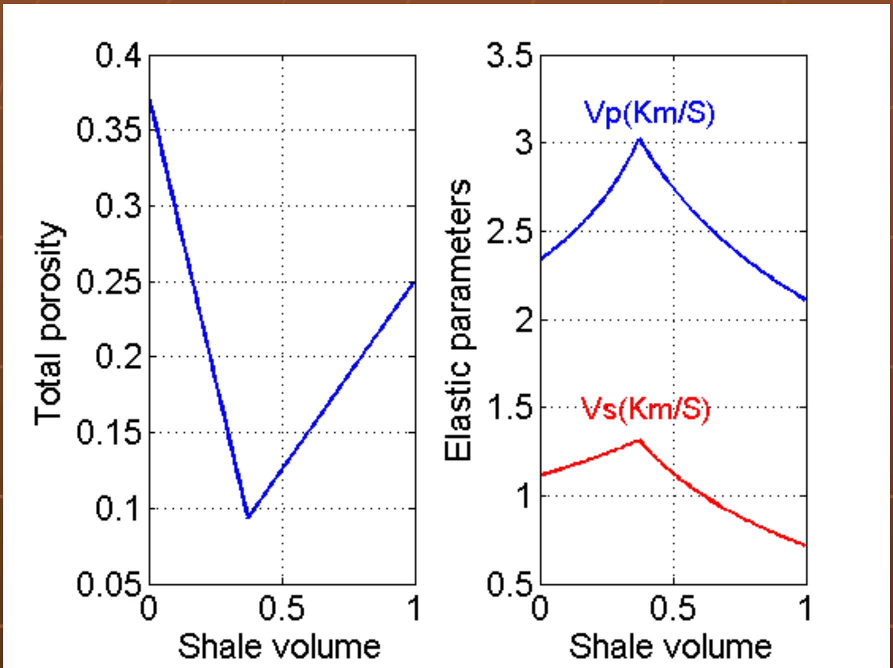
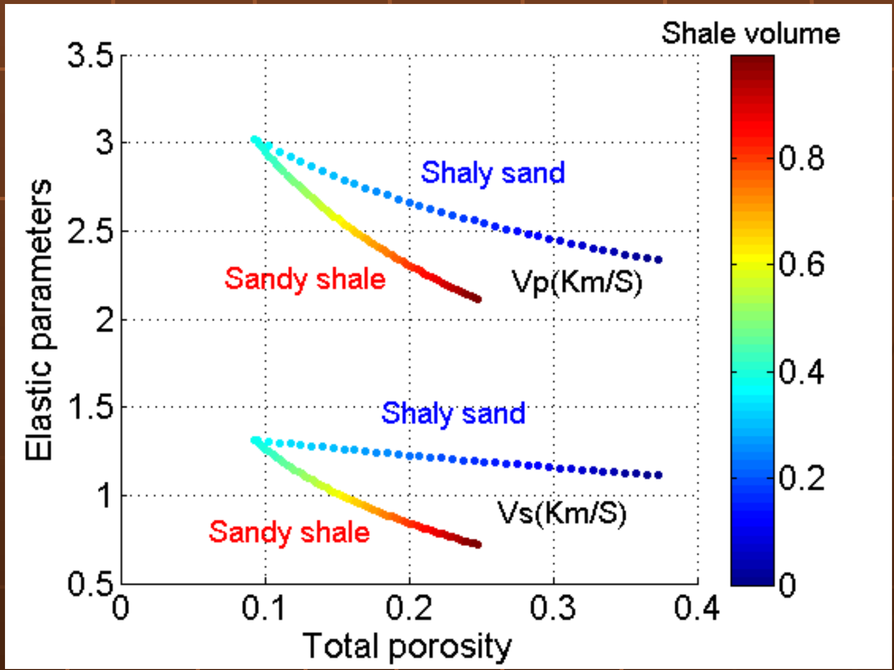
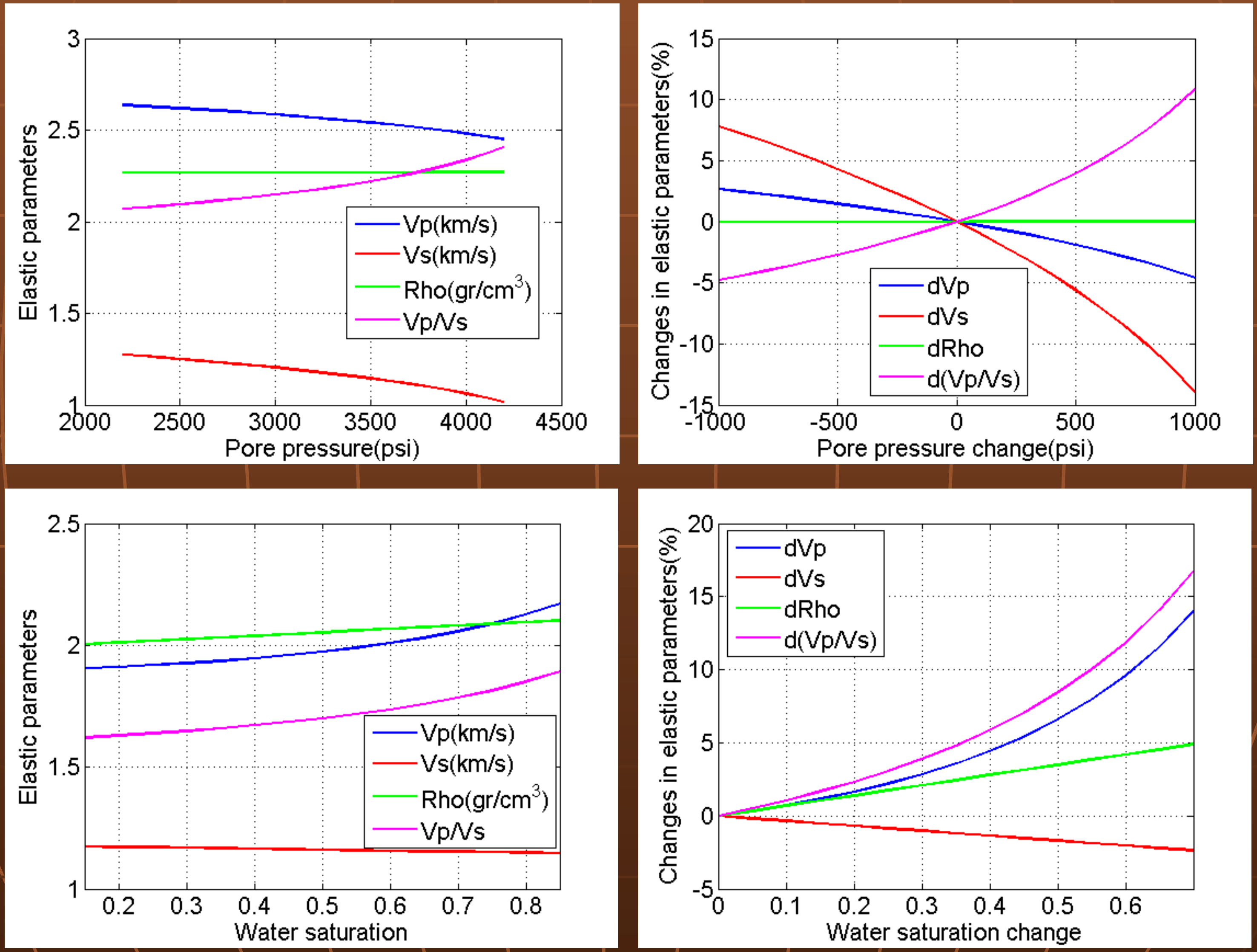
Petro-elastic model



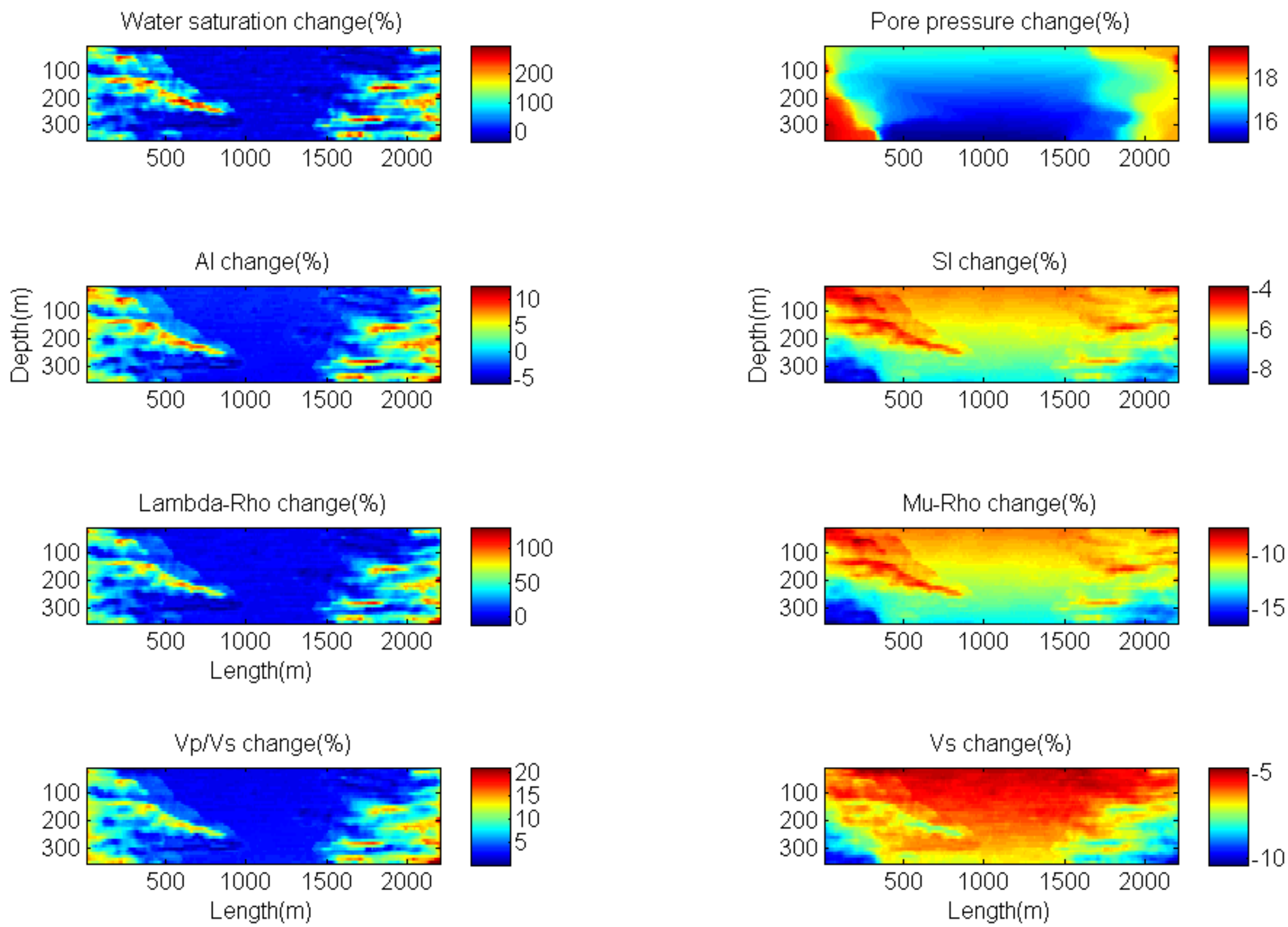
Full water saturated case



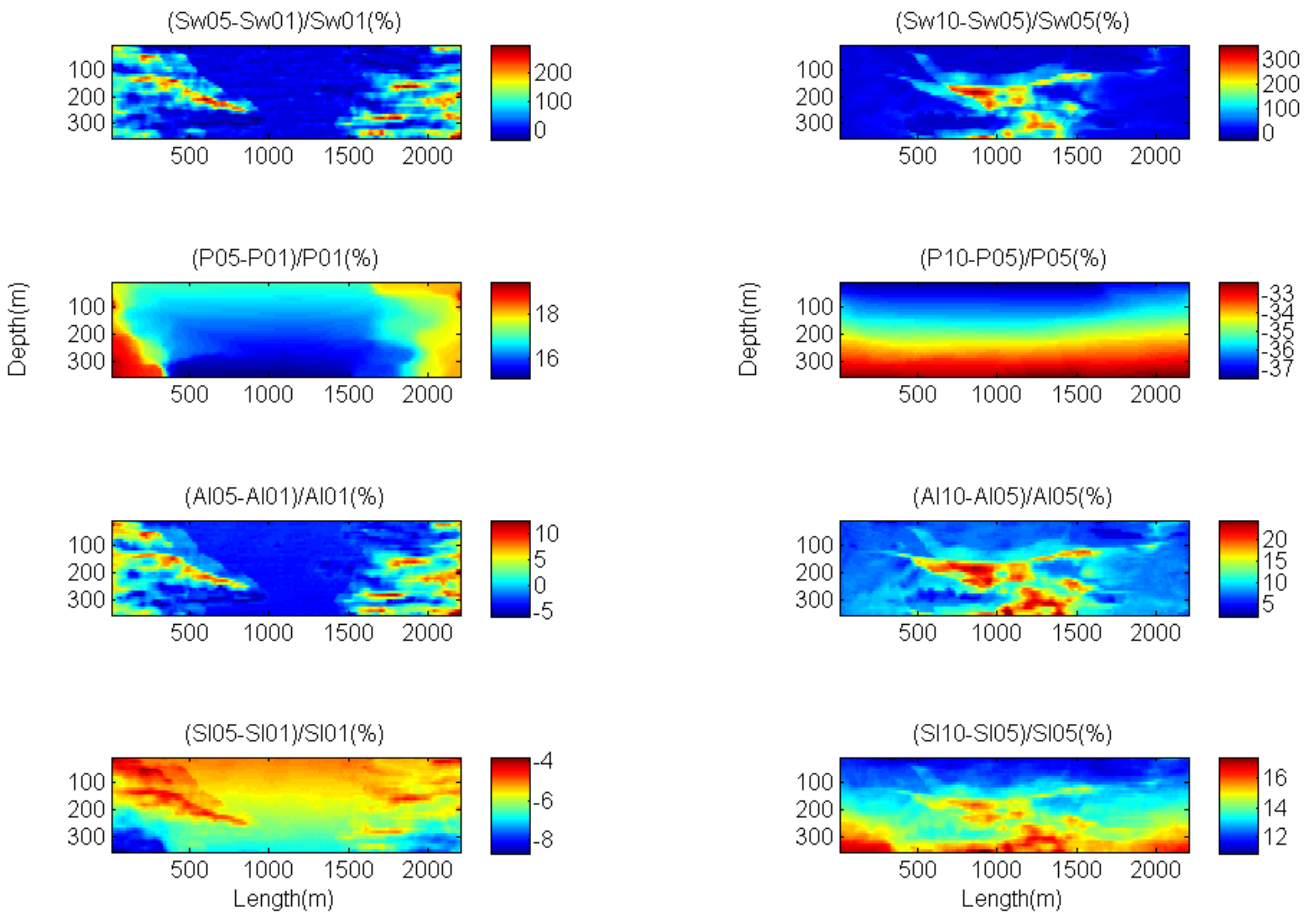
Pressure and saturation effects



Time-lapse change in reservoir properties and associated elastic parameters



Time-lapse change in reservoir properties and associated elastic parameters



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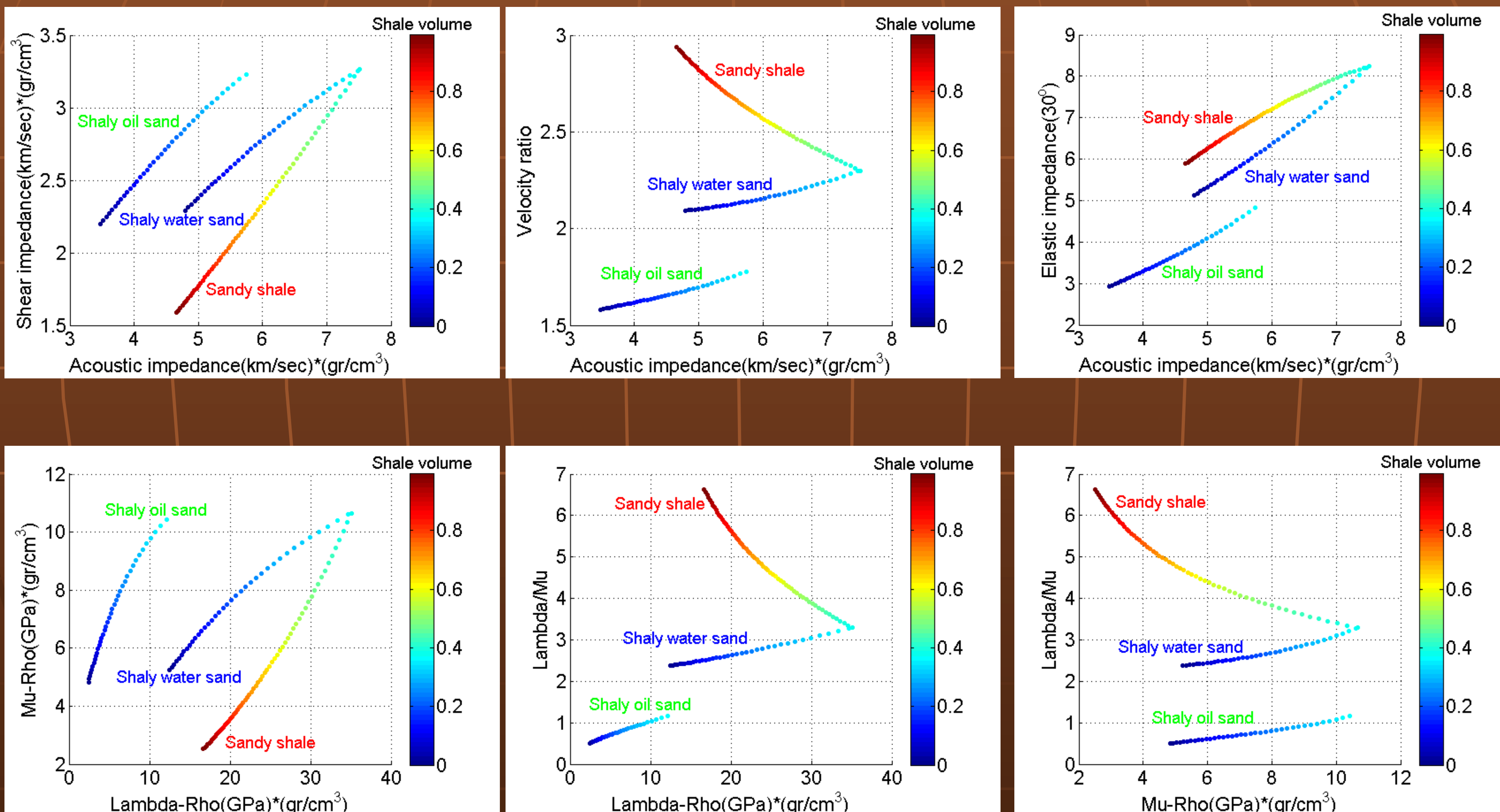
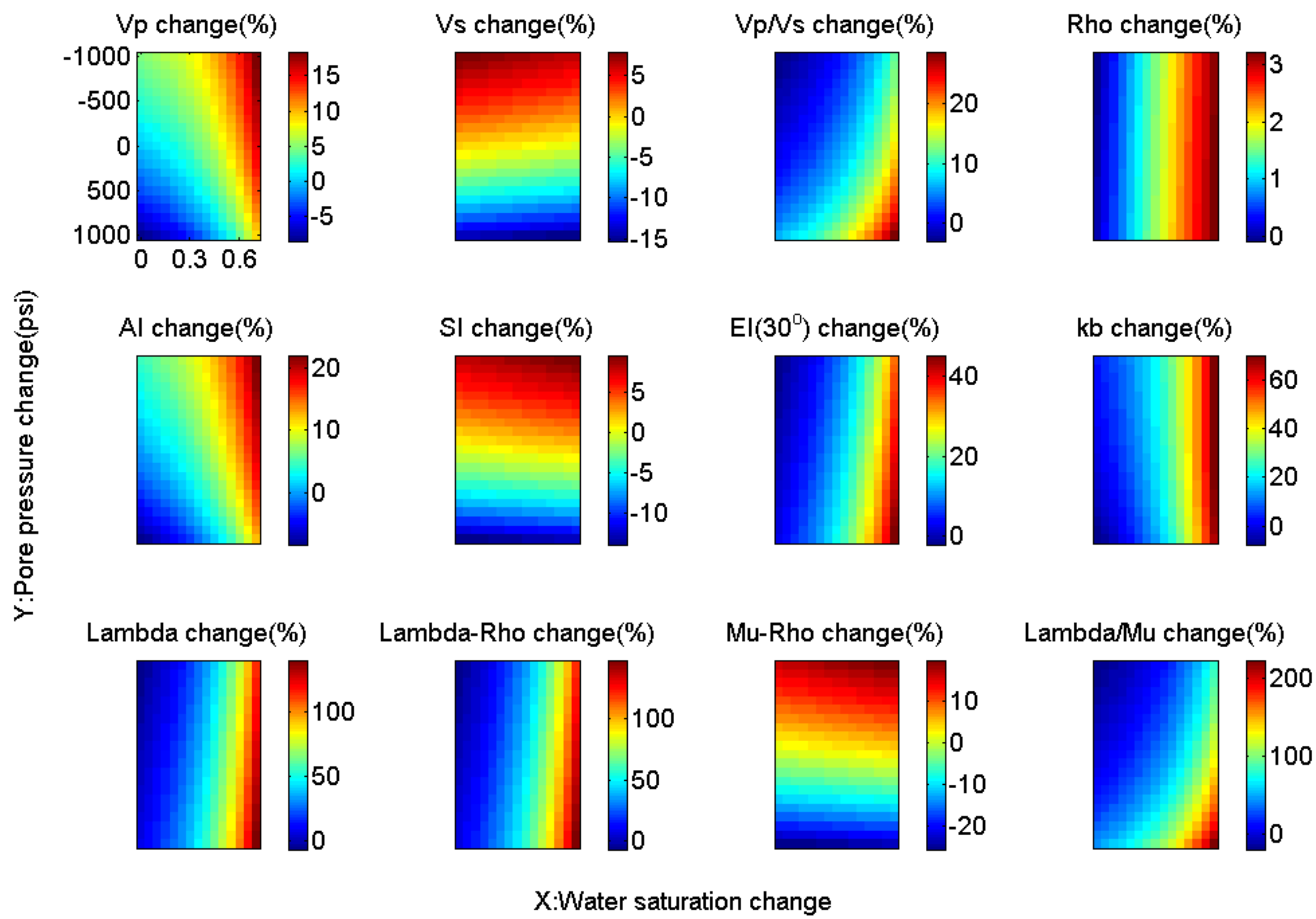
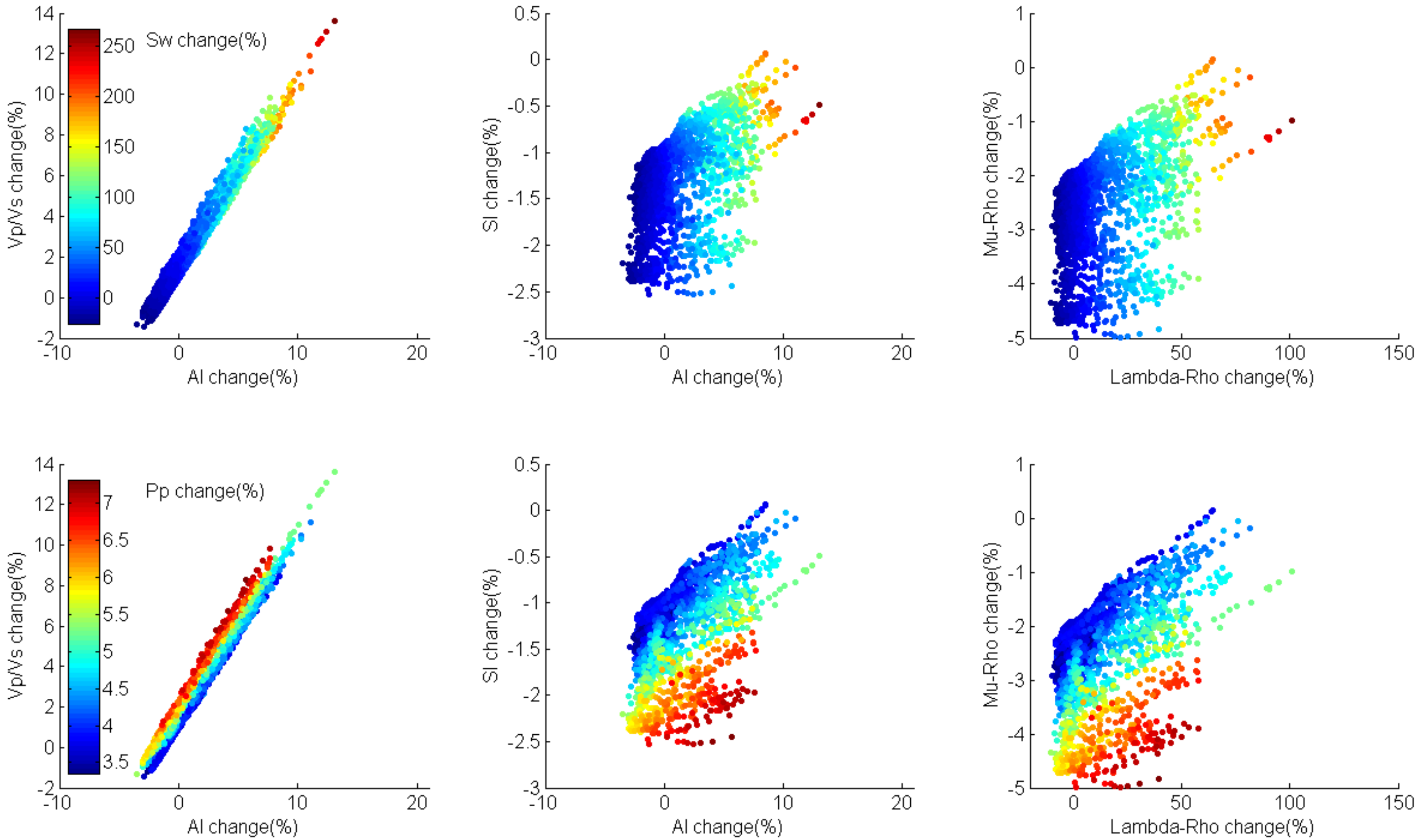
Lithology and fluid discrimination



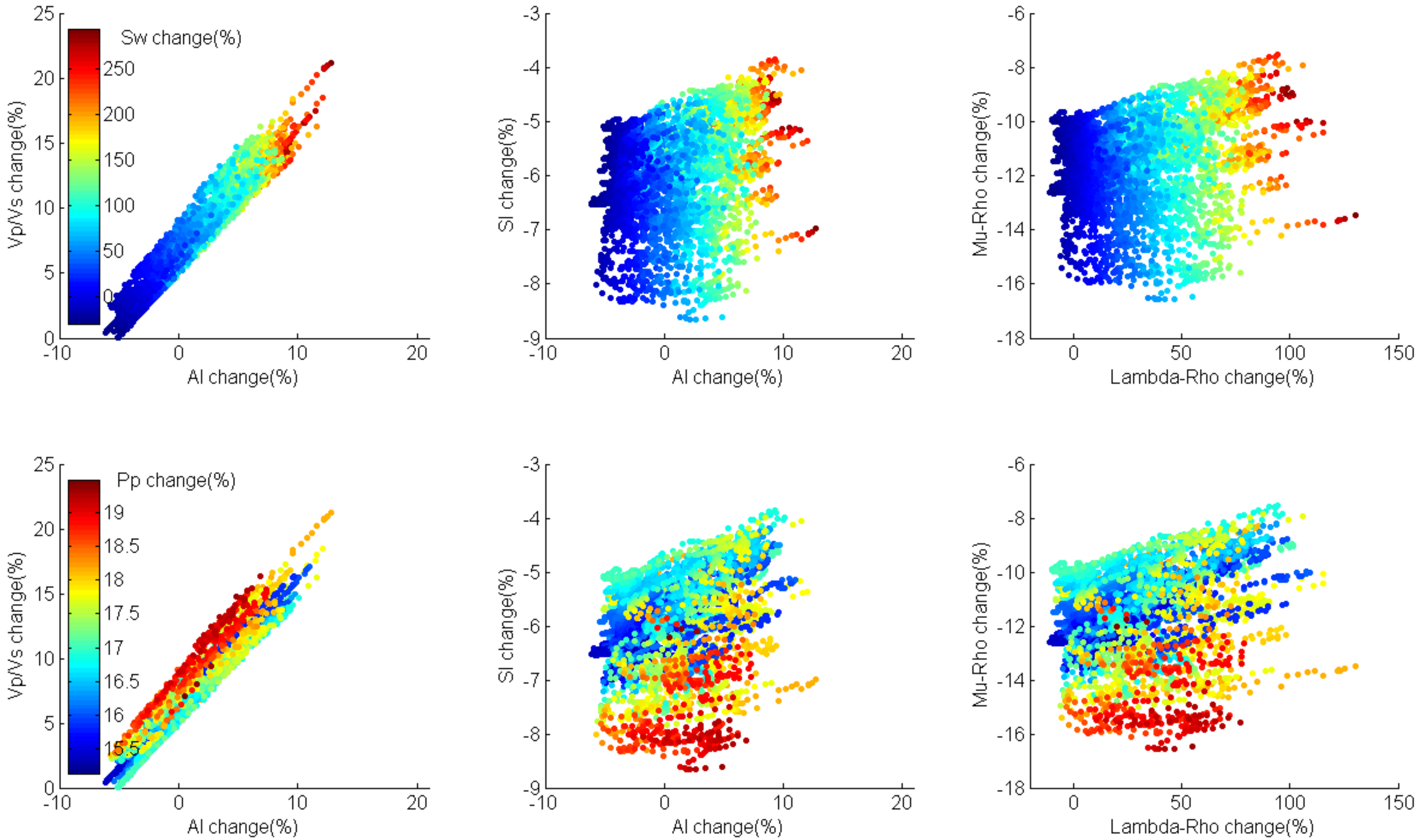
Sensitivity of elastic parameters to joint effect of pore pressure and water saturation change



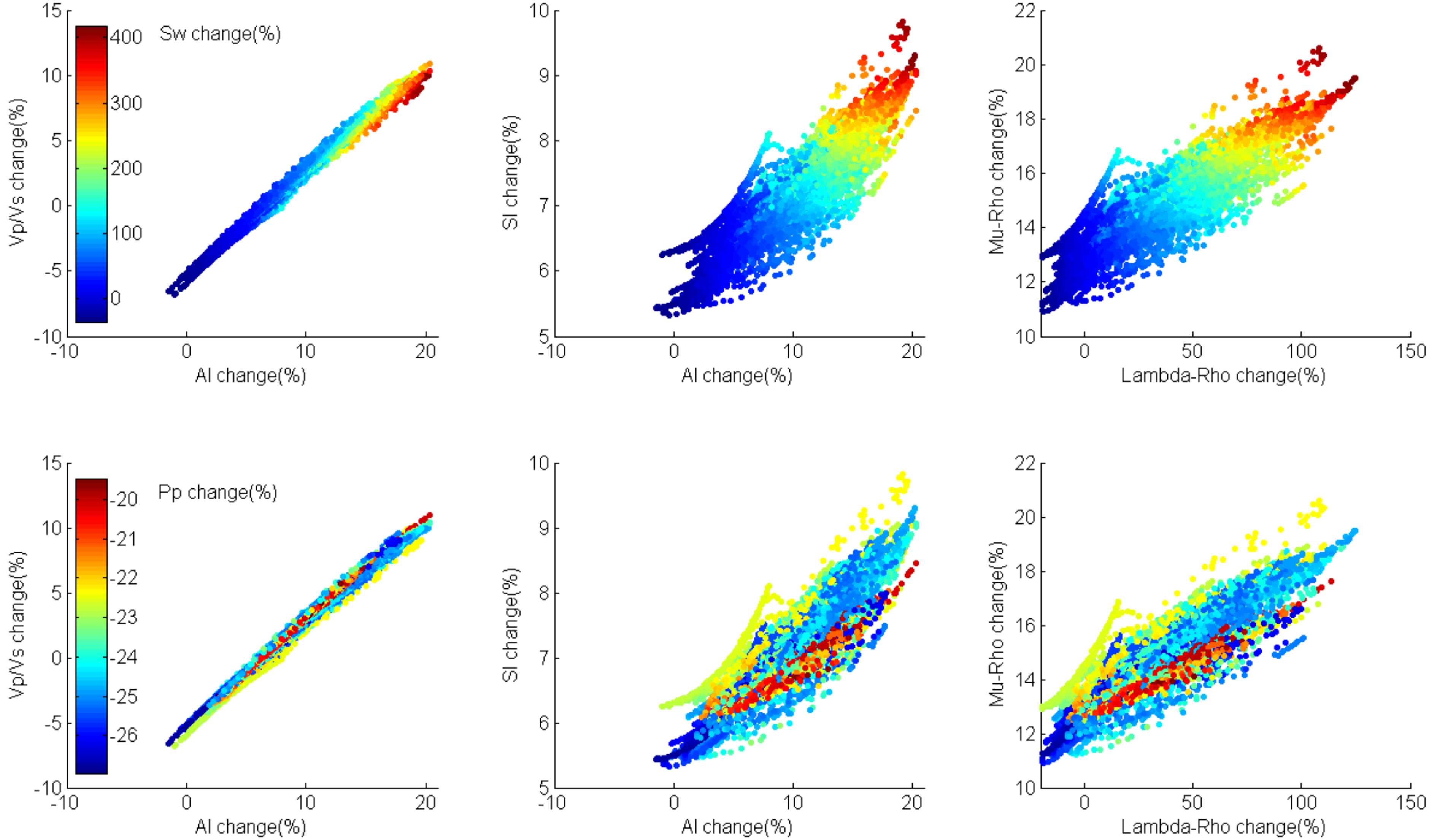
Time-lapse crossplot (2-1)



Time-lapse crossplot (4-1)



Time-lapse crossplot (11-1)



Summary and conclusions

- A realistic semi-synthetic reservoir model is generated.
- A petro-elastic model based on the dispersed clay model is developed.
- The imposed production conditions create variant states of pressure & saturation, so opportunity exist to analyze various scenarios of changes in corresponding elastic seismic attributes.
- Sensitivity analysis demonstrates that LMR (Lambda-Rho vs. Mu-Rho) crossplot is the most convenient way to discriminate changes in saturation and pressure, and commonly used crossplots, e.g., (AI, SI) , or (Vp/Vs, AI) , have less discriminatory power than that of LMR.
- The overall trend of LMR and (AI, SI) crossplots are similar, but LMR has wider rage in both axes. However, (AI, SI) are the original and the most stable inverted seismic attributes with least amount of noise, while noise level in any other derived seismic attributes, e.g., LMR, is amplified and make the use of corresponding crossplot less appropriate. Consequently, cross-plotting of (AI, SI) should be the most conservative and stable way to discriminate saturation and pressure.
- Saturation discrimination is much easier and stable compared to that of pressure

Research outcomes

- **Previous work**
  - **Sensitivity analysis of multi-component seismic attributes to fluid content and pore pressure (SEG Abstract, presented in Las Vegas meeting 2008)**
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- **Future work**
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  - **Global reservoir history matching constrained by seismic and production data**

Acknowledgment

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- My supervisors, Dr. Paul Stoffa and Dr. Bob Tatham
- Dr. Kyle Spikes and Dr. Diana Sava for technical discussion of rock physics
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Thanks for your attention

Questions?