SKUA – A Step Change in Modelling

Subsurface knowledge unified approach (SKUA) is a pure 3D method that unifies all subsurface discrete models, embedding 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 geo-chronological surfaces. Working with a paleo-geographically “correct” mesh, geobodies, reservoir properties and other attributes can be correctly modelled in their depositional state.

Currently, in the E&P field of 3D modelling and construction of 3D grids, competing application technology is more or less equal. Model construction begins with modelling 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.

Fault Pillar Limitation

The main default and limitation of this technique is the construction of the fault pillars. This process is a manual or semiautomatic process, 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.

By using this technique, many geological settings exist 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 cells geometry that are unacceptable for all geostatistical algorithms. These algorithms demand cell distances that are equal throughout the volume.

UVT Transform Technology

Because of the underlying UVT Transform technology, SKUA is a step change improvement in modelling. Many benchmarks have shown that SKUA reduces modelling time significantly. For example, in a geological setting such as reverse faults or in a compressive environment, where conventional pillar modelling can take as many as three days, SKUA can cut the time to as little a two hours.

Two Reservoir Models

Modelling technology often suffers from the assumption that geological grids and flow simulation grids should be modelled similarly. However, this is not accurate, as requirements for flow simulators and geological modelling grids are often at odds with one another. As a result, neither grid is modelled optimally. In order to ensure that cells are orthogonal and of uniform size for a simulator, while still maintaining accurate structural and strati-graphic complexity for well planning and volumetric calculations, SKUA differentiates between a geological grid and a flow simulation grid, which is not the case for most modelling applications.

Geological 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. An image of such a geologic grid is represented in the figure to the right. The constant cell dimensions and their regular shape across Cell 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 geo-statistical operations and property population should be conducted on this grid, in addition to prospect generation and strati-graphic 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.
Flow Simulation 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 neighbouring cells of significantly differing sizes. As a result, in SKUA a separate flow simulation grid is created from the original geological grid. This new second grid is a corner point grid which has faults represented either as pillars (with the known limits of pillar grids) or as stair steps across mostly vertical pillars. This allows the grid to honour the requirements of reservoir simulators, that of having simple orthogonal cells with the minimum possible deformation.

The reasons for not using stair-stepped faults for geological grids are well known. These include the fact that the fault location, displacement and geometry are only approximated by stair steps. Therefore, depending upon the size of the cell, this can result in significant errors in both hydrocarbon volumetric calculations and well target locations. Additionally, geological calculations of reservoir properties can be in error as the I, J, K locations across the faults are not aligned. This is of particular concern in reverse faults, as there is an overlap of cells.

Better reservoir models are the result of constructing flow simulation grids based on geologically correct grids, which, in turn, enable better history matching and better production forecasts. Correct up-scaling of structure and properties from the geological grid to the flow simulation grid is ensured due to the inherent link between the two.

Improved Decision Making

Increased understanding of the reservoir can lead to an increase in known flow barriers or pressure regimes. Previously, the workflow to update the grid was a manual one, which was cumbersome, time-consuming and often frustrating. However, the unique algorithms in SKUA make the process a simple one of adding the additional data and watching the grid refit to the new information — much as it would for property population.

Removing the pain of manual labour from the process of creating the fault network results in a model that is more often updated with new information. This results in a more accurate grid and improved decision-making capabilities.

Improved Predictive Power

Too often the difficulty in constructing a software-compliant fault network would result in the removal of interpreted faults from a reservoir model. As a result, the limitations in the software would drive how much complexity could be imaged in the constructed reservoir model. Through the use of the paleo-geochronological transform, all data can be incorporated into the reservoir model, regardless of its complexity. Complex truncations, Y and reverse faults, thrust faults and extremely thin beds can all be honoured in the geological grid constructed in SKUA.

As a result in improving the quality of the model by using all available data, the predictive power of the resulting grid is also significantly improved. The reservoir grid will be able to more accurately predict structure and stratigraphy encountered by wells, as well as the probably flow paths of reservoir fluids and hydrocarbons.

Speed Lowers Cost

Time savings — and therefore cost savings — are also in evidence when the model is updated with additional faults or structural complexity. Implementing SKUA radically improves the speed of modelling, from what has previously taken weeks or months to now can take only a matter of hours.

This time saving can be used in many practical ways — including taking time to understand the range of potential structural scenarios possible. This was often not possible previously, as the time taken to create a software-compliant fault network was so extensive. Just as a range of geo-statistical scenarios exist for property modeling, so too are there multiple possibilities for structural scenarios. Understanding the range of possible scenarios will ultimately lead to reduced risk in the field, and potentially less dry wells.

Now that the difficulties in modeling complex structural situations (such a reverse, Y and truncated faults) are removed, geologists can concentrate on understanding the reservoir, rather than outwitting the software.