CO2驱页岩气在鄂尔多斯盆地应用的可能性及潜力研究

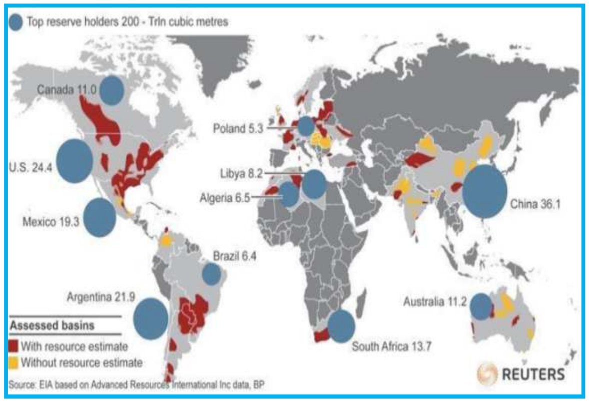
Possibility and Potential of CO2 Enhanced Shale Gas Recovery in Ordos Basin

刘丹青
中国地质大学（武汉）
2014.11.19，武汉

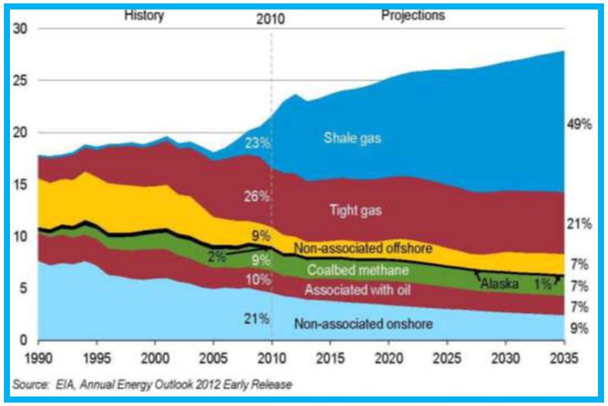
cags China Australia Geological Storage of CO_2
中澳二氧化碳地质封存

页岩气资源与勘探现状
Shale gas resources and exploration status

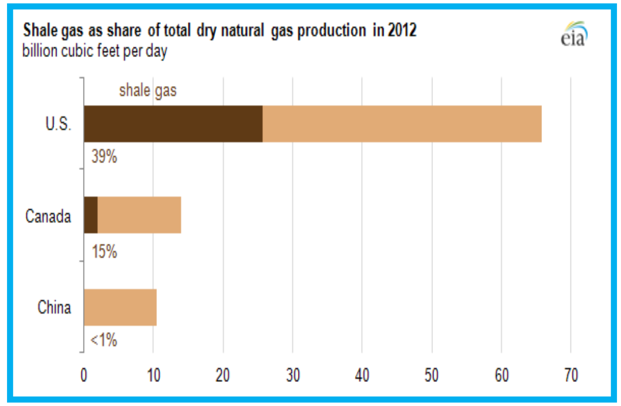
全球页岩气资源量
Global shale gas resources



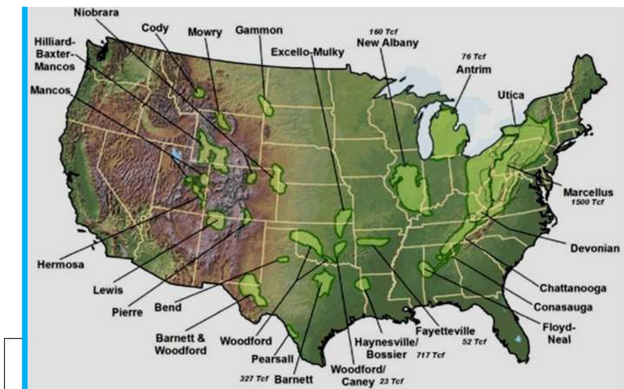
全球能源年度前景
Annual outlook of global energy



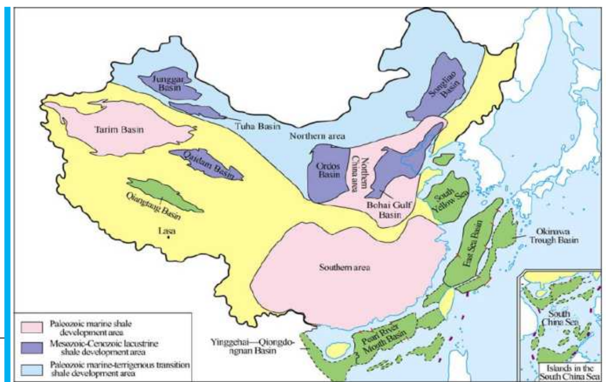
页岩气全球能源配额
Global energy quota of shale gas



美国页岩气资源分布
Distribution of shale gas resources in the America



中国页岩气资源分布
Distribution of shale gas resources in China



中美页岩气储层区别
Difference of shale gas reservoir between China and America

对比条件		中　国	美　国
地质条件	构造	复杂，多次改造，断裂发育	简单，一次抬升，断裂稀少
	沉积类型	多样，海相有效范围保存少	单一，主要为海相页岩
	有机碳含量	偏低，以1%~5%为主	丰富，以5%~10%为主
	含气量	偏低(数据少)	高(数据多)
	热演化程度	复杂，海相较高，湖相偏低	适中，普遍为成气高峰阶段
开发条件	埋深	偏大，>3500 m埋深为主	较浅，以2500~3500 m为主
	地表条件	复杂，南方多高山，北方少水	平原或丘陵，水源好
	油气管网	总体不发达，部分地区无管网	发达，遍及各地

世界核心页岩气开采技术
Shale gas resources exploration technologies

Reservoir Evaluation

- logging technique
- Evaluation of the core area
- Yield assessment
- Reservoir parameters

Drilling Technology

- Horizontal Drilling
- Open hole completion
- perforation completion
- gravel packing completion

Monitoring Technology

- Micro seismic monitoring

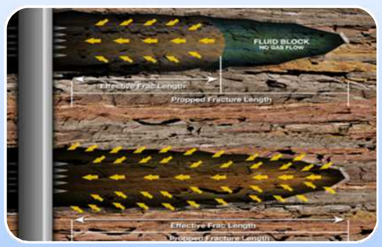
Fracturing Technology

- Hydraulic fracturing
- Liquefied petroleum gas fracturing
- CO_2 fracturing

世界核心页岩气开采技术
Shale gas resources exploration technologies

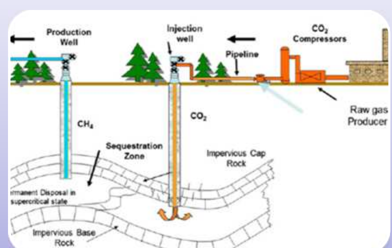
水力压裂 / Hydraulic fracturing

- Mature skill with abundant types, including slick-water frac, Massive hydraulic frac, compound frac, Hydraulic jetting frac and so on.
- Its negative side is threat to the crust stable and the surrounding environment, such as shallow aquifers and drinking water.



液化石油气压裂 / Liquefied petroleum gas fracturing

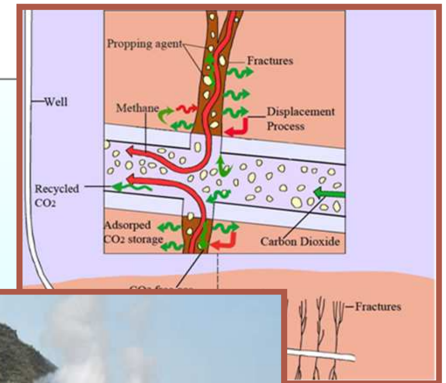
- Enhance well productivity & performance and can full compatibility with reservoirs which with no fluid loss and no water used.
- However, LPG is explosive and should be stored in pressurized tanks and reliquefied after each fractruing , which means high investment costs.



CO2压裂 / CO2 fracturing

- Based on competitive absorption between Methane and CO2 to enhance the shale gas recovery and realize the CO2 geological storage at the same time.

CO2压裂技术
CO2 fracturing technology



技术原理 Technological principle

以携带支撑剂，表面活性剂和泡沫稳定剂的超临界CO2作为压裂液，于低压、低渗透和水敏性储层代替水力压裂，并利用与CO2的竞争性吸附增强页岩气开采，同时封存可观的CO2。

技术分类 Technical classification

CO2增能压裂，CO2泡沫压裂，CO2/N2泡沫压裂，液态CO2压裂。

技术优缺点 Advantages and disadvantages

优势：用水量低，反排率高，适用于水敏性储层，对储层伤害小，增强页岩气开采，降低环境污染。

缺点：支撑剂携带能力差，泡沫压裂成本较高，泵入压力高，压裂液运输困难等。

鄂尔多斯盆地CO_2增强页岩气开采可能性研究

Feasibility of CO2 enhanced shale gas recovery in the Ordos Basin

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

鄂尔多斯盆地页岩气开采可能性研究

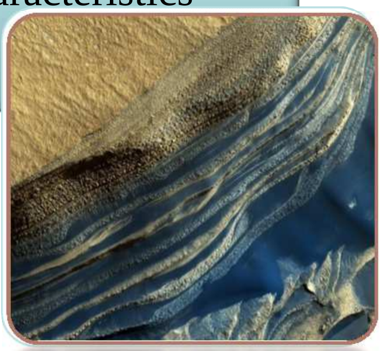
Feasibility of CO2 enhanced shale gas recovery in the Ordos Basin

储层优选
Reservoir selection

可能性岩心级模拟验证
Core sample simulation

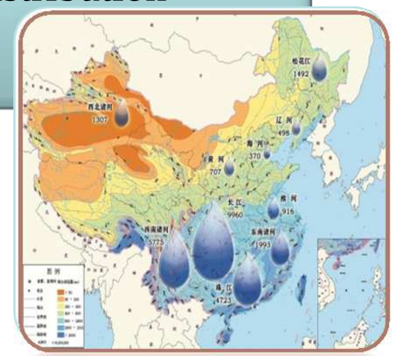
可能性盆地级模拟验证
Basin scale simulation

地质匹配
Geological characteristics



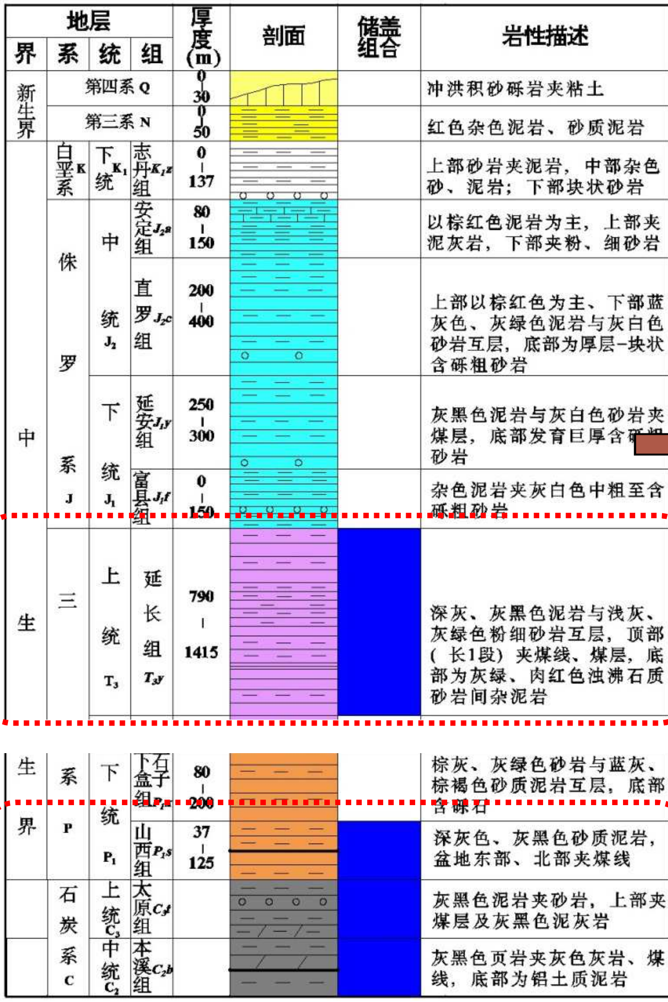
碳源匹配
Carbon sources distribution

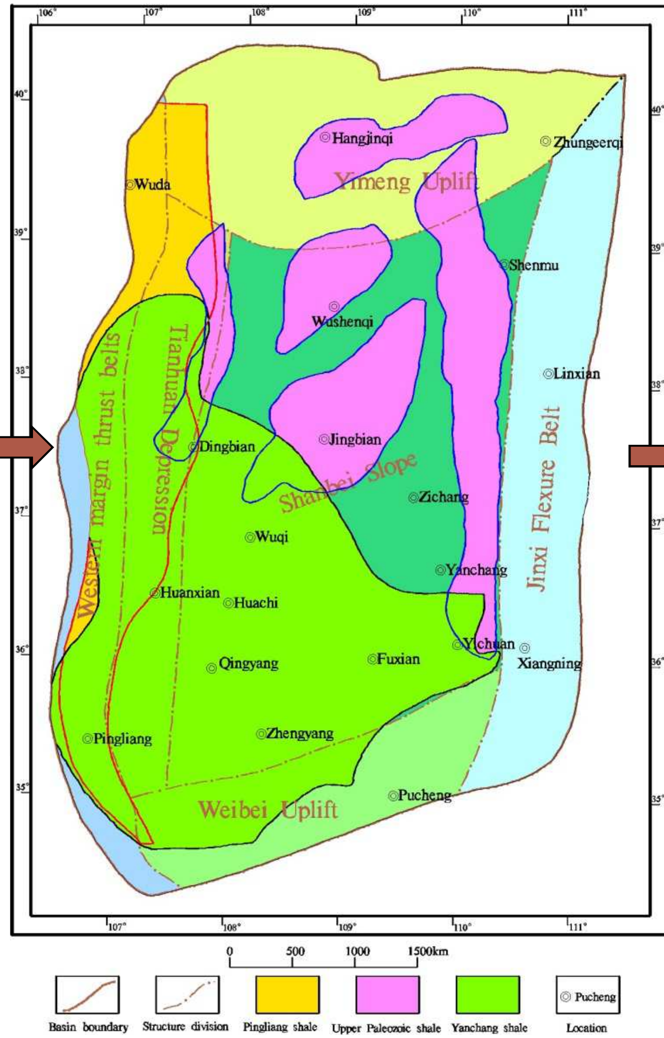
水资源匹配
Water resources distribution



鄂尔多斯盆地页岩气储层优选——地质表征

Reservoir characterization of shale gas reservoir selection





上三叠延长组
Yanchang formation of the upper Triassic

上古生界
The upper Paleozoic

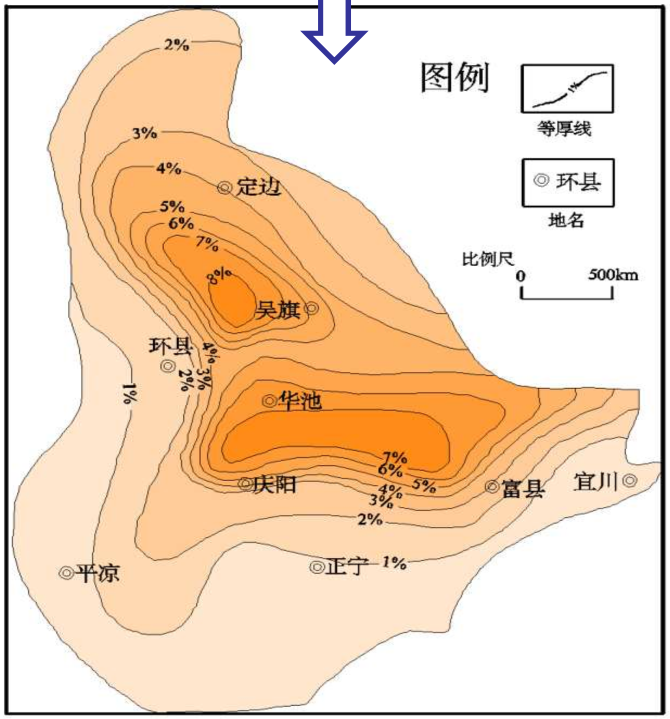
奥陶系平凉组
Pingliang formation of Ordovician

鄂尔多斯盆地页岩气储层优选——地质表征
Reservoir characterization of shale gas reservoir selection

上三叠统延长组
Yanchang formation of the upper Triassic

上古生界山西-本溪组

奥陶统平凉组



地层	组	埋深 (m)	厚度 (m)	TOC (%)	Ro (%)	粘土含量（%）
三叠系湖相	延长组	1500-1800	45-100	6~14	0.56-1.4/0.96	长石：20-66/46.1 伊利石：30-76/47.6 蒙脱石：13-48/30.2 绿泥石：19.6%

Stratigraphy	Group	Depth (m)	Thickness (m)	*TOC* (%)	*Ro* (%)	Clay share
Triassic lacustrine facies	Yan chang	1500-1800	45-100	6~14	0.56-1.4/0.96	Andreattite:20-66/46.1,Illite:30-76/47.6,smectite:13-48/30.2, chlorite:19.6

鄂尔多斯盆地页岩气储层优选——地质表征
Reservoir characterization of shale gas reservoir selection

上三叠统延长组

上古生界山西-本溪组
Shanxi - Benxi formation of the upper Paleozoic

奥套统平凉组

地层	组	埋深(m)	厚度(m)	*TOC* (%)	*Ro* (%)	粘土含量
上古生界海陆过渡相	山西	1000-3500	80-120	1.06-5.32/2.37	1.52-2.53	粘土： 57.5-64.1，长石： 50，伊利石 3-13，高岭石：12-44，绿泥石： 6-17
	本溪	1000-3500	10-90	2.80	1.3-2.5	粘土：69.4，高岭石： 48，伊利石：26.6
	太原	1000-3500	0-80	2.70	1.3-2.5	

Stratigraphy	Group	Depth (m)	Thickness(m)	*TOC* (%)	*Ro* (%)	Clay share （%）
Upper Paleozoic Marine-terrestrial facies	San xi	1000-3500	80-120	1.06-5.32/2.37	1.52-2.53	Clay 57.5-64.1%:andreattite 50,illite 3-13, Kaolin 12-44, chlorite 6-17
	Ben xi	1000-3500	10-90	2.80	1.3-2.5	Clay：69.4, kaolinite:48,illite:26.6
	Tai yuan	1000-3500	0-80	2.70	1.3-2.5	

鄂尔多斯盆地页岩气储层优选——地质表征
Reservoir characterization of shale gas reservoir selection

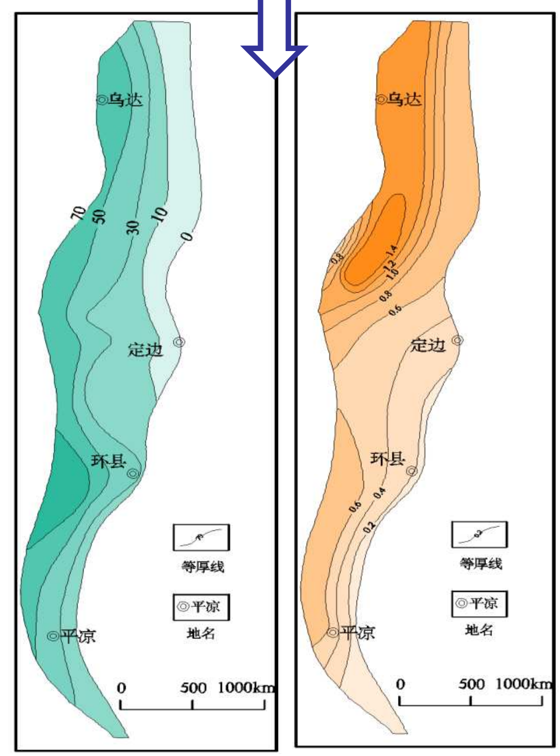
上三叠统延长组

上古生界山西-本溪组

奥套统平凉组
Pingliang formation of Ordovician

地层	组	埋深 (m)	厚度 (m)	TOC (%)	Ro (%)	粘土含量（%）
奥套系海相	平凉组	2800 - 5000	10-70	0.17-1.4/0.58	1.9-2.1	伊利石，绿泥石：19-72/35

Stratigraphy	Group	Depth (m)	Thickness(m)	*TOC* (%)	*Ro* (%)	Clay share (%)
Ordovician marine facies	Ping liang	2800-5000	10-70	0.17-1.4/0.58	1.9-2.1	19-72/35:illite and chlorite



鄂尔多斯盆地页岩气储层优选——地质表征
Reservoir characterization of shale gas reservoir selection

待评储层 Reservoir

- 上三叠延长组 Yanchang formation
- 上古生界 The upper Paleozoic
- 奥陶系平凉组 Pingliang formation

地质评价方法 Evaluation method

页岩厚度	＞50m
TOC	＞2.0%
R0	1.0%～3.0%
埋深	300m～3000m
岩性	粘土矿物＜30%，粉砂质15～25%，有机质4～30%。
构造发育位置	生烃中心及其附近地区

适宜储层 Suitable reservoir

- 上三叠延长组
- 上古生界

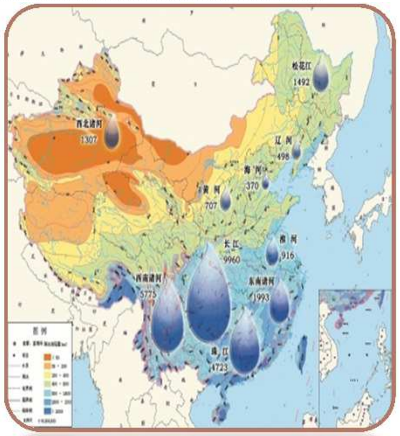
鄂尔多斯盆地页岩气储层优选
Shale gas reservoir selection

Step 1

地质匹配
Geological characteristics

Step 2

水资源匹配
Water capacity



Step 3

碳源匹配
Carbon sources

鄂尔多斯盆地页岩气储层优选——碳源、水资源分布
Carbon source and water resources

Evaluation method：

➢国土资源部页岩气资源/储量计算与评价技术要求 (试行). GB/T 19492-2004. 2012

➢Ministry of Land and Resources. Shale gas resources/reserves calculation and evaluation technical request (pilot version). GB/T 19492-2004. 2012

Stratigraphy	A_g, $10^4 km^2$	P_f, MPa	T, ℃	ϕ	Z_i	S_g	C_a, m^3/t	E_{Rg}
Triassic lacustrine facies	8.78	11.709	55.307	1.82%	0.89	0.85	3.34	0.27
Permo-Carboniferous Marine-terrestrial facies	4.599	15.82	75.875	3.20%	0.93	0.85	1.52	0.175

$$G_x = 0.01 A_g h \rho_y C_x / Z_i$$

$$G_y = 0.01 A_g h \phi S_{gi} P_i T_{sc} / P_{sc} Z_i T$$

$$G_z = G_x + G_y$$

其中， G_x—吸附气资源量；
G_y—游离气资源量；
G_z—页岩气总资源量；
A_g—页岩气分布面积，m^2；
h—页岩气有效厚度，m；
ϕ—页岩有效孔隙度；
S_{gi}—原始地层含气饱和度；
P_i—原始地层压力，mPa；
T_{sc}—地面标准温度，℃；
P_{sc}—地面标准压力，Pa；
Z_i—原始气体偏差系数，0.89；
T—原始地层温度。

Stratigraphy	G_a, tcm	G_f, tcm	G_t, tcm	$G'_{a,CH4}$, tcm	$G'_{f,CH4}$, tcm	$G'_{t,CH4}$, tcm
Triassic lacustrine facies	0.582	0.033	0.615	0.157	0.009	0.166
Permo-Carboniferous Marine-terrestrial facies	0.333	0.023	0.563	0.058	0.004	0.099
Total	0.915	0.058	1.178	0.215	0.013	0.265

鄂尔多斯盆地页岩气储层优选——碳源、水资源分布
Carbon source and water resources

Four Major deep Shale plays in U.S.A

Shale gas reservoirs	Average water consumption (m^3/single well)	Average shale gas production ($10^4 m^3$/single well)	Water consumption per unit shale gas production （$m^3/10^4\ m^3$）
Haynesville	15141.64	18406.05	0.82
Marcellus	15520.19	11893.14	1.30
Barnet	12870.40	7504.01	1.72
Fayetteville	15141.65	6796.08	2.23

Adapted from:[1] Chesapeake Energy 2009b, [2]Chesapeake Energy 2009c,[3] USDOE 2007

页岩气开采用水量分析 Water consumption analysis for Ordos basin

鄂尔多斯盆地有利区页岩气可采储量：0.265 tcm

Gross shale gas resources in Ordos basin : 0.265 tcm

如果每年按1%开采： Annul 1% exploitation rate：

开采量= 2.65 bcm（相当于美国2013年页岩气产量（276.4 bcm）的1/100）

Gt,CH4= 2.65 bcm（about 1/100 of shale gas production of USA in 2013 (276.4 bcm)

需水量=1.139 ～2.913 mcm Water usage for the whole basin=1.139~2.913 mcm

鄂尔多斯盆地页岩气储层优选——碳源、水资源分布
Carbon source and water resources

Water resources in Ordos basin

Regions	Available water resources/0.1bcm	Water demand for 2010/0.1bcm	Industrial water consumption/0.1bcm	Residual water resources/0.1bcm
Shaanxi（Shaanbei）	25.92	18.17	3.71	7.75
Gansu（Longdong）	10.87	11.12	1.15	-0.25
Ningxia（East）	3.05	5.75	0.25	-2.7
Inner Mongolia（Yimeng,WuHai）	44.11	21.38	3.74	22.73
Shanxi（West）	19.99	15.18	4.02	4.81
Total	103.94	71.6	12.87	32.34

Industrial water consumption in Ordos basin: 1.287bcm/a

Proportions for shale gas exploitation : 1.06‰ ~2.28‰

Conclusions

- **The water resources are abundant for the exploitation of shale gas in Ordos basin.**
- **Regional water shortages restrict the application of hydraulic fracturing in Ningxia and Gansu**

鄂尔多斯盆地页岩气储层优选——碳源、水资源分布
Carbon source and water resources

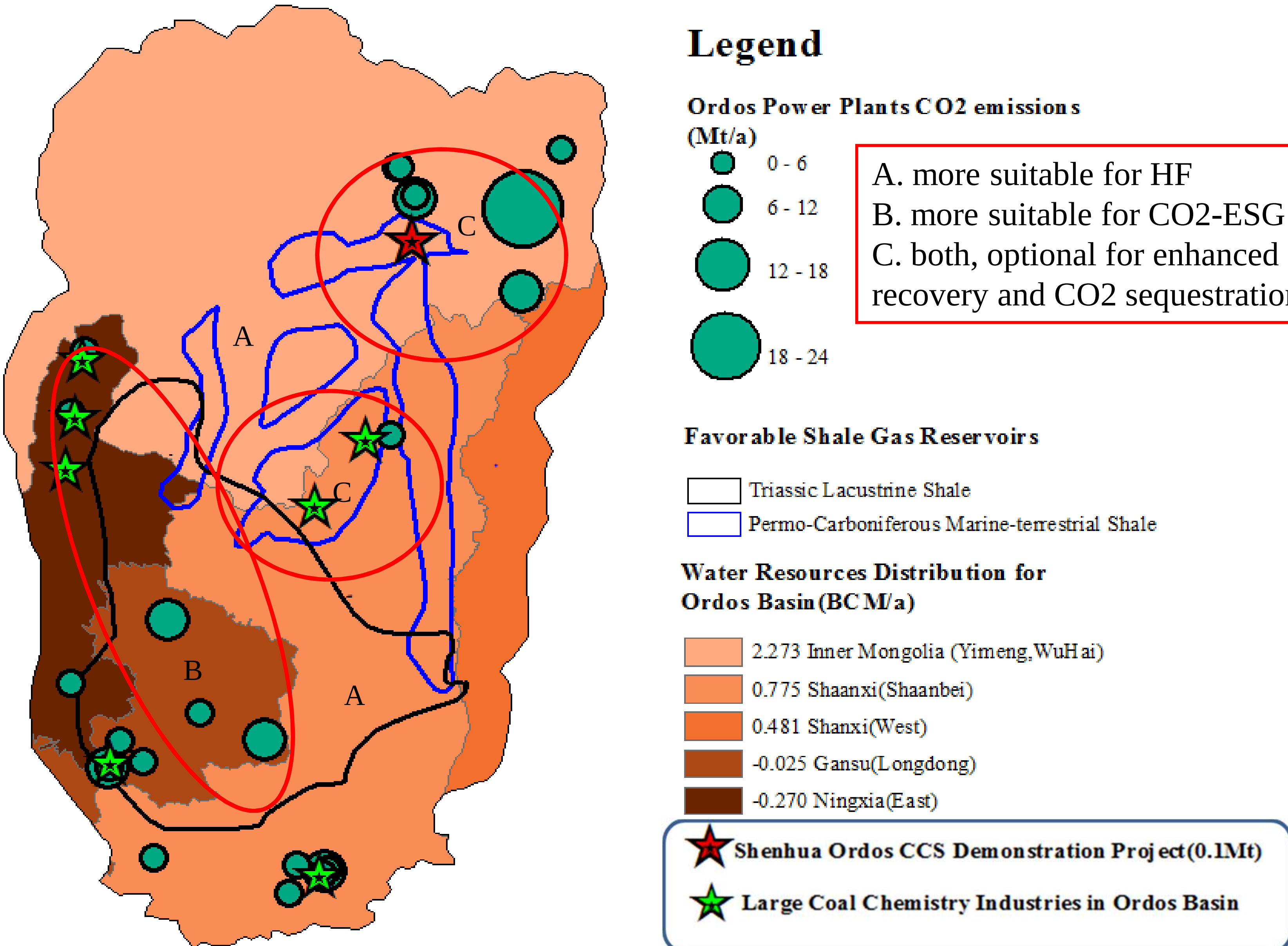
The CO2 utilization during CO2-ESG

Stratigraphy	$G_{a,CH4}$ /tcm	$G_{f,CH4}$ /tcm	$G_{t,CH4}$ /tcm	$G_{a,CO2}$ /bt	$G_{f,CO2}$ /bt	$G_{frac,CO2}$ /bt	$G_{t,CO2}$ /bt
Triassic lacustrine facies	0.157	0.009	0.166	1.086	0.0176	0.015	1.1186
Permo-Carboniferous Marine-terrestrial facies	0.058	0.004	0.099	0.3998	0.0078	0.011	0.4186
Total	0.215	0.013	0.265	1.4858	0.0254	0.026	1.5372

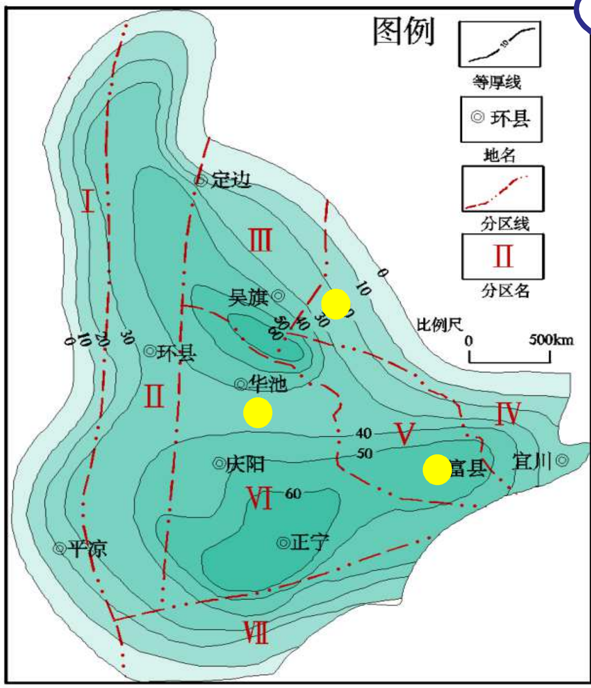
$$G_{CO2}\text{（utilization）} = G_{\text{storage}} + G_{fracturing}$$

$$G_{storage} = aG_{CH4} + G_{CH4}$$

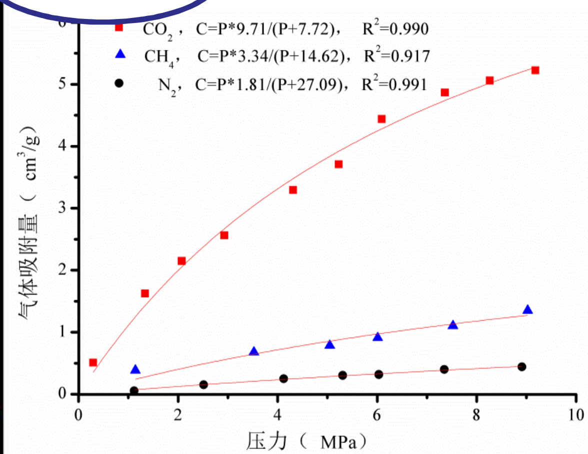
鄂尔多斯盆地页岩气储层优选——碳源、水资源分布
Carbon source and water resources



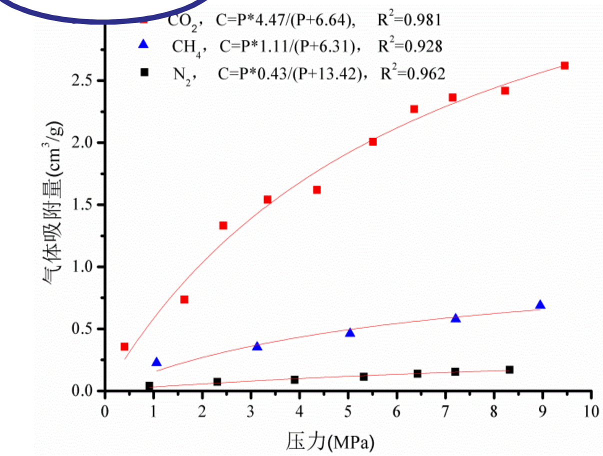
可能性岩心级模拟验证
Feasibility demonstration based on core samples

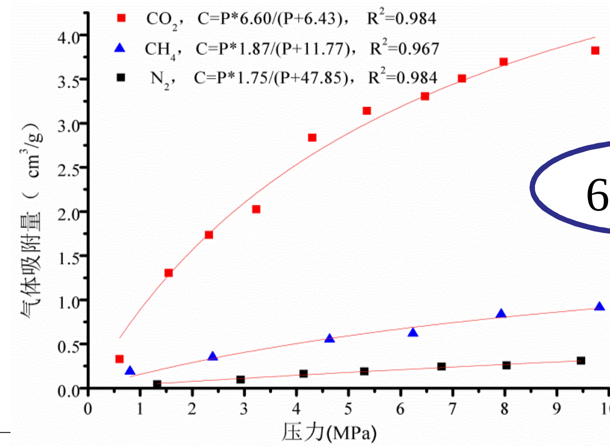


30°C



45°C





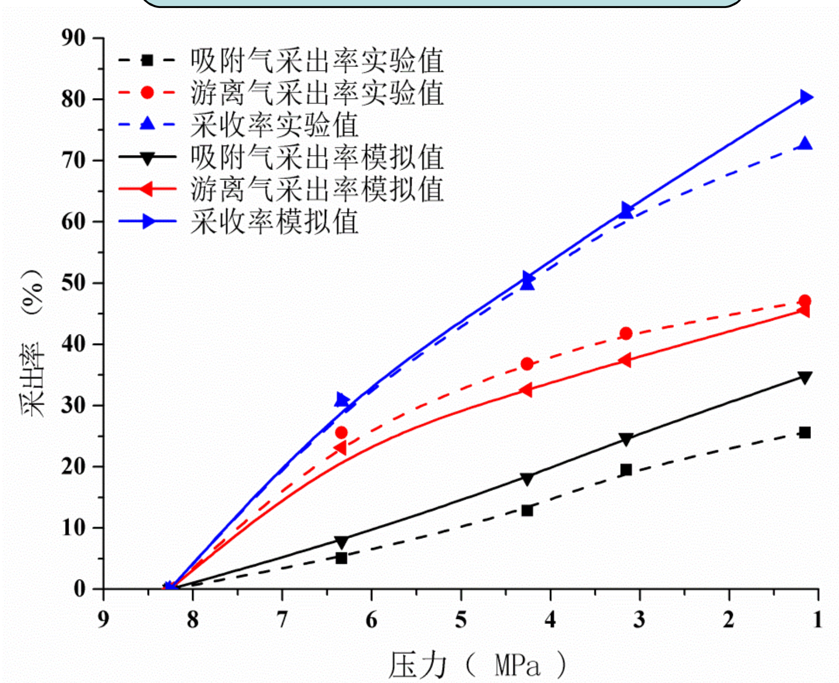
60°C

三叠系延长组页岩厚度等值线图及资源分区图

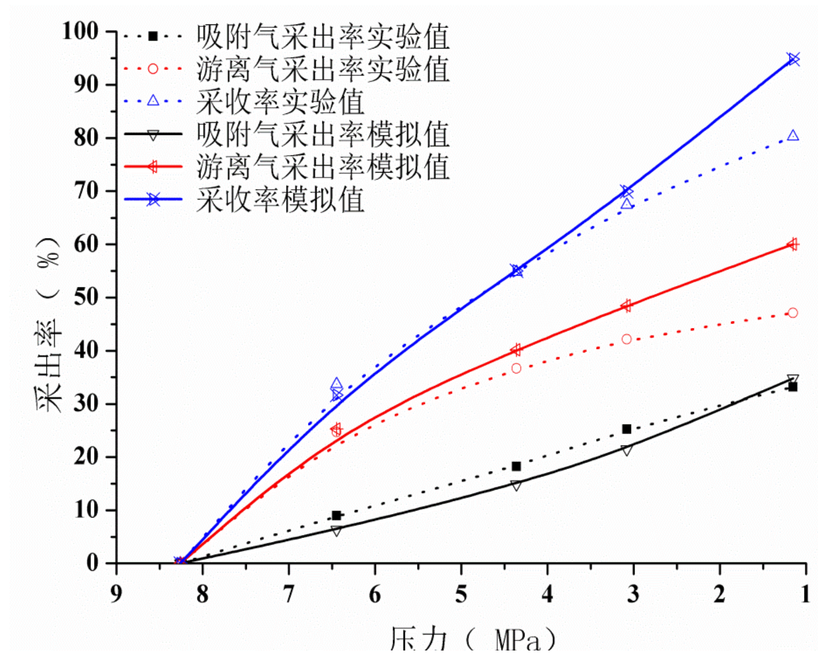
Yanchang shale thickness contour and resources partition

可能性岩心级模拟验证
Feasibility demonstration based on core samples

单纯抽采
simple extraction

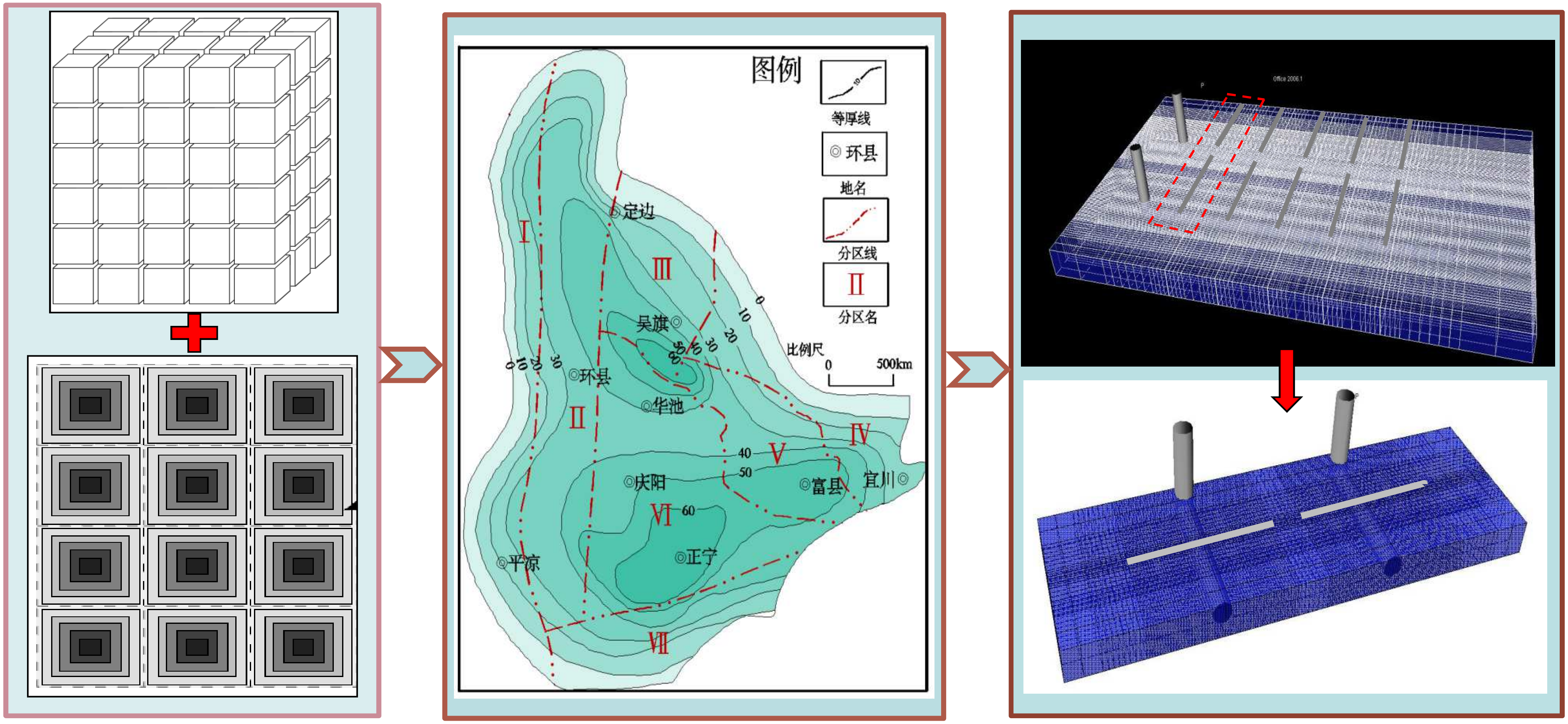


CO2增强开采
CO2 enhanced extraction



岩心级驱替试验证明CO2驱确实能提高页岩气的开采量，该技术原理可行。

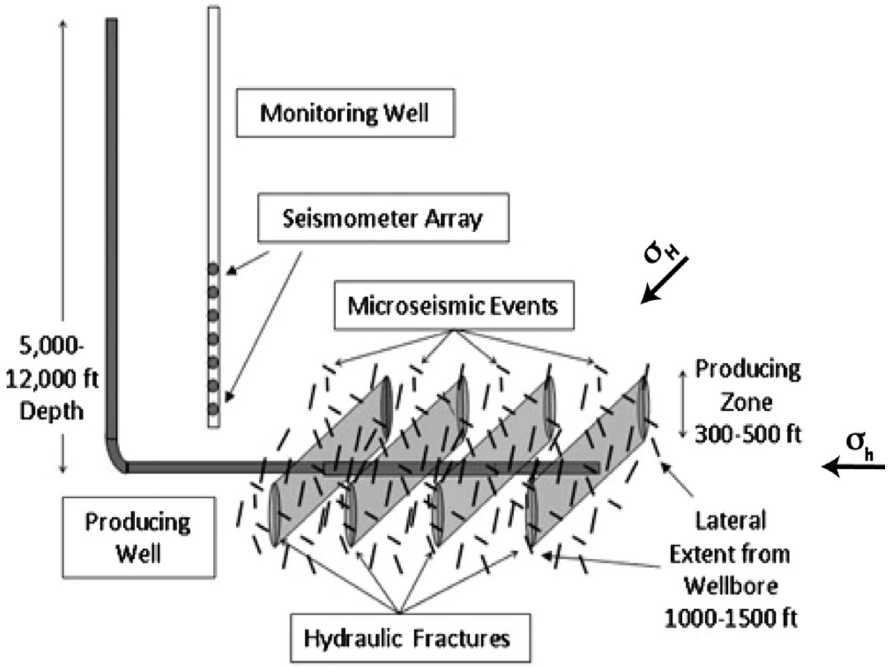
可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

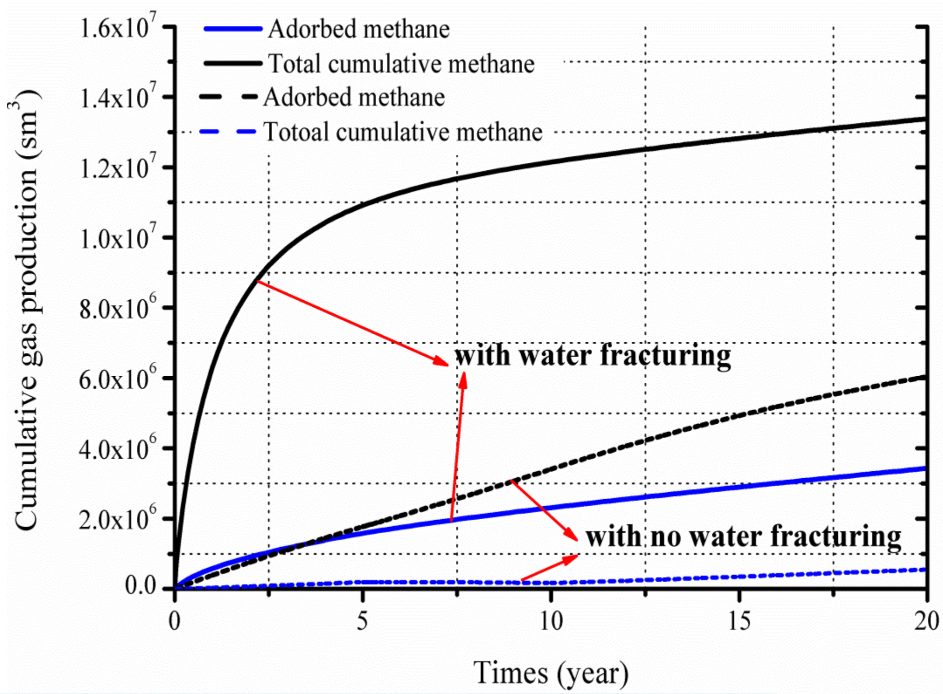


可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

Reservoir properties	The corresponding values	Unit
Depth	2000	m
Thickness	30	m
Temperature	65	℃
Pressure gradient	6.89	Mp/km
Porosity	0.068	SI
Matrix permeability	0.0056	md
Diffusivity	1.0E-9	m^2/s
Formation water saturation	0.4802	SI
Shale density	2.6	g/cm^3
TOC	3%	
The maximum adsorption of CO2	0.0066	m^3/kg
CO2 Langmuir adsorption pressure	76.97	bar
Adsorption constant of CH4	0.00187	m^3/kg
Adsorption pressure constant of CH4	61.615	bar
Radius of the fracture surface	150	m
permeability of the fracture surface	50	md

可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale





水力压裂技术能显著提高页岩开采率，单级压裂能使页岩气开采量由$6.06\times10^6 m^3$提高到$1.44\times10^7 m^3$。

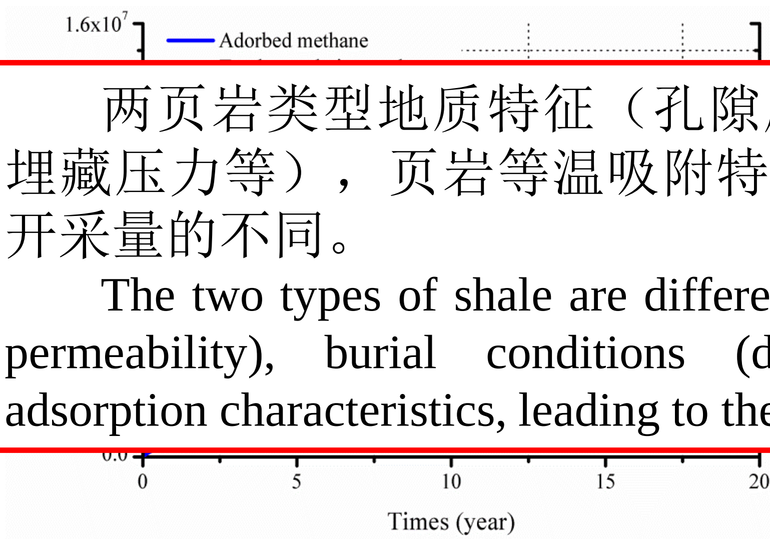
Hydraulic fracturing technology can significantly improve the extraction rate of shale, only one level of fracturing can make shale gas production increased from $6.06 \times 10^6\ m^3$ to $1.44 \times 10^7\ m^3$.

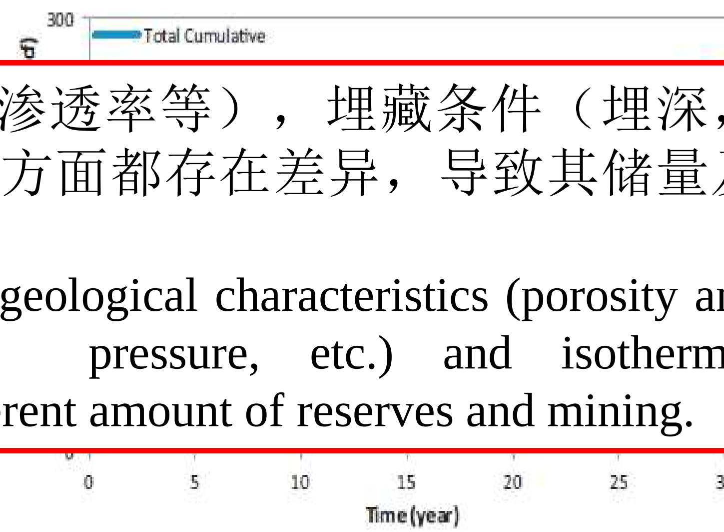
可能性盆地级工程数值模拟验证

Feasibility demonstration based on basin scale

Contrast of Upper Paleozoic shale in Ordos and New Albany shale

页岩类型	页岩气储量 (×10⁷sm³)		单级水力压裂开采量 (×10⁶sm³)	
	吸附气	游离气	吸附气	游离气
New Albany 页岩	5.35	2.2	4.65	2.88
鄂尔多斯延长组页岩	10.68	1.35	4.43	9.96





两页岩类型地质特征（孔隙度、渗透率等），埋藏条件（埋深，埋藏压力等），页岩等温吸附特征等方面都存在差异，导致其储量及开采量的不同。

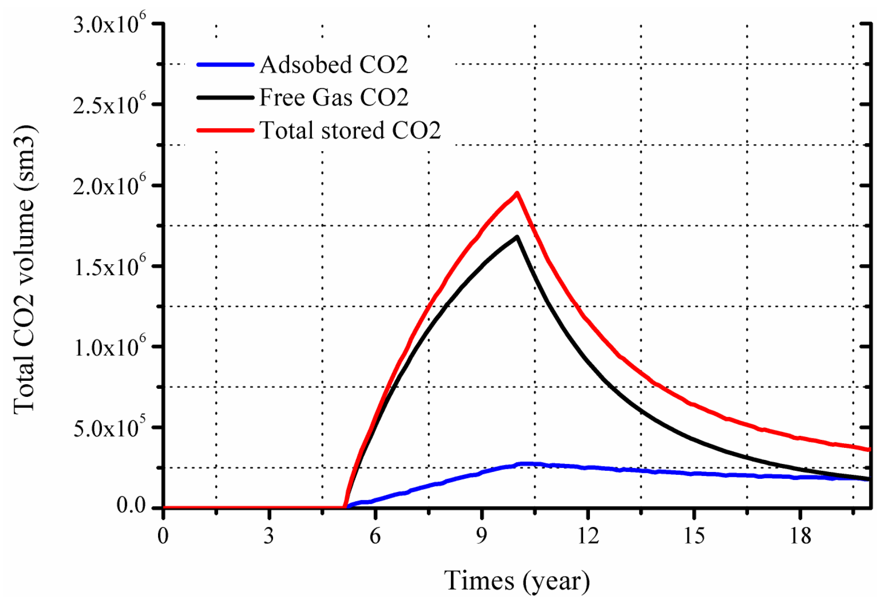
The two types of shale are different in geological characteristics (porosity and permeability), burial conditions (depth, pressure, etc.) and isothermal adsorption characteristics, leading to the different amount of reserves and mining.

Sourced from Faye Liu et al., 2013)

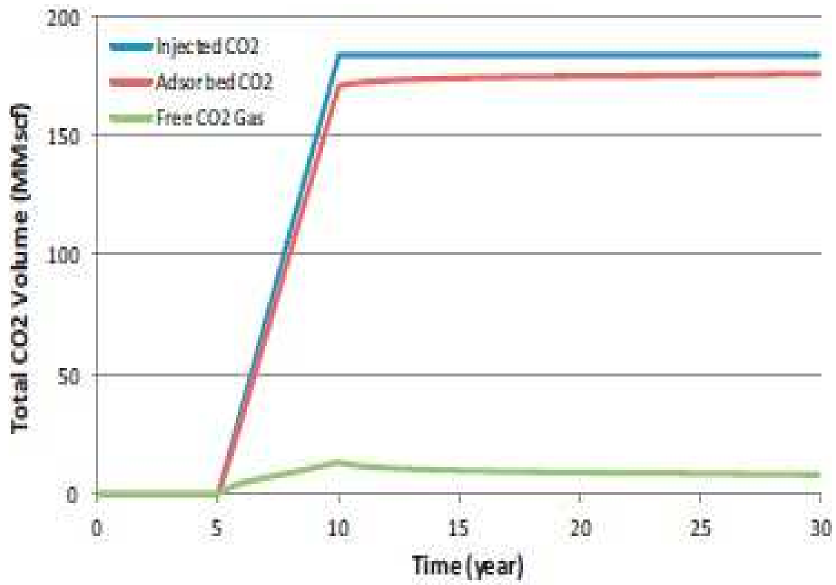
可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

鄂尔多斯上古生界页岩与New Albany 页岩对比
Contrast of the Upper Paleozoic shale in Ordos and New Albany shale

Yanchang shale

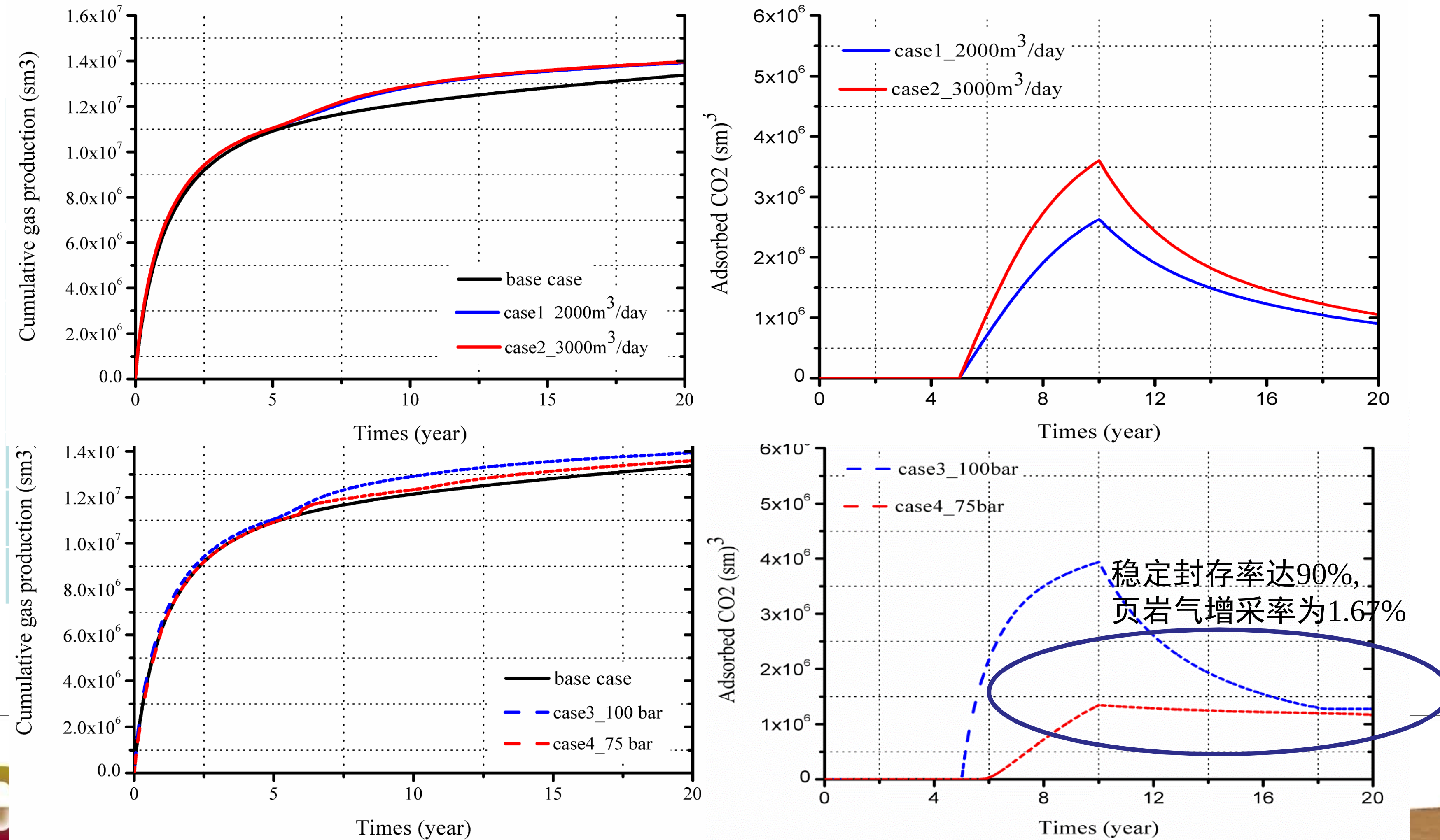


New Albany shale



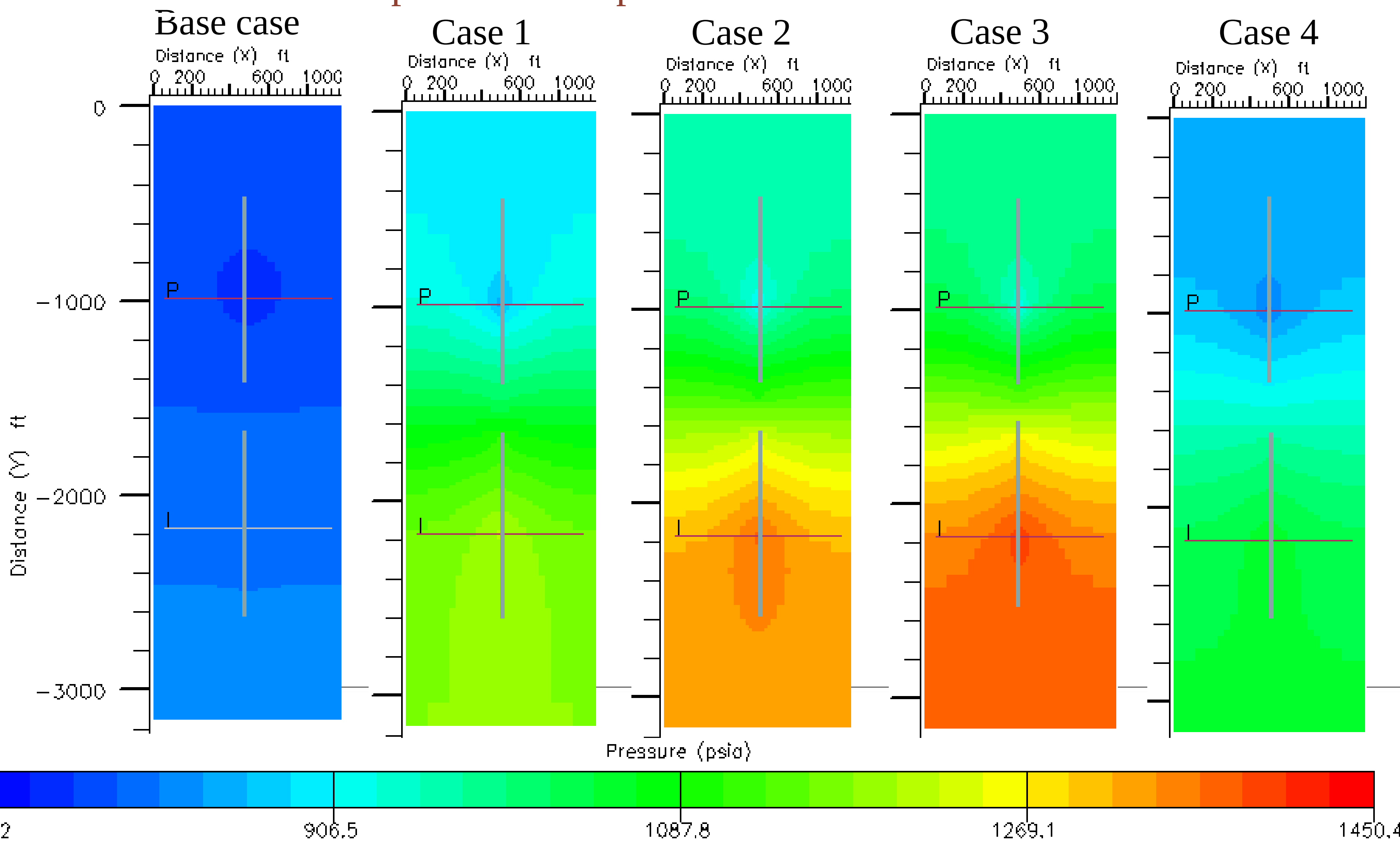
可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

不同灌注模式CO2封存量对比
Comparison of CO2 storage capacity in different perfusion modes



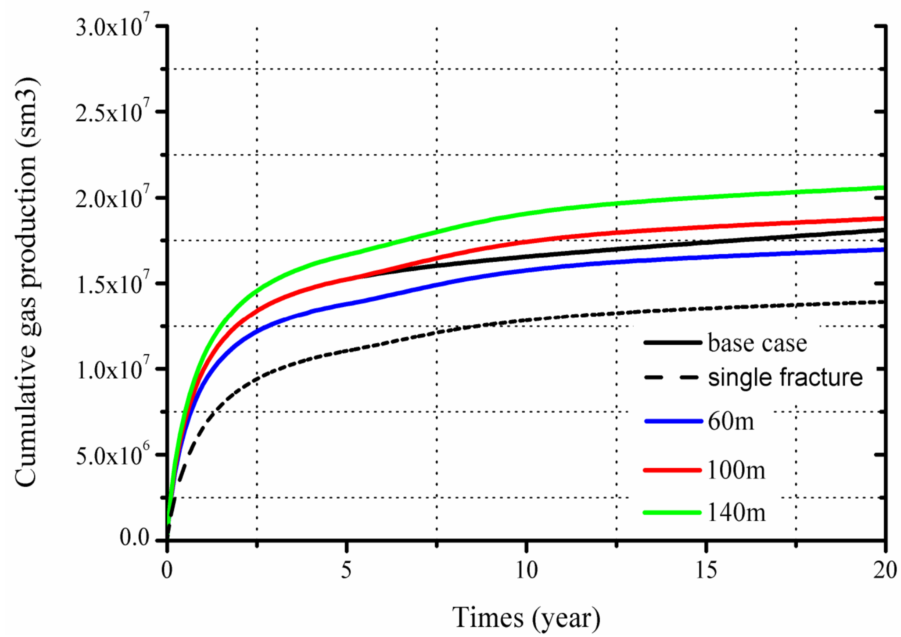
可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

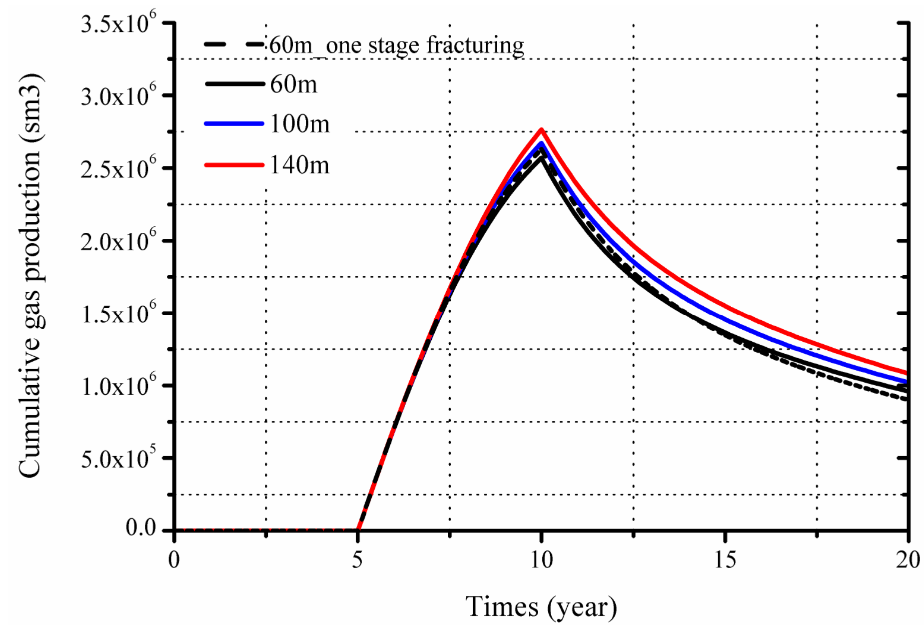
不同灌注模式压力分布图—井间距影响储层压力分布间接影响CO2的封存
Pressure distribution map in different perfusion modes



可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

二级压裂页岩气产量变化及CO2封存量变化
The changes of shale gas production and sequestration of CO2 in two stage fracturing





页岩气产量与压裂级数呈非线性关系，而压裂级数不同及各级压裂间距离也会对CO2封存量产生一定影响。

The relationship between shale gas production and fracturing stages is nonlinear, and the distance between the different fracturing will have a certain impact on CO_2 storage capacity.

可能性盆地级工程数值模拟验证
Feasibility demonstration based on basin scale

页岩气采收率及CO2封存有效系数
Shale gas recovery efficiency and CO2 storage effective coefficient

参数/**parameters**	延长组页岩	New Albany 页岩
页岩气储量/Shale gas reserves ($\times 10^7 m^3$)	12.03	7.45
单级水力压裂开采量/One stage fracturing shale gas production ($\times 10^6 m^3$)	14.39	7.53
一次采收率/Primary recovery efficiency (%)	11.96	10.11
CO2驱开采量/CO2 enhanced shale gas production ($\times 10^6 m^3$)	16.40	7.55
二次开采量/Secondary recovery efficiency (%)	13.63	10.13
CO2理论封存量/CO2 theory storage capacity ($\times 10^7 m^3$)	39.05	24.62
CO2实际封存量/CO2 actual storage capacity ($\times 10^5 m^3$)	9.19	5.21
CO2有效封存系数/CO2 effective storage coefficient E	0.00235	0.00212

$$G_{storage} = E(aG_{CH4} + G_{CH4})$$

鄂尔多斯盆地CO_2增强页岩气开采潜力研究
Capacity of CO2 enhanced shale gas recovery in Ordos Basin

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

鄂尔多斯盆地CO2驱页岩气可能性及潜力评价

Simulation of CO2 enhanced shale gas recovery base on Ordos Basin

鄂尔多斯盆地延长组页岩气资源量估算

Estimation of shale gas resources of Yanchang Formation in the Erdos Basin

Zoing	Shale volume ($\times 10^{11}m^3$)	Rock density (g/cm3)	Porosity %	Adsorbed gas content (cm3/g)	Gas saturation %	Shale gas resources ($\times 10^{11}m^3$)			Recoverable resources ($\times 10^{10}m^3$)
						Free gas	Adsorbed gas	total	
I	2.02	2.53	2.28	3.34	0.85	0.0136	0.107	0.121	0.165
II	6.31	2.53	1.45	3.34	0.85	0.0307	0.335	0.366	0.499
III	2.74	2.53	2.05	3.34	0.85	0.0175	0.146	0.163	0.223
IV	1.82	2.53	0.9	3.34	0.85	0.0037	0.097	0.100	0.137
V	3.41	2.53	1.5	3.34	0.85	0.0149	0.181	0.196	0.267
VI	7.44	2.53	2.28	3.34	0.85	0.0651	0.514	0.579	0.789
VII	2.01	2.53	2.28	3.34	0.85	0.0135	0.107	0.120	0.164
Total						0.159	1.49	1.65	2.244

鄂尔多斯盆地CO2驱页岩气可能性及潜力评价

Simulation of CO2 enhanced shale gas recovery base on Ordos Basin

鄂尔多斯盆地延长组CO2增强页岩气开采理论封存量

Shale gas storage capacity in theory of Erdos Yanchang Formation

Zoing	Adsorption ratio of CO2 to CH4,A	Free shale gas ($\times 10^9 m^3$)	Adsorbed shale gas ($\times 10^{10} m^3$)	CO_2 storage effective coefficient, E	theory CO_2 storage volume ($\times 10^{10} m^3$)			Effective CO2 storage volume （Mt)
					Free phase	Adsorbed phase	total	
Ⅰ	3.53	1.361	1.918	0.00235	0.136	3.79	3.926	0.181
Ⅱ	3.53	3.074	5.988	0.00235	0.307	11.84	12.14	0.560
Ⅲ	3.53	1.747	2.605	0.00235	0.175	5.148	5.322	0.246
Ⅳ	3.53	0.373	1.725	0.00235	0.037	3.409	3.446	0.159
Ⅴ	3.53	1.493	3.238	0.00235	0.149	6.400	6.549	0.302
Ⅵ	3.53	6.513	9.179	0.00235	0.651	18.14	18.79	0.867
Ⅶ	3.53	1.355	1.909	0.00235	0.135	3.773	3.909	0.180
Total					1.592	52.5	54.09	2.495

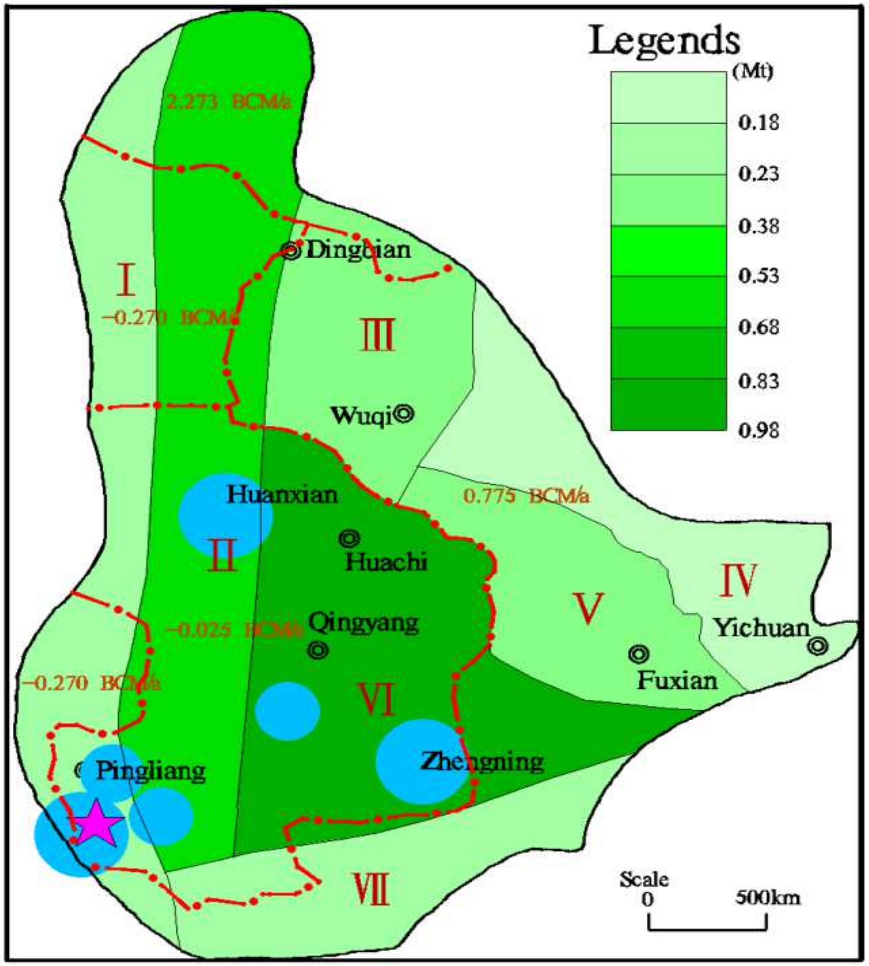
鄂尔多斯盆地CO2驱页岩气可能性及潜力评价
Simulation of CO2 enhanced shale gas recovery base on Ordos Basin

Calculation areas	Areas (km2)	Annual Shale Gas production Ga($\times 10^9 m^3/a$)	Average water consumption for hydraulic fracturing (mcm)	Available Water Capacity (mcm)	CO2 usage for CO2-ESG (Mt)	CO2 emissions from Surrounding Power plants (Mt/a)
Ⅰ	13300	0.121	0.375	-60	0.670	16.374
Ⅱ	20400	0.366	1.149	-12.5	3.126	16.748
Ⅲ	9130	0.163	0.507	48.113	1.148	
Ⅳ	9490	0.1	0.322	102.234	0.304	
Ⅴ	8020	0.196	0.618	42.264	1.122	
Ⅵ	19400	0.579	1.800	-12.5	3.208	11.310
Ⅶ	8070	0.12	0.374	45.847	0.667	

NB: Annual shale gas production=1% technical recoverable shale gas resources

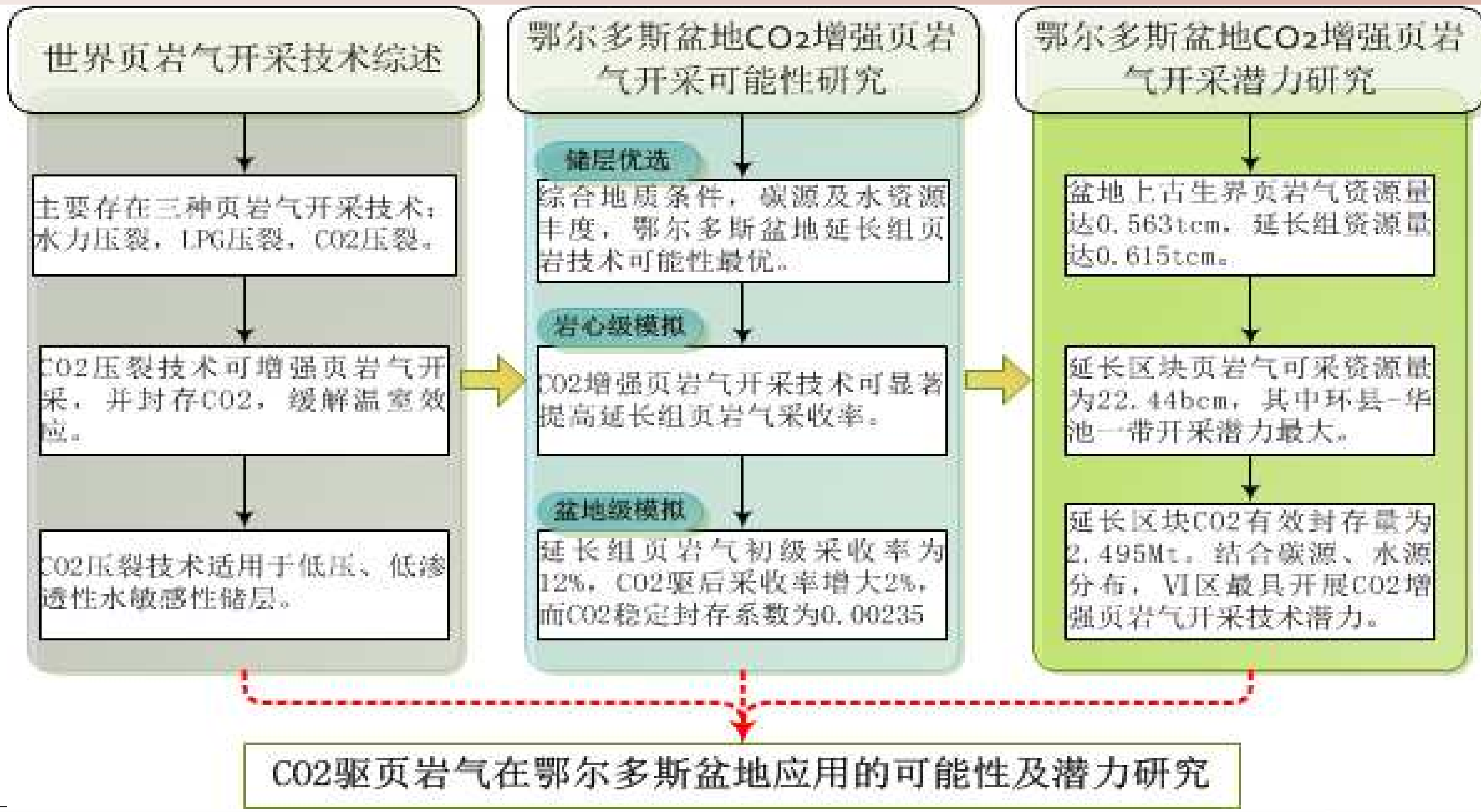
鄂尔多斯盆地CO2驱页岩气可能性及潜力评价

Simulation of CO2 enhanced shale gas recovery base on Ordos Basin



- The biggest CO2 storage volume located in zone Ⅵ and zone Ⅱ ;
- The coal chemistry industry are intensively distributed in the south west of this study area which can provide abundant carbon sources;
- Zone Ⅰ, Ⅱ and zone Ⅵ are lack in water which are not suitable for traditional water fracturing to produce shale gas;
- To sum up, combined with CO2 storage potential , water resources and carbon source, zone Ⅵ is the sweet spot for CO2 enhanced shale gas recovery technology.

结论与建议
Conclusion and suggestion



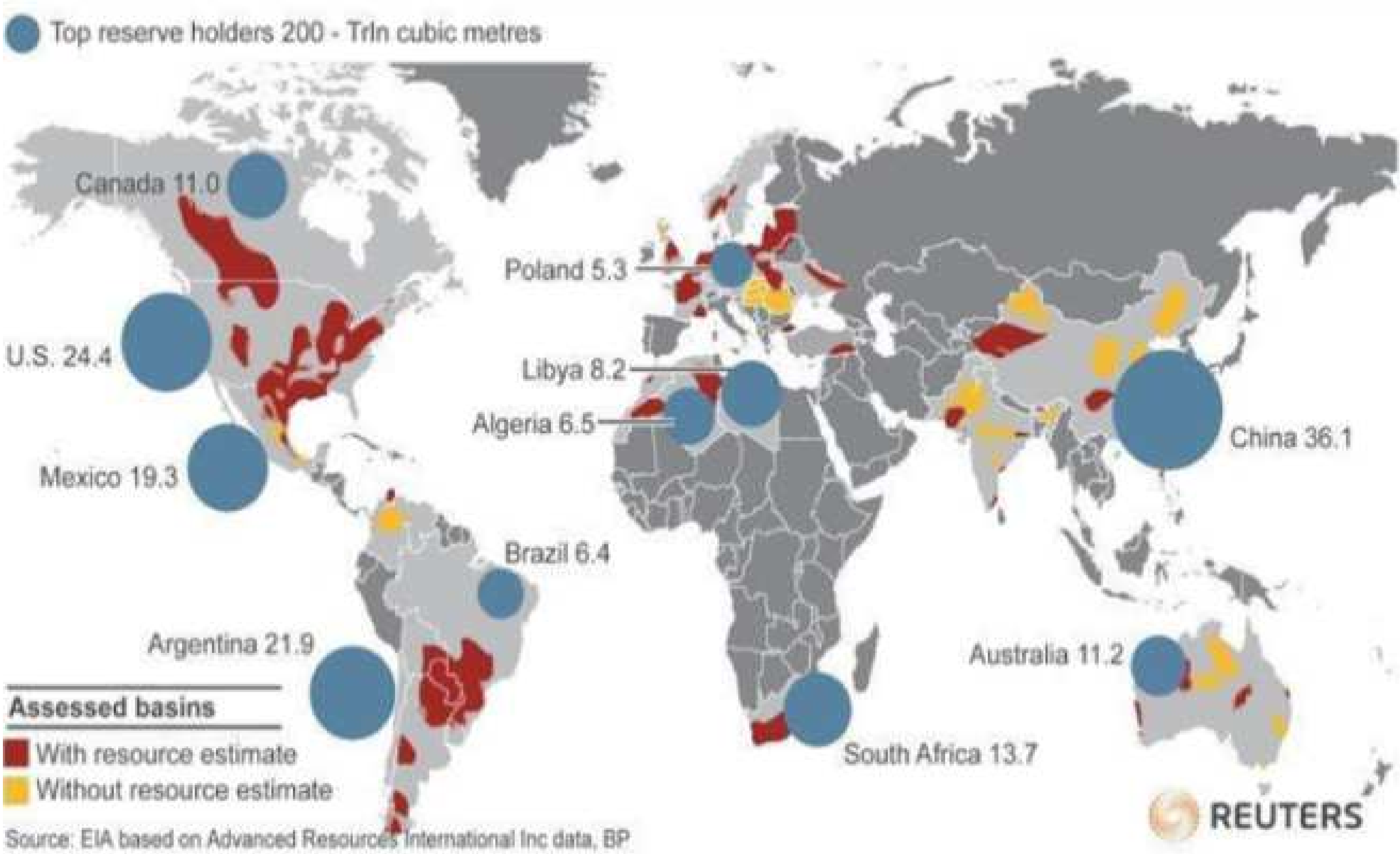
结论与建议
Conclusion and suggestion

- ◆Fracturing stages, well distances, the stimulated volume are all influential factors to the efficient of CO_2 enhanced shale gas recovery, it is a must to conduct comprehensive research on the most suitable and effective mode of injection and production.
- ◆Conduct feasibility research of CO_2 enhanced shale gas recovery of the whole China to provide theory support for policy maker and producer.

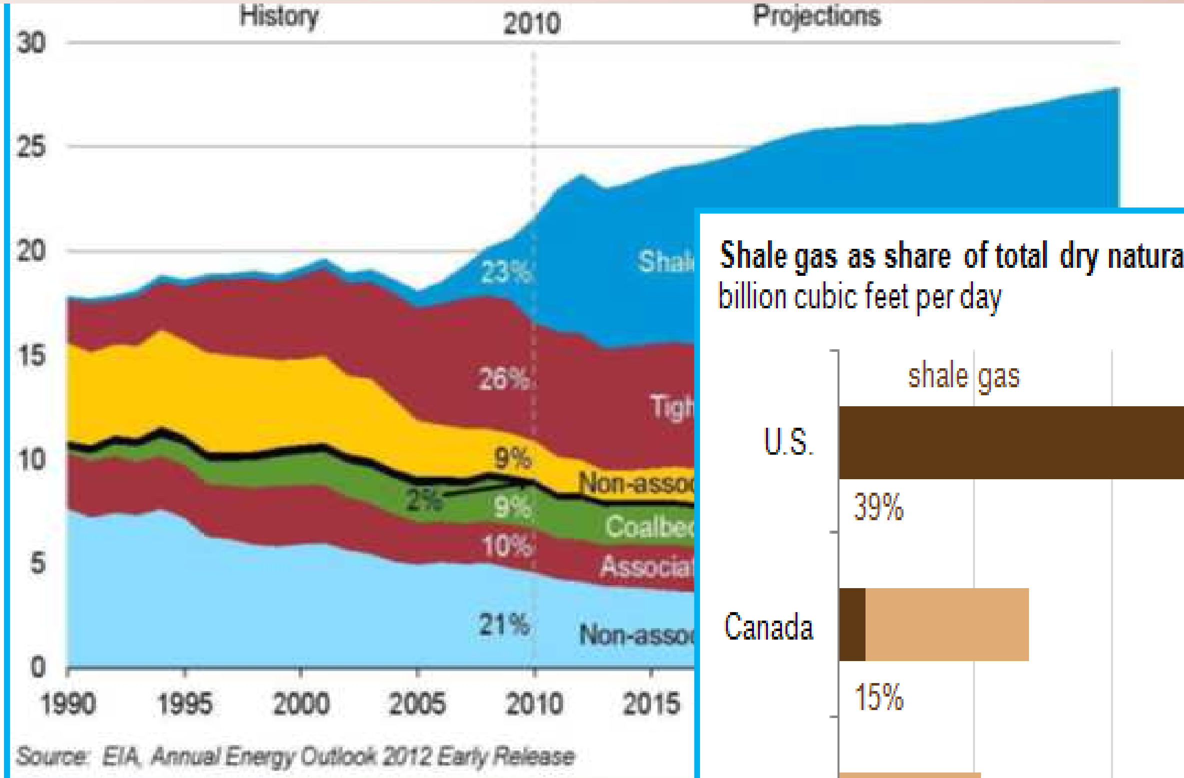
敬请各位专家批评指正

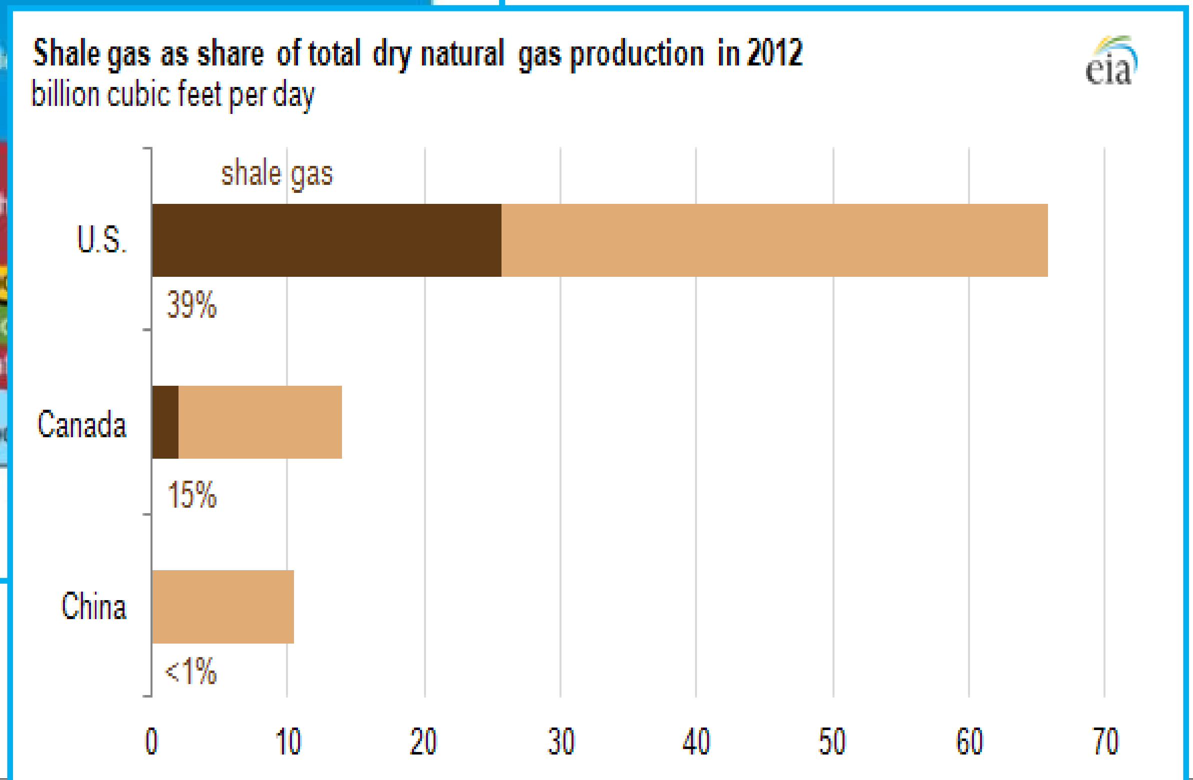
Thank you!

页岩气资源与勘探现状
Shale gas resources and exploration status

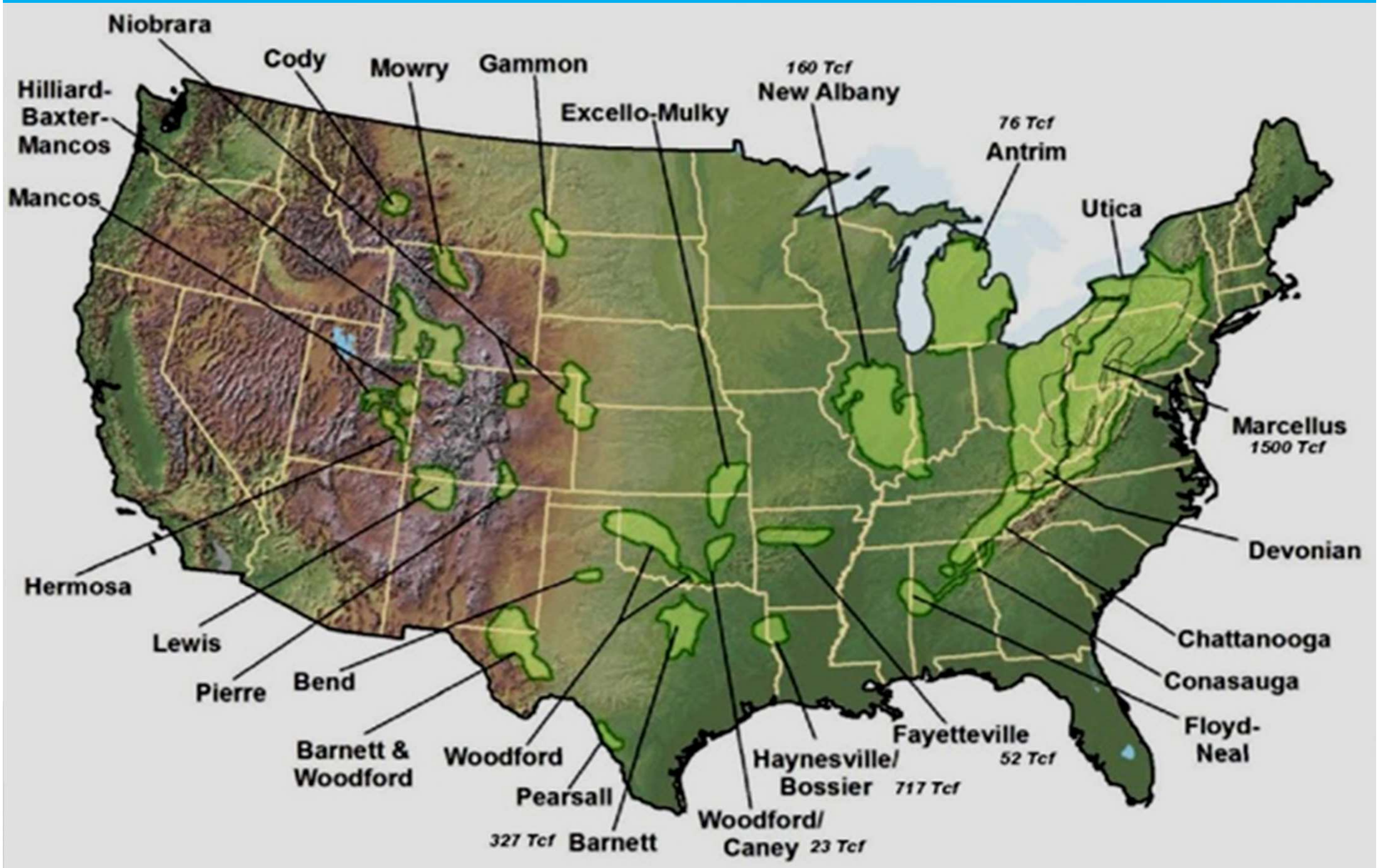


页岩气资源与勘探现状
Shale gas resources and exploration status

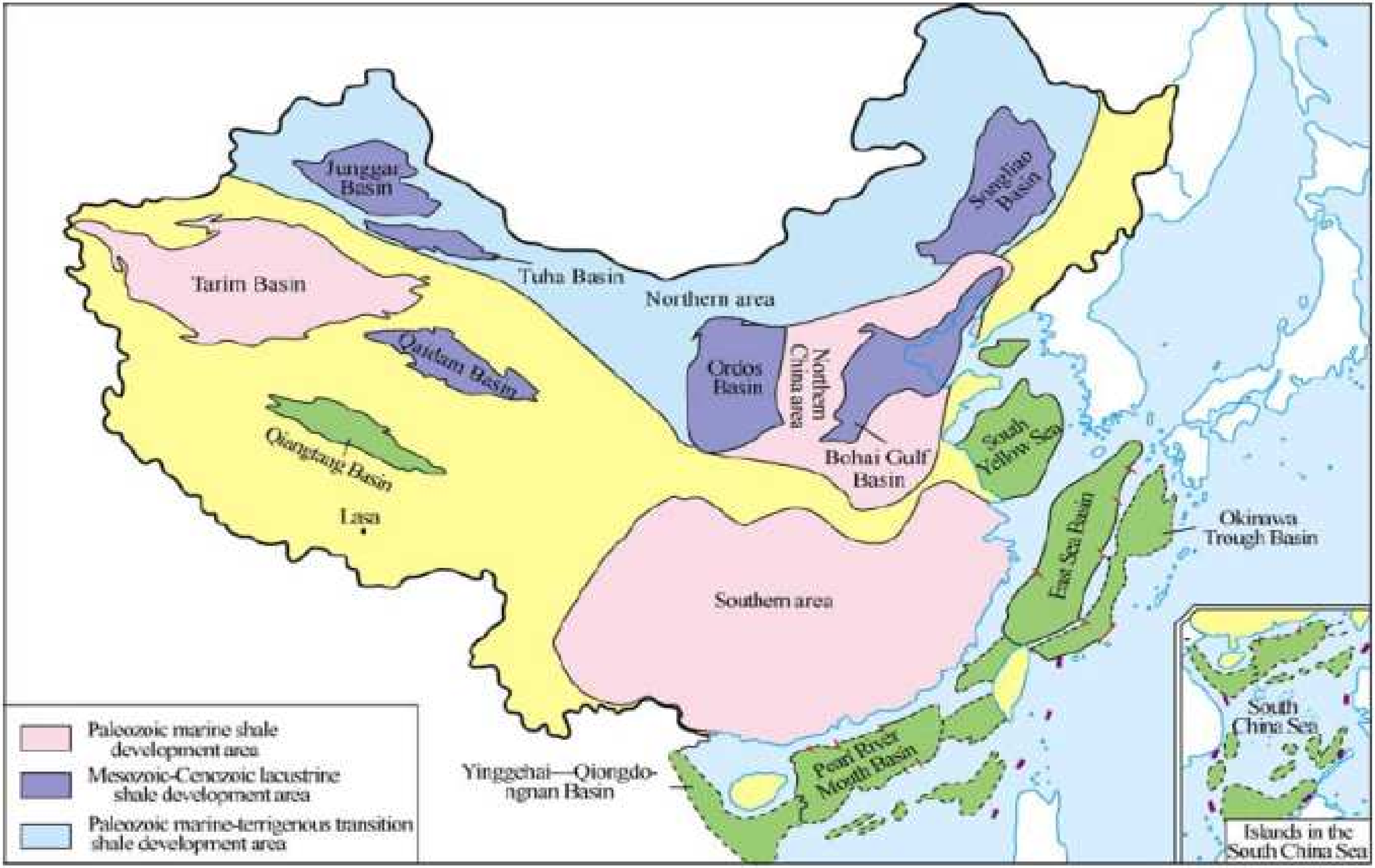




页岩气资源与勘探现状
Shale gas resources and exploration status



页岩气资源与勘探现状
Shale gas resources and exploration status



Contrast of geology and development conditions of shale gas between U.S.A and China

Comparative Condition		China	America
Geologic conditions	Tectonic	Go through several transformation and complicated fault developed;	One time uplifting with scarce fault and fracture developed;
	Sedimentation	Marine, terrestrial shale	mainly marine shale,
	TOC	Complicated, extremely higher for marine	Higher 5%-10%
	Gas content	Lower	Higher
	Ro	Complicated, extremely higher for marine	Moderate for shale gas window
Exploitation condition	Burial depth	Deeper, mainly 3500m	Shallower, 2500 ~3500m
	Surface conditions	Complicated, mountainous in the south, arid in the north	Plain or hilly, enough water
	Pipeline network	Undeveloped, need further constructions	Wholly developed

鄂尔多斯盆地页岩气储层优选——碳源、水资源分布
Carbon source and water resources

Potential Coal chemistry and CCS pioneering projects

PlantName	Production
Qingyang ChangQingQiao coal chemical industry park	17Mt/amethyl alcohol,10Mt/a dimethyl ether, 6Mt/a synthesis ammonia,10.4Mt/a urea,3.6Mt/a acetic acid
Pingliang coal chemical industry base	18Mt/a methyl alcohol,7Mt/a Methanol to Olefins,2Mt/a polyethylene,3Mt/a polypropylene
Lanbai coal chemical industry area	16.7Mt/a methyl alcohol,5Mt/a polypropylene,40bcm Synthetic Natural Gas(SNG)
Shaanxi Yanchang Petroleum Yulin coal chemistry company	15Mt/ methyl alcohola,4Mt/a acetic acid,3Mt/a Vinyl Acetate,2Mt/a acetic anhydride,1Mt/a cellulose acetate fiber
Shaanxi Xianyang chemical industry co., LTD	18Mt/a methyl alcohol
Yanzhou yulin energy chemical co., LTD	24Mt/a methyl alcohola,10Mt/a olefins
Ordos Shenhua CCS demonstration Project	0.1Mt/a carbon dioxide capturing project