[PS]Modeling Low Net-to-Gross Complex Fluvial Reservoir- A Case Study from Aishwariya Field, Barmer Basin, NW India*

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Abstract

Aishwariya field is one of the major oil fields in Barmer basin, NW India. Fatehgarh Formation is primary producing formation deposited in continental fluvial environment in a Paleocene failed rift. The formation is divided into five units. Younger units (FA1 -2) were deposited in low-energy fluvial environment; older units (FA3-5) are dominated by multistoried braided channel facies associations. The field has been in oil production since 2013, currently producing with edge water drive mechanism.

Reservoirs deposited in fluvial environment commonly contains significant heterogeneity in facies association, ranging from channel sands, point-bar deposits, flood-plain mud and crevasse splay deposits, etc. The Aishwariya field has relatively low NTG (~20%) with individual channel average width ranging 20-100 m; reservoir modeling in such a low net fluvial reservoir has always been a challenge, especially in simulation scale grids. Existing dynamic models struggled to replicate field performance without multiple local modifiers; hence model has limited predictive capabilities.

This paper describes how thin channels were integrated into modeling workflow by adopting both top-down and bottom-up approaches. This is integration of conceptual understanding, regional data, analogues and careful sub-zonation of exiting units based on inter-well connectivity understanding, and integrating field surveillance and production data into concepts.

As modeling workflow to capture reservoir facies heterogeneity, two facies were classified. The facies classes were grouped according to porosity-permeability information by zone and cross-checked against core interpreted depo-facies. The facies were modeled using conventional sequential indicator simulation. Thin sand bodies and channels were incorporated into model as deterministic objects.

The updated static model honors regional depositional trends and reasonably captures local fluvial bodies. The static model is now able to explain the reservoir connectivity issue, especially in low-energy fluvial reservoir units (FA1-2). Updated dynamic reservoir model is able to

closely replicate water flood performance and have shown a significant improvement in matching high water-cut wells without local modifiers as compared to previous model. This indicates that the modeled depositional heterogeneity reflects field geological complexity and provides a better basis for estimating ultimate recovery and production forecast.

MODELLING LOW NTG COMPLEX FLUVIAL RESERVOIR- A CASE STUDY FROM AISHWARIYA FIELD, BARMER BASIN, NW INDIA

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INTRODUCTION

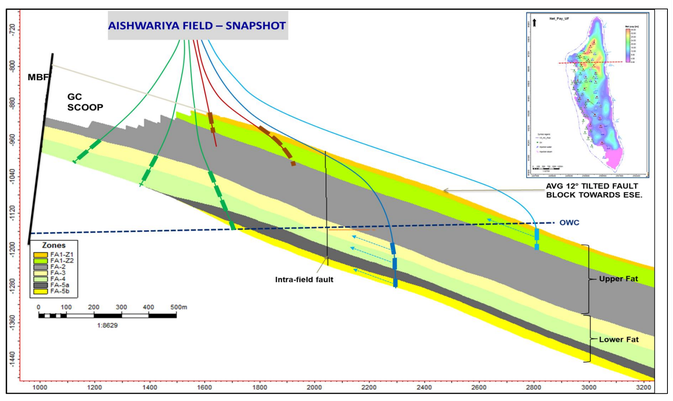
Aishwariya field is one of the major oil fields in Barmer basin, NW India. Fatehgarh Formation is primary producing formation deposited in continental fluvial environment in a Paleocene failed rift. The formation is further divided into five units. Younger units (FA1 -2) are deposited in low-energy fluvial environment; older units (FA3-5) are dominated by multistoried braided channel facies associations. The field is in oil production, from 2013, currently producing with edge water drive mechanism.

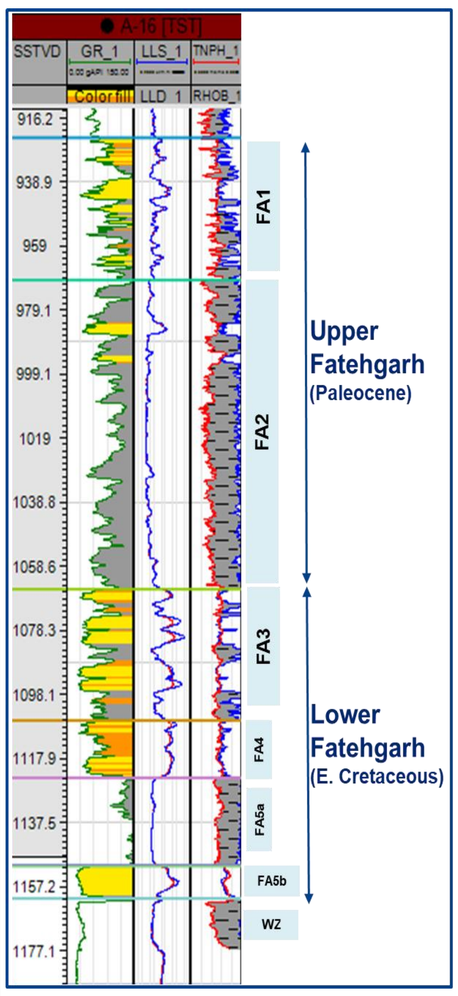
Reservoirs deposited in fluvial environment commonly contains significant heterogeneity in facies association, ranging from channel sands, point-bar deposits, flood-plain mud and crevasse splay deposits, etc. The Aishwariya field has relatively low NTG (~20%) with individual channel average width ranging 10-100 m; reservoir modeling in such a low net fluvial reservoir has always been a challenge especially in simulation scale grids. Existing dynamic models struggled to replicate field performance without multiple local modifiers; hence model has limited predictive capabilities.

This paper describes how thin channels were integrated into modeling workflow by adopting both top-down and bottom-up approaches. This is integration of conceptual understanding, regional data, analogues and careful sub-zonation of exiting units based on inter-well connectivity understanding, and integrating field surveillance and production data into concepts.

FIELD OVERVIEW

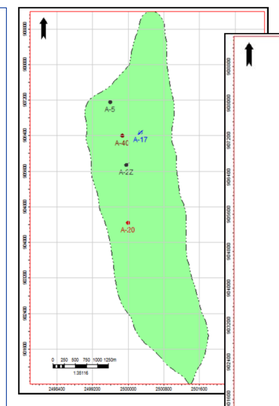
- Discovered in 2005; Production started in 2013 (current average production~18Kbopd)
- Tilted fault-lock structure bounded by a normal fault (MBF). Crestal part is affected by gravity collapse faults.
- Continental/fluvial sands of L. Cretaceous and Paleocene are main reservoir units.
- Area: 12 sq. km; Max. Oil Column: ~300m
- Relatively low Net To Gross (~ 20%); Upper Fatehgarh has thin sand bodies

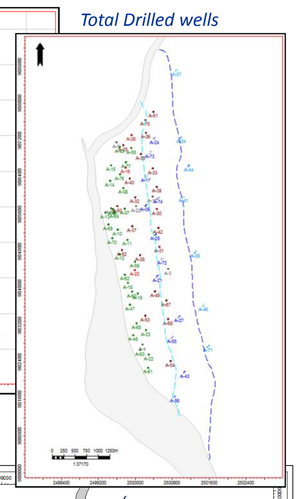


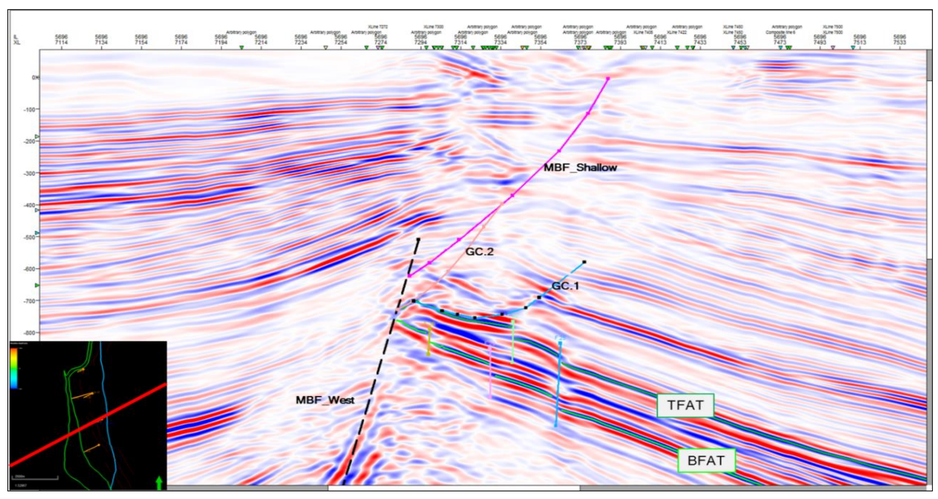


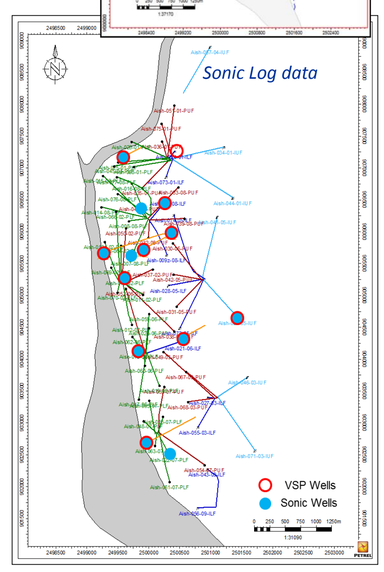
DATA AVAILABLE

- 3D seismic data PSTM and Beam migrated PSDM.
- Sonic Logs (13 Wells and VSP/Checkshot (11 Wells).
- Basic logs for 71 wells and Core data for 5 Wells- (limitation- no core towards southern part)
- Core sedimentological reports, XRD and SEM data SCAL and RCA analysis
- Production logs and reservoir saturation logs
- Field pressure data at multiple time stages.









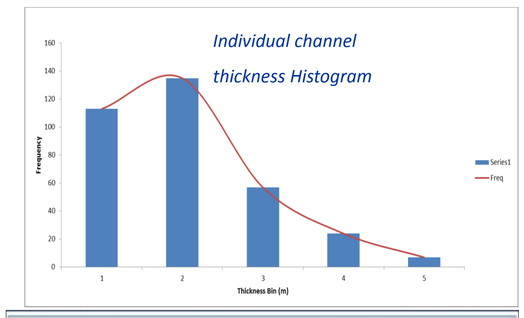
KEY RESERVOIR MODELING CHALLENGES

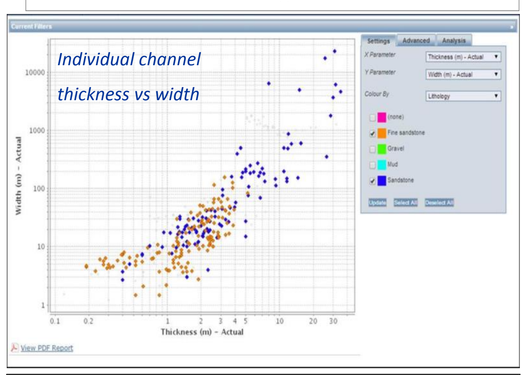
Majority of the channel thickness range: 1m- 3m.

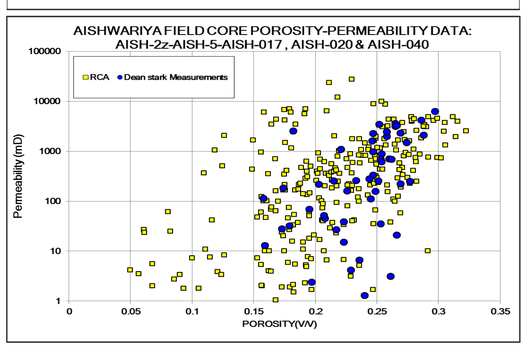
Based on the thickness-width correlation and geological understanding, the range of sinuous channel system would be width (of channel sand bodies) (10m to 100m).

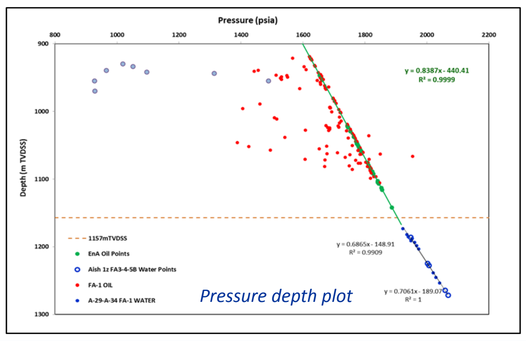
Core analysis shows high scatter in poro-perm plot- challenging to group different rock classes.

As pressure-depth plot of Upper Fatehgarh wells show high scatter- which indicates limited connectivity in reservoir.



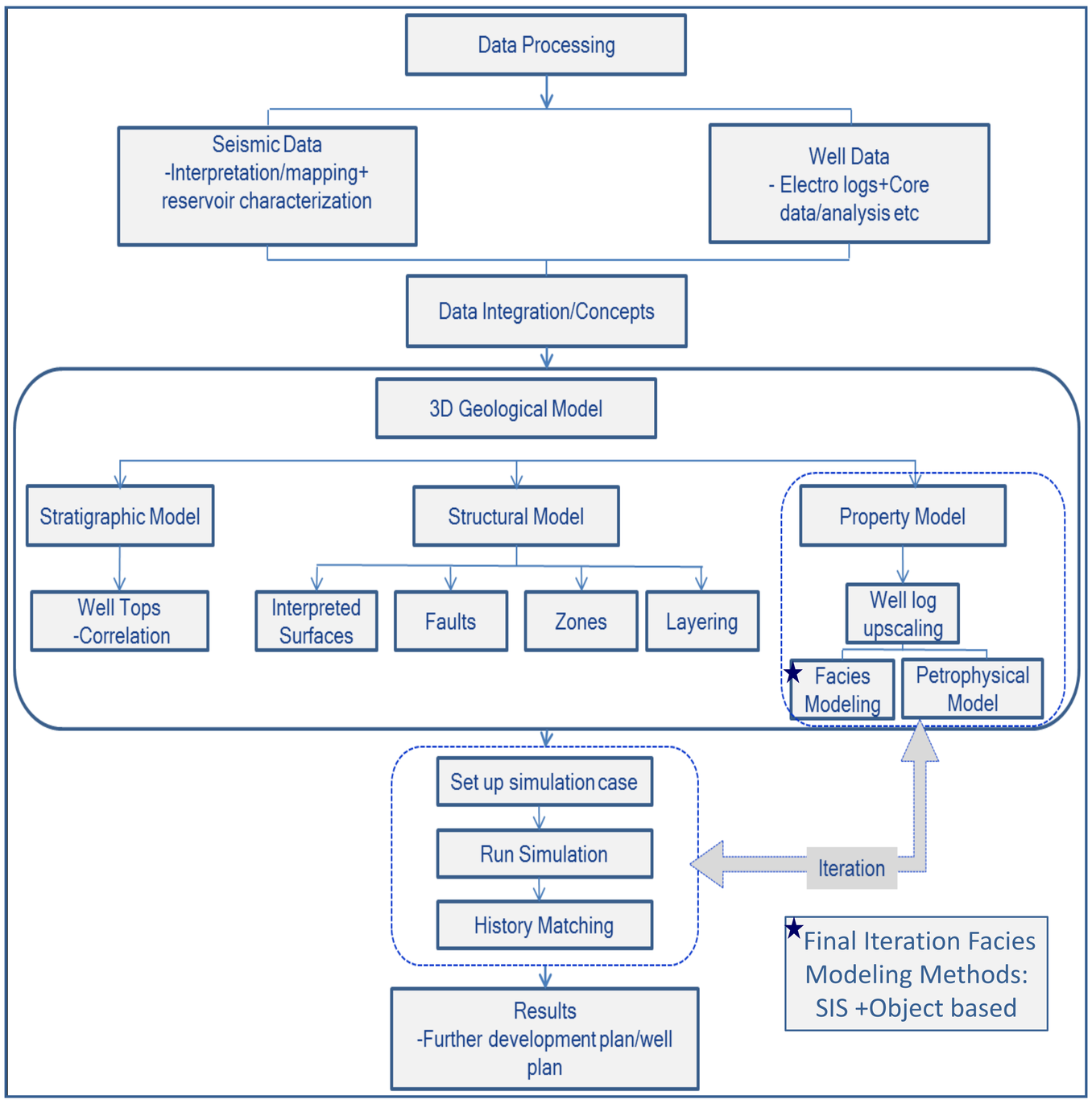






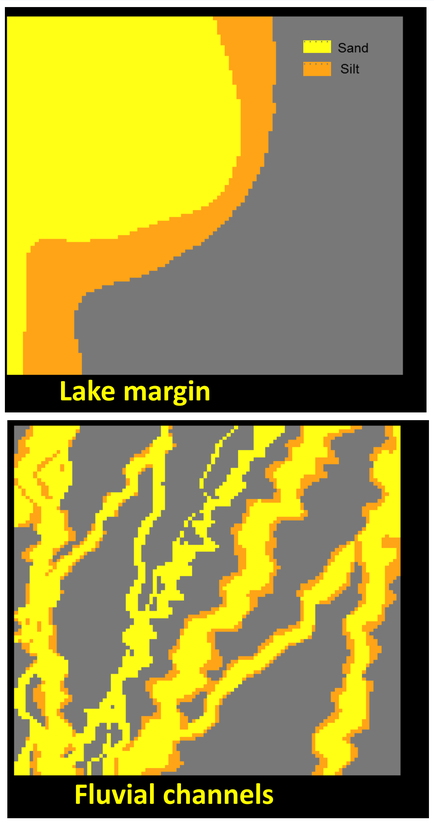
- Upper Fatehgarh was deposited in low-energy fluvial environment.
- Modeling thin and narrow channels in 50mx50m simulation grid has been a key challenge.

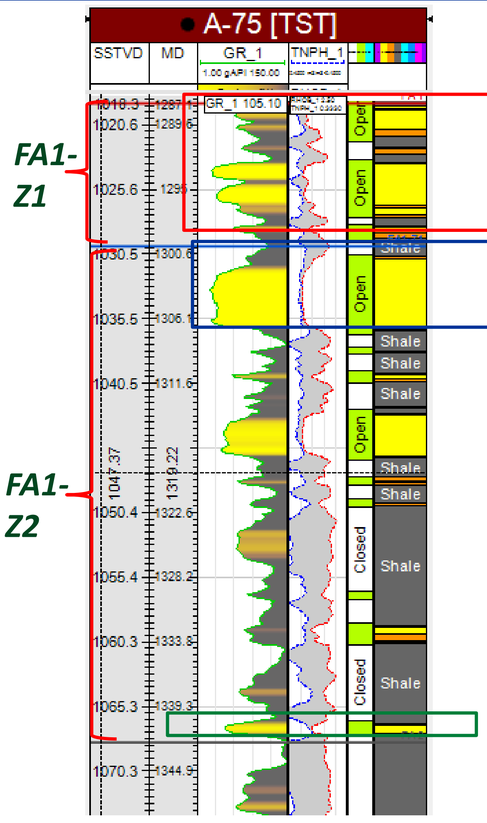
MODELING WORKFLOW



- Most efforts were put on facies modeling.
- Various iteration and modeling methods were tested before choosing best fit approach.

UF RESERVOIR CONCEPT AND CHARACTERIZATION

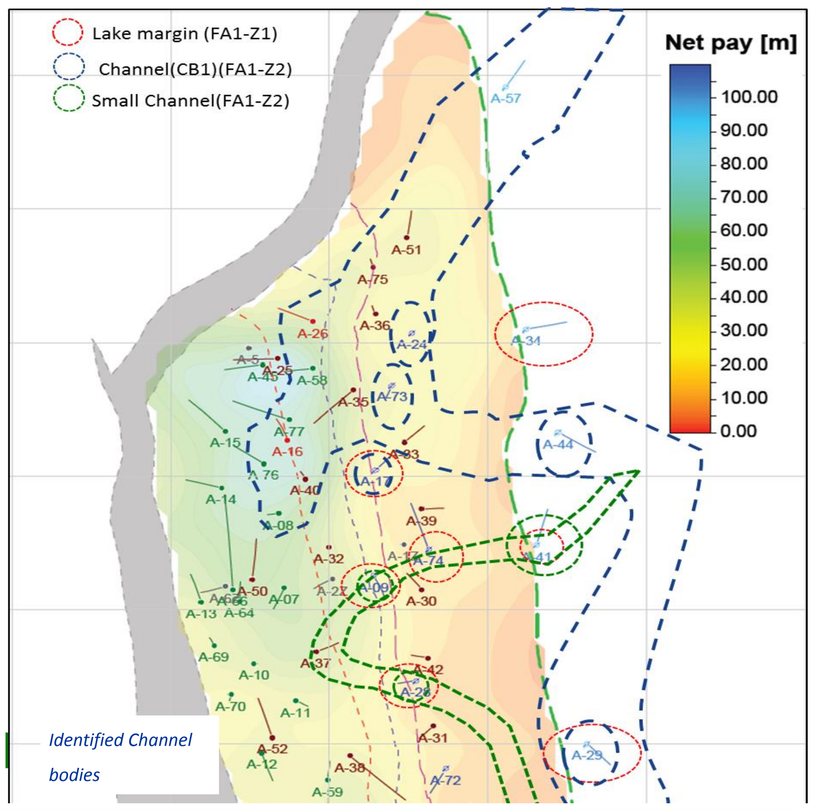




Lake Margin (FA1-Z1): Grossly correlated as coarsening-up sequence. It has very good and wider connectivity.

Channel-Levee complex (CB1)

- Lower part of the FA1-Z2 has thinner and sinuous channels.
- It has limited and local connectivity.
- Channels are identified with the help of conventional log correlation and production logs, pressure data and RST logs.



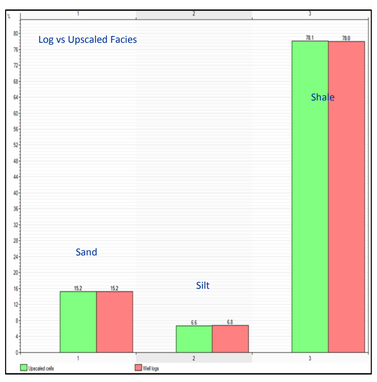
FA1 divided into two zones based on gross depositional environment understanding

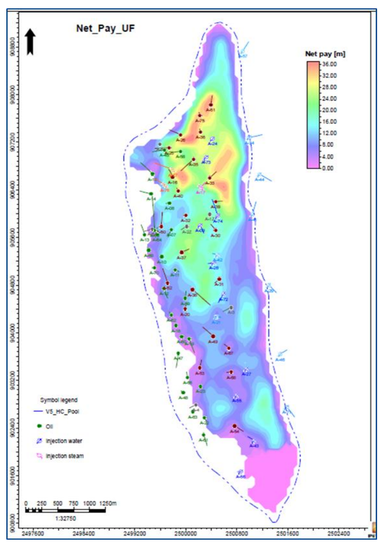
Multiple channels are identified and correlated in conventional logs and production data and finally integrated into static model.

PROPERTIES MODEL SUMMARY

- Grid statistics Ix Jx K- 50(m)x 50(m)x 0.6 (m)
- Same grid used for dynamic simulation

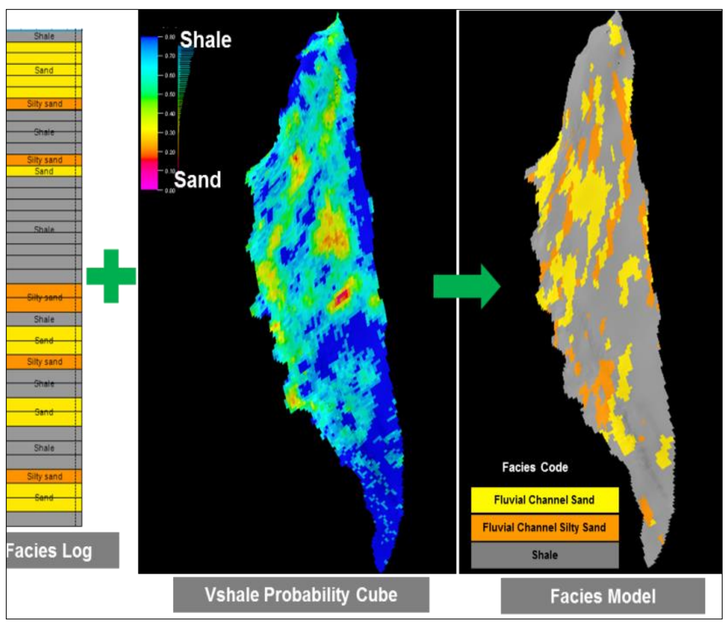
- Two reservoir facies (sand and silt) modeled.
- Reservoir facies can be identified in poro-perm plot.
- Multiple facies modeling approach (SIS, object based, MPS and combinations) tested.
- Final facies model was based on pixel based/SIS facies model with deterministic reservoir bodies incorporated as identified and mapped.



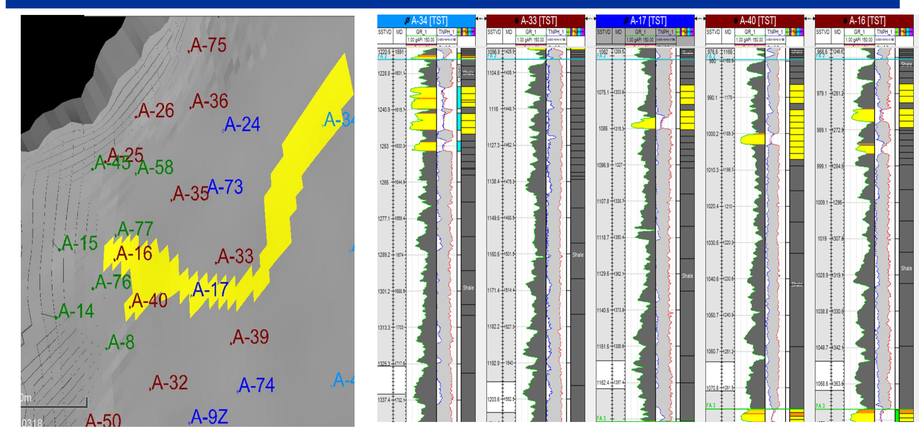


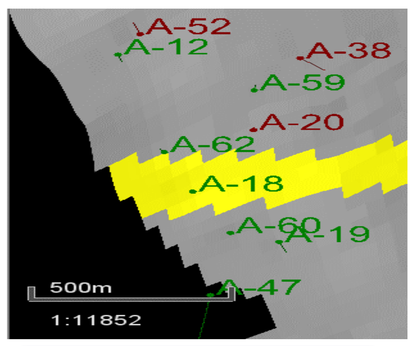
SEISMIC QI STUDY INTEGRATION

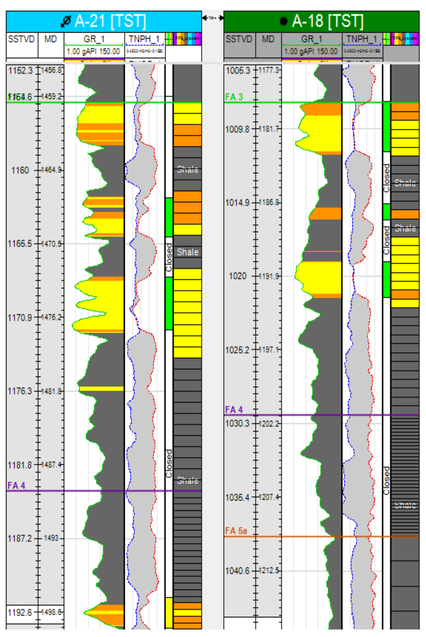
- Seismic Inversion followed by multi-variate analysis was used to derive a pseudo-Shale volume.
- The new volume was used as probability cube (secondary trends) to populate reservoir and non-reservoir facies.



INTEGRATION OF DETERMINISTIC RESERVOIR BODIES

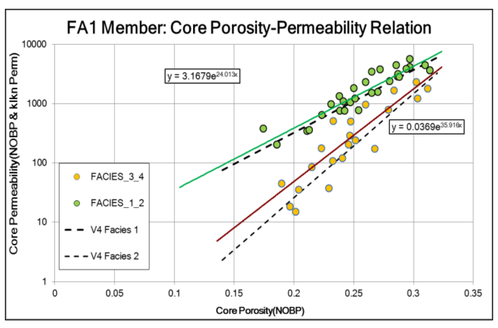


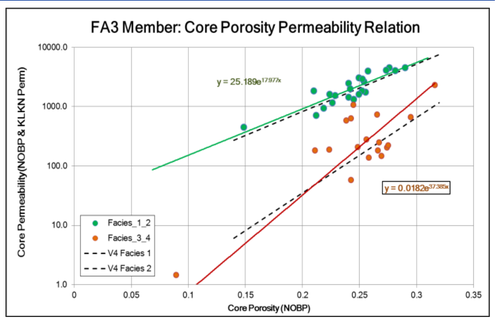


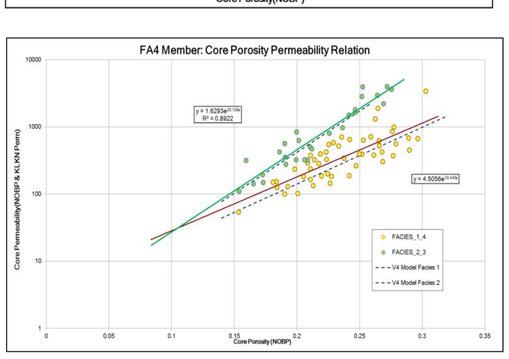


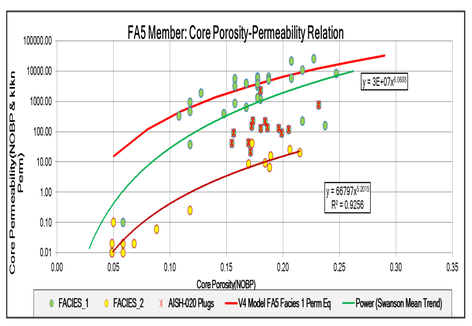
Identified sand bodies or channels are integrated into facies model as part of workflow by creating discrete filter.

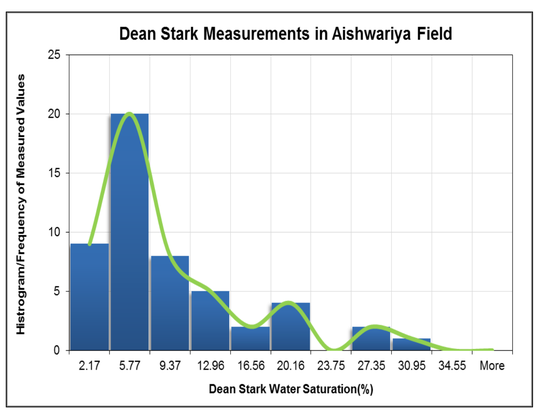
PERMEABILITY AND SATURATION CALCULATIONS







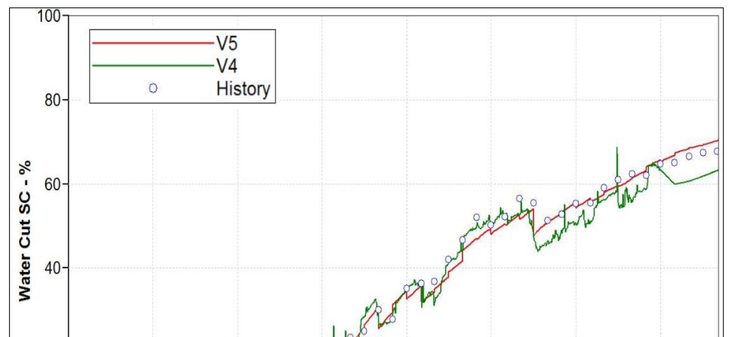




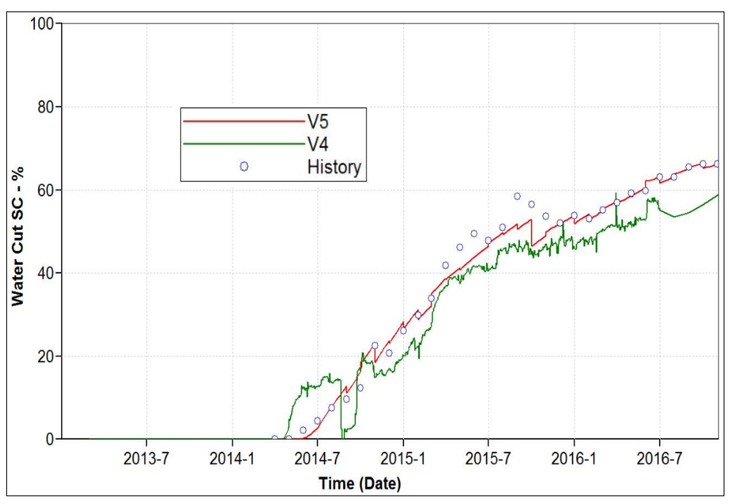
- Permeability and saturation are calculated after facies and total porosity model.
- Poro- perm transform based on core data.
- Saturation model based on capillary pressure data and calibrated to Dean Stark saturations.

RESULTS AND CONCLUSIONS

- Regional depositional trends are well captured in the updated facies model.
- The static model is now able to explain reservoir connectivity issue, especially sinuous-channel-dominant zone of Upper Fatehgarh (FA1-2).
- Updated dynamic reservoir model is able to closely replicate water flood performance and has shown a significant improvement in matching high water-cut wells without local modifiers as compared to previous model.
- This indicates that the modeled structural and depositional heterogeneity reflects field geological complexity and provides a better basis for production forecast.
- The model is being used as basis for further field development- Polymer EOR.



History match comparison from previous version (Full Field)



History match comparison from previous version (Upper Fatehgarh)