# Exploration Risking and Impact of Direct Hydrocarbon Indicators: Application of Scenario-based AvO Classification Technology

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## Abstract

Seismic amplitude anomalies have been used for over 40 years to identify and de-risk exploration opportunities with a great degree of success. Beginning in the late 90s, the global industry portfolio of solid amplitude-supported opportunities started to get depleted in many basins. The depletion of high-confidence opportunities resulted in drilling of intrinsically riskier amplitude anomalies leading to significant exploration failures and unexpected outcomes. Some of the failures involved non-commercial hydrocarbons (low-saturation gas or residual gas), some involved anomalous lithologies (e.g. marl, ash or high-porosity wet sand) and some appeared to be related to seismic artifacts. The exploration community realized that seismic anomalies have to be rigorously verified and evaluated within a correct geological context to facilitate realistic risk assessment.

Detecting amplitude or AvO anomalies is always a significant factor in prospect evaluation. True and robust DHI's have large impact on prospect chance of success and drill or not drill decisions. Thus any detected seismic anomalies are sometimes streamlined as true DHI's, creating high expectation and potentially resulting in spectacular failures. The learning from successes and failures demonstrates that potential DHI's must be tested against a broad range of subsurface scenarios and the results must pass the consistency test against geological expectations. At a high-level, the DHI evaluation process should include four steps:

- DHI detection – constrained by previous knowledge of rock properties system and seismic analogues to define detection strategy
- DHI verification – inspection of pre-stack data and qualitative AvO interpretation carried out in a context of reservoir/seal stratigraphy and possible trapping configurations
- DHI assessment – detailed comparison of the observed and predicted seismic response for full range of subsurface scenarios with sensitivity analysis and quantification of scenario likelihoods
- Fluid contact analysis – focused on geophysical and geological consistency and reduction of volumetric uncertainties

The results of detailed quantitative interpretation studies are integrated with independent geologic risk and confidence level assessments. Good quality 3D seismic data facilitate rapid multi-attribute AvO classification and probabilistic chance factor updates. The process is guided by scenario-based forward modeling based on applicable predictive frameworks and with considerations of success and failure outcomes. This paper presents several examples of volume and scenario-based DHI assessment workflows from selected Circum-Atlantic basins, with discussion of underpinning rock properties systems and lessons learned from drilling results.