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Coupling geomodeling and fracture stimulation modeling – preliminary results

Thomas Jerome (RPS), Idi Ishaya (RPS) and Brad Golinowski (Wyatt Oil & Gas)

Introduction

Engineers use simplified, layer-cake representations of the reservoir to model fracture treatment in 2D. Rock properties are computed on a nearby vertical well and propagated horizontally to create this model. A different approach is presented here. Reservoir modeling techniques are used to represent the reservoir in 3D and generate inputs for the fracture treatment modeling/design by engineers. This captures the structural and stratigraphic complexity in a reservoir for the purpose of fracture modelling/ design by engineers without the complexity of fracture modelling/ design in a full 3D modelling package. The workflow used is detailed and tested on a Midale reservoir produced with horizontal multi stage fractured wells.

Geomodeling and fracture stimulation modeling workflow

The proposed workflow consists of three steps.

Firstly, the geomodel is built. The horizons and the faults are interpolated from the well markers and the seismic interpretation and a 3D geological grid is built. Facies and petrophysical properties are distributed in 3D using geostatistical techniques. In the whole process, the different sources of uncertainty are identified (data, interpretation, workflow) and integrated in the geomodel. The result is a set of geomodel realizations. Each realization is made of a possible geometry for the reservoir coupled to a possible petrophysical and facies 3D distributions.

Secondly, all the additional properties needed for fracture modeling, including mechanical properties, are also modeled in 3D. The geomodel is then sampled along the plane on which fracture modeling will be conducted and the plane is transferred into the fracture modeling package.

Finally, once the fracture modeling is completed, the output fracture geometry and properties are reimported in the 3D modeling package for 3D visualization and reservoir simulation.

Application in a Midale reservoir

The workflow proposed by the authors was tested on a multistage fractured horizontal well in a Midale reservoir.

Firstly, the geomodel was built. The geological units were modeled from the tops picked on both the vertical and the horizontal wells, coupled with the seismic interpretation of the top horizon. Each geological unit was interpreted as being homogeneous in terms of facies. As such, porosity (Figure 1~~Figure 1~~), water saturation and permeability were modeled directly, by geological unit, using gaussian simulation. Additional properties, specifically needed for fracture modeling, were also populated in 3D.

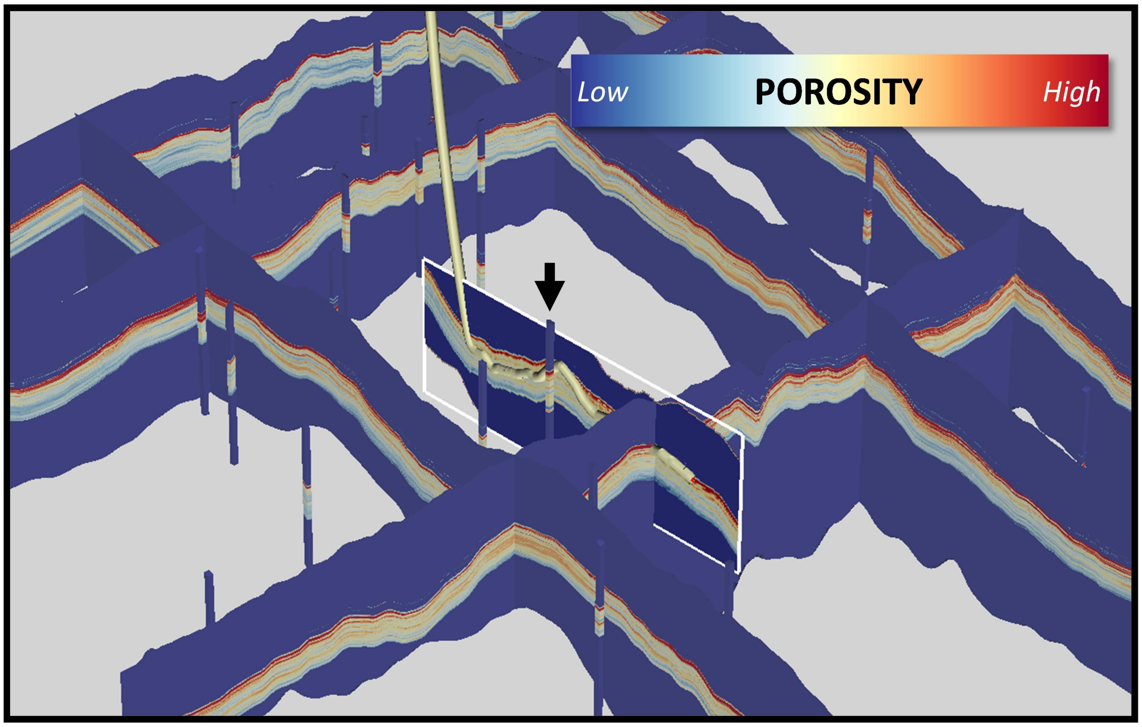

Figure 1. 3D porosity distribution in the 3D geomodel. Black arrow: closest, reference vertical well. Vertical colored pillars: input log data from all the vertical wells used in the geomodel.

The geomodel was then sampled along the plane of the studied horizontal well (Figure 1~~Figure 1~~ and Figure 2~~Figure 2~~B). For sake of comparison, these properties were also distributed in the traditional way used in fracture modeling (Figure 2~~Figure 2~~A).

With the traditional approach, the horizontal well appears primarily in the lower part of the reservoir. This is, in fact, incorrect as shown by the input coming from the geomodel; the horizontal is seating in the middle and the upper part of the reservoir. One might argue that the geometry of the geomodel should be used with caution far from the vertical wells. This is generally a valid comment, but it doesn't apply here, as the geological units were picked on the horizontal well itself. Beyond the geometry of the reservoir, the two inputs vary on another essential point; in the geomodel distribution the properties are laterally varying while they are laterally constant in the traditional approach.

Fracture geometry and properties generated from this workflow have shown to better match the observed well performance in the example under consideration. It is expected that the results observed in this example will be the case in any reservoir with significant variation in rock properties and/or long multistage horizontal wells in most fields.

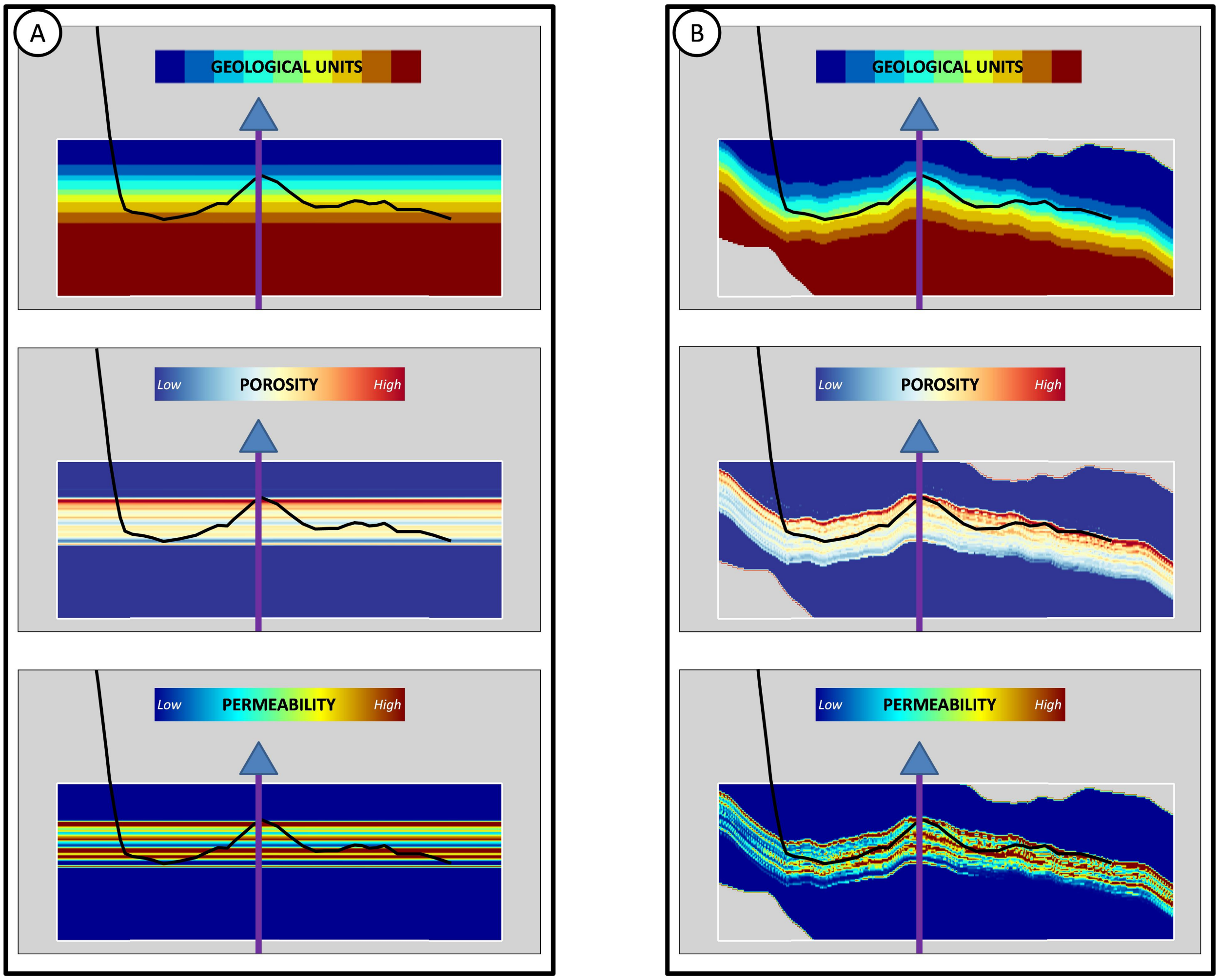

Figure 2. Geological layers, porosity distribution and permeability distribution: traditional fracture stimulation modeling approach (A) versus true geomodeling input (B)

Conclusions

Reservoir engineers are using 3D reservoir models for many purposes; uncertainty management, flow simulation, reserves computation and well planning among other things. This paper illustrates that output from reservoir models can also be useful to production engineers and improve the quality of their work, such as fracture design, by following a simple workflow. The results are promising and show that more research should be done to push this workflow even further; for example, with transfer of the uncertainty carried in reservoir models into the world of 2D fracture treatment modeling.

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