新疆大学

Xinjiang University

新疆广汇煤制气CCUS先导项目预可行性研究

Pre-feasibility study on Xinjiang Guanghui CCUS Pilot Project

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Perth, Australia, 26 June, 2018

cags China Australia Geological Storage of CO_2 中澳二氧化碳地质封存

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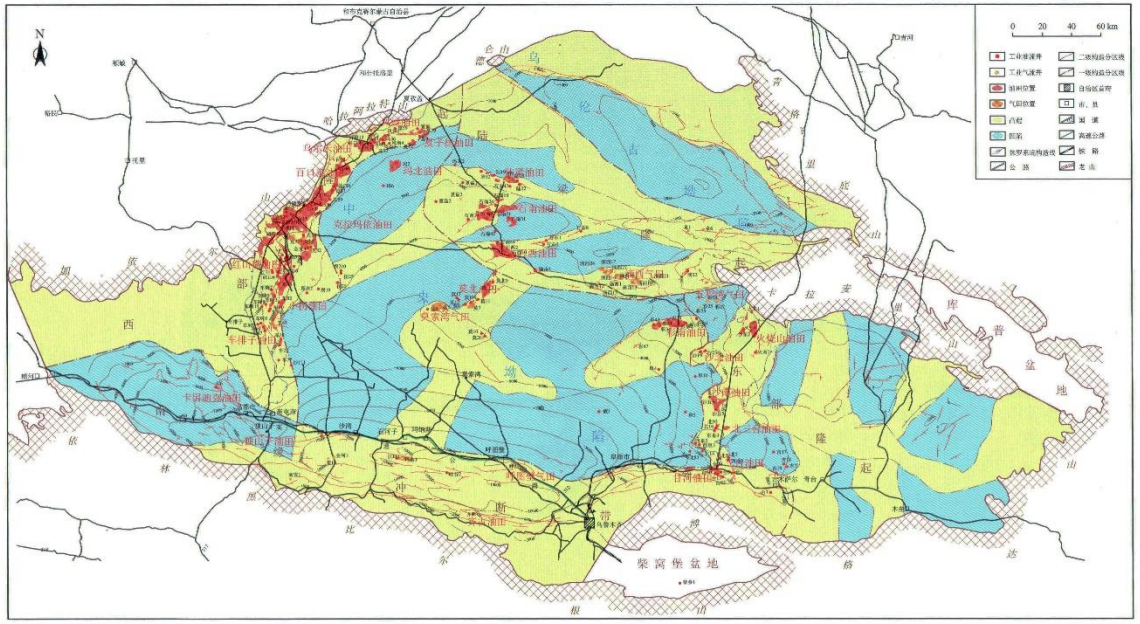
1. 项目背景　Background

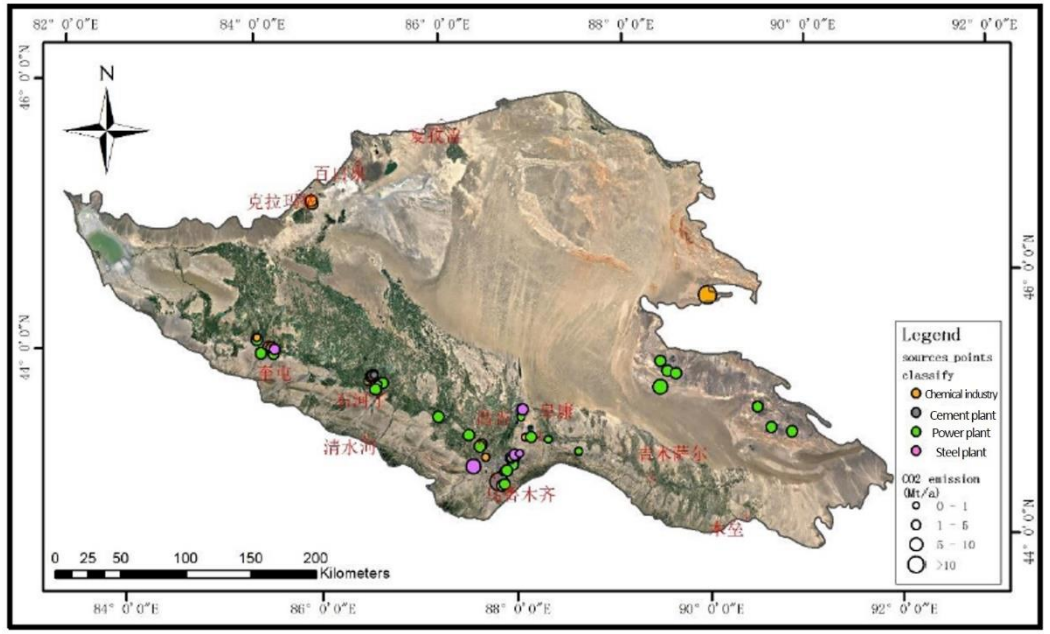
- 中澳二氧化碳地质封存项目（CAGS 3）
- China Australia Geological Storage of CO_2 (Phase 3)
- 新疆大学二级项目（CGS）:新疆广汇煤制气CCUS先导试验预可行性研究
- The Feasibility Research of Xinjiang Guanghui CCUS Pilot Project（2016-2018）
- 参与单位：新疆大学、中科院武汉岩土力学研究所
- Xinjiang University, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences

1. 项目背景 Background

- Xinjiang has various industrial sectors and numerous CO_2 emissions.
- The CO_2 emission points have relatively intensive distribution.
- Xinjiang has abundant of oil resources.



Oil fields distribution in Xinjiang

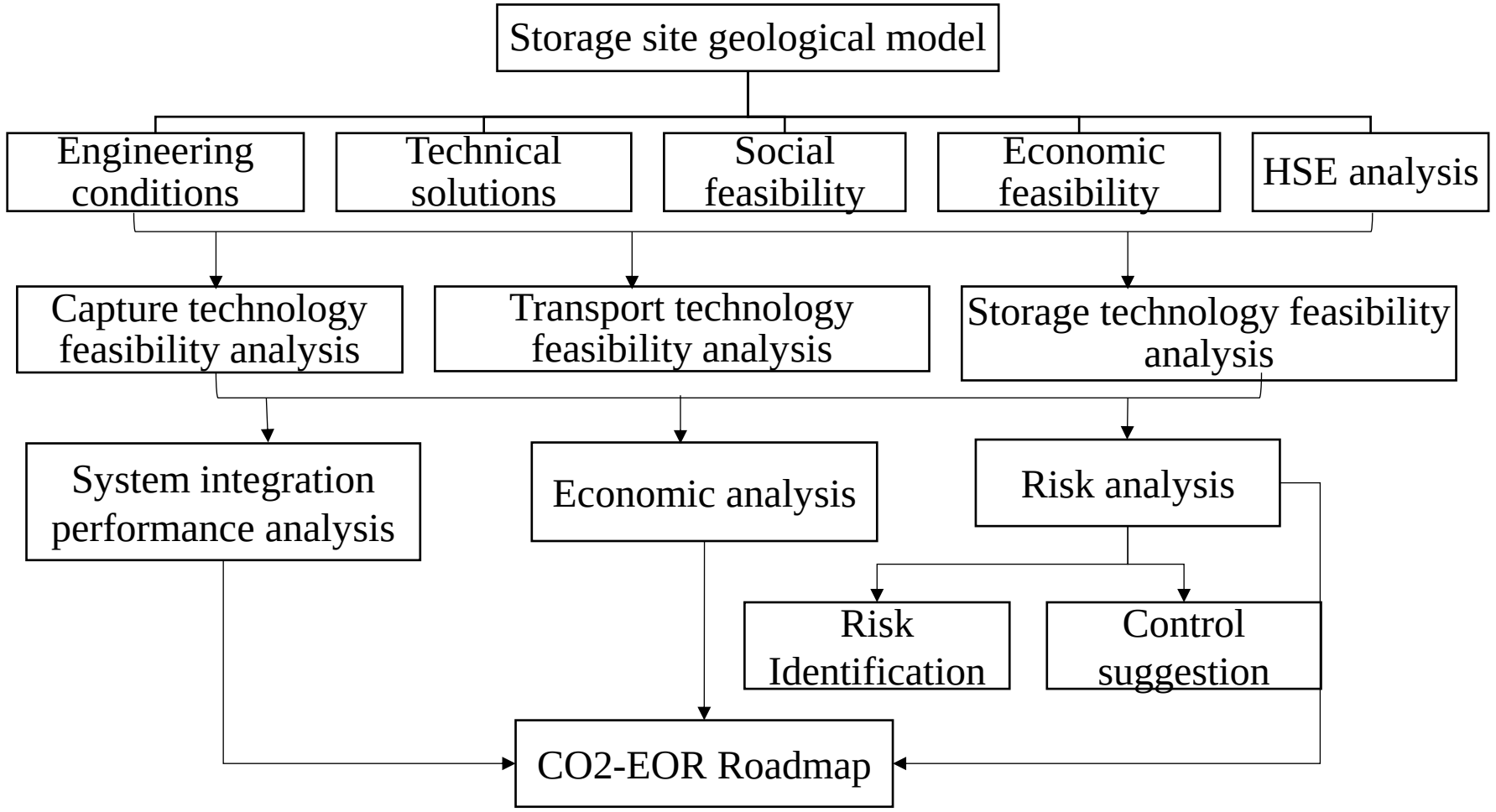


CO_2 sources distribution in Xinjiang

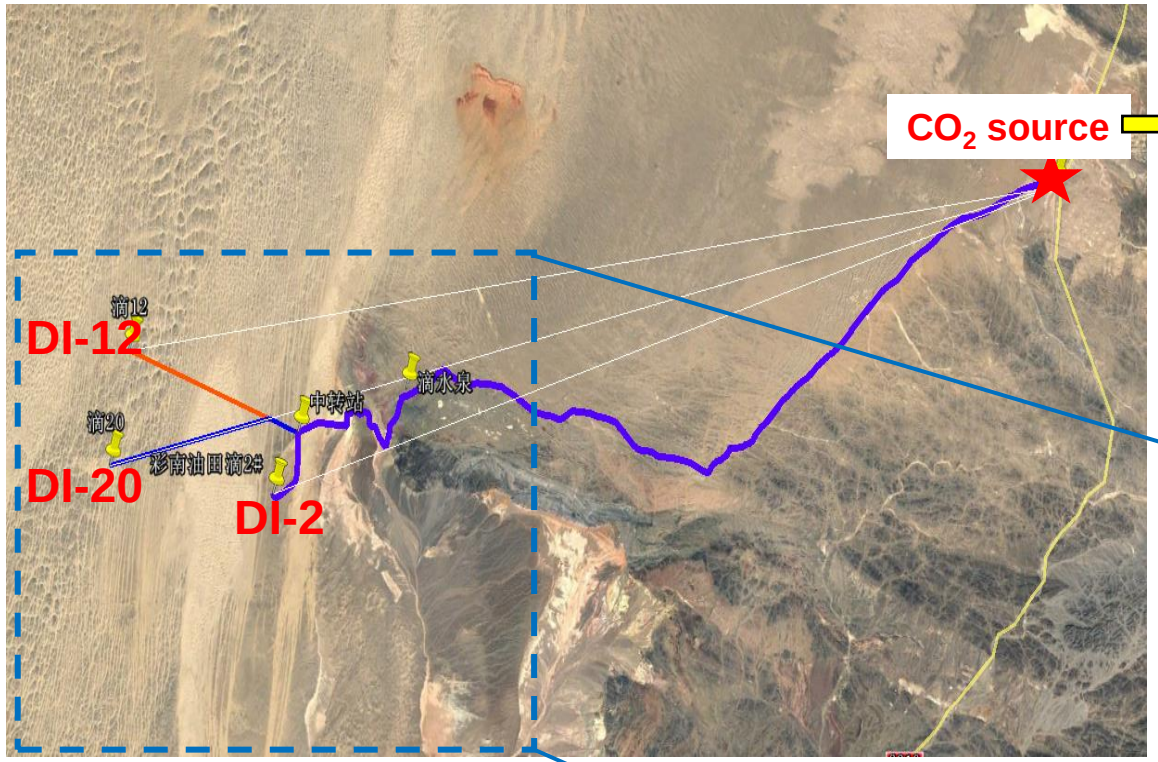
2. 项目概况　Project overview

- **Main activities:**
  - Field investigation
  - CAGS-III Symposium
  - Training course in Xinjiang University
  - Other academic activities

2. 项目概况 Project overview



2. 项目概况 Project overview



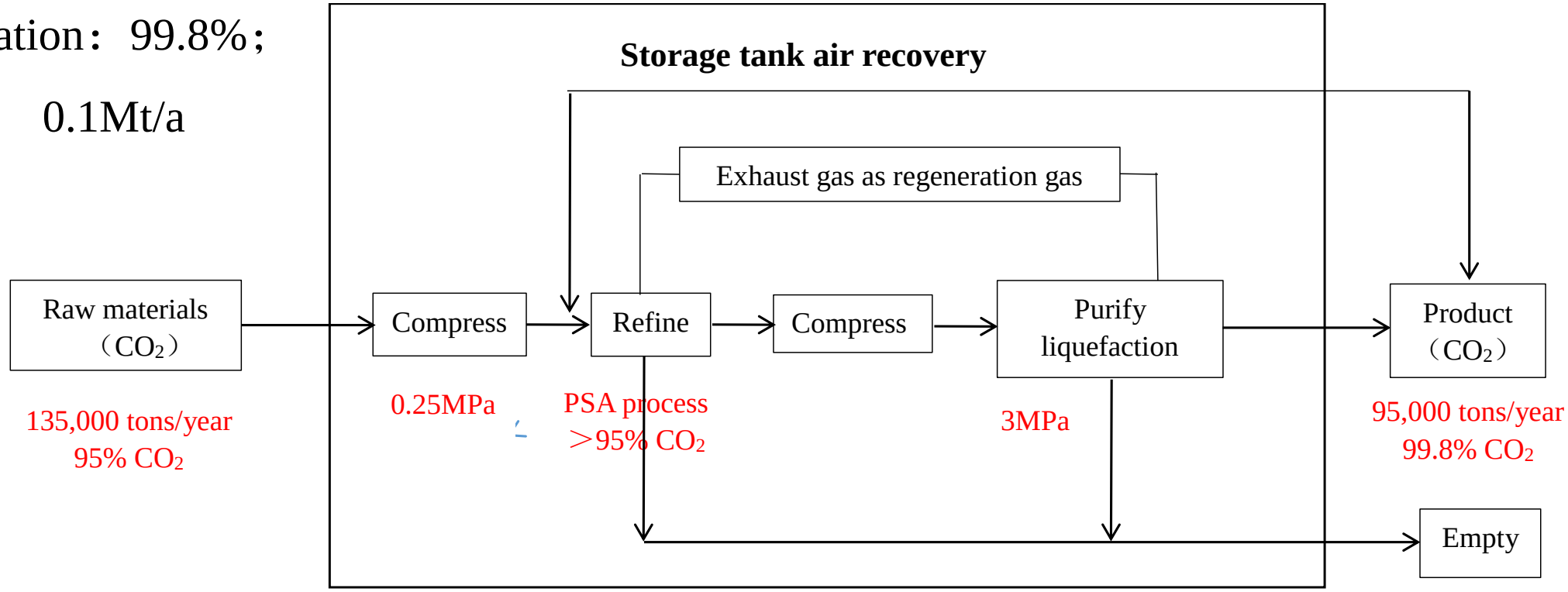
- Xinjiang Guanghui
- CO_2 concentration：99.8%；
- Capture scale： 0.1Mt/a
- Duration：3years and 20years

- Several oil fields or oil blocks are suitable for CO_2-EOR.

3. 捕集环节可行性分析
Feasibility analysis on capture

☐ Capture technology

- CO2 concentration： 99.8%；
- Capture scale： 0.1Mt/a



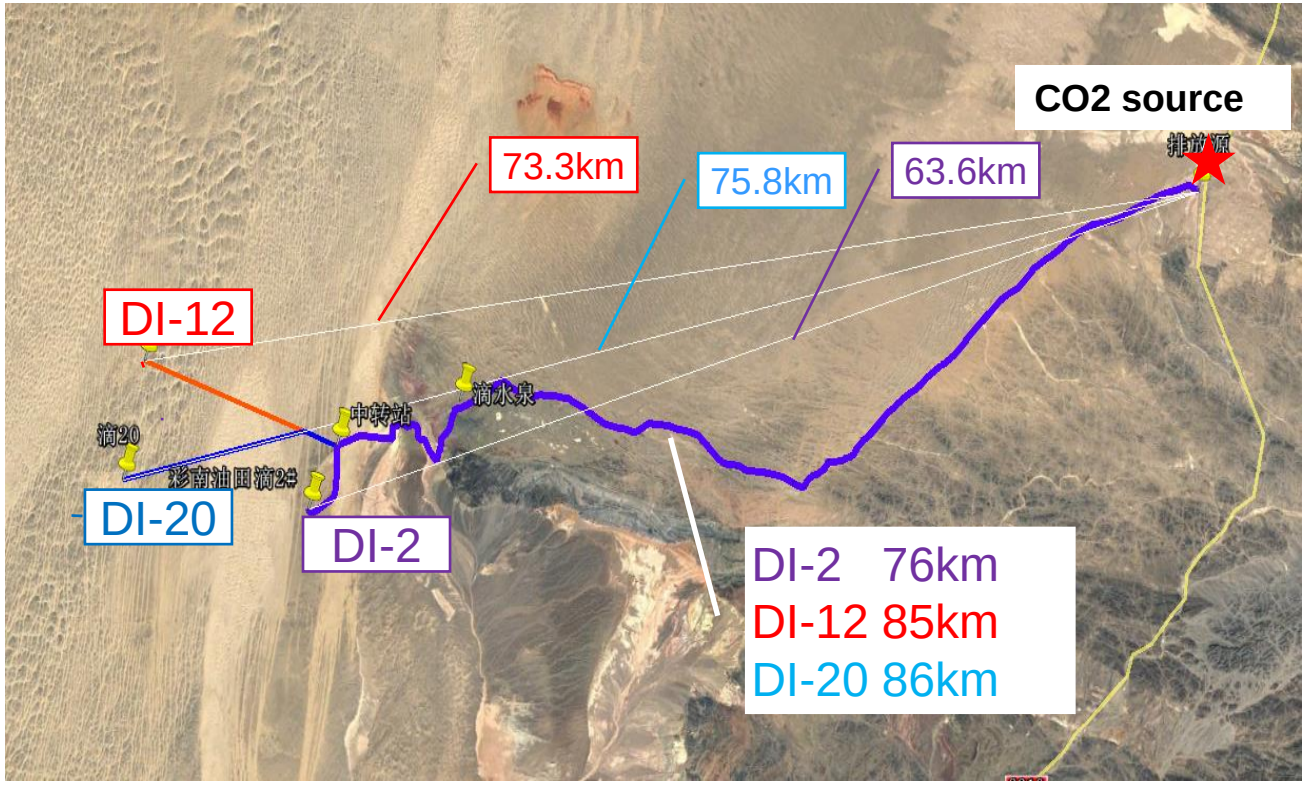
3.捕集环节可行性分析
Feasibility analysis on capture

☐ Energy consumption

序号	项目	小时耗量		产品单耗		耗能指标		单位能耗
		单位	数量	单位	数量	单位	数量	MJ/t
1	电	kWh	1282	kWh	226.554	MJ/kWh	10.89	2467.175
2	新鲜水	t	2	t	0.353	MJ/t	6.28	2.22
3	循环冷却水	t	510	t	90.127	MJ/t	4.19	377.632
8	除盐水	t	1	t	0.177	MJ/t	96.3	17.018
4	蒸汽（0.3MPaG）	t	18	t	3.181	MJ/t	2763	8788.959
5	工艺压空（0.6MPaG）	Nm^3	100	Nm^3	17.672	MJ/Nm^3	1.17	20.676
6	仪表压空（0.6MPaG）	Nm^3	50	Nm^3	8.836	MJ/Nm^3	1.59	14.049
7	氮气（0.6MPaG）	Nm^3	100	Nm^3	17.672	MJ/Nm^3	6.28	110.98
	加工总能耗				11798.709 MJ/t			

注：耗能指标采用《石油化工设计能耗计算标准》（GB/T 50441-2007），以CO2产品47533t/a计。

4. 输送环节可行性分析
Feasibility analysis on transportation



Transportation routes

The distance of different transportation options

Well	DI-2	DI-12	DI-20
Truck transport distance	76km	73.3km	86 km
Pipeline transportation distance	63.6km	73.3km	75.8km

- Terrain conditions: flat; mainly gobi and desert.
- Truck transport conditions :
  - Pressure：2MPa, temperature: -30℃;
  - Tank capacity: 50t
  - Price: 1.1 yuan/(t.km)

4. 输送环节可行性分析
Feasibility analysis on transportation

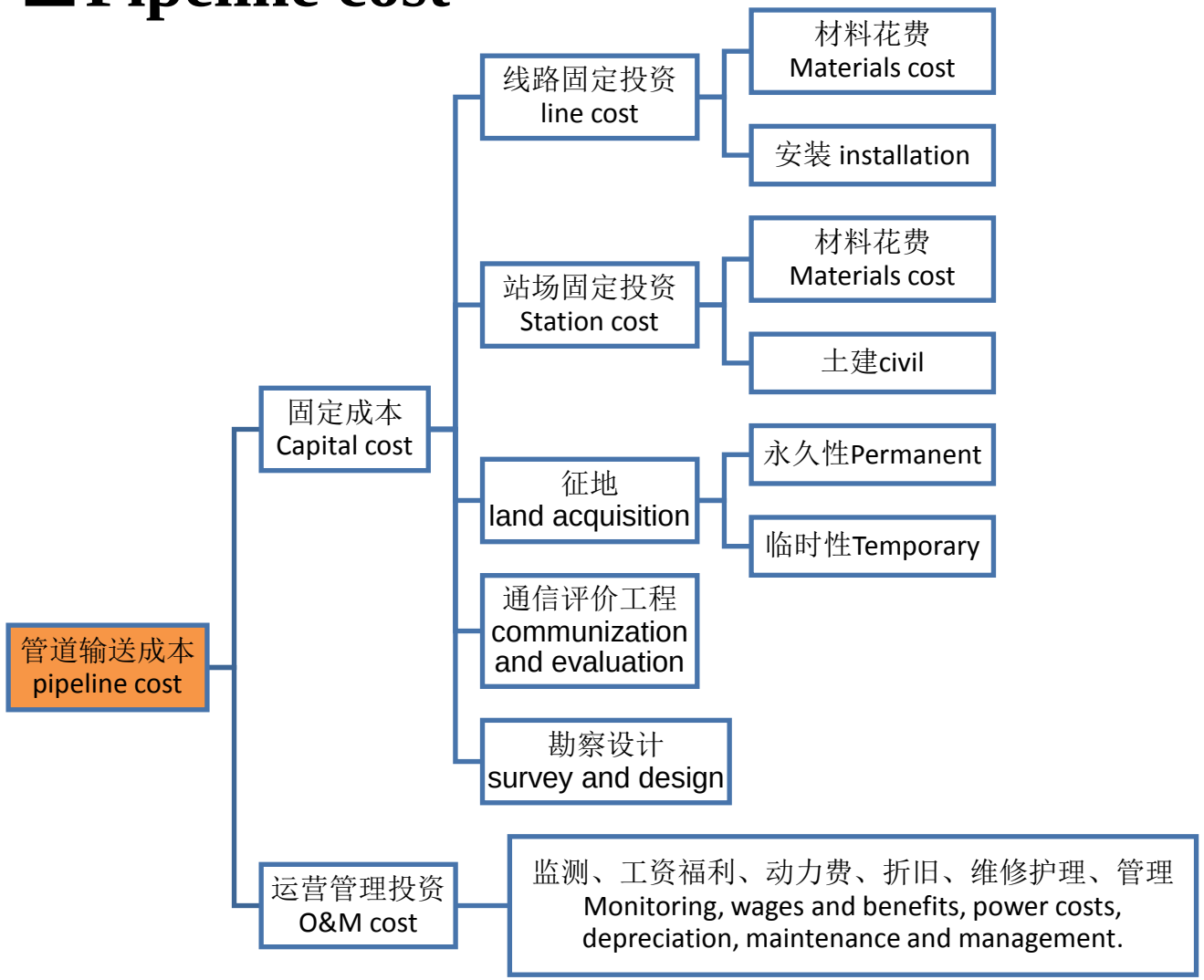
Pipeline design parameters

- Dense phase, liquid
- Pipe laying depth: 1.0-1.2m

Name	Unit	Value
Import pressure	Pin[MPa]	12
Export pressure	Pout[MPa]	9.2
Delivery temperature	T [K]	>20℃
Delivery scale	M[t/a]	0.1
Delivery distance	L [km]	80
CO_2Compression factor	ZCO_2	0.32
CO_2 density	ρ_{CO2} [kg/m^3]	625-1025
Steel density	ρ_s [g/cm^3]	7.85
Electrovalency	pc [RMB/KW.h]	0.066
Device capacity factor	CF	0.8
Period of depreciation	N[yr]	20

4. 输送环节可行性分析
Feasibility analysis on transportation

☐ Pipeline cost



Pipeline transportation cost

	3 years [￥]	20 years [￥]
增压成本 Supercharging cost	8.934×10^4	5956×10^4
固定总成本 Fixed total cost	2.125×10^8	2.125×10^8
运营成本 Operation cost	670.86×10^4/yr	543.38×10^4 /yr
运输总成本 Total cost	2.415×10^8	3.807×10^8
均化成本 Average cost	115.20 /t CO_2	38.00 /t CO_2
平准化成本 Levelized cost	1.44 /（t. km）	0.48/（t. km）

4. 输送环节可行性分析
Feasibility analysis on transportation

☐Truck transportation cost &Pipeline transportation cost

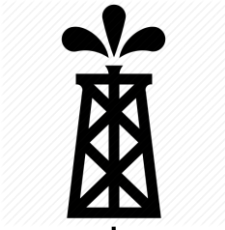
Total cost	Distance (km)	3 years(￥)	20 years (￥)
Tanker transportation	76	**1.053×10^8**	7.02×10^8
Pipeline transportation	63.6	2.415×10^8	**3.807×10^8**

- For a 3-year pilot project, it is better to choose truck transportation.
- For a 20-year project, the pipeline transportation is much cheaper.

5.封存试验场地筛选
Storge test site screening

Screening indexes

natural condition



Distance between source and sink

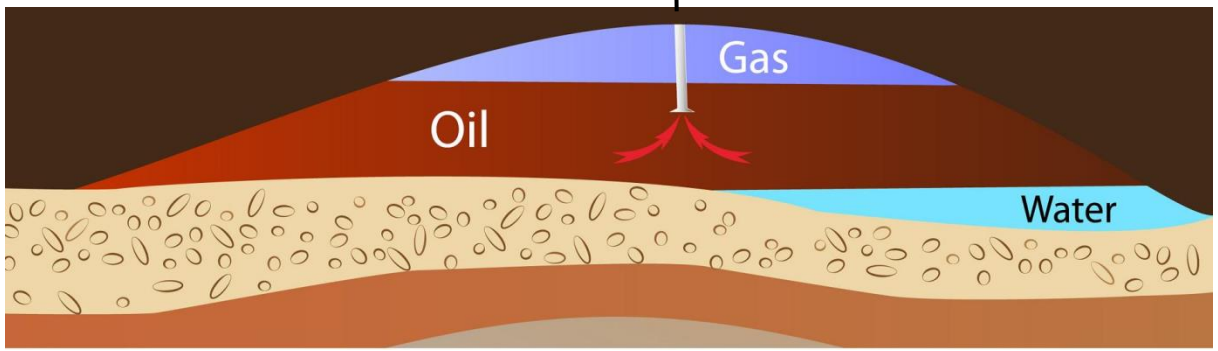
well condition

reservoir depth

reservoir temperature

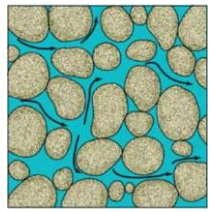
reservoir dip angle

formation pressure



recovery degree

crude oil properties



mineralization

Porosity

permeability

5.封存试验场地筛选
Storge test site screening

Natural condition

- The farer away from the communities of plants and animals, the lower the environment risk.
- Flat surface will reduce the engineering cost.

Reservoir Condition

- Higher permeability, easier for injection.
- Thick caprock will increase the safety.
- Pressure, viscosity and temperature

Source and sink match

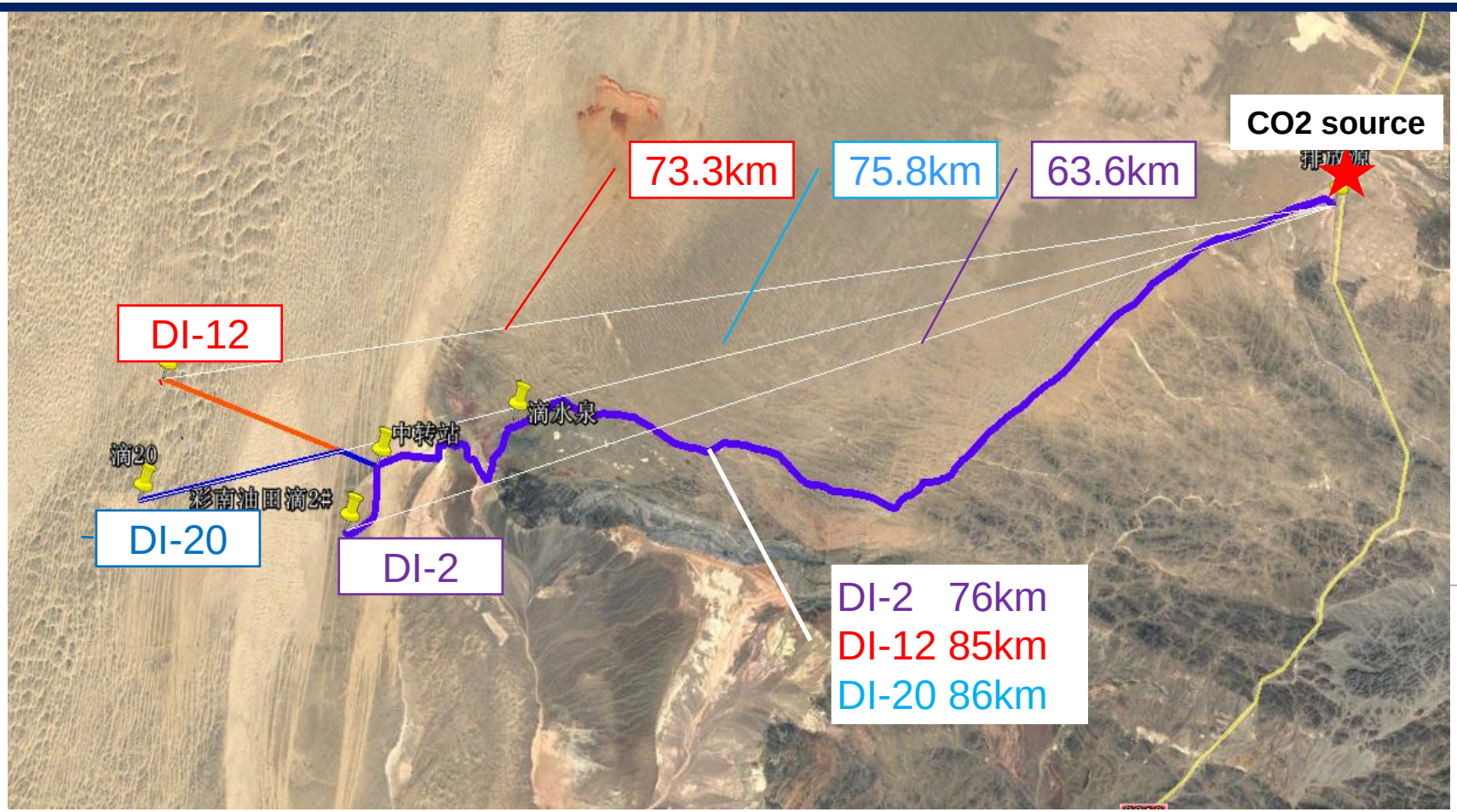
- Shorter distance, lower transportation cost.
- Reservoir must have enough capacity.
- More wells, more flexible.

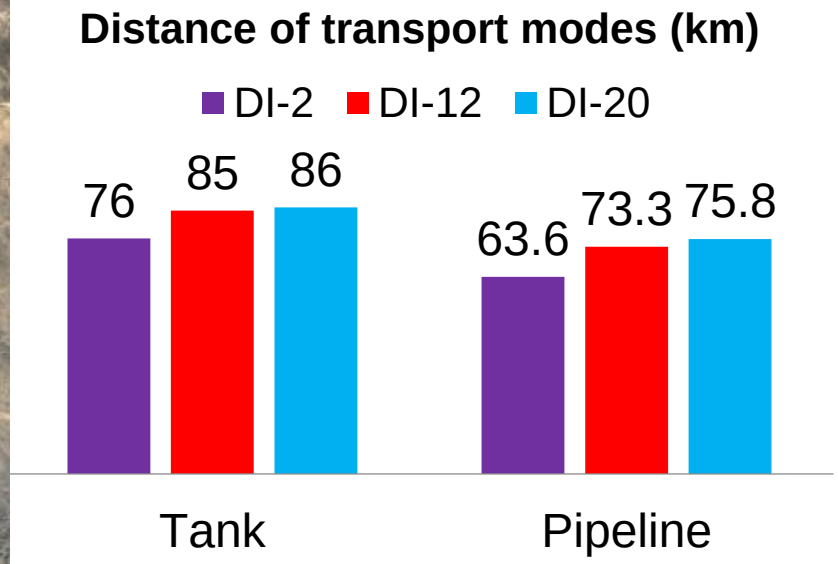
5.封存试验场地筛选
Storge test site screening

Natural condition

- ✓ Gobi desert
- ✓ Uninhabited, no residential area
- ✓ Open and flat
- ✓ little vegetation covered
- ✓ No surface water system

5.封存试验场地筛选
Storge test site screening

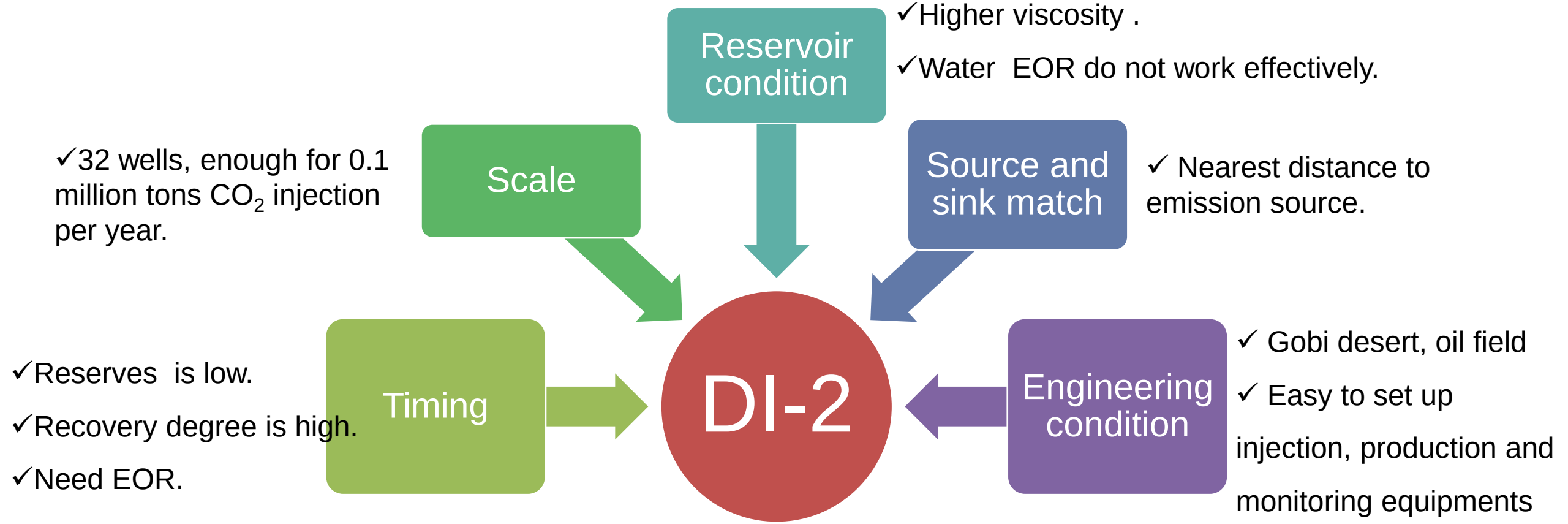




Reservoir properties and wells

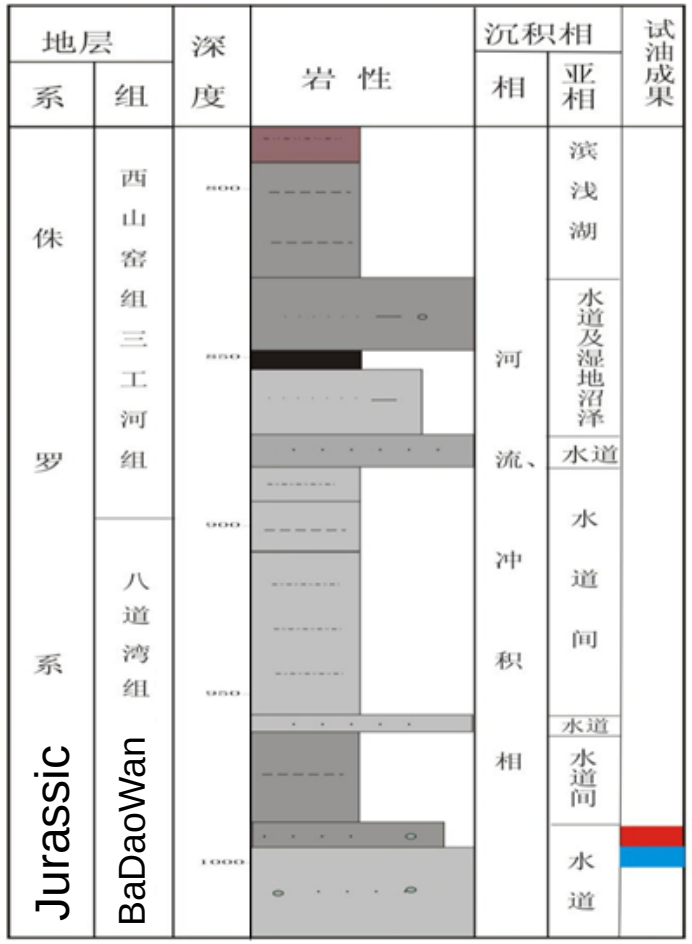
Region	DI-12	DI-2
Reservoir description	Reservoir: Gray, medium - thin, medium coarse, conglomerate sandstone, Caprock: Mudstone, > 15m thick	
Buried depth of reservoir	Middle depth 1115 m	Middle depth 970 m
Ground temperature	44.6℃	40.3℃
Reservoir dip angle	5-8°	5-8°
Formation pressure	Central pressure8.678 MPa	Central pressure7.043 MPa
Oil area of oil reservoir	5.57 km^2, > 6.6m thick	1.43 km^2, > 5 m thick
Initial oil saturation	55.8%	54.4%
porosity	19.20%	17.80%
Effective thickness	6.6 m	5.0 m
Viscosity of crude oil (mPas)	39.8 (ground)	110.1 (ground)
Density of crude oil g/cm^3	0.87-0.883	0.9-0.909
Saturation pressure	5.773 MPa	5.92 MPa
Pressure coefficient	0.778	0.726
Saturation degree	66.5%	84.1%
Injection well	20 (not all opened)	9 (not all opened)
Producing well	45 (not all opened)	23 (not all opened)
Well spacing	< 280 m	< 280 m
Time and degree of reservoir mining	Development in 2005 The recovery degree is less than 15%	Development in 2007 The recovery degree is more than 15%

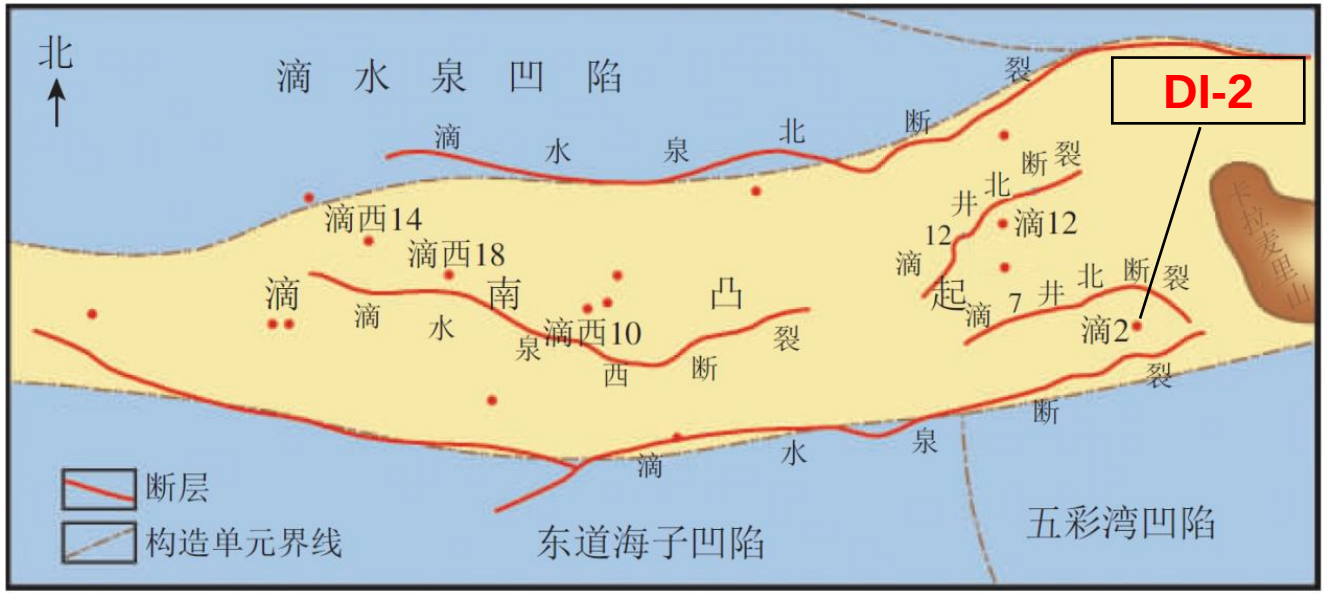
5.封存试验场地筛选
Storge test site screening



6. 封存环节可行性分析
Feasibility analysis on storage

- Brief introduction to DI-2



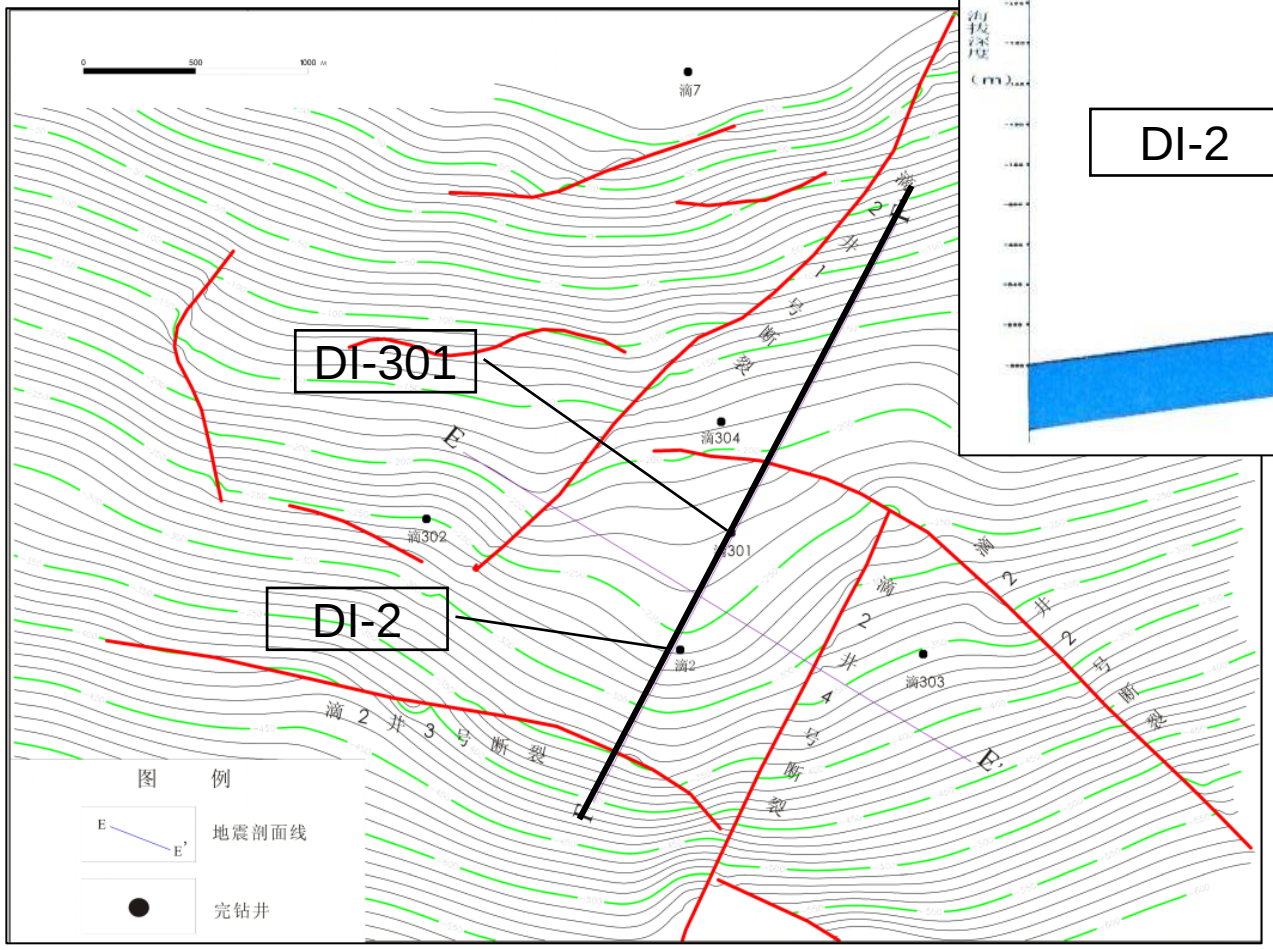


DiNan Bulge

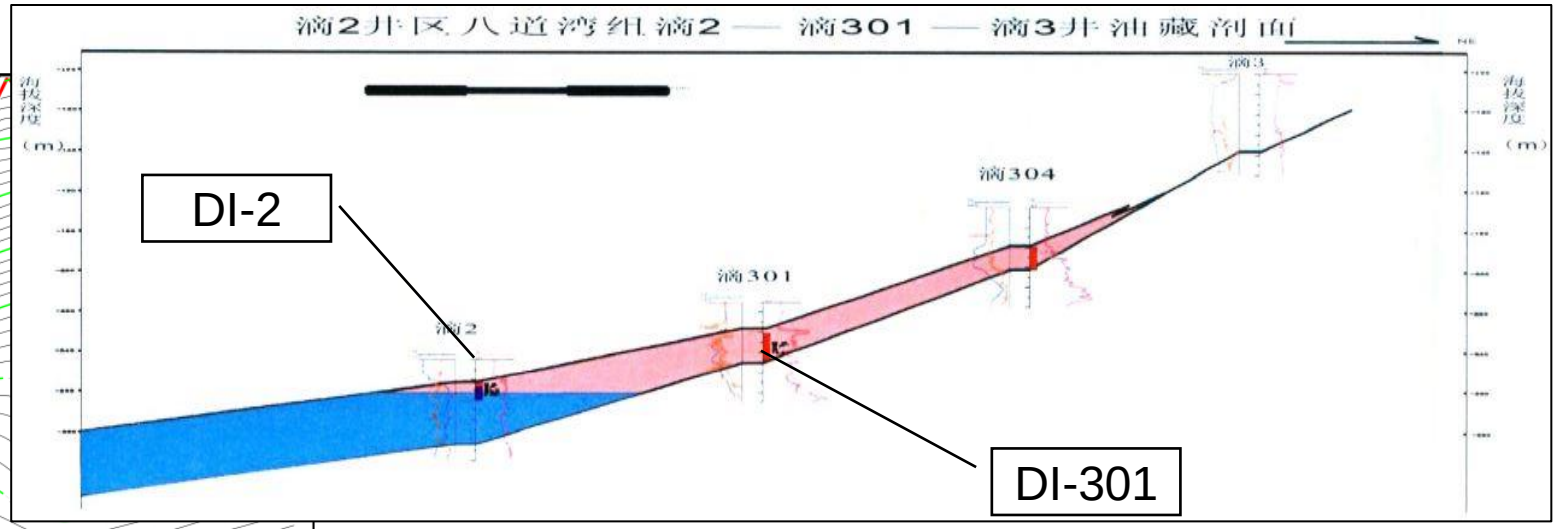
- The DiNan Bulge was formed in the middle late Carboniferous.
- Upper Jurassic , some Middle Jurassic, Triassic and Permian formations are missing , because of the Indosinian movement and denude start from the end of the Upper Triassic.
- BaDaoWan group belongs to the low/early Jurassic, 900m ~ 1000m depth.
- Below BaDaoWan group is the BaShan group, which belongs to Upper Carboniferous.

6. 封存环节可行性分析
Feasibility analysis on storage

- Brief introduction to DI-2

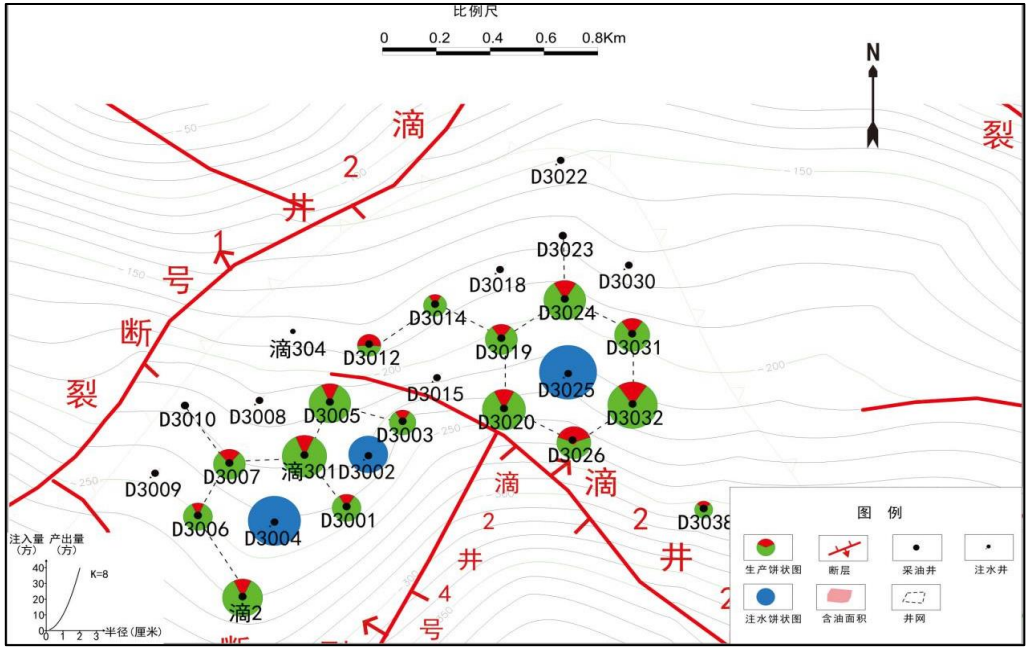


Structural map of top Jurassic BaDaoWan Group

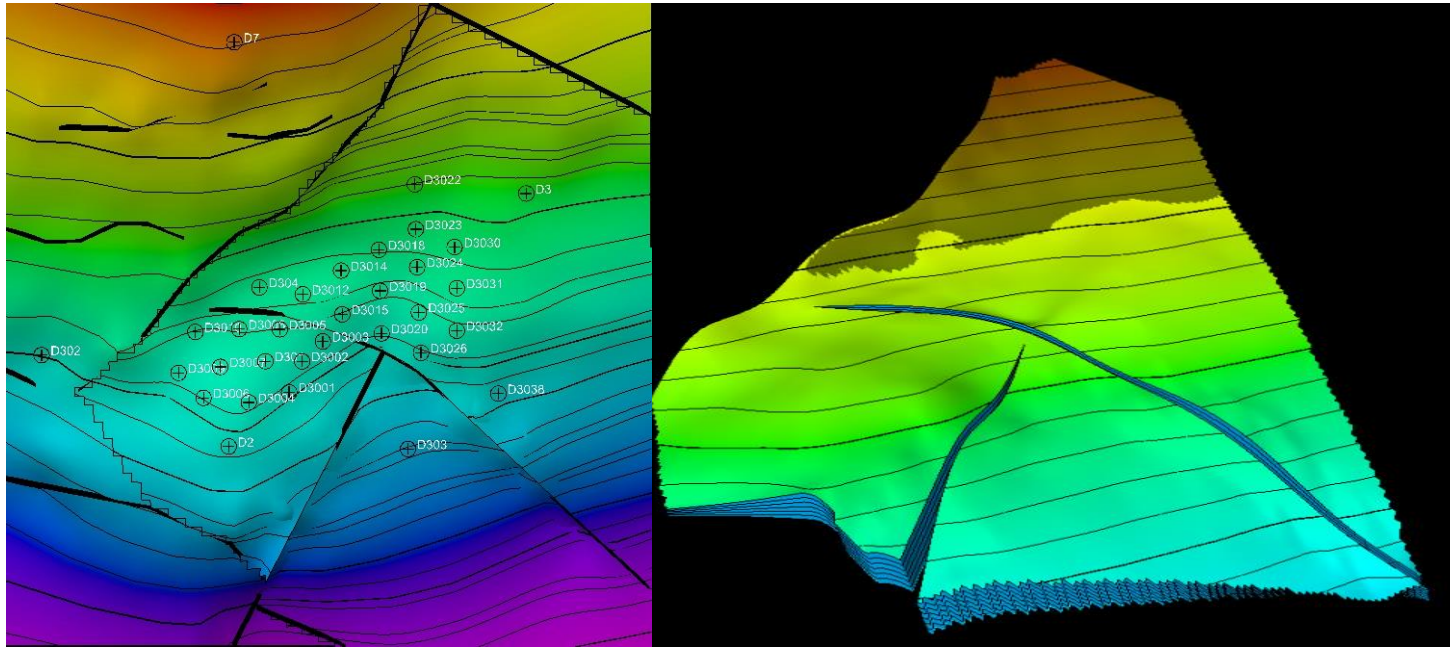


- Reservoir belongs to BaDaoWan group.
- Monocline
- 4 large faults
- Reservoir is about 10 ~ 20m thick.

6. 封存环节可行性分析
Feasibility analysis on storage



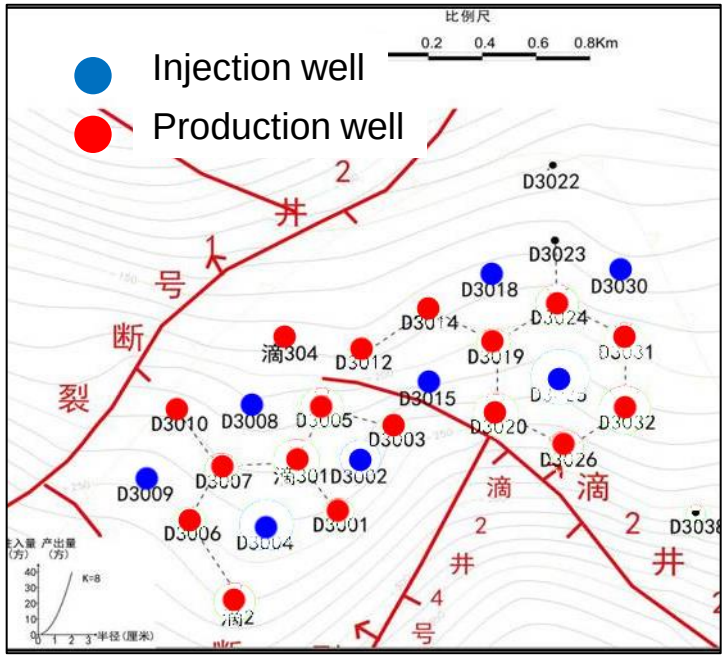
Well distribution of DI-2 field



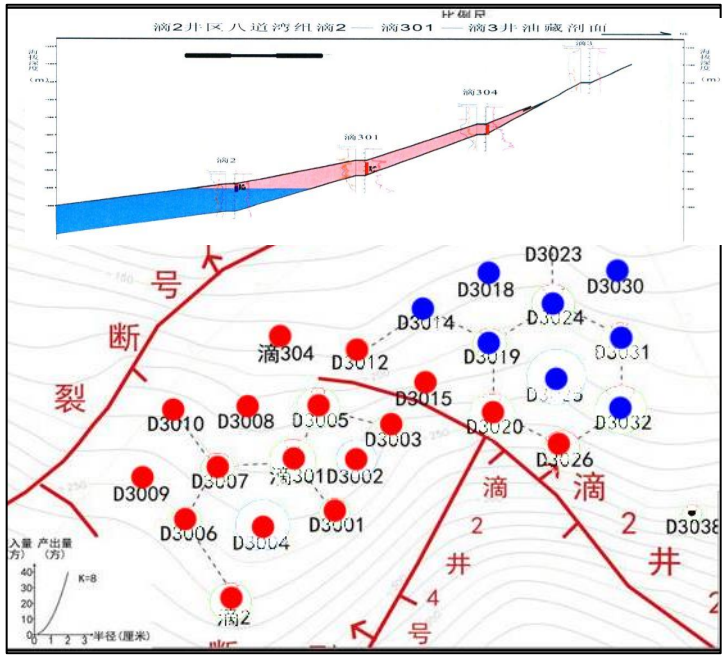
model of Reservoir and well

6. 封存环节可行性分析
Feasibility analysis on storage

Simulation injection scheme



Pattern 1



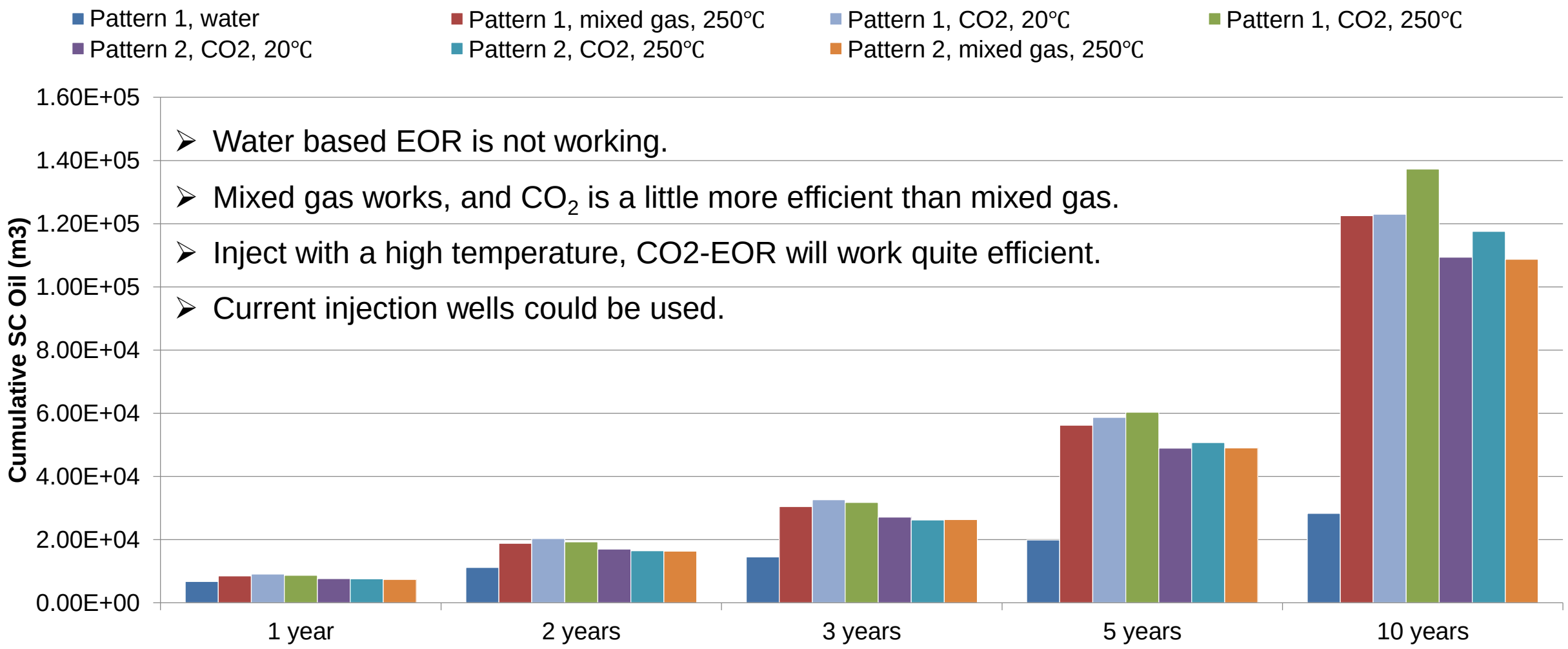
Pattern 2

	Injection Fluid	Temperature
Pattern 1	Water	20℃
	Mixed Gas	250℃
	CO_2	20℃
	CO_2	250℃
Pattern 2	Mixed Gas	250℃
	CO_2	20℃
	CO_2	250℃

- 7 injection schemes
- Mixed Gas is 67% N_2 and 33% CO_2.
- 0.1 million tons CO_2 per year, for 10 years.
- The oil field have already test the mixed gas EOR in few wells, and it is working.

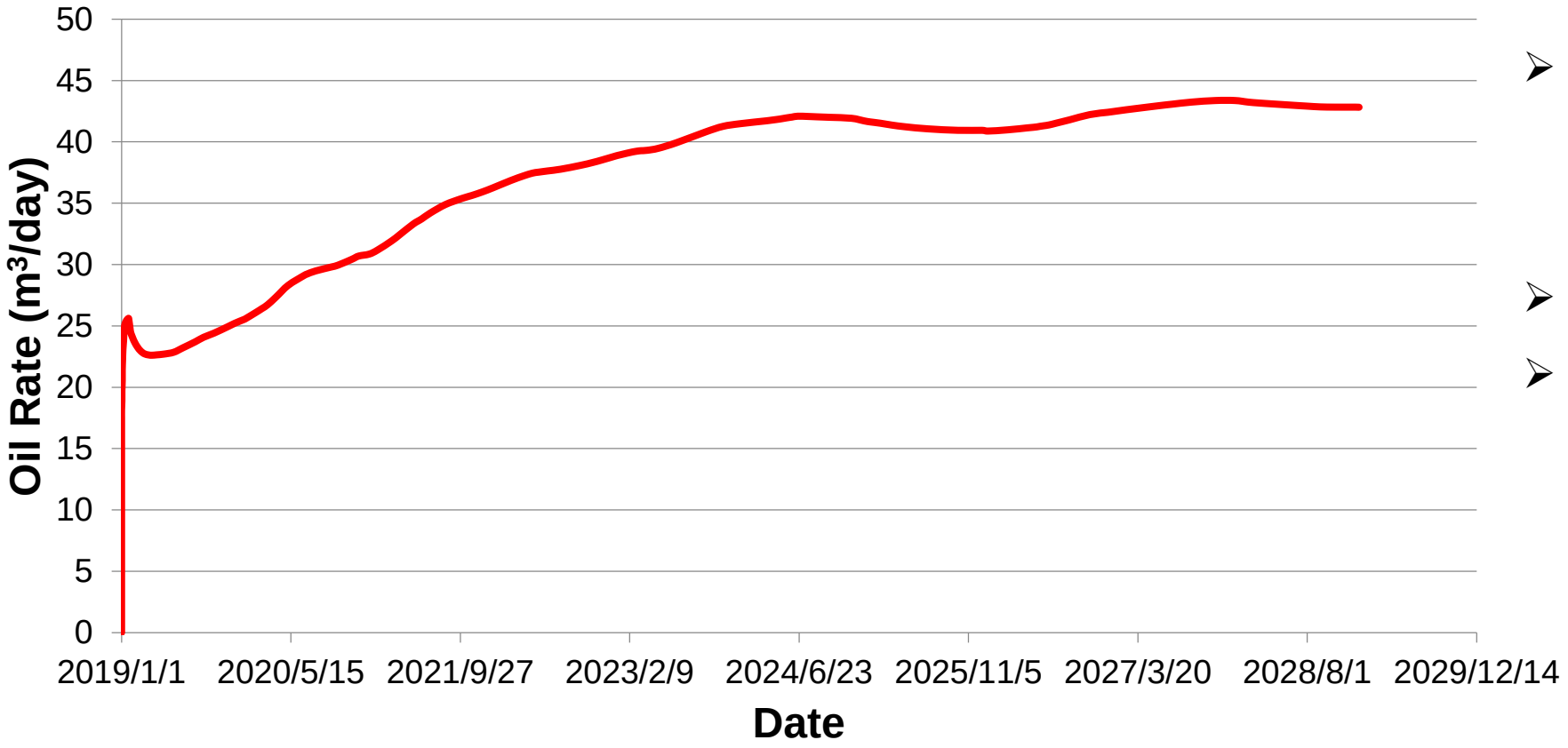
6. 封存环节可行性分析
Feasibility analysis on storage

Simulation Result



6. 封存环节可行性分析
Feasibility analysis on storage

Simulation Result



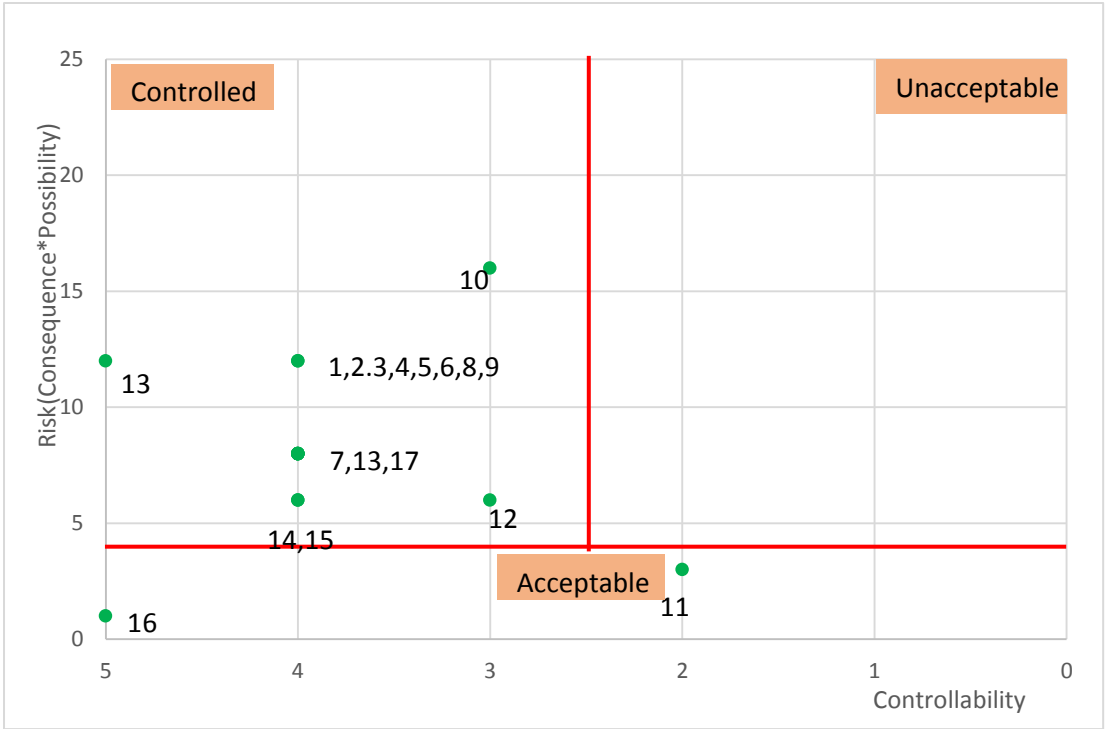
The oil production rate of Di-2,
with current 17 production wells, CO_2, 250℃

- After about 5 years injection, reach the max production rate.
- The max rate is 43.37 m^3/day.
- 2.551 m^3/day/well.

7. 环境风险评估
Environmental risk assessment

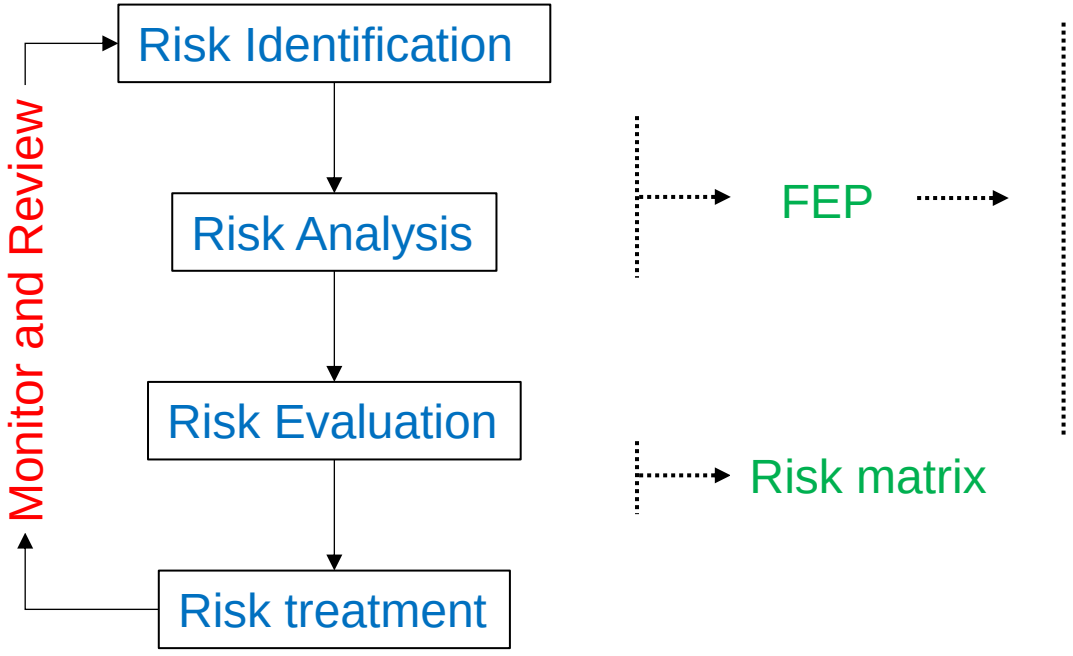
Transport component:

NO.	Risk list	Risk assessment			Explain
		Consequence (1~5)	Possibility (1~5)	Controllability (1~5)	
1	System design defects	4	2	4	Through strict audit procedures and process management, the risk of design can be very low.
2	Insufficient material for system design	4	2	4	
3	Improper design in the process of piping design (such as incorrect or inappropriate valve placement)	4	2	4	
4	Improper operation in the process of installation	4	2	4	Strengthening the management of the construction process can greatly improve the controllability of the construction risk
5	Equipment or material quality is not passed in the process of installation, pipe laying and valve room	4	2	4	
6	Overpressure operation	4	2	4	Establish training process and strengthen operation management
7	Operation of pipeline / equipment / valve malfunction, leakage, corrosion	4	3	4	
8	Operation failure of pipeline, equipment and valve	4	2	4	
9	Human error in operation	4	2	4	
10	Unintentional destruction caused by third parties (mining operations)	4	4	3	Strengthen publicity, enhance public awareness and increase the identification of pipeline
11	Failure of formation / soil movement to pipeline / equipment / valve chamber	4	2	2	Establishment of emergency chain mechanism
12	External corrosion (soil type, wall thickness loss, abnormal density, rupture pressure increase, DC/AC interference)	3	1	3	
13	Non fault leakage and corrosion caused by pipe release operation	3	4	5	Rationalizing the operation Arrangement and strengthening the monitoring of the operation process
14	Failure, leakage, corrosion caused by maintenance of pipeline / equipment / valve	3	2	4	
15	Failure, leakage, corrosion in the process of redebugging	3	2	4	
16	CO_2 gas source interruption	1	1	5	Strengthening communication with the suppliers of gas sources
17	Phase transition caused by temperature change	3	4	4	Select the appropriate thermal insulation material



7. 环境风险评估
Environmental risk assessment

Storage component:



Lithosphere

- Geology
- Fluid

External

- Geology
- Near surface environmental: human behavior, land environment
- Future human activities

Storage system

- Drill hole: well completion, borehole sealing and abandonment
- Carbon dioxide interaction
- CO_2 storage

Influence receptor

- System performance
- Environmental medium: atmosphere, soil, surface water, and groundwater
- Health
- Animal and plant
- Microorganism

7. 环境风险评估
Environmental risk assessment

- Storage component:

  - **Environmental risk assessment standard**

The classification of the risk possibility level

The definition of risk possibility	
Type	**Description**
Rare 1	The possibility is very low, never occur before. But is possible in theory.
Unlikely 2	The occurrence possibility is very small within the project period.
Possible 3	My occur in the project period.
Likely 4	May occur more than one time in the project period.
Almost certain5	May occur every year.

7. 环境风险评估
Environmental risk assessment

☐ Storage component:

The consequence serious degree classification

Influence	Grade	Influence degree
Insignificant	1	The environment index like the soil/underground water/surface water/environment air does not exceed the environment quality standard or environment background value of the project site. Or the carbon dioxide density exceeds the environment background value. Do nor have continuous influence on the environment risk receptors.
Minor	2	The environment index like the soil/underground water/surface water/environment air does not exceed the environment quality standard or environment background value of the project site. Or the carbon dioxide density exceeds the environment background value. Have some adverse influence on the environment risk receptor but can be solved and recovered.
Significant	3	The environment index like the soil/underground water/surface water/environment air exceeds the environment quality standard or environment background value of The project site. Or the carbon dioxide density exceeds the environment background value. Have certain adverse influence on the environment risk receptor but can be solved and recovered.
Major	4	The environment index like the soil/underground water/surface water/environment air exceeds the environment quality standard or environment background value of the project site. Or the carbon dioxide density exceeds the environment background value. Have some adverse influence on the environment risk receptor and is difficult to be recovered.
Severe	5	The most environment indexes of soil/underground water/surface water/environment air exceed the environment quality standard or environment background value of the project site. Or the carbon dioxide density exceeds the environment background value. Have serious influence on the environment risk receptor but can bring some irreversible damages.

7. 环境风险评估
Environmental risk assessment

- Storage component:

Work out the risk matrix by calculating the influence degree*possibility based on the above mentioned classification criteria. The higher than value is, the higher risk occurrence possibility is and the more serious the consequence is.

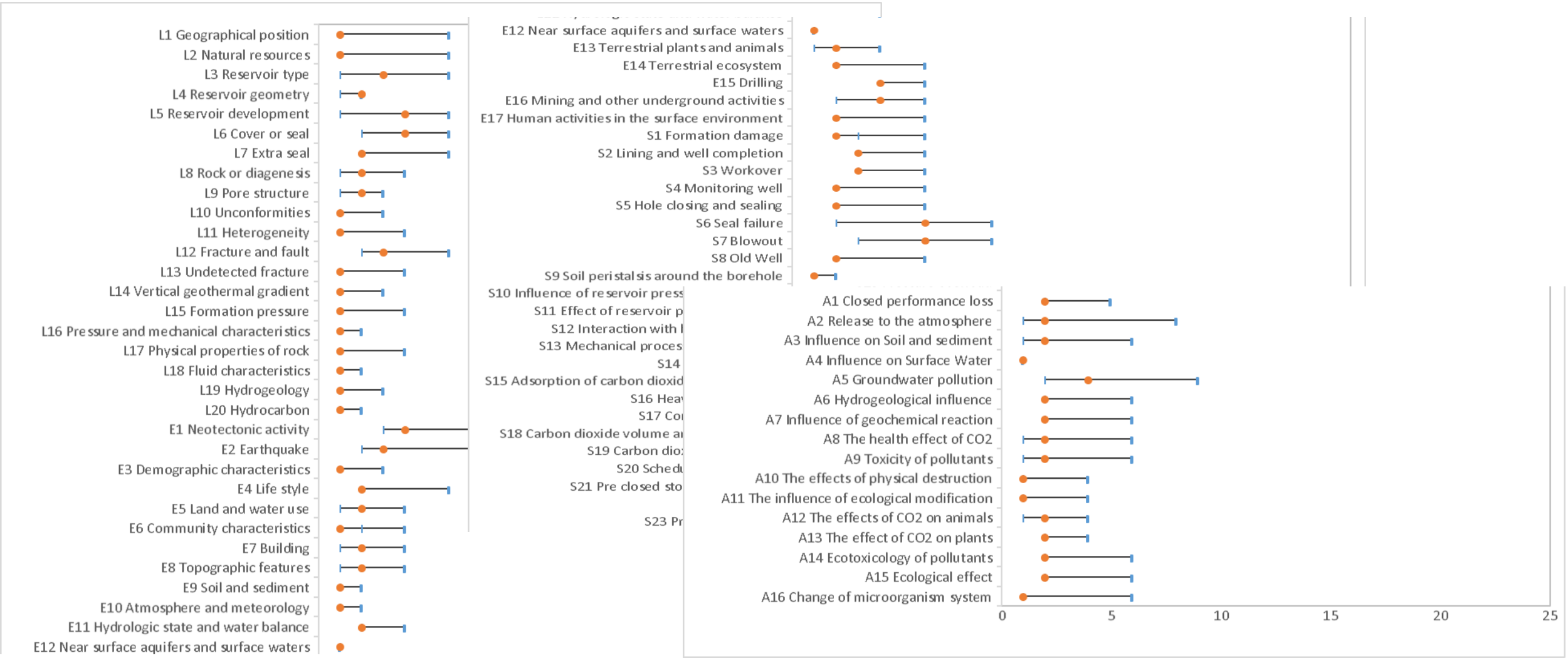
Risk consequence = possibility * the degree of influence.

The consequence matrix

		Influence				
		Insignificant1	Minor 2	Significant 3	Major4	Severe 5
Possibility classification	Almost certain5	5	10	15	20	25
	Likely 4	4	8	12	16	20
	Possible3	3	6	9	12	15
	Unlikely 2	2	4	6	8	10
	Rare 1	1	2	3	4	5

7. 环境风险评估
Environmental risk assessment

☐ Storage component: Analysis result



7. 环境风险评估
Environmental risk assessment

- Storage component:

Evaluation results

Atmosphere
Groundwater
Population

Possibility	Consequence 1	2	3	4	5
5					
4					
3					
2					
1					

Soil
Surface water
Flora and fauna

Possibility	Consequence 1	2	3	4	5
5					
4					
3					
2					
1					

Risk level		
Acceptable risk		Extra-low
		Low
Unacceptable risk		Moderate
		High
		Extra-high

8. 总结 Summary

- Good geologoical conditions for CO_2-EOR
  - Good reservoir physical properties
  - Cainan oil field best for EOR;
  - Three oil blocks: DI-12, DI-20, DI-2 (best)
- Demonstration project recommend:
  - Xinjiang Guanghui + DI-2 block (Cainan oil field)
  - Based on the economic analysis on transportation component:
    a) For a short time pilot, truck is recommended;
    b) For a long time demonstration project, pipeline is cheaper.
- Risk assessment:
  - Leakage or erosion by pipe venting;
  - Leakage from re-builded wells; phase transition caused by temperature change; caprock damaged by mining.
- Current barrier:
  - The new planned nature reserve covers Guanghui pilot site.

- 用于CO_2-EOR的地质条件良好
  - 物性好；
  - 彩南油田最适于用CO_2-EOR；
  - 滴12、滴20、滴2(条件最好)
- 示范项目建议：
  - 新疆广汇+彩南油田滴2
  - 基于输送环节的经济性分析：
    a) 短期试点，推荐用罐车运输；
    b) 长期示范项目，推荐用管道运输。
- 风险评价：
  - 由于管道放空泄漏或腐蚀；
  - 通过重建井泄漏，温度改变引起相变，其他矿产开采破坏盖层；
- 当前障碍：
  - 新疆广汇试验场区处于新规划的自然保护区范围内。

Thanks for your attention

谢谢！