



Sim2Seis: Synthetic Seismic Volumes

The CoViz Sim2Seis Workflow

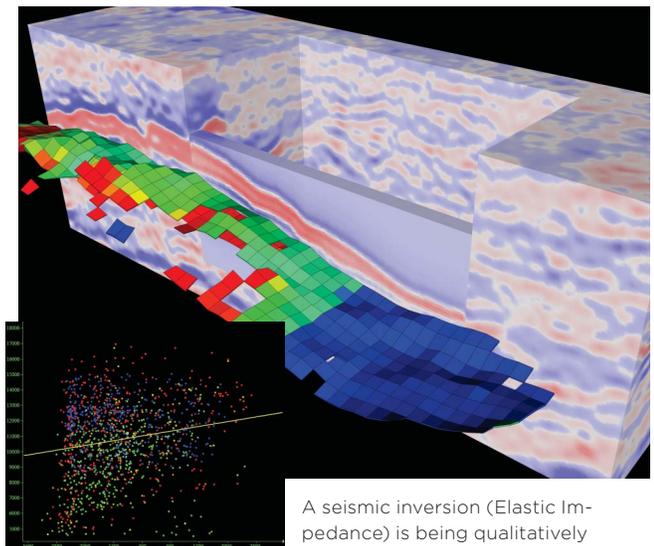
CoViz® 4D leads the industry in the stunning visual display of diverse subsurface and surface data used in hydrocarbon asset development. This 3D/4D visualization is complimented and extended by a formidable array of 3D/4D qualitative and quantitative tools and functionality; core amongst these is a seismic history matching workflow via the available CoViz Sim2Seis modules, an option to CoViz 4D.

The CoViz Sim2Seis workflow allows the reservoir engineer and geophysicist access to powerful and flexible synthetic seismic volume creation tools from directly within the data fusion framework inherent to the software, resulting in better, faster seismic history matching, and 4D seismic feasibility studies.

Sim2Pem: Simulation to Petroelastic Model

The available Sim2Pem module in the CoViz Sim2Seis workflow quickly and easily guides the user from flow/saturation model to petroelastic (velocity and density) model. Some of the available options include:

- Cellular model import from a variety of simulators/sources
- Creation of petroelastic models from rock physics parameters via Gassmann substitution
- Krief or polynomial options for expression of dry moduli
- Various options for rock moduli stress sensitivity
- Optional accommodation of time-varying porosity
- Optional Extended Elastic Impedance calculation
- Batzle-Wang or user-provided custom fluid calculations
- Up to 25 different lithology regions are accommodated
- Various tools and options for the rapid interactive QC and scanning of the output attributes



A seismic inversion (Elastic Impedance) is being qualitatively compared to a calculated Synthetic Impedance volume of the same extents. The input PEM cell model is also shown. The cross plot displays the observed and synthetic seismic values extracted on a horizon approximately at the top of the PEM cellular grid.

Pem2Seis: Petroelastic Model to Synthetic Seismic

The creation of 4D synthetic seismic volumes from a petroelastic model (Pem2Seis) is the next step in the CoViz Sim2Seis workflow. Focused around an intuitive and easy-to-use graphical interface, the Pem2Seis module offers a wide variety of options for synthetic-seismic volume creation:

- Integrated Depth-to-Time and Time-to-Depth conversions
- Option for band-limited impedance or reflectivity volumes
- Multiple options for modeling background properties: constants, trends, 2D & 3D grids, well data
- 4D difference volume outputs
- SEG-Y and other export options
- Multiple intermediate output options for QC
- Easily scripted/batched workflows for rapid looping, and sensitivity analysis



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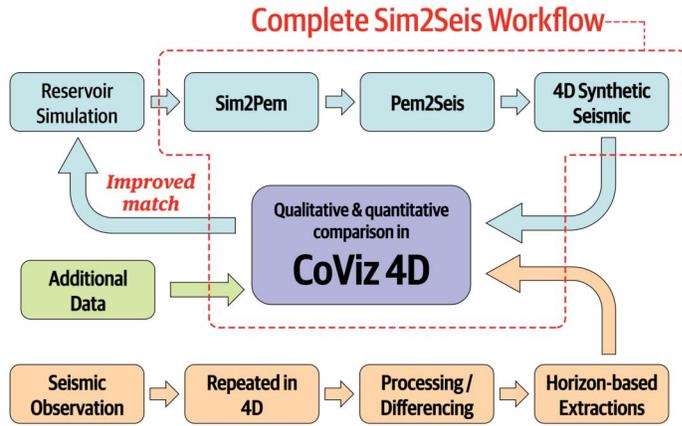
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Schematic illustrating how the CoViz Sim2Seis workflow, tightly coupled with qualitative and quantitative analysis in the CoViz 4D Viewer, offers full seismic history-matching capabilities.

Geomechanics Workflow

As a complement to the Sim2Seis Workflow, CoViz 4D offers a 4D Geomechanics workflow, which calculates displacement, strain and seismic time-shifts in the overburden due to thickness change in the reservoir. This functionality enables rapid, first-order screening of overburden deformation and time-shifts, based on reservoir compaction.

The CoViz 4D Geomechanics workflow offers the following features:

- Calculation options are quickly parameterized based on an input reservoir simulation grid
- Makes full use of CPU and GPU resources for fast analytical computations, even for very large reservoir models
- Allows for rapid sensitivity analysis

This agile workflow enables teams to assess 4D geomechanical effects in cases where finite element modeling could be prohibitively expensive and time-consuming.

Quantitative Visualization and Seismic History Matches

Once the synthetic seismic volumes are created, the next step in the Sim2Seis workflow is the qualitative and quantitative comparison of the synthetic volumes with the field-measured (or inverted) seismic, and the reservoir simulation input. The CoViz 4D visual analytic environment is ideal for accomplishing these comparisons with its built-in tools for rapid, integrated, quantitative analysis and statistical comparison of geometrically diverse, yet spatially-overlapping 3D and 4D data sets. As the comparisons are made, information can be sent back to the reservoir simulation for adaptations and improvements in the seismic history match. Some of the many features in this area include:

- Time-step arithmetic operations (rapid calculations of differences over time)
- Interactive tools for property averages and attribute extractions in seismic space and cellular space
- Back-interpolations of properties between spatially and temporally overlapping data
- Statistical analysis, including histograms, probability plots, and cross-plotting of diverse data types
- Powerful interactive links between statistical plots and the 3D/4D viewing space
- On-the-fly volumetric calculations
- Integrated calculator for arithmetic operations on any quantitative CoViz 4D object
- Multiple output options to capture and export the results of the quantitative analysis
- Optional well planning module (CVIWD)