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# The Analysis of Meaningful Uncertainty in Pore Pressure Prediction

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## SUMMARY

Pre-drill pore pressure models are typically obtained using offset well data and seismic velocities. The workflows used to generate these pressure models are, actually, relatively straightforward and the algorithms used, not complex. However, this is deceptive as there are very many other factors, not just simple-to-understand or visualise issues such as data quality etc, that can mean that the results produced are inaccurate, and at worst, potentially dangerous. One of keys questions therefore is how to reduce the overall uncertainty such that the final pore pressure range is as small as possible. Perhaps the ultimate achievement would be to say what the odds were of the highest modelled pressures “coming in”, rather than saying it’s “possible”.

This paper therefore will aim to explain and define meaningful uncertainty, whether this is purely in data itself, the choice of algorithms we choose and investigate how or if statistics can play an important part. An important conclusion however, is that if statistics are to be used, they need to be sensibly applied, and then this approach needs to be run in parallel with a geological approach. The two together can be adding confidence that “you have done the best possible job”.

## Introduction

Pre-drill pore pressure models are typically obtained using offset well data and seismic velocities. The workflows used to generate these pressure models are, actually, relatively straightforward and the algorithms used, not complex. However, this is deceptive as there are very many other factors, not just simple-to-understand or visualise issues such as data quality etc, that can mean that the results produced are inaccurate, and at worst, potentially dangerous. One of keys questions therefore is how to reduce the overall uncertainty such that the final pore pressure range is as small as possible. Perhaps the ultimate achievement would be to say what the odds were of the highest modelled pressures "coming in", rather than saying it's "possible".

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## Current Industry Approach

As a rule, the industry follows/adopts the following approach to designing a well for pore pressure;

- Standard practice is to provide at least two cases for pore pressure. These are often called the "Expected" and High cases.

- Often a water-wet case or cases are constructed then iterated as fluid status changes i.e. a base case estimate of shale pressure with oil charged reservoirs, a low case shale pressure with water wet reservoirs & a high case shale pressure plus maximum columns of hydrocarbons

- Some observed examples of how uncertainty is handled includes generating cases that can be based on various iterations of seismic velocity data, Eaton vs. Bowers to provide a range, "Scenario-Modeling", Standard Deviation (1σ, 2σ) , Monte Carlo (P10, P50, P90) and output from basin models.

- As a general comment, often predictions are made where the uncertainty is clearly done without much thought or care. An example of this would be using the range in a data type such as density from all available wells rather than from only those that are genuine analogues.

## An approach to meaningful uncertainty

The first task is to recognise and understand how the data were acquired in the first place, such as seismic data, and how it was processed and collated. Following this an assessment of data limitations to provide an answer to "the task in hand" must be made. For instance, if the geology at a prospect location is substantially different to that experienced by the offset wells, then even a robust offset dataset may be of little use. The maturity of the basin is part of this phase of the assessment. The more drilled a basin is, the more accumulated knowledge there will be to help reduce uncertainty.

Next, which inputs are likely to have the most significant effect if associated uncertainties are propagated though the model. The model inputs can be a specific data type i.e. density or an interpretation of data i.e. a fluid gradient or overburden, each with an intrinsic uncertainty of differing magnitude.

Thirdly, the choice of pore pressure algorithm itself can impact or constrain the final pore pressure model simply due to the mathematical nature of the relationship used. This is particularly true of shales, where "human" influence such as the definition of an NCT can introduce additional bias.

Finally, what is the applicability of standard statistical techniques to the uncertainty process, for instance the Monte Carlo simulation for shales? Can we accurately compare different models and thus improve on the "Scenario" approach where a High Case "exists" rather than being mathematically "risked".

Further, is there a way to improve on Monte Carlo where there is no attempt to understanding the inter-dependency of each input – for example if there is accurate porosity and velocity information available, this will constrain what is most likely in a range of density data. To this end, approaches such as those using Bayes which examine inter-dependence may offer new opportunity to understand, examine and quantify uncertainty.

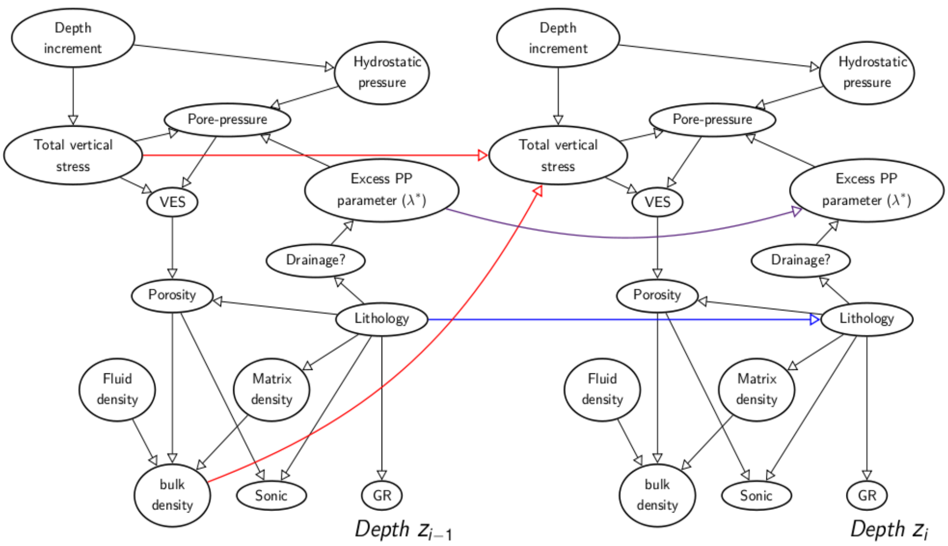


***Figure 1*** *Two consecutive levels of the sequential dynamic Bayesian network ("SDBN") are shown above. The main advantage is the inter-dependency of each input.*

**Conclusions**

We propose that best practice for pore pressure should use an integrated approach, one where it's not just the data which is queried, but also that the process itself, including how the mathematical nature of the algorithms we chose may actually constrain the output itself.

A combined "geological" and "statistical" approach is recommended that may offer some advantages over "Scenario" models.

We also highlight how using an approach where the entire system is modelled as in Bayes theorem may provide a valuable tool for the future.