Eliis - Advanced Technologies for Seismic Imaging and Interpretation

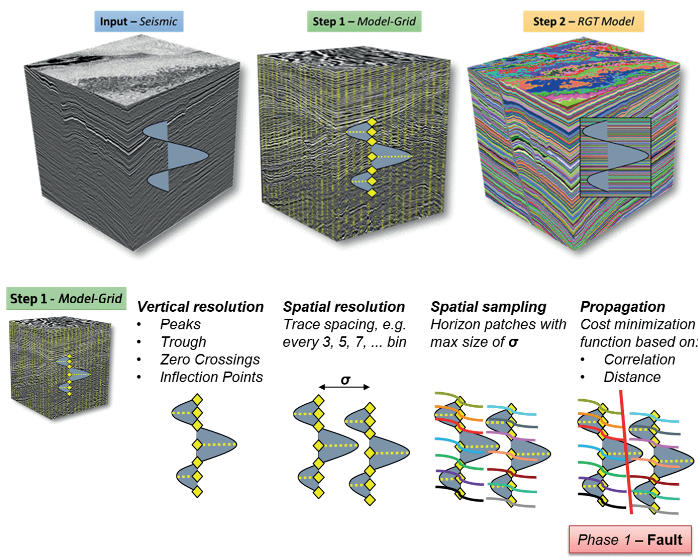
From the early methods of hand-drawn seismic interpretation to the most advanced computer-aided technologies, it has taken more than six decades of technological innovation and development to produce the current state-of-the-art of seismic interpretation techniques.

Back in the 1970s and 80s, geoscientists typically interpreted 2D paper stacks using coloured pencils, mapping prospects through hand contouring calculated TWT values for a given target. This laborious process underpinned many of the world's biggest hydrocarbon discoveries. However, as the quality of 3D seismic surveys improved through the 1990s, the amount of available seismic data increased exponentially, requiring faster and more accurate methods. Geoscientists subsequently gained experience and knowledge, constantly fed with new geological concepts and software tools. With the evolution in compute capacity over the past 15 years, we witnessed an acceleration in the development of more advanced visualization and interpretive technologies, including automated workflows, which allow geoscientists to capitalise on the vast amounts of subsurface data with ever greater certainty.

Today the role of a seismic interpreter has radically changed, in part due to technological advances, new computer-aided interpretation methods and increased computational power. Furthermore, the convergence of geological and geophysical workflows, allows the interpreter to undertake more cross-disciplinary tasks, facilitating greater collaboration withing multi-domain assets teams. Today the E&P industry is experiencing a big data revolution, where cloud compatibility and AI-assisted solutions are at the heart of emerging technologies.

Since 2007, Eliis has been at the forefront of technical innovation in the seismic interpretation domain, developing PaleoScan™, a fully integrated 2D & 3D platform that leverages a unique global stratigraphic framework and machine aided workflows to accelerate the interpretation process whilst reducing inherent uncertainty. PaleoScan™ innovative solutions deliver high quality results that further our subsurface understanding, adding value throughout the E&P value chain, from prospect generation to reservoir management.

Figure 1: Automated workflow for Relative Geological Time modelling.



PaleoScan™ Technology

The seismic interpreter's ultimate goal is to generate a geologically consistent subsurface model from seismic data interpretation in combination with well and other forms of data. A typical seismic survey is designed to collect the 'earths' reflectivity response to acoustic impulses that propagate over time from source points deep into the subsurface before being reflected and being recorded at distant receiver locations. The surveys often have a specific imaging objective in mind and the ray-paths travelled by the seismic energy, as well as the Earth's response, are extremely complex impacting the quality of the recorded signal. Once acquired the data undergoes a complex series of time processing and imaging steps before being transformed into a meaningful picture of the underlying geology. The subsequent reconstruction of the geology, from the final seismic image, generally entails complex data analysis steps that seek to identify the geological layers, normally one by one and independently from each other. Conventional approaches therefore require users to undertake a seismic interpretation workflow through an intensive and laborious process, involving manual picking or auto-tracking a few key horizons within a seismic volume.

Eliis' innovative approach is based on semi-automated global seismic interpretation workflow which uses a cost minimization function to generate a chronostratigraphical framework unique to PaleoScan™ (Pauget et al., 2009). Patented in 2009, the "Geological modelling method of seismic data by trace correlation" remains the core engine within PaleoScan™ integrated platform and is based on a powerful algorithm designed to automatically compute a Relative Geological Time (RGT) model directly from the reflectivity responses in seismic data.

PaleoScan™ is a disruptive technology that aims to work at the seismic expression scale to automatically derive a consistent geological model that encompasses structural and

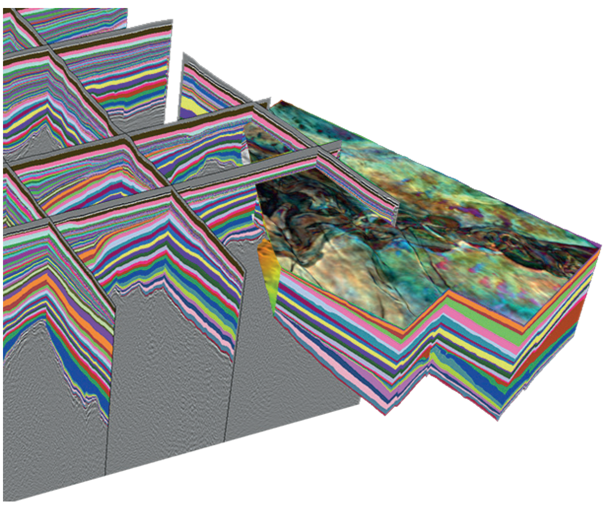
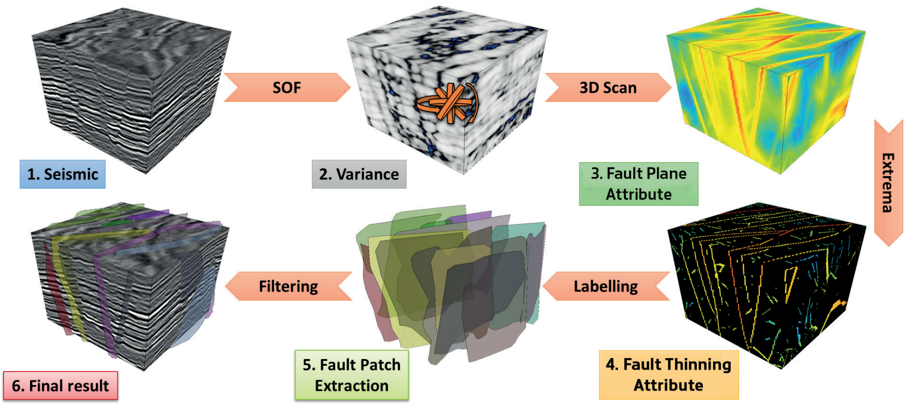


Figure 2: Example of an integrated 2D & 3D-RGT model.

Figure 3a: Automated Fault Extraction (AFE) workflow; SOF = Structurally-Oriented Filtering.



stratigraphic discontinuities, such as faults and stratigraphic changes. It relies on computing a model-grid from the extraction of a billions of polarity-consistent micro horizons directly from the seismic image (Figure 1). These horizon patches can then be auto correlated on a regional or local scale, allowing the interpreters to focus on critical decisions relating to geological interpretation process. The auto-tracked horizons can then be interactively refined within the model grid to rapidly achieve a high quality geologically consistent interpretation. Once validated, the user computes a Relative Geological Time (RGT) model from the interpolation of the previously refined horizons within the model-grid.

Since the RGT model is both vertically and spatially continuous, an unlimited number of chronostratigraphic surfaces can be generated. These depositional time surfaces can be extracted as dynamic series of horizon stacks. The Horizon Stack enables an interactive stratal slicing through the seismic volume where sedimentary and structural features can be highlighted with a strong precision.

The RGT Model therefore opens a multiple interpretation and analysis workflows that allow the user to perform detailed stratal slicing that is both geologically and signal consistent. For example, an RGT model can be used to rapidly generate detailed horizon stacks, within any given zone or geological layer, upon which any derived attributes, inversion data, seismic facies volumes, spectral decomposition, diffraction images etc. can be extracted and visualized at the chronostratigraphic level (Figure 2).

Used in combination with PaleoScan™ AFE - Automated Fault Extraction (Figure 3) and AI Fault Volumes, the RGT Model can capture unique geological features in the most complex structural settings.

AFE is an automated process that first generates a Fault Plane attribute volume from a variance cube through the analysis of each voxel's average vector field variance and the maximum variance along a scanning disk, calculated in the three dimensions. Fault Plane attribute extrema are then extracted from which the maxima of the gradient vector is detected to yield the Fault Thinning attribute, to depict the skeleton of the fault network. As a final step in the automated process, fault patches are extracted from the Fault Thinning attribute, labelled and transformed into elementary fault planes (Figure 3a). This fault network can rapidly be sorted, filtered by dip, azimuth and size, edited and merged before being organized and saved as distinct fault sets (Figure 3b).

This holistic approach has proven to be invaluable for performing high quality seismic interpretation, dramatically reducing the time to screen 2D Lines and 3D seismic volumes (Figure 3) and identify sweet spots at an early exploration stage, or for performing detailed reservoir analysis during development. The model-grid algorithm, combined with the cross-navigation functionality, was successfully tested in various geological contexts (Gupta et al., 2008; Lemaire et al., 2010; Lacaze et al., 2011, Schmidt et al., 2013). From basin-scale evaluation and prospect maturation, to detailed reservoir management, this technology enables the user to reduce the interpretation cycle by 80% whilst reducing subsurface risks and inherent uncertainties, empowering the teams to make better informed investment decisions.

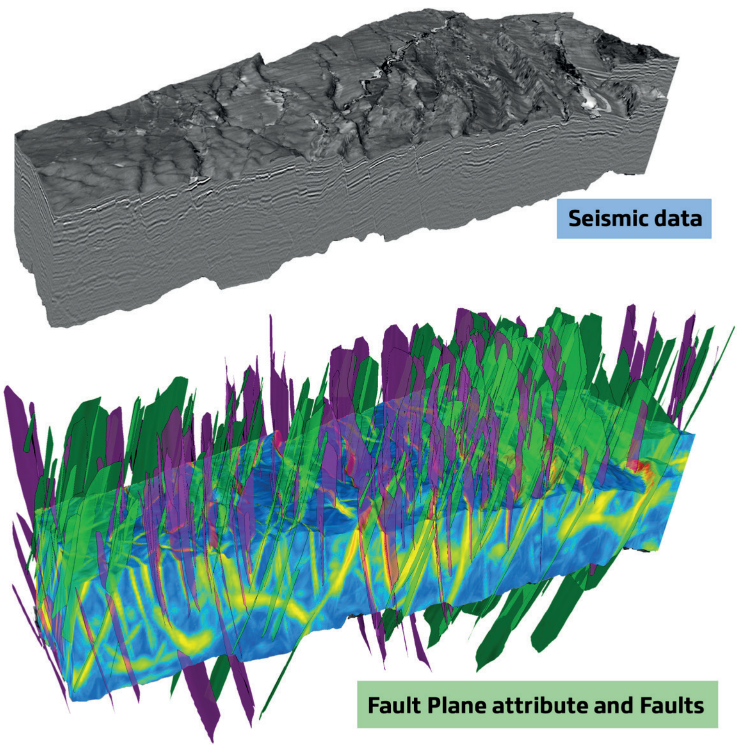


Figure 3b: Example of Fault Extraction from seismic amplitudes (case study, Exmouth Sub-Basin, Carnarvon Basin, offshore Australia).

Through further implementation of machine learning and further advances in artificial intelligence, PaleoScan™ continues to push the limits of seismic interpretation, offering methods of deep learning that impact prospect generation and reservoir management. Eliis continues to advance the automation of conventional G&G workflows, fostering openness offered by initiatives like OSDU™ (Open Subsurface Data Universe), in an effort to improve customer outcomes, that capitalise on new data formats and cloud compute capacity.

PaleoScan™ is a disruptive technology that is gaining wide acceptance in the E&P industry. By transforming seismic data into a global chronostratigraphic framework, the RGT model unlocks subsurface geological details previously unavailable to exploration and production companies. In doing so, these companies are able to extract ever more value from increasingly complex and expensive seismic acquisition, including high density and wide azimuth data used in diffraction imaging. By integrating cross disciplinary knowledge and offering advanced analytical workflows PaleoScan™ facilitates cross-disciplinary collaboration adding value throughout the entire Asset Lifecyle. •

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