Ranking DHI attributes for effective prospect risk assessment applied to the Otway Basin, Australia

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SUMMARY

The first evidence of seismic brightening linked with gas charged reservoirs was recognised by Shell in the very late 1960s in the Gulf of Mexico. Since that time the terms bright spots, flat spots, amplitude versus offset (AVO) anomalies or gas anomalies have been used interchangeably (and often loosely) to imply positive evidence for gas charge. Collectively known as Direct Hydrocarbon Indicators (DHI), they have reduced risk and driven the successful exploration of many hydrocarbon discoveries. However, DHIs are not infallible and misinterpretation can lead to disappointment. We contend that it is very difficult to misinterpret a genuine DHI anomaly but easy to falsely characterise a seismic anomaly as a genuine DHI. In our experience, it is a combination of fundamental seismic attributes within the context provided by a sound geological and structural model that derives the most value in DHI assessment.

A seismic DHI is defined as an anomalous seismic attribute or pattern that could likely be explained by the presence of hydrocarbons. Seismic amplitudes which conform to depth structure within a prospect are one of the primary characteristics for ranking the quality of a DHI anomaly. It is uncommon to generate this seismic amplitude conformance with depth structure in the absence of hydrocarbons. AVO anomalies and bright spots conversely may be generated by numerous lithological or seismic processing related phenomena.

By assessing the key criteria that determines the quality of DHI anomalies associated with proven hydrocarbon accumulations, it is possible to build a catalogue of DHI anomalies calibrated to known accumulations. Utilising the DHI quality to modify the initial chance of geological success is crucial to reducing subjectivity in ranking drilling opportunities. We demonstrate how we apply our understanding of DHI statistics from the Otway Basin, using Bayes' theorem.

Key words: DHI, AVO Anomaly, Flat Spot, Chance of Success, Prospect Risk, Bayes' Theorem

INTRODUCTION

In a basin where the elastic parameters of the rocks are favourable (rock physics) and the seismic imaging is adequate, a genuine DHI anomaly is difficult to miss. However, seismic anomalies can easily be falsely characterised as genuine DHIs by the optimistic explorationist. To be used properly, DHIs need to be interpreted in terms of the local geology, and objectively incorporated into the geological risking by assessing their effectiveness against historical results. In doing so, DHIs can be powerful indicators that support good drilling decisions or guard against poor ones. We discuss what constitutes a genuine DHI, show various examples and rank their effectiveness. Using drilling statistics from the Otway Basin, this paper describes one method of applying Bayesian probability to incorporate the DHI ranking into an updated chance of geological success, (P_g). This methodology can be adapted to other basins with DHI favourable geology by gathering statistics from drilling results or adapting published statistics of other authors such as Roden *et al* (2012).

RECOGNISING DHIs

A seismic DHI is an anomalous seismic attribute or pattern that could most likely be explained by the presence of hydrocarbons within a reservoir. Shell first recognised evidence of seismic brightening linked with gas charged reservoirs in the late 1960s in the Gulf of Mexico (Forest, M., 2010). Where seismic data quality and rock physics conditions allow for a hydrocarbon versus brine response to be detected, hydrocarbon-charged reservoirs exhibit repeatable and distinct seismic attribute responses. A DHI can take many forms, such as down-dip amplitude conformance to structure, flat spots, phase changes, consistent elevated amplitudes within the mapped prospect, AVO anomalies and bright spots in general.

To be a genuine DHI, it is not sufficient just to be anomalous. A DHI interpretation must be valid in the context of a supportable geological model. It is this combination of the DHI interpretation and a valid geological model that makes DHIs powerful predictors of hydrocarbon charge as well as seal and trap integrity. Generally, the following conditions should be satisfied to confidently identify and interpret a DHI anomaly (or downgrade a prospect if a DHI is absent when one is anticipated):

1. High fidelity seismic data (usually 3D) nominally with confidence in the phase of the data. Imaging at the target level should be uncompromised by shallow geological features (e.g. igneous bodies, variable fill channels, carbonate features, coal, shallow gas and salt).

2. A plausible geological model that supports the prospective hydrocarbon trap, which is especially important for stratigraphic traps or combined structural-stratigraphic traps. Seismic forward modelling is a useful tool to test geological hypotheses, especially where nearby well control can constrain key model parameters.
3. An understanding of the rock physics of each reservoir and seal. While this is not always essential where a clear DHI exists, it is essential if the absence of a DHI is used to decrease the chance of success of a prospect. Consideration needs to be given to the reliability of elastic log data used for fluid substitution modelling, the knowledge of depth trends and the poro-velocity relationships.

RANKING DHIs

Not all DHIs will confer similar levels of confidence about the presence of hydrocarbons. To quantify any DHI interpretation it is necessary to rank them, preferably using statistics from local drilling results. A suite of criteria has been developed by Roden *et al* (2012) for the robust application of a range of different DHIs. Roden *et al* (2005) found that the most diagnostic DHI is "amplitude down-dip conformance (fit to closure) on stacked or far offset seismic data". We mostly concur with Roden *et al*'s relative ranking except for "flat spot" type DHIs, which we recognise as being highly definitive indicators. In the author's experience, it is very difficult to misinterpret a genuine DHI anomaly and very few non-hydrocarbon related factors can produce a DHI response with true conformance to depth structure. Buoyancy is the driving force of most conventionally trapped hydrocarbons and hence in most cases trapped hydrocarbons will be associated with a hydrocarbon-water interface. If seismic data is detecting the presence of hydrocarbons, in geologically favourable circumstances it therefore follows that it should also respond to the hydrocarbon-water interface. Hence the combination of amplitude conformance and a flat spot are highly diagnostic. For example, the Minerva Field (Figure 1), exhibits a clear flat spot anomaly.

Conversely bright spots, dim spots and Class 2/3 AVO anomalies (Rutherford *et al*, 1989) are produced by numerous non-hydrocarbon related phenomena. Hence these have a relatively lower rank in the summary of DHI types (see Table 1).

DHI Rank Order	DHI Type	Physical Phenomena associated with DHI type
1	Down-dip attribute conformance with depth	Strongly associated with buoyancy driven fluid phase boundaries, mostly Gas-Water Contacts (GWC)
2	Flat spot	Strong evidence of GWC. Requires confidence from geological model for thick reservoir section
3	Phase change	Modest evidence for fluid phase change associated with top reservoir horizon at GWC. Requires confidence in geological model and seismic wavelet.
4	Amplitude consistency (over prospect)	Modest evidence for unique fluid associated with top reservoir horizon. Requires confidence in uniformity of geological model.
5	AVO anomaly	Potentially powerful attribute, but highly dependent on geological model. Many false positives

Table 1: Summary of DHI types (for Class 3 AVO anomalies) in order of significance. The order is a variation on that published by Roden *et al* (2012). The table captures hydrocarbon related generators for these attributes.

PITFALLS and EXCEPTIONS

Undeterred by the historical results, geoscientists are naturally optimistic explorers – optimism which must always be balanced with scientific objectivity. However, a lack of rigour can adversely influence the interpretation of DHI ranking criteria. Some common pitfalls and exceptions related to DHIs are listed below.

"Partial" attribute conformance with depth structure: recognising that attribute conformance with depth structure is king can often lead interpreters to seek out any "hints" of amplitude conformance along a common depth contour. "Partial" conformance describes any along strike and or up dip variation in the distribution of anomalous amplitudes relative to a common depth contour. Often this is observed as narrow, high amplitude bands that exhibit a common shutoff in amplitudes but only over part of the down-dip structural flank. Other amplitude shutoffs along strike may vary tens of metres above or below the interpreted amplitude conformance depth. The pitfall is to use "partial" conformance to de-risk a prospect when in fact the correct DHI interpretation is that there is no convincing conformance, leading to a lower quality DHI ranking. Note, seismic tuning has the capacity to contribute to partial attribute conformance where strata thicken off structure.

Colour bar manipulation: "visual hyperbole" commonly applied to improve a patchy attribute response over a prospect area to better satisfy DHI ranking criteria #4 from Table 1. Clipping or squeezing the colour bar range provides a false impression of improved amplitude consistency across the prospect extent and may improve the visual contrast between a prospect and the background. The validity of these amplitudes may be checked by applying the full dynamic colour range for attribute analysis and looking for truly anomalous amplitudes above background with conformance to depth structure (Figure 5).

Expecting a "hidden" gas accumulation- false hope that a prospect in a proven play will be the exception and contain hydrocarbons when no DHI is present despite analogues or forward modelling showing that DHIs should be expected. There are some examples of "hidden" gas discoveries within a DHI supported play however, these examples are interpreted to be below the current limits of seismic resolution.

It is recognised that DHI lookalike anomalies can be produced by numerous non-hydrocarbon related geological scenarios, some of which are listed in Table 2. Advancing a prospect based upon questionable DHI attributes in the absence of amplitude conformance with depth structure and or flat spot anomalies should be considered cautiously. Key exceptions that can have observable down-dip conformance include:

- Diagenetic interfaces (apparent flat spots) such as the opal CT to quartz transition observed across a high porosity, low density biosiliceous claystone in the Warrabkook-1 exploration well in the Browse Basin (Ellis, 2008).
- Low saturation residual gas sandstones (theoretically it is possible to distinguish from producible gas saturated reservoirs by derivation of a density attribute, but rarely does data quality permit) – Figure 6 Pecten East-1 encountered residual gas at the down-dip edge of the target DHI anomaly.
- The seismic response of inert gases (e.g. carbon dioxide, nitrogen) is indistinguishable from hydrocarbons.

Causes of DHI False Positive	DHI Type	Pre-drill QC
Low saturation residual gas	Attribute Conformance with depth, Flat Spot, Phase Change, Amplitude Consistency, AVO Anomaly	Unable to differentiate between high saturation gas (moveable) and low saturation gas (residual)
Diagenetic effects	Attribute Conformance, Flat-spot, Phase Change, Amplitude Consistency, AVO Anomaly	Check for potential diagenetic effects e.g. opal CT, devitrification of volcaniclastics
Cross-cutting multiple energy	Flat Spot	Multiple event extends beyond prospect closure area
Unconformity surface	Flat Spot	Unconformity unlikely restricted to prospect closure area
Gas Hydrates	Flat Spot	Temperature/Depth dependent - restricted to narrow overburden range
Manipulation of colour bar dynamic range or inappropriate windowing of attributes	Amplitude Consistency	Assess data using full dynamic range over discrete target intervals
Brightening due to seismic tuning	Amplitude Consistency, AVO Anomaly	Seismic forward modelling
Shale on Shale AVO	AVO Anomaly	No conformance with depth structure
Brine sand gives Class 3 AVO response	AVO Anomaly	No conformance with depth structure

Table 2: Summary of potential causes of false positive DHIs (for Class 3 AVO anomalies) in order of significance. The table captures non-hydrocarbon related generators and the DHI types that may manifest due to their presence in the place of hydrocarbons. There are numerous non-hydrocarbon related anomaly generators at the lower end of the DHI ranking scale.

SEISMIC MODELLING

Seismic forward modelling is a powerful tool to assist interpretation and DHI calibration. Where reliable and comprehensive elastic log data exists, ideally covering both brine-filled and gas-charged reservoirs, interpreters should draw confidence from the forward modelling predictions when compared with the observed seismic response. In these situations, interpreters need to actively expect a DHI, and be wary if their prospect does not have one. However, if limited measured log data is available, it is prudent to take a cautious approach to predicted outcomes at the prospect location.

A genuine DHI anomaly is generally difficult to misinterpret. Four comparable synthetic models demonstrate genuine DHI anomalies due to a gas versus brine response. The contrast in seal to reservoir acoustic properties were designed to capture key end-member geological scenarios (Figure 2). An Upper Waarre reservoir sandstone, which is penetrated in the Minerva 2A well, formed the basis for building these synthetics seismic models within the RokDoc™ software package.

The most subtle hydrocarbon response is a thin, high-impedance sandstone scenario that produces a Class 2/2a AVO character (Figure 3). DHIs generated in this scenario, would generally attract a more modest ranking although a strong impedance contrast at the gas-water interface can often still be detected in the form of a phase change. Ambiguous DHIs often require additional evidence for gas charge such as comparing the near vs far stack amplitude response.

Thick, high-impedance sandstone scenarios are the next most responsive to changes in fluid content (Figure 4a). Although the amplitude response of the top porosity event is subdued, the Gas-Water Contact (GWC) interface remains consistent. This is an important observation as where a thick, high net-to-gross sandstone exists, the gas-water interface should be observable given that only the fluid properties are changing within a common reservoir tank. The Minerva Field in the Otway Basin aptly demonstrates this scenario where stacked amplitudes at the top reservoir interface are not above background across the known hydrocarbon accumulation whilst the flat spot consistently remains visible (Figure 1).

Geological scenarios with the best DHI anomalies and a classic Class 3 AVO response result from low-impedance sandstone reservoirs (Figures 4b and 4c). Consider a thin, low-impedance sandstone (Figure 4b) where a decrease in the reservoir impedance due to gas charge results in a brightening over the crest of the structure above the gas-water interface. Seismic tuning can produce a similar response and forward modelling studies may be warranted to rule this effect out. The most responsive scenario occurs with a thick, low-impedance sandstone (Figure 4c). In this scenario, a strong Class 3 AVO response is modelled at the top porosity interface and a robust flat spot predicted at the GWC.

It is observed for all the models, that over at least some part of the trapping configuration, a seismic response related to the gas-brine interface should be expected. However, where a thin-sandstone is significantly below tuning thickness or stacked

multiple thin-sandstones exist, a DHI response to gas charge may not be observed. In such situations, the expected geological model dictates that a reliance on DHI information is inappropriate. The confidence of any DHI interpretation relying upon forward modelling is premised upon an understanding of the geological model.

RISKING WITH DHIs IN THE OTWAY BASIN

Application of a DHI quality factor to modify the initial chance of geological success is crucial to objectively grading drilling opportunities. By assessing key criteria that determine the quality and confidence of a DHI anomaly associated with proven gas accumulations, it is possible to build a catalogue of DHI quality assessments calibrated to known gas accumulations. The DHI Consortium have a database of over 200 wells in 20 basins worldwide and has shown a high correlation between DHI quality and well outcome (Roden *et al.* 2012). We have applied this logic to the Otway Basin.

Four key steps are required to quantify, calibrate and then modify the initial geological risk using a DHI quality factor:
1. Use the five key DHI types to define an overall DHI quality rank for each drilled prospect in the basin (e.g. none, weak, moderate, strong). Our methodology utilises attribute conformance with depth structure, flat spots (where sufficient reservoir thickness exists), consistency of bright amplitudes, down-dip phase changes and AVO.
2. Develop a local database of well test outcomes where success vs failure outcomes are linked with the overall DHI anomaly ranking. Note that in the absence of sufficient local well results, it is possible to use global analogues or subscribe to the DHI Consortium's global database (Rose & Associates, The DHI Consortium).
3. Use the five key DHI types to define a quality ranking for the undrilled prospect of interest.
4. Modify the initial geological risk using the historical database of DHI anomaly ranking versus well outcome.

Developing a DHI database for a given play or basin is necessary to objectively utilise DHIs for prospect risk analysis. Forty-nine valid drilled traps were assessed across the eastern Otway Basin for a DHI rank. The size of the database population, which includes both offshore and onshore traps was only sufficient to divide the DHIs into four ranks; no DHI, weak DHI, moderate DHI and strong DHI. Traps with no DHI or a weak DHI were considered unlikely to be related to hydrocarbons whilst traps with a moderate or strong DHI were expected to contain hydrocarbons. The study revealed that 41 of the 49 tests were true positives either containing hydrocarbons with a moderate to strong DHI or being brine saturated with a weak or no DHI (Figure 7a). While the six false positive DHIs where no commercial hydrocarbons were discovered related to either high carbon dioxide, dry holes or residual gas. The remaining two false negatives which contained hydrocarbons without a DHI were weak DHI gas discoveries in small onshore structures.

From this DHI database for the eastern Otway Basin, the correlation between the presence of hydrocarbons and a DHI appears extremely strong. In these circumstances, it is tempting to use the DHI information to directly influence the perceived risk of new prospects. This approach inevitably incorporates DHI information directly into the risk assessment by adjusting the geological chance of success of certain petroleum elements. This is a subjective technique based upon the interpreted presence and quality of a DHI. Whilst initially intuitive the results often appear to be heavily biased and inconsistent due to the circular reasoning around false positives and false negatives.

Multiple methods have been proposed and implemented to more objectively utilise DHI information in the risking process. The DHI Consortium applies a systematic and consistent approach to evaluating, grading and cataloguing the impact of seismically observed amplitude anomalies on prospect risking. Their DHI interpretation workflow captures geological, data quality and seismic attribute characteristics assessments. The defined characteristics of the prospect are compared against a database of relevant analogue prospects and initial geological risk is adjusted accordingly, based upon the strength and weight of positive or negative supporting evidence. In this manner, an assessment of a prospect DHI quality and impact can be completed where local analogue data is scarce.

Without a global database, it is still possible to systematically incorporate DHI criteria into prospect risking. Methods to apply Bayes' theorem to this problem have been proposed by Lowry et al (2005) and Ruhl and Samuelsson (2017). Each workflow updates the initial geological risk, assessed disregarding any DHI information by estimating the DHI Bayesian probabilities for a prospect. Lowry et al (2005) implement a qualitative assessment of a prospects DHI whilst Ruhl and Samuelsson (2017) describe a quantitative process and both are founded in comparisons with a single DHI-supported example. Our approach takes in a more regional perspective of DHIs by incorporating the play ranked DHI statistical populations from steps 1 and 2 above, to establish Bayesian probabilities based upon many DHI tests.

Bayes' theorem describes the probability of an event when given some information related to that event. Generally, the related information is imperfect (as for our DHIs); otherwise it could be used directly to infer the outcome. In this example, the DHI (or lack thereof) at a prospect is included in the risk assessment by considering how our knowledge of DHIs across the basin and play affects the initial geological chance of success (P_g). Bayesian Inference provides the mechanism by which we adjust our hypothesis (P_g) using evidence related to that hypothesis (the DHI to success statistical model). Bayes' theorem is superior to subjective risking with a DHI because it considers the chance of a DHI being a False positive and in the counter case, the chance that the absence of a DHI does not preclude the presence of hydrocarbons (False negative) (Lowry *et. al* 2005).

In Bayes' theorem the $x|y$ notation is used to indicate the probability of x occurring given y. The probability of hydrocarbons given a DHI $P(hc|dhi)$ is described as (Simm and Bacon 2014):

$$P(hc|dhi) = \frac{P(dhi|hc)P_g}{P(dhi|hc)P_g + P(dhi|nohc)(1-P_g)}$$

The adjustment is made using the observed probability of a DHI occurring given the presence of hydrocarbons $P(dhi|hc)$; this is our basin DHI model. In practise, we set the observed probability of a DHI occurring without the presence of hydrocarbons $P(dhi|nohc)$ and $P(dhi|hc)$ to be complimentary to one.

A quantitative summary of $P(dhi|hc)$ and $P(dhi|nohc)$ and their counterparts $P(nodhi|hc)$ and $P(nodhi|nohc)$ are given in Figure 7b. The well test statistics represent an incomplete data set and as a result we have chosen to adjust the values that will be applied to take into account other unknown outcomes such as residual gas. The DHI adjusted P_g for any input P_g using our eastern Otway Basin DHI statistical model is demonstrated in Figure 7c.

Often the Bayesian adjustment is applied to the final estimate of geological risk. However, in some cases it may be more appropriate to consider applying the Bayesian adjustment to individual petroleum risk elements. Adjusting individual petroleum risk elements represents a consideration of which petroleum elements for a given play are best de-risked by the presence of a DHI. This would be specific to each play. For prospects in the eastern Otway Basin, DHIs were assessed to best support the presence of a working seal (vertical and lateral) and successful hydrocarbon charge into the trap (recognising some pitfalls e.g. inerts). The remaining petroleum element risks of closure, source and reservoir are arguably less influenced by a valid DHI because there is generally other supporting evidence to quantify their risk. Hence Bayesian adjustments were applied to the individual charge and seal risk elements before consolidating the petroleum risk elements into a final P_g.

Table 3 shows four fictional prospects that have had their initial geological chance of success adjusted using the model described above. A moderate DHI at Prospect 1 sees its P_g increase significantly after the Bayes adjustment. Prospect 1 becomes very low risk because charge and seal are de-risked by the moderate DHI. Comparatively, Prospect 2 starts with a similar P_g to Prospect 1 but the P_g after Bayes adjustment does not increase to the same level as Prospect 1 because the reservoir risk is not adjusted in the process. Prospects 3 and 4 demonstrate opposing ends of the spectrum; a geologically risky prospect with a strong DHI at Prospect 3 and an initially attractive Prospect 4 with no DHI support. After the Bayes adjustment Prospect 3 becomes less risky than Prospect 4.

	Prospect 1		Prospect 2		Prospect 3		Prospect 4	
	Initial	Bayes	Initial	Bayes	Initial	Bayes	Initial	Bayes
DHI Rank	N/A	Moderate	N/A	Moderate	N/A	Strong	N/A	None
Closure	0.95	0.95	0.95	0.95	0.9	0.9	0.95	0.95
Reservoir	0.9	0.95	0.5	0.6	0.5	0.5	0.9	0.9
Source	0.9	1	0.9	1	0.8	0.8	1	1
Charge	0.6	0.83	0.9	0.97	0.7	0.95	0.5	0.10
Seal	0.7	0.89	0.9	0.97	0.6	0.93	0.8	0.31
Pg	32%	67%	35%	53%	15%	32%	34%	3%

Table 3: Example prospects with initial geological chance of success and geological chance of success after applying a Bayes correction that uses the eastern Otway Basin DHI ranking and statistical model.

CONCLUSIONS

The presence of a genuine DHI anomaly within a DHI-supported play does not guarantee drilling success, but prospects without robust DHI characteristics should be considered very carefully. Amplitude conformance with depth structure is the most diagnostic of DHIs and in the authors' experience, flat spots when verified, are also highly definitive. With any exploration optimism is required, but a dispassionate assessment of the science is critical to any success. Assessing each seismic anomaly against criteria founded in the knowledge garnered from historical results, robust modelling, and then matching it to the local geology will support sound decision making. This has been an effective methodology used in the Otway Basin.

DHIs in the Eastern Otway Basin are strongly but imperfectly correlated with the presence of hydrocarbons. Bayes' theorem provides one approach by which the basin-wide DHI information can be more effectively incorporated in the geological risk assessment process. The approach to revising P_g using Bayes' theorem is effective because it removes some subjectivity that often obscures the true geological assessment of P_g.

In DHI-supported plays, the method can both effectively highgrade prospects or downgrade others that would be considered viable exploration candidates. When a DHI-supported play has been exhausted of untested DHIs consideration could be given to alternative options, such as deeper underexplored structural or stratigraphic plays which are naturally less likely to have clear cut DHIs.
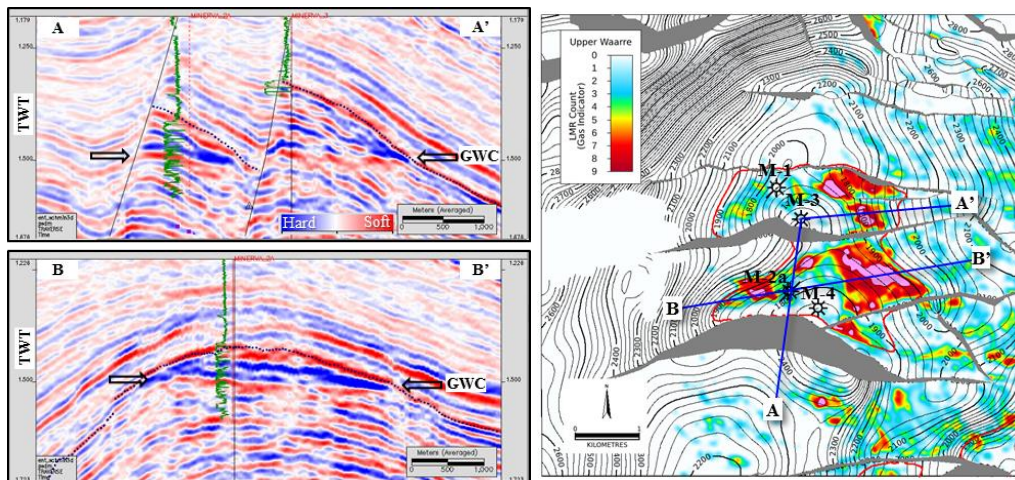
ACKNOWLEDGEMENTS

FIGURES

Figure 1 – Minerva Field, Otway Basin. Upper Waarre depth structure map with Lambda-Mu-Rho Gas Count attribute exhibiting strong DHI conformance with depth structure on east flank (field outline shown in red). The response over the crest of the field is compromised by limited impedance contrast between the top seal and reservoir. The two full-stack 3D seismic arbitrary traverses display strong DHI flat spot anomalies coincident with the field GWC.
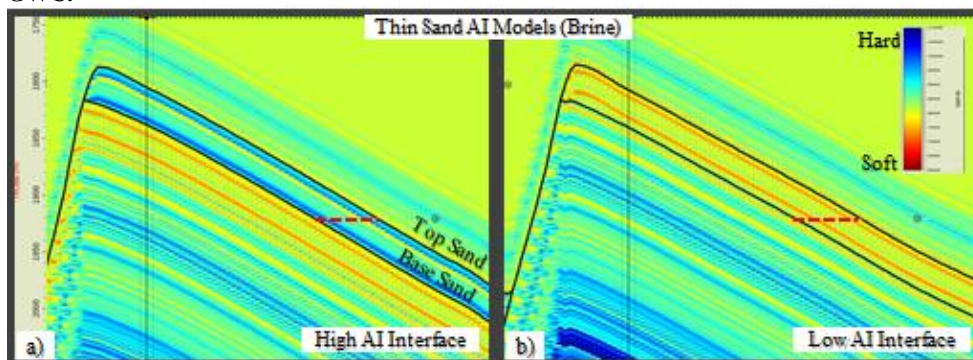

Figure 2 – Acoustic Impedance (AI) Models (Brine case) showing Thin sand scenarios with high and low impedance units at the seal to reservoir interface.
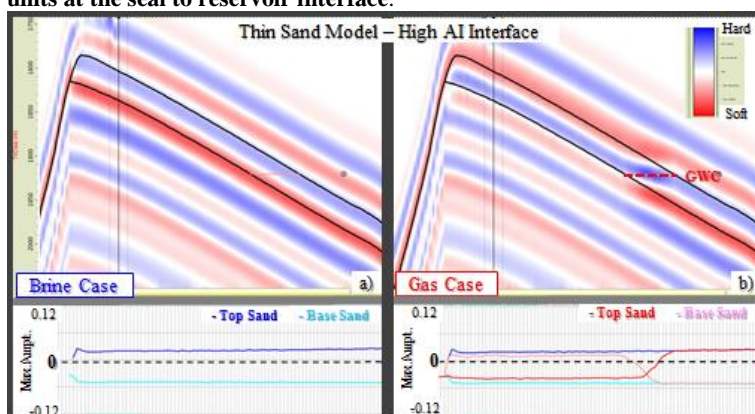
Figure 3 - Synthetic 2D model for the most subtle hydrocarbon response scenario – a thin, high impedance sandstone. Modelled amplitude responses for the top and base reservoir interfaces are shown below each model for the gas vs brine cases (a) vs (b). A subtle change in polarity is predicted at both the top and base interface (Class 2/2a AVO response). In spite of this, the strong contrast at the gas-water interface may still be detected as a phase change (b). [Model parameters: Full stack (5-35deg), Ricker 25 Hz, SEG polarity].
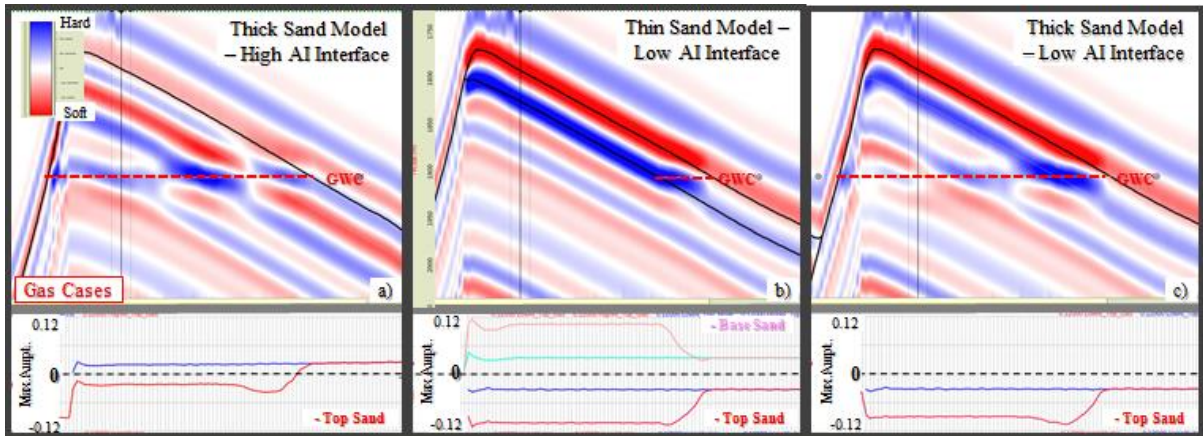
Figure 4 - Three synthetic gas-case models demonstrating more definitive gas-related DHI characteristics. It is apparent that even in the absence of a strong top porosity gas response for the thick, high impedance sand shown in (a), the large contrast between gas and brine fill produces a distinct flat spot response at the GWC interface. The low impedance scenarios in (b) and (c) display classic Class 3 AVO behaviour at the top porosity interface, with the addition of the flat spot at the GWC for the thick sand. [Model Parameters: as above]
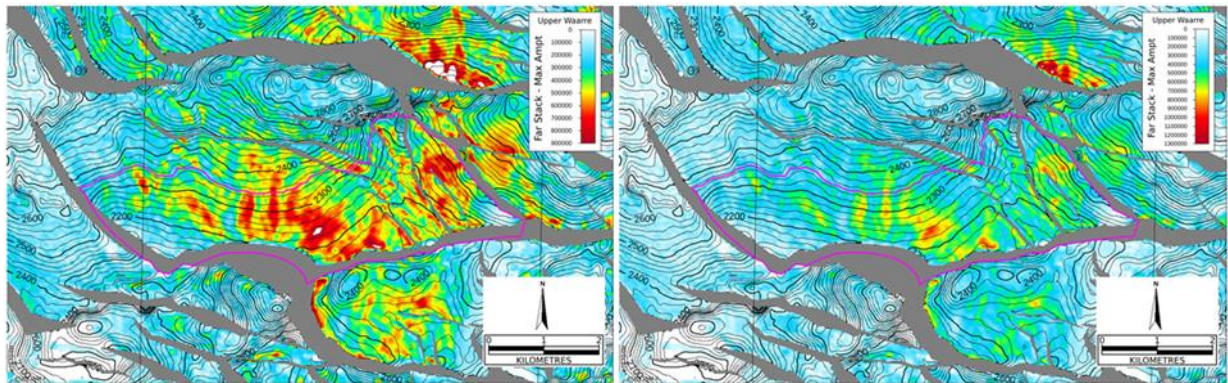

Figure 5 Example of a colour bar squeeze applied to enhance the apparent attribute response for a prospect X, within Shipwreck Trough, Otway Basin. Compressed range on left hand far stack amplitude map gives the false impression of a more favourable seismic attribute response not evident when the full dynamic range is displayed (right hand map).
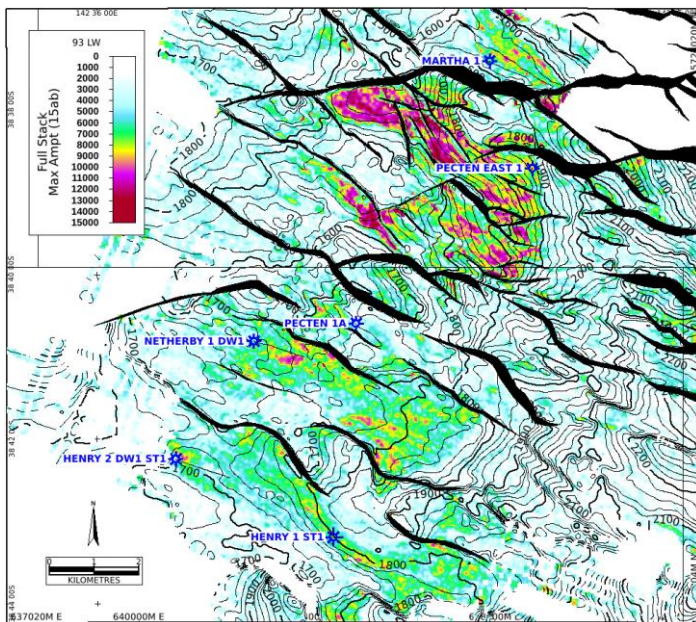

Figure 6 Pecten High, Otway Basin. Lower Waarre Formation full stack maximum amplitude attribute map. Henry-1 and Netherby-1 discoveries were drilled in 2005 and 2008. The Pecten East prospect Pg was elevated to 73% COS (Adderley, 2008) ahead of drilling in late 2008. Proving there are no silver bullets, the well encountered porous sands with low saturation gas on the down-dip edge of the target DHI anomaly.
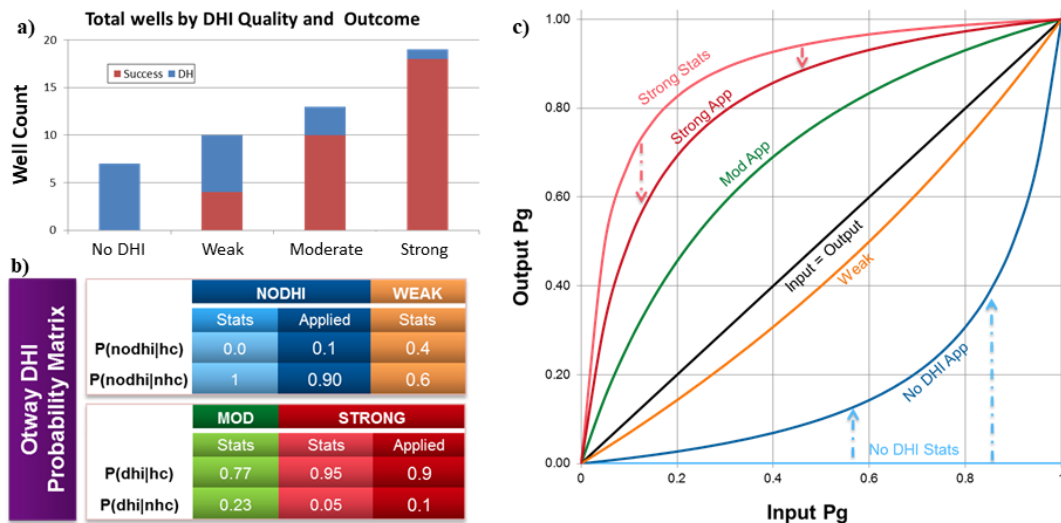
FIGURE 7 – a) Eastern Otway basin test results categorised by DHI rank and hydrocarbon outcome; b) The Otway DHI probability matrix captures the Bayesian DHI Populations and Eastern Otway Bayesian Risk Model; c) Using our values from Figure 5b (colour coded) the Bayesian algorithm output P_g can be calculated for all possible input P_g values to demonstrate its effect. The strong correlation between DHIs and hydrocarbons results in polarised results. A basin or play with a weaker correlation between DHIs and success would result in smaller adjustments to the input P_g.

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