geoconvention
Calgary • Canada • May 11-13 2026

Core-to-Seismic Scale Controls on Reservoir Quality and Potential: Defining the Economic Threshold Between Conventional and Tight Gas in a Mixed-Influence Delta

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Summary

This study investigates the controls on reservoir quality in a mixed-influence deltaic system of the Cretaceous Lower Goru Formation, with the objective of differentiating economically viable conventional gas reservoirs from tighter, marginal intervals. Various lab-based techniques such as thin-section petrography and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) were utilized to investigate depositional and diagenetic processes, revealing that authigenic chlorite and quartz cementation are the principal factors influencing reservoir quality. The porosity was preserved by chlorite coatings through the inhibition of quartz cement. Core-derived facies and their associations aided in interpreting depositional settings. Porosity and permeability relationships, log-based sequence stratigraphy, and identification of diagenetic facies were conducted through integrated core-log petrophysical analysis. Porosity and permeability distribution were assessed using Sequential Gaussian Simulation (SGS) and Gaussian Random Function Simulation (GRFS) algorithms. Seismic volumes were inverted into acoustic impedance volumes using Simultaneous Seismic Inversion. The results show that distributary channels, delta fronts, and proximal delta fronts are among the best reservoir having conventional reservoir potential in the Sawan gas field, while sand-dominated delta plain/marginal marine embayment and middle shoreface facies exhibited unconventional tight reservoir characteristics. Pore-to-seismic workflow facilitated a dual-resource assessment, identifying both conventional targets and a tight gas sweet spot in the Sawan field, and equally applicable to similar tectonic settings worldwide.

Workflow

Data collection, lab-based analysis, interpretation, petrophysical analysis, and seismic analysis were performed to evaluate reservoir quality and locate exploration sweet spots. The workflow used in hydrocarbon exploration and geoscience research is emphasized by its potential to be repeated in comparable projects in conventional and unconventional locations and reservoirs worldwide. A generalized workflow is given below.

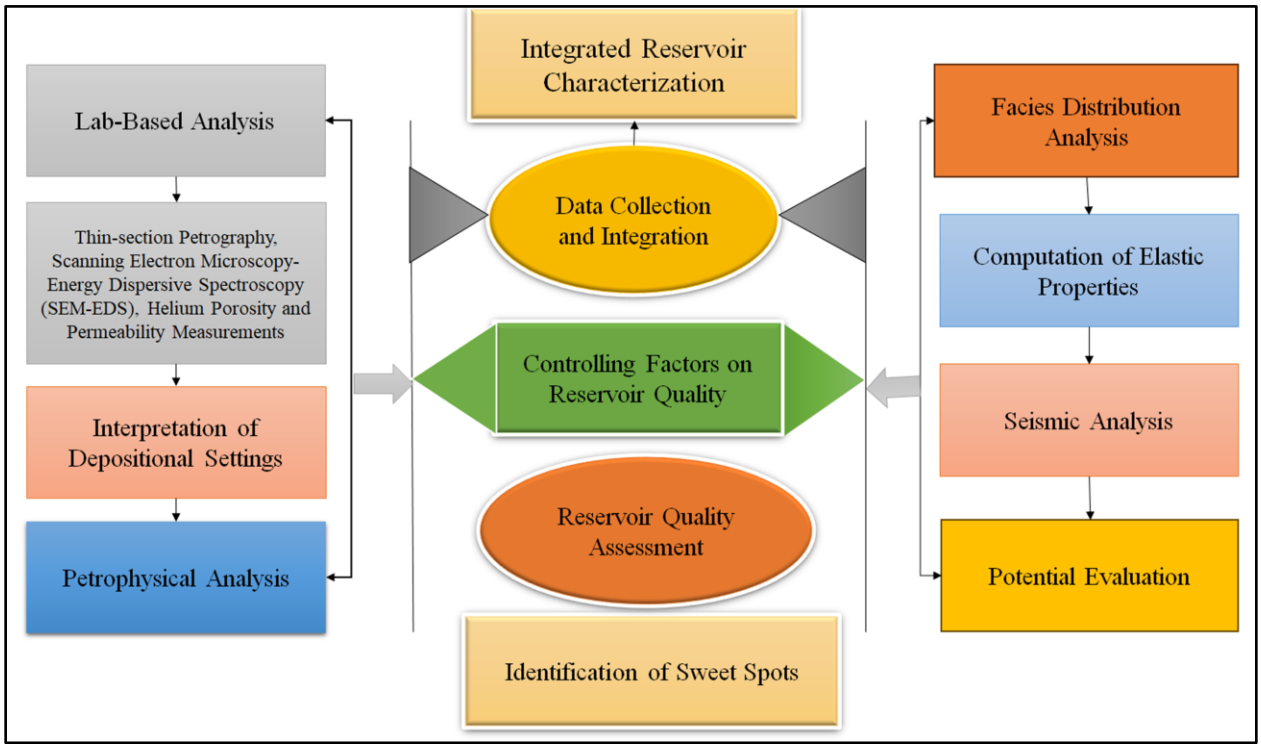


Figure 1 Generalized workflow used in the research work

Observations

1. Authigenic chlorite and quartz cementation are the principal factors controlling reservoir quality. Well-developed chlorite coatings preserve porosity and inhibit quartz cementation.
2. Porosity and permeability distribution across the reservoir using simulation algorithms shows significant heterogeneity. Distributary channels, delta fronts, and proximal delta fronts are identified as having best reservoir quality, while sand-dominated delta plain/marginal marine embayment and middle shoreface facies exhibit tight reservoir characteristics.
3. A dedicated petrophysical analysis, including 3D cross-plot diagnostics, confirms the C sands in southern Sawan as a tight gas target. Integration of acoustic impedance with petrophysical data identifies the C sand as a potential sweet spot for tight gas exploration along with its conventional potential.

Novel/Additive Information

1. A novel multi-scale workflow establishes a genetic link of diagenesis to seismic inversion.
2. Significantly high-resolution core-derived results for geostatistical modeling
3. A unified model for conventional and unconventional reservoir potential
4. Successfully characterizes reservoir potential and heterogeneity in tide- and wave-influenced delta

Acknowledgements

We thank the Directorate General of Petroleum Concession (DGPC), Pakistan, for granting permission to use core lab facilities at the Hydrocarbon Development Institute of Pakistan (HDIP). The American Association of Petroleum Geology (AAPG) and Higher Education of Pakistan (HEC) are deeply acknowledged for funding this research. The authors express their gratitude to the EasyCopy Company ApS for granting the EasyCore license as part of their academic program.

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