

# Fine scale modeling of carbonate gas condensate field using high resolution reservoir simulator

Khakim Baigazin

Reservoir Development Manager

Karachaganak Petroleum Operating



## What's Next?

SIS Global Forum 2017

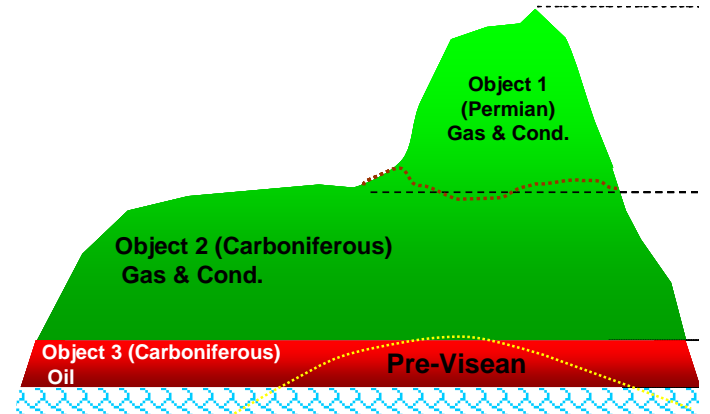
September 13-15

Le Palais des Congrès de Paris

**Schlumberger**

# GAS CONDENSATE FIELD OVERVIEW

- Giant gas condensate field located in West Kazakhstan
- Area of 280 km<sup>2</sup>
- Discovered in 1979
- Production started in 1984
- Complex field:
  - Fluid compositional gradient
  - Fractures
  - High heterogeneity
- Partners of the field: ENI, Shell, Chevron, Lukoil, and KMG



# FINE SCALE MODELLING & INTERSECT TESTING

## Aims & Objectives

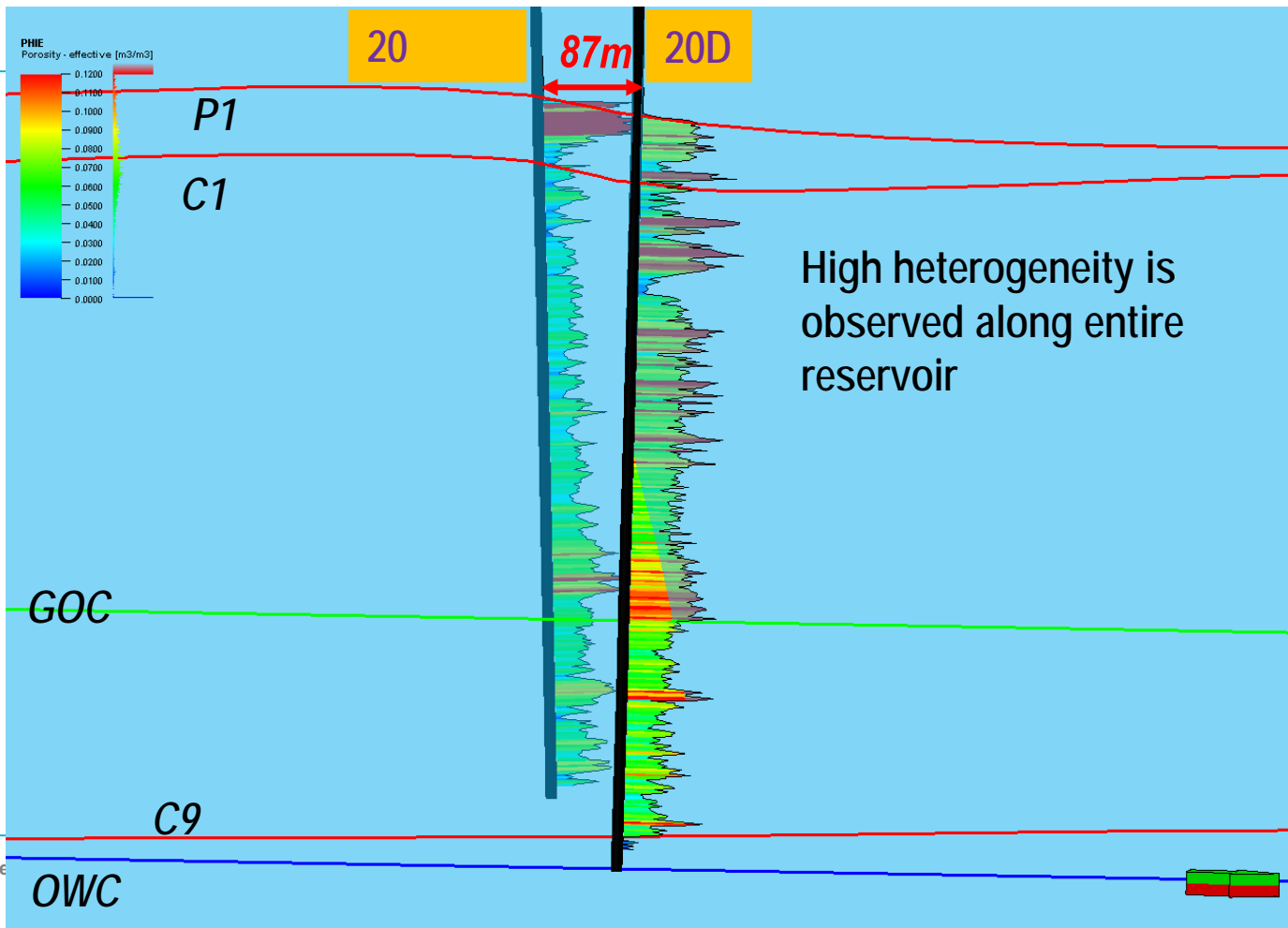
- Test possible benefit of finer scale model (X/Y refinement) to better capture the heterogeneity of the field
- Assess the speed-up of INTERSECT versus ECLIPSE
- Assess the requirement for KPO to migrate to a faster reservoir simulator for next model build

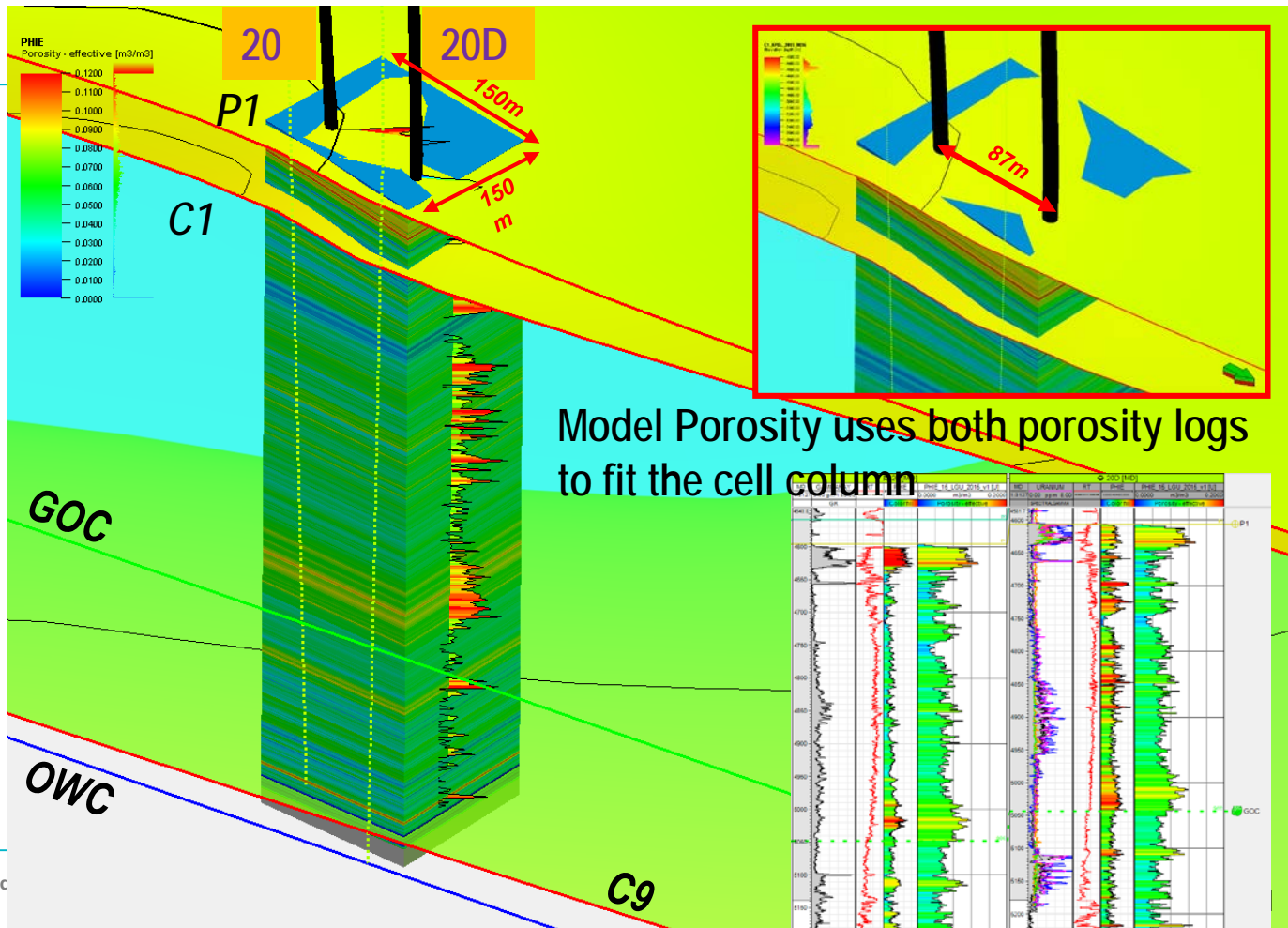
## Methodology

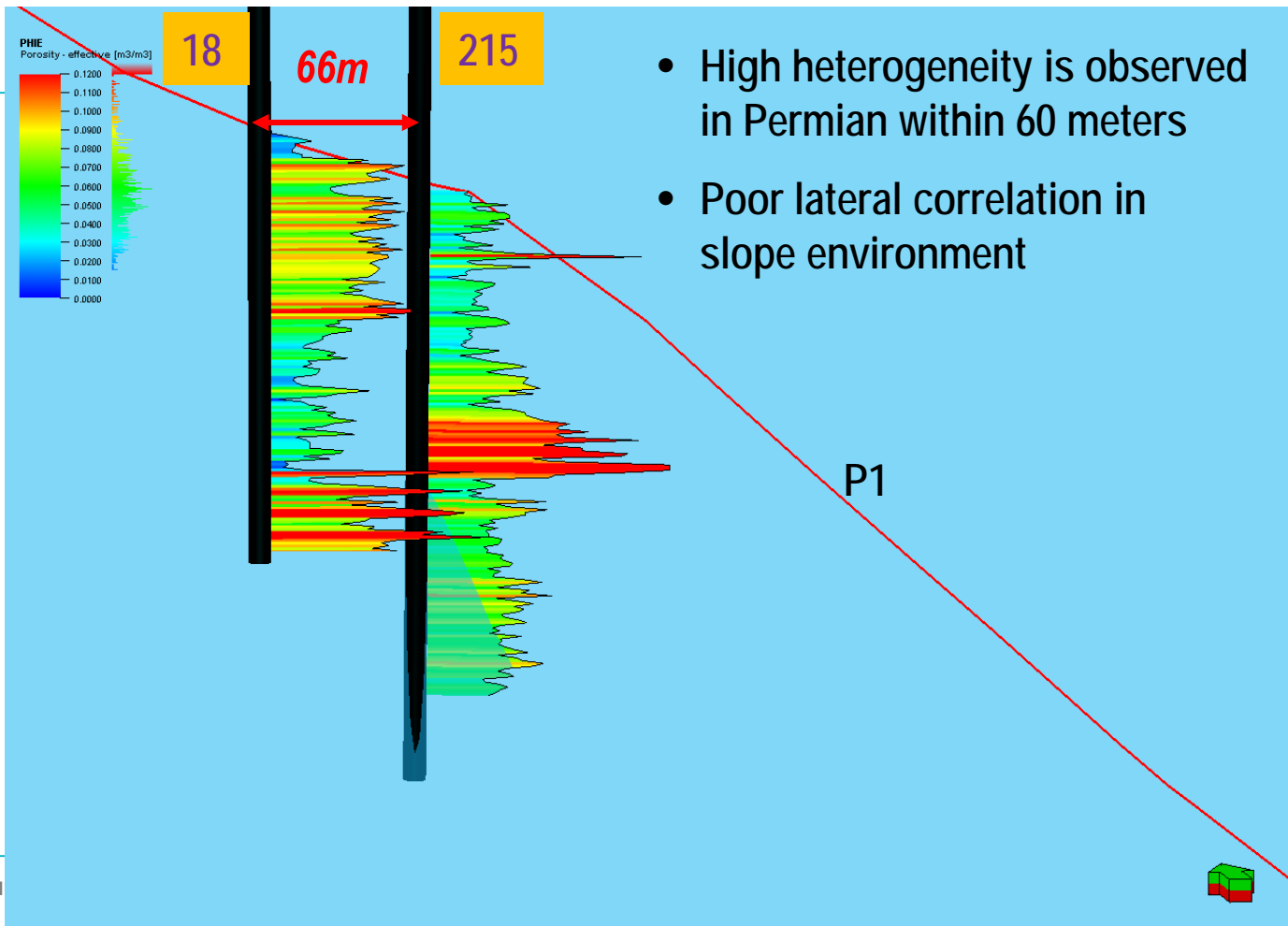
- Fine scale model built from refined coarse model
- INTERSECT testing done by Schlumberger to assess
  - If INTERSECT could replicate results from ECLIPSE
  - Assess runtime benefit
- Fine scale model run using ECLIPSE to assess
  - Impact on History match with different degree of heterogeneity in fine scale model

# WHY REFINE IN X/Y DIMENSION – LATERAL HETEROGENEITY

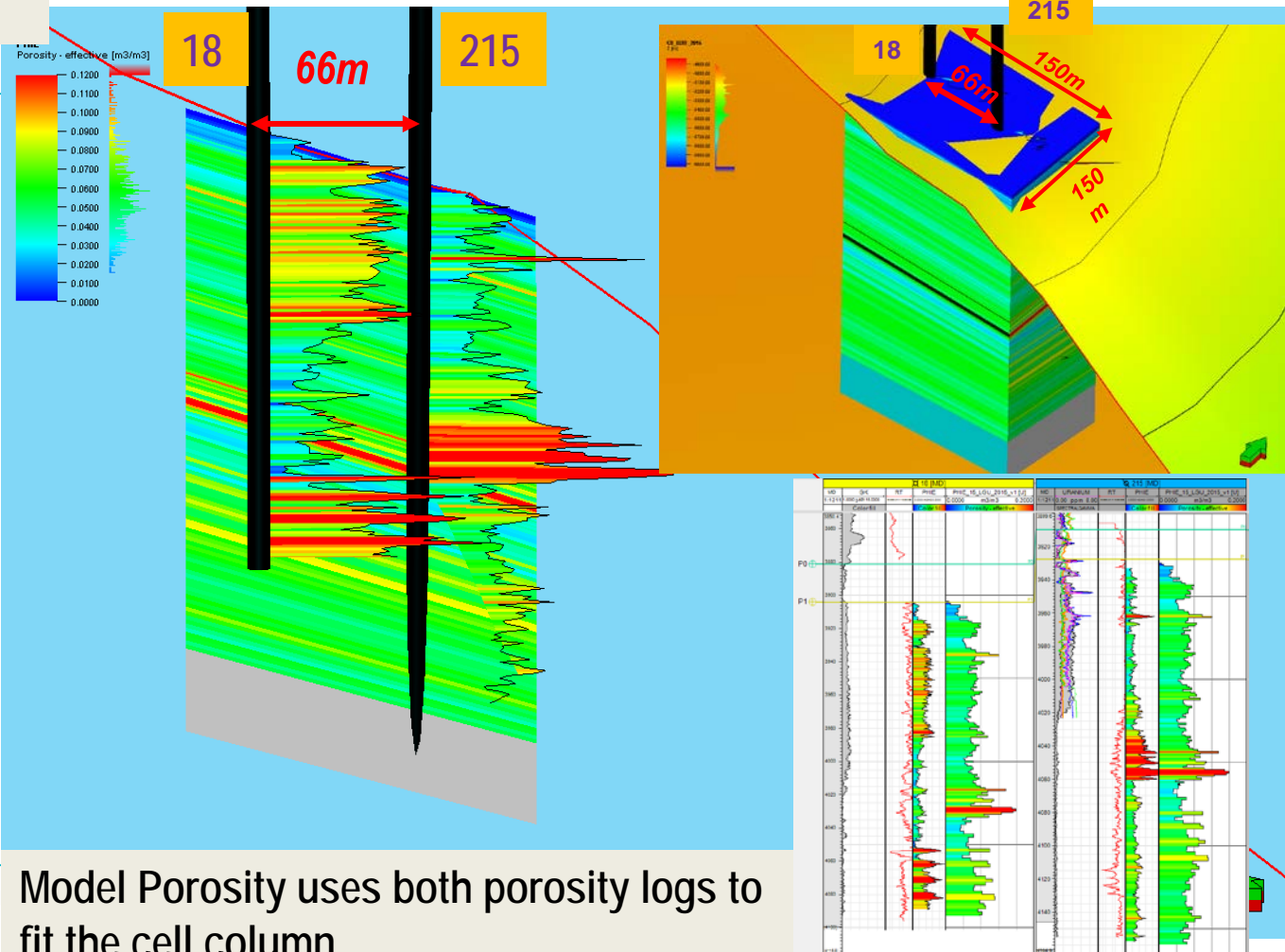
- Sector modelling studies with refinement in Z direction
  - Resulted in very poor connectivity.
  - Low permeability cells (150m in XY) create “large slabs” that have very poor vertical connectivity
  - Flow has difficulty to find its way around
- This is opposite from the reality as it is clearly evident in Karachaganak from pressure and production data
- Lateral heterogeneity examples and disadvantages of the current grid dimensions are presented in the next slides







P1



Fine Scale Model

Model Porosity uses both porosity logs to fit the cell column

RDS

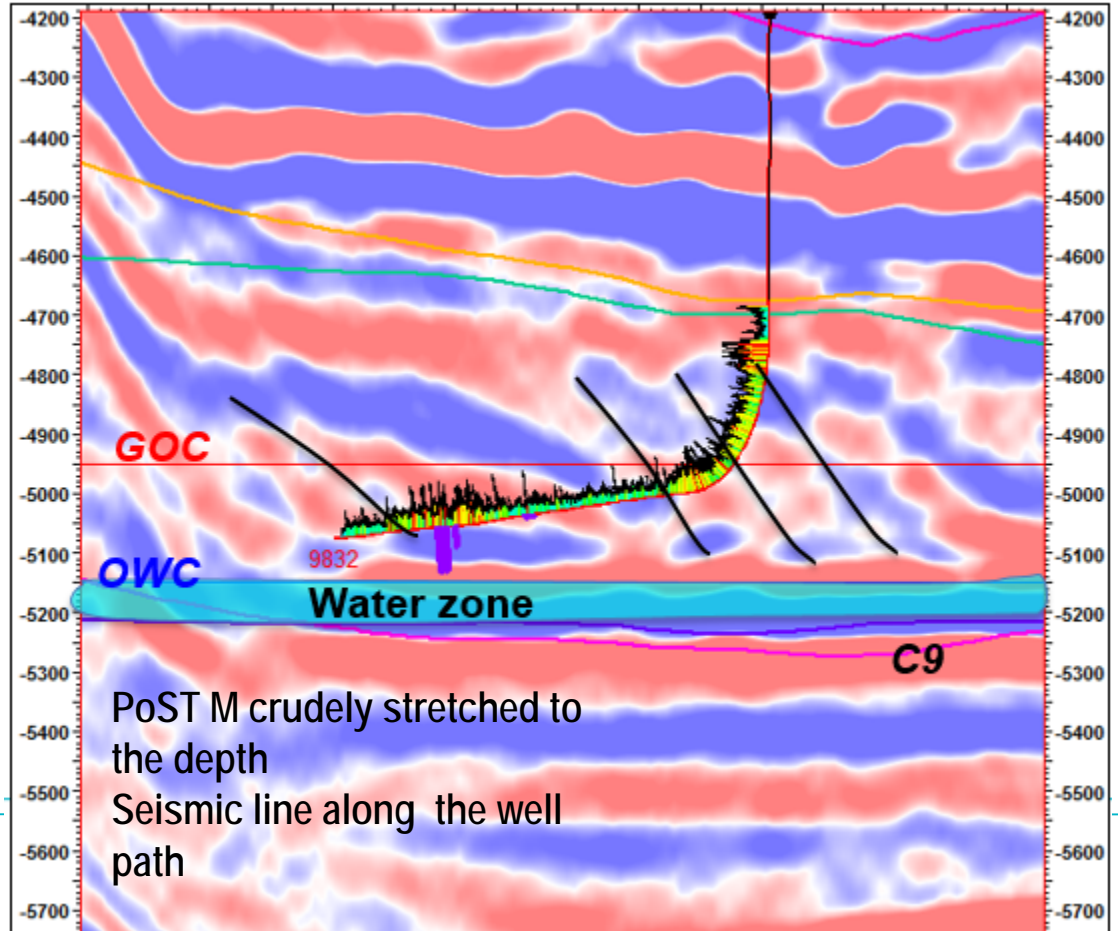
8



# WHY REFINE IN X/Y DIMENSION – WATER PRODUCTION

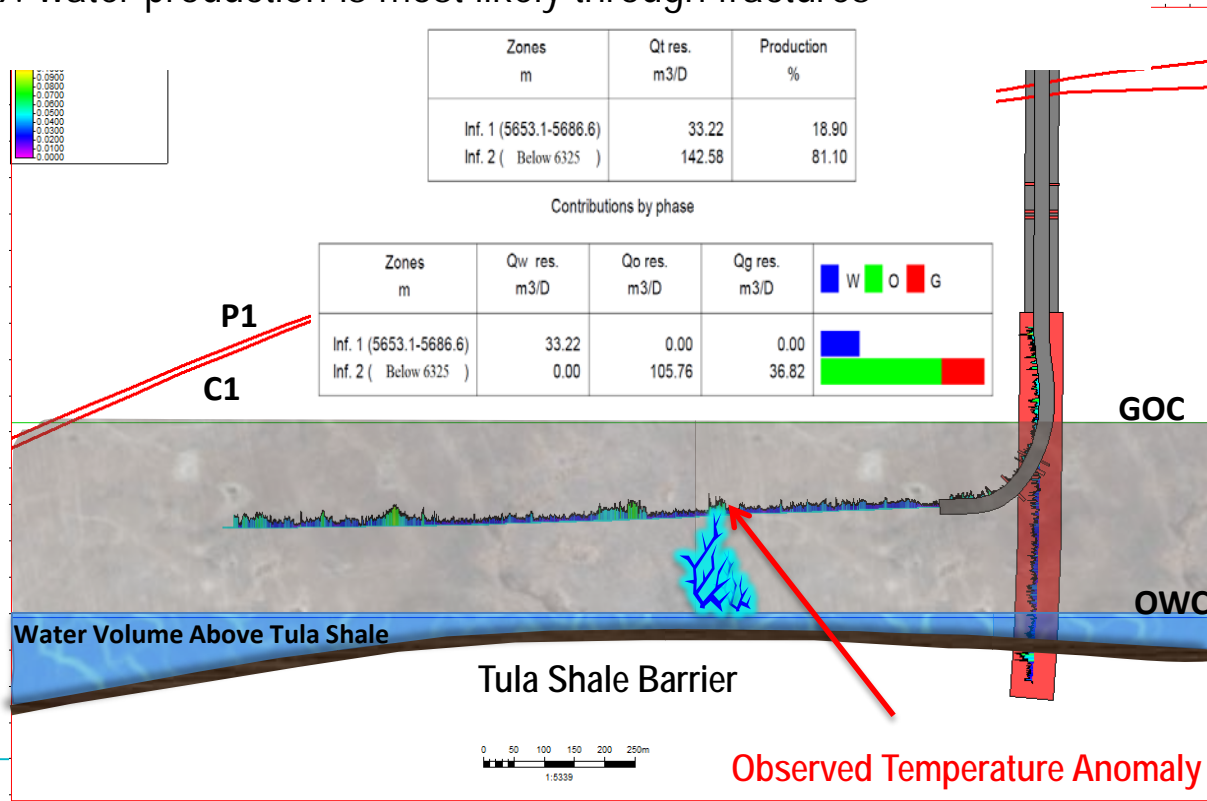
Well 2389 water production through high permeability zones:

- Most likely through high permeability fractures and vugs
- Less likely is coning through matrix (a bottom water drive)



# WHY REFINE IN X/Y DIMENSION – WATER PRODUCTION

- Well 9189: water production is most likely through fractures



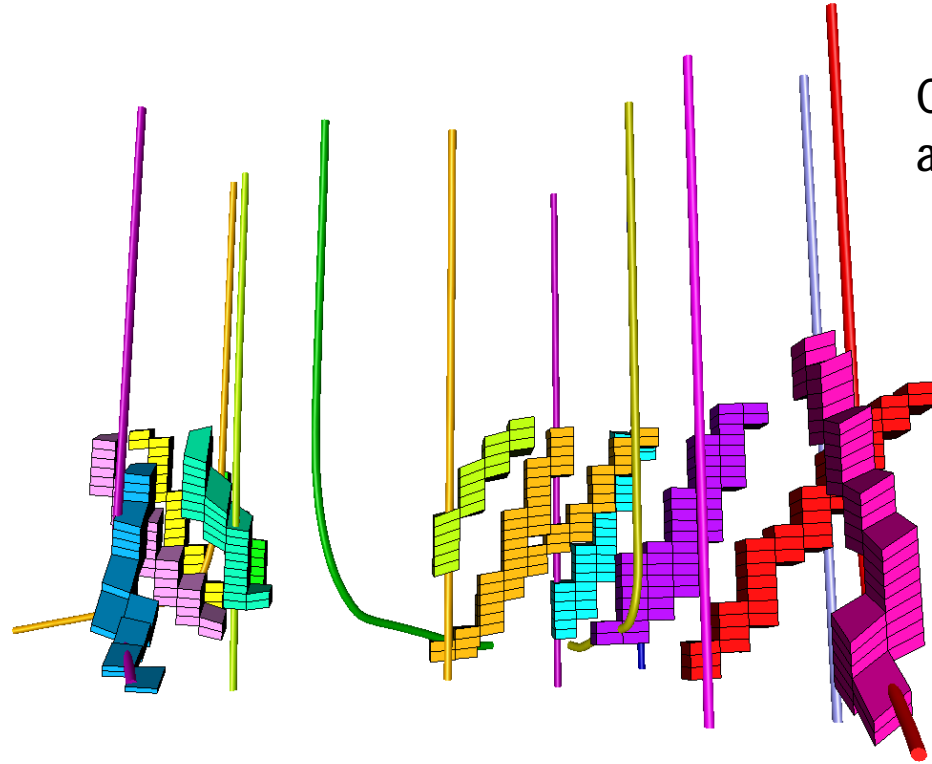
# IMPROVING WATER CUT MATCH FOR WELLS >5% WCUT AND GOR

The wells with certain threshold water cut were matched.

This was done in ECLIPSE using:

- 1) Inclined 'pipes' were used to represent some form of conduit from aquifer to well.
- 2) The same approach was used as done to improve the GOR match where the pipes were inclined to be parallel to clinofom orientation
- 3) Enhancement of permeability within the 'pipe' was done through adding a set constant value of permeability to every grid cell in the pipe (for continuity of the flow)
- 4) PI multipliers added to cells that connect to pipes to represent fractures and to improve match of PLT

# IMPROVING WATER CUT MATCH FOR WELLS >5% WCUT AND GOR

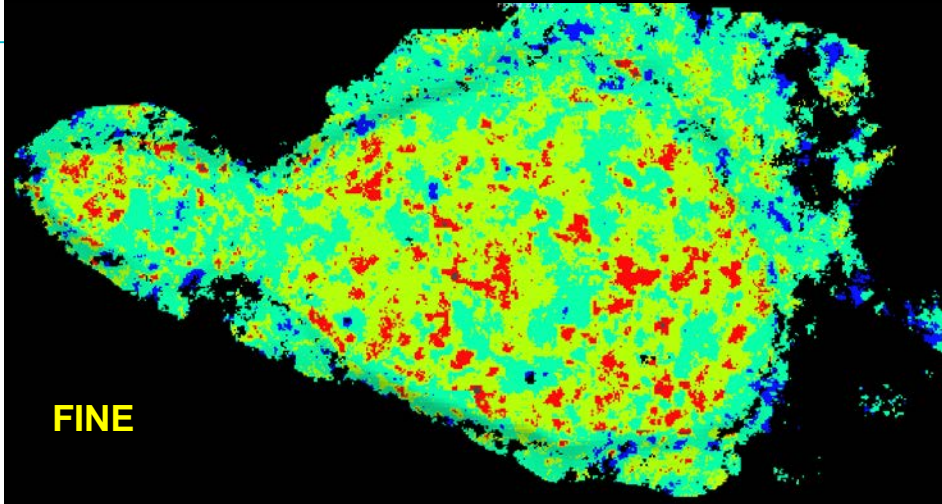
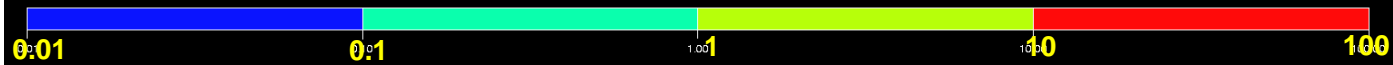


Cells representing fractures  
are 150x150m



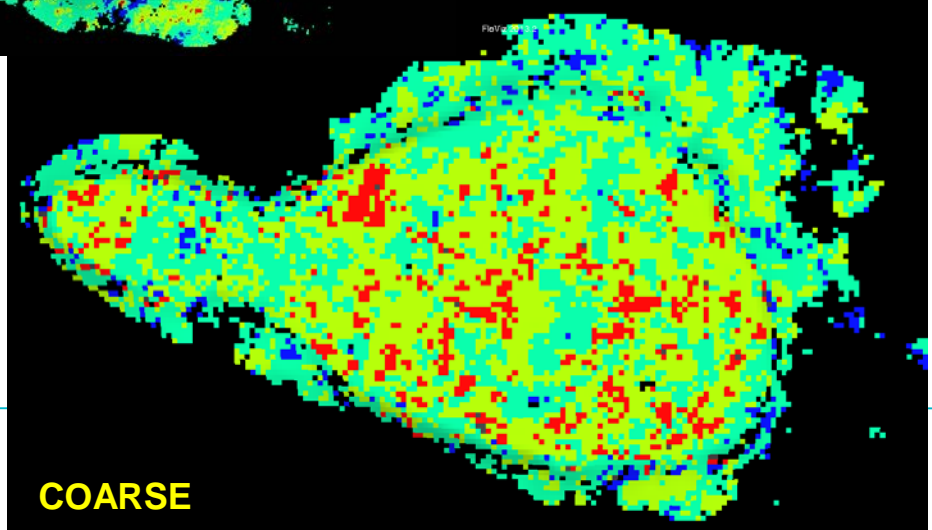
# MODEL BUILD METHODOLOGY

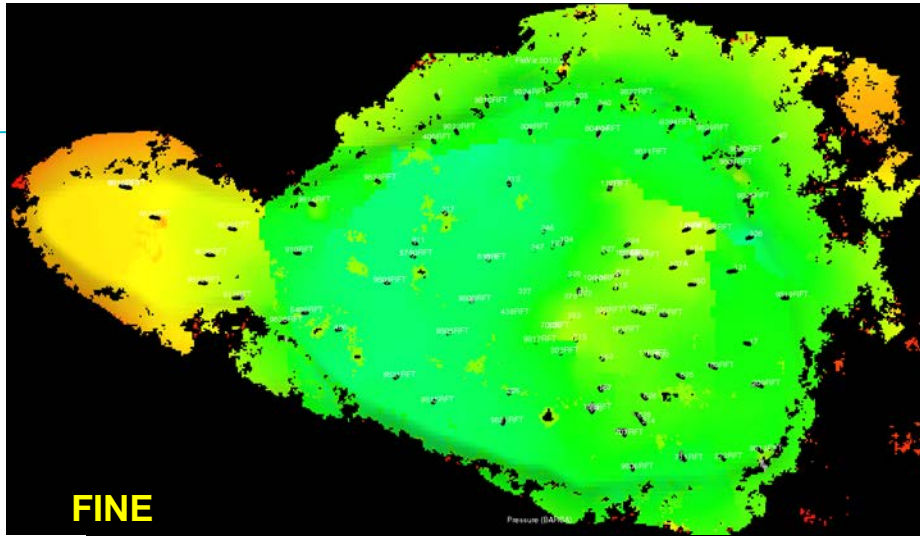
- Static model was refined from 150x150 to 50x50
- The Z direction dimensions remained the same
- Comparison of fluid in place
  - HM (official)
  - HM – 50x50m grid
  - Fluid in place is reproduced
- Permeability distribution replicates coarse scale model
- Active cells
  - Coarse Model = 315,000
  - Fine Model = 2,800,000 (~9x bigger)



Layer 25  
Horizontal Permeability

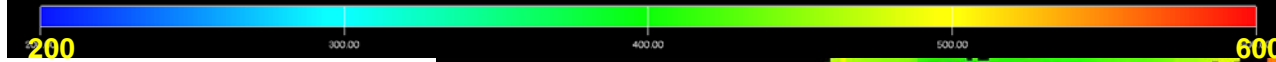
QC done on all input static and region properties  
Maps show very similar distribution of properties



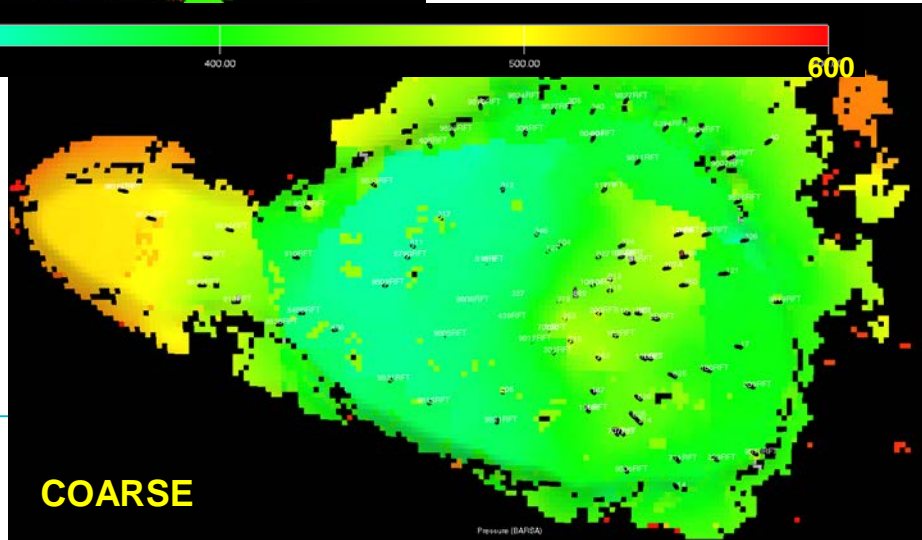


Layer 25  
Pressure distribution  
at end of history

**FINE**



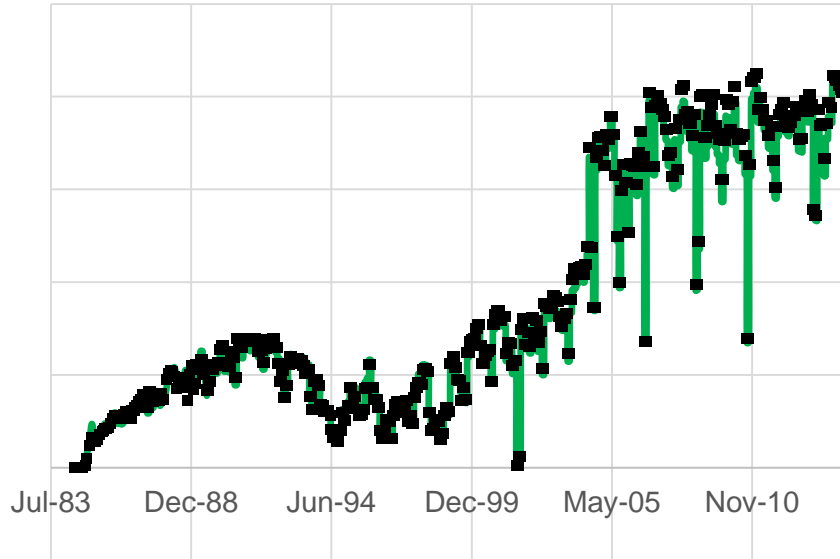
Models  
responding in  
similar manner



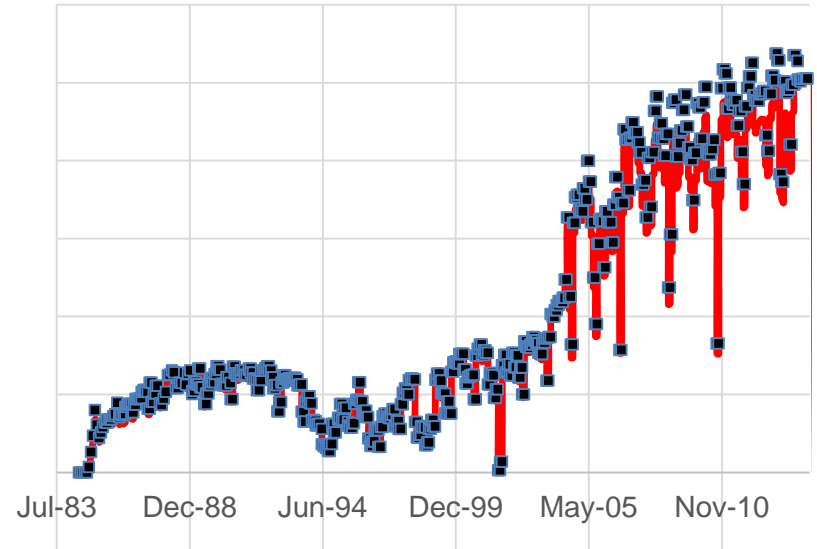
**COARSE**

# FINE GRID RESULTS HM

## Field Oil Production Rate

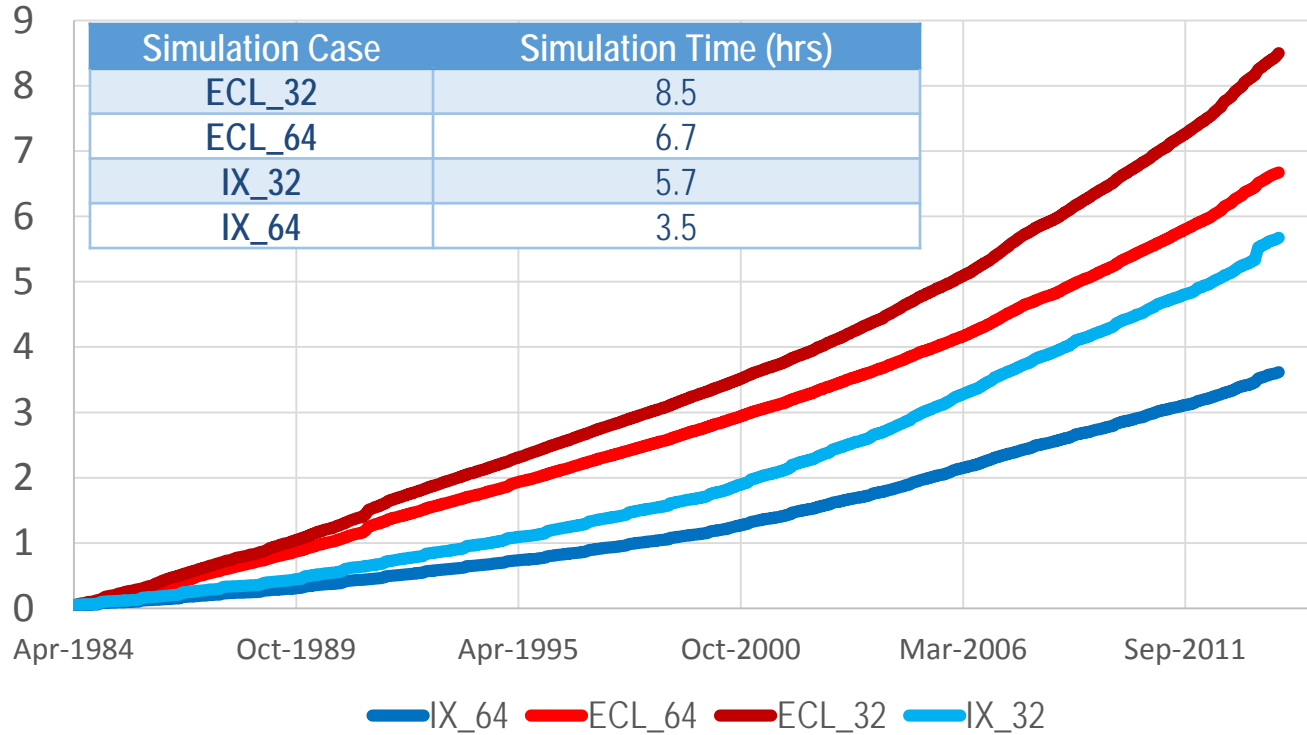


## Field Gas Production Rate



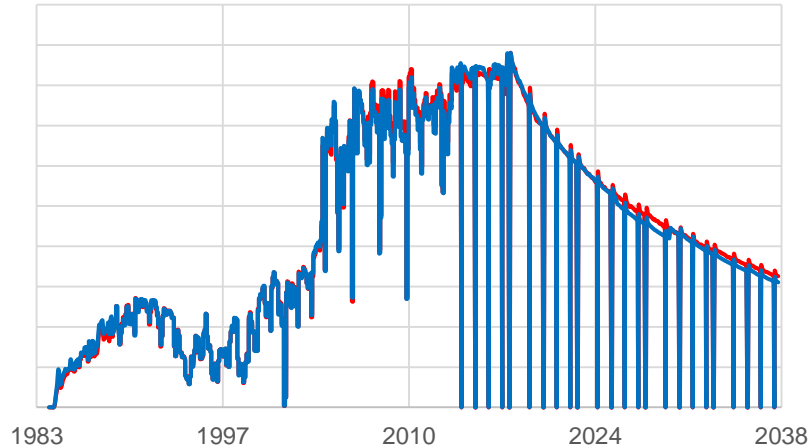


# SIMULATION TIME HM MODEL ECLIPSE – INTERSECT (IN HOURS) IN 32 & 64 WAY PARALLEL

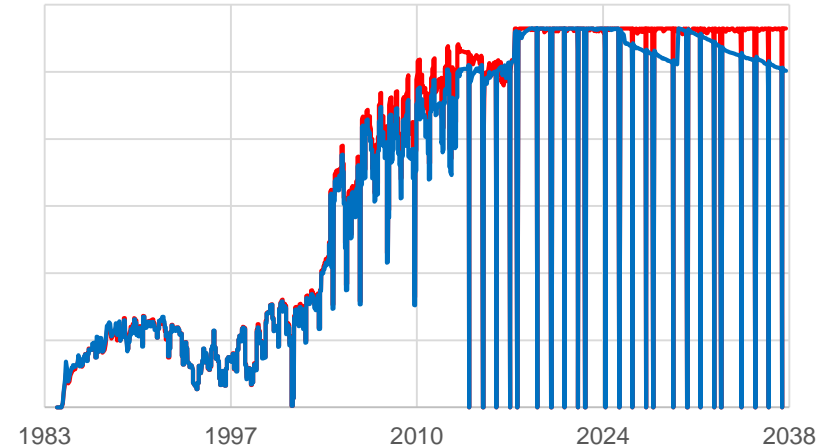


# COARSE & FINE GRID RESULTS HM + FORECAST

## FIELD OIL PRODUCTION RATE



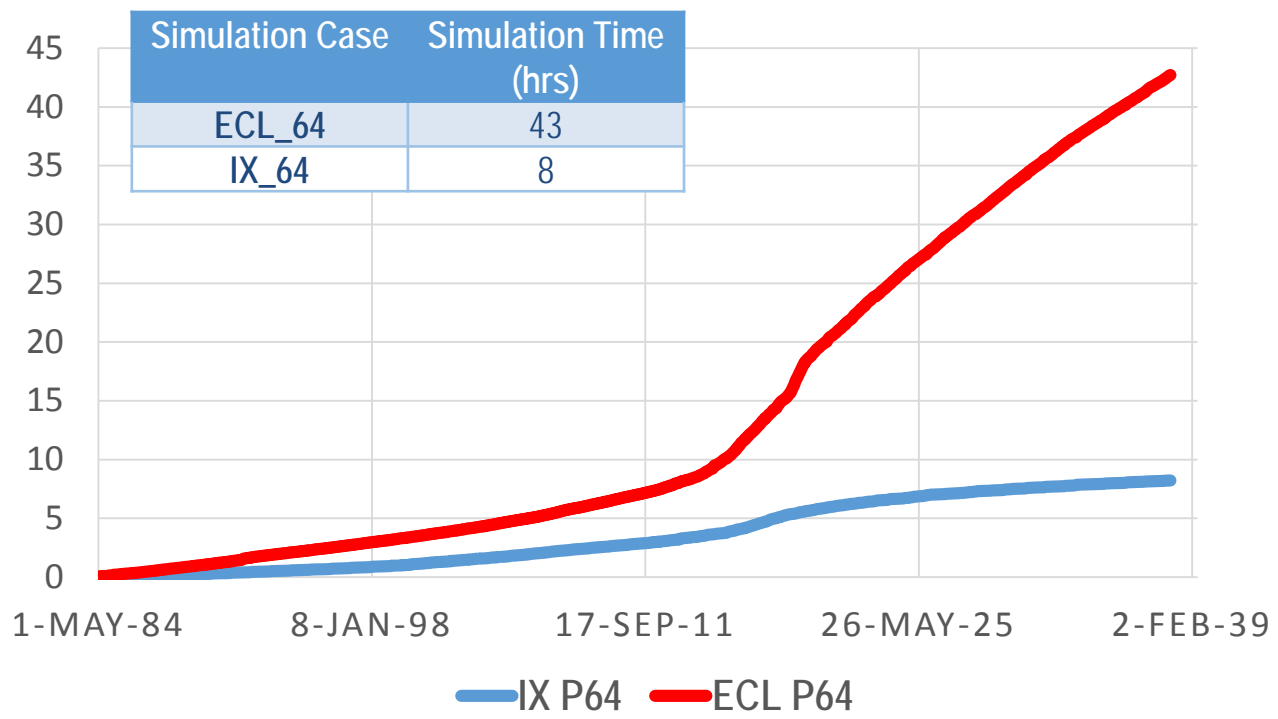
## FIELD GAS PRODUCTION RATE



— Fine model ECLIPSE

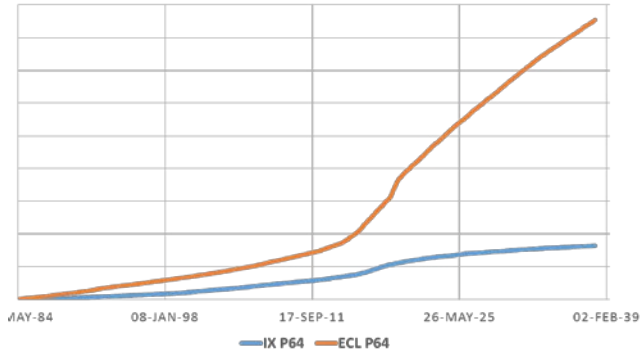
— Coarse model ECLIPSE

# SIMULATION TIME HM + FORECAST MODEL ECLIPSE – INTERSECT (IN HOURS) IN 64 WAY PARALLEL

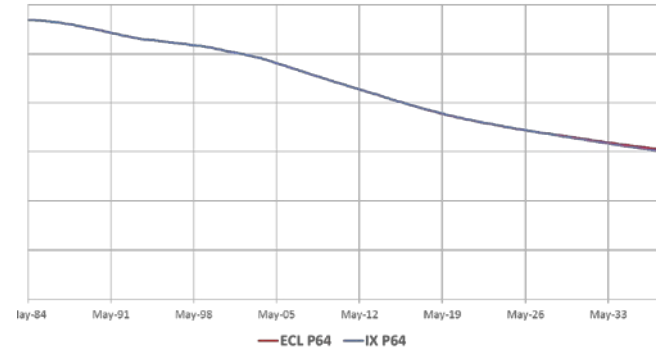


# ECLIPSE & INTERSECT FORECAST CASE COMPARISON

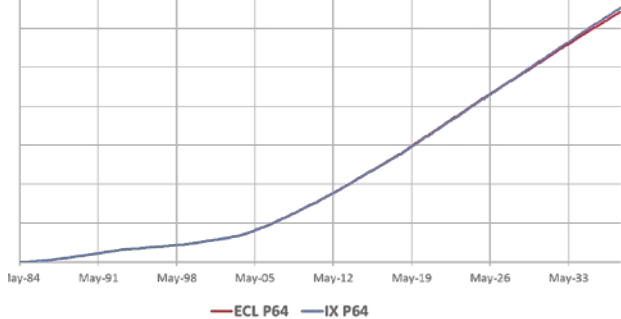
## Simulators Performance



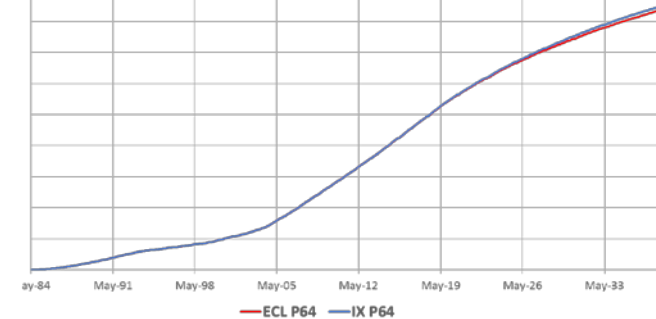
## Field Pressure



## Cumulative Field Gas Production



## Cumulative Field Oil Production



# CONCLUSION

- INTERSECT helps to:
  - Reduce numerical dispersion related grid cell size
  - Better capture complex reservoir heterogeneity
  - Reduce 'artificial' tweaks to model when history matching
  - Accurately model fluid behavior inside reservoir including miscibility
  - Capture NW effects
  - More accurately predict water & gas breakthrough
- KPO purchased INTERSECT recently
- INTERSECT enables to:
  - Run complex & high resolution models within acceptable timeframe
  - Seamless integration with Petrel
  - *Flexible field management tool*
  - *Integration with surface network simulators*

THANK YOU ! QUESTIONS ?