AAPG HEDBERG CONFERENCE
"Paleozoic and Triassic Petroleum Systems in North Africa"
February 18-20, 2003, Algiers, Algeria

Basin modeling: results obtained and new trends

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The development of Basin Modelling has been considerable over the last five years. Most companies are now routinely using 1D and 2D basin models in order to reduce risk in Exploration, while the more recently appeared 3D models are rapidly spreading among National Oil Companies (NOC's), majors, and independent oil companies. Several important results have been achieved in the last five years :

1. It is now widely accepted that the physics that describes the generation and migration of oil and gas is relatively well understood. In particular, there is a consensus that Darcy law can be used as a valid approximation to represent shale compaction and migration of HC fluids along carrier beds. It is also accepted that Arrhenius kinetics provides a reasonable approximation of oil and gas formation.
2. The methodology of basin modelling has made considerable progress. It is now widely accepted that 1D basin modelling is a good approach for thermal/maturation modelling in immature/mature basins. Thermal history is generally dominated by conductive heat transfer, sometimes by topography-related convective flow. Compaction-drive has a moderate effect on maturation of organic matter. Volcanic dyke or sill intrusions have a localised thermal effect on organic matter maturity, but become inefficient over distances of a few meters away from the volcanic bodies.
3. 2D basin modelling has grown into a mature technique, particularly well adapted to represent water, oil and gas migration along and across carrier beds. It has been shown that high resolution sequence stratigraphy highlights the macroscopic permeability configuration of sedimentary basins, a key for predicting migration directions.
4. There has been considerable improvement in our ability to model gas/oil ratio in the hydrocarbon "kitchen" and along migration pathways. Compositional kinetics associated with thermodynamic description of phase of state have shown a remarkable capacity to account for API gravity and GOR characteristics of entrapped oil.
5. 3D basin modelling techniques have really introduced a major change of paradigm. While 1D or 2D reconstruction are qualitative in nature and conceptual in their objectives, it has been proven that 3D basin modelling techniques offer a remarkable capability to interpret the size or volumetrics of entrapped hydrocarbons (HC.) Recent studies confirm with very good accuracy the amount of trapped HC accumulations, while comparison of different scenarios provides an efficient means for prospect ranking. Significant progresses has been made in the solvers, which are now much more rapid than previously, thanks in particular to the use of implicit methods and parallel computing techniques. It is in particular now possible to represent in 3D salt and shale movements, as it was already previously possible in 2D.

6. 1D, 2D and 3D models need to offer a integrated work environment, where by 1D or 2D sections can by automatically extracted from 3D data, and whereby all models can be built under seismic control, and shared functionalities.

The above results will be exemplified using the 1D, 2D and 3D basin modelling software of IFP Group, the Temis family.

In the future, it is possible to forecast some major trends :

1. More accurate faults geometries will be introduced, requiring different numerical methods to be developed. The objective is to have the capability to solve any kind of deformation and fault movements. These techniques will first be solved in 2D, for which advanced prototypes like IFP's Ceres already exist.
2. Users require a more scientific approach to uncertainty modelling. Rather than using the heavy and time consuming Monte Carlo approach, it seems that more sophisticated techniques like IFP's Qubs method, based on experimental design techniques, will become very popular.
3. It is expected that basin modelling techniques will be more and more applied at the smaller field scale simultaneously with regional scale applications. This will reduce the gap that currently separates basin modelling techniques from Reservoir characterization. In order to prepare this trend, IFP Group has developed an approach were its reservoir modelling software shares the same components and modules as the basin modelling software.