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Thoughts on Geological Uncertainty Assessment in Integrated Reservoir Modeling

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SUMMARY

Geological uncertainty assessment is most often addressed by considering several geostatistical realizations on some given reservoir grid, and/or by perturbing the geometry of that grid under some hypotheses. These grid-focused approaches are practical but make it difficult to address two major types of geological uncertainties: conceptual uncertainty which can be critical in green field studies, and topological uncertainty which can be important even for mature fields. I argue that these high-level types of geological uncertainties can be better addressed by working directly with geological parameters. Several challenges exist in this type of approach, both educational (changing the way interpreters work) and technical (formalizing geological concepts and defining robust gridding and discretization methods). However, the main benefit of this vision is to provide descriptions of static geological uncertainties which are explicitly compatible with interpretation concepts and data. This strategy is most useful for generating a large set of models which would be considered as discrete scenarios with classical methods and it clears the path for joint inversion and assimilation of reservoir monitoring data.

In reservoir modeling, geological uncertainty assessment is most often performed by considering several geostatistical realizations on some given reservoir grid, whose geometry may be perturbed to account for relatively small structural uncertainties. Although this practice has been significantly improved through advances in multiple-point simulation and the possible use of multiple scenarios, it is often restricted in practice by the small number of scenarios which can be used in practice; another practical limitation lies in the limited resolution and fixed orientation of the geocellular grid.

In this paper, I discuss an alternative paradigm in which geological uncertainty is described through probabilistic models of geological parameters and not solely though spatial random function models in geocellular grids. Defining such geological parameters can be challenging, because it amounts to converting part of geologists' knowledge into numerical data structures, rules and probabilities. However, recent examples have shown that such approaches are possible, for example in fault detection (Hale, 2013), stochastic structural modeling (Cherpeau et al, 2012; Georgsen et al, 2012; Julio et al, 2013), stochastic well correlation (Lallier et al, 2009) and chronostratigraphic mapping (Mallet, 2008; Laurent et al, 2012). One challenge in applying these types of methods is to define geological concepts and parameters and how these are translated numerically. Another challenge, possibly not the least, is to change the culture of geological interpretation which is generally deterministic and which does not often formalize the knowledge used for interpreting. A third challenge is to move from static spatial 3D models generated with these approaches to 3D grids which can be used to solve the question at hand (e.g., reservoir forecast).

Nevertheless, such geological parameterizations are essential for uncertainty modeling, because they focus on the cause of geological uncertainties and not on their effect on a specific reservoir grid. They can be used to address conceptual uncertainty which is often critical in green field studies (e.g., Bond et al, 2007), and topological uncertainty (e.g. in understanding reservoir compartmentalization), which can be important even for mature fields. Additionally, together with model ranking and clustering methods (e.g., see Scheidt and Caers, 2009), they clear the path for solving joint inverse problems by using numerical models suited to the medium and not to a particular type of physical computation.

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