Detection of natural gas leakage from deep-seated reservoir

a) Dip & Azimuth calculation
b) Structural filtering

2)Attributes Computation

Seismic attributes are mathematically derived parameters from the seismic data, which act as a value addition to the qualitative seismic interpretation like enhancing subsurface structural features or identifying active petroleum system (Chopra and Marfurt, 2007). In this study to enhance the features related to gas chimney following attributes has been used (please refer figure 3);

Table 2: Signature of attributes in the gas zones

Attribute	Property	Signature
Energy	Square of amplitude	Low energy
Similarity	Shows coherency between traces	Low similarity
Variance dip	Change in dip direction	Highly variable dip
Frequency wash out	Ratio of low and high frequency	High frequency wash out
Signal/Noise (S/N)	Signal to noise ratio	Low S/N value
TWT	Twice of travel time	More TWT

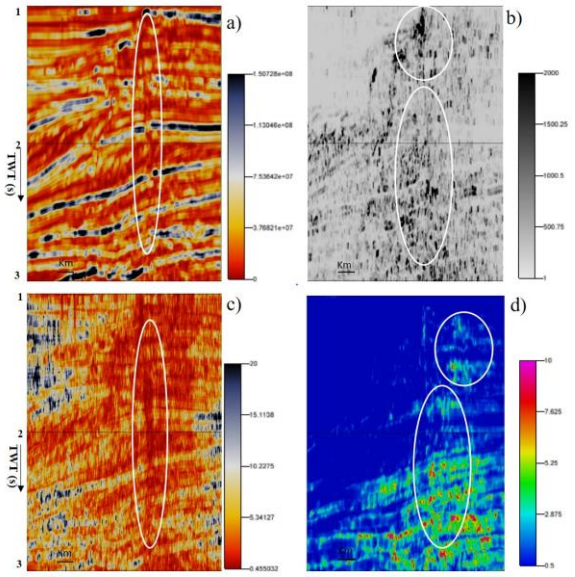

Figure 3: Signature of attributes highlighting gas leakage zones a) Energy – vertical low energy zone, b) Dip variance – high dip variance zones, c) Signal/noise – low vertical zones & d) Frequency wash out – patches of high wash outs

3)Applying NN to seismic volume

For applying NN to complete seismic volume, first dataset needs to be trained by manually picking points of Chimney and non-chimney zones then NN train itself through the data and try to establish the relation between extracted attributes (input) and Chimney yes and no points (output) (please refer figure 4). As it's an iterative process where weights of attributes keep changing and we have to train NN till the time we get minimum RMS error between expected and observed output. For quality check the output of NN can be seen in a section and after getting satisfactory result it can be applied to whole seismic volume.

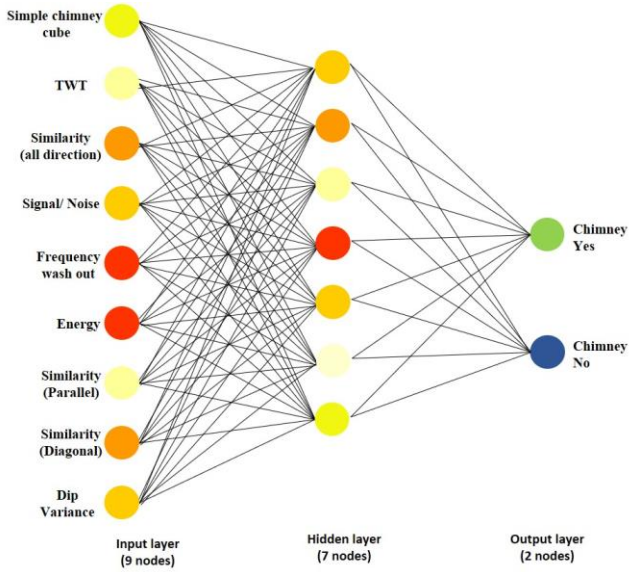

Figure 4: MLP network

Table 3: weights of the extracted attributes

Attributes	Weights
Simple chimney cube	42.0
TWT	16.7
Similarity (all direction)	80.0
Signal/ Noise	53.9
Frequency wash out	85.7
Energy	55.1
Similarity (parallel)	58.9
Similarity (diagonal)	68.9
Dip variance	76.6

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Results & Discussion

The created chimney cube clearly indicate that the source of leaked gas is from the deep reservoir (i.e. top plover formation of Jurassic age) and because of seal beach it continued its path through Jamieson formation (i.e. cap rock, Cretaceous age), Johnson formation (Tertiary age) till the seabed (please refer figure 5). In a Johnson horizon we can analyze the close relation between low similarity, which caused due to fault structures and structural deformation and high probability of chimney i.e. gas patches (please refer figure 7).

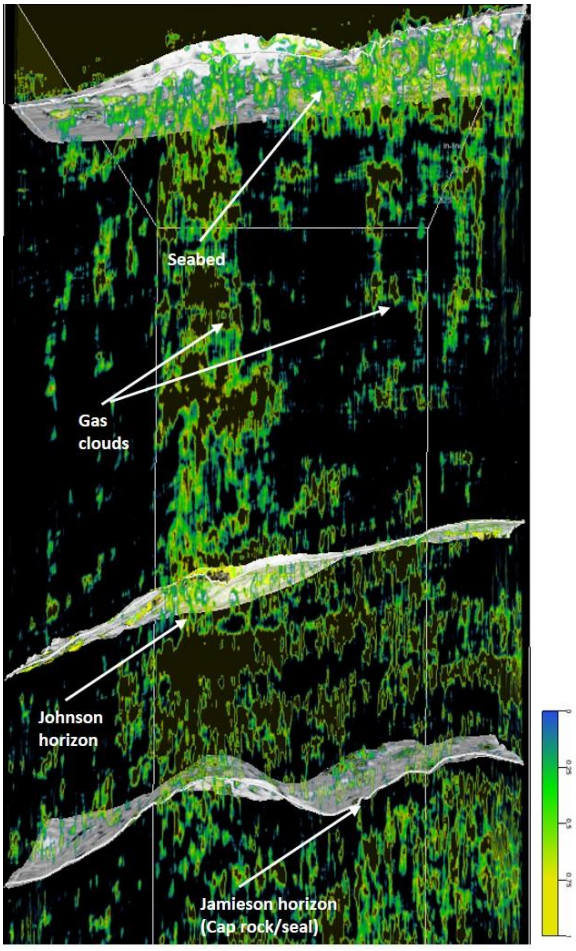

Figure 5: 3D chimney cube

The gas chimney cube can be validated by following parameters;

1) Presence of geological features

In this study area features like DHI, gas pipes and pockmarks are present, which shows that this is a plausible zone for hydrocarbon leakage and the presence of pockmarks clearly indicates that seepage of hydrocarbons are able to come up on the surface (please refer figure 6).

2) Carbonate growth pattern/ Isolated carbonate buildups

Many authors have reported the fluid flow features in North-West shelf Australia (Tuyl et al., 2018) and the occurrence of these fluid flow features in specific areas of the late Oligocene-Miocene and their association with the Pre-Miocene faults could be possible but when it was analyzed with deeper petroleum system of browse basin, it showed remarkable semblance (Serié et al., 2012). Even hydrocarbon leakage from deeper reservoir has been reported in the near area Timor Sea (Gartrell et al., 2003), and Australian Basin (Logan et al., 2010)

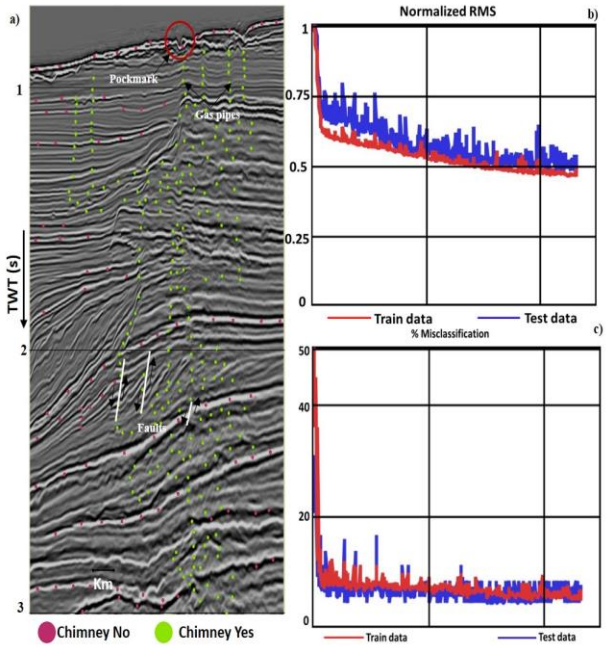

Figure 6**:** a) section (Inline: 2370)showing selected points for training the NN and graphs showing b) RMS error and c) misclassification

Detection of natural gas leakage from deep-seated reservoir

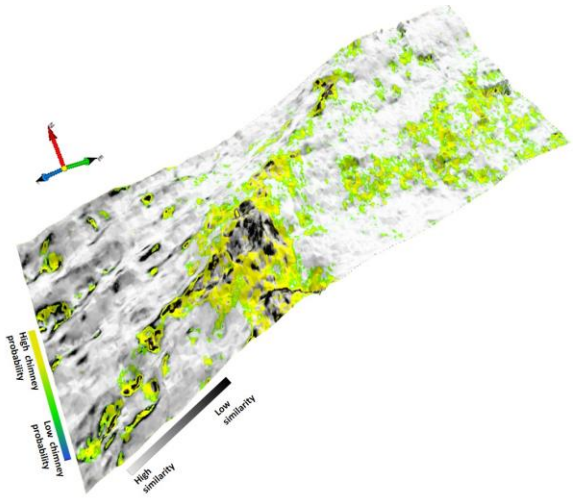

Figure 7: Chimney and similarity attributes are in conjuction at horizon slice of Johanson formation.

Conclusions

This study evidently shows that the main source of gas leakage in Poseidon area, Browse basin is from the deeper petroleum system (Breach in seal) and continued through Jamesion horizon, Johnsons horizon till the seabed. The used technique is robust and reliable for enhancing the subsurface features. The breach in seal can be attributed due to the reactivation of Jurassic faults and regional tectonic inversion that happened after the onset of subduction in the Timor Trough which resulted in highly variable style of deformation in the entire Browse basin .

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