A Geoengineering TASK Long-March to Great Success
--- *Development of a Unique & Giant Gas Field in Kucha Basin*

Wang Qing Hua
Director, Exploration Department
PetroChina Tarim Oilfield Company

Schlumberger
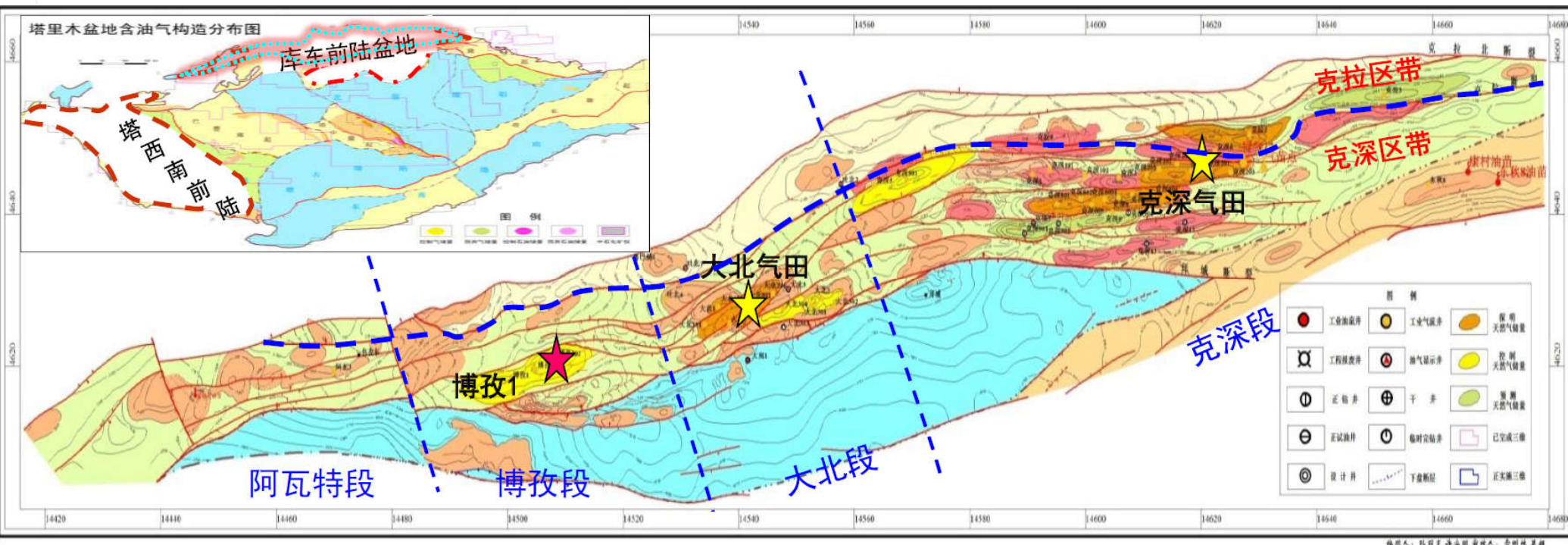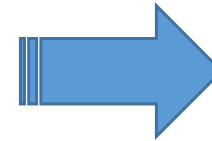
Kucha Foreland Basin – The Strategic Area For Gas

- E-W: 450 km, S-N: 30-125 km, Area: ~42,700 km^2
- Estimated Gas Resources > 3.0×10^{12} m^3, Oil Resources > 6.0×10^8 ton.

All-In-One: Challenge of Extreme

1. Complex Thrust-nappe Structure
2. Extremely Harsh Surface Conditions
3. Super Deep
4. Thick Conglomerates on The Top
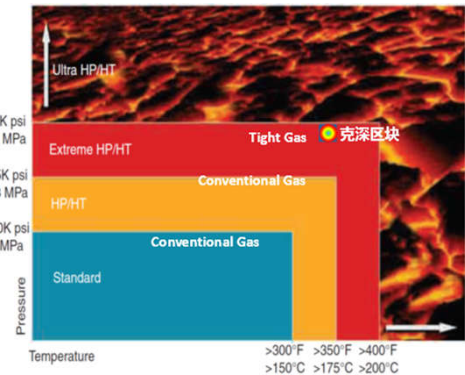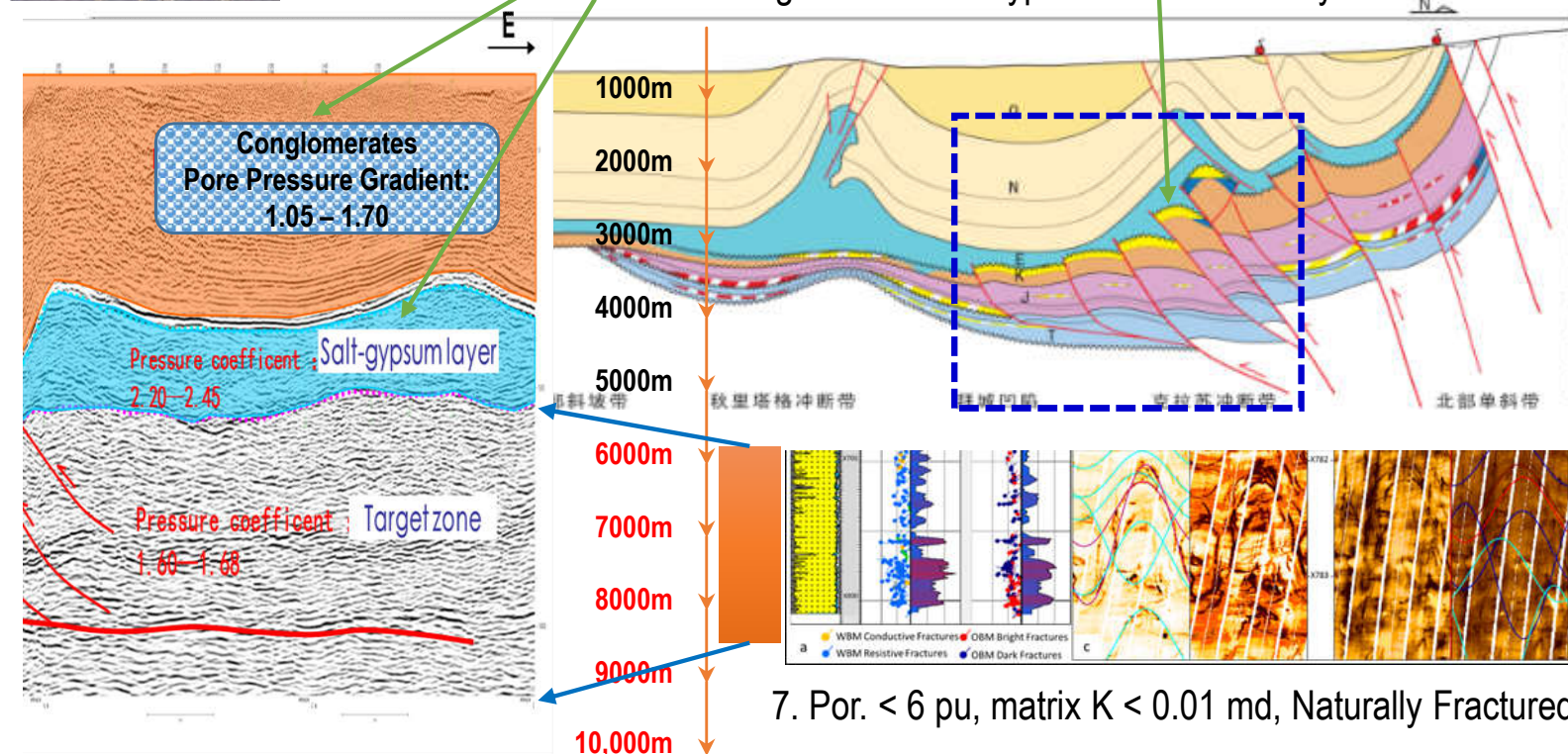5. Heterogeneous Salt-Gypsum Laminated Layers

(Seismic) Characterization & Evaluation

Drilling & Completion Engineering

Production & Economics

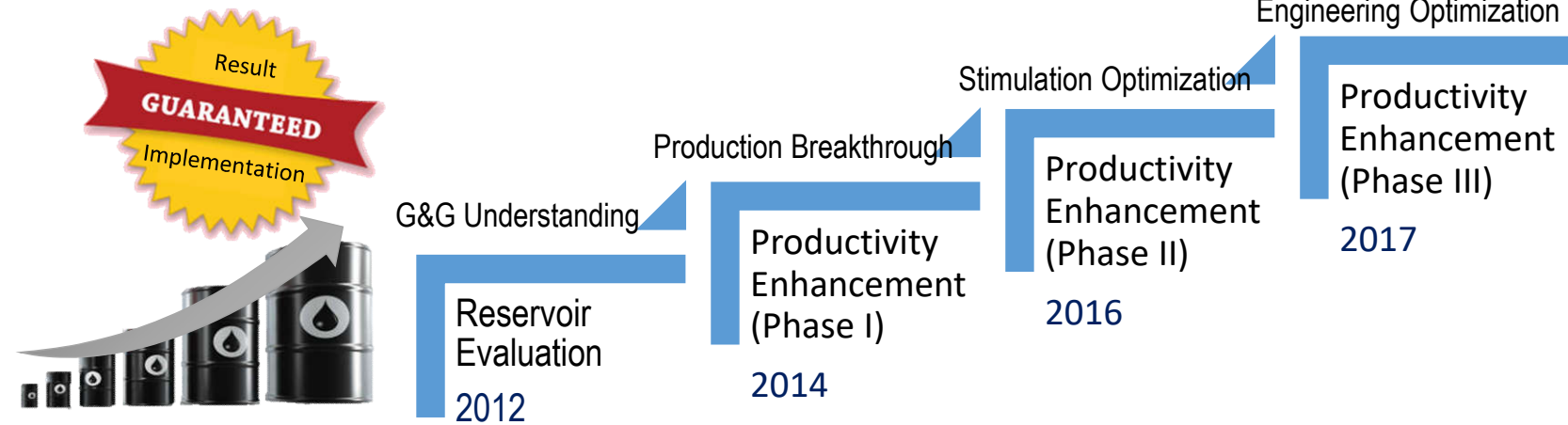Conglomerates Pore Pressure Gradient: 1.05 – 1.70

Salt-gypsum layer

Pressure coefficent: 2.20 – 2.45

Pressure coefficent: 1.60 – 1.68

Target zone

6. HPHT: >120 MPa, >150 C°

7. Por. < 6 pu, matrix K < 0.01 md, Naturally Fractured

"TASK" Geoengineering Study Project

"TASK" = PetroChina TArim and Schlumberger Kuqa

Production Enhancement

Result
GUARANTEED
Implementation

Engineering Optimization

Stimulation Optimization

Production Breakthrough

G&G Understanding

Reservoir Evaluation
2012

Productivity Enhancement (Phase I)
2014

Productivity Enhancement (Phase II)
2016

Productivity Enhancement (Phase III)
2017

Research
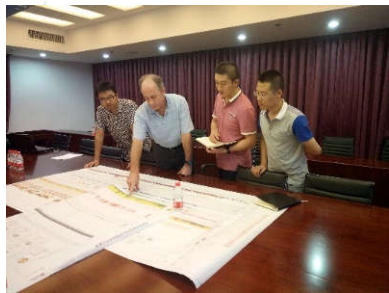
Engineering

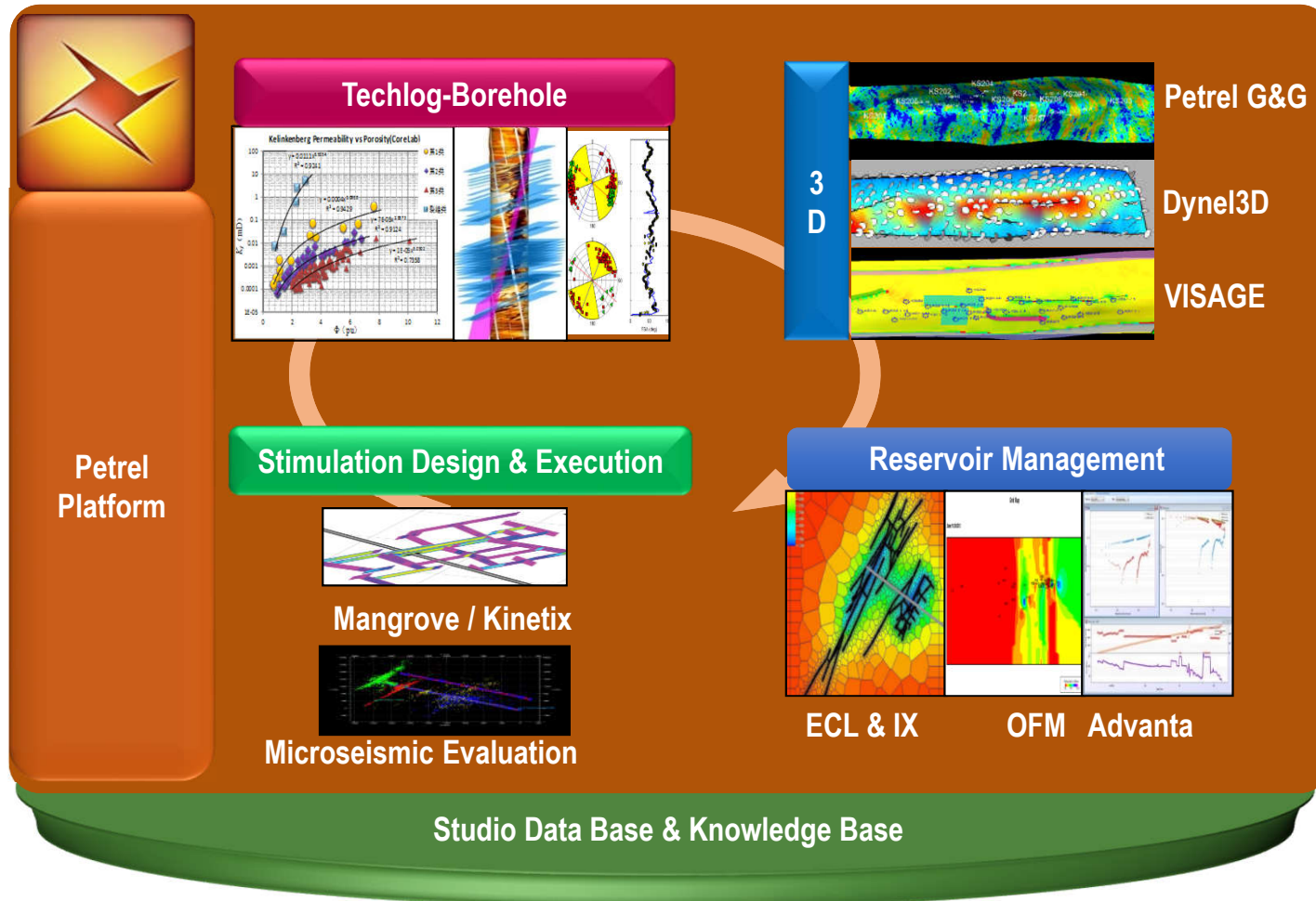# TASK Geoengineering Study Project
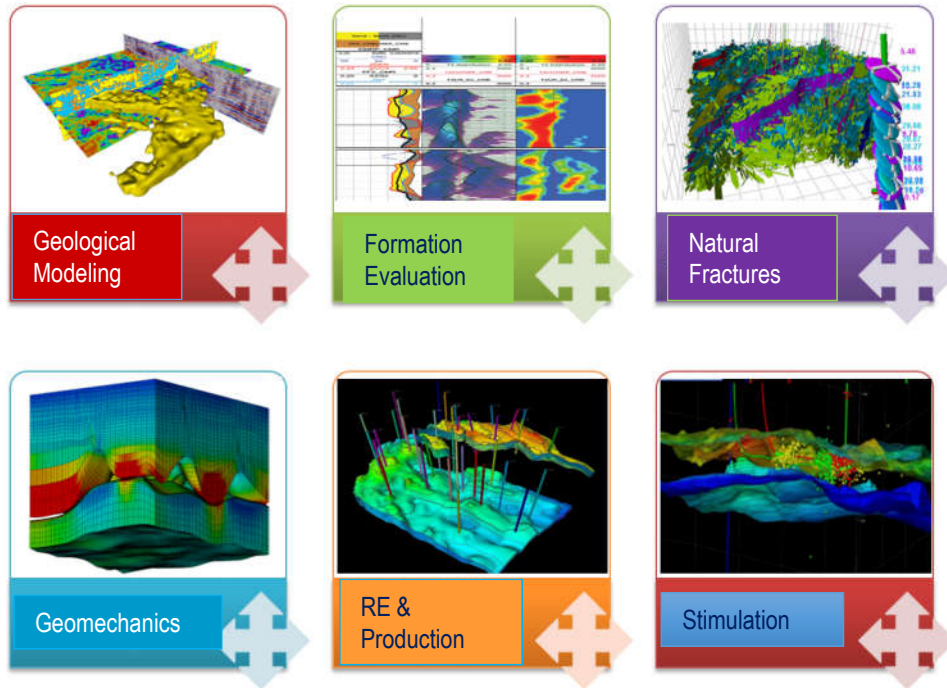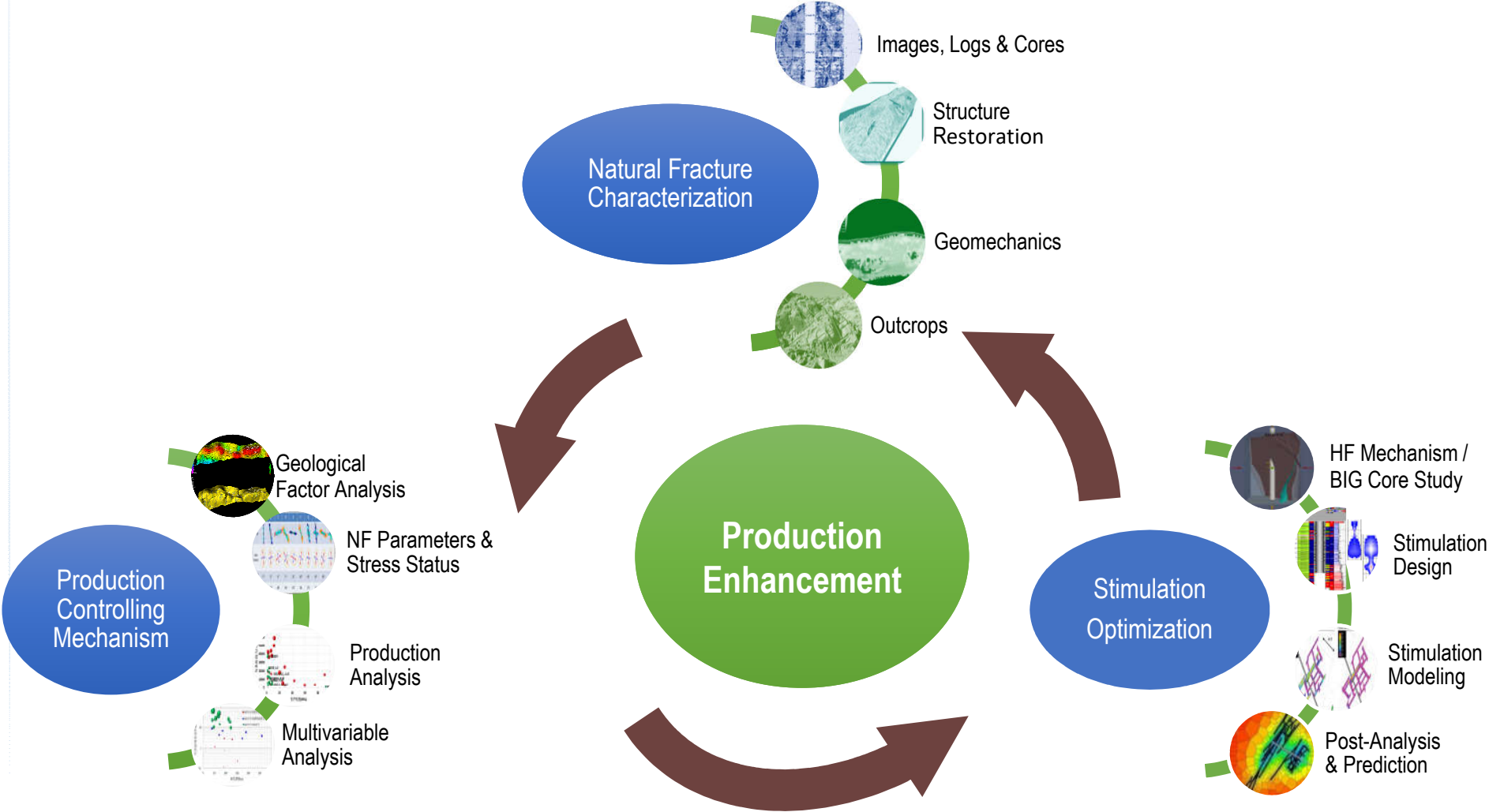

Study Elements
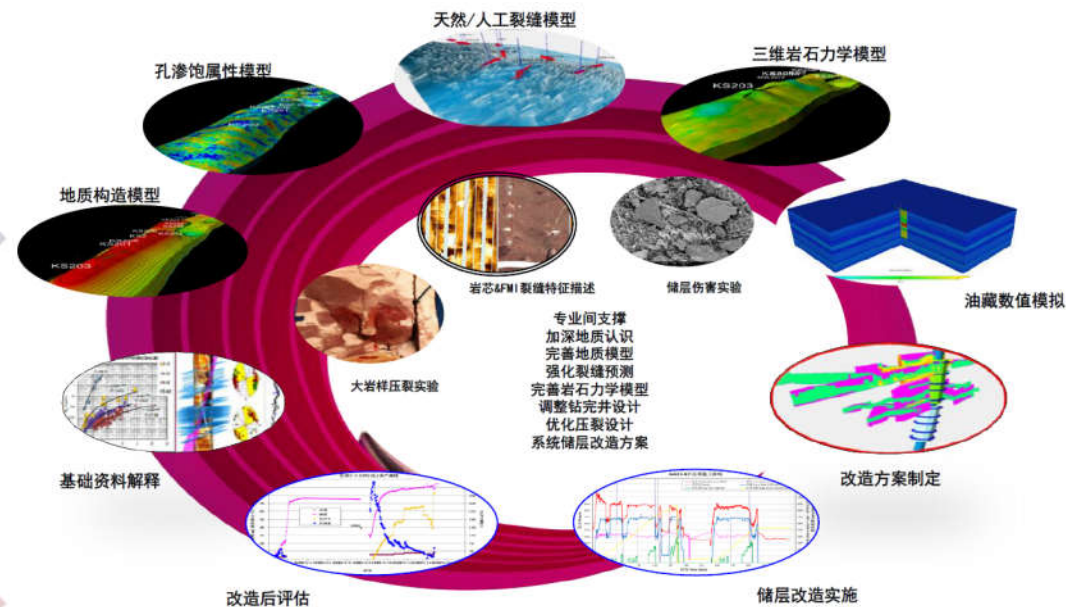
Study Workflow

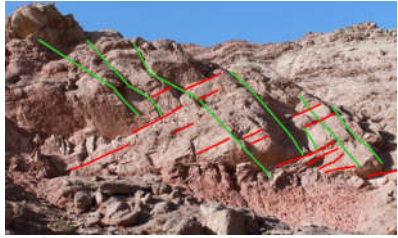# TASK Geoengineering Study: Software Integrated Solution

Three Critical Parts for Production Enhancement

Natural Fracture Characterization
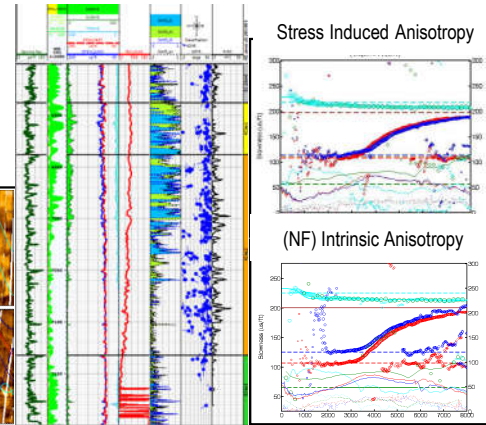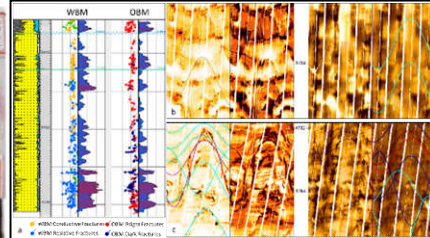
Outcrops

Cores

Images & Logs

Stress Induced Anisotropy

(NF) Intrinsic Anisotropy
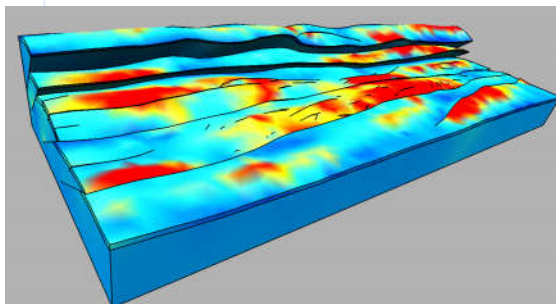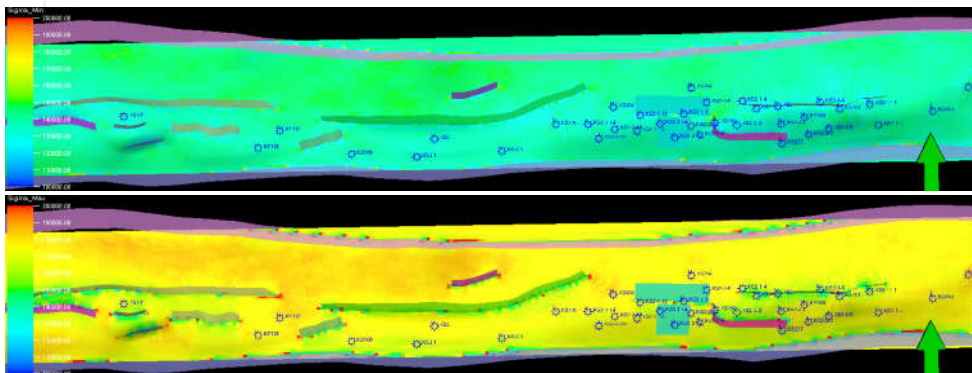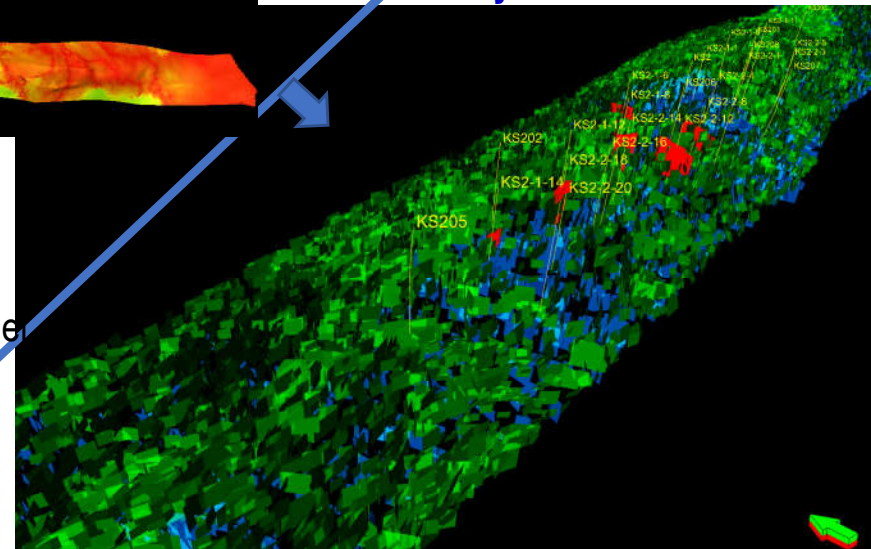
NF Evaluations
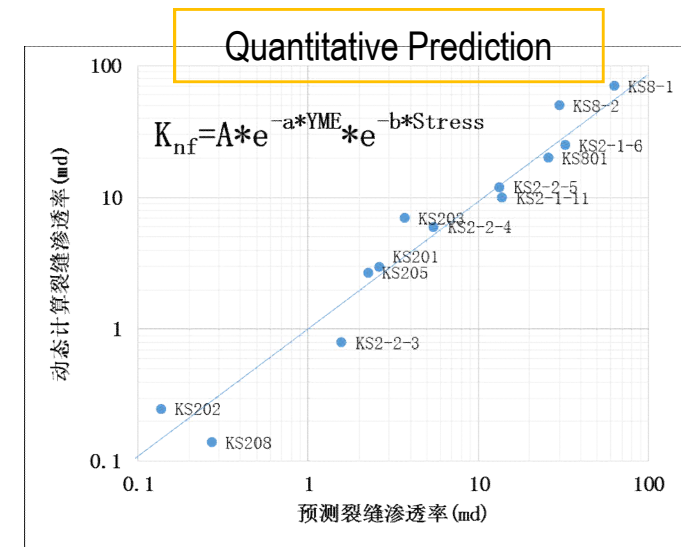(Parameters & Effectiveness)
Techlog
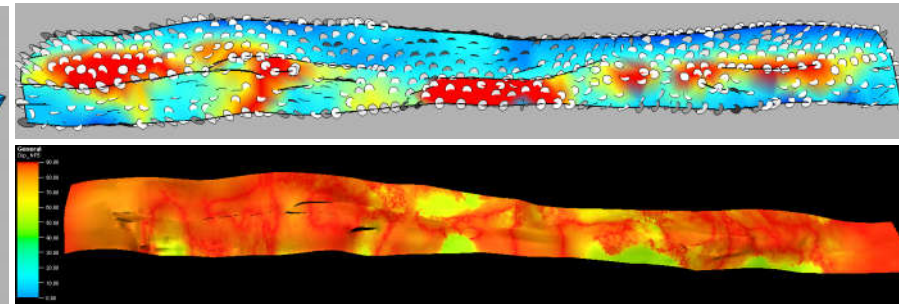
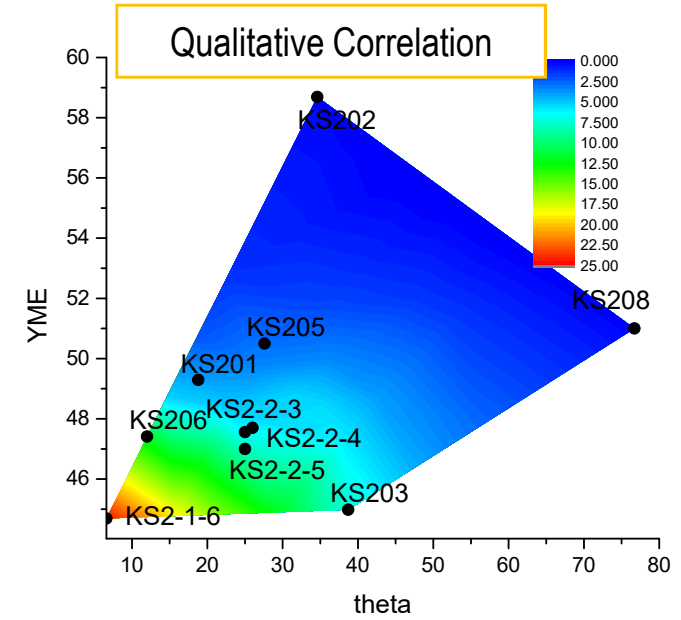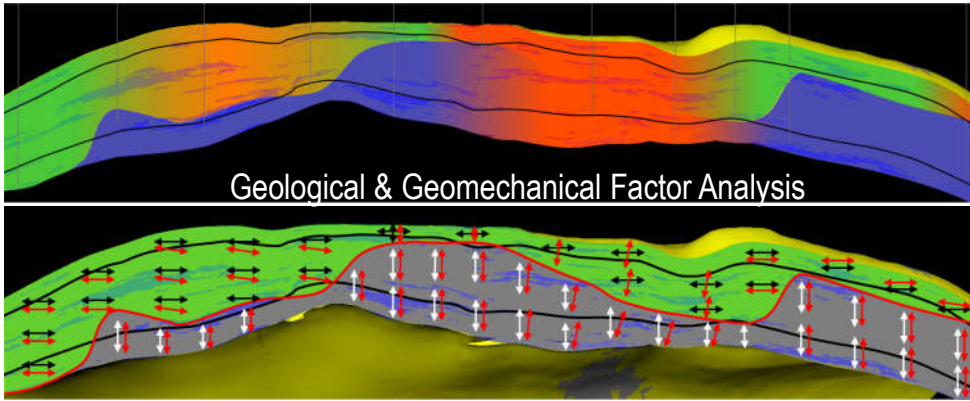Structure Restoration
, Paleo Stresses, NF Prediction
Dynal3D

3D Stress Model
VISAGE

Production Controlling Mechanism

Geological & Geomechanical Factor Analysis

Qualitative Correlation

YME / theta

KS202, KS208, KS205, KS201, KS206, KS2-2-3, KS2-2-4, KS2-2-5, KS203, KS2-1-6

0.000 2.500 5.000 7.500 10.00 12.50 15.00 17.50 20.00 22.50 25.00

NF & Stress Relationship

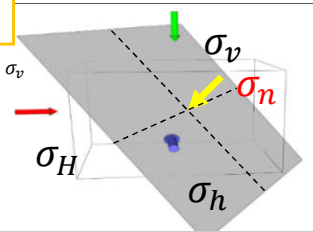| Well	A	B	C	D	E	F	G	H		
NF Strike										
Stress Direction										
NF-Stress Angle	0°	5°	8°	9°	20°	40°	40°	45°	68°	80°
Production	637	680	600	766	875	256	179	50	143	6

$$\sigma_n = l^2 \cdot \sigma_H + m^2 \cdot \sigma_h + n^2 \cdot \sigma_v$$

$$a_c = \frac{a_0}{1 + 9\sigma_n/\sigma_{nref}}$$

$$K_f = \frac{a_c^3}{12}$$

σ_v σ_n σ_H σ_h

Production Analysis

Quantitative Prediction

动态计算裂缝渗透率(md) / 预测裂缝渗透率(md)

$$K_{nf} = A * e^{-a*YME} * e^{-b*Stress}$$

KS8-1, KS8-2, KS2-1-6, KS801, KS2-2-5, KS2-1-11, KS203, KS2-2-4, KS201, KS205, KS2-2-3, KS202, KS208
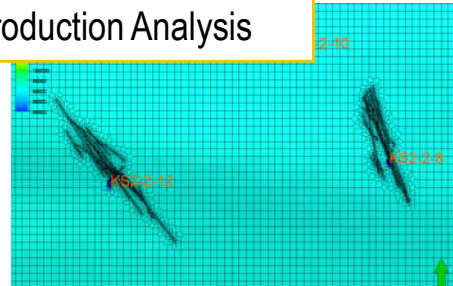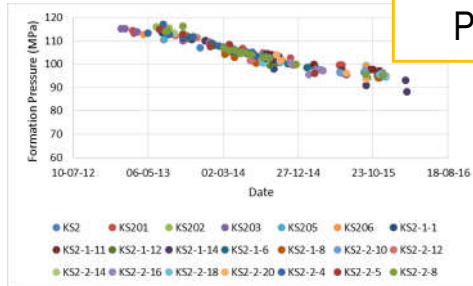
Stimulation Optimization

Big Core Studies
Fracturability, NF & HF Interactions, Impacts of HF Fluids

HF Modeling & Parametric Study

Engineered Completion Design
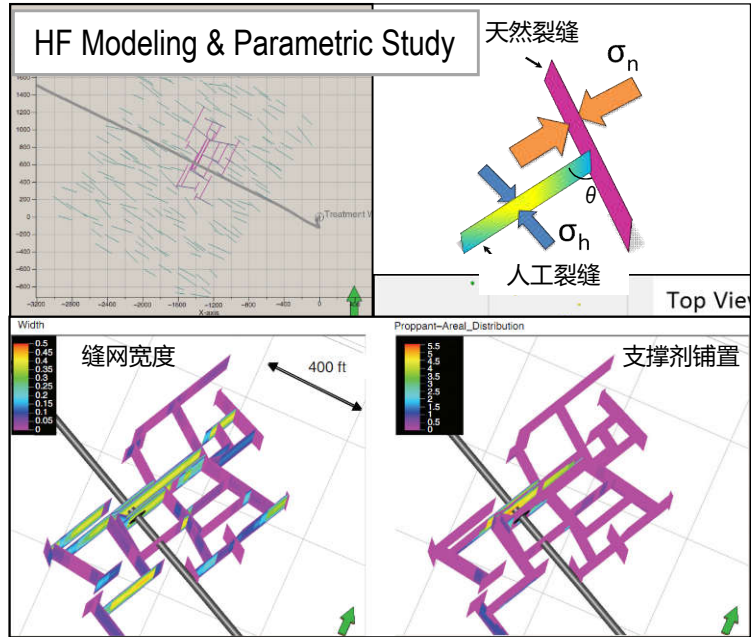
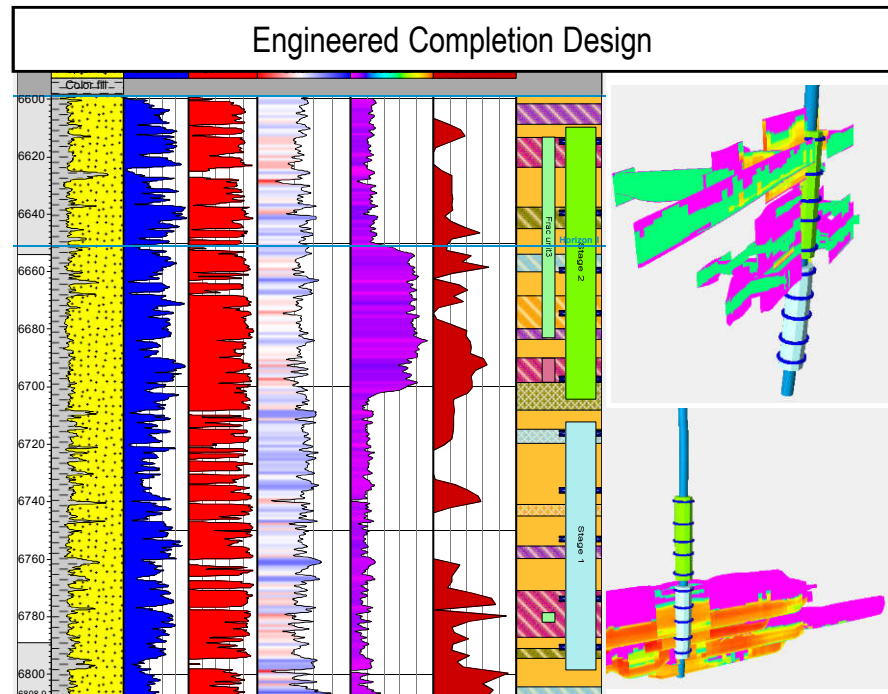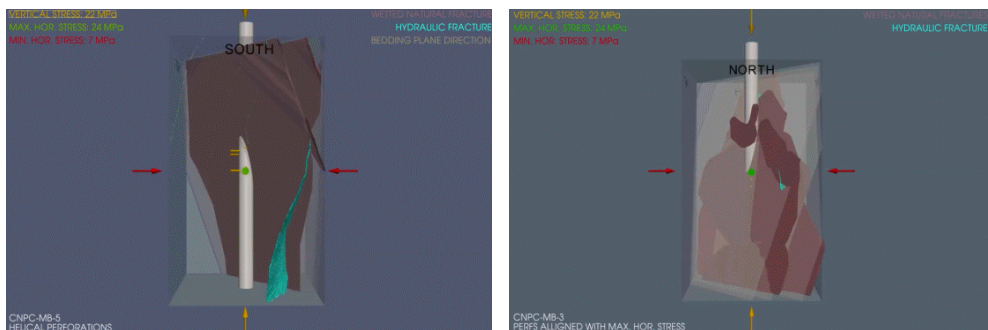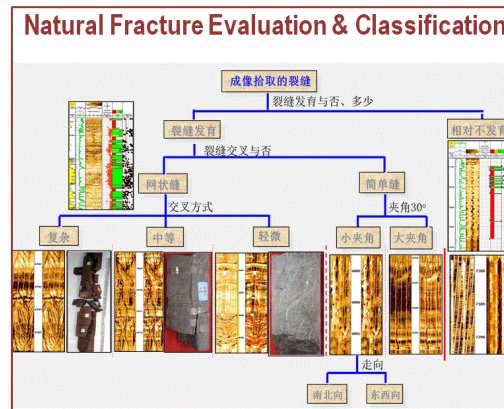Integrated Post-Frac Analysis & Optimization
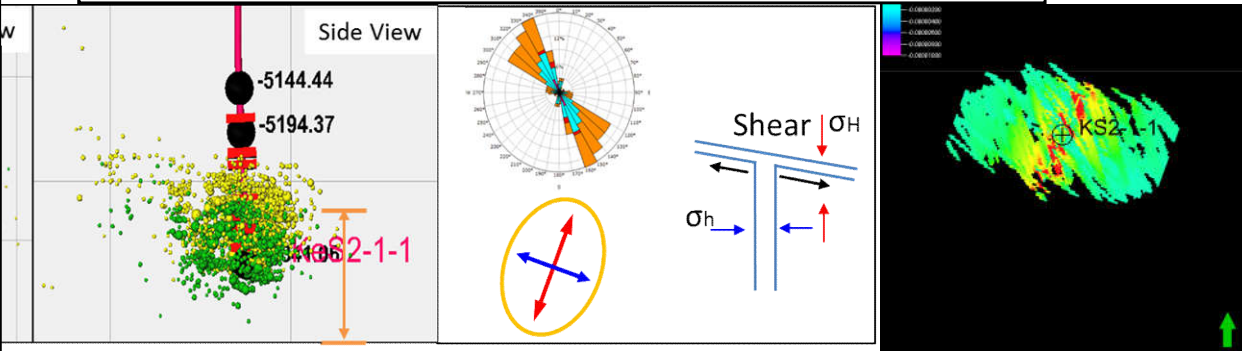
Outstanding Technique Achievements for Engineering Applications:

GURU Guided Rapid Completion Optimization Methodology as Example

克深高温高压裂缝性致密砂岩储层改造优化方法
(Version: 2016)

Natural Fracture Evaluation & Classification

成像拾取的裂缝

裂缝发育与否、多少

裂缝发育   相对不发育

裂缝交叉与否

网状缝   简单缝

交叉方式   夹角30°

复杂   中等   轻微   小夹角   大夹角

走向

南北向   东西向

Note 1：NF Type Classification

| 类别	复杂网状	中等网状	轻微网状	小夹角-东西	小夹角-南北	大夹角
典型井	KS8-1	KS8	KS11	KS508	KS505	KS10
校正裂缝密度	9.93	5.85	6.2	1.83	7.8	2.35
交叉缝条数	171	81	42			
地应力方向						
裂缝走向						
裂缝倾角 Theta	80	83	83	69	81	60
	45	40	48	15	26	69
Theta分布						
Theta偏度	0	0.11	-0.19	1.4	1.1	-1.28
Theta标准差	27	26.4	22.8	13.5	11.2	16.4
AOF均值/万方	1770	608	256/388	34/227	195	3、14
AOF/万方	1846	561	281.2	17.1	140	24.8

Note 2：Effective Permeability Calculation Equation

$K_{nf} = A * e^{-a*YME} * e^{-b*Stress}$

- A= 21.23
- a= -0.30
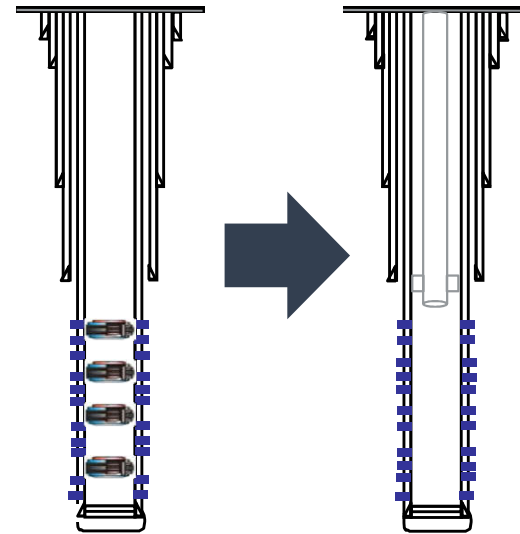- b= -0.14
- YME：储层段（泥质含量小于15%）平均杨氏模量
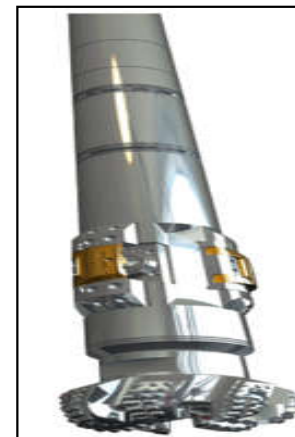
TASK Project – Beyond Study

Upgraded HPHT Per. System – Lab Tests in Doll Research
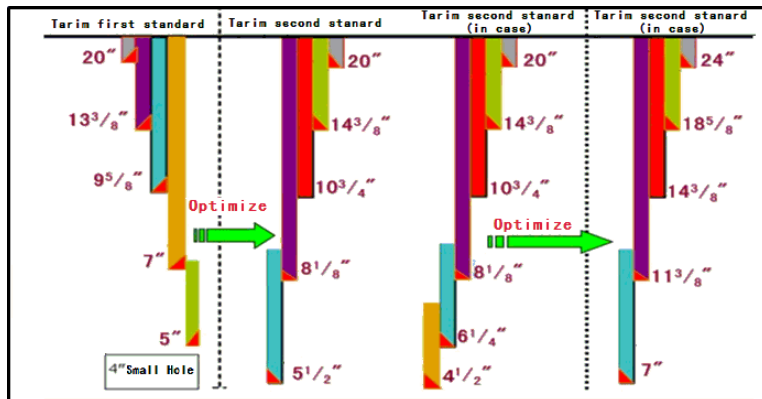
Optimized Casing Programs

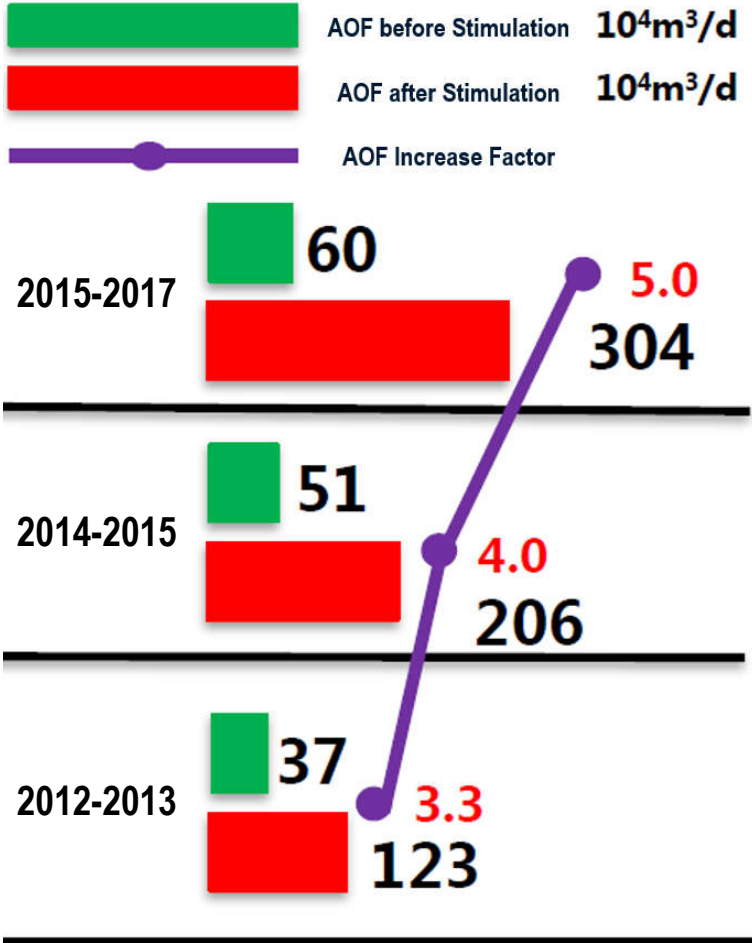Optimized Lower Completion for Stimulation

Vertical drilling technology

Engineered Drilling & Completion Fluids Designs

TASK Project – Notable Contributions to Great Achievements

10th IPTC Excellence in Project Integration Award Finalist

Conclusions

- PetroChina Tarim Oil Company Has Successfully Overcome The Challenge Of Extreme To Economically Develop Giant Gas Resources In Kucha Basin.

- Software Integrated Solutions Have Notable Contribution to This Great Success

- Geoengineering Integration Is Proven As One Effective Approach

- The Geoengineering TASK Long-March Is An Exceptional Model

- The Long-Term Cooperation Between PetroChina Tarim and Schlumberger Is Truly Win-Win

Thanks

Q&A