

## It's time to innovate on the WRM workflow

*Erich Funk – Funk Indivo GeoConsult*

*Leopoldo Farias Rodriguez – DNO Technical Services AS*

### Summary

Predicting reservoir flow behavior based on limited data on geological, fluid dynamic and thermodynamic variables is a general challenge subsurface teams have to face. The conventional approach follows multiscale data uploads into software platforms in order to create a digital clone of nature that is capable to replicate reservoir reactions in response to human interventions. As the analytical data lense narrows from field to well scale, challenges and uncertainties magnify. Conventional modeling faces challenges at the near-wellbore scale where a range of wellbore scenarios, coupled with high fluid velocity and mobility effects demand agile and data-driven WRM (Well and Reservoir Management) solutions.

This paper describes an alternative analysis method that is aiming to overcome the limitations of the conventional approach. It deconstructs reservoir flow processes, identifies fundamental geo-variables for flow and addresses uncertainties using numerical models for conceptualization and quantification of parameters and uncertainties.

This modeling phase optimizes computation efficiency by portraying essential reservoir architectural elements and facilitating meaningful analytical sensitivity series. Depending on the uncertainty level, a catalog linking flow-relevant geo-variables with pressure/production signatures is created and compared against actual reservoir behavior to identify the geo-features influencing actual reservoir behavior. This method enables a quick and focused iterative understanding of key reservoir dynamics by avoiding unnecessary computational complexity.

### Theory / Method / Workflow

The following structured workflow is showcased in this paper:

- (i) identify key geo-denominators driving the reservoir process in question. This is the core of the multi-disciplinary work and ends with the generation of an inventory of relevant geo-variables
- (ii) model the simplified process by testing geo-variables individually or in groups of interdependent variables,
- (iii) rank geo-variables based on their impact on the production signature as determined in the previous step and determine the most influential, flow-critical geo-denominators,
- (iv) create a catalog linking geo-variables to production signatures,

- (v) run the actual reservoir process through the catalog and nominate the best matched behavior as the closest approximation to the reservoir feature. This step is carried out in applications with high level of uncertainty and can be assisted with machine learning algorithms.

This method systematically evaluates key geo-variables and their contributions to observed flow patterns, leading to more insightful understanding reservoir dynamics see Figure No. 1 & 2.

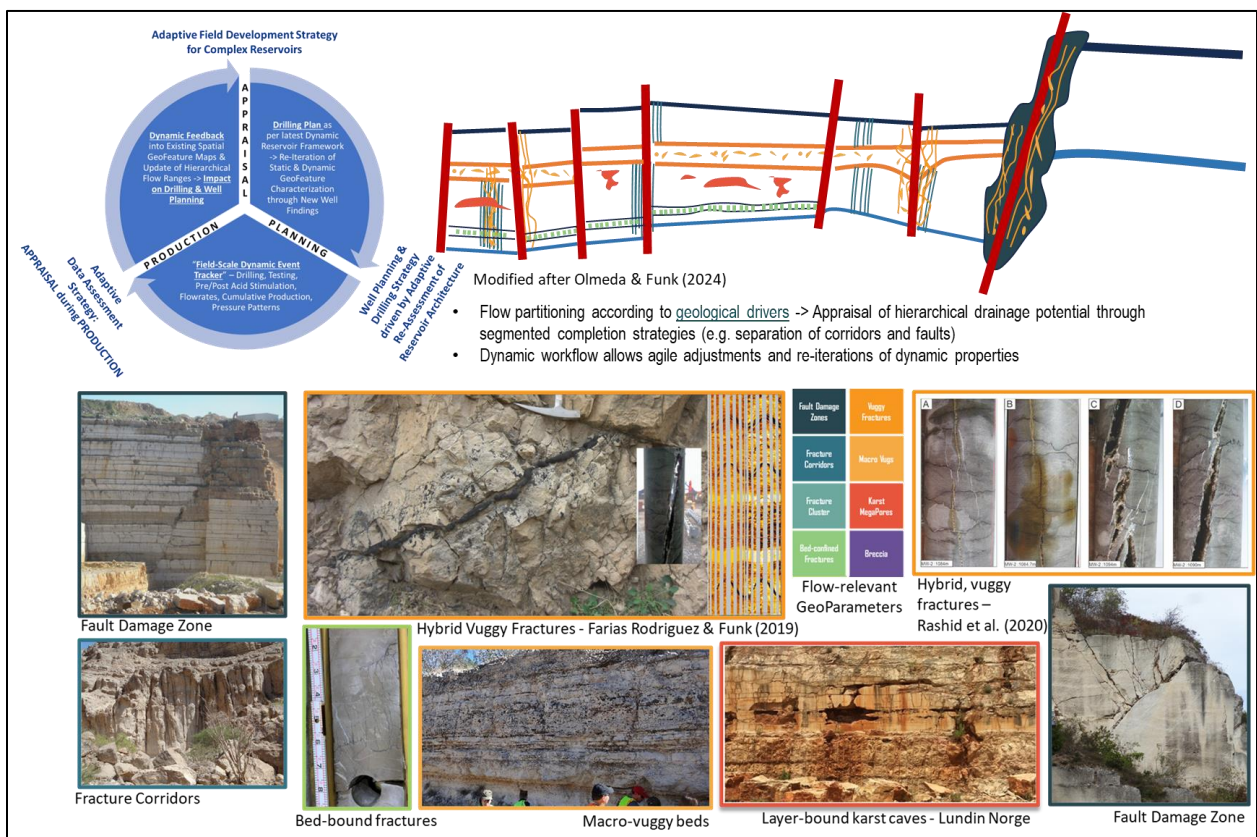


Fig. 1 – Identification and evaluation of flow-relevant geo-parameters

## Results, Observations, Conclusions

In summary, these are the five benefits of the proposed approach, see Figure No. 2:

1. Allows for inexpensive and quick models to capture salient reservoir geological architectures and flow-dominating features. They work well with a limited dataset and do not require history matching

2. Useful to design physical proxies and to conduct a physics-based assessment of risk
3. Provides critical information for informed decision making
4. They can be used as standalone tools for reservoir studies or can be incorporated into work flows for full field modeling. They are the tools of choice for evaluating the “worst-case” scenarios, validating the analyst’s intuition, and support informed decision making
5. Abstract models naturally link to machine learning, which in turn can be used to boost its predictive power and contribute to appropriate decision making in reservoir management strategies

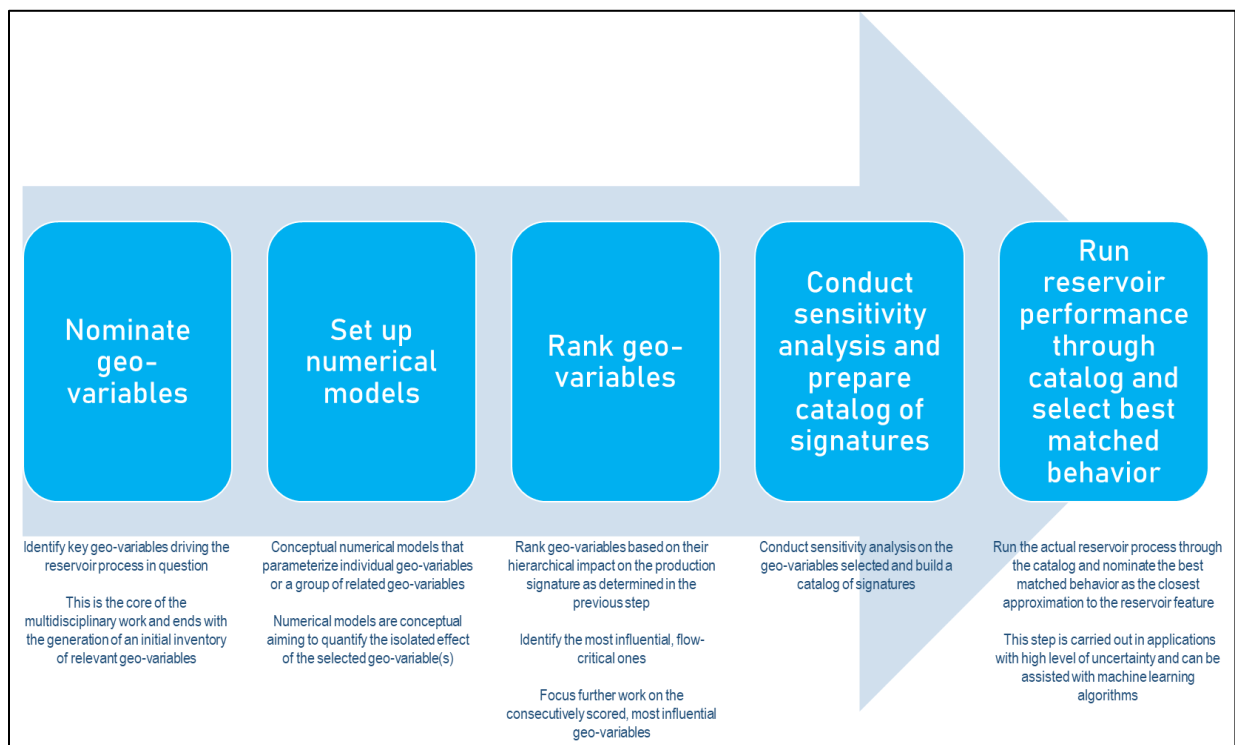


Fig. 2 – Proposed workflow allows the deconstruction of reservoir flow processes based on identifying fundamental geo-variables for flow, followed by uncertainty evaluation using numerical models for conceptualization and quantification of parameters

The paper details an application of the method to a naturally fractured carbonate field subjected to gas injection. The objective was to analyze bottomhole pressure signatures in production wells to discern the displacement mechanism between injector-producer pairs.

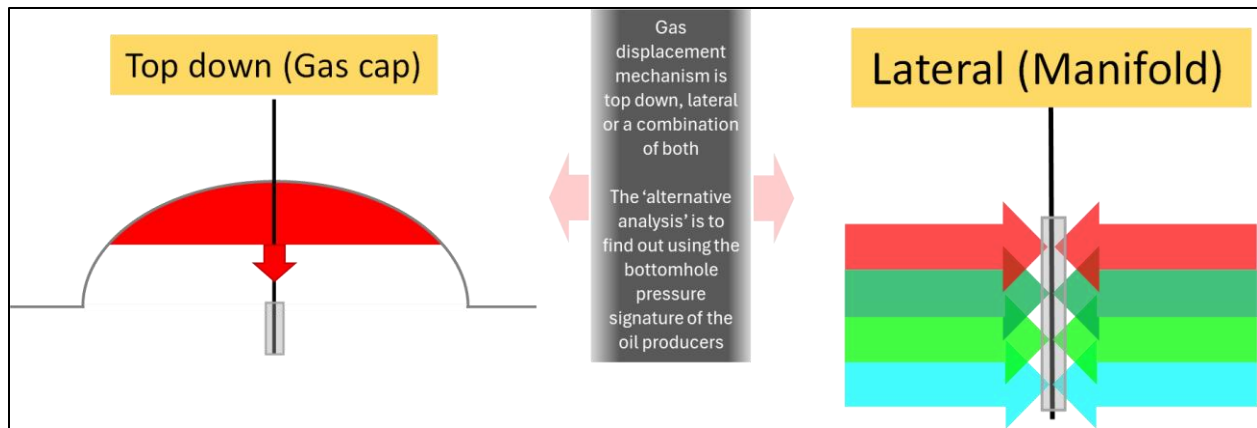


Fig. 3 – Gas-oil displacement in the reservoir occurs following one of these schemes or a blend thereof

The displacement mechanism refers to the pathway through which gas travels from the injector to the producer. Possible routes include: (i) top-down mode, where gas rises to the reservoir's top, forming a gas cap that expands and floods the producers vertically; (ii) lateral mode, where gas moves horizontally from injector to producer, resembling a manifold with reservoir layers feeding gas into it; or (iii) a combination of top-down and lateral flow.

In early IOR projects with limited gas breakthrough data, it is beneficial to generate synthetic bottom hole pressure corresponding to specific gas displacement routes. A catalog of bottom hole pressure profiles for various gas arrival routes was generated and compared against actual data. The geometry of the displacement corresponding to the best matching curve was deemed most representative. As depicted in the sketch below, the bottom hole pressure of Well 1 matches the synthetic pressure signature 1, therefore gas arrived at Well 1 following the route that generated pressure signature 1. Similarly, gas arrived to Well 2 via the route yielding pressure signature 3.

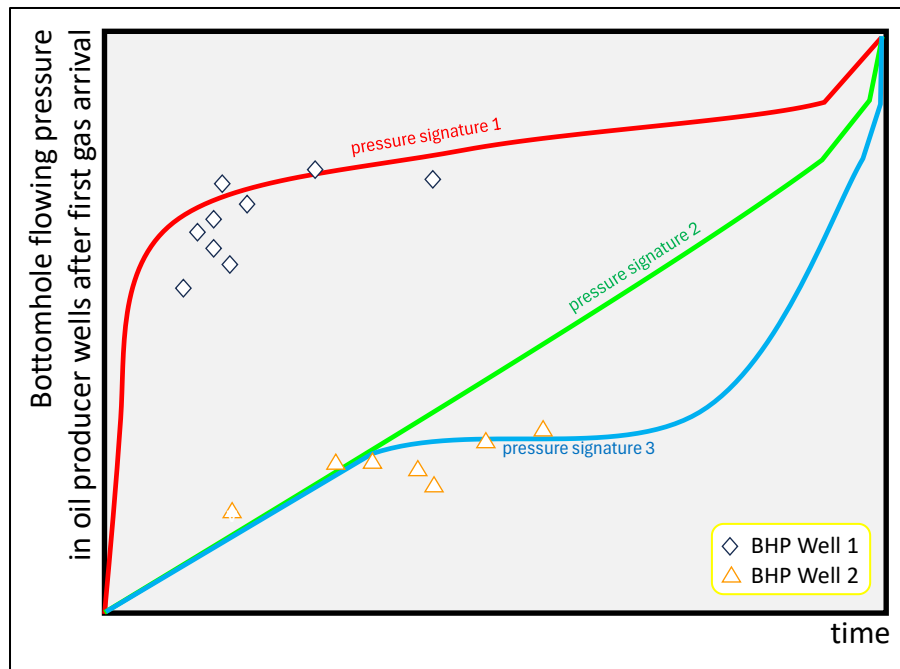


Fig. 4 – Matching actual well bottom hole pressures (discrete) against calculated pressure signatures in catalog

Knowing the way gas arrives to the producer is a valuable information to design well intervention to remediate excess gas production.

### Novel/Additive Information

The proposed approach delivers remarkable value where the computational cost or the impracticality of detailed, high-resolution models are of concern. By removing non-essential details for flow, engineers can gain quick insight into reservoir behavior enabling them to mature decisions for the optimization of hydrocarbon recovery. This approach proves particularly beneficial at well scale and supports WRM applications, where processes develop rapidly, and subtle geo-features can exert a substantial impact on flow behavior.