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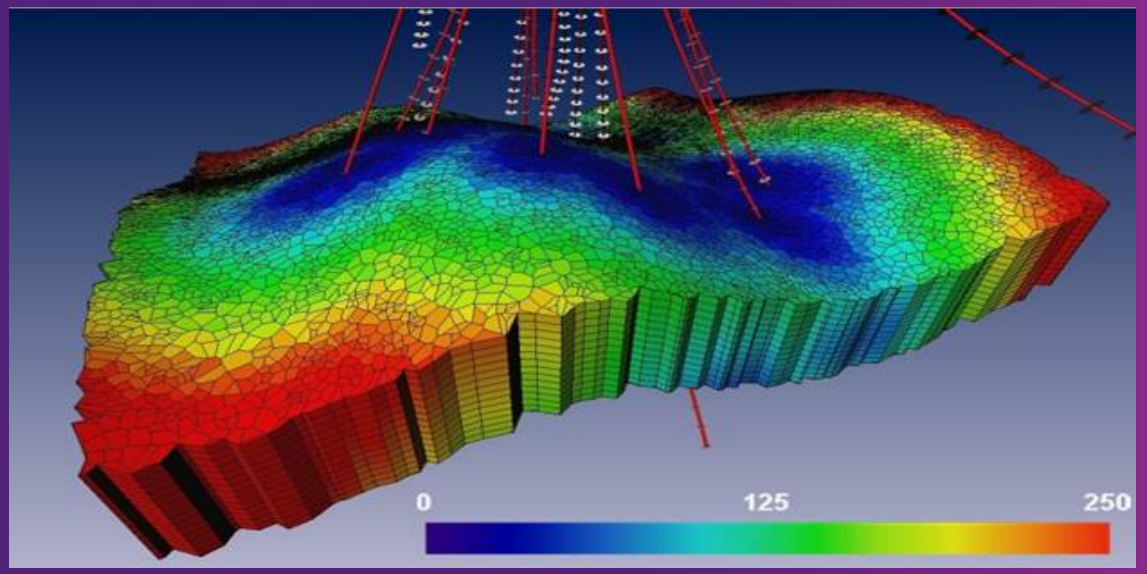
CREATE CHANGE



https://www.quora.com/What-is-the-difference-between-reservoir-simulation-characterization-and-modeling

Integrated Reservoir Modelling: Quo Vadis?

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Centre for Coal Seam Gas (UQ, APLNG, Arrow Energy, Santos)

Queensland Exploration Commission Forum; 26 February 2019

Outline

Uses of reservoir modelling for petroleum industry

Integrated Reservoir Modelling

How can modelling and models be improved?

Two examples on how to better use existing data:

1. Methodology for correlation (how to tie data into a framework)
2. How to distribute properties in our models (geostatistics)

Summary and Conclusion

Why do we build models?

Estimate reservoir (hydrocarbon) volume

Estimate uncertainty

Identify flow units, map their continuity

Perform simulations of fluid flow to estimate possible rates of extraction, well pattern, inter-well distances.

Ultimately, to make decisions.

Available Data (different scales)

Outcrop

Core

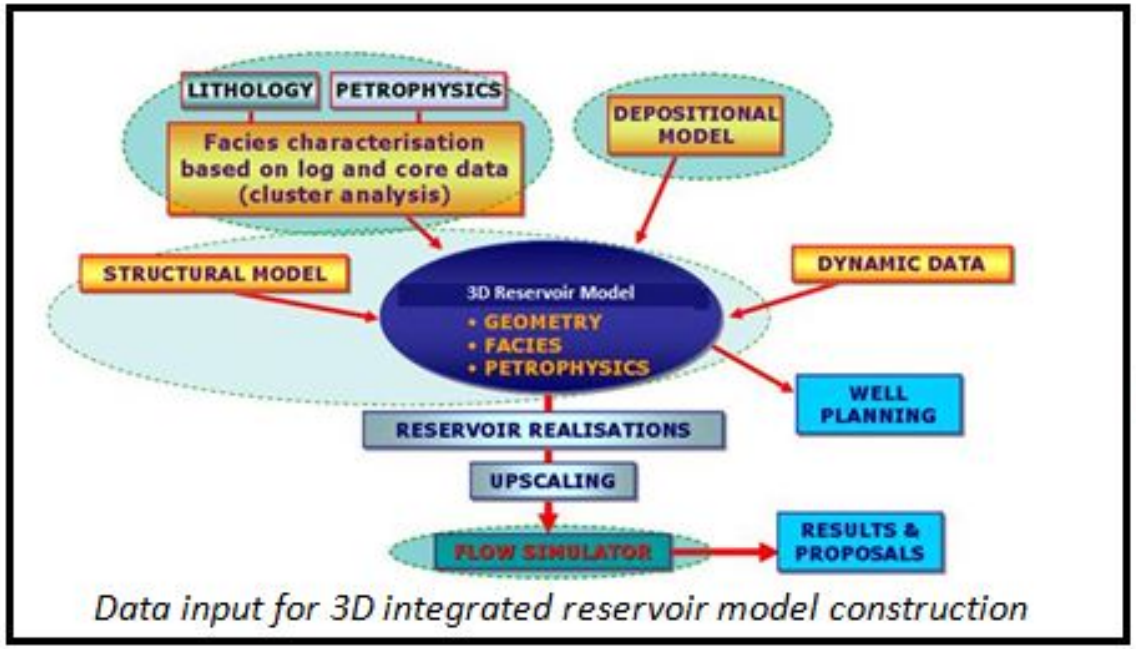
Wireline logs

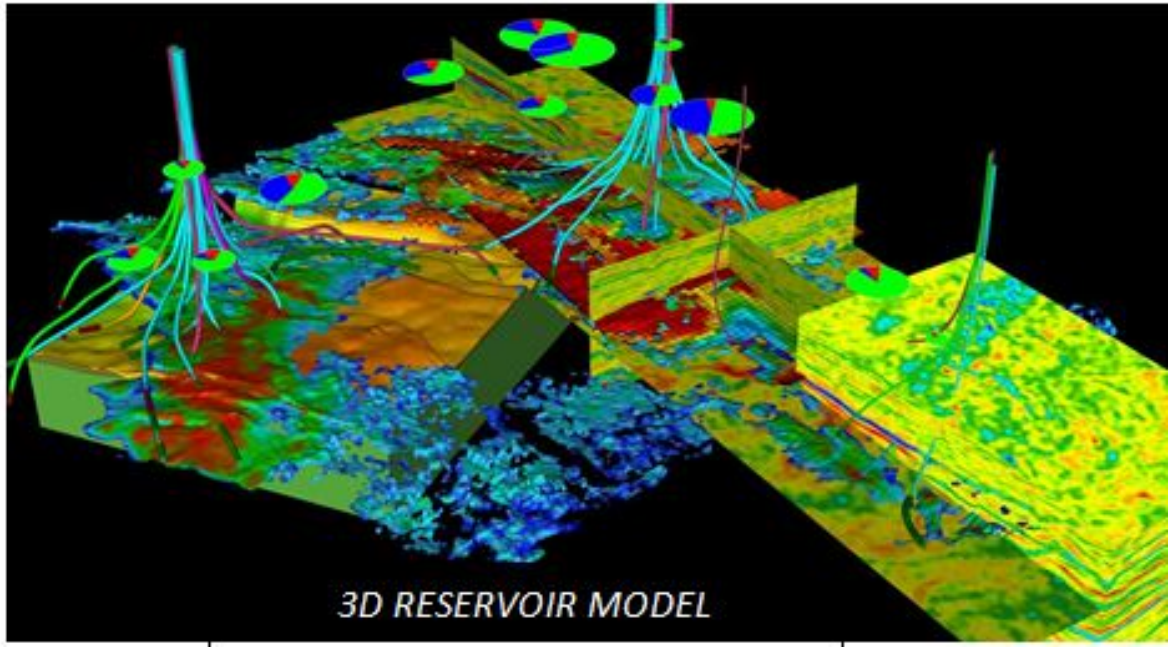
Seismic

Event ages based on fossils or radiogenic age dates

Well tests

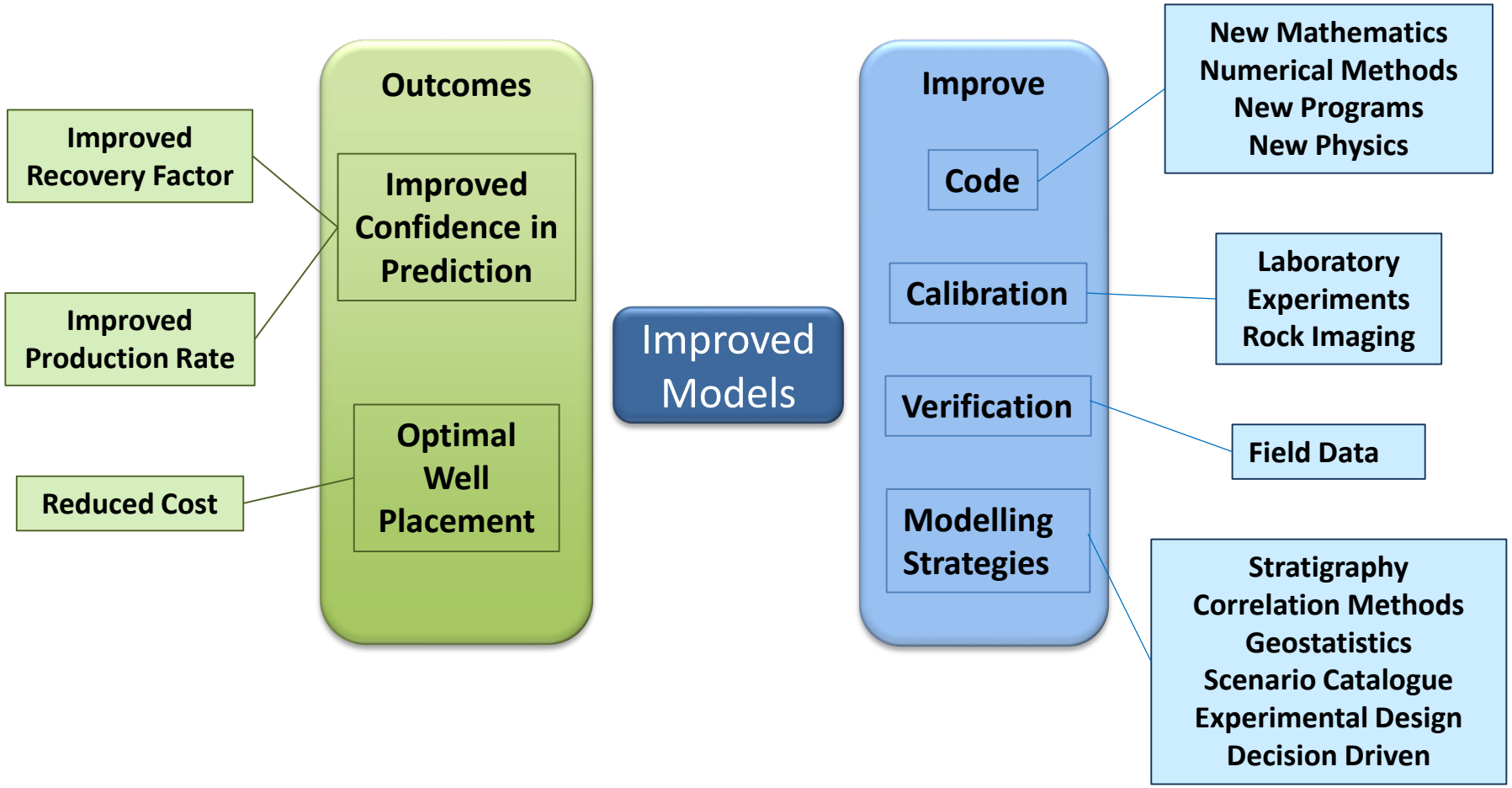
Integrated Reservoir Modelling





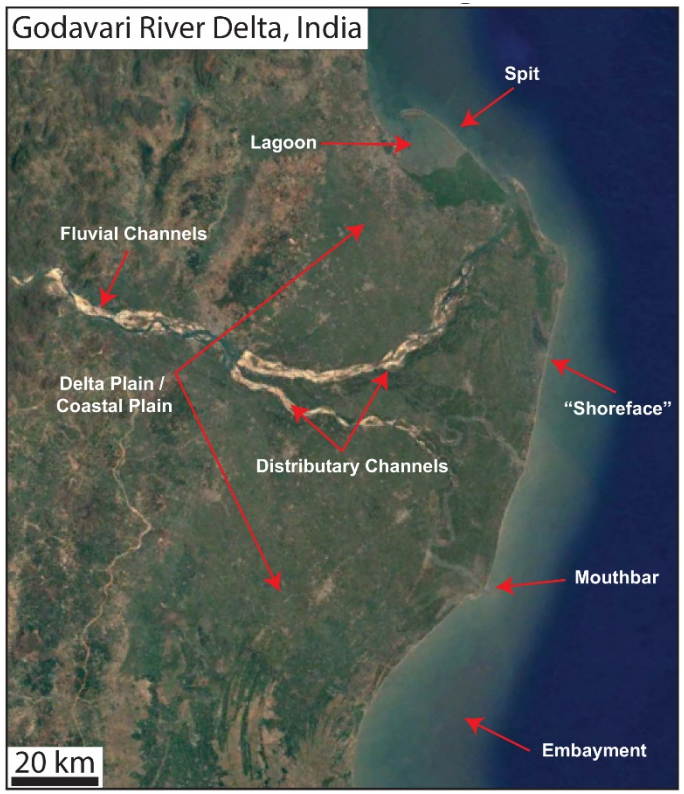
www.oil-gasportal.com

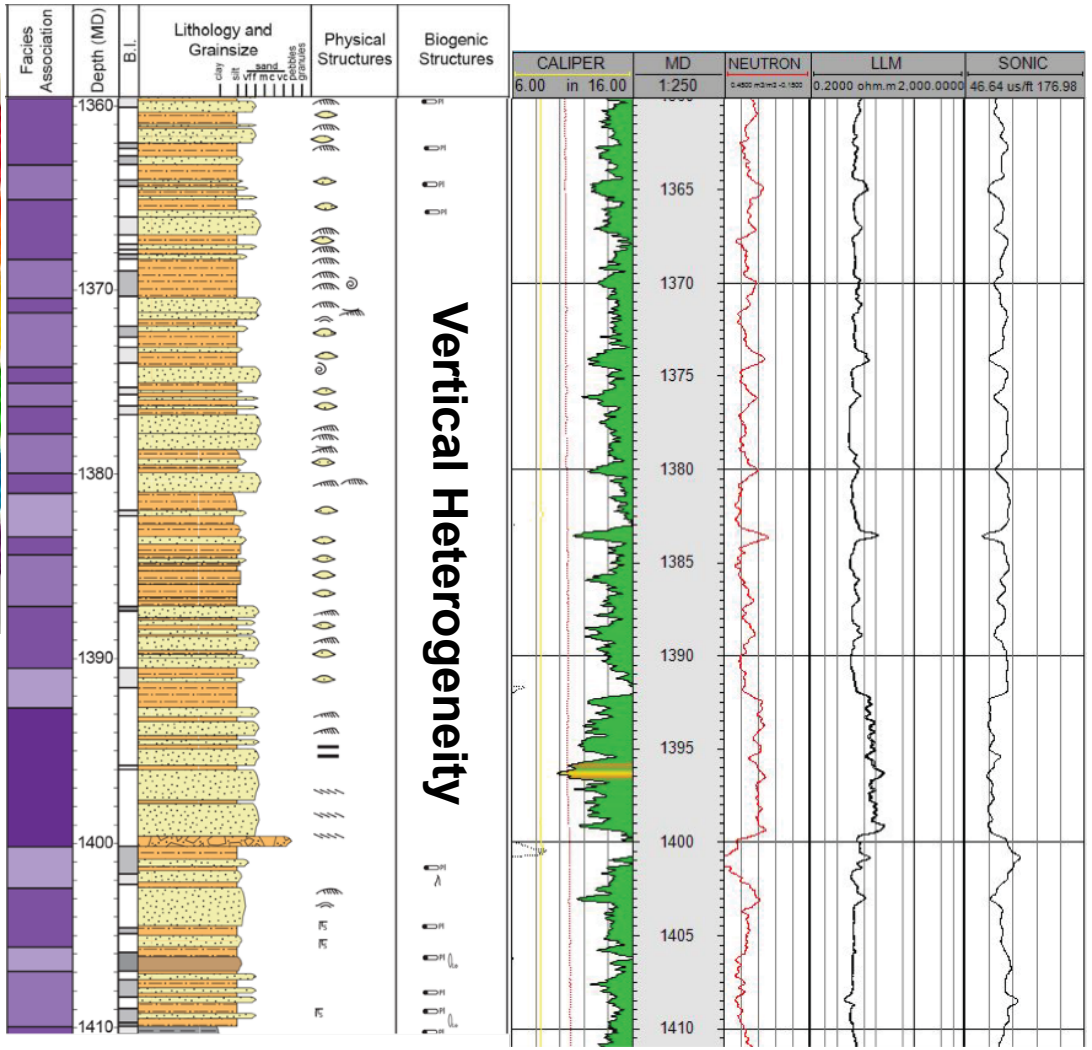
Reservoir Simulation



Heterogeneity and Building Static Models

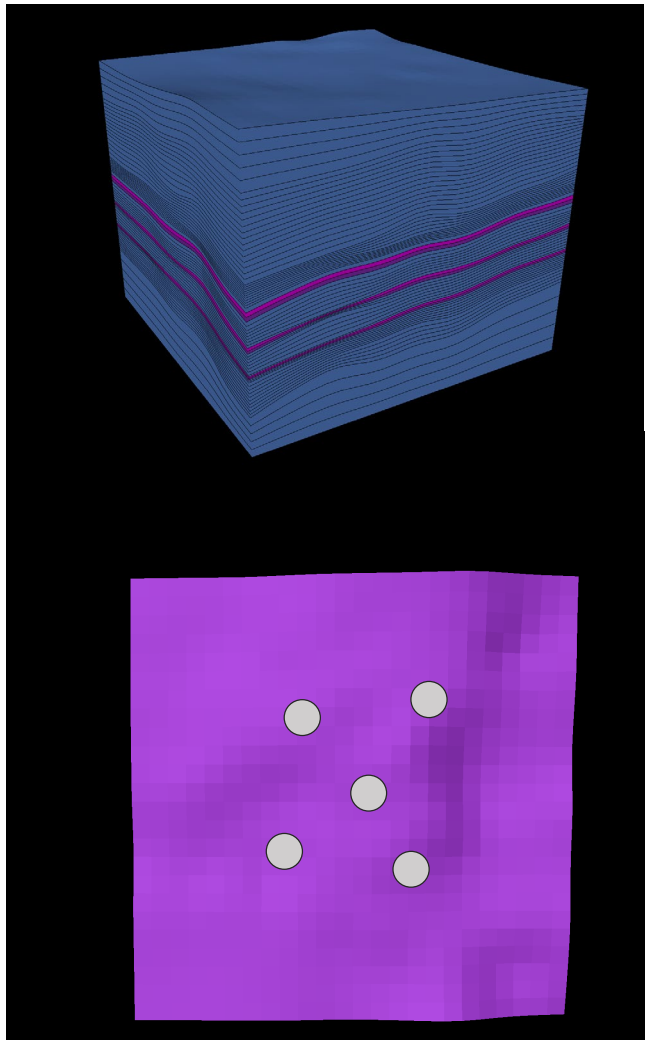
Horizontal Heterogeneity

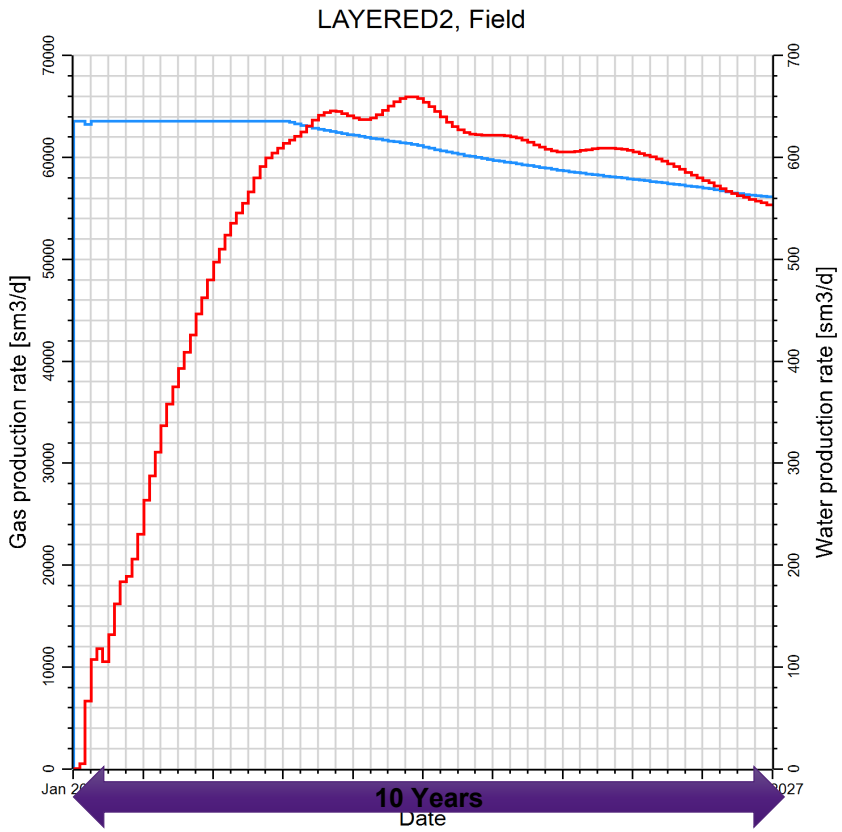




Layer Cake Model for water and gas production

Laterally homogenous model of coal seams (purple)

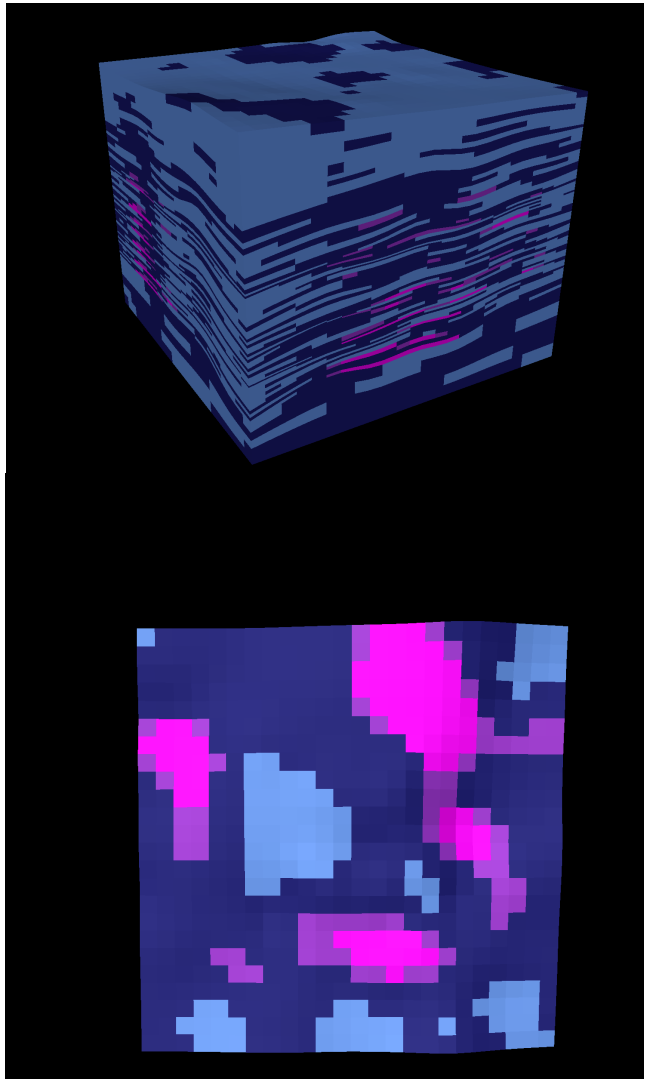




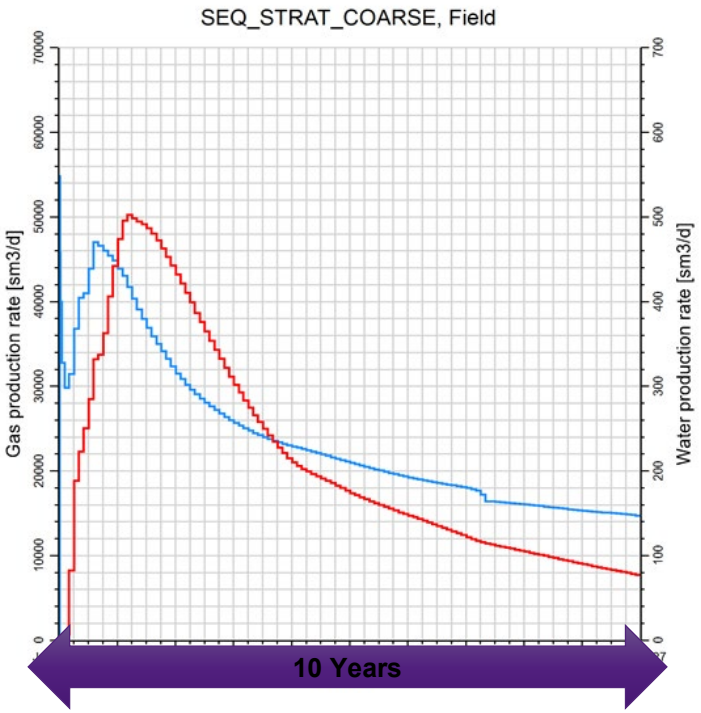
Water produced from day 1 from the whole model.
Sustained high gas production

Heterogeneous Model: gas, water and pressure

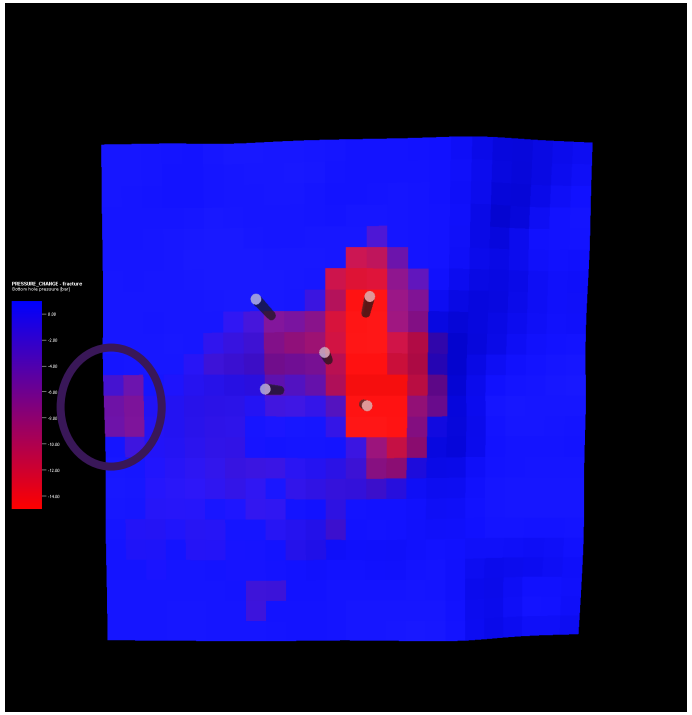
Heterogeneous model of coal seams



Geostatistics is used to create heterogeneous models



Less gas and water produced.
Greater decline rate



Pressure impact far from the well related to connectivity of coals in the model

Heterogeneity Matters

Collaborative Research with CGS Industry

There is a sense that models are not satisfactory in evaluating gas volumes and predicting future field performance.

Projects addressing heterogeneity by using existing data in different ways.

1. CCSG Project: Sequence stratigraphic methods for correlations (example Surat Basin)
2. CCSG-NERA Project: New geostatistical tools that honour heterogeneity better.

Building Models – Step 1 - Correlation

Correlation: process of matching geological events or rocks in geographically different locations based on type of material (lithology) or time during which material was deposited.

Lithostratigraphic correlation is based solely on matching rock types. It assumes that the rock type is continuous across the region being studied. Across small distances one may be able to assume lateral continuity.

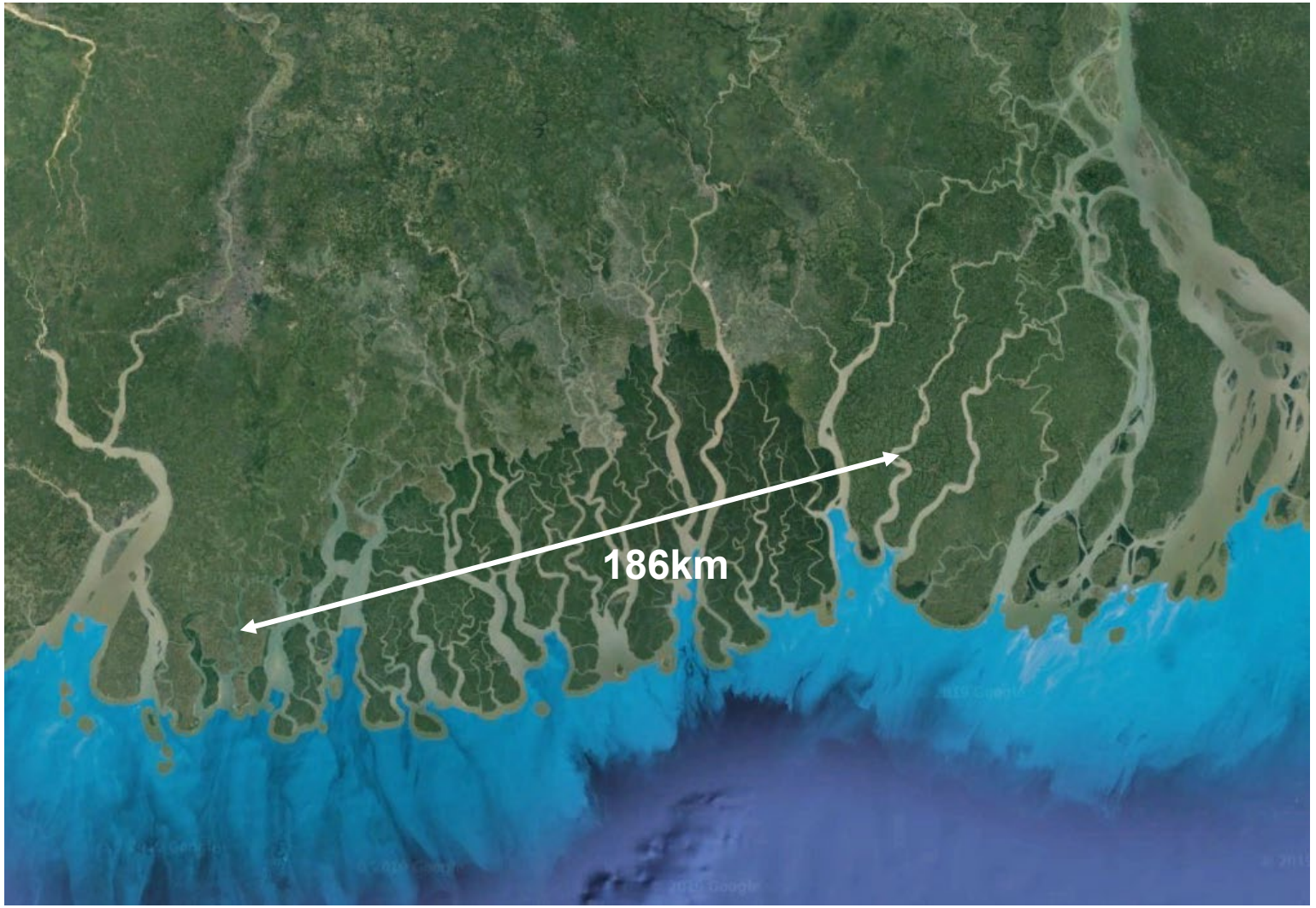
However, over large distances, the same rock type may be of different ages and *may not be laterally connected*. Environment of deposition.

Sequence Stratigraphic correlation is based on identifying time equivalent packages of sediments (sequences). Sediment deposition is cyclic.

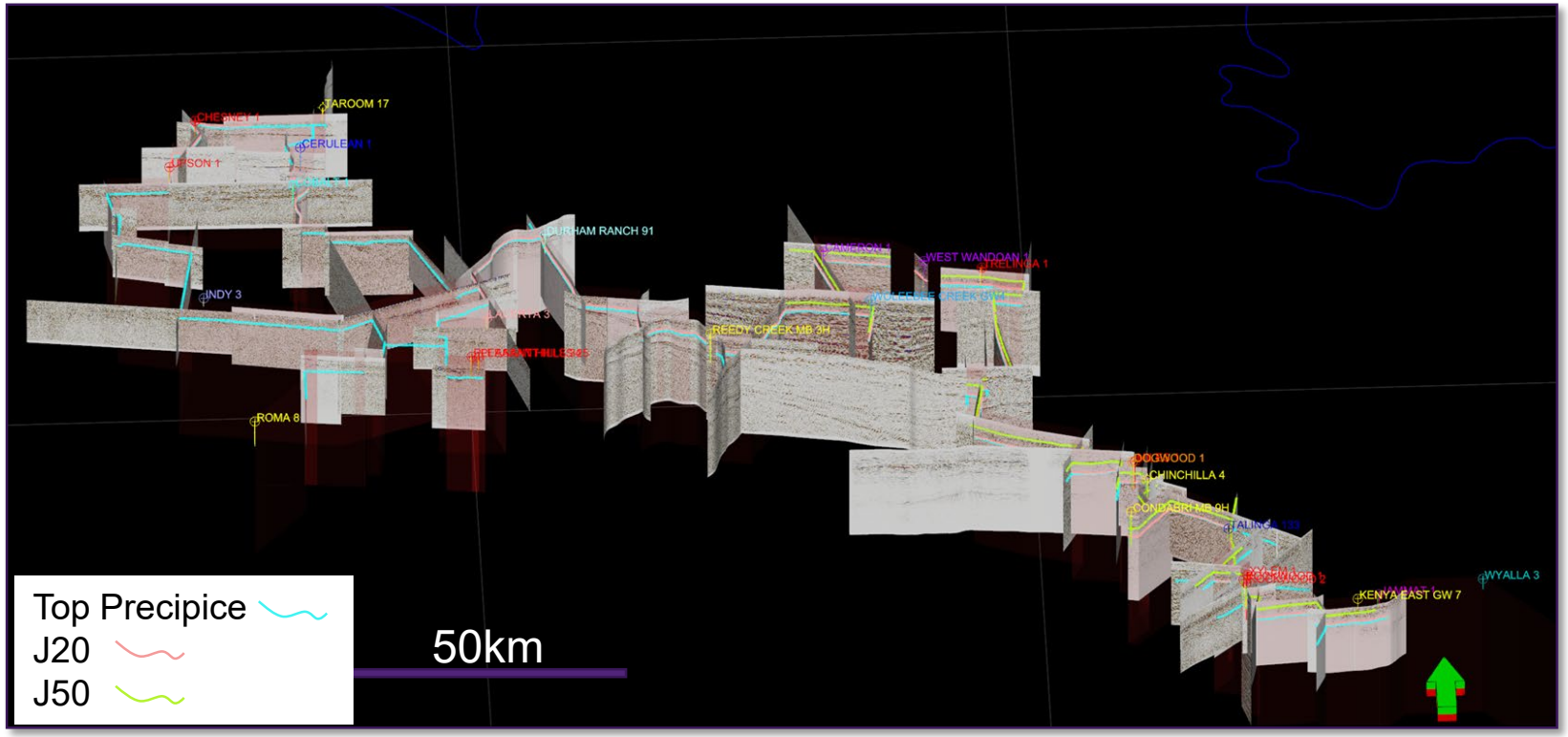
Environments of Deposition (EOD)

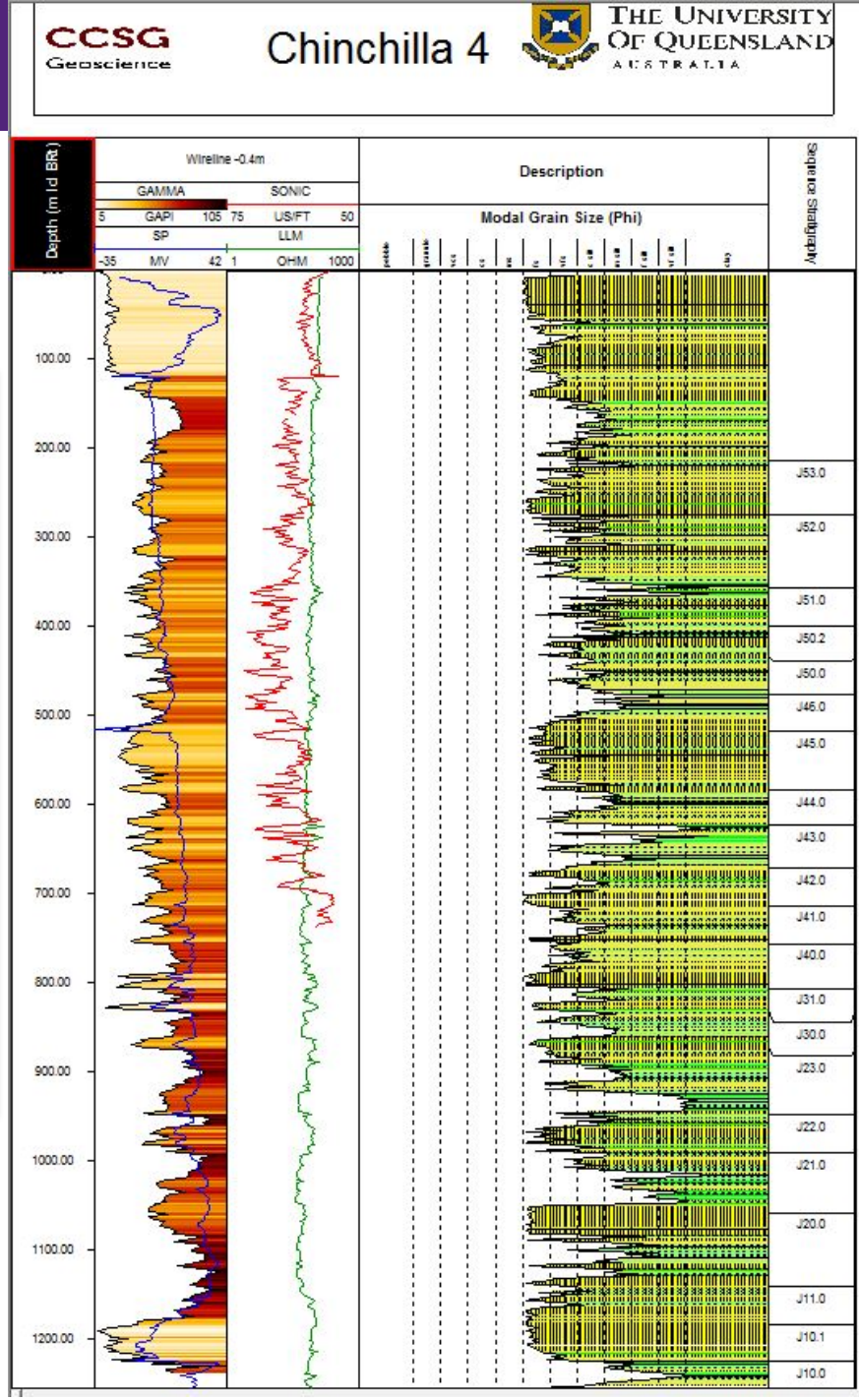
Geometry and Extent of deposits are associated with the EOD and sub-EOD

Example of a coal forming environment



Sequence Stratigraphic Framework for the Surat Basin

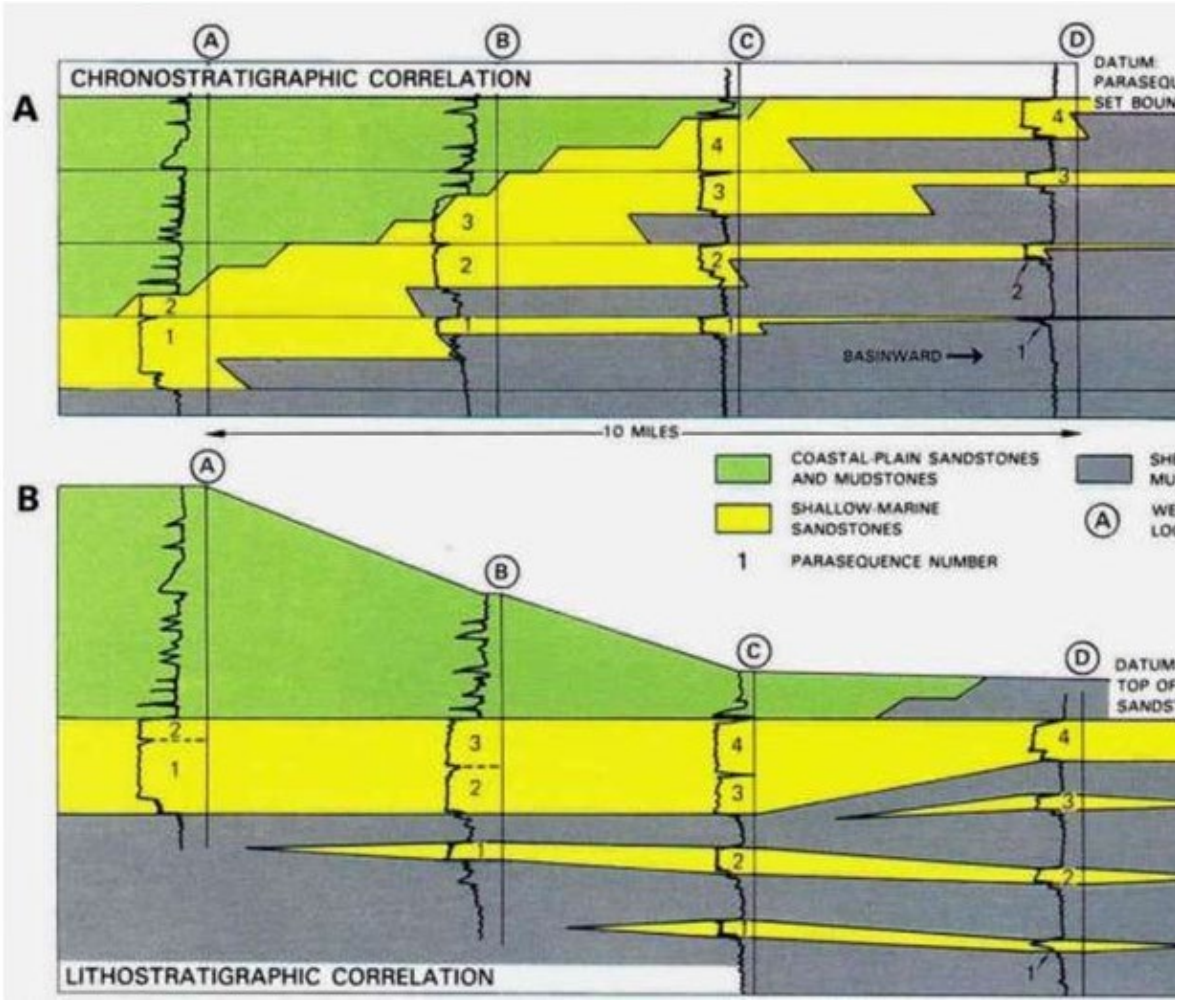


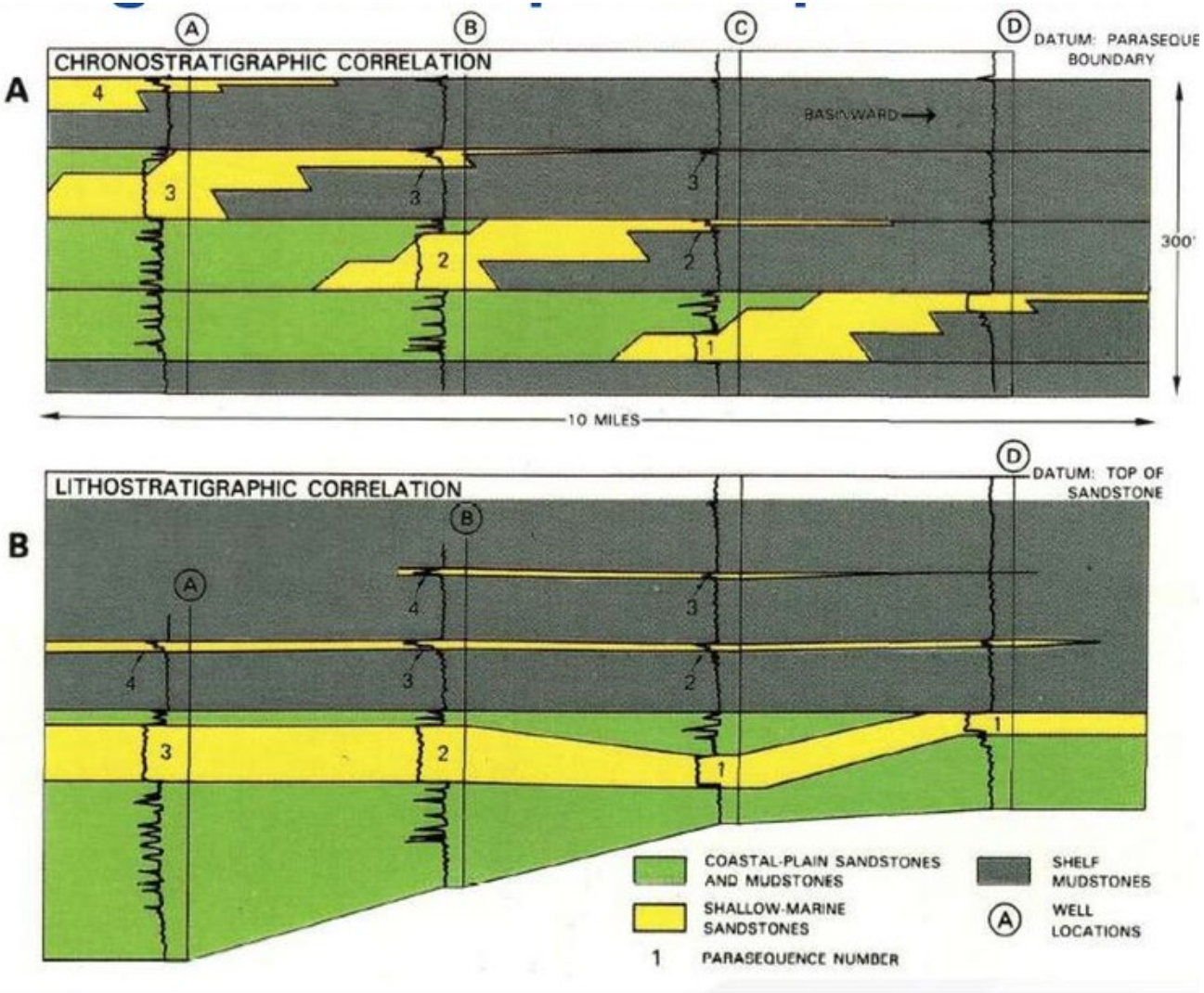


Integration of well data and seismic allow sedimentary cycles to be identified across the basin to provide a framework for interpretation of new data and model building

Does it make a difference?

Impact of Correlation on Volumes and Flow





based on Van Wagoner (1990)

Correlation and Pressure Transmission

Correlation matters for volumes, pressure transmission, i.e. fluid flow !

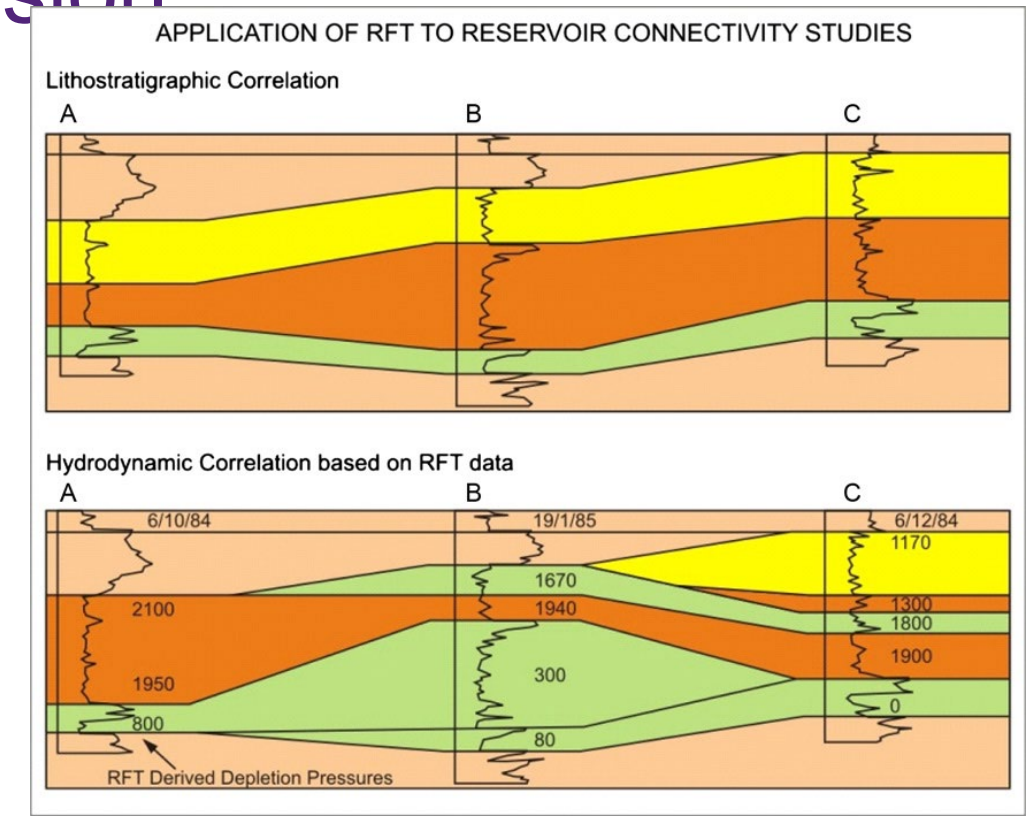


FIGURE 6.31 Upper diagram shows a lithostratigraphic correlation of sandstones across three wells (A, B, and C). The lower diagram shows the same three wells, but with correlations based upon repeat formation tester (RFT) pressure measurements. Note that the pressure-derived correlations crosscut the lithostratigraphic boundaries and define a greater degree of compartmentalization than had been interpreted originally on the basis of lithostratigraphic parameters. *Source of figure is unknown.*

Building Models – Step 2 – Populate Properties

Geostatistics

Spatial or spatial-temporal data sets.

Technique to estimate values in unsampled points.

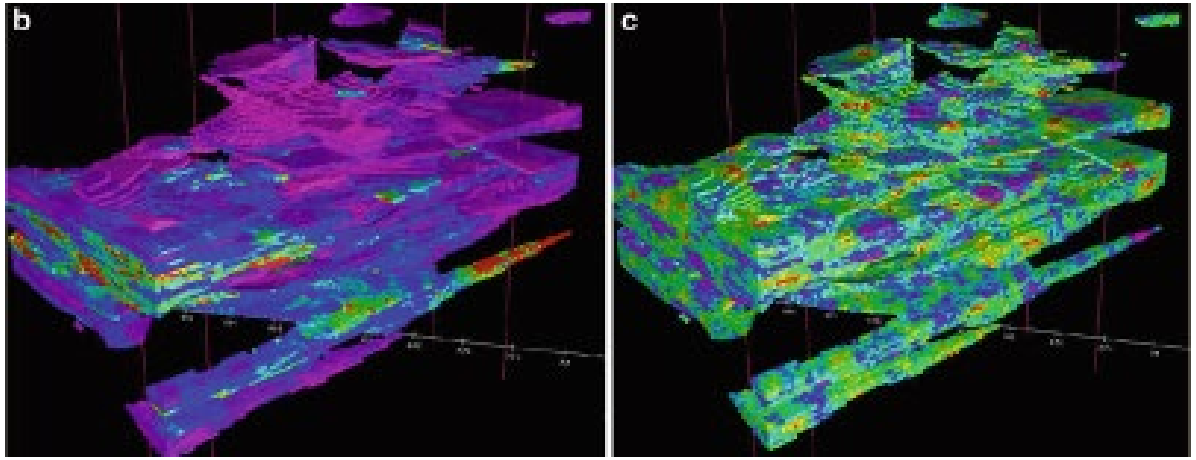
Examples:

Kriging

Sequential Gaussian Simulation.

Both assume a Gaussian dependency, i.e. symmetric distribution around a mean characterized by a standard deviation or variance.

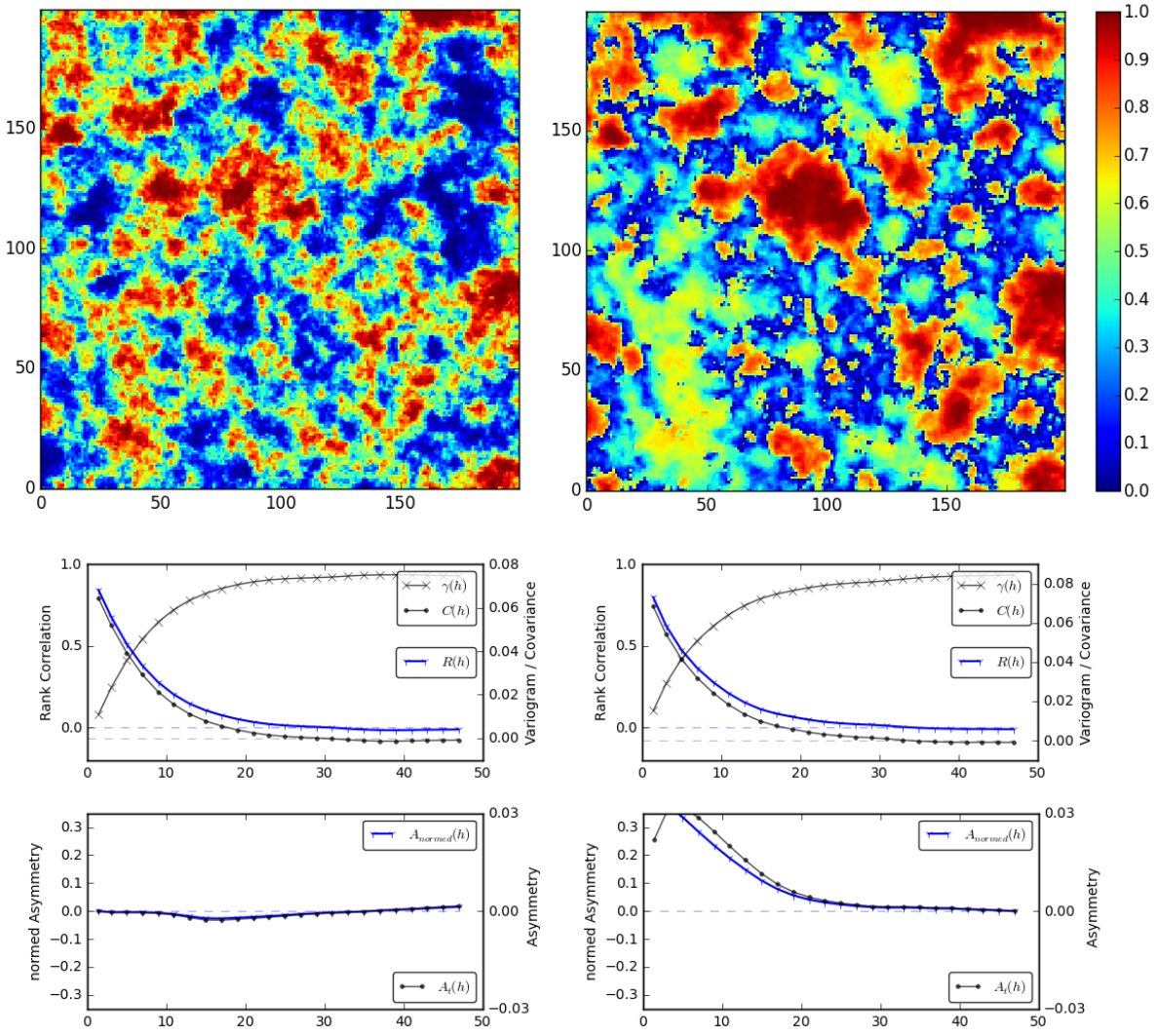
Some properties are not Gaussian!



Properties measured on core, log or well test
Estimate between data points ?

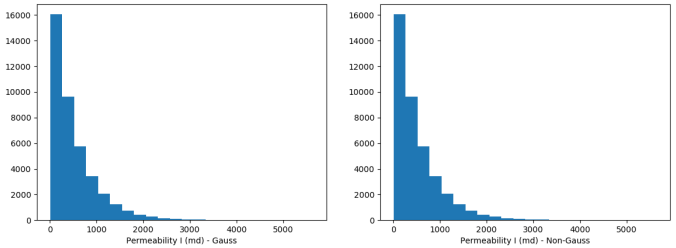
Copula based Geostatistics

- Linear geostatistics: based on Gaussian behavior (mean, standard deviation, variance)
- Most relevant properties for flow are not Gaussian.
- Copula Geostatistics represent better distributions where extreme values are important, i.e. flow path versus flow barrier
- This project's commercialization goal is to deliver a Petrel Plug-in

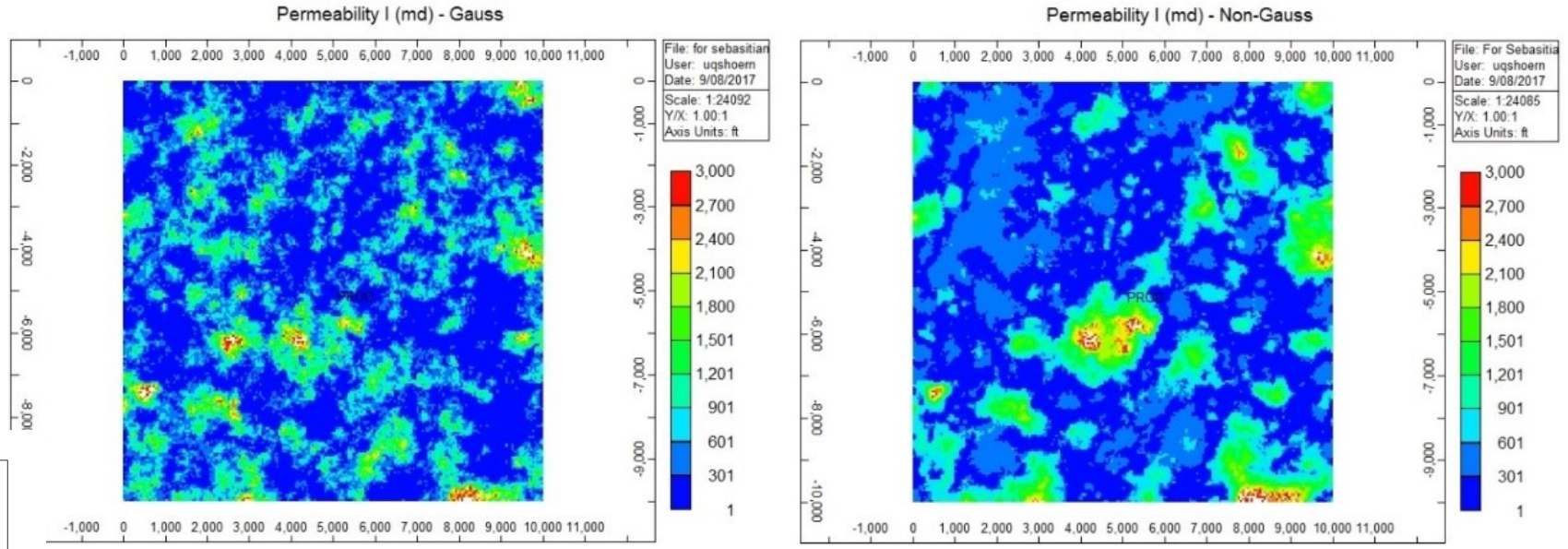


Geostatistical Technique Choice Affects Flow Models

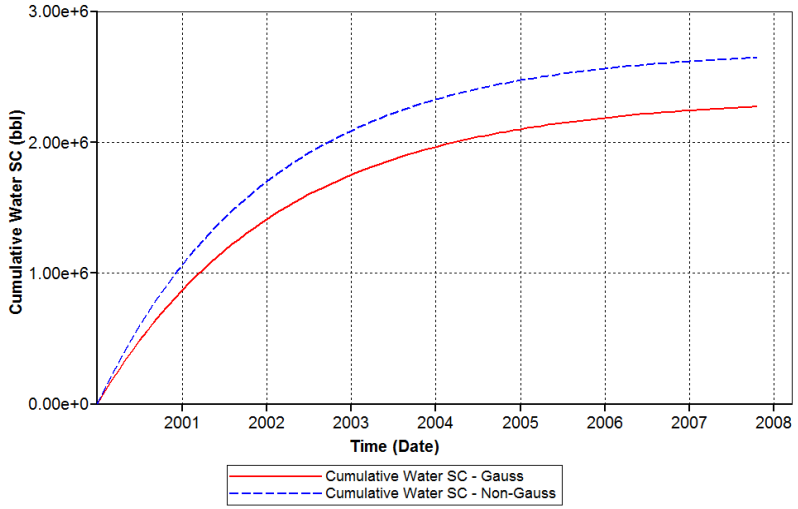
same permeability

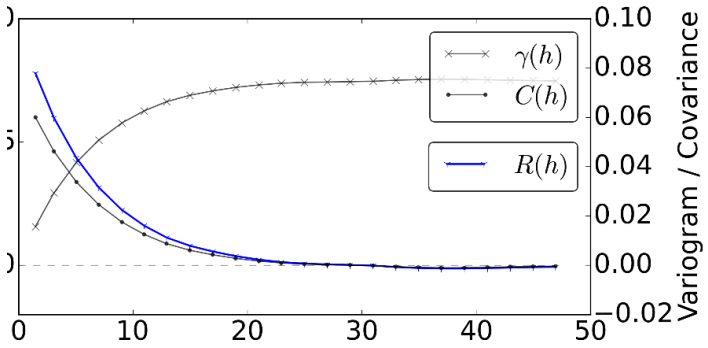


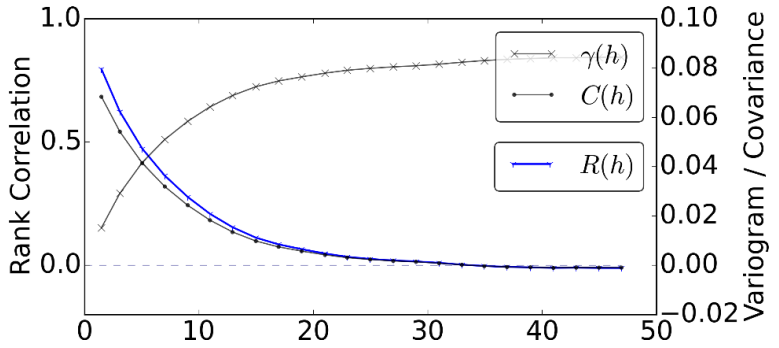
different spatial structure



different production curves







Conclusions

1. Subsurface heterogeneity has a profound effect on fluid flow and pressure transmission.
2. Correlation techniques matter for volume and flow models
3. The environment of deposition determines initial extent and volume of facies and rocks.
4. Lithostratigraphically define reservoir bodies may not be in pressure communication
5. Copula based geostatistics better represents extreme parameter values (e.g permeability)
6. The geostatistical technique employed results in different fluid flow behavior.

Thank you!

Acknowledgements:

UQ - CCSG
NERA
Energi Simulation

Schlumberger provided geomodelling software.