



U.S.—China Clean Coal Forum

25-26 August, 2015 • Billings MT U.S.



Practices & Outlook of CCS in CNPC, China

中国石油CCS实践与展望

中国石油天然气集团公司

China National Petroleum Corporation (CNPC)

25-26 August, 2015 · Billings MT U.S.



Contents 目录

1. Status of CCS

CCS发展现状

2. CCS Practices in CNPC

中国石油CCS实践

3. Outlook

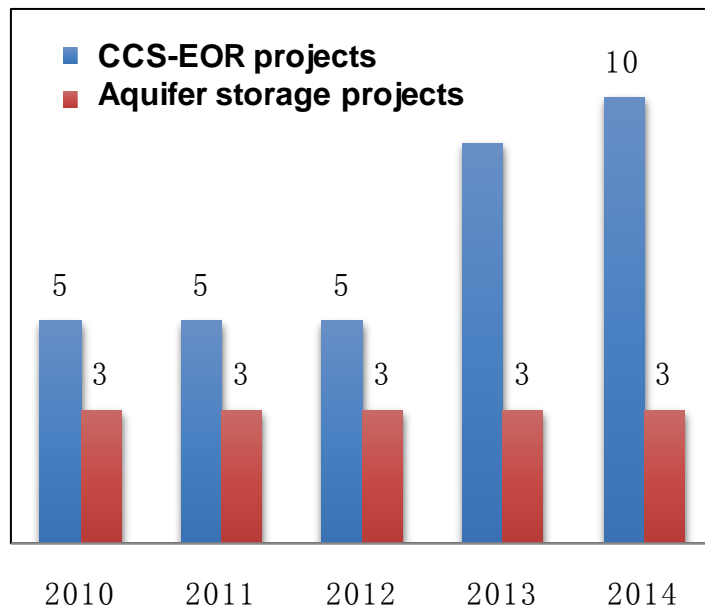
CCS发展前景展望



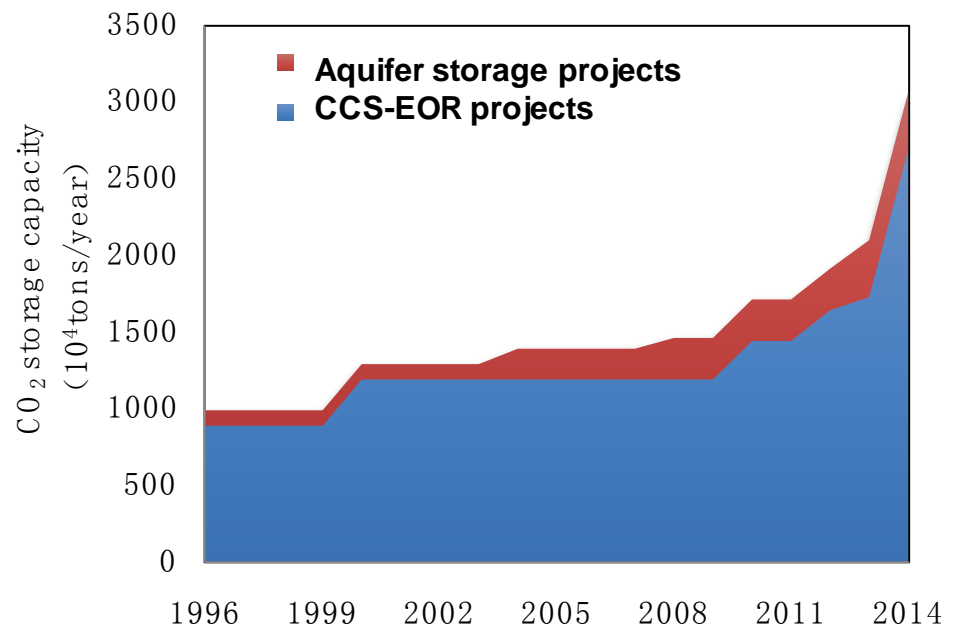
1. Status of CCS 发展现状

1) Since 1990s, many countries have devoted themselves into CCS research and practice to cope with the global climate changes, the main methods are aquifer storage and EOR.

20世纪90年代以来，为积极应对全球气候变化问题，西方发达国家开始了CCS技术的研究与实践，主要方式是盐水层封存和提高石油采收率



Global ongoing large-scale CCS Projects
全球大型一体化CCS运行项目统计
(GCCSI, 2014.11)



CO₂ storage capacity of ongoing large-scale projects
全球大型项目CO₂年埋存量

1. Status of CCS 发展现状

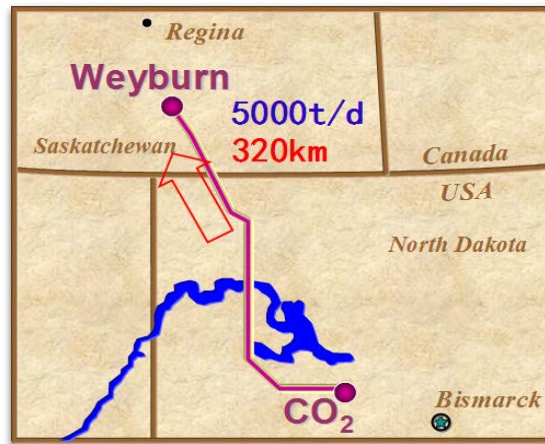
2) CCS, a hot topic in recent years, still faces huge challenges, so far, there are only 13 large-scale projects implemented in the world. The goal of these projects is to demonstrate or avoid high carbon taxes.

CCS是近年来的热议话题，全球实际运行的规模化CCS项目仅为13项，多数项目实施目的是为避免高碳税或者仅作示范，CCS发展仍面临巨大挑战



Sleipner in Norway, operating from 1996, annual CO₂ storage capacity: from 1 million tons to 0.9 million tons

挪威Sleipner CO₂盐水层封存项目，1996年开始，年埋存量从100万吨减至90万吨



Weyburn in Canada, operating from 2000, annual CO₂ storage capacity: 3 million tons

加拿大Weyburn油田CCS-EOR项目，2000年开始，年埋存量300万吨



Salah in Algeria, from 2000, terminated

阿尔及利亚萨拉CO₂盐水层封存项目，2000年开始，目前已终止



1. Status of CCS 发展现状

3) Since 2000, China has taken responsibility actively to cope with climate change. Lots of energy-saving and emissions-reduction projects have been implemented. Chinese government made great determination and efforts on CCS.

2000年以来，中国能源行业主动承担应对气候变化责任，积极开展节能减排工作，建设和运行了一批CCS项目，中国在CCS方面虽然起步较晚，但是决心和力度很大



《China-U.S. Joint Statement on Climate Change》

《中美气候变化联合声明》

Beijing, China, Nov 12th, 2014

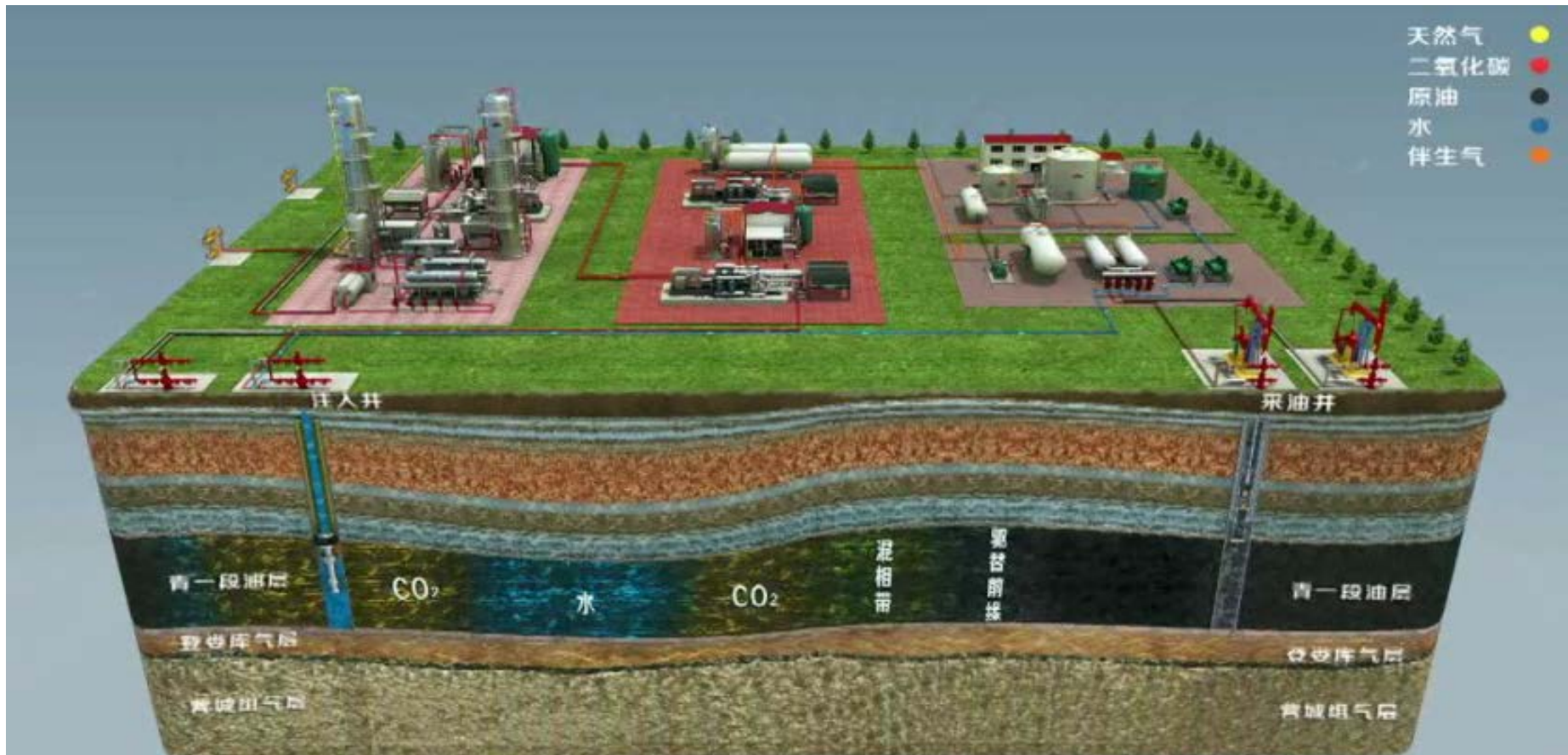
Technological innovation is essential for reducing the cost of current mitigation technologies, leading to the invention and dissemination of new zero and low-carbon technologies and enhancing the capacity of countries to reduce emissions.



2. CCS Practices in CNPC 中国石油CCS实践

1) Established the first integrated CCS-EOR Pilot in Jilin Oilfield, China, 2008

2008年，中国石油在吉林油田建成并运行集含CO₂天然气脱碳/捕集、管输、驱油利用与埋存的全流程CCS-EOR示范工程

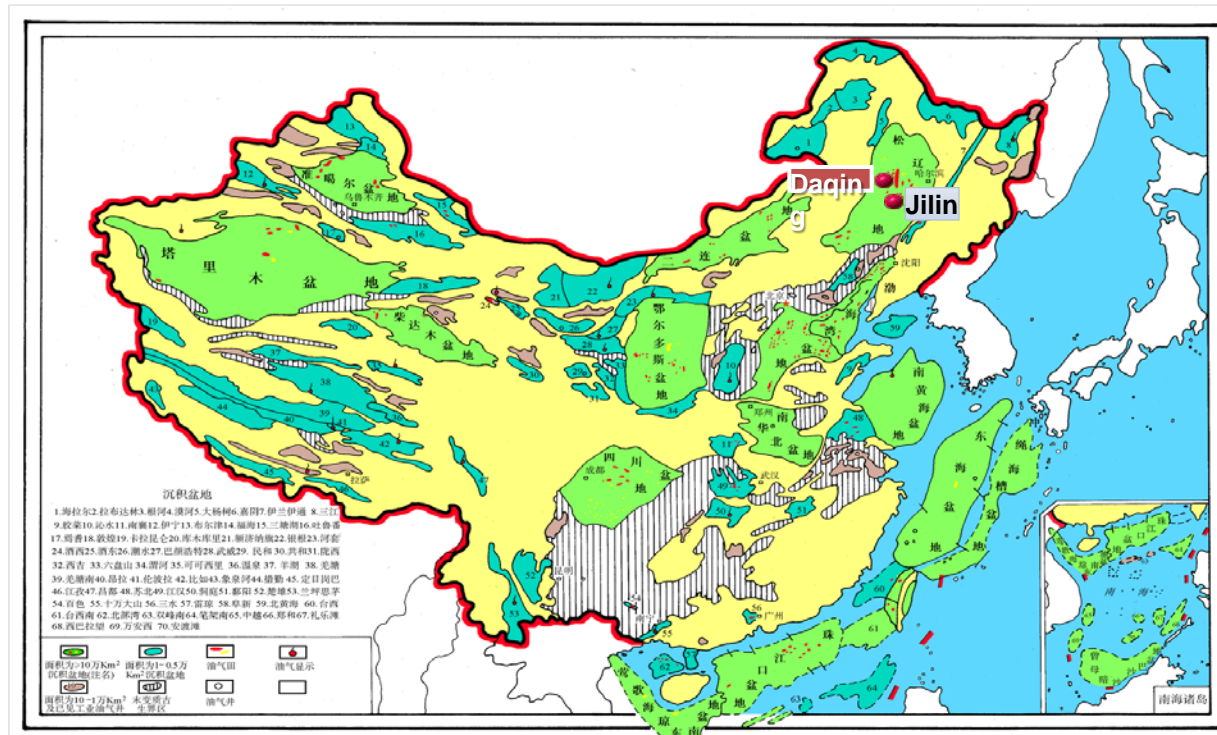


2. CCS Practices in CNPC

中国石油CCS实践

- So far, CCS-EOR commercial tests have been implemented in Daqing and Jilin Oilfield in Songliao Basin, with more than accumulative one million tons CO₂ storage

目前在松辽盆地的大庆和吉林油田进行CCS-EOR工业化试验, CO₂累积埋存量已超过百万吨



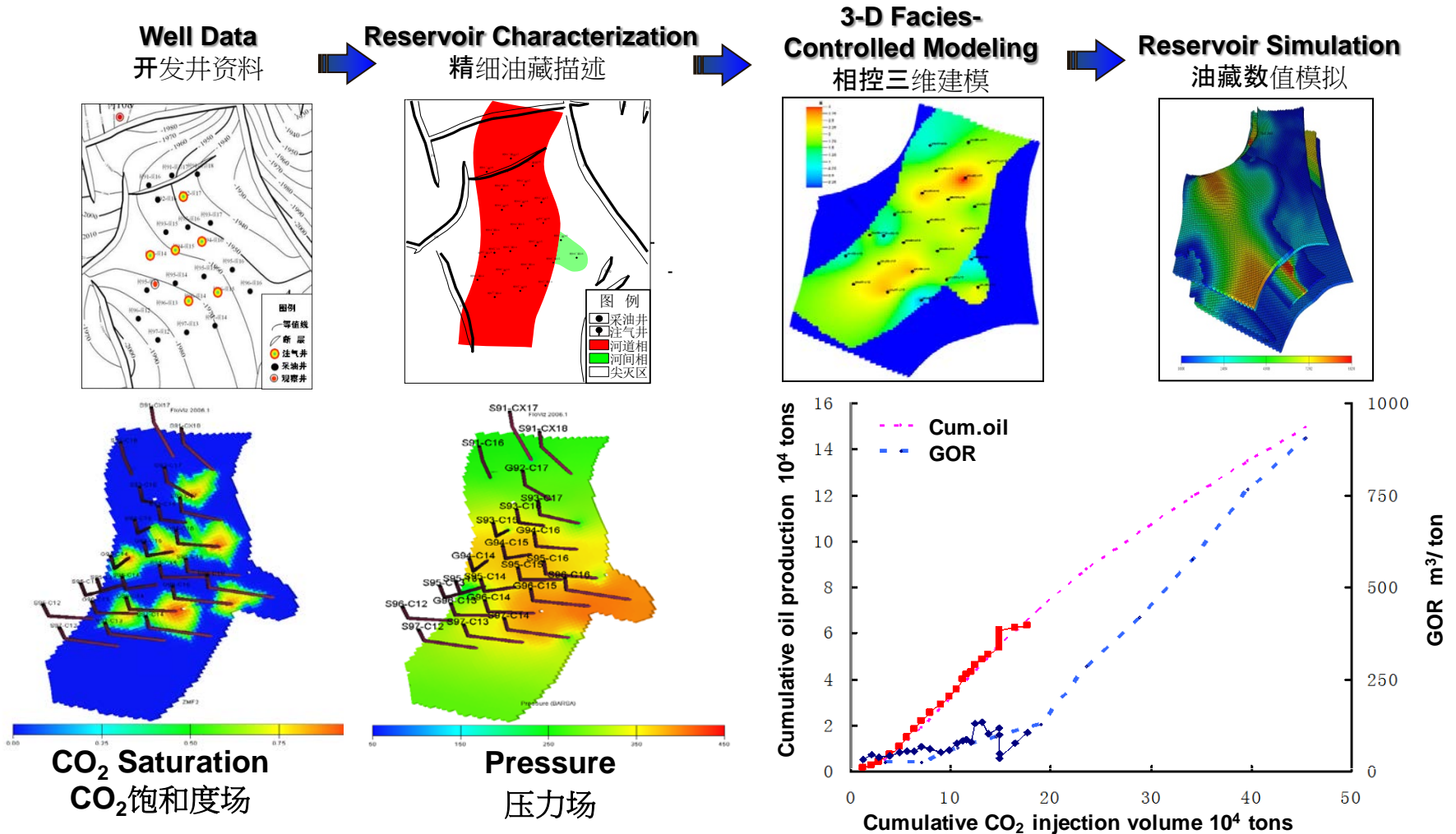
Distribution of major oil & gas basins and fields in China
中国主要含油气盆地和油气田分布图

2. CCS Practices in CNPC

中国石油CCS实践

- Positive results in CCS-EOR laboratory study, pilot tests, commercial tests

CCS-EOR基础研究、先导性试验和矿场应用效果显著



2. CCS Practices in CNPC 中国石油CCS实践

2) National Energy CO₂ Flooding & Storage Technology R&D Center established by CNPC in 2012 -- a valuable platform for CCS-EOR technology research and development

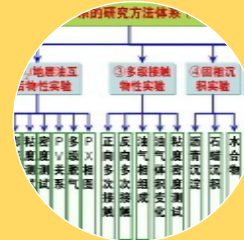
2012年中国石油开始建设“国家能源CO₂驱油与埋存技术研发（实验）中心”，将成为中国CCS-EOR技术研发和推广应用的有效平台



Work Team



Experimental Apparatus



Standards for Experimental Methods



CCS Pilot Test





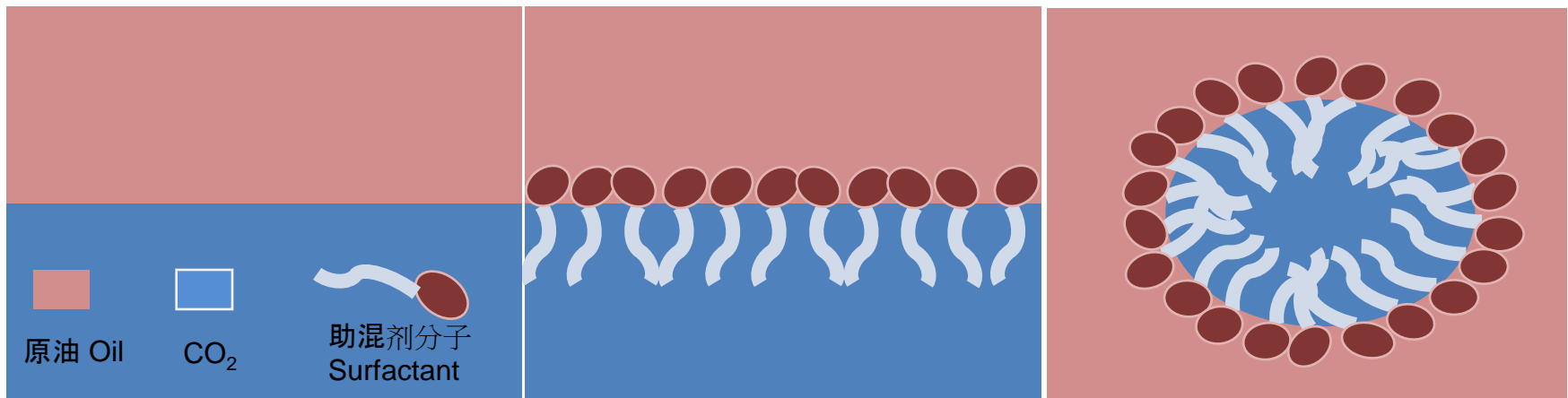
2. CCS Practices in CNPC

中国石油CCS实践

➤ Mechanism study of CO₂ flooding for non-marine sedimentary reservoirs 建立了陆相沉积油藏CO₂驱油机理试验测试研究方法

- Developing the surfactant assisted in improving CO₂-oil miscibility 研制化学助剂改善CO₂驱混相能力

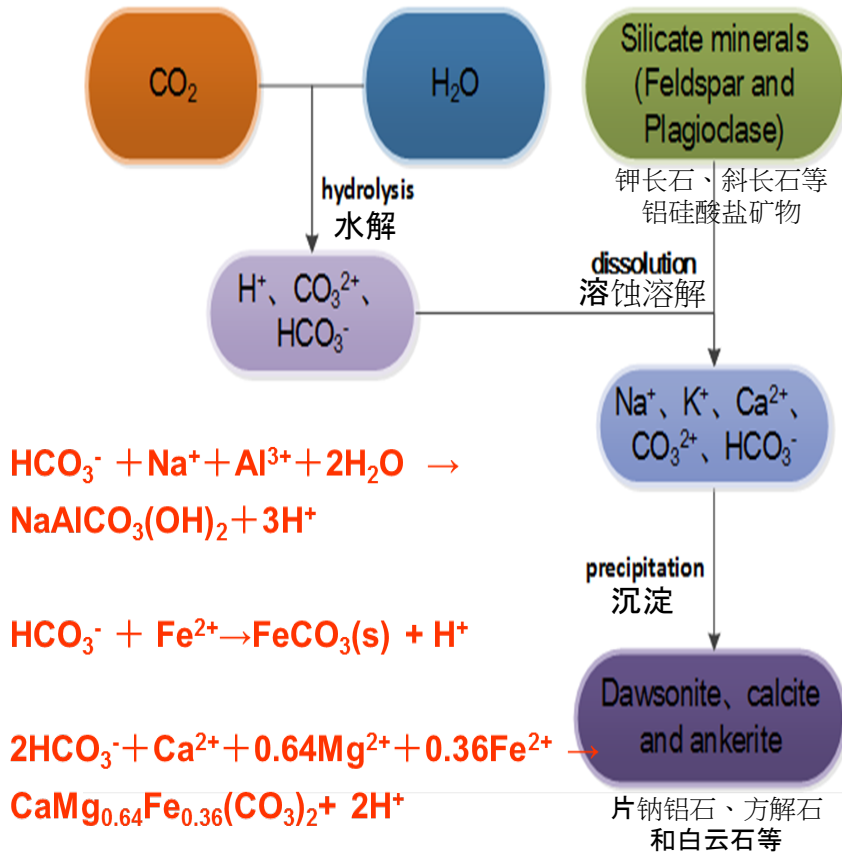
Parameters 油藏参数	US 美国	China 中国
Sediment 沉积类型	Marine Sediment 海相	Non-marine Sediment 陆相
Temperature 油藏温度	<60°C	>70°C
Oil Viscosity 原油粘度	Heavy Oil 稠油>50cp Conventional Oil 普通油 < 5cp	Conventional Oil 普通油8~50cp
MMP最小混相压力	Lower 低	Higher 高



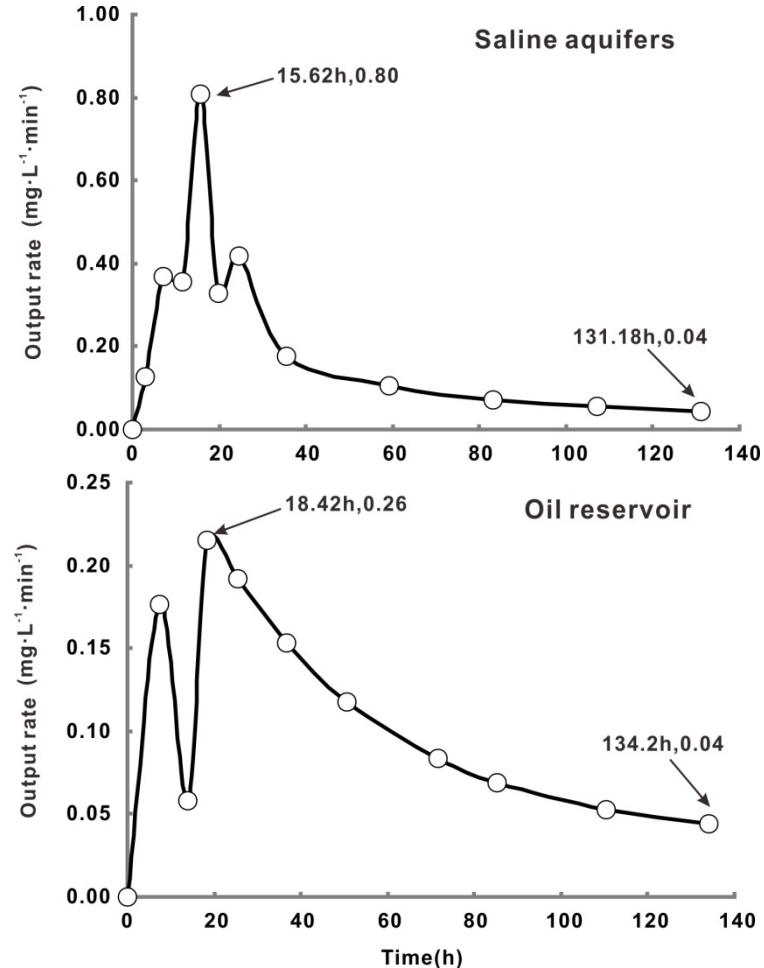
2. CCS Practices in CNPC

中国石油CCS实践

➤ Experimental study of CO₂/oil/brine/rock interaction during CCS 研究CO₂埋存过程中CO₂-油-水-岩石的化学反应



Carbonate dissolution rate
碳酸盐溶蚀速率



Main Geochemical Reaction During CCS
CCS过程中主要地球化学反应

Dissolution Rate of Sensitive Minerals Reacting with CO₂
与CO₂反应主要敏感矿物的溶蚀速率



2. CCS Practices in CNPC 中国石油CCS实践

➤ **Developing “Lab→Pilot→Field” integrated corrosion evaluation system** 形成“室内→中试→矿场”一体化腐蚀评价技术

- **The corrosion evaluation lab and corrosion simulation test system have been established**

建成室内腐蚀评价实验室和综合模拟试验装置，形成了“室内+中试+矿场”一体化腐蚀评价方法



Anti-corrosion Lab 防腐实验室
(Jilin Oilfield 吉林油田, 2012)



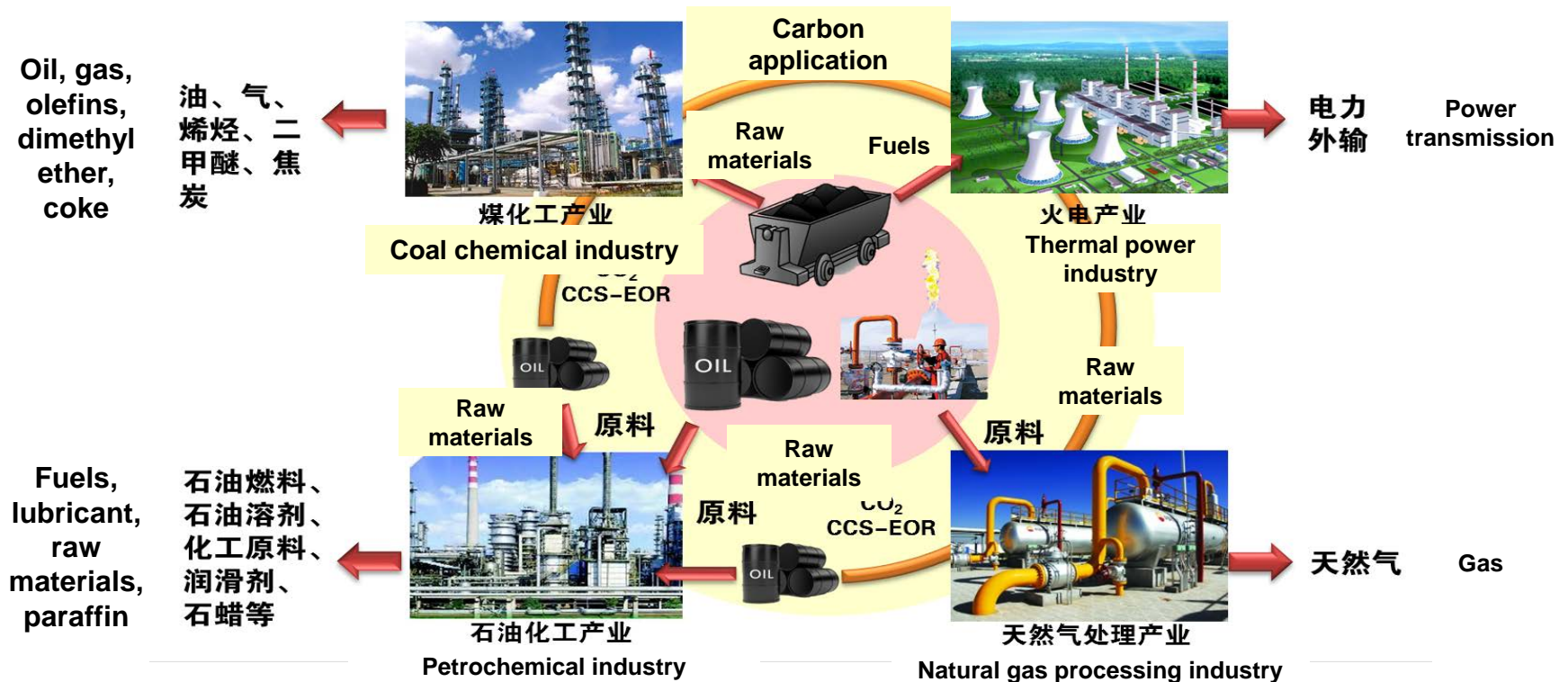
The First Real-time Corrosion Testing System in China
中国首套中试腐蚀在线检测装置
(Jilin Oilfield 吉林油田, 2010)



2. CCS Practices in CNPC 中国石油CCS实践

3) CNPC are working with Shenhua Group closely on promoting CCS in China 中国石油与神华集团作为骨干国有企业，紧密合作，探索CCS发展模式

- Ordos basin has abundant resources of coal, oil and gas. The key is to explore the resources in an effective and environmental friendly way
鄂尔多斯盆地富含煤、石油和天然气，关键问题是能否和谐有序地开发这些资源



2. CCS Practices in CNPC

中国石油CCS实践

4) CNPC actively promote CCS-EOR projects in Shan-Gan-Ning-Meng areas and made the primary roadmap and vision in the region 中国石油积极推动陕甘宁蒙地区CCS示范项目，提出陕甘宁蒙地区CCS初步设想及愿景

■ CNPC and Shenhua Group identified CCS-EOR pilot location according to the gas source. The injectors had been drilled and are ready for injection 与神华集团合作，优化气源与油田位置，确定了CCS先导试验区，目前试注工作已基本准备就绪





3. Outlook CCS发展前景展望

1. **A great potential of CCS-EOR in China -- good and practical choice for carbon emissions reduction.**

CCS-EOR应用潜力巨大，是碳减排与利用务实选择

2. **CO₂ fracturing -- promising results both on fresh water saving and CO₂ emissions reduction.**

CO₂无水蓄能压裂既节约水资源又实现CO₂减排，最具发展前景

3. **In the long term, renewable resources might be obtained by injecting CO₂ into TOZ & ROZ, abandoned oil & gas reservoirs, oil shale, formations of coal with organic matter and rock with oil & gas, and brine aquifers.**

油水过渡带、低含油饱和度带，废弃油气藏、油页岩、含有机质煤系和油气岩系地层、盐水层可通过注CO₂获得再生资源，是远期技术发展与应用的方向



3. Outlook CCS发展前景展望

- 1) 13 billion tons of oil in place might be suitable for CO₂-EOR in China, which is huge potential for CCS-EOR and CO₂ storage.
中国约130亿吨原油地质储量适合CO₂驱，已开发油田CCS-CO₂驱油与埋存潜力巨大

Preliminary Evaluation of CO₂ Storage Potential (billion tons)
中国CO₂埋存潜力初步评价结果 (10亿吨)

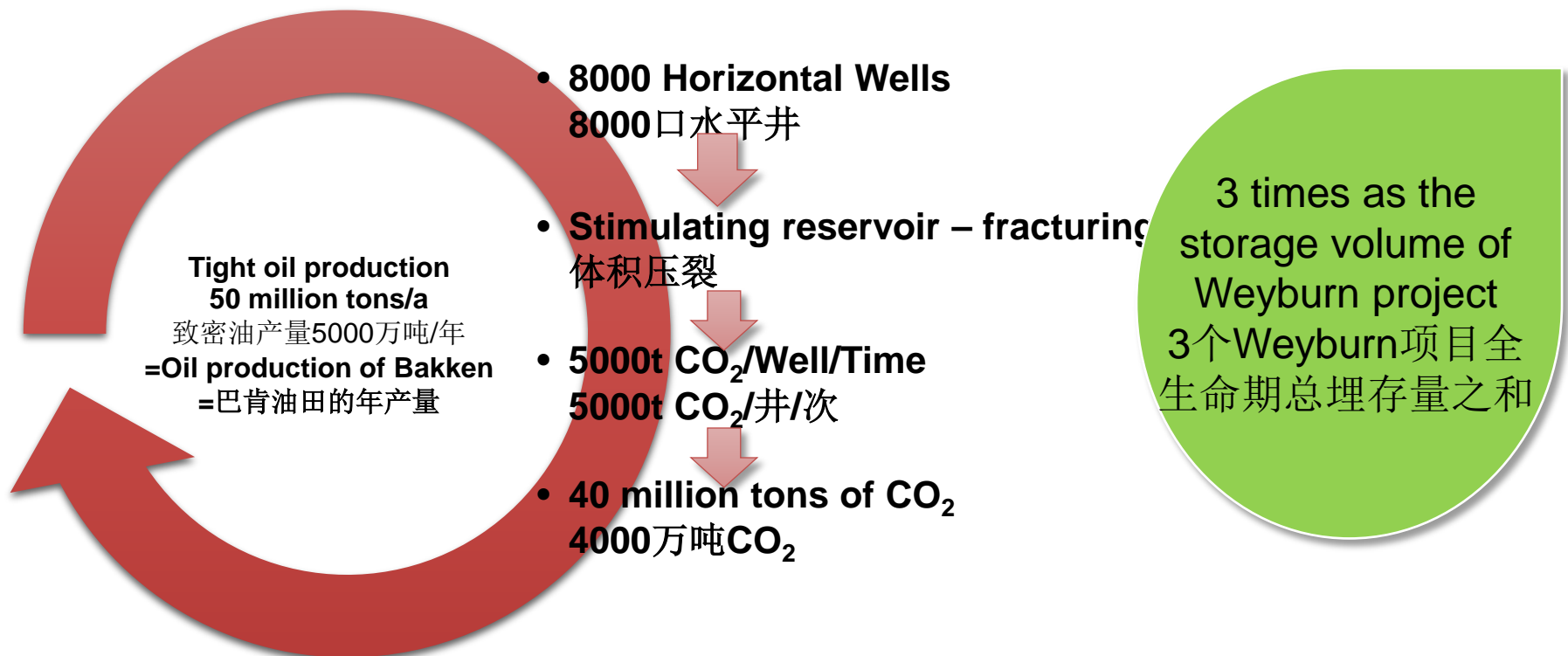
Storage Objects 埋存对象	OOIP 地质储量	Incremental Recoverable Reserves 增加可采储量	CO ₂ Storage Capacity CO ₂ 埋存量
Miscible Flooding Reserves 混相驱储量	7	0.72	1.7~2
Ultra-Low Per. Reserves难动用储量	6	1.2	3~3.5



3. Outlook CCS发展前景展望

2) CO₂ fracturing might be applied to replace traditional hydraulic fracturing. It could achieve multiple goals including fresh water saving, stimulating reservoirs, increasing formation pressure and CO₂ storage.

CO₂无水蓄能压裂技术可以用液态CO₂替代传统水基压裂液改造储层，可实现节约水资源、大规模改造、增加地层能量、CO₂埋存等多重目标



3. Outlook CCS发展前景展望

3) Reservoirs with initial oil saturation lower than 40%

天然低含油饱和度油藏是原始含油饱和度低于40%的非常规储量资源

- **Low permeability & dip angle reservoirs** 低渗、低幅度油藏——油层岩性致密和构造倾角小导致油水分异差
- **The original accumulation could be subject to be breached, then repaired seal & form a ROZ** 受破坏古油藏——构造运动导致油气封闭失效，原始油层遭受底水上侵
- **Typical TOZ & ROZ in the U.S.** 美国油水过渡带和残余油带油藏

Low permeability & dip angle
低渗、低构造幅度

Breached the original
reservoirs
受破坏的古油藏

TOZ & ROZ in the U.S.
美国油水过渡带和残余油带
油藏

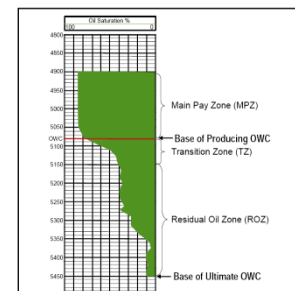
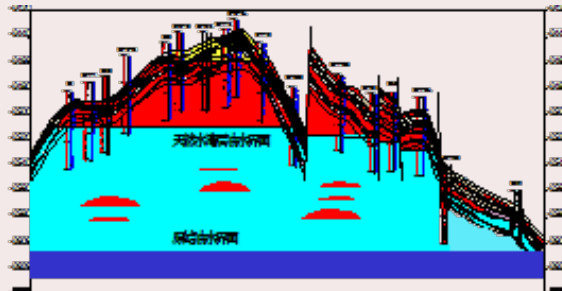
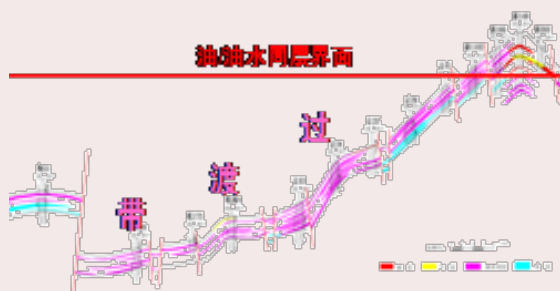
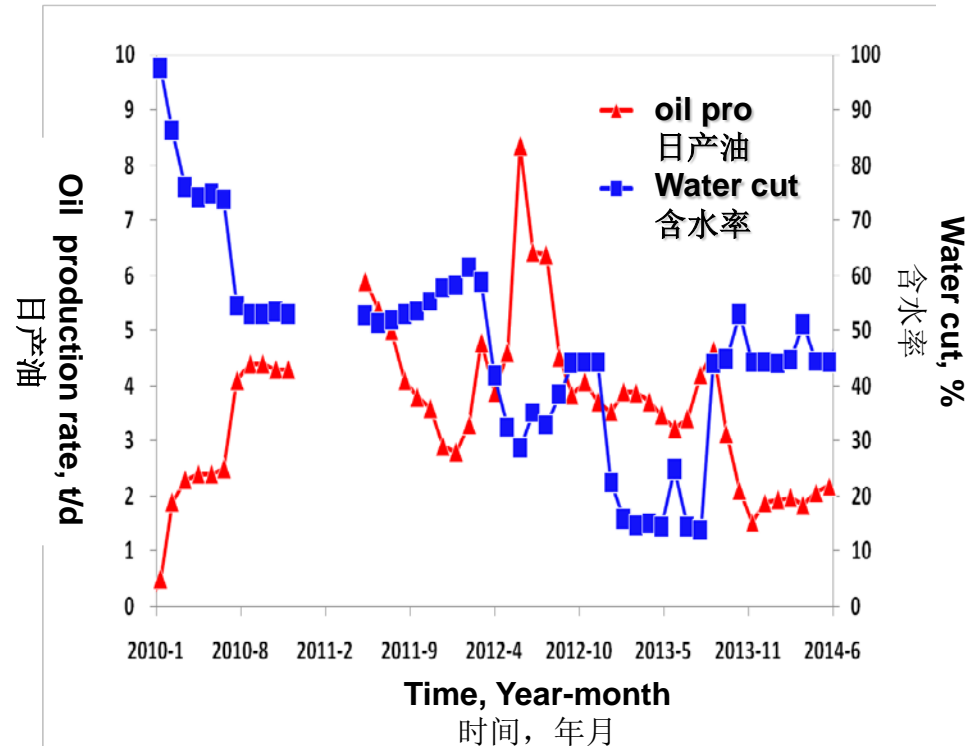
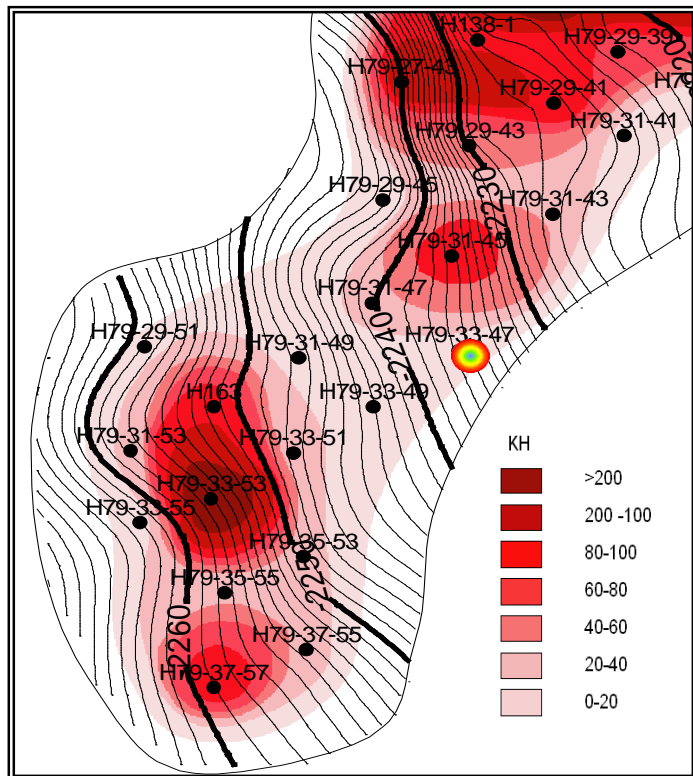


Figure 1. Oil Saturation Profile in the TZ/ROZ. Adapted from a Wason Denver Unit Well.



3. Outlook CCS发展前景展望

- **ROZ/TOZ reserves of 3 basins in Texas reach 5.81 billion tons, its large-scale development started in 1995, going through pilot and extension phase. It's verified that these kind of reservoirs could be effectively developed by CO₂ flooding.** 美国德克萨斯三个主要盆地的此类储量达58.1亿吨，规模开发始于1995年，经历了试验和推广阶段，实施的多个CO₂驱现场试验，证实此类油藏可以用CO₂驱技术有效开发

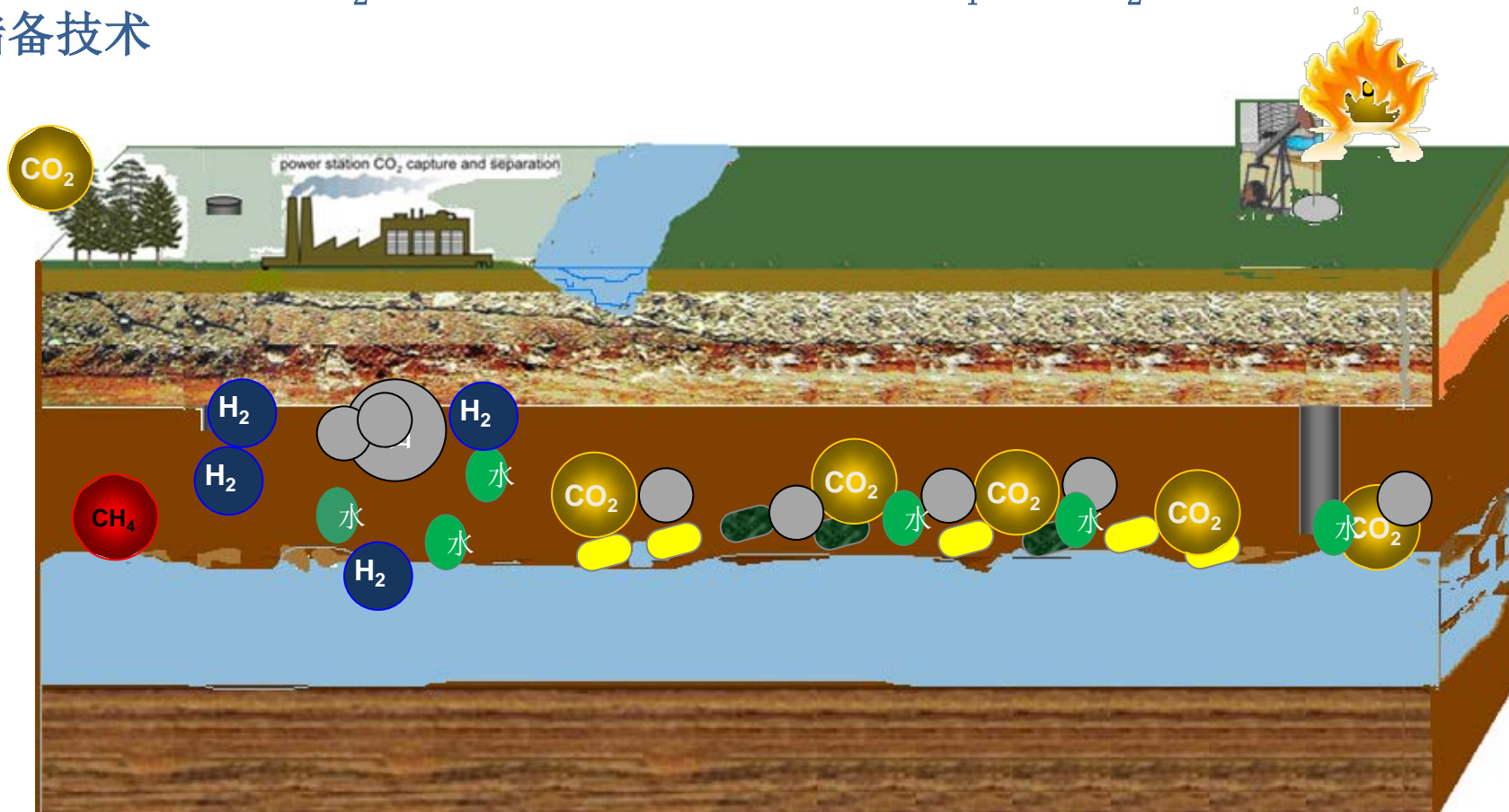




3. Outlook CCS发展前景展望

- The future techniques of CO_2 emission reduction and energy regeneration includes biological conversion to methane from CO_2 stored in abandoned reservoirs, oil shale, brine aquifer.

废弃油气藏、油页岩、盐水层埋存 CO_2 生物转化甲烷的基本原理：利用本源微生物将埋存的 CO_2 和有机质以生物途径合成 CH_4 ，是 CO_2 减排和能源再生的储备技术





Summary 结束语

Taking the responsibility to global climate change is the common duties and obligations for all human beings. The international community has reached the consensus of reducing CO₂ emissions unconditionally with a series of measures.

CCS-EOR is the main way and trend of carbon emission reduction and utilization in the world. The first integrated CCS-EOR demo project in China, which has been built and running by CNPC, proved that the implementation in non-marine sedimentary reservoirs is successful, and CCS-EOR can produce both economic and environmental benefits, thereby, Chinese oil industry will stick to and actively promote CCS-EOR in China.

应对全球气候变化是全人类的责任和义务，开展一系列举措、无条件地消减碳排放已成国际社会共识。CCS-EOR是国际上碳减排与利用的主要方式和主流发展方向。中国石油已建成并运行着国内首个全流程CCS-EOR示范项目，实践证明，CCS-EOR技术在中国陆相沉积油藏实施是成功的，可实现经济效益和和环境效益的双赢，并将成为中国的石油企业长期坚持并积极推广的CCS技术方向



Thank You !

<http://www.cnpc.com.cn>