

CO₂ storage potential in Songliao and Subei basins

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•Aim

To assesses CO₂ storage potential in China and undertake preliminary characterization for site selection of CO₂ storage.

•Objectives

To provide information on the future potential for CO₂ storage as enhance oil recovery (EOR), and storage in saline aquifers in a range of basins.



Selected areas

Hydrocarbon fields in Songliao Basin and Subei Basin

EOR

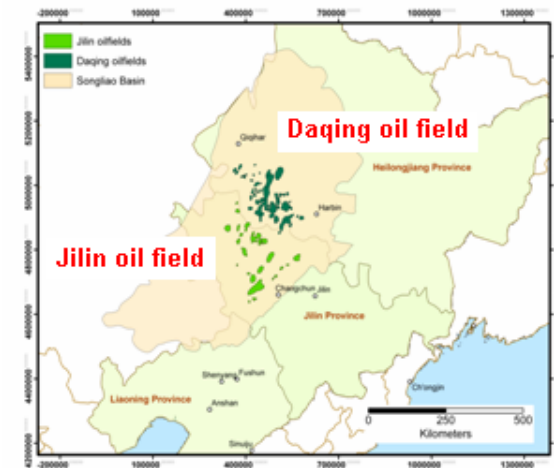
Aquifer

Songliao basin: 260000 km²

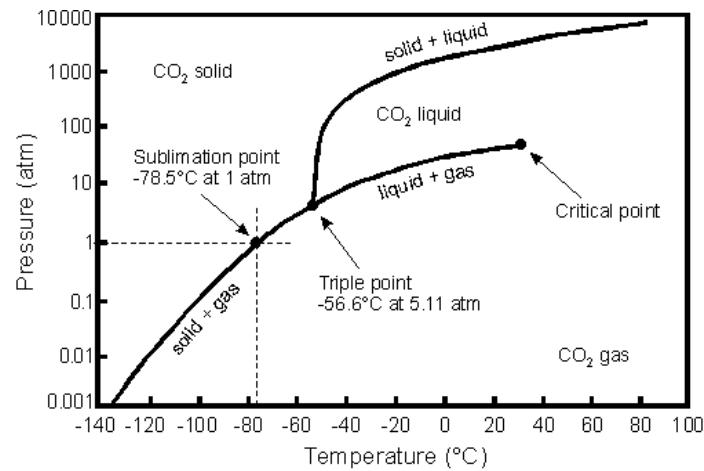
Daqing oil field: 720 km²

Jilin oil field: 510 km²

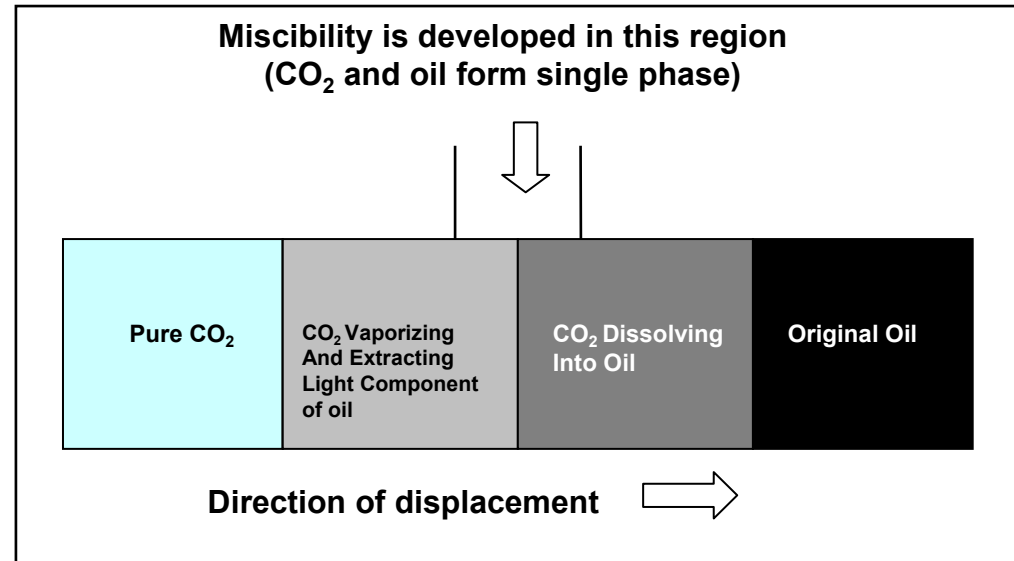
Jiangsu oil field in Subei Basin
is small



CO₂-EOR(Enhanced Oil Recovery)



Pressure-Temperature phase diagram for CO₂.



Affect factors:

- Pressure
- Temperature
- Property of oil
- Property of reservoir

CO₂ in liquid or supercritical state

Methodologies

1. CSLF method

2. Assessment model for CO₂ storage potential (CUP)

$$M_{(\text{CO}_2)} = M_1 + M_2 + M_3 + M_4$$

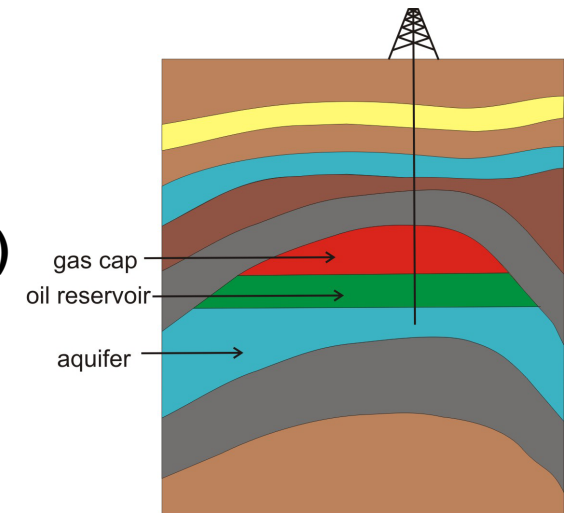
$M_{(\text{CO}_2)}$ - total storage capacity of CO₂ (m³)

M_1 - storage capacity of CO₂ dissolved in oil and water in oil bearing reservoir

M_2 - storage capacity of CO₂ dissolved in formation water

M_3 - storage capacity of CO₂ in oil bearing reservoir during CO₂ flooding

M_4 - storage capacity of CO₂ reacted with rock



$$M_{(\text{CO}_2)} = E_f \times A \times h \times \varphi \times [S_o \times R_{o(\text{CO}_2)} + (1 - S_o) \times R_{w(\text{CO}_2)}] + h \times A \times \varphi \times R_{w(\text{CO}_2)} + (M_p \times 4\% / \rho_f)$$

E_f —overall sweep efficiency(fraction), $E_f=5\%-25\%$, assume $E_f=18\%$;

A —oil-bearing area (m^2);

h —formation thickness (m);

φ —porosity (fraction);

S_o —oil saturation (fraction) , assume $S_o=75\%$;

$R_{o(\text{CO}_2)}$ — CO_2 solubility in oil (fraction);

$R_{w(\text{CO}_2)}$ — CO_2 solubility in water(fraction);

S_w — CO_2 solubility in formation water (fraction);

M_p —residual oil in reservoir (10^4t)(in 2000);

ρ_f —oil density in formation (kg/m^3);



CO₂ storage potential in Songliao basin

1. Daqing oil field

The basic parameters of the oil bearing reservoirs in Daqing oil field complex

oil field	h (m)	φ (%)	A ($\times 10^6 \text{m}^2$)	$R_{o(\text{CO}_2)}$ (m^3/m^3)	Mp ($\times 10^6 \text{t}$)	ρ_f (kg/m^3)
Lamadian	72	23.7–26.7	100	0.149	570	803
Sa'ertu	35–62	23–31	200	0.201	930	797
Xingshugang	13–20	21.4–25	216	0.202	250	791
Gaotaizi	4.4	23	9.5	0.227	2.9	792
Taipingtun	2.9–3.3	23	61	0.226	13	795
Putao Hua	2.0–4.5	23–24	95.2	0.128	22	781
Aobaota	1.0–1.5	23	40	0.231	3.3	780
total			721.7		1791.2	

CO₂ storage capacity in oil bearing reservoirs of Daqing oil field complex

Oil field	M1 (Mt)	M2 (Mt)	M3 (Mt)	Total using CUP(Beijing) (Mt)	Estimate (Mt CO ₂) based on CSLF
Lamadian	26.0	90.6	32.7	149.2	187.4
Sa'ertu	48.5	130.8	47.1	226.5	308.1
Xingshugang	15.4	41.3	14.9	71.5	83.4
Gaotaizi	0.2	0.5	0.2	0.9	1.0
Taipingtun	0.9	2.2	0.8	3.8	4.3
Putaohua	0.9	3.7	1.3	5.9	7.4
Aobaota	0.3	0.6	0.2	1.0	1.1
Total	92.2	269.7	97.2	458.8	592.7

2. Jilin oil field

Reservoir parameters of Jilin oil field complex

Oil field	A/km^2	h/m	$\varphi/\%$	$Mp/(\times 10^6\text{t})$	$\rho_f/(\text{Kg}/\text{m}^3)$	$T/^\circ\text{C}$	P/MPa
Hongang	49.4	4.6	22	17.54	885	55	12
Xinli	120.6	5.3	16.3	49.36	863	66	12.2
Mutou	20.0	6.9	23.5	18.21	891	40	6.8
Qian'an	170.5	8.8	15	121.39	857	76	19.3
Yingtai	51.7	16	22	100.17	874	65	15
Total	510.1						

CO₂ storage capacity in Jilin oil field complex

Oilfield	M1 (Mt)	M2 (Mt)	M3 (Mt)	Total M _{CO2D} (Mt)	Estimate by CSLF M _{CO2C} (Mt)
Honggang	0.7	2.5	0.5	3.7	5.77
Xinli	1.7	5.2	1.4	8.2	16.35
Mutou	0.6	1.6	0.5	2.7	6.08
Qian'an	3.8	11.2	3.4	18.4	40.46
Yingtai	3.1	9.1	2.8	14.9	33.27
Total	9.9 Mt	29.6 Mt	8.6 Mt	47.9 Mt	101.9 Mt

CO₂ - EOR potential in Songliao basin

1. Daqing oil field

EOR potential by CO₂ flooding in Daqing oil field complex (Mt)

Oil field	Mp/(Mt)	EOR rate (%)				
		2	4	6	8	10
Lamadian	570.00	11.40	22.80	34.20	45.60	57.00
Sa'ertu	930.00	18.60	37.20	55.80	74.40	93.00
Xingshugang	250.00	0.500	10.00	15.00	20.00	25.00
Gaotaizi	2.90	0.058	0.116	0.174	0.232	0.29
Taipingtun	13.00	0.26	0.52	0.78	1.04	1.30
Putao Hua	22.00	0.44	0.88	1.32	1.76	2.20
Aobaota	3.30	0.066	0.132	0.198	0.264	0.33
Total	1791.20	31.324	71.648	107.472	143.296	179.12

2. Jilin oil field

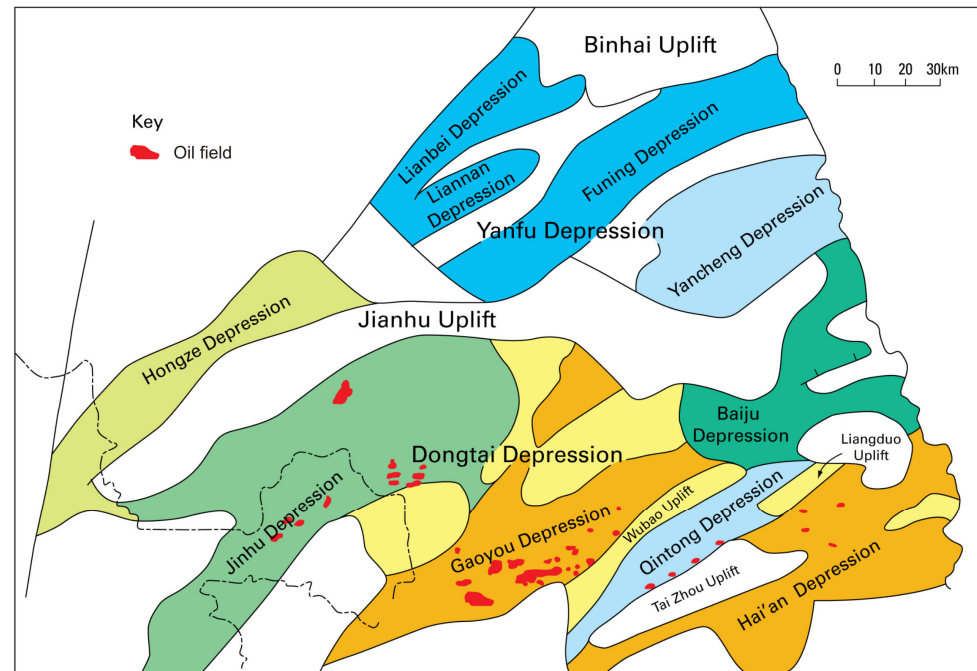
EOR potential by CO₂ flooding in Jilin oil field complex (Mt)

Oil field	Mp/(Mt)	EOR rate (%)				
		2	4	6	8	10
Hongang	17.54	0.351	0.701	1.052	1.403	1.754
Xinli	49.36	0.987	1.974	2.961	3.949	4.936
Mutou	18.21	0.364	0.729	1.093	1.457	1.821
Qian'an	121.39	2.428	4.856	7.283	9.711	12.138
Yingtai	100.17	2.003	4.006	6.01	8.014	10.017
Total	306.67	6.133	12.266	18.399	24.534	30.666

CO₂ storage and EOR potential in Jiangsu oil field

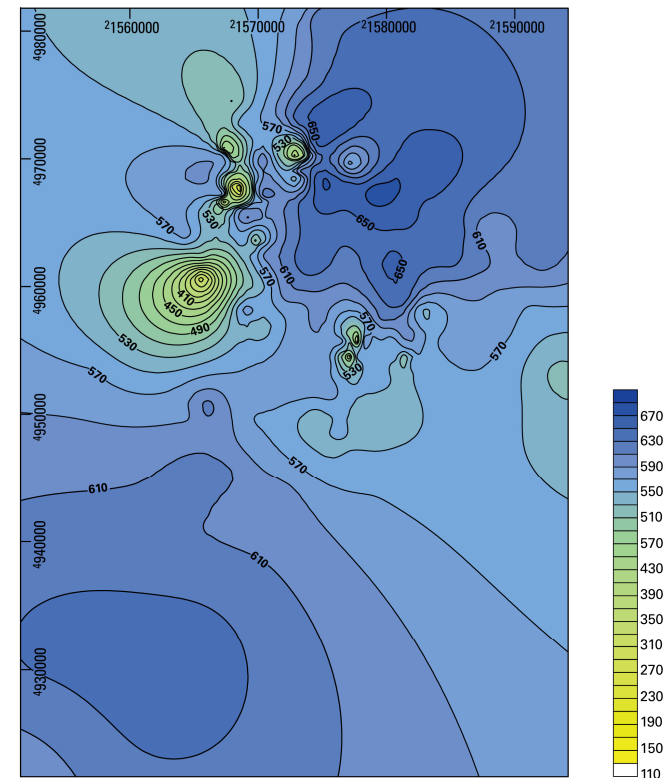
For all the 108 reservoirs in Jiangsu oilfield, the total CO₂ storage potential is **20.5 M t**.

For the 75 reservoirs suitable for CO₂ EOR, the CO₂ storage potential during EOR process is **15.8 M t**, the incremental oil production is **4.7 M t**, and the incremental recovery factor is **5.71%**.



CO₂ storage potential in aquifer of Songliao basin

Area of regional aquifer km ²	260000		
Average height of aquifer m	380 (net:gross ratio 50 – 95%)		
Average reservoir porosity %	10		
CO ₂ density at reservoir conditions kg/m ³	700		
Storage coefficient	1%	2%	10%
Effective CO ₂ storage capacity Mt	692	1383	6916



Conclusion

- The oil/gas bearing reservoirs in Songliao basin could be for CO₂ storage, the total storage capacity of CO₂ is about **695** Mt in supercritical state.
- The potential of the oil enhanced by CO₂ flooding could be large in Daqing and Jilin oil fields.
- The storage capacity of CO₂ in saline aquifer of Songliao basin is about **1383** Mt(2%) in supercritical state.



Thanks

