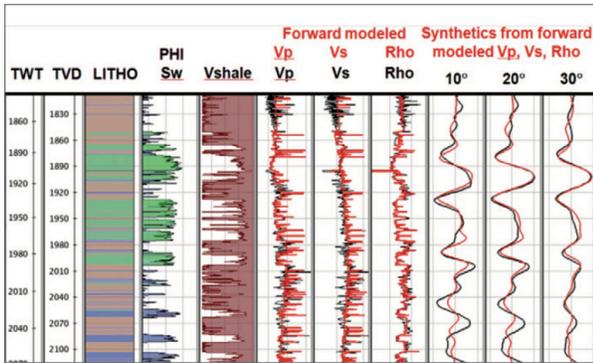


## Rock Physics Modeling

**RockSI** is a powerful tool for exploring the link between rock properties and seismic data for quantitative interpretation and feasibility studies. It can create detailed Petro-Elastic Models (PEMs), calibrate them with well data, and generate 3D and 4D Rock Physics Templates which show the relationship between elastic attributes, lithology, saturation, and pressure. It also provides statistical rock physics capabilities, using Monte Carlo simulation, to create training data sets for lithology classification when well data are sparse, or to simulate the seismic signature of different production scenarios.



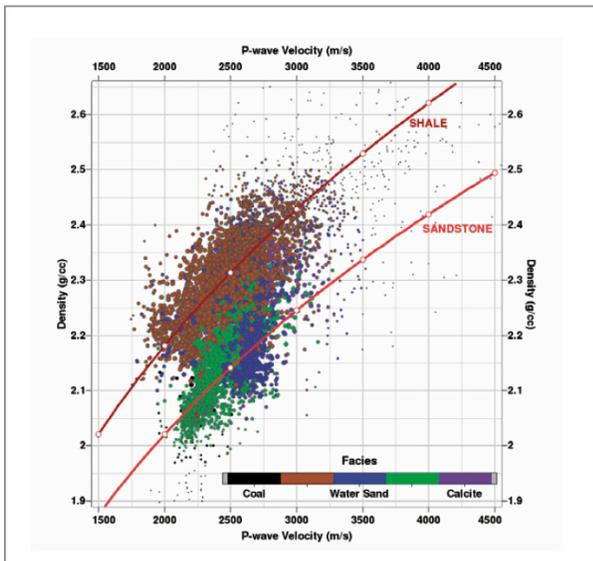
Rock Physics Modeling. Well calibration display showing input logs for PEM calculations and comparison of predicted and measured values of velocities, density and seismic amplitudes.

### Key Features

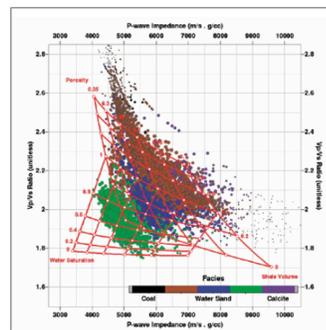
- Built-in petro-elastic models (PEMs), with the ability to create customized PEMs for clastic or carbonate reservoirs
- Calibration of PEMs with well log and seismic data
- Prediction of velocity and density curves and their comparison with real log data
- Generation of 3D or 4D rock physics templates for quantitative seismic interpretation
- Creation of 'what if' rock physics scenarios by combining PEMs with Monte Carlo simulations
- Generation of simulated data sets for lithology and fluid classification with LithoSI software

### Benefits

- Complete understanding of the link between seismic and rock properties
- Reduction of uncertainty in interpretation of elastic attributes
- Study of pressure and saturation effects for producing reservoirs



Gardner equation curves calibrated for shale and sandstone facies.



Interpretation of elastic attributes for a clastic reservoir using a specific rock physics template.

### Customizable Rock Physics Workflow

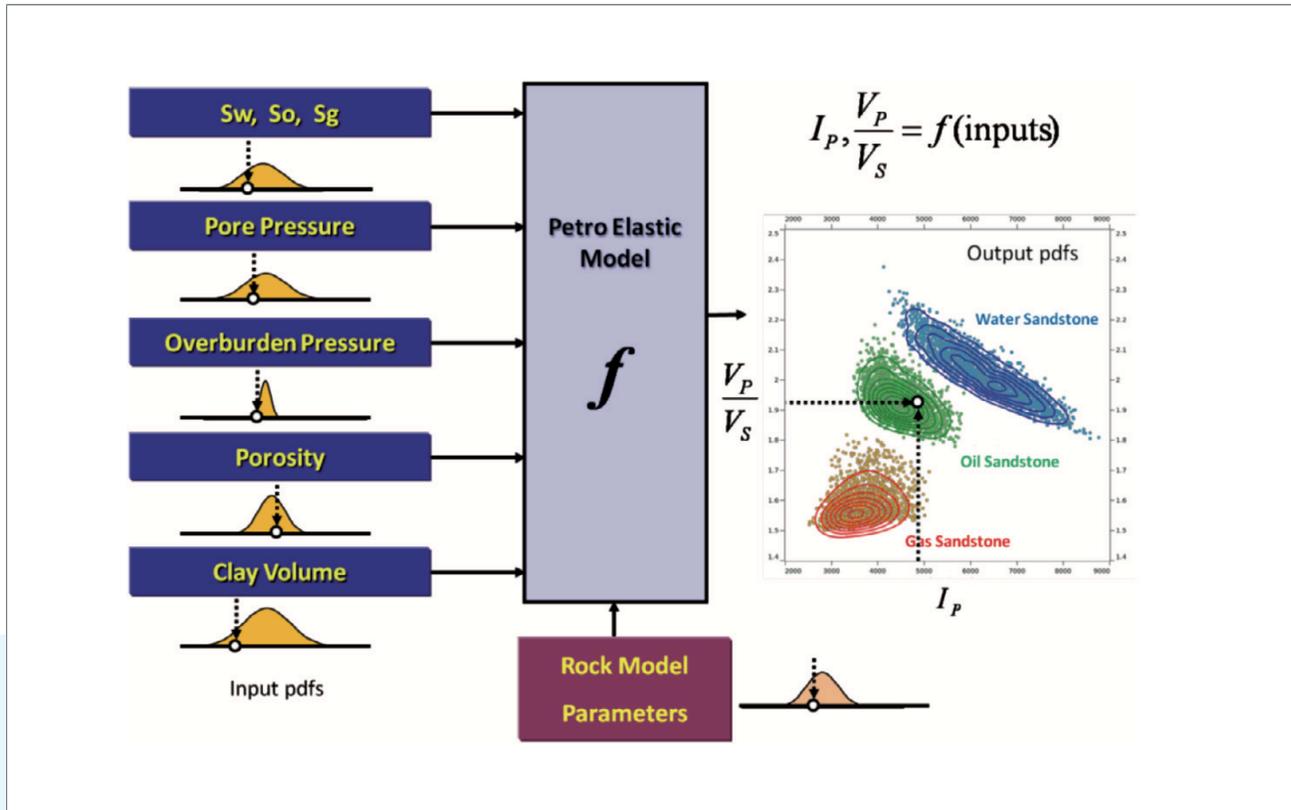
The **RockSI** workflow includes the creation of detailed Petro-Elastic Models (PEMs) and their subsequent calibration with well log data. As an input, **RockSI** uses interpreted logs for rock properties such as lithology, mineral composition, porosity and fluid saturations.

The user-defined PEMs are used to calculate estimates of elastic properties such as effective bulk and shear moduli, P-wave and S-wave velocities. A multi-well log display system allows visual comparison of PEM-based velocity predictions with measured velocity logs and interactive calibration of the PEM equation parameters.

Once the PEM has been calibrated, it is possible to generate Rock Physics Templates (RPTs). These can be visualized in cross-plots superimposed with log data or inversion results to help study the relationship between lithology, porosity or fluid saturations and seismic velocities.

A library of rock physics models is available for both clastic and carbonate rocks but it is also possible to customize the PEM and use field-specific equations and model parameters. In addition to 3D rock physics templates, 4D templates can be generated to interpret time-lapse changes in velocities in terms of changes in reservoir pressure and fluid saturations.

**RockSI** supports statistical rock physics modeling. Probability Distribution Functions (PDFs) are specified for the PEM input variables and for uncertain PEM parameters. The input PDFs are sampled using Monte Carlo simulation, and the corresponding elastic properties and velocities are calculated by applying the PEM to each set of simulated inputs.



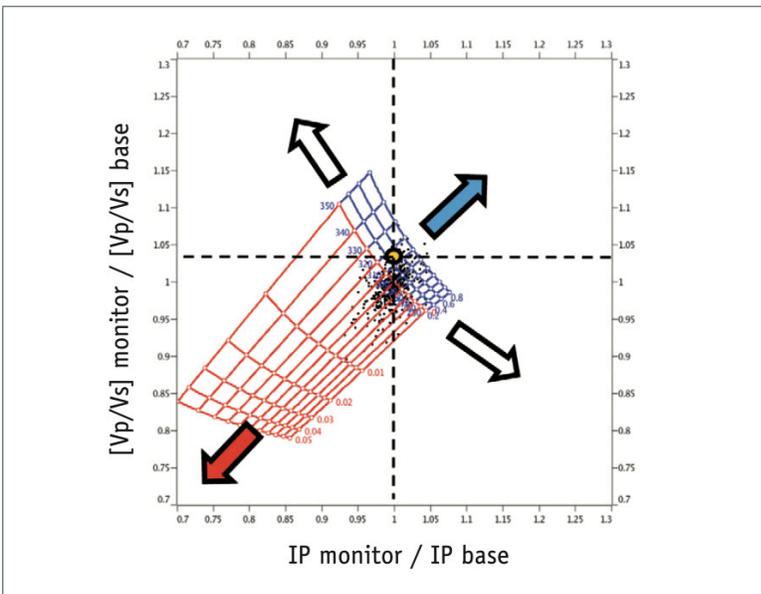
Monte Carlo modelling workflow. The input for PEM are pdfs of petrophysical parameters, and the output are pdfs of specific lithology classification.

### 4D Applications

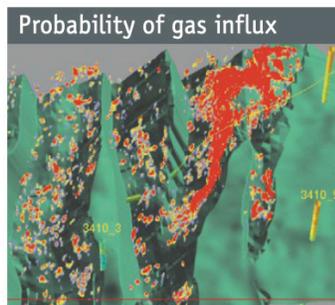
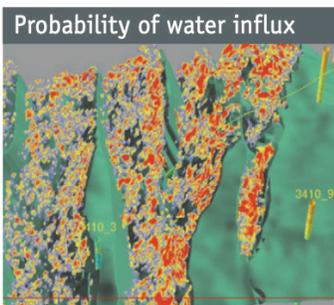
4D Rock Physics Templates provide the link between dynamic reservoir properties and 4D seismic. Below, the PEM-predicted changes in pressure and saturation are displayed as a graduated rock physics template in a 4D attribute cross-plot to aid the interpretation of time-lapse inversion results.

**Initial oil reservoir conditions:**

Phi = 0.3, Pp = 300 bar, Sw = 0.2, So = 0.8, Sg = 0



Crossplot with the overlaying PEMs demonstrates how elastic Vp/Vs and Ip attributes change as fluid saturation and pore pressure change.



Monte Carlo simulation is used to model the 4D signature of water flooding and gas injection in an oil reservoir. 4D attribute PDFs are constructed from the PEM-based simulations and used to predict the probability of gas and water influx from StratiSI 4D inversion results.

### Statistical Rock Physics

Monte Carlo simulation is used to generate different scenarios of reservoir properties such as porosity and saturations. The PEM is used to simulate corresponding values for elastic properties, for example, such as acoustic impedance and Vp/Vs ratio. Finally, empirical PDFs of elastic properties are calculated from the simulated points and used for seismic lithology and fluid classification.

The PEM-based Monte Carlo simulation can be used to create PDFs of elastic attributes representative of the expected natural variability in static or dynamic reservoir properties. In exploration situations where well data are sparse, this Monte Carlo procedure is particularly useful to generate training sets for supervised Bayesian classification of lithology with LithoSI. Statistical rock physics can also be used to drive time-lapse fluid classification workflows.