Tengiz oilfield simulation techniques

Scientific Research Institute of Production and Drilling Technologies «KazMunayGas»

Akzhan Kassenov

What's Next?
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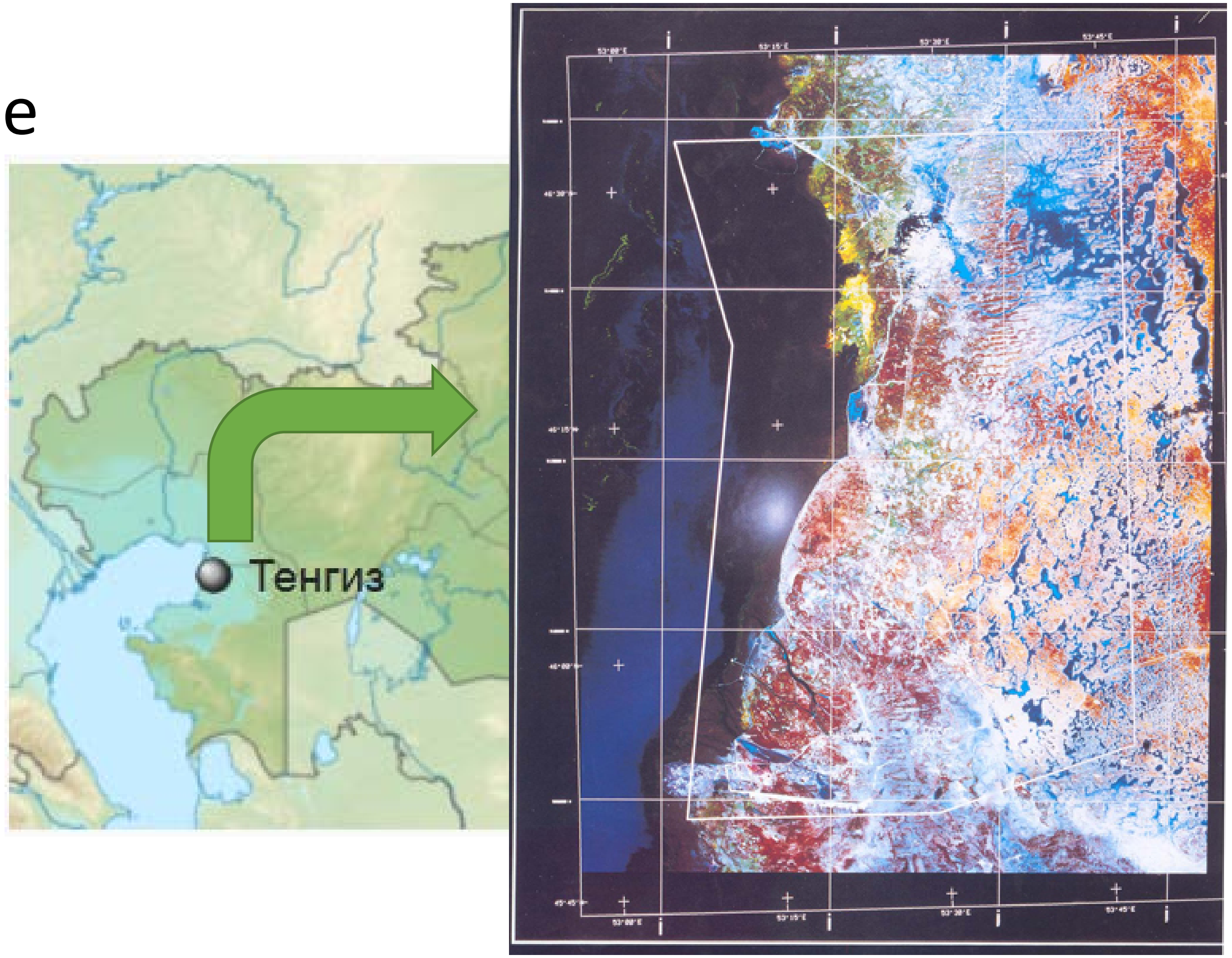
Schlumberger

Outline

- Short description of the field
- Model description
- Model running
- History matching – hydraulic flow units
- Conclusion

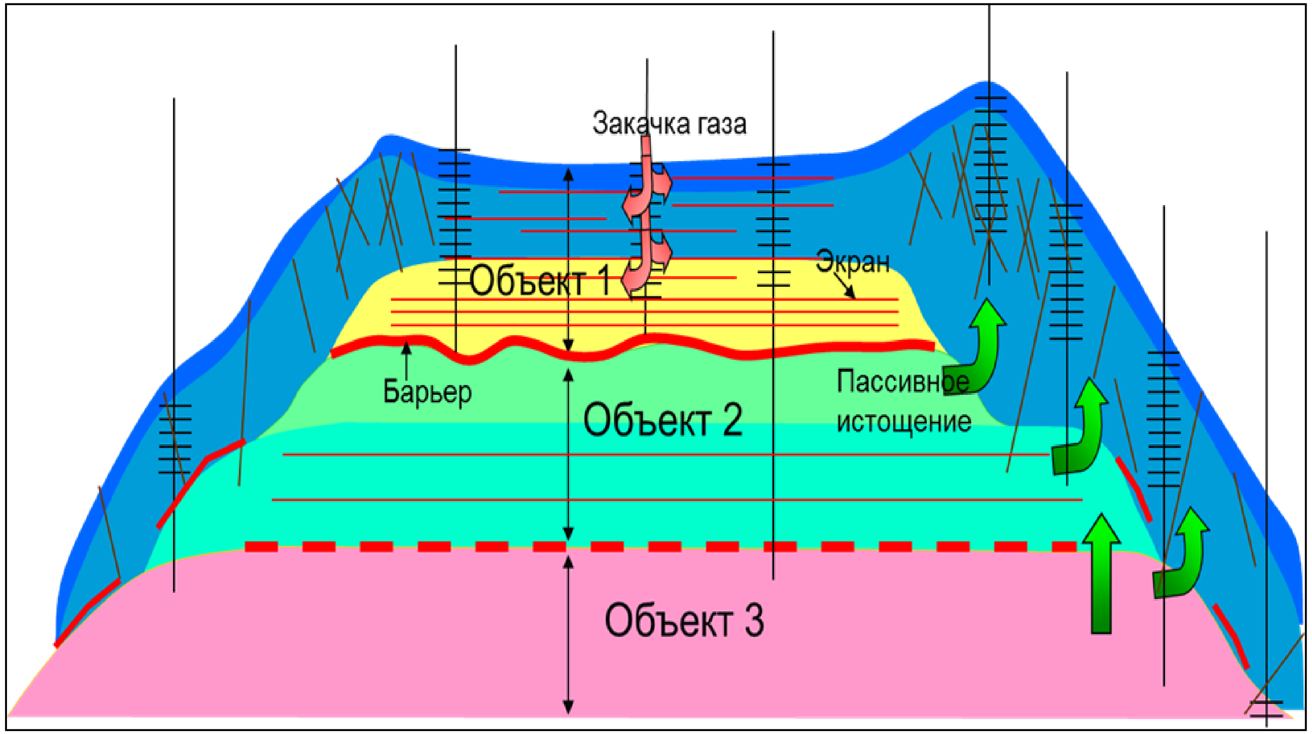
Short description of the field

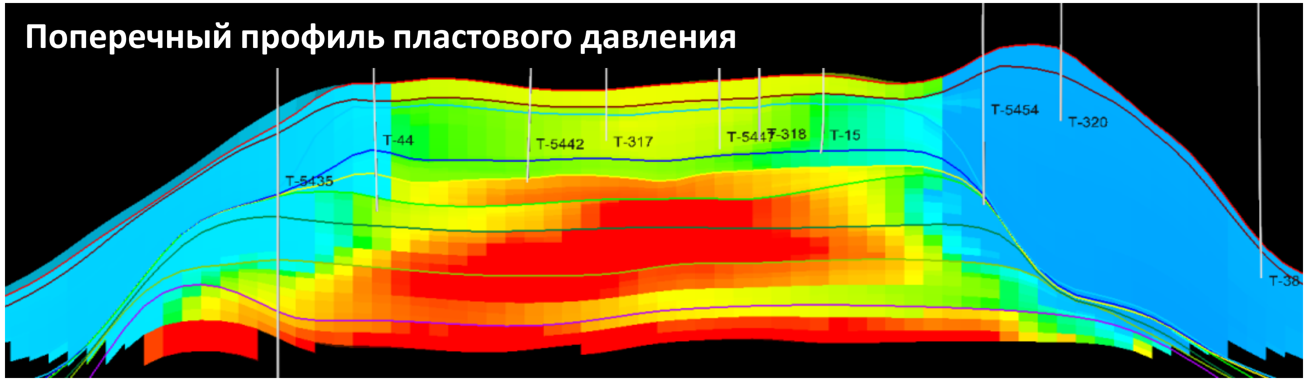
- One of the deepest giant oil fields in the world
- Oil saturated thickness – 1600 meters
- More than 100 wells
- Production since 1993
- Reserves X billion tons of oil
- 2 marathon course to run around the field



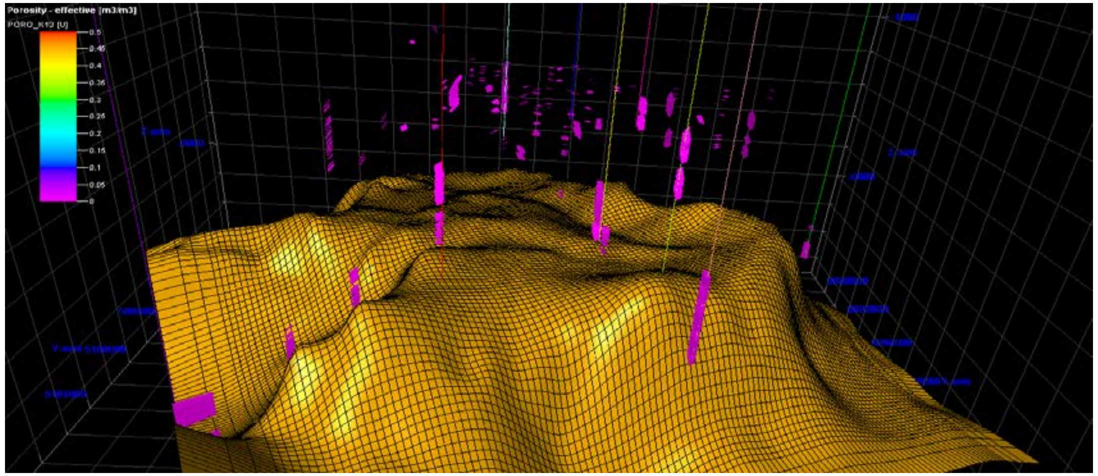
Short description of geology

- Reservoir – carbonaceous:
  - Unit I (bashkirian-serpukhovian deposits)
  - Unit II (lower visean-tournasian deposits)
  - Unit III (Devonian deposits)
- Three units make one hydrodynamic system
- Two main zones were selected: platform and slope



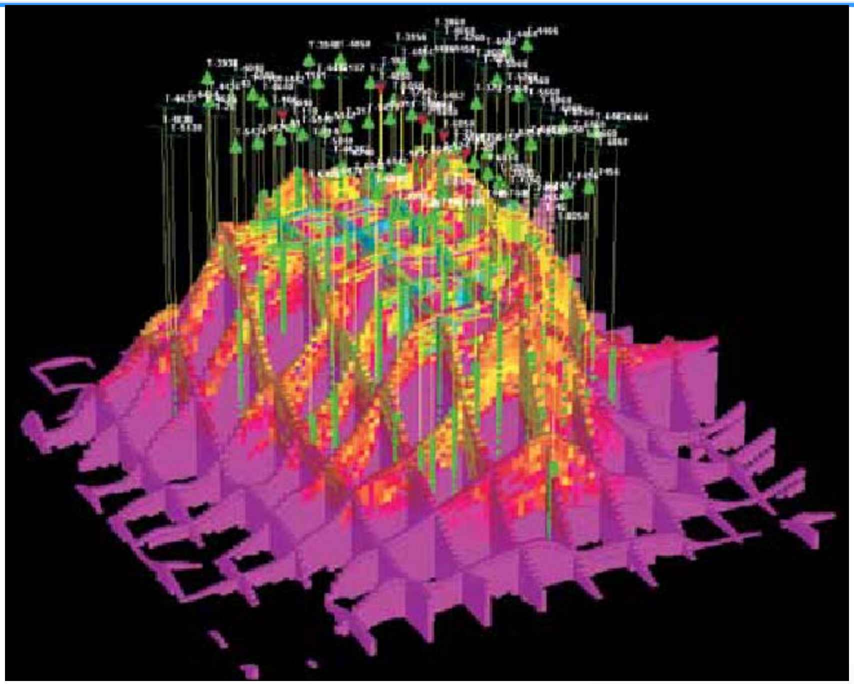


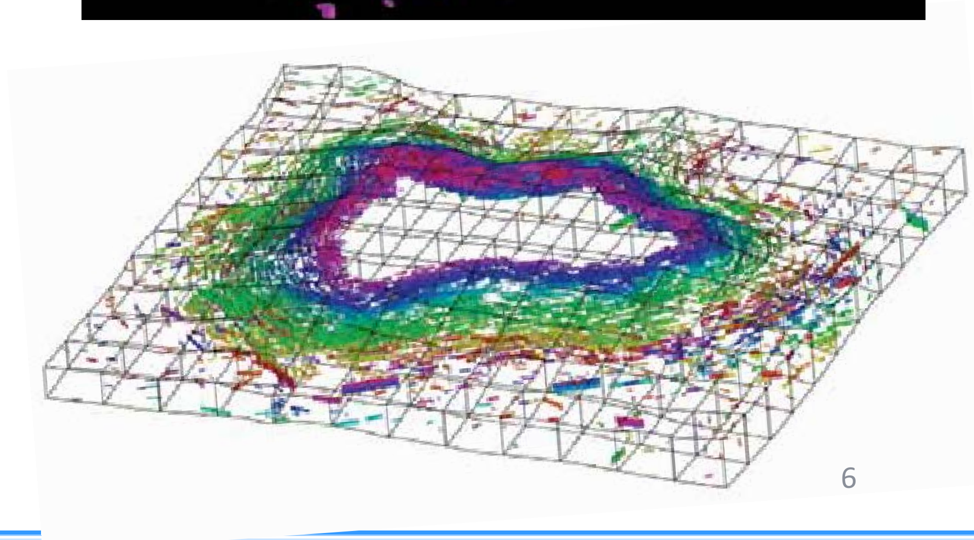
Creation of simulation model and recreation of historic production data and bottom hole pressure



Short description of the model

- Number of active cells – more than 1 million
- Carbonate reservoir with fractures on slopes
- Dual porosity and dual permeability model
- Low matrix permeability
- Fluid model: 8 components with high H_2S content
- VFP for wells





Model building methodology

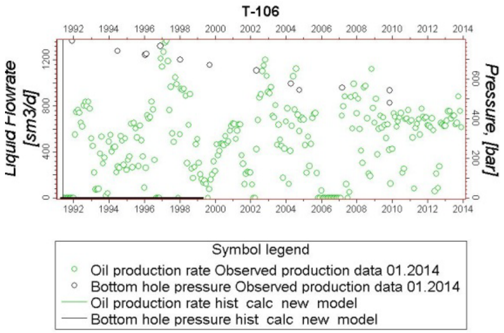
Grid modelling and layering process → **Reservoir description** (upscaling and selection of effective cell parameters: ϕ, k, NTG) → **Relative permeability curves and capillary pressure curves** → **Fluid parameter** (PVT model) → **Water drive system modeling**

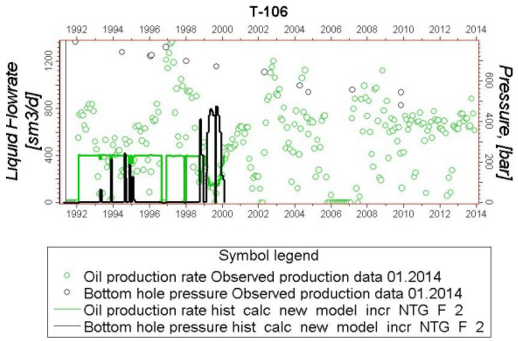
→ **Well modeling** (coordinates, construction, perforations) → **Definition of well parameters in accordance with history data** → **Optimization process to decrease model run time** → **History matching** → **Definition of various prediction cases**

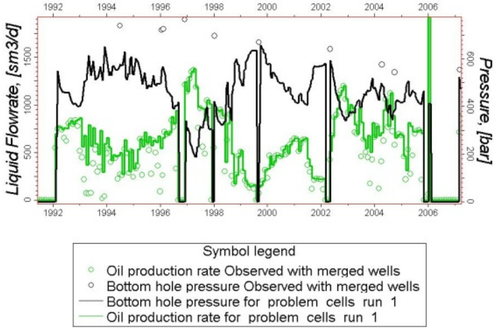
Correction of certain geologic parameters

History matching of well by well production rates

History matching of well by well bottom hole pressure



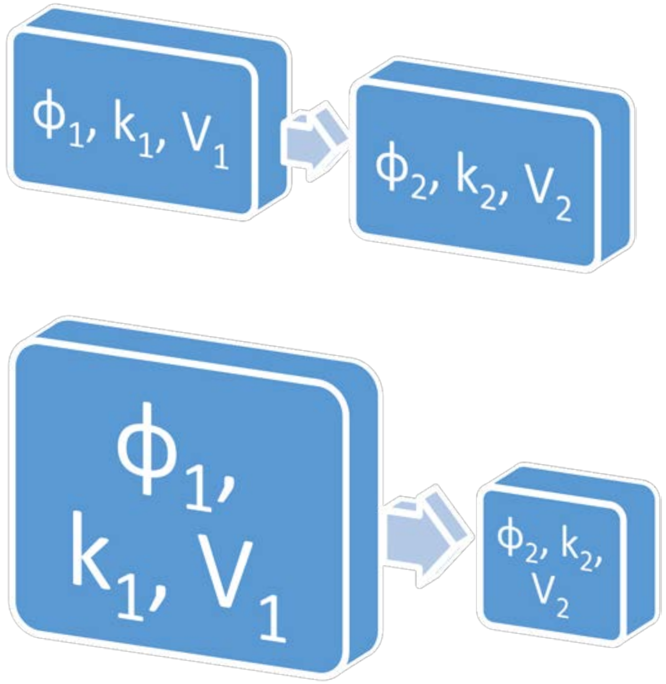




Difficulties in building of Tengiz simulation model

- Integrated approach in “matrix-fracture” system modeling
- Significant difference in porosity and permeability of “matrix-fracture” system

- Displacement mechanism: oil moves from matrix cell to fracture cell
- Significant difference between pore volume results in decrease of simulation model time step



1) $Vpor_1 \approx Vpor_2$

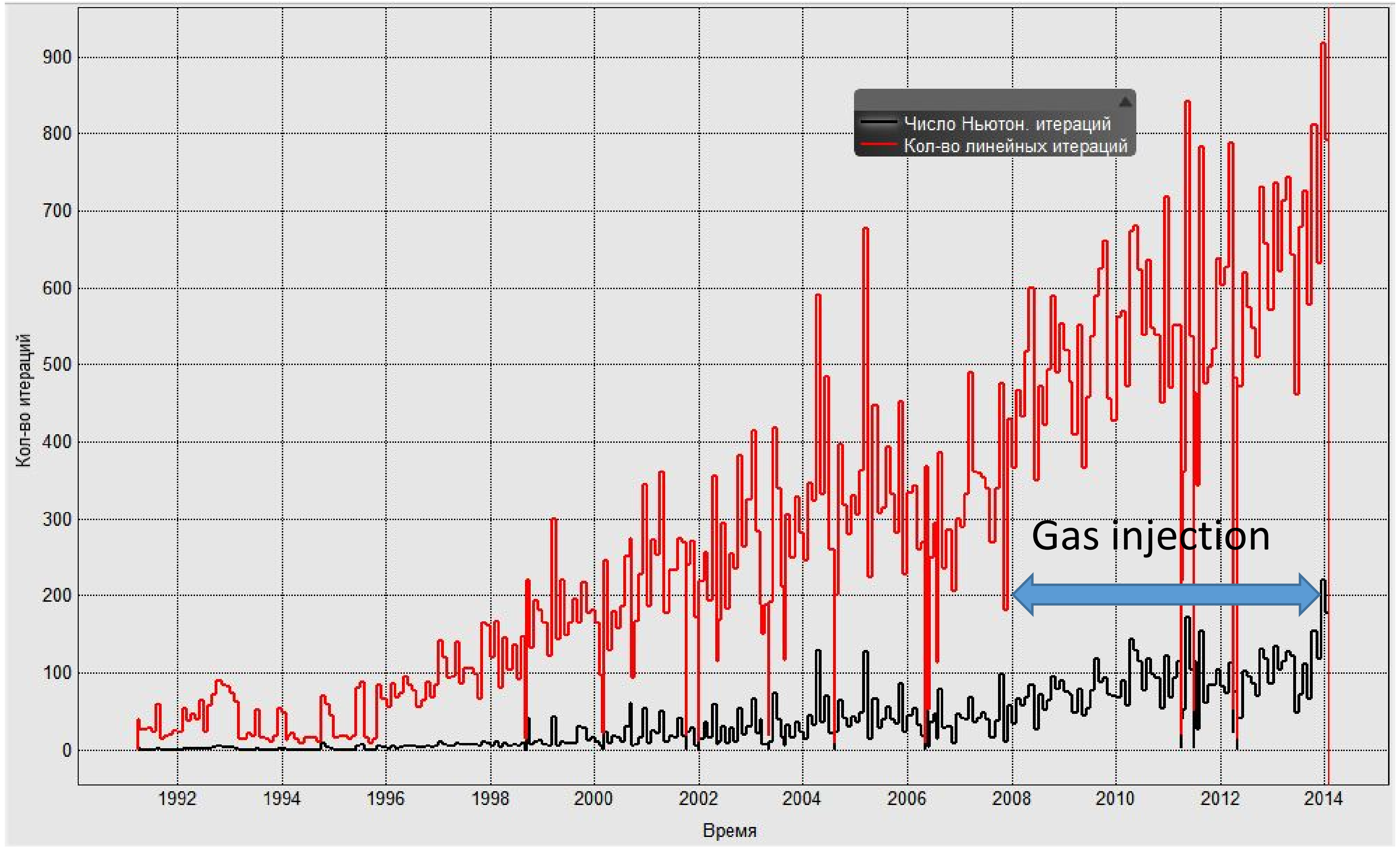
$\Delta t = 1$

2) $Vpor_1 >>> Vpor_2$

$\Delta t <<< 1$

Difficulties in building of Tengiz simulation model

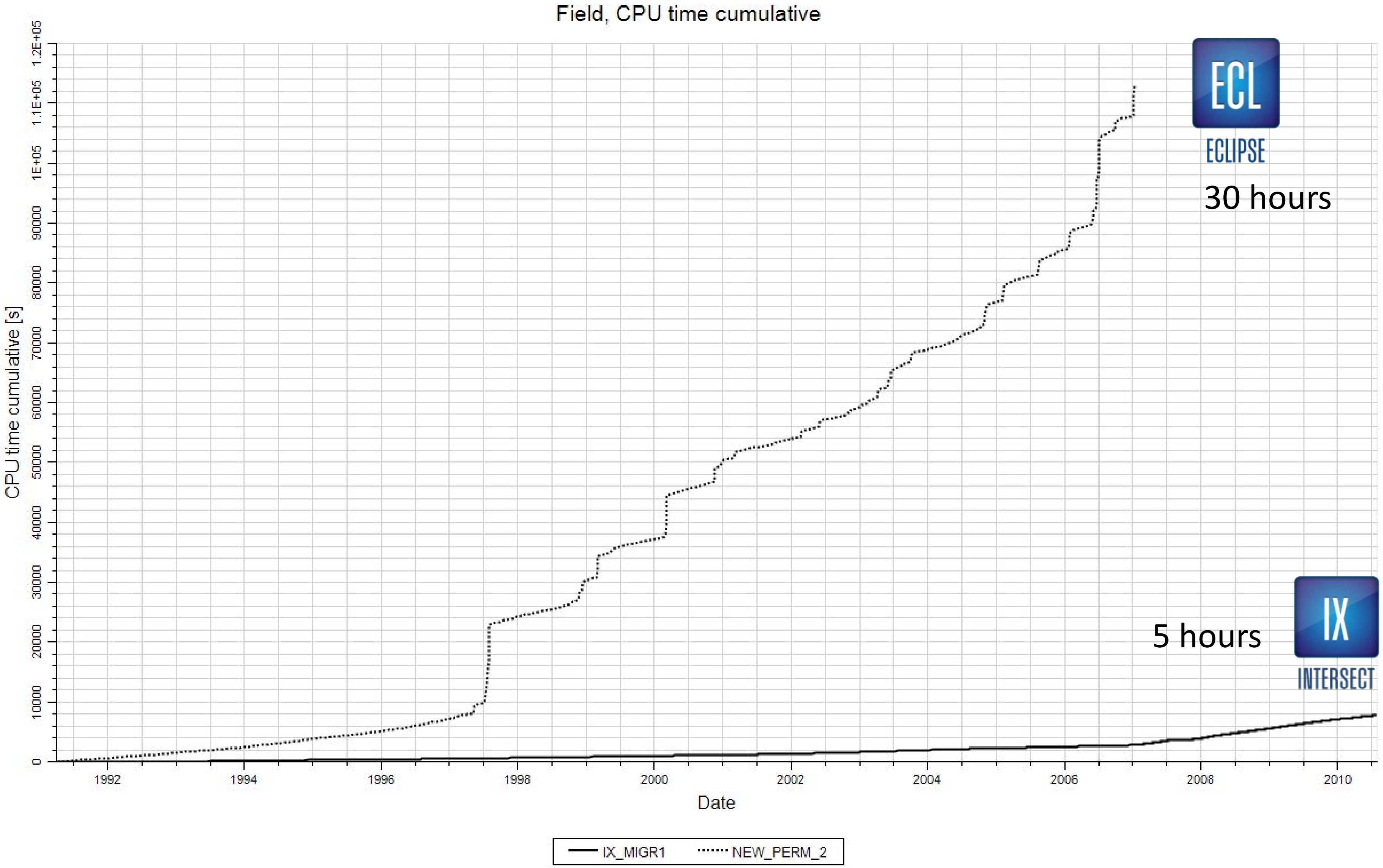
Decrease of simulation model time step results in big amount of consecutive model iterations (Newtonian iterations) in order to history match. Simulation becomes even more complicated when injection phase begins.



Appropriate program choice

- Reasons of increasing the model run time
  - Dual porosity and dual permeability
  - Elaborate structural model
  - Gas reinjection
  - Gigantic size
  - Compositional model with big number of components

Comparison of run time spent with INTERSECT and E300 using cluster (72 cores)



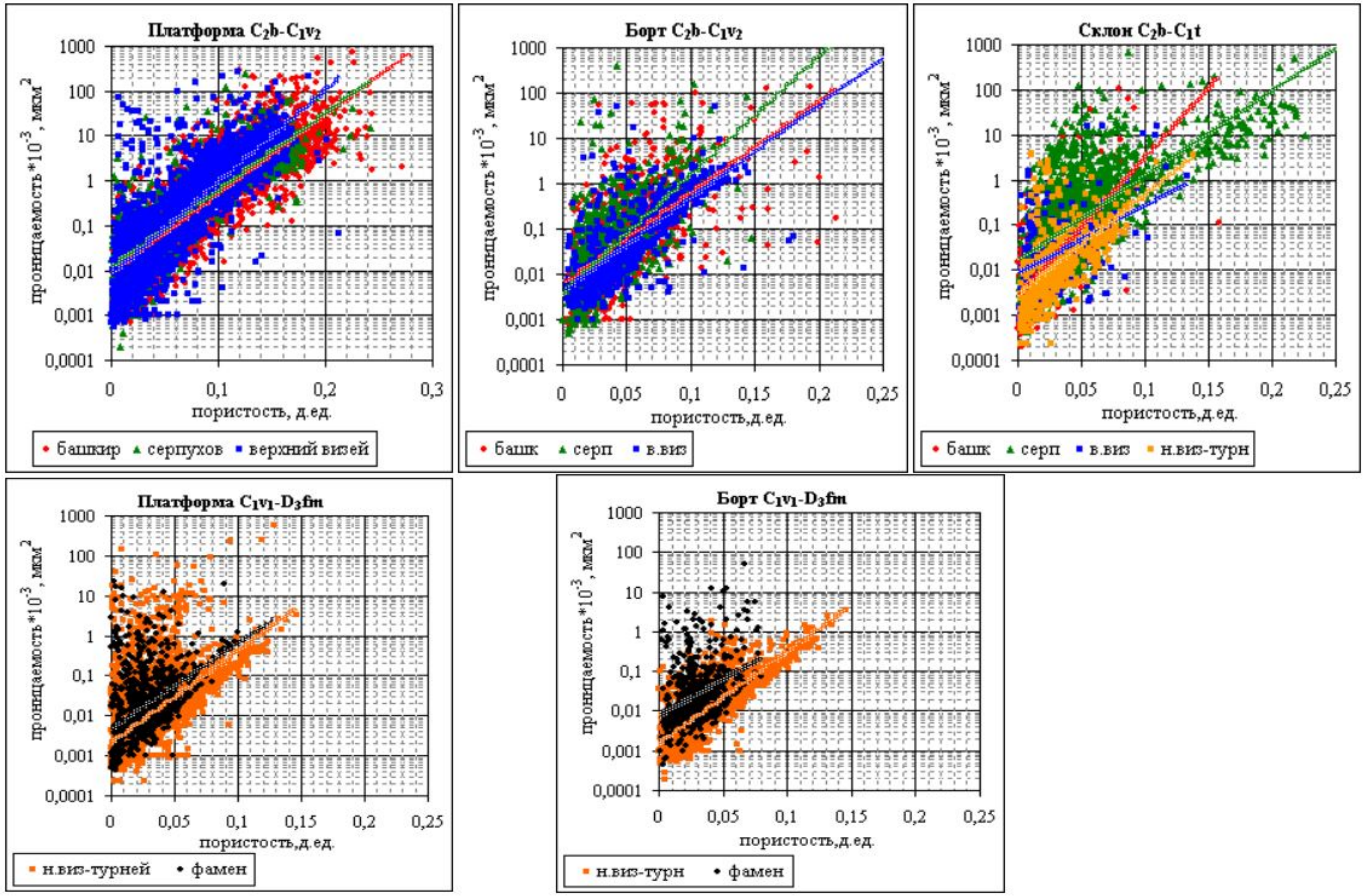
30 hours

5 hours

History matching methodics

Standard approach for permeability calculation

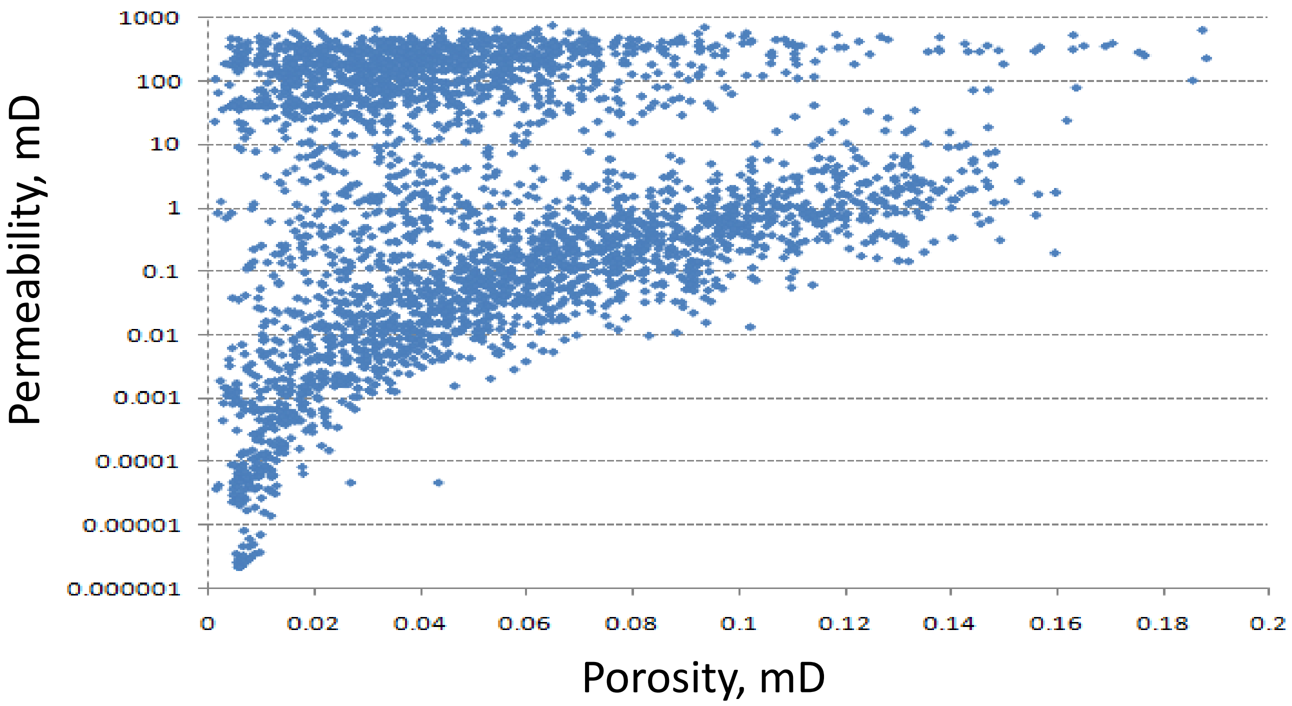
- Porosity from permeability dependence graph
- Correlation coefficient
- Permeability coefficient dependence from porosity
- Created separately for each horizon



Separation of petrophysical properties on HFU (hydraulic flow units)

SPE 63072 “Effective petrophysical fracture characterization using the flow unit concept”,
J.G.Rincones, R.Delgado, H.Oheh, P.Enwere

6744 values (by wells)



$$k = 1014 * FZI^2 * \frac{\phi_e^3}{(1-\phi_e)^2}$$

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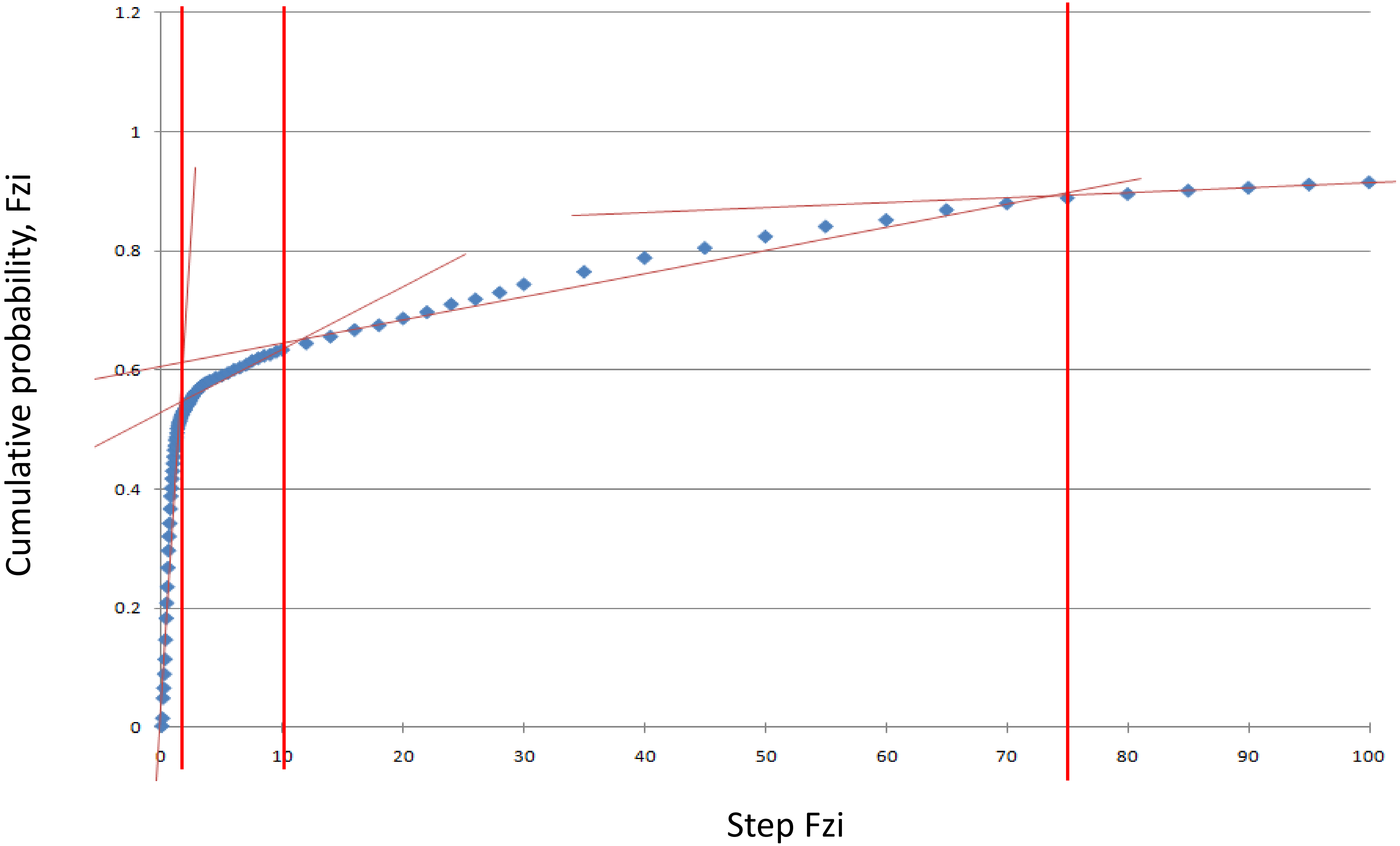

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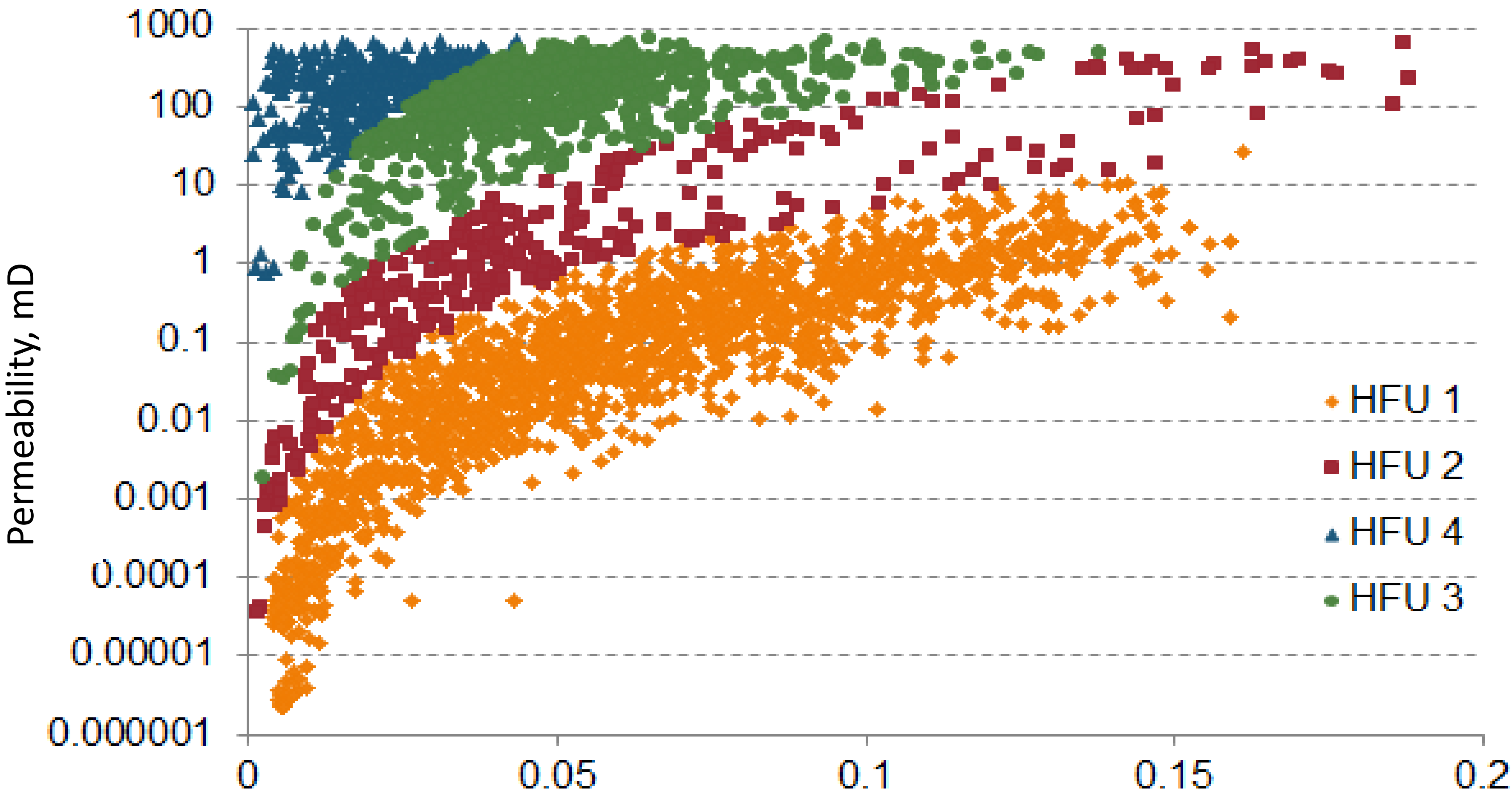


HFU Characteristics

- **1 HFU:** low Filtration and Carrying Properties (FCP)

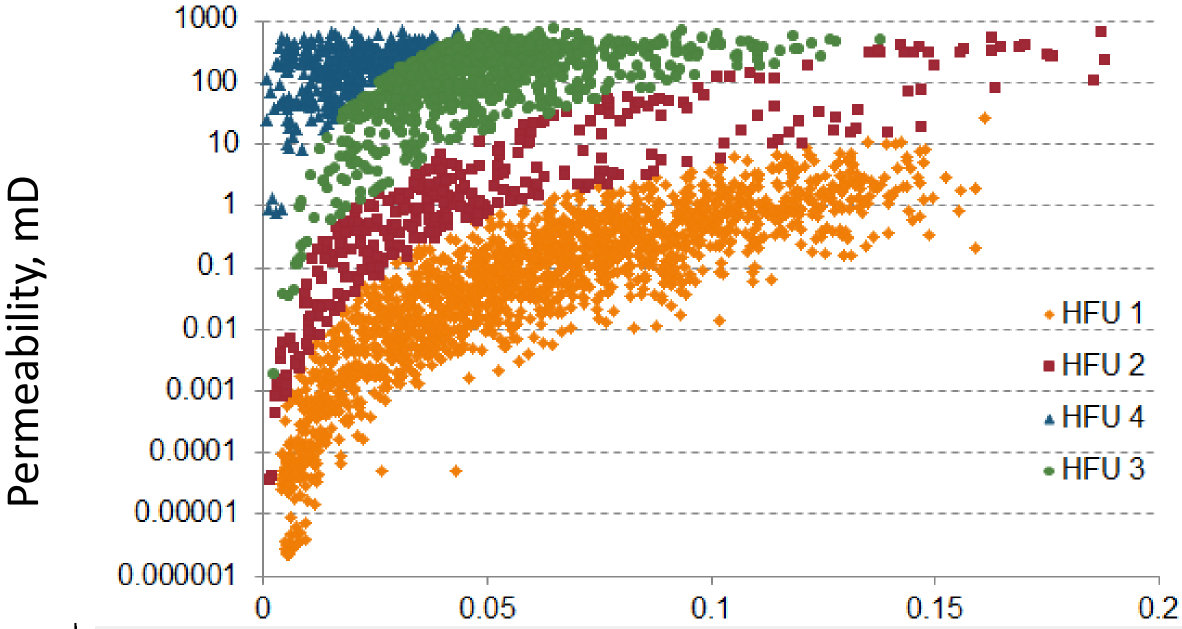
k=0.001÷5 mD, ϕ=0.002÷0.16

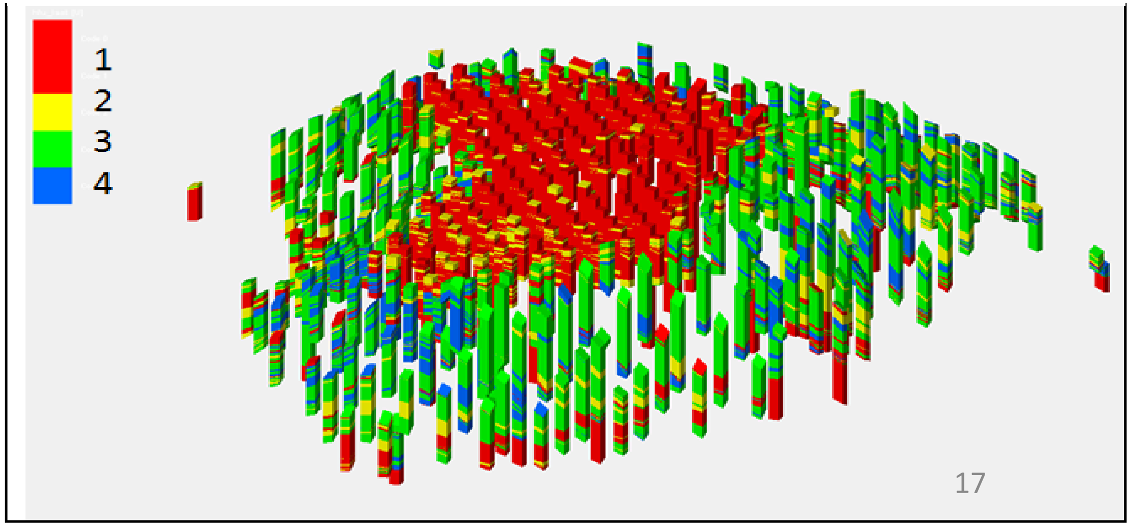
Distributed at platform of all units and near basin parts of slope in the zones with low “energy” and **absence of fractures**;

- **2 HFU:** low FCP

k=0.001÷400 mD, ϕ=0.002÷0.18

Distributed at platform and slope zones of reservoir. Reservoir type mainly porous-fractured.





HFU Characteristics

- **3 HFU:** medium FCP

k=0.1÷900 mD, ϕ=0.002÷0.13

Distributed at slope zone of reservoir.

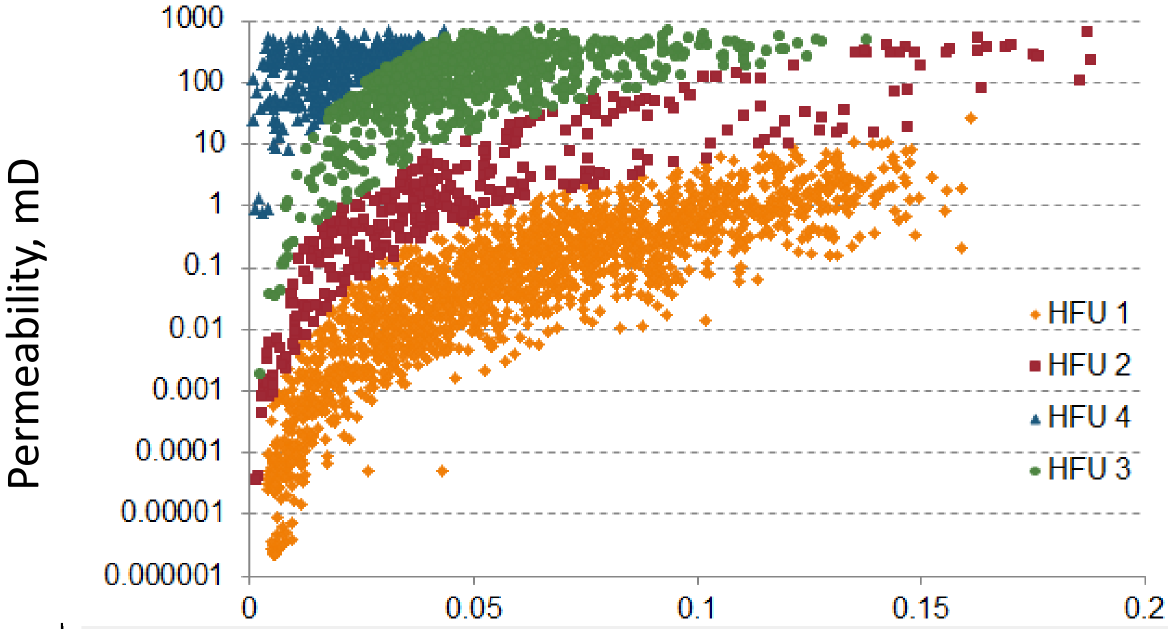
Reservoir type mainly fractured.

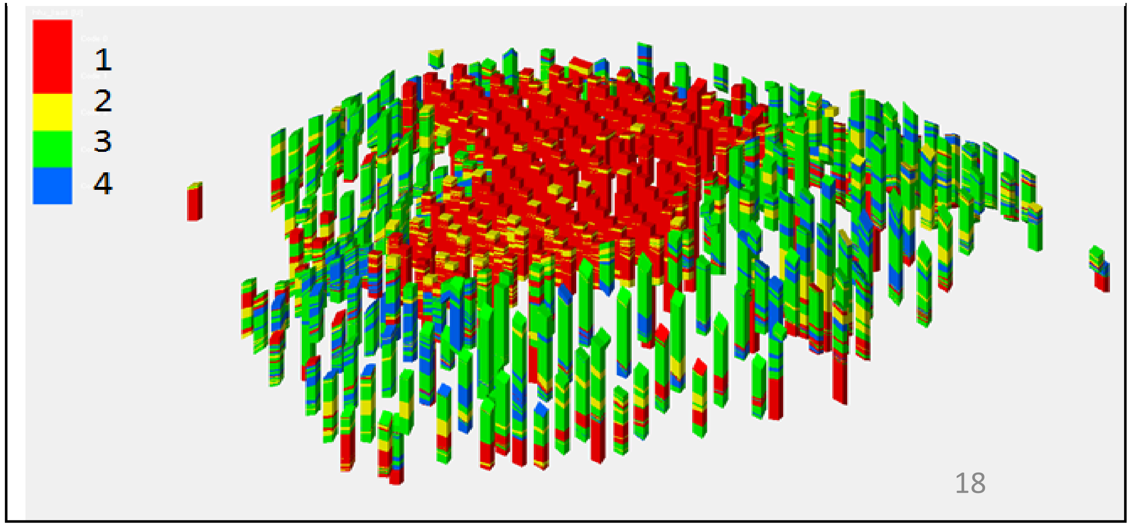
- **4 HFU:** medium FCP

k=1÷900 mD, ϕ=0.002÷0.04

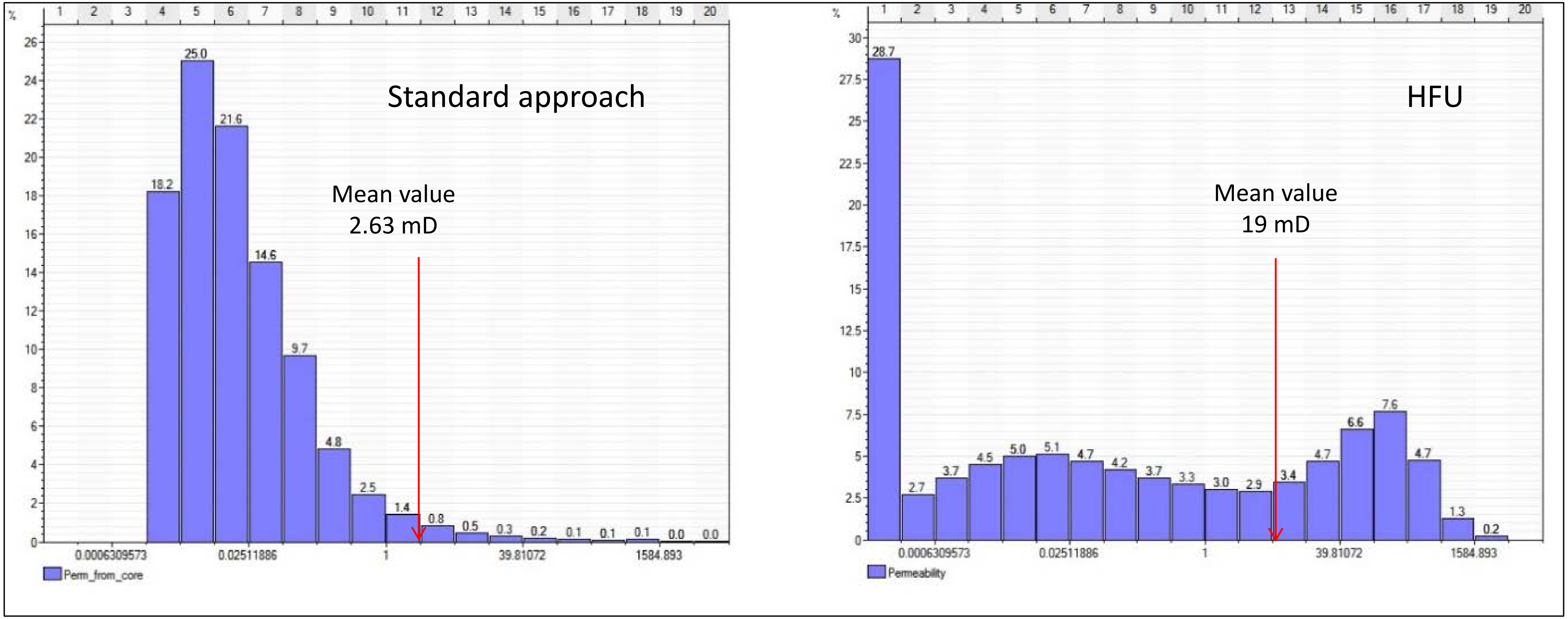
Distributed at slope parts of reservoir in zones with highest angles of inclination.

Reservoir type mainly fractured





Comparison of histograms of permeability models made by standard approach and by HFU



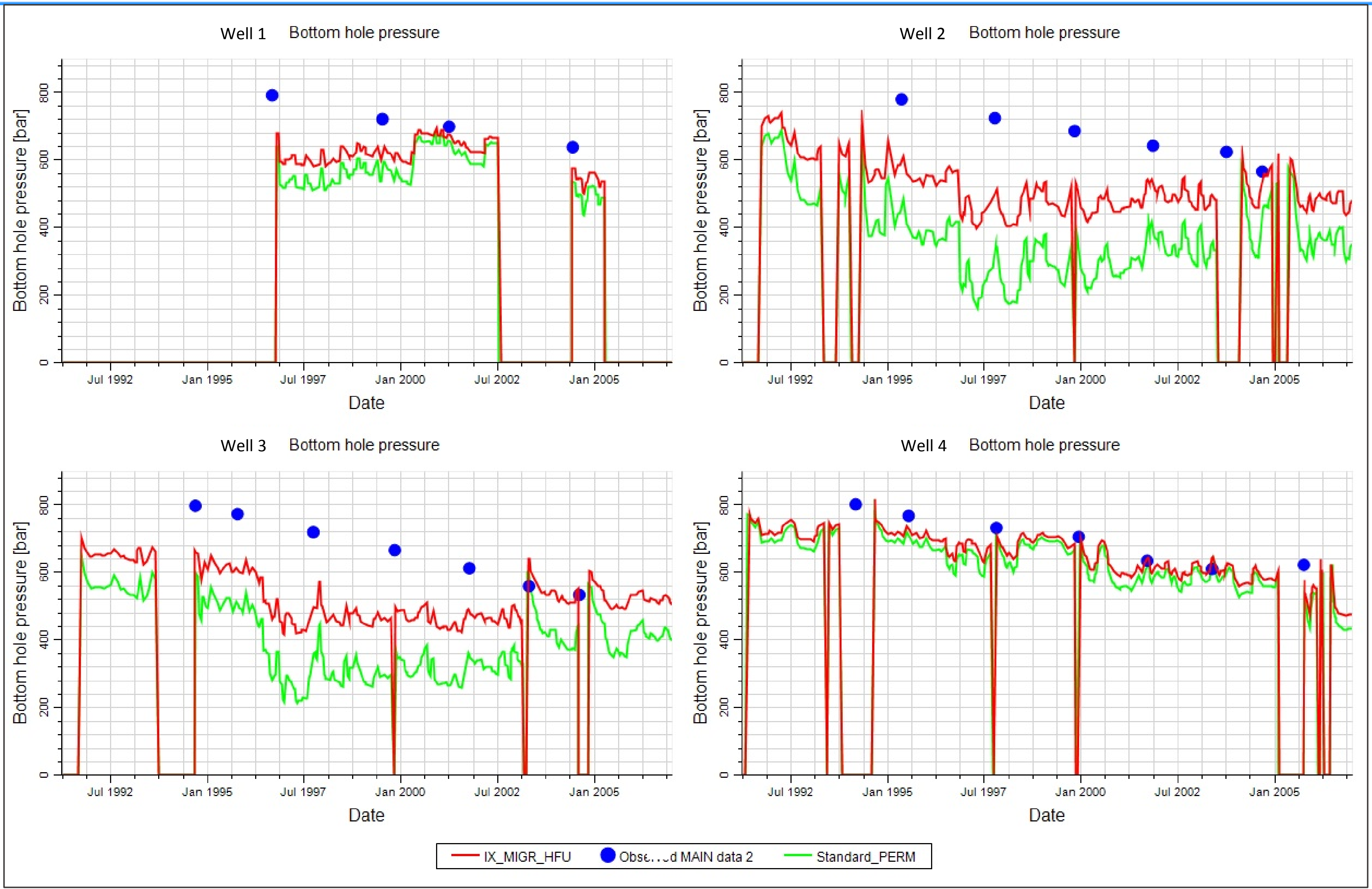
Standard approach

Mean value
2.63 mD

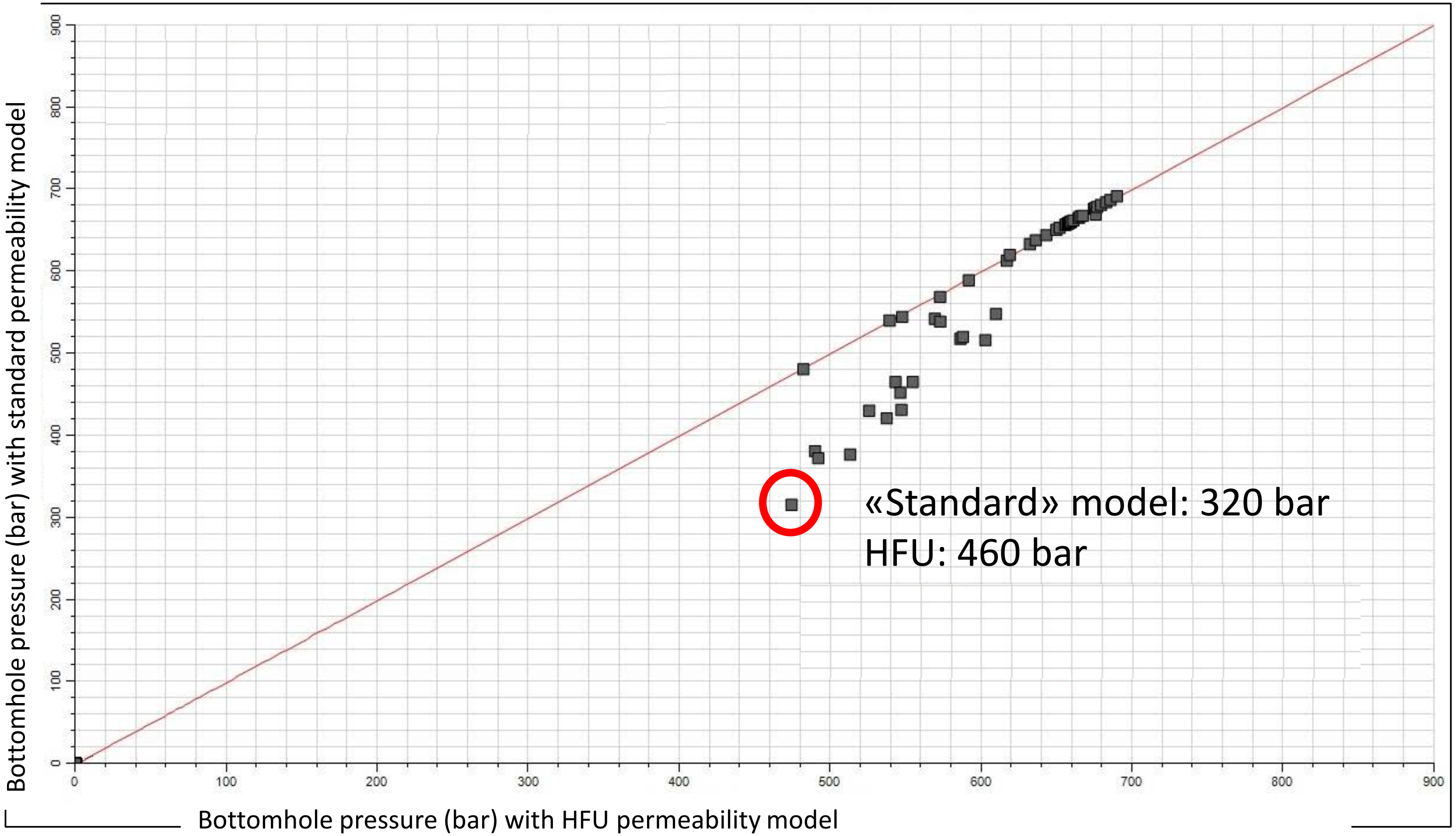
HFU

Mean value
19 mD

Example of wells history matching of bottomhole pressures



Comparison of bottomhole pressure values by application of different permeability models



«Standard» model: 320 bar
HFU: 460 bar

Insufficient level of bottomhole pressures matching were observed by some wells, located at zones of high FCP. Application of HFU allowed considerably improve situation

Conclusions

- Tengiz field model represents a complex simulation model with maximum available software requirements needed for simulation run
- Implementation of INTERSECT hydrodynamic simulator considerably reduced simulation run time and allowed to apply different history matching methods
- Application of HFU considerably improved history matching of bottomhole pressures
- HFU helped to qualitatively make and forecast reservoir characterization

Thank you for attention!