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## **New Grids for Robust Reservoir Modeling**

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### **Abstract**

Geostatistical modeling of reservoir facies and petrophysical properties (e.g. porosity and permeability) must be performed in a pre-faulted, deposition space in order to reproduce the true spatial correlations of these properties. A transformation function is therefore required to bring the data from the current position of the reservoir into the modeling space where experimental variograms are computed; reservoir properties are then stochastically simulated in the deposition space and mapped back to the real space. Current reservoir modeling practice uses a stratigraphic grid to conform to the reservoirs structure (bounding horizons and faults). The (i, j, k)-indexing of the nodes of the cells is used as a discretization of a curvilinear coordinate system which acts as the transfer function to the deposition space. This leads to a very strong underlying assumption: the geological distances (in the deposition space) are a function of the (i, j, k)-indexing. In the presence of non-vertical faults, the cells of the stratigraphic grids are either stretched or squeezed, violating this assumption. Moreover, in the presence of complex structural geology, these grids simply cannot be constructed without tremendous simplifications. The new proposed approach uses a 3D parameterization of the subsurface yielding a grid that minimizes the distortions of distances imposed by geostatistical simulation algorithms. These new Geologic Grids allow the construction of robust reservoir models whatever the structural complexity of the reservoir. Additionally, they guarantee the accurate mapping and upscaling of reservoir properties into either structured or unstructured Flow Simulation Grids. They also enable the creation of structured Flow Simulation Grids in which faults are defined as stair-steps allowing representation of the complete reservoir structure and ensuring orthogonality of cells.

### **Introduction**

Today, reservoir modelers and engineers use the same 3D reservoir grid definition to construct their respective reservoir models. These grids are “structured” in the sense that each row contains the same number of cells; the same is true for each column which must have the same number of layers. The geoscientist should align the grids with the principal directions of deposition. The engineer should align them to preferential flow directions. However, in practice, the same grid is often used by both disciplines; only the resolution of the grids will differ. Depending on the oil and gas companies preferred approach, the Flow Simulation Grid is either down-gridded to a finer resolution, or the geological model is up-gridded to a coarser one. Both of these approaches can lead to erroneous results. As we show in this paper, the use of these types of grids has two major shortcomings. Firstly, it is extremely difficult and often impossible to accurately represent many structurally complex reservoirs – models have to be simplified; the geometry of the fault network is modified and some faults are even ignored. Secondly, once the reservoir model is constructed, cells are (i, j, k) indexed with implications that are often ignored. The indexing is commonly used to provide a transformation of the reservoir geometry from its current faulted and folded structure to an un-faulted, unfolded environment assumed to represent the reservoir geometry at the time of sediment deposition. Petrophysical properties such as net-to-gross, porosity and permeability, are stochastically distributed in this deposition space and mapped back onto the reservoir model. As described below, the structured nature of the reservoir grid leads to large volume variations from cell to cell which, if not properly taken into account, can lead to erroneous reservoir volume and reserve estimations.

Reservoir modeling therefore suffers from current 3D grid technology both in terms of structural accuracy and petrophysical content. This paper presents a new way to represent accurately both the reservoir structure and the integrity of the property model. Based on the space/time transformation theory (Mallet, 2004), it is possible to disconnect the constraints of structural representation and the distribution of reservoir properties. A ‘*Geologic Grid*’ is introduced which can be created whatever the complexity of the reservoir structure, while guaranteeing conservation of distances and volumes through the ‘*uvt-transform*’. Additionally, since most commercially available reservoir flow simulators still require a structured description of the reservoir