Advances Improve Reservoir Modeling

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Summary

Introduction to the Next Generation Modeling Technology

In the E&P field of 3D modeling and construction of 3D grids, the state-of-the-art among competing applications are roughly equal. The current technique for constructing a model starts with modeling the top and bottom surfaces. To create a 3D volume, "pillars" are constructed from the top surface to the bottom surface along directions parallel to the faults. Faults are themselves composed of pillars, and intersecting faults should have one identical pillar. The construction of a 3D grid model is therefore decomposed into a series of 2D and 1D operations through the creation of the two 2D surfaces, and the construction of 1D pillars in the 3D space.

The main default and limitation of this technique is the construction of the fault pillars. This process is manual or semi-automatic, tedious, cumbersome and possesses serious limitations in the complexity of models that it can handle. The one-by-one construction of pillars does not automatically ensure the consistency of the 3D model.

In fact, by using this technique, there are many geological settings where faults need to be removed from the geological model or deformed substantially to allow the construction of a reservoir model. In environments containing Y faults or oblique faults, the grid constructed using pillars aligned to faults introduces deformations of the cell geometry that are unacceptable for all geostatistical algorithms. These algorithms demand cell distances that are equal throughout the volume.

A Step Change in Modeling

SKUA (Subsurface Knowledge Unified Approach) is a pure 3D method which unifies all subsurface discrete models. SKUA embeds a native full 3D description of the volume. The immediate advantage is that the need for pillars disappears. Horizons and grids geometry are constructed simultaneously in the 3D space using a technology called the "UVT Transform™" based on the observation that horizons represent geochronological surfaces. Working with a paleo-geographically 'correct' mesh, geobodies, reservoir properties and other attributes can be correctly modeled in their depositional state.

Because of the underlying "UVT Transform™" technology, SKUA is a step change improvement in modeling. Many benchmarks have shown that SKUA reduces modeling time by large amount of times. Below is a table comparing pillar-based modeling time and SKUA modeling time.

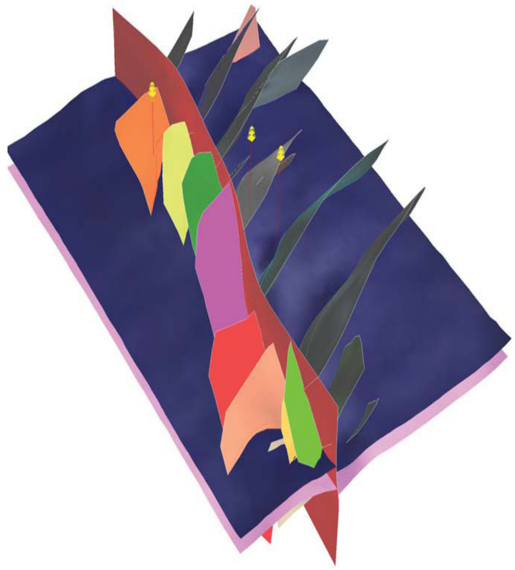

Figure 1: Structural model inside a fault rift system.

Geological Setting	Pillar Modeling Time	SKUA Modeling Time
Compressive Environment Reverse Faults Large Displacement	3 days	2 hours
Extensive Environment 51 Faults 3 Thin Beds and 12 Horizons	2 months (4 models)	3 hours
Highly Compressive Thrust 30 Faults	2 weeks	2 hours

Figure 2: comparison of time differences between pillar-based modeling and SKUA modeling

Two Reservoir Models

Today, modeling technology suffers from the assumption that geological grids and flow simulation grids should be modeled similarly. However, this is not true as requirements for flow simulators and geological modeling grids are often at odds with one another. As a result, neither is modeled optimally.

How do you ensure that cells are orthogonal and of uniform size for a simulator, while still maintaining accurate structural and stratigraphic complexity for well planning and volumetric calculations ?To ensure that both situations are modeled successfully, SKUA differentiates between a geological grid and a flow simulation grid, which is not the case for most modeling applications.

Geological Grid *(static grid*)

Using the paleo-geochronological transform, a geological reservoir grid can be constructed that will not have cell columns parallel to faults. Rather, cells will be split by faults and offset by the fault throw. (See Figure 2) The constant cell dimensions and their regular shape across the entire grid are ensured through the use of specific algorithm constraints when interpolating the paleo-geochronological transform. This transform conserves both volumes and distances, and is inherently a geological grid to model geology. All geostatistical operations and property population should be conducted on this grid, in addition to prospect generation and stratigraphic target planning for well design. This workflow ensures correct object deformation, correct spatial correlation of well samples, correct geobody computation and therefore, correct hydrocarbon volumetric calculations.

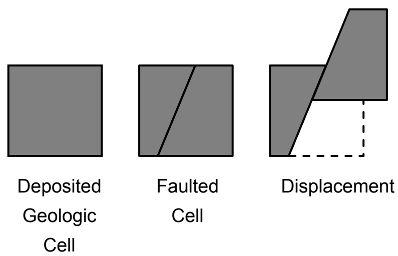

Figure 3

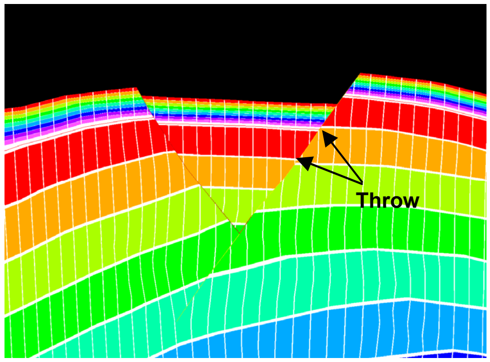

Figure 4: Cells should not be parallel to faults, truncated by faults or offset by the fault throw

Flow Simulation Grid *(dynamic grid)*

Reservoir simulators must solve complex flow equations that are based on the orthogonal nature of the cell, and therefore do not work optimally with partial or oddly shaped cells, or with neighboring cells of significantly differing sizes. .SKUA handles this problem by creating a separate flow simulation grid from the original geologic grid. It is a corner point grid which has faults represented either as pillars (extrusion with the known limits of pillar grids) or as stair steps across mostly vertical pillars. This allows the grid to honor the requirements of reservoir simulators.

Stair-stepped faults should not be used for geological grids because the fault location, displacement and geometry are only approximated by stair steps. In addition stair-step faults do not conserve paleo-distance across the fault gap Therefore, depending upon the size of the cell, this can result in significant errors in both hydrocarbon volumetric calculations and well target location.

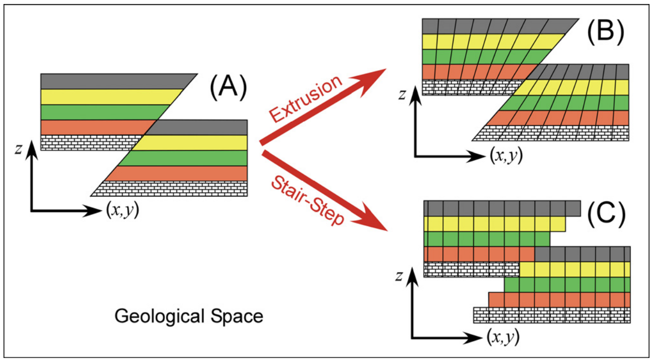

Figure 5

Correct upscaling of structure and properties from the geological grid to the flow simulation grid is ensured due to the inherent link between the two in SKUA. The construction of flow simulation grids that are based on geologically correct grids leads to better reservoir models, which enable better history matching and better production forecasts

Conclusions

By removing the modeling barriers of application complexity and time consumption, engineers and geoscientists will be able to provide better reservoir models that allow better history matching and produce improved production forecasts. This step-change will also allow, more scenarios to be explored thereby reduicing overall exploration and production risk and improving our confidence in business decisions.