Oil and gas exploration fundamentals and a case example of the Qaidam Basin

Yanpeng Sun

Outline

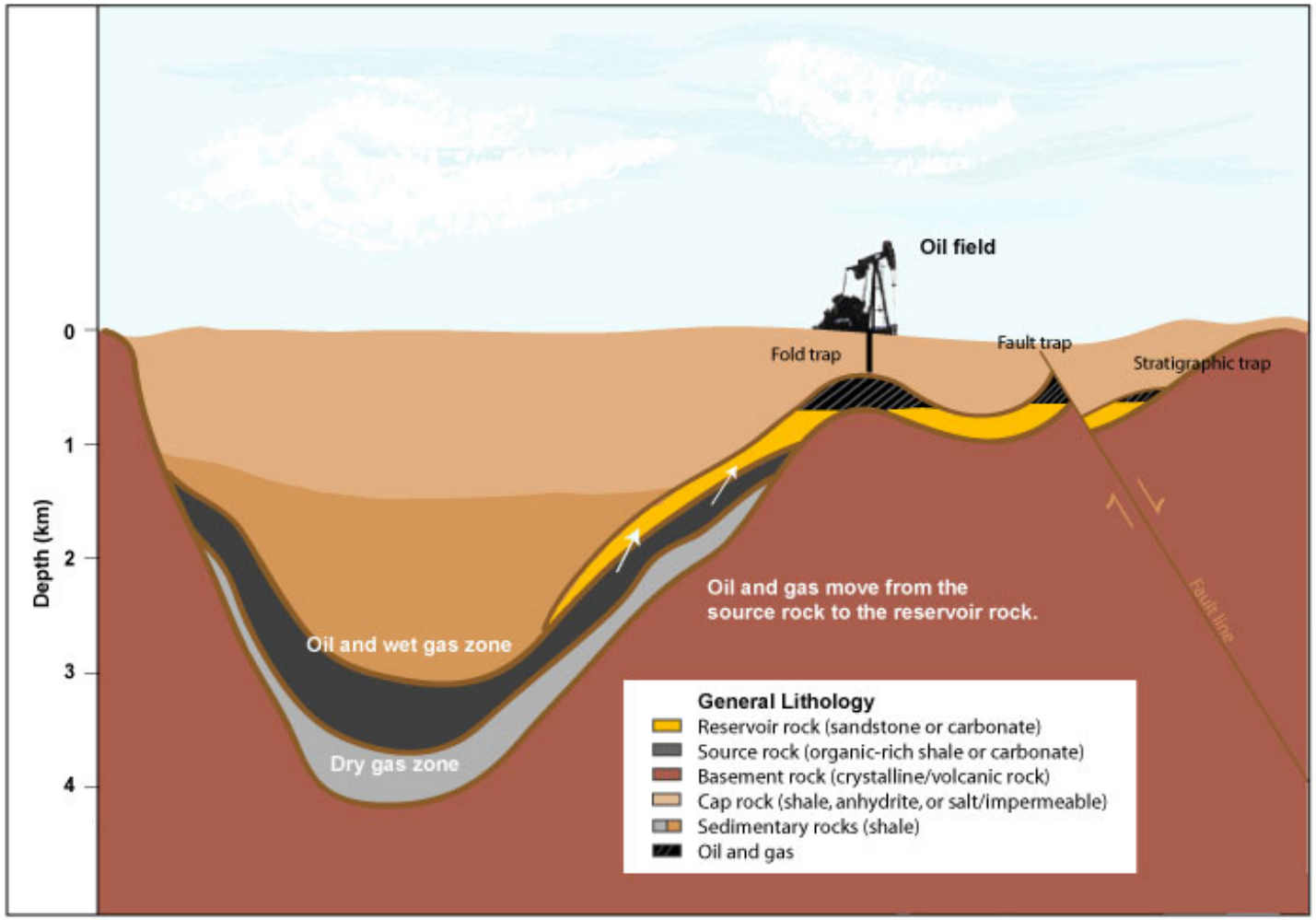
1 Petroleum system.

2 How we geologists find hydrocarbon.

3 Qaidam basin, an active oil and gas field.

4 Implications of our study for the industry and academic community.

Petroleum system elements (EPS 109 Lecture notes)



Source

- generation
- expulsion
- charge

Reservoir

Seal

Trap

Shaw and Holdren (2011)
Michelle Hardy

Hydrocarbon source

(EPS 109 Lecture notes)

Organic production

Environment	Area/10^6 km^2	Organic carbon/ 10^{16} t yr^{-1}
desert	68	0.2
grassland	26	0.65
forest	41	3.25
agricultural land	14	0.90
near-shore seas	2	0.40
continental shelf	84	2.325
open ocean	276	2.275

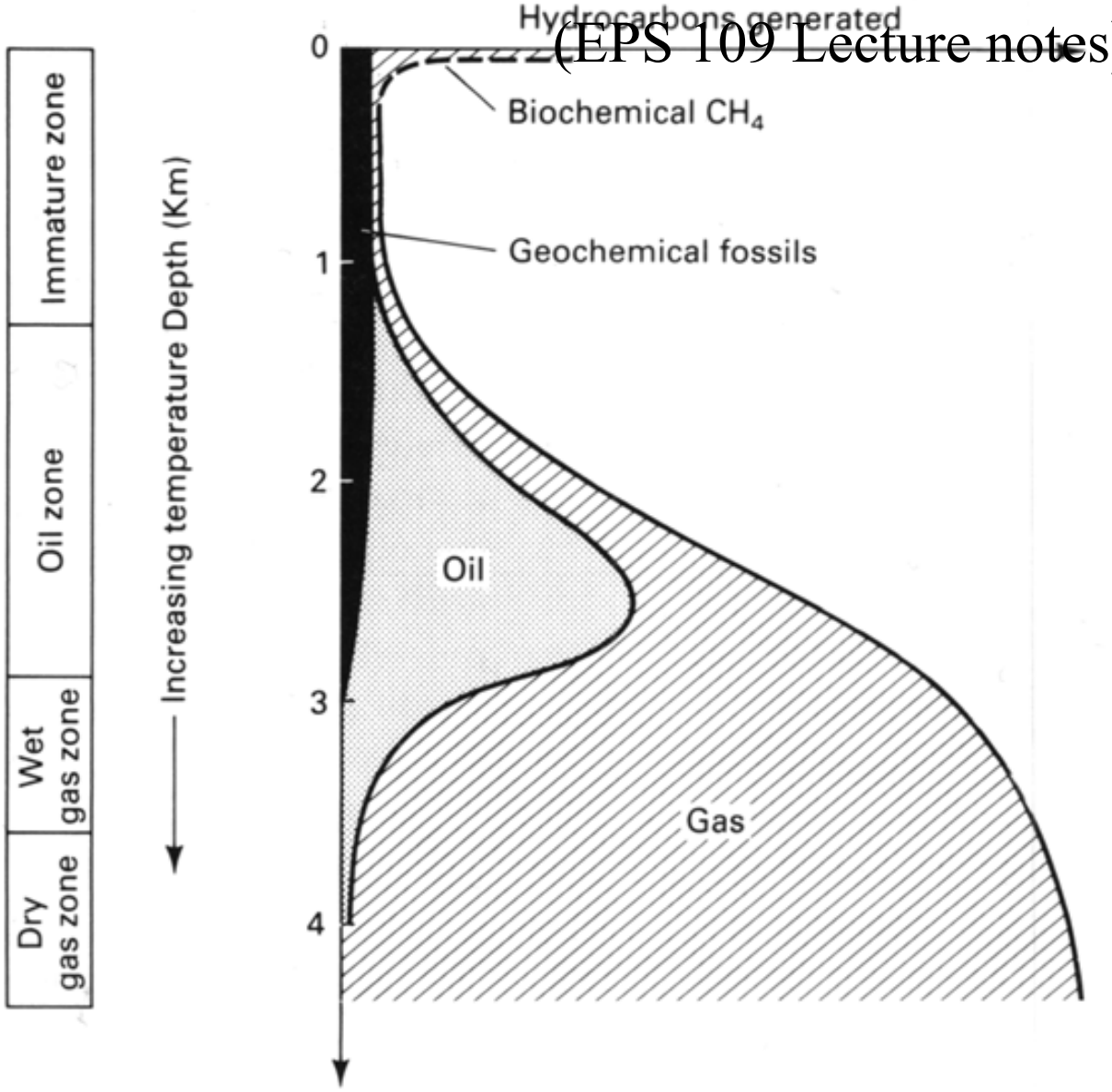
Brown and Skipsey, 1986

Highest marine organic production comes from the continental shelf due to the upwelling of nutrient rich waters.

Source rocks

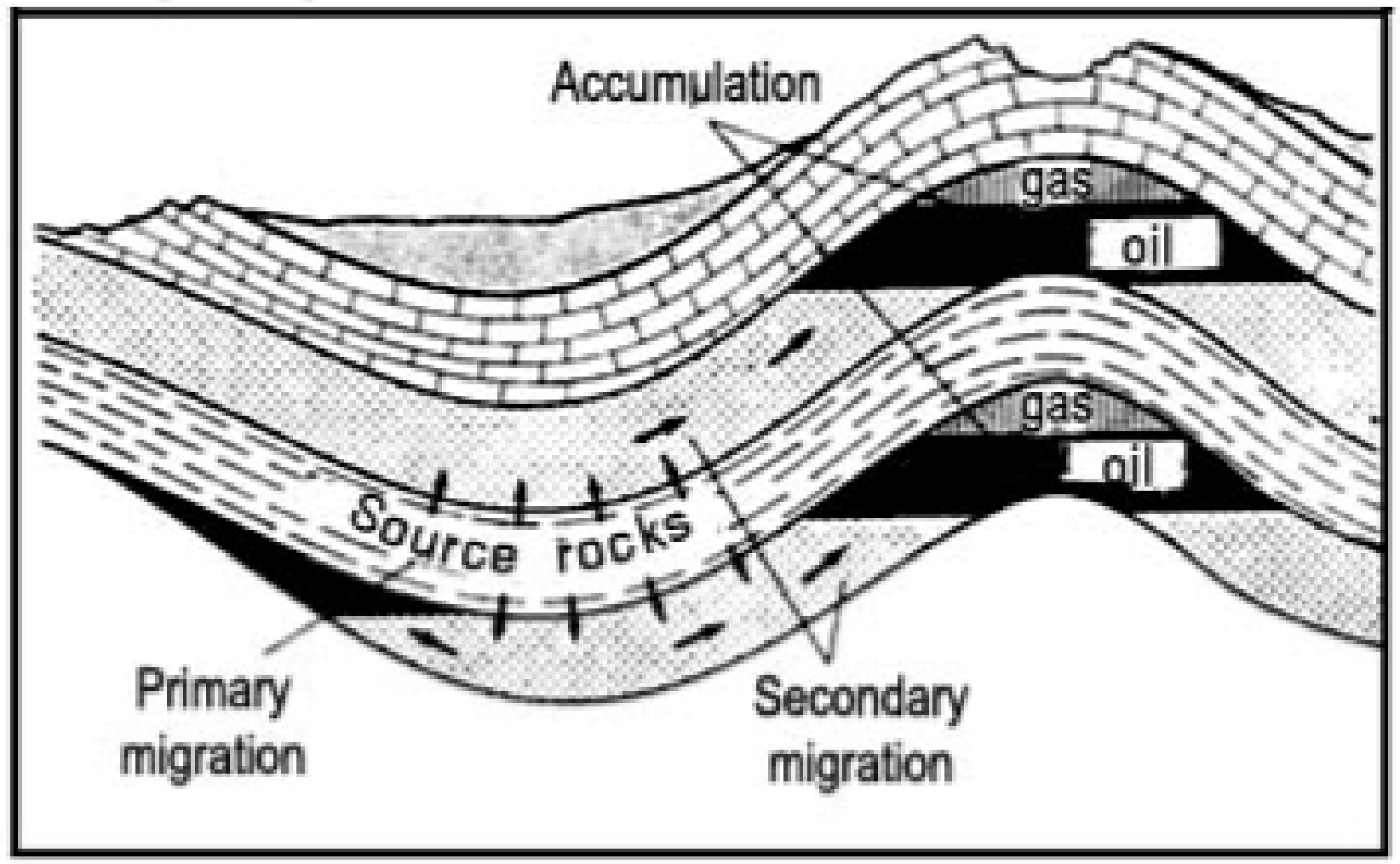
Thermal maturation & generation

(EPS 109 Lecture notes)

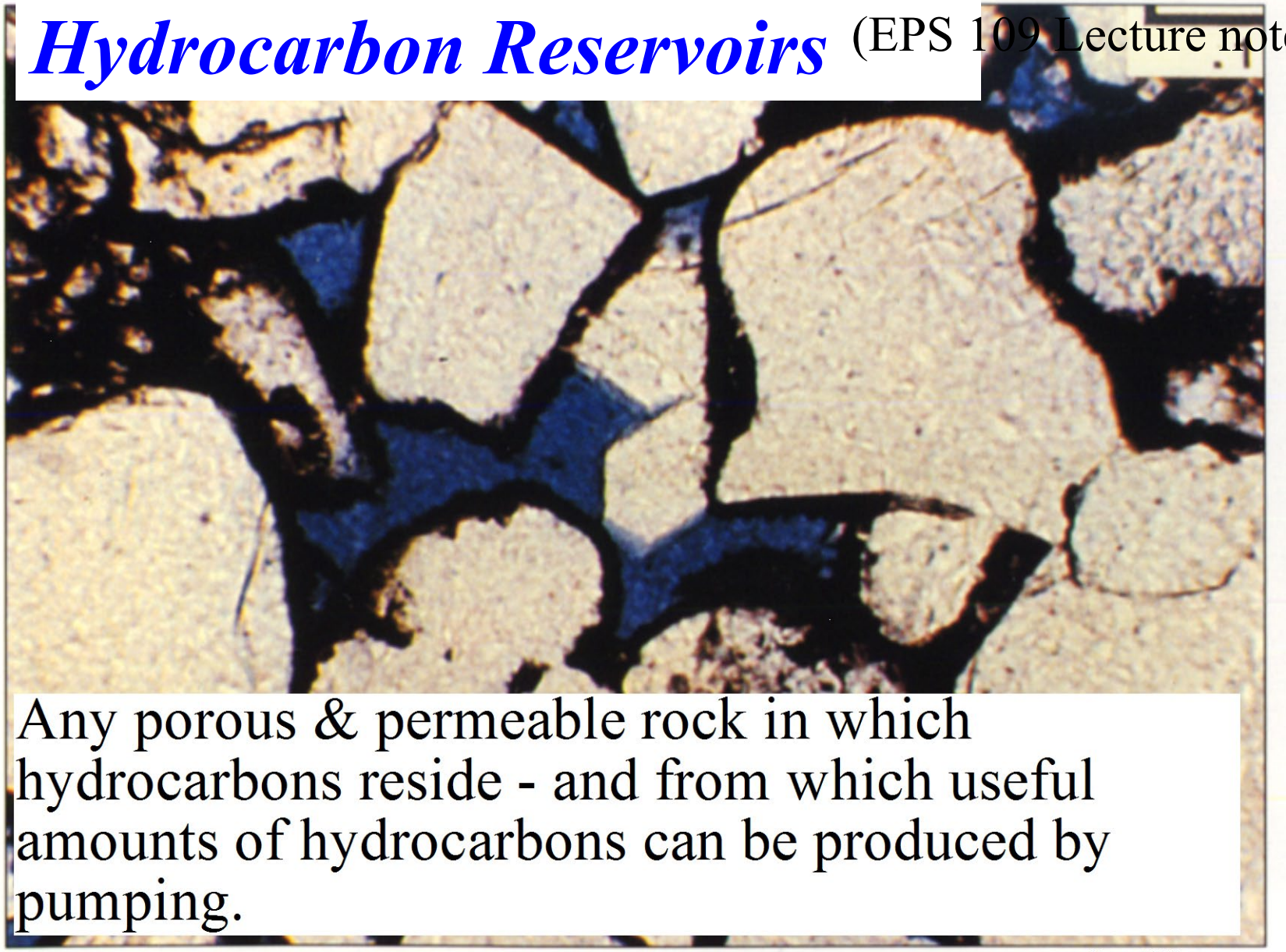


Craig, Vaughan, & Skinner (1996)

Migration


Accumulation
gas
oil
gas
oil
Source rocks
Primary migration
Secondary migration

Hydrocarbon Reservoirs (EPS 109 Lecture notes)



Any porous & permeable rock in which hydrocarbons reside - and from which useful amounts of hydrocarbons can be produced by pumping.

Hunt, 1995

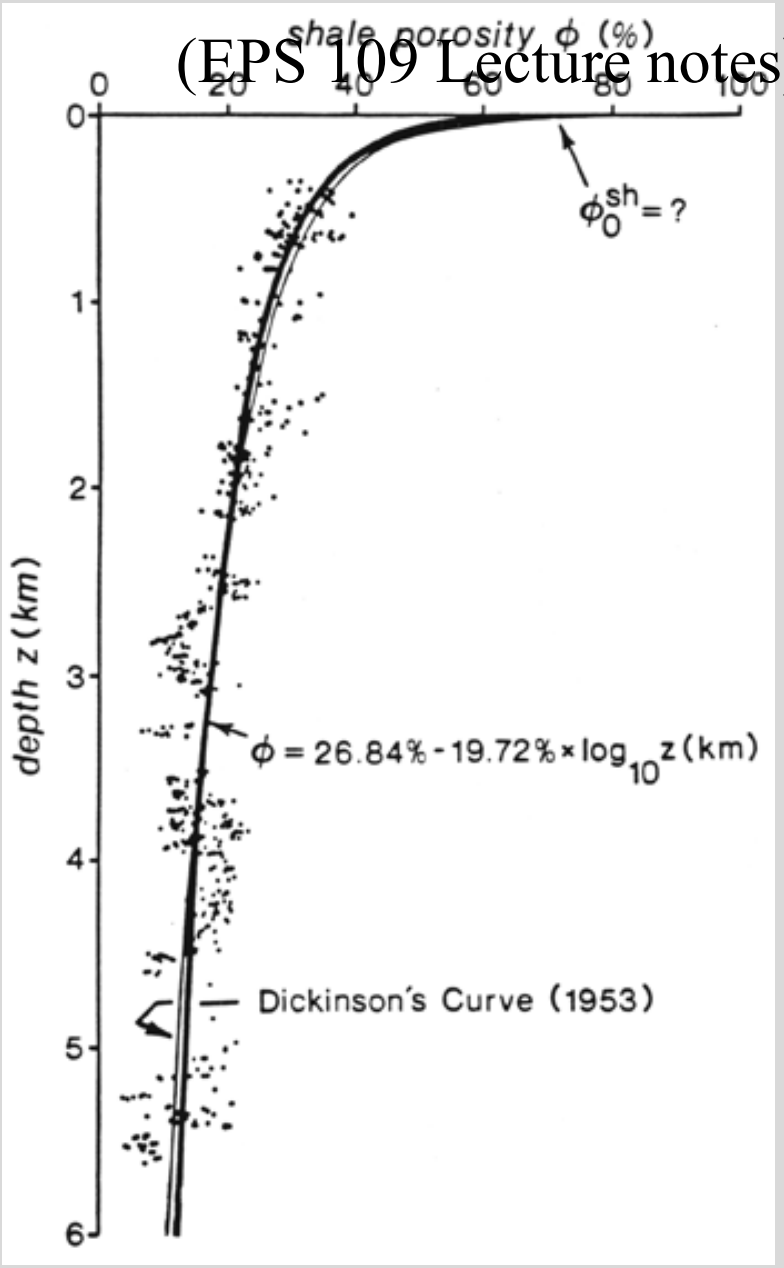
Hydrocarbon Seals

rocks with low permeability that impede the migration of hydrocarbons.

Conditions that favor the development of reservoirs prohibit the development of seals.

- generally shales or evaporites.
- fluid over-pressures reflect sealing capacity.
- fracturing can dramatically reduce sealing capacity - thus ductile materials such as salt often form good seals even in highly deformed terrains.

(EPS 109 Lecture notes)

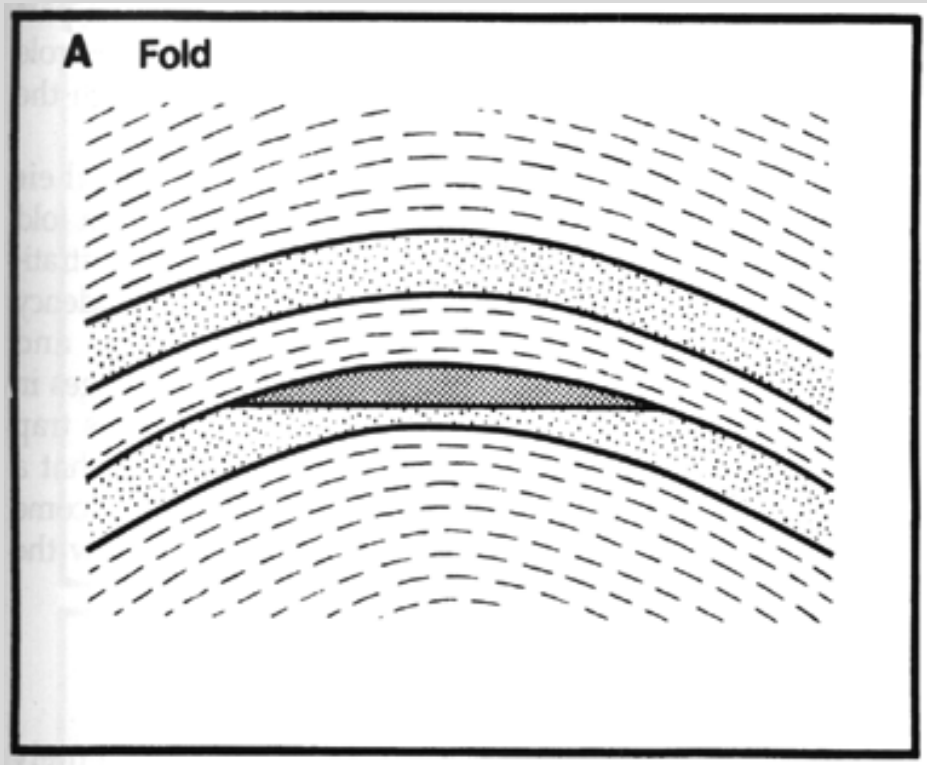


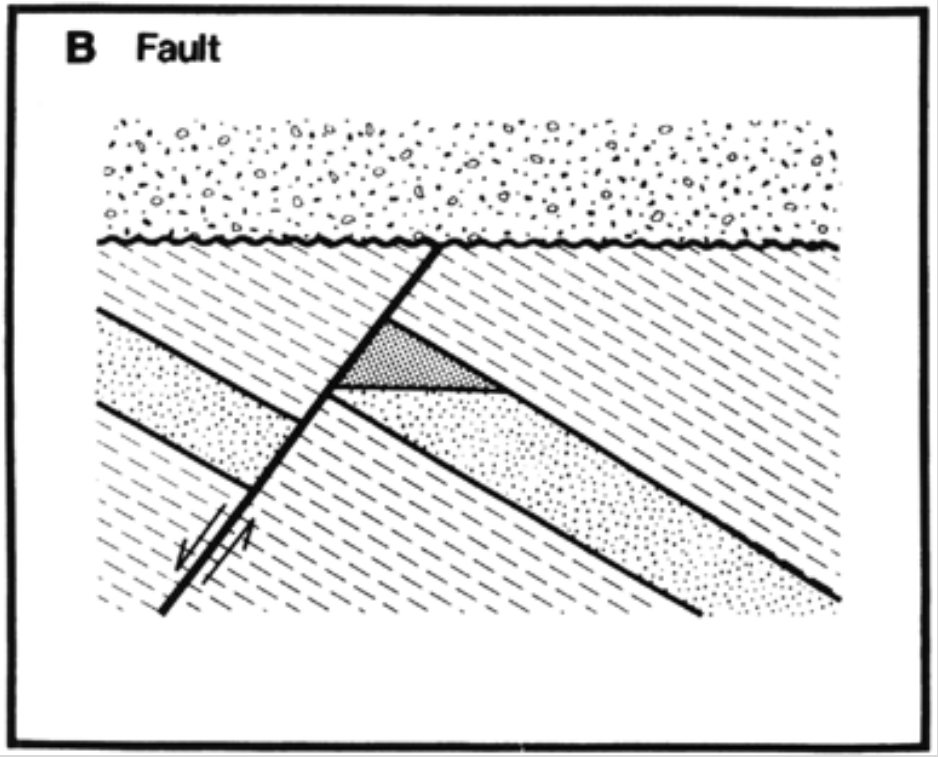
Hydrocarbon Traps

(EPS 109 Lecture notes)

A configuration of rocks which is able to confine hydrocarbons.

Structural Traps

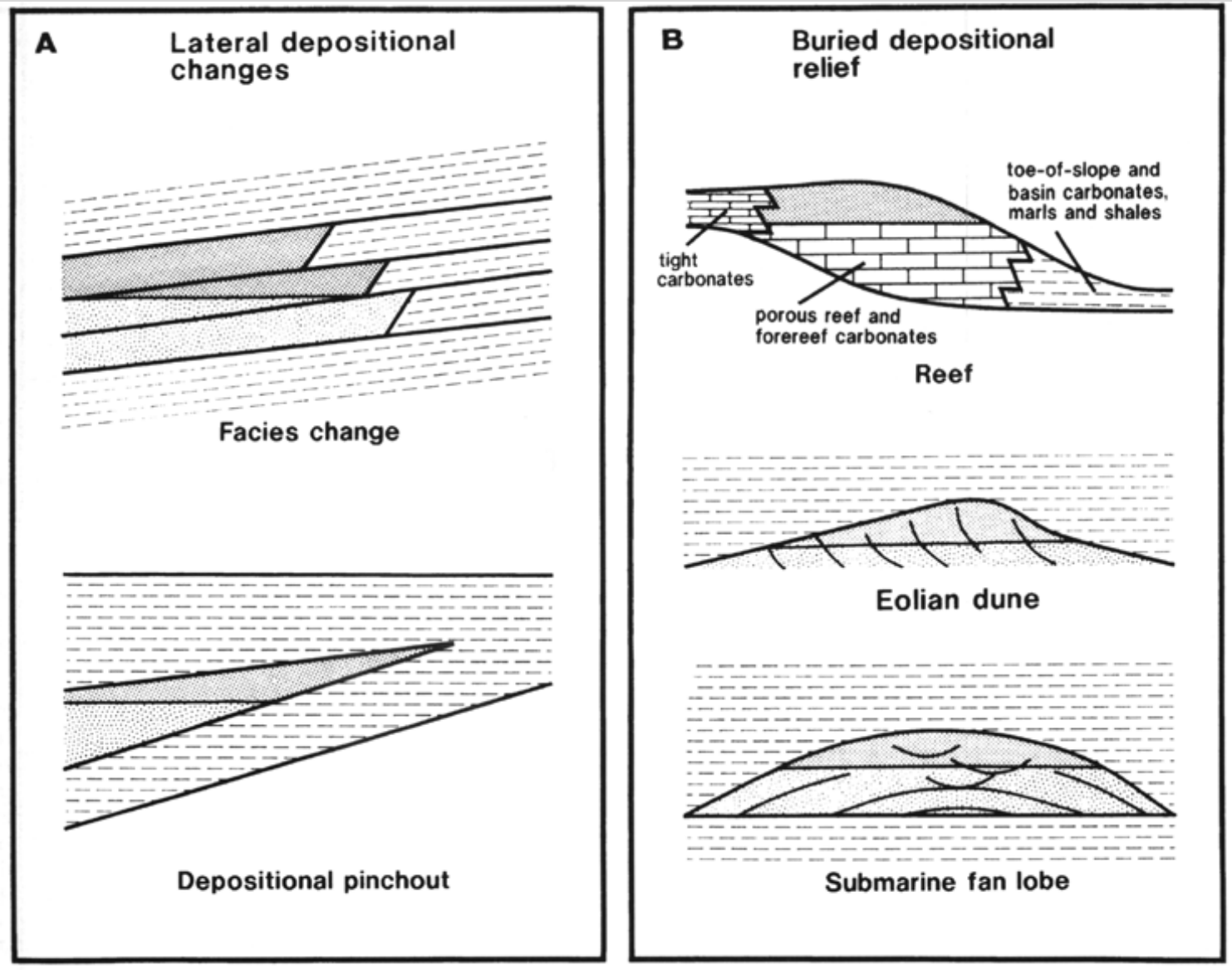




Biddle, 1984

Stratigraphic traps

(EPS 109 Lecture notes)



Biddle, 1984

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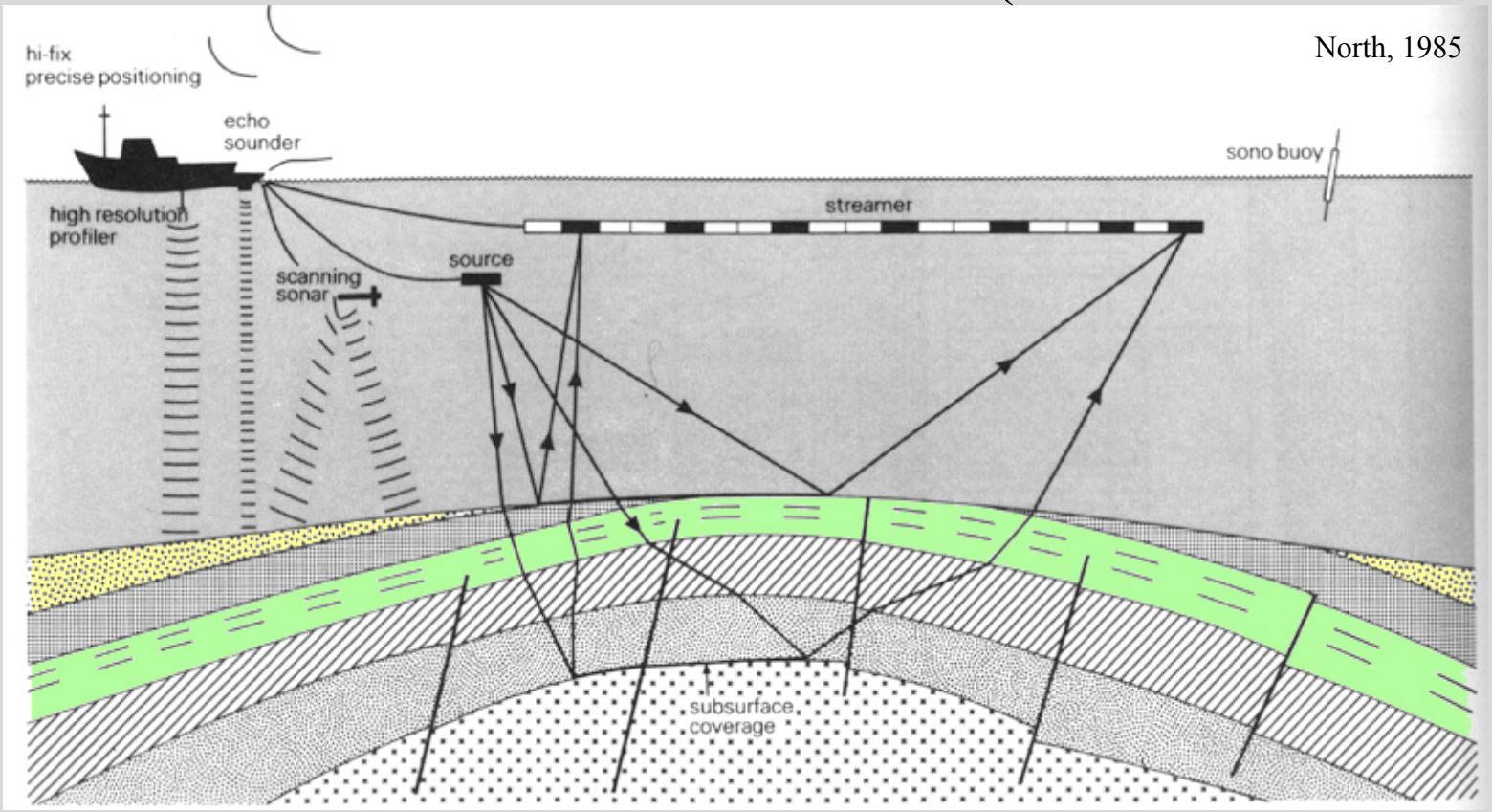
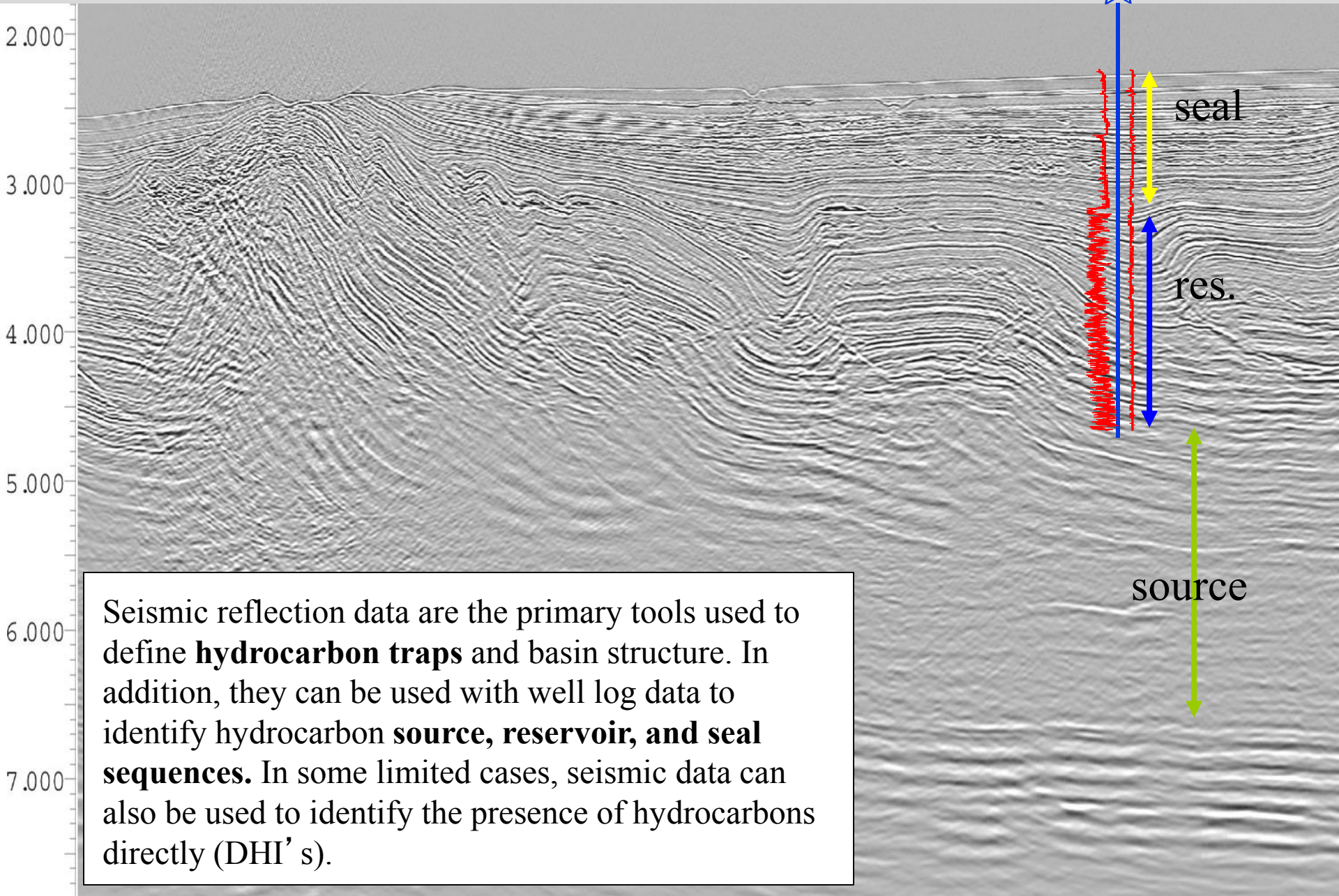
Geophysical imaging techniques (EPS 109 Lecture notes)



• Seismic reflection data are 2- and 3-D representations of subsurface geology, generated by recording how sound waves generated by a source interact with different rock types and geologic structures (e.g., faults) in the subsurface and are reflected back to the surface, where they are recorded by receivers.

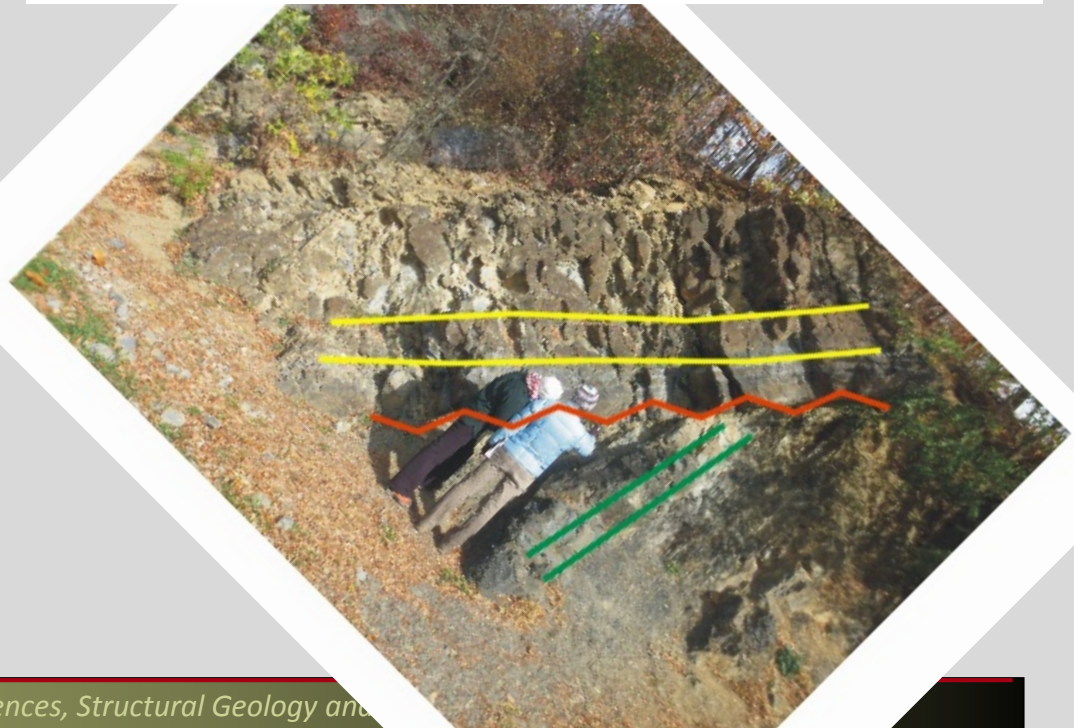
Seismic prospecting

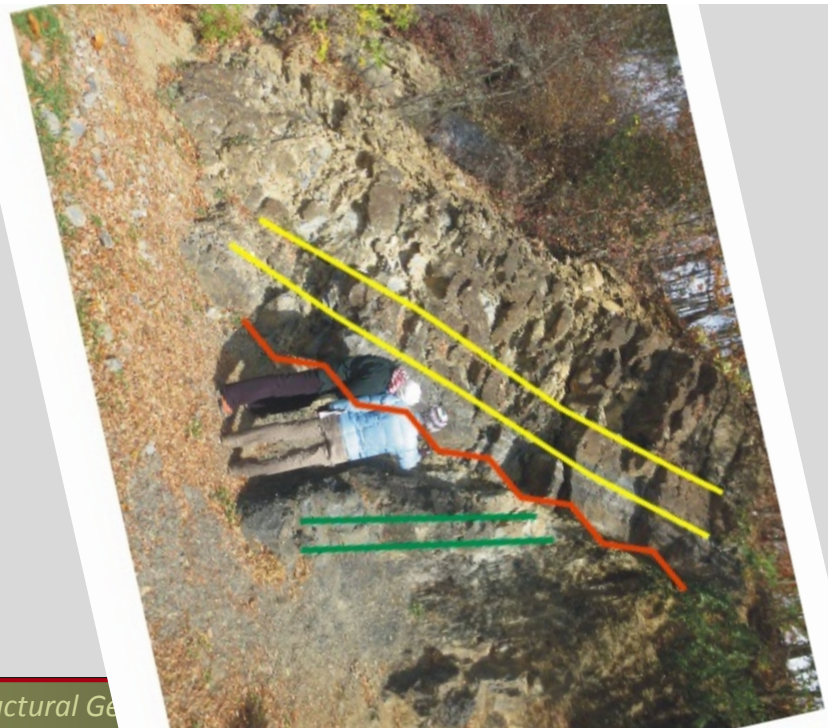
(EPS 109 Lecture notes)



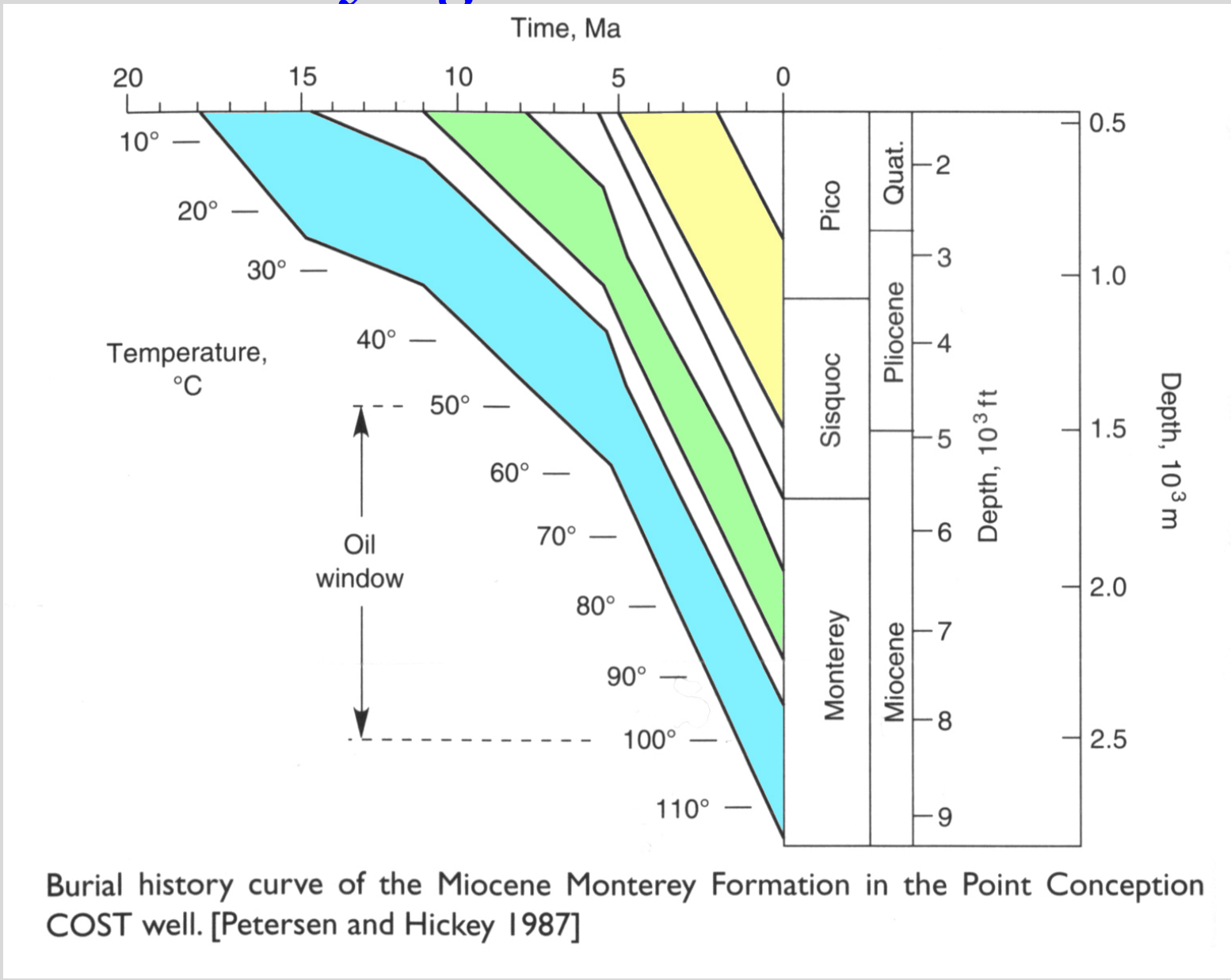
Seismic reflection data are the primary tools used to define **hydrocarbon traps** and basin structure. In addition, they can be used with well log data to identify hydrocarbon **source, reservoir, and seal sequences.** In some limited cases, seismic data can also be used to identify the presence of hydrocarbons directly (DHI's).

Field study to understand the geologic history





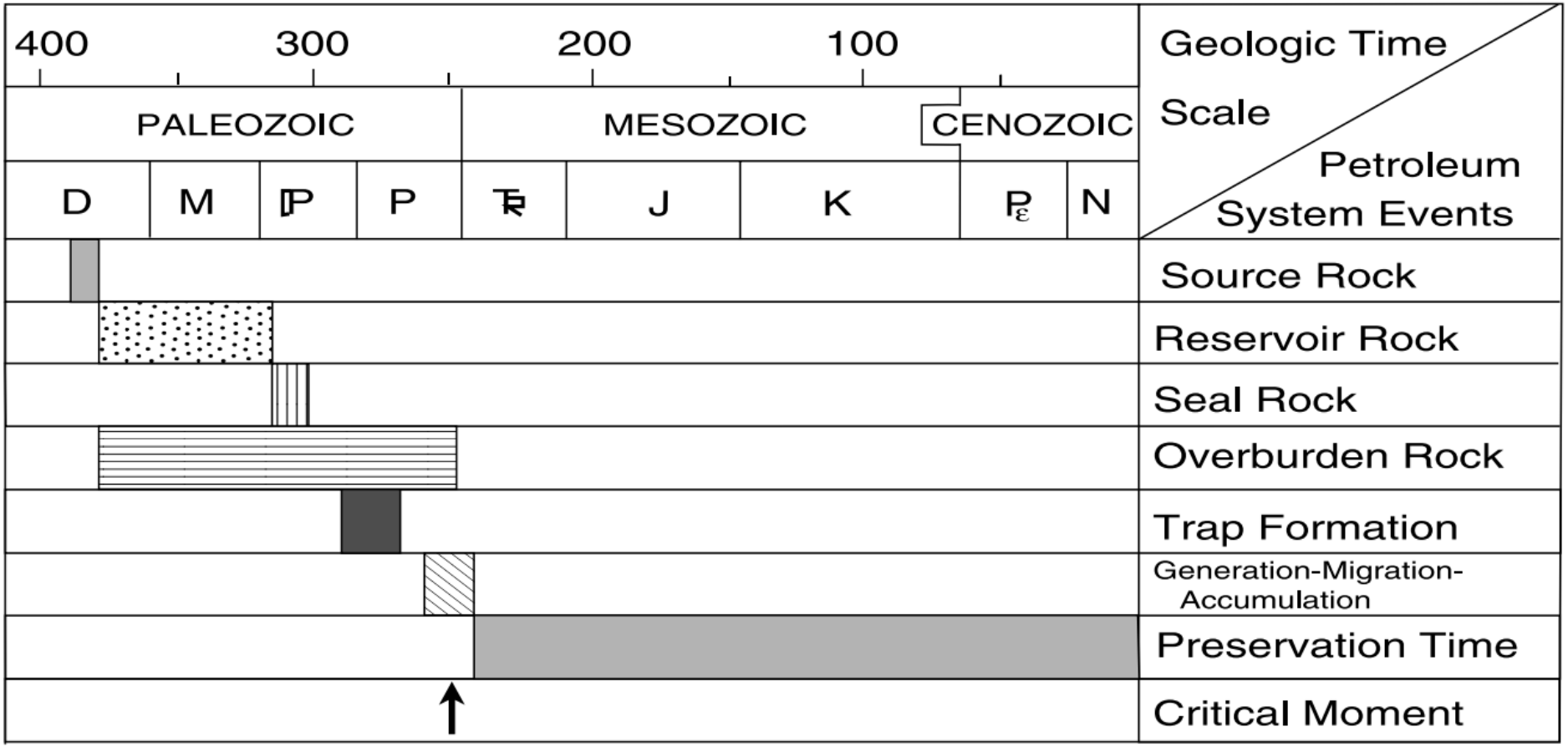
Burial history - generation curves



Burial history curve of the Miocene Monterey Formation in the Point Conception COST well. [Petersen and Hickey 1987]

Hunt, 1995

Event chart



From Magoon and Dow, 1994; courtesy AAPG.

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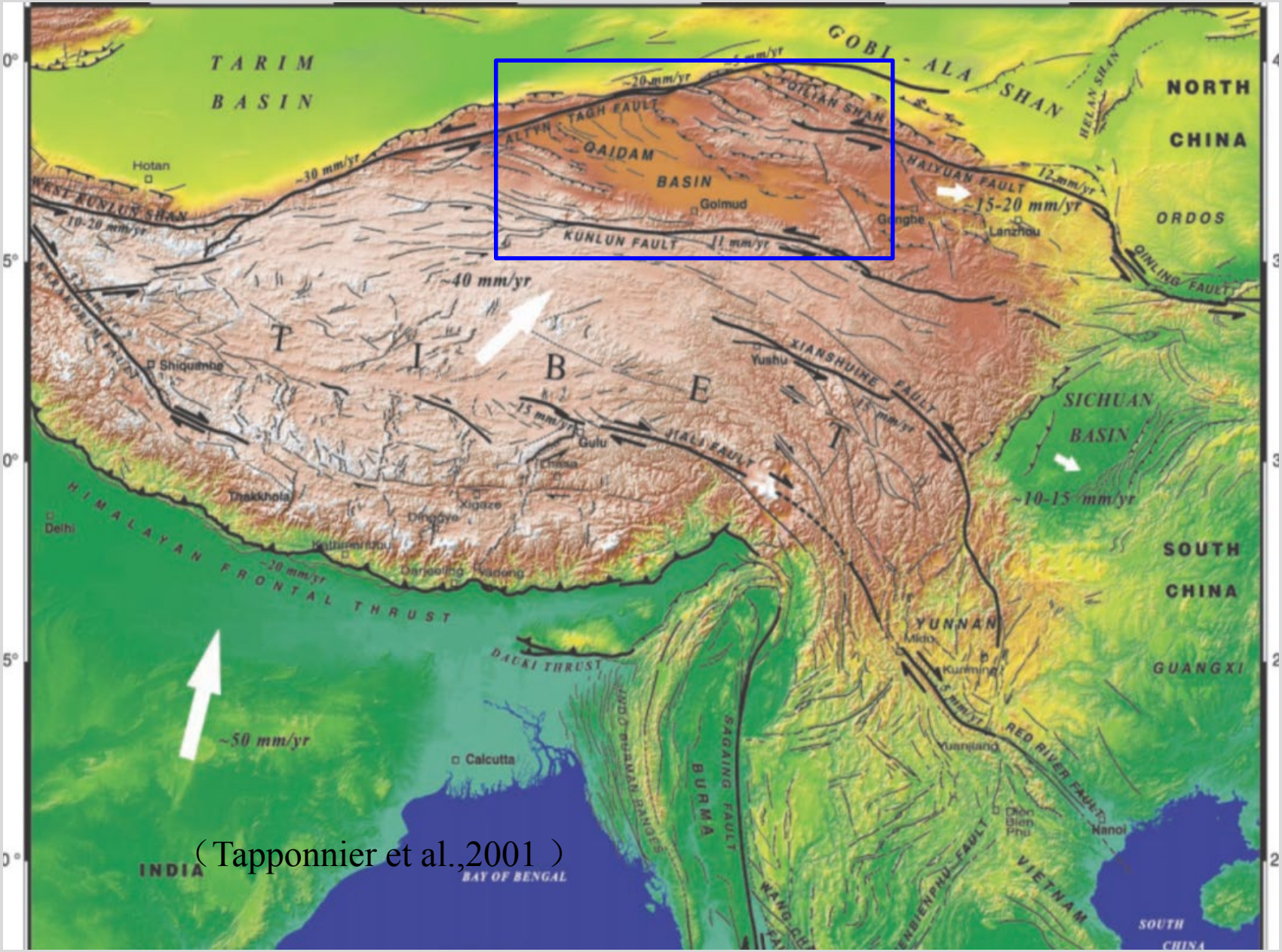
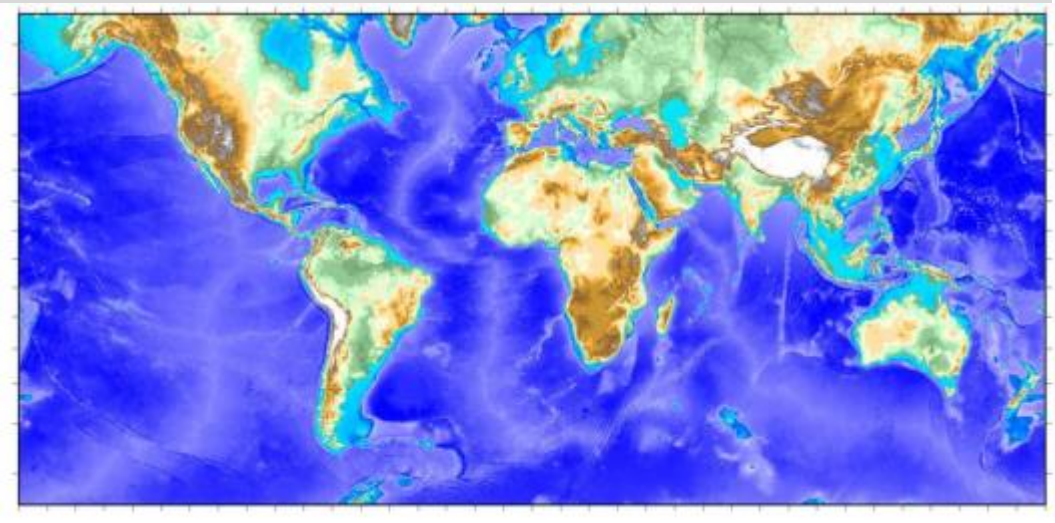
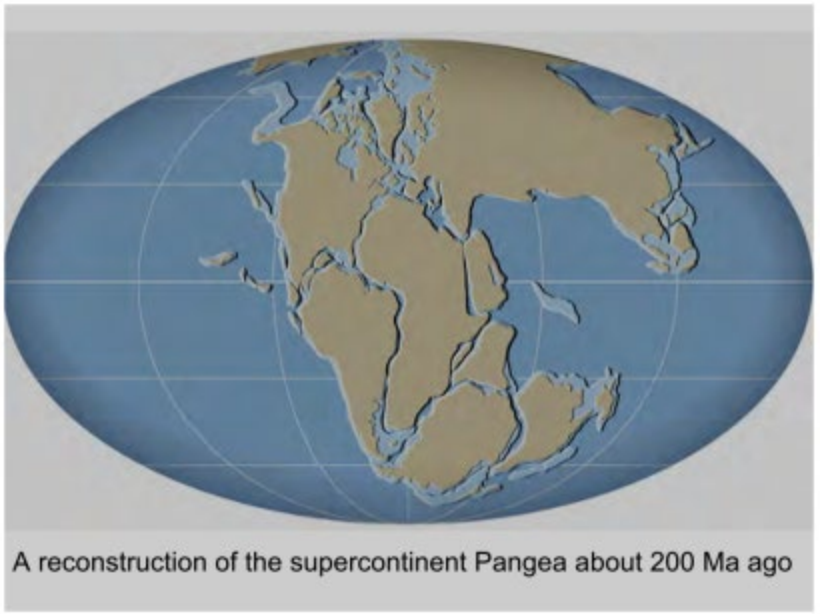


（Tapponnier et al.,2001）

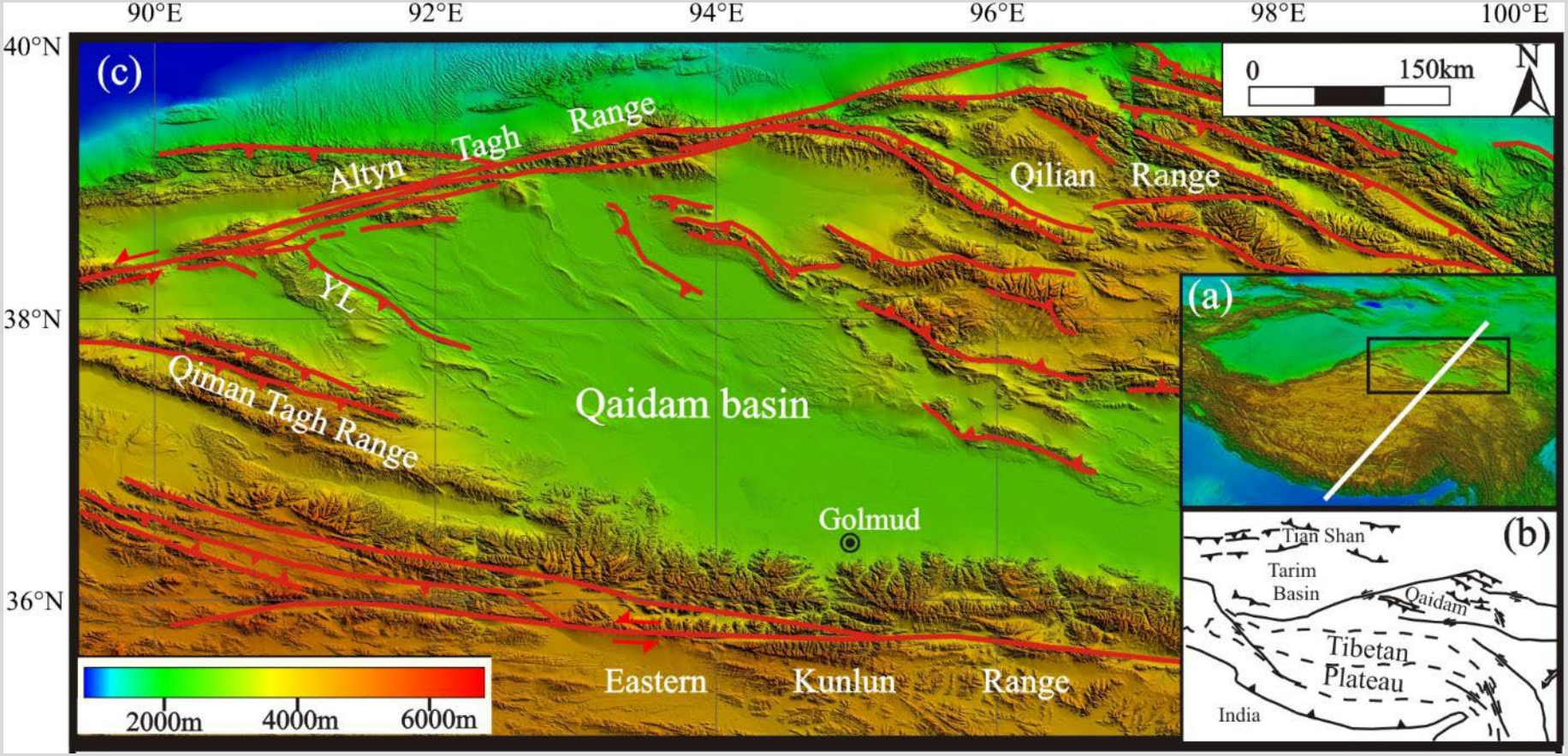
Continental drift (plate tectonics)

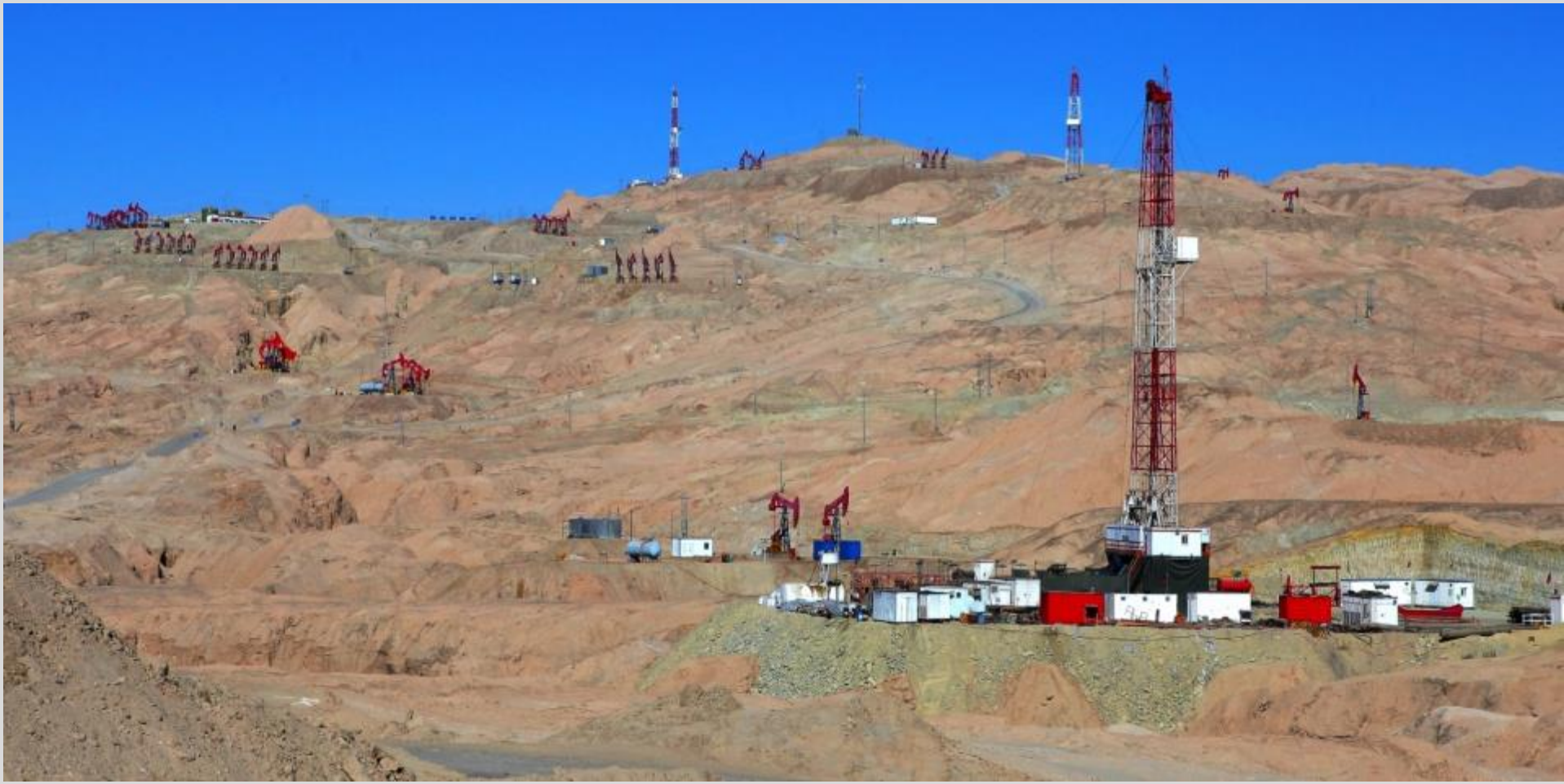




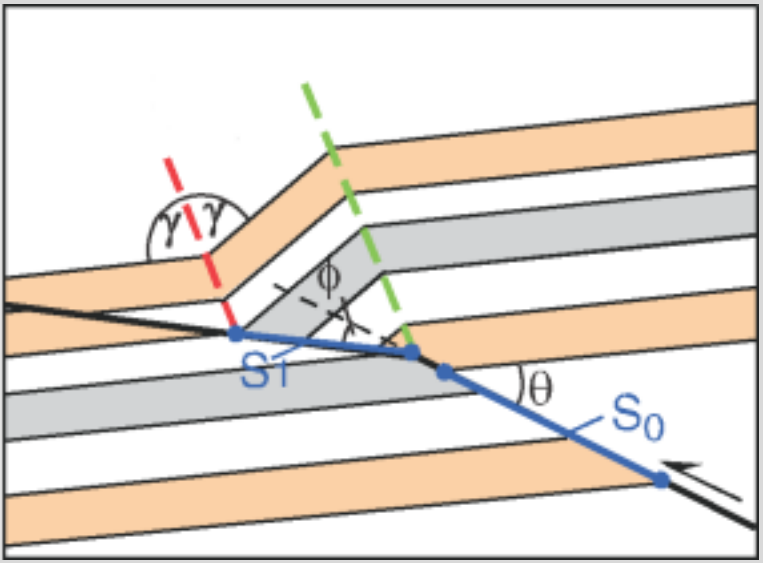
A reconstruction of the supercontinent Pangea about 200 Ma ago

Geology of the Qaidam basin





Quantitative fault related folding relationships



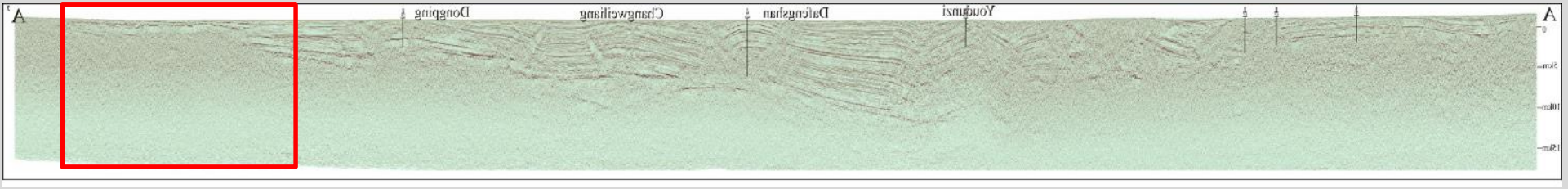
$$\phi = \tan^{-1}\left\{\frac{-\sin(\gamma-\theta)\,[\sin(2\gamma-\theta)-\sin\theta]}{\cos(\gamma-\theta)\,[\sin(2\gamma-\theta)-\sin\theta]-\sin\gamma}\right\}$$

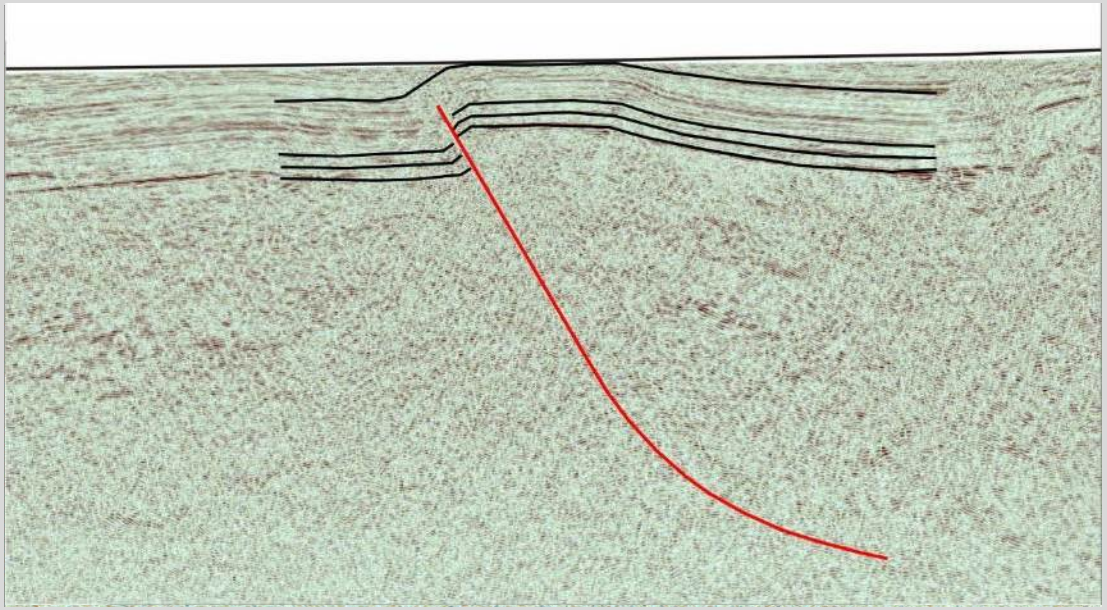
$$\beta = \theta - \phi + (180 - 2\gamma)$$

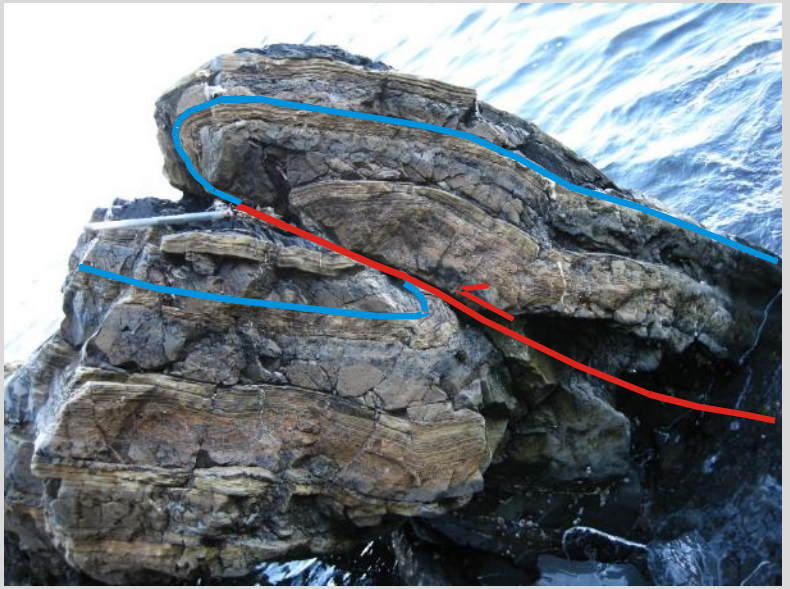
$$R = \frac{S1}{S0} = \frac{\sin(\gamma-\theta)}{\sin(\phi+\gamma-\theta)}$$

(Suppe, 1983)

Various types of structures in Qaidam basin







（Newfoundland, Canada）

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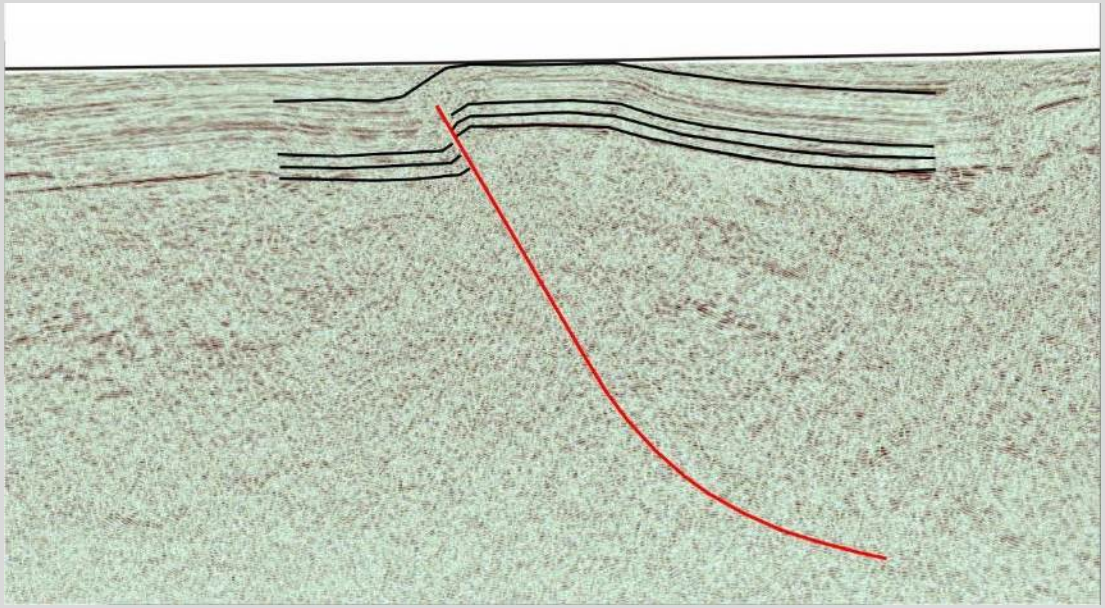
Implications of our study for oil and gas exploration:

1 Better understanding of regional and basin deformation style and timing;

2 Characterization of deeper structural traps;

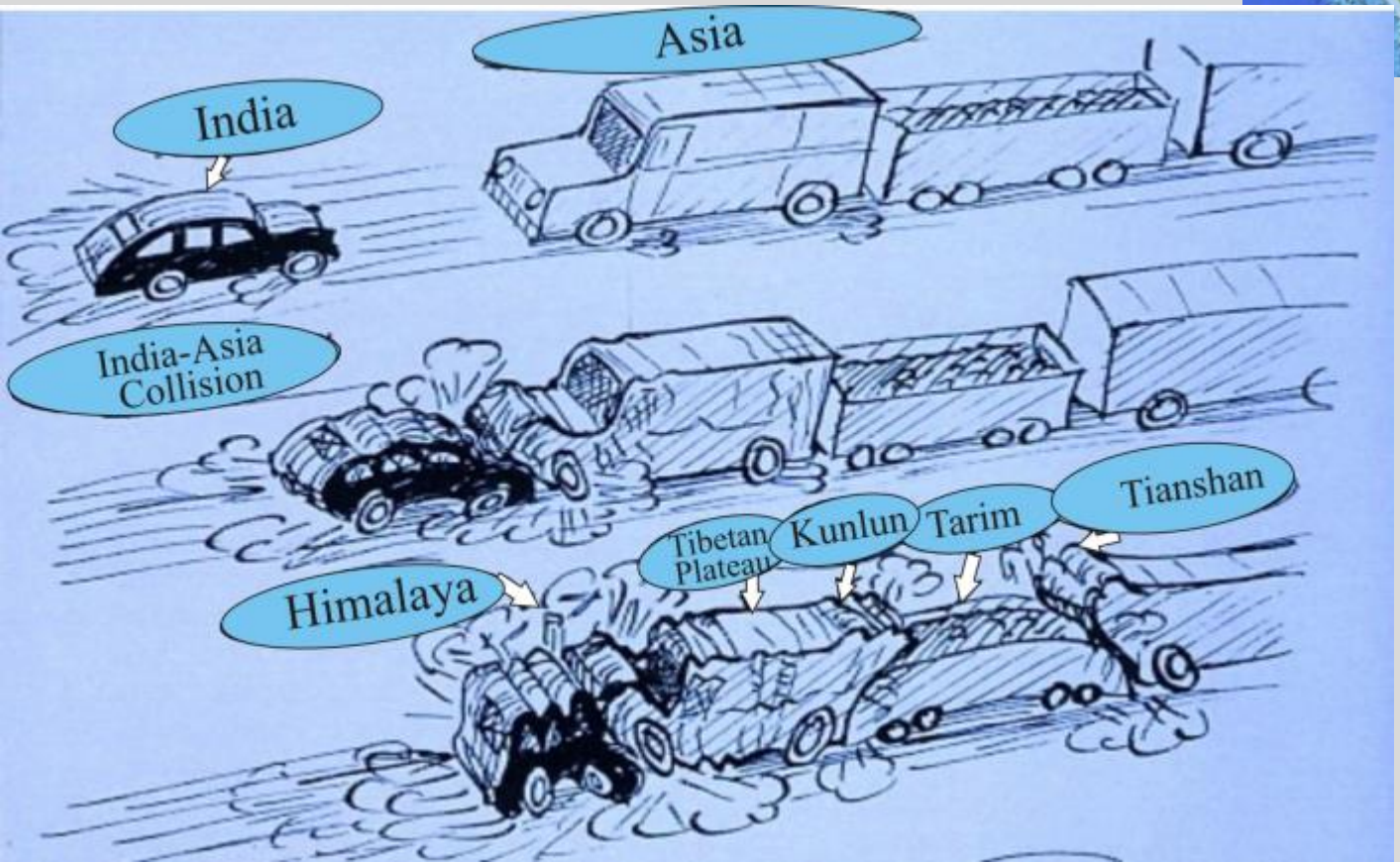
3 Identifying possible migration pathway for lower hydrocarbon sources.



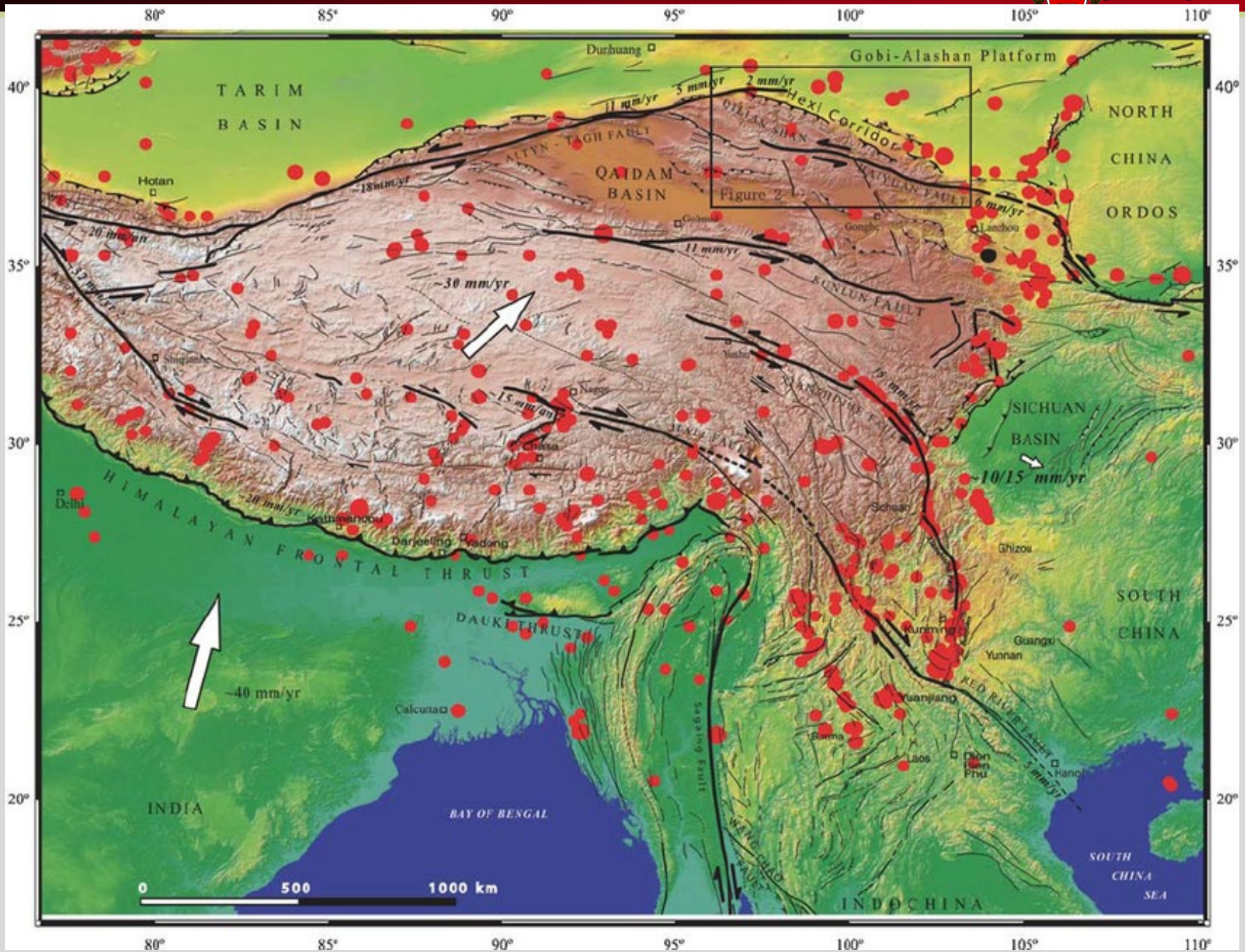
Implications of our study for the broader academic community:

Better characterization of earth history and geologic events.

Understand the seismic hazards.



(Modified after Xu et al., 2011)


80°
85°
90°
95°
100°
105°
110°
40°
35°
30°
25°
20°
TARIM BASIN
QAIDAM BASIN
Gobi-Alashan Platform
Hexi Corridor
Figure 2
NORTH CHINA
ORDOS
SICHUAN BASIN
SOUTH CHINA
INDIA
INDOCHINA
BAY OF BENGAL
SOUTH CHINA SEA
HIMALAYAN FRONTAL THRUST
DAUKI THRUST
ALTYN - TAGH FAULT
KUNLUN FAULT
XIANSHUIHE FAULT
XIANNAN FAULT
RED RIVER FAULT
WANG CHAO FAULT
Sagaing Fault
~30 mm/yr
~40 mm/yr
~10/15 mm/yr
11 mm/yr
5 mm/yr
2 mm/yr
~18mm/yr
20 mm/yr
32 mm/yr
15 mm/yr
20 mm/yr
6 mm/yr
5 mm/yr
Durhuang
Hotan
Golmud
Gonghe
Lanzhou
Yushu
Nagqu
Shiquanhe
Lhasa
Delhi
Kathmandu
Darjeeling
Yadong
Calcutta
Sichuan
Guizhou
Kunming
Guangxi
Yunnan
Yuanjiang
Burma
Laos
Dien Bien Phu
Hanoi
0
500
1000 km

(Xu et al., 2010)

Thank you!