Uncertainty assessment in subsurface modeling: considering geobody shape and connectivity in complex systems.

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Modeling the subsurface is a complex task because the data scarcity leads to ambiguous interpretations. As a result, subsurface models are prone to many uncertainties, which can be accounted for by stochastically simulating a large set of possible models. These models are constrained by the data (of various resolution and types), but also by geological knowledge and concepts. Integrating the latter in simulation methods emerges as a key point to reduce uncertainties, although it adds another layer of complexity to the modeling process. In this presentation, I focus on two different geological contexts characterized by specific geobody shapes and connectivity: channelized systems and salt tectonics.

Channelized systems are, indeed, characterized by elongated and sinuous structures, the channels, which evolve through time by continuous lateral and vertical migrations, and abrupt events like avulsion or meander cut-offs. The combination of erosion and deposition processes is an additional source of complexity in the sedimentary records. When considering the 3D reconstruction of channelized systems, honoring data while reproducing the complex spatial architecture of these structures - so their specific connectivity - remains challenging. The various methods we have recently developed can now be combined to achieve such a goal: (i) single channels or channel parts (for avulsion) can be simulated consistently with well-data, probability cubes, or confinement thanks to a method based on Lindenmayer systems; (ii) from a channel path, consistent 3D architectures can be generated with a reverse-time channel migration approach (ChaRMigS) handling the observed abandoned meanders; (iii) to honor well data within this reverse-time reconstruction, the stochastic simulation of abandoned meanders and avulsions offers interesting solutions. The impact of such modeling methodology on connectivity reproduction has been demonstrated using static criteria, and a flow-based evaluation constitutes an obvious next step.

In the case of salt tectonics, one difficulty comes from the highly convoluted shapes taken by salt bodies, incompatible with the hypothesis of minimal surface classically used in geomodeling methods. To tackle this issue, we have developed a dedicated method to stochastically generate various salt envelopes in a pre-defined uncertainty zone. Simulations of welds, i.e. surfaces (or
most often thin volumes) resulting from the removal of salt from a former layer or diapir stage, also allow us to reproduce topological singularities between salt and the surrounding sediments. Welds connect the different salt volumes, which let us recover a more geologically-consistent representation of such complex systems. The present method is still in its early days, and further improvements need to be undertaken to fully integrate the diversity of structures actually observed in the field.