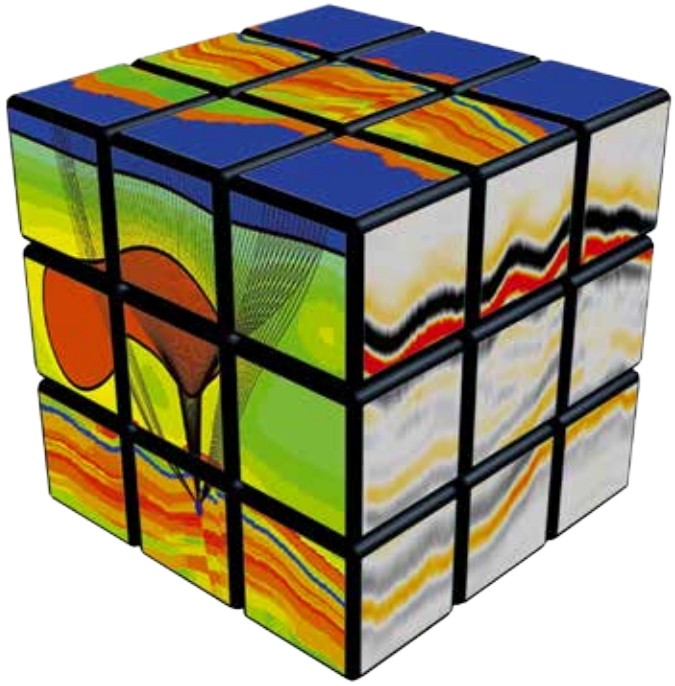
Exploring the Earth

SeisRoX



Bridge the gap between reservoir and seismic

- *Do you want to easily and efficiently simulate realistic 3D PSDM seismic images?*
- *Is a 4D seismic signal change expected from replacing oil by water in your reservoir?*
- *How do variations in survey, wavelet, overburden, and reservoir properties affect your depth migrated seismic response?*
- *How can the expected vertical and lateral seismic resolution be quantified?*
- *Are you interested in 4D feasibility and sensitivity?*
- *Do you want to check your geological interpretations?*

Find the answers with SeisRoX

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Simulating PSDM seismic images from reservoirs

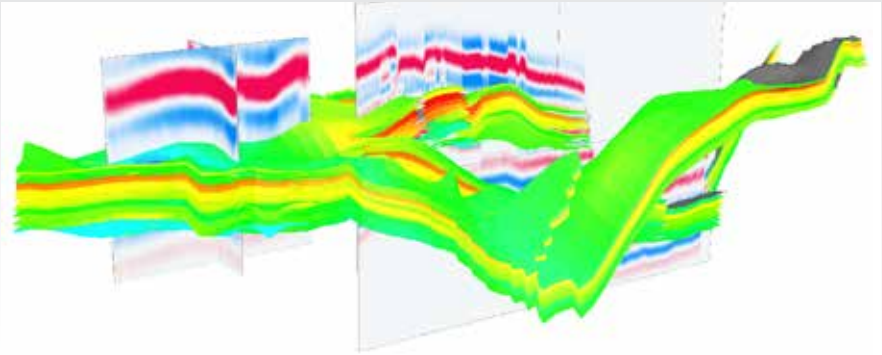
SeisRoX™ is a software suite developed by NORSAR to efficiently model 3D PSDM seismic images at detailed reservoir scale.*

Each tool can be used to provide innovative solutions to problems faced by the E&P scientist. However, the true benefit of SeisRoX is realised when the tools are integrated to provide the user with a robust, efficient and flexible workflow. In this format, the software guides the user from the generation of the rock physics model to the simulation and analysis of the 3D PSDM seismic image. This approach is particularly useful for investigating the seismic sensitivity of geological properties, seismic properties and reservoir geometry.

Capable of handling both large scale and small scale models, the effect of the overburden and survey characteristics can be incorporated while giving the user the functionality to assess the sensitivity to variations in rock properties and seismic parameters at the reservoir scale.

A key to the success of the software is the design, which overcomes the limitations and simplifications inherent in conventional analysis.

*PSDM: Prestack Depth Migration



SeisRoX™ provides integrated and efficient workflows for simulating PSDM seismic images that incorporate the 3D effects from the survey, overburden and reservoir.

SEISROX KEY FEATURES

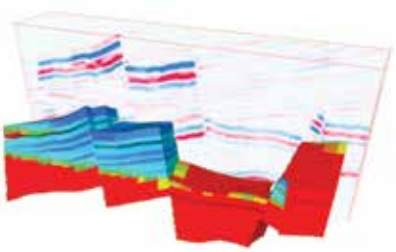
- Rapid simulation of PSDM seismic images.
- Inclusion of 3D illumination and resolution effects from overburden and survey.
- Rock physics modelling.
- Intuitive workflow operation.
- Direct links such as Eclipse* simulations model import and Petrel* plug-in.

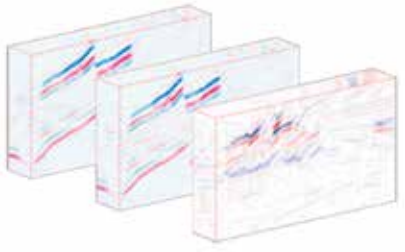
*Eclipse and Petrel are trademarks of Schlumberger

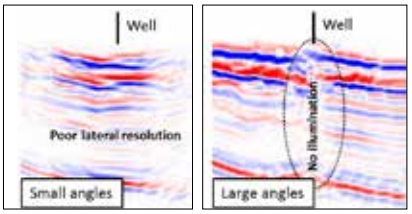
Reservoir to Seismic
Bridge the gap between the reservoir and seismic by coupling comprehensive rock physics modelling with advanced seismic simulation.

4D Feasibility and Sensitivity
Improve your seismic predictions and history matching by including 3D illumination and resolution effects from the survey and overburden.

Ilumination and Resolution Analysis
Simulate PSDM images for different kinds of surveys, velocity models and pulses, in a fast and flexible manner.







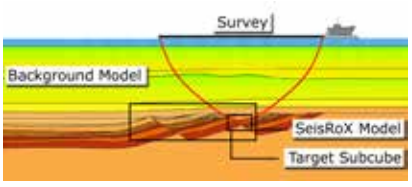
SeisRoX™ provides a selection of efficient workflows which can be used to investigate how the constituents of the subsurface regime influence on the seismic reservoir response, e.g. the effect of wavelet, survey geometry, overburden structures and reservoir properties.

Integration of rock physics and seismic modelling

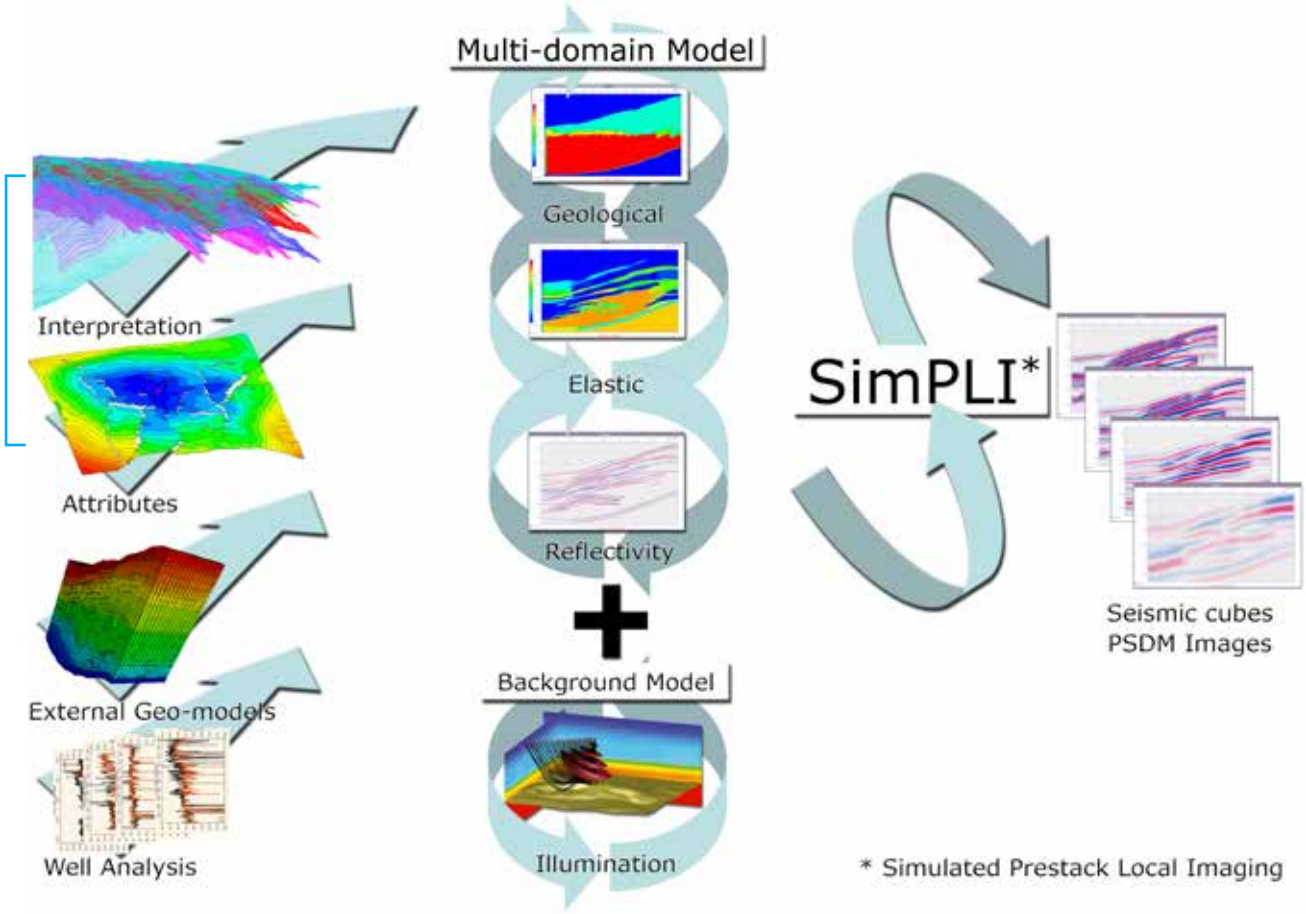
Quantitative seismic interpretation
The concept behind SeisRoX™ is that the seismic interpretation should be related to a well-defined geo-model, i.e. a spatial representation of geophysical and geological properties in a certain volume of the subsurface. This model should contain sufficient information to allow a simulation of the seismic response, given external constraints such as survey geometry and source signature. This gives the interpreter the possibility to perform quantitative interpretation in the context of a geo-model containing physical properties rather than exclusively with observed attributes.
Using this approach, when the physical geo-model has been established within SeisRoX, any model parameter can be interactively perturbed and the effect on the seismic response seen immediately by the interpreter. This environment makes the understanding of parameter sensitivity and their corresponding effects on elastic parameters and the seismic attributes a real possibility, enabling efficient checks of the consequences of different model hypotheses.

Target-orientated modelling
An important characteristic of the system is that the seismic modelling process is designed for target-oriented analyses. The model-based analysis is concentrated within a user-defined sub-area. This is the area for which the detailed SeisRoX geo-model is created, containing the structure and available physical properties. The user may then either define a local target or a full-field one for which the 3D seismic image will be produced.

A background velocity model is defined to account for the seismic propagation effects to and from the area of interest, including 3D resolution and illumination effects from the survey and overburden. The background model is decoupled from the target model, as in PSDM where an image of the scattering structures is obtained upon a given velocity model.



By decoupling the target area from the background model, SeisRoX™ gives increased flexibility when calculating the seismic response of numerous scenarios, as it allows the parameters describing the local target and the overburden to be changed independently.



SeisRoX™ provides integrated and efficient workflows for modelling the seismic response of hydrocarbon reservoirs and other targets.

The core of the SeisRoX workflow is the multi-domain model, travelling from the geological domain via the elastic domain to the reflectivity domain. The innovative seismic modelling technology incorporating the patented SimPLI* process combines the output of the multi-domain model with the illumination information gained via ray tracing to simulate a PSDM seismic image. This process is completed in moments and provides the user with a very accurate simulation of the seismic image, where both 3D resolution and illumination effects are integrated. This speed, together with the option to import data into any stage of the multi-domain model, results in a highly versatile tool.

The SeisRoX™ multi-domain model

Geological, Elastic and Reflectivity domains

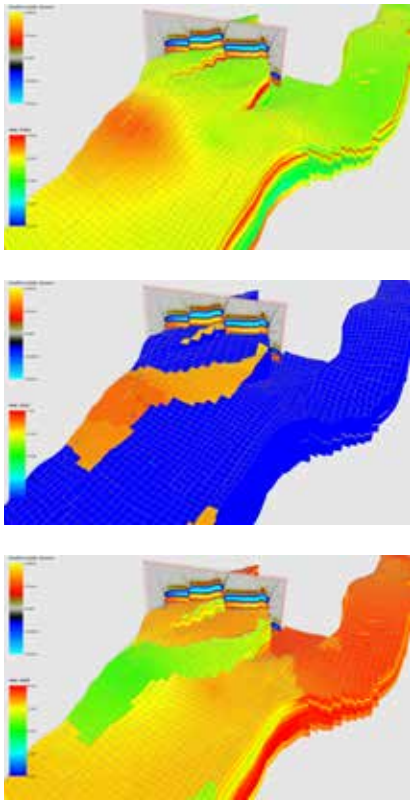
At the core of SeisRoX™ is the multi-domain model which combines different types of data elements in a consistent framework. It consists of the following domains:

- The geological domain: Rock-related properties including porosity, rock type, mineral volumes, fluid type, saturation and more.
- The elastic domain: Elastic parameters such as seismic impedance, seismic velocities, density and elastic moduli.
- The reflectivity domain: Horizon-related parameters like angle-dependent reflection coefficients, AVO/AVA parameters.

The user is guided through the definition of a rock model for the layers in the geological domain, transforming the geological properties into elastic parameters, before calculating the reflectivity using an industry-standard algorithm such as the Zoeppritz equations.

Advanced functionality allows the users to enter the multi-domain model at any stage depending on the data they have available. For example, to facilitate 4D studies, the PSDM Simulator workflows allow users to predict the 3D seismic images to production from fluid simulator data in Eclipse* format.

*Eclipse is a trademark of Schlumberger



The porosity (top), gas saturation (middle) and P-impedance (bottom) of a SeisRoX model generated from a fluid simulator model, plotted together with a seismic line modelled by the SimPLI method.

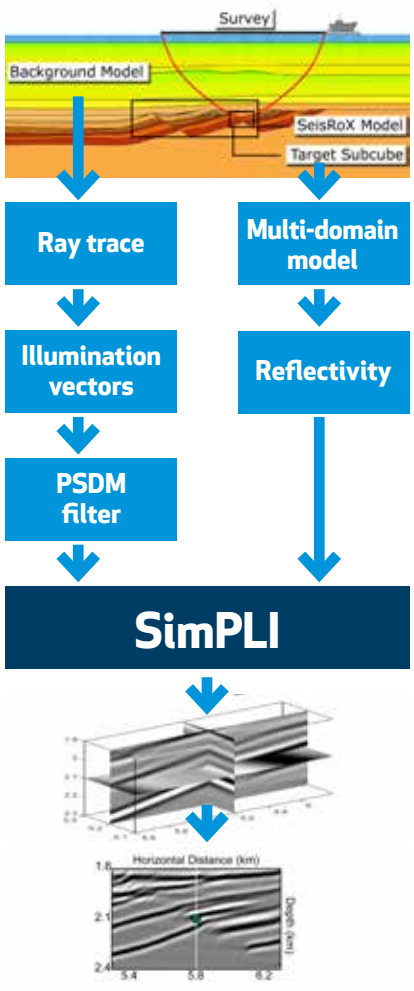
PSDM simulator (SimPLI™ patent)

The patented SimPLI™ method** allows an interpreter to analyse the seismic response of both static and dynamic reservoir models. SimPLI efficiently simulates the PSDM seismic response of the model taking into account survey characteristics, overburden structures and reservoir properties.

The seismic illumination and resolution effects from a given survey and overburden are quantified using illumination vectors. For selected subsurface targets, the illumination vectors are calculated for each pair of source and receiver in the survey. This can be done by ray tracing prior to the analysis. The illumination vectors are selected e.g. according to the offset or angle intervals chosen by the interpreter.

The user may also define the frequency band of interest using a given wavelet. The illumination vectors and wavelet chosen are used to generate the unique PSDM filters. These filters are applied to reflectivity grids of the multi-domain SeisRoX model to simulate 3D PSDM seismic images.

**SimPLI™ is patented by NORSAR in:
- Norway (322089),
- USA (7,376,539),
- Canada (2,521,919), and
- UE (1611461; validated in France, Germany, Netherlands, and UK).



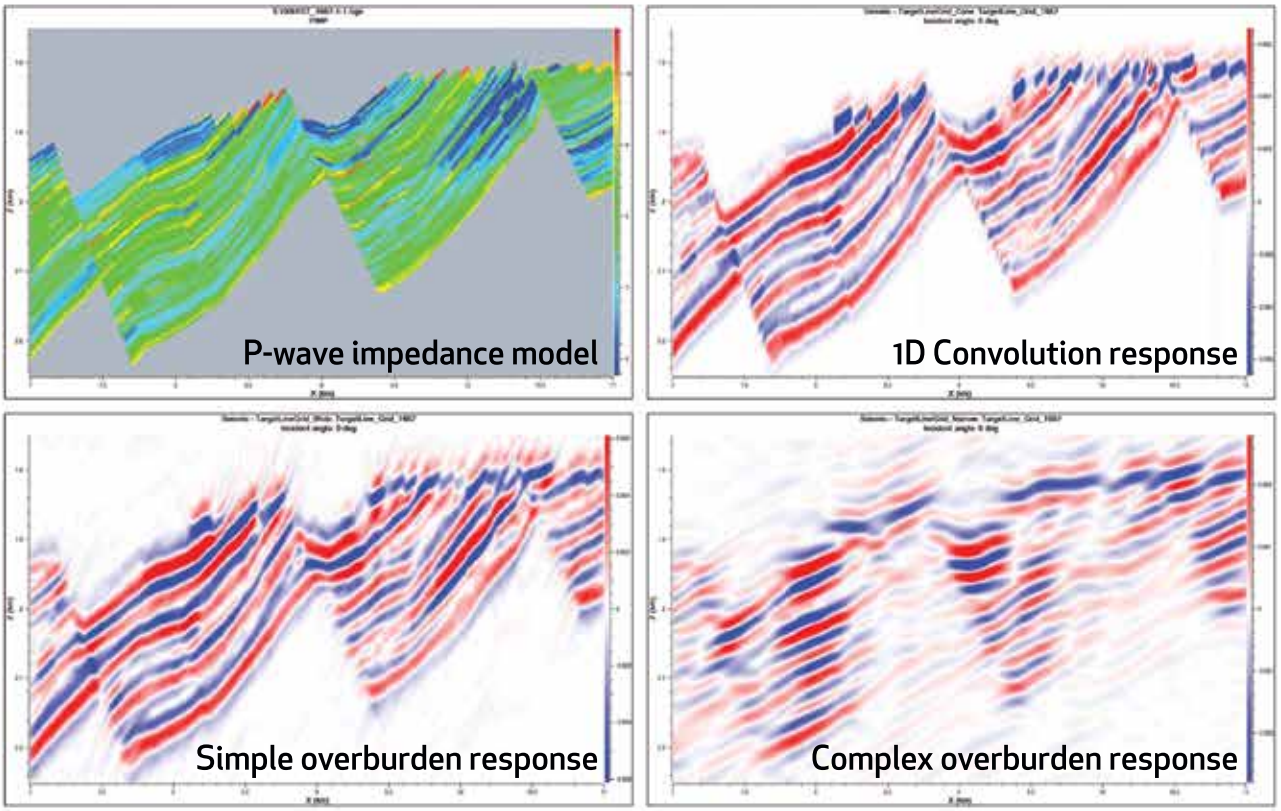
Using the background model, illumination vectors are calculated by ray tracing from the point of interest within the target subcube. The PSDM filter is created by combining the illumination vectors with the source wavelet. The filter is finally combined with the reflectivity from the multi-domain model inside the SimPLI method to simulate the 3D PSDM seismic image.

Local and Full-field Seismic Modelling

SeisRoX predicts PSDM seismic images from reservoirs and other targets, in consistency with 3D illumination and resolution characteristics caused by overburden, seismic survey geometry, and wavelet.

SeisRoX PSDM simulators (local and full-field) are a major step forward compared to industry-standard 1D convolution which works only in poststack time domain, without survey considerations, and is only suitable for simple overburden.

For small targets, the dedicated local PSDM simulator needs only one PSDM filter and is thus very efficient. For larger targets, in order to take into account the spatial variability of the PSDM filters, the full-field PSDM simulator is used.



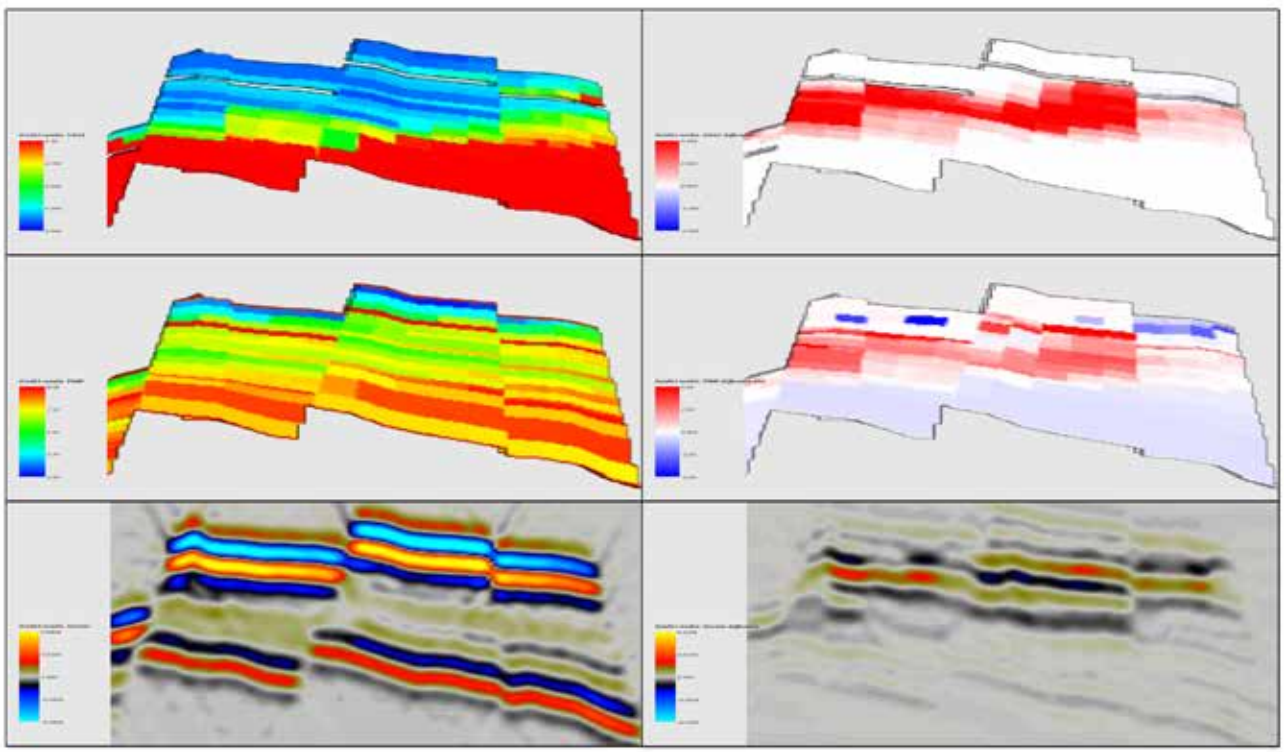
Example of a reservoir target with input impedance (top left), industry-standard 1D convolution for comparison (top right), simple overburden effects (bottom left; no major illumination issues but with proper lateral resolution), and complex overburden effects (bottom right; strong illumination and resolution effects).

Time-lapse modelling of reservoirs

Seismic time-lapse (4D) monitoring is an essential reservoir management tool. But interpreting 4D seismic data can be complicated since the reservoir model contains both detailed stratigraphic units and production data. Relating all this information to a seismic image can be done in SeisRoX.

The software combines a rock modelling tool VelRock with SimPLI, a fast and flexible PSDM seismic simulator, to provide an efficient link between geology and seismic response.

Reservoir models can thus be verified and updated by comparing simulated images with acquired seismic data. SeisRoX can be used in both feasibility studies, e.g. to assess the sensitivity of a new monitor survey to the production response of the reservoir, and to assist in the actual 4D interpretation, e.g., by checking the consistency of observed seismic changes with the current best knowledge.



The figure shows the baseline properties (left) and the predicted response to production (right).Left: from top to bottom the properties are water saturation, P-impedance and the seismic response, this assuming a 3D marine-streamer survey. Right: predicted changes in the same properties after 5 years of production.

Quality and Excellence
NORSAR is an independent research foundation recognised internationally for its scientific research and innovation. NORSAR's seismic modelling division has been at the forefront of software solutions for seismic oil and gas prospecting since the release of our first commercial seismic ray modelling package in 1991.

Software Products
The core applications for NORSAR Seismic Modelling packages are 2D and 3D seismic ray modelling, survey planning, time lapse studies, reservoir analysis, and Green's functions for PSDM.

NORSAR software products are used by the leading E&P and O&G service companies throughout the world. The products are supported by experienced sales, services, and support teams from our main office in Norway. For your convenience, additional support centers are located in Houston and Beijing.

Research and Development
Research and development is the foundation upon which NORSAR's software products are built. Through the development of a world class research centre, NORSAR is able to provide its clients with a product that evolves as new, innovative solutions are developed to meet the needs of a dynamic industry.

Microseismic Research and Services
Since 2000, NORSAR has been engaged in research and development of advanced software solutions for microseismic data analysis and interpretation. Over the years NORSAR has been leading numerous research projects and consultancy studies.

Support and Maintenance
At NORSAR we pride ourselves on the level of support offered to our customers. We value client feedback as a vital ingredient for the continued improvement and evolution of the software. Therefore, software support is an integral aspect of the software package we offer to our customers.

The maintenance service includes telephone support, on-line support, software updates, and new releases as they become available.

Consulting services
Our Services division undertakes commercial projects in survey evaluation, Illumination analysis, 4D-studies, and reservoir monitoring. The scope of this group is to use NORSAR Seismic Modelling Software to provide tailored solutions and independent advice to our clients.

Training Courses
Whether you are a new user or an experienced one, we provide training that will reduce the uptake time and improve your application of our software.
We are offering both public and private training courses. Booking a private course enables you to tailor the course content to suit the application of your company.

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