Collaborative Geological-Engineering Integration for Unconventional Reservoir Development

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Application Examples of Geology-Engineering Integration in Mahu Shale Oil Field, Xinjiang

Jiaxin Dong

Research Institute of Petroleum Exploration & Development, CNPC

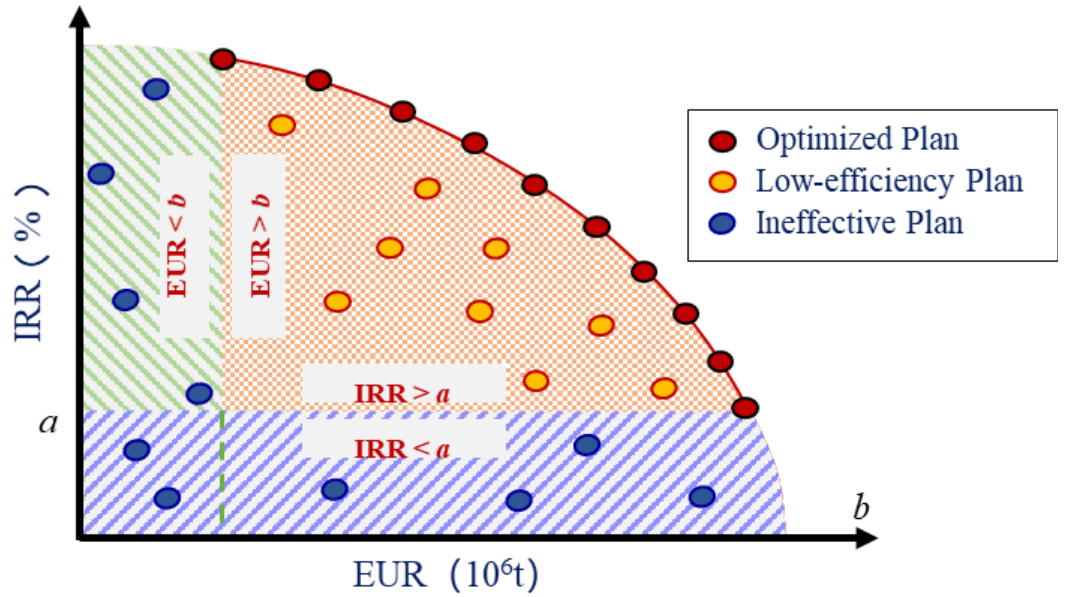
Outline

1. Existing Problems
2. Solution Overview
3. Application Examples in Mahu Shale Oil Field
4. Optimization of Key Parameters
5. Integrated optimization solution
6. Conclusion

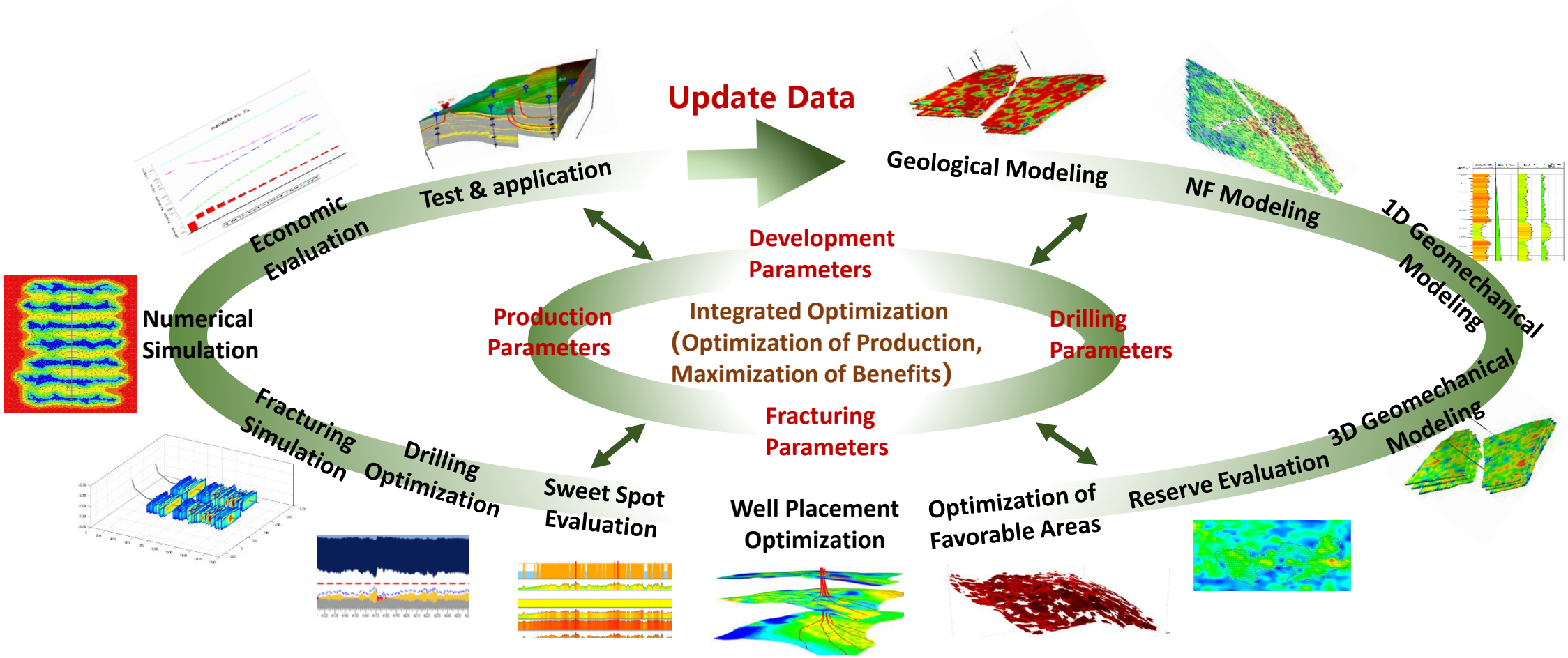
1. Existing Problems

How to balance the investment, production, and profitability?

- Geological Challenges
- High Drilling Cost
- High Fracturing Cost
- Low Production
- Low Oil Price
- High-efficiency Development

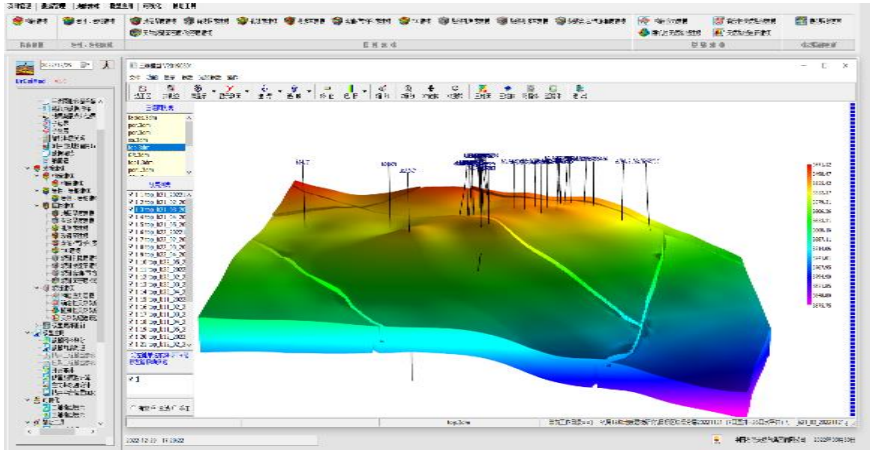


2. Solution Overview

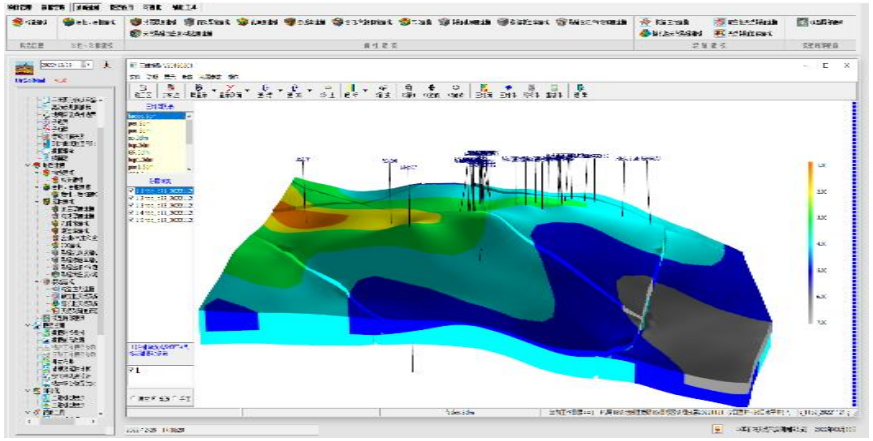


3. Application Examples in Mahu Shale Oil Field

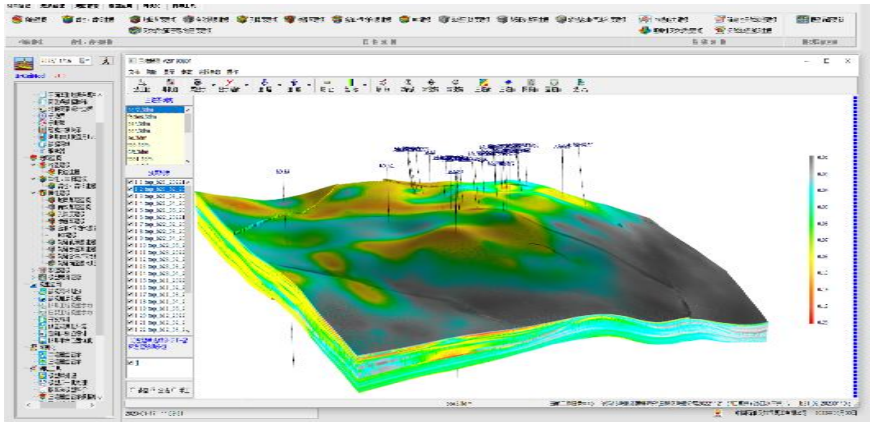
☐ Geological Modeling



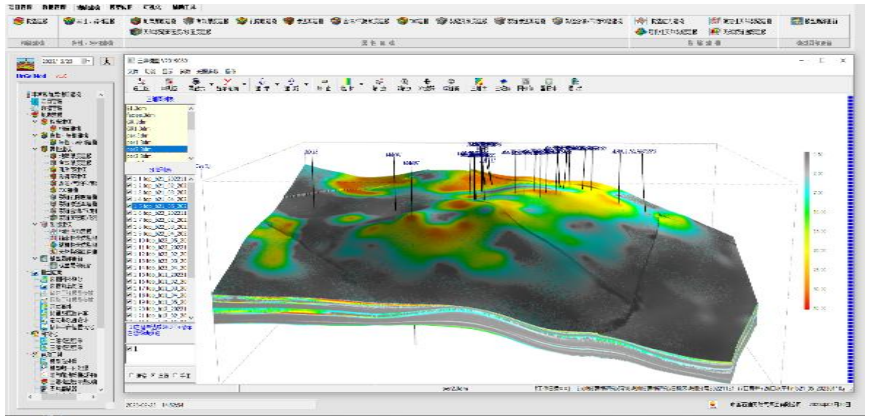
Structural model



Lithology and lithofacies model

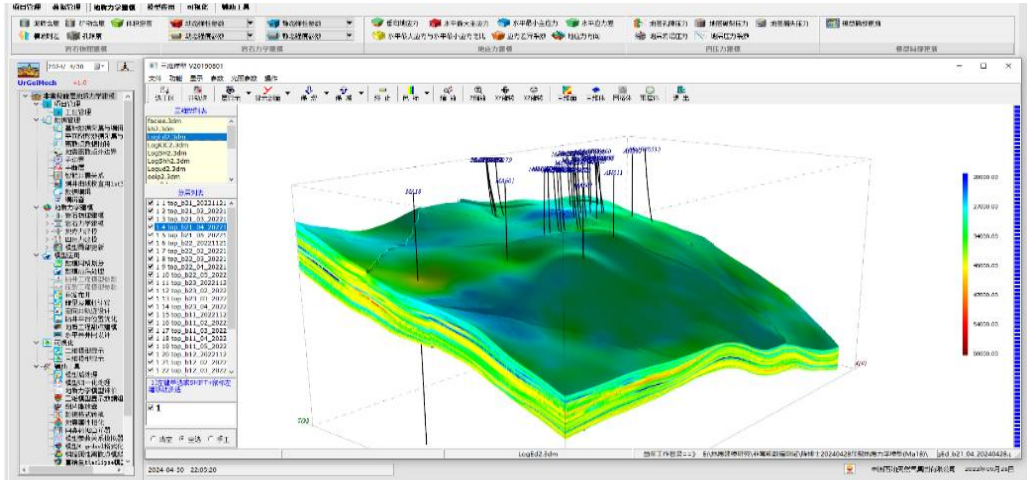


Porosity model

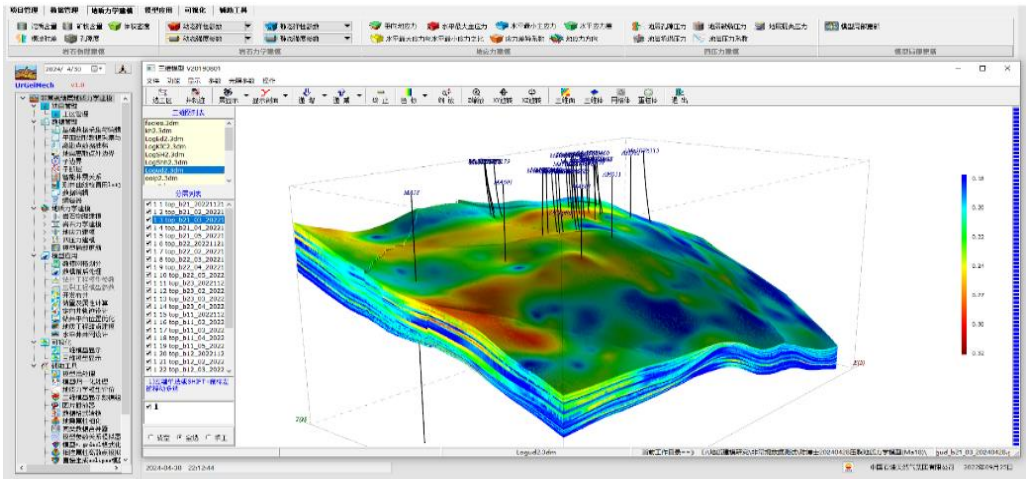


Permeability model

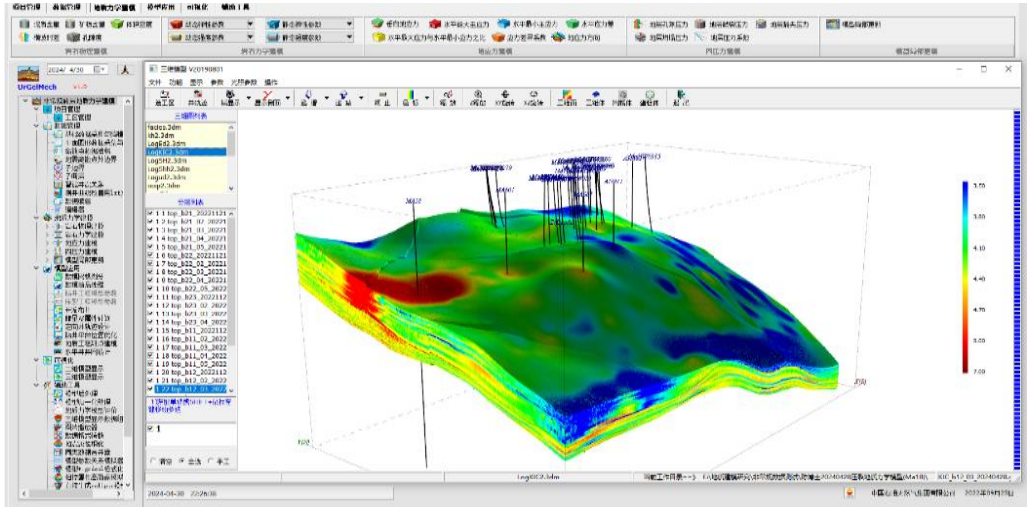
3D Geomechanical Modeling



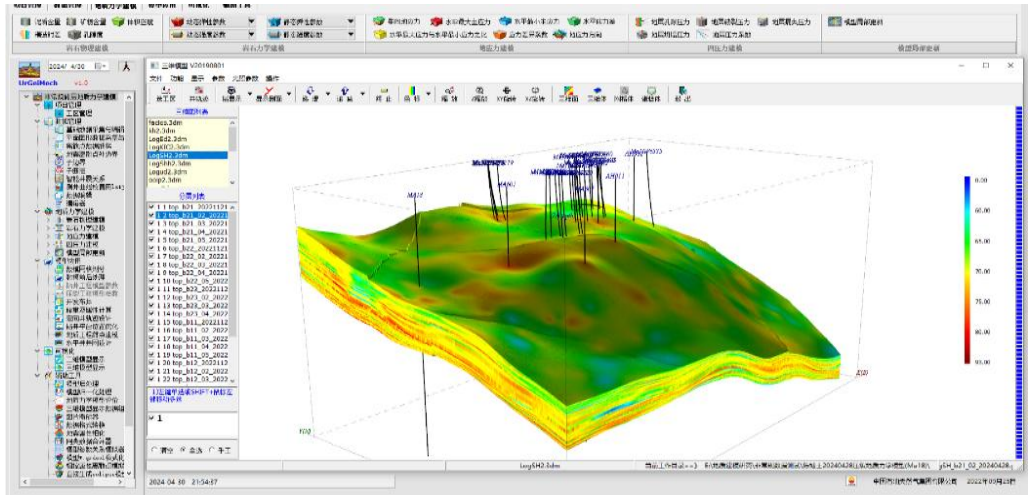
Young's Modulus



Poisson's Ratio

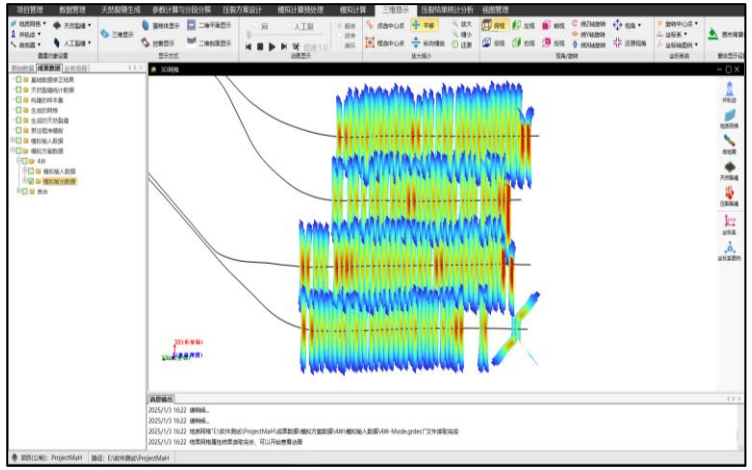


Fracture Toughness

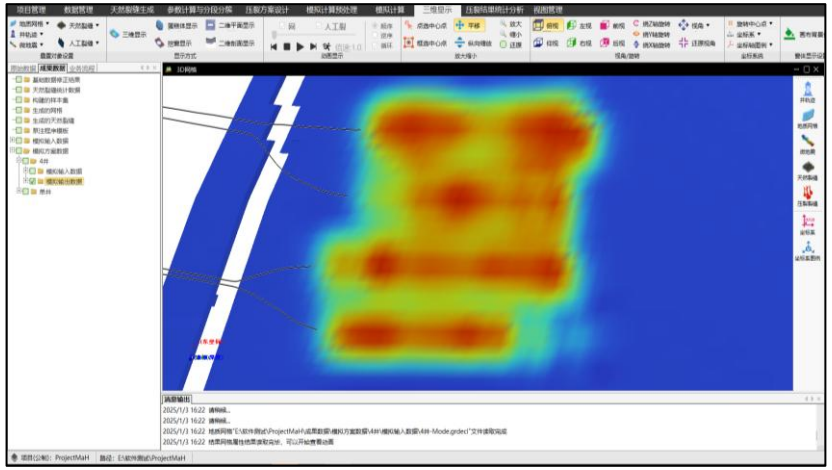


Maximum Horizontal Principal Stress

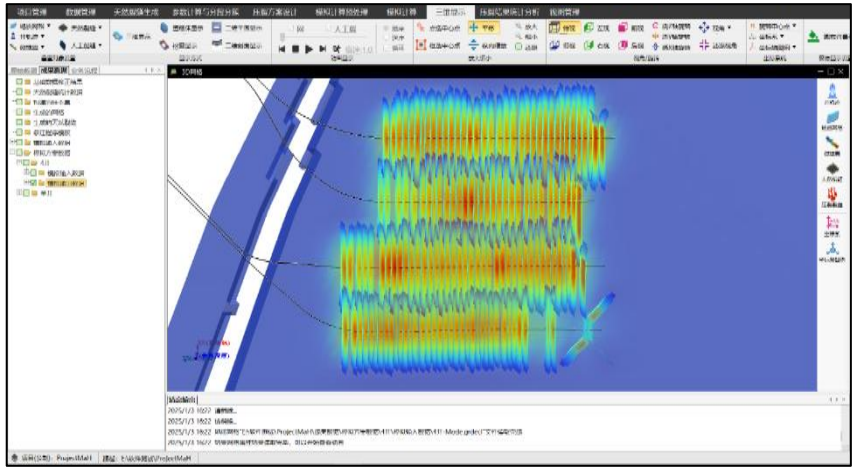
Fracturing Simulation



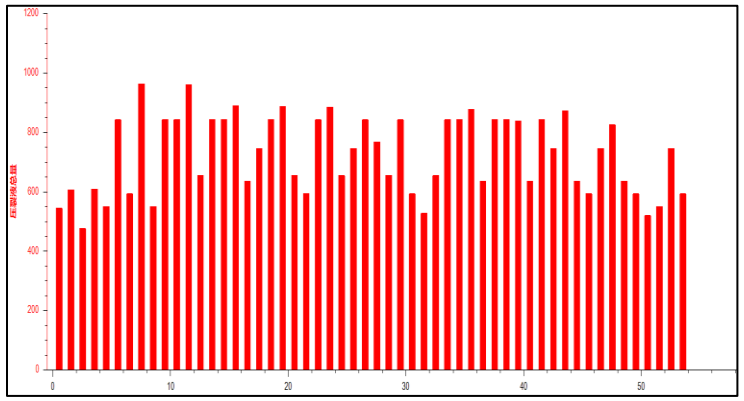
Post-frac artificial fracture geometry map



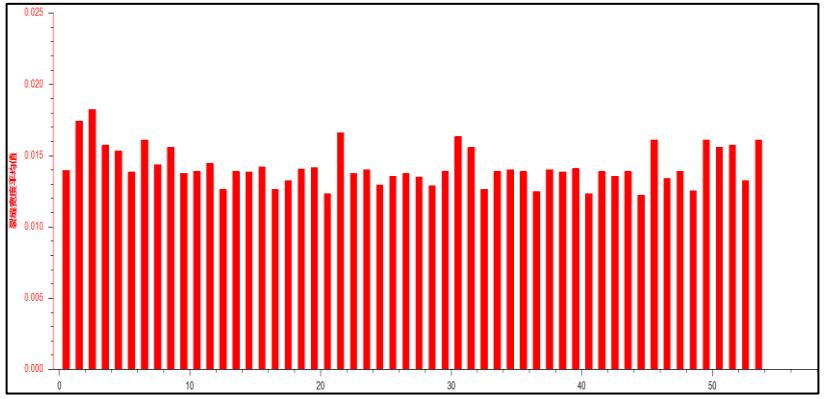
Post-frac induced stress field distribution map



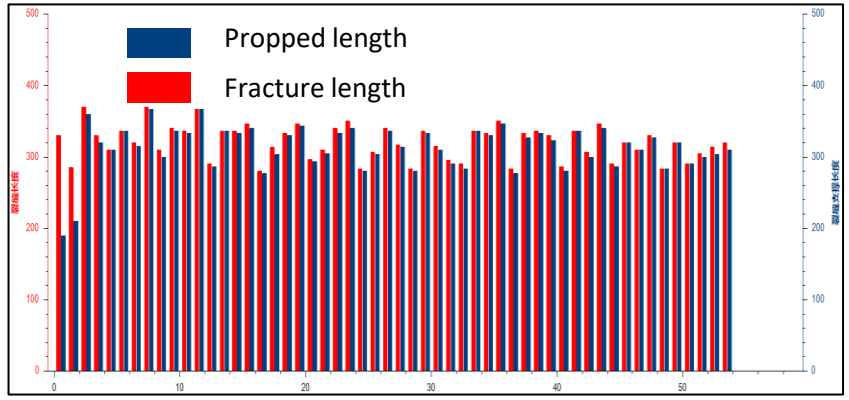
Overlay map of post-frac induced stress field and fractures



Fracturing fluid volume distribution diagram

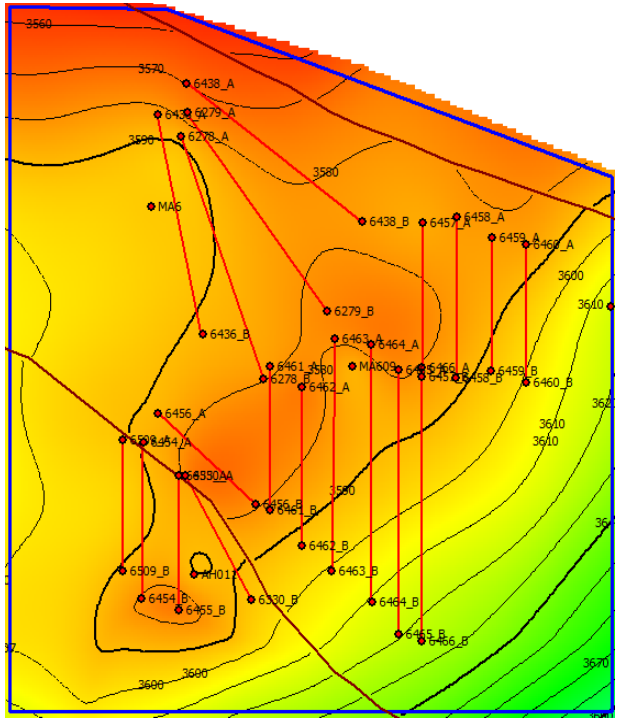


Fracture width distribution diagram

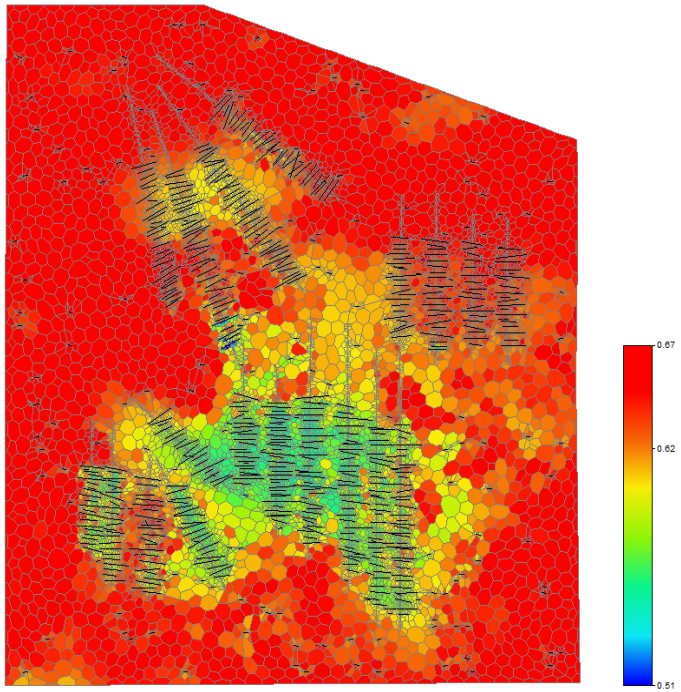


Fracture length distribution diagram

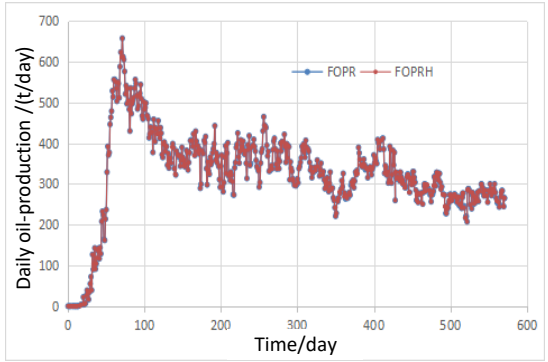
Numerical Simulation



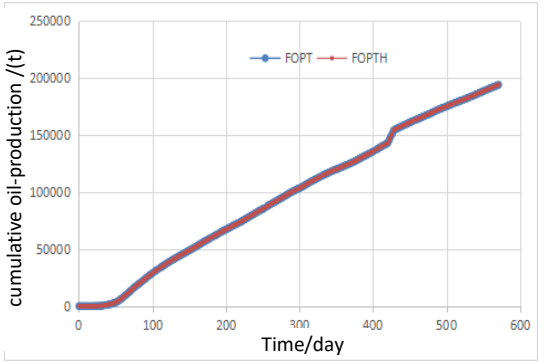
Well location map



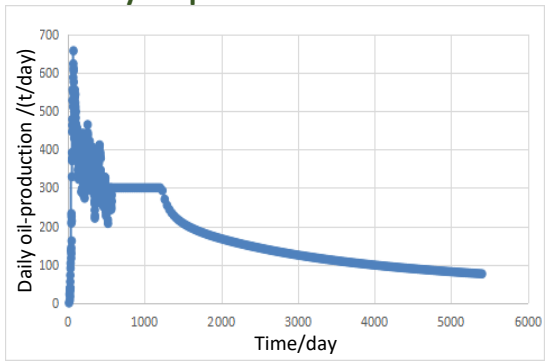
15-year forecast map
of oil-saturation distribution



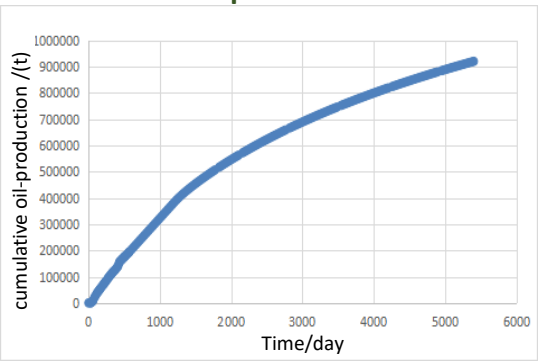
History-matched
daily oil-production curve



History-matched
cumulative oil-production curve



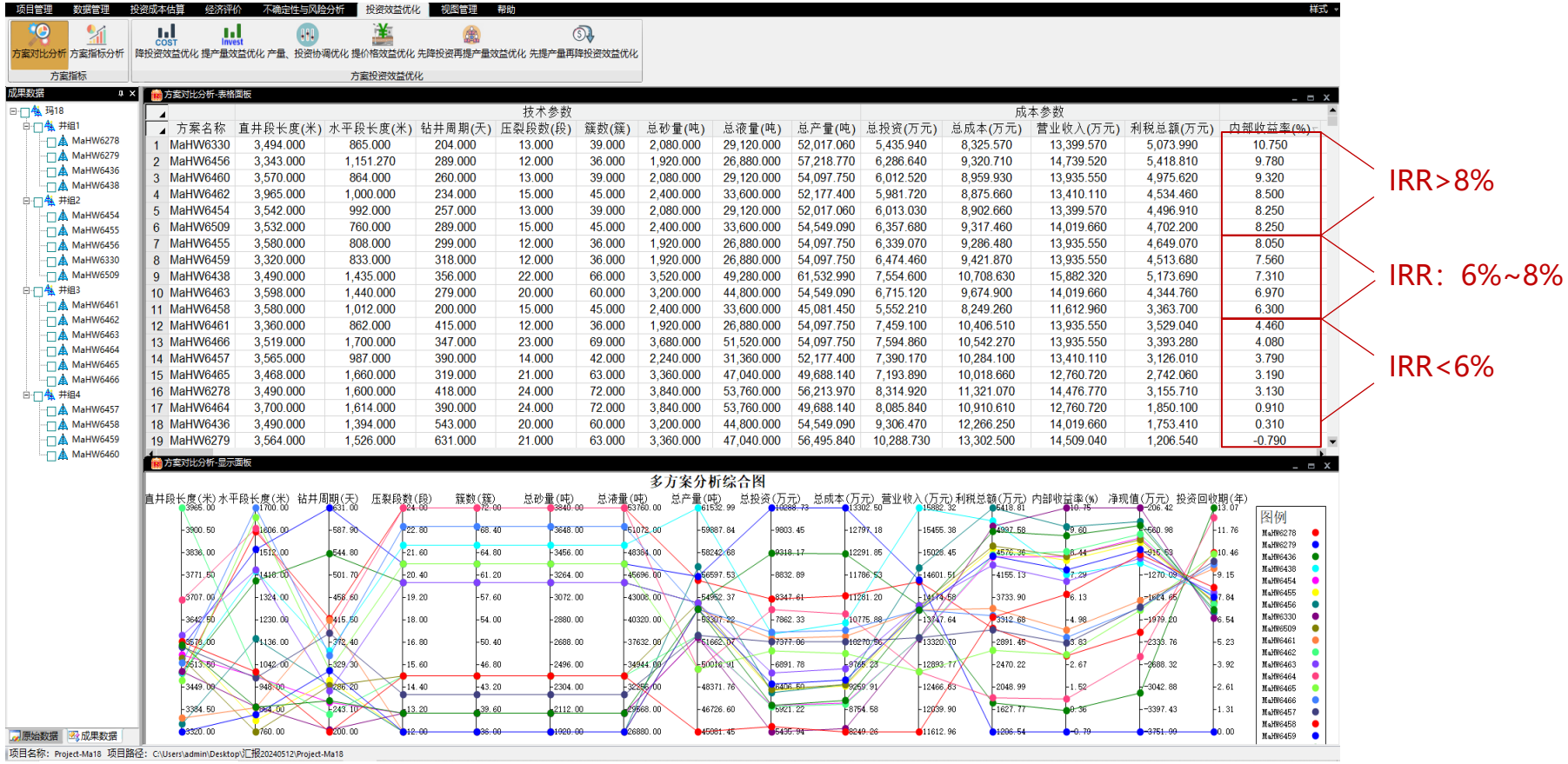
Forecast daily
oil-production curve



Forecast cumulative
oil-production curve

Economic Evaluation

Conducted economic evaluations at the single-well, platform, and block levels.

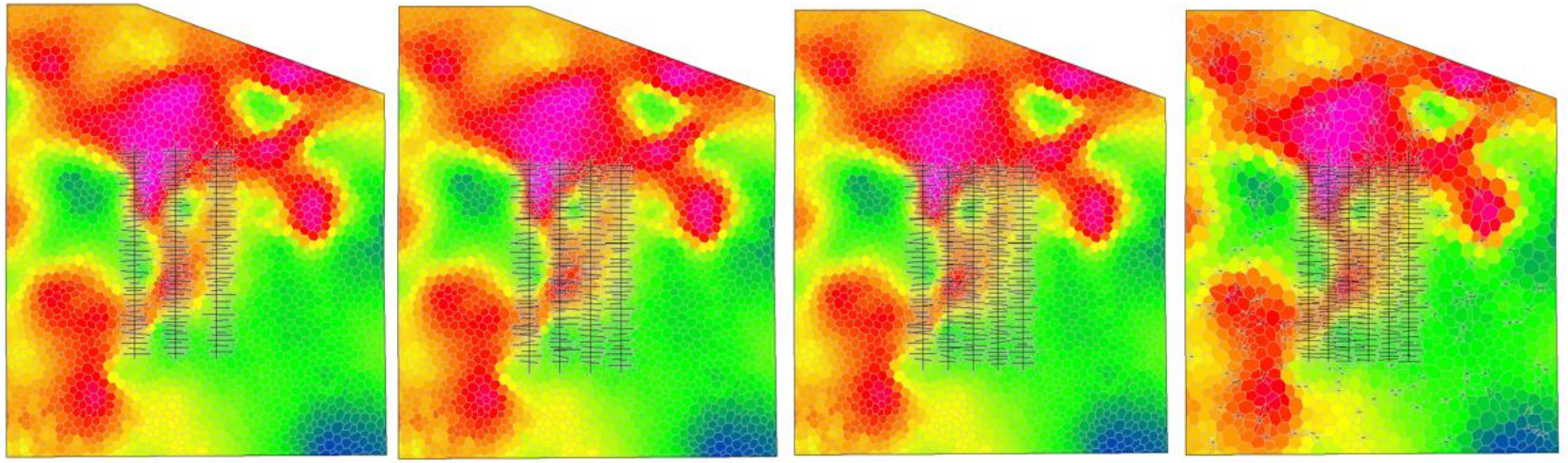


4. Optimization of Key Parameters

☐ Development deployment parameter optimization

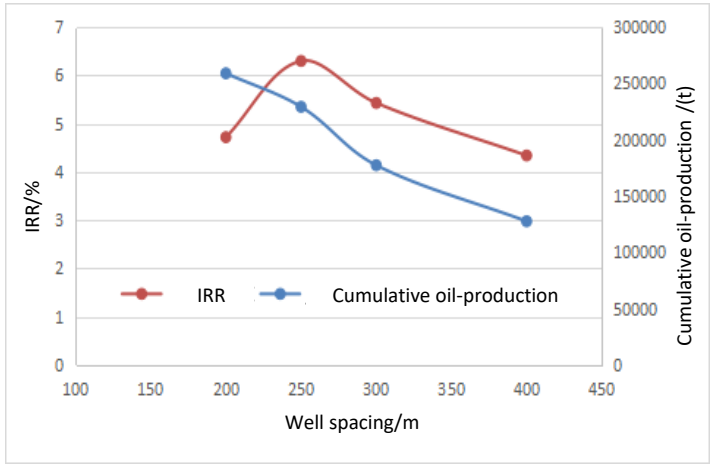
Conduct a collaborative optimization of target location, well placement, well pattern, well spacing/well count, well-array mode, and development strategy to maximize economic returns and obtain the optimal development-deployment parameters.

➢ Well spacing



400m well spacing, 3 wells | 300m well spacing, 4 wells | 250m well spacing, 5 wells | 200m well spacing, 6 wells

Diagram for different well spacings

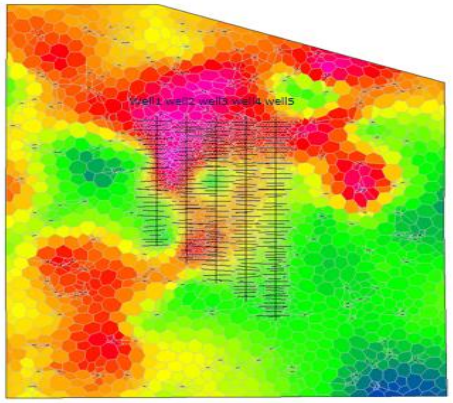


IRR vs. well-spacing curve

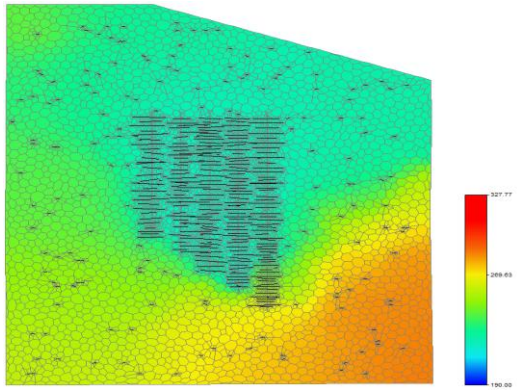
IRR

Drilling parameter optimization

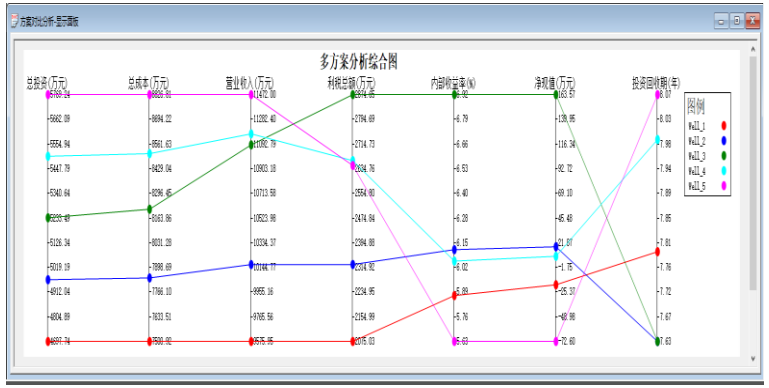
Collaboratively optimize well type, horizontal-well azimuth, lateral length, and lateral trajectory to achieve the best economic outcome and derive the optimal drilling parameters.



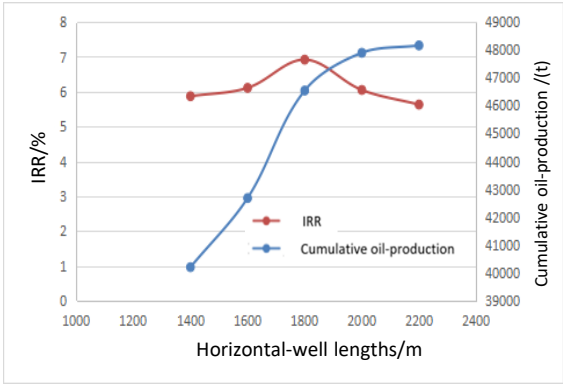
Different horizontal-well lengths



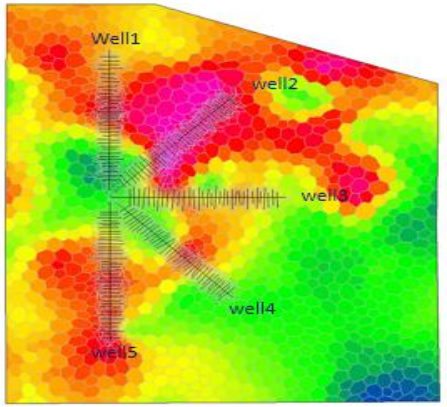
15-year simulated pressure-field distribution map



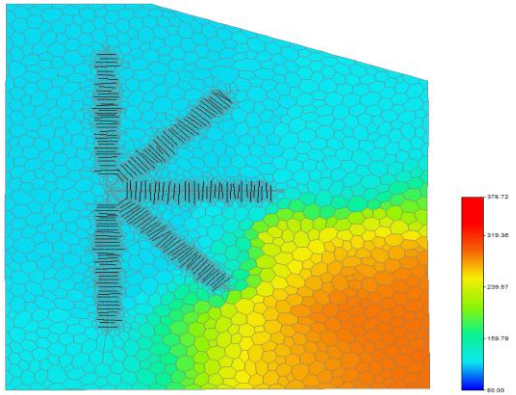
Economic-indicator comparison chart for different horizontal-well lengths



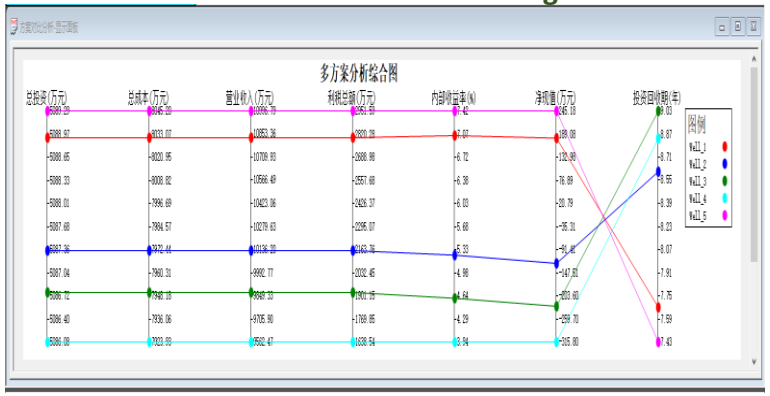
IRR vs. horizontal-well-length curve



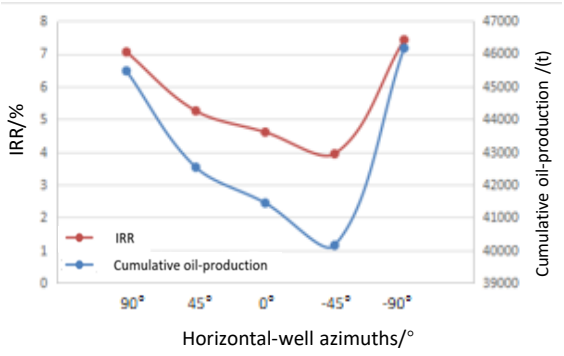
Different horizontal-well azimuths



15-year simulated pressure-field distribution map



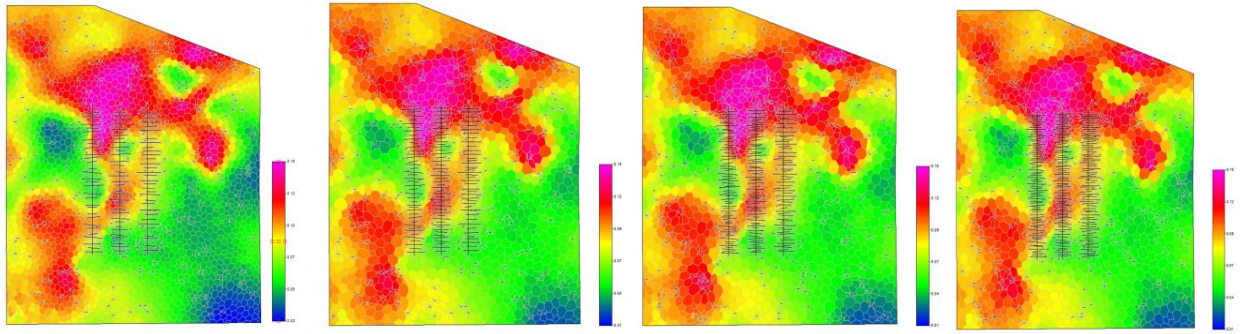
Economic-indicator comparison chart for different horizontal-well azimuths



IRR vs. horizontal-well-azimuth curve

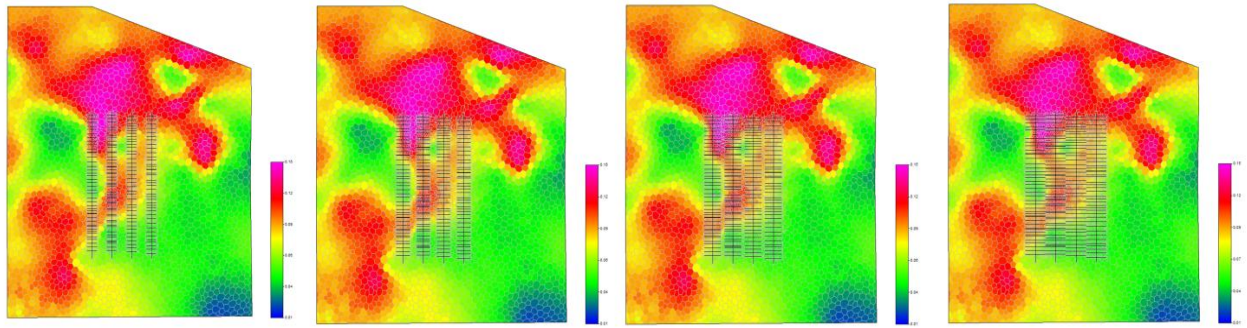
Fracturing parameter optimization

Carry out a joint optimization of fracturing stages (stage count/spacing), clusters (cluster count/spacing), fluid volume, proppant volume, and injection rate to maximize benefits and establish the optimal fracturing parameters.



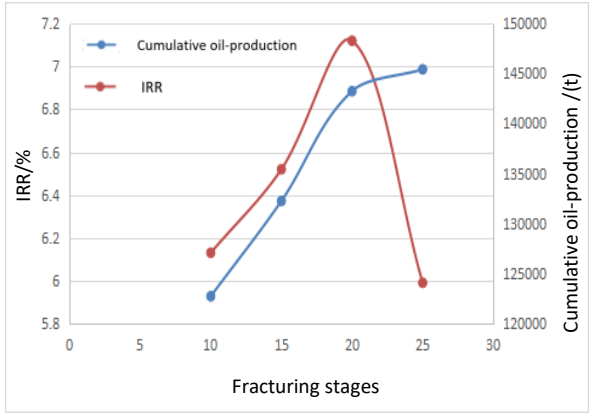
10 stages 15 stages 20 stages 25 stages

Diagram for different numbers of fracturing stages

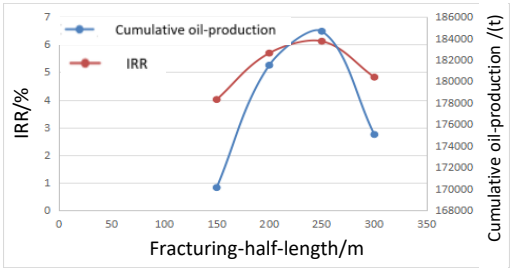


150 meters 200 meters 250 meters 300meters

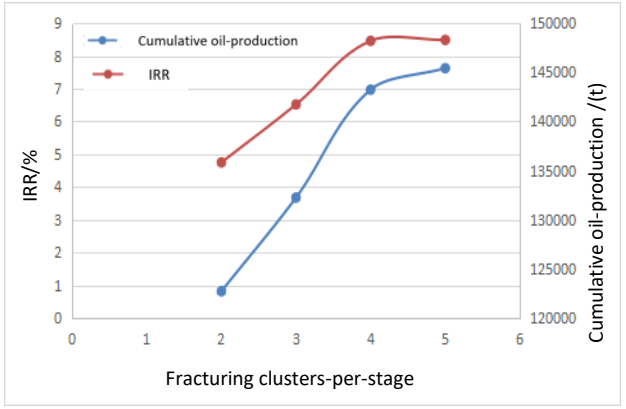
Diagram for different fracturing scales(changing Fracture half-length)



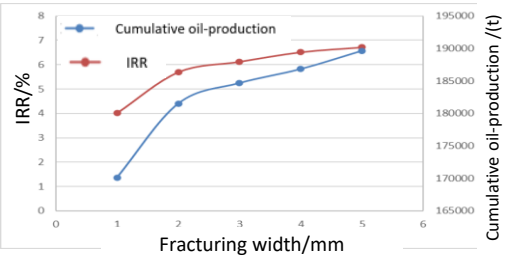
IRR vs. number-of-stages curve



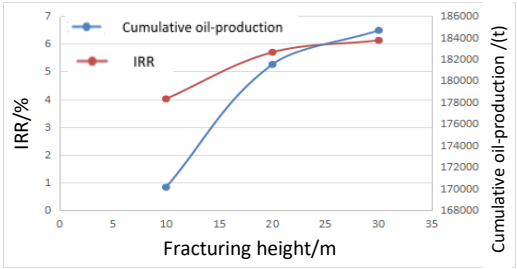
IRR vs. fracture-half-length curve



IRR vs. number-of-clusters-per-stage curve



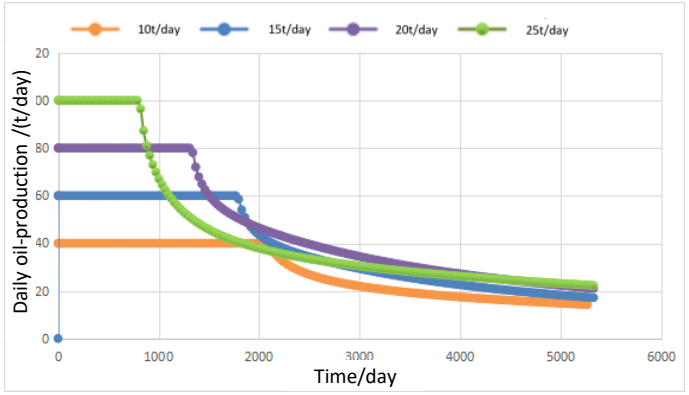
IRR vs. fracture-width curve



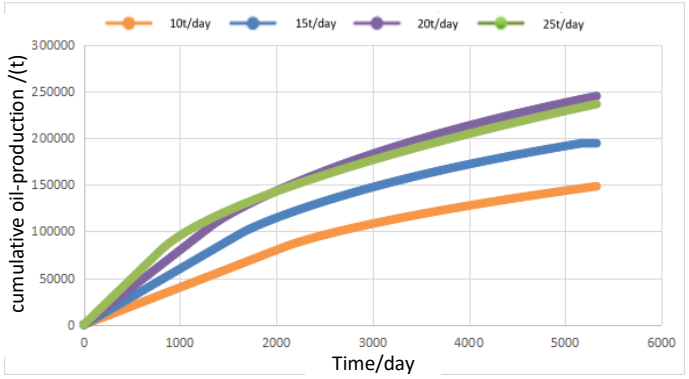
IRR vs. fracture-height curve

Production parameter optimization

Collaboratively optimize individual-well production allocation and flowing bottom-hole pressure to attain the best economic performance and identify the optimal production parameters.



Forecast daily oil-production curve



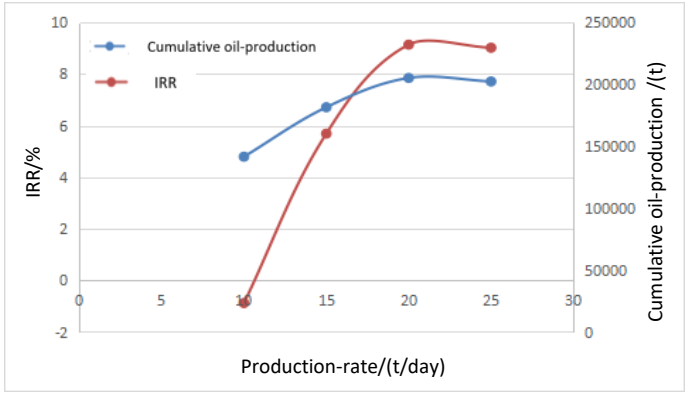
Forecast cumulative oil-production curve

Table of economic-indicator results under different production-rate

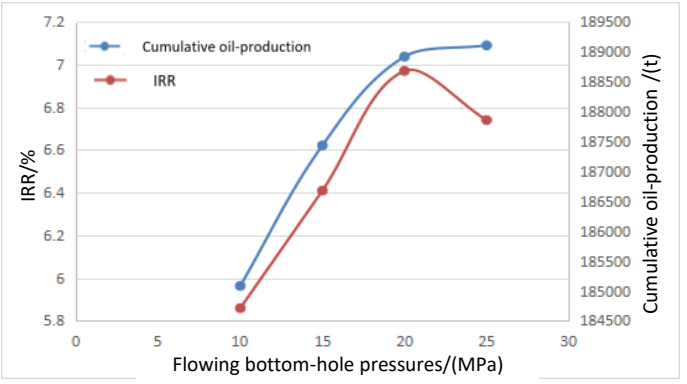
Rate	IRR (%)	NPV (10^4yuan)	PBP (Year)
10 t/d	-0.88	-4713.13	12.04
15t/d	5.69	-223.68	8.4
20 t/d	9.14	2312.57	6.77
25 t/d	9.02	2145.87	6.73

Table of economic-indicator results under different flowing bottom-hole pressures

Pressure	IRR (%)	NPV (10^4yuan)	PBP (Year)
10MPa	5.86	-103.73	8.73
15MPa	6.41	302.97	8.12
20MPa	6.97	682.64	7.59
25MPa	6.74	544.89	7.59



IRR vs. production-rate-allocation curve



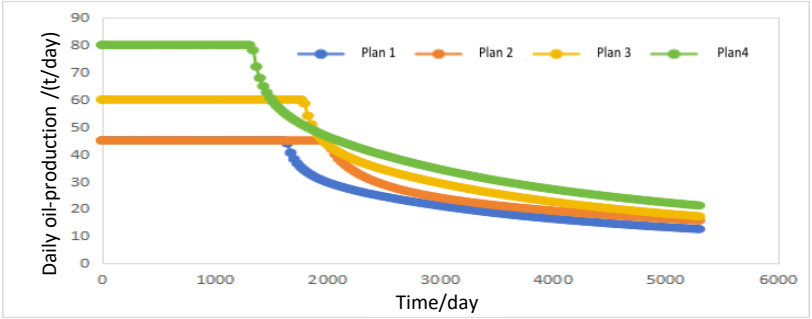
IRR vs. bottom-hole-flowing-pressure curve

5. Integrated optimization solution

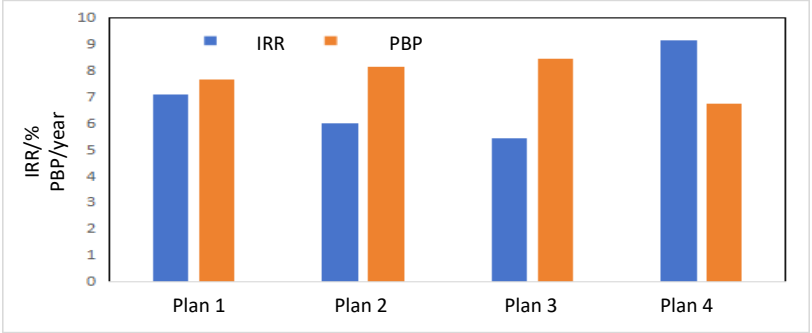
Key geo-engineering parameters across development deployment , drilling, fracturing, and production are assembled into multiple plans and subjected to multidisciplinary, integrated optimization aimed at maximizing economic return, yielding the optimal field-development plan.

Plan Performance Comparison Table

Plan	Number of Well	Well Space (m)	numbers of fracturing stages	numbers of fracturing clusters	Production Rate (t/day)	IRR (%)	NPV (10^4yuan)	PBP (year)
Plan1	3	400	20	60	15	7.12	608.02	7.66
Plan2	3	400	25	75	15	5.99	-6.06	8.14
Plan3	4	300	20	60	15	5.43	-405.01	8.47
Plan4	4	300	20	60	20	9.14	2312.57	6.77



Daily oil production curves for different plans



Bar chart of IRR comparison across plans

6. Conclusion

Integrated geo-engineering, multi-disciplinary collaborative optimization is an effective pathway to cost-effective development of tight oil reservoirs.

Utilizing the systematic and real-time optimization capabilities of geo-engineering software can enhance single-well production/EUR, reduce capital expenditure, and achieve profitable development.

Thank you for your attention.

Comments and suggestions are welcome.