Managing Geological and Simulation Models within Geometrically Complex Geological Settings Combined with a Thin Producible Oil Rim*

Adam Robinson[1], Pablo Chimienti[1], Jose Luis Corregidor[1], and John Baillie[1]

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[1]Addax Petroleum, Geneva, Switzerland.

Abstract

Addax Petroleum have operated interests in onshore Gabon, West Africa, where oil reserves are being exploited from thin oil rims within the range of 15-10m of vertical-net-oil-column thickness.

For each asset, static and dynamic modelling is undertaken to manage and monitor reservoir performance and optimize the field development strategy. In order to achieve reasonable history match and conform to the geological setting, careful model and grid design screening is reviewed.

The grid screening and review identified that, under certain conditions, the geometrical arrangement of the models' grid, as a result of the geology with respect to the oil-column thickness, was having an impact not only on the oil in-place calculation but also on the modelling of certain reservoir parameters, individual well performance, and history match. Screening undertaken assessed the most optimum, yet pragmatic grid design (and its associated workflow) to achieve expected and respectable results from the geological scale model through to the full field dynamic model.

This poster demonstrates the established grid design workflow that has been adopted to deliver manageable and pragmatic reservoir models for more than one thin oil rim within Addax Petroleum's onshore Gabon portfolio (e.g., Tsiengui field) and attempts to assess the merits of grid design to achieve such valid population of key reservoir properties.

References

Bradley, C. A., and M. N. Fernandez, 1991, Early Cretaceous paleogeography of Gabon/North-Eastern Brazil: A tectono-stratigraphic model based on propagating rifts: Geologie Africaine, Collge Gologique de Communications, Libreville, recueil des communications., 6-8 May 1991, p. 17-30.

Brink, A.H., 1974, Petroleum geology of Gabon Basin: AAPG Bulletin, v. 58, no. 2, p. 216-235.

Teisserenc, P., and J. Villemin, 1989, Sedimentary basin of Gabon, *in* Geology and Oil Systems: AAPG Memoir 48, p. 117-199.

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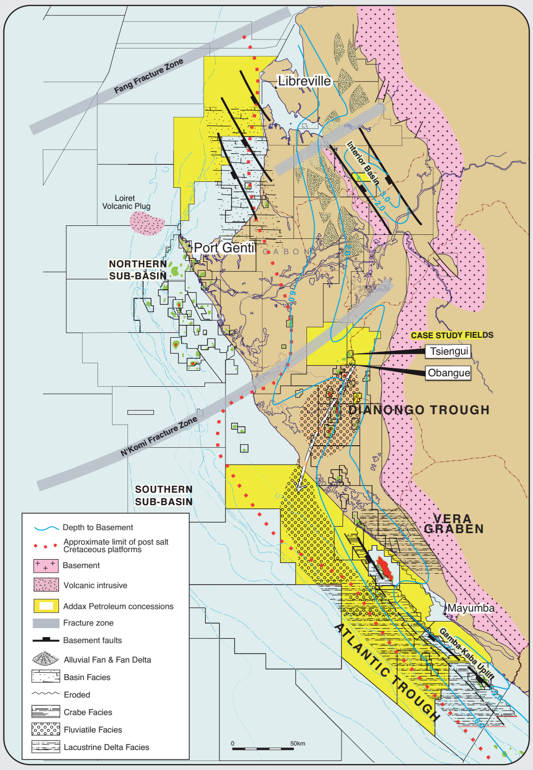
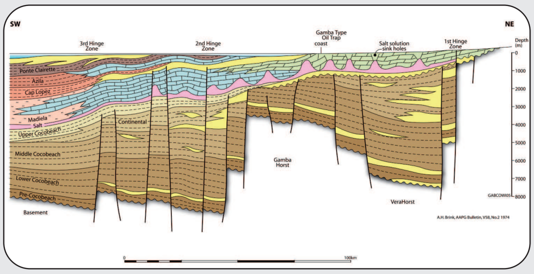
REGIONAL SYNOPSIS



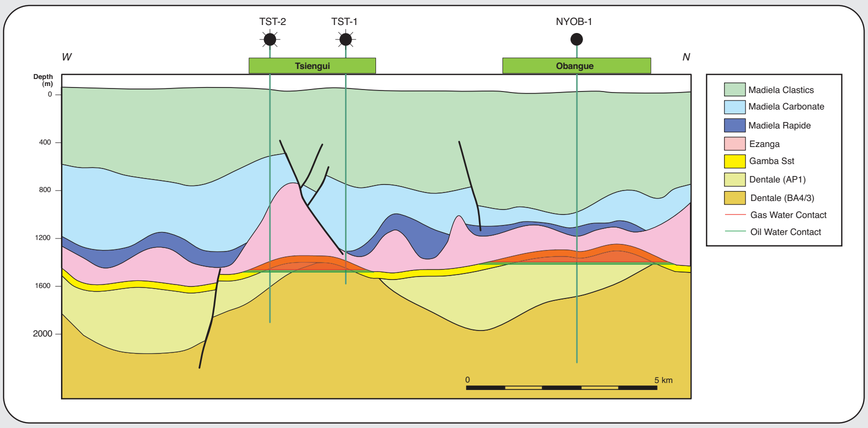


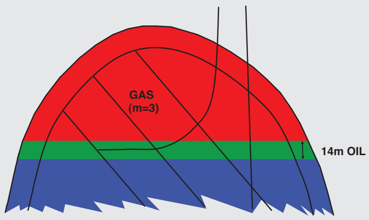
TSIENGUI OIL FIELD, CASE STUDY

- Pre-Salt, 4-way dip closure structure
- Angular unconformity present between the Gamba and the Dentale
  - Thin oil rim (33° API, viscous 6-7 cp oil) field with large gas cap
  - Producing from Gamba Sandstone and Dentale Formation
  - Primary target reservoir = Gamba Sandstone
  - Secondary target reservoir = Dentale Formation

WELL DATA

- 8 Pilot Holes, 2 Cores, abundant wire-line and pressure data
- 43 Horizontal Producers
- 1 gas injector
- 1 water disposal

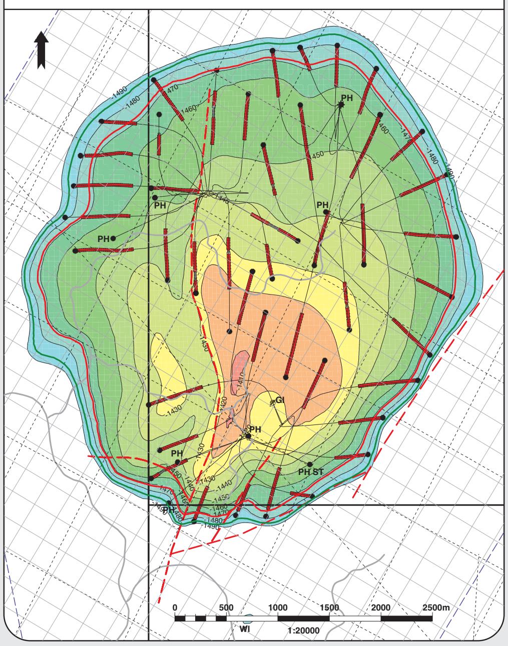




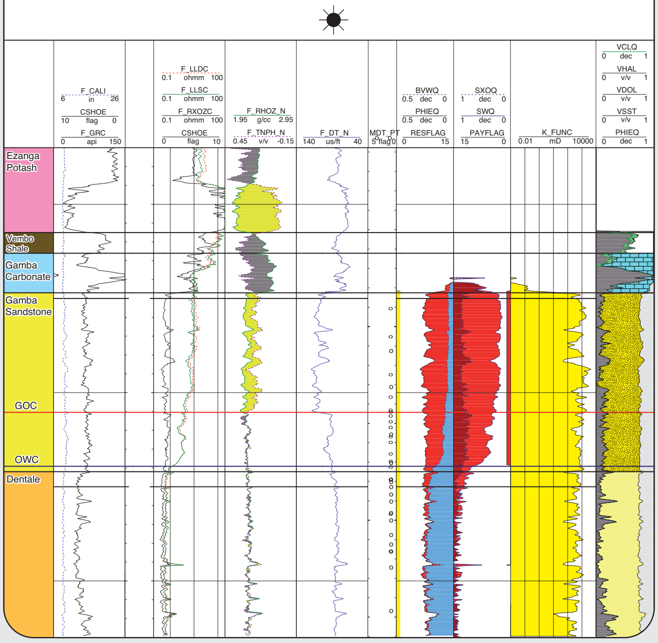
RESERVOIR QUALITY

- Gamba = High N:G,
- Gamba = High porosity and permeability
- Dentale = Variable reservoir quality, variable N:G,
- Dentale = Variable porosity with permeability dependant on facies

Tsiengui Field Top Gamba Sandstone Depth Map



RESERVOIR SECTION TYPE LOG



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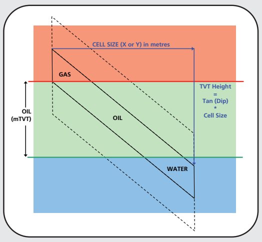
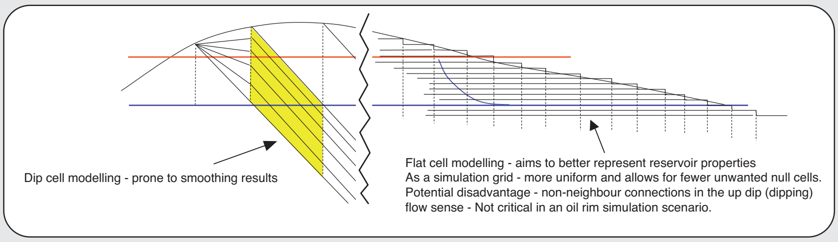
GRID DESIGN - GEOMETRIC OR SHOE-BOX

- Model required representation of both tilted "Rift" sequence (Dentale) combined with "flat-lying" post rift-drift sequence (Gamba Sandstone).
- Development Plan considers horizontal producers drilled into a thin oil rim.
- Full communication "cross-flow" of stratigraphic units had to be maintained.
- Grid design had to be optimised for geological and simulation model run-times in combination with maximising the ternary fluid phases, gas, oil and water.
- A conventional geometric model to follow stratigraphy is not optimal for reservoir modelling, e.g., representation of the water saturation profiles, STOIIP calculations (as a function of modelling parameters), representative net oil pay maps and well and full-field history match due to scaling effects in the dynamic model.
- Experimental Dynamic Sector Models for this reservoir type show that the optimal grid design for modelling coning of water and gas into the well bore is best achieved with shoe-box grid geometry.

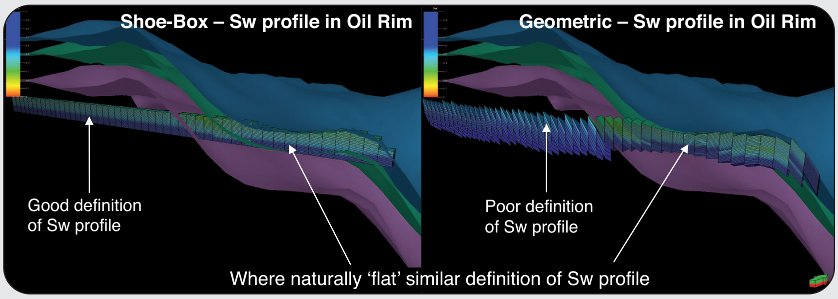
WATER SATURATION - PROFILE MODELLING IN A THIN OIL RIM

	Cell size in X or Y (metres)	Dip of Cells (Degrees)	TVT Height of a cell relative to dip (metres)	Oil Column (TVT) metres	Cells in Column
Thin Oil Rim "A" (11m TVT)	100	18	32.49	11	0.34
	75	18	24.37	11	0.45
	50	18	16.25	11	0.68
	25	18	8.12	11	1.35
	12.5	18	4.06	11	2.71
	6.25	18	2.03	11	5.42
Thin Oil Rim "B" (14m TVT)	100	15	26.79	14	0.52
	75	15	20.10	14	0.70
	50	15	13.40	14	1.04
	25	15	6.70	14	2.09
	12.5	15	3.35	14	4.18
	6.25	15	1.67	14	8.36

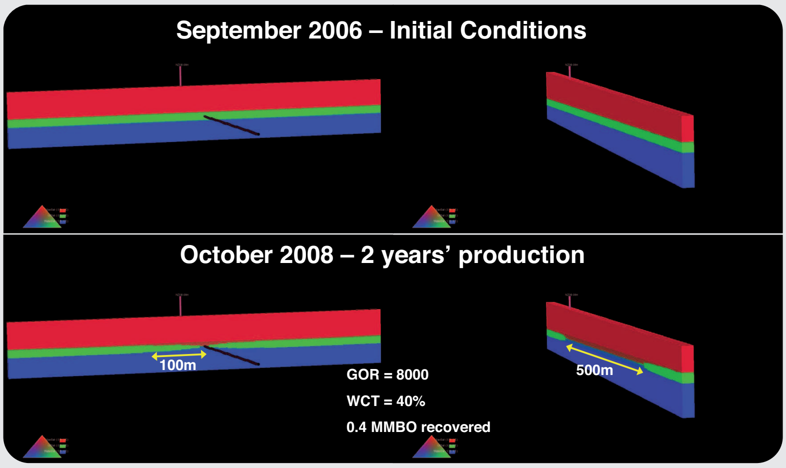




- Derived from logs and matched to Archie a height function is used to model Sw.
- Height is a key component to the function.
- Dipping cells which cross all fluid phases mis-represent the Sw profile in the Oil Rim.
- Flat Cells solve Saturation mis-representation.
- With a coarser grid (Dx-Dy and Dz) the problem is amplified – Shoe Box grid = Effective Model



SECTOR MODELLING - WELL BEHAVIOUR IN A THIN OIL RIM



- Sector Model Grid Size : Dx/Dy = 15m : Dz = 1m
- No drainage observed 100m away from the wellbore
- No drainage observed 50m away from the heel/toe
- Low Drawdown well combined with frictional flow studies demonstrate that total well length contribution of 50% or less is more likely
- Difficult to fully represent well bore behavior in geometric arranged cells where oil phase cannot be isolated properly – Shoe Box grid = Effective Model

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EXAMPLE OF FINAL STOIIP AS A FUNCTION OF GRID GEOMETRY

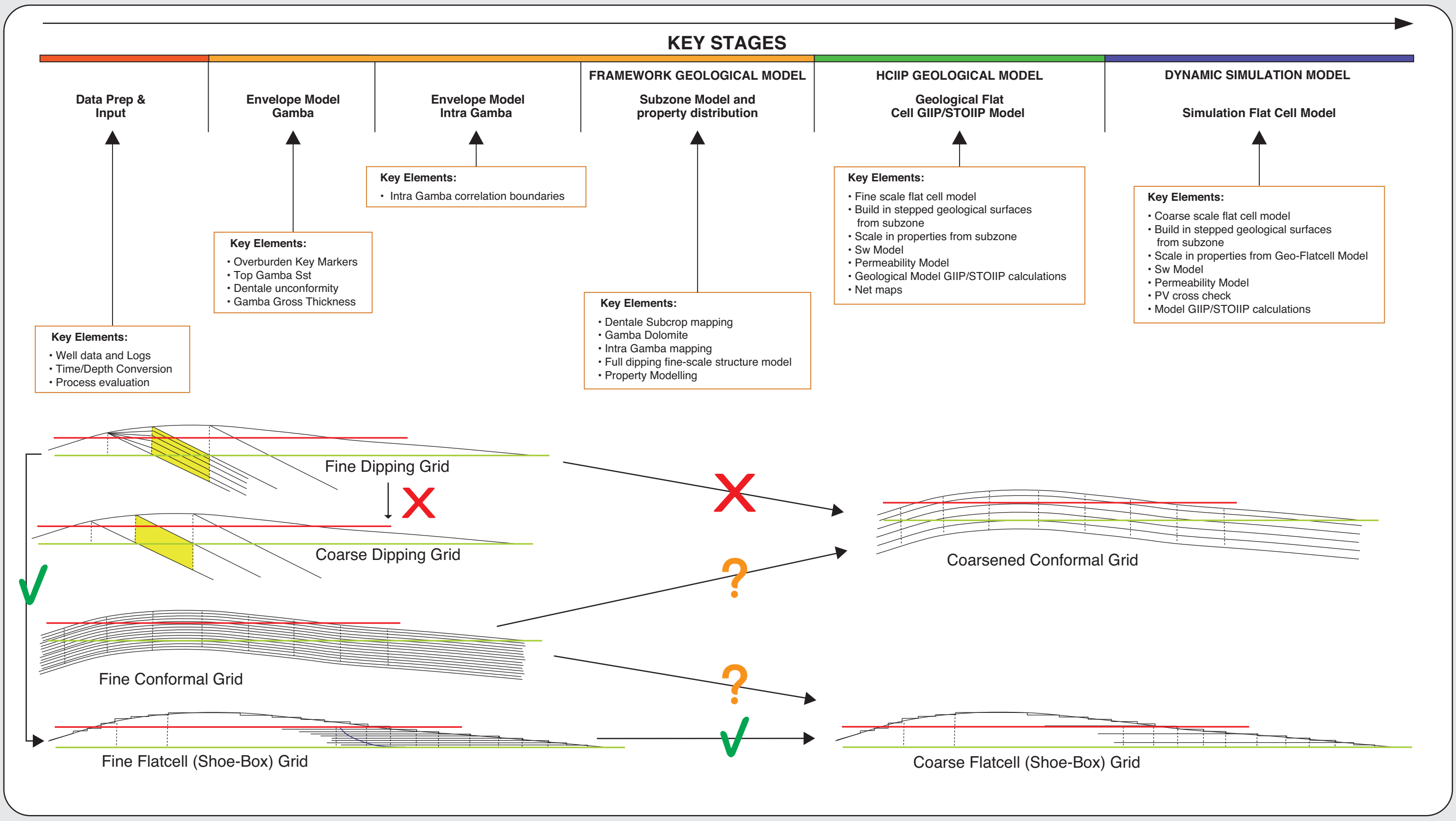
Reservoir Unit	Geometric Model	Shoe-Box Model
Gamba Sandstone	97	100
Upper Dentale Sands	82	100
Middle Dentale Sands	82	100
Lower Dentale Sands	77	100
Total Dentale Sands	*241*	*300*
Total STOIIP	338	400

All numbers are normalised

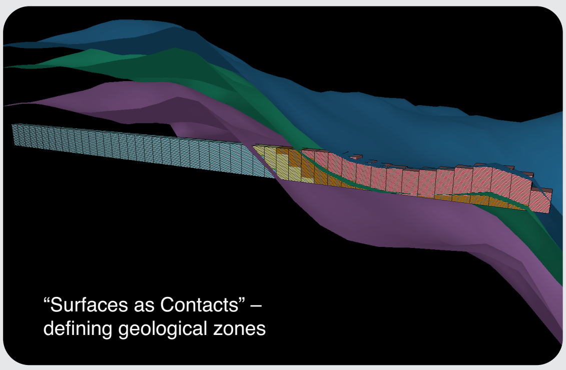
Large (up to 20%) difference in STOIIP observed in dipping Dentale Sands

- Gamba Sandstone is flat lying – impact of cell geometry is low in the geometric grid.
- Gamba Sandstone Sw profile similar therefore volume match.
- Dentale is impact by thin oil rim and cell geometry for Sw profile.
- Geometric model volumes are under estimated in the Dentale due to poor Sw profile modelling.
- Effect is worsened in coarsened models.
- All numbers were compared to Average Reservoir properties for each reservoir unit as a reality check of which a closer match is achieved with the Shoe-Box.
- GIIP numbers were rarely affected as with height the error is assumed to be smoothed.

ESTABLISHED WORKFLOW



- Geological Model is constructed in “geometric space”.
- Surfaces of main deterministic boundaries exported as “fluid contacts”.
- Flat grid is subdivided based upon fluid zones and main geological boundaries (by back-interpolation related to height).
- Fine-scale up-scaling to geological STOIIP model is undertaken capturing geological reservoir property detail.
- All steps are check for correct representation of properties



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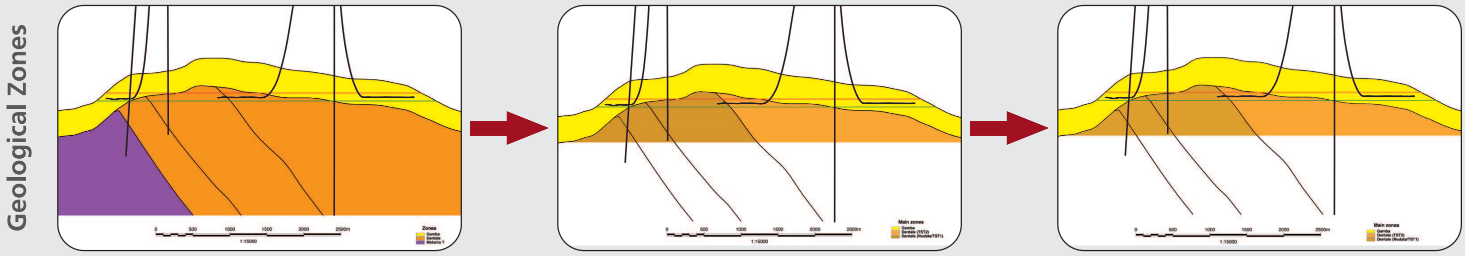
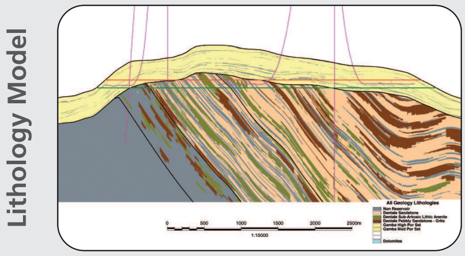
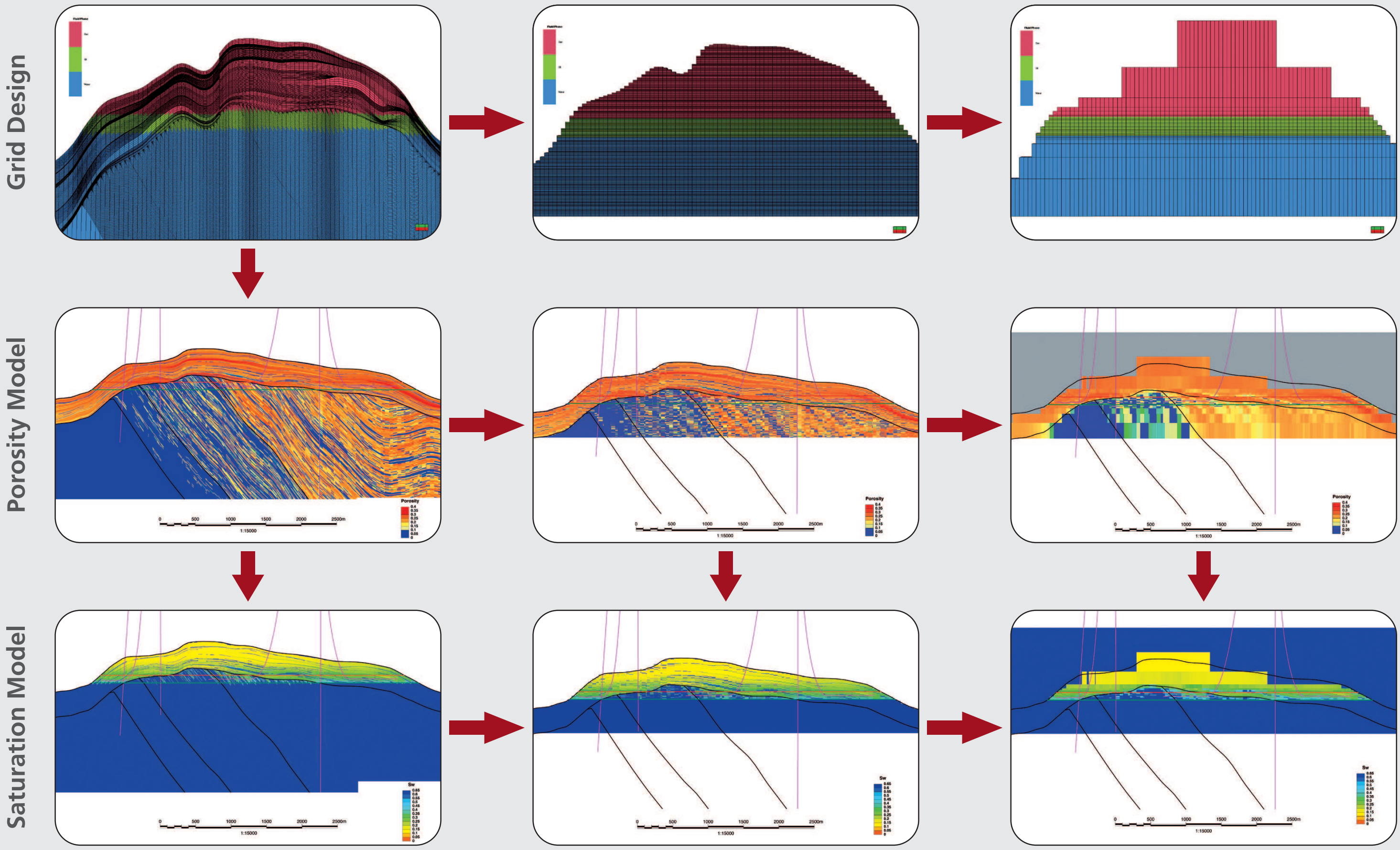
GEO-FRAMEWORK → GEO-STOIIP → DYNAMIC





- Adopted Modelling workflow “Geological to Dynamic” is designed and well suited for the thin oil rim model
- Oil column resolution is maintained through the scaling steps
- Full Field History Match and well modelling can be achieved without the impact of instantaneous water or gas breakthrough due to cell geometry problems.
- Full Field and single well History Match achieved also without too many local grid refinements and adjustments.
- STOIIP calculations are more realistic particularly in thin oil, high dip and coarse grid models.
- Output Net Oil Pay maps are properly represented – No spurious net thickness spikes and no need to data clip on expected min and max.



Further Reading

- Bradley, A.C., Fernandez, M.N. Early Cretaceous Paleogeography of Gabon/ North-Eastern Brazil a tectono-stratigraphic model on propagating rifts, 1991.
- Brink A.H. Petroleum Geology of Gabon Basin. AAPG Bull. V58 no.2, 1974.
- Teisserenc, P., Villemin, J. Sedimentary Basin of Gabon – Geology and Oil Systems. AAPG Mem. 48.

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