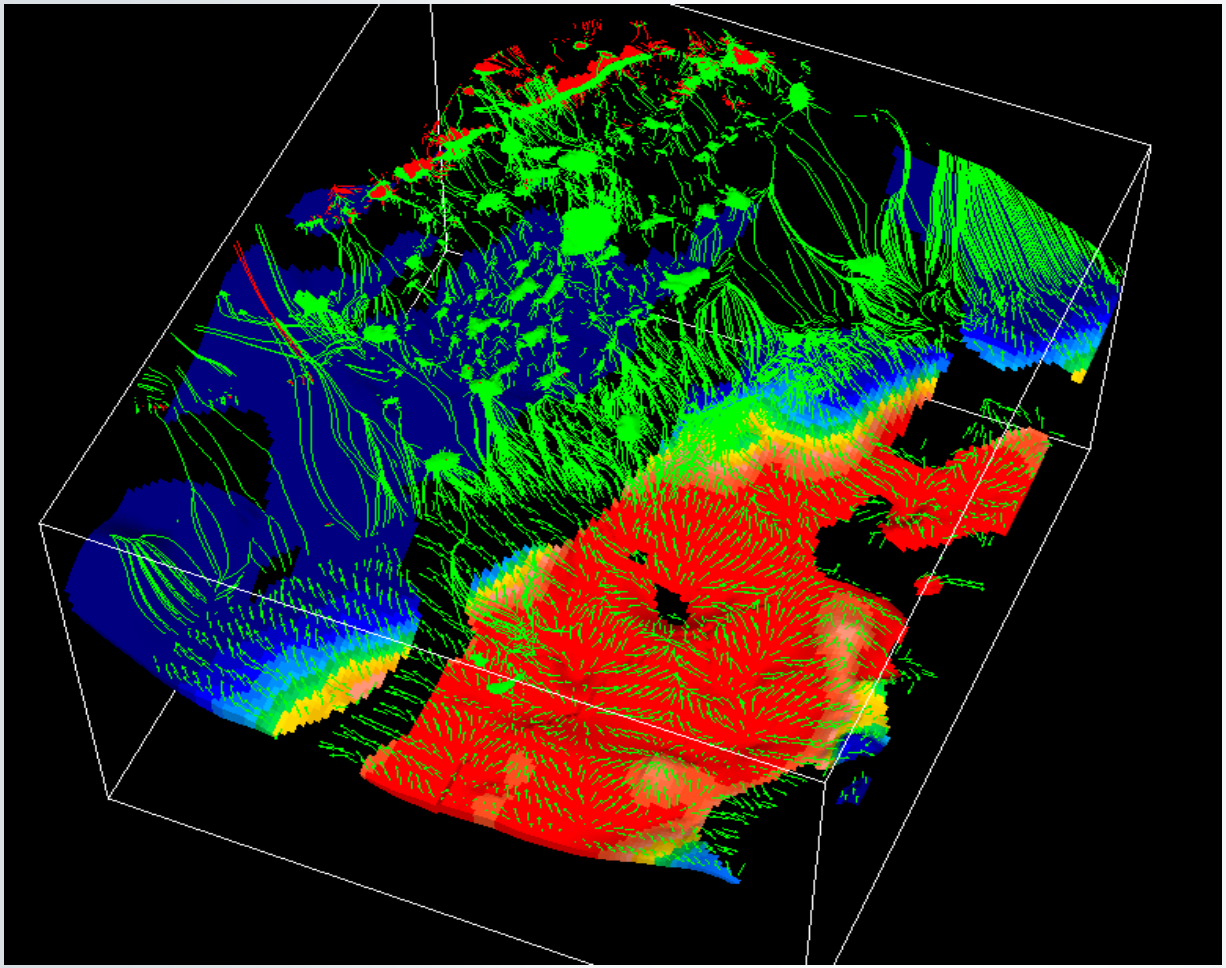
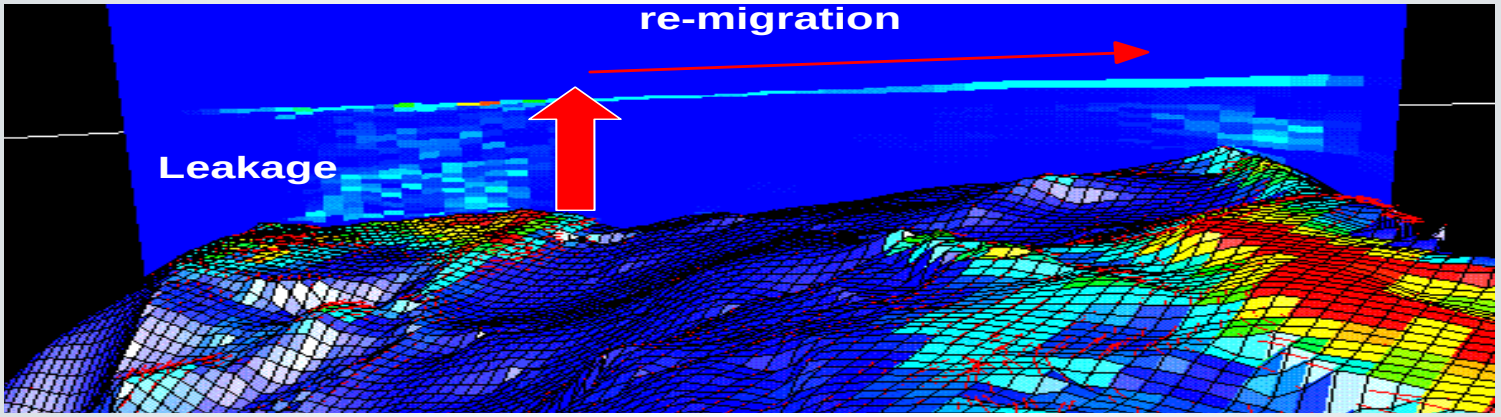
8. Migration & Fluid flow

Application of Darcy, Flowpath, and Percolation Models to Petroleum System Models



Migration

Darcy Flow Modeling



Concept: Based on equations of flow through porous media

Advantages:

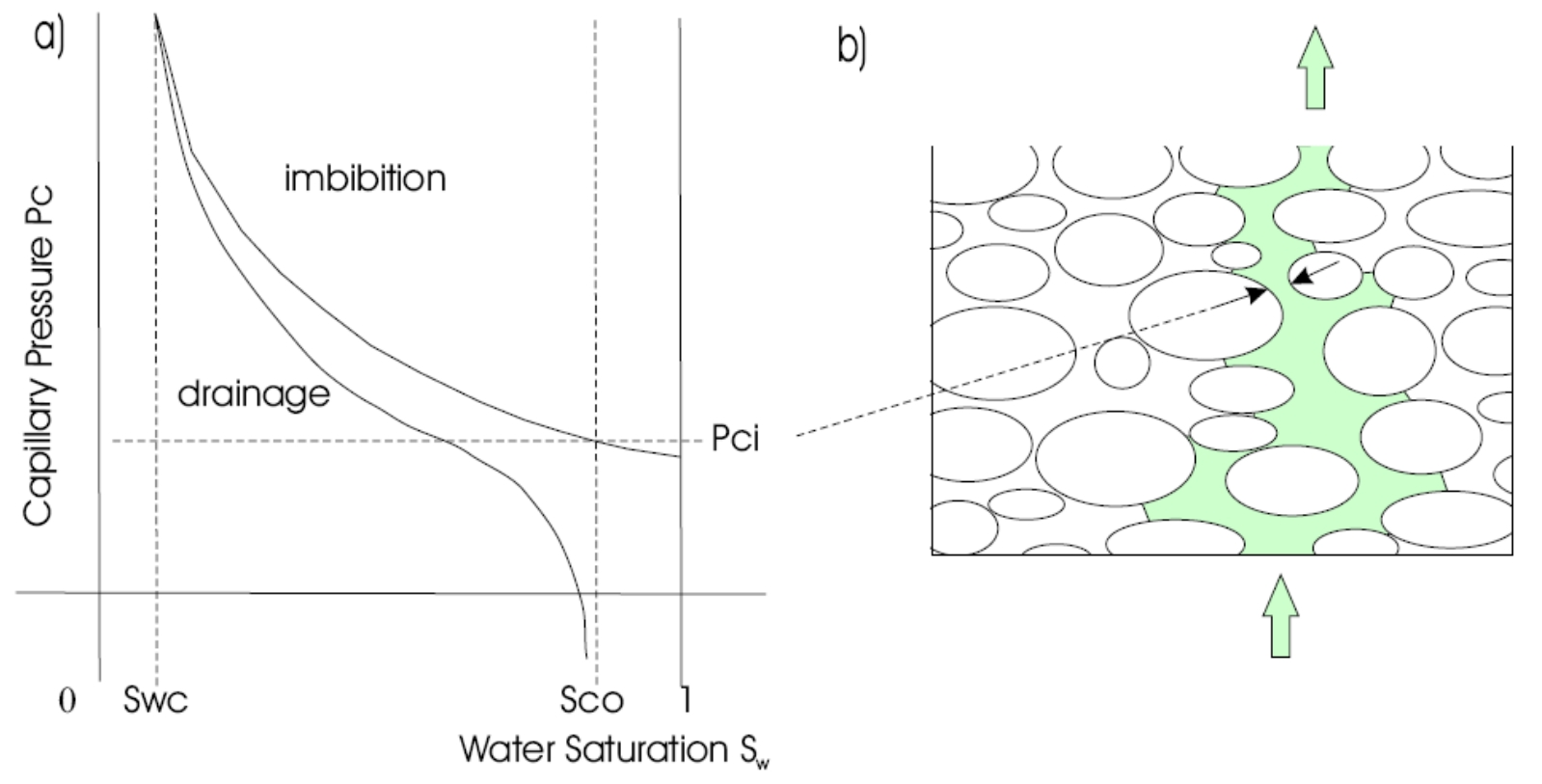
- Good definition of carrier and seal system
- Easy inclusion of complex migration and transport processes such as multi-phase migration, gas diffusion and PVT controls
- Only method that fully integrates pressures into the modeling process

Disadvantages:

- Cannot accurately handle accumulations and breakthroughs
- Long processing times
- In order to obtain acceptable processing times, models must be simplified with a loss of geometric information

Migration from the deep kitchen

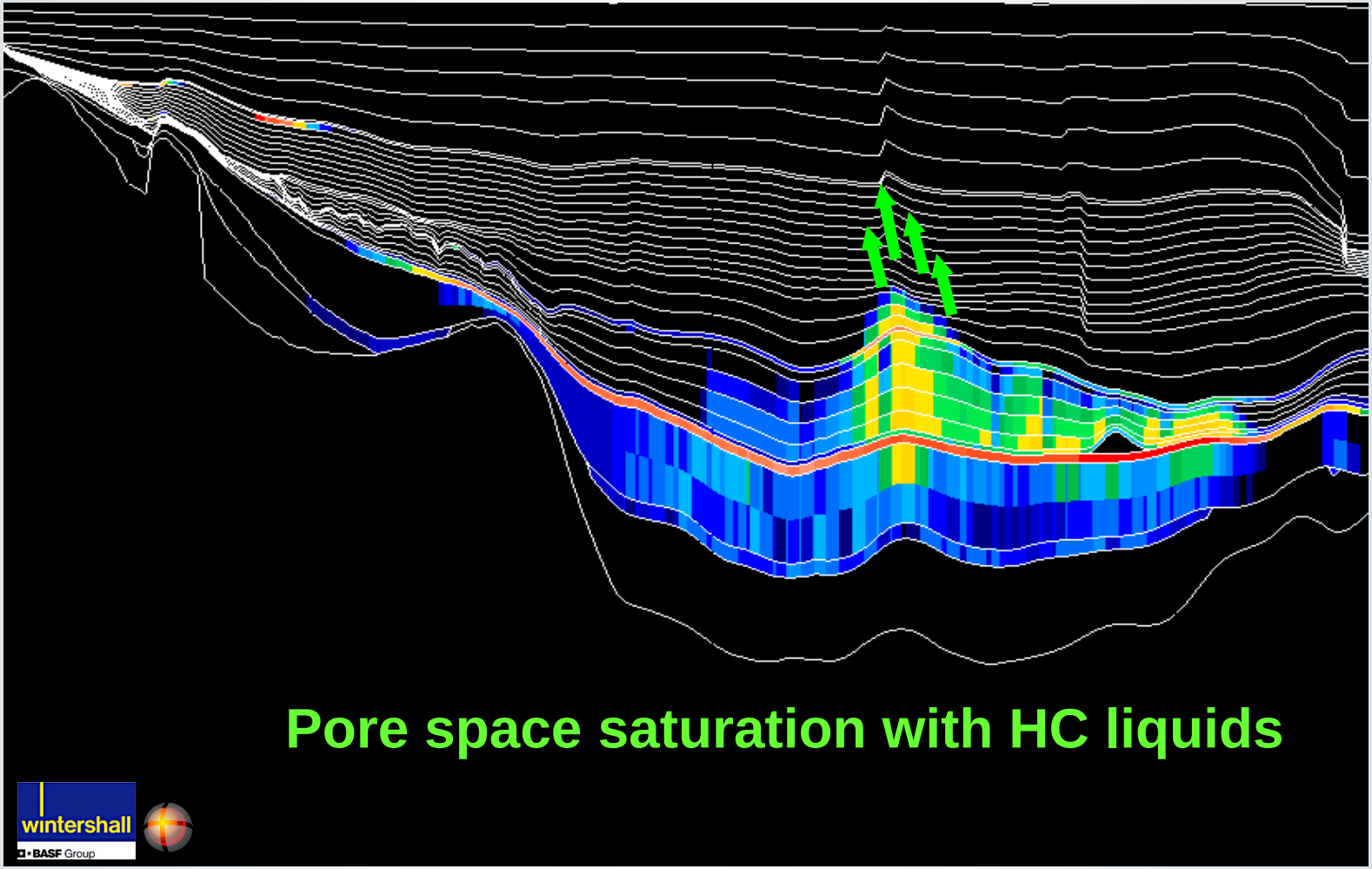
Darcy Law **Capillary entry pressure**



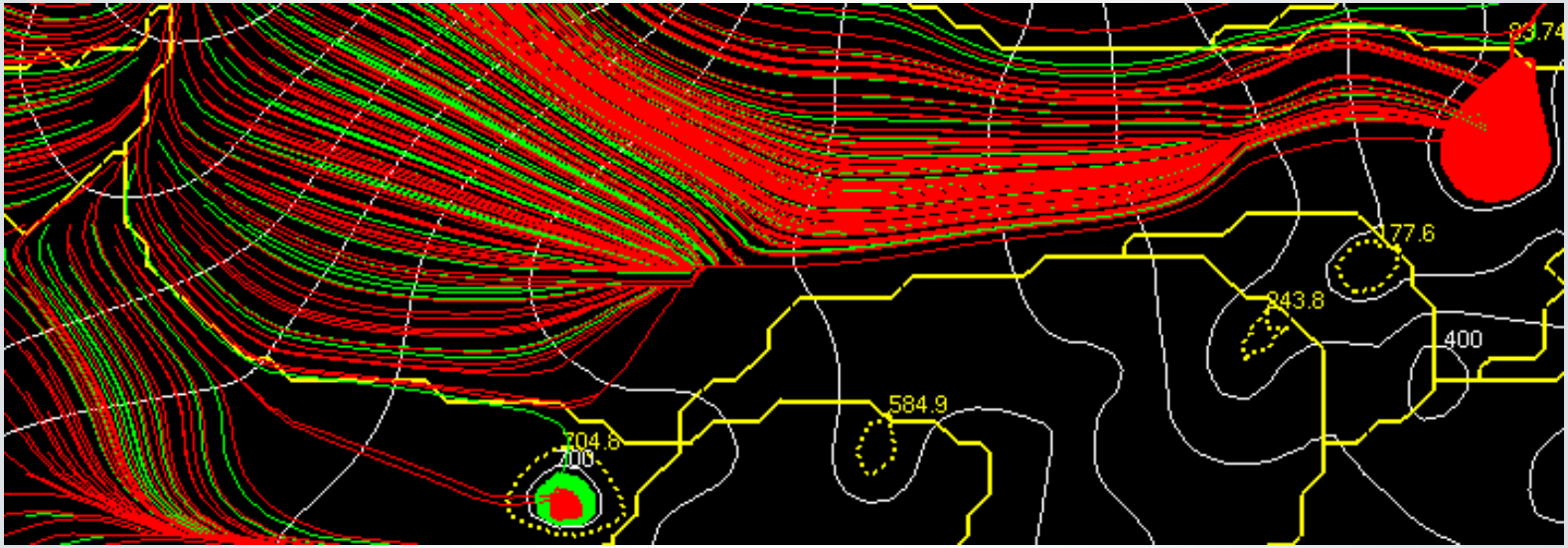
Pore space saturation with HC liquids

Migration from the deep kitchen

Darcy Law in low permeability environment



Flowpath (= ray tracing) Modeling



Concept: Geometrical **surface** analysis (**buoyancy** driven migration)

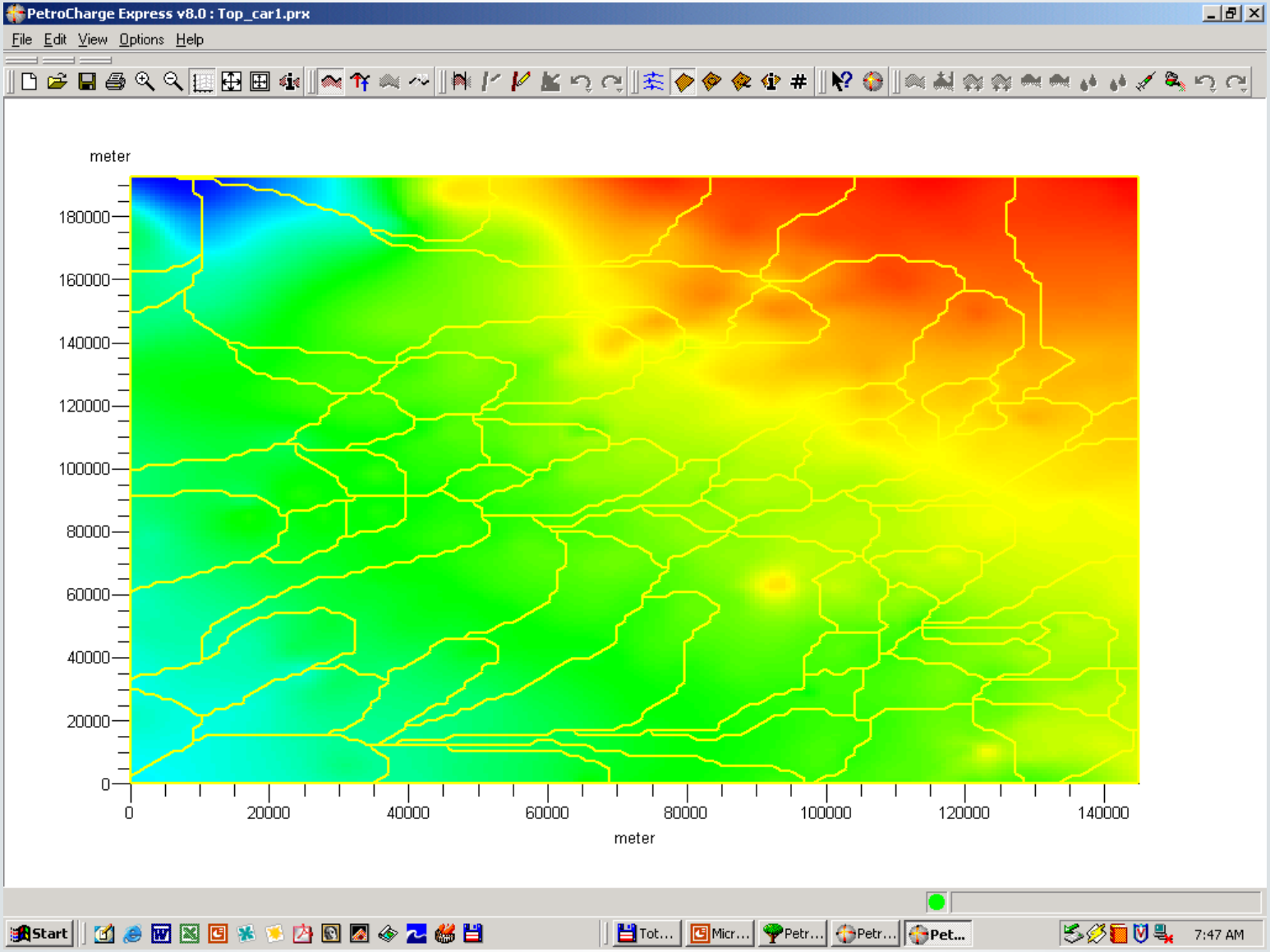
Advantages:

- Fast processing
- High resolution modeling
- Accurate reservoir geometries can be included

Disadvantages:

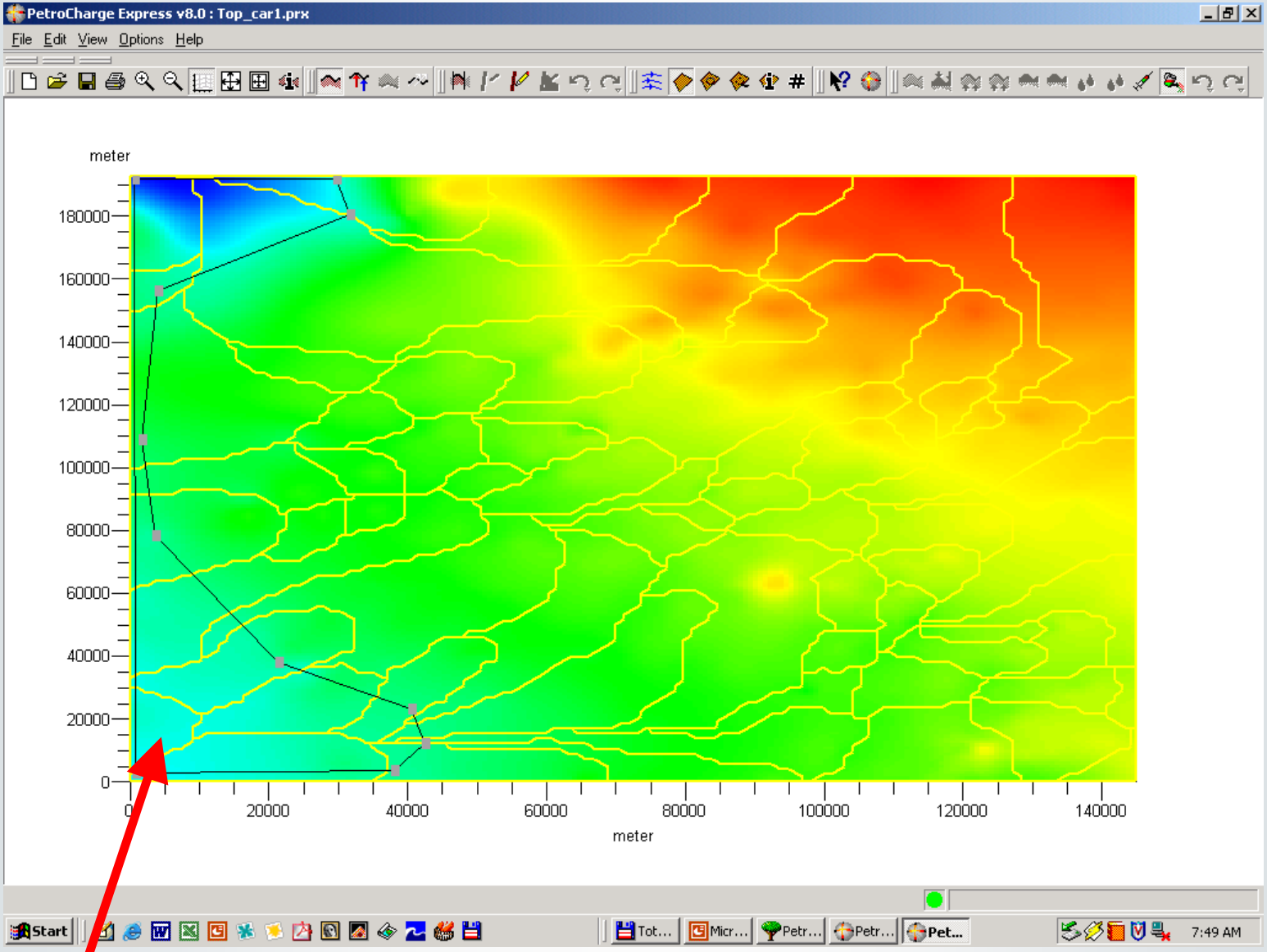
- Incomplete physical model of petroleum migration
- Arbitrary definitions of the migration system, e.g. of seals
- Not suitable for complex migration processes
- Misleading simplicity

Flowpath



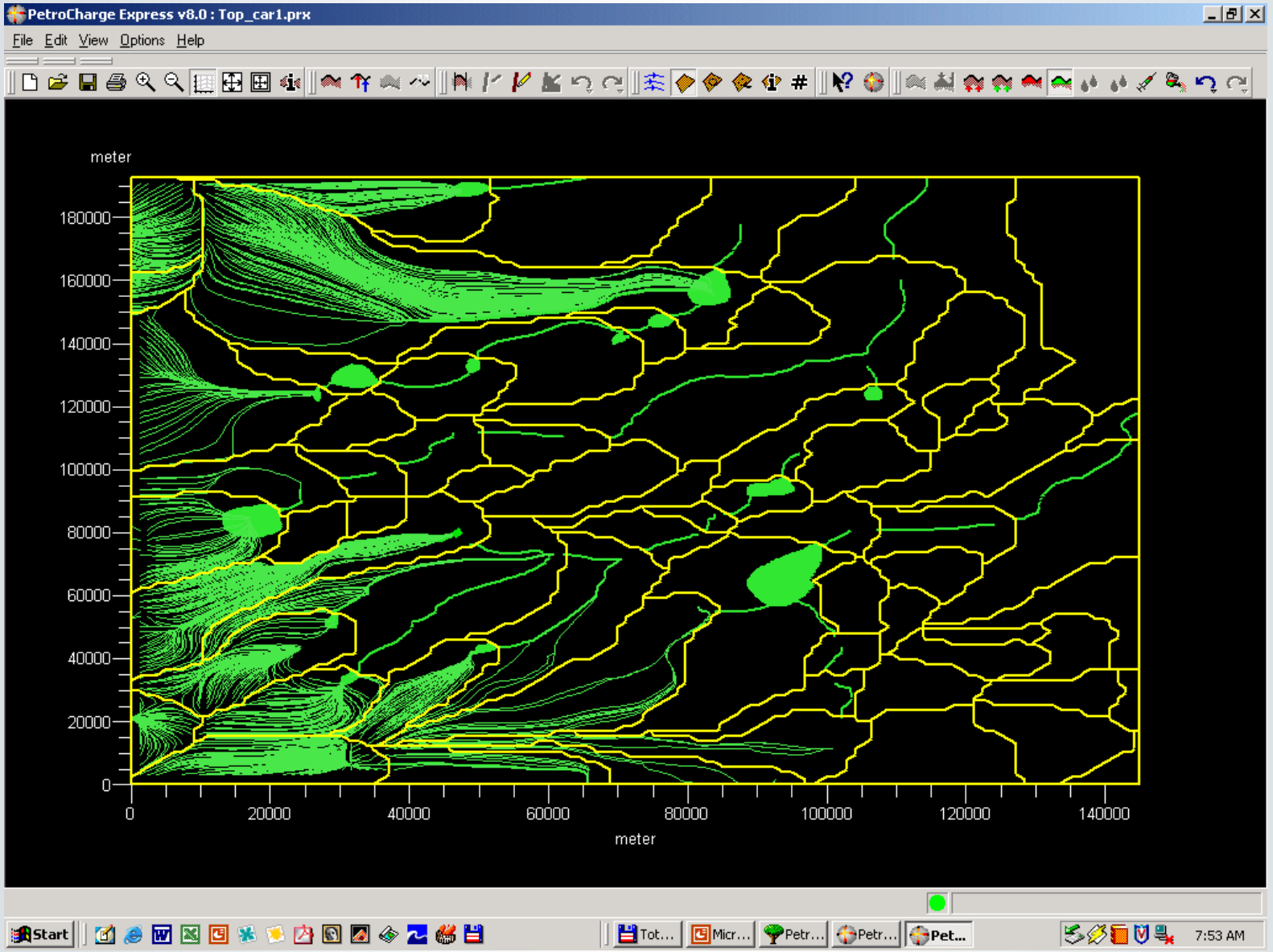
Import structural map – show fetch areas

Flowpath



Poloygon of active source kitchen – inject oil and gas generated

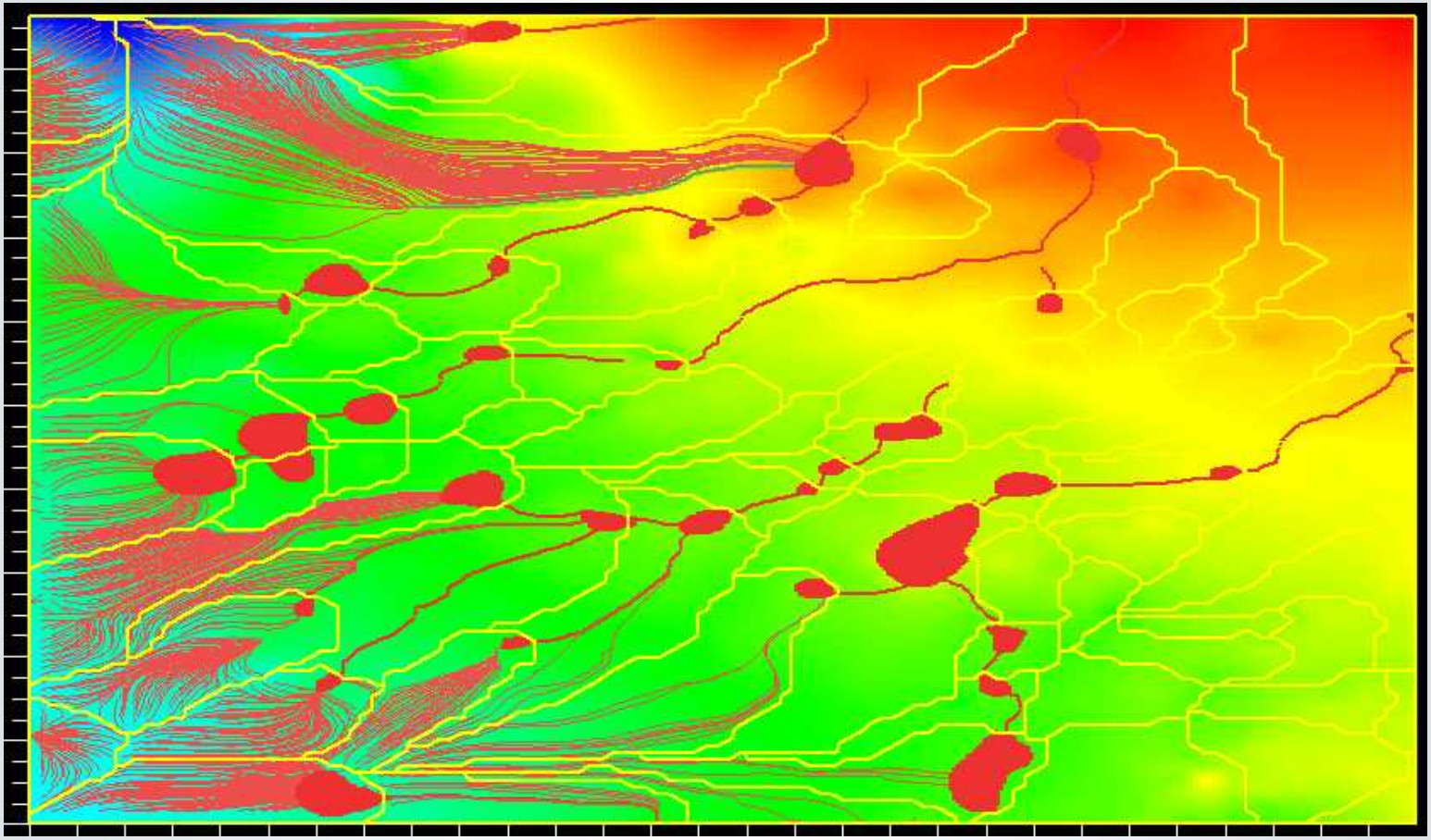
Flowpath



Oil migration, accumulation and spills

Migration – Flowpath

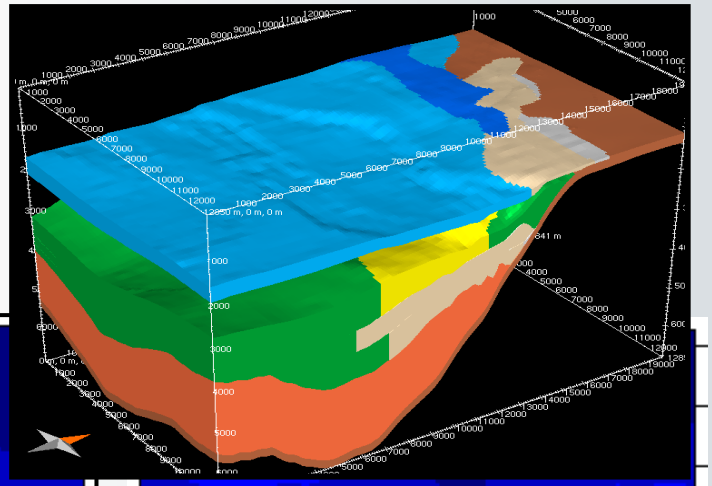
Flowpath – Buoyancy Driven – Following Topography



Liquid (oil) and vapour (gas) migration, accumulation and spills

Fault Assignments in 3D

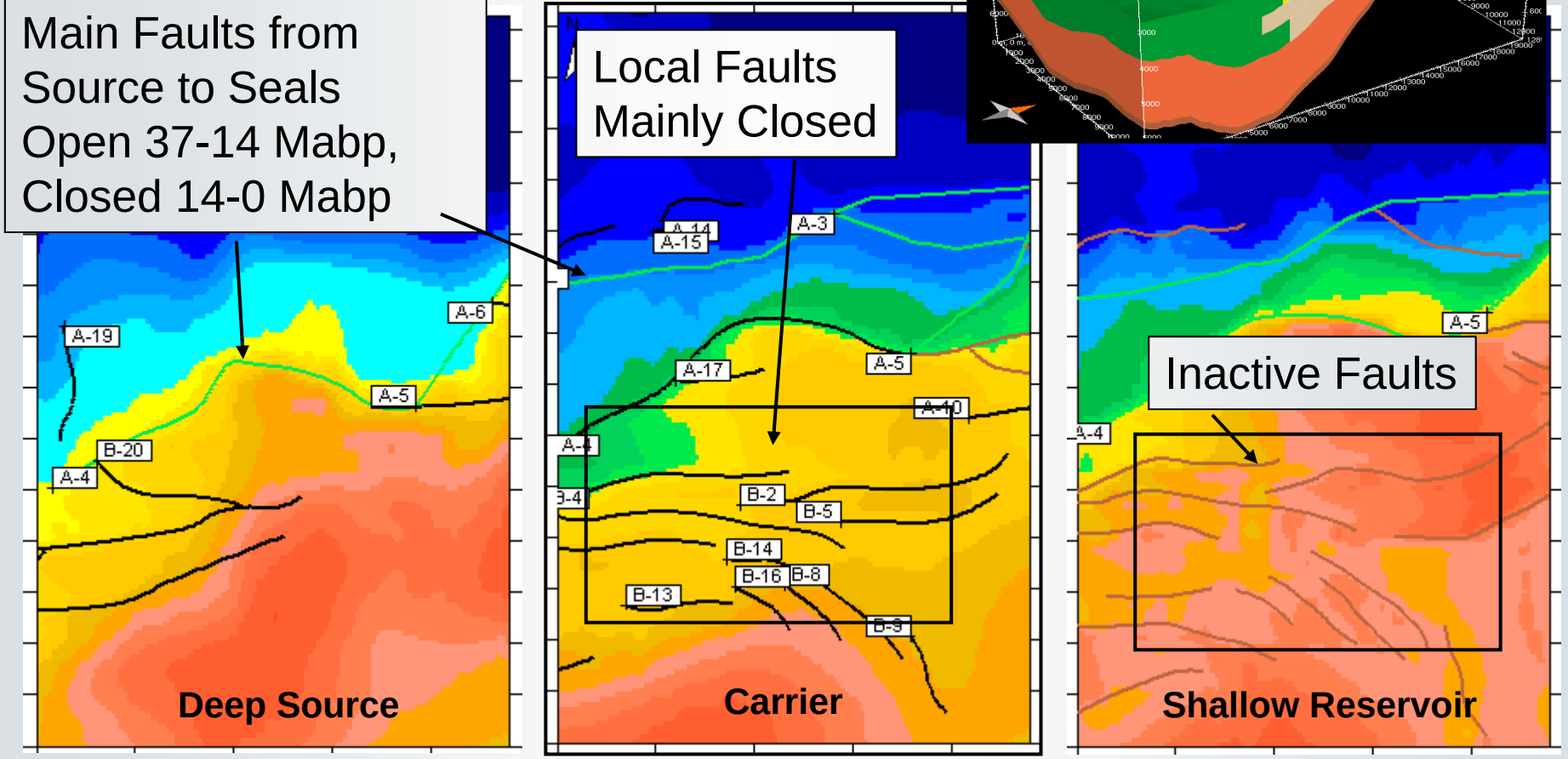
Layer-Maps
Properties are different for:
- Geological Ages
- Geological Layers



Main Faults from Source to Seals Open 37-14 Mabp, Closed 14-0 Mabp

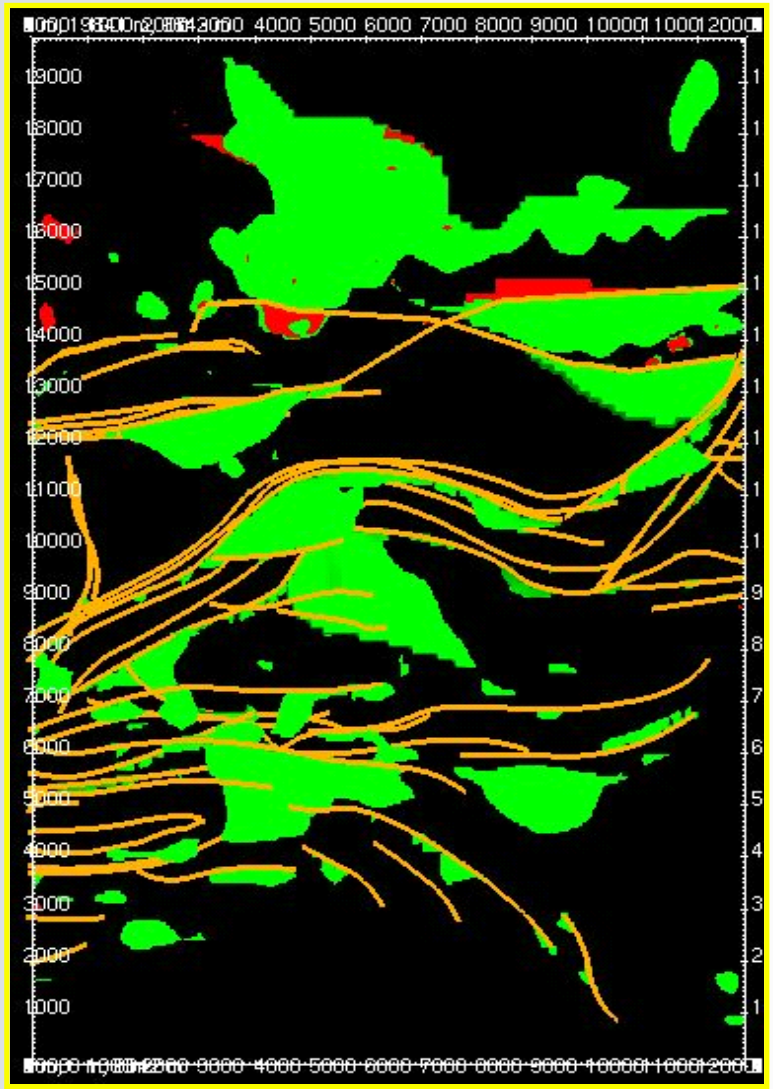
Local Faults Mainly Closed

Inactive Faults

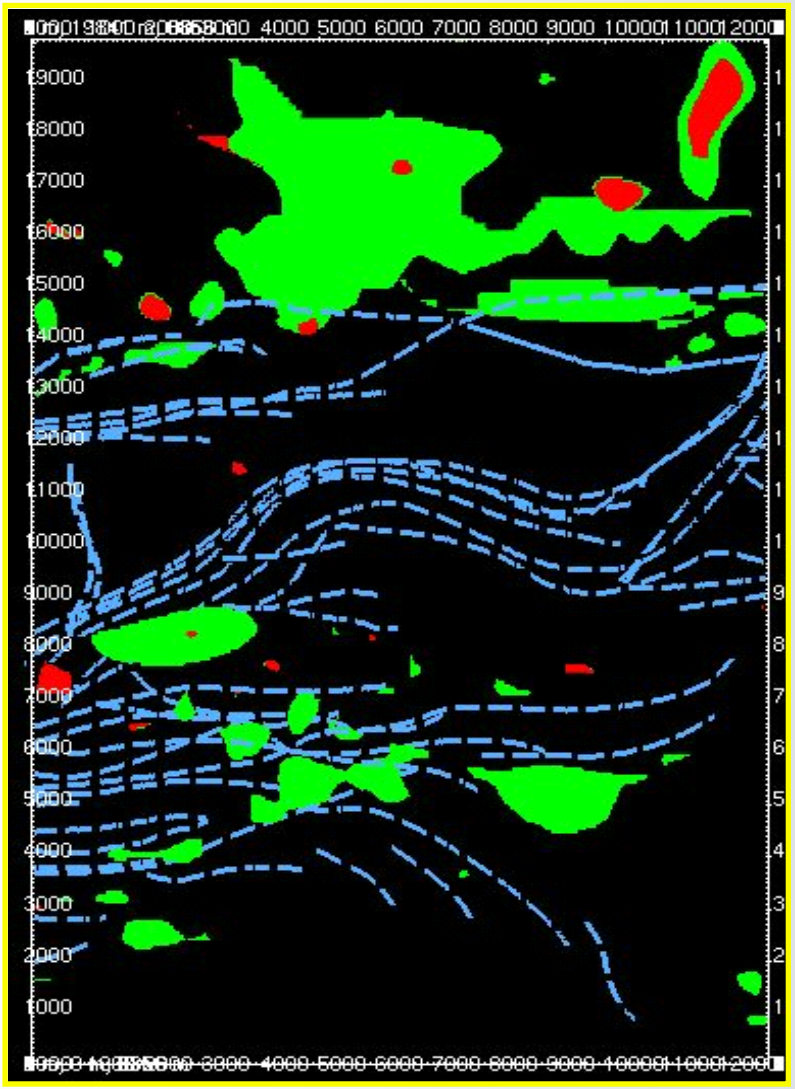


Faults as conduits or seals

Closed faults scenario

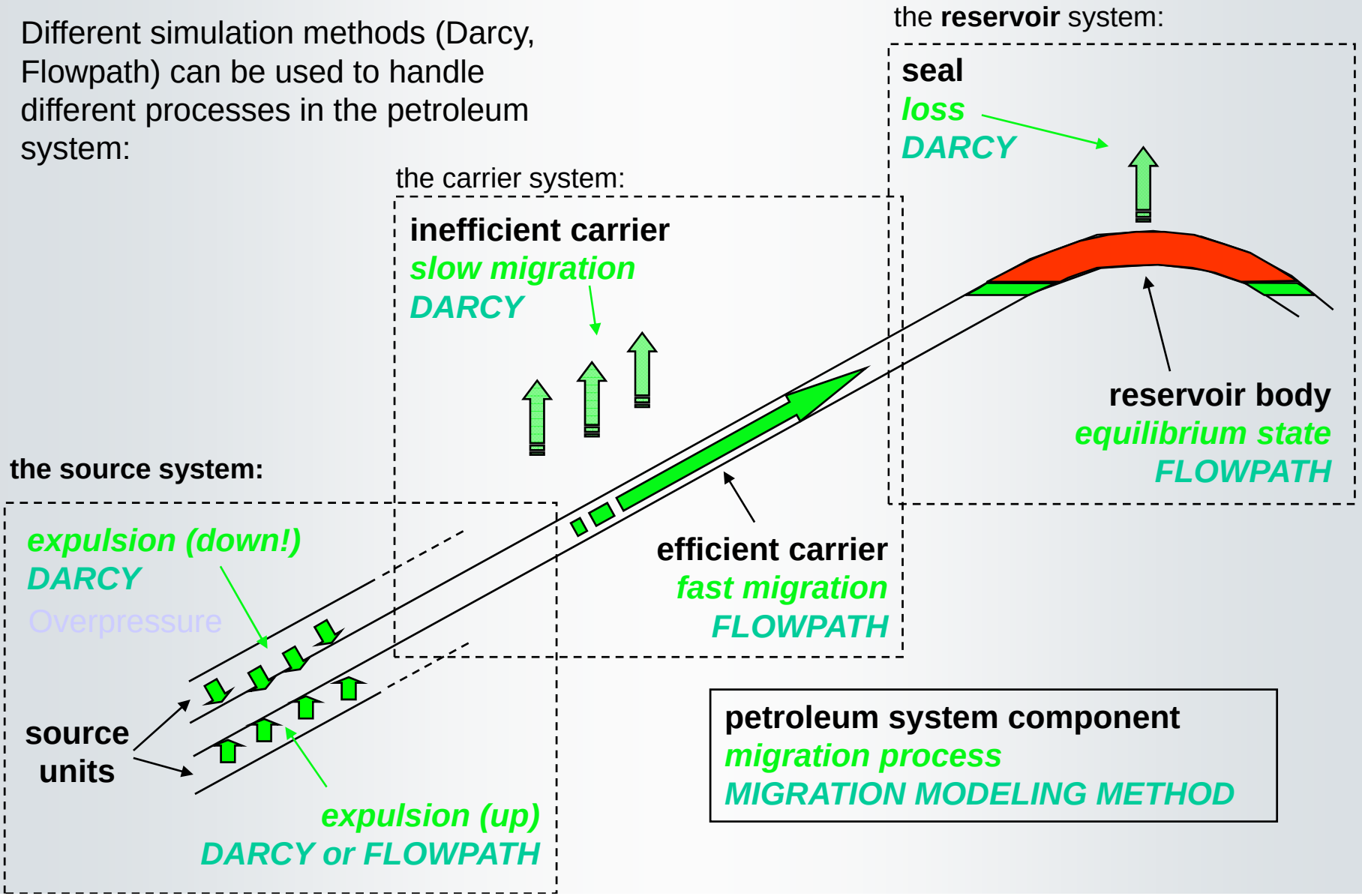


Open faults scenario

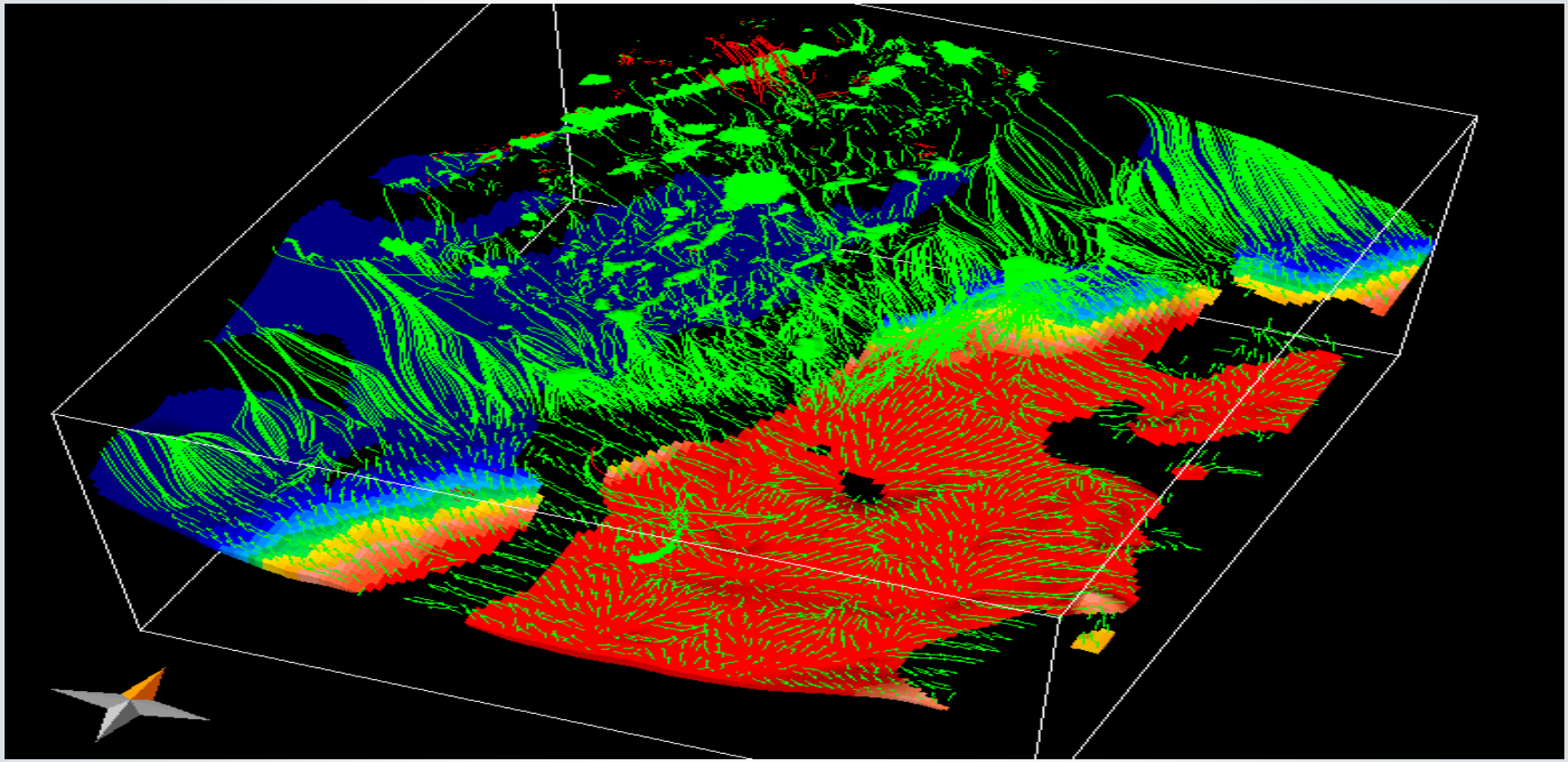


Hybrid Migration Modeling: The Petroleum System

Different simulation methods (Darcy, Flowpath) can be used to handle different processes in the petroleum system:



HC Generation / Migration



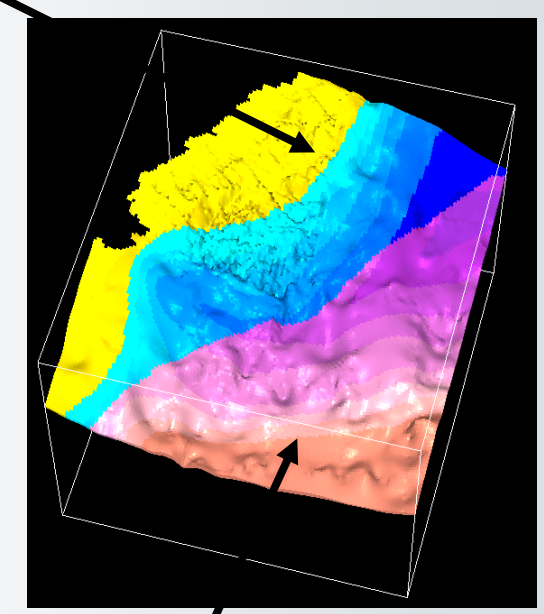
Rift stage source rock with transformation ratio accumulation bodies, vectors and flow paths.

Late Neogene

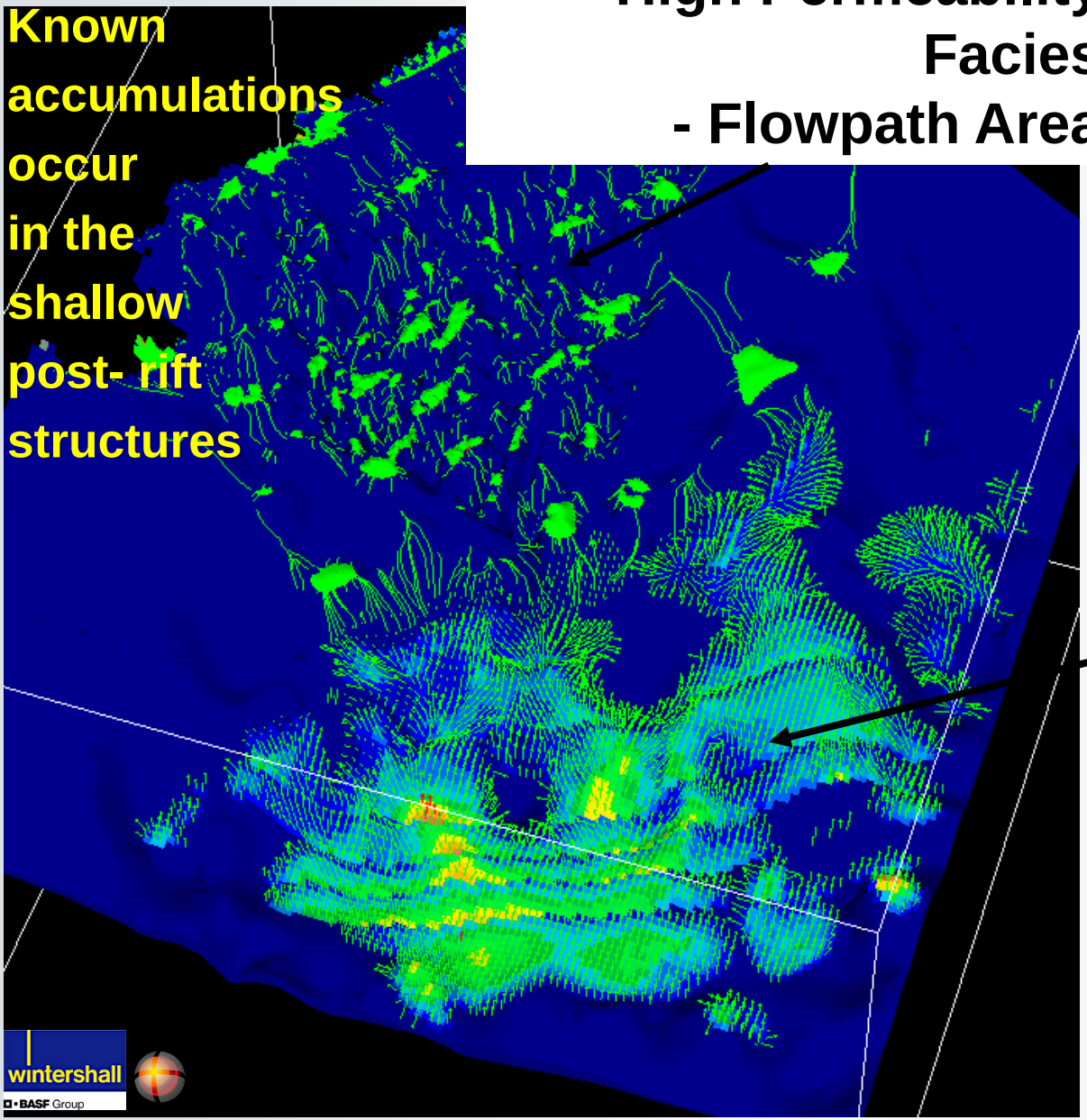
Migration – hybrid method

High Permeability Facies - Flowpath Area

Carrier Rock Facies



Known accumulations occur in the shallow post- rift structures

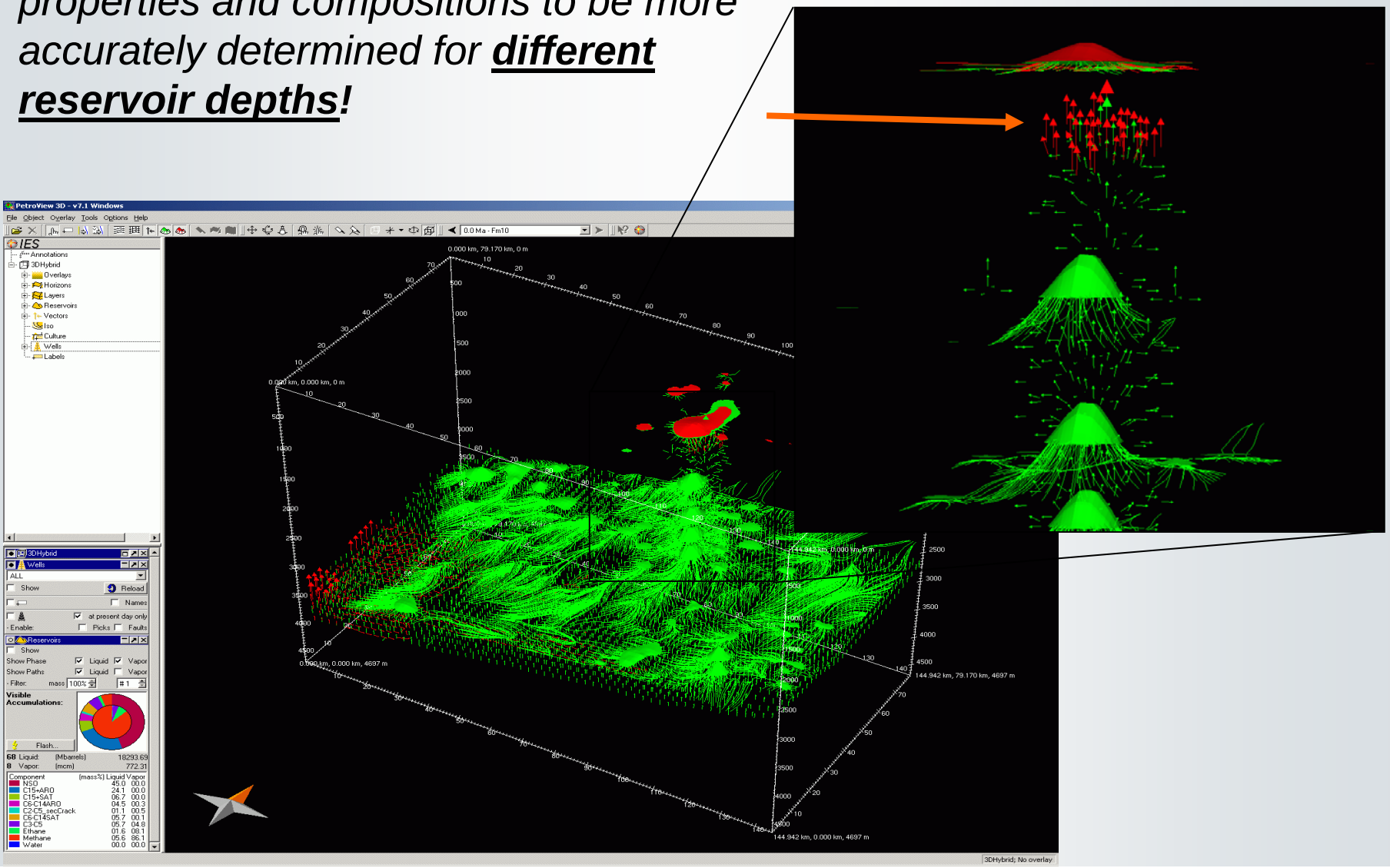


Low Permeability Facies - Darcy Area

8. n-Component / Phase Modeling:

flash calculations

properties and compositions to be more accurately determined for ***different reservoir depths!***



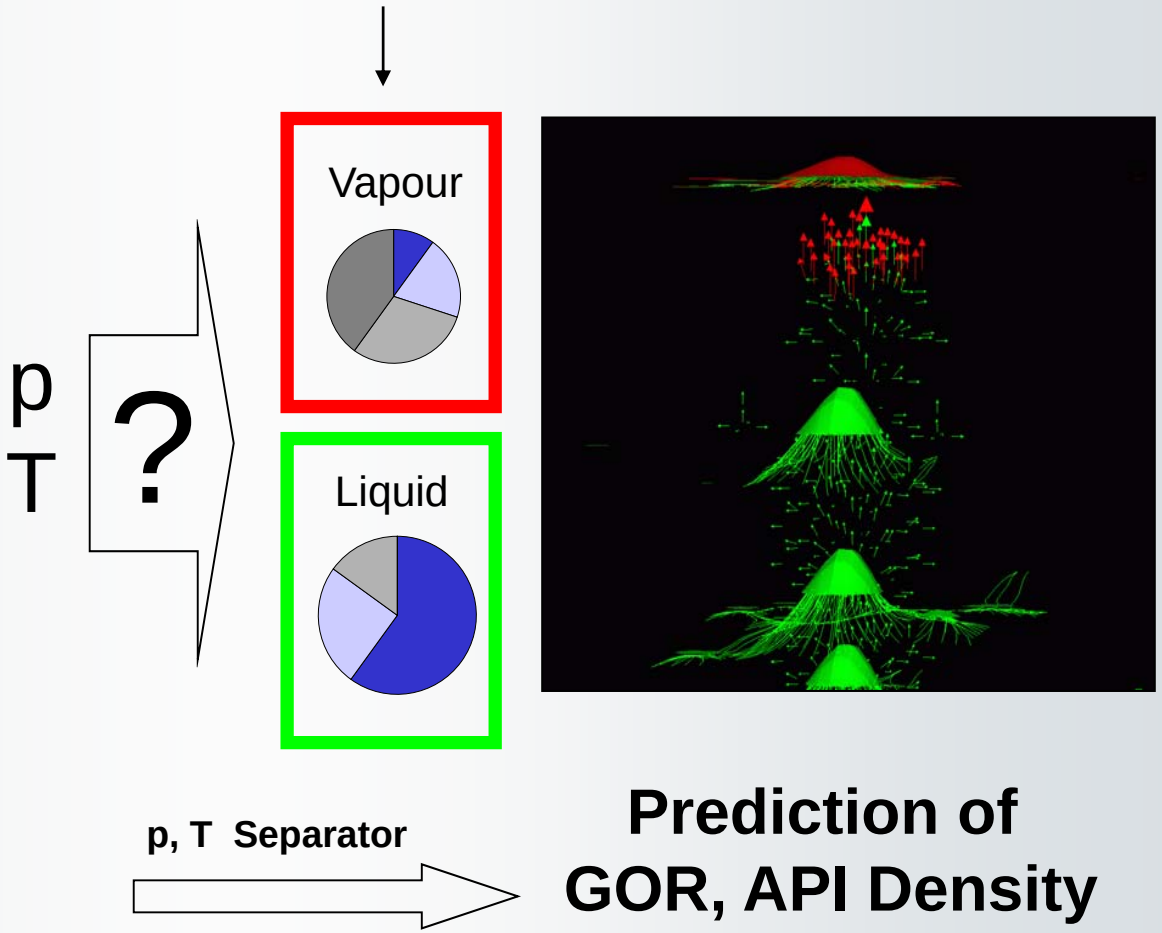
Fluid Composition and Phase prediction

Multicomponent pvT-Analysis

HC Components

Component	Mol%	Mass%
CO2	0.91	0.43
N2	0.16	0.05
C1	36.47	6.24
C2	9.67	3.10
C3	6.95	3.27
iC4	1.44	0.89
nC4	3.93	2.44
iC5	1.44	1.11
nC5	1.41	1.09
C6	4.33	3.97
C7+	33.29	44.71

HC Phases



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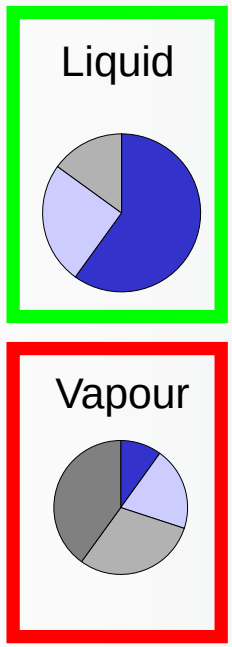
p
T
?

HC Phases



Volume
Liquid, Vapour, (Water) Phase

Composition
Liquid, Vapour, (Water) Phase

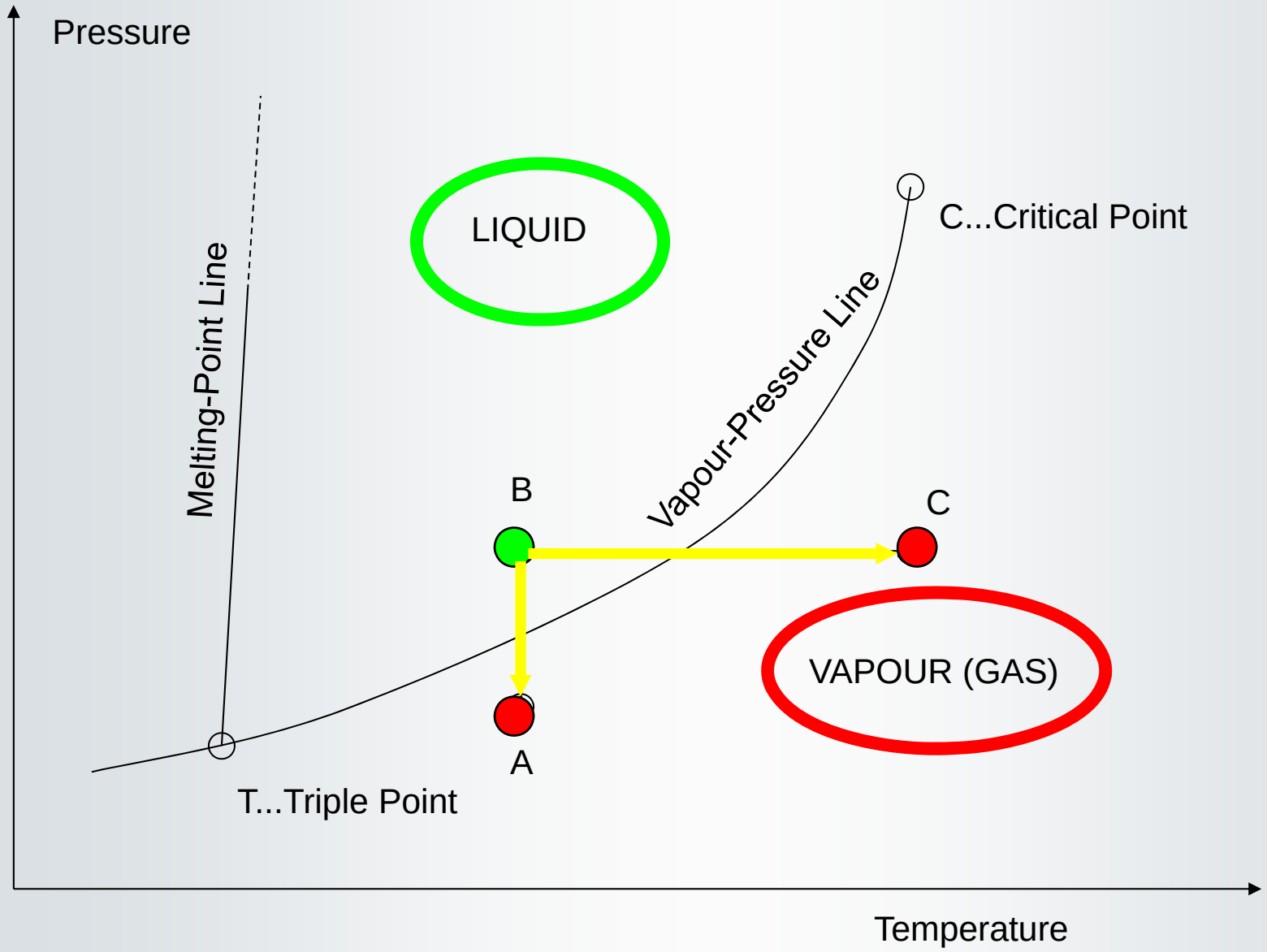
Density
Liquid, Vapour, (Water) Phase

Viscosity
Liquid, Vapour, (Water) Phase

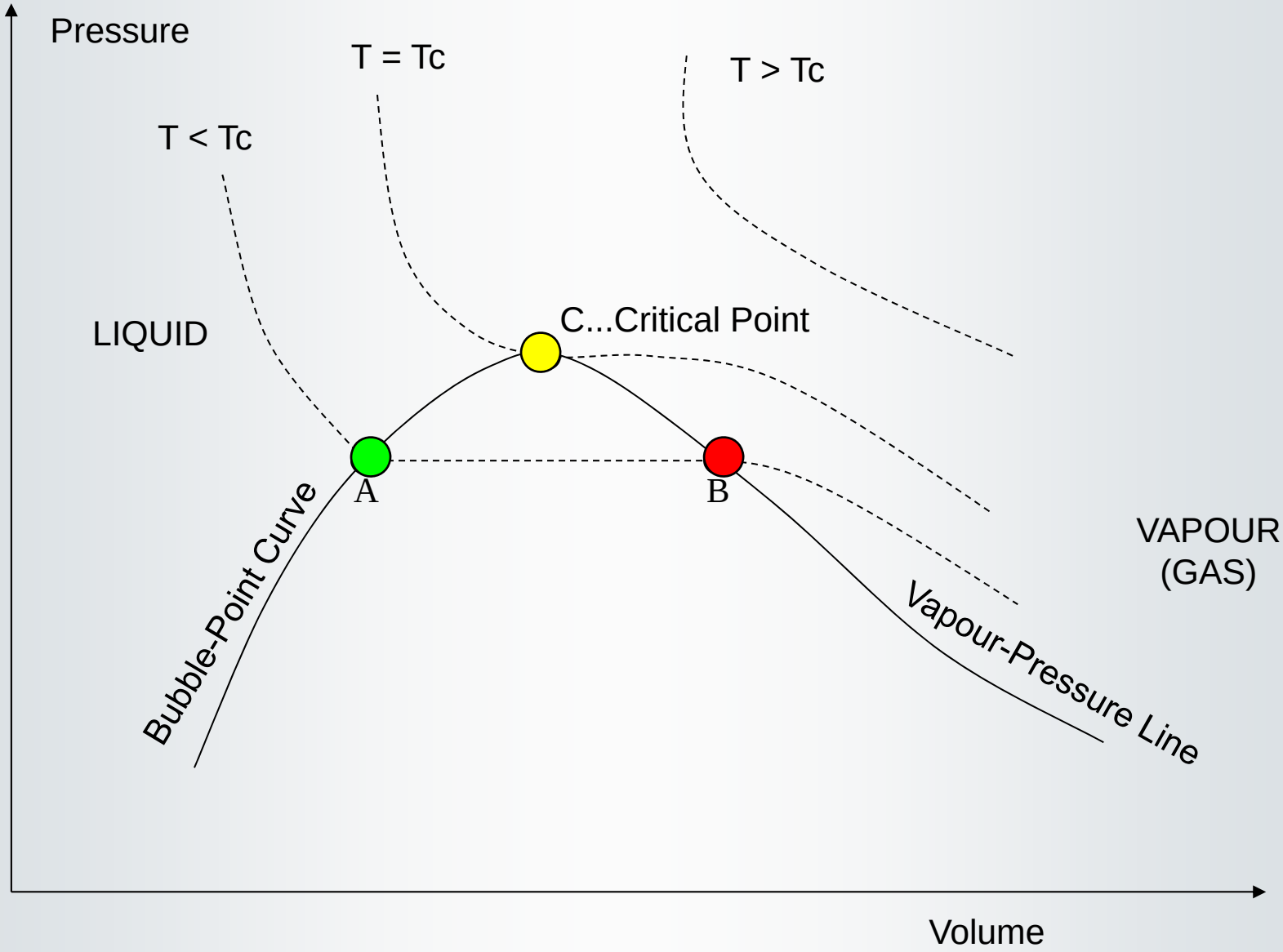
p, T Separator

Prediction of GOR, API Density

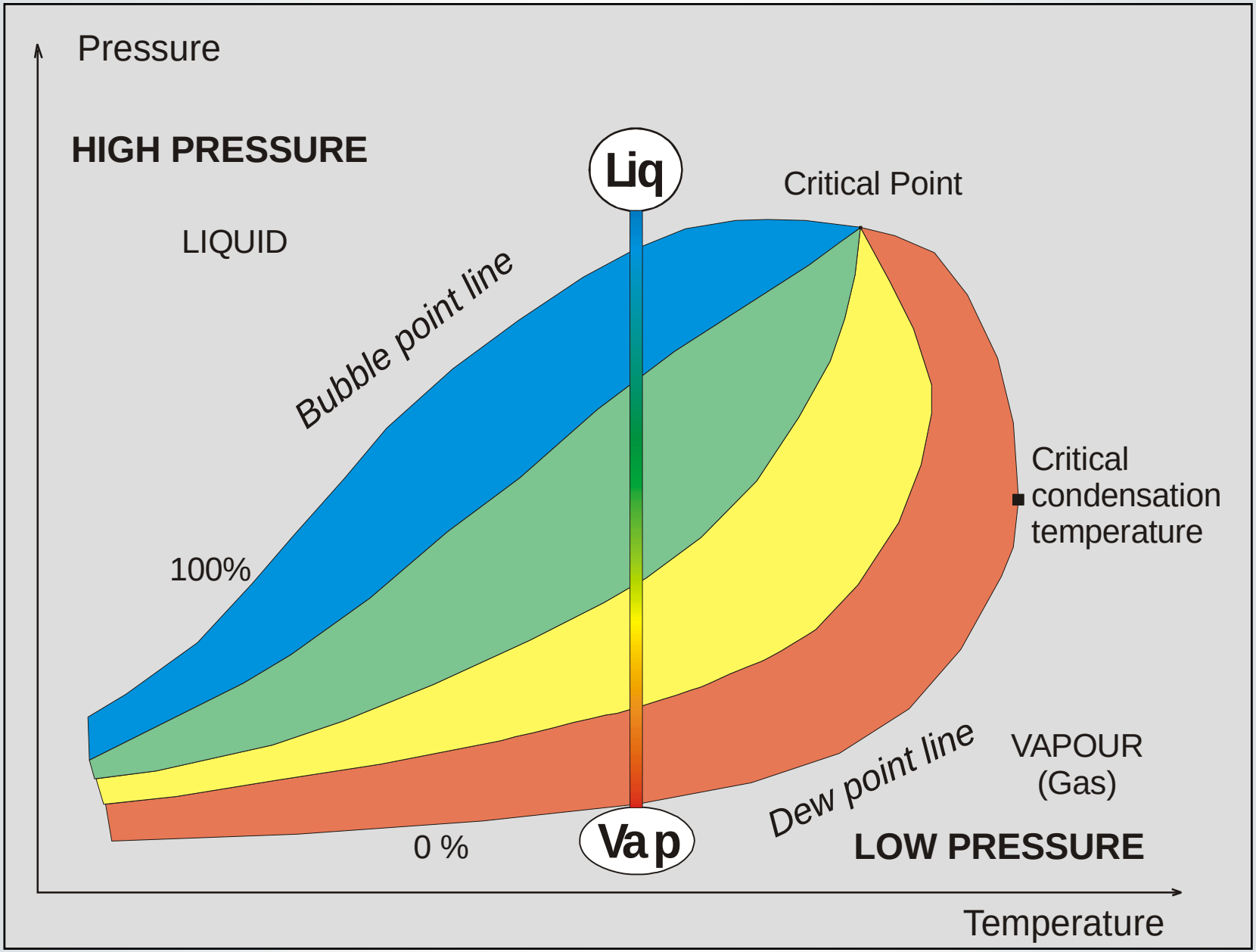
pT Diagram of Pure Substance
(single component)



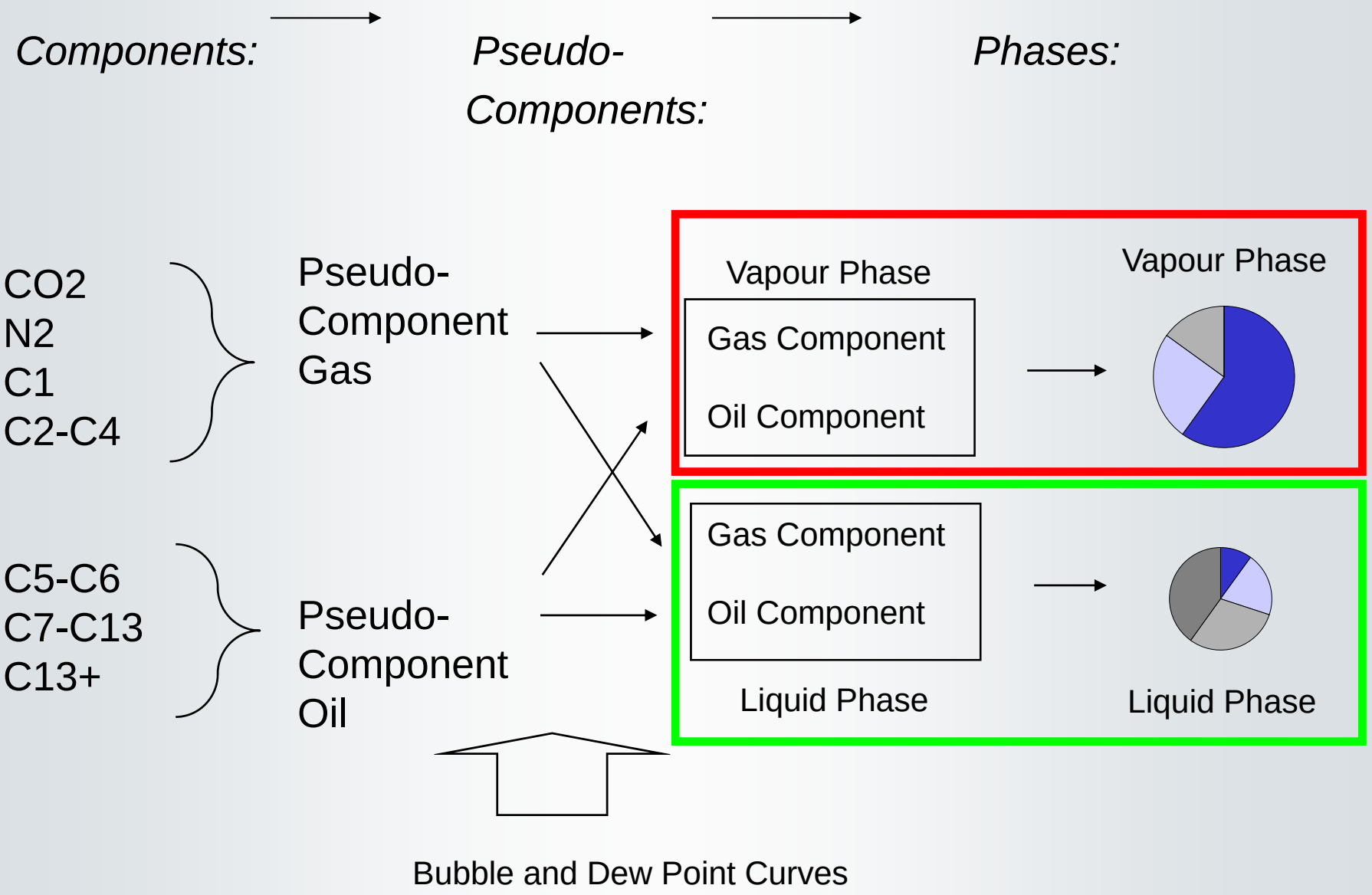
pV Diagram of Pure Substance
(single component)



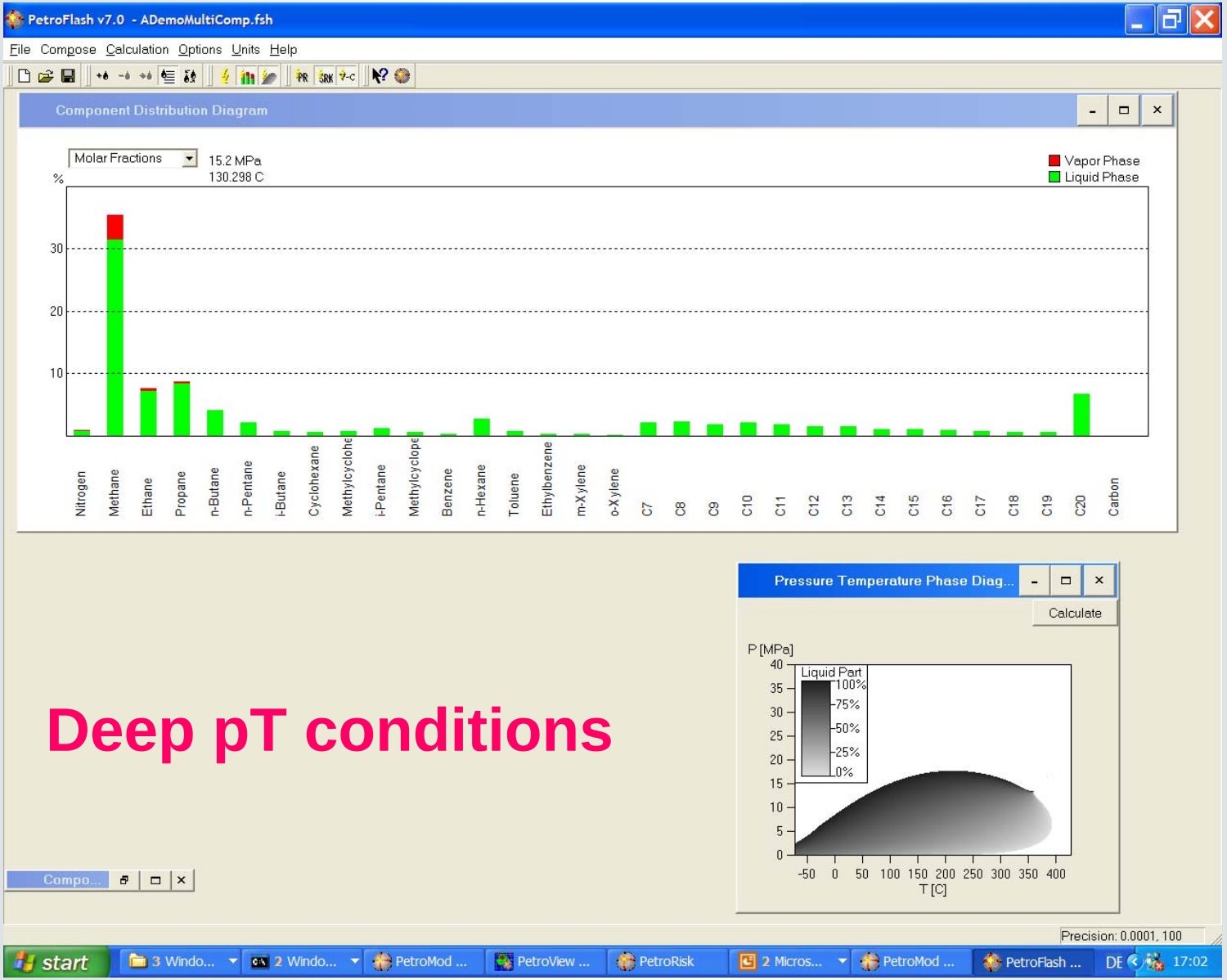
pT Diagram of a Mixture (two components)



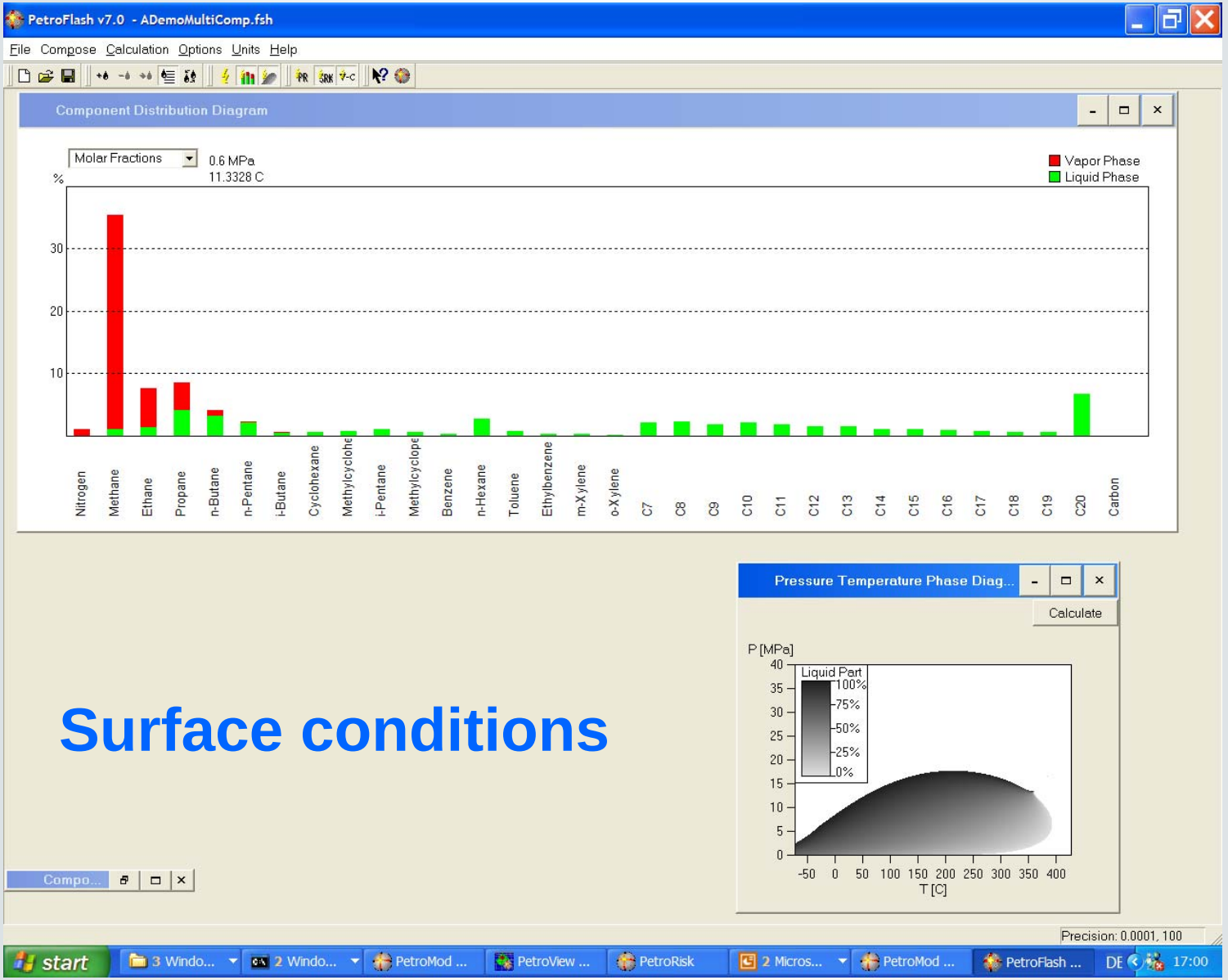
Symmetrical Black Oil Model (SBO)



Flash Calculations



Flash Calculations



Surface conditions

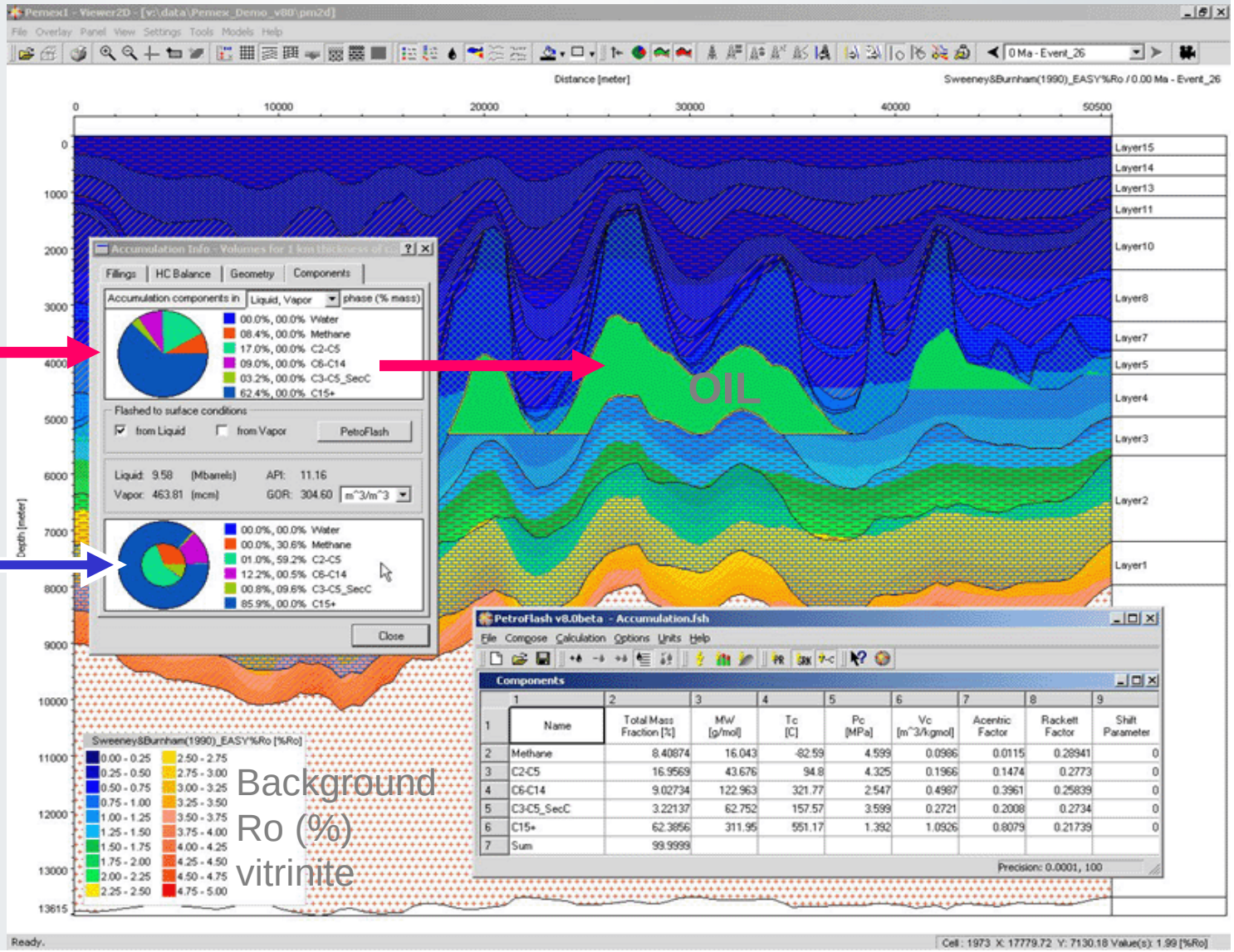
Flash calculations

2-D 2-phase / n-component modeling:

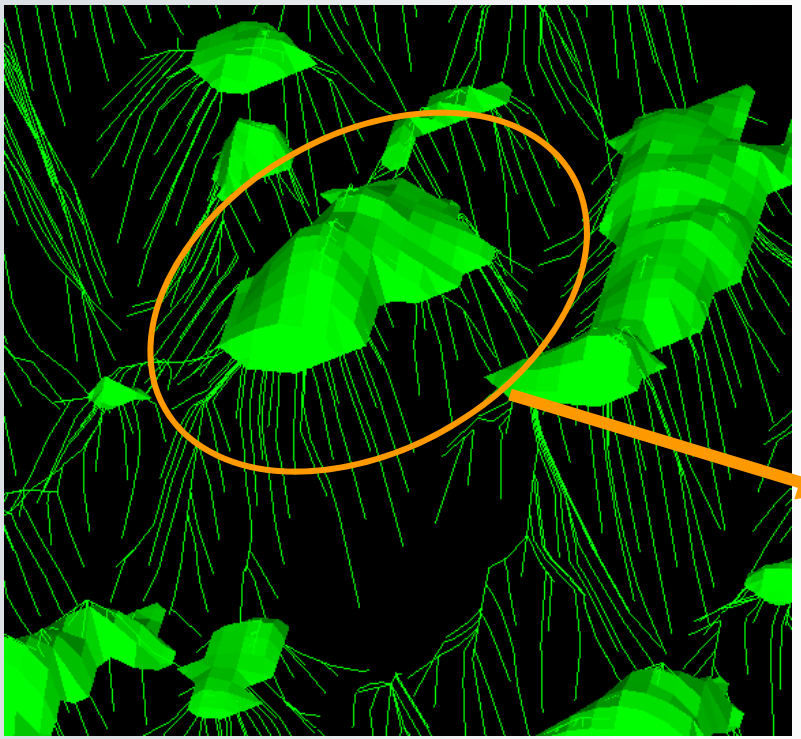
Composition of 1-Phase fluid at reservoir conditions

Composition of the same fluid flashed to surface conditions

(GOR = 305 m^3/m^3)

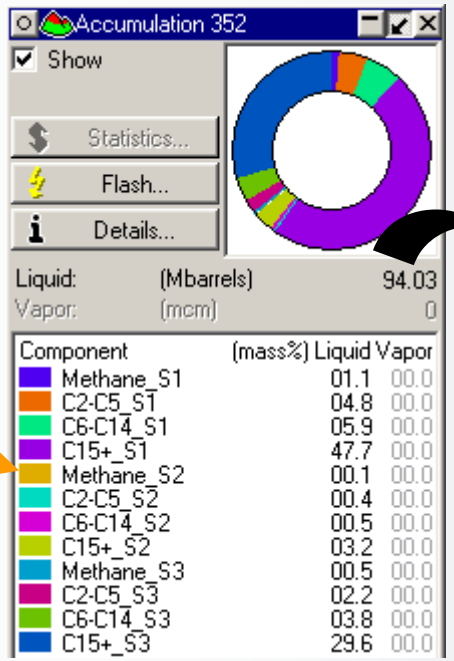


HC Quality Prediction



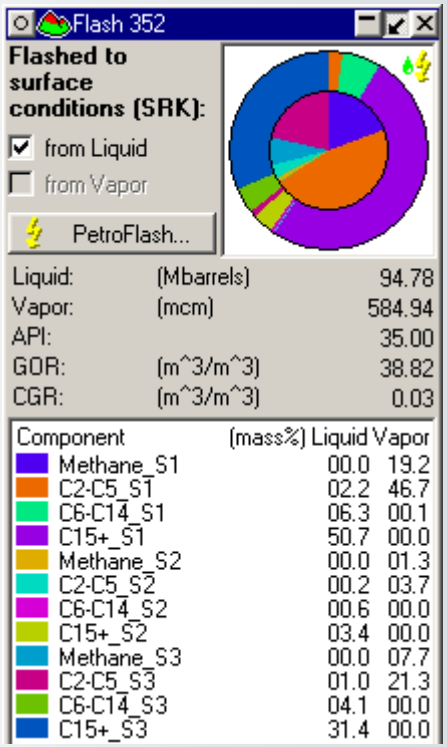
wintershall
BASF Group

Tscherny et al, 2004



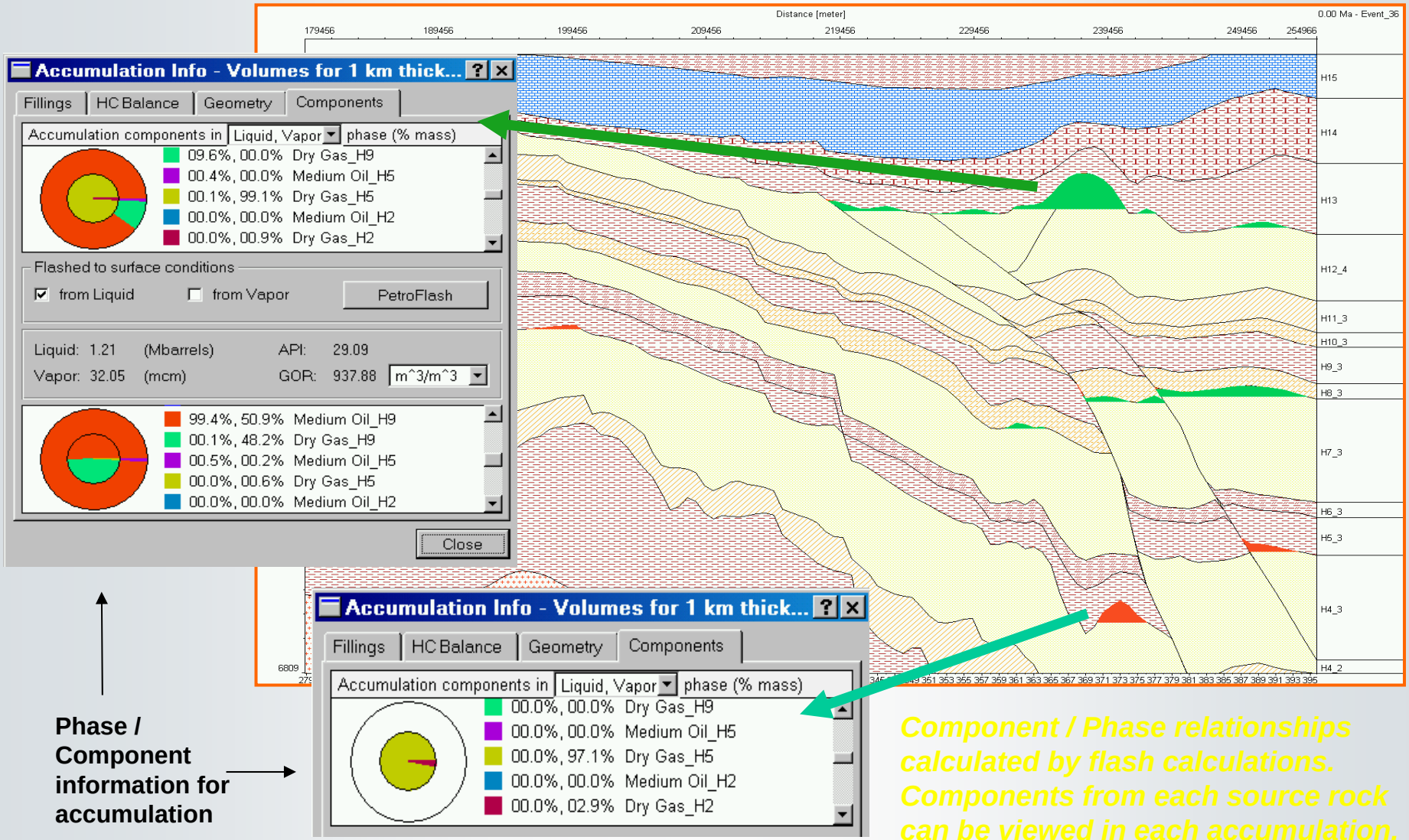
Accumulated HC's

Flashed to surface conditions Predicts API=35 GOR=39



What it looks like
when it comes to the surface

Component Tracking



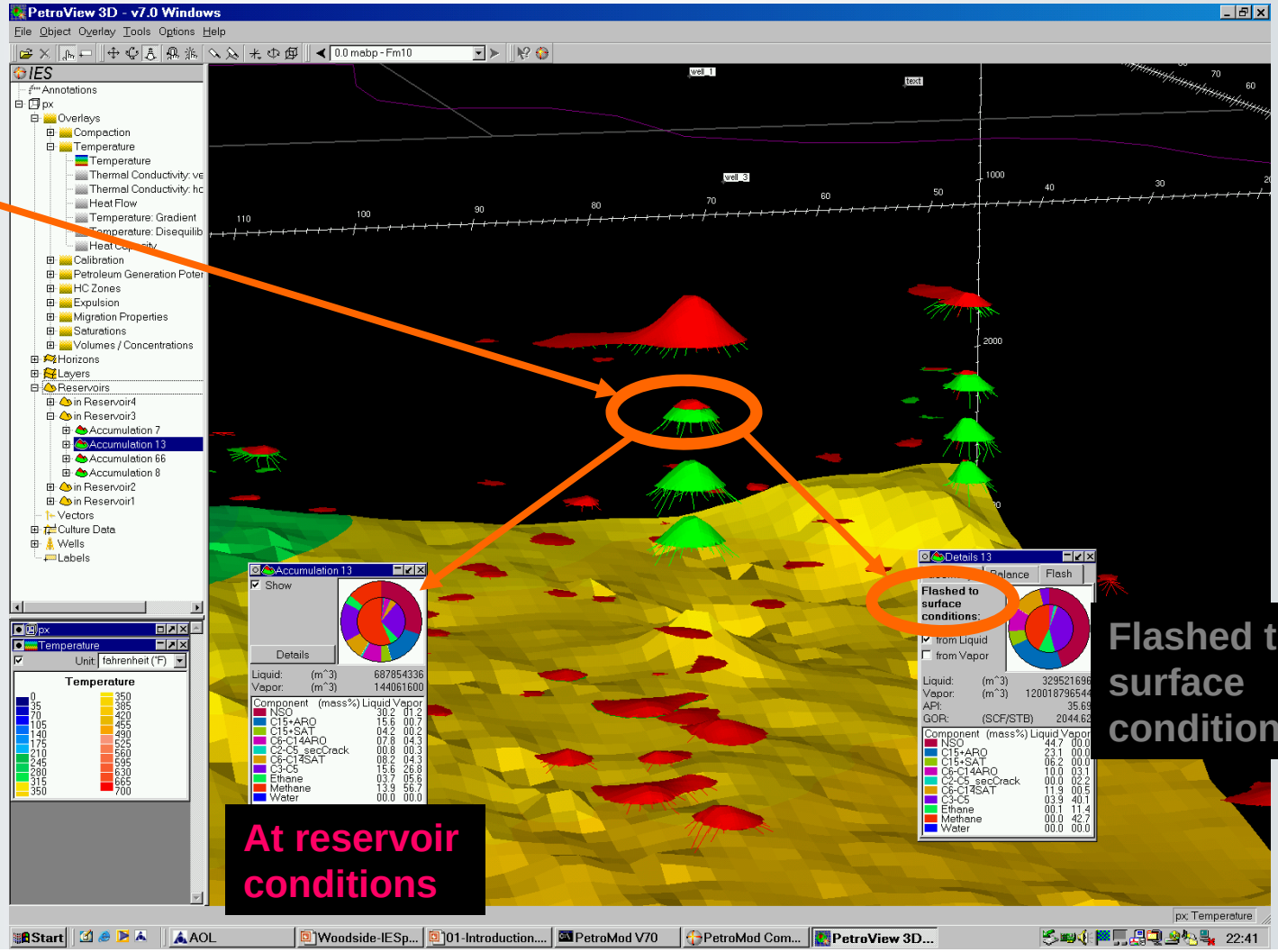
Phase / Component information for accumulation

Component / Phase relationships calculated by flash calculations. Components from each source rock can be viewed in each accumulation.

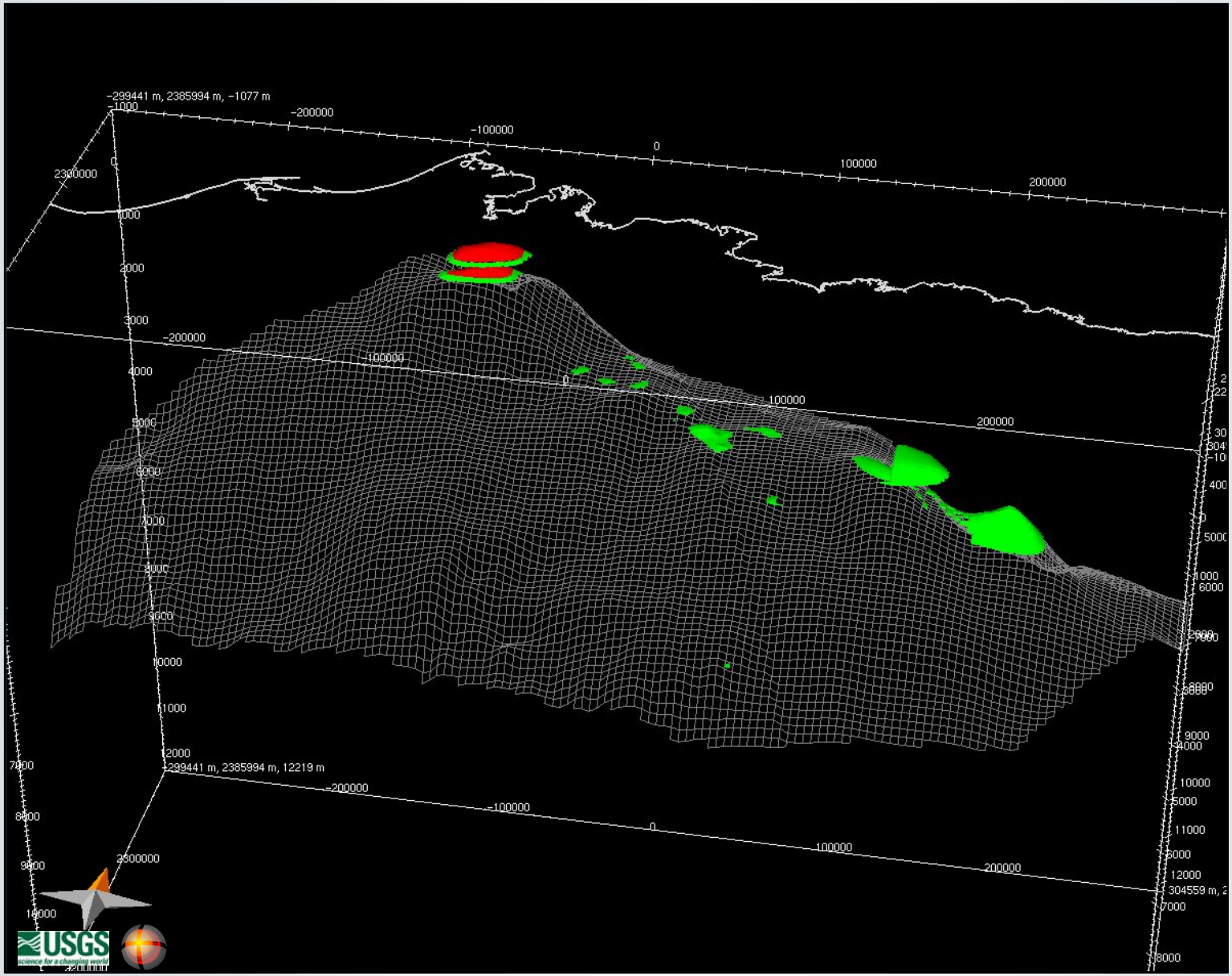
Flash calculations

3D 3-phase / n-component modeling:

View of the hydrocarbon accumulation with volumetrics, properties, phase and component information



Dynamics of Accumulation and Phase Partitioning



present

8

16

21

30

40

55

60

65

86

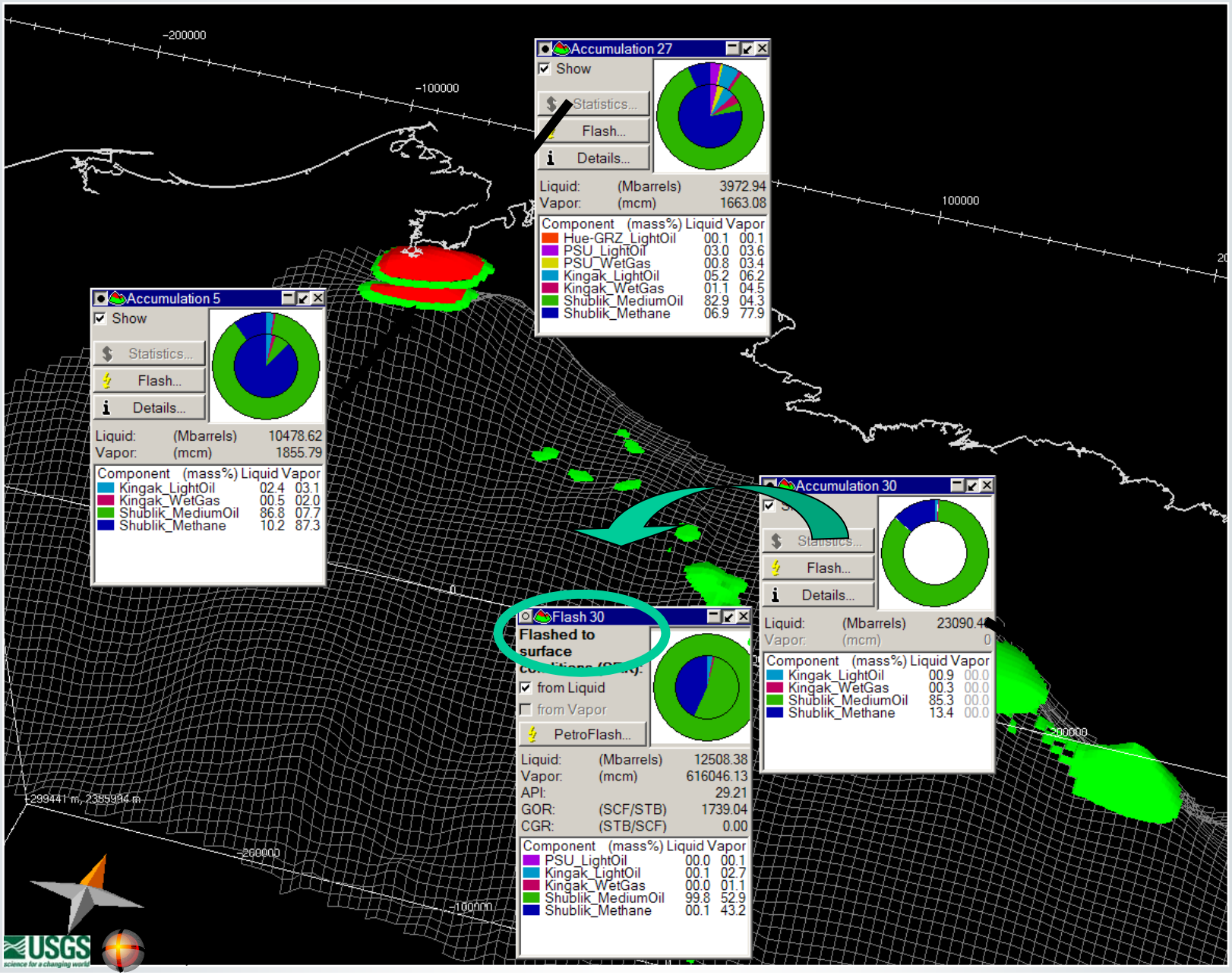
94

98

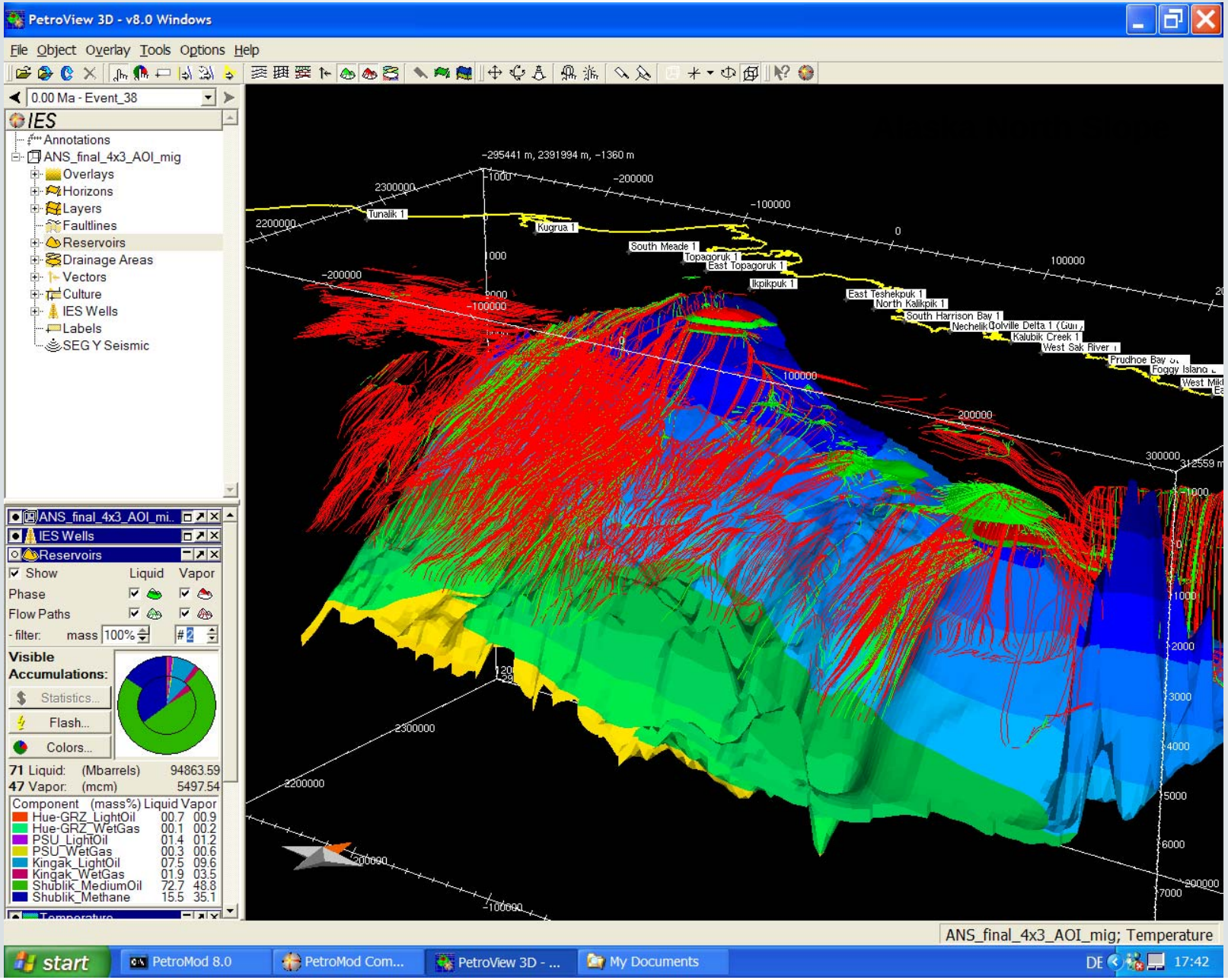
102

110 Ma

Prediction: Volume/Phase/Composition



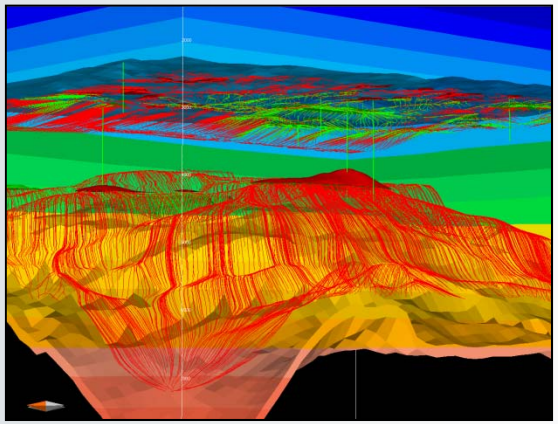
Example: 3-D Fluid Flow Models



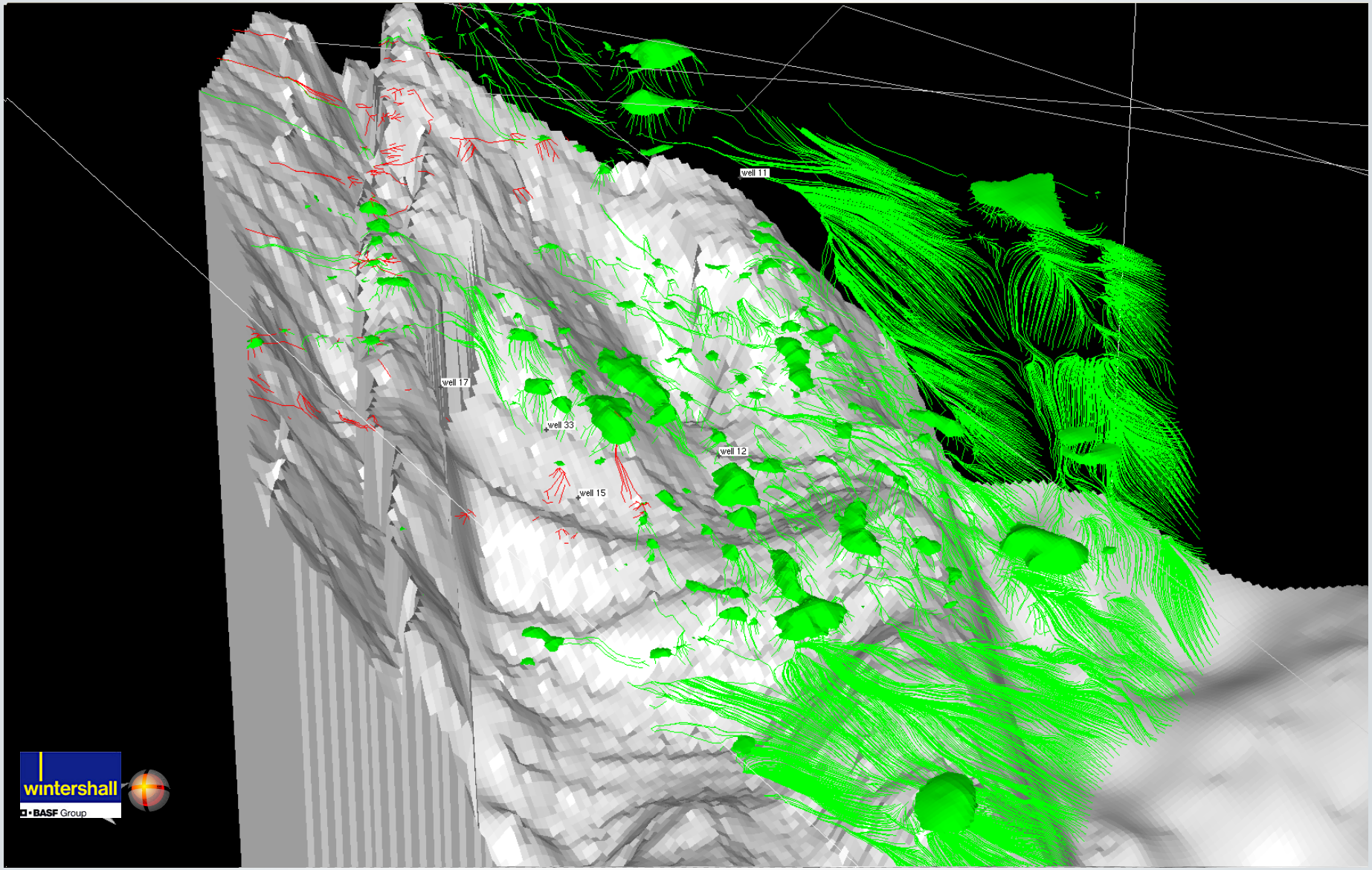
Summary - Migration

Progress in Basin Modeling

- **From basin to reservoir scale**
- **Thermal histories -> Fluid Flow -> Component / Phase Composition (pVT)**
- **Prospect appraisal (ranking and risking) -> product predictions to regional reserves assessments**



Gracias por su atención



Juraj Francu jfrancu@egi.utah.edu