延长石油二氧化碳驱油提高采收率工程化示范

Engineering Demonstration of Yanchang Petroleum CO_2-EOR in Northern Shaanxi Area

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Shaanxi Yanchang Petroleum (Group) Co., Ltd

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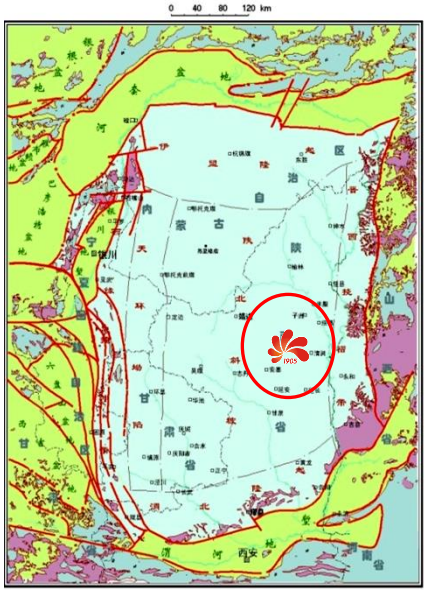
（一）延长石油集团概况 Brief Introduction

中国陆上发现最早的油田
The earliest oilfield discovered on the Chinses mainland



- 延长石油成立于1905年，是中国拥有石油和天然气勘探开发资质的四家企业之一； **Yanchang Petroleum founded in 1905 is one of the four qualified enterprises for oil & gas exploration in China.**
- 2007年原油产量突破1000万吨，已连续10年千万吨以上增产稳产，2016年天然气年产量23亿方； **The oil production has reached 10 MM ton in 2007, and maintained for 10 years. In 2016, the natural gas production was 2.3 billion m^3.**
- 业务涵盖油气勘探开发、煤矿开采、油气煤综合化工及科技研发等； **Its business include oil and gas E&D, coal mining, chemical industry, and R&D etc.**
- 2016年世界“500强”排名325位。 **Ranking 325th in Fortune Global 500 in 2016.**

油田开发 Oilfield

综合化工 Chemical industry

科技研发 R&D

（二）延长石油CO_2-EOR工程示范优势

Advantages for Yanchang CO_2-EOR Engineering Demonstration

1、一体化优势 Integrated Advantages

延长石油拥有**延长油田、延安气田及多个煤矿和煤化工企业**，可自主开展全流程一体化碳捕集、利用与封存项目。**Yanchang petroleum possesses Yanchang Oilfield, Yan'an Gasfield and several coal mines, coal-chemical plants, and can carry out the whole process of CCUS projects independently.**

特低渗油田
Oil Fields with Low Permeability

煤化工企业
Coal-Chemical Plants

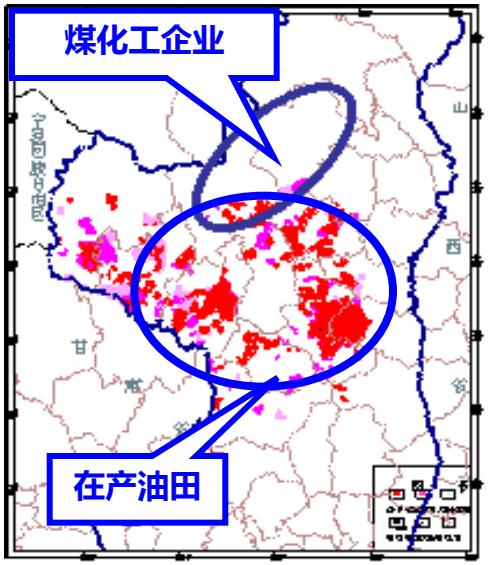
煤矿
Coal Mine

（二）延长石油CO_2-EOR工程示范优势

Advantages for Yanchang CO_2-EOR Engineering Demonstration

2、低成本优势 Low Cost Advantages

- **捕集成本低：**煤化工企业产生的CO_2浓度高达98.8%，捕集成本约**20美元/吨；** **Low cost of high concentration CO_2 (about 98.8%) from coal chemical plants (approx. 20 USD per ton).**
- **输送成本低：**在产油田与煤化工企业处于同一区域，输送距离**小于150公里。** **Low pipeline cost, less than 150 km between coal chemical plants and oil fields.**



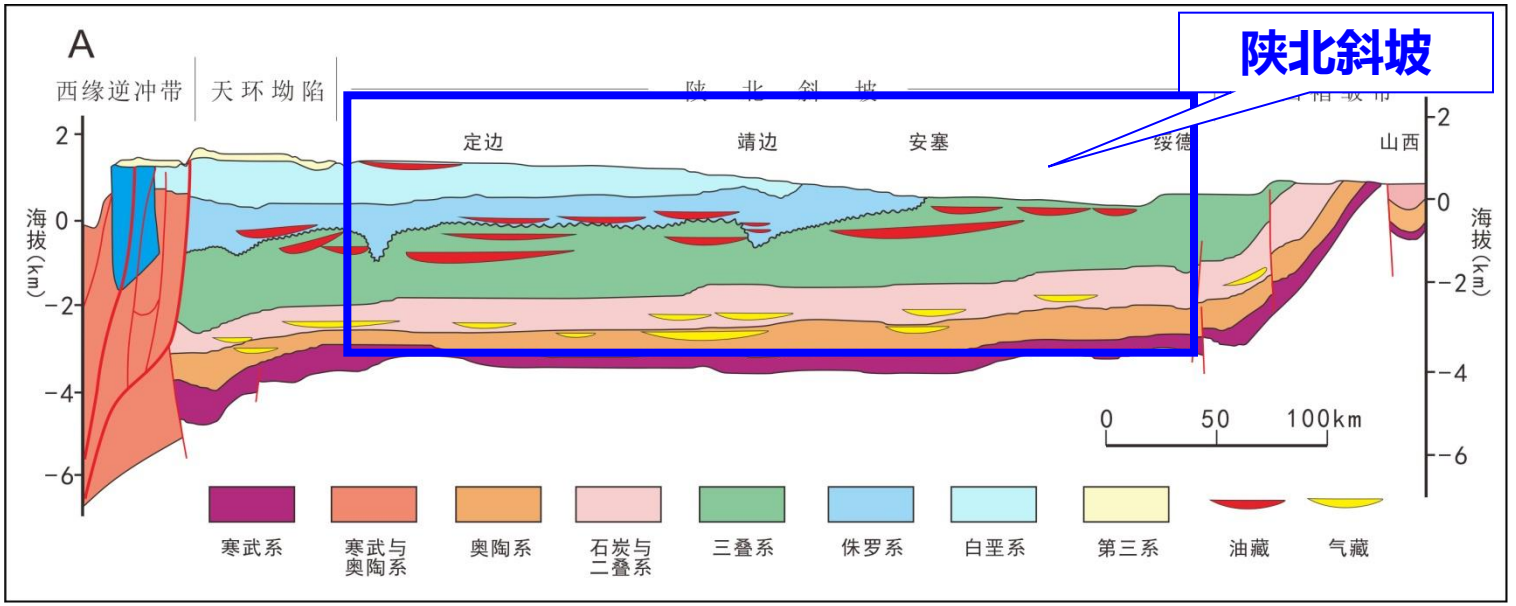
（二）延长石油CO_2-EOR工程示范优势

Advantages for Yanchang CO_2-EOR Engineering Demonstration

3、地质条件优势 Geological Advantages

- **应用前景广阔：**延长油田有**12亿吨探明储量**适合CO_2驱油，**可增加可采储量1亿吨以上**，支撑油田长期稳产；**Great prospects: Yanchang petroleum has over 1.2 billion tons of oil reserve is suitable for CO_2 EOR. And increase over 100 million tons of recoverable oil.**

- **封存条件好：**陕北斜坡构造简单，地层稳定，断层不发育，CO_2封存安全可靠。**Good store conditions: Shanbei Slope has simple structure, stable formation, and less fault developed, CO_2 sequestration is secured and reliable.**



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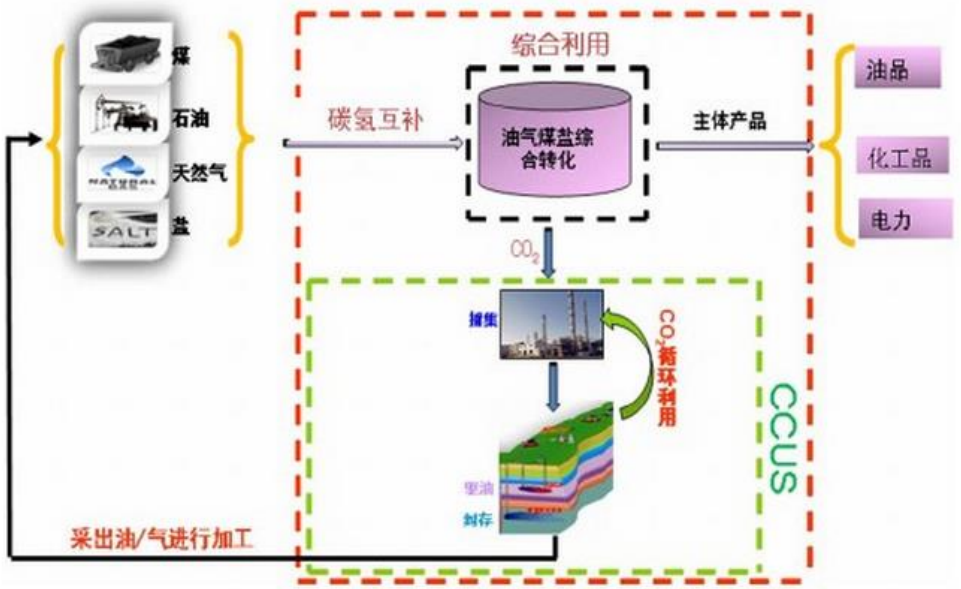
（一）发展模式 Development Patterns

2007年以来，延长石油先后承担了国家“十一五”、“十二五”科技支撑计划项目、 国家863计划、陕西省科技统筹计划等多个重大省部级项目。

Since 2007, Yanchang has carried out the national “11th five-year plan” “12th five-year plan” project, 863 national high-tech R&D project, etc.

初步形成了碳捕集、封存和特低渗油田提高采收率技术系列。**Initially forming the technologies on carbon capture, storage and EOR**



通过开展CCUS项目，将“碳捕集—碳封存—提高油田采收率”融为一体，是延长石油实现低碳、可持续发展的必然选择。**CCUS project integrates CO_2 capture, CO_2 storage and EOR altogether, and it will help Yanchang Petroleum. to realize low carbon and sustainable development.**

（二）工程示范进展 Progress of Engineering Demonstration

进展一：初步形成煤化工低成本CO_2捕集技术；

I. Initially forming low-cost CO_2 Capture from Coal-chemical Industry

➢ 实现高浓度CO_2低成本捕集。**Realizing CO_2 Capture with High Concentration and Low-cost.**

2012年延长石油榆林煤化公司建成5万吨/年的CO_2捕集装置，采用低温甲醇洗技术，实现低成本捕集。**In 2012, the 50000 tons p.a. CO_2 capture facility was completed at Yulin Coal-chemical Company by Rectisol technology. This is a low-cost CO_2 capture project.**

序号 NO	项目 Items	成本 Cost（CNY）
1	原料气 Feed Gas	0.00
2	电 Energy	52.00
3	脱盐水 Desalted Water	1.00
4	循环水 Circulating Water	3.00
5	液氮 Liquid Nitrogen	2.5
6	仪表空气 Instrument Air	3.0
7	折旧费 Depreciation Cost	50.52
8	维修费 Maintenance Cost	2.52
9	人工工资 Salary	2.80
Total		117.35

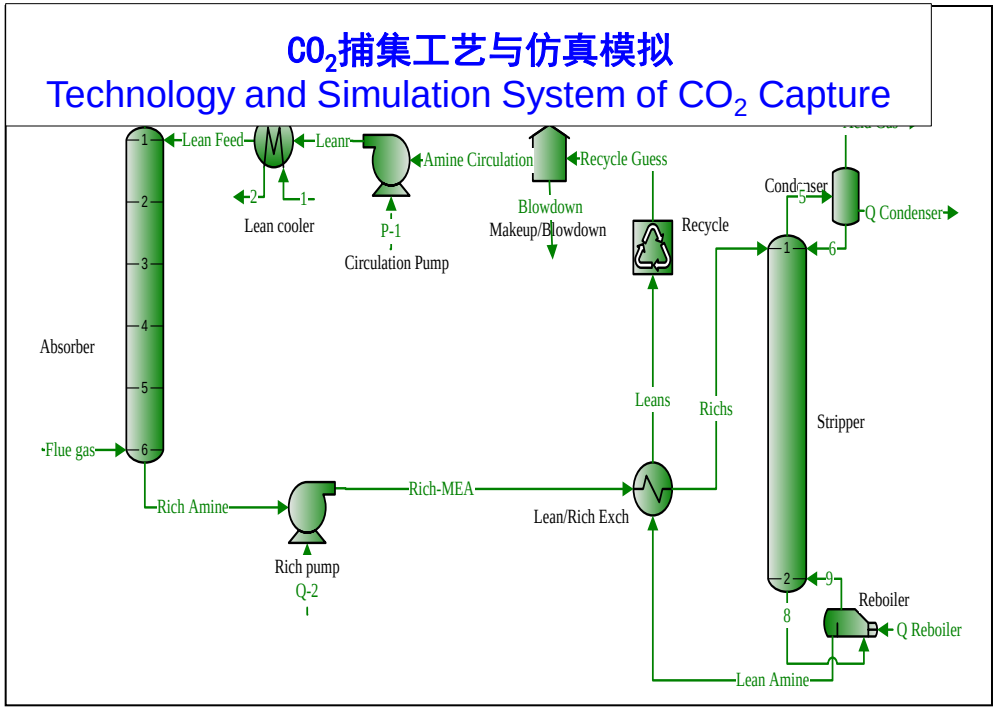
进展一：初步形成煤化工低成本CO_2捕集技术

I. Initially forming Low-cost CO_2 Capture from Coal-chemical Industry

➢ 针对低浓度CO_2捕集，已完成工业化工艺包开发和中试装置建设。**Industrialized process package and pilot plants have been developed for low concentration CO_2 Capture.**

多功能中试装置
Multifunctional Pilot Plant

CO_2捕集工艺与仿真模拟
Technology and Simulation System of CO_2 Capture



CO_2捕集能力近期将达到50万吨/年。

The total CO_2 capture capacity would be 500,000 tons p.a recently.

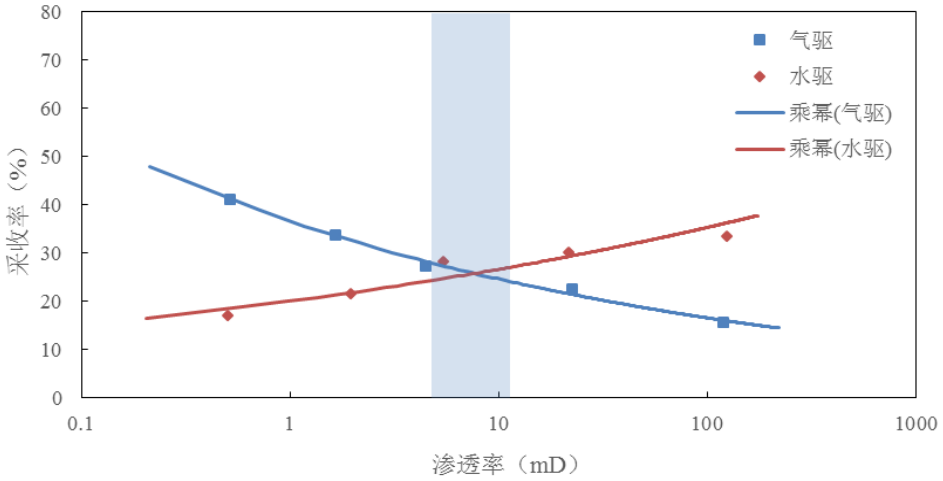
（二）工程示范进展 Progress of Engineering Demonstration

进展二：建立了特低渗透油藏CO_2驱油适应性评价体系

II. The feasibility evaluation system of CO_2 flooding in ultra-low permeability reservoir has been established.

- 揭示了CO_2驱采收率随渗透率变化规律。**Reveal the law of oil recovery ratio changing with the permeability during CO_2 flooding.**

气驱采收率随渗透率降低而提高，水驱采收率随渗透率降低而降低，气驱对特低渗油藏适应性更好；
The oil recovery ratio increases with the permeability decline by gas flooding, and decreases with the permeability increases by water flooding. So, gas flooding is more suitable for ultra-low permeability reservoir.



气驱与水驱的驱替界限
The critical point of displacemet

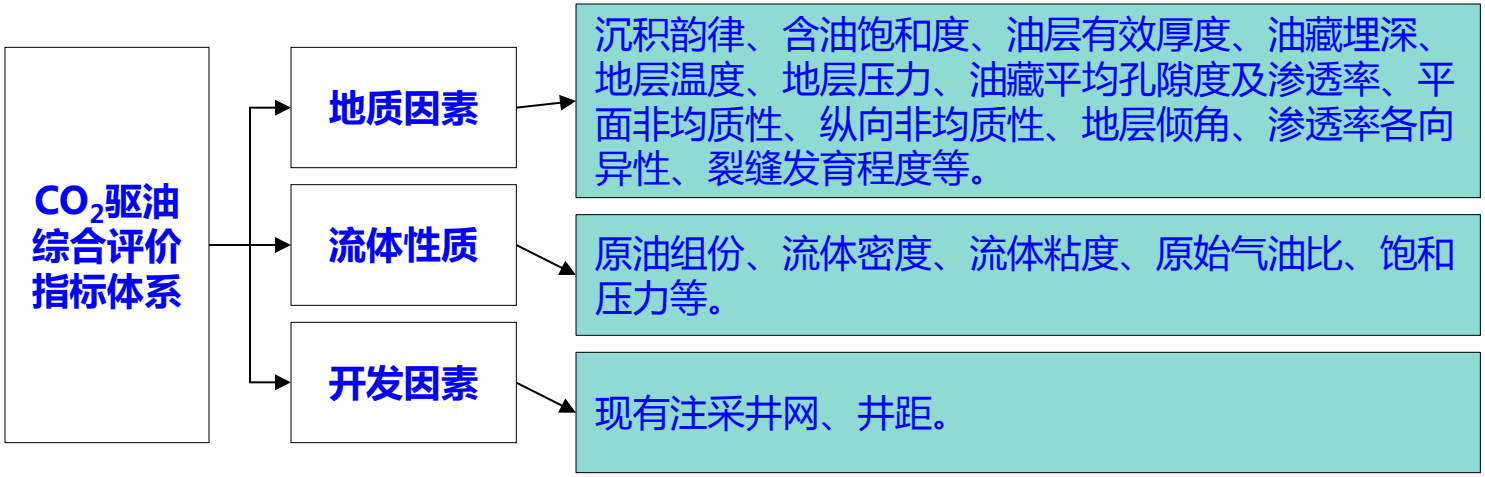
注气和注水开发的渗透率界限范围为 $8\sim10\times10^{-3}\mu m^2$
The permeability limit between gas and water injection is about $8\sim10\times10^{-3}\mu m^2$

进展二：建立了特低渗透油藏CO_2驱油适应性评价体系

II. The feasibility evaluation system of CO_2 flooding in ultra-low permeability reservoir has been Established.

- 建立了特低渗透油藏CO_2驱油适应性评价的**指标体系及方法**，综合考虑包含地质因素、流体性质和开发因素在内的**多项关键指标**。**We have established a method for feasibility study of CO_2 EOR in low-permeability reservoirs. which considered more key parameters.**

- 对延长油田**176个区块**进行了CO_2驱油适应性评价，结果表明**25亿吨**地质储量中，**12亿吨**适合CO_2驱油。**By applying this method, we have evaluated 176 blocks and the results show that 1.2 billions of oil reservoir is suitable for CO_2 EOR within 2.5 billion tones geological reserves.**

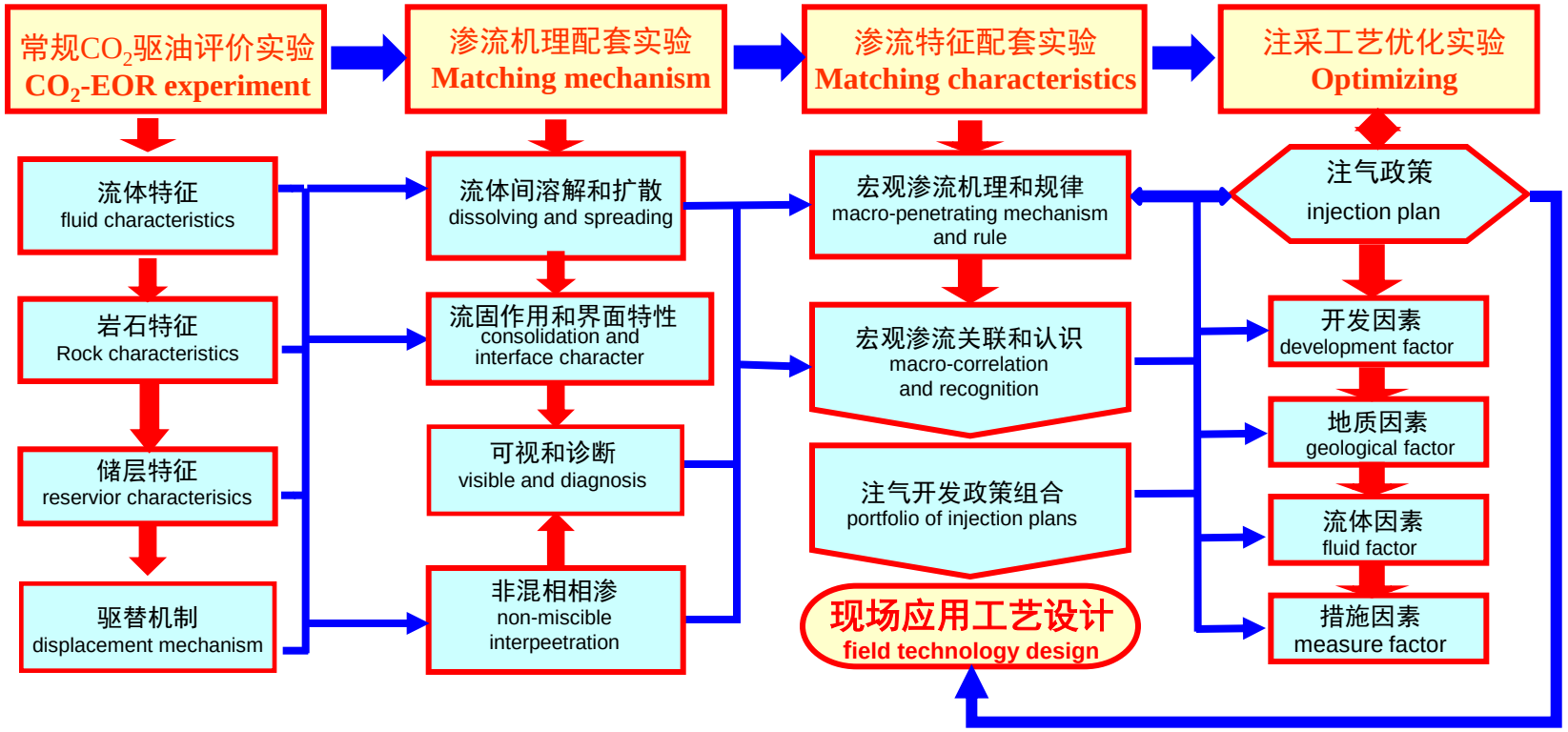


（二）工程示范进展 Progress of Engineering Demonstration

进展三：建立了特低渗油藏CO_2驱油室内实验评价方法。

III. Formed in-door experimental evaluation method of CO_2-EOR.

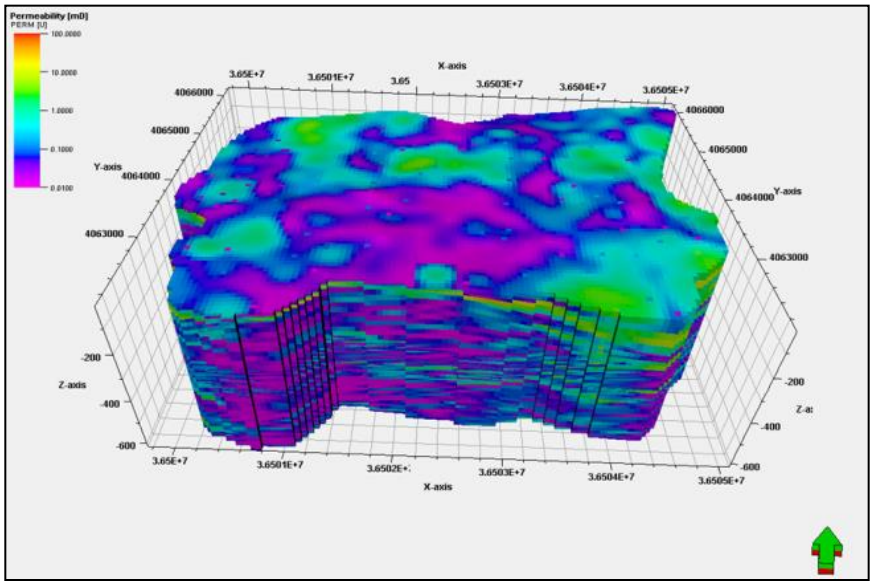
➢ 以室内物理模拟实验为基础，模拟地层条件CO_2驱替特征，建立了CO_2驱油实验评价技术体系。**Establishing the evaluation system of CO_2-EOR based on the simulation of formation condition in the indoor physical simulation experiment.**

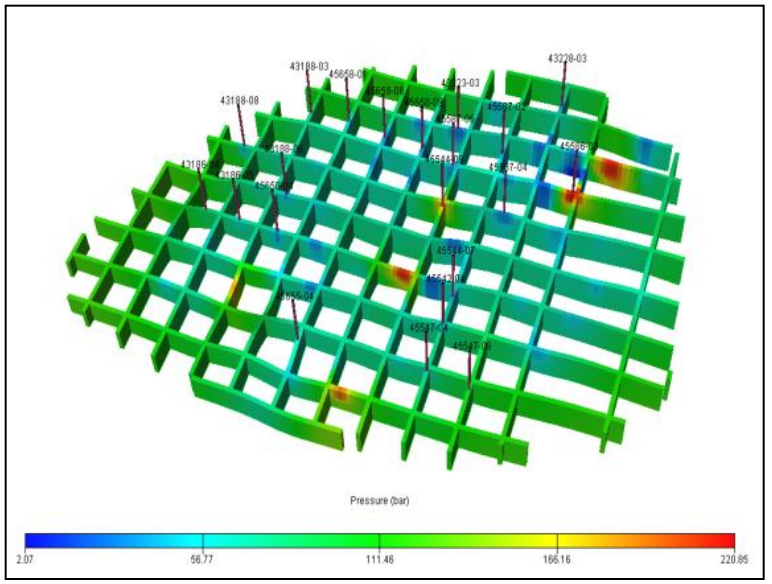


进展四：建立了CO_2驱油油藏工程设计方法
IV. Establishing the reservoir engineering design for CO_2-EOR

- 开展了精细油藏地质研究。**Carrying out the fine study on the reservoir geology.**

通过对精细地层对比和沉积相研究的基础上，对储层物性、含油性、封盖层及油藏压力等进行深入分析，建立了油藏精细地质模型。**After analyzing the reservoir property, oil-bearing probability, cap rock and pressure, the fine reservoir geological model was established based on stratigraphic correlation and sedimentary facies.**





进展四：建立了CO_2驱油油藏工程设计方法

IV. Establishing the reservoir engineering design for CO_2-EOR

➢ 基于精细地质研究，提出油藏工程方案设计

The reservoir engineering design based on the fine geological research.

以靖边油田乔家洼二氧化碳驱油示范区为例：

Example of Jingbian CO_2-EOR Pilot:

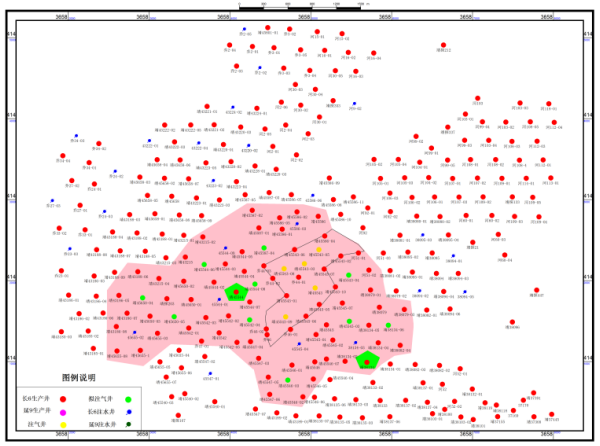
◆**试验井组：21个不规则反七点井组，21注，总井数98口；Test wells：**21 well groups with inverted seven-spot pattern, include 21 injection and 98 producing wells.

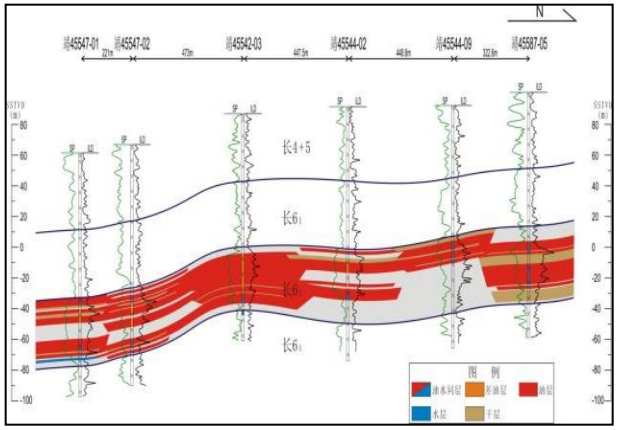
◆**注气方式：先连续注气，根据动态变化适时转水气交替，水气比1:1； Method of gas injection:** start with continuous gas injection, and turn to WAG with water-air ratio about 1:1.

◆**注气速度：10-15t/d液态CO_2；Optimal injection rate: 10**-15t/d.

◆**注气压力：注CO_2时井底最大注入压力不超过26MPa，井口注入压力大于16MPa； Injection pressure:** The maximum bottom injection pressure and the minimum surface injection pressure are 26Mpa and 16Mpa.

乔家洼油区CO_2试验区井位图





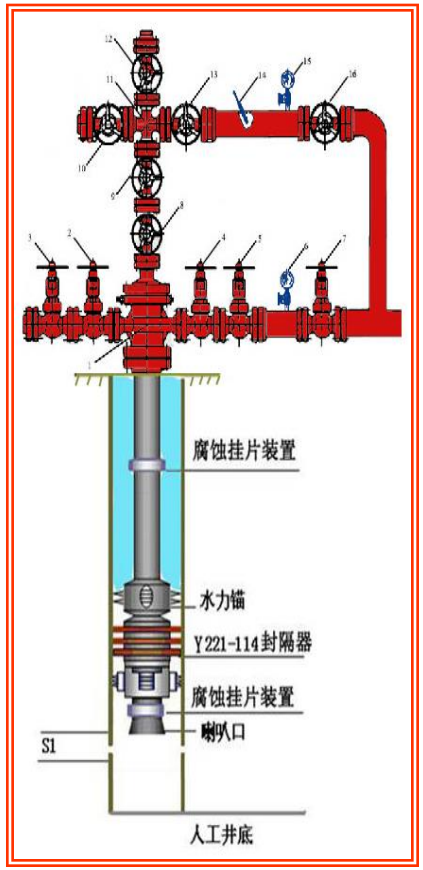
（二）工程示范进展 Progress of Engineering Demonstration

进展五：形成了注采管柱设计及防腐配套工艺技术。

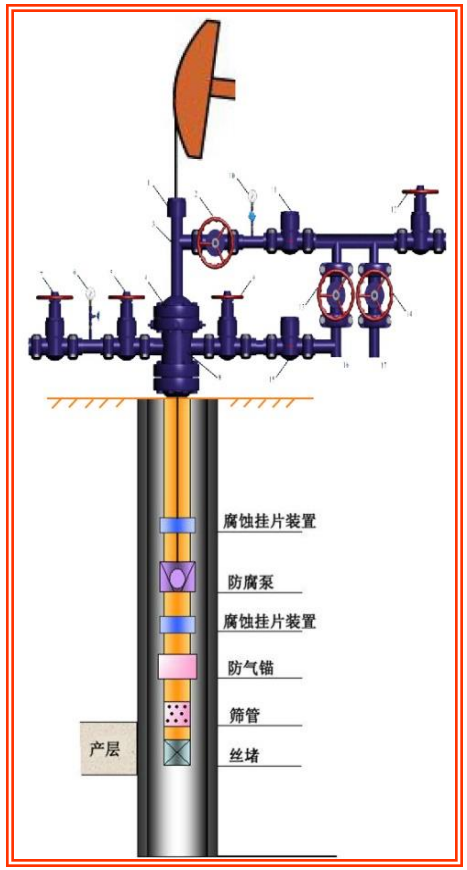
Formed practical design of injection-production string and anti-corrosion technology.

通过研究，优化了注采管柱设计，优选了“普通碳钢+缓蚀剂”防腐配套工艺。

By research, design of injection-production string has been optimized, and the anti-corrosion technology has been determined as “ordinary steel+ inhibiter”.



注入工艺系统
Injection system



采油工艺系统
Production system

（二）工程示范进展 Progress of Engineering Demonstration

进展六：初步形成CO_2驱油“三位一体” 安全监测体系
Initially forming the safety monitoring system of CO_2-EOR

油藏监测reservoir monitory

套管气监测 Casing-gas monitory

地表监测Surface monitory

土壤气监测 Soil monitory

大气监测Atmosphere monitory

在线监测Online monitory

地震监测 Seismic monitory

植物生理生化分析
Plant biochemical analysis

定期取样分析
Sample analysis

（二）工程示范进展 Progress of Engineering Demonstration

进展六：初步形成CO_2驱油“三位一体” 安全监测体系

Initially forming the safety monitoring system of CO_2-EOR

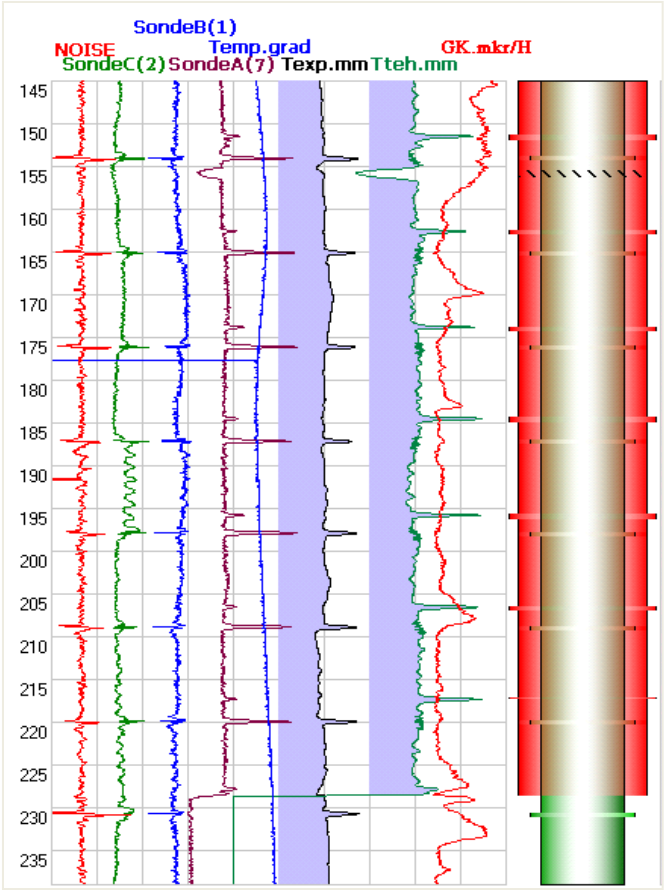
注气井井筒完整性监测：

Logging Items of CO_2 Injection well :

（1）四十臂井径测量，对应井段没有发现套管变形。**By forty arm caliper measures, without casing deformation.**

（2）电磁探伤测井，未发生套管严重腐蚀。**By electromagnetic detection logging , there is no serious casing corrosion .**

（3）声幅变密度测井，水泥胶结良好。**By the acoustic amplitude variable density logging tool, cement bond is good .**



（三）CO_2驱油工程建设情况

Progress of CO_2-EOR Engineering Demonstration

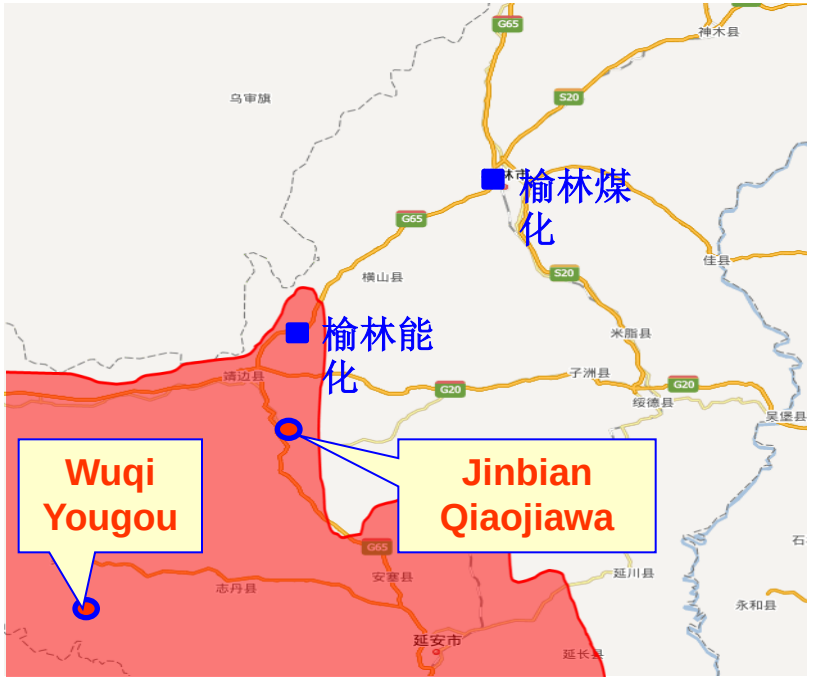
先导试验区选择 The selection of pilot test areas

- **靖边乔家洼油区：**距离气源地最近，运输成本低；典型的**衰竭式开采区块**；**Jingbian Qiaojiawa oil area:Close to CO_2 source, low transpotation cost, the typical depletion-drive Development block.**
- **吴起油沟油区：**适宜CO_2驱油区块的中心位置，便于推广；典型**注水开发区块**。**Wuqi oil area: Located in the center of CO_2-EOR suitable area, the typical water-flooding block.**

目标区块CO_2驱适应性排序

The ranking of feasibility of CO_2-EOR Blocks

序号 No	油田 Oilfield	油区 area	层位 formation	综合评价值 value
1	定边 Dingbian	樊学Fanxue	长6	0.858
	.....			
6	吴起 Wuqi	长官庙 Changguanmiao	长4+5	0.808
	.....			
44	靖边 Jingbian	乔家洼 Qiaojiawa	长6	0.698
	.....			
176	七里村 QiliCun	寨子沟 Zhaizigou	长6	0.499



1、靖边乔家洼试验区 Jingbian Qiaojiawa pilot test area

➢ CO_2驱油注气方案 CO_2 injecting scheme

◆ 先导试验方案（1.6Km²）

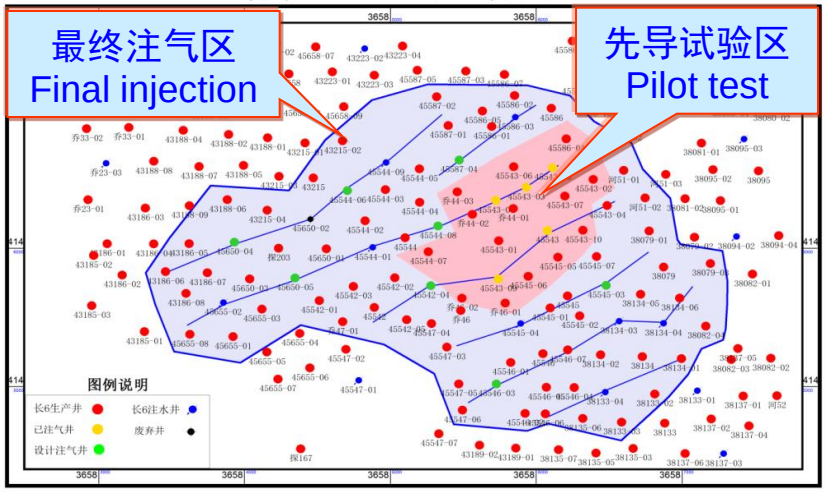
Pilot test scheme(1.6Km²):

- 5个注采井组；**5 well groups of injecting and producing.**
- 单井日注气量15t；**Inject 15 tons per well per day.**
- 最大井口注气压力16MPa。**The max gas injection pressure is 16 MPa in wellhead.**

◆ 最终注气方案：(6.6Km²)

Final injection scheme (6.6Km²)

- 21个注采井组；**21 well groups of injecting and producing.**
- 单井日注气量15t；**Inject 15 tons per well per day.**
- 最大井口注气压力16MPa。**The max gas injection pressure is 16MPa in wellhead.**



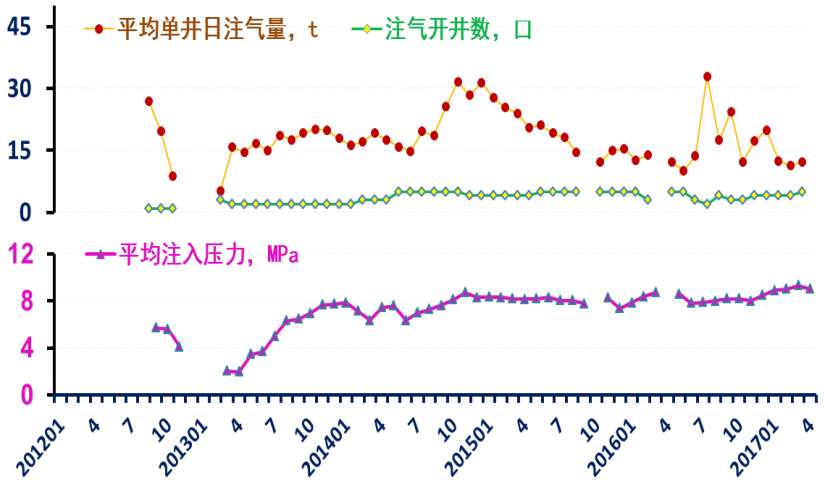
试验区注采井网

well network of injection and extraction

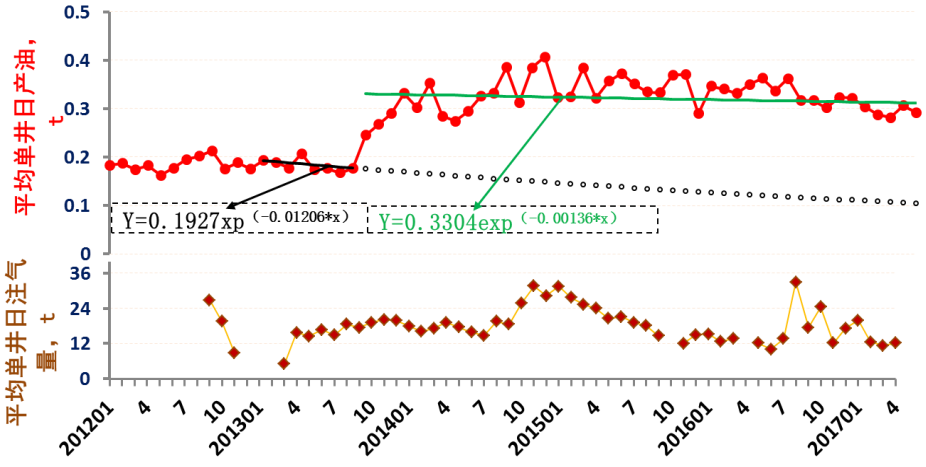
1、靖边乔家洼试验区 Jingbian Qiaojiawa pilot test area

➢ CO_2注入状况与驱油效果 CO_2 injection status and flooding effect.

2012年9月开始实施，平均注入压力8.3 MPa，平均单井日注液态$CO_2$15.8吨，见效时间12个月。目前，累计注入$CO_2$7.26万吨，增油2556吨。**Since September 2012, the average injection pressure has been 8.3 MPa, injected 15.8 tons liquid CO_2 per well per day, and get production effect after 12 months. At present, the accumulative amount of CO_2 injection is 72600 tons, The enhanced oil produciton is 2556 tons.**



试验区注气曲线
The curve of gas injection in Pilot area

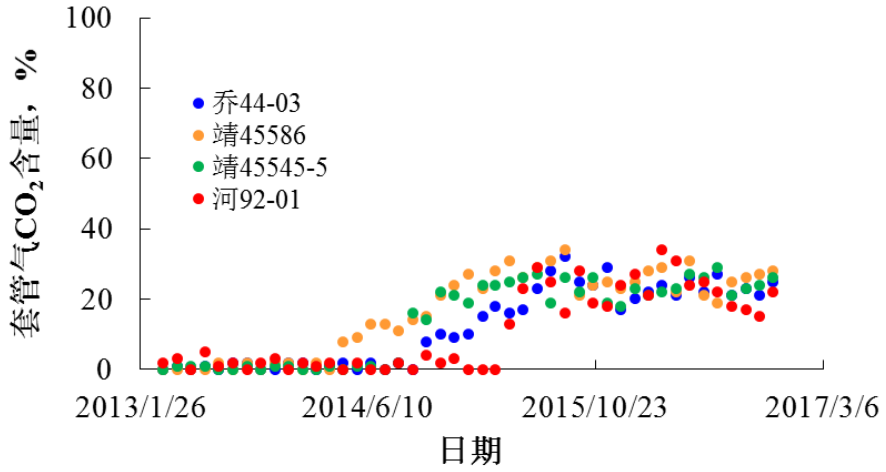


试验区见效井平均单井日产油递减规律
The decline rule of oil production of average per well per day of response wells

1、靖边乔家洼试验区 Jingbian Qiaojiawa pilot test area

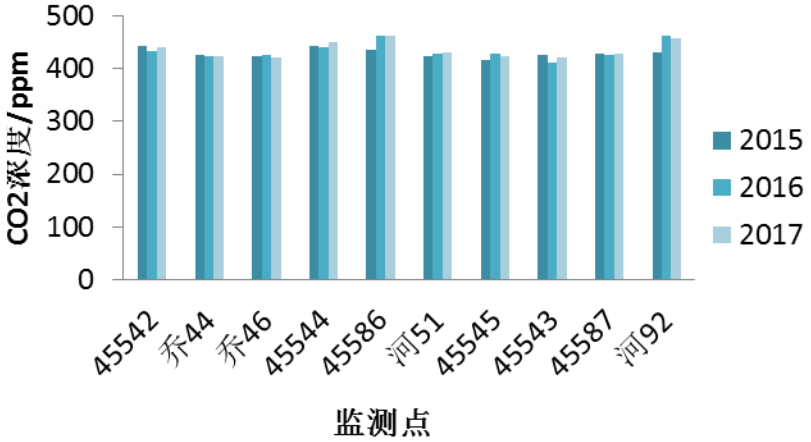
➢ CO_2封存状况监测结果 Monitering result of CO_2 storage situation

油藏监测结果表明，注入井与生产井之间存在少量窜溢，但大气监测结果未检测到CO_2泄漏。基于该监测结果，靖边实验区注气方案由连续气驱调整为气水交替驱，窜溢得到有效抑制。**Reservoir monitering result reveal that there is a small amount breakthrough, but atmosphere monitory found nothing. Based on the result, exchange the inject mode from continous inject to WAG, and the breakthrough was suppressed.**



油井套管气CO_2浓度

CO_2 percentage in Casing Gas



试验区大气中CO_2浓度

CO_2 percentage in atmosphere

2、吴起油沟试验区 Wuqi Yougou pilot test area

➢ CO_2驱油注气方案 CO_2 injecting scheme

◆ 先导试验方案（2.8Km²）

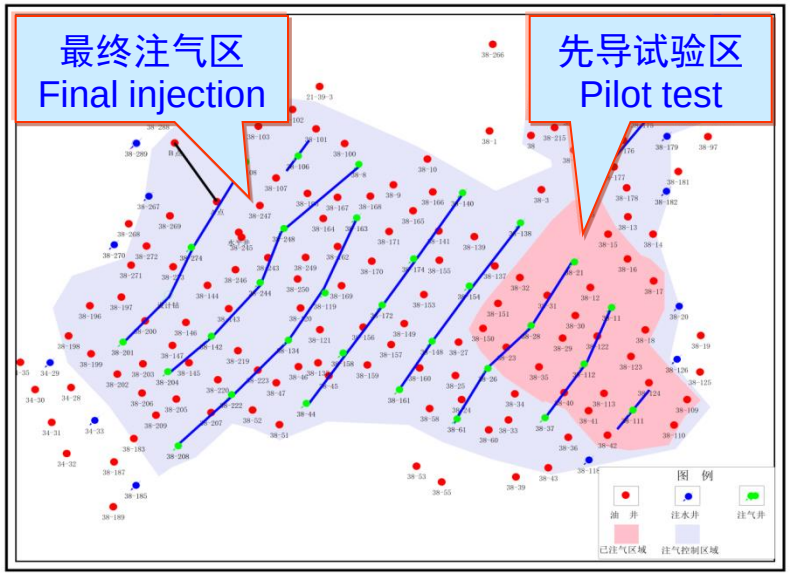
Pilot test scheme(2.8Km²):

- 5个注采井组；**5 well groups of injecting and producing.**
- 单井日注气量20t；**Inject 20 tons per well per day.**
- 最大井口注气压力25MPa。**The max gas injection pressure is 25 MPa in wellhead.**

◆ 最终注气方案：(15.2Km²)

Final injection scheme (15.2Km²)

- 35个注采井组；**35 well groups of injecting and producing.**
- 单井日注气量20t；**Inject 20 tons per well per day.**
- 最大井口注气压力25MPa。**The max gas injection pressure is 25 MPa in wellhead.**



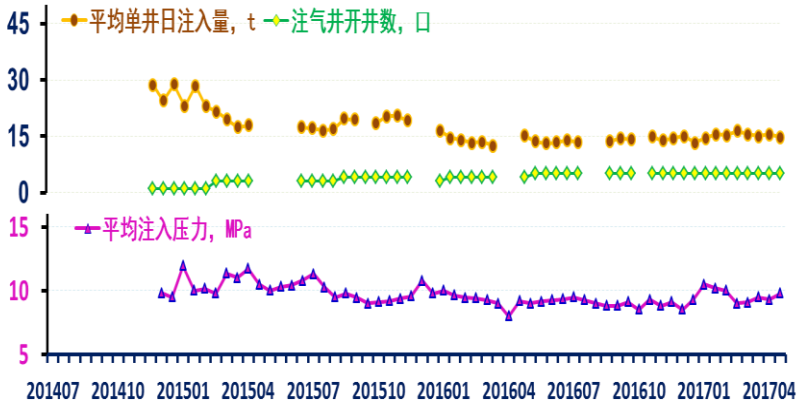
试验区注采井网

well network of injection and extraction

2、吴起油沟试验区 Wuqi Yougou pilot test area

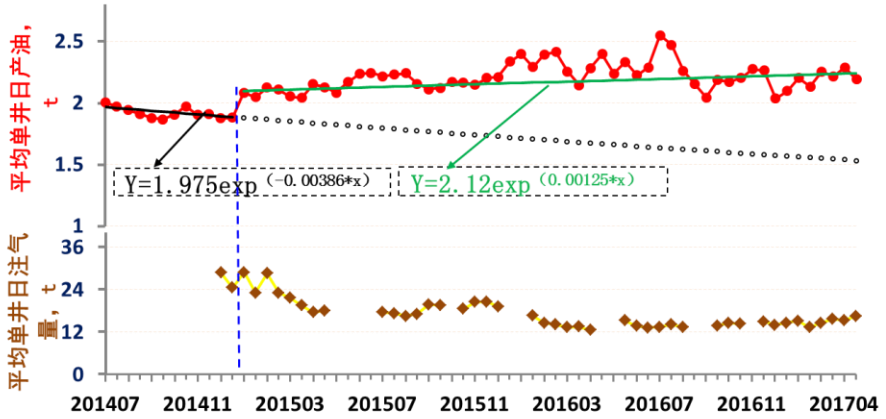
➢ CO_2注入状况与驱油效果。CO_2 injection status and flooding effect.

2014年12月开始实施，平均注入压力9.5MPa，平均单井日注液态$CO_2$14.5吨，见效时间2个月。目前，累计注入$CO_2$2.14万吨，增油4547吨。**Since December 2014, the average injection pressure has been 9.5MPa, injected liquid CO_2 14.5 tons per well per day, and get production effect after 2 months. At pressent, the accumulative amount of CO_2 injection is 21400 tons, The enhanced oil production is 4547 tons.**



试验区注气曲线

The curve of gas injection in Pilot area



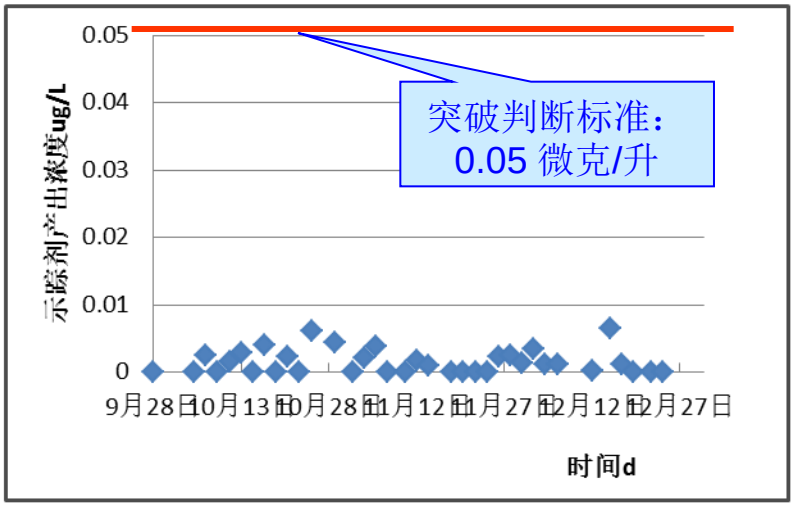
试验区见效井平均单井日产油递减规律

The decline rule of oil production of average per well per day of response wells

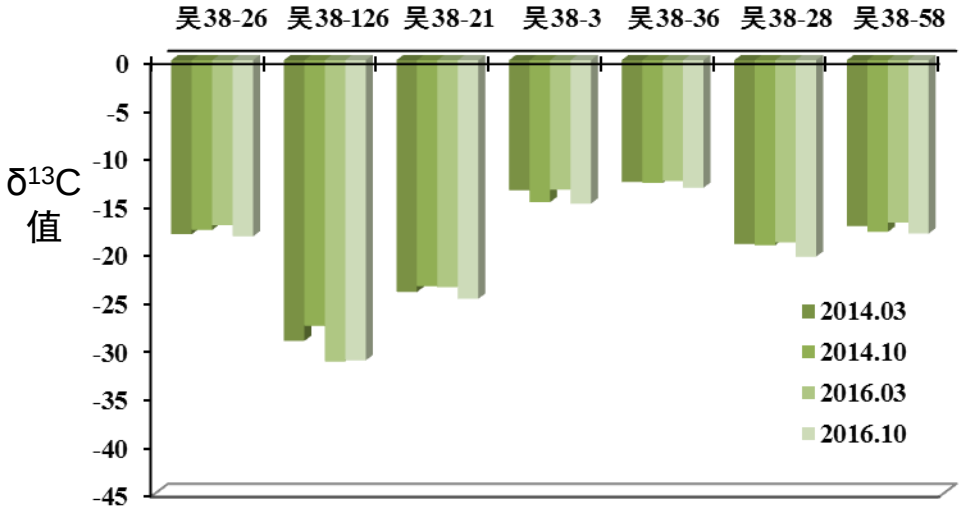
2、吴起油沟试验区 Wuqi Yougou pilot test area

➢ CO_2封存状况监测结果 Monitering result of CO_2 storage situation

油藏示踪剂监测和土壤气监测结果表明，未发生井间窜溢和地表渗漏，实现CO_2动态封存。**It is shown by reservoir and soil gas monitering that the CO_2 storage has realized because no leakage and gas flow across wells were found.**



38-31井示踪剂产出检测曲线
Trace material content curve



^{13}C同位素监测结果对比
^{13}C isotope monitering result

初步监测结果表明：特低渗油藏CO_2驱油可实现碳封存

The result shows that CO_2 storage can be realized by CO_2 EOR in ultra-low permeability reservoir.

3、整体封存状况 Overall storage situation

截止目前，延长油田两个先导试验区CO_2埋存量约93936.32t。

Until now, 93936.32 tones of CO_2 has been stored in two pilot areas of Yanchang Oilfield.

先导试验区CO_2埋存量 （截止2017年4月）
The amount of CO_2 storage in pilot areas (until April 2017)

试验区 Pilot areas	埋存潜力 Potential	注入量 Injection amount	埋存量 Storage amount
	10^4t	t	t
靖边乔家洼 Qiaojiawa in Jiangbian	209.87	72598.26	72512.52
吴起油沟 Oil arae in Wuqi	194.25	21423.80	21423.80
合计 Total	404.12	94022.06	93936.32

备注：利用油藏工程方法、气油比当量、CO_2监测浓度量进行计算。
Note: Reseroir engineering method, Gas-oil ratio equivalent and CO_2 concentration amouint monitering are used.

（四）最新工程进展 Latest construction of the project

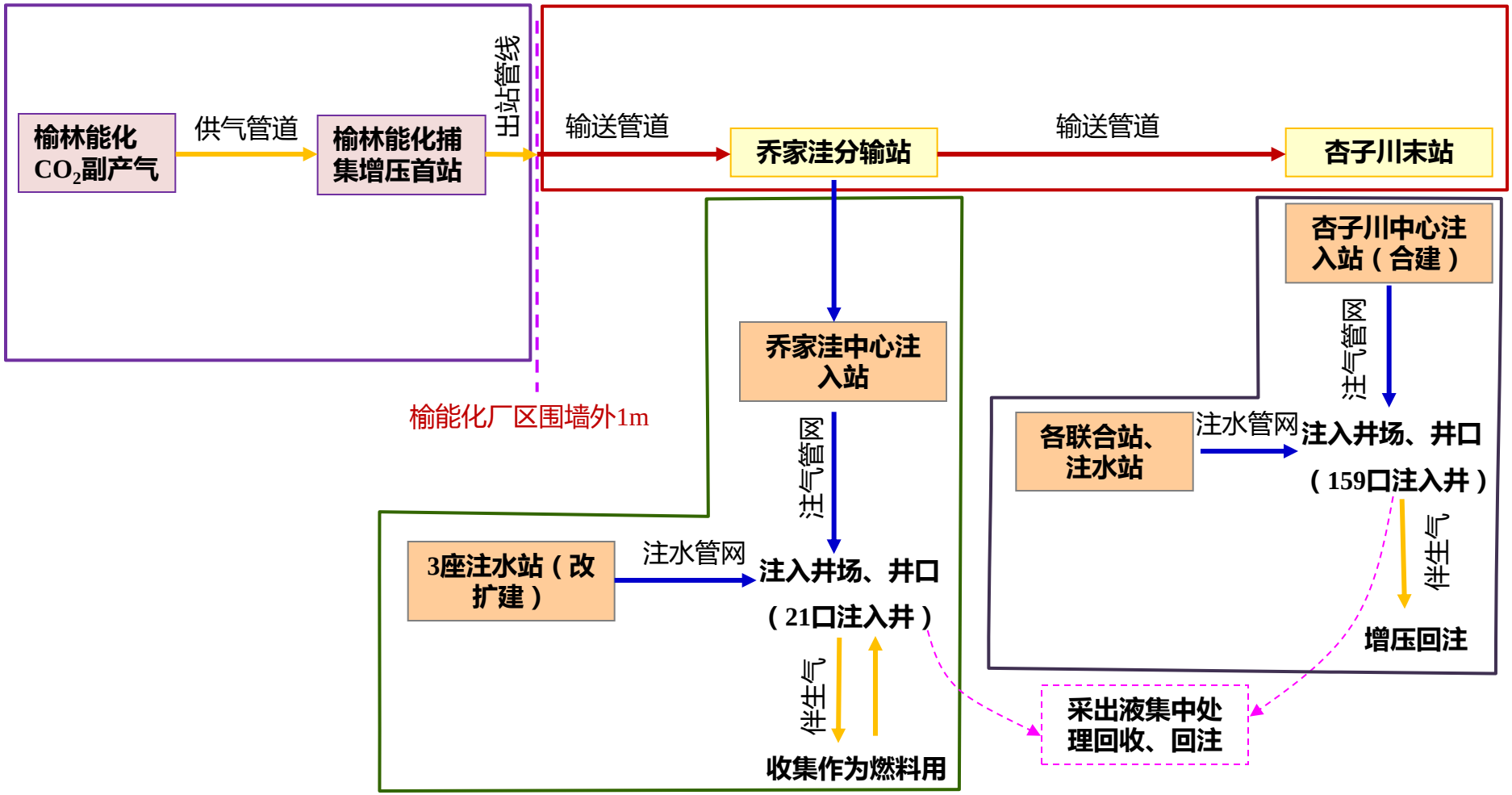
➢36万吨CCUS项目建设情况 Progress of 360,000 t/a CCUS Project

已完成延长石油36万吨/年CO_2捕集、管输及封存示范项目可研报告论证。
Feasibility study on 360000 tons CCUS project has been finished.

延长中煤榆林能化公司 36万吨/年CO_2捕集项目
360,000 t/a CO_2 Capture Project

36万吨CCUS项目建设情况
Progress of 360,000 t/a CCUS Project

36万吨CCUS项目工程建设思路（初设）如下图。



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二、延长石油CO_2-EOR工程示范进展

Progress of Yanchang CO_2-EOR Engineering Demonstration

三、社会影响力与主要成果

Influence and Achievements

四、面临的挑战与展望

Challenges and Working Plan

（一）社会影响力 Influence

1、项目得到了国内外广泛关注与认可。Widely news report: Yanchang CCUS Project received wide attention and recognition at home and abroad.

（一）社会影响力 Influence

2、社会各界的大力支持 Strong support from all sectors of society

延长石油CCUS项目已得到中国政府及美国、澳大利亚相关机构的大力支持。

国家发改委有关司局领导现场考察

国家科技部组织专家现场考察

中国石油和化学工业联合会领导现场考察

澳大利亚地调局与发改委气候司专家现场考察

美国能源部专家现场考察

美国金德摩根公司专家现场考察

（二）主要成果 Main Achievement

➢ **中-澳碳捕集、利用与封存（CCUS）一体化国际合作示范项目：**获得230万澳元资金支持；**Sino-Australia International Cooperation on CCUS:** Acquired funds support of about 2.3 million Austrilia Dollar.

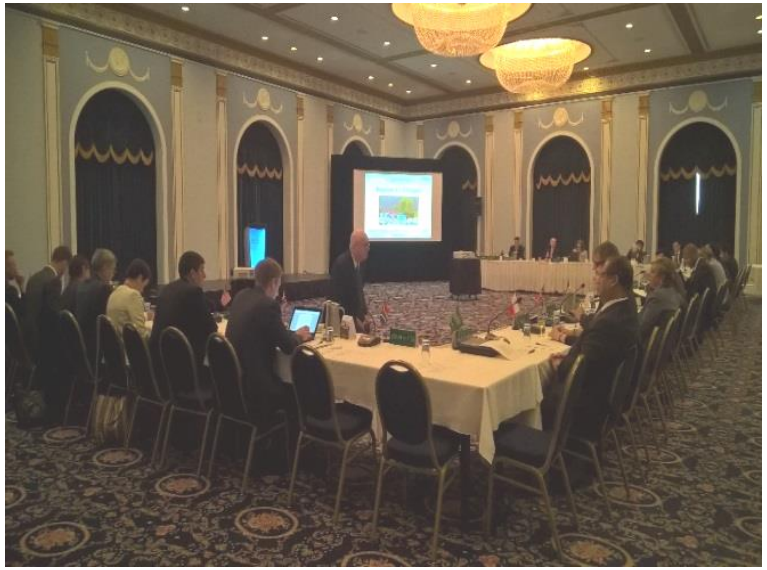
➢ **中-美气候变化工作组合作项目：** 与美国西弗吉尼亚大学、怀俄明大学等签署合作备忘录，共同围绕延长石油CCUS项目开展合作研究。**US-China Climate Change Cooperation Project:** signed the memorandum with West Virginia University and University of Wyoming, aiming at the study of Yanchang CCUS project.

与澳大利亚全球碳捕集与封存研究院签署合作协议
Cooperation with GCCSI

与西弗吉尼亚大学、怀俄明大学签署合作备忘录
Cooperation with WVU and UOW

（二）主要成果 Main Achievement

➢ 2015年6月，靖边CCS项目获得**全球碳封存领导人论坛（CSLF）认证**，成为**发展中国家第一个**得到国际认证的一体化CCS项目。**In June 2015, Yanchang CCS Project was recognized as the first internationally certified CCS project from a developing country by CSLF (Carbon Sequestration Leadership Forum).**



认证会现场（加拿大里贾纳）
CSLF meeting at Regina

延长石油CCS项目认证书
Certificate of Recognition from CSLF

（二）主要成果 Main Achievement

➢ 2016年6月，“延长石油CCUS一体化技术示范”作为资源与海洋开发领域重大科技成果亮相国家“十二五”科技创新成就展。**In June 2016, “Yanchang integrated CCUS technology demonstration” take part in the "twelfth five-year" science and technology innovation exhibition as the major scientific and technological achievements in resources and ocean development areas.**

“延长石油CCUS一体化技术示范”亮相国家“十二五”科技创新成就展

Take part in the "twelfth five-year" science and technology innovation exhibition

（二）主要成果 Main Achievement

➢ 2015年9月，《中美两国元首发表气候变化联合声明》宣布将陕西延长石油公司位于延安－榆林地区的碳捕集、利用和封存项目作为两国新的重大合作项目。

In September 2015, Presidents of U.S.-China issued the Joint Statement on Climate Change, Which announced the CCUS project operated by Shaan'xi Yanchang Petroleum as a new major cooperation projects between the two countries.

BRIEFING ROOM | ISSUES | THE ADMINISTRATION | PARTICIPATE | 1600 PENN

Press Briefings
Statements & Releases
White House Schedule

U.S.-China Joint Presidential Statement on Climate Change

13. Building on the robust bilateral cooperation initiatives that support the achievement of ambitious domestic actions, the two sides commit to further deepen and enhance these efforts through the U.S.-China Climate Change Working Group (CCWG), the premier mechanism for facilitating constructive U.S.-China dialogue and cooperation on climate change. The two sides have made concrete progress in each of the initiatives, including heavy-duty and other vehicles, smart grids, carbon capture, utilization, and storage (CCUS), energy efficiency in buildings and industry, collecting and managing greenhouse gas emissions data, climate change and forests, industrial boilers efficiency and fuel switching, and climate-smart/low-carbon cities, and will continue to work together on green ports and vessels and zero emission vehicles, as well as the enhanced policy dialogue and cooperation on HFCs. Furthermore, a new Domestic Policy Dialogue was established this year to share information on respective domestic actions. The two sides will continue to devote significant effort and resources to the existing initiatives. On the CCUS project agreed to in the 2014 Joint Announcement, the two countries have identified the project site in Yan'an-Yulin, Shaanxi Province, China, operated by Shaanxi Yanchang Petroleum. The two sides will continue to collaborate to demonstrate the utilization of CO2 for enhanced water recovery.

"两国确定CCUS项目运行地点为陕西延长石油集团的延安-榆林示范区"

The two countries have identified the project site in Yan`an-Yulin,Shaanxi Province, China, operated by Shaanxi Yanchang Petroleum.

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四、面临的挑战与展望

Challenges and Working Plan

（一）面临的挑战 Challenges

挑战一：延长石油CCUS项目是全球首个由企业独立承担的CCUS全流程一体化项目，国内外无成熟系统经验可借鉴。Challenge 1: This project is the very first integrated CCUS project operated by just one company alone, so there is no reference to learn from.

煤化工
低成本CO_2捕集
Low-cost CO_2 capture from coal chemical plant

CO_2管输
CO_2 Pipeline

CO_2二次捕集
CO_2 recapture

CO_2综合利用
CO_2 utilization

CO_2埋存
CO_2 storage

驱油
EOR

压裂
Fracturing

技术？
Technology
?

经济？
Economic
?

安全环保？
Environment friendly and Safe?

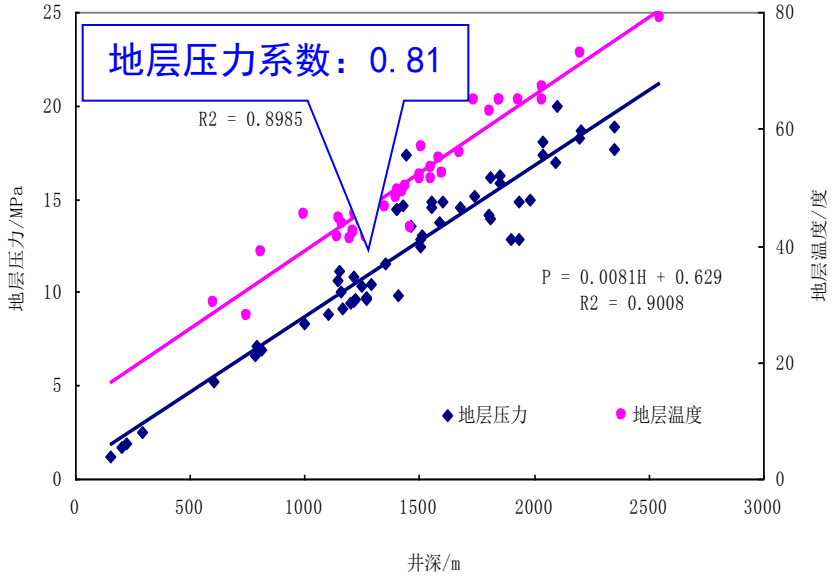
（一）面临的挑战 Challenges

挑战二：特低渗低压油藏CO_2驱油国际上尚无先例，延长油田是典型的特低渗油藏，且地层压力偏低，难以实现混相驱，如何提升驱油效果面临很大挑战。**Challenge 2: CO_2 flooding in ultra-low permeability reservoir is unprecedented in the world. Yanchang oilfield is typical ultra-low permeability reservoir with low formation pressure, which is difficult to do miscible displacement. Therefore, how to improve displacement effect is the great challenge.**

油藏分类	渗透率（mD）	CO_2驱油项目数
超低渗	K < 1	0
特低渗	1≤K < 10	0
低渗透	10≤K < 50	19
中渗透	50≤K < 500	26
高渗透	K≥500	5
		50

美国CO_2驱油砂岩油藏渗透率分布

The CO_2 EOR project in sandstone reservoir of US



地层压力与深度交汇图

The crossplot of formation pressure and depth

（一）面临的挑战 Challenges

挑战三： CO_2在油藏中运移及泄漏监测方法有待进一步研究和完善。**The CO_2 migration and leakage inspection method needs to be improved.**

监测类别 Types	监测对象 Inspection Objects	国际通用技术/方法 International Method	延长采用技术/方法 Yanchang Method
大气&土壤气/ Atmosphere & soil gas	CO_2通量	涡度相关法	CO_2浓度在线监测
	CO_2浓度	红外分析仪/气相色谱仪	便携式分析仪/气相色谱
	碳同位素 δ ^{13}C值	CO_2同位素分析仪	CO_2同位素分析仪
地表 /Surface	地表变形	卫星遥感技术	未开展
	植被生长	地表超谱成像	植物生理生化分析
油藏 /reservoir	井底温度、压力	井下温度计、压力计	井下温度计、压力计
	流体化学	色谱、质谱分析	色谱、质谱分析
	CO_2运移方向和波及范围	U型管系统；流体示踪	示踪剂
	CO_2运移和地下分布	四维地震、微地震等	三维地震

地表及油藏监测方面需要引进先进技术 New technology are needed

（一）面临的挑战 Challenges

挑战四：特低渗裂油藏CO_2封存机理、CO_2动态封存量预测等方面研究基础较薄弱。

Challenge 4: the CO_2 storage mechanism in ultra-low permeability reservoir and the prediction of storage amount need to be strengthened.

油藏CO_2封存机理研究 Study on mechanism	（1）CO_2贮存方式分析； Analysis on storage method
	（2）不同CO_2贮存方式量化。 Quanlification of storage method
CO_2封存量预测 Storage amount Prediction	（1） CO_2封存量计算方法建立； Establishment of calculation method
	（2） CO_2封存量计算软件开发； Development of calculation software
	（3） CO_2封存潜力预测。 Protential Prediction

（二）展望 Plan

➢ 总体规划：General Plan

近期目标：2018年建成36万吨/年CCUS示范区；

Short-term target: By the end of 2018, finish construction of integrated CCUS

中期目标：2020年建成100万吨/年CCUS示范工程；

Medium-term target: By the end of 2020, finish construction of CCUS demonstration

远期目标： 2030年建成400万吨/年能力的CCUS示范基地。

Long-term target: By 2030, finish construction of CCUS demonstration base with 4 million tons/year capacity.

力争建成中国首个百万吨级CCUS旗舰项目，形成完整的煤化工二氧化碳捕集、驱油、封存和压裂技术体系与标准，打造一支专业的碳捕集、管输、驱油、封存、监测等技术团队，探索CCUS的商业模式，为我国其他地区的低碳发展提供可借鉴的经验。 **Complete formatting CCUS technology system and standard, explore CCUS commercial operating mode, and provide relevant experiences for other domestic regions.**

结 束 语 Ending

二氧化碳捕集、利用与封存（CCUS）是能源企业积极应对气候变化，实现碳减排和循环发展的有效途径。将煤化工与碳捕集相结合，将驱油与碳封存相结合，可以降低成本，保障CCUS项目可持续发展。延长石油愿与国际同行进一步加强交流与合作，积极倡导低碳理念，为全球化石能源的高效、清洁、低碳利用做出积极的贡献。**For energy enterprises，CCUS is an positive response towards climate change, and an effective way to achieve low CO_2 emission and recycle. Combined coal chemical industry and carbon capture together, displacement and storage together, cost will be remarkably down, and CCUS projects will be sustainably developed. Yanchang Group is open to knowledge exchanges and work collaborations with worldwide researchers on advocating low carbon style, making contribution to utilizing fossil energy in a more efficient, cleaner way with lower CO_2 emission.**

汇 报 结 束

Thanks