Chimney Atlas to Quantify Top Seal and Charge Risk: Case Study from Maari Oil Field, Taranaki Basin, New Zealand

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Background

Many hydrocarbon producing basins of the world are dominated by vertical hydrocarbon migration. This hydrocarbon migration is often directly detected in the seismic record as zones of vertically aligned, chaotic, low energy data. Depending on their morphology we term these features gas chimneys, mud volcanoes, or gas clouds. Chimneys have often been observed in relationship to producing oil and gas fields. However, this relationship has not been systematically documented. Therefore, we are compiling an Atlas of chimney occurrences associated with known producing reservoirs and non-producing reservoirs which were drilled on valid structures thus failing because of a lack of effective seal or charge.

Aims

The purpose of the Chimney Atlas is to improve risk assessment for vertical charge and seal, and provide analogs for exploration prospect evaluations. The morphology of chimneys immediately *below* the reservoir provides us information about the vertical hydrocarbon charge into the reservoir. The morphology of the chimneys immediately *above* the reservoir provides us information about the top seal. A recent survey of major exploration companies determined that seal and charge were the major risks in exploration.

Methodology

Gas chimneys are detected using a supervised neural network trained on reliable examples of gas chimneys. The resultant chimney probability meta-attribute can then be displayed on key seismic lines. Not all chimneys, detected by neural network training, are related to hydrocarbon migration. Thus the resultant chimneys must be validated based on a set of criteria (Connolly et al., 2013). Valid chimneys can then be output as 3D geo-bodies, and superimposed on 3D reservoir geo-bodies (based on seismic facies attributes).

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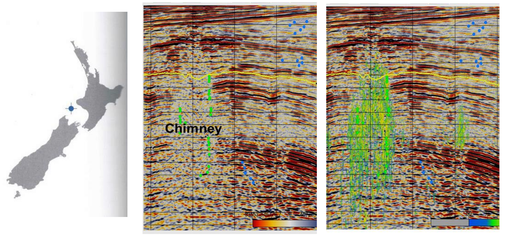
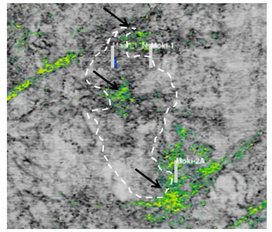
Typical Chimney Atlas Example: Maari Oil Field, Eocene Moki Reservoir

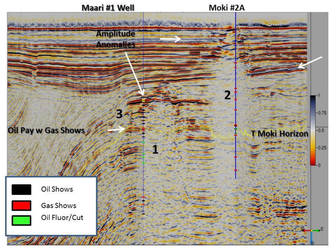


1a. Location

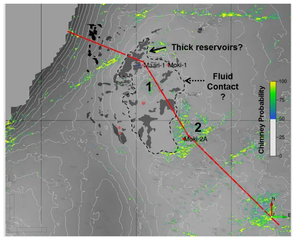
2a. Key line showing example of chimney used in NN training.



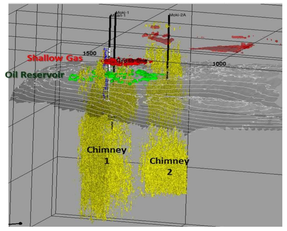
3a. Validation Criteria: pock mark morphology on time slices.



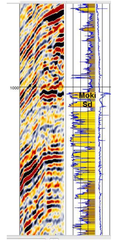
4a. Key un-interpreted line through producing wells and non-producing wells.



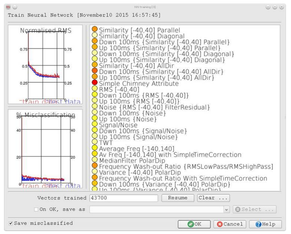
5. Vertical Seal: Horizon 200m *above* Moki Reservoir shows no chimneys above main reservoir (gray).



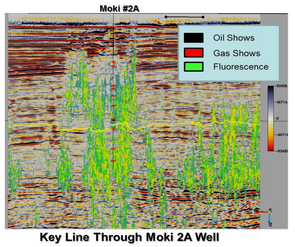
7. 3D Image of reliable chimneys linked to reservoir geo-bodies, or pay.



1.b. Reservoir.

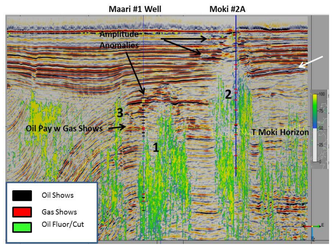


2b. Results of Neural Network Training: Seismic Attributes most critical to NN training in red to orange.

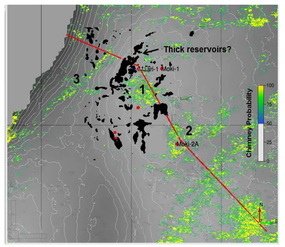


Key Line Through Moki 2A Well

3b. Validation Criteria: Link to shallow DHI's & Well Shows.



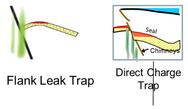
4b. Key interpreted line through producing wells and nonproducing wells.



6. Vertical Charge: Horizon 200m *below* Moki Reservoir shows chimneys providing charge to reservoir.

Maari Oil Field: Miocene Moki Reservoir
Trap: Compressional Anticline
Reservoir: Miocene Sands
Depth: 1200-1600 m
Production: Oil w Associated Gas
Initial Field Production: 40000 bopd
Reservoir Pressure: Normal
Hydrocarbon Column Height: 55 m to spill?
Origin of Chimneys: Cretaceous / Eocene
Seal Litho-facies: Marine deepwater clays
Reservoir Litho-facies: turbidite sands

Classification:



8. Summary & Classification

Conclusion

A worldwide Chimney Atlas is being compiled to document the seismic character of gas chimneys associated with known oil & gas discoveries and dry holes with effective reservoir and trap. A typical Atlas entry will focus on a specific reservoir/trap, and will include: 1) information on reservoir; 2) key interpreted and un-interpreted seismic lines which best show the chimneys; 3) the criteria used in validating the chimneys; 4) a horizon, or time slice *above* the reservoir showing the character of leakage; 5) a horizon or time slice *below* the reservoir showing the character of charge; 6) a 3D image of the chimneys in direct communication with the reservoir; 7) a classification based on the morphology of the chimneys above and below the reservoir. The results of this Atlas will be used to improve the risk assessment for vertical charge and seal and provide analogs for exploration & development prospect evaluations.

Key References

Connolly, D., Aminzadeh, F., Brouwer, F., and Nielsen, S., 2013, Detection of Subsurface Hydrocarbon Seepage in Seismic Data: Implications for Charge, Seal, Overpressure, and Gas-hydrate Assessment, *in* F. Aminzadeh, T. Berge, & D. Connolly, eds., Hydrocarbon Seepage: From Source to Surface, SEG AAPG Geophysical Developments no. 16, p. 199-220.

Heggland, R., 2013, Hydrocarbon Trap Classification Based on Associated Gas Chimneys, *in* F. Aminzadeh, T. Berge, & D. Connolly, eds., Hydrocarbon Seepage: From Source to Surface, SEG AAPG Geophysical Developments no. 16, p. 221-230.