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Using AI/ML to Explore & Develop Quickly and Efficiently

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Summary

See how on Premise and Cloud based Unbiased Artificial Intelligence (AI) Machine Learning (ML) produces data driven interpretations (eg. top and base salt) to reduce risk and uncertainty. The approach produces waveform maps of almost every peak and trough quickly. In addition to the amplitude and structure a new seismic fitness attribute is generated. The fitness attribute depicts paleo-geomorphology which is used to interpret facies. Sub-waveform analysis of the fitness attribute is used to carry out reservoir characterization leading to a full field reservoir model of each petroleum system identified.

Theory / Method / Workflow

The technology provides a comprehensive petroleum systems analysis of the entire 3D seismic data volume to identify and high grade, quality leads and prospects with high resource potential in the near, medium and long term. This approach evaluates each petroleum system geological risk (reservoir distribution, trap, seal, source, hydrocarbon migration pathway from source into reservoir) and reservoir risk (initial possible hydrocarbon content/type evaluation (e.g. DHI evaluation) without disrupting your current workflow. The results will quickly delineate possible structural, stratigraphic and combination targets.

The combination of increasing seismic dataset sizes and accelerated project timelines, combined with the increasing difficulty of finding and exploiting new reserves, means that developing new seismic interpretation technologies and approaches is critically important for the future of the industry. In this paper, we demonstrate how the integration of Artificial Intelligence (AI) / Machine Learning (ML) technology using unsupervised genetics algorithms in Exploration, Field Appraisal, Development to increase capital efficiency and reduce geological risk and uncertainty. Genetic pre-interpretation processing algorithms inspired by the Human Genome Project have enabled the rapid evaluation of any size 3D seismic volume quickly, resulting in recognition of previously unrecognized prospectivity, reducing geotechnical risk and uncertainty and optimizing the cycle time from Lead to Production.

3D Seismic and the Human Genome

Each waveform within a seismic volume is characterised by a unique suite of attributes (i.e. location, amplitude, neighbour trace shape, etc.). Similarly, DNA is comprised of a unique arrangement of base pairs. During the Human Genome Project, significant advances were made in the field of sequence analysis. Here we show how these advances can be leveraged to enhance the interpretation of 3D seismic data.

Genetic Processing Algorithms

Using Seisnetics® patented genetic processing algorithm to automatically segment seismic trace data into populations of related waveforms, artificial intelligence populations (known as 'GeoPopulations') are 'grown' by the software from random and disordered seed points, eliminating any bias that might be introduced by user defined seed points.

The resultant GeoPopulations shown in Figure 1 below (which represent a group of genetically and spatially related waveforms), appear similar to a 'user-propagated surface', but critically are based on waveform characteristics rather than amplitude-based propagation used in the majority of E&P software packages, and are imbedded with seismic attributes.

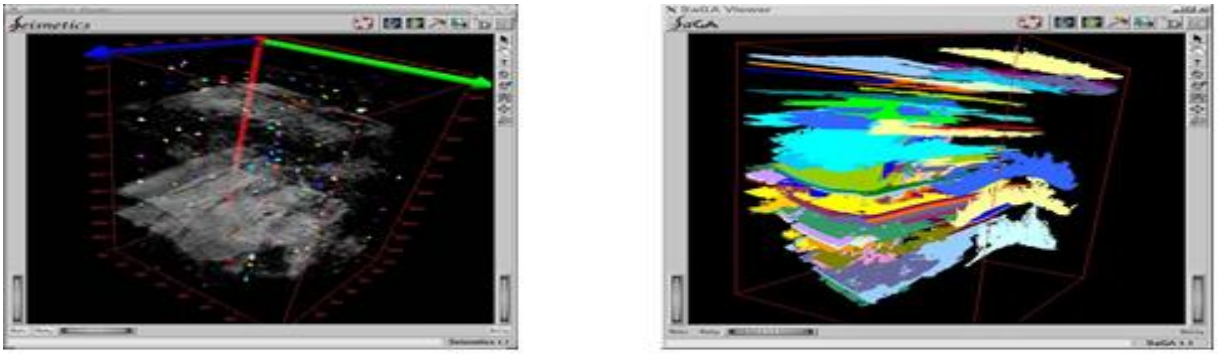


Figure 1: 3D global search criteria used in creating families of waveforms

The suite of embedded attributes includes 'Fitness', which represents a measure of the genetic similarity between any waveform in a GeoPopulation and the common waveform ('genotype') of that population. The fitness attribute, shown in Figure 2, is primarily calculated over the whole waveform but can also be calculated on a sub-waveform basis to enable reservoir-level seismic facies analysis. High Fitness indicates a direct genetic relationship between an individual and the genotype, whereas lower Fitness suggests a more distant relationship. Fitness maps highlighting areas of changing waveform morphologies associated with changing reflectivity geometries, which may be mature into geological facies maps.

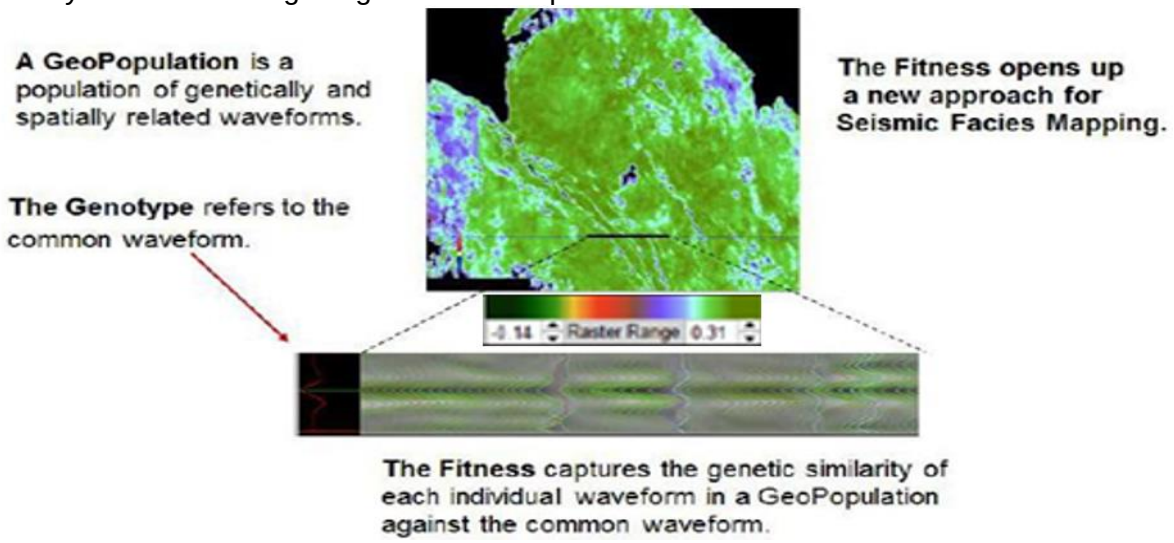
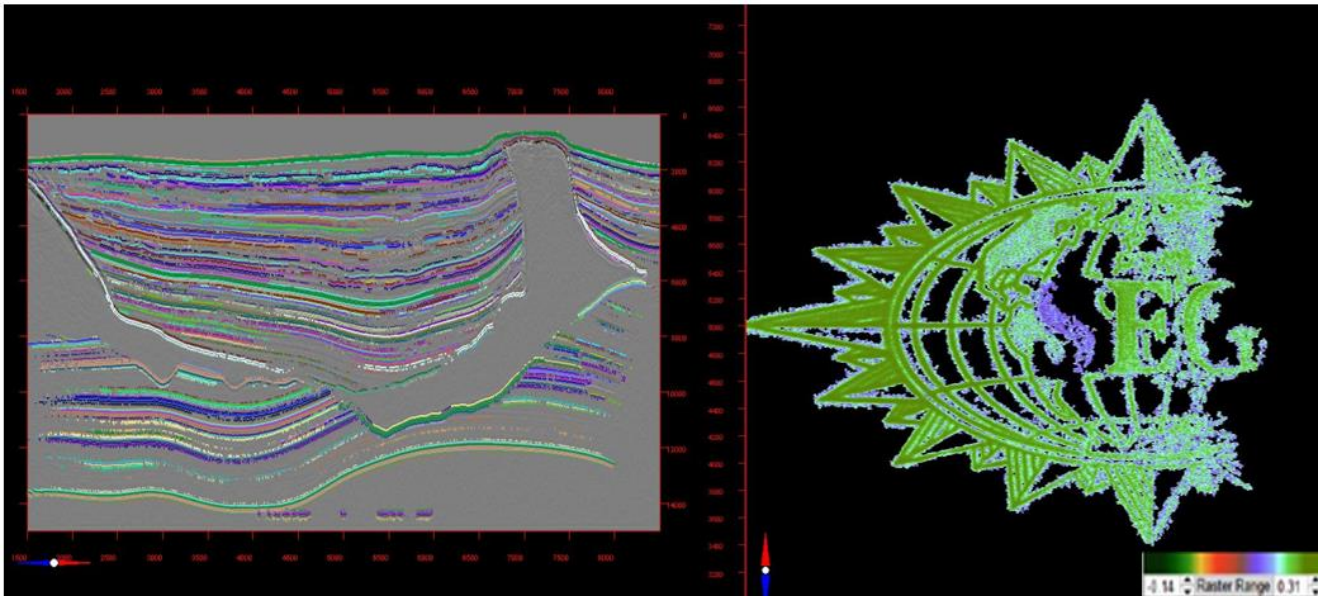


Figure 2: Depictions of GeoPopulation, Genotype and Fitness definitions. (Higher raster values imply higher Fitness)

Results and Observations

The Society of Exploration Geophysicists (SEG) Advanced Modelling Program (SEAM) test volume was processed with the AI/ML technology and produced the results shown in Figure 3. The left side of Figure 3 shows the GeoPopulations interpretated (each in a different colour) and one of the Fitness maps on the right side (high Fitness in green)



Figue 3: Example of GeoPopulations on the left and a Fitness map on the right from a SEAM 3D dataset. (Higher raster values imply higher Fitness)

Outputs include a comprehensive analysis of the entire 3D Seismic Data Volume of every peak and trough. The G&G team can use the results to identify and high grade leads and prospects with high resource potential in the near, medium and long term. So it is important to callibrate the GeoPopulation maps created with well data. Figure 4 shows a Fitness map of a GeoPopulation with well ties that have sand with different saturations of gas, shale and coal, showing Good correlation to rthe well data.

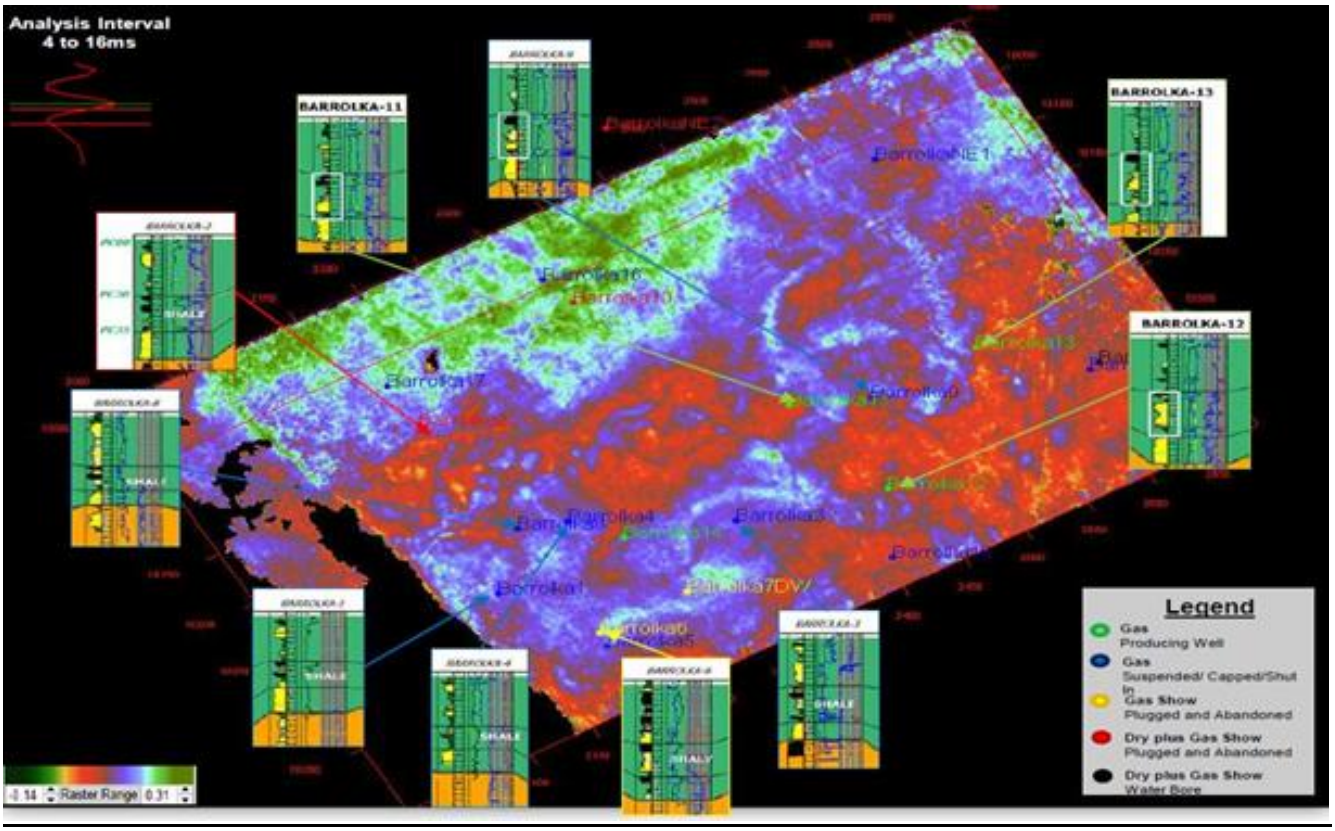


Figure 4: Fitness map of a GeoPopulation showing Geomorphology with well ties (Higher raster values imply higher Fitness)

GeoPopulation attributes may be analysed at sub-waveform level, allowing the interrogation of seismic facies and attributes at reservoir-scale. Targeting a specific portion of the waveform (and associated waveform Fitness and other attributes automatically calculated over the calculation window) can reveal more insights about structure and stratigraphy, enables the analysis of different depositional facies captured within a single seismic waveform and allows the focus on subtle changes in the sidelobes of the waveform (normally obscured by the dominant energy towards the centre of the waveform). Figure 5 shows the sub waveform / facies analysis on the Fitness attribute of a GeoPopulation. It shows possible channeling above and below the horizon of interest. This can be interpreted that there may be seal inefficiency and trapping opportunity below, channel in right bottom corner of Figure 5.

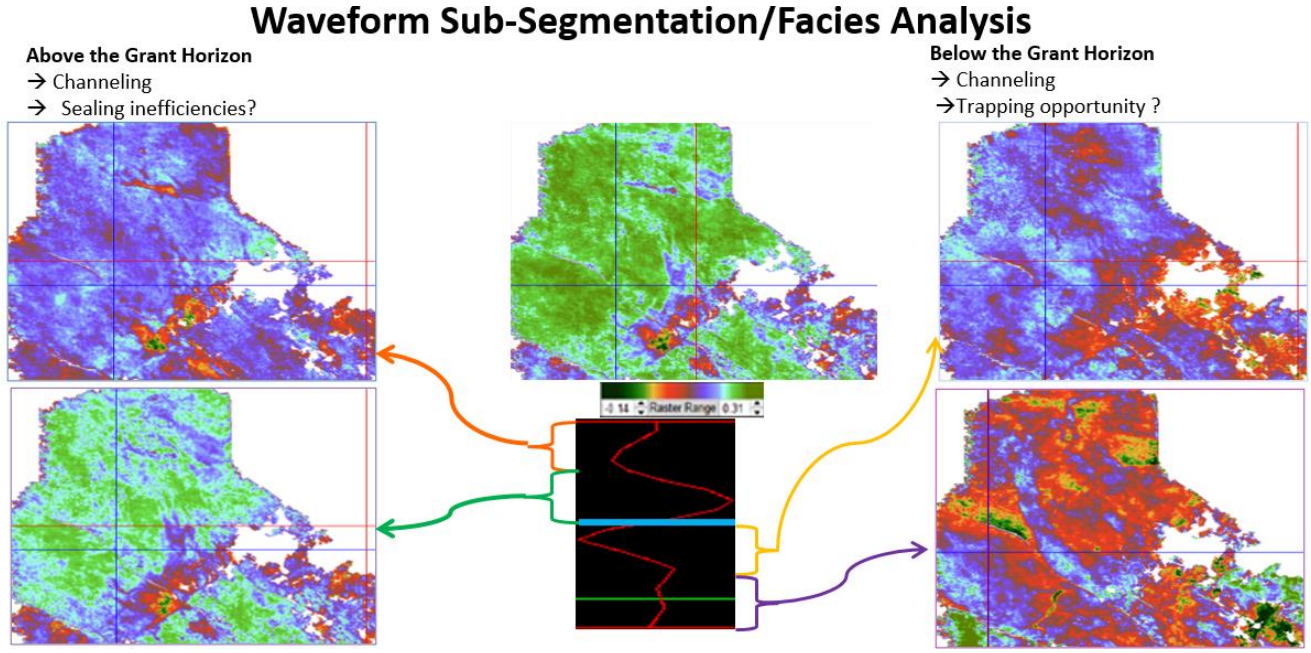


Figure 5: Sub-waveform analysis provides the ability to do detailed facies and reservoir analysis within, above and below each surface. (Higher raster values imply higher Fitness)

Case Studies

There will be strong focus on case studies and examples presented to demonstrate how the AI technology and new seismic Fitness attribute shows the paleo geomorphology in several types of structural and stratigraphic environments.

Figure 6 shows a Fitness map that depicts a deltaic geomorphological pattern. Channel sand and other deltaic type facies can be interpreted.

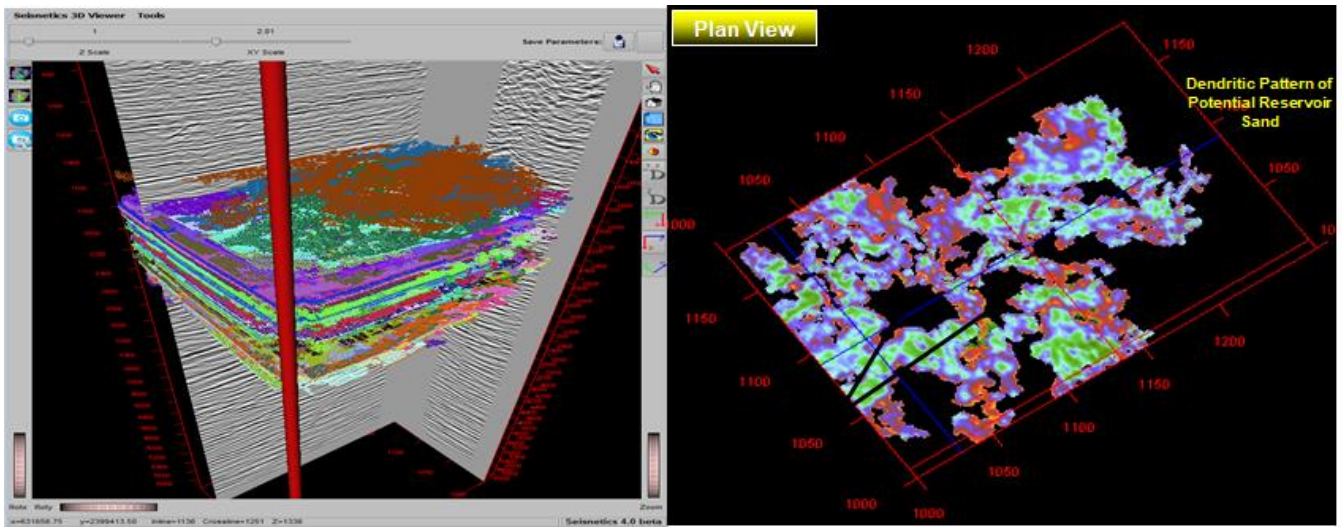


Figure 6 GeoPopulations and Fitness map showing deltaic geomorphology. (Higher raster values imply higher Fitness)

Figure 7 shows a comparison of the conventional amplitude and Fitness attributes. The Fitness map on the left side of figure 7 shows the geomorphology of a channel fan. The red, blue, and green lines show the locations of the corresponding vertical seismic lines. The channel facies interpreted from the Fitness map is not seen on the conventional amplitude attribute on the seismic lines.

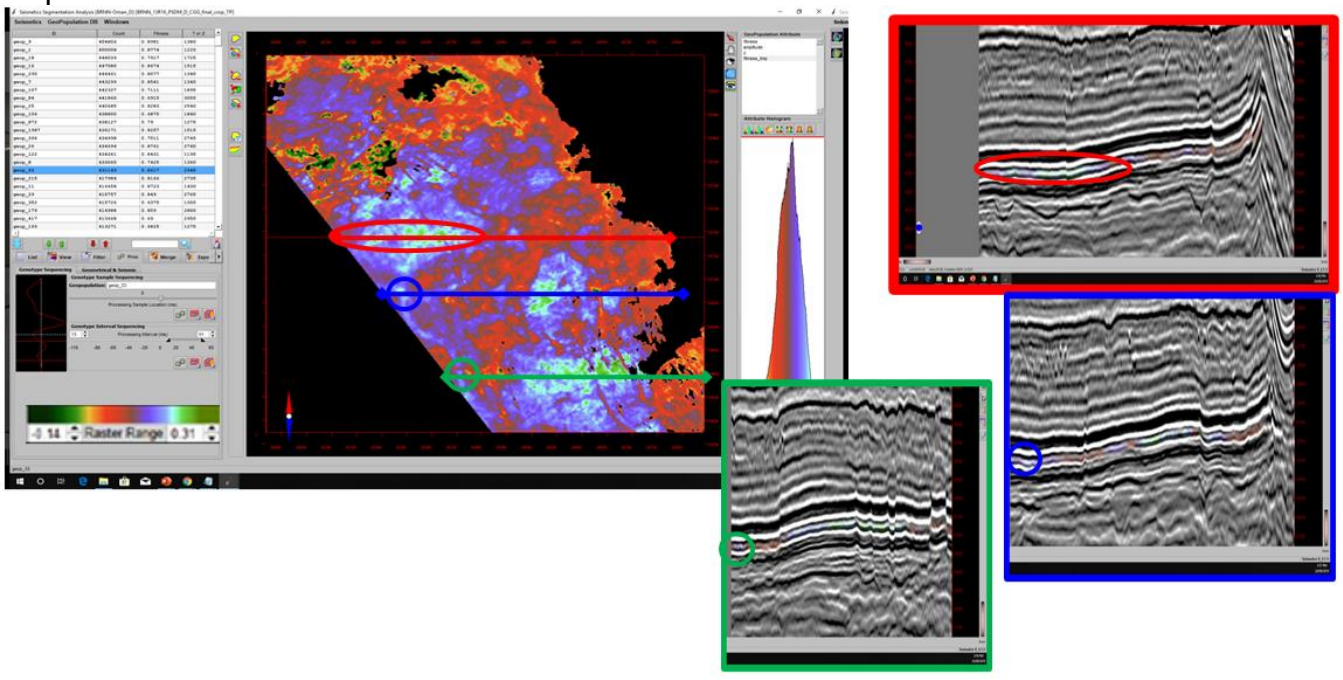


Figure 7 Comparison of conventional attribute analysis and Fitness attribute showing a CVhannel Fan Geomorphology. (Higher raster values imply higher Fitness)

Figure 8 shows several GeoPopulations that combine to represent a single seismic amplitude event. There are different GeoPopulations (waveform families) because of varying reservoir properties.

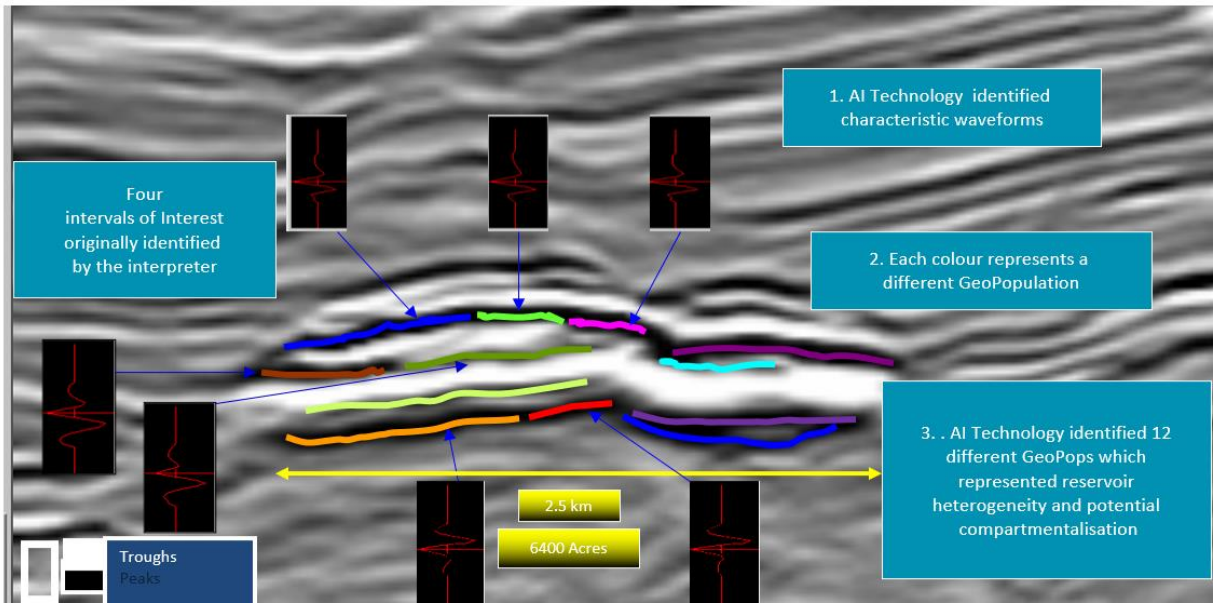


Figure 8: GeoPopulations that show reservoir characterisation.

Figure 9 is a plot of the vertical Fitness and can be used to predict:

- fluid movement (4D applications)
- drilling hazards
- Structural (eg faults, diapirs) and stratigraphic (eg unconformities) trapping mechanisms
- Comparison of multiple volumes, eg AVO, 4D, etc

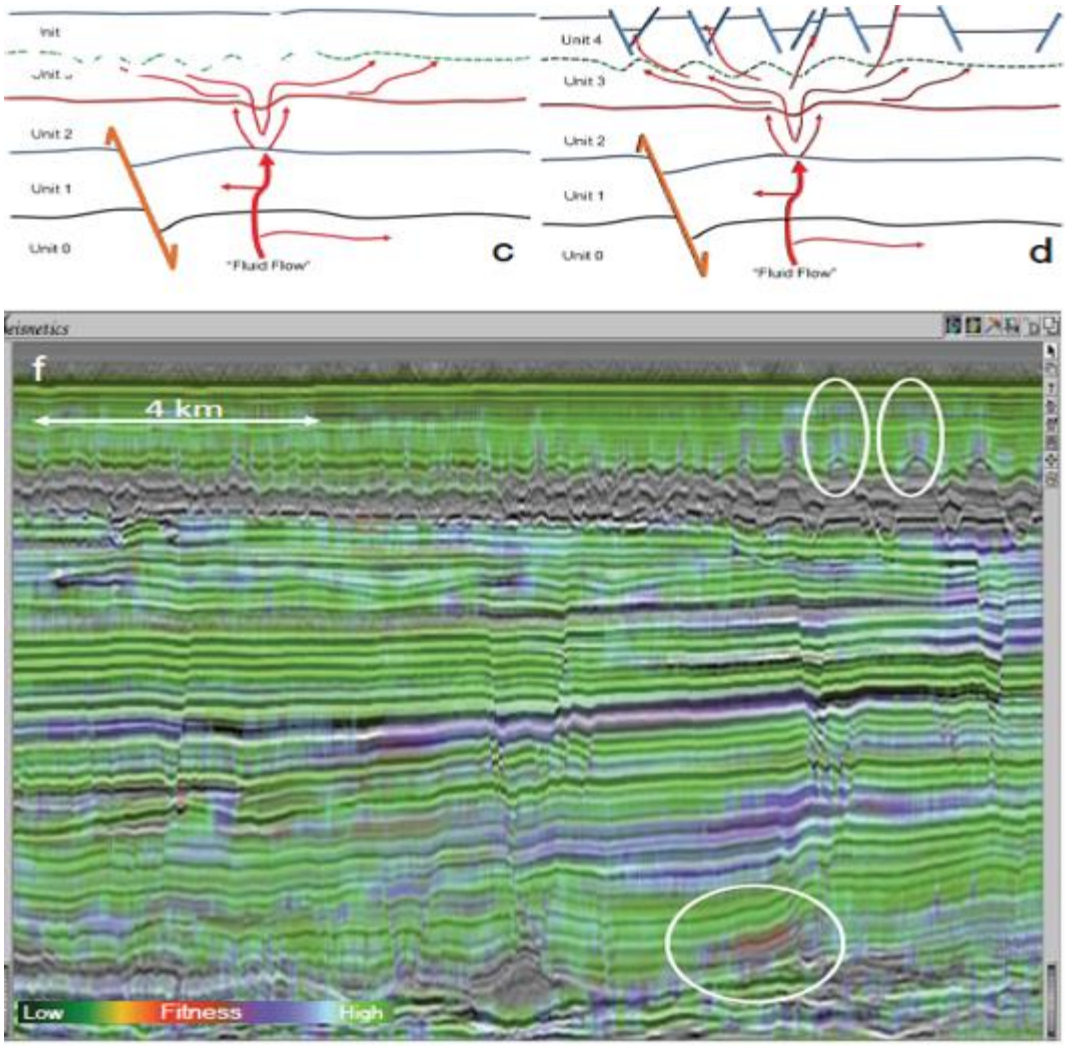


Figure 9: illustrates how the Fitness attribute can be used to predict drilling hazards and fluid movement.

Conclusions

The case studies and examples presented demonstrate how the on premise and cloud based unique AI/ML technology and approach serve to reduce risk and uncertainty resulting in higher probability of success leading to increased capital efficiency and profitability.

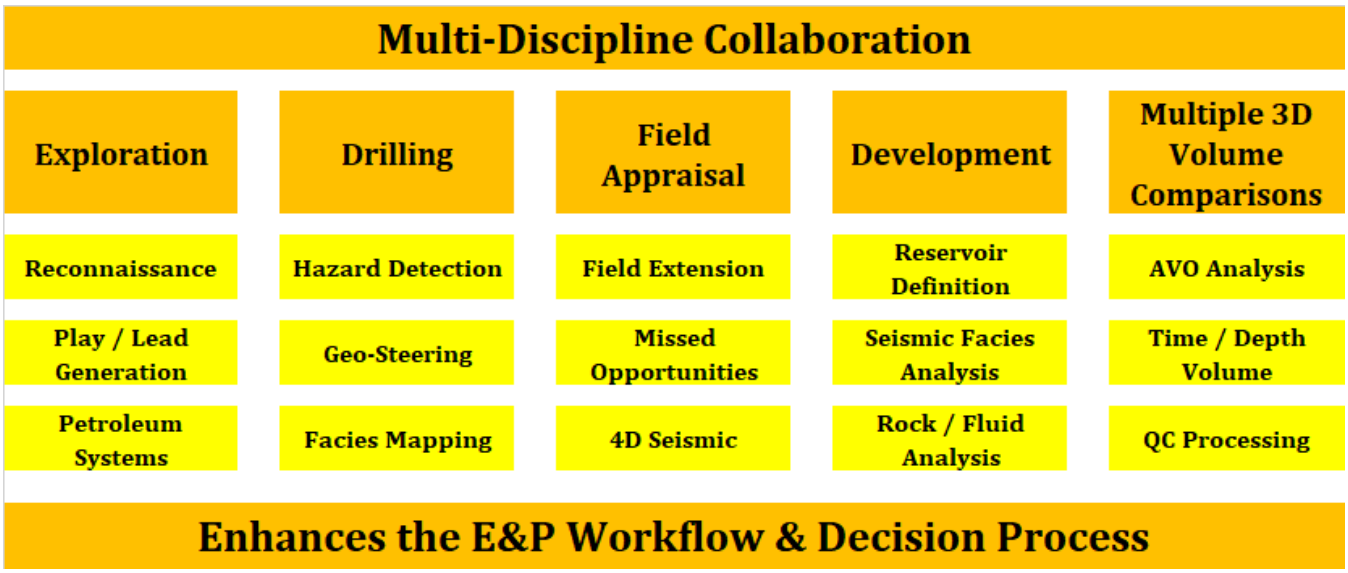


Figure 10: shows Multi-Disciplinary areas where the AI/ML technology can be beneficial

The AI technology generates GeoPopulations/maps of almost every peak and trough in the 3D seismic volume. Amplitude, Fitness/Geomorphology and Structure maps are generated for every GeoPopulation. The results will quickly delineate possible structural and stratigraphic targets. This approach will allow an evaluation of the field geological risk (reservoir distribution, trap, seal, source, hydrocarbon migration pathway from source into reservoir) and initial possible hydrocarbon content/type evaluation (e.g. DHI evaluation) without disrupting your current workflow. Figure 11 illustrates how and where the results of AI/ML technology fits into the interpretation work Flow in green.

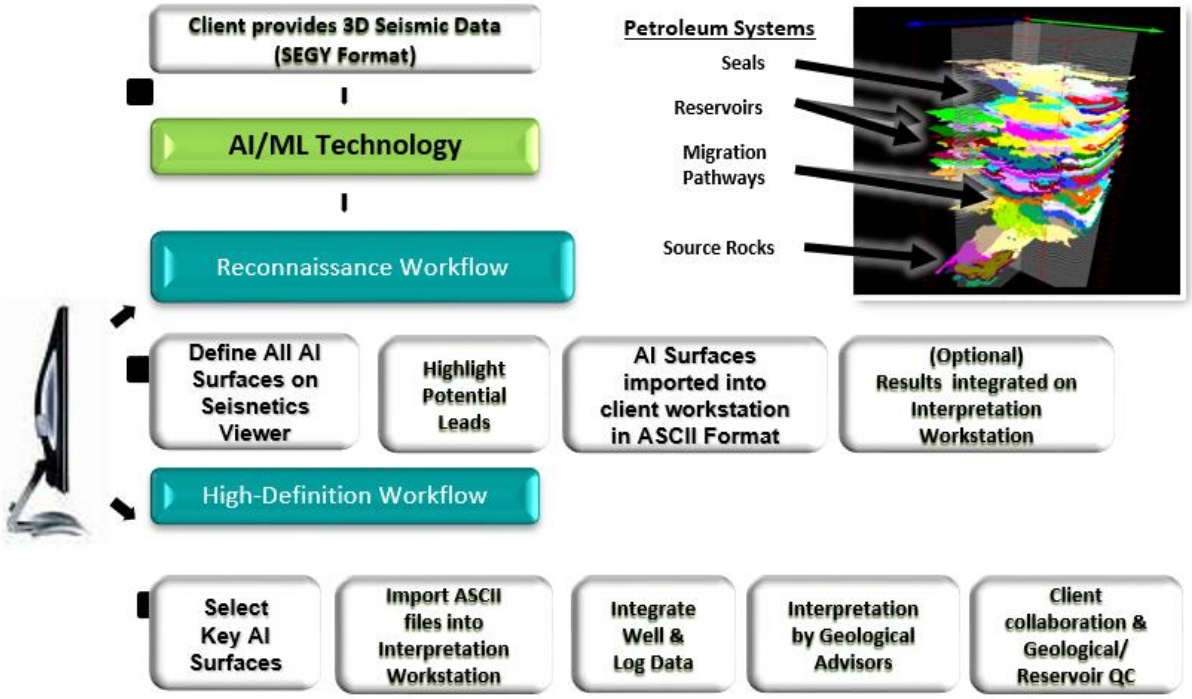


Figure 11: The AI technology fits into any existing interpretation work flows

Examples presented demonstrate how the new AI Technology and seismic Fitness attribute serve to increase the probability of success leading to increased capital efficiency and profitability in several types of structural and stratigraphic environments

Novel/Additive Information

The unique, unbiased AI/ML technology uses the waveform to create families of waveforms called GeoPopulations (maps) for every peak and trough in the 3D Seismic Volume. The new Fitness seismic attribute is a trace to trace comparison of the waveforms within each GeoPopulation and reflects the Paleo-Geomorphology of the surface. Sub-waveform analysis of the Fitness produces maps that can be used to do detailed facies analysis, reservoir characterization, etc. It has been used to reduce risk and uncertainty of each petroleum system evaluated.
The following capabilities are provided by the AI/ML technology:

- Totally unbiased AI/ML technology uses famalies of waveforms to créate GeoPopulations of every peak and trough, providing a comprehensive analysis, of the entire 3D Seismic Data Volume, quickly
- Structure, Amplitude and Fitness seismic attribute maps for each GeoPopulation
- Fitness attribute depicts the paleo geomorphology/facies
- Detailed sub-waveform/facies analysis of the Fitness maps

Pre-interpretation processing is quick and repeatable

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References

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