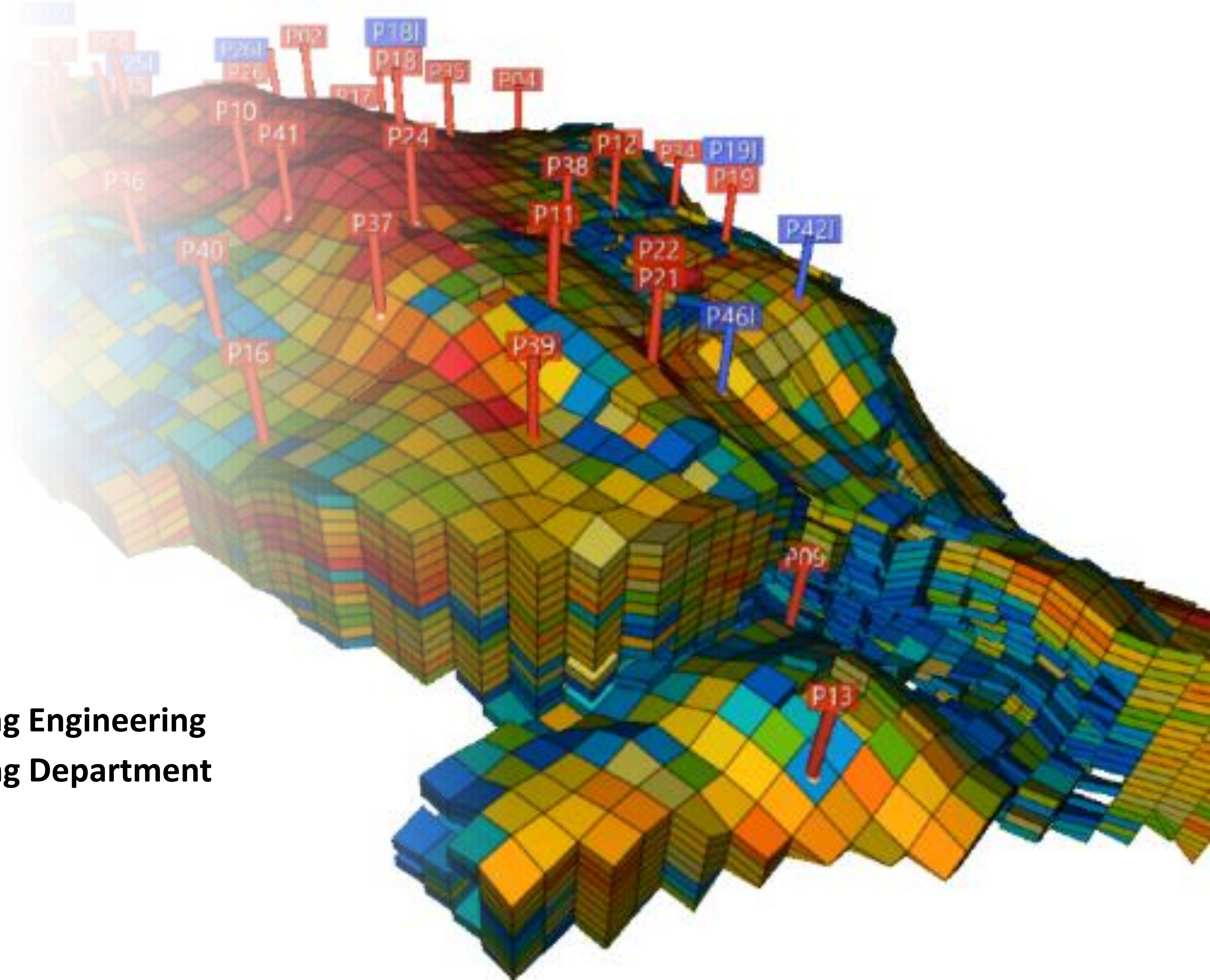
Reservoir Simulation



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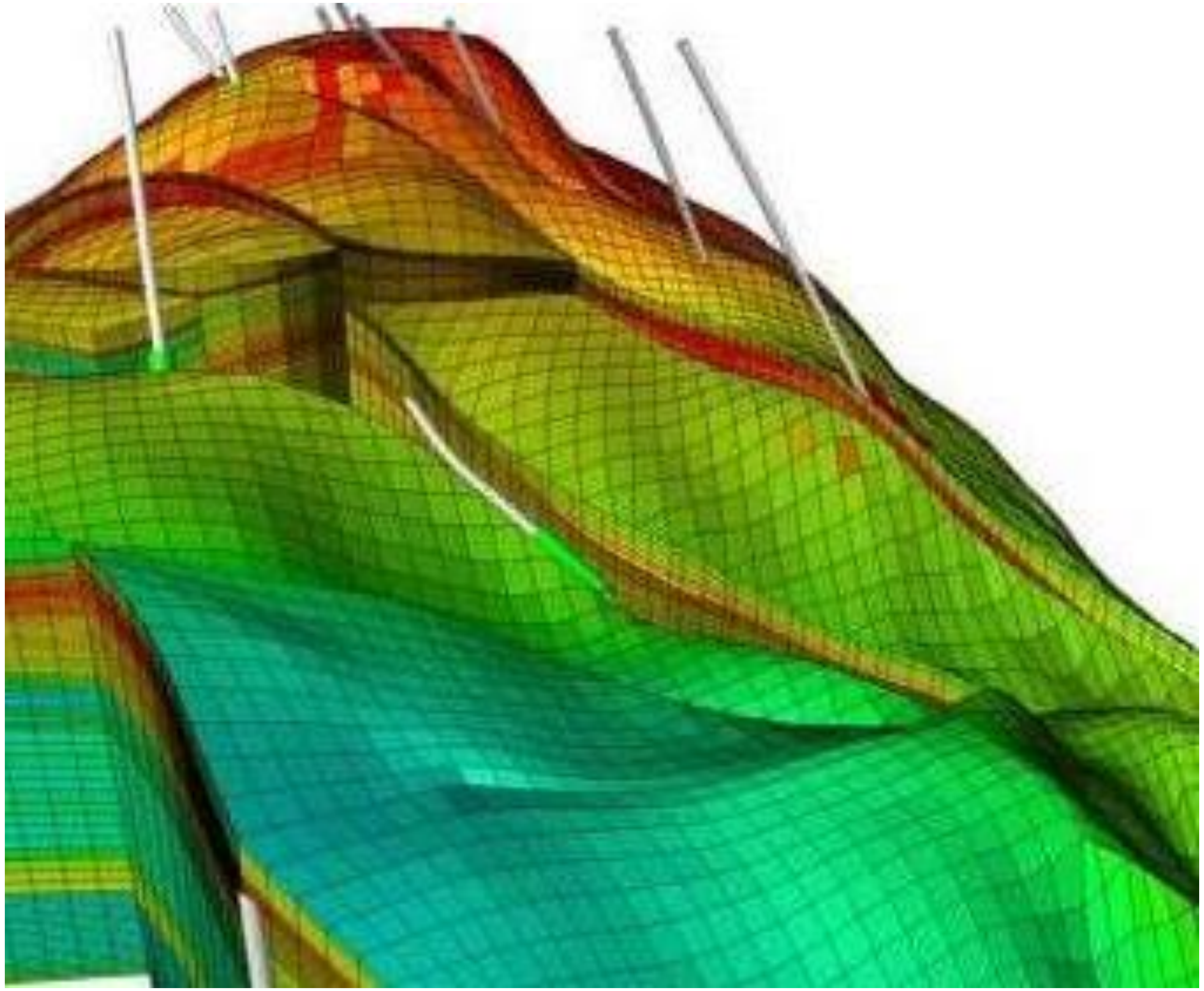
In general, simulation is a theoretical or a physical representation of an operation and an imitation of its system/processes in real-life. Reservoir Simulation is a field developed in petroleum engineering where it utilizes porous media in computer modeling to estimate the fluids dynamics, its goal is to predict the field performance under varies producing strategies. Reservoir Simulation is grounded on recognized engineering equations, engineers started calculating reservoir engineering with basic mathematical model long before the emergence of modern technology. Although Reservoir simulation is not new to the industry, it has become more efficient than before due to the advanced capabilities provided by modern day technology. Proficiency, efficiency and effectiveness are the reasons why many engineers became a competent to the model and its development

Reservoir simulation is the art of combining physics, mathematics, reservoir engineering, and computer programming to develop a tool for predicting hydrocarbon reservoir performance under various operating strategies.



Uses

- Geological Model
- Flow Model
- Gridding
- Nonconventional wells
- Integrated reservoir models and multiple reservoirs
- Subsurface Modeling

Geological Model
The geologic model (Geocellular model) is built as a numerical/mathematical imitation of the reservoir. It offers seismic structural interpretation, well petrophysical data with known depositional characteristics and 3D volume (porosity, permeability and water saturation) model. It consists of over 50 million cells on large complex reservoir, which enabled the industry to simulate equal number of this large magnitude of cells in a reservoir simulator.

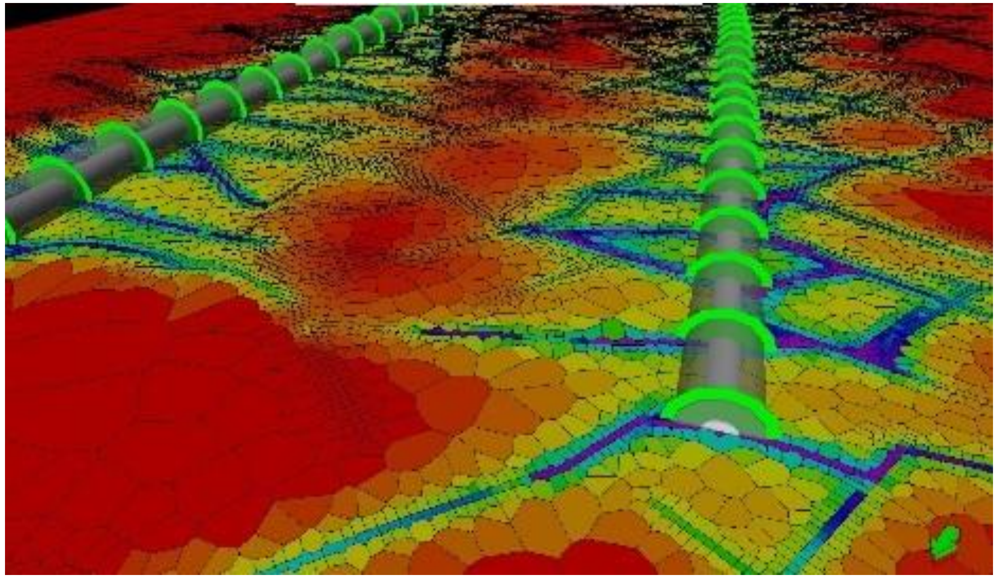
Flow Model
The geological model is large and contains lithology, facies, major faults and pinch-outs. Therefore, the model is upscaled in vertical and areal directions introducing new methods including local flow-based methods and global flow methods to calculate transmissibility. Faults and pinch-outs upscaled models have been developed by knowing the general information of faults and calculated. The inclusion of faults became an important factor in reservoir information and modelling.

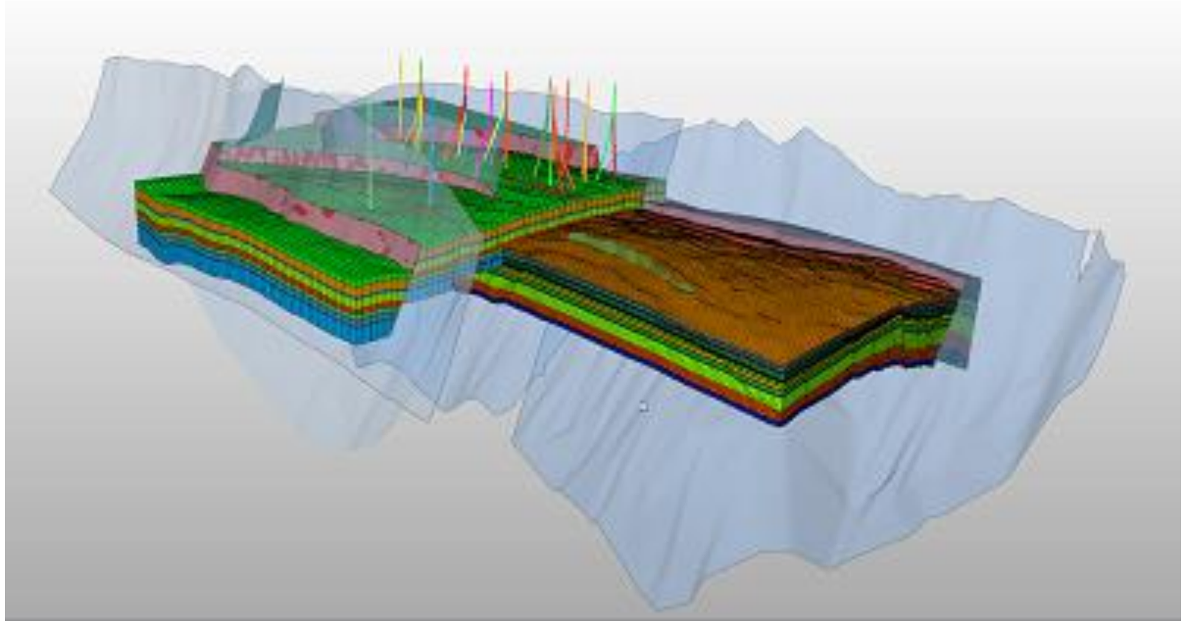
Gridding
Complex geometries in reservoir simulation studies use Cartesian or corner point structured grids. The 3D System in a grid allows a better examination of infill well locations and water/gas calculations.

Nonconventional wells
Nonconventional wells are utilized to enlarge production rates and recovery in petroleum industry. There are several steps to simulate nonconventional wells that will help the well to have a uniform inflow that are in use today in the industry.

Integrated reservoir models and multiple reservoirs
Enhancement of reservoir management, this connects multiple wells from different fields (ex. Subsurface and surface fields) and simulates their integration which enhances recovery and developments.

Subsurface Modeling
Assembling precise 3D models of complex structures. New reservoir and geological information can be updated and combined with new data sets. This software provides operators a better knowledge of the subsurface which will improve production planning reserves estimation and well placement.

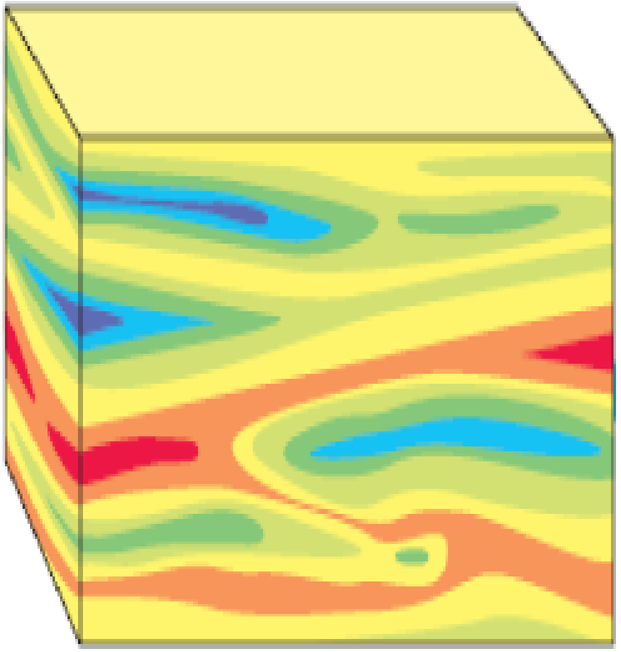




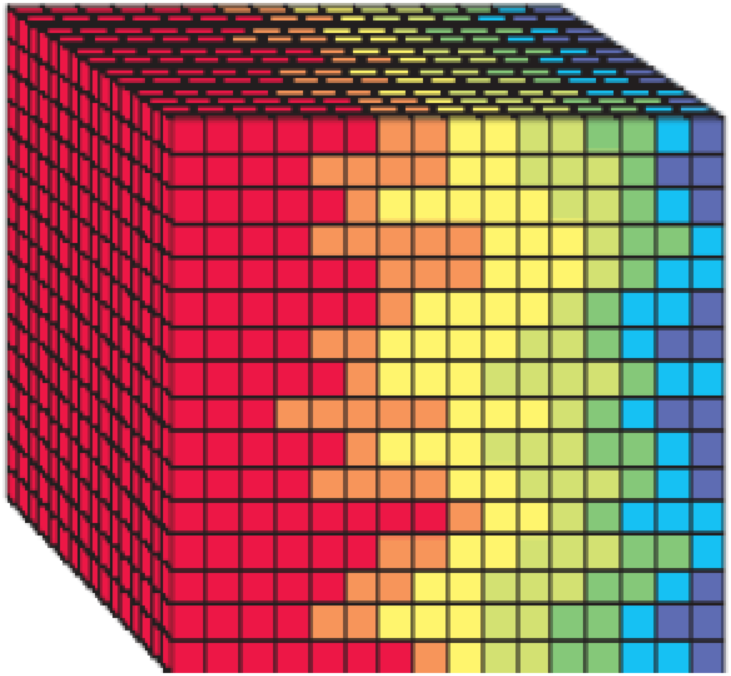
- Simulation means to imitate the behavior of a reservoir in terms of production pressure and production rates as a function of time by using a reservoir model

Real Reservoir

Reservoir Model



Dynamic Reservoir Model



Early in a fields life, it is essential to be able to evaluate how much Hydrocarbons will be produced through time:

- **How much hydrocarbon is in the reservoir ?**
- **How much of that hydrocarbon can potentially be recovered ?**
- **How quickly can the recoverable hydrocarbons be produced ?**
- **How will the reservoir perform under various development scenarios ?**

A Dynamic Reservoir Model is a useful tool that may help to answer those questions.

Main objectives of reservoir simulation

1- To build a model of the reservoir and to examine its performance in terms of production and pressure

2- To predict future performance.

3- To find ways to increase ultimate recovery hydrocarbons more economically

Methodology of Reservoir Simulation

1- The reservoir is divided into a number of blocks (or grid blocks)

2- Basic geological and reservoir data is provided for each block

3- Wells are positioned within the arrangement of blocks

4- The target rate and well pressure are specific as a function of time

5- The appropriate equations derived from Darcy's Law are solved to give the pressure and saturation of each block as well as production and injection for each well.

The Computer Model

- **The reservoir model** Fluid flow Equation within the reservoir
  The reservoir is modeled by subdividing the reservoir volume into an array, or grid, of smaller volume elements, which called: gridblock, cell, or node.

- **The well model** Fluid flow that represents the extraction of fluids from the reservoir or the injection of fluids into the reservoir

- **The well bore mode** Fluid flow from the sand face to the surface

- **The surface model** constraints associated with surface facilities, such as platform and separator limitations

1 Reservoir Simulation Model = 1 Numerical Calculator + 1 Set of Modelled Data

Modeled Data

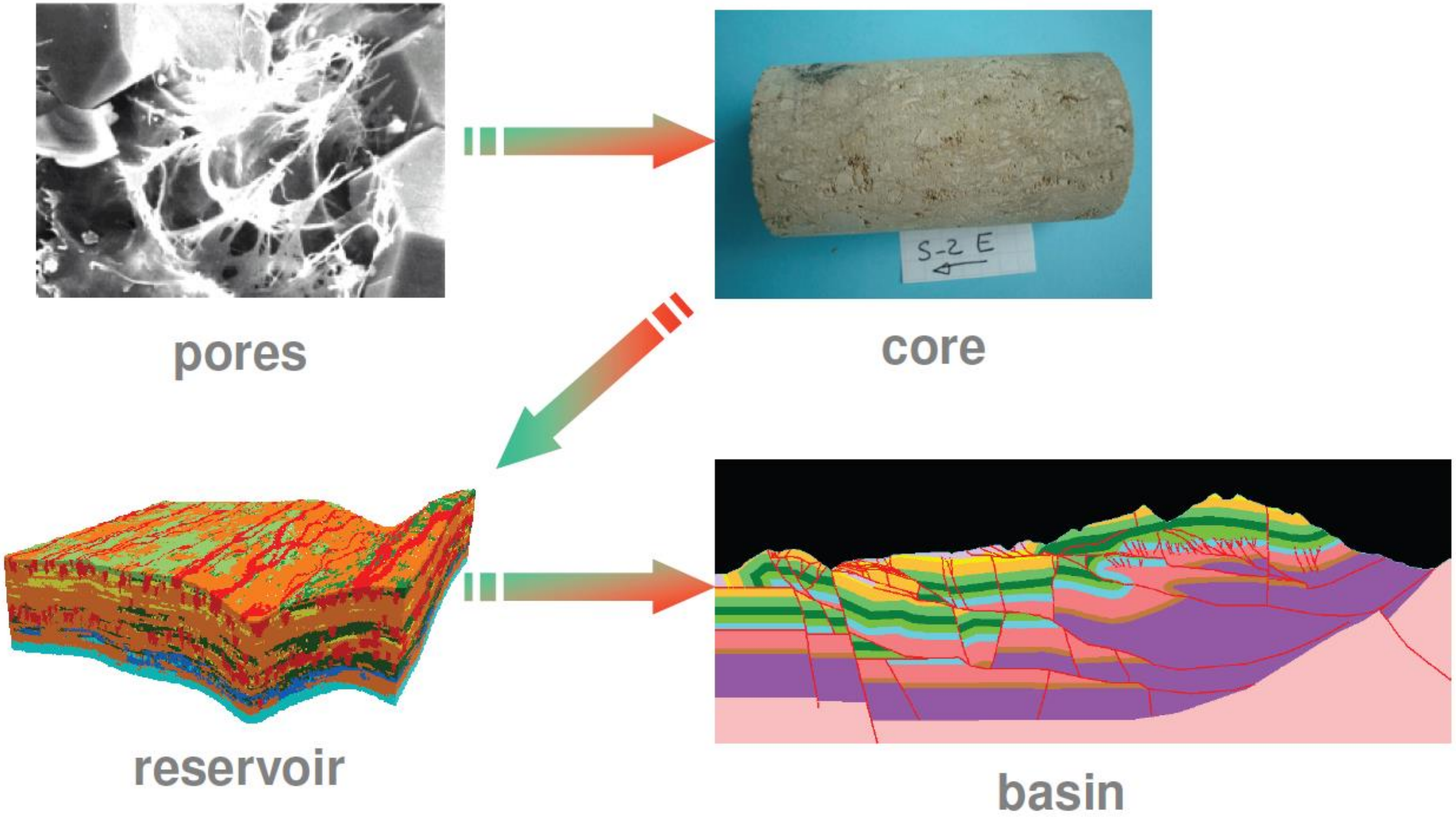
- **Reservoir properties**
- **Fluid properties (in reservoir conditions)**
  - Liquid vapour equilibrium
  - Compositions
  - Density, viscosity
  - Compressibility

  } for each phase
- **Flow (in reservoir conditions) :**
  - Permeability
  - Relative permeability and capillary pressure
- **Material balance (in each cell)**

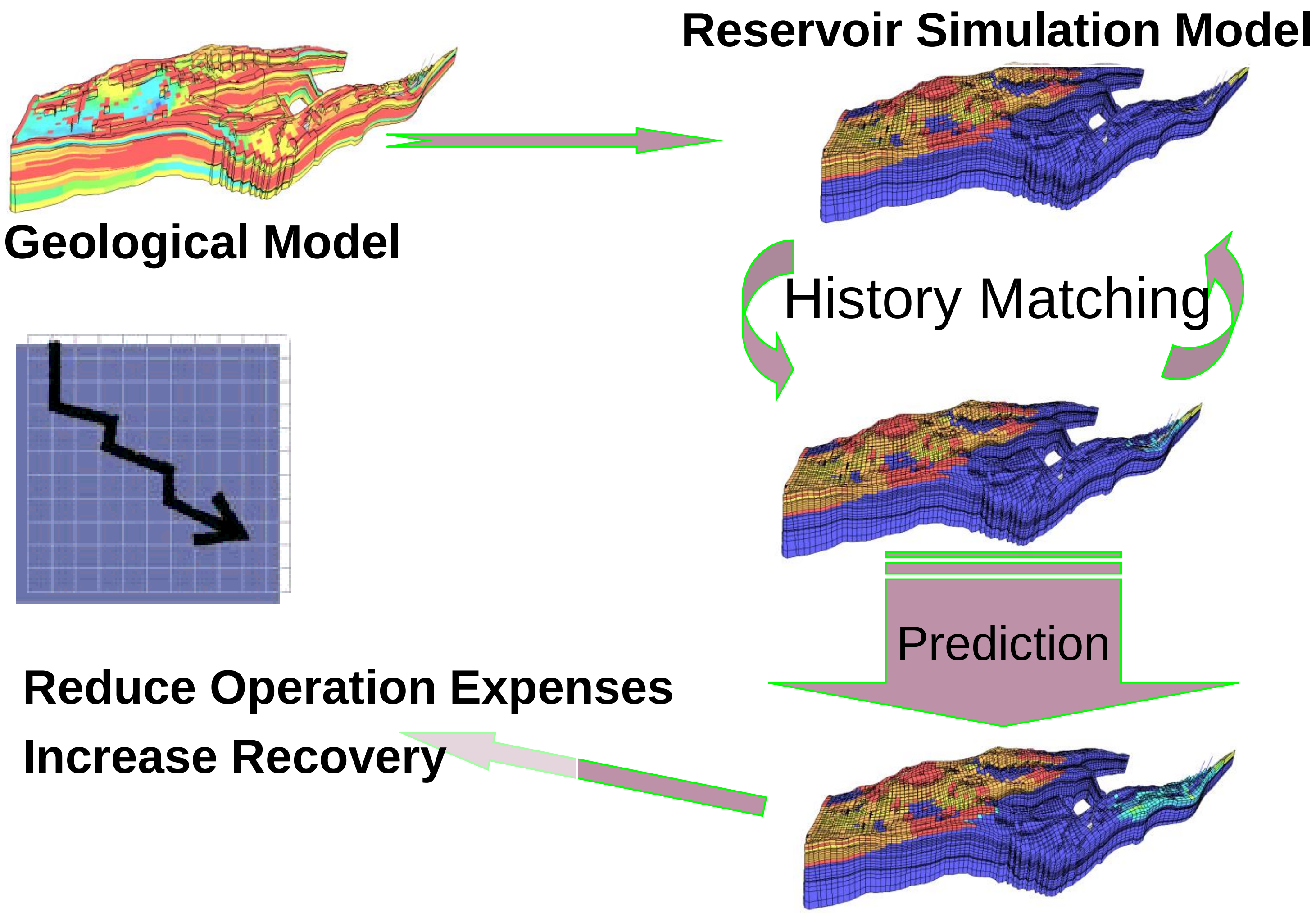
Reservoir Simulation PLANNING

- **Reservoir simulation study duration : from weeks to years**
- **Necessity to plan carefully the study to give correct results in time, before to take decisions for the field management :**
  - *Problem definition*
  - *Data review*
  - *Data acquisition*
  - *Approach selection*
  - *Reservoir characterization - build geological static model*
  - *Upscaling to generate dynamic reservoir simulation model*
  - *Computing support*
  - *Initialisation*
  - *History matching*
  - *Prediction*
  - *Reporting*

Examples of Scale



Prediction Future performance



Problem definition

- Determine present reservoir performance and associated
  operating issues in order to define future performance

  - Collect information
  - Identify the problems
  - Determine the objectives

Data review

- **Data generally must be reviewed and reorganized because :**

→ they come from several sources of information
→ the review evidences inconsistencies and gaps

- **The objective of data review is to :**

→ decide if the data quality is sufficient to conduct the study
→ plan data acquisition for the study purpose

Main Types of Data

TYPE	Geometry	Petrophysics	Fluids	Wells	Production
Description	Shape Thickness Dimensions Faults Contacts	Porosity Permeability Compress. Pc's Kr's Swi Sorw	Bo, μo, … Bg, μg, … Bw, μw, …	Coordinates Completion PI	Qo = f(t) Qg = f(t) Qw = f(t) Separat. Cond.
Origin	Seismics Geology Well tests	Logs, cores Laboratory Tests	Laboratory Abacus	Well report Tests	Field

Study approach

- **What is the most suitable model to answer the problems :**
  - model dimensions (1D, 2D, 3D)
  - PVT type (Black oil, compositional)
  - Special physical options (double media, thermal, chemical …)

- **Factors influencing the study approach are :**
  - availability of simulators and computing environment
  - time, money and manpower

Study approach

➢ **Model design is influenced by :**

- type of process to model
- complexity in fluids mechanisms
- objectives of the study
- quality of data
- needed level of details
- budget

Thank you

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