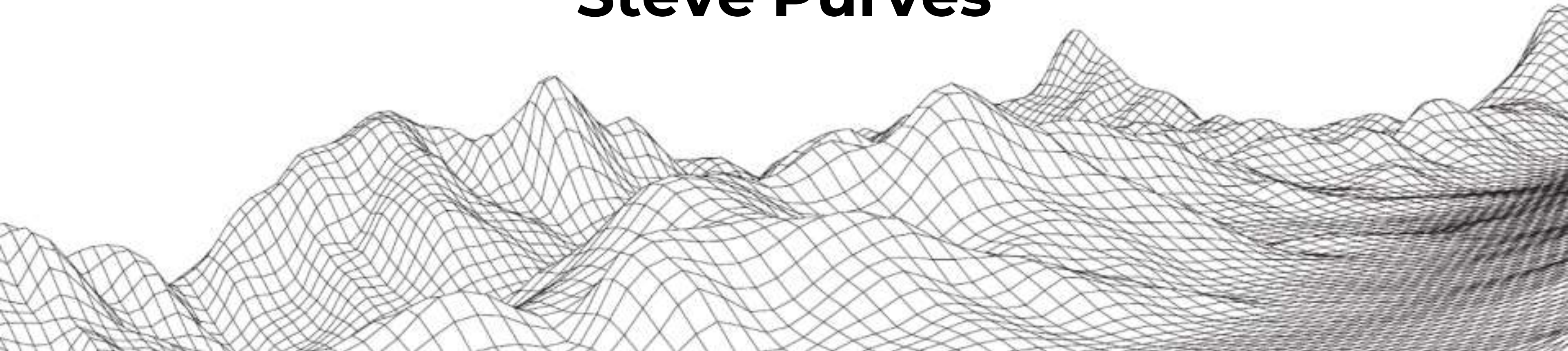
Incorporating Uncertainty in Automated Seismic Interpretation; Geobody Volumetrics

Steve Purves



Introduction

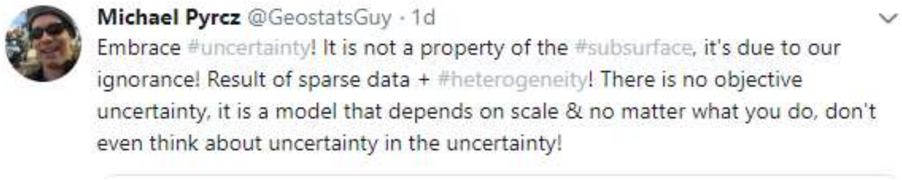
- ML based seismic interpretation in an exploration context
- Uncertainty analysis in deep learning models
- Discuss how the additional information provided by machine learning can impact on volume estimates via examples on a well known dataset

Subsurface Uncertainty

The subsurface is not uncertain.

What is uncertain is our measurements and models of the subsurface.

It is the uncertainty of these that we need to in turn model and work to quantify as well as understanding their accuracy.

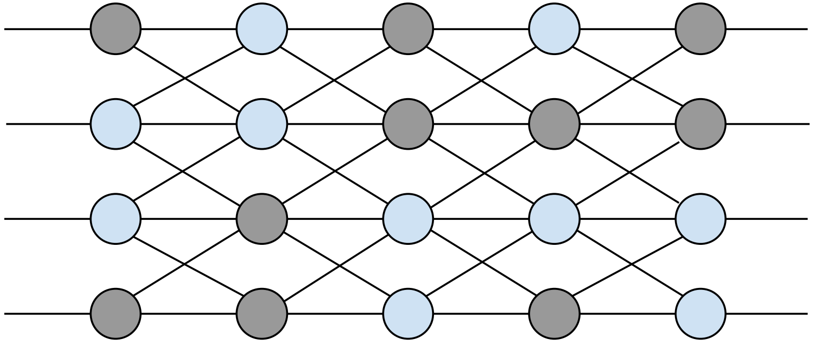


Uncertainty in Deep Learning

Dropout as a Bayesian Approximation: Representing Model Uncertainty in Deep Learning. Gal, Ghahramani. 2015 (rev. 2016) [https://arxiv.org/abs/1506.02142]

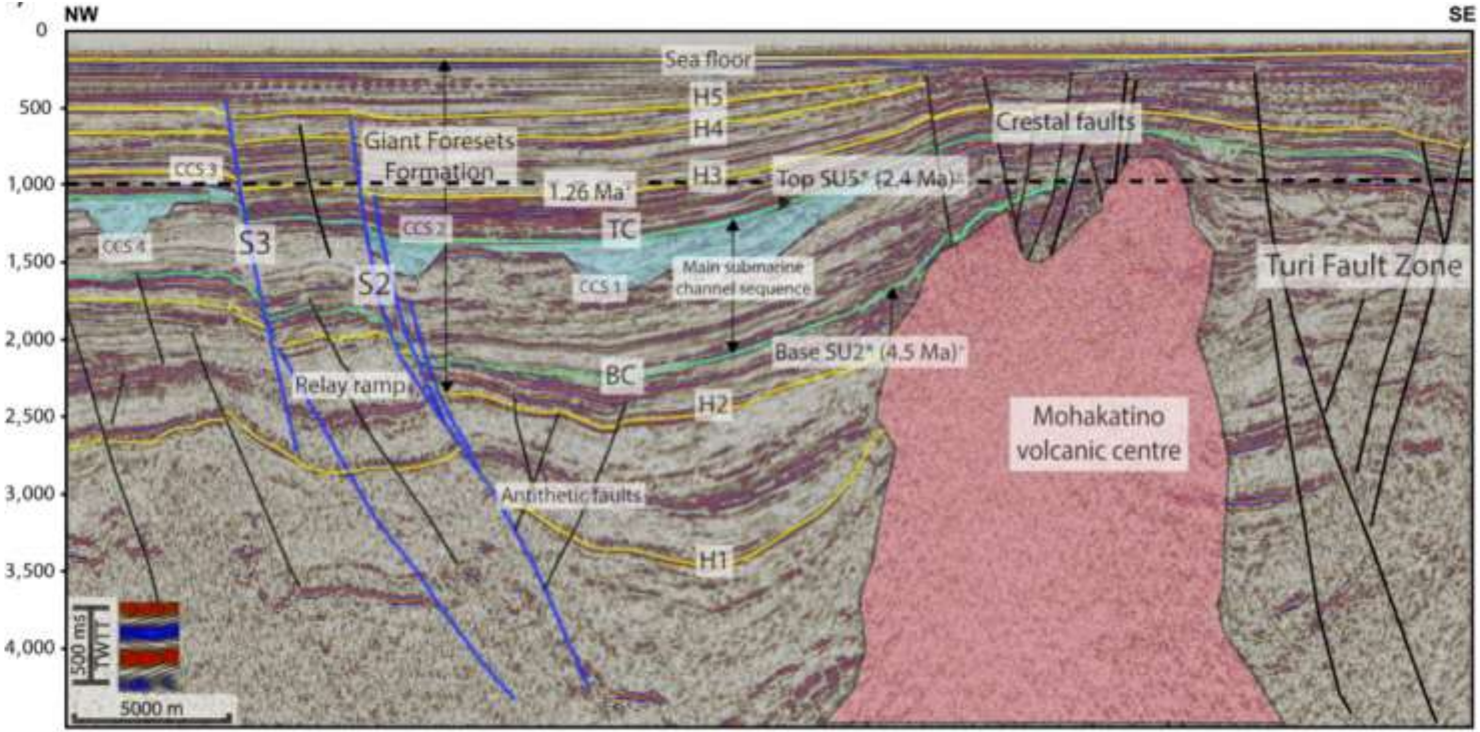
Probabilistic Seismic Facies Classification. Mosser, Stevenson, Oliveira. FORCE Seminar 2018 [https://doi.org/10.5281/zenodo.1466917]

Dropout randomly disables X% of units in a network during training.



MC Dropout applies 50% dropout at training and prediction time to approximate a random process (Bernoulli Distribution)

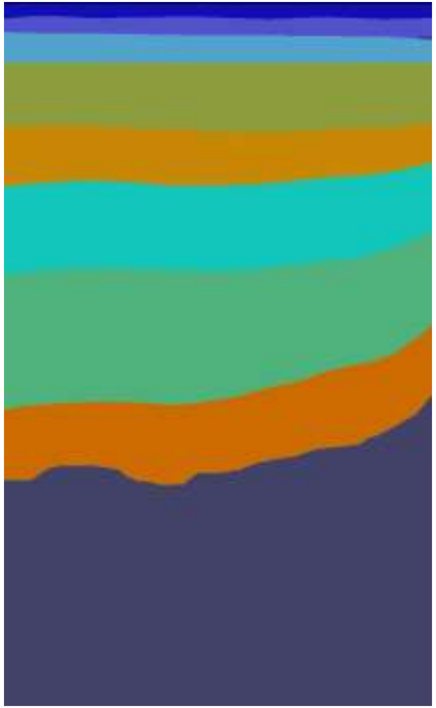
New Zealand - Taranaki Basin

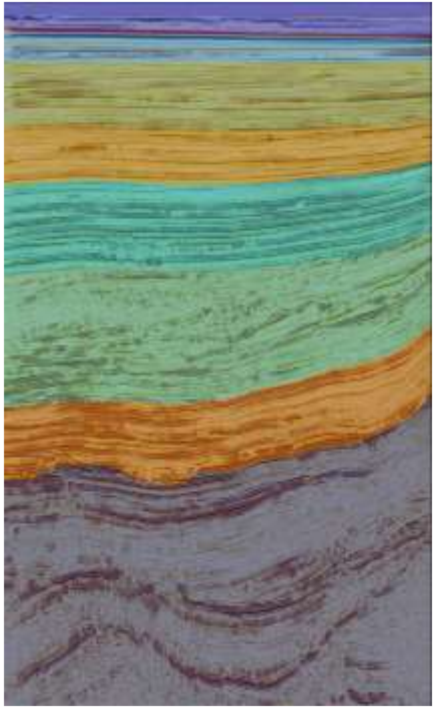


Thanks to New Zealand GNS for providing the open seismic dataset

Reproduced from Mattos, Alves & Scully 2018

Lithostratigraphic Unit - Labelling



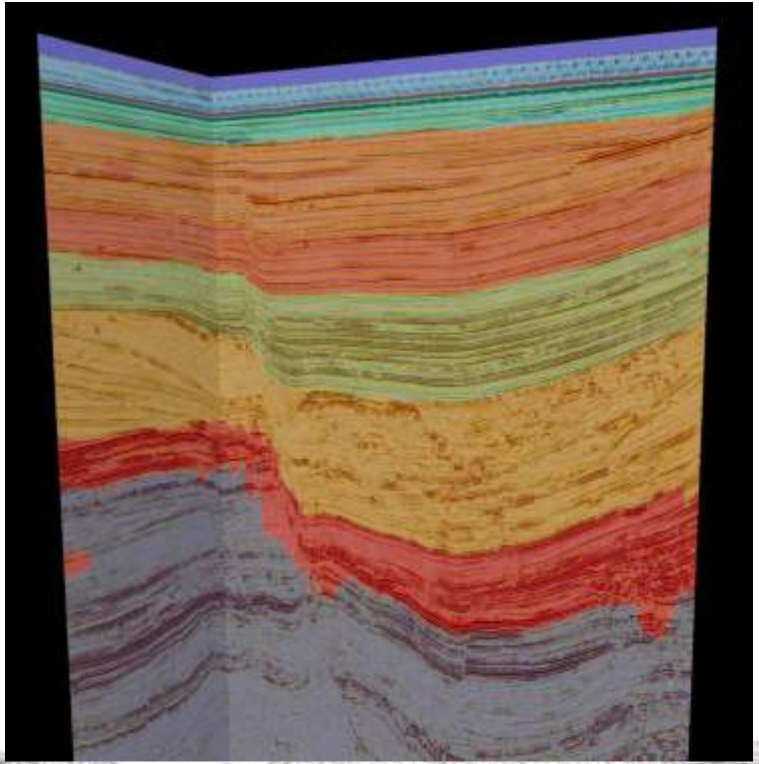


Lithostratigraphic Predictions

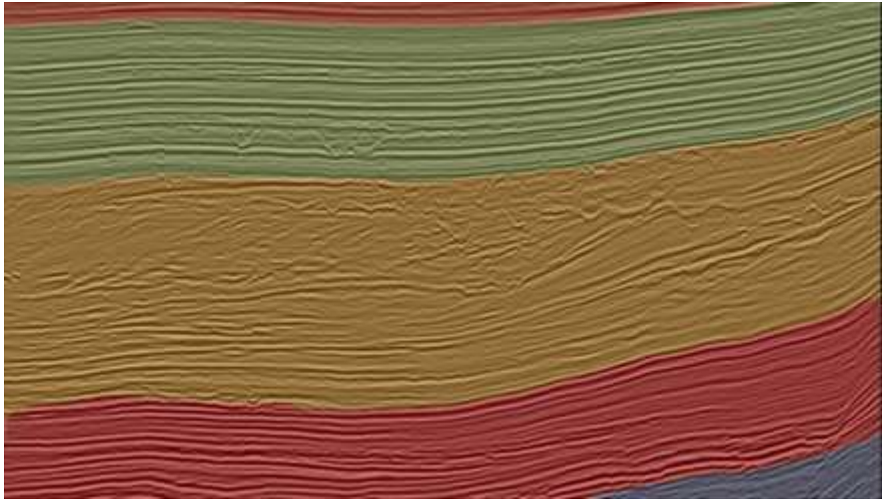
Example labels

Inline Prediction

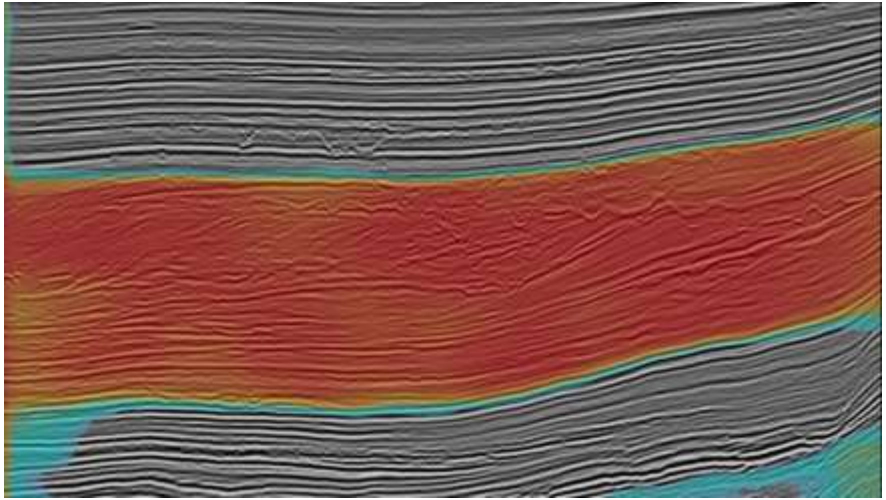
Crossline Prediction



200 Realisations - Lithostratigraphy



Predicted lithostratigraphy classes (orange) clinoform package



Frequency (occurrence, voxel-wise) for clinoform package

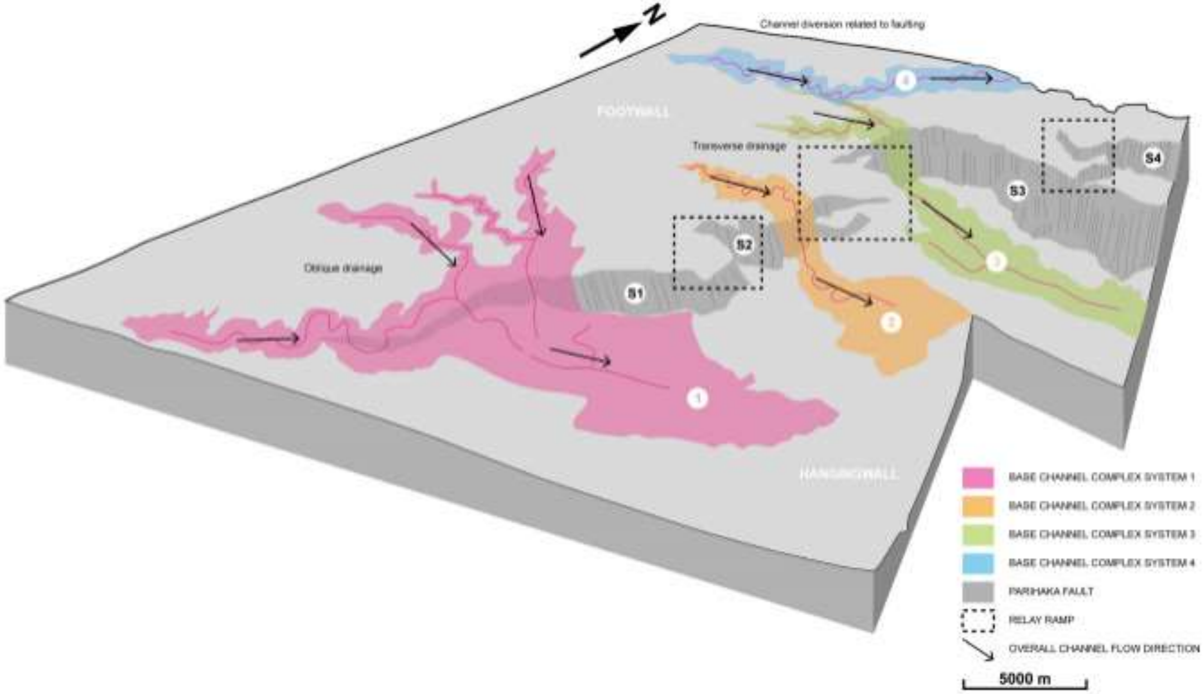
Gully Systems

Potential stratigraphic traps

Complex geomorphology

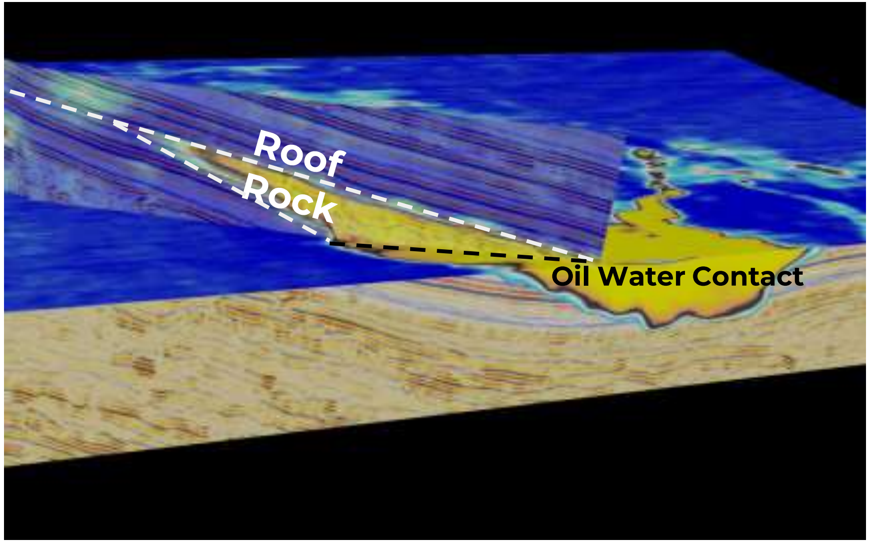
Varying infill response

Extensive and difficult to pick



Reproduced from [Mattos, Alves & Scully 2018]

The Objective



$\color{red}{HCIIP} = \color{green}{GRV} \times N/G \times POR \times S_{hc} / FVF$

HCIIP = **hydrocarbons in place***

GRV = **gross rock volume**

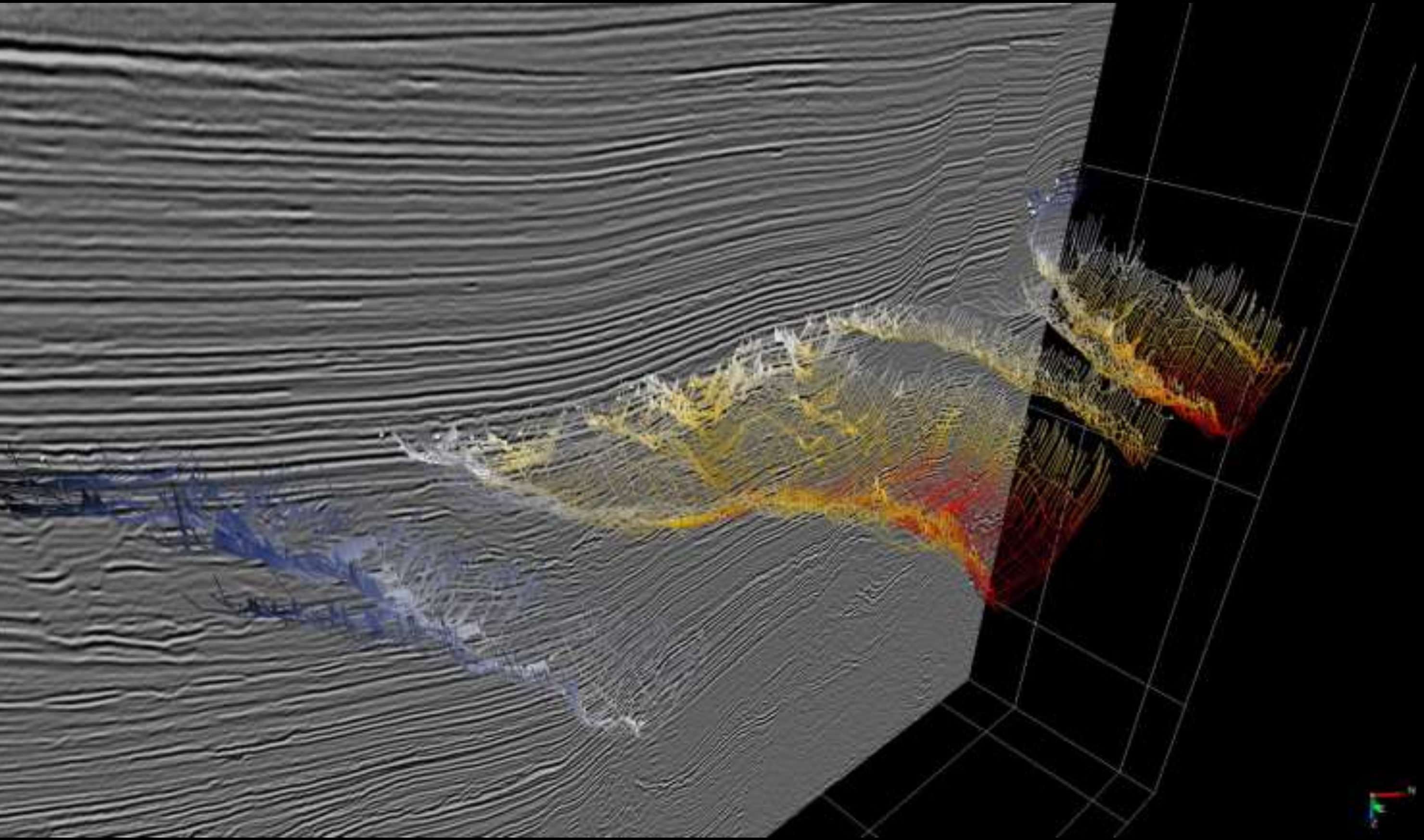
N/G = **net / gross ratio**

POR = **porosity**

S_{hc} = **hydrocarbon saturation**

FVF = **formation volume factor**

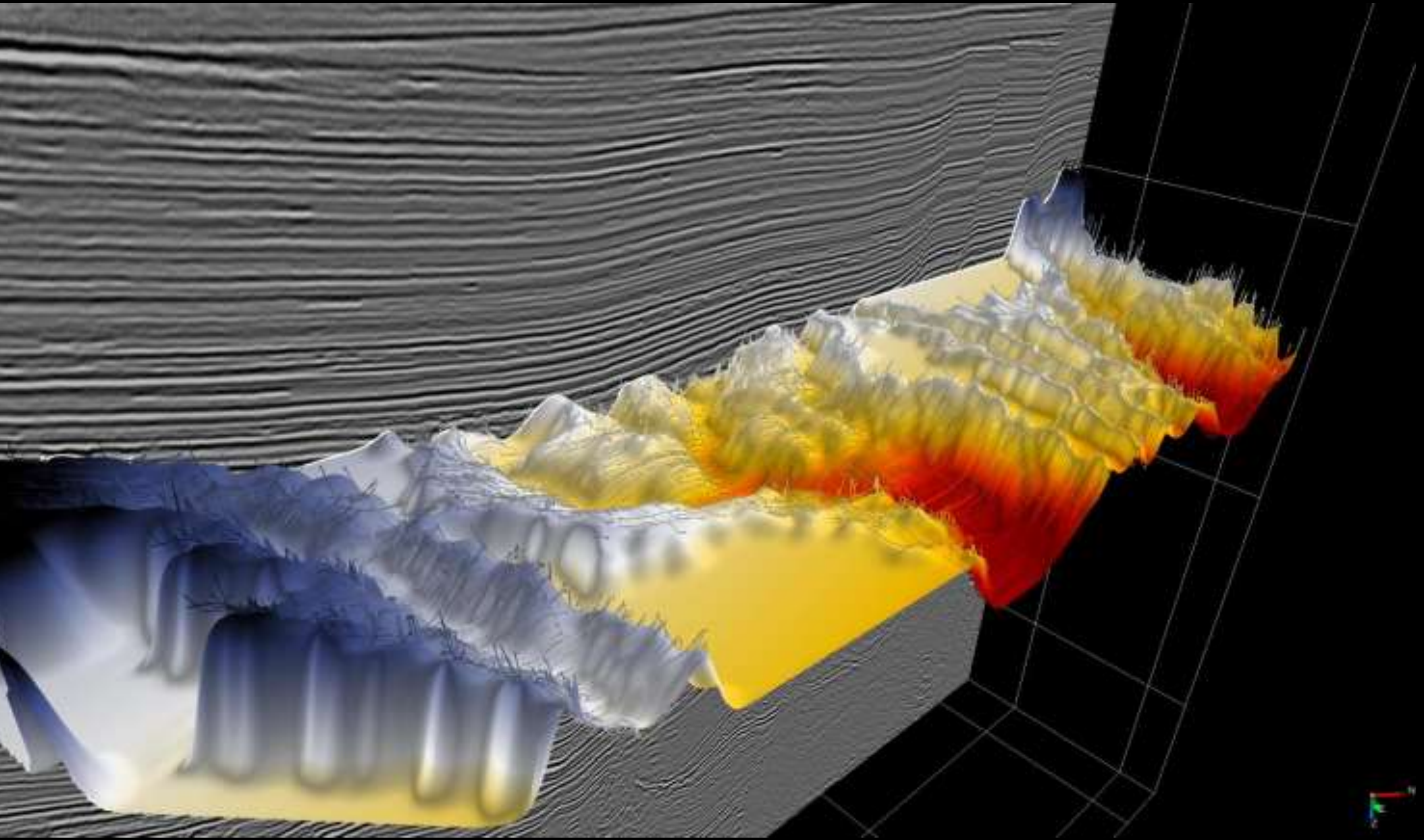
*of oil, solution gas, free gas, condensate and normal surface conditions



Interpretation of complex geobodies

hard-to-track basal surfaces

Manual (point) interpretation in traditional software takes time and is prone to errors



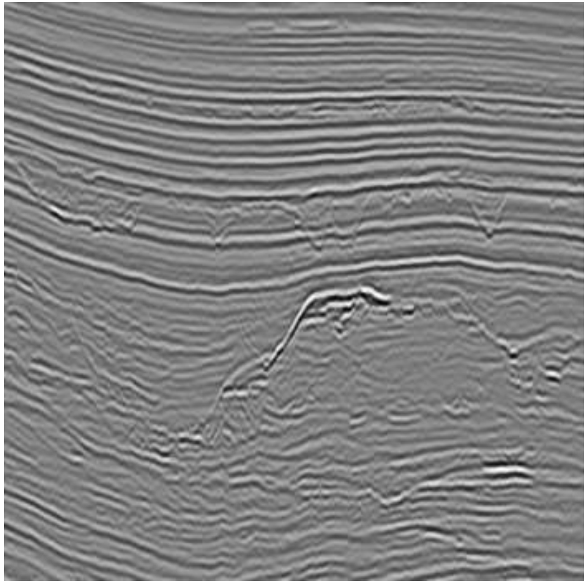
Interpretation of complex geobodies

hard-to-track basal surfaces

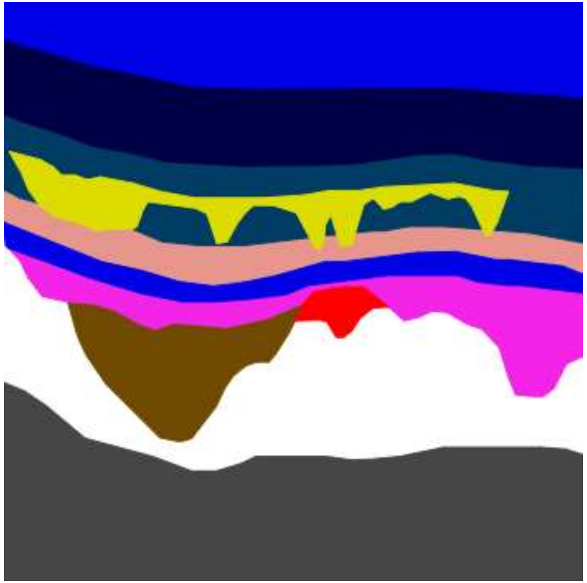
Manual (point) interpretation in traditional software takes time and is prone to errors

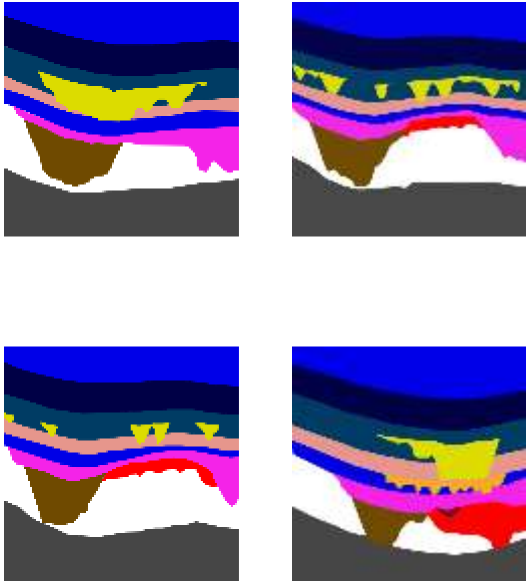
Gridding of manual (point) interpretation suffers from picking inconsistency

Gullies Labels

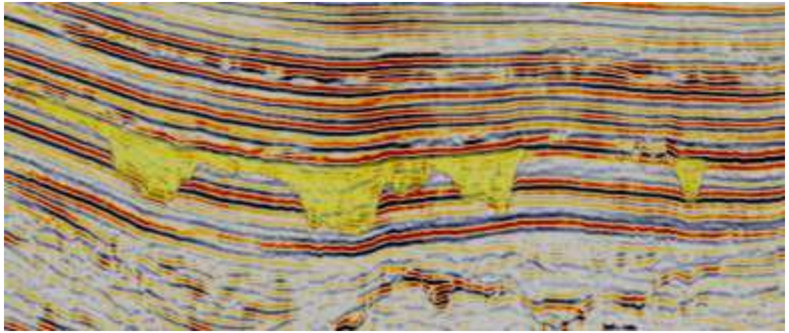


XI4910 - crop

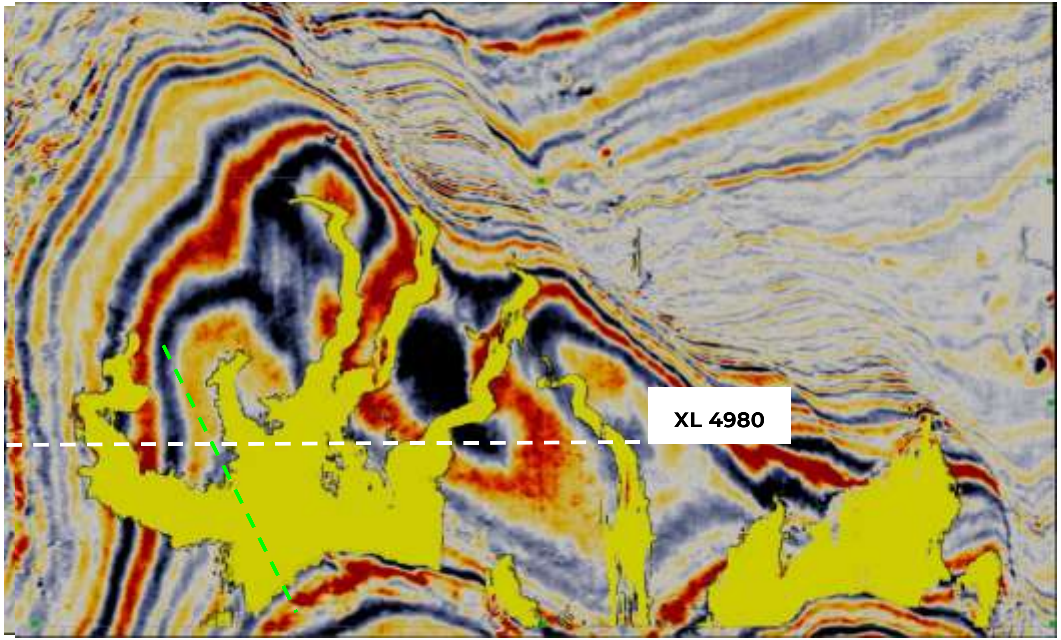




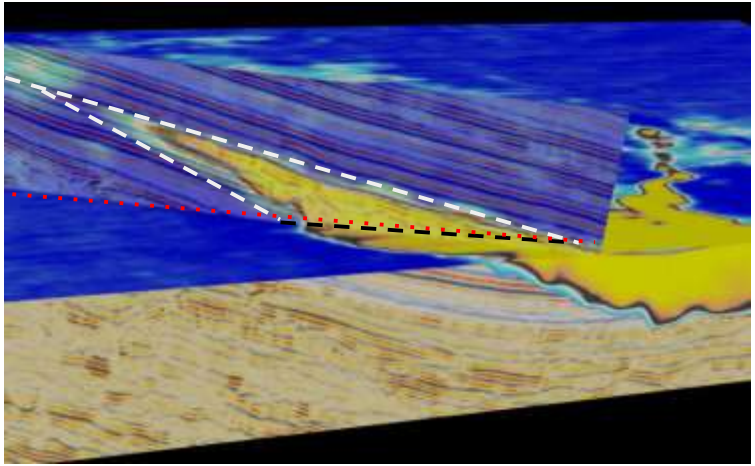
Gullies Prediction



XL 4980

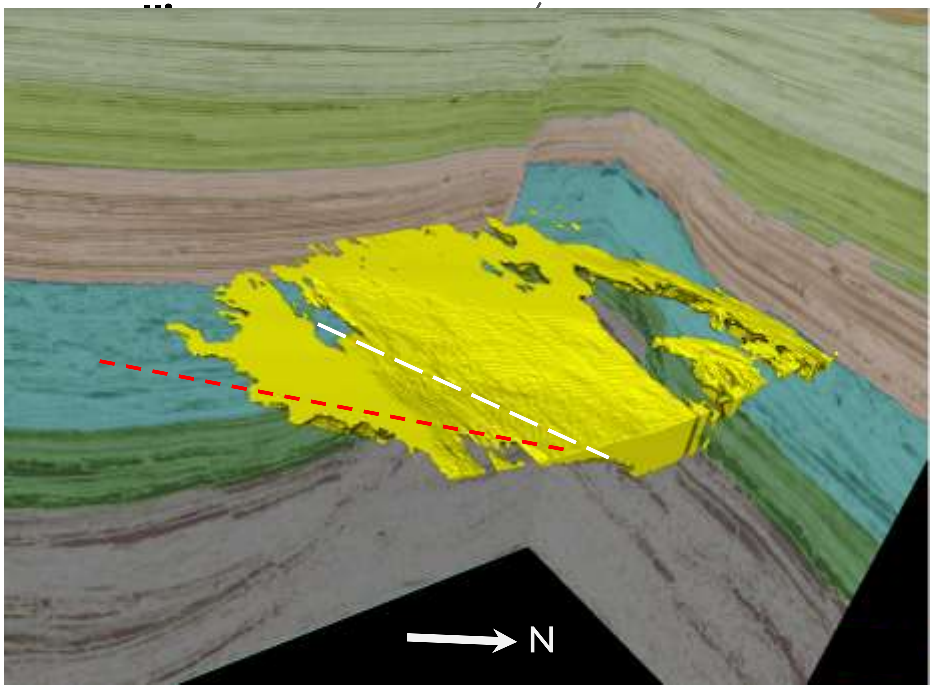


Isolating Potential Trap



(yellow) average across a number of realisations

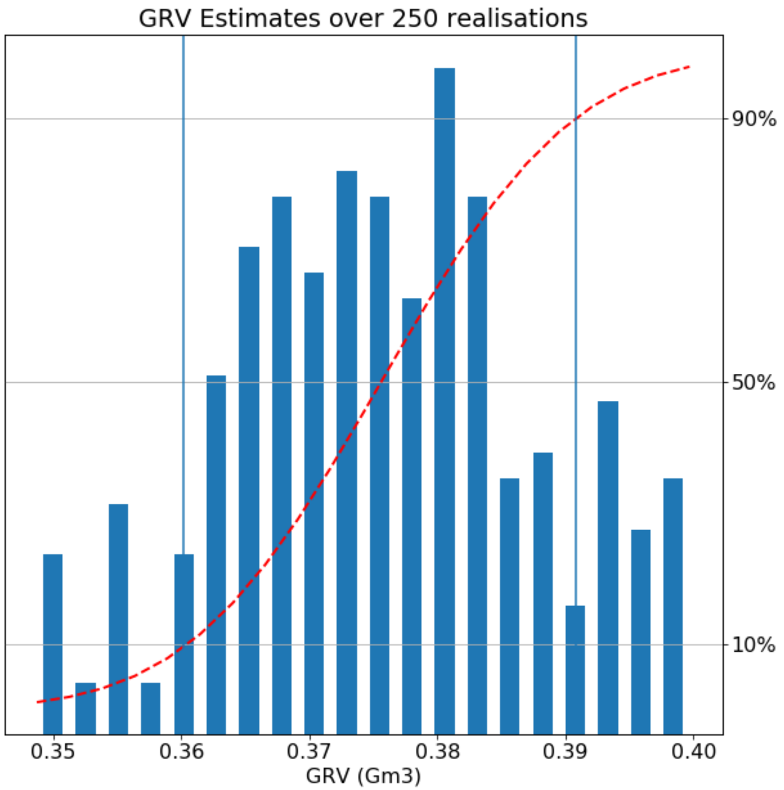
Saddle point between N & S feeding

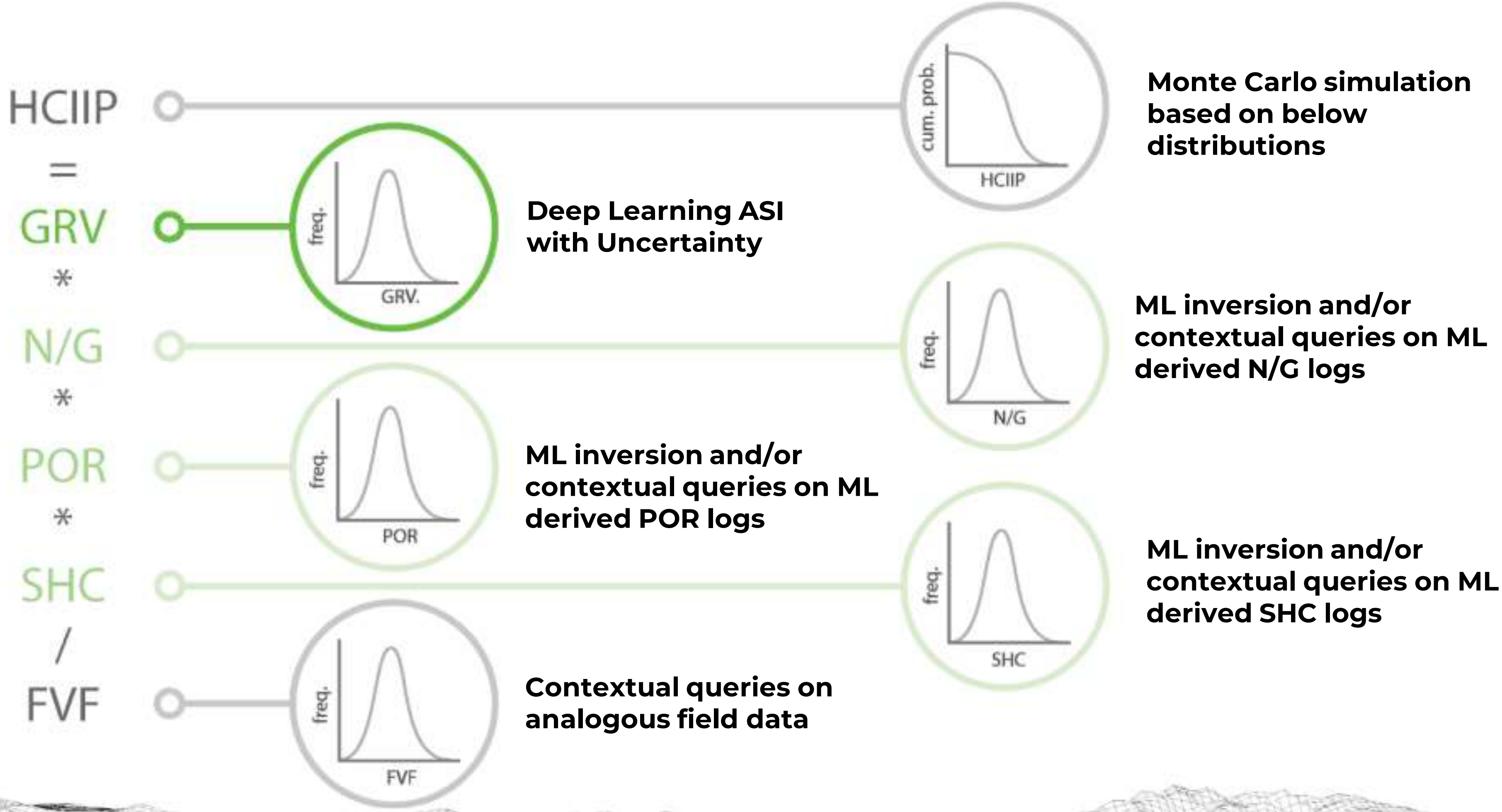


GRV Estimate for Gully

- 250 realisations using Monte Carlo Dropout
- Cropped at Oil/Water contact 1248ms
- Created stacked volume & examined the bounding geobody
- Created a bounding polygon & calculated GSV in this area for all realisations
- (p10=0.360, p90=0.391) Gm3

Training Time: 3 hours
Prediction: 1 min / realisation




HCIIP
=
GRV
*
N/G
*
POR
*
SHC
/
FVF
cum. prob.
HCIIP
Monte Carlo simulation based on below distributions
freq.
GRV.
Deep Learning ASI with Uncertainty
freq.
N/G
ML inversion and/or contextual queries on ML derived N/G logs
freq.
POR
ML inversion and/or contextual queries on ML derived POR logs
freq.
SHC
ML inversion and/or contextual queries on ML derived SHC logs
freq.
FVF
Contextual queries on analogous field data

Conclusions

- Various approaches to introducing model uncertainty in ML methods (MC Dropout demonstrated here). These type of methods will be prevalent in approaches to ASI.
- This enable us to look a significantly more variation in static models than scenario analysis can achieve
- We will be generating interpretation data with quantification of uncertainty for probabilistic volumetrics
- Generate multiple realisations for flow simulation

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