# The Kaleidoscope Project

## A Technology Collaboration with Repsol for Improving Subsurface Imaging and Interpretation

The Kaleidoscope technology collaboration project between Emerson and Repsol is designed to bring advanced subsurface seismic imaging technologies to the oil and gas industry. As part of the project, Emerson will implement and deploy advanced subsurface imaging solutions based on Repsol core technologies. Combining the latest in high-end visualization, high-performance computing and cloud delivery, the solutions will be available to the Repsol geoscience community and to all oil and gas companies that choose to license the technologies, to support their digital transformation processes.

Technology collaborations are more important than ever in this time of lean oil and gas prices and the emergence of digital transformation, which impacts all industry verticals. The objectives of this collaboration include the following:

**Time to result.** Accelerate the time to first oil by collapsing the time from seismic imaging to prospect identification. By embedding the Repsol Kaleidoscope technologies in Emerson's E&P seismic imaging, interpretation, and modeling platform, the full power of Repsol's technology with Emerson's high-end visualization and interpretation establishes the connections needed to compress project timelines.

**Democratization of technology.** Democratization through software licensing allows geoscientists from Repsol and other oil and gas operators to experience and exploit the value of advanced subsurface imaging technology.

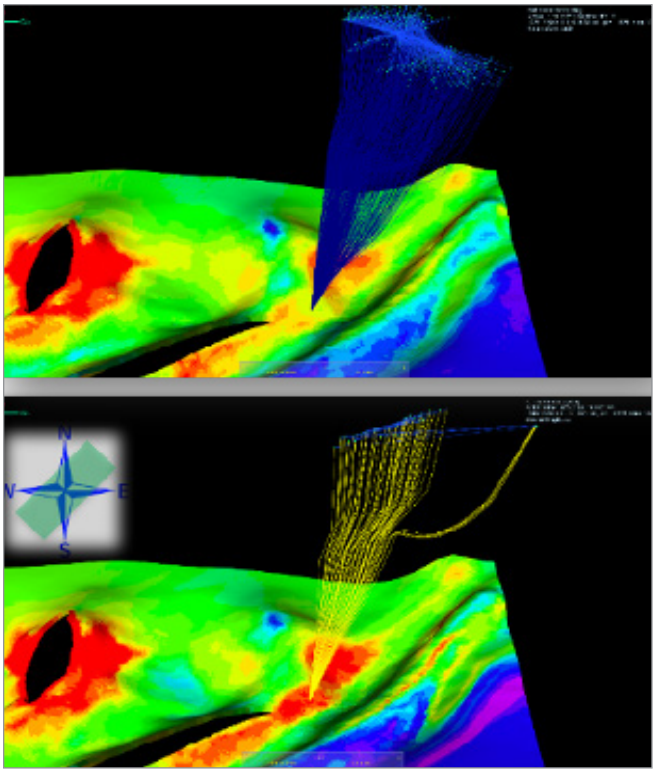
**Better asset team cooperation.** Kaleidoscope is a valuable asset for improving ties between the seismic imaging, modeling, and seismic interpretation communities. Advanced tools that were previously used by seismic imaging experts are now available to interpreters for their daily work, enhancing collaboration across domains.

**Cloud enablement**. Based on Emerson's experience in cloud deployment of workstation and high-performance computing (HPC) applications, the full advantage of cloud services and cloud computational elasticity can be leveraged for the complete suite of Kaleidoscope applications.

**Deep water and onshore prospecting and evaluation.** Originally developed for deep water objectives, many of the applications have been adapted to onshore seismic acquisitions, increasing the value for oil and gas operators with significant onshore assets.

### Available Kaleidoscope Applications

**Full-azimuth Illumination:** The Emerson illumination package has been enriched with additional functionalities that are key to understanding how seismic acquisition affects illumination. This technology, which has always been available to seismic imaging specialists and seismic interpreters, is now also a useful tool for seismic processing and acquisition specialists. New features include: Ray filtering using field geometry, ray filtering using polygons, and ray filtering using synthetic geometry. In addition, a Resolution Analysis utility allows users to estimate the horizontal and vertical resolution of their data.



▲ Full-azimuth illumination before (top) and after (bottom) raw filtering. Tempest velocity model courtesy of Devon Energy.

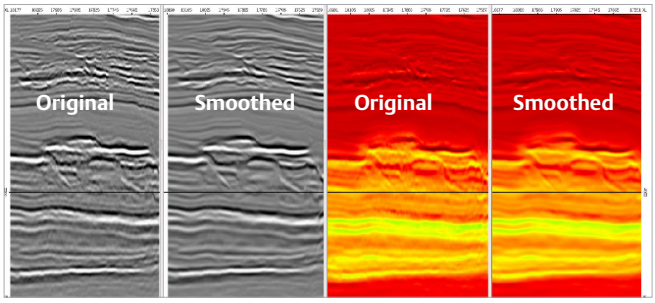
### Velocity Accelerators

**Seismic Guided Velocity Smoothing:** Smoothing and filtering a velocity grid is a common procedure used in various steps of the seismic processing/imaging/reservoir characterization workflow. It is also often applied to other types of attributes, e.g. to impedance for building background models as part of the amplitude inversion workflow, etc. Conventional smoothing or filtering of the velocity grid is usually structure independent and can be highly biased

EMERSON

REPSOL

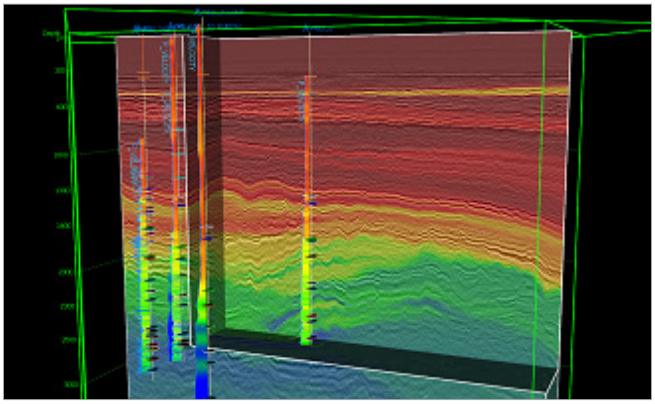
# The Kaleidoscope Project




▲ Original and improved seismic and velocity attribute image using the structural smoothing tool

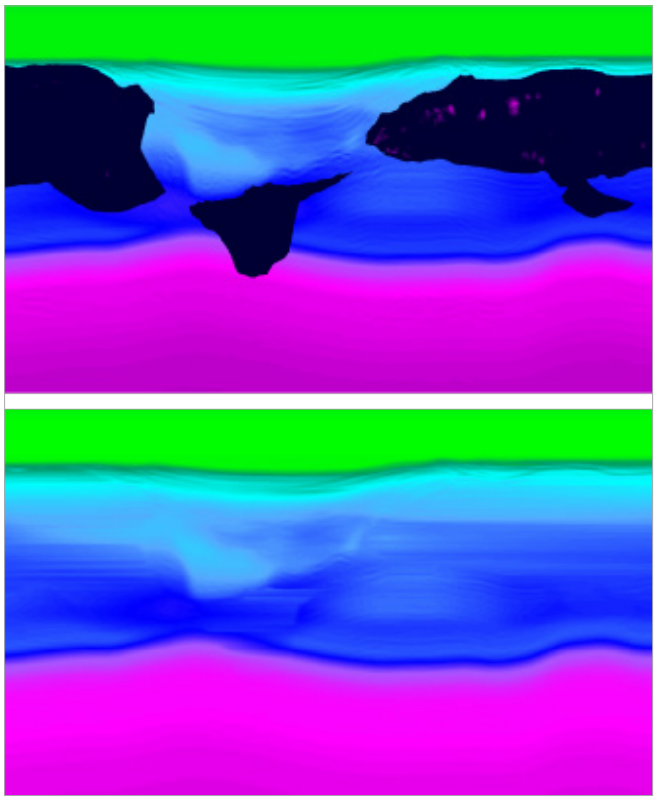
laterally, so the resulting velocity models may be inconsistent with the geology. Seismic guided velocity smoothing is guided by the seismic structure, providing a geologically consistent result.

**Seismic Guided Velocity Interpolation:** Used to interpolate subsurface properties measured in sparsely distributed locations. The application integrates sparsely sampled measurements from the borehole with richly sampled measurements from seismic data to derive the properties of geological formations. The method is based on calculating the structure tensors from the seismic image and using them to guide the interpolation. Unlike other interpolation methods that require interpretation data (e.g. picks, grid surfaces), seismic guided interpolation works with coherent amplitude trends in the seismic data. Using a 3D seismic image as an interpolation guide enables simultaneous interpolation for locations that are on and between horizons, including locations in the vicinity of unconformities and diapirs, that may be difficult to represent accurately and efficiently with interpretations. Inputs are well logs or vertical functions and a seismic image; outputs are uniform 3D volumes of input properties whose values conform to geologic layers and faults appearing in the seismic image.



▲ Seismic guided interpolation: Interpolated velocity from logs overlayed on seismic

**Desalting:** Enables editing an existing velocity model to exclude a salt body and replace it with background sediment velocity. The replacement of salt bodies or other anomalous features is done by extrapolating sediment velocities from the surrounding area. This provides a new velocity model that can serve as a background model for migrations.



▲ Desalting before (top) and after (bottom). Images courtesy of Repsol.

**3D Poststack RTM Demigration Migration:** Poststack demigration of an existing seismic image and remigration with alternative velocity models, enable seismic interpreters to economically evaluate different scenarios while incorporating their experience and knowledge of the field, maintaining consistency with available data.

A new application has been developed to efficiently carry out this workflow. The process incorporates a modeling (demigration) step of the zero offset seismic data using the current depth migrated image and its corresponding velocity model, followed by zero offset migration (poststack migration) using an updated velocity model. The application utilizes the forward modeling and back propagation algorithm of the accurate Reverse Time Migration (RTM) method.

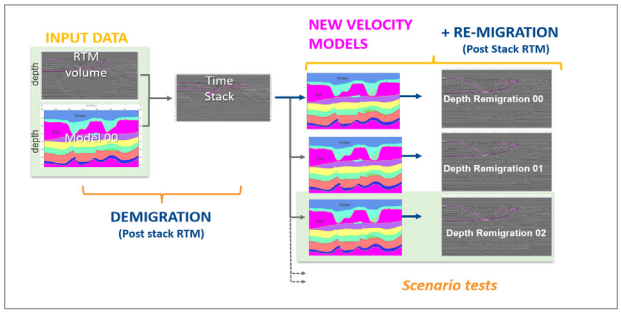
EMERSON

REPSOL

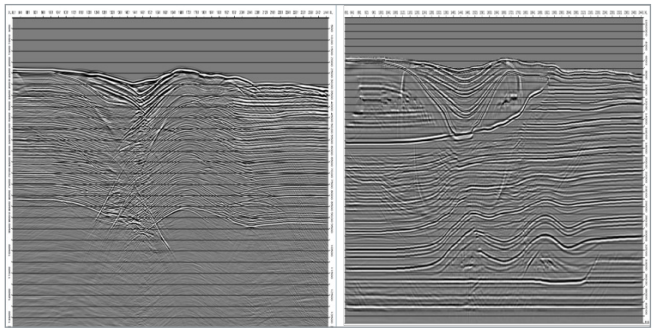
# The Kaleidoscope Project

The migration can be run several times, each with a different perturbed velocity. The output is multiple depth images. One way to obtain the different velocities is through Time Preserving Tomography (TPT), which enables the construction of kinematically equivalent subsurface models, given a background model and a set of model parameter perturbations.

The application is designed to run on workstations or clusters, on-prem or on the cloud, and supports both CPU and GPU hardware configurations. It can be run with isotropic and anisotropic (TTI) velocity models with or without density.



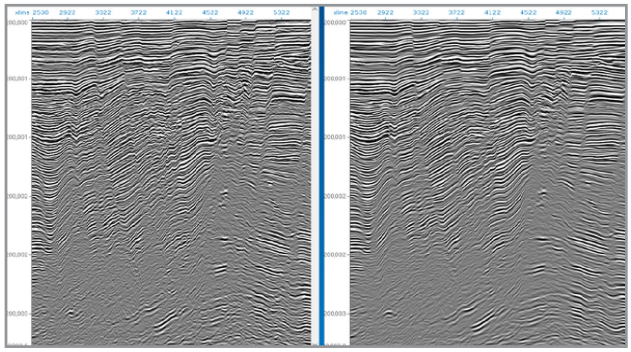

▲ Poststack RTM demigration/migration workflow



▲ Poststack RTM demigration (left) and remigration (right)

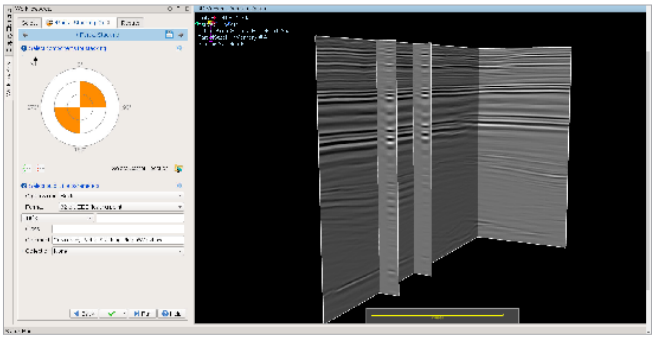
**Structural Guided Seismic Enhancement:** Enhances seismic images along the structure using the structure tensors to enhance correlated events and clean up noise, while preserving important discontinuities such as faults and channels. The result is an enhanced seismic image optimized for interpretation.

**Partial Stacking:** Designed to improve the seismic image when stacking Vector Offset Gathers (VOG). VOG is a common prestack seismic data organization method that preserves offset (or reflection angle) and azimuthal information when performing modern depth migrations. VOG data organization is suitable for selective and preferential stacking of the dominant directional energy, contributing to a more focused subsurface image. Selective stacking is useful for excluding poorly imaged directions, noise and artifacts of migration, or poor images resulting from incomplete acquisition geometries. Vector offset/angle gathers, which are the input to this application, are output by many migration methods, including Kirchhoff, Reverse Time Migration, and Local Angle Domain migrations.



▲ Original seismic image (left); improved image (right) using the structural guided enhancement tool.

Our interactive partial stacking operation is designed to help users QC their data and optimize parameter selection for stacking in order to improve the image. It works on volumes of VOG data and enables visualization of multiple volumes with on-the-fly re-organization capabilities, moving between volume view and gather view. It supports both offset/azimuth volumes and angle /azimuth volumes. The application is useful for both seismic imaging specialists and for seismic interpreters.



▲ An intuitive user interface enables analysis of multiple offset/azimuth volumes and angle/azimuth volumes by incorporating on-the-fly partial stacking and interactive gather creation from input volumes.

*The technologies described in this document represent a subset of Kaleidoscope applications. Other significant applications (e.g. Full Waveform Inversion and pre-stack Reverse Time Migration) will be available in the next release. All of the applications developed as part of this project will be available as add-ons to Emerson's E&P Software Processing & Imaging and Interpretation products.*

EMERSON

**www.emerson.com/epsoftware**



REPSOL