AAPG Annual Convention
Salt Lake City, Utah
May 11-14, 2003

Practical Analysis for Reservoir Uncertainty

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Understanding and managing subsurface risk is becoming an increasingly important business driver for oil companies. The ability to generate, manage and rank multiple models of a reservoir will allow for better economic forecasting, particularly at early project stages.

3D geological modeling is becoming a standard work process in many oil companies. Properly utilizing multiple scenarios and realizations for risk analysis, however, is a technique that requires a more sophisticated work process. Two main themes are discussed. First: how to frame the problem to generate reasonable model trees that will contain multiple stochastic realizations. Second: how to perform model ranking and select a small number of models for further investigation and analysis.

This is an evolving workflow in many companies. In this presentation we provide some ideas and guidelines for streamlining and focusing the work to the desired goal.

Framing Multiple Geologic Scenarios

An important initial step in modeling is the creation of a detailed model tree that is an outline for the project's workflow. Depending on the maturity of the project, varying amounts of information will be available. The first step is to define several geologic scenarios that fit the available data. As more data become available, these scenarios will be more tightly constrained and it may become possible to eliminate some branches of the model tree.

In the figure 1 the decision workflow for multiple scenarios and multiple realizations is diagramed. Three examples of different scenarios are discussed.

An example of multiple scenarios (primary level) would be changing the depositional environment being modeled. There may be competing hypothesis of the reservoir deposition, for example in a project with little data alternate scenarios might be a channels or sand bars.

By creating a model family for both scenarios, they can be investigated to determine the reasonableness and fit to the available data. At times neither can be initially ruled out but often, subsequent data collected will allow one to emerge as the most likely possibility.

Another example (secondary level) of the use of multiple scenarios is the effect of channel orientations in a fluvial environment on field performance. With limited well data, the orientation of the channels may be poorly defined. By using multiple scenarios, each providing a different orientation, several models may be created and analyzed (for example, by running a dynamic simulation). The impact of the different scenarios on field performance can then be estimated.

Figure 2 and 3 illustrate two examples of channel scenarios: one modeled with a North – South orientation, the other with an East – West orientation. Intuitively, these models will exhibit different responses in a flow simulator, since the main flow direction is modeled differently.

A third example where multiple scenarios are used is when the depositional environment is determined but one may wish to investigate variations in parameterization of the scenarios (tertiary level). Modeling alternate net-to-gross ratios (while keeping a single depositional scenario) allows another level of investigation.

Multiple Model Ranking and Analysis
Such scenarios above may be further utilized to generate *n* equally probable realizations; all of which are conditioned to the available data. Analysis of these realizations will help to capture some of uncertainty associated with the particular scenario.

Multiple realizations use identical input data, but a different seed number for each realization. All other user-defined settings are the same, resulting in each realization being different. See the example below of 5 such realizations, each with the same input data, but a different seed number for each realization.

Using current commercial software packages, it is relatively straightforward to generate many hundreds of scenarios and realizations of geological models. Putting every realization through the flow simulation process, however, will not generally be practical because of time constraints. We need mechanisms to rank and select realizations of the geological model to take to flow simulation.

The mechanism chosen for ranking will, in part, depend on the nature of the problem to be solved. Possible ranking methods include STOIIP, static connected volumes, and rapid dynamic tools such as streamline analysis.

An example of ranking with dynamic tools (streamlines) is shown in figure 5.

From this type of ranking a high, middle and low case can be determined and carried forward into a full field flow simulation analysis.

A representative number of geological models, sufficient to capture the reservoir uncertainty, may then be taken forward for further study.

Conclusions
Improved understanding and analysis of reservoir uncertainty can be achieved at early stages of a project by careful framing of the modeling problem, which includes multiple geologic scenarios. This added level of sophistication in the modeling process can be achieved in a coherent and efficient manner by adopting a systematic approach. The techniques presented here can aid in the formulation of a reservoir management plan.

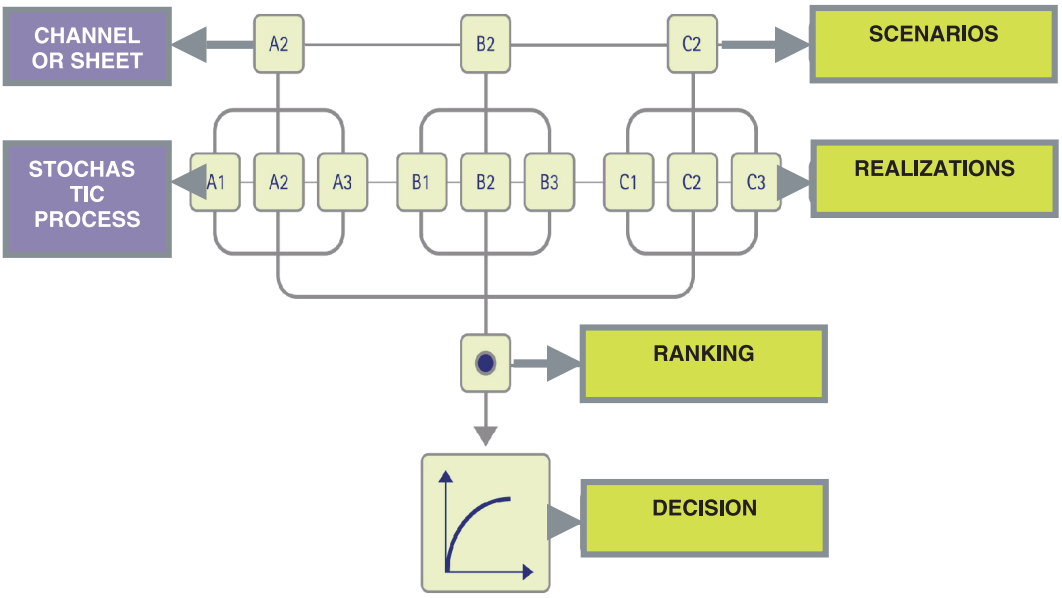

Figure 1

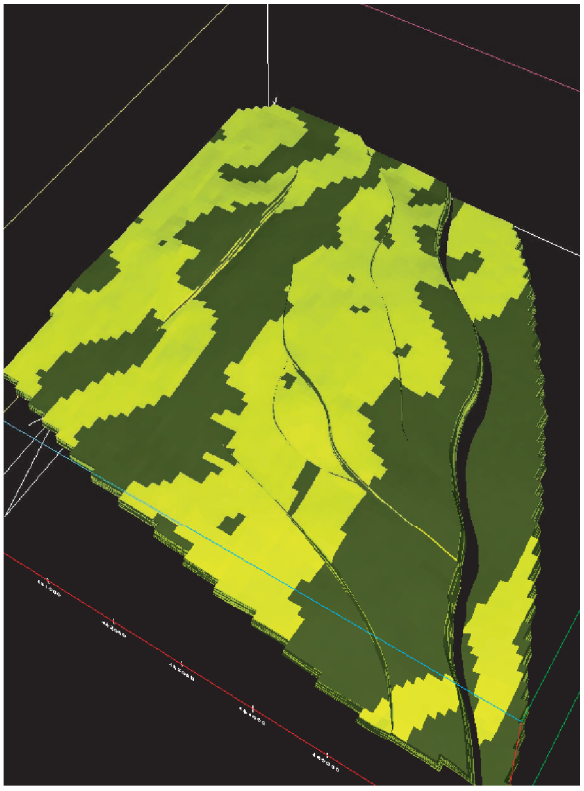

Figure 2

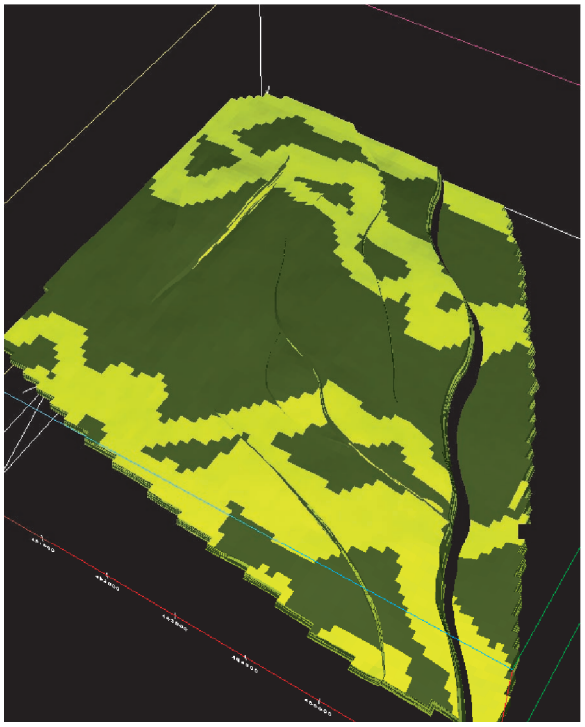

Figure 3

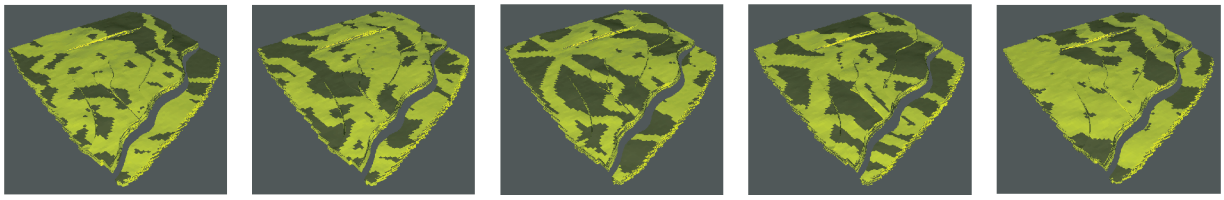

Figure 2

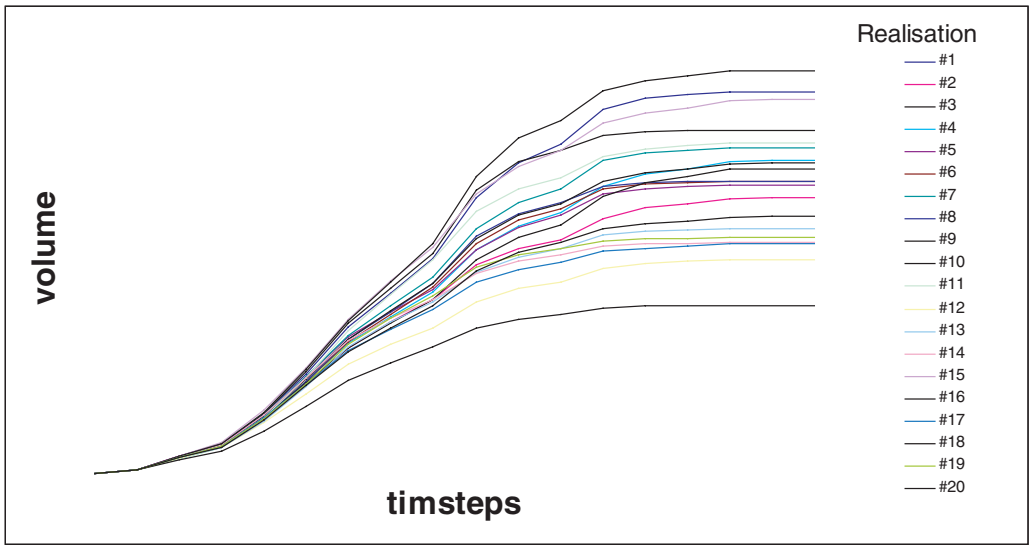

Figure 3