Tishk International University
Engineering Faculty
Petroleum and Mining Engineering Department

Reservoir Simulation

Lecture 9: Reservoir Simulation Workflow

Fourth Grade- Spring Semester 2020-2021

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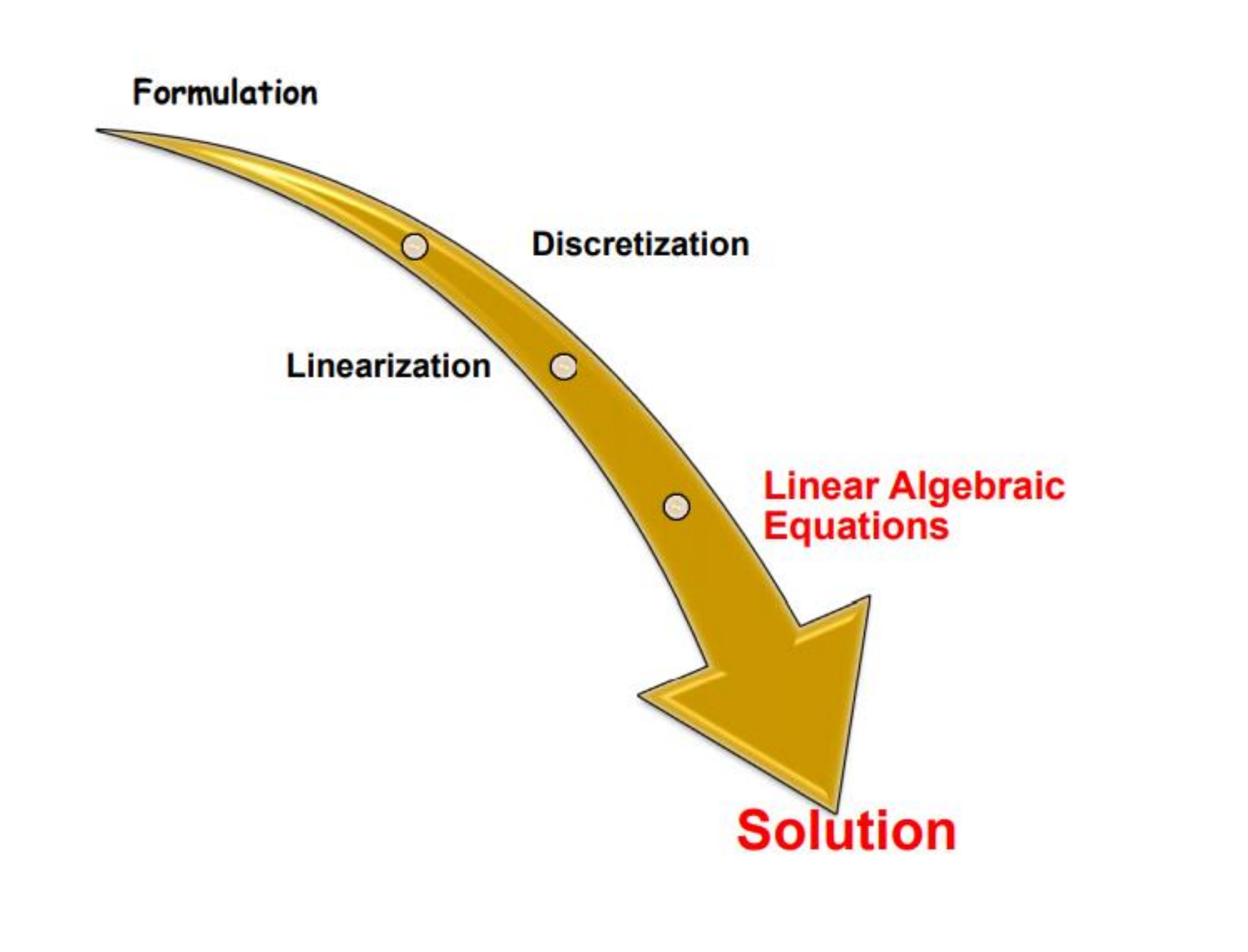
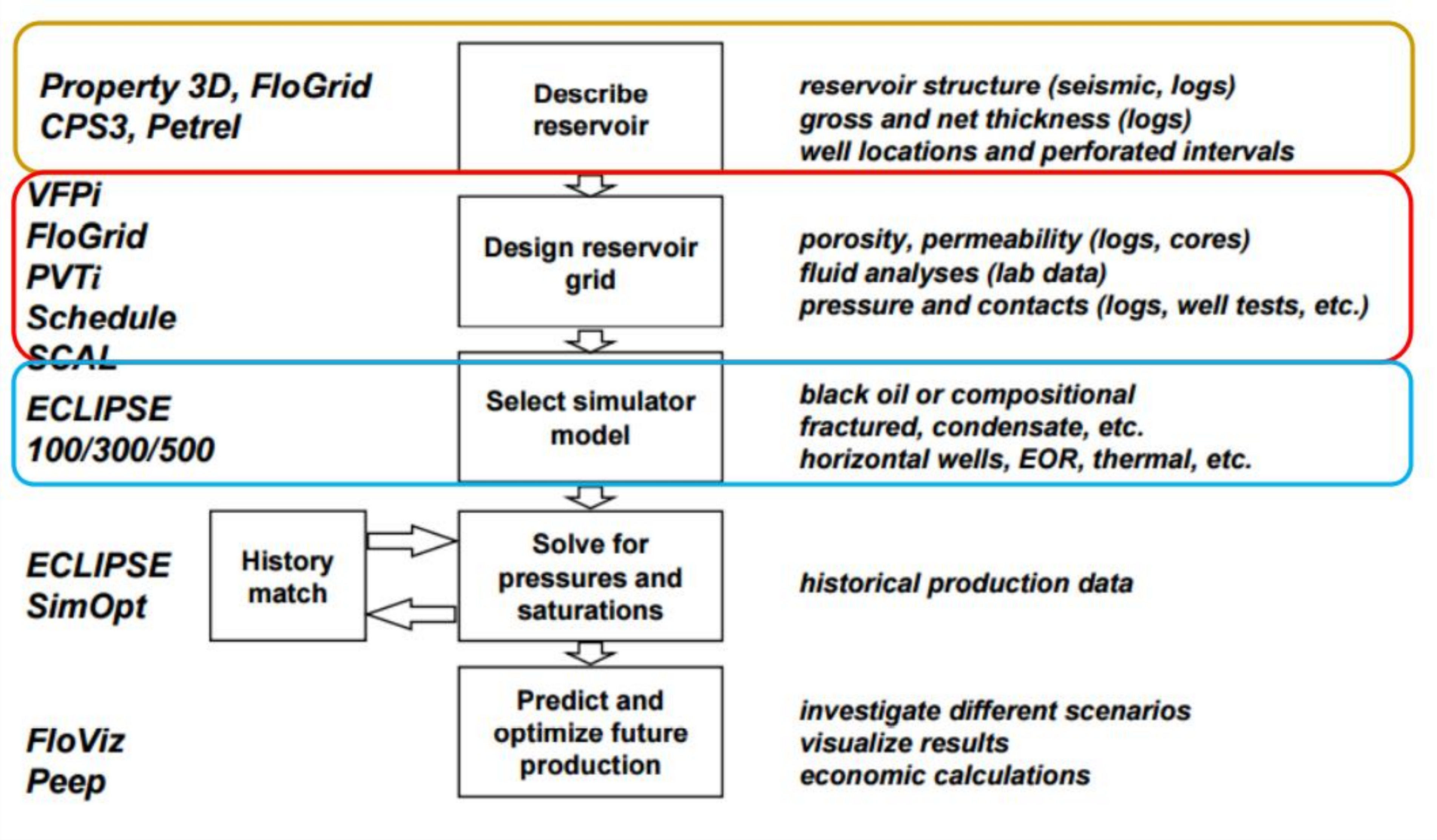
Content:

- Overview of Modeling Procedure
- Reservoir Simulation Workflow
- Reservoir Simulation System
- Eclipse Workflow

Major Steps of Numerical Solution



Overview of Modeling Procedure:



Reservoir Simulation Workflow:

- ✓ Building a geo-model
- ✓ Assemble other necessary data (PVT, SCAL, …)
- ✓ Initialization: calculation of P, S, Hydrocarbon in place
- ✓ History Matching: reduce the uncertainty in the geo-model
- ✓ Forecast: compute production profiles and reserves

- For different development scenarios (production mechanisms, well architecture, ….)
- Taking into account the surface facility constraints

Reservoir Simulation Workflow:

- What do we have at the start of this process?

➢ **Static model:**

✓ Structure- tops, thickness, layering, faults, boundaries, shales, sands, rock type, depositional environment, grain size distribution fractures (all locations), property of aquifer.

✓ Rock properties at all points in the reservoir, permeabilities in all directions, porosities, capillary pressure, relative permeabilities.

Reservoir Simulation Workflow:

- What do we have at the start of this process?

➢ **Static model:**

✓ Initial reservoir conditions- water, oil and gas saturations, pressures at all points in the reservoirs, contacts.

Reservoir Simulation Workflow:

- What do we have at the start of this process?

➢ **Well Data:**

✓ Well locations, trajectory, completions, workover schedule

✓ Production rates of oil, water, and gas as a function of time

✓ Pressure history of the wells- bottom hole flowing pressure and/or build-up pressures (well tests) at specific times

✓ Injection history- rates, fluids, pressures, etc.

Reservoir Simulation Workflow:

- What do we have at the start of this process?

- **Fluid data-** PVT experiments with the reservoir fluids, viscosities, densities.
- **Material balance of the reservoir history**
- **Reservoir Compartments**
- **Reservoir mechanisms**
- **Surface facilities and conditions**

Reservoir Simulation Workflow:

- Static model
- Well Data
- Fluid data
- Material balance of the reservoir history
- Reservoir Compartments
- Reservoir mechanisms
- Surface facilities and conditions

Reservoir Simulation System:

- Suite of Software Applications for:

➢ **Pre-Processing**

✓ Data Loading and Importing

✓ Gridding

➢ **Processing**

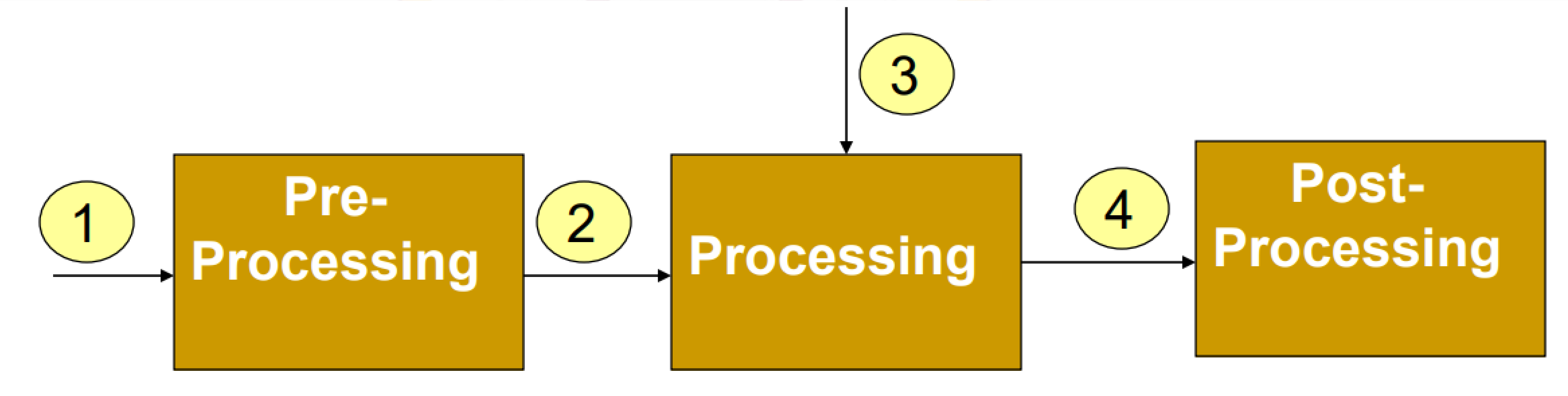
✓ Numerical Calculations

➢ **Post-Processing**

✓ Visualization of calculated results

Reservoir Simulation System:

1) Importing Geological Data
2) Parameterized Grid, Neighborhood Connections
3) Rock-, PVT-, and Well data
4) Simulated Results for Visualization



Reservoir Simulation System:

- **Pre-Processor:**
- ✓ Automatic Grid generation
- ✓ Cartesian, Radial and Corner Point grids
- ✓ Local Grid Refinement, Aquifer Modeling
- ✓ Flexible Well Modeling (arbitrary directed wells)
- ✓ Fault Modeling (vertical, sloping)

Reservoir Simulation System:

- **Pre-Processor:**

- ✓ Data Importing from various sources and formats
- ✓ Graphical User interfaces and Visualization
- ✓ Data preparation modules (Rock, PVT and Well data)
- ✓ Validation of Geological Model

Reservoir Simulation System:

- **Processor:**

- ✓ Black-Oil Models (single phase to three phase models)
- ✓ Extended Black Oil (Salt, Polymer, API)
- ✓ Compositional Model (n components, EOS model)
- ✓ Thermal Model
- ✓ Solution Techniques: IMPES, Fully implicit, adaptive implicit method

Reservoir Simulation System:

- **Processor:**

- ✓ Dual Porosity Dual Permeability Models
- ✓ Rock compaction and hysteresis models
- ✓ Analytical and numerical aquifer treatment
- ✓ Flexible and multilevel well management controls

Reservoir Simulation System:

- **Post-Processor:**

- ✓ Visualization of calculated results on grid: distribution plots for any object
- ✓ Visualization of results vs. time
- ✓ Well plots, well group plots, reservoir plots: Animation of results
- ✓ Supporting all major graphic formats
- ✓ Exporting maps

Content:

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- Reservoir Simulation Workflow
- Reservoir Simulation System
- Eclipse Workflow

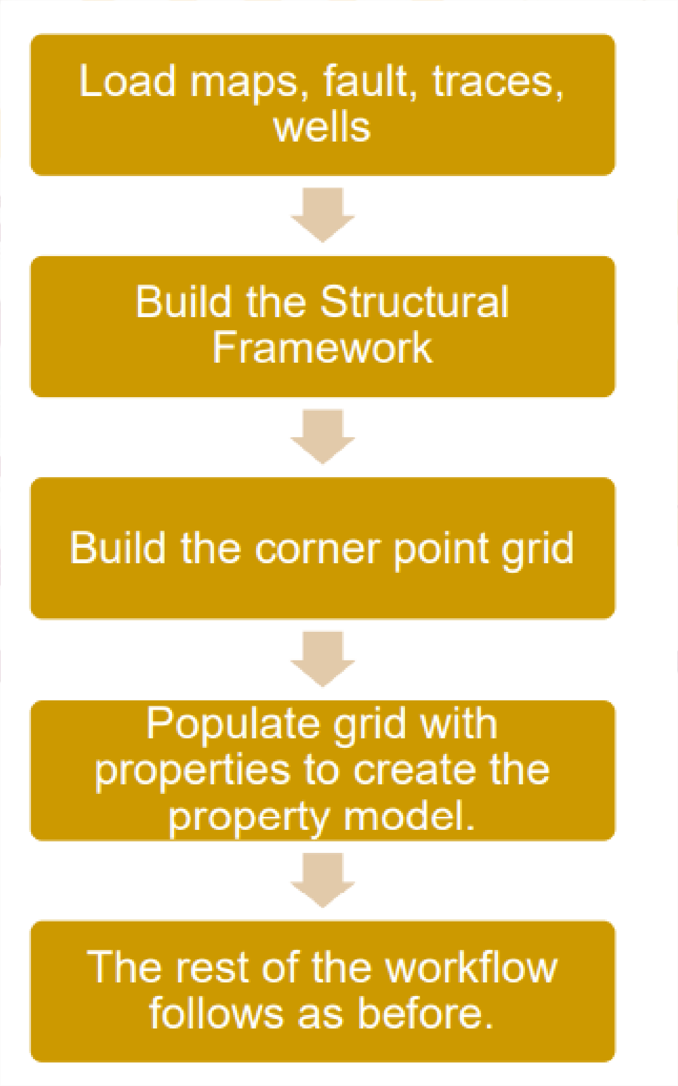
Eclipse Workflow:

- FloGrid: From the Static Model-Create a numerical grid of the reservoir (flow field) that includes at all points

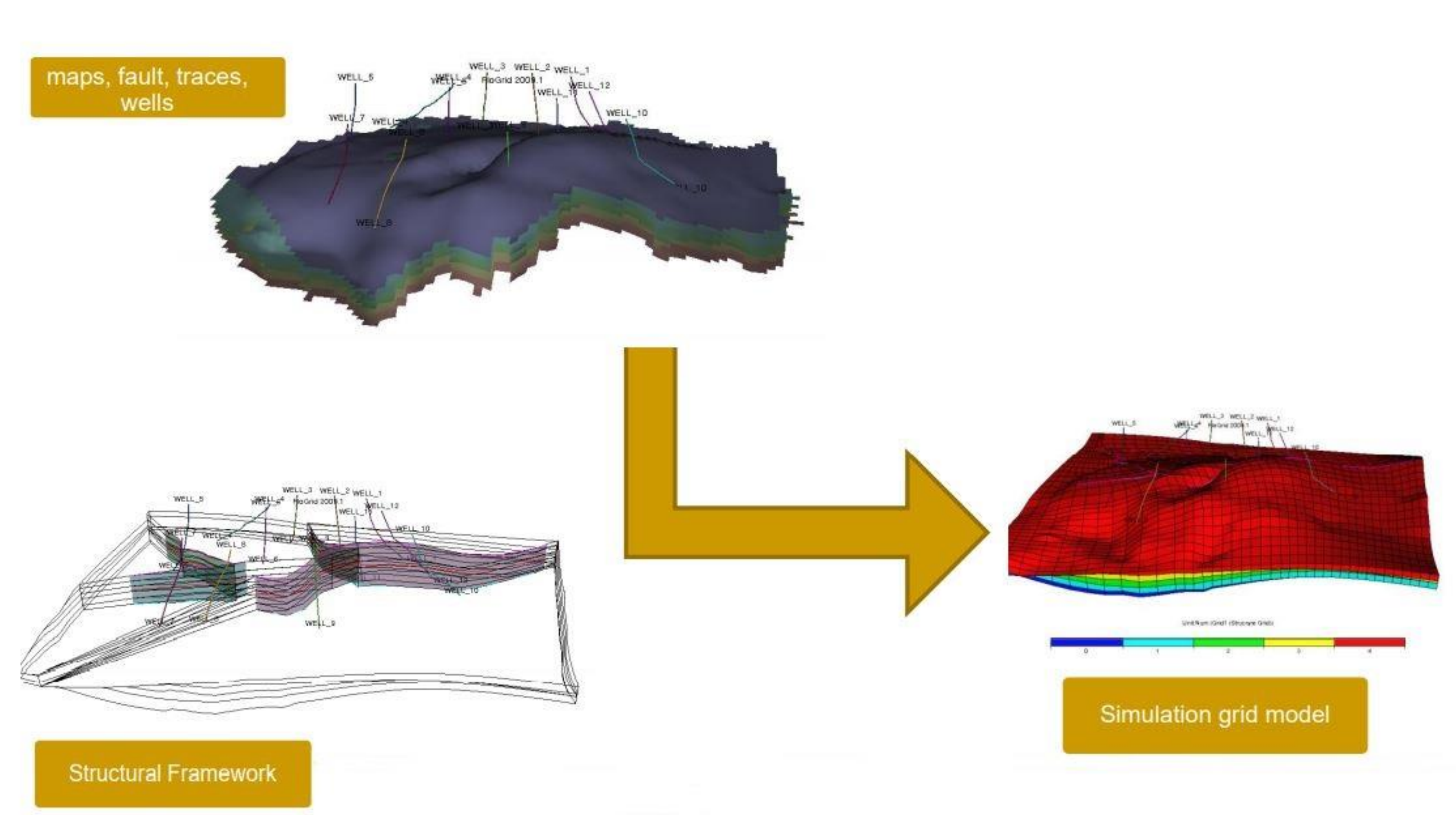
- Rock permeability, porosity, relative permeability, capillary pressure, pressure saturations
- Location, volumes, adjacent rocks or features

- The input data are a set of mesh maps and fault traces, generated in an external mapping package, and well deviation surveys.
- The output is a simulation grid and cell properties.

Eclipse Workflow:



Eclipse Workflow:



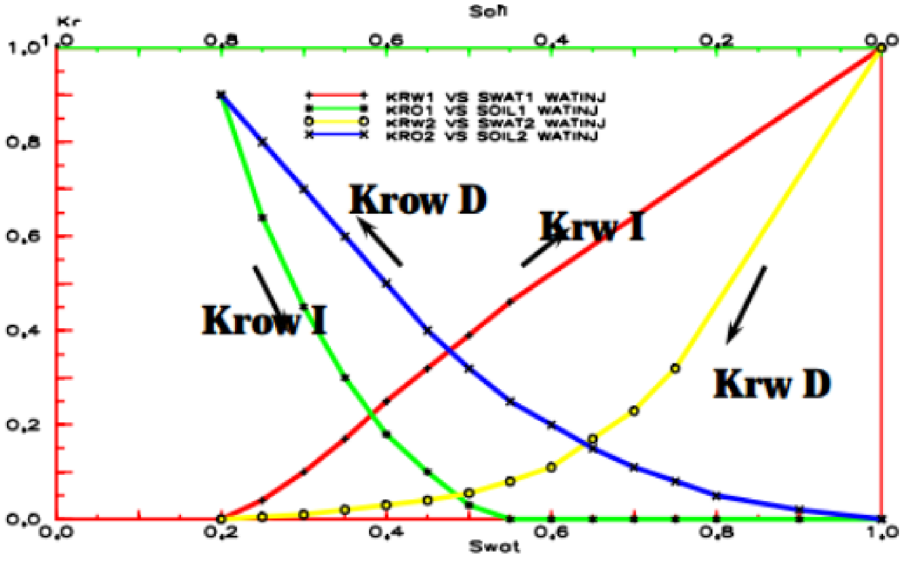
Eclipse Workflow:

- PVTi:

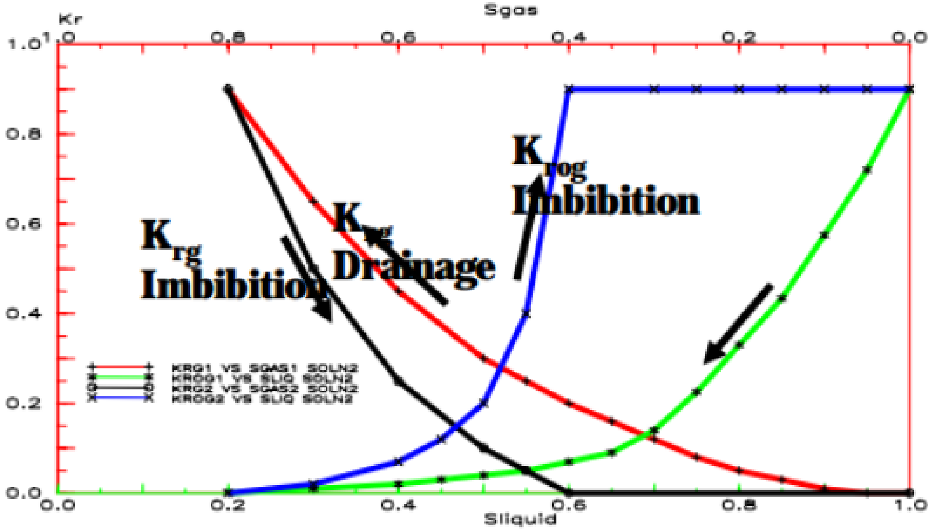
- ✓ PVT Analysis and Fluid Characterization
- ✓ Using Equation of State and PVT Program characterize oil and/or gas and match laboratory phase behavior experiments
- ✓ Export PVT files for Blackoil, Compositional, or Thermal simulations

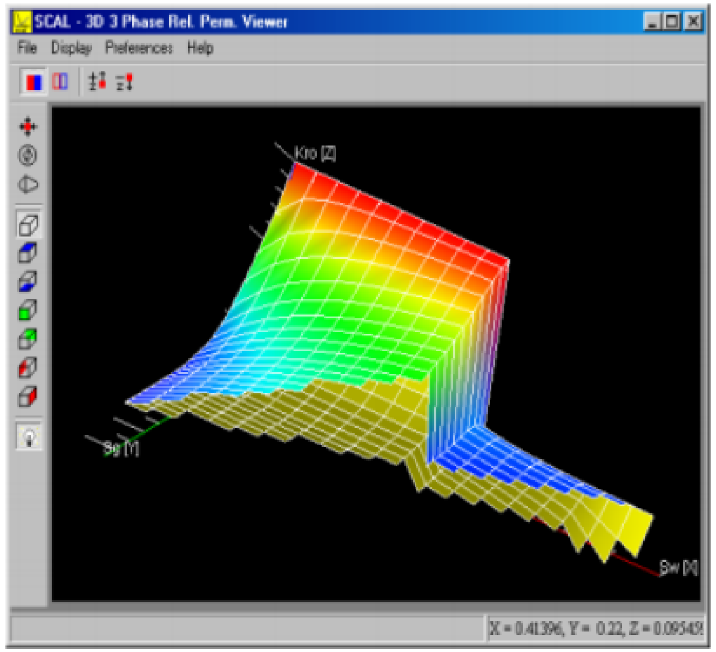
Eclipse Workflow:

- ➢ SCAL:
- ✓ Analysis of Rock Types
- ✓ Relative Permeabilities
- ✓ Capillary Pressure
- ✓ Imbibition and Drainage
- ✓ Assignment of curves to grid blocks



Drainage and Imbibition Krw and Krow





Eclipse Workflow:

- Schedule:

✓ Well Data Preparation

✓ Location of wells in the grid

✓ Averaging and Assignment of production rates to wells

✓ Workover wells

✓ Assign all well, control, economic limits and time stepping keywords to ECLIPSE data set

Eclipse Workflow:

➢ VFPi:

✓ Create Table relating BHP to THP as a function of

- Well design – depth, ID, roughness, depth, temperatures,
- GOR, Water Cut
- Oil rates
- Pumps, gas lift, compressors

- Simulator need BHP – if you want to control well from the surface must have lift curves

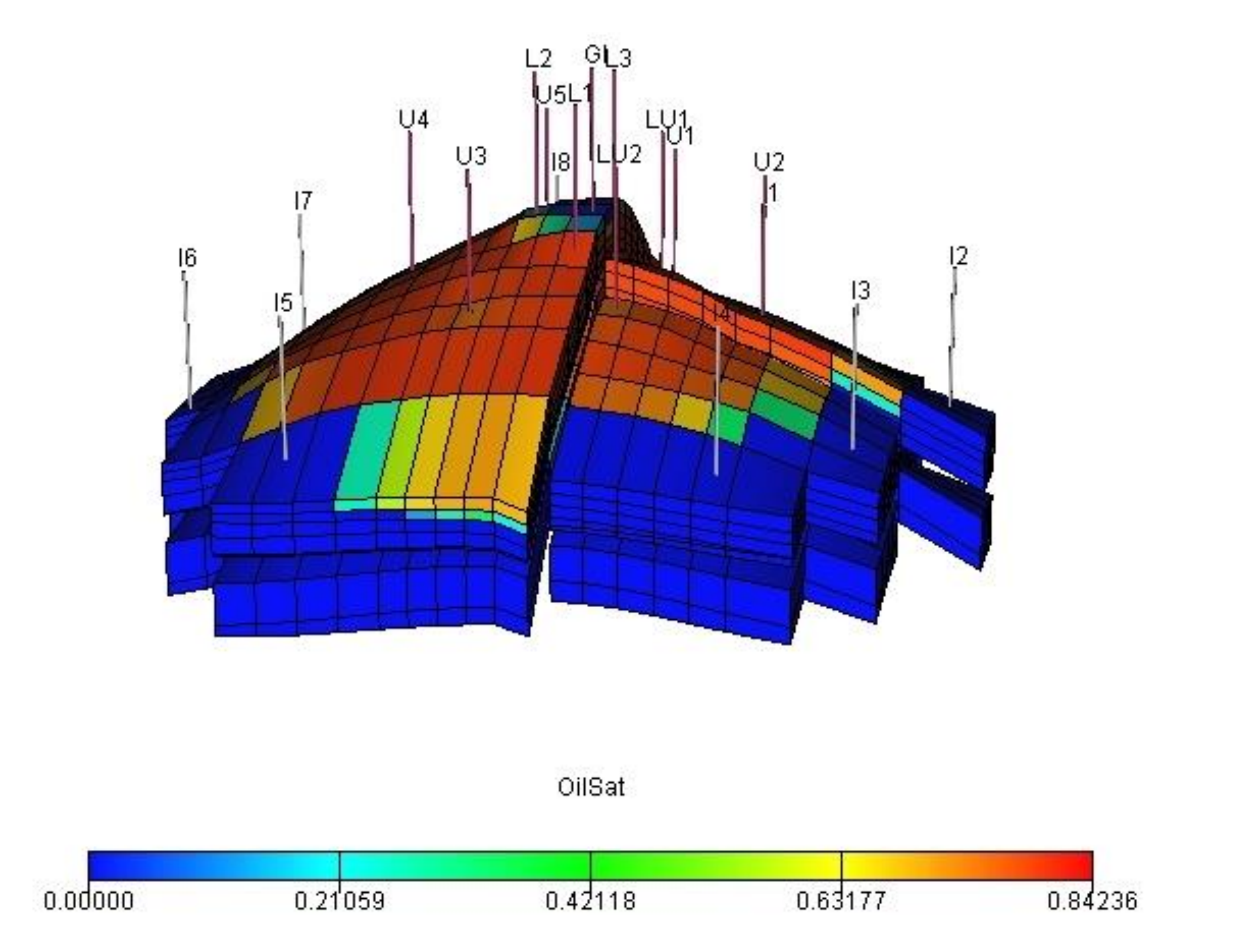
Eclipse Workflow:

- FloViz:

- ✓ Provides 3D visualization capabilities for display and analysis of reservoir simulation results.

- ✓ FloViz can display both structured and unstructured grids.

FloViz:


L2
G
L3
U5
L1
U4
LU1
U1
U3
I8
LU2
U2
I1
I7
I6
I2
I3
I5
I4
OilSat
0.00000
0.21059
0.42118
0.63177
0.84236

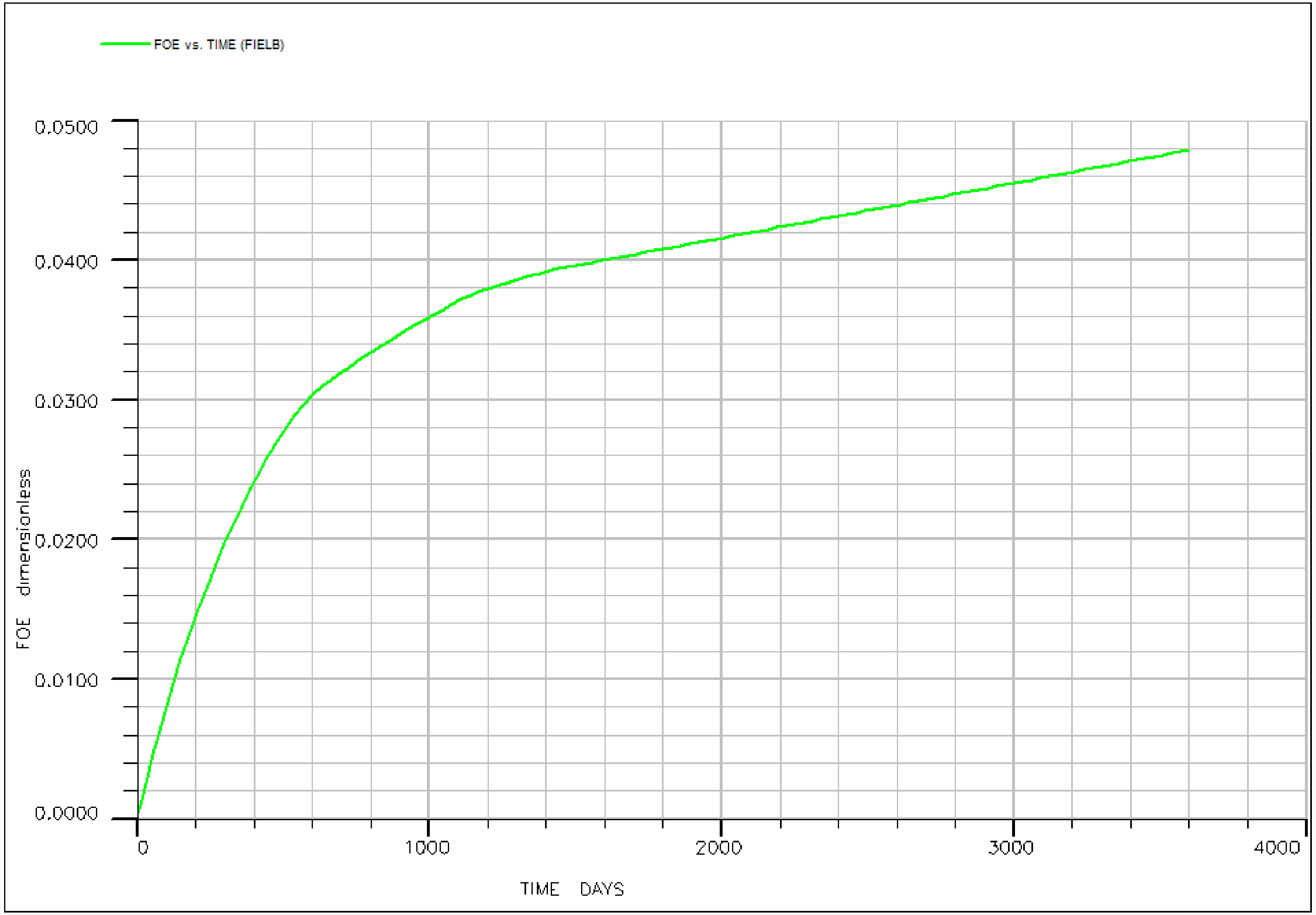
Eclipse Workflow:

➢ Office:

✓ Provides an environment for simulation pre- and post- processing.

✓ It can be used for creation and modification of models, submission and control of runs, analysis of results and report generation.

Office:


FOE vs. TIME (FIELB)
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
FOE dimensionless
0
1000
2000
3000
4000
TIME DAYS

Eclipse Workflow:

- SimOpt:

- ✓ To achieve a history match between an ECLIPSE 100/300 simulation model and the corresponding observed reservoir data

- ✓ By applying mathematical techniques, it provides additional information on which the reservoir engineer can exercise judgement to improve the history match.