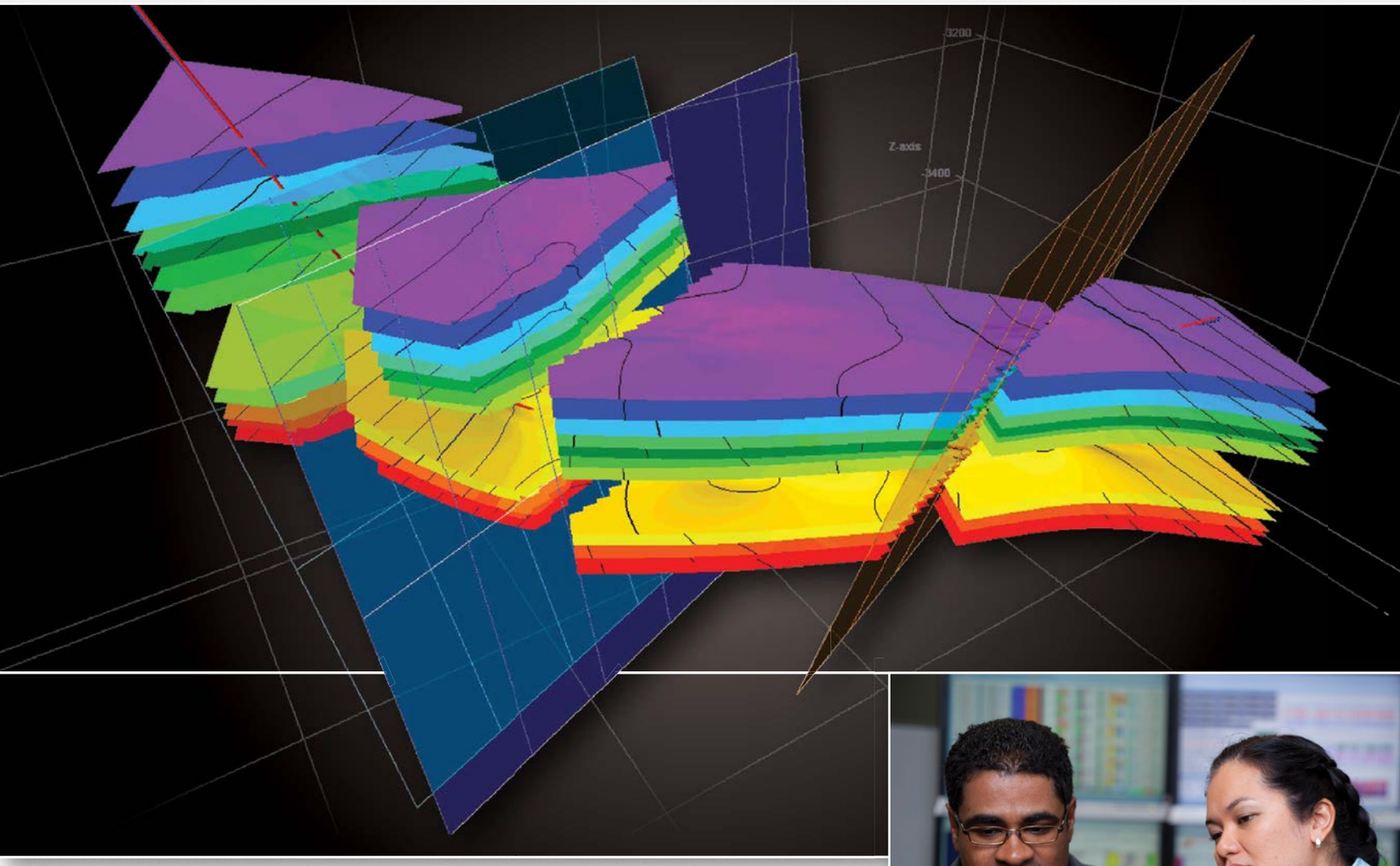
Schlumberger



Multiscale Structural Interpretation Services

Measurement integration for 3D reservoir mapping

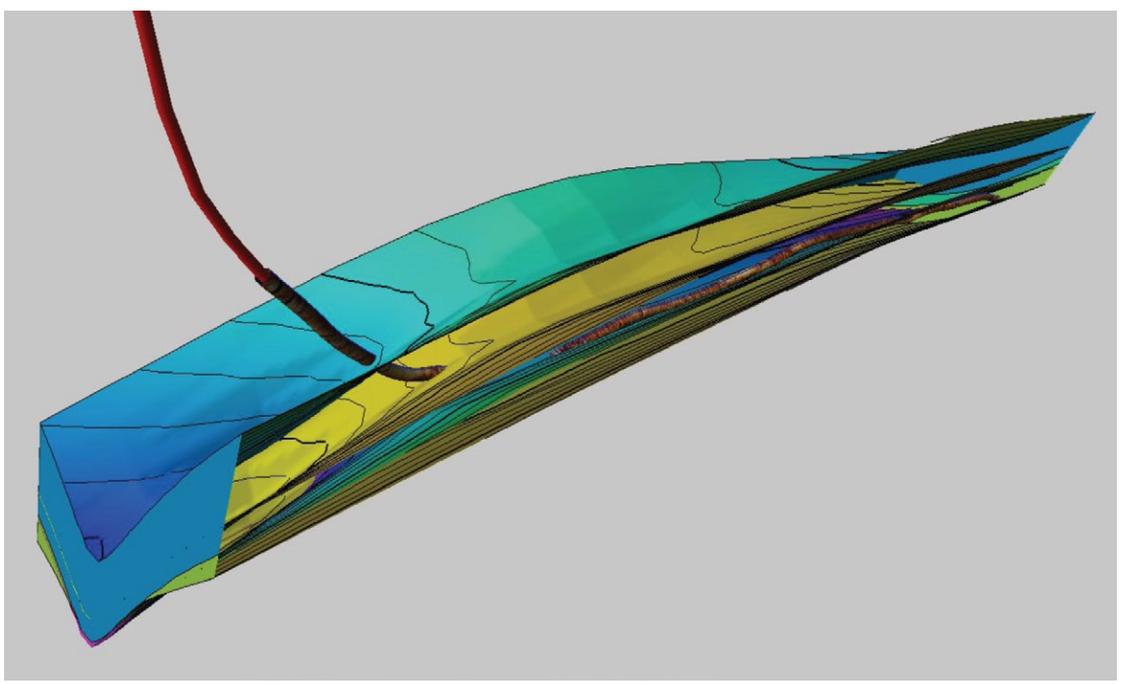
Overcoming today's increasingly complex technical challenges requires advanced, accurate geological solutions that can model structures beyond the resolution of surface seismic.

Multiscale Structural Interpretation Services

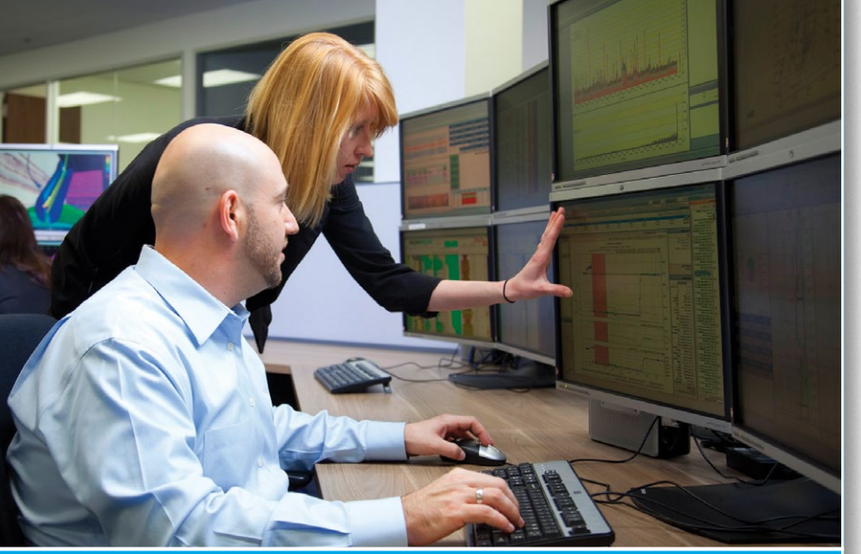
When an operation's success depends on obtaining and interpreting the highest-resolution geological data, Schlumberger multiscale structural interpretation services can help.

Using industry-leading software platforms, innovative technologies, and customizable workflows, our petrotechnical experts build 3D near-well structural models from the highest-quality reservoir data. This information helps you better illuminate the subsurface, even in the most complex environments.

Schlumberger comprehensive 3D near-well structural models are based on integrated interpretation of multiwell measurements. The comprehensive geological information derived from the models can enhance your decision making at every stage of the E&P life cycle—from guiding geosteering and confirming well placement to optimizing completions and field development strategies.



Schlumberger petrotechnical experts integrate logs, borehole images, dip data, and deep-reading electromagnetic data to create one 3D structural model for comprehensive geological interpretation.



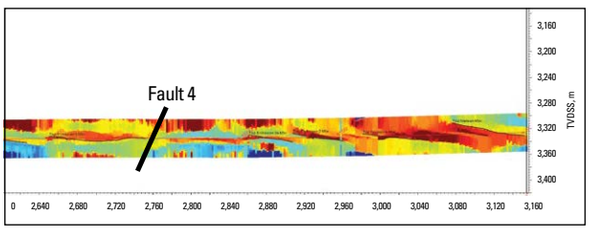
Expertise that improves decisions at every stage of operations

UNIQUE ADVANTAGES

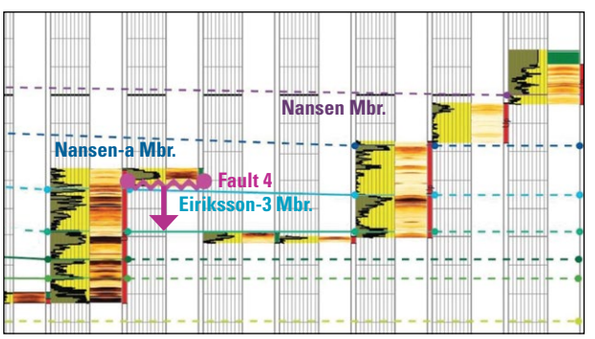
- High-definition imaging to expand visualization beyond the wellbore
- High-resolution structural geology and reservoir modeling based on integrated multiscale measurements
- Advanced 3D interpretation workflow leveraged by petrotechnical expertise
- Visualization of complex formations and static models for accurate dynamic simulation
- High-performance computing infrastructure that provides over 20-times-faster updating of workflows for multiple scenarios

MEASURABLE BENEFITS

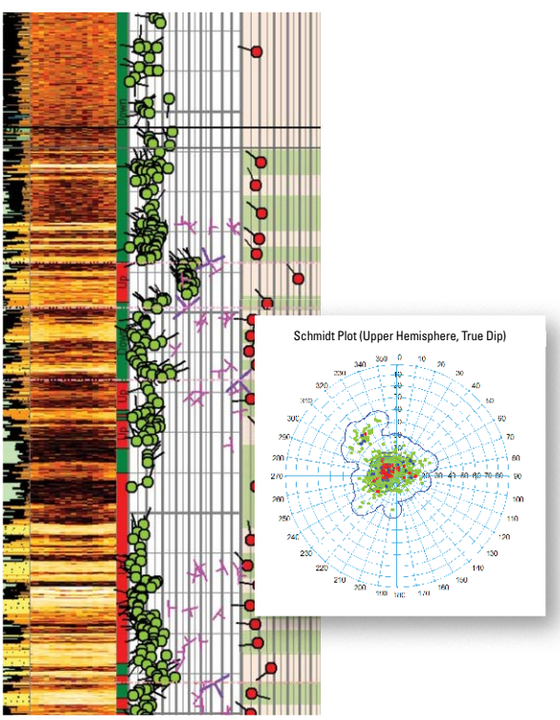
- Advanced interpretation of data logging, allowing optimal results from data imaging, especially in challenging structural environments
- Data accuracy and interpretation robustness in the subseismic-resolution range with an advanced 3D look around the wellbore
- Superior results back to the reservoir space in the versatile Petrel* E&P software platform
- Development of more-efficient completion programs and optimized recovery from complex geologic structure



Reservoir-scale interpretation of deep-reading electromagnetic horizons helps to optimize landing, reduce drilling risk, and maximize reservoir exposure.



Correlating logs and images enables identifying and characterizing faults, which helps support completion solutions, solve production uncertainties in naturally fractured reservoirs, and optimize the plan of future well trajectories.



Formation dips are picked on an LWD density borehole image. Resulting bed boundary dips are upscaled so they can be compared and combined with GeoSphere reservoir mapping-while-drilling service and surface-seismic scale of interpretation.*

WORKFLOWS

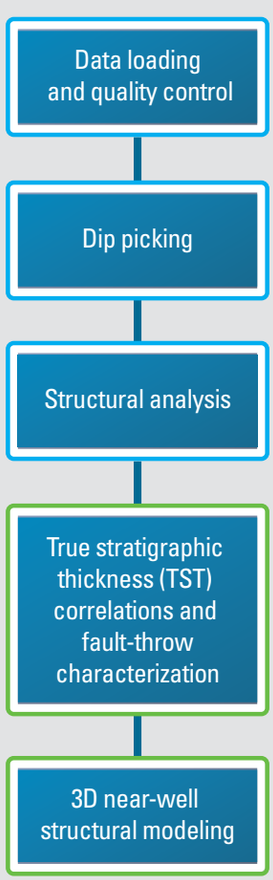
Integrating **workflows**, **technology**, and **expertise** to enhance the value of your data

Standard Services

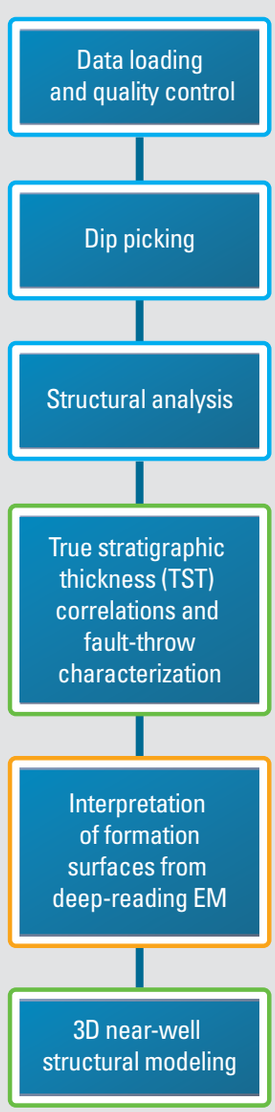
LWD Image
Structural Analysis

Advanced Services

LWD Image
3D Structural Modeling



Multiscale LWD Image and Deep-Reading Electromagnetic (EM) 3D Structural Modeling



TECHNOLOGY

Combining multidisciplinary expertise and integrated digital technologies, we work with you to customize an actionable workflow that extracts the maximum value from your borehole and reservoir measurements to transform your data into knowledge.

Data Loading and QC

Geological and drilling data

- Lithostratigraphic column
- Regional tectonic framework
- Directional survey

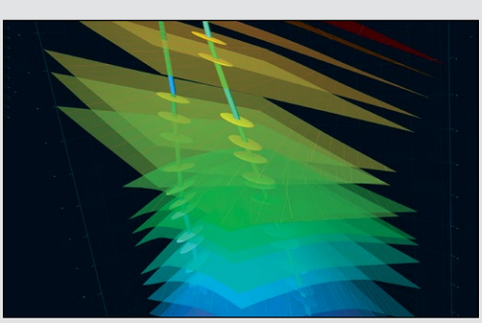
LWD data

- Resistivity and density image
  - MicroScope* resistivity- and imaging-while-drilling service
  - EcoScope*† multifunction logging-while-drilling service
  - NeoScope* sourceless formation evaluation-while-drilling service
- Deep-reading EM
  - GeoSphere* reservoir mapping-while-drilling service
  - PeriScope* bed boundary mapping service
- Gamma ray, density, and spectroscopy logs for correlation and lithofacies

Seismic data

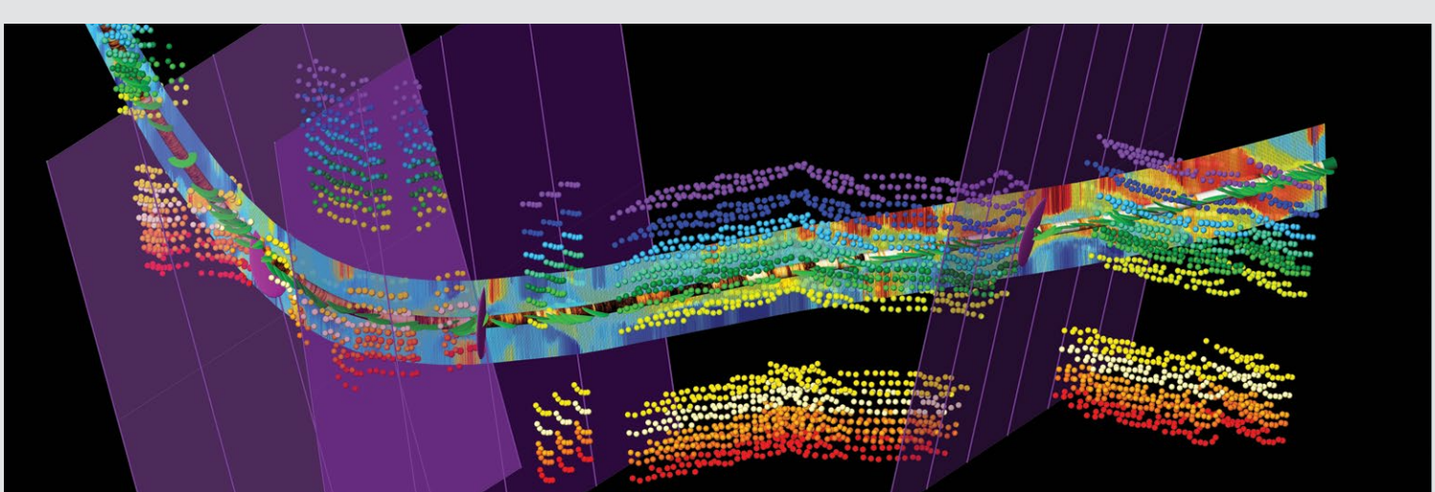
- Interpreted horizon and fault surfaces (in depth domain) from surface seismic data or 3D vertical seismic profile (VSP)

Enabling Technologies



eXpand^{BG} software extends high-resolution borehole modeling to reservoir scale to enable improved drilling and reservoir development decisions.

- **Petrel** E&P software platform brings disciplines together with best-in-class applied science to standardize workflows from exploration to production.
- **eXpand^{BG}*** near-wellbore to reservoir-scale modeling software, a proprietary technology that provides a geological interpretation of borehole images and dip data to perform both single- and multiwell interpretation, 3D structural modeling, and well placement services.
- **eXpand^{GST}*** well placement planning and real-time geosteering software, a proprietary technology that performs inversion and enables evaluation of distance-to-boundary information in real time.
- **eXtrema^{SG}*** geological seismic interpretation software, a proprietary technology that quantitatively integrates geophysical and geological data into a unified workflow for improved efficiency and quality of reservoir characterization models.



EXPERTISE

Revealing more **reservoir details** to enhance decisions

INPUTS

Schlumberger geologists use enabling software to set the interpretation project in a coordinate reference system (CRS) and then load the well deviation survey and log data. This process allows accurately locating the outputs, including dips, formation tops, faults, and surfaces, in the 3D space. A quality review is performed after the data loading.

DIP PICKING ON THE BOREHOLE IMAGE

From the borehole image, the interpreter performs a manual dip picking of sedimentary and tectonic features, such as fractures and faults. At this stage, a quicklook lithofacies zonation log can be produced from a combination of mineral dry weights provided by the spectroscopy measurements.

STRUCTURAL ANALYSIS

Major tectonic structures, such as monoclines, folds, and unconformities, are characterized from the analysis of formation dip trends. Characterization is based on a combination of arrow, dip vector, and stereonet plots of the bedding dips. Once this process is complete, the bedding dip output is upscaled through a structural-dip computation process. The upscaled dips (structural dips) are the basis of the 3D near-well structural model. They are comparable with the seismic interpretation scale.

TST CORRELATIONS AND FAULT-THROW CHARACTERIZATION

The true stratigraphic thickness (TST) index and a stratigraphic drilling polarity log are computed to improve the correlation process. The TST index enables the development of a borehole image and log display that accurately illustrates the true thickness of the formation, where the drilled-up stratigraphic intervals are flipped upside down. Correlations are performed between different sections (drilled up or drilled down) of the horizontal well. The TST indexed display better correlates horizontal and vertical well data, and the interpretation system allows simultaneous interpretation of multiple well datasets.

Among all fractures identified on a borehole image, major faults are first characterized by structural analysis (changes in dip angle and azimuth they introduce in the formation dip trend). Then TST correlations allow estimating the amount of missing or repeat sections introduced by the fault throw.

INTERPRETATION OF DEEP-READING EM DATA

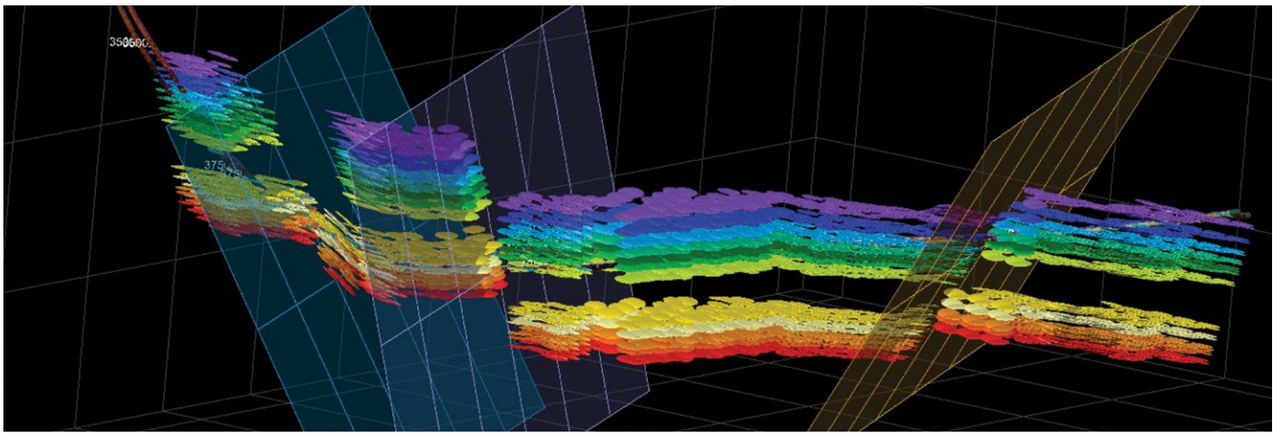
When the borehole image is logged in combination with a deep-reading EM tool, the interpreter picks the formation boundaries at the borehole and at a distance from the borehole. The picking is performed on the resistivity inversion profile. GeoSphere reservoir mapping-while-drilling service provides deeper formation boundary detection—more than 100 ft [30 m] from the wellbore. This reservoir-scale view provides an unprecedented depth of investigation, helping to optimize landing, maximize reservoir exposure, and refine field development plans.

3D NEAR-WELL STRUCTURAL MODELING

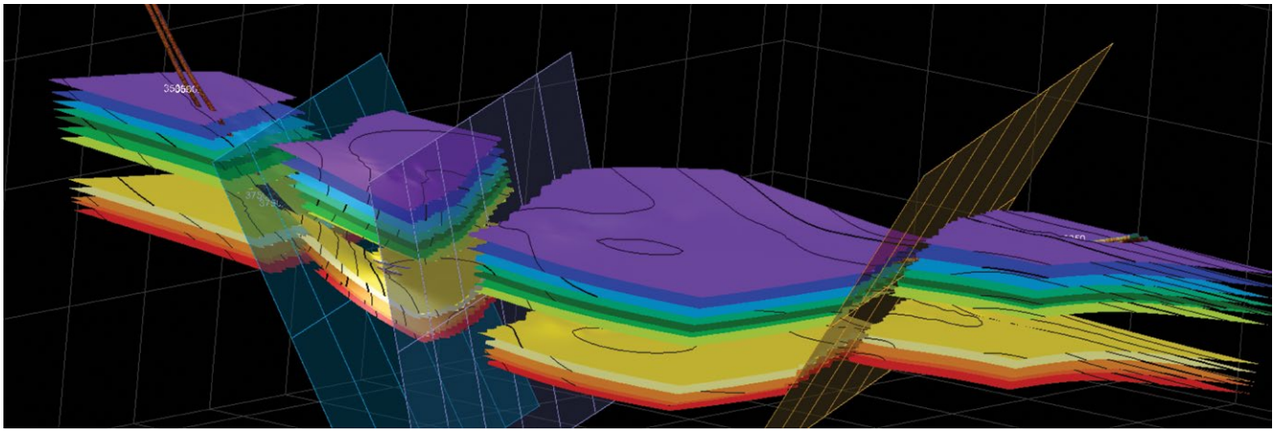
3D modeling is based on a structural delineation technique applied to a single well or multiple wells. The geometrical properties of each tectonic structure crossed by the well(s) characterization are correlated with the geological structures and similar geometrical properties of other wells.

The geometrical properties of each identified structure define the projection directions of the structural dips and formation tops. All the structural element properties are combined with the formation thickness to project the structural dips and the horizons interpreted from the deep-reading EM tools. The 3D projection populates the near-well space with point sets representing the position and the dip of stratigraphic horizons.

The point sets guide the 3D modeling of stratigraphic surfaces in the near-well space. Surface modeling processes may combine borehole data with seismic data representing stratigraphic and fault surfaces. Modeled surfaces honor the structures and findings of the various depths of investigation provided by the tool combination.



Structural dips are projected in near-well space.

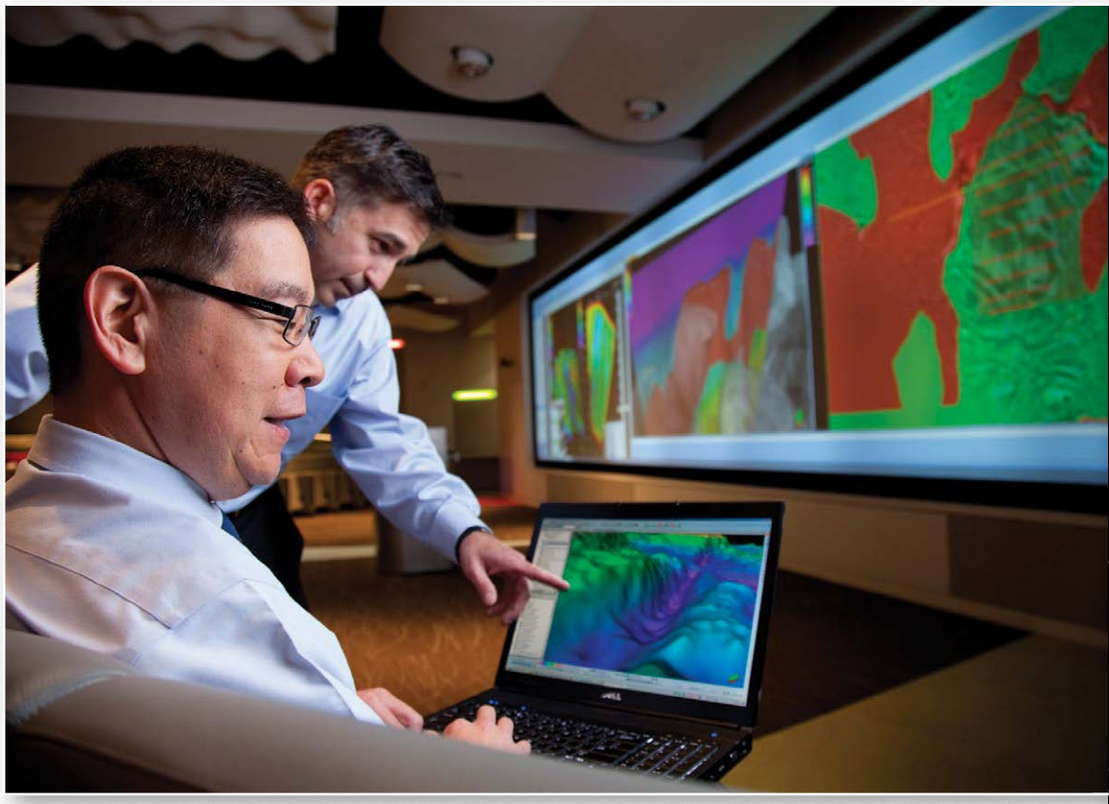


The structural dips are further evaluated to create surfaces that can be interpreted.

Comprehensive geological information can optimize decisions at every stage of the E&P life cycle. Our petrotechnical experts build 3D near-well structural models that, once expertly interpreted, can transform your data into actionable information you can use—from guiding geosteering and confirming well placement to improving completions and field development strategies.

Multiscale Structural Interpretation Services

The Schlumberger portfolio of petrotechnical services offers a unique combination of multidomain expertise, proprietary technologies and software, and expert support to transform your well, field, and reservoir data into better-informed business decisions at every stage of the E&P life cycle.



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* Mark of Schlumberger.

† Japan Oil, Gas and Metals National Corporation (JOGMEC), formerly Japan National Oil Corporation (JNOC), and Schlumberger collaborated on a research project to develop LWD technology that reduces the need for traditional chemical sources. Designed around the pulsed neutron generator (PNG), EcoScope service uses technology that resulted from this collaboration. The PNG and the comprehensive suite of measurements in a single collar are key components of the EcoScope service that deliver game-changing LWD technology.