DELFI G&G deployment helps reduce modeling time for multiple reservoirs by 92-96%

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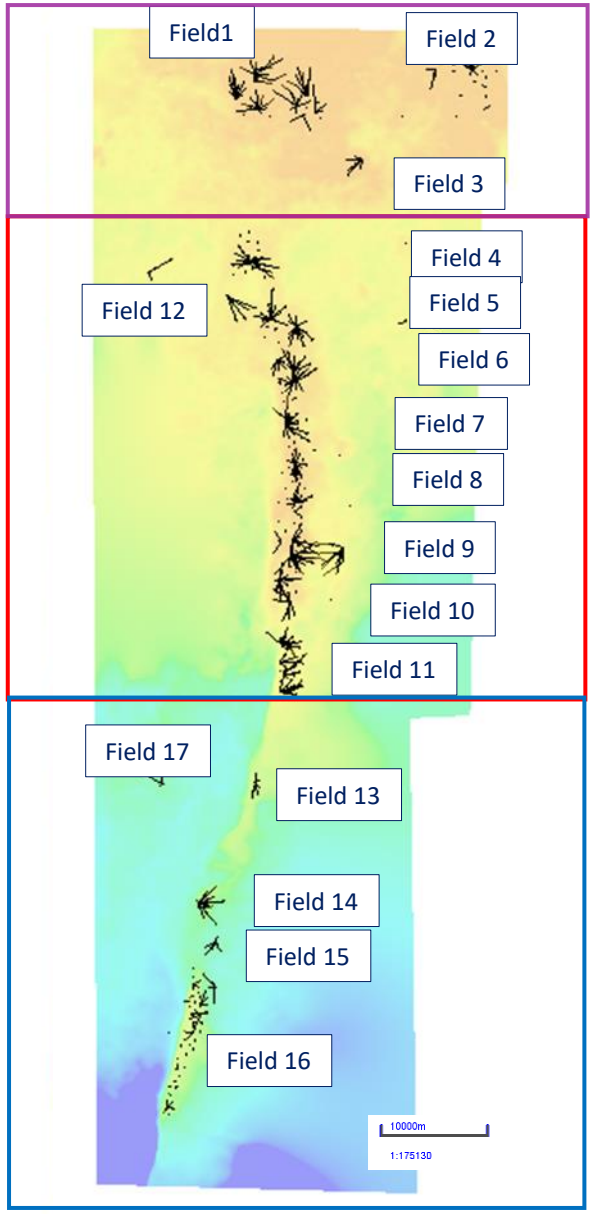
Agenda

- Asset background
- Geological Settings
- Main challenges
- Workflows implemented in DELFI
- Results
- Conclusions

Project Background



- ❑17 fields scattered over +100 Km (NS) ≈ 783 Km2
- ❑Seven reservoirs, 500 wells
- ❑Excellent quality reservoir properties: Phi=12-17%, K=200-700mD)
- ❑Gravity [API]= 33 -15
- ❑Viscosity [cp]= Res1, Res2: 2.5 – Res 3-Res 6: 9 & Res7: 18
- ❑Producer Mechanisms:

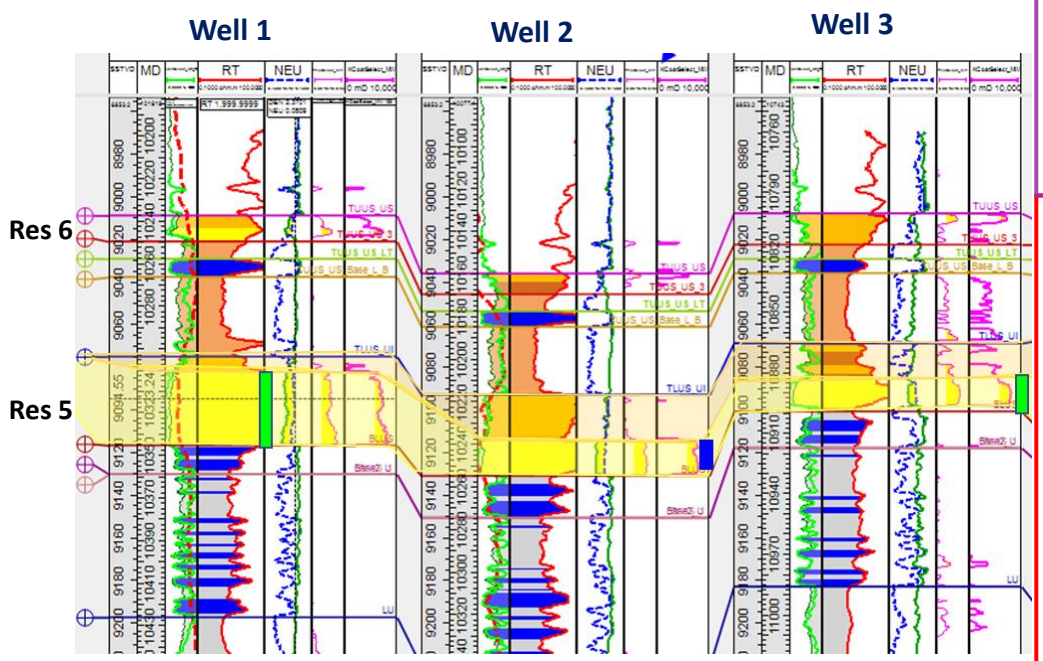
  Res1 active aquifer

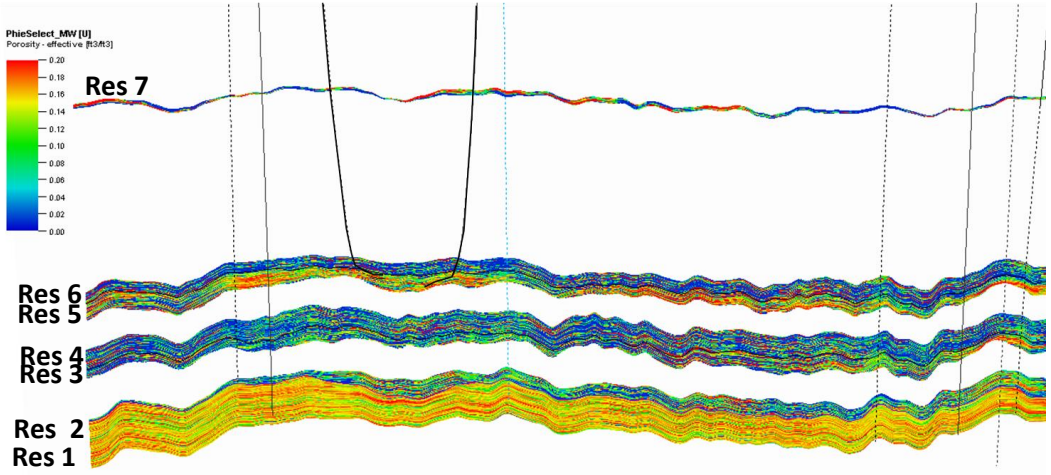
  Res 2-Res 7: rock- fluid expansion solution gas drive.
- ❑Reservoir management currently migrated from primary to secondary recovery.

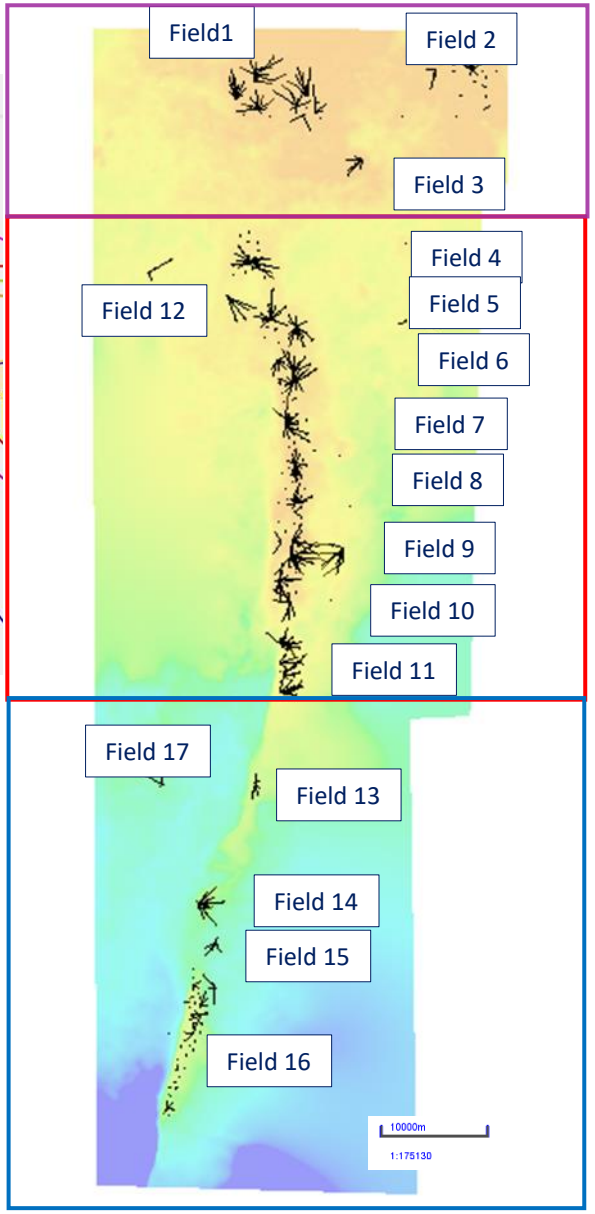
Main Challenges

- 17 Fields: 3 North Area, 9 Central Area & 5 South Area
- Complex Reservoirs
  - Drastic thickness changes
  - Relatively heterogeneous with lateral facies variations, Lateral and vertical heterogeneity
  - Multilayered w/7 clastic sequences (Res 1, Res 2, Res 3, Res 4, Res 5, Res 6 & Res 7)
  - Highly depleted reservoirs with limited active aquifer (except Res 1)

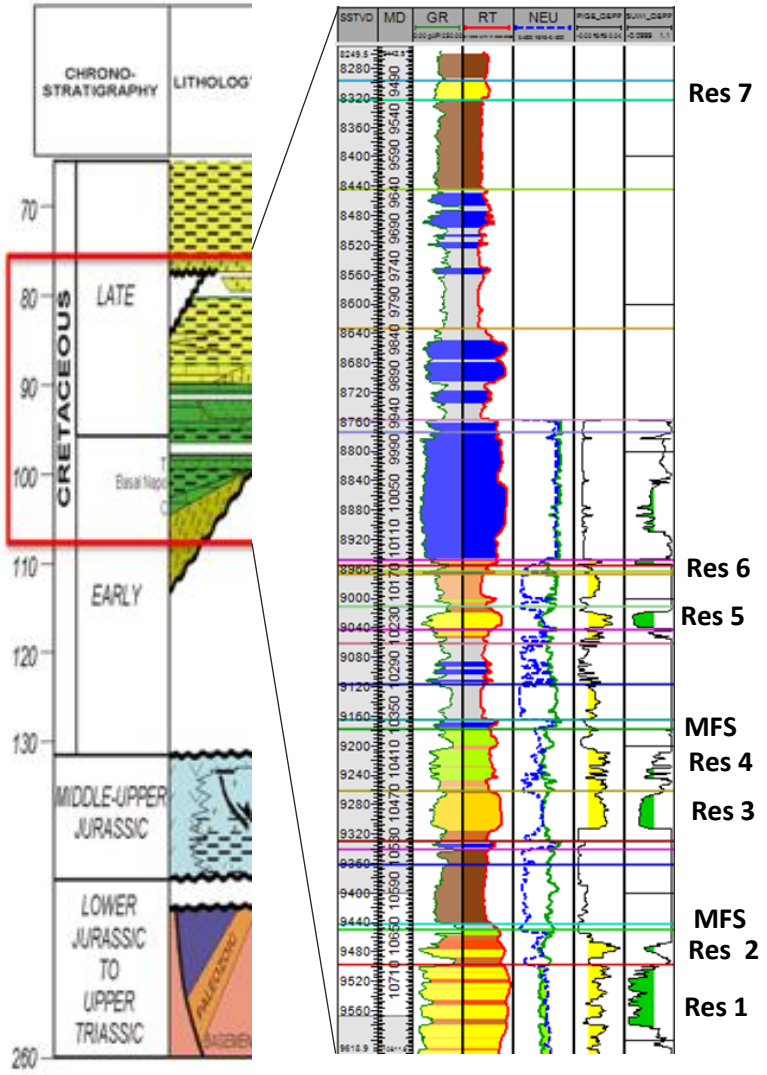
A better assessment of the waterflooding strategy has been obtained, guiding the full-field implementation by integrating adequate Hydraulic Units (HU) identification, heterogeneity modeling, uncertainty management, and lessons learned from an existing pilot.



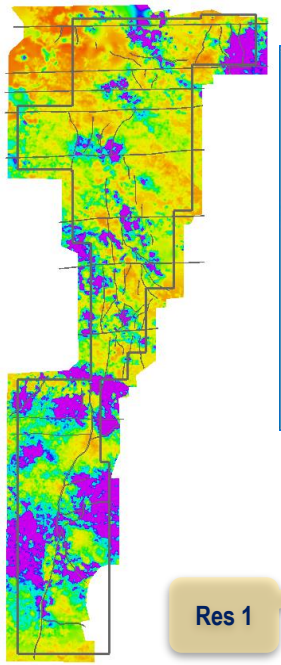




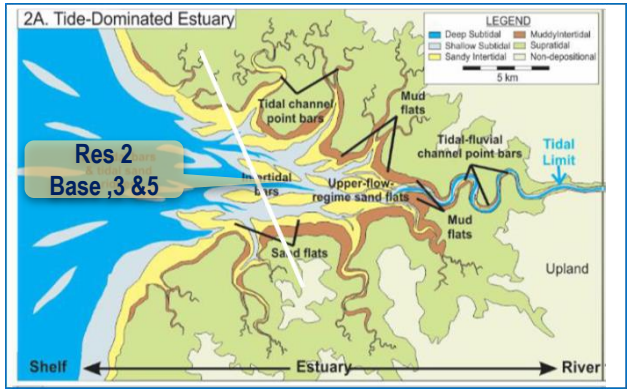
Geological Setting and Sedimentological Environments



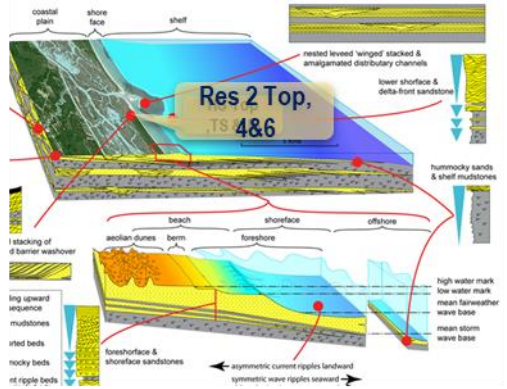
Res 5 Seismic Attribute AI



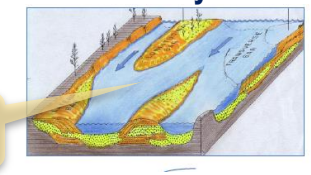
Tide Dominated Estuary



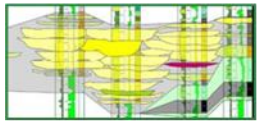
Shorefaces

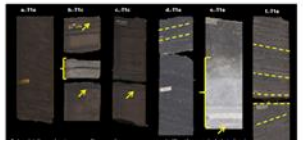


Fluvial System



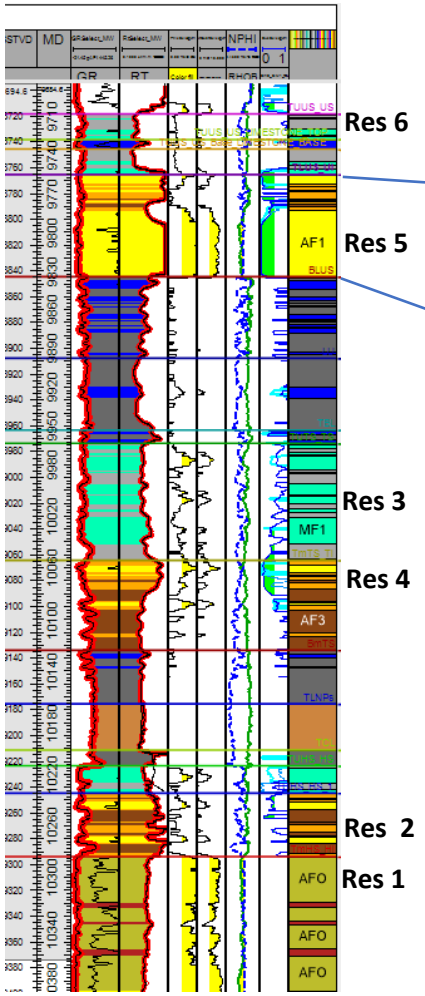
Res 1





- 7 Clastic Reservoirs: Res 1, Res 2, Res 3, Res 4, Res 5, Res 6 & Res 7
- Source Rock: The interbedded Napo shales are rich in organic matter type II and III,
- Seal: Interbedded cretaceous marine shales
- Res 1: Fluvial Environment channels/bar with distal positions to the tops, tidal influences
- Res 2 Base: Estuarine tidal dominated. Top: Lower Shorefaces, marine System
- Res 3 & Res 5 are interpreted as tide dominated estuary that grade to marine deposits Res 4 & Res 6.
- Res 7 It is the result of a rapid progradation (tidal deltaic facies).

Log Type and facies



AF1: Tidal Channels/Bars

AF2: Overbank channels

AF3: Tidal Plain

MF1: Sandstones Lower Shorefaces

MF2: Shale Lower Shorefaces

M5: Limestone

M6: Mudstone

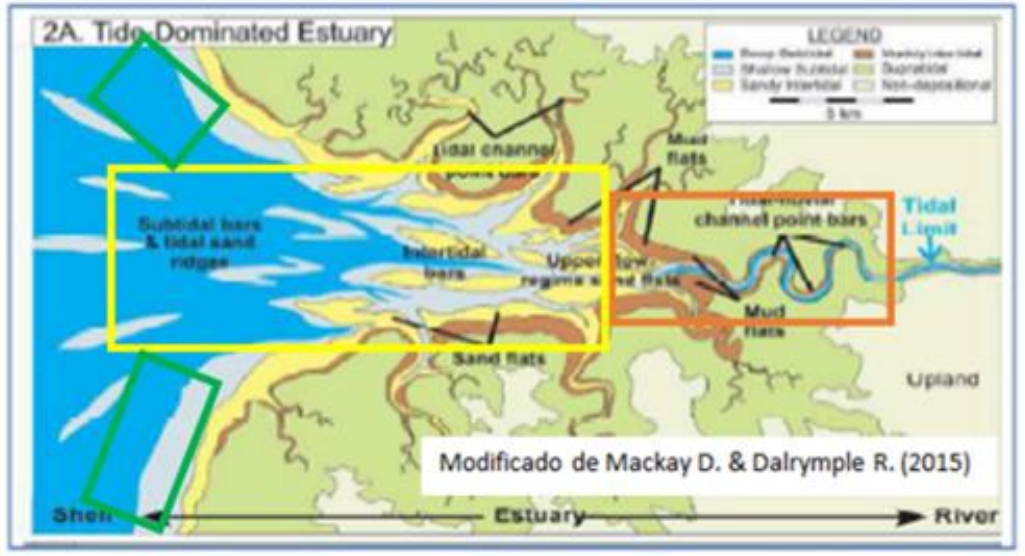
AFO: Fluvial channels

Estuarine Tidal Dominated

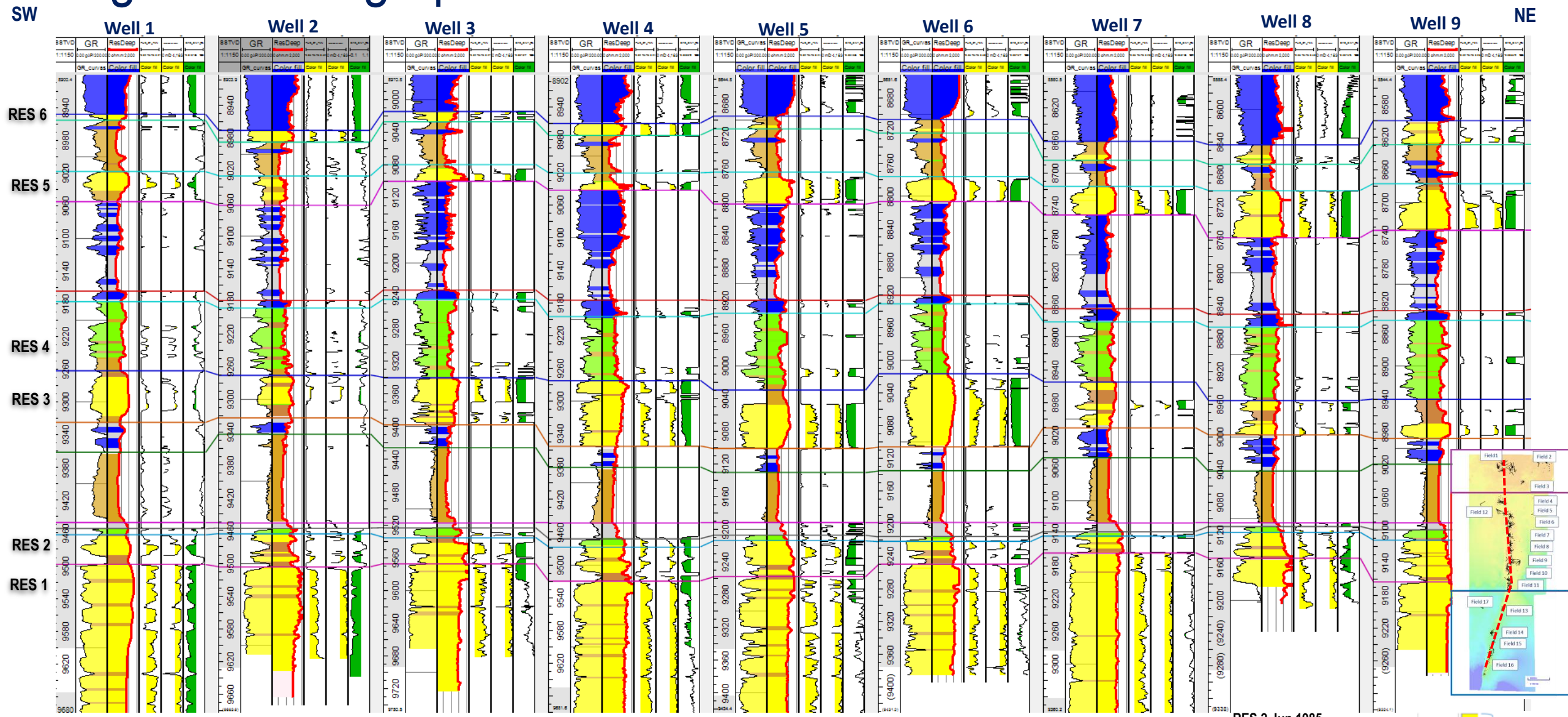
Marine Deposits

Platform Deposits

fluvial



Regional Stratigraphic Wells Section



- RES 1
- Oct 1983

NP= 11 Million STB
WP= 7.2 Million STB
Gp= 150 MMCF @ Jun 2016

- RES 1 & 2

NP= 2.5 MMSTB
RES 6 May 2016
NP=482MSTB @Agust2020

- RES 2 Sep 1996

NP= 790 MSTB
RES 3 Ene 2017
NP=270 MSTB @Jun 2020

RES2 feb 2012
NP= 749MSTB
RES 3 Jul 2013
NP= 855 MSTB @Mar 2022

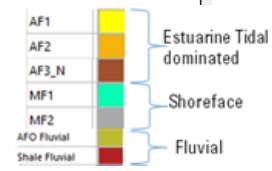
RES 2 May 1976
NP= 5.7 MMSTB
RES 3 Sep 2000
NP= 1.1 MMSTB @Sep 2005

RES 1 Ago 2011
NP= 129 MSTB
RES 3 & RES 5 Sep 1976
NP= 12.5 MMSTB @Dic 2010

- RES 5

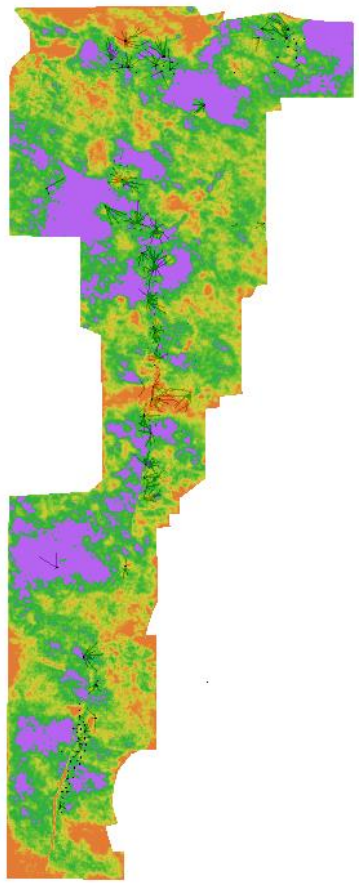
NP= 6.1 MMSTB
RES 3 Mar 1981
NP= 17 MSTB @ Jul 1982

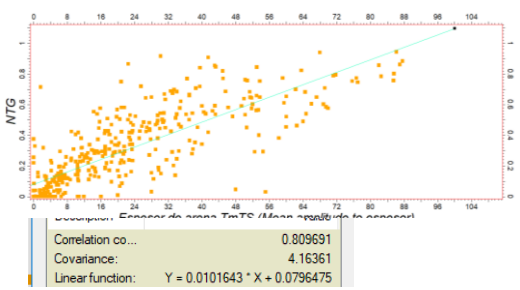
RES 2 Jun 1985
NP= 680 MSTB
RES 5 Nov 1990
Np= 4.3 MMSTB Sep 2011
RES 3 Nov 2011
NP= 14 MSTB @Dic 2015



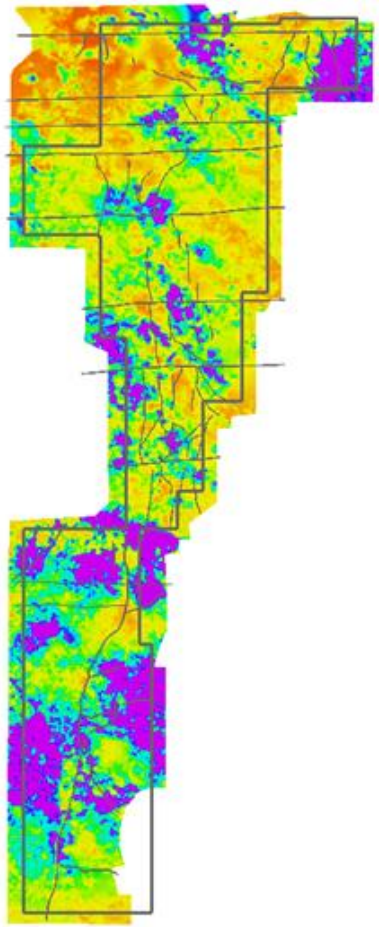
Seismic atributes correlation Well to Seismic

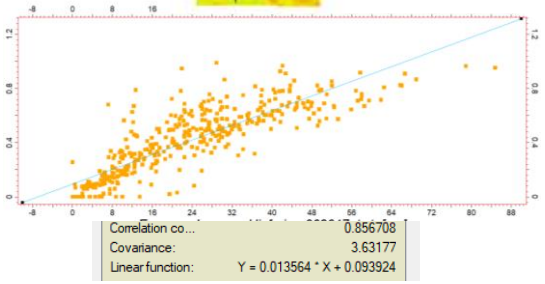
RES 3

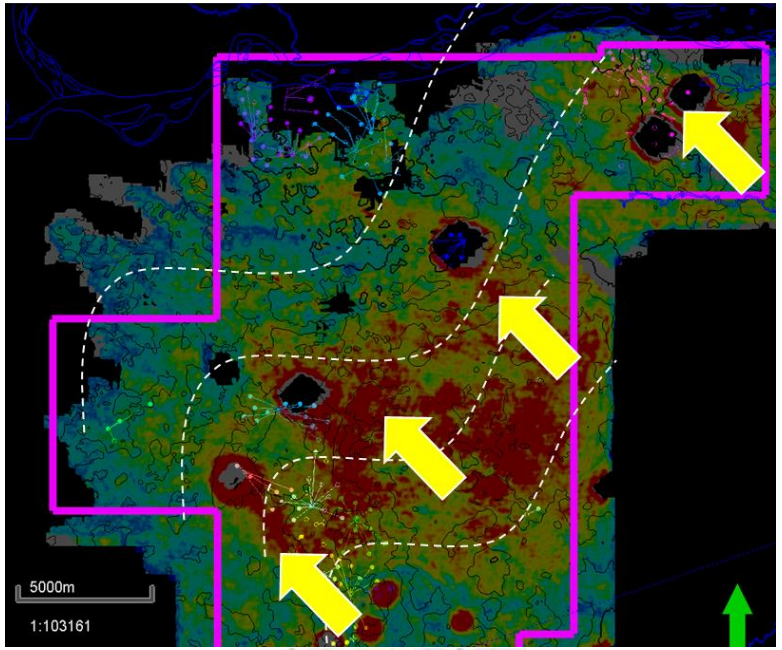


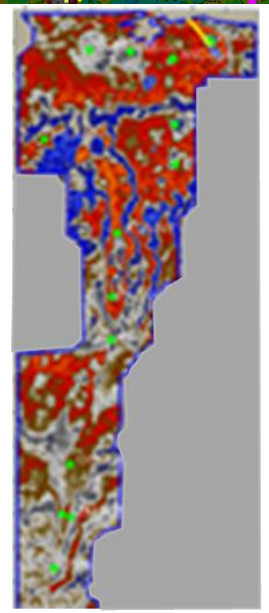


RES 5



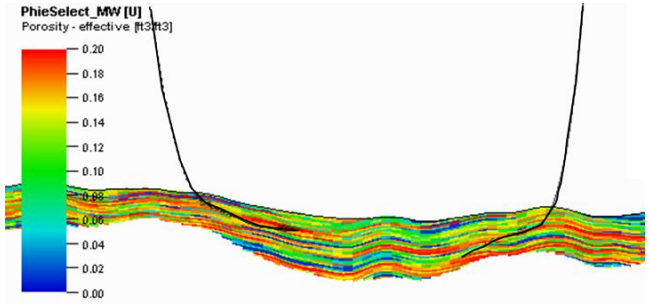


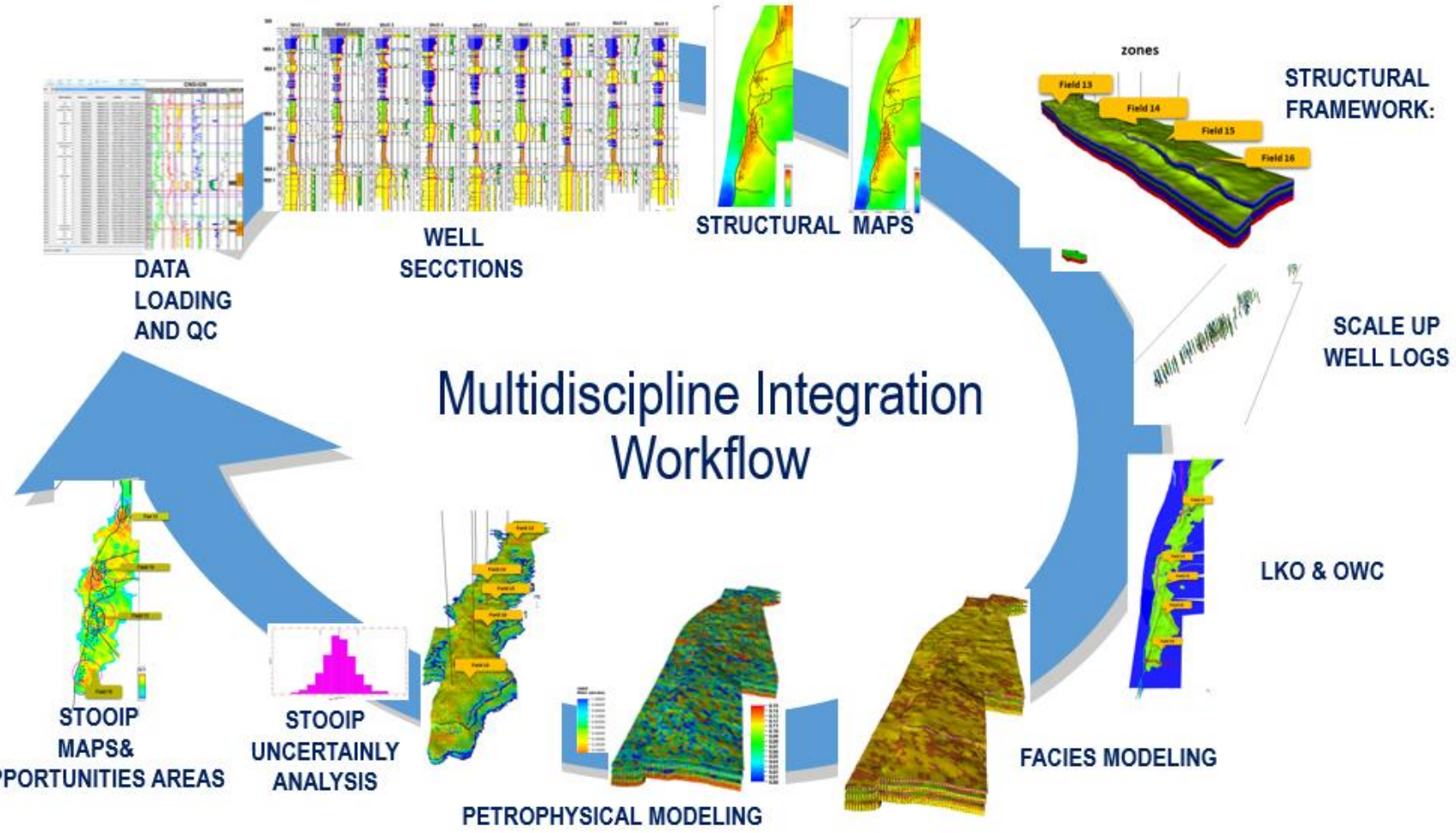




Geological Modeling Workflow

- For run this workflow for Regionals Static Models (Several fields Integrated) is necessary to have **powerful** computation **processing capacity** as is only available in the virtual Machine in DELFI

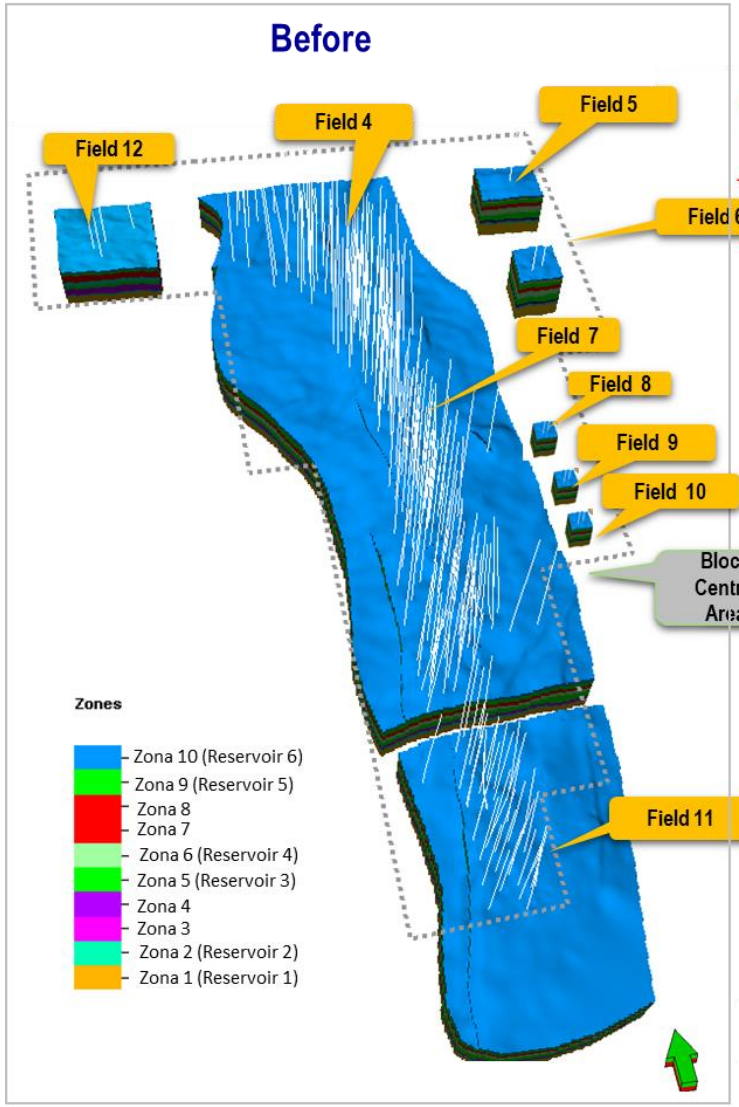


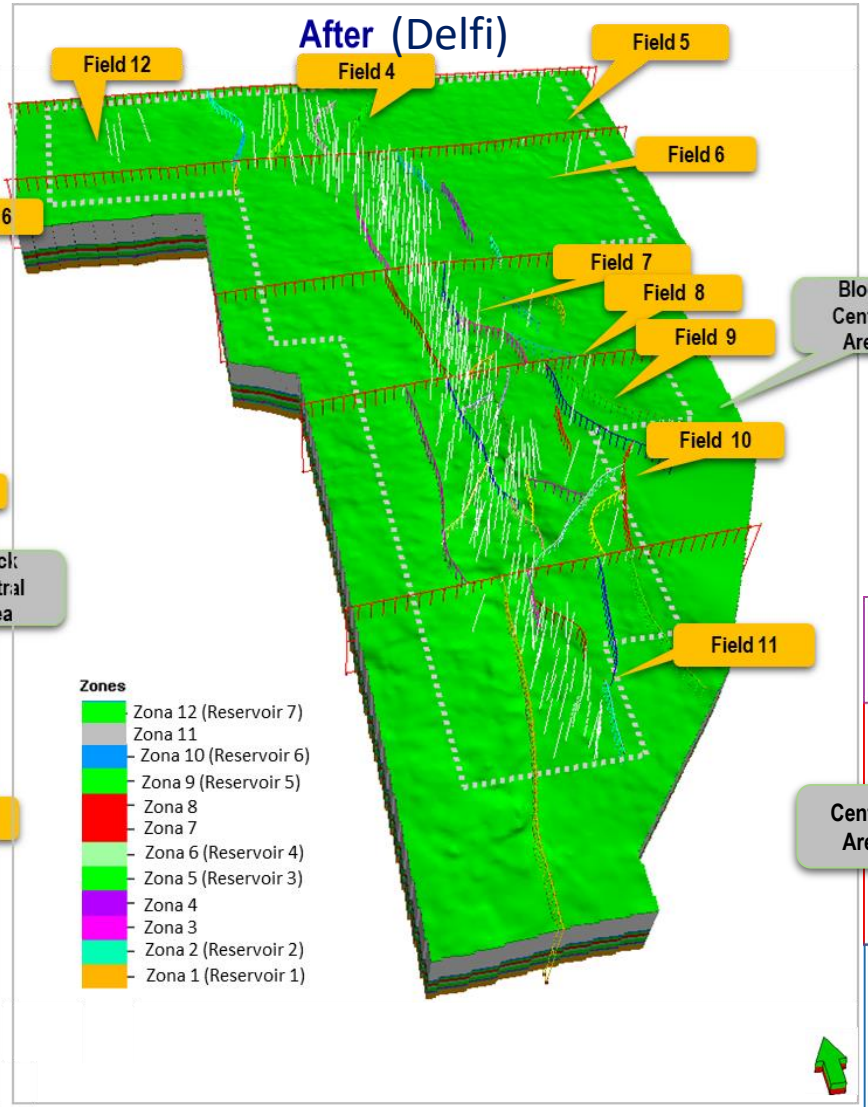


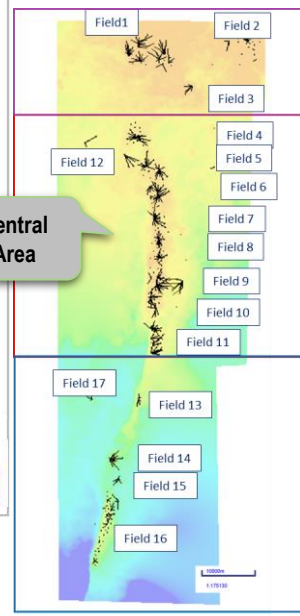
Comparison Sector Models Vs Integrated Regionals Models

- Before For Central Area: 8 Statics Model with 9 fields and only 6 reservoirs, 269 wells, Cells size: 100 x 100 m, 3 ft average cell height, Total Cells =12.2 million

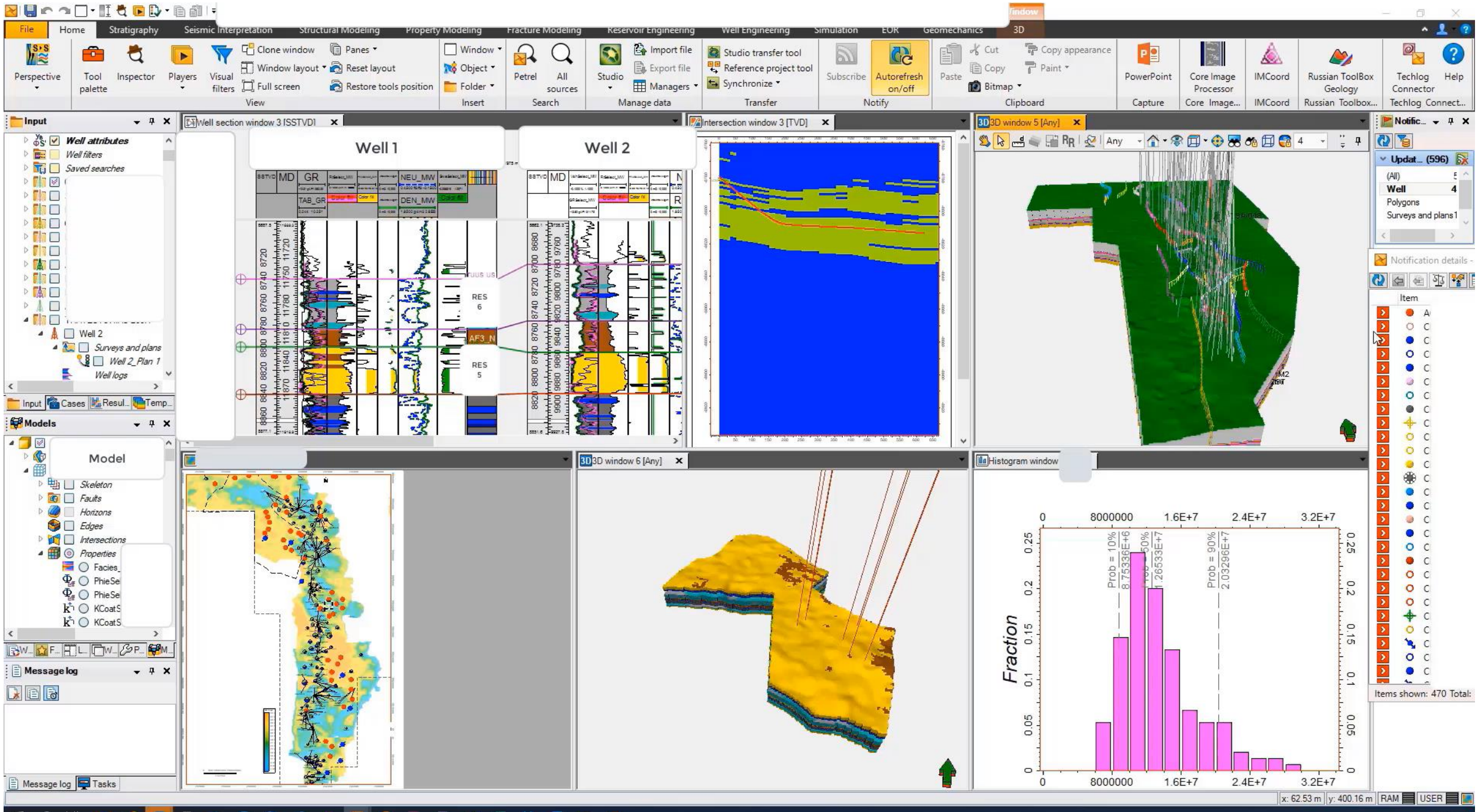
- Currently for the Central Area there is only one Regional Static Model that includes the 9 integrated fields with their 7 Reservoirs, 286 wells, Cells size 50 x 50m, 1.5 ft average cell height Total Cells =54 million.







Video


File
Home
Stratigraphy
Seismic Interpretation
Structural Modeling
Property Modeling
Fracture Modeling
Reservoir Engineering
Well Engineering
Simulation
EOR
Geomechanics
3D
Perspective
Tool palette
Inspector
Players
Visual filters
Clone window
Window layout
Full screen
Panes
Reset layout
Restore tools position
View
Window
Object
Folder
Insert
Petrel
All sources
Search
Studio
Import file
Export file
Managers
Manage data
Studio transfer tool
Reference project tool
Synchronize
Transfer
Subscribe
Autorefresh on/off
Notify
Paste
Cut
Copy
Bitmap
Copy appearance
Paint
Clipboard
PowerPoint
Capture
Core Image Processor
Core Image...
IMCoord
IMCoord
Russian ToolBox Geology
Russian Toolbox...
Techlog Connector
Techlog Connect...
Help
Input
Well attributes
Well filters
Saved searches
Well 2
Surveys and plans
Well 2_Plan 1
Well logs
Input
Cases
Resul...
Temp...
Models
Model
Skeleton
Faults
Horizons
Edges
Intersections
Properties
Facies_
PhieSe
PhieSe
KCoatS
KCoatS
Message log
Message log
Tasks
Well section window 3 [SSTVD]
Well 1
Well 2
MD
GR
TAB_GR
NEU_MW
DEN_MW
RES 6
AF3_N
RES 5
Intersection window 3 [TVD]
3D window 5 [Any]
Any
Notific...
Updat... (596)
(All)
Well 4
Polygons
Surveys and plans1
Notification details -
Item
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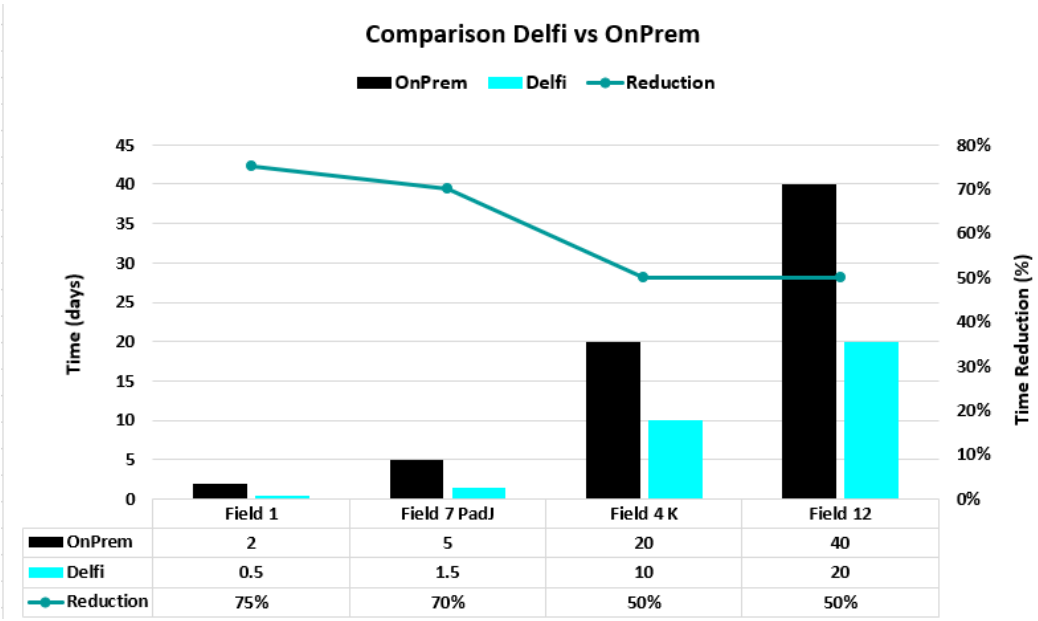
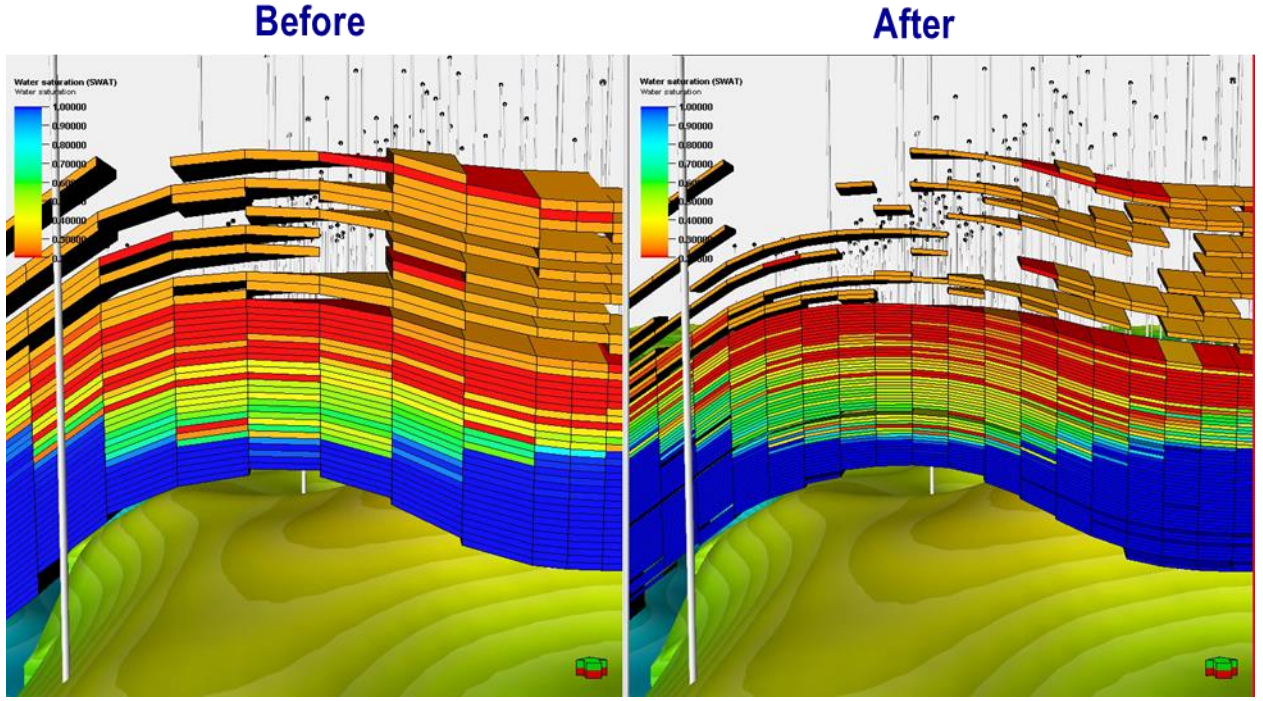
3D window 6 [Any]
Histogram window
Fraction
Prob = 10%
8.75336E+6
Prob = 90%
2.03296E+7
1.26533E+7
0
8000000
1.6E+7
2.4E+7
3.2E+7
x: 62.53 m
y: 400.16 m
RAM
USER
2:40 PM

Reservoir Model



	Field 1	Field 7 PadJ	Field 4 K	Field 12
OnPrem	2	5	20	40
Delfi	0.5	1.5	10	20
Reduction	75%	70%	50%	50%

- The time that took to finish a specific sensitivity analysis (evaluation of well performance) with 100 runs on average.
- The use of DELFI had significantly decreased the time **(50 – 75%)** for this analysis allowing more time to evaluate additional scenarios.



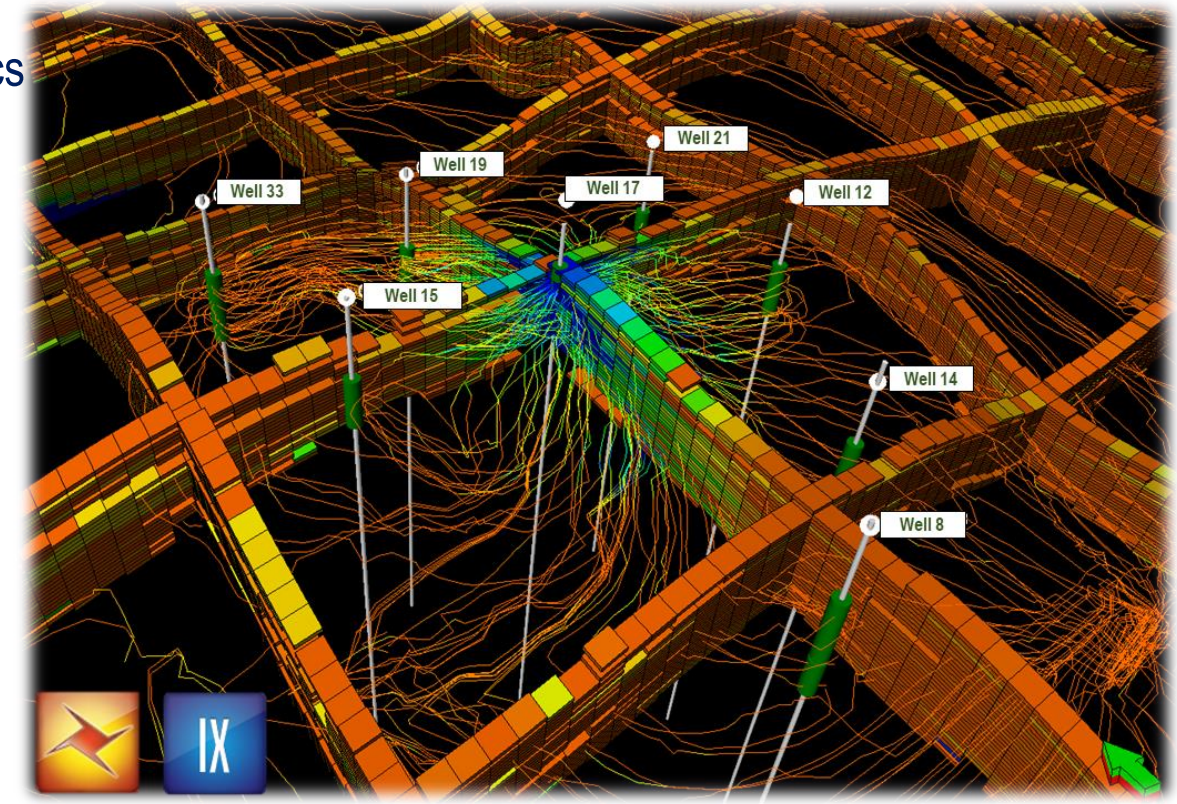
Dynamic Model Before and after

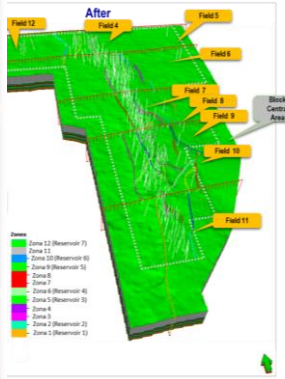
Before: A coarse grid reservoir model that was used on a sector-based simulation to be able to run and produce a forecast for field development.

After high resolution required for waterflooding optimization capturing the correct interaction between fields for optimum analysis in field development planning.

Regional Reservoir Model can be done only in DELFI

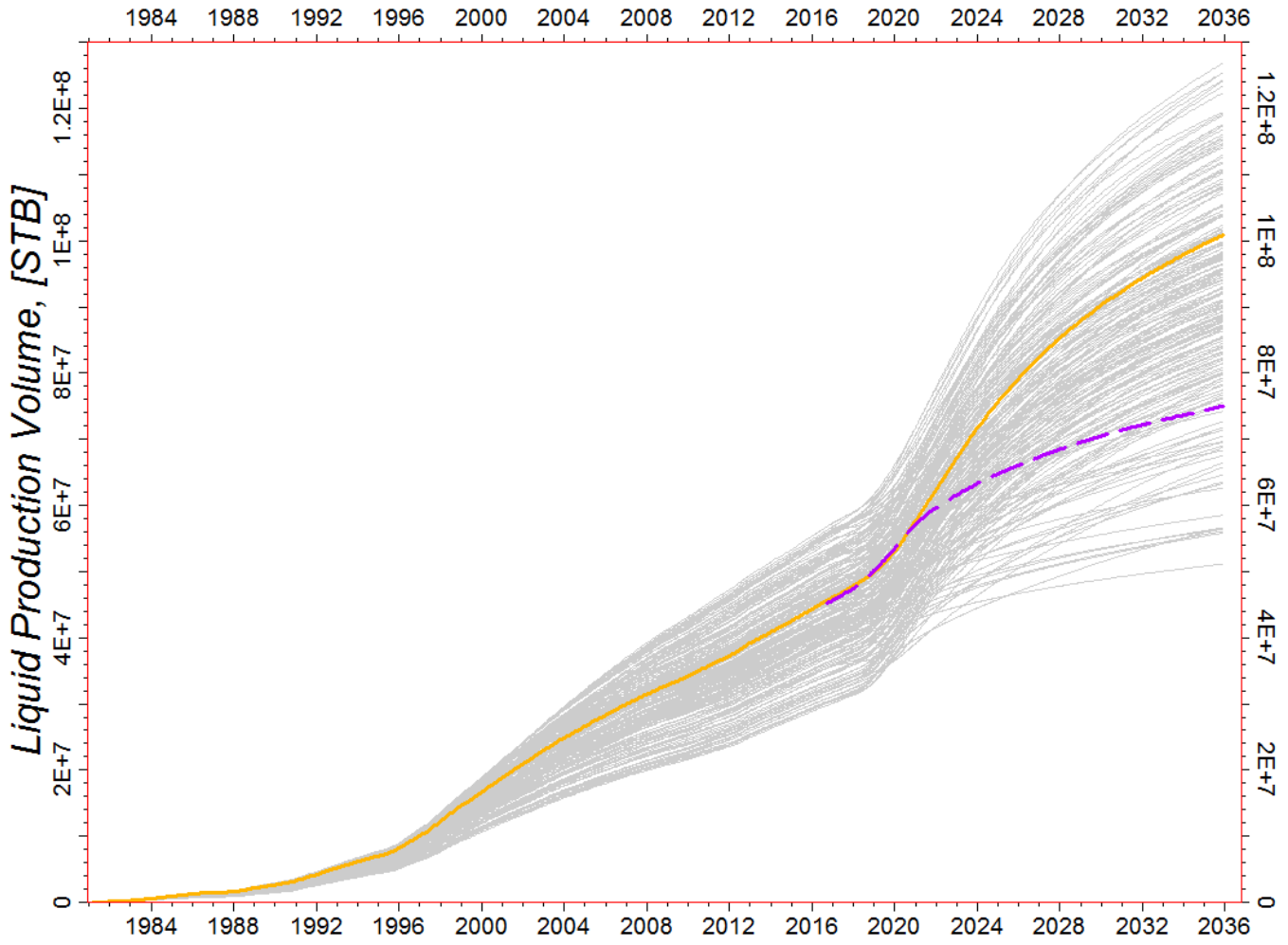
- ✓ High-resolution reservoir model with detailed Physics
- ✓ Capture complex geology
- ✓ Robust model definition
- ✓ Model construction automation
- ✓ Significantly reduce calibration process
- ✓ Faster new wells update
- ✓ Assess commingled opportunities
- ✓ Waterflooding strategy Optimization
- ✓ Faster decision making



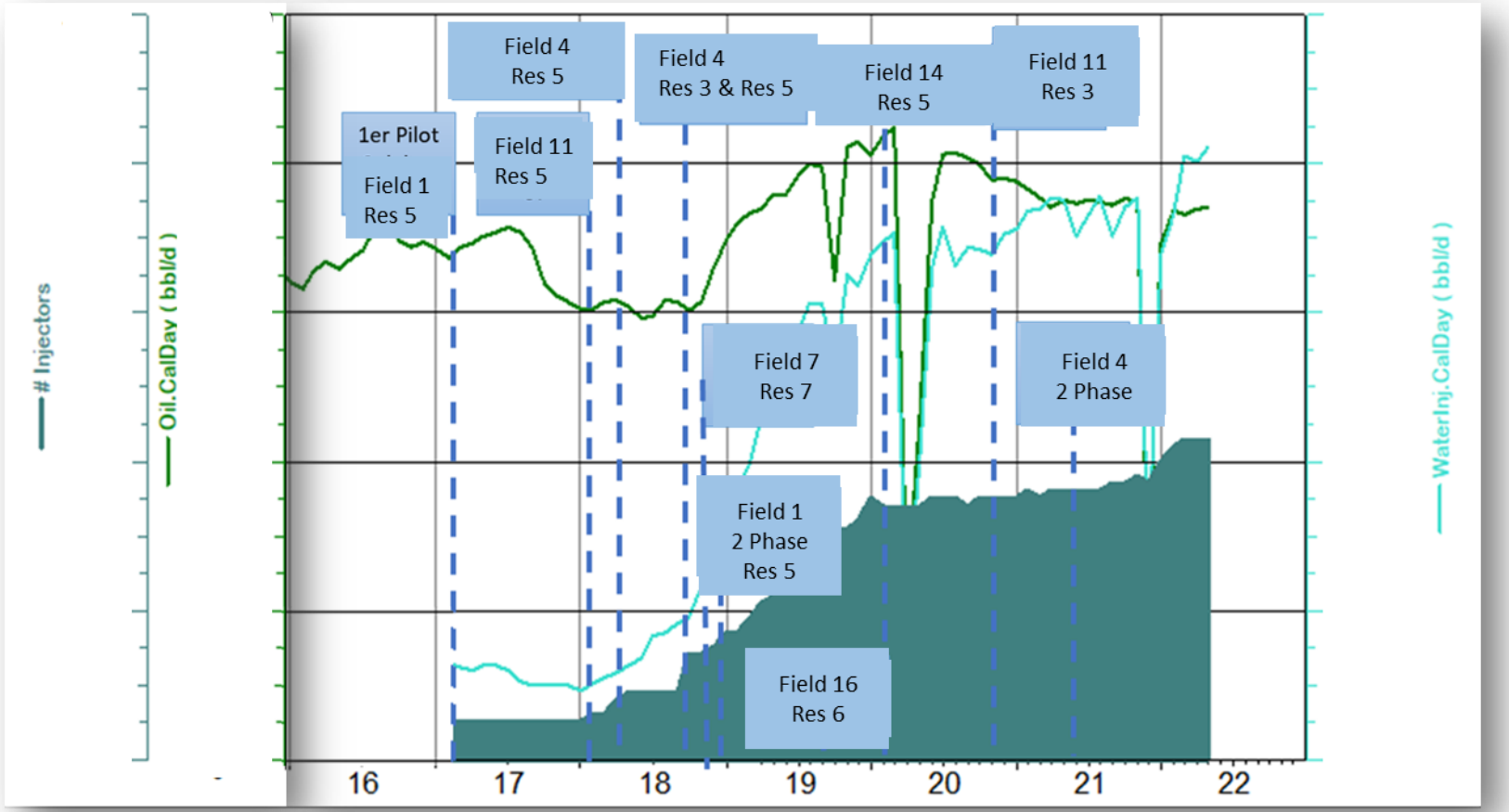


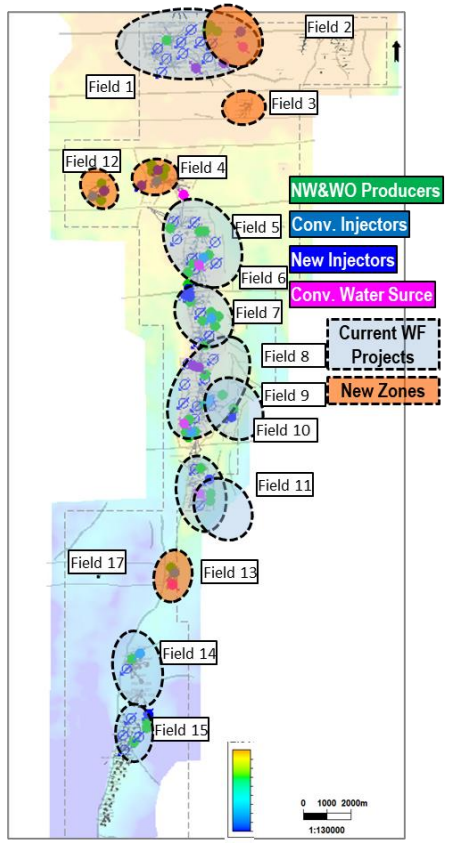
Managing Field Uncertainty : Probabilistic results

- Orange line is the base Case HM and FDP WF case
- Purple case is the primary scenario (New and existing wells, without water injection)
- Run >200 cases with not limitations in time and computing power due to the cluster available in **DELFI**



Production profile





- Waterflooding has been certainly the biggest success in the block
- Currently higest historical Injection
- Total Incremental average production stable (last months) due to best practice in pattern balancing

Conclusions

DELFI has significantly advantages and benefits:

- ✓ G&G faster and parallelized computations:
  - ✓ Update 3D Regional Statics model (several fields): time is reduced from 1 day down to 2 hours
  - ✓ Run Original Oil in Place Uncertainty in those regional static models (Probabilistic result): time is reduced from 1 Week down to 6 hours.
  - ✓ Run Original Oil in Place Uncertainty in 1 Fields time is reduced from 2 Hours down to 6 minutes.
  - ✓ **DELFI G&G deployment helps reduce modeling time for multiple reservoirs by 92-96%**
- ✓ Powerful VM – no need workstations
  - ✓ Accessibility y portability
  - ✓ Centralized & QC' Data (Repository) & Sharing data through VM, is simpler compared to other traditional means (Mail, OneDrive, Disc…)
  - ✓ Regionals 3D Models with Several Fields & multireservoirs can be processing only in DELFI.
- ✓ No longer working in silos and removing manual work giving geoscientists more time to collaborate, to explore, and to improve subsurface characterization/representation.
- ✓ **DELFI Petrotechnical Suite and On Demand Reservoir Simulation drastically reduce modelling and simulation times by 50- 75%.**
- ✓ This solution allows better planning and support to operations and permit to have integrated strategy (combining horizontal, directionals wells and waterflooding) changed significantly the production trend in the area which then allowing for better field development plans and more **robust portfolio opportunities** for **production** and **reserves increase**.