SRC software

Rock physics modelling tools for analyzing and predicting geophysical reservoir properties

Seismic Reservoir Characterization
University of Bergen, Norway

Outline

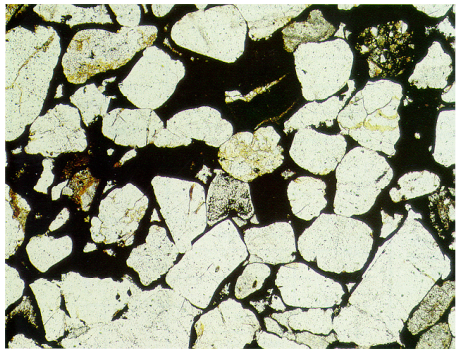
- About SRC software.
- Introduction to rock modelling.
- Rock modelling program structure.
- Examples of rock physics analyses.
- Future developments.
- Examples of integrated modelling analyses.

About SRC software

- The SRC software contains methods and results obtained by the SRC scientists, both as integrated functionalities in the rock modelling environment of VelRock and as stand-alone programs.

- The SRC software is available to the SRC sponsors free of charge, released every year in Q4. The software can be downloaded directly from the protected area of the SRC web site.

Introduction to rock modelling



V_P = 2.6 km/s
V_S = 1.4 km/s
ρ = 2.2 g/cm^3

minerals

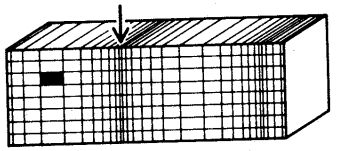
fluids

porosity

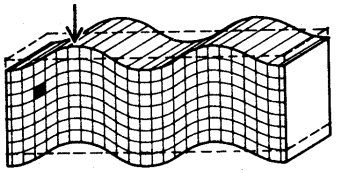
permeability

:

V_P: P-velocity

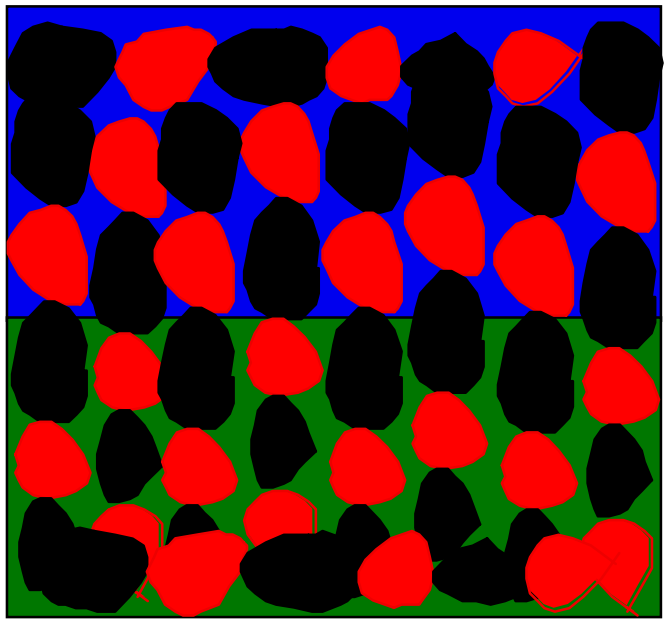


V_S: S-velocity



Rock model parametrization

- Consider porous rocks as multi-component materials, e.g.
  - a solid phase (matrix) and
  - a fluid phase.
- Each component may be heterogeneous and a mixture of sub-components (mineralogy, fluid types, etc.).
- Rock models consists of parameters for:
  - properties, shapes and orientations of each phase,
  - phase interaction effects.
- Effective elastic properties of rocks are predicted by geophysical transformation theories.



Rock modelling program elements

- Rock component library.
  - Default library of rock components (minerals, fluids, pore geometry, …).
  - Tools for defining and mixing components.

- Rock model builder.
  - Combine rock components with appropriate geophysical transformation theories to define rock models.

- Analysis and application tools.
  - Log data analysis and predictions.
  - Lab data analysis.
  - 2D and 3D grid data predictions.
  - Rock models for NORSAR-2D and –3D applications.

- Graphical presentation of data.

Rock component library

- Default library of rock components supplied with each installation.
- Tools for defining rock components.
  - Solid phase, fluid phase, pore space and fluid geometry parameters.
- Solid builder for defining effective solid parameters.
  - Scattering theories: self-consistent, differential effective medium.
- Fluid builder for defining effective fluid parameters.
  - Batzle-Wang / Han and Batzle theories.
- Tools for mixing of rock components.
  - Boundary methods: Reuss, Voigt, Hill, Hashin-Shtrikman.

Rock modelling strategies

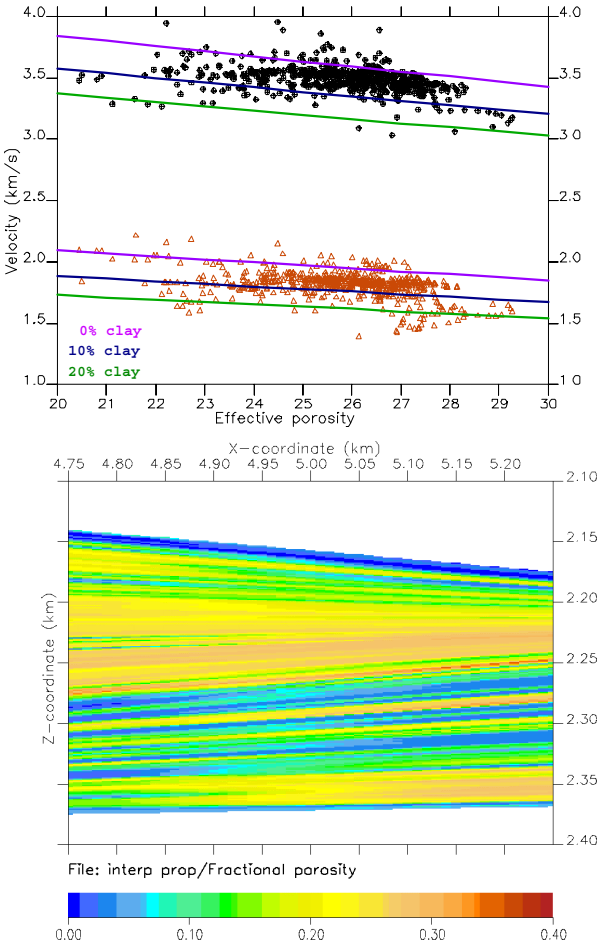
Choice of modelling strategy:

- Depend on the model limitations
  - physical model vs theoretical model.
- Depend on *a priori* knowledge:
  - statistical/empirical model
  - implicit vs explicit model.
- Depend on effects to be modelled:
  - porosity
  - pore fluid properties
  - pore space properties ...

Available models:

- Empirical/statistical relationships.
- Poroelastic equations:
  - Biot-Gassmann approach.
- Scattering theories:
  - first order approach (Kuster-Toksöz),
  - self-consistent (SC) approach (Berrymann, Korringa),
  - differential effective medium (DEM) approach.
- Hybrid theories.
  - DEM + Biot-Gassmann

Graphical presentations



- Cross-plots of data samples, rock models, rock components, well log data, other data files on specific format.
- Well log data plots.
- 2D grid data plotted as grid pixels, smooth colour shaded plots, contours…
- VelRock creates plots on the CGM-format.

Examples of analyses involving VelRock

- Calibration of rock models for integration with seismic modelling studies (geophysical models), log data analysis, lab data analysis etc.
- Sensitivity analysis of reservoir properties using calibrated rock models and seismic modelling.
- Log data analysis, including S-wave log prediction, fluid substitution, correction for drilling mud invasion, prediction of derived properties, lithology analysis.
- Lab data analysis.
- Integrated rock physics and seismic modelling studies (1D, 2D and 3D), including effect of fluid and pressure changes during production, prediction of time-lapse responses, testing of reservoir hypotheses, etc.

Rock model calibration

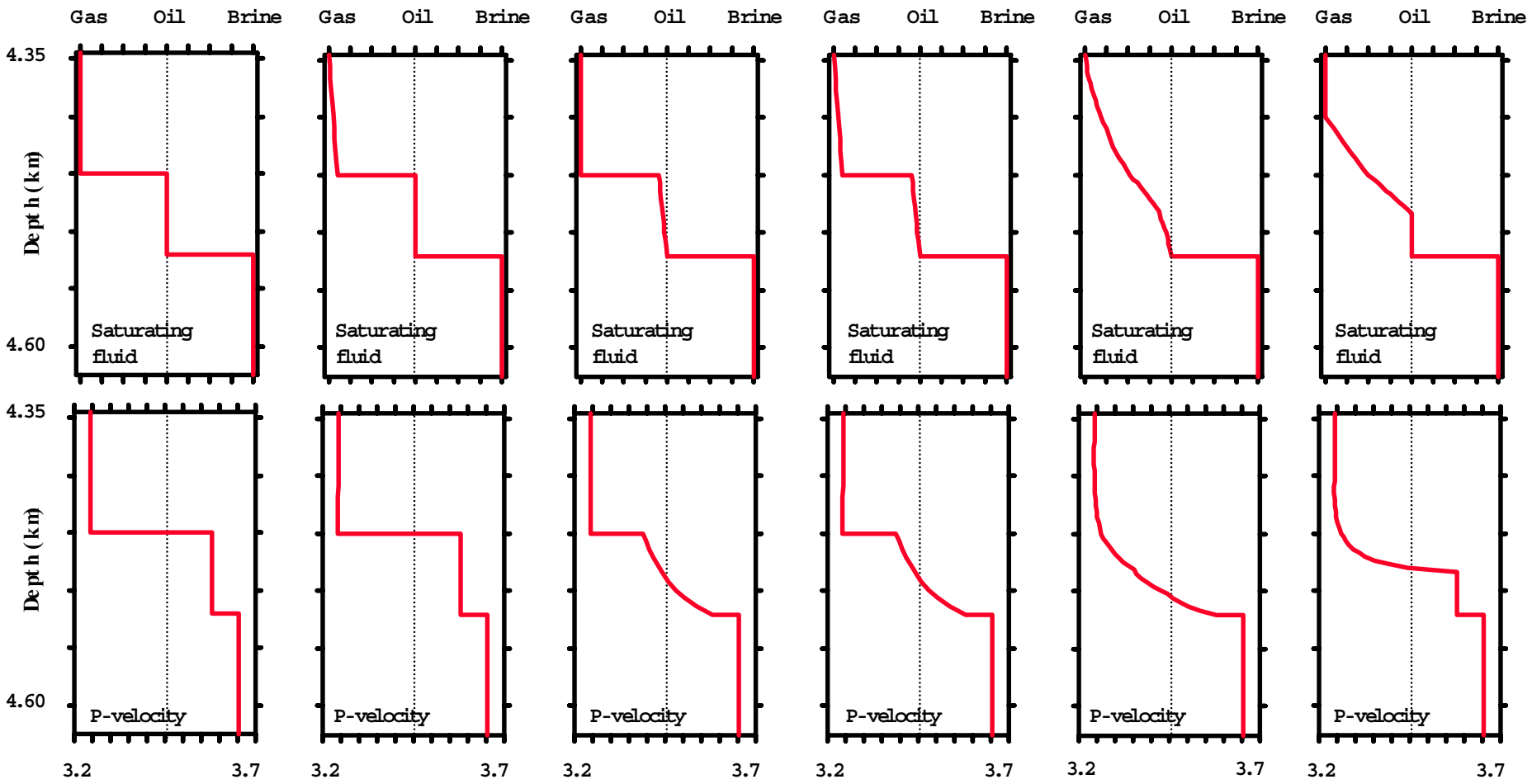
Input:

- A weighted combination of P-velocity, S-velocity and density information.
- Available porosity, lithology and fluid information.
- Unknowns, e.g. pore geometry, clay volume, fluid saturation ...

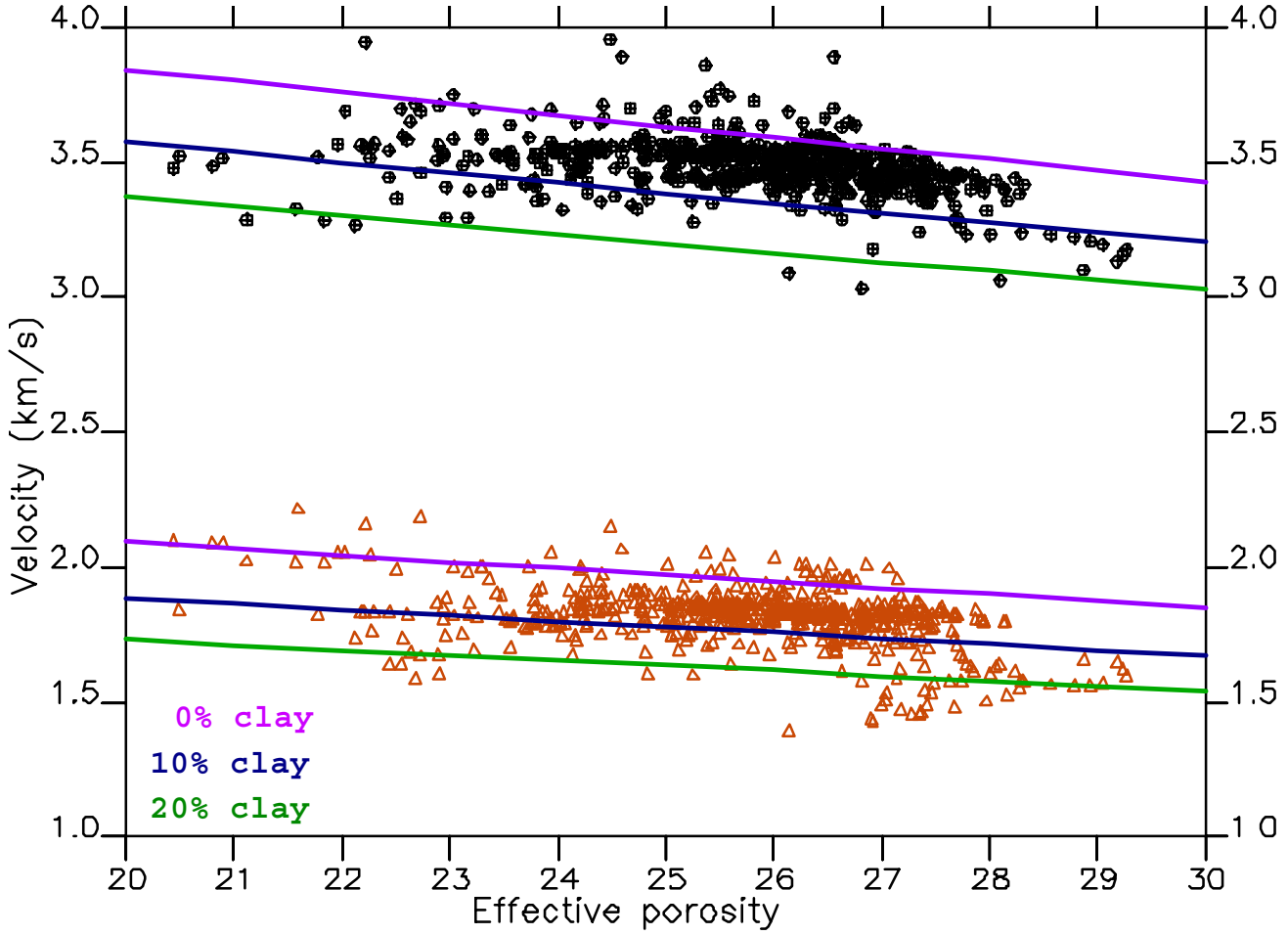
Output:

- Calibrated rock model components.
- Prediction of sensitivity.
- Prediction of properties under other conditions, e.g. fluid substitution ...

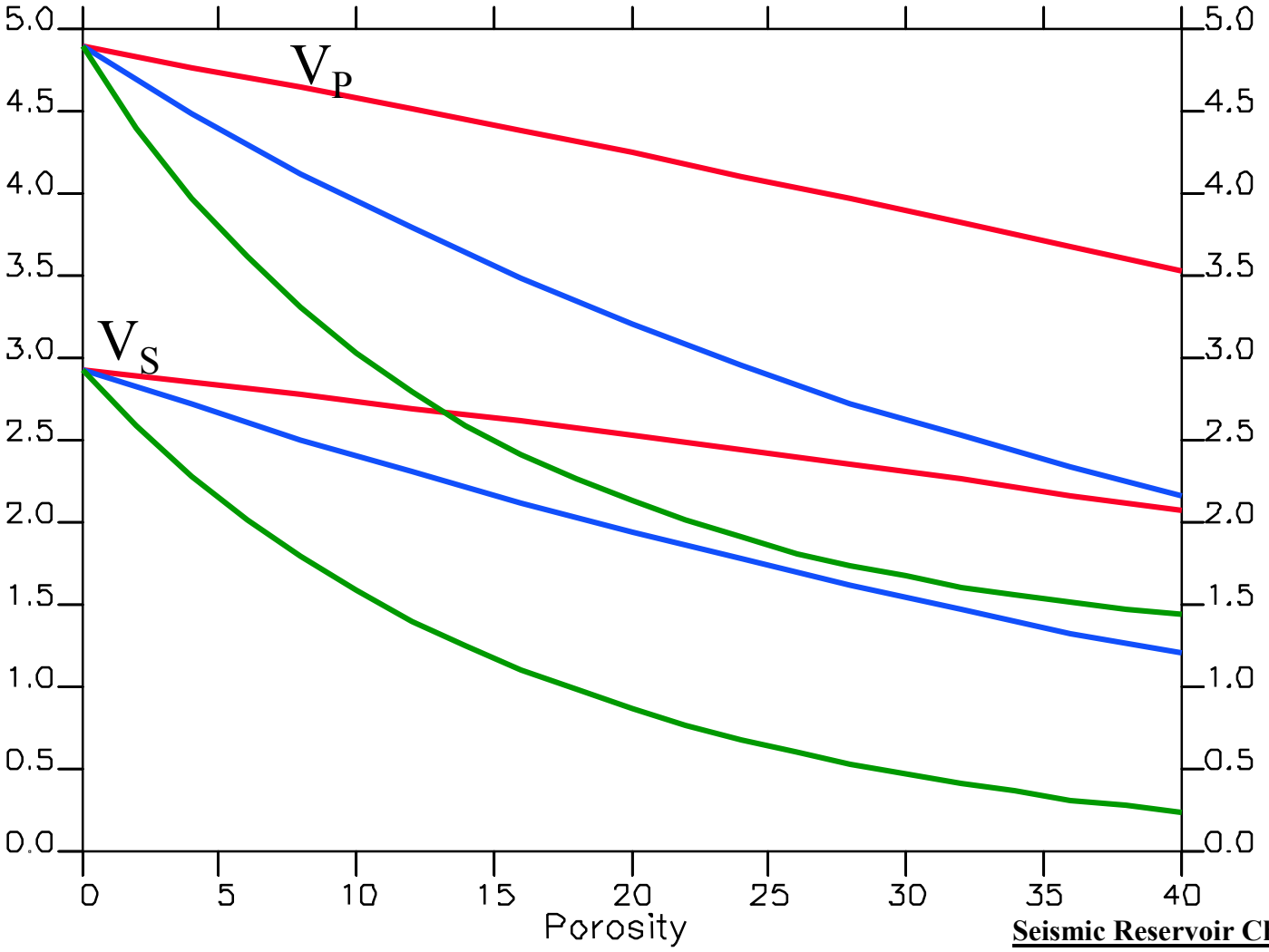
Effect of fluid composition on P-velocity



Porosity and clay contents vs seismic velocities



Effect of pore geometry on seismic velocities

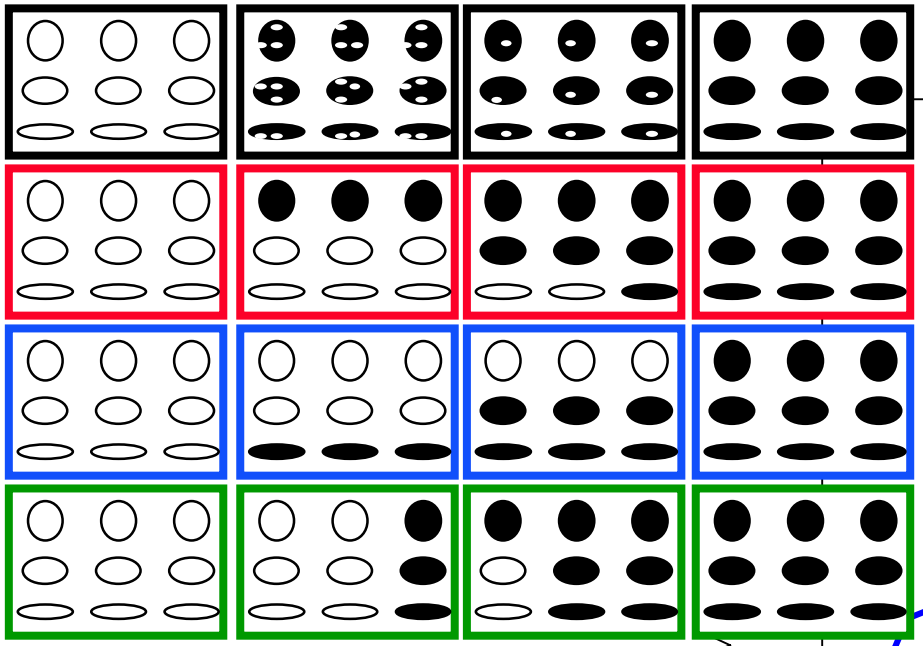


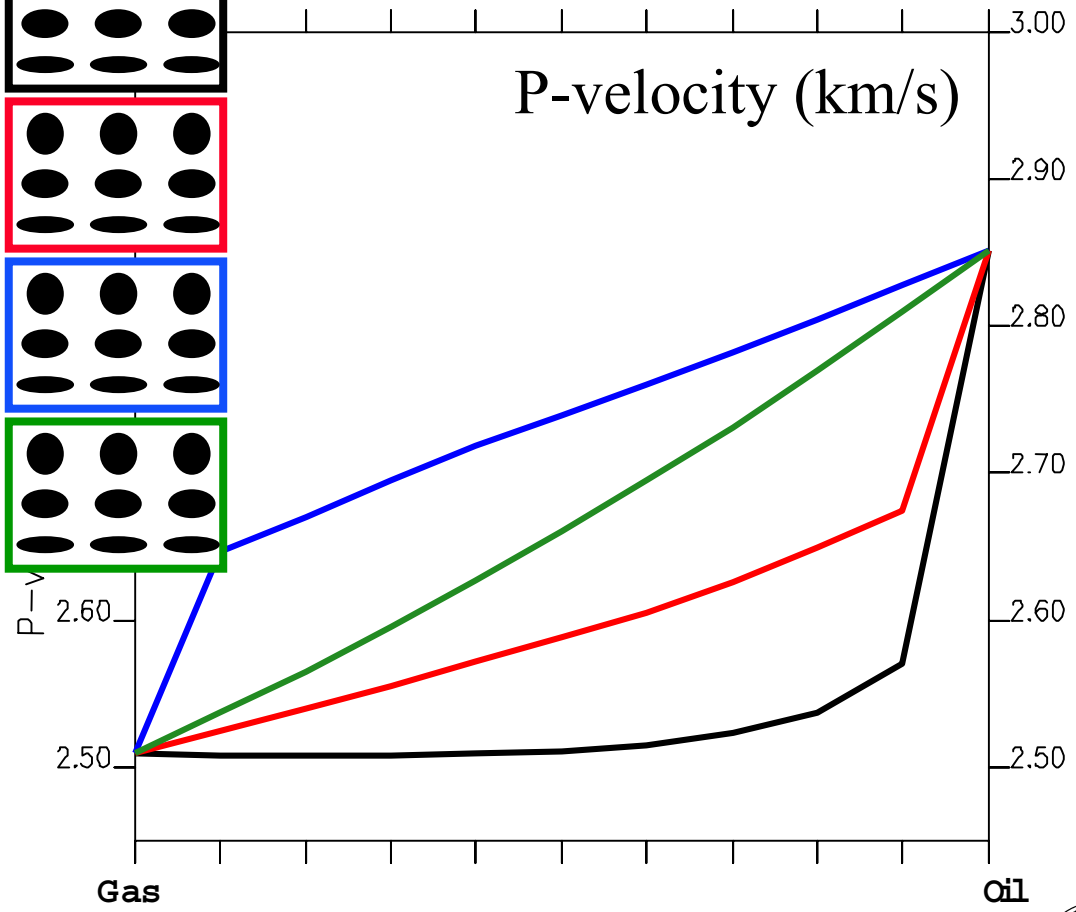
α	c(α)
1.00	**1.0**

α	c(α)
0.10	**1.0**

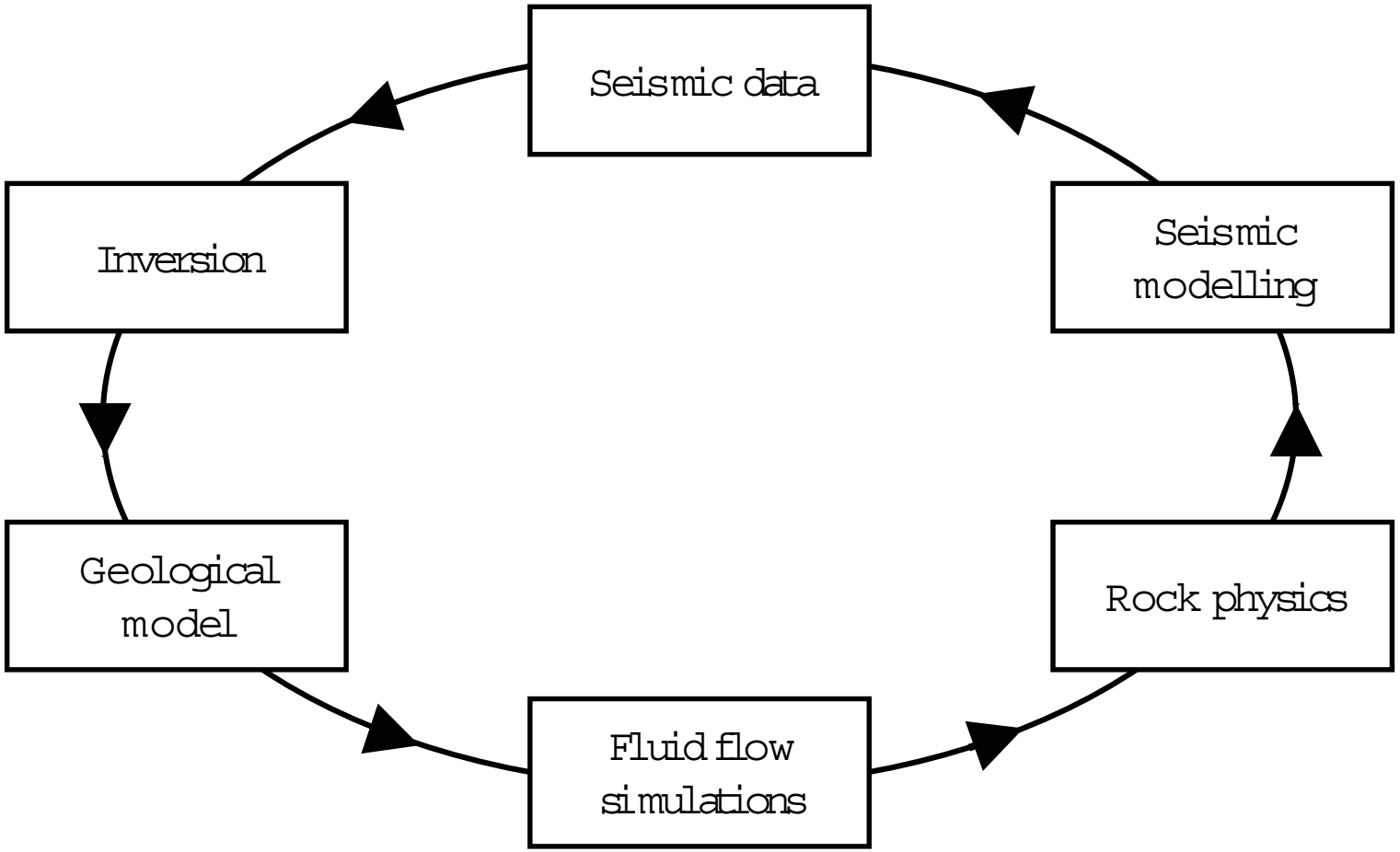
α	c(α)
0.10	**0.60**
0.01	**0.40**

Influence of fluid geometry on seismic velocity

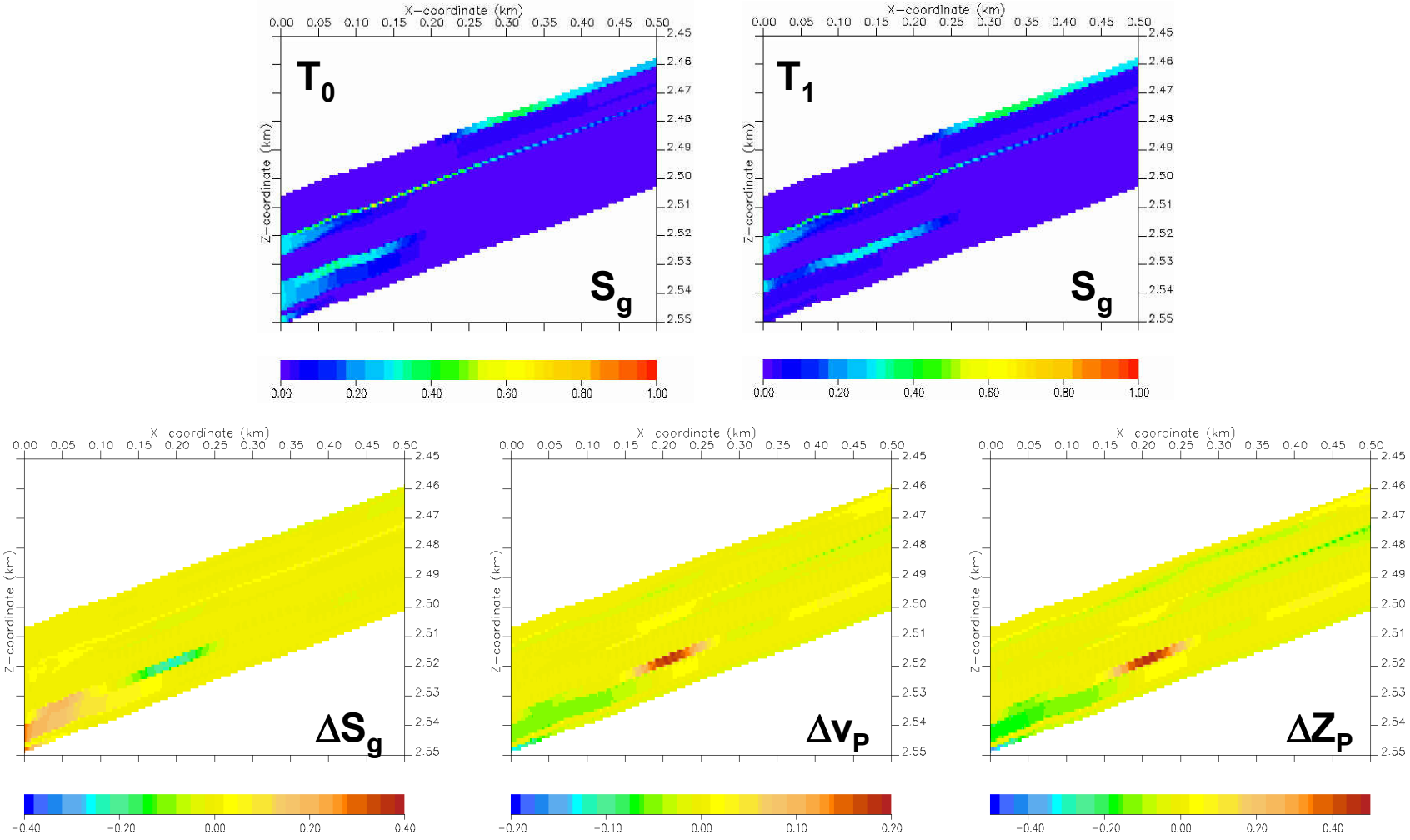




Rock physics modelling in a 4D modelling loop



Rock physics analysis using fluid simulations



SRC software for rock modeling

The SRC software

- is available to the SRC sponsors,
- is a fully operational stand-alone system for rock physics analyses,
- consists of additional program modules for special analyses,
- contains functionalities for rock model based data processing,
- contains pre-releases of selected methods developed in the SRC project,
- will only run on Sun Solaris systems,
- does not include any user support besides installation guidance.

- First SRC version of the SRC software will be available to the sponsors from the SRC website in Q4 2001.
- A new version will be available in Q4 every year.

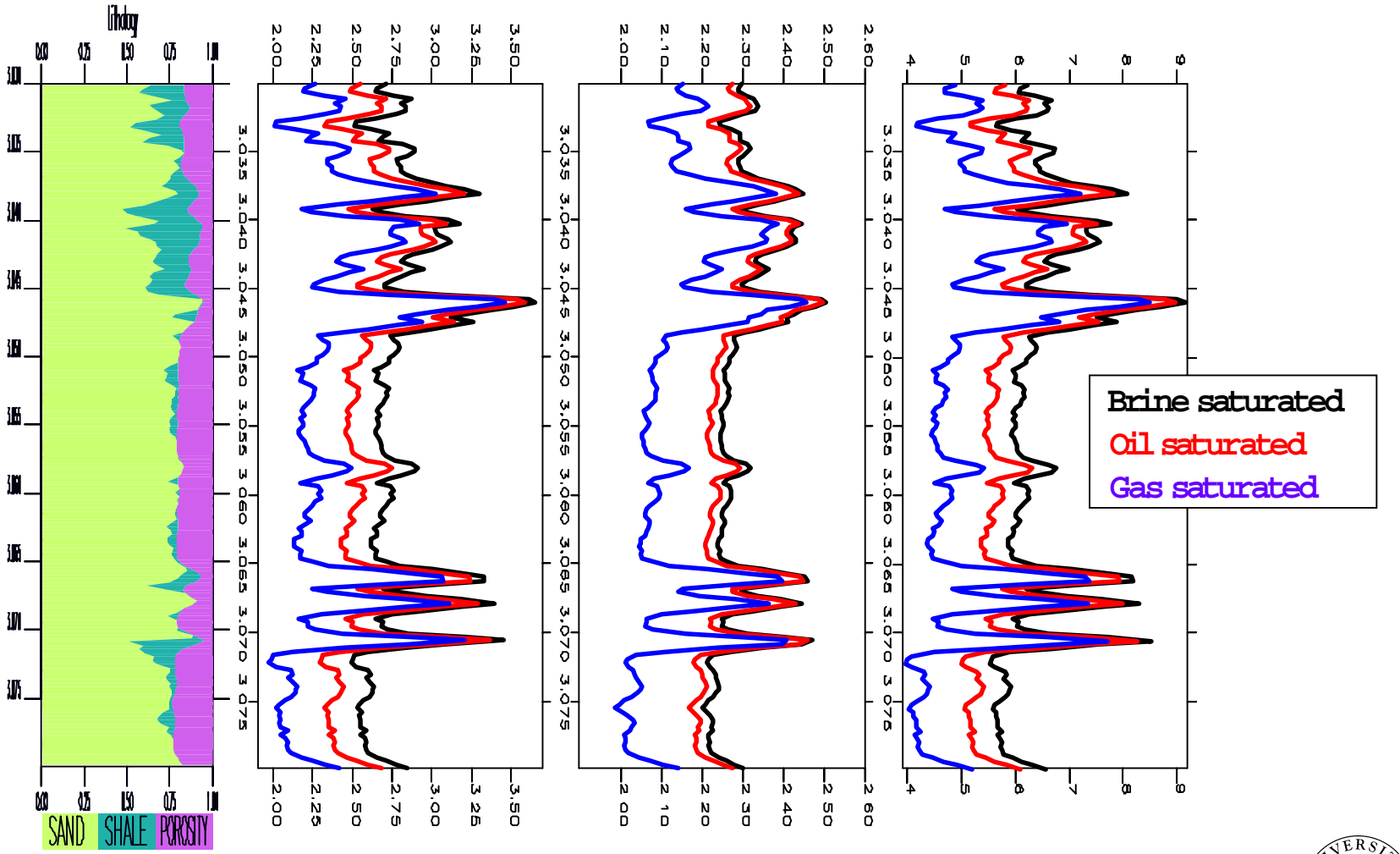
Near future developments

- Improved well log data module, with
  - Import / export of tabular ASCII data.
  - Data editing and corrections.
  - Rock model based data predictions, S-wave logs, fluid substitution, etc.
  - Upscaling/homogenization.
  - Adapted plotting abilities.

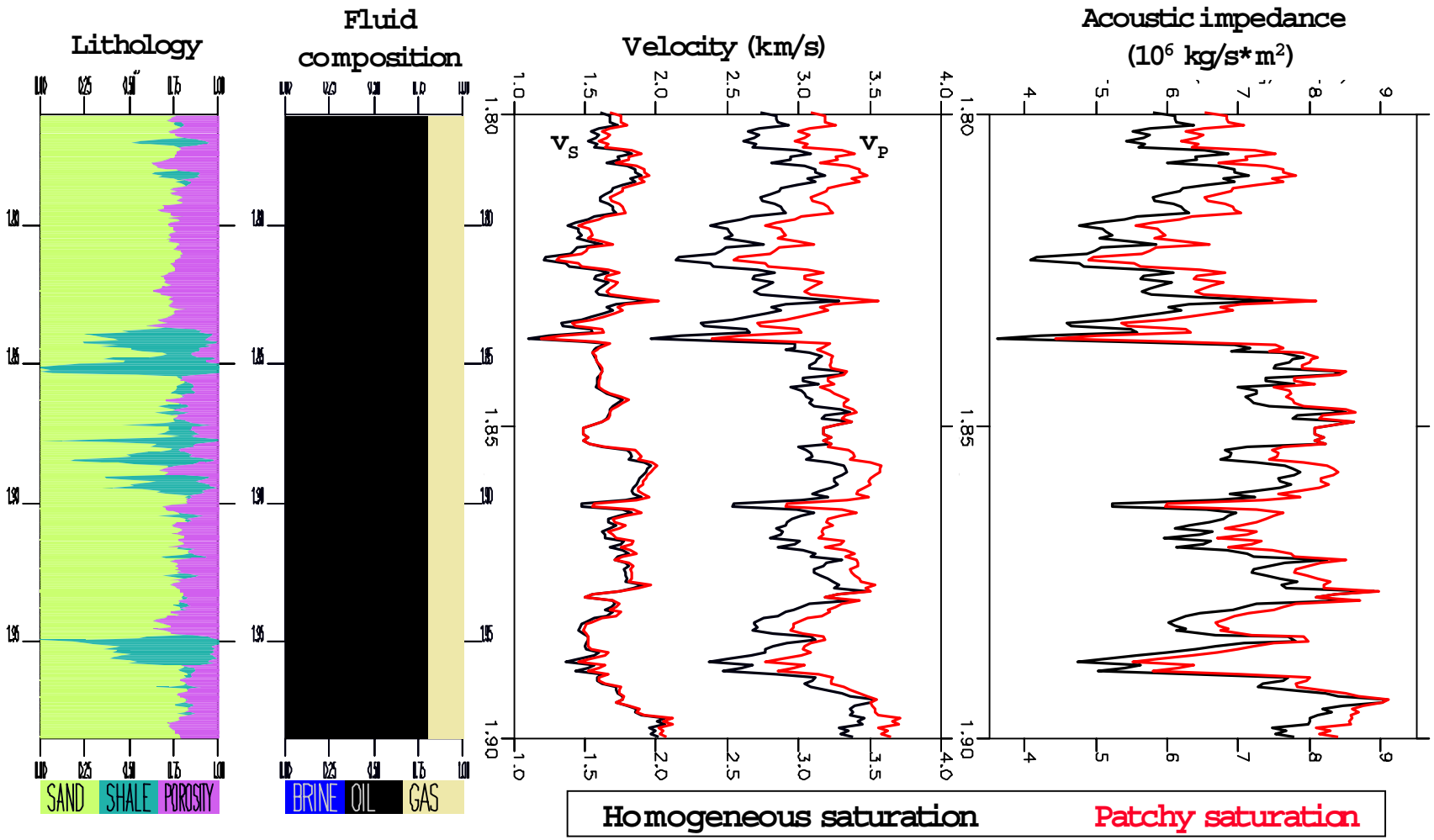
- Improved grid prediction module using rock physics constraints.

- Implementation of contact model and contact cement model.

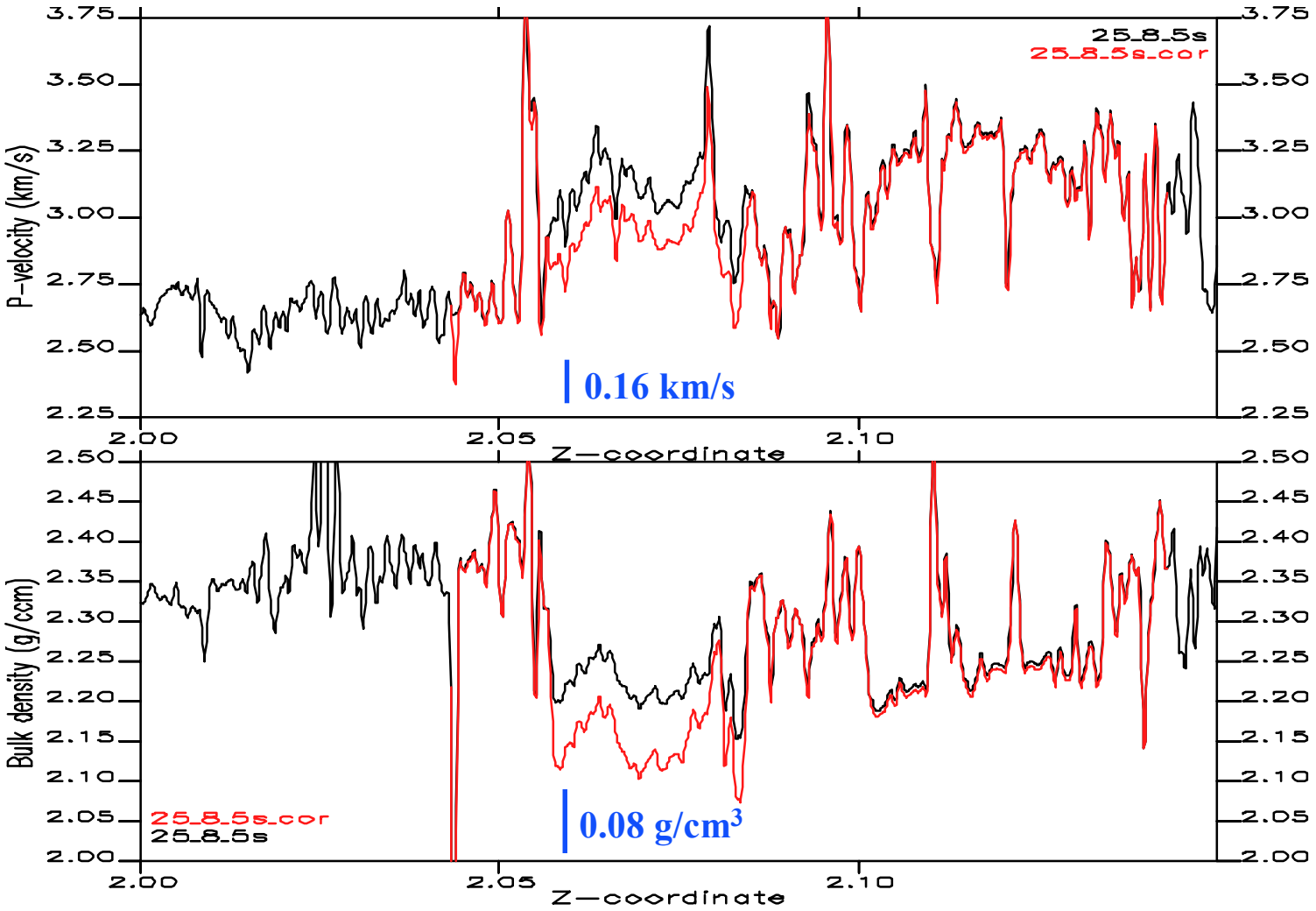
Fluid substitution in well logs



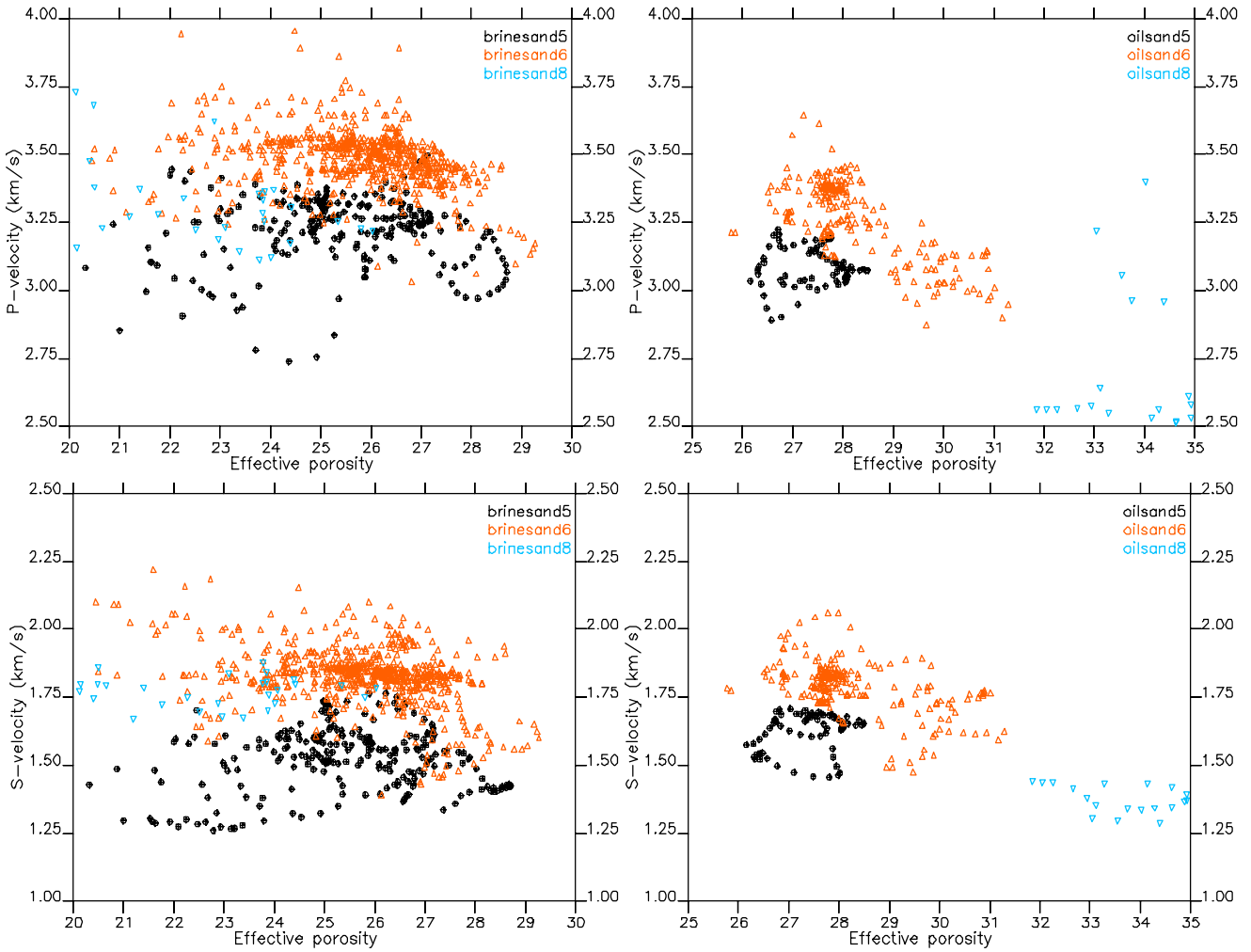
Effect of fluid geometry on log data



Correction for drilling mud invasion in formation

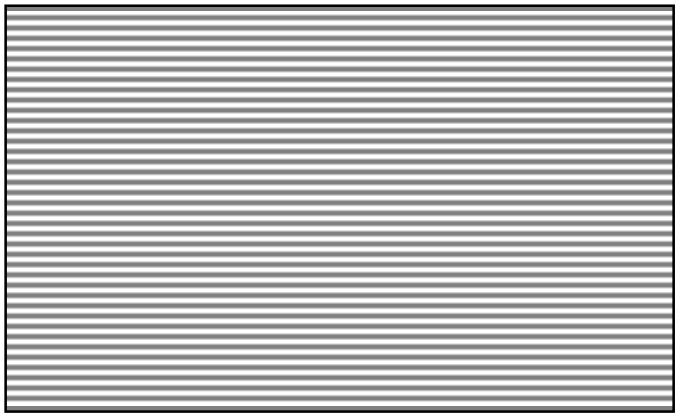


Crossplot of properties from different wells



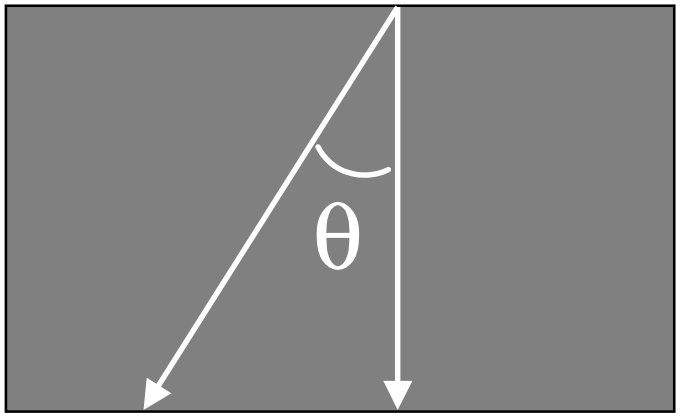
Backus average upscaling

Layered rock



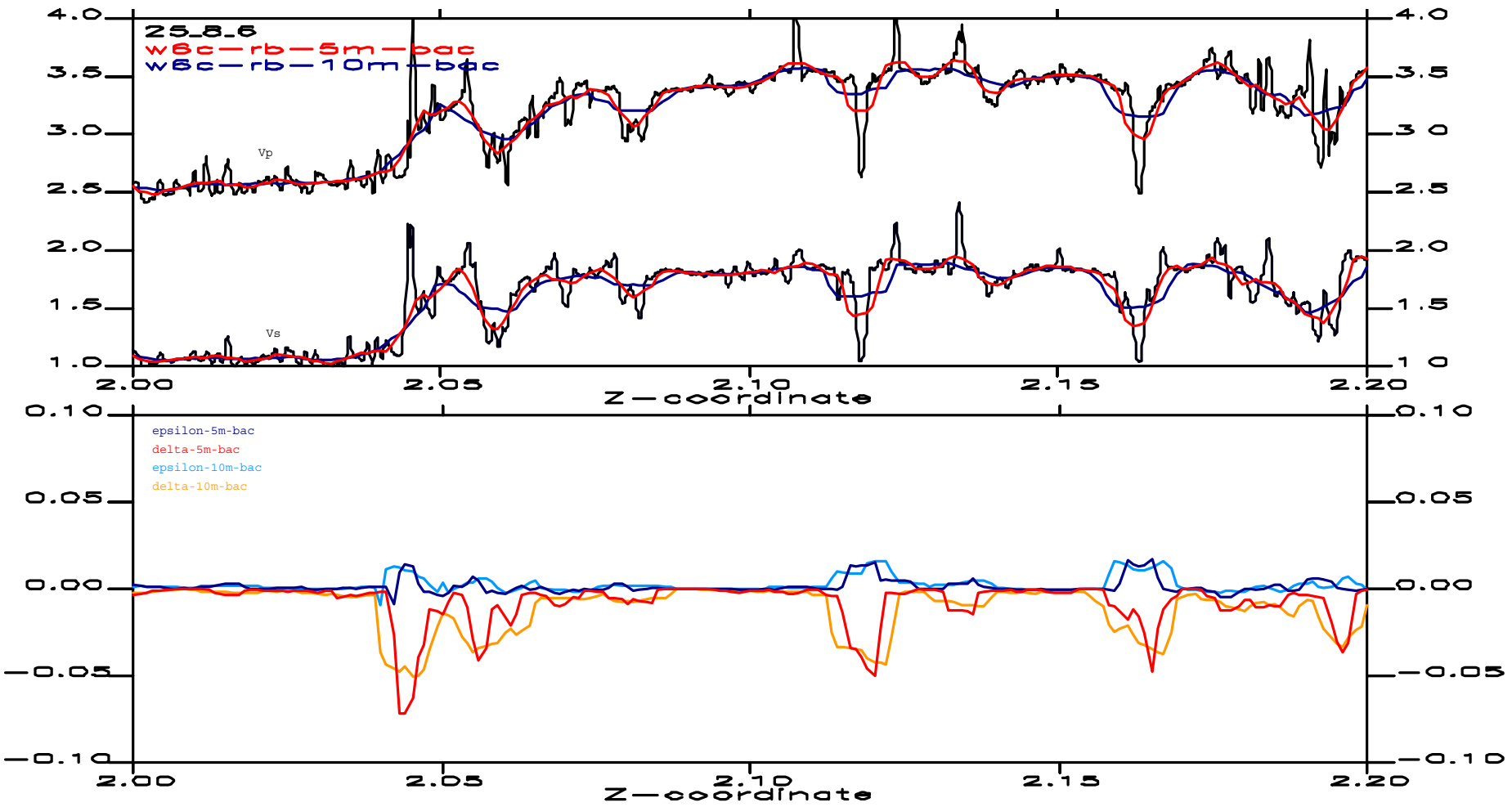
$\lambda >> h$

Effective rock

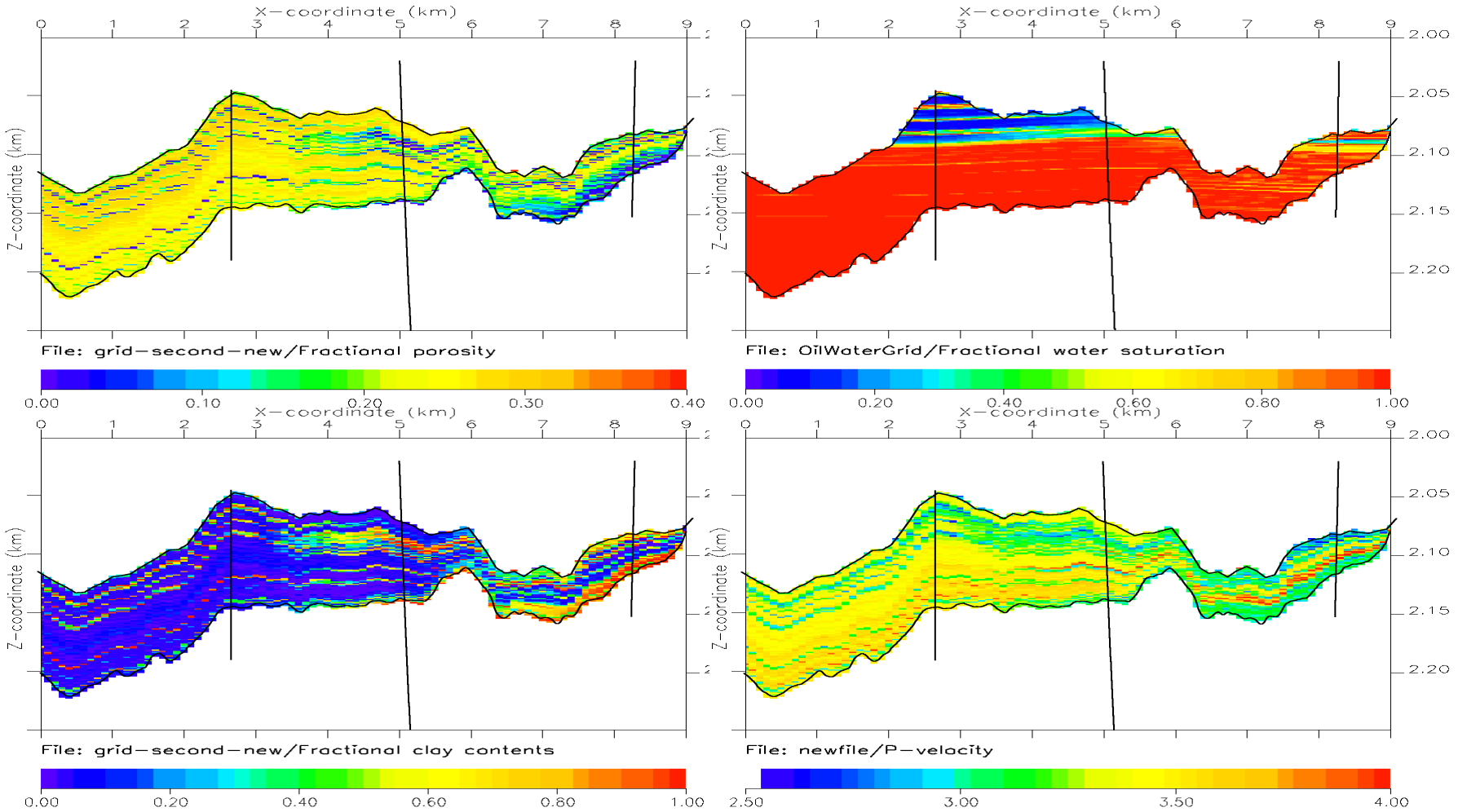


$$V(\theta)=f(C_{11},C_{13},C_{33},C_{44},C_{66},\rho)$$

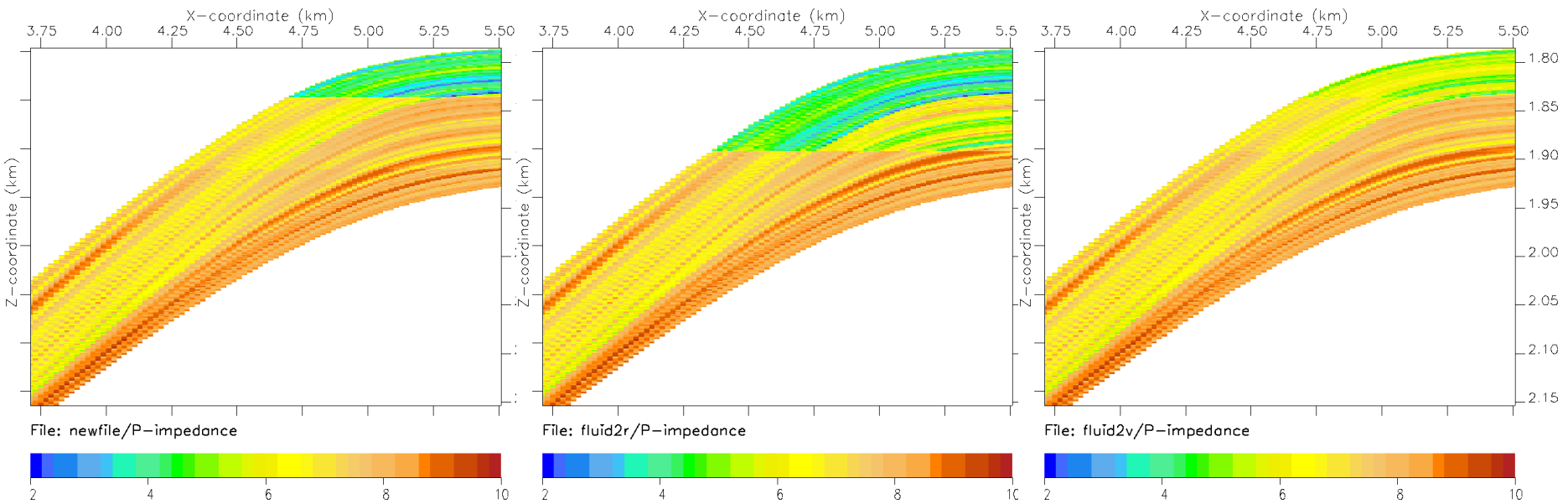
Backus upscaling of well log data

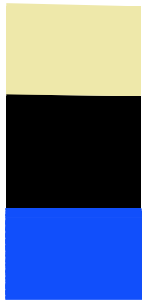


Prediction of grid properties

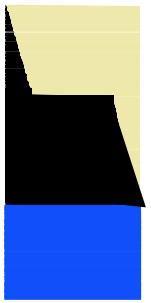


Effect of fluid saturation models on fluid contacts



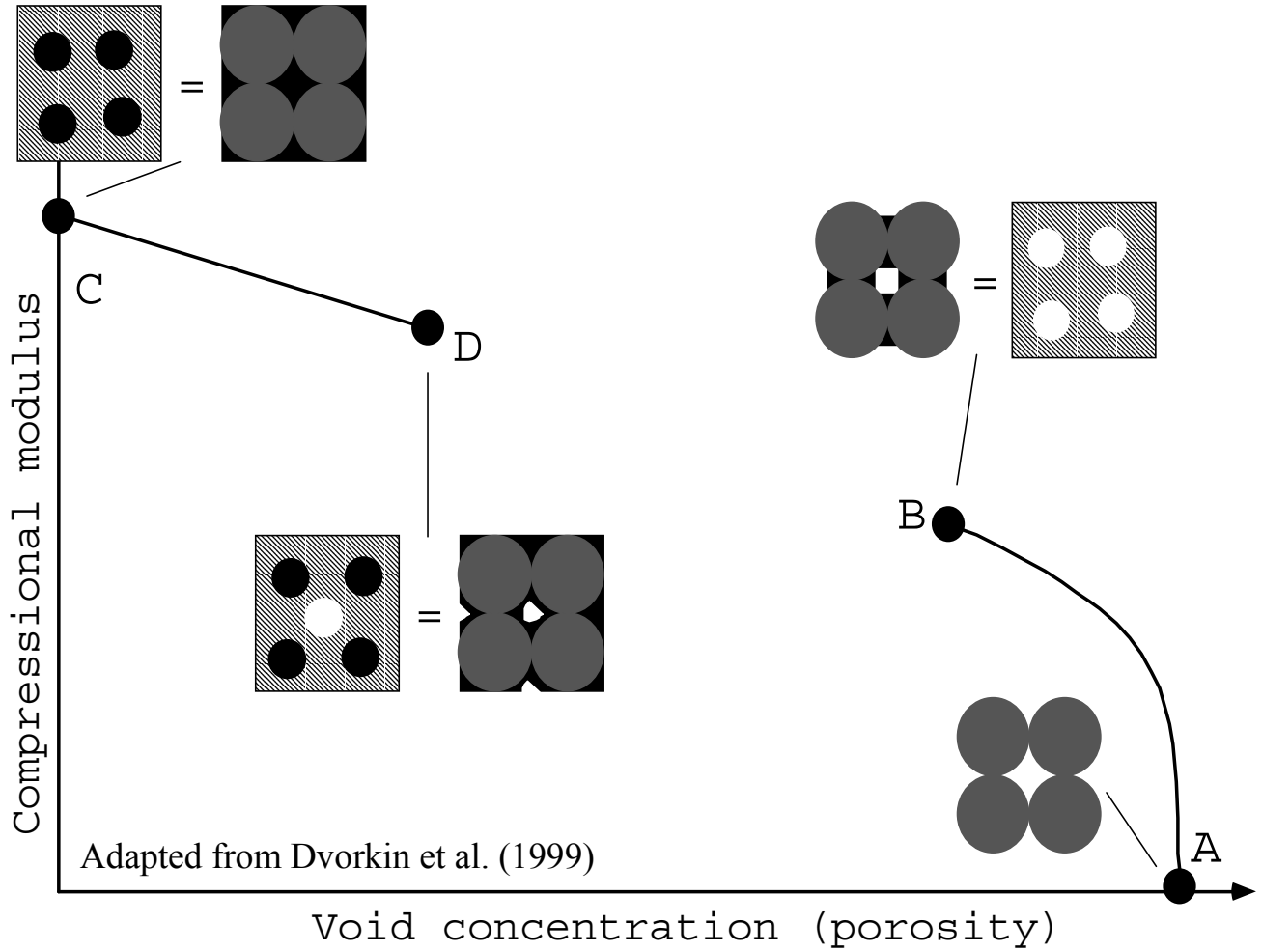


Homogeneous gas/oil mixing

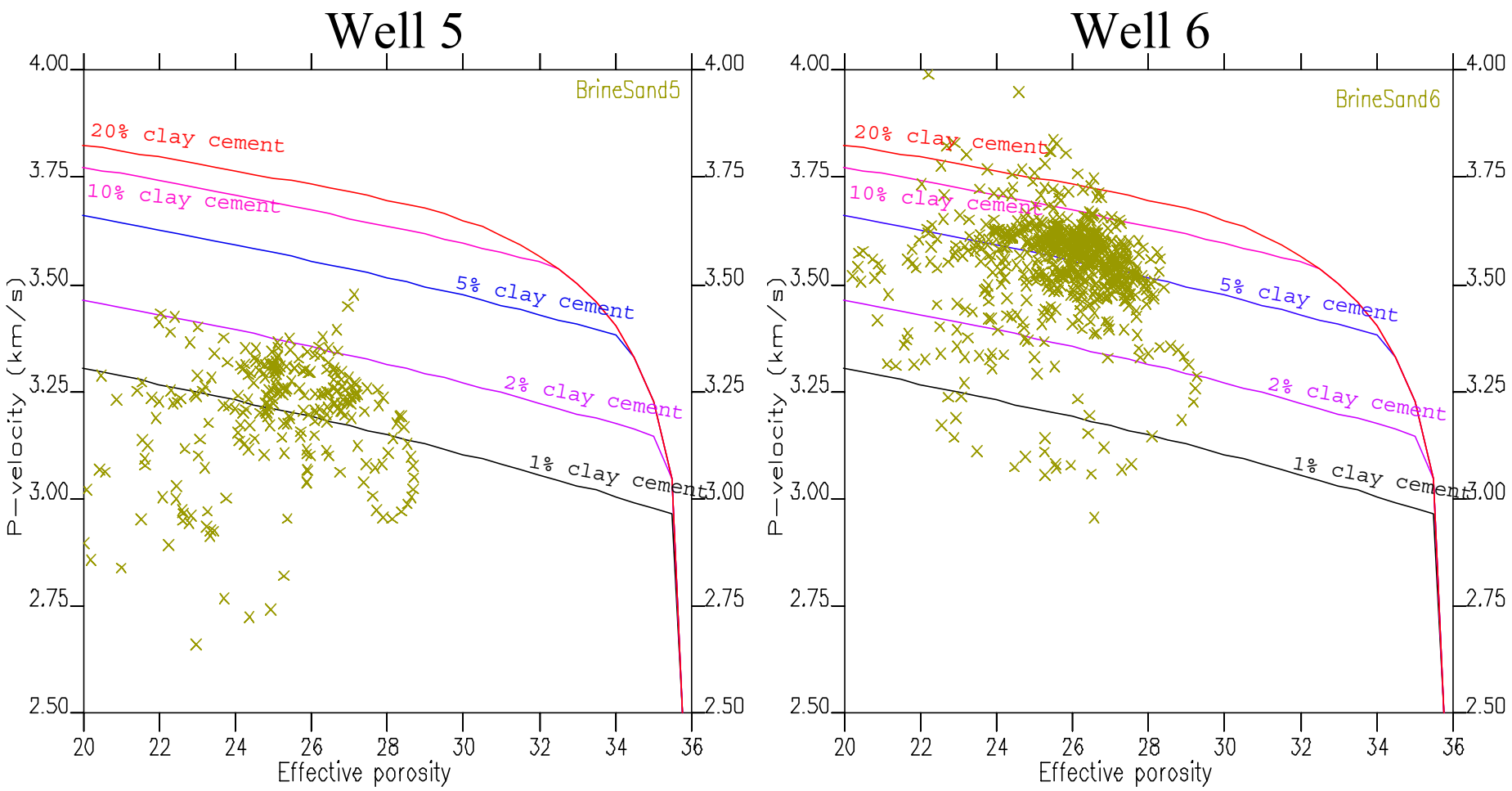


Patchy gas/oil mixing

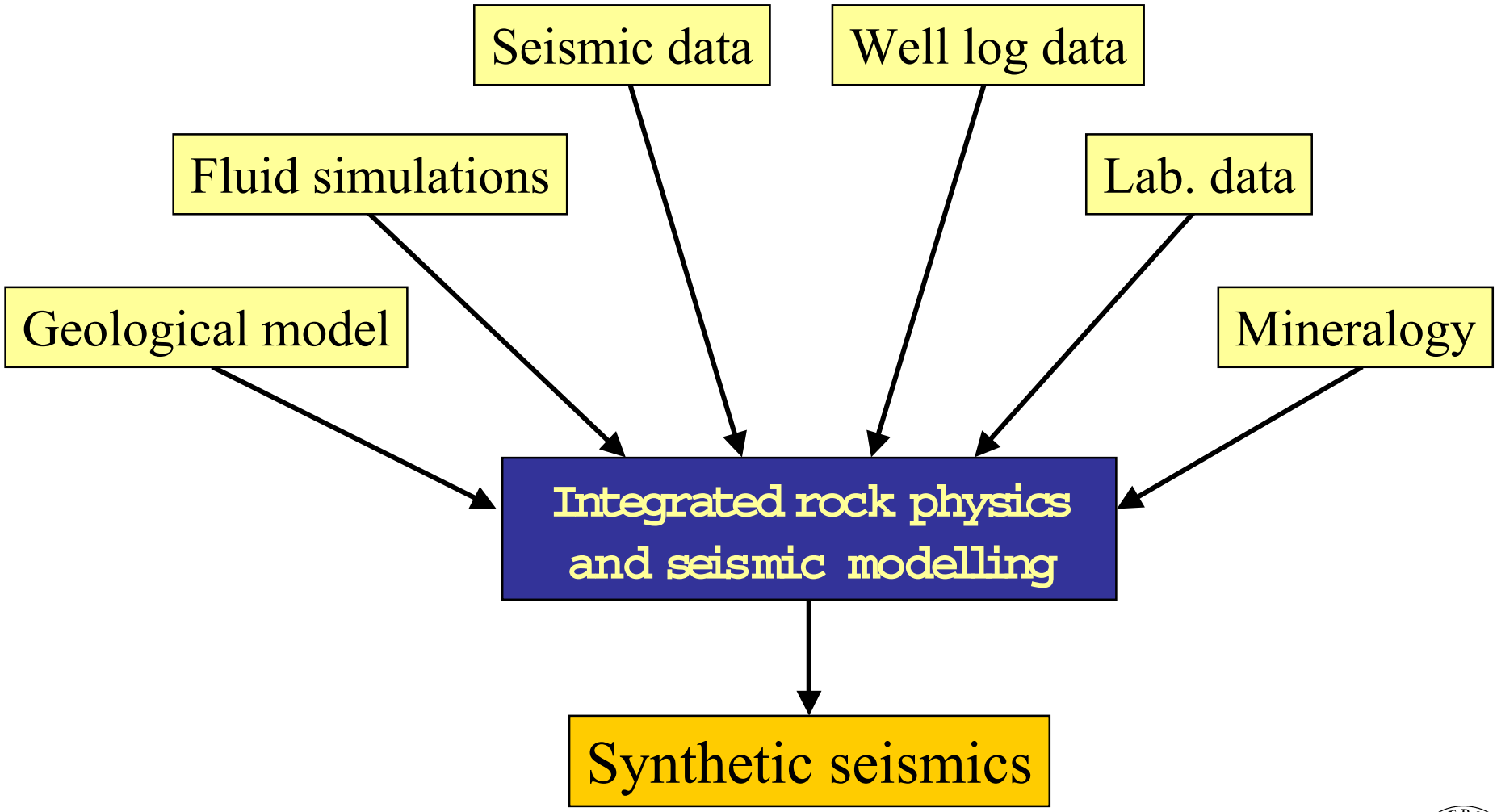
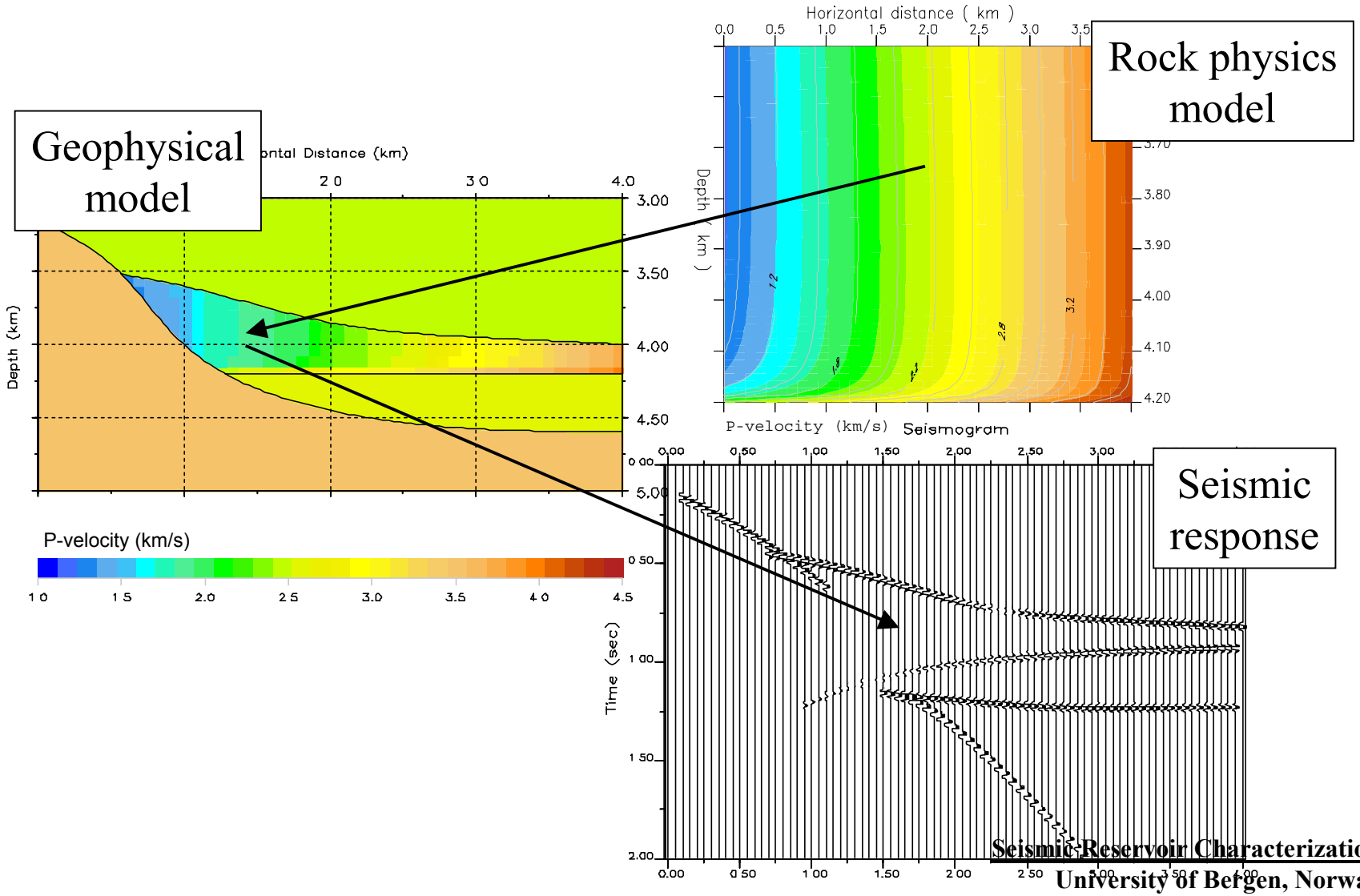
Contact cement model principle



Log data vs. contact cement model



Integrated rock physics and seismic modelling



Integrated modelling with rock model in target