



Paradigm 17

A High Definition Platform –
Better Results with Less Effort



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High-definition seismic acquisition and well log data are now common among oil and gas companies. But having spent significant amounts on acquiring the data, organizations still lack the tools to extract the deeper levels of information available. The challenge extends from data processing and imaging to tying to logs, performing interpretations, honoring complex geology in the model, and outputting it all into simulation.

With this in mind, and based on a long history of innovation, Paradigm has undertaken to create the first high-definition software platform to ensure that investments in data acquisition result in added value to drilling, completion and production.

In Paradigm® 17, the latest version of our solution suite, we leverage a high-definition platform and the integration of Machine Learning, along with advanced technology and seamless integration, to improve asset team effectiveness in achieving superior decision-making results.

With Paradigm 17, users can:

- Work in a truly integrated ecosystem, for everything from well log analysis to seismic imaging, interpretation and modeling.
 - » Gain a deeper understanding of assets through the use of all available data in integrated workflows, including the consolidation of interpretation windows in a single application in SeisEarth.
- Recover, process and visualize all available data from seismic for better imaging and property distribution.
 - » Use the multi-2D line framework for processing and imaging to maximize productivity and minimize manual intervention.

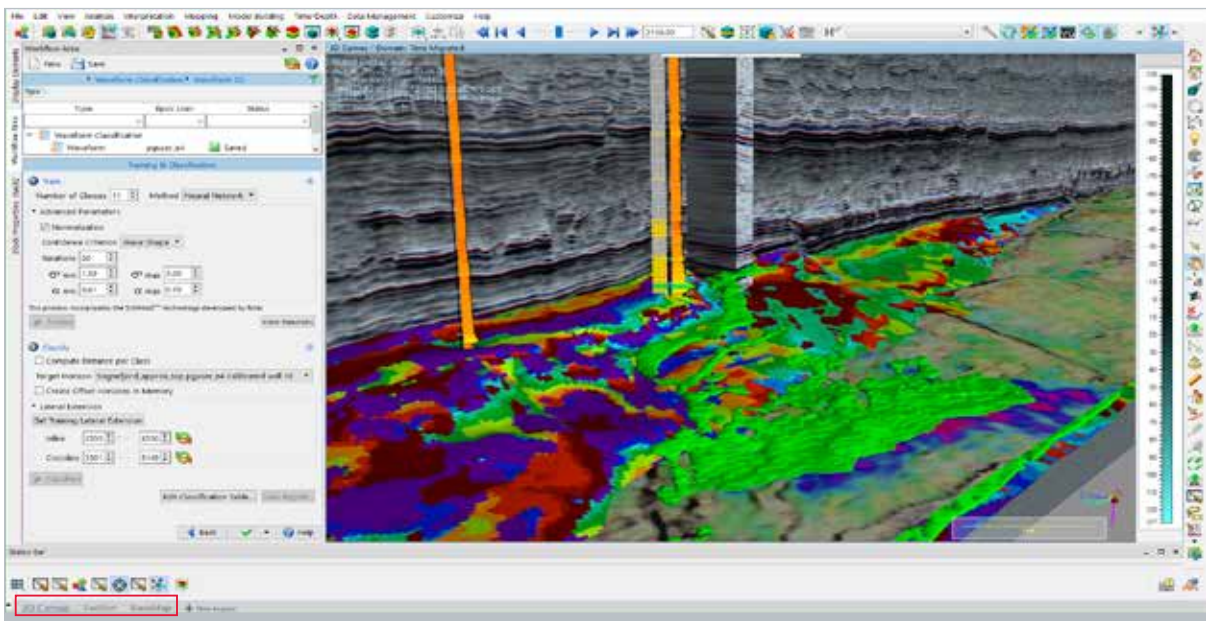
- Better identify sweet spots through advanced well log analysis.
 - » Perform detailed interpretation of high angle and horizontal wells with the help of advanced 3D petrophysics, and use extended engineering capabilities to plan, complete and produce with greater confidence.
 - » Benefit from Machine Learning technology to extrapolate property probabilities away from the well bore.

How does Paradigm 17 increase workflow productivity and efficiency?

A high-definition, integrated G&G platform streamlines data access, analysis and manipulation, and ensures a more accurate earth model.

Critical capabilities

- Consolidation of interpretation windows in a single application, resulting in improved cross-product integration, shorter work time and fewer button clicks.
- Paradigm 17 introduces Machine Learning techniques into the Paradigm interpretation platform. Waveform facies classification powered by Stratimagic is now part of the interpretation environment, to support daily tasks. A new-generation, supervised Machine Learning algorithm, rock-type classification, is also available to calibrate facies properties to high-definition facies logs.
- A new multi-line 2D framework significantly enhances user productivity while optimizing utilization of customers' hardware.



▲ Paradigm 17 includes a single application combining Section, BaseMap and 3D Canvas windows.

- Production-oriented estimation and correction for effective Q enable enhanced broadband seismic workflows.
- New volume fusion capabilities in VoxelGeo®, including a new mode - HSV (Hue Saturation Value) with opacity.

Advanced interdisciplinary workflows make it easier to share data, and improve synchronization between velocity model updates and the geologic model.

Critical capabilities

- Improved VVAZ/AVAZ analysis through enhancements to EarthStudy 360 Imager
- Crossplot lithoseismic classification for quantifying uncertainty in lithofacies and fluid prediction
- Quantitative Seismic Interpretation capabilities extended to Windows users

Expanded third-party data interoperability enhances co-existence with common third-party platforms, including GIS systems.

- Increased interconnection with third-party solutions, including the closest integration in the industry to OpenWorks and Petrel*, as well as to many other third-party data stores.

(* is a mark of Schlumberger)

Critical capabilities

- Direct transfer of seismic, well and interpretation data from the Epos® database to Petrel (2015 and 2016)
- Connectivity to Petrel from standalone configurations of Geolog®, VoxelGeo, Stratimagic® and SKUA-GOCAD™
- Link from SKUA-GOCAD to Dassault Systèmes Abaqus® geomechanical simulator for stratigraphic grids and solid models
- Direct access to Matlab™ code for Geolog users, enabling research work and custom calculations to be easily delivered to end users
- New ULA interface for batch loading data from OpenWorks® and GeoFrame®

Workflow Enhancements

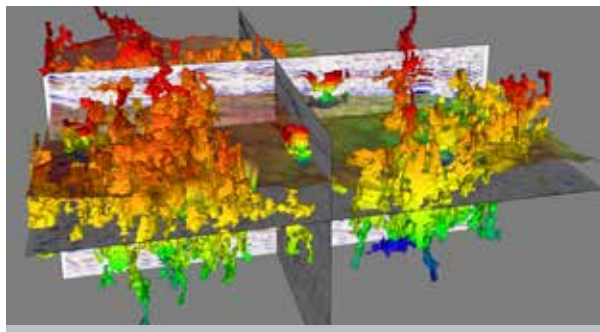
Seismic processing (Echos®)

- New production oriented estimation and correction for effective Q
 - » Automated Q determination from seismic data
 - » Support for Q function in Epos database and shared tools
- New production oriented first break picking

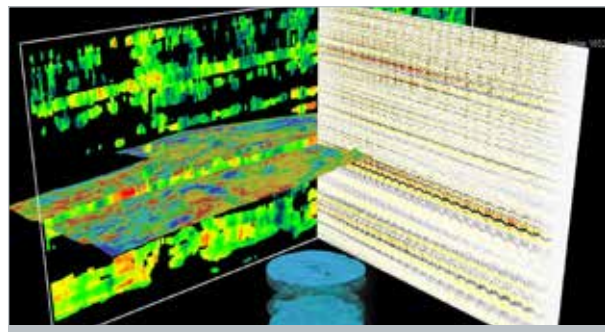
- Improved 5D Fourier data regularization
 - » New trace interpolation functionality
 - » New simplified parameterization
- Updated coordinate storage and operations
 - » Support for point index in survey geometry
 - » SPS import/export in spreadsheet
- Marine slanted cable redatuming
 - » Handles single and multiple streamer acquisition

Velocity modeling and depth imaging (GeoDepth®)

- Multi-2D depth velocity model building workflows
 - » New multi-line 2D framework
 - Generic GUI runs supported applications on multiple 2D lines
 - Cluster-based parallelization engine easily runs hundreds of 2D jobs over the cluster
- New 2D grid tomography workflow
 - » Automatic horizon picking based on dip and continuity with ImageDAC
 - » Create 2D pencils from 2D models or directly extracted from dip and continuity sections
 - » 2D prestack Autopicker - output autopicked moveouts and QC moveout attributes (similar to 3D implementation)
 - » 2D grid tomography with full support for anisotropic models
- New QC tools for 2D grid tomography workflow
 - » Visualize 2D prestack data in 2D/3D Canvas with autopicked moveouts for multi-lines
 - » Full visualization of QC attributes for multi-lines in 3D Canvas
 - » Multi-line mask capabilities for removal of anomalous points
- New 2D Kirchhoff time migration
 - » Based on 3D running on multi-2D lines
 - » New GUI: Script saving, memory evaluation, tooltips
 - » Multi-2D line batch support
 - » Shared command line parameters with KMig3D
 - » New functionalities based on 3D Kirchhoff
- Improvements to 3D velocity model building workflow
 - » Support for complex models in structural model-based tomography and other tomography enhancements
 - » New investigative full wave elastic modeling add-on



▲ Complex geobodies (karst features) detected from volumetric curvature attribute generated from diffracted energy partial dip stacking. Jointly visualized with structural interpretation.



▲ Fracture determination using EarthStudy full-azimuth reflection angle gathers

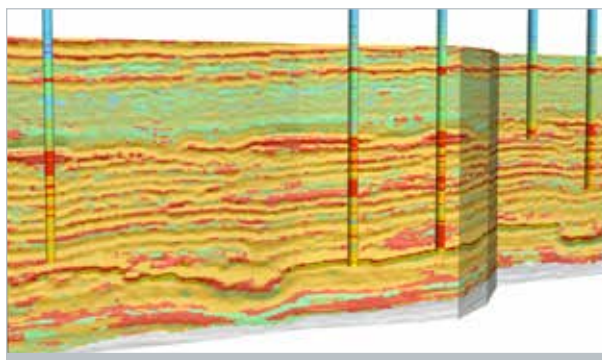
Full-azimuth imaging (EarthStudy 360®)

- Support for 3D gathers in 2D/3D Canvas gather operations and new operations for 3D gathers
 - » All 3D gather operations in the Probe AVO inversion window are now also available as Seismic Operations in 2D/3D Canvas
 - » Platform expanded to Windows
- Improvements in prestack RMO autopicker for EarthStudy 360 gathers
 - » Option to apply vertical and horizontal smoothing on-the-fly operations to assist in picking the main events
 - » Support for minimum mute
 - » QC autopicking results in 3D Gather Viewer
- New diffraction & specular operations in EarthStudy 360 Imager
 - » Available in 2D/3D Canvas
 - » Recover and separate specular and diffraction energy from EarthStudy 360 directional angle gathers
 - Use specular reflection stacks to emphasize and interpret major continuous events and major discontinuities
 - Use diffraction stacks to interpret and delineate high-resolution subsurface stratigraphy and structure
- New internal operations in the 5D LAD domain
 - » Enable interpolated and regularized illumination coverage, resulting in more continuous and better balanced events on the reflection angle gathers

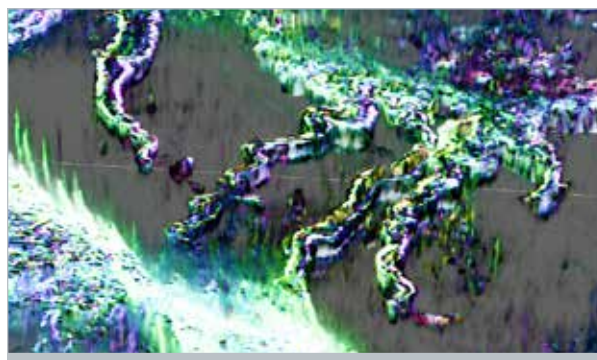
Seismic interpretation

- **SeisEarth®**
 - » Consolidation of 3D Canvas, Section and BaseMap interpretation windows into a single application. Incorporated (in part or in full) into many Paradigm products and bundles.
 - » Machine Learning techniques have been introduced into the integrated SeisEarth interpretation platform.
 - Waveform classification plug-in for interpreters
 - Based on Stratimagic Neural Network method for classifying wave shapes
 - Generates facies maps based on true waveform analysis
 - Compares seismic facies to wedge model, to map the impact of tuning on amplitude data
 - Controls seismic facies mapping with synthetic traces from fluid substitution, and plays the “what if” game

- » New rock type classification uses seismic data and facies logs to predict facies volumes and their probability of occurrence, to improve reservoir characterization in conventional and unconventional plays
- Vertical image visualization
 - » Vertical image files converted on load to 2D seismic
 - » Displayable in SeisEarth and SKUA-GOCAD
 - » Interpretable (with snapping)
 - » Renderable with opacity
- Global Velocity Models
 - » “Single instance” of Global Velocity Model Builder in SeisEarth saves time and steps
 - Use of well lists per layer for well marker-derived models
 - Ability to use more than one unstructured data type
 - Formation volumes as a structural source
 - Full use of all Global Velocity Model types for seismic scaling
 - » Extraction of Vertical Functions along deviated well bores
- Seismic Data Attributes
 - » New application to calculate pore pressure volumes from seismic interval velocities
 - Multiple methods for creating density and normal compaction trend volumes
 - Supports layer by layer definition
 - Deliverable volumes: hydrostatic, density, normal compaction trend line, overburden, pore pressure, vertical effective stress, horizontal effective stress, and fracture pressure
 - Onshore and offshore
 - Quick computation of volumes, processing in GPU
 - Guided workflow for every step of the process puts pressure data analysis at the interpreter’s fingertips
- **VoxelGeo®**
 - » New capabilities in VoxelGeo volume fusion
 - Dedicated interface for Volume Fusion (color blending)
 - Repository for all color blending methods
 - Enhancements to RGB blending
 - New fusion mode option: HSV (Hue Saturation Value) with opacity
 - Support for multi-volume rendering in GPU



▲ Rock type classification calibrated to wells on a carbonate reef reservoir



▲ Channel complex visualization using VoxelGeo Volume Fusion HSV blending of dip, azimuth and semblance data

- » Sub-volume detection: New option for azimuthal fault sculpting
- » Access to Epos culture studies and Epos grids
- Quantitative Seismic Interpretation
 - » Crossplot enhancements
 - Shared crossplot (logs, maps, volumes)
 - Full crossplot functionality for each separate multi-plot entity, to distinguish between different wells, intervals and lithologies
 - Additional coloring functionality: Two sides of a relationship are highlighted in different colors
 - Scale synthetic to seismic in crossplot window
 - » Crossplot lithoseismic classification - from prestack inversion results to seismic lithofacies probability volume
 - » Inversion stochastic refinements - use SKUA-GOCAD simulation technology to produce multiple, equally probable, high-resolution impedance volumes from inversion results
 - » Wedge/2D forward modeling workflow enhancements
 - Additional, simplified interface for geometrical wedge modeling
 - Possibility to use horizons as top and bottom of model
 - Ability to create and display synthetic gathers
 - Availability of AVO plot in well log window
 - New amplitude tracking tool
 - Integration into Stratimagic supervised classification workflow - available on both Linux and Windows
 - » Improvements to QSI workflows
 - Full QSI functionality now available to Windows users
 - Improved lithology and interval management in Well Log Window
 - Colored inversion in depth domain
 - » Enhancements to AVO/AVAZ/VVAZ plot tool
 - Special enhancements for 3D gathers with azimuthal dependency
 - Automatic azimuthal and residual velocity estimation
 - Allows tracking of amplitude on azimuthal gathers
 - New curves for traveltime and azimuthal anisotropy
 - Also available in Well Log window for amplitude tracking on gathers

Geologic interpretation enhancements (StratEarth®)

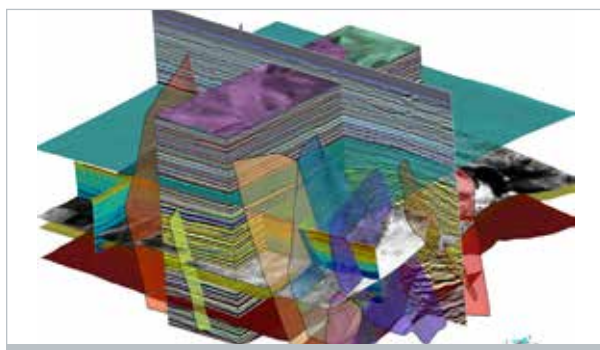
- Split-track correlation of sinusoidal wells
 - » Tie stratigraphy of horizontal wells that turn upwards to vertical pilot wells

Subsurface modeling enhancements (SKUA-GOCAD™)

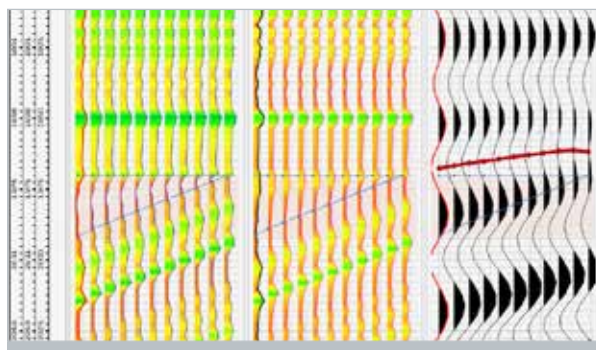
- New horizon modeling algorithm
 - » Better integration of well markers and seismic interpretations
 - » Achieve marker-fitted horizons in one step
 - » Automatic horizon data filtering to reconcile horizons, faults and markers
 - » Streamlined user interface
- Geomechanics: New robust tessellation tools
 - » Optimized tetrahedron solid models conforming to faults and horizons
 - » Optimized meshes with spatially varying resolution
- Link to Dassault Systèmes Abaqus geomechanical simulator for stratigraphic grids and solid models
- Enhanced automation
 - » Increased usability of macros
 - User interface-driven scripting for common functions
 - Auto-completion for variables and functions while scripting
 - More built-in macro examples
 - Improved macro runs
 - » Advanced geostatistics for automation and sensitivity analysis
 - » Automation of velocity modeling through commands
- Improved workflow for opening and saving data from/to Epos
- Ability to save logs created in SKUA-GOCAD to Epos
- Improved connectivity to Petrel
 - » New Petrel direct connector: New server-client direct connection through web socket
 - » Improved connection through RESQML files
 - » Support for Petrel 2015 and Petrel 2016

Formation evaluation enhancements (Geolog 8)

- Petrophysics capabilities
 - » New Multimin Monte Carlo Uncertainty
 - Assess overall uncertainty on a Multimin petrophysical analysis and identify variables with the greatest impact



▲ Build accurate reservoir models using volumetric interpretation of seismic



▲ Wedge model integrated into Stratimagic supervised classification workflow

- » Full Waveform Sonic – New slowness frequency analysis module
 - Derive slowness frequency relation from input waveforms using Matrix Pencil method
 - Output slowness frequency map at each depth, as well as projection of log to slowness axis
- » 3D Petrophysics
 - New functionality for interpretation in high-angle/horizontal wells
 - Implementation of initial output from 3D formation evaluation research
- » Environmental corrections
 - Full wireline and LWD corrections from Baker Hughes in the form of libraries
 - Baker Hughes Environmental Corrections V3.0 – Feb 2016
 - Inteq MWD / LWD, Baker Atlas Wireline
- » Rework of routine core analysis
- Engineering
 - » Geomechanics extended to work in anisotropic conditions
 - » Production logging support for PVT data
 - » Casing inspection
 - » Cement evaluation workflow for performing cement evaluation alongside open hole logs
 - » Pulsed neutron
 - » DTS/DAS handling
- Additional data loading formats
 - » CT data in SEG Y format (DICOM supported in Geolog 7.4)
 - » Additional depth-registered raster image formats: Petra .LIC, IHS .XML
 - » XTF format files (Atlas format, used in China)
- User interface and display improvements
 - » New tracks, options and views; auto-hide empty tracks
 - » New multi-well formation test viewer
- Interactive visualization of geological structures in 3D
 - » Dip planes in Image3D View
 - » CT support in Image3D track
 - » Improved speed correction in high-angle wells
- Extended connectivity
 - » Import completions information stored in Peloton WellView® and displayed in Geolog well schematic track

- » Directly populate engineering displays with data retrieved from Peloton; no need to manually re-enter data
- » Geolog-Petrel connectivity updated to Petrel 2016

Data management and connectivity

- Extended direct third-party connectivity
 - » New Petrel Connector to Epos
 - » Totally redesigned multi-survey multi-platform ULA to OpenWorks and GeoFrame
 - » Synchronization of well data from Epos to OpenWorks
- Direct access to Matlab code from Geolog through Loglan
- Import of vertical images as 2D seismic
 - » 2D and 3D seismic SEG Y export within polygons
 - » Direct load of SEG Y to Compressed BrickExport 3D single-value picks and grids in ESRI ASCII GRID format

The Paradigm Advantage

- Integrated G&G Platform
 - » Streamline data access, analysis and manipulation through integration.
 - » Improve productivity and effectiveness using multi-2D depth velocity model building workflows.
 - » Perform accurate, high-certainty seismic interpretation using detailed diffraction and specular images.
- Advanced Interdisciplinary Workflows
 - » Increase confidence in pore pressure models through the integration of borehole data and seismic velocities.
 - » Improve reservoir prediction by creating high-resolution facies models using probabilistic crossplotting tools or Machine Learning techniques.
 - » Enjoy synchronization between velocity model updates and the geologic model.
- Third-party Data Interoperability
 - » Efficiently exchange data, interpretation and models with third-party applications.

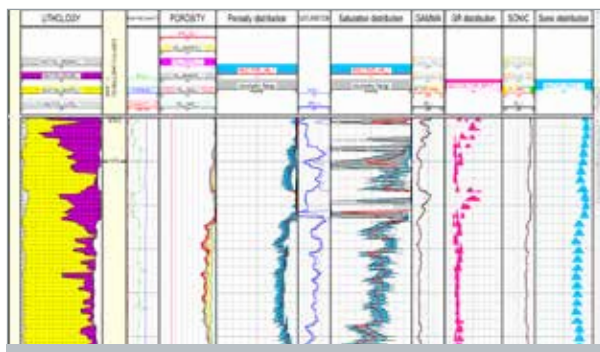
Interoperability

All Epos-based applications enable interoperability with third-party data stores, including:

- OpenWorks® R5000
- GeoFrame® 2012
- JavaSeis

System Specifications

- Red Hat® Enterprise Linux® 6.5 and subsequent minor releases, and 7.0 and subsequent minor releases
- Microsoft® Windows® 7, 8.1, 10



▲ Multimin Monte Carlo uncertainty brings high end innovation to the market