The Distribution and Resource Potential of Oil Sands in China*

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General Comments

Oil-sand resources are found in Cenozoic and Mesozoic strata, with the presence of oil sands in units of the former age accounting for 1.098 billion tons (18.4%of the country's total) and 3.933 billion tons (65.9%of the national total) in units of the latter age. Oil sands are also present in Upper and Lower Paleozoic layers, accounting for 560 million tons (9.38%of the country's total), of which 378 million tons (6.33%of the national total) are recoverable.

The geological resources stored in 11basins total 5.842 billion tons (97.6%of the total in China), of which 3.241billion tons are recoverable (98.2% of the total).

Selected References

Liu, D. et. al., 2009, Prediction of subtle reservoir in the first and the second members of Shahejie formation in the southern transition zone, Huanxililng oilfield: Petroleum Geology and Engineering, Web accessed 20 June 2012. http://en.cnki.com.cn/Article_en/CJFDTOTAL-SYHN200902007.htm

Shan, Z., C. Che, J. Li, C. Fan, C. Zang, and Q. Wang, 2007, Present status of oil sand resources at home and abroad: Global Geology, v. 4, p. 459-464.

Unconventional Hydrocarbon Plays in Asia-PACIFIC GTW-AAPG

The Distribution and Resource Potential of Oil Sands in China

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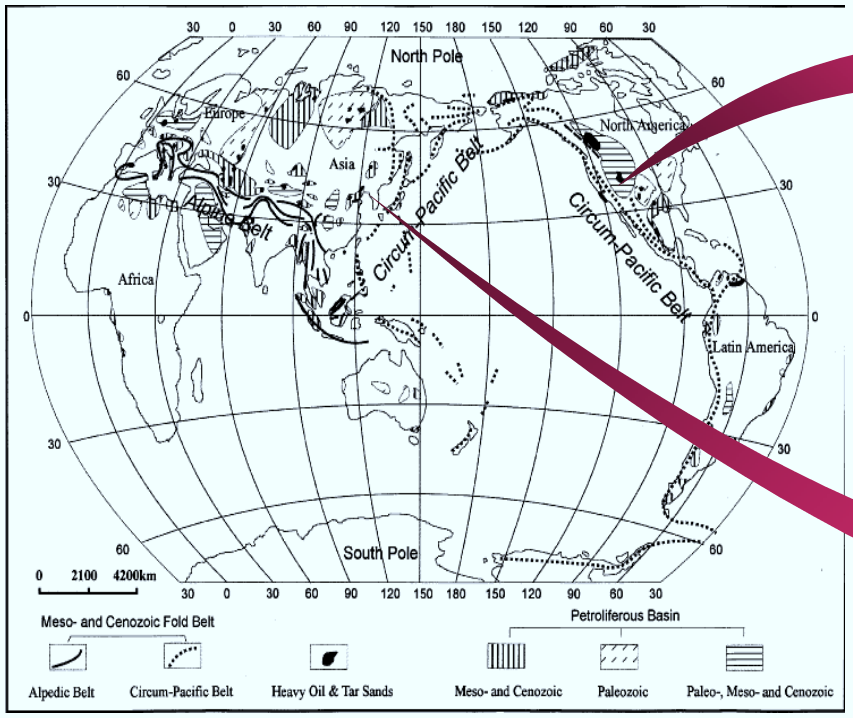
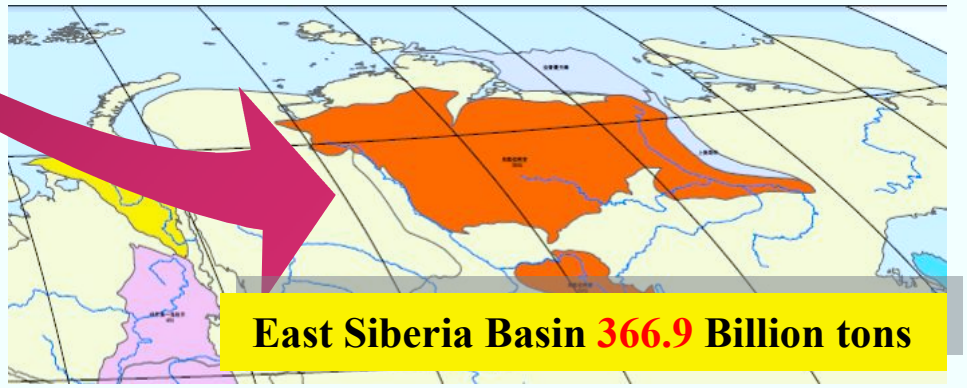
- 5、 Resource-potential analysis

1、Introduction

The total recoverable resource from oil sands is up to 651 billion bbl (103.51 × 10^9 m^3), or 32.0% of the total recoverable resource of oil in the world .The resource volumes of oil sands in Alberta Basin and East Siberia Basin were estimated at close to 382.5 and 366.9 billion tons in 2010.



Distribution of heavy oil and tar sands in the world（BGR 1998）



QUESTION:HOW ABOUT CHINA?

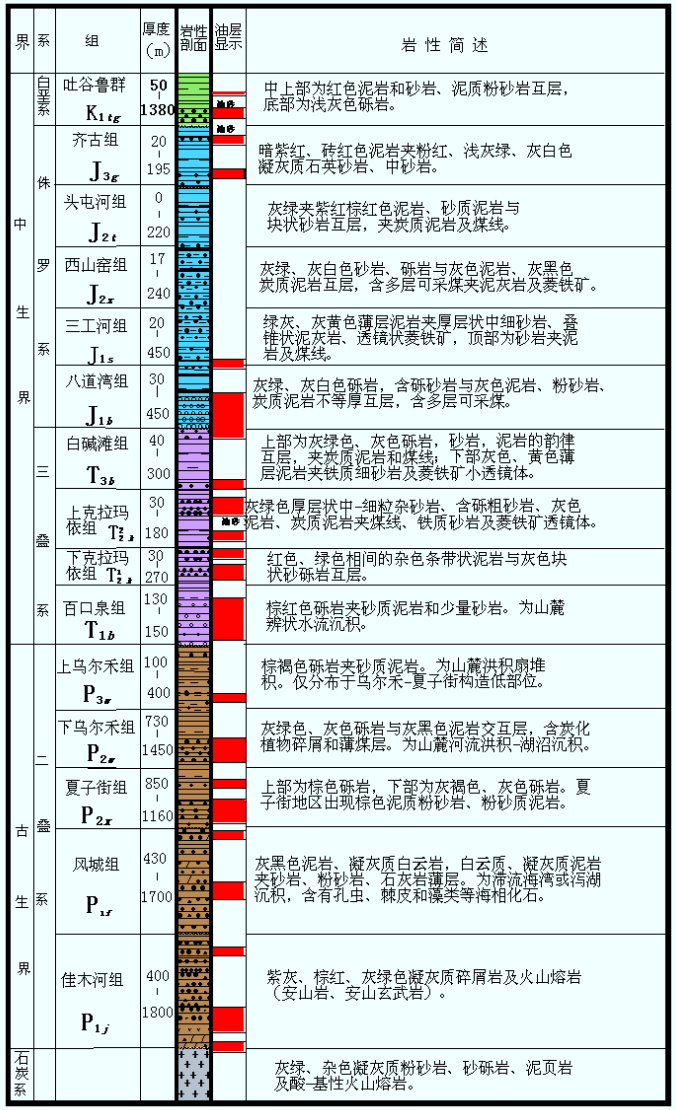
2、Distribution of oil sands in China

3 differences of distribution of oil sands in China :

Regional difference

Basinal difference

Geological time difference



2、Distribution of oil sands in China

- **2.1 Uneven regional distribution of oil sands**

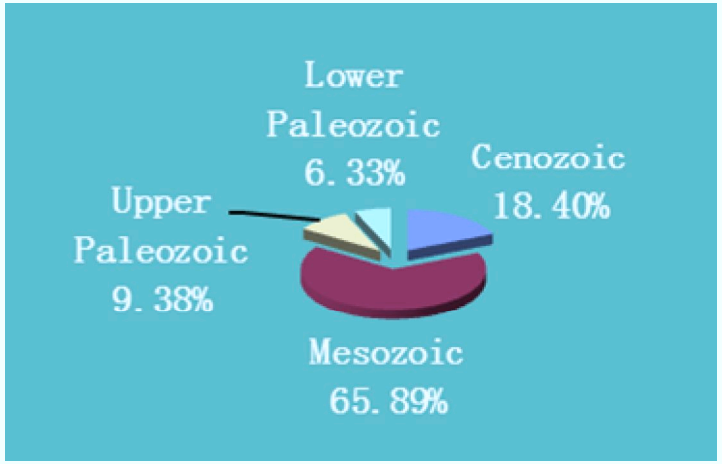
region	Geological resources (billion)	Percentage (%)	Recoverable resources (billion)	Percentage (%)
West	3.289	55.1	2.064	62.5
Tibet	0.974	16.3	0.261	7.9
Centre	0.726	12.2	0.449	13.6
East	0.531	8.9	0.331	10
South	0.45	7.5	0.198	6

• 2.2 Oil sands developed in many geological units

Area	Horizon	Sedimentation and facies	Period of reservoir formation
Eastern	K_1	River and lake facies	Yanshanian, Himalayan period
Central	J ,D_1, K_1,T_3	River and lake facies, Litteral and shallow sea facies	Late Yanshanian, Himalayan period
Western	K_1,J, T_2,N	River and lake facies, braid deltas, Alluvial fan facies	Yanshanian, Himalayan period
Southern	N_1 E_2	River and lake facies, Alluvial fan facies Delta facies	Himalayan period
Qinghai-Tibet	J_2 E_2	Sedimentary facies associated with lagoons, tidal flats, sandy banks, biogenic reefs, and tidal-flat facies	Late Yanshanian , Himalayan period
		lake, underwater fan, fan deltas, proluvial fan facies	Himalayan period

Distribution of oil sands according to area/age

Oil-sand resources are found in Cenozoic and Mesozoic strata, with the presence of oil sands in units of the former geological time accounting for 1.098 billion tons (18.4% of the country's total) and 3.933 billion tons (65.9% of the national total) in units of the latter age. Oil sands are also present in Upper and Lower Paleozoic layers, accounting for 560 million tons (9.38% of the country's total), of which 378 million tons (6.33% of the national total) are recoverable.



2、Distribution of oil sands in China

- **2.3 The significant difference of oil-sand resources of different basins**

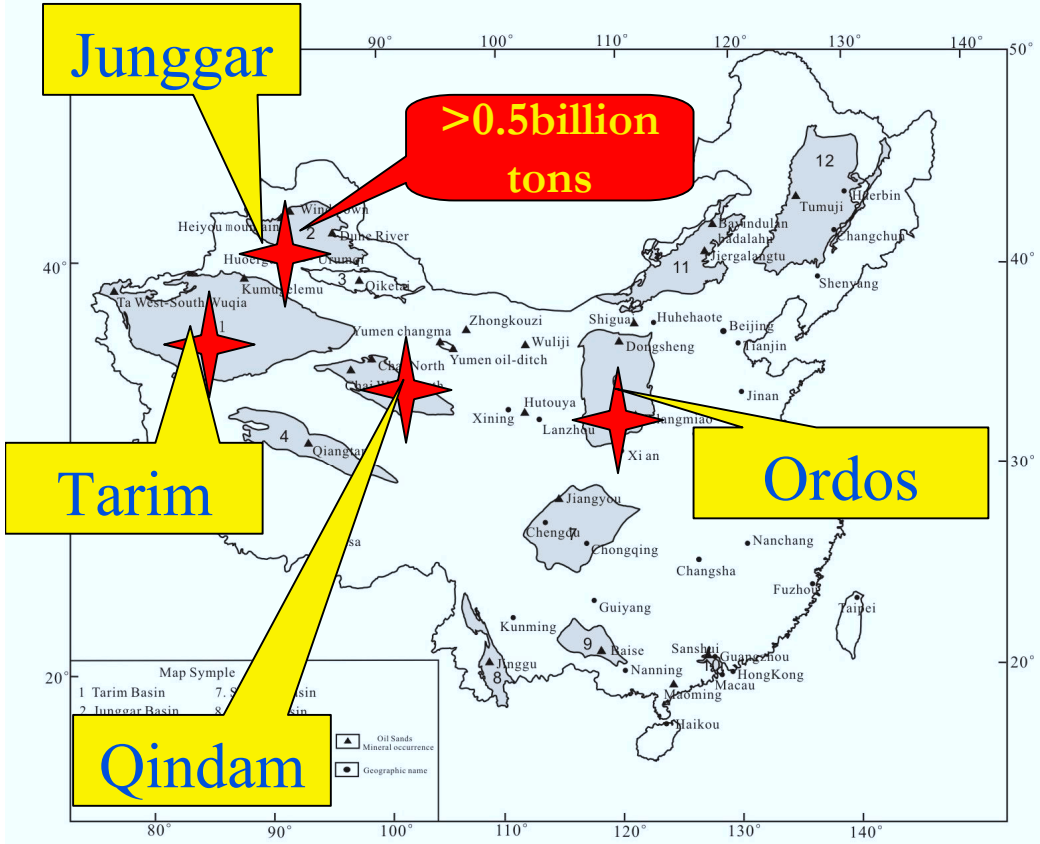
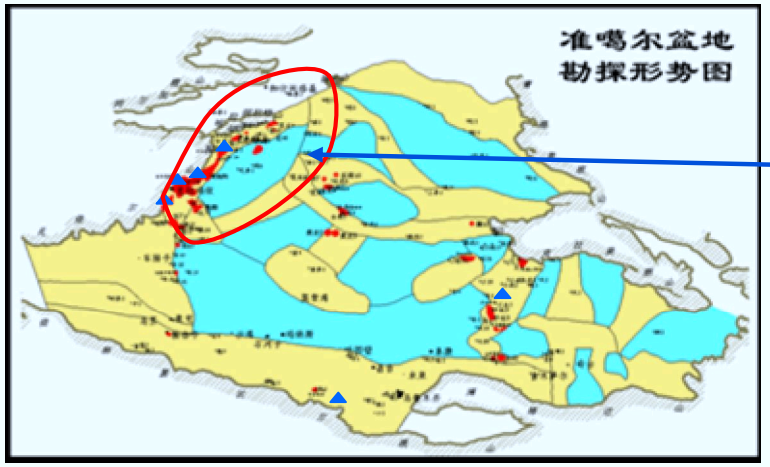


Fig.1 Distribution of oil-sands resources in China(after Shan Xuanlong, 2007)

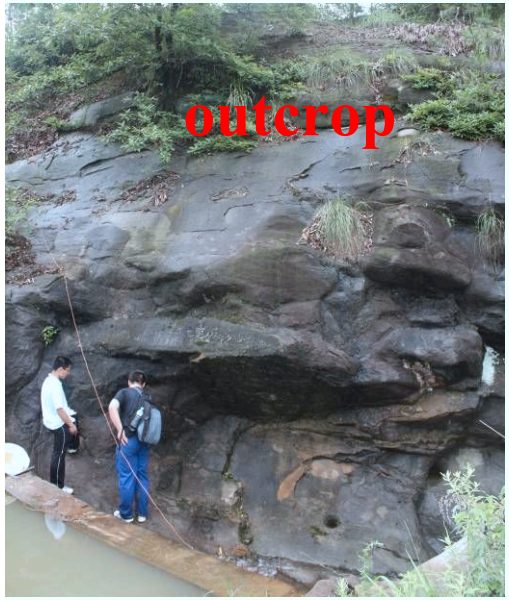
The geological resources stored in these 11 basins total 5.842 billion tons (97.6% of the total in China), of which 3.241 billion tons are recoverable (98.2%).

Principal oil sands deposits

Northwest Junggar deposits



Northwest Sichuan deposits



Oil sands outcrop in Houshanshuiku

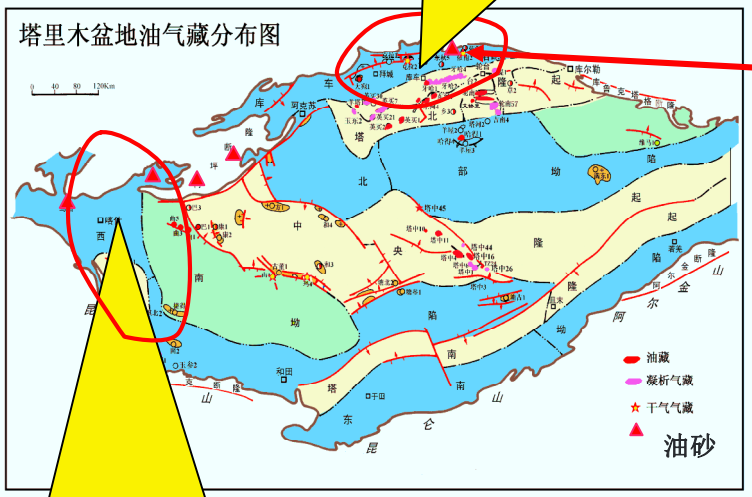
Heiyoushan oil spring

Oil sands outcrop in Pingliang ditch

ZK64 Producing Picture

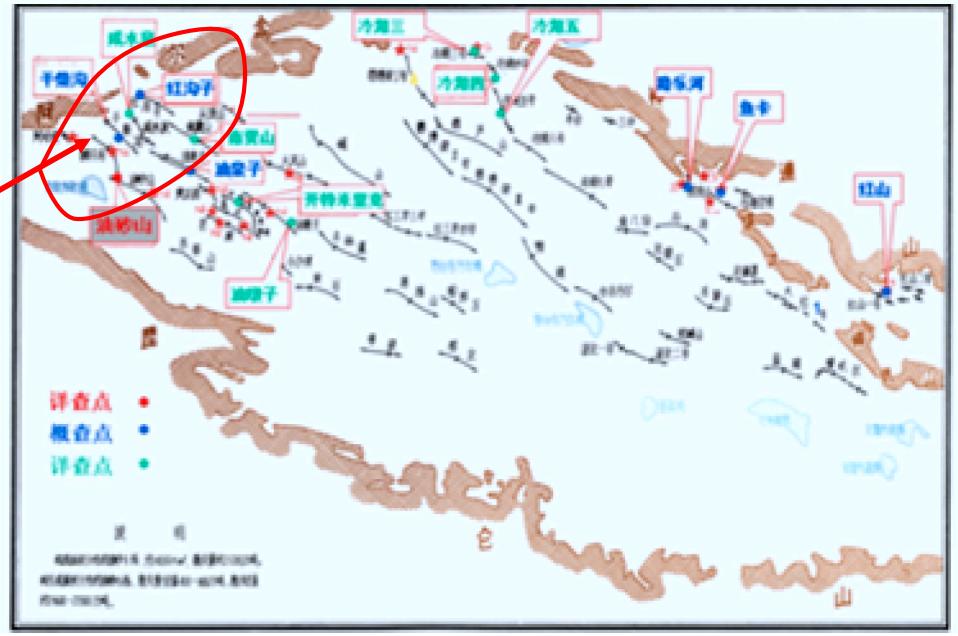
High-oil content、High-quality oil

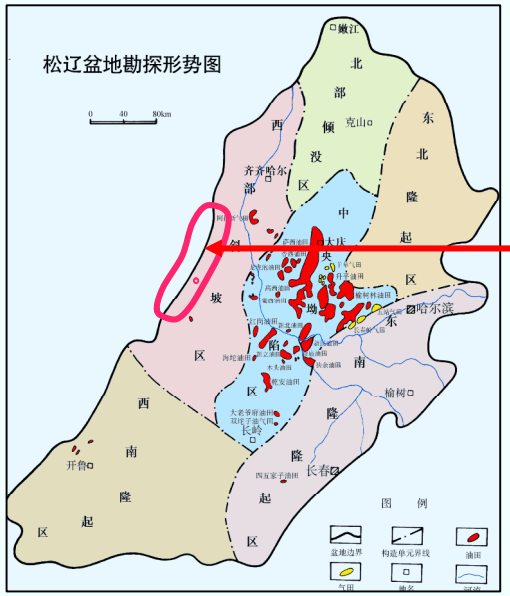
North Tarim deposits



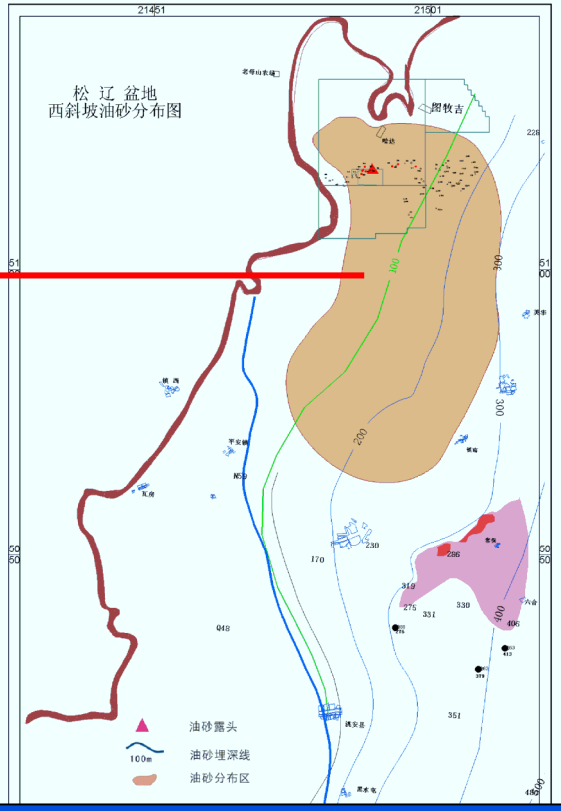
Northwest Qindam deposits

Southwest Tarim deposits

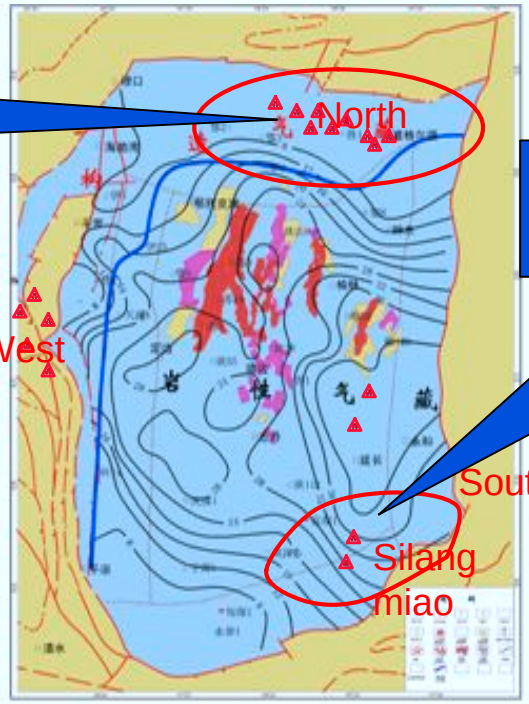




west Songliao deposits



North Ordos deposits



Southeast Ordos deposits

QUESTION: Why are oil sands distributed mainly in the basins?

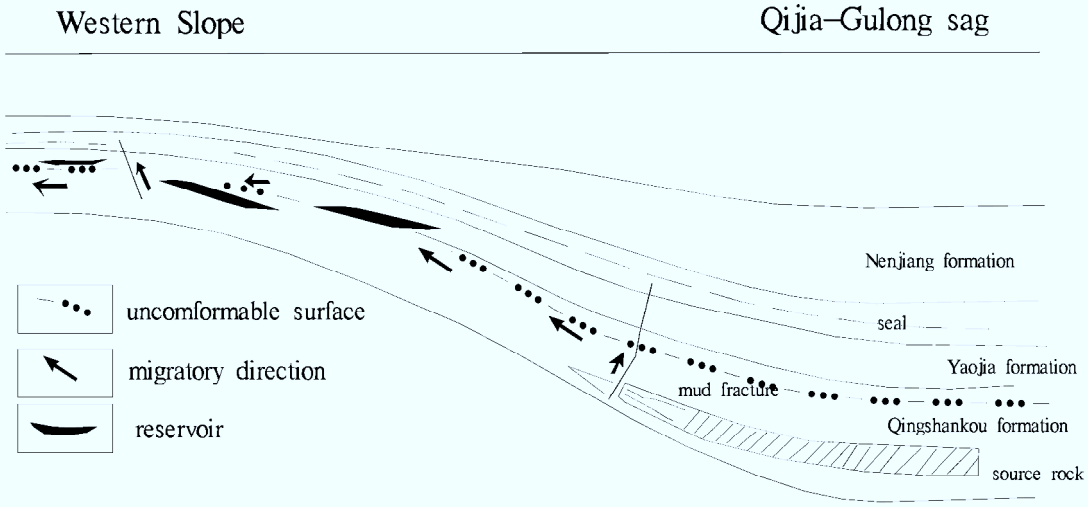
3、Oil-gas geologic conditions determining the distribution of oil sands in large petroliferous basins

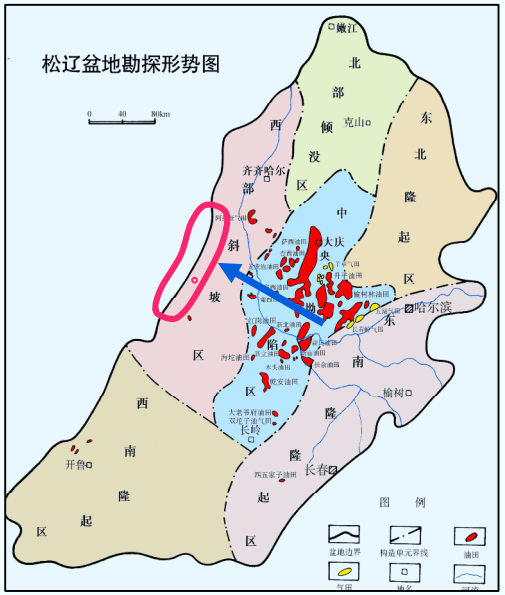
- 3.1 Abundant oil supply
- 3.2 Considerable Mesozoic and Cenozoic tectonic activity
- 3.3 Existence of large-scale oil-gas migration pathways

3.1 Abundant oil supply

- **Oil may come from three primary sources**

- **1).Crude oil from basin center that has migrated to the surface or shallow reservoirs in basinal uplift or slope area**

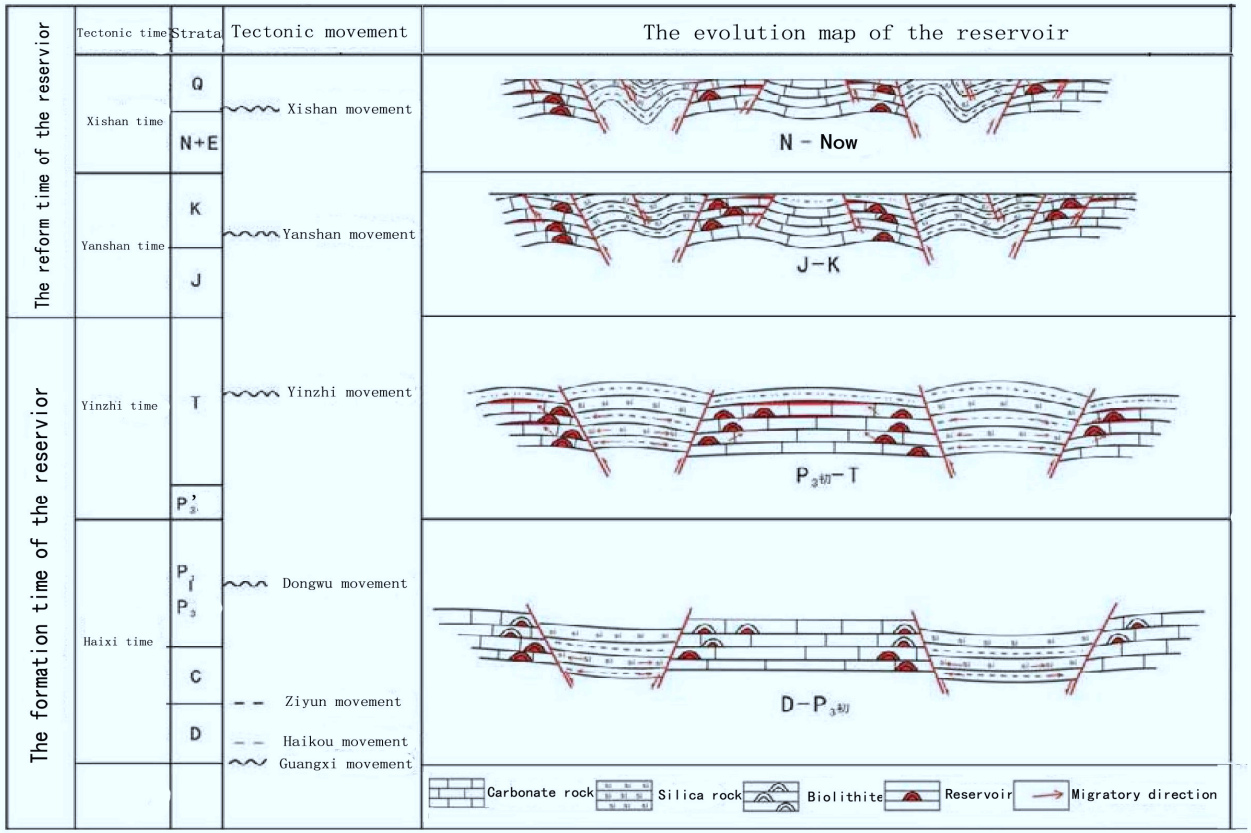




The oil sand reservoir forming pattern of western slope in Songliao basin (after Zhang Weiqin, 2005)

3.1 Abundant oil supply

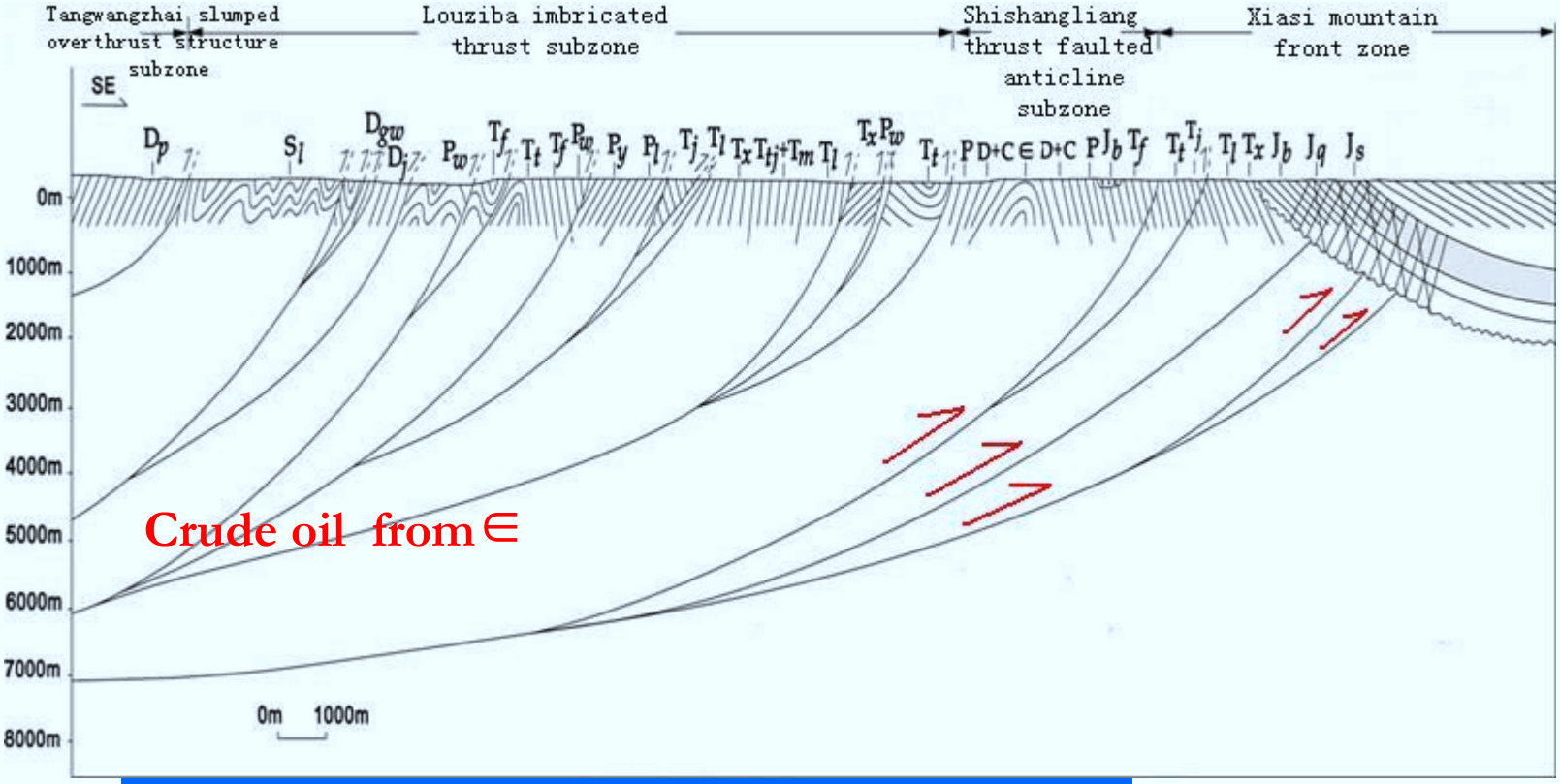
- **Oil may come from three primary sources**
  - **2).Crude oil in sandstone resulting from the direct uplift of paleo-reservoirs to the surface by tectonic movement**



The evolution of the reservoir (after Liu Dongcheng, 2009)

3.1 Abundant oil supply

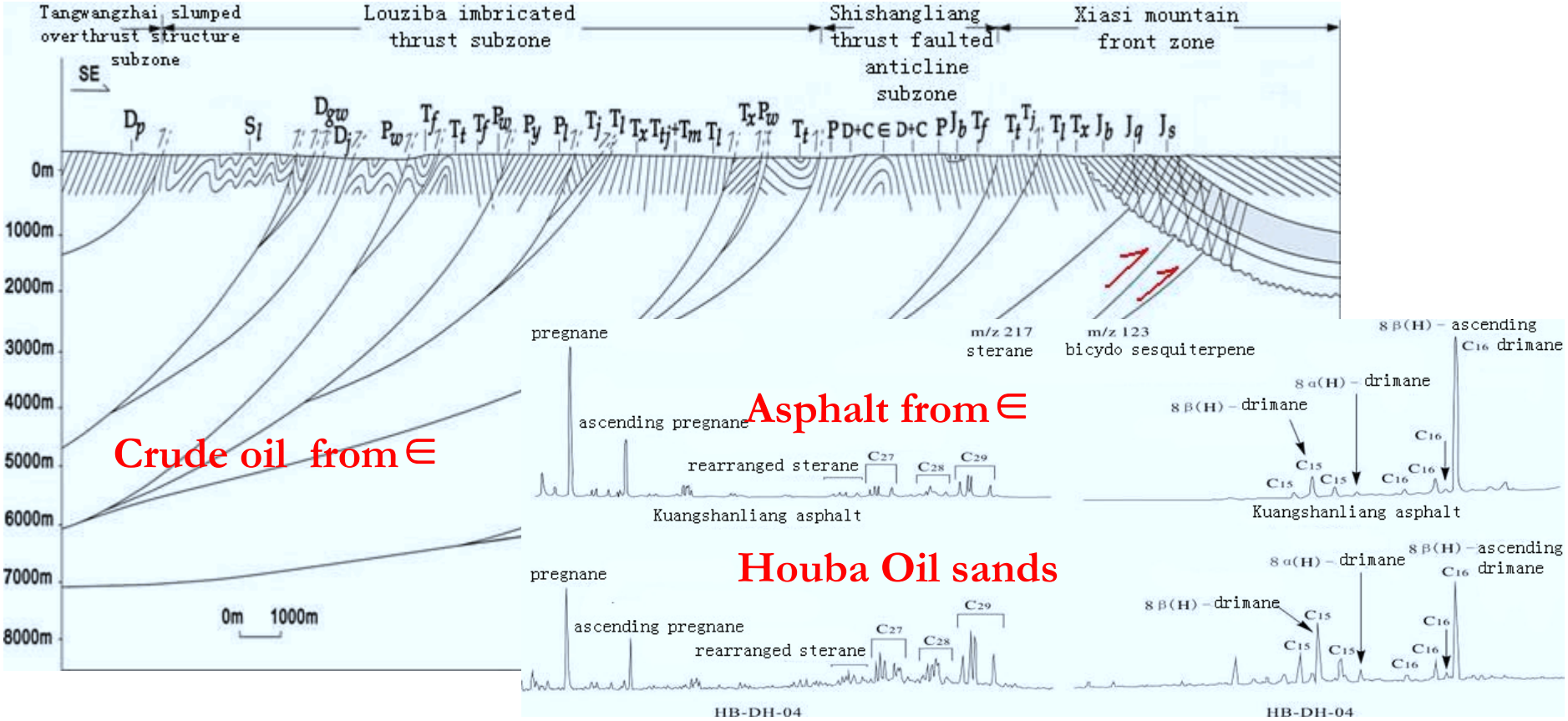
- **3).crude oil in paleo-reservoirs that migrated to surface or shallow reservoirs through the faults or unconformity layers**



The oil sand reservoir forming pattern of Houba oil sands

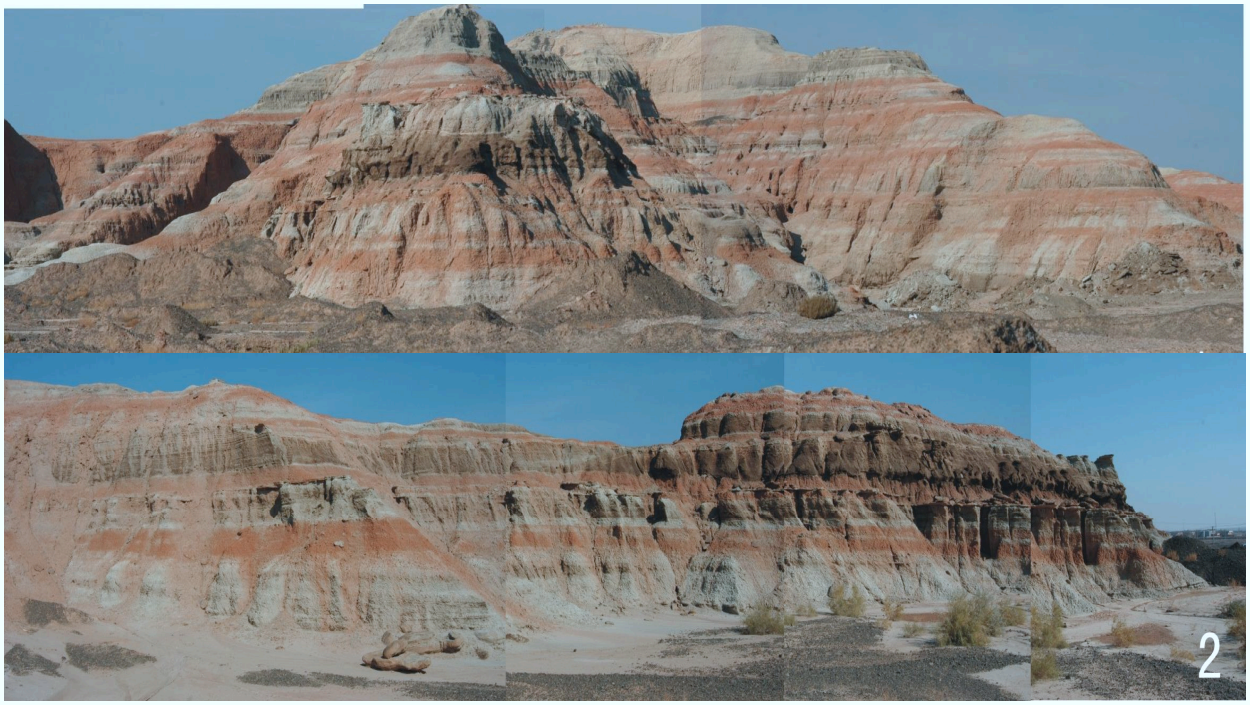
3.1 Abundant oil supply

- **3).crude oil in paleo-reservoirs that migrated to surface or shallow reservoirs through the faults or unconformity layers**

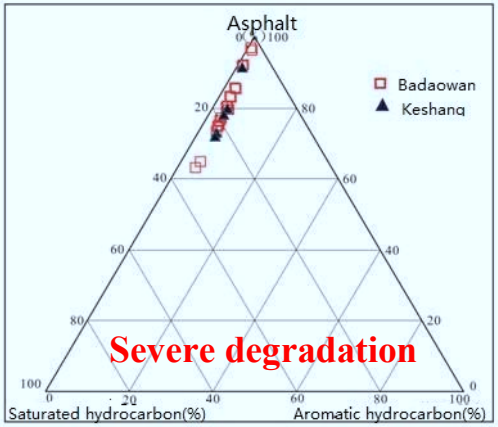


Comparison Diagram of group composition (after Huang Dipan 2008)

- During oil-sand formation, a considerable amount of crude oil is lost



The oil sands in Junggar basin



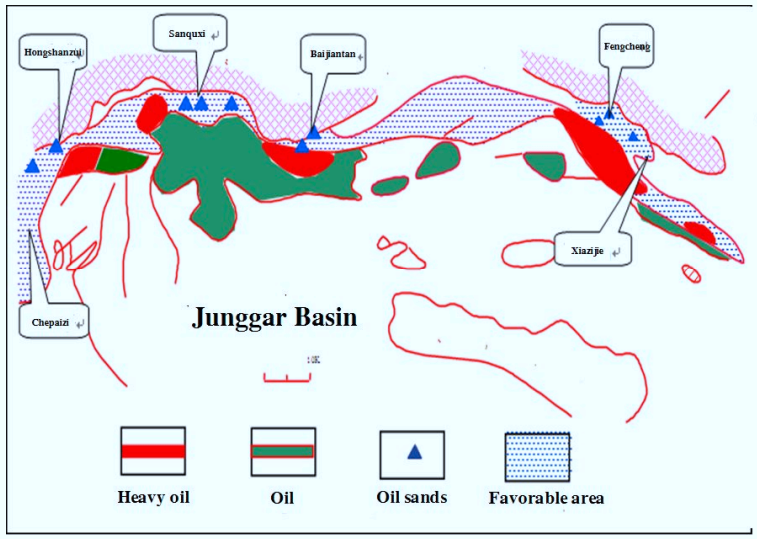
- Therefore, oil-sand deposits form in basins with abundant oil and gas.

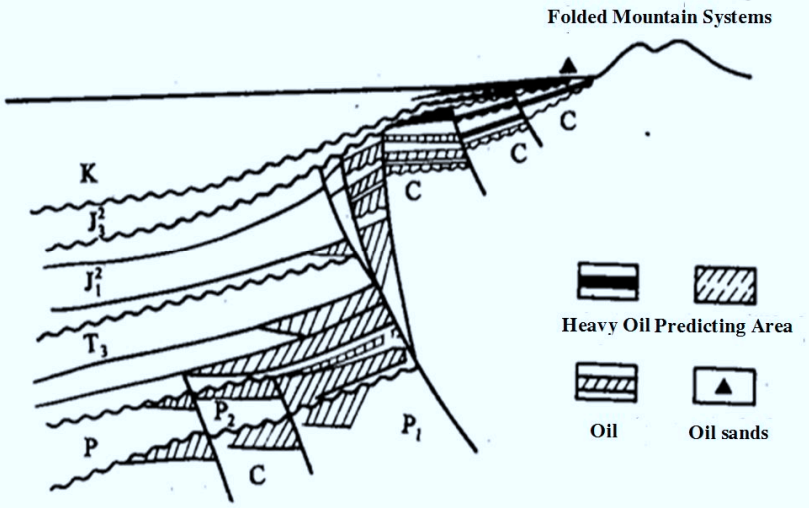
3.2 Considerable Mesozoic and Cenozoic tectonic activity

- **Research in China has revealed a strong correlation between oil sands and regions that experienced considerable Mesozoic and Cenozoic tectonic activity (particularly associated with the Himalayan movement)**

1) Exhumation and uplift of basins in western China

- **Crude oil also migrated to the basin slope and uplift area through oil-gas migration pathways.**



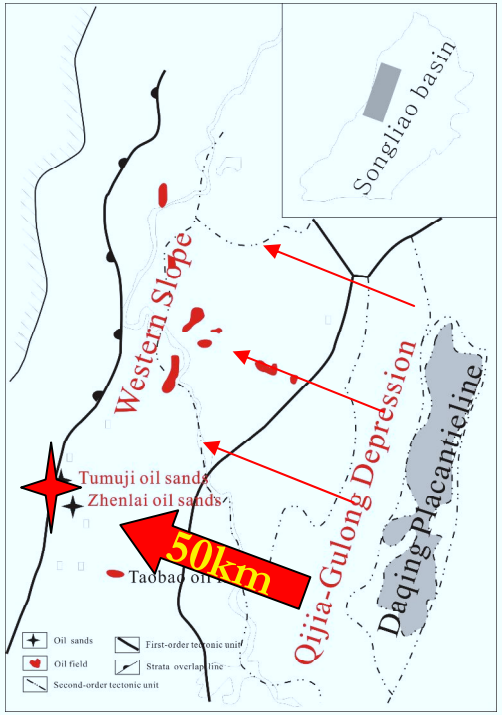


The distribution of oil sands in Junggar basin in western China

3.2 Considerable Mesozoic and Cenozoic tectonic activity

2) The rift basins in eastern China

- **In the eastern rift basins in China, tectonic movement caused hydrocarbons from source rocks to migrate to the surface via the fault and unconformity surfaces, forming oil sands.**



Tumuji oil sands

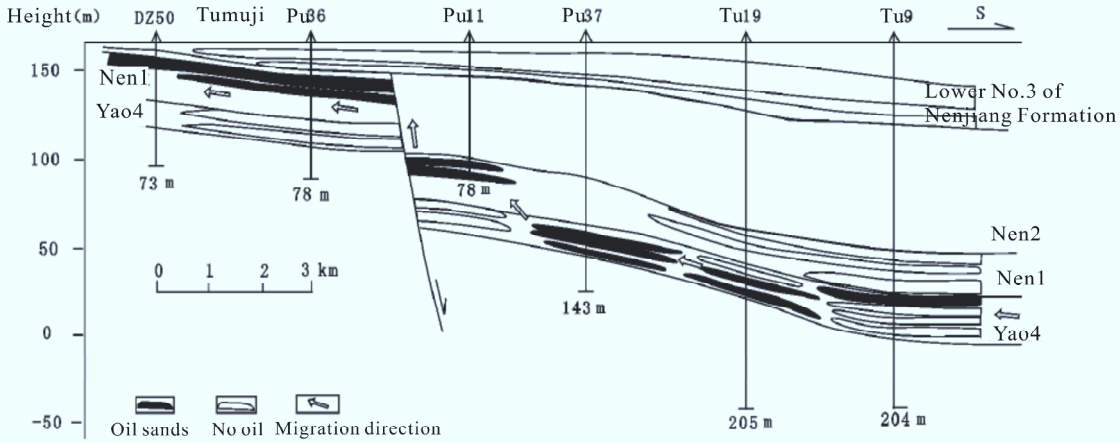


Fig. 1 Pattern of oil-sand formation in the western slope of the Songliao Basin

（After Bai Wenhua et al，2009）

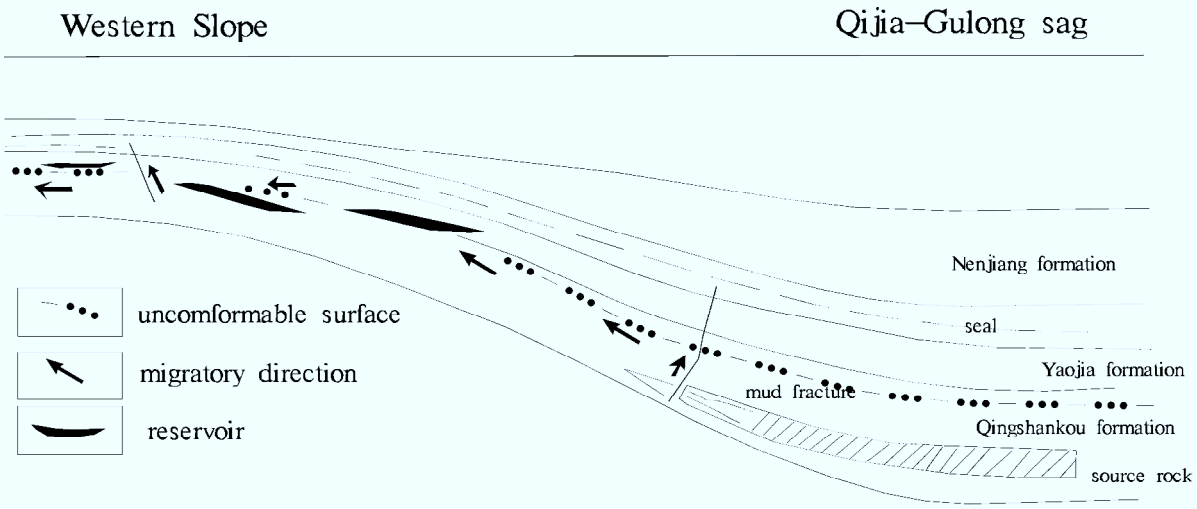
3) The transition basins in the central and southern regions

- **Basins in the central and southern regions were affected by Mesozoic and Cenozoic tectonic activity, with basin uplift and stratum denudation exposing the paleo-reservoirs. Crude oil then formed oil sands or bitumen deposits through loss, oxidation, and degradation.**

The Houba oil sands in Sichuan basin： the shallow layer sandstone of Shaximiao formation and the oil sands are in Jurassic series; the asphalt in fine sandstone in small thrust fault belt.

3.3 Existence of large-scale oil-gas migration pathways

- **The crude oil in oil-sand deposits may come from the oil-generating center of the basin or the paleo-reservoir. Regardless of the origin, the existence of large-scale oil-gas migration pathways is necessary, and ultimately determines the formation and distribution of oil sands.**



The reservoir-forming pattern on western slope in Songliao basin (after Zhang Weiqin, 2005)

The oil-sand deposits on the western slope of Songliao basin : Oil source comes from Qijia-Gulong depression

QUESTION: In which parts of the basins are oil sands distributed?

4、Basin characteristics and the effect of tectonic activity on the favorable zones of oil sands

4.1、Transitional belts between basins and mountain beltss of Mesozoic and Cenozoic strong tectonic activity in "extrusion" background

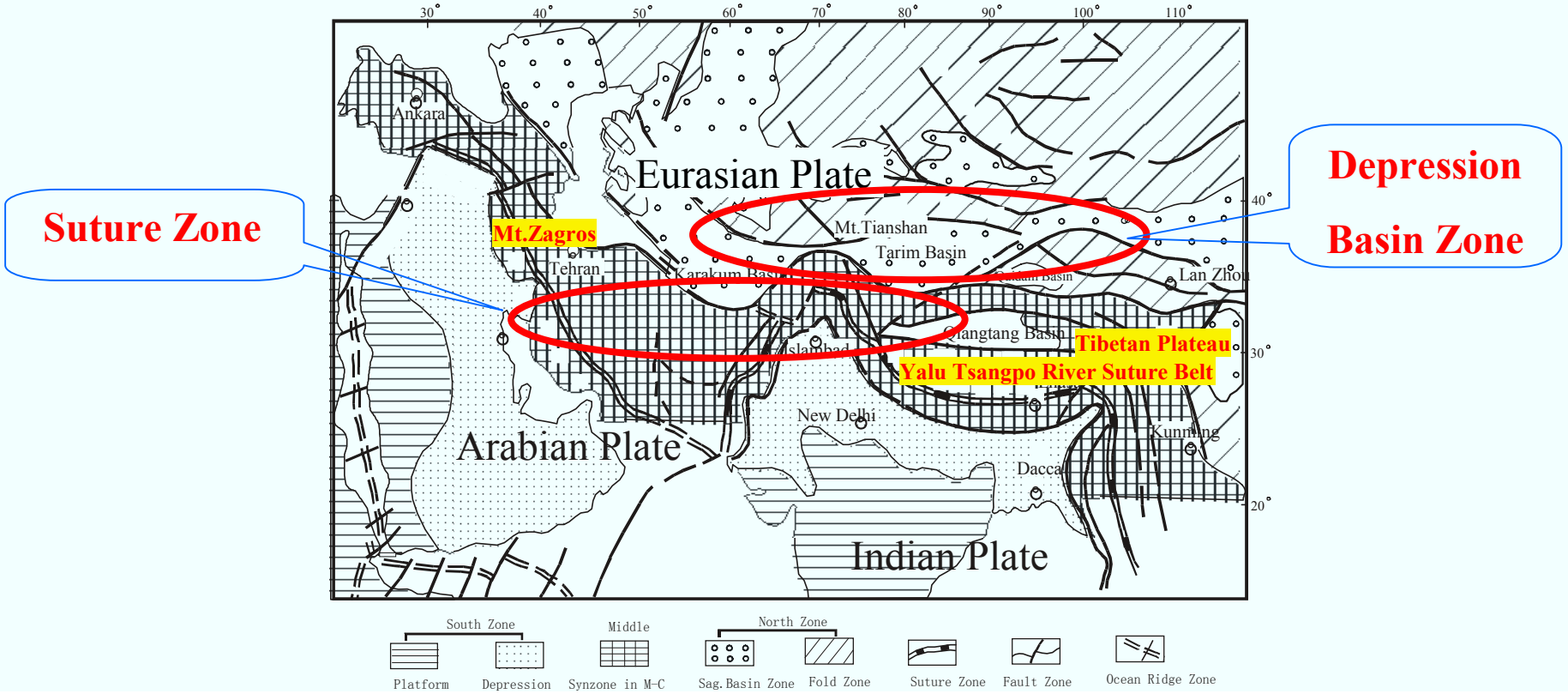
4.2、Reverse structural belts in extensional basins

4.3、Large-scale uplift and slope belts of superimposed oil-gas basins

4.4、Paleo-reservoir structures in residual oil-gas basins formed by uneven uplift during the late "fossil" plate period

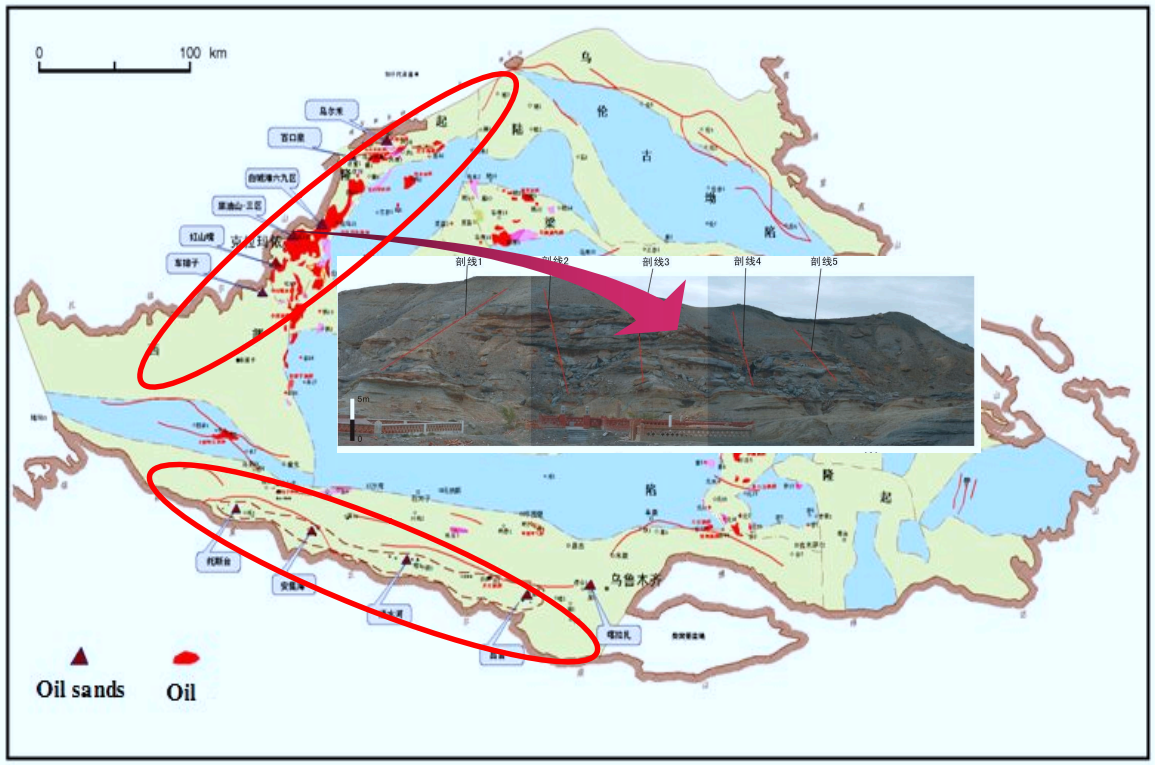
4.1、Transitional belts between basins and Mountain belts of Mesozoic and Cenozoic strong tectonic activity in exhumed background

Compressional basin are mainly developed in western mainland of China. Since the Cenozoic, orogenic movement obviously happened in the western region and oil sands are mainly distributed in transitional belt between basin and mountain or large-scale uplift belt or uplift structure in oil-generating depression, where strong tectonic activity occurred.



4.1、Transitional belts between basins and Mountain belts of Mesozoic and Cenozoic strong tectonic activity in "extrusion" background

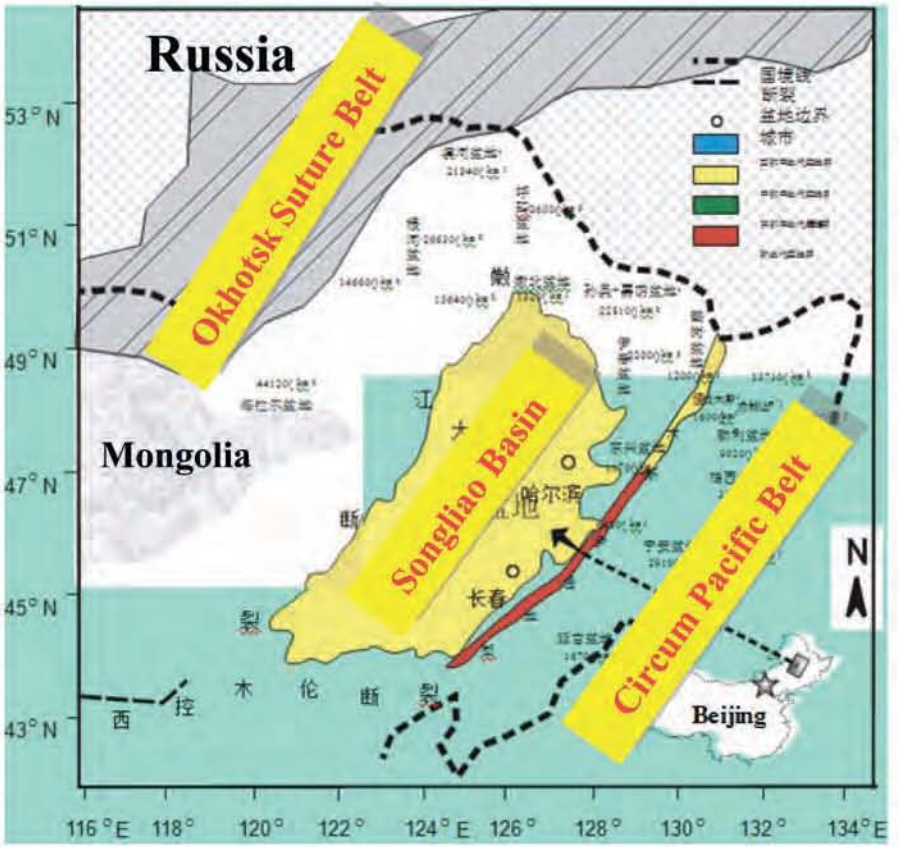
For example, the oil sands of Junggar basin experienced late Hercynian and the Indo-China Yanshanian and Himalayan deformation. Tectonic activity during many periods created reservoirs; the reservoirs were exposed; a considerable amount of oil and gas was lost, forming the oil-sand deposits present today.

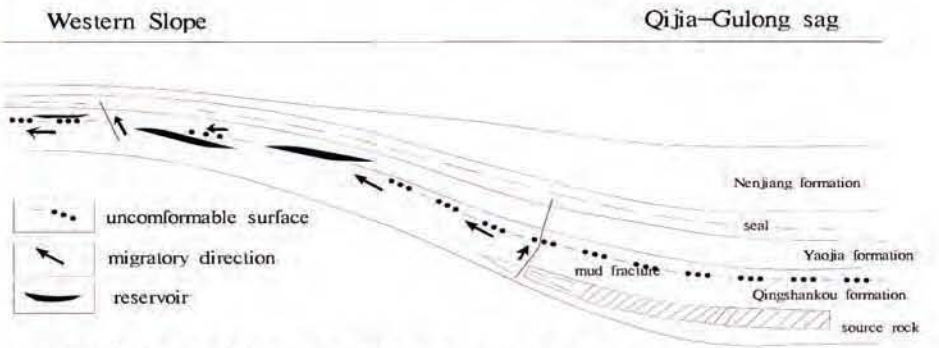


The oil sands in Junggar Basin

4.2、Inversion in structural belts in extensional basins

The basins found in eastern China are rift basins that formed during the Mesozoic and Cenozoic eras. Tectonic inversion during the late Yanshan or Himalayan period created the oil sands- on the slopes or uplifts.



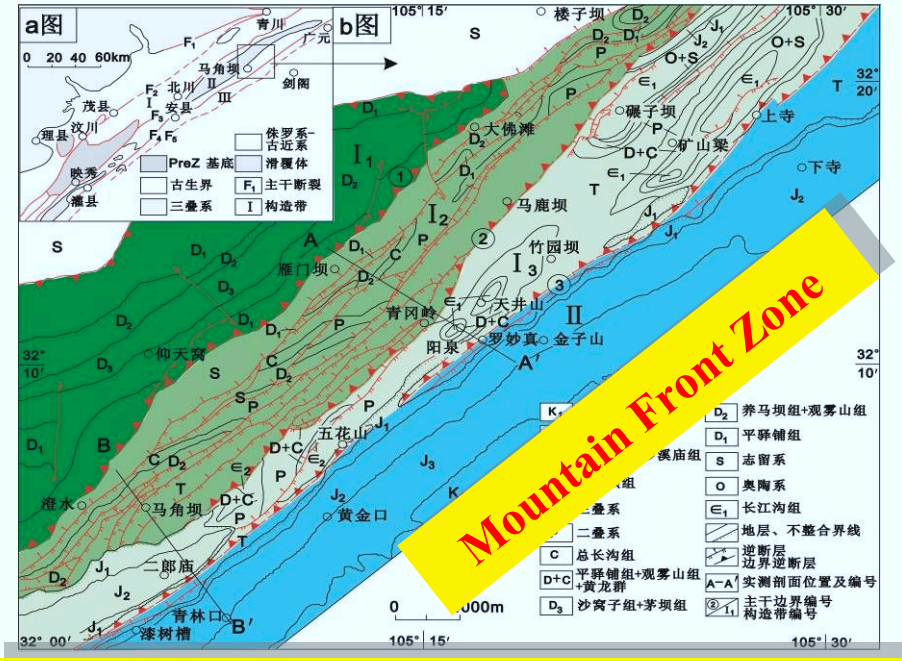


The reservoir-forming pattern on western slope in Songliao basin (after Zhang Weiqin,2005)

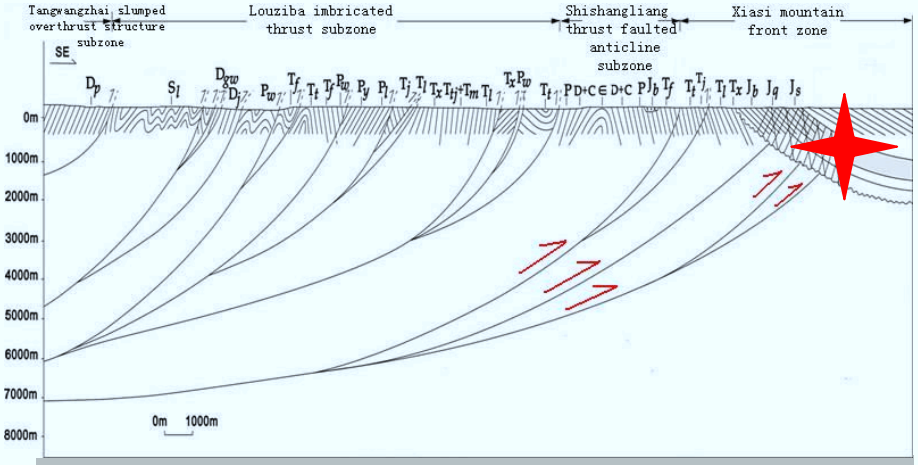
For example, the oil-sand deposits on the western slope of Songliao basin were derived from the oil-gas in the central depression of the Qingshankou Formation.

4.3、Large-scale uplift and slope belts of superimposed oil-gas basins

A transition zone known as the Central Superimposed Basins Group lies between the eastern rift basins and the western compression basins. In the central part of the country, oil sands are found either in the anticline belt or the fault block in the "subprime" sag of basins.Thus, the uplift belt on the edge of the basin formed as a result of strong tectonic movement during the Mesozoic and Cenozoic eras.



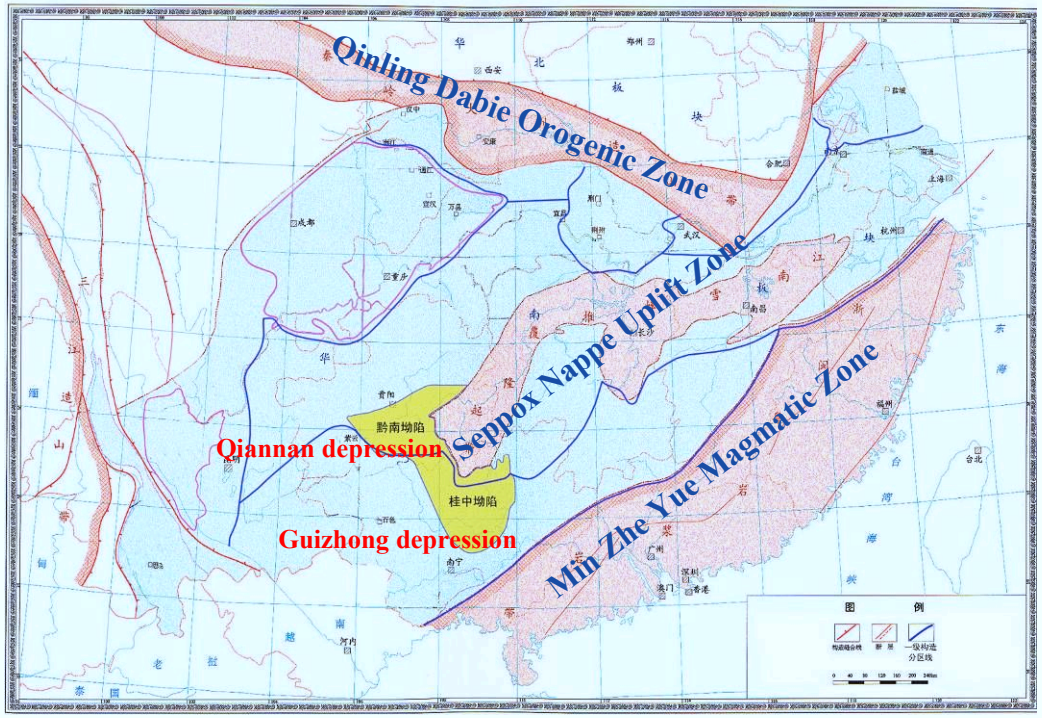
Distribution of Houba oil-sand metallogenic belt



The Houba oil- sand deposits on the slope of Sichuan basin

4.4、Paleo-reservoir structures in residual oil-gas basins formed by uneven uplift during plate movement in late geological periods

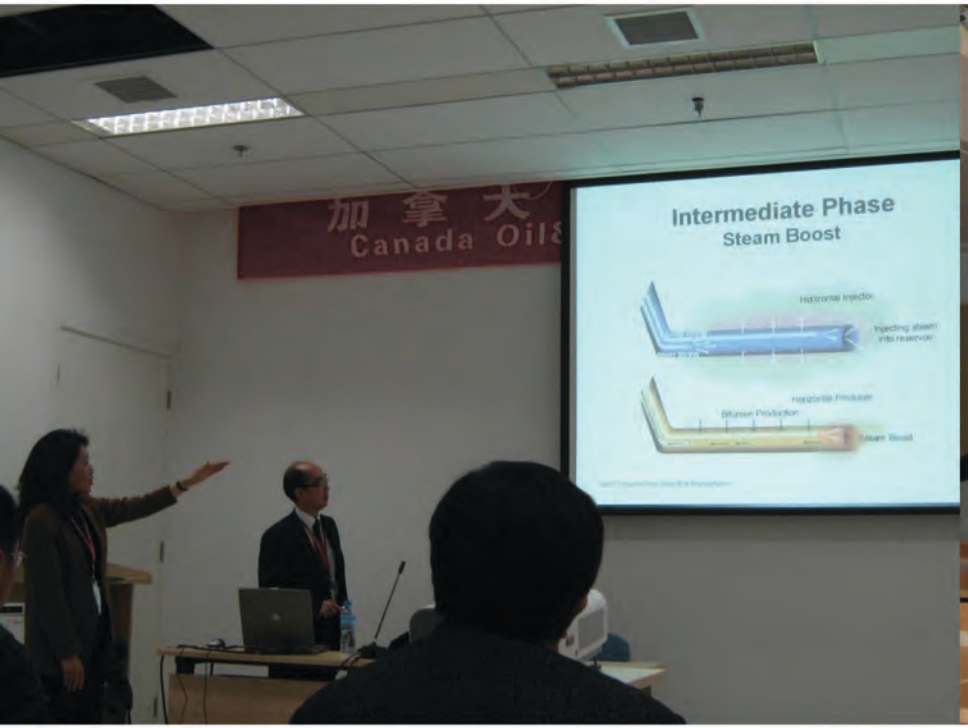
Platform basins are primarily found in Yunnan, Guangxi, and Guizhou. Most are depression or fault basins in the surface layer of the Yangzi Platform. A small number of basins are superimposed above the fold belt of southern China Oil sands deposits in the form of asphalt found in the paleo-reservoir structure belts of residual oil-gas basins formed by uneven uplift of the Yangzi Plate during late geological periods.



i.e., **Guizhong depression** is developed in **depression or fault basin** after multiple-phase deformation

5、Resource-potential analysis

- **China's oil-sand resources as an important complement to conventional oil-gas resources.**

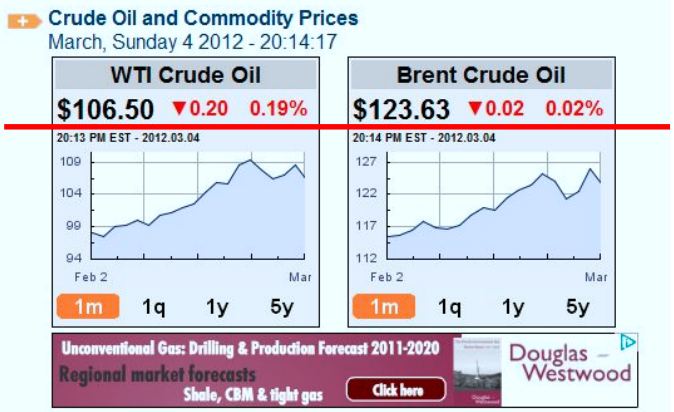


2010.3.22－3.24, Canada oil and gas technology workshop

5.1、Development of oil-sand deposits to combat high oil prices

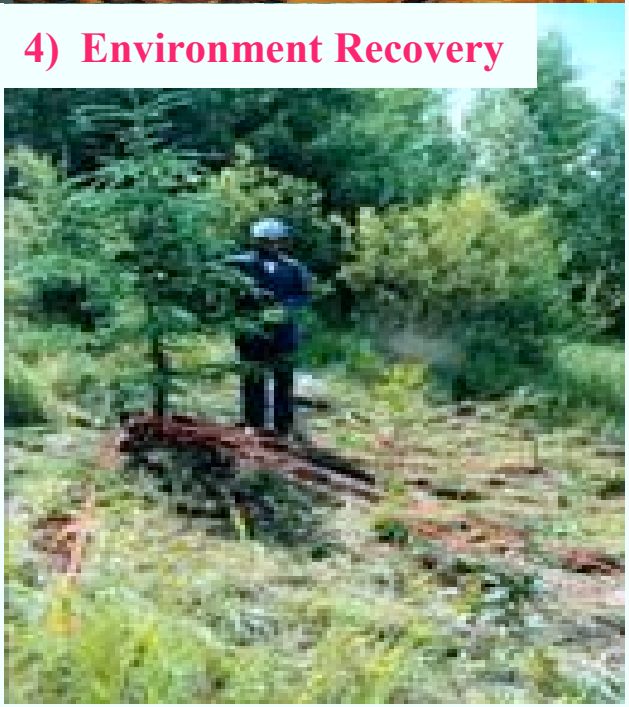
1) mining

2) extract



3) upgrading

4) Environment Recovery



Surface Mining:

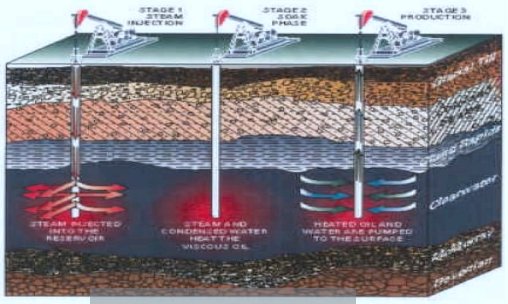
The mining depth is less than 50-75m and operation cost is 8-12 dollars/bbl

In situ recovery:

The operation cost of N-SOLV technology provided by Hatch Company of Canada is 34 dollars/bbl

5.2、Development of oil sands recovery technology

- **With technological developments, the different types of steam, solvents and well tube structure are mainly used for oil-sand recovery technologies and they are often developed or combined with several kinds of characteristics for adapting to the different type of oil sand mine exploration, especially the development of horizontal well technology, with a qualitative leap of in situ recovery technology.**



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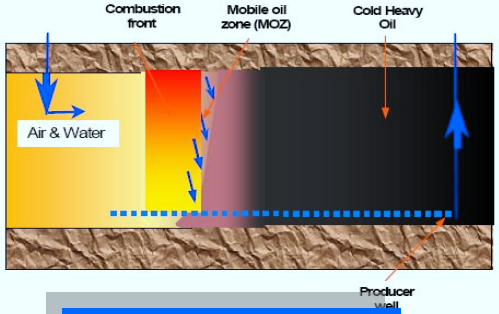
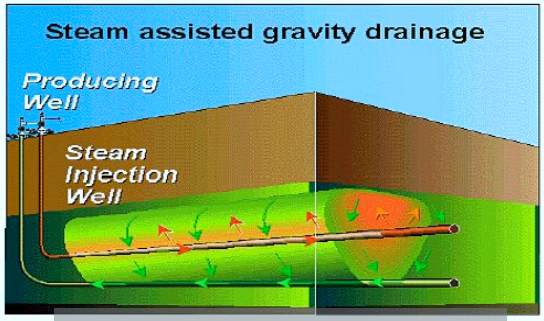
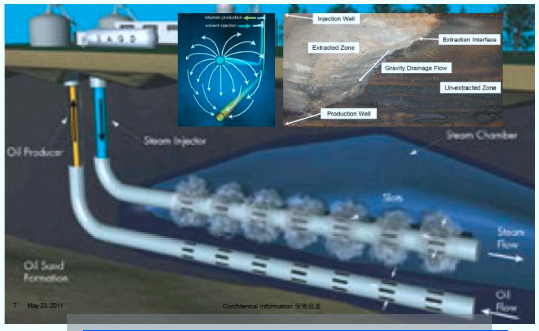


ISC



SAGD

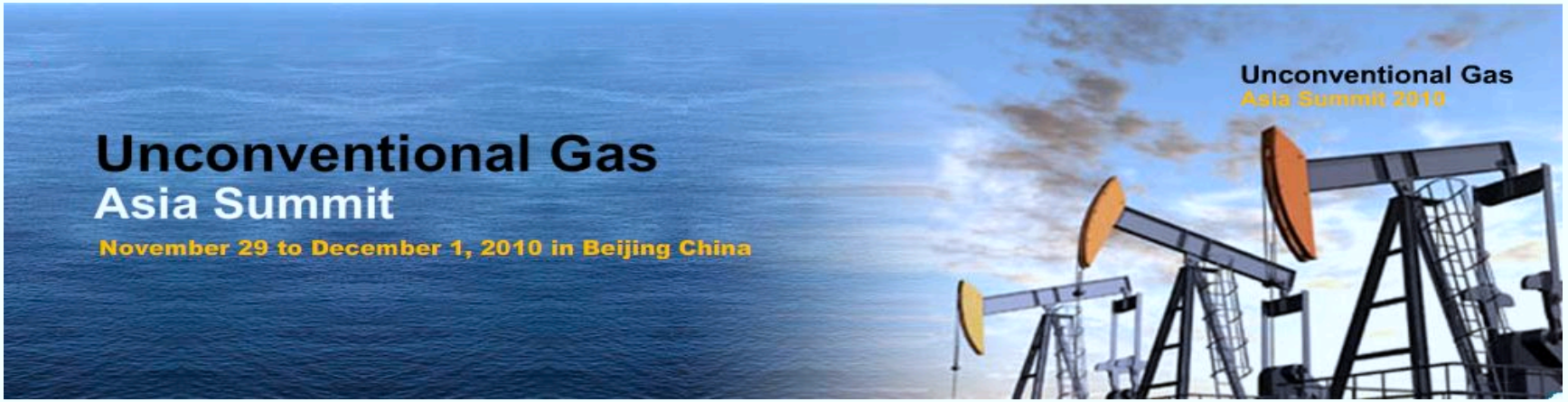


N-solv

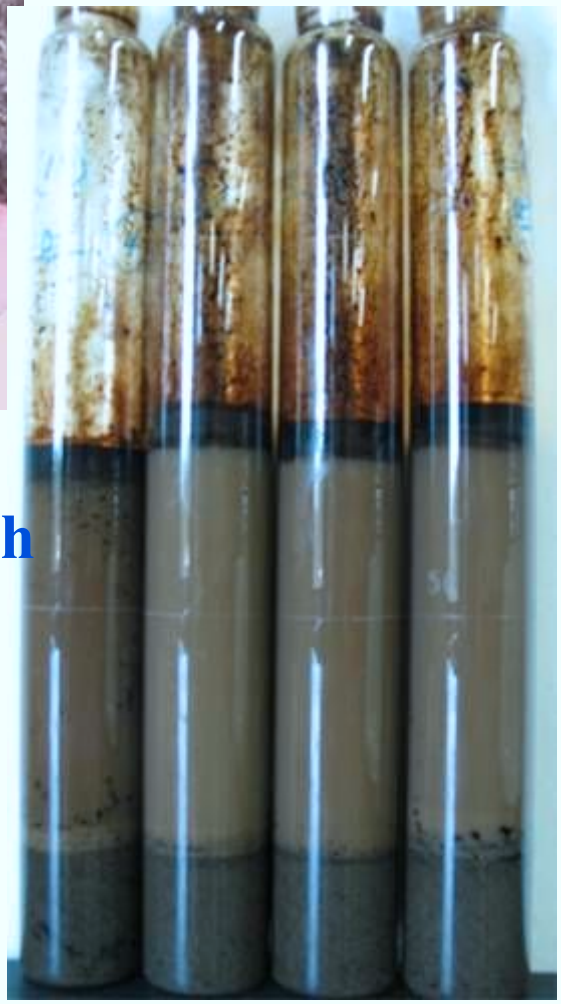
N-SOLV: With N-SOLV, the most advanced technology , 65-75% of the oil in oil sands can be recovered.

5.3、An important complement to conventional oil-gas resources

- **Oil-sand resources are rich in China where there are 3.302 billion tons of recoverable resources.**
- **340 million tons recoverable resources within the shallow surface of 100 m with the advantages of shallow burial, higher oil content and higher mining value, which provides resource assurance for oil-sand exploitation.**
- **The Junggar, Tarim, Qaidam, Songliao and Sichuan basin are key areas and further exploration target areas for oil sands .**



Tumuji deposit——hot chemical water wash（85 ℃）



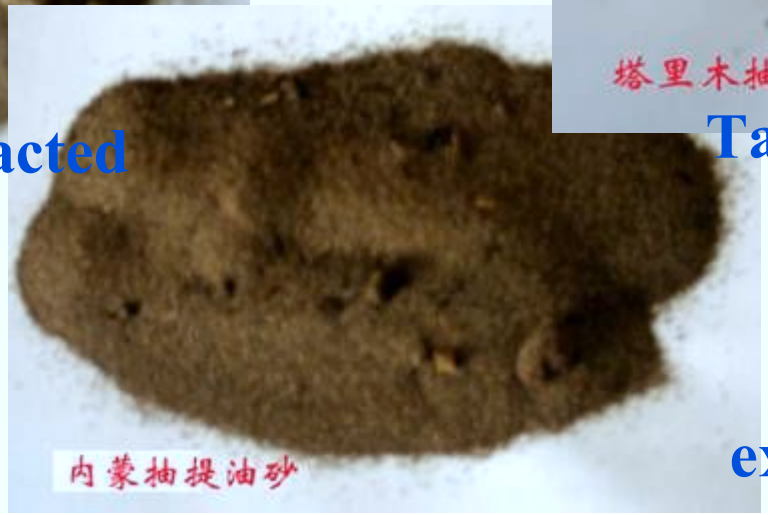
Inner Mongolia oil-sand oil

- ➢85 ℃ hot water wash
- ➢5%consistency of chemical Solvent
- ➢Time :half hour
- ➢Efficiency: 95%

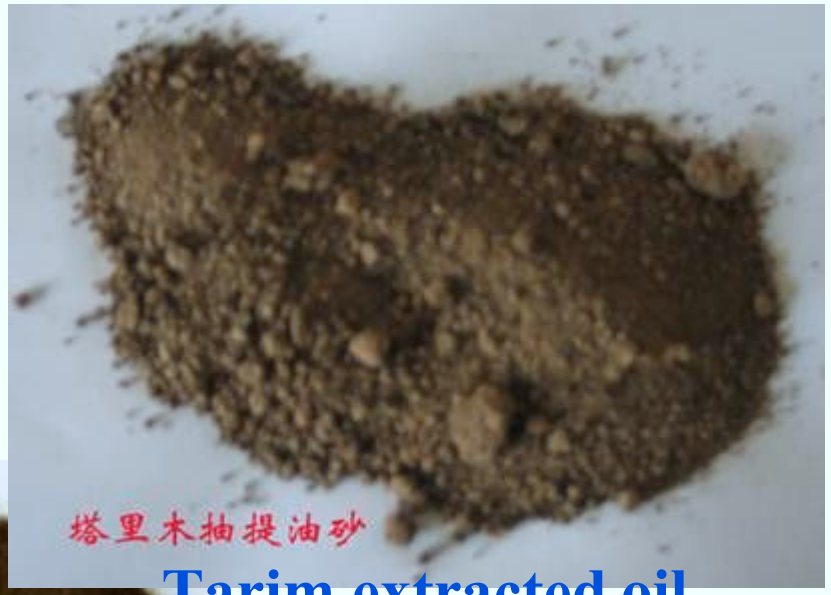
Organic solvent extraction

Agitation: **half hour, Efficiency: 95%**

Baijiantan extracted oil sands



Inner Mongolia extracted oil sands

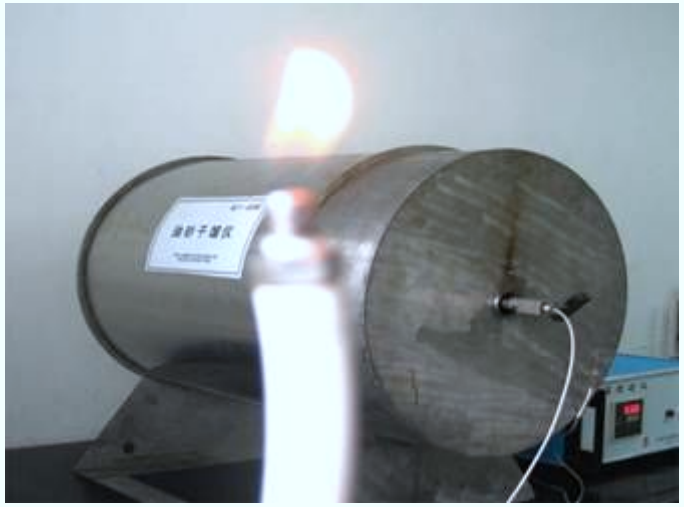


Tarim extracted oil sands

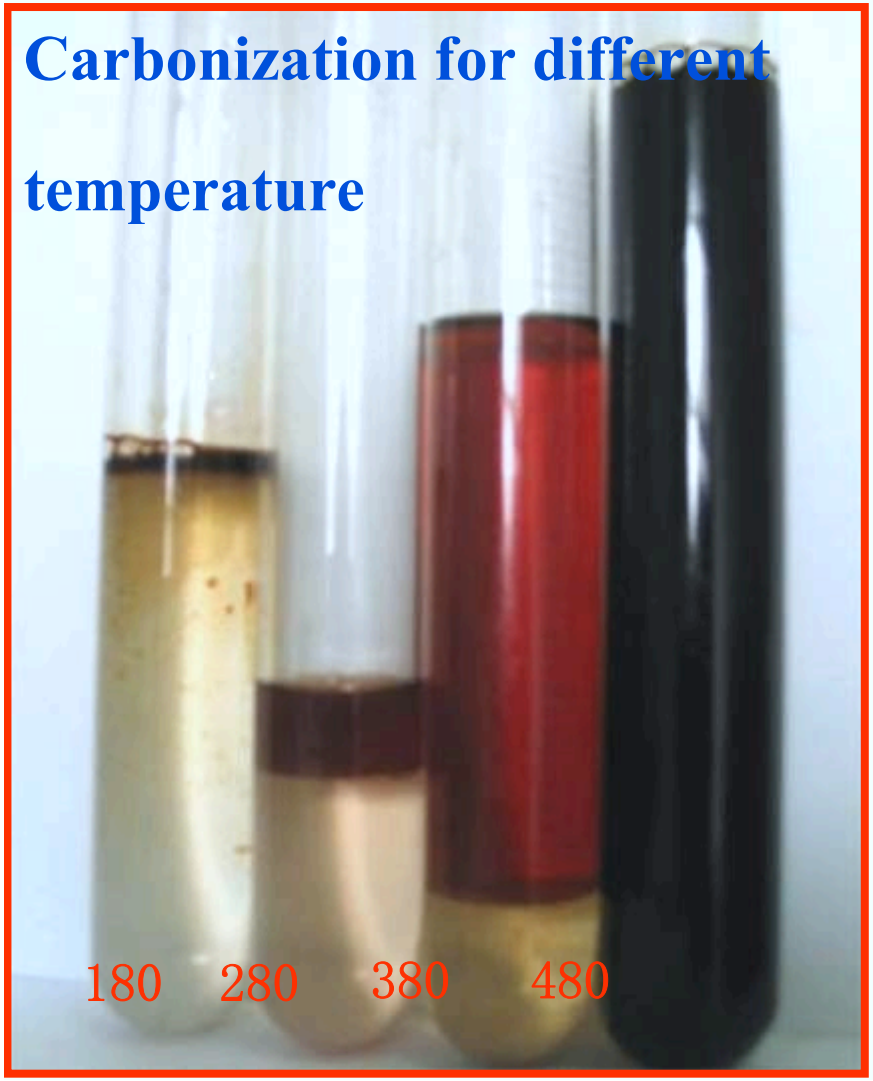
Xingjiang oil-sand deposits ——**dry distillation**

It is a fit for northwest China oil-sand deposits.

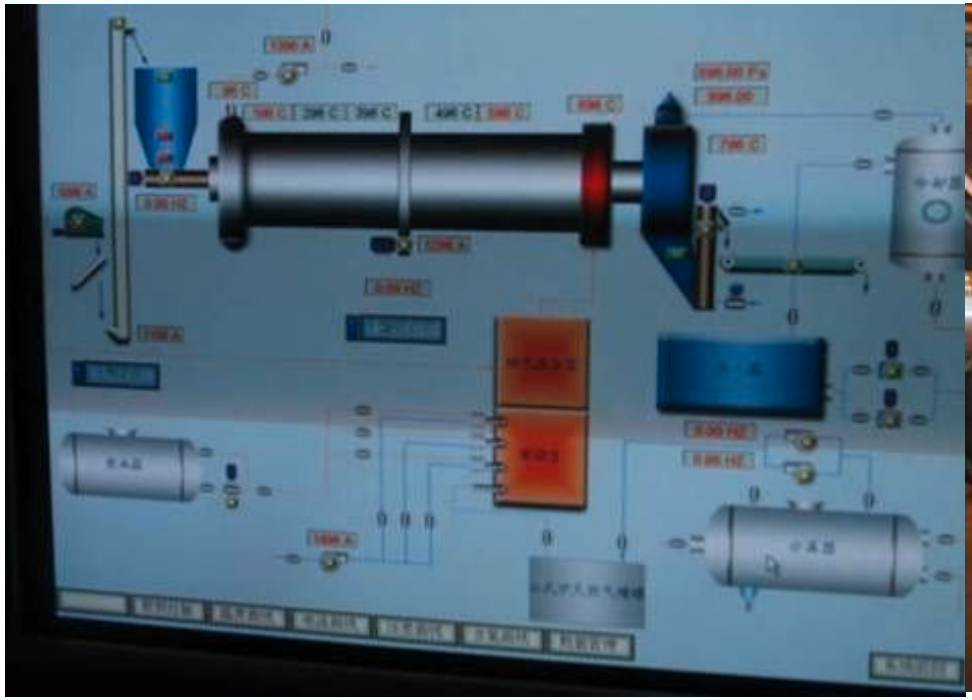
recovery efficiency: 70%



Carbonization for different temperature



Horizontal-stove dry distillation



Computer control system

horizontal stove

First **barrel oil by dry distillation,** Wuerhe, Xingjiang

First producing well , Zhenlai Oil Sands, in western slope of Songliao Basin


Thank you!