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Honoring Structural Geology & Basin Modeling Constraints: Application of a New Kinematic Tool for Basin Modeling in Complex Geological Settings

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ABSTRACT

When it comes to assess tectonically complex basins featuring listric, thrust and strike slip faults, mud and salt tectonics, conventional basin modeling tools are no longer sufficient. The vertical shear backstripping method commonly used for basin reconstruction through time must be replaced by a step by step restoration allowing movement along discontinuities and lateral displacement. New workflows relying on existing structural restoration packages have thus emerged in the industry in the past years. Usually requiring a three step process, they consist in building the present day model within the structural restoration package, performing the restoration and then exporting the paleo-models collection to the basin modeling package in which new generation simulators are able to model fluid migration through faults and other geological features.

While they definitely bring an added value to basin modeling in complex structural settings, these workflows still have practical limitations impacting their operational use. 1/ The number of steps to restore. Structural geologists usually focus on the main deformation phases whereas petroleum system modeling requires a basin geometry at the end of deposition of each simulated layer. This constraint imposes additional work with tools that are not necessarily suited to build easily full kinematic scenarios. 2/ The ability of generating a mesh continuously deformed through time. We believe this point is essential for mass balance considerations in basin simulation but it is optional in structural restoration and most packages do not honor this constraint. 3/ Any modification made on the structural model or the structural scenario post simulation (such as additional layer insertion or new hypothesis on eroded thicknesses) requires starting again the kinematic work in the restoration package. All of these technical issues drastically limit the efficiency and productivity of such methods.

We here illustrate a new workflow intending to overcome these problems with the introduction of a new kind of 2D kinematic tool, designed in the first place for basin modeling purposes. This new tool aims at producing very easily and rapidly consistent geological scenarios in order to feed new generation simulators able to take advantage of an accurate description of structural evolution through time. In addition to classic geometrical methods, a new mechanical engine taking into account compaction and rock mechanical properties (anisotropic elastic behavior) is being investigated along with several deformation models. The ability to provide geologically valid results in all structural contexts and an intuitive definition of deformation parameters to optimize productivity constitute the core of the tool, dynamic mesh deformation being guaranteed through the model topology preservation as restoration work progresses. Additional research works focus on an automated generation of intermediate steps between two given stages and the capability to replay full or part of a kinematic scenario after a minor modification of the model through an innovative operation record process.

Two application cases demonstrate the prototype usability for salt tectonics and compressional environments (Gulf of Mexico and Albanian foothills) as well as its ability to quickly generate tens of paleo-sections continuously deformed through time for the simulation of compaction, heat transfer and hydrocarbon generation, migration and accumulation. Bridging the gap between structural geology and basin modeling, the achievement of this project will be a major step forward to easily increase basin models structural complexity without any compromise neither on execution time nor results quality.