



Mechanism and mitigation of earth fissure in China

Chang'an University Jianbing Peng

e-mail:dicexy_1@chd.edu.cn

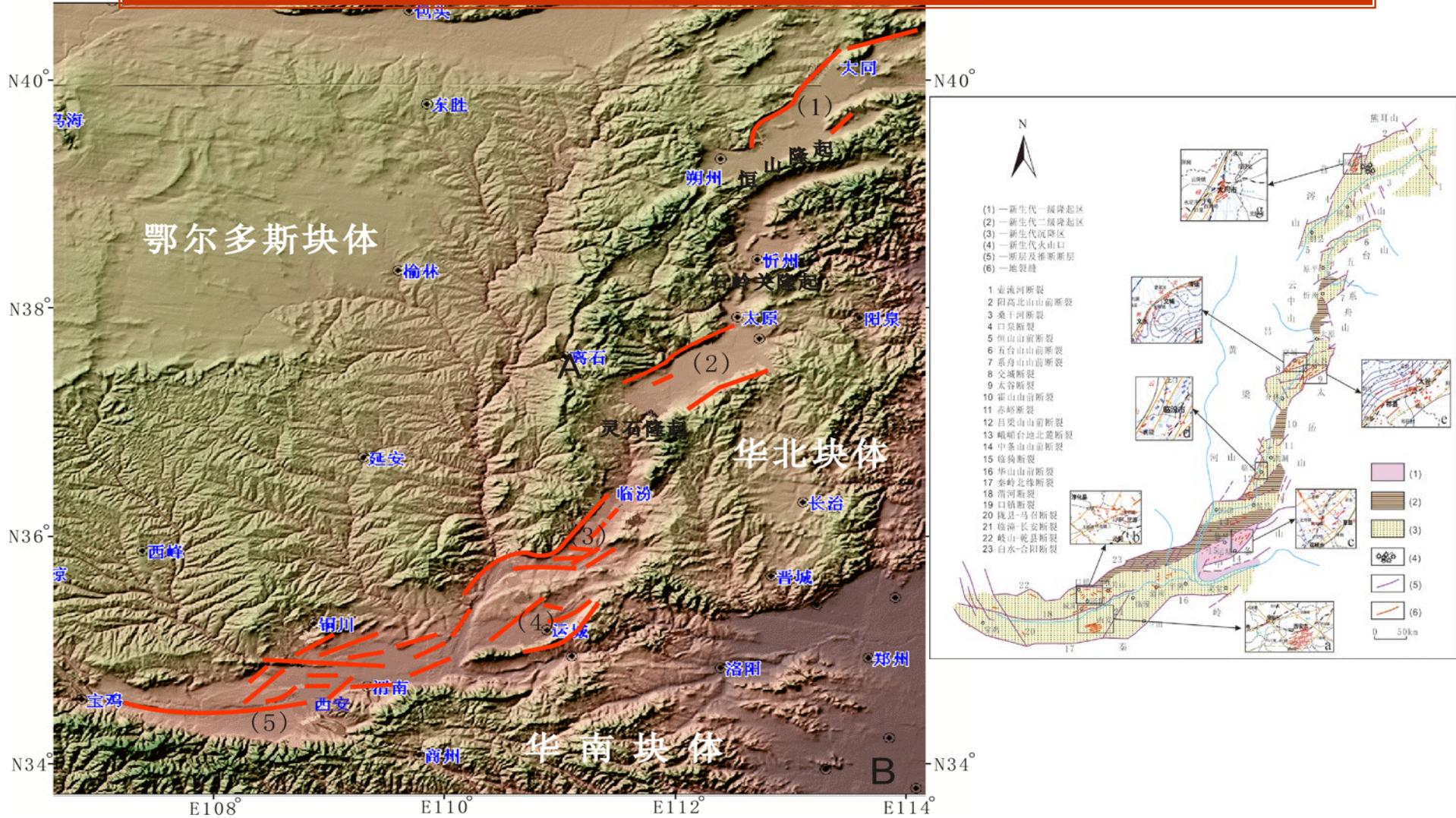
April. 2017

Main achievement

4. The mechanism of earth fissure is analyzed by physical and numerical simulation.

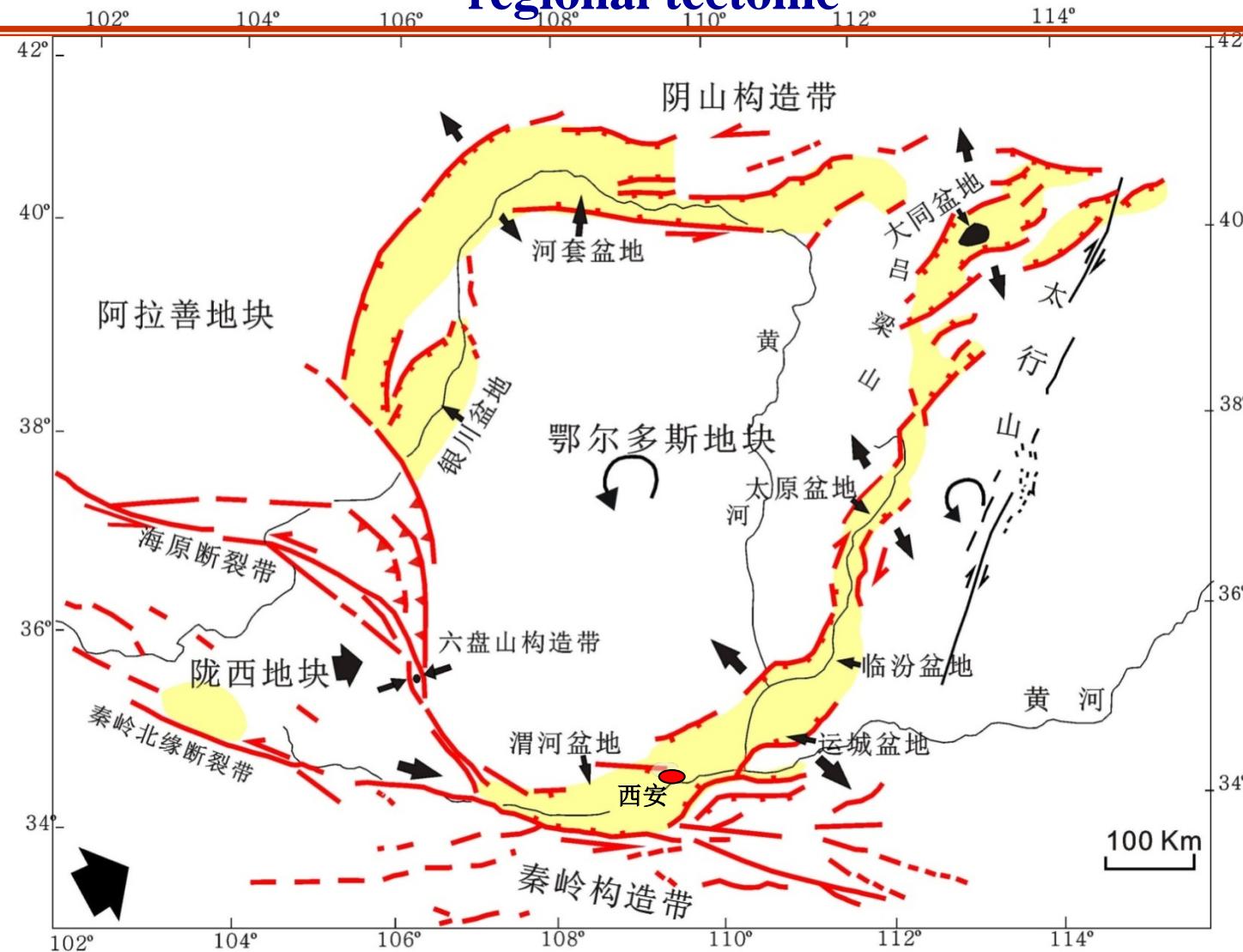
Main achievement

Continental dynamics—Mass-developed mechanism of earth fissures in several basins was explained



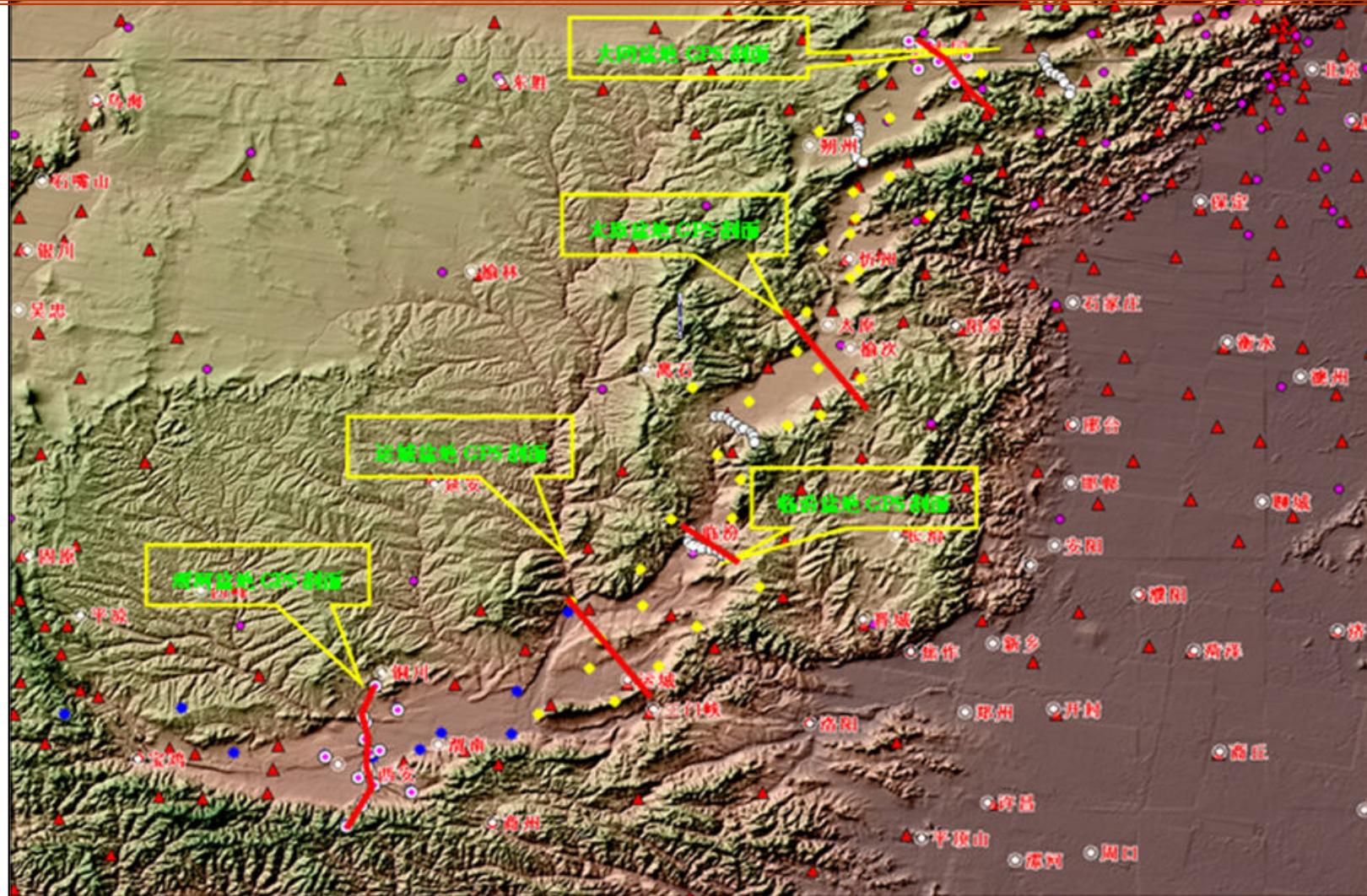
Main achievement

The relationship between earth fissures in Fenwei Basin and regional tectonic



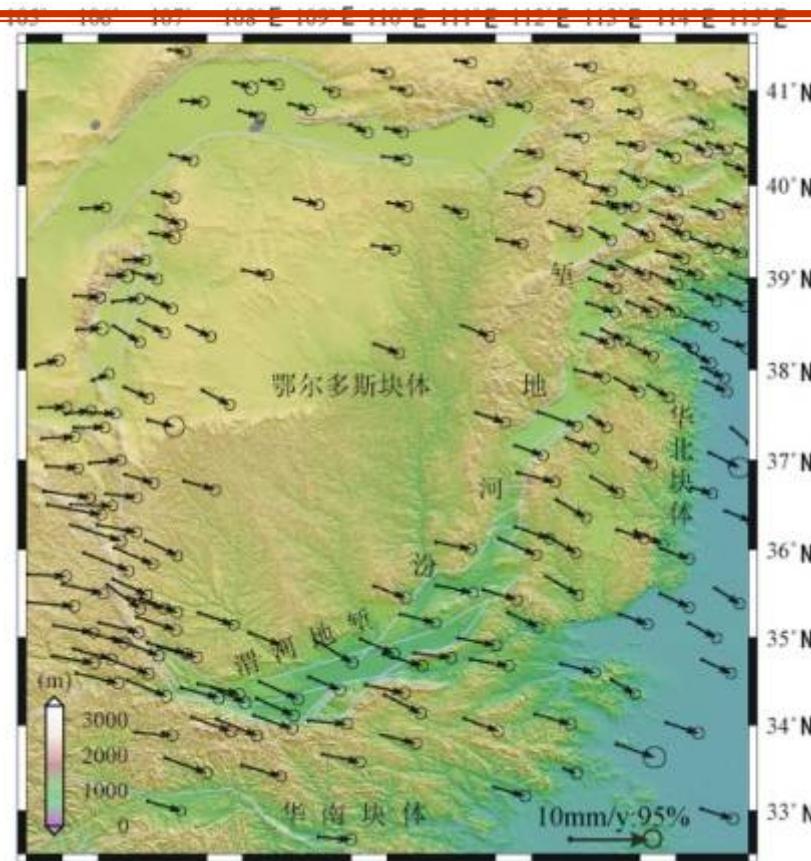
Main achievement

Genesis analysis of earth fissure in Fenwei basin from the horizontal velocity field of continental crust of China

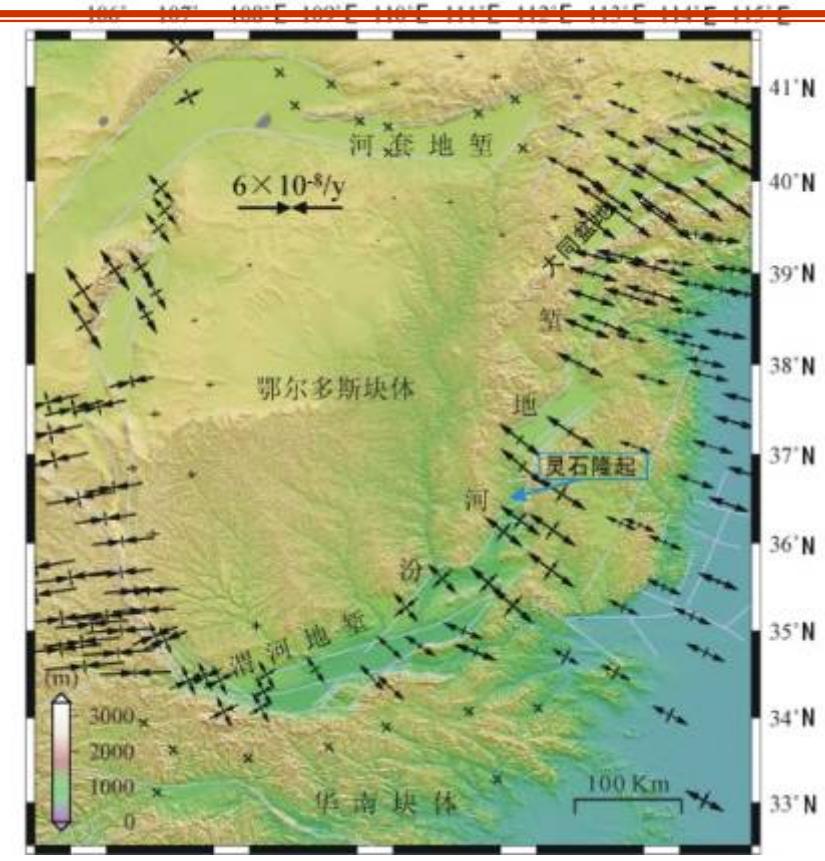


Main achievement

Based on monitor data of GPS, surface tension of Fenwei basin was controlled by the uplift of Tibet Plateau. The tensile rate was 2 to 5mm.



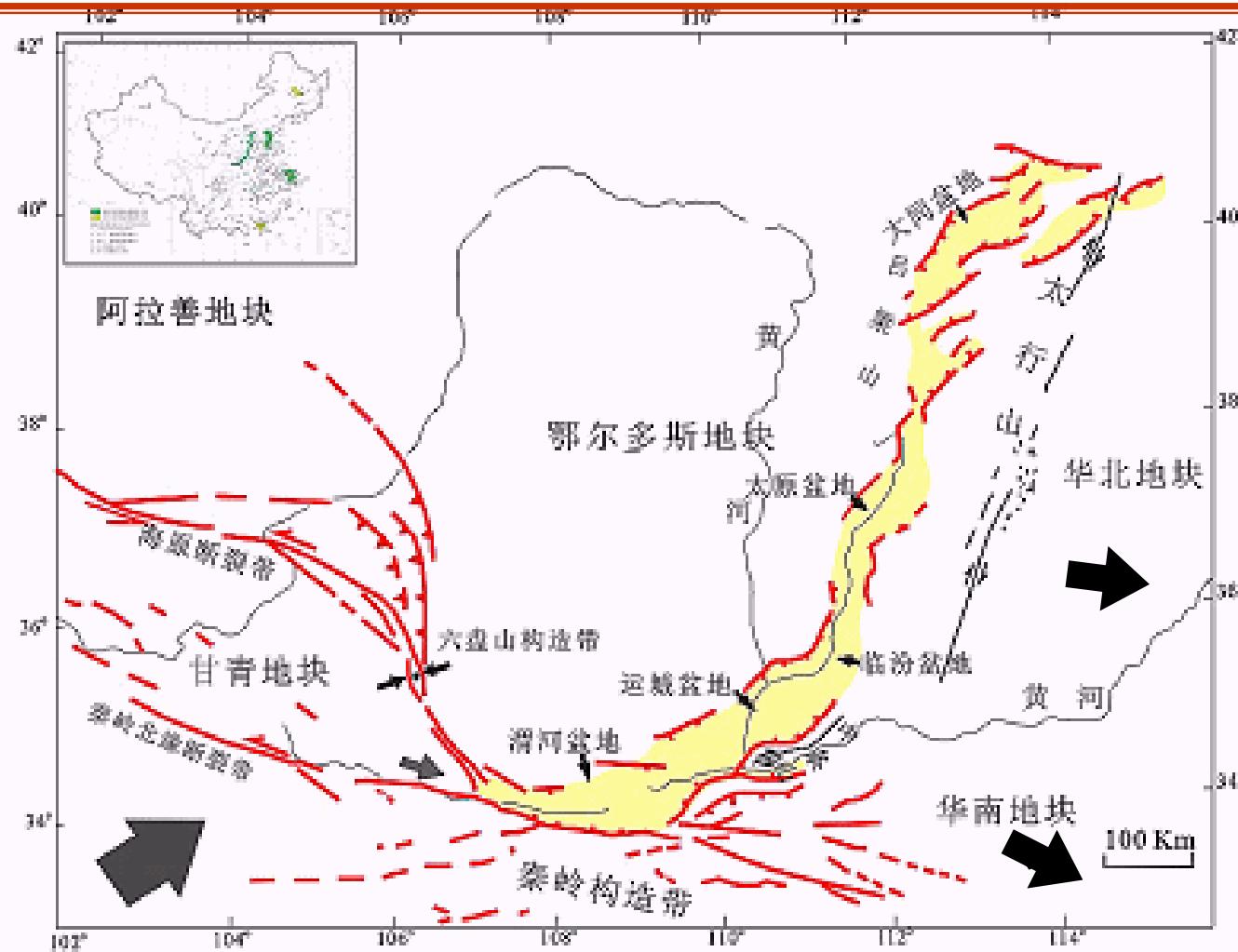
Horizontal crustal deformation



Crustal stress of Fenwei basin

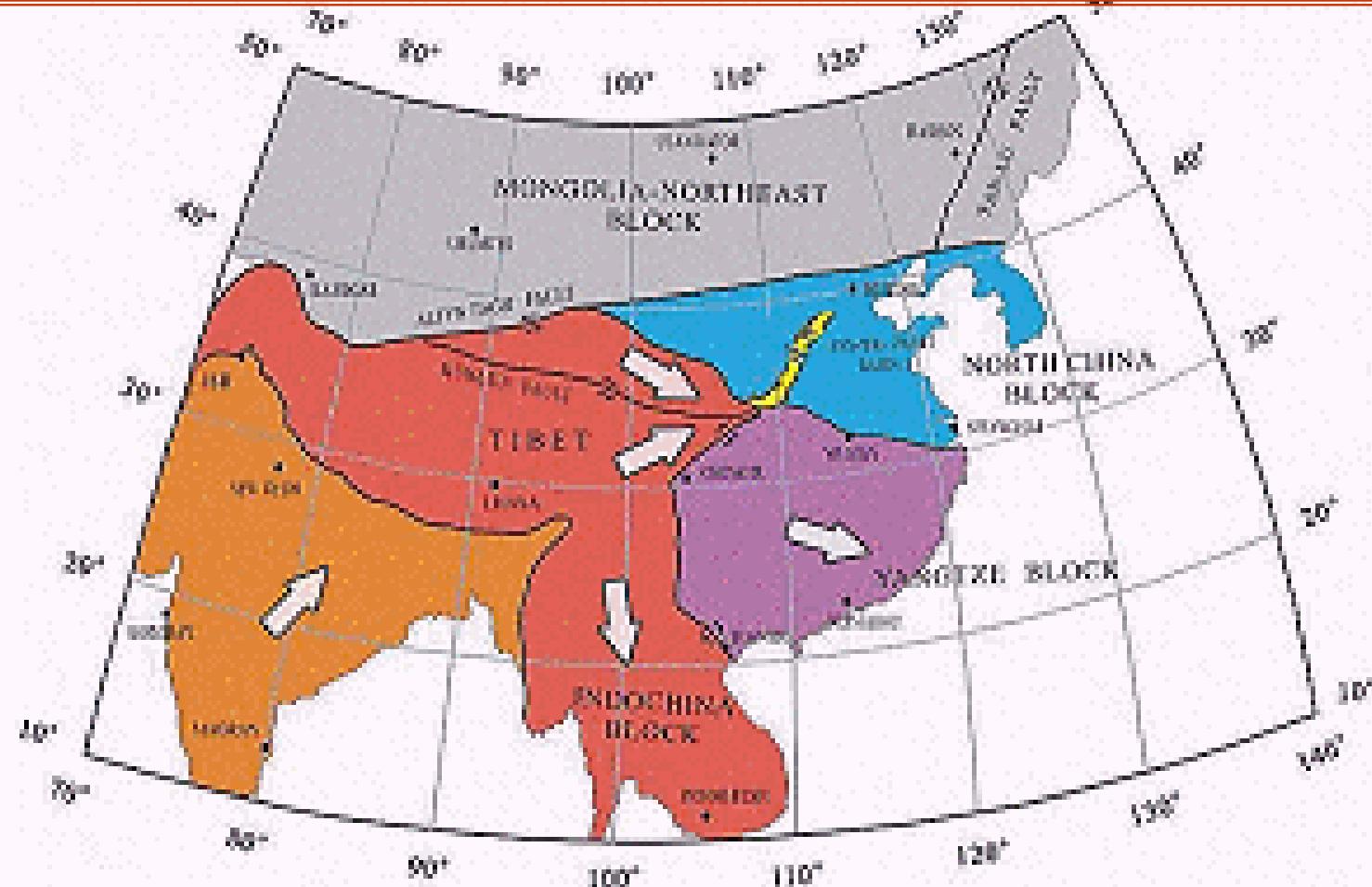
Main achievement

Mass-developed mechanism: Under the effect of the uplift of Tibet Plateau, Fenwei basin was NW-SE extension, which provided tensile stress field for the mass-developed earth fissures.



Main achievement

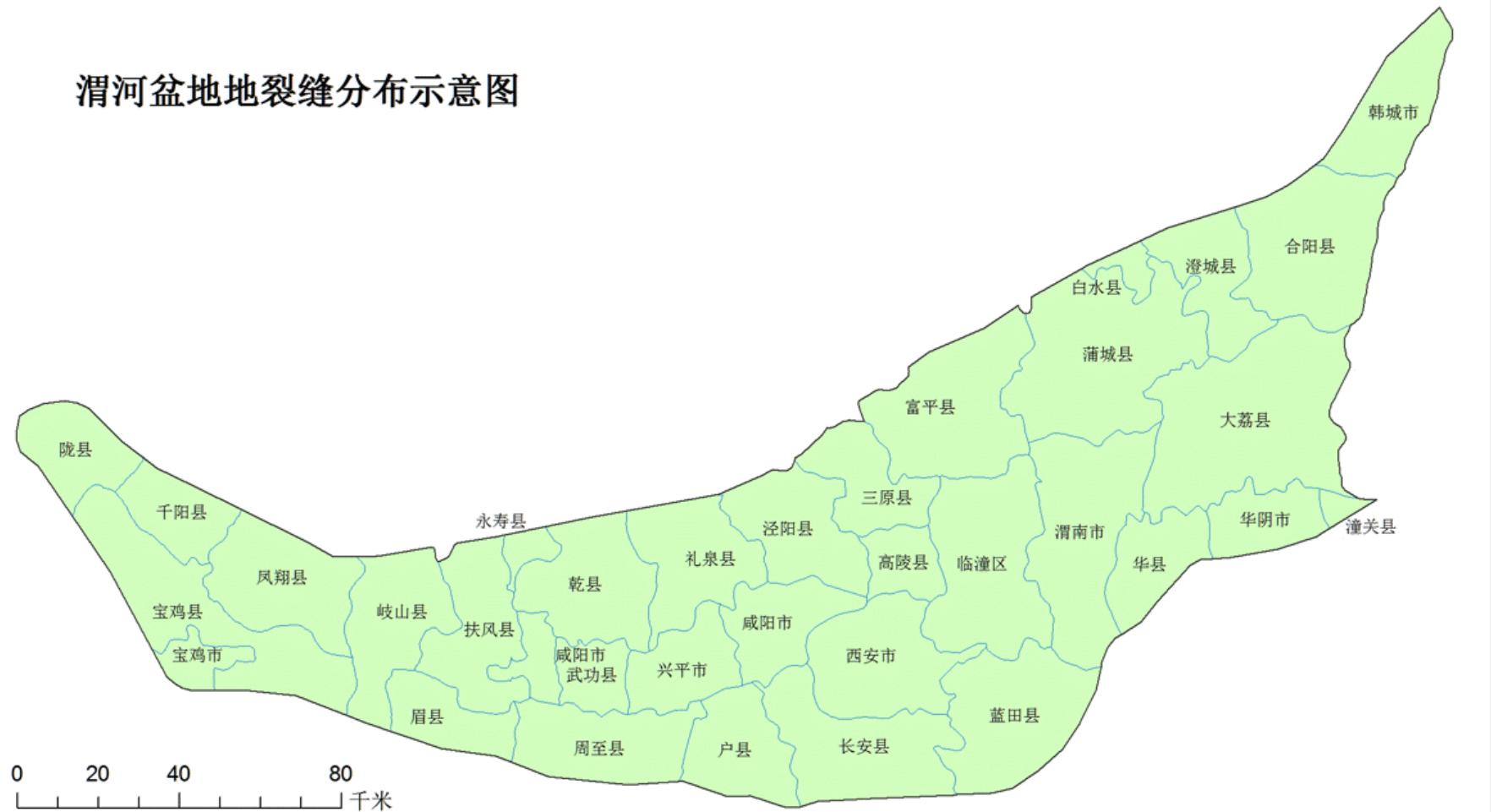
The mass-developed earth fissures in Fenwei basin was a surface rupture response to the uplift of Tibet Plateau



Main achievement

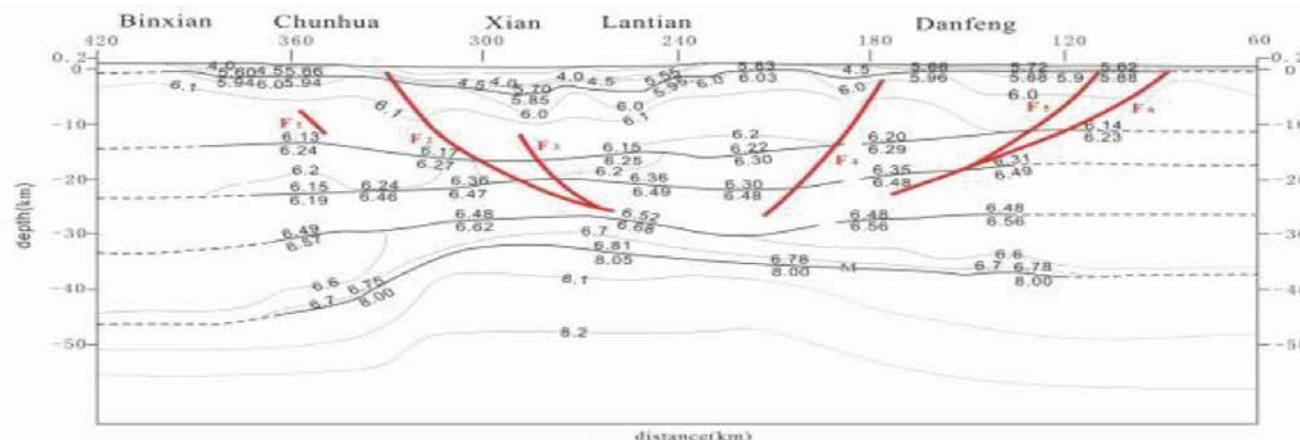
Basin dynamics—Syngeneic mechanism of several earth fissures in a single basin was explained

渭河盆地地裂缝分布示意图

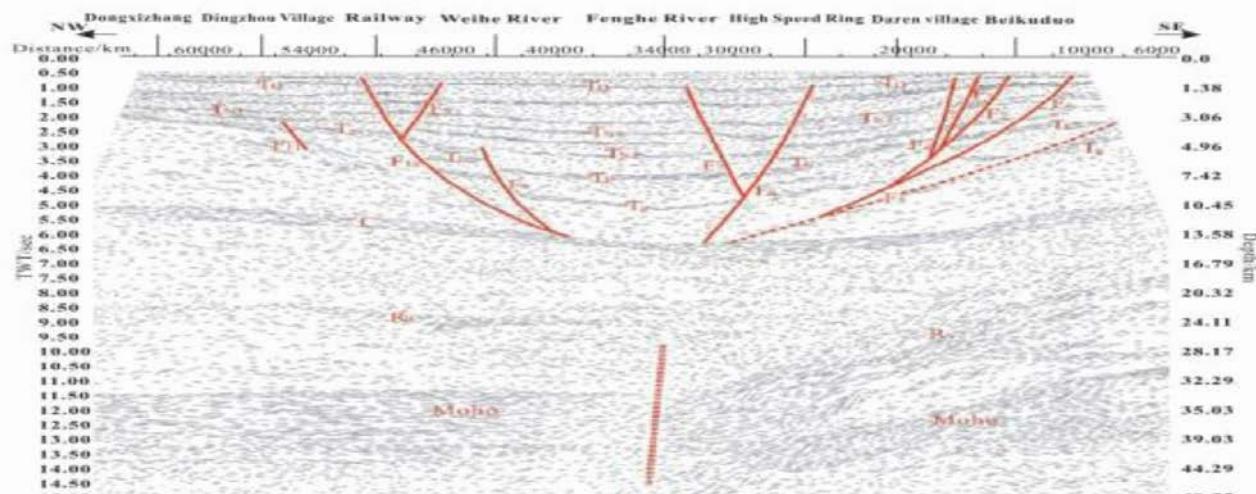


Main achievement

The upper mantle is uplifted dramatically, and all the upper crust faults are converge to the middle rheological layer.



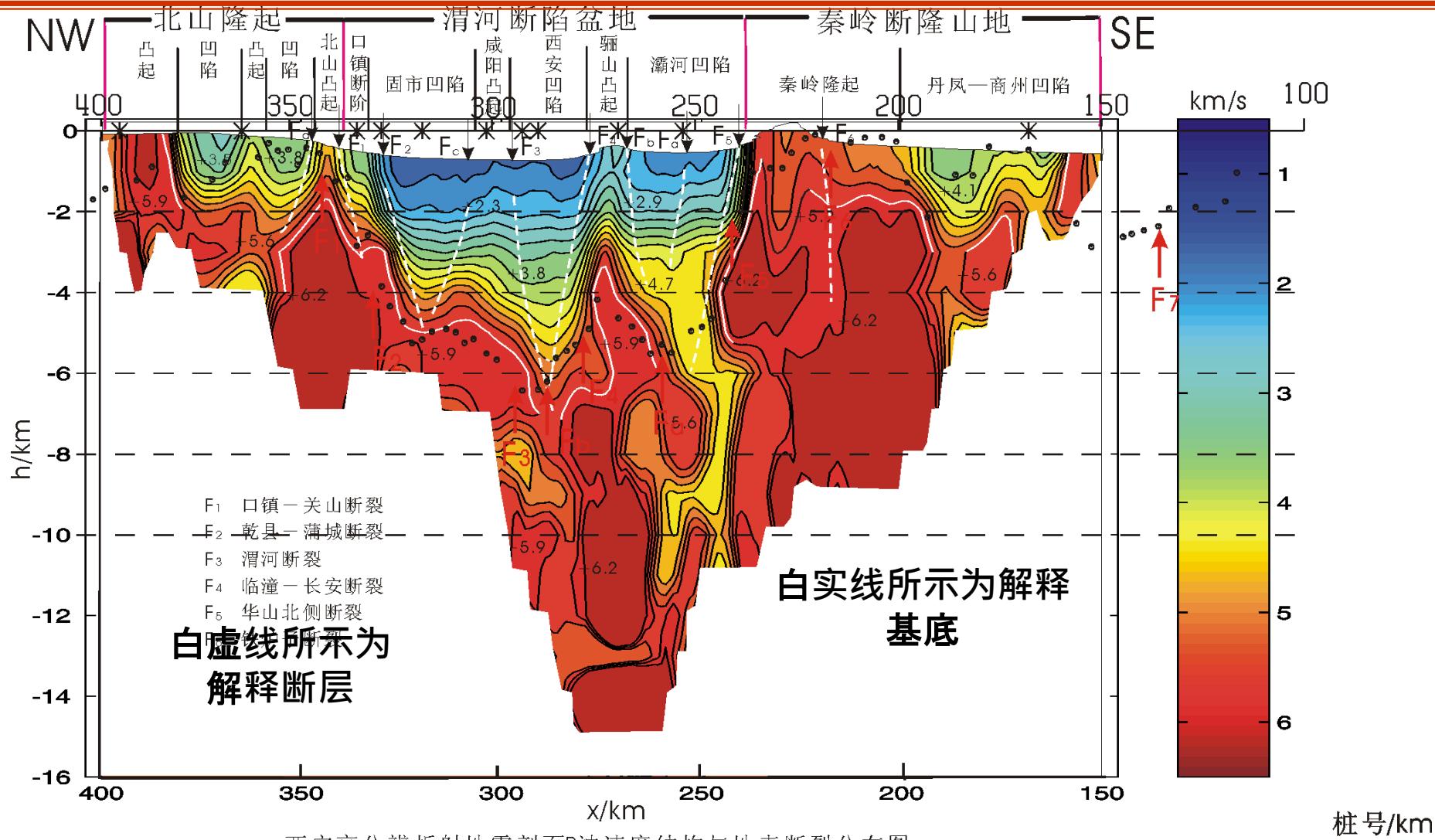
6.65 The seismic interfaces and velocity values(km/s) ⑥.6 Velocity contour ----- Inference interface —C— Shell interface
 —M— Moho discontinuity F—Kouzheng-Guanshan Fault F—Qianxian-Pucheng Fault F—Weihe Fault F—Lintong-Changan Fault
 F—North Huashan Fault F—Tieluji Fault



F 1 :Kouzheng-Guanshan Fault F 2 :Qianxian-Pucheng Fault F 3 :Weihe Fault F 4 :Lingtong-Changan Fault F 5 :North Huashan Fault
 F 6 :Tieluzi Fault

Main achievement

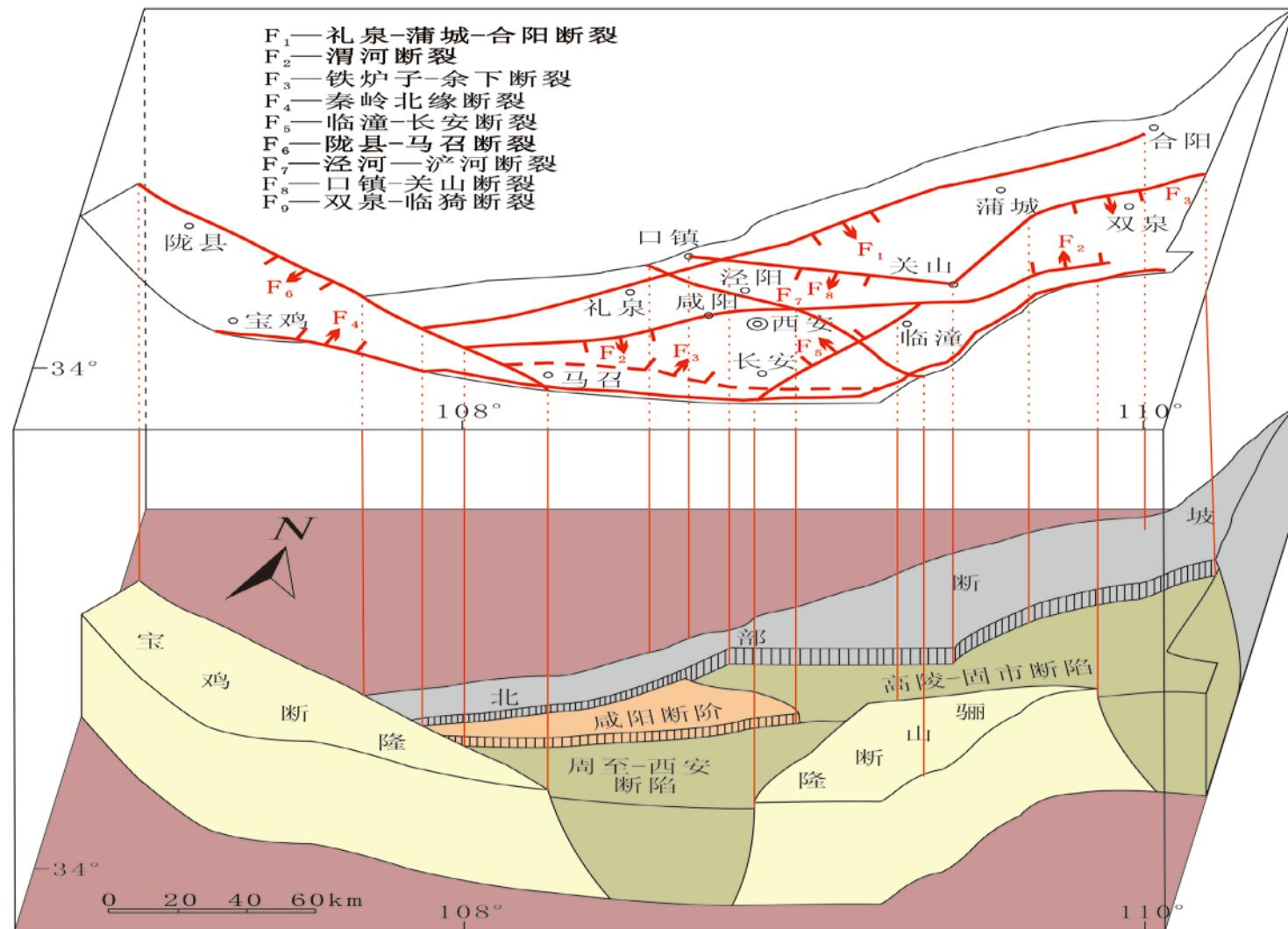
High-resolution seismic refraction profile in Weihe basin showed the waviness of the basin basement.



西安高分辨折射地震剖面P波速度结构与地表断裂分布图

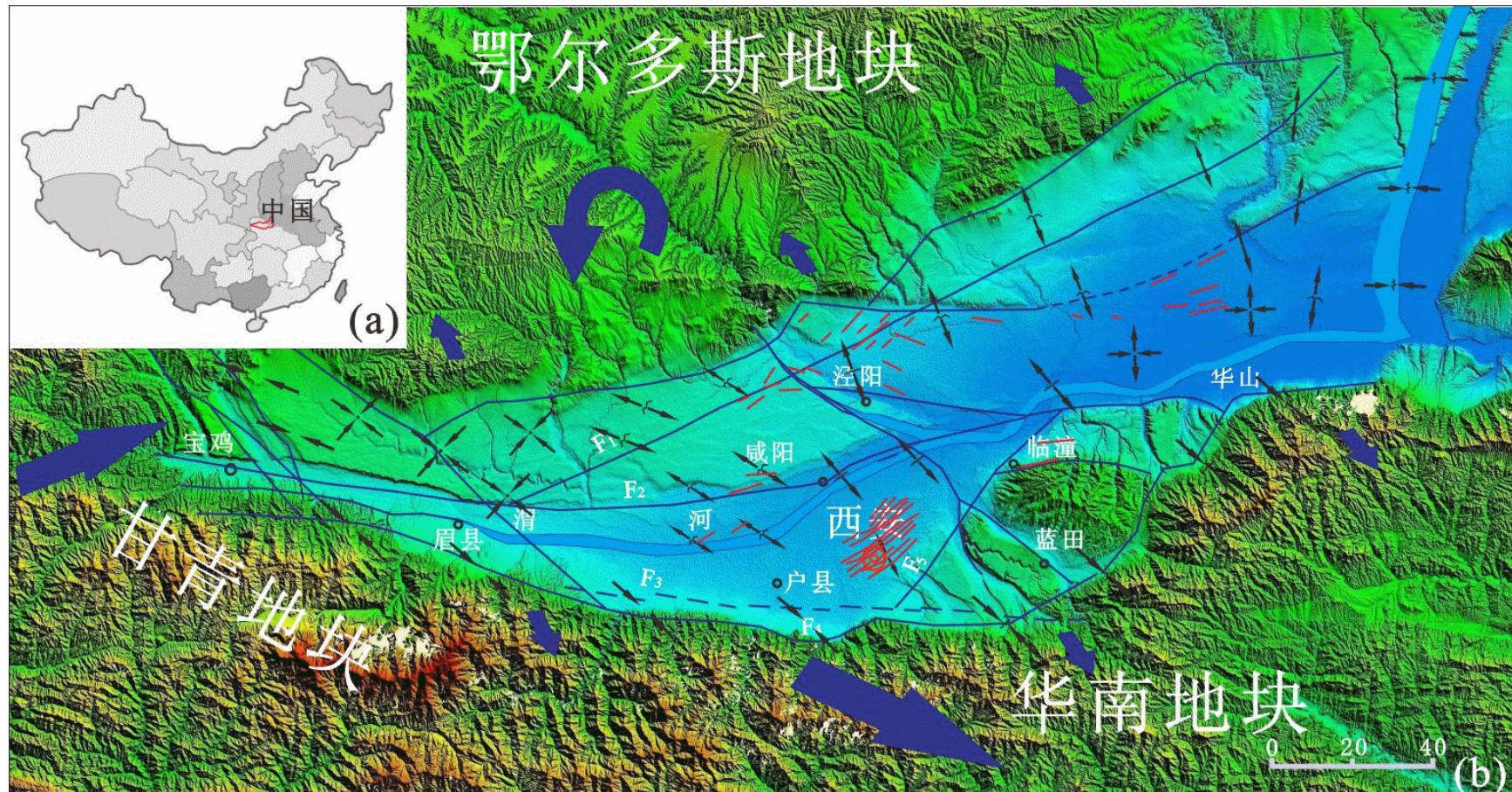
Main achievement

Faulting activity was affected by fractured basement and differential movement of blocks.



Main achievement

Faulting activity and soil fractures were stimulated by the tensile stress field.



断裂

地裂缝

F₁ 礼泉-蒲城-合阳断裂

F₄ 秦岭北缘断裂

F₂ 渭河断裂

F₅ 临潼-长安断裂

F₃ 铁炉子-余下断裂

→ ← 0.3×10^{-3}

Main achievement

The syngeneic ground fissures were controlled by four-layer structure of Fenwei basin.

Earth fissures



Surface tension



Faults stretch



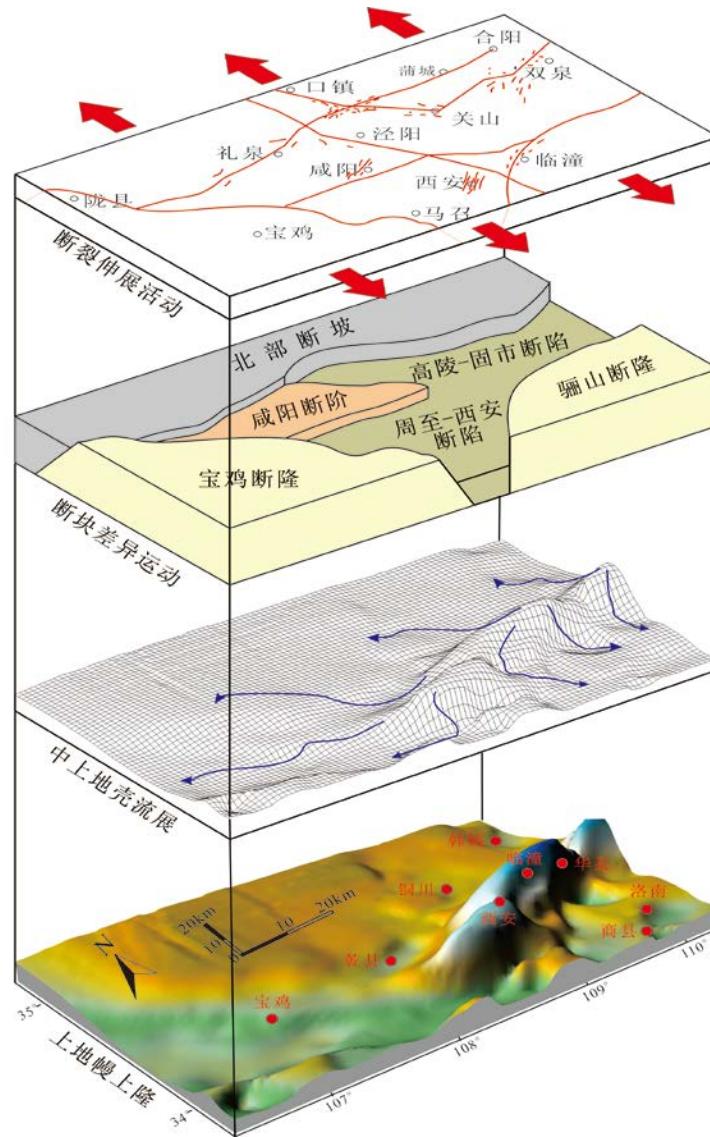
Basement blocks move



Crustal extension

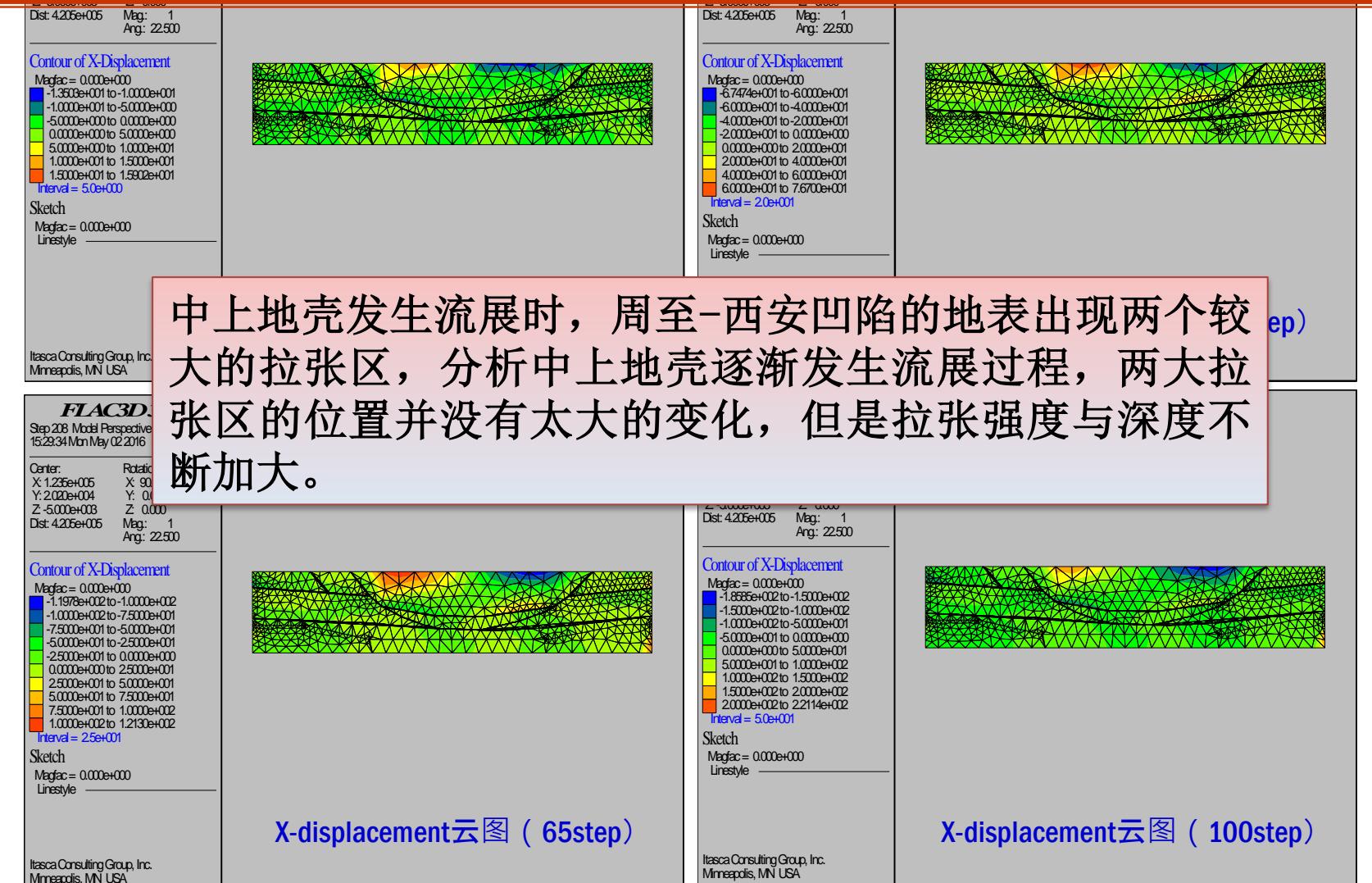


Upper mantle uplift



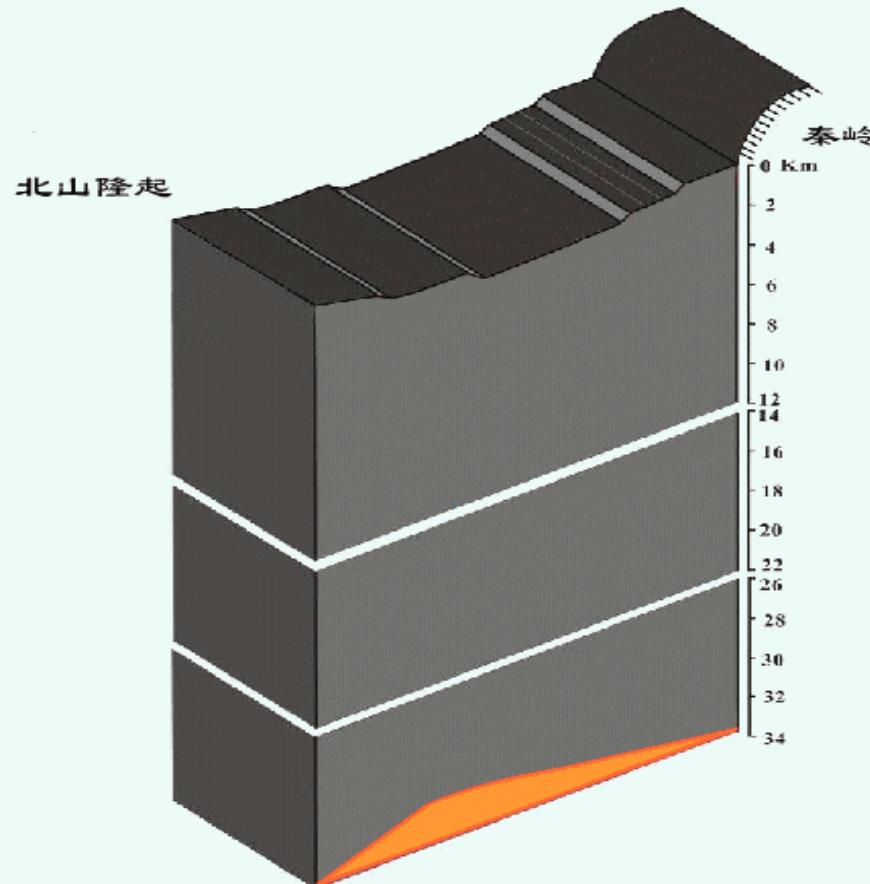
Main achievement

Numerical simulation results on the flow and stretch mechanism of mid-upper crust



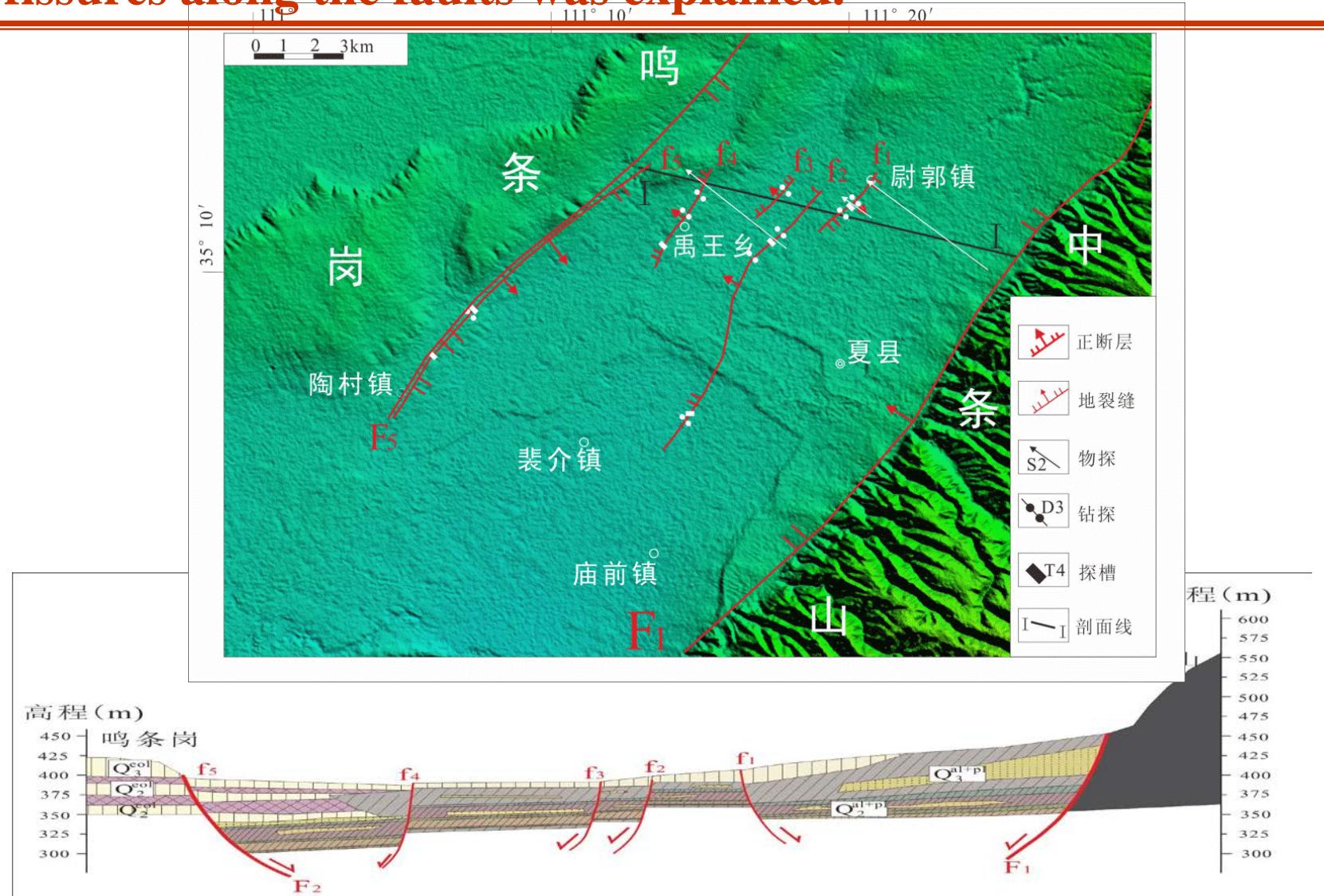
Main achievement

Syngeneic mechanism in a single basin: Deep tectonic activity triggered the differential movement of blocks and faults creeping. Combined with regional tensile stress leading to ground fissures.



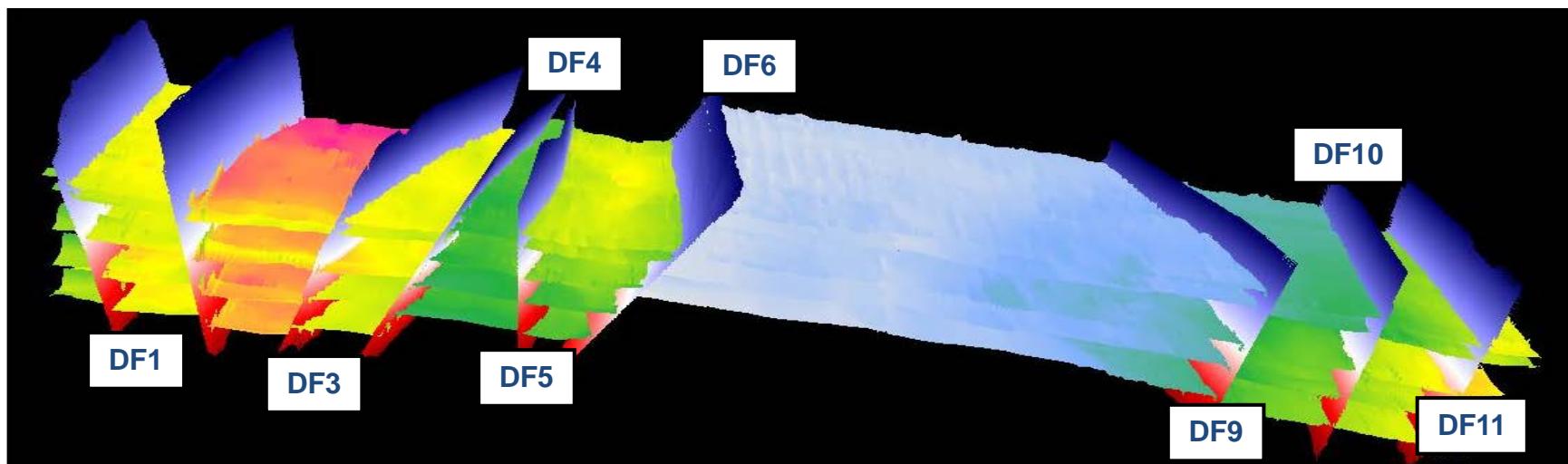
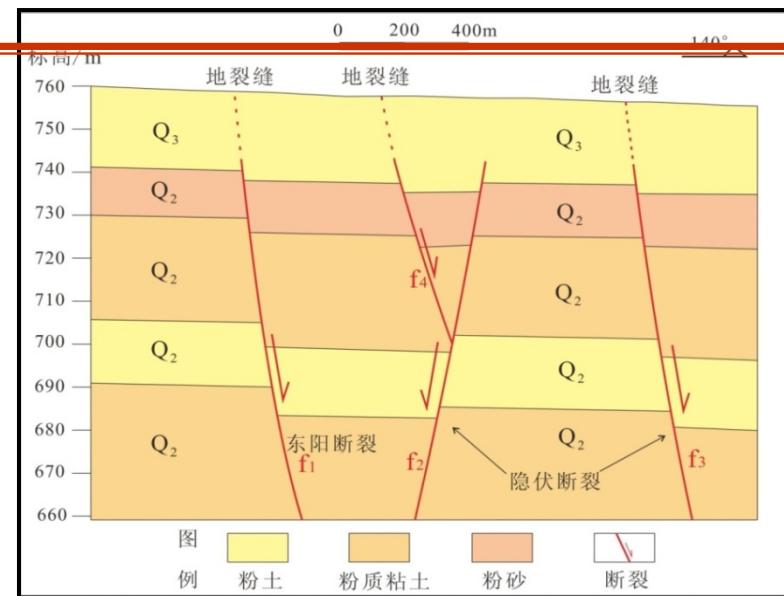
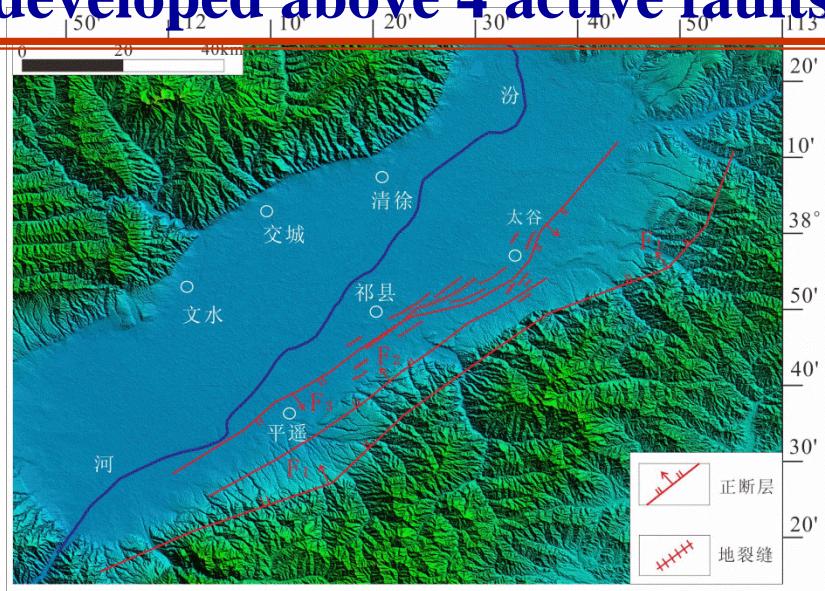
Main achievement

Fault structure mechanics—Symbiosis mechanism of earth fissures along the faults was explained.



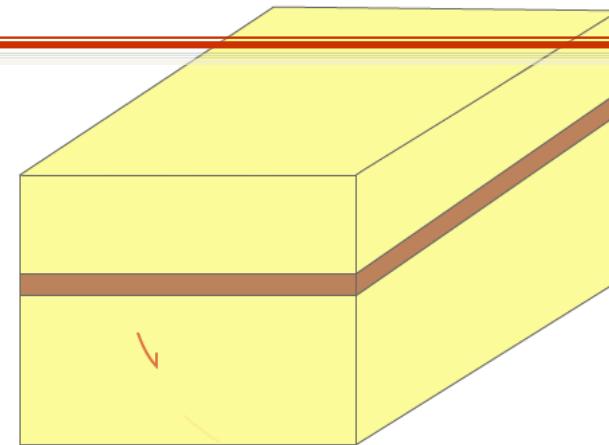
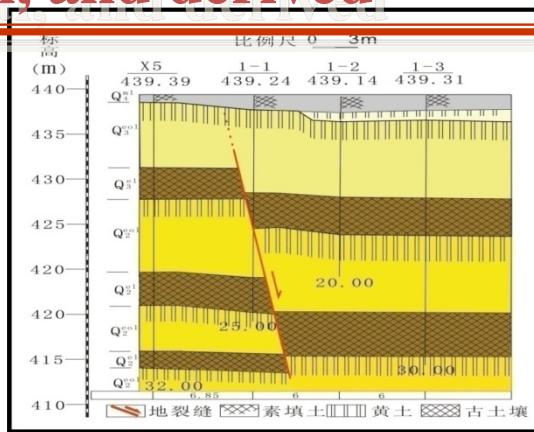
Main achievement

3D seismic exploration of Qi county showed, 4 ground fissures developed above 4 active faults.

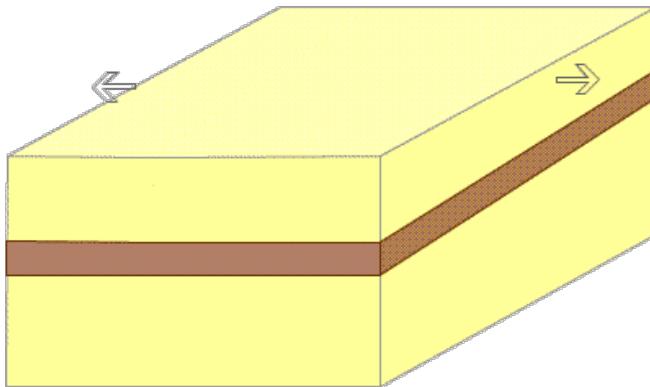


Main achievement

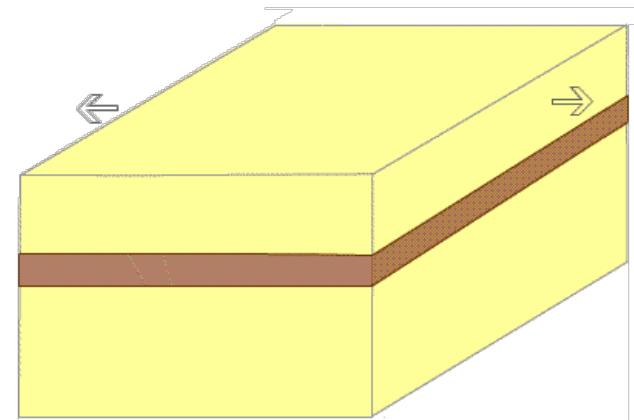
3 growth modes of symbiosis ground fissure with the fault: Vertical, horizontal, and derived



Developed along the fault plane



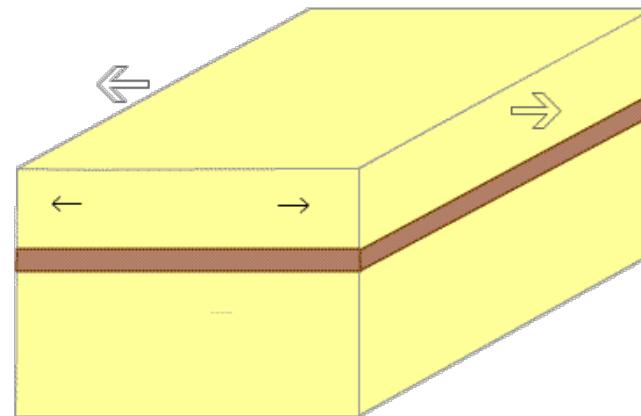
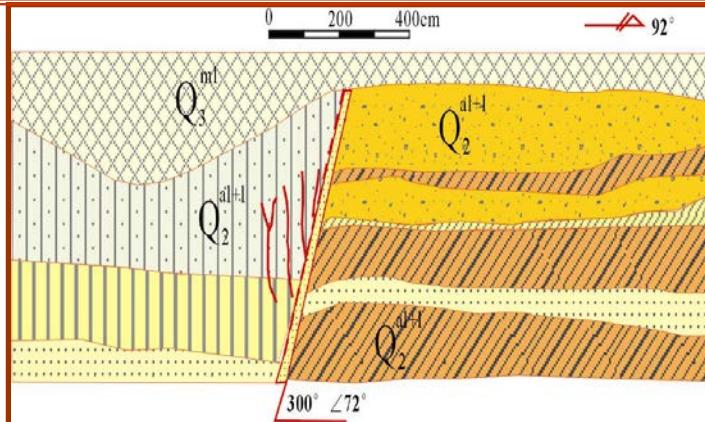
Develop toward the hanging wall



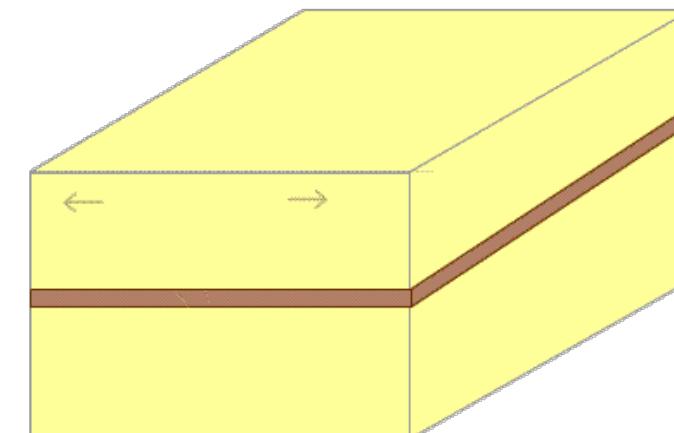
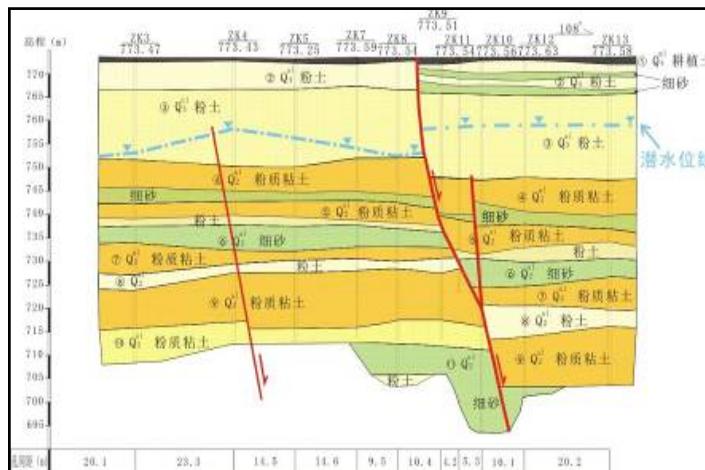
Develop toward the footwall

Main achievement

Horizontal growth mode: on the hanging wall, footwall, both the hanging wall and footwall.

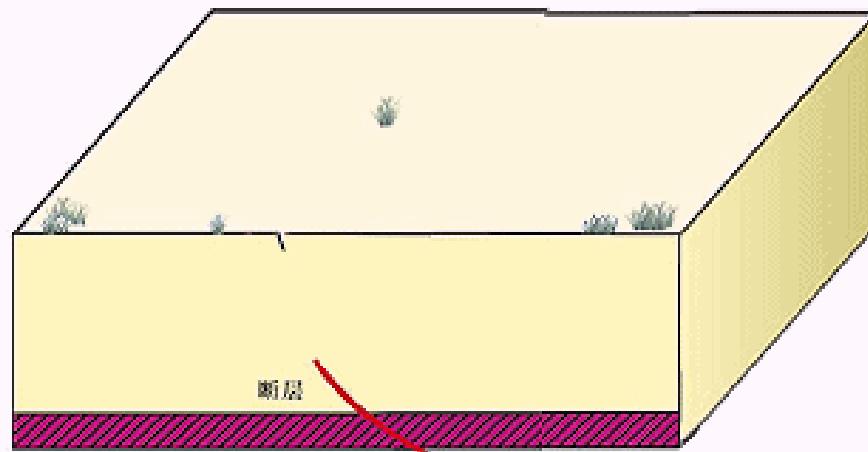
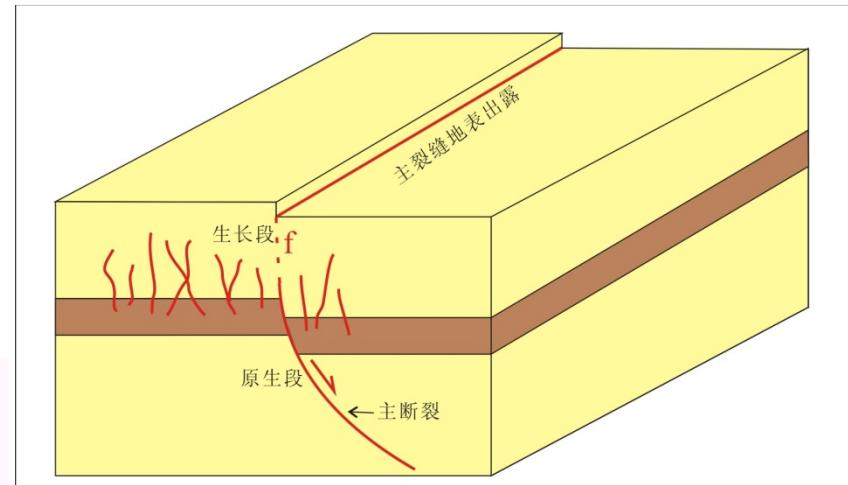
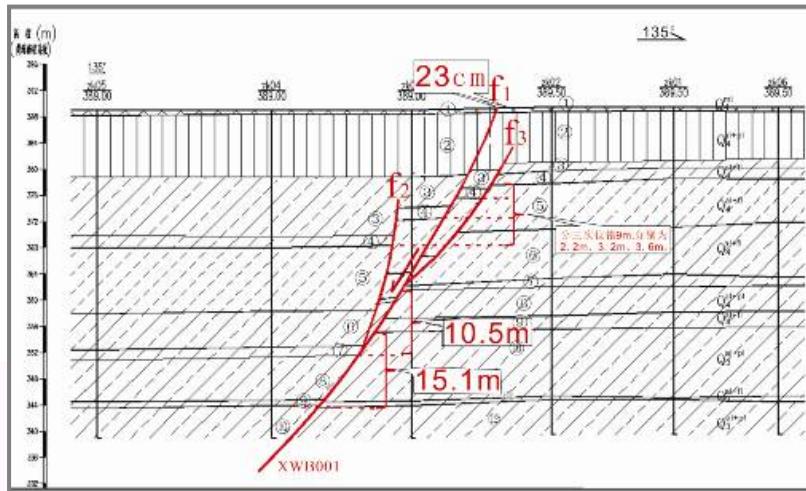


Develop on the hanging wall



Develop on the footwall

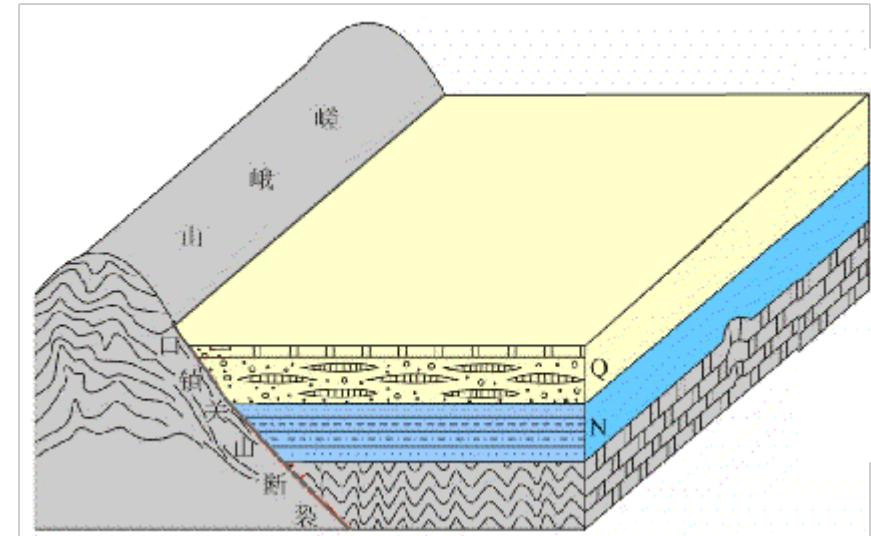
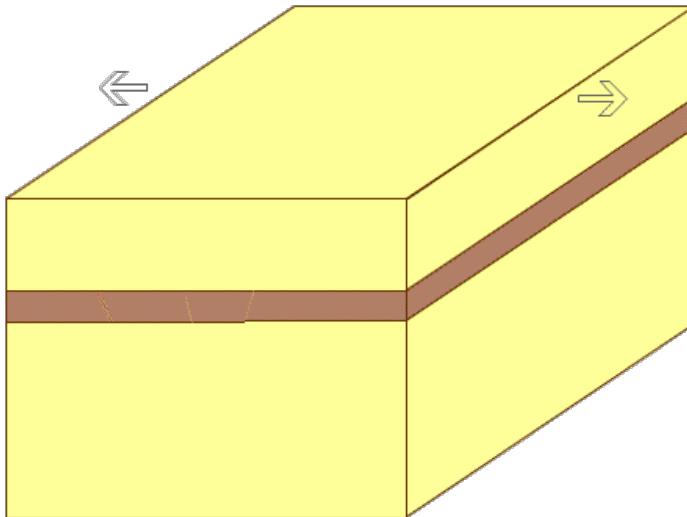
Main achievement



Develop on both the hanging wall and footwall

Main achievement

Derived growth mode: derived from secondary, and from local stress of the fault

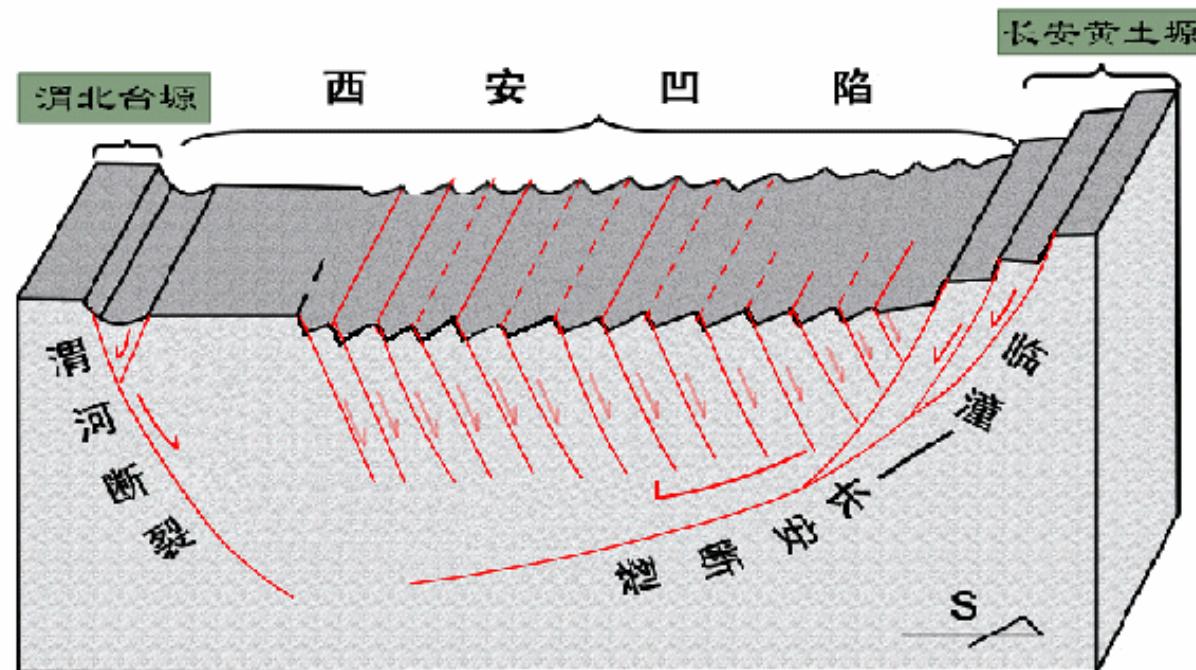


New fissures derived from secondary fissure's offset

Secondary fissures derived from the block twisting

Main achievement

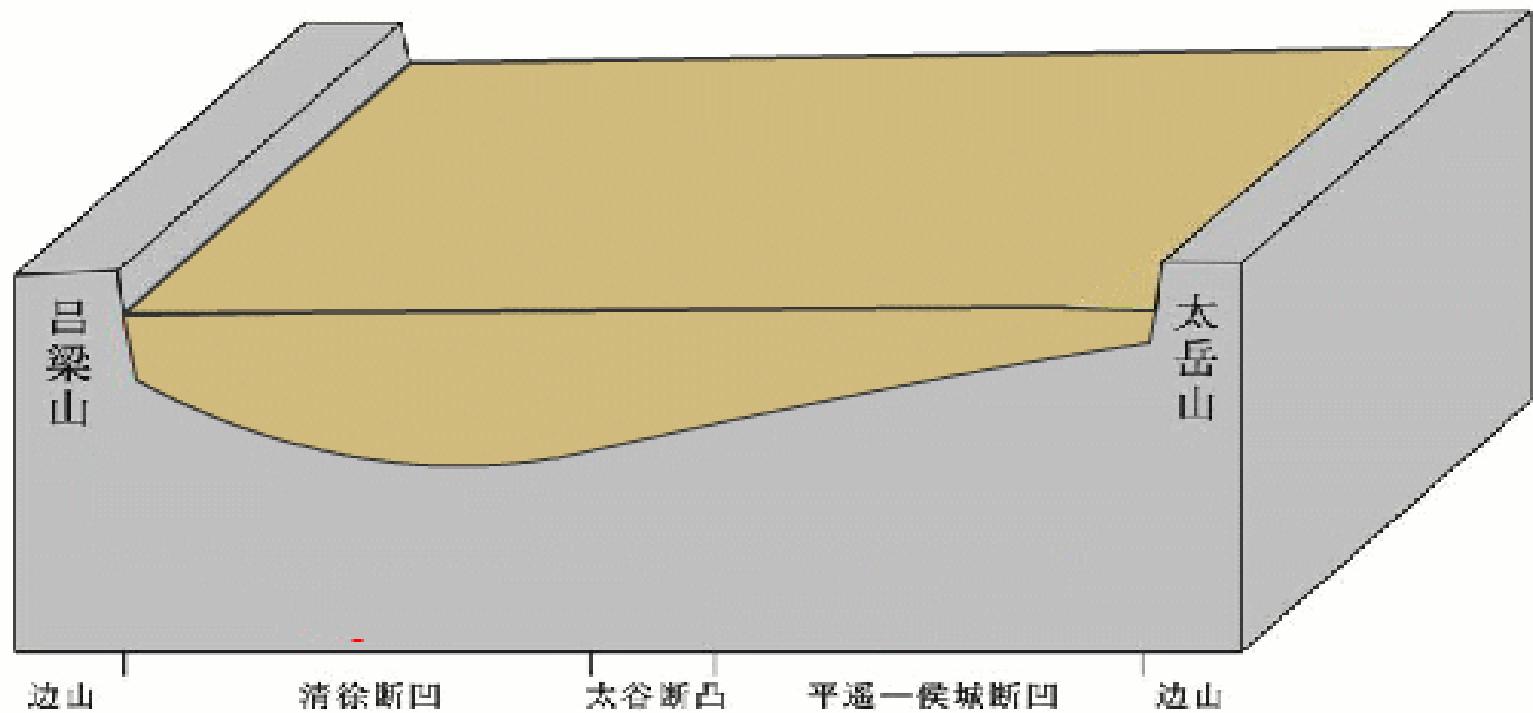
Ground fissures in Xi'an derived from the dip-slip activity of Lintong-Chang'an fracture zone.



The development of Xi'an ground fissures are controlled by the fault

Main achievement

Ground fissures in Taiyuan basin derived from the dip-slip activity of faults on the basin rim and within the basin.

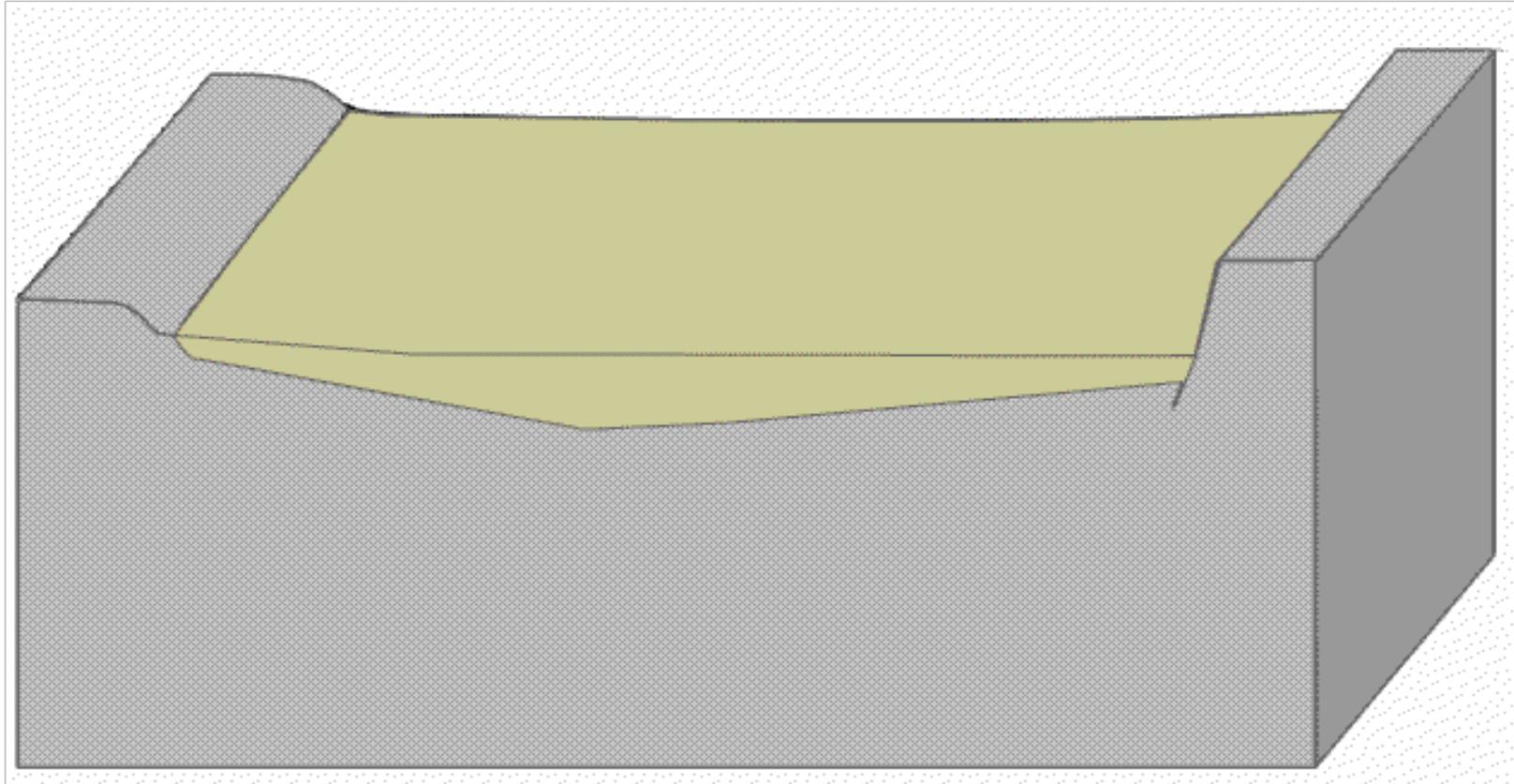


f_1 清徐-交城文水地裂缝 f_2 太谷武家堡地裂缝 f_3 原西-里村地裂缝

f_4 白圭-郑家庄地裂缝 f_5 太谷北洸地裂缝 f_6 闫漫-下古县地裂缝

Main achievement

Ground fissures in Yuncheng basin derived from the
strengthening activity of block-secondary fault.



f_1 半坡一司马地裂缝

f_4 大吕一白张地裂缝

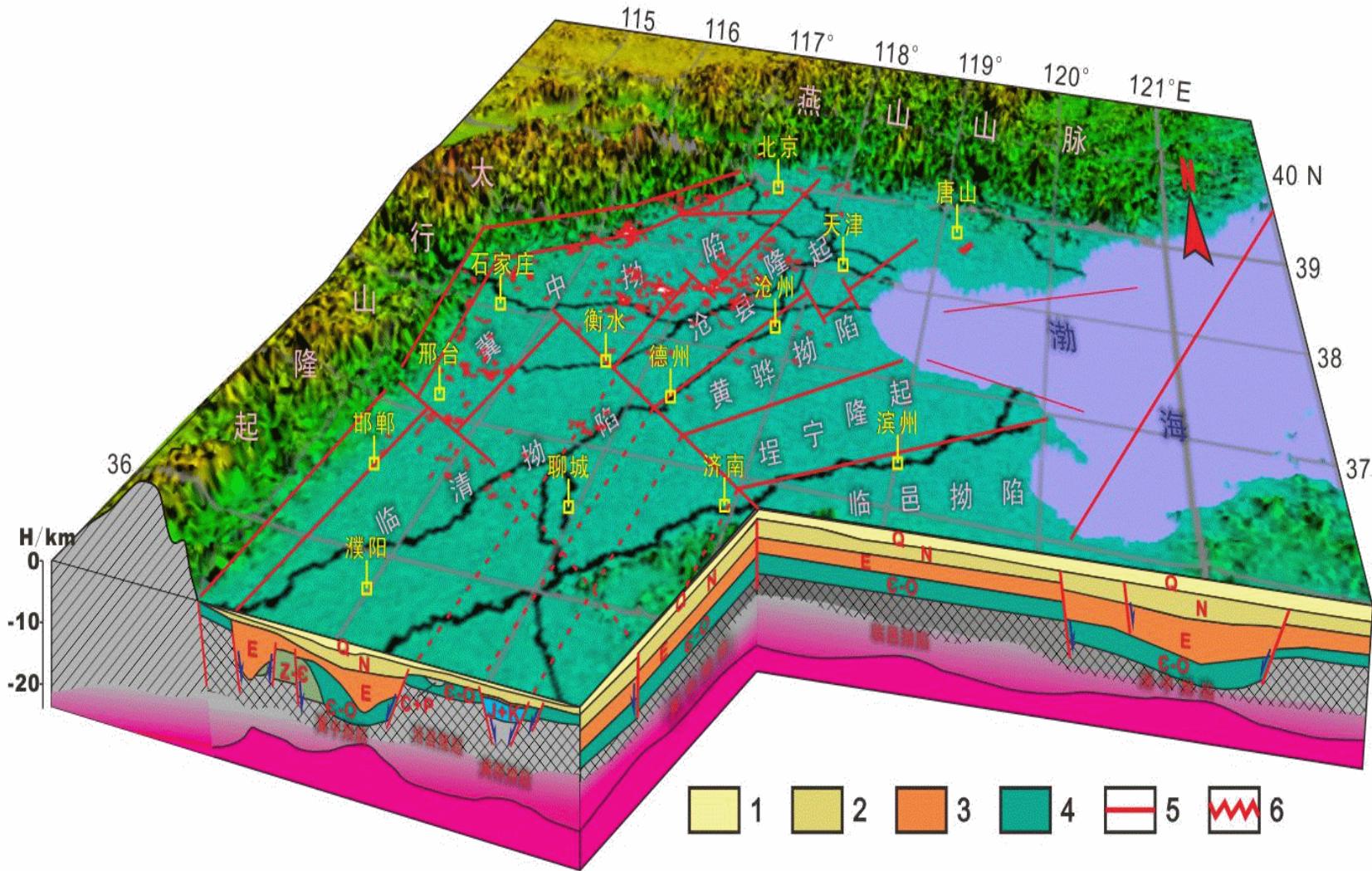
f_2 禹王地裂缝

f_5 尉郭地裂缝

f_3 西董地裂缝

Main achievement

Earth fissures in North China Plain usually coexist with faults.



Main achievement

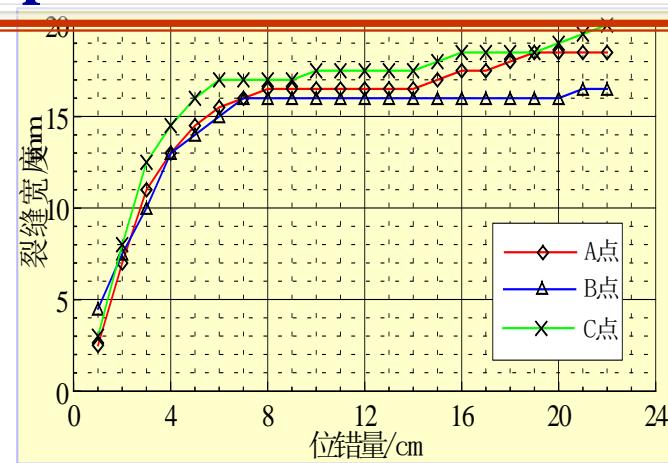
Large scale physical model test confirmed that creeping can lead to surface rupture.



Physical model platform



Photo of ground fissure profile



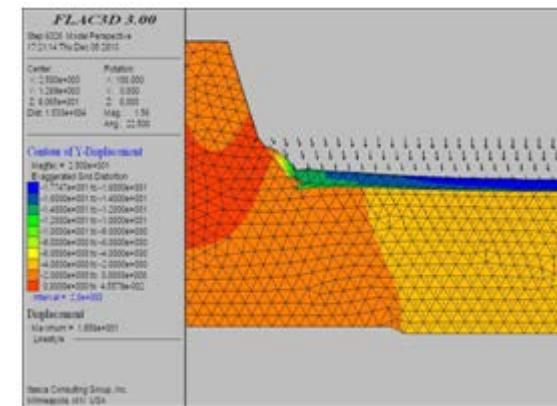
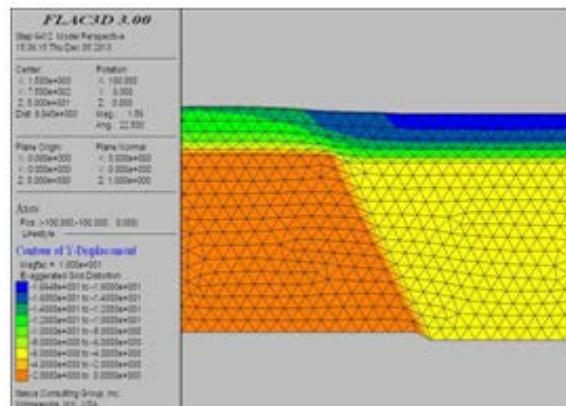
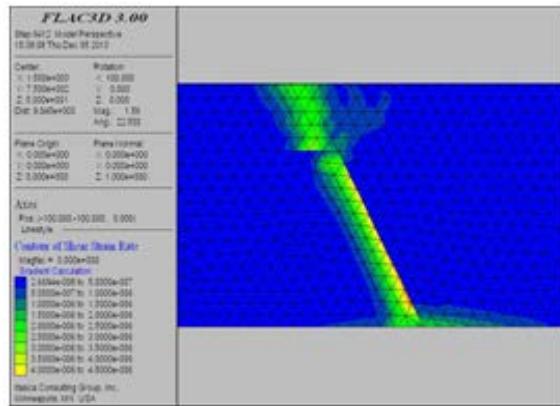
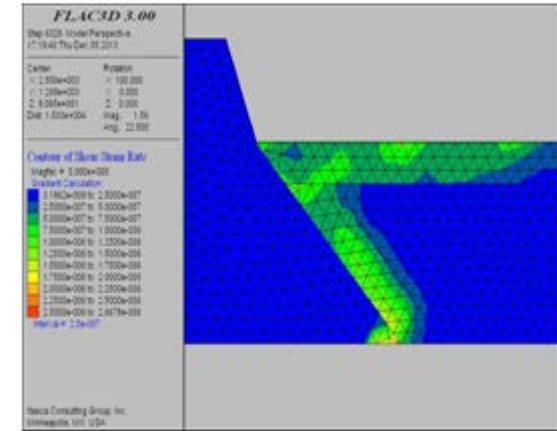
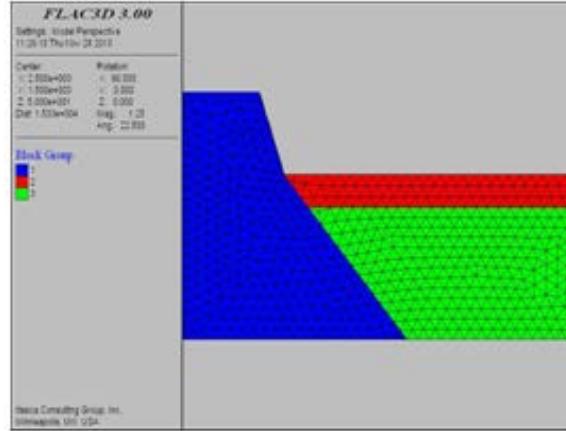
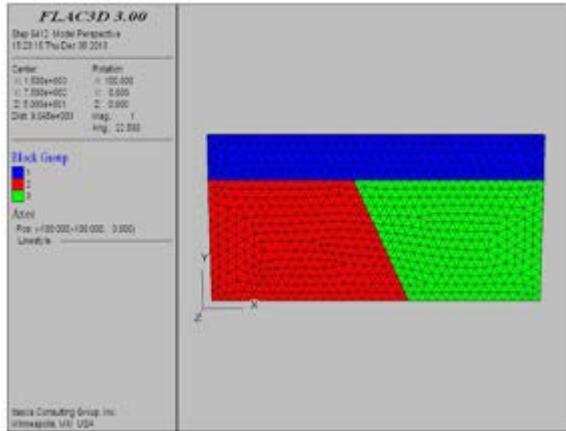
Soil displacement curve



Sketch of ground fissure profile

Main achievement

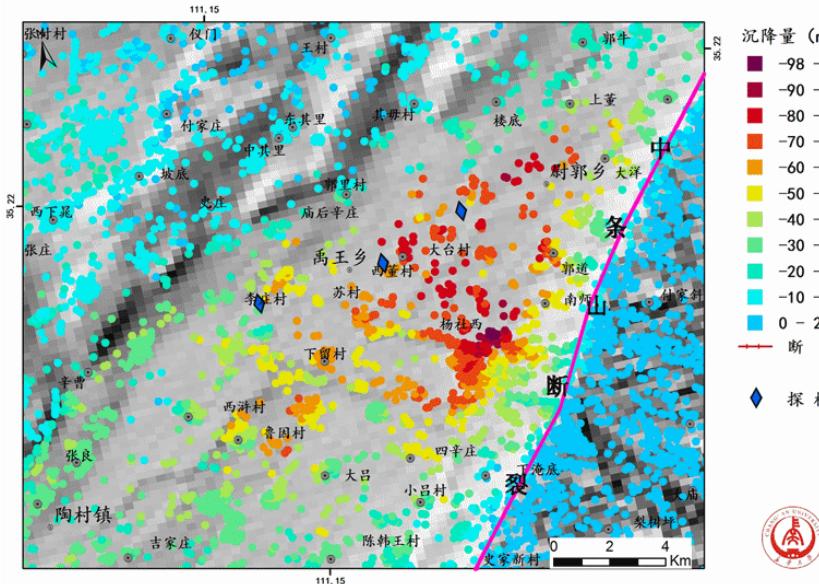
Tensile strain zone appeared on the hanging wall and footwall of a normal fault.



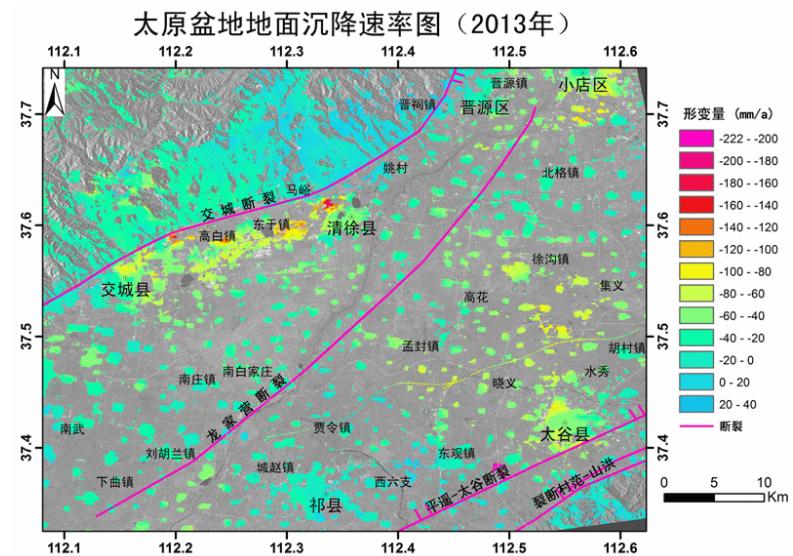
Main achievement

Hydrodynamics—Regeneration and propagation mechanism of ground fissures were explained.

Ground fissures developed with land subsidence area.



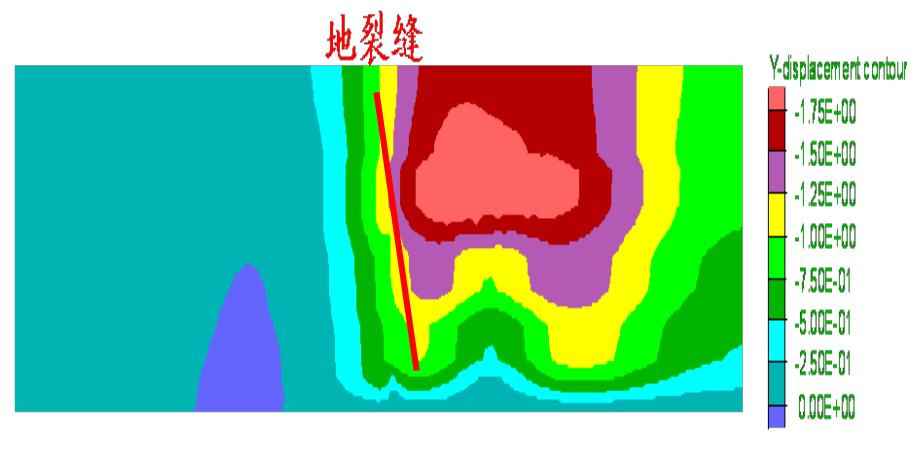
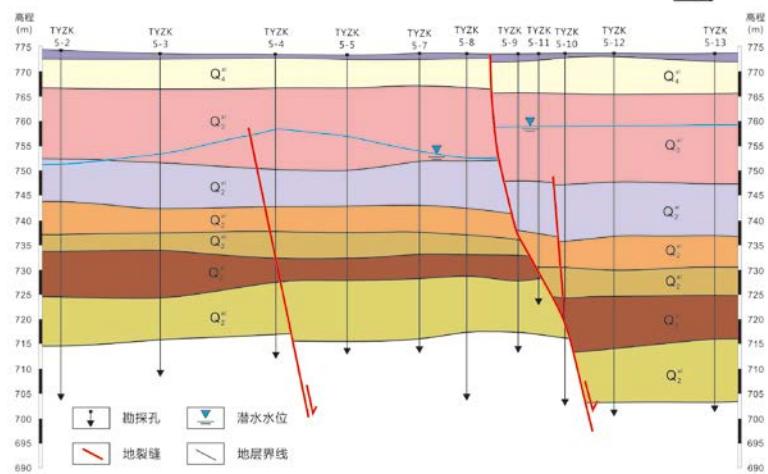
Xia county ground fissure developed in land subsidence area.



Jiaocheng ground fissure developed along land subsidence zone.

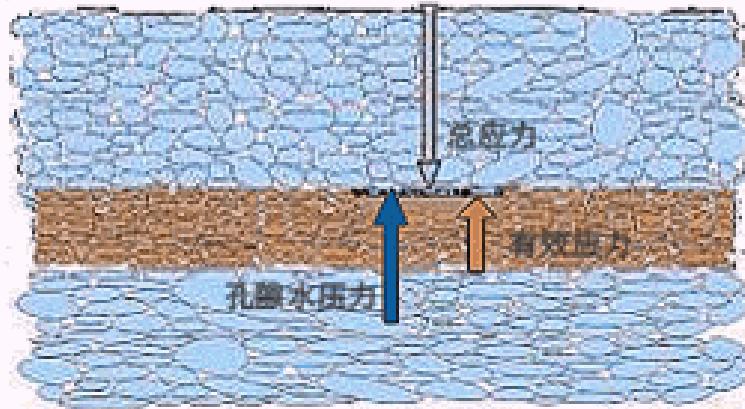
Main achievement

Based on the model test and field seepage test, ground fissure acted as permeation channel in its open state, while as aquiclude in its closed state.



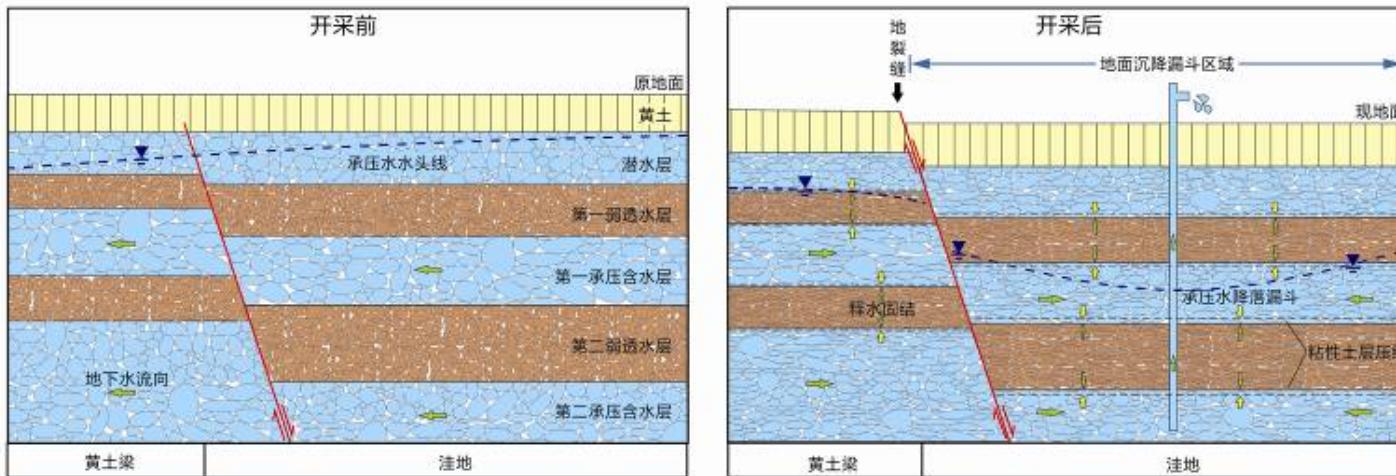
Main achievement

It is complex to explain how land subsidence triggers earth fissure.



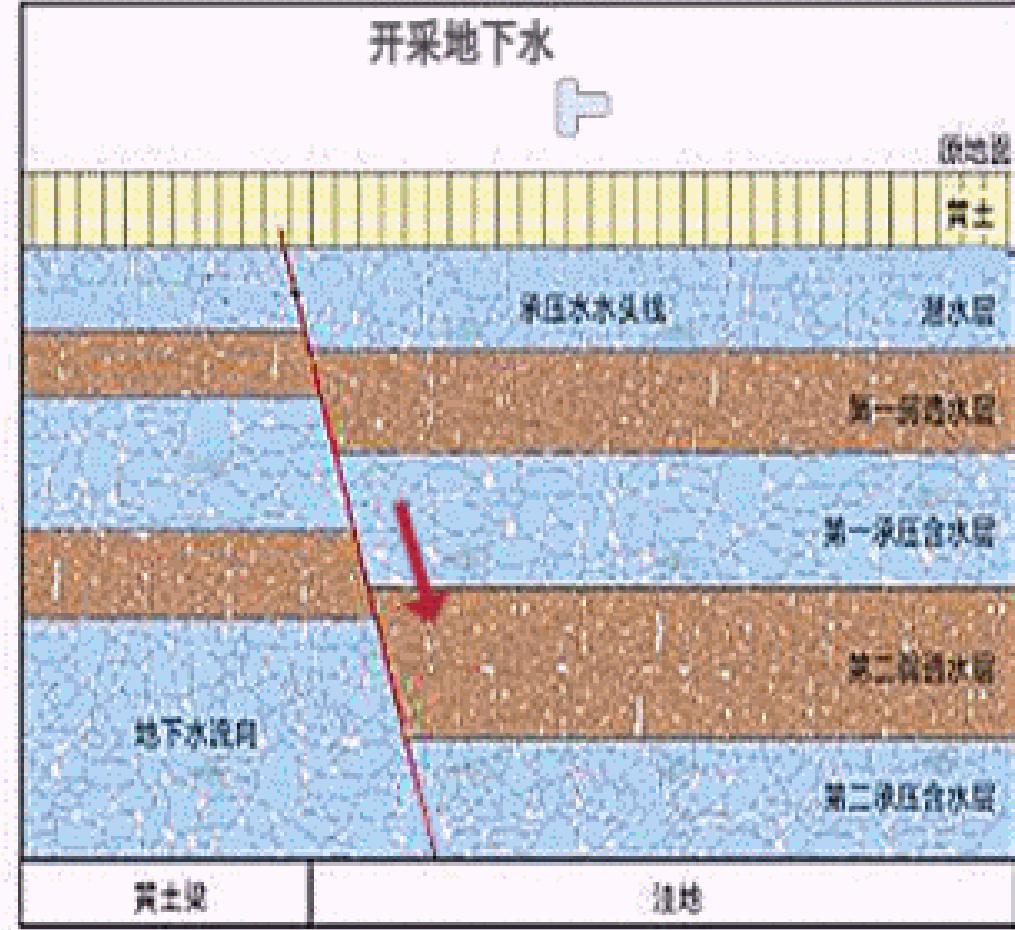
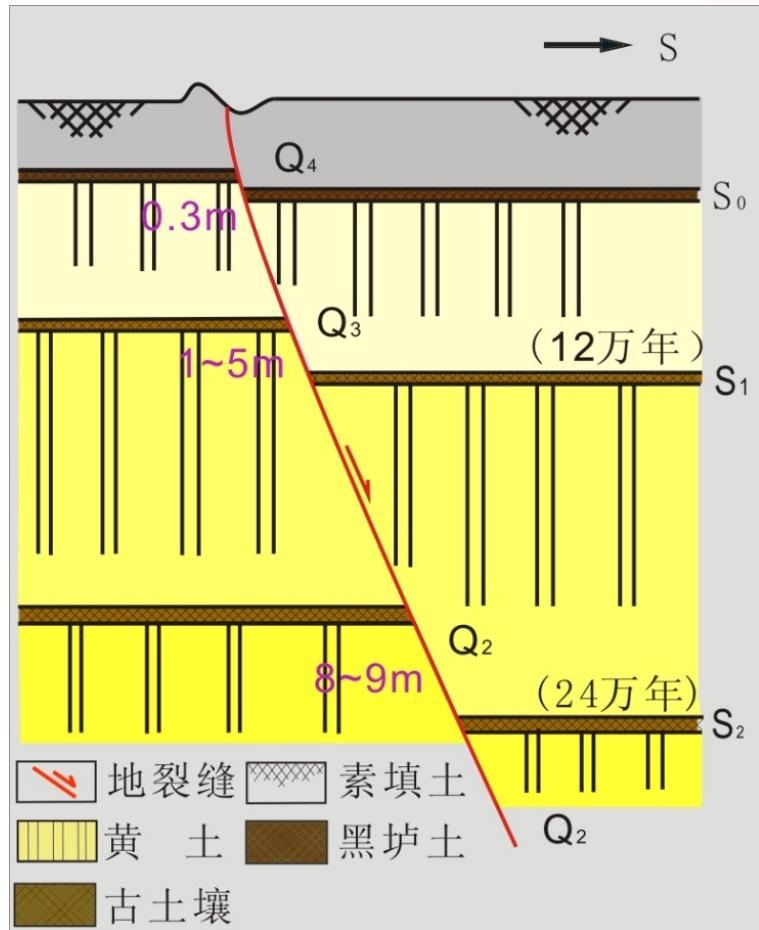
$$S = \frac{\gamma_w \cdot AH'CD}{E} = \frac{\gamma_w \cdot \Delta h \cdot H_{\text{砂}}}{E}$$

1960 年



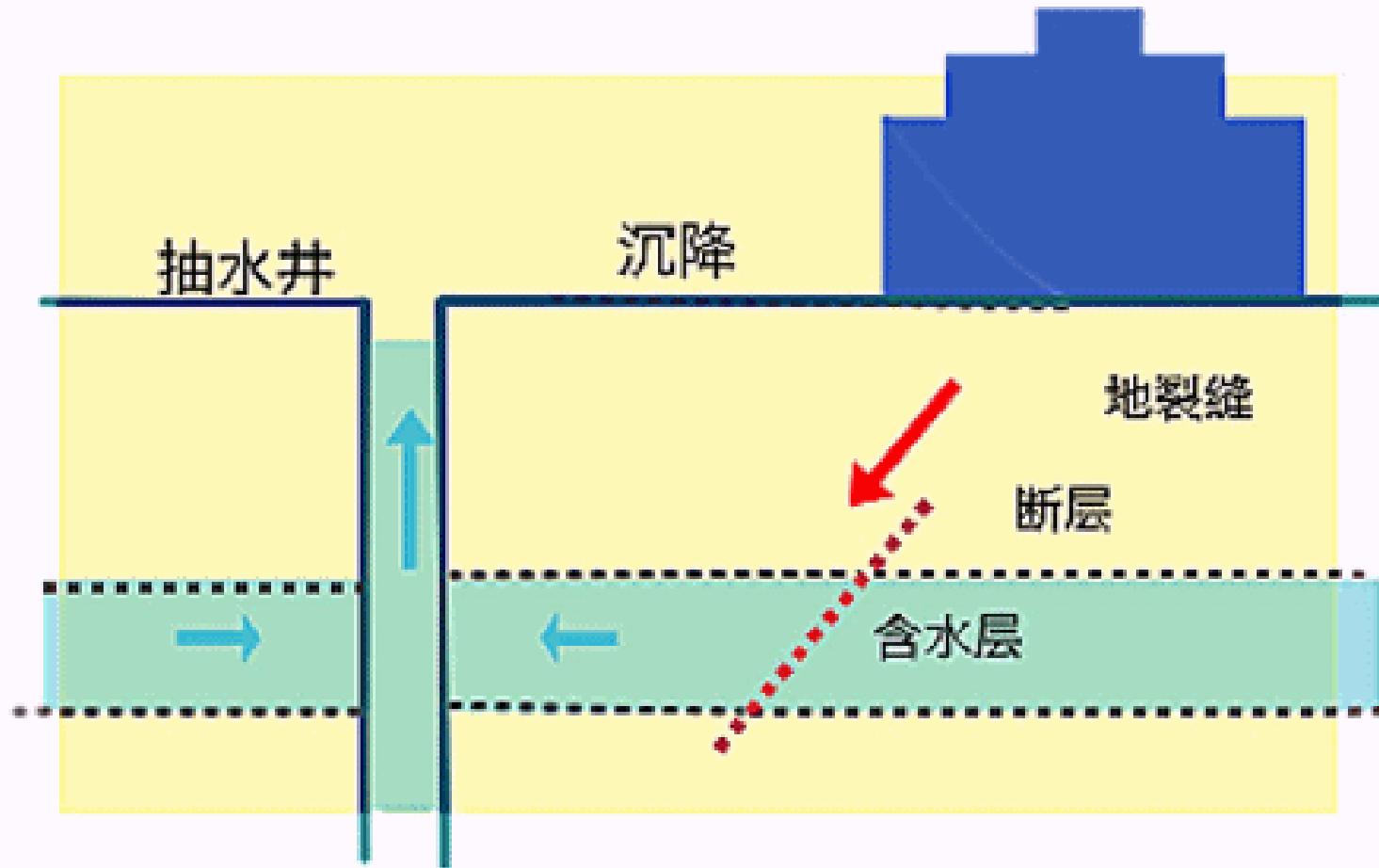
Main achievement

Pumping factor I: Differential settlement of the clay.



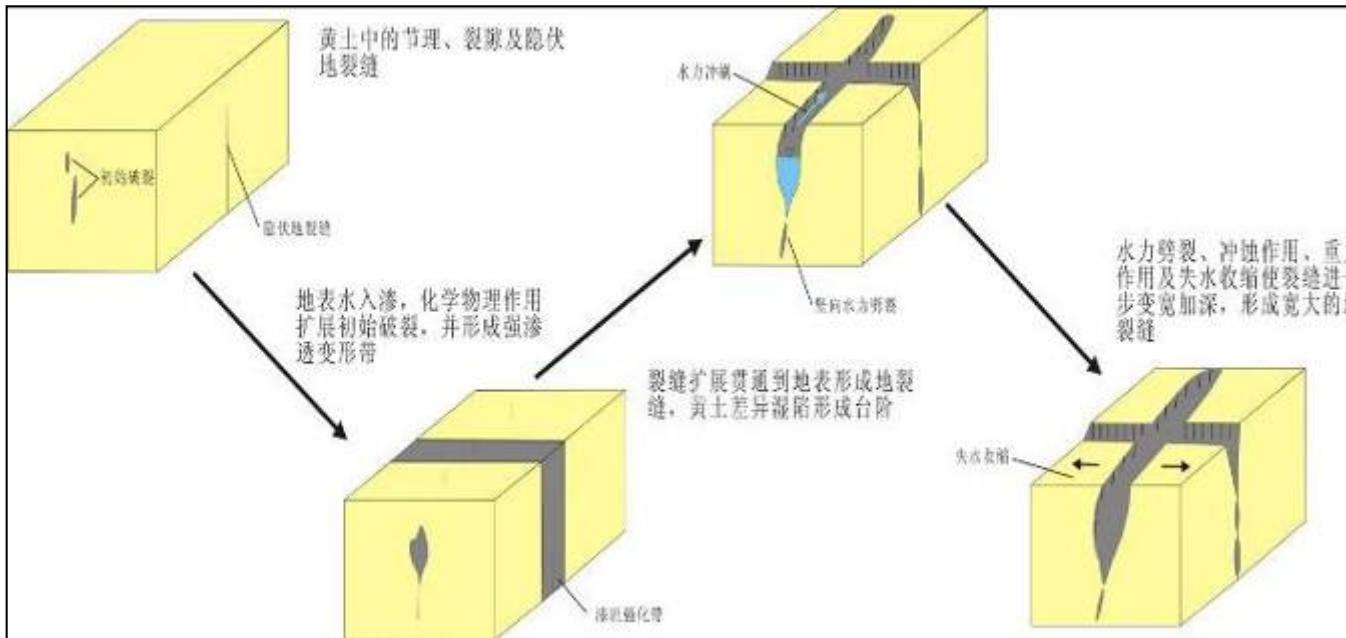
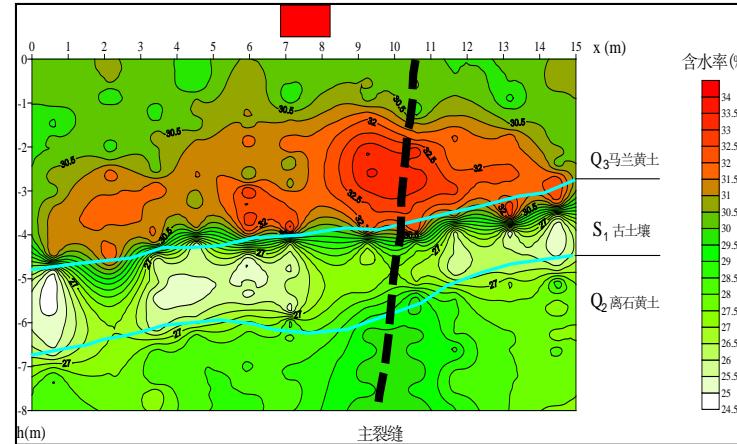
Main achievement

Pumping factor II: horizontal displacement of aquifer.



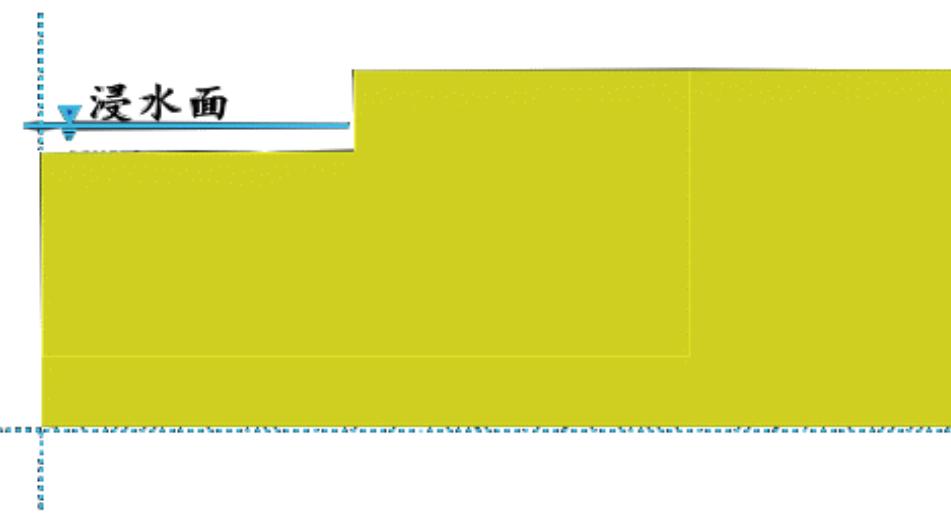
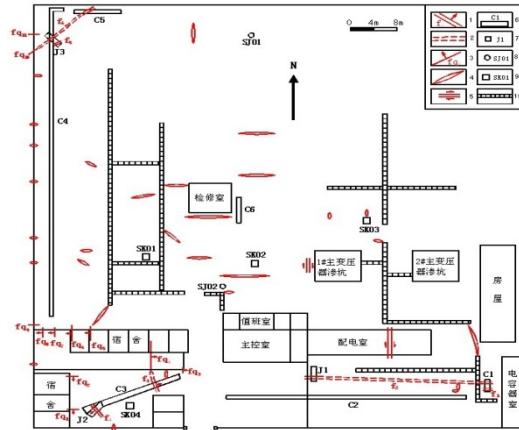
Main achievement

Water immersion factor I: Heavy rainfall infiltration.



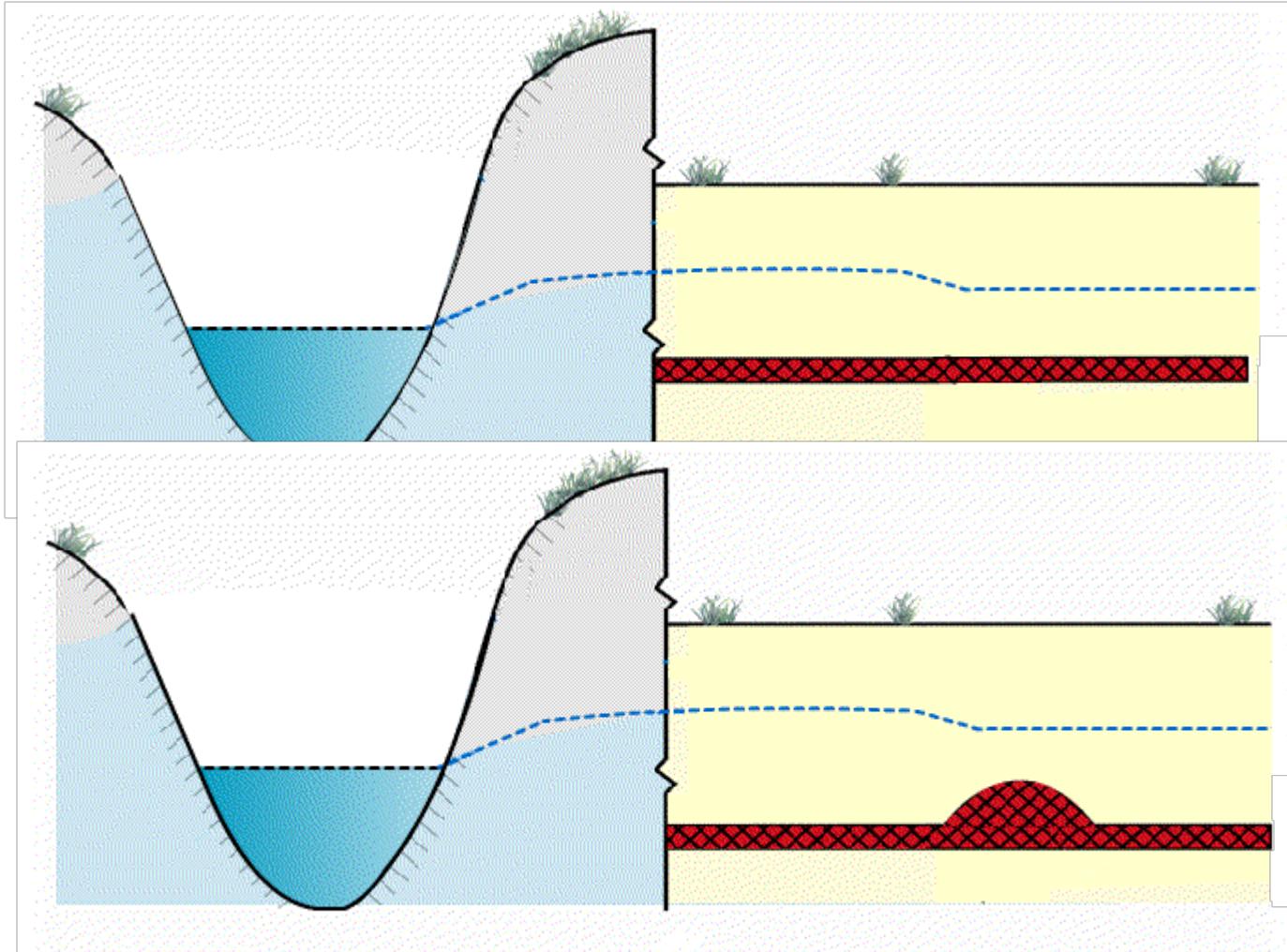
Main achievement

Water immersion factor II: Loess collapsibility.



Main achievement

Water immersion factor III: groundwater table rise and hydrocompaction.



Main achievement

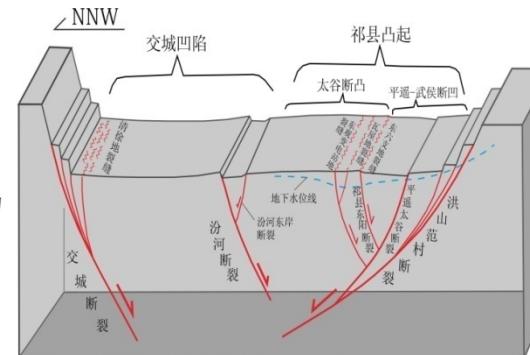
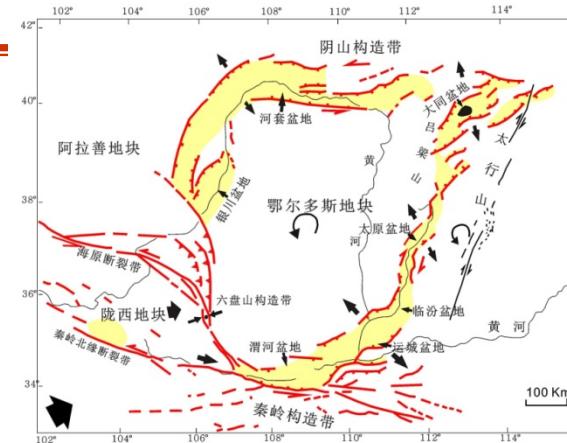
Genetic theory of ground fissure: tectonism, stress, pumping, and water immersion

Tectonism

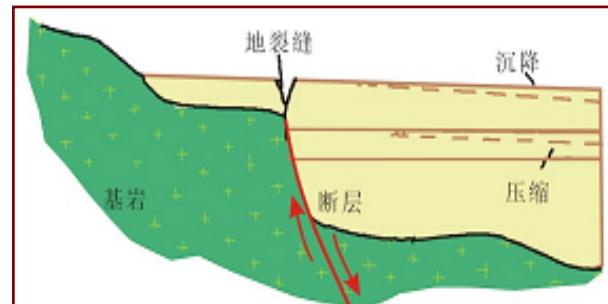
Region tectonism
→ planar distribution

Basin tectonism
→ zonal distribution

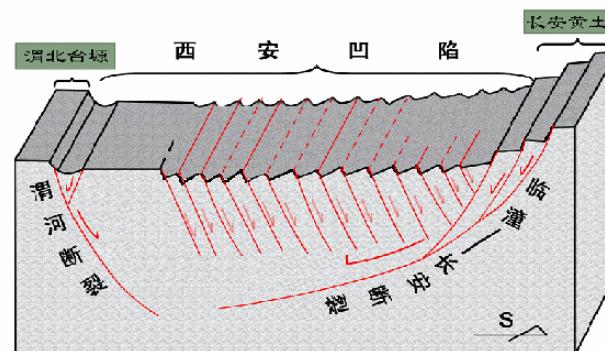
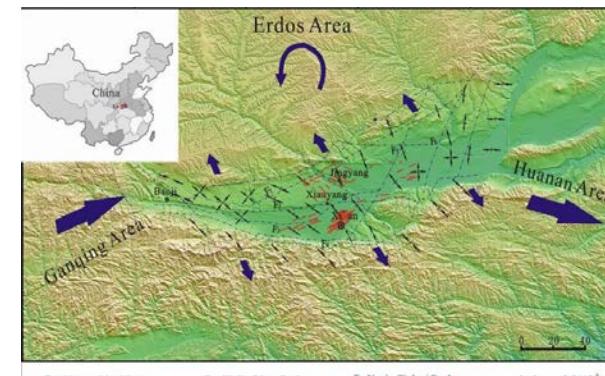
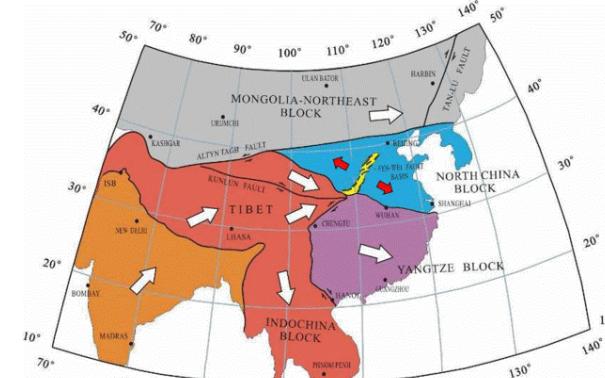
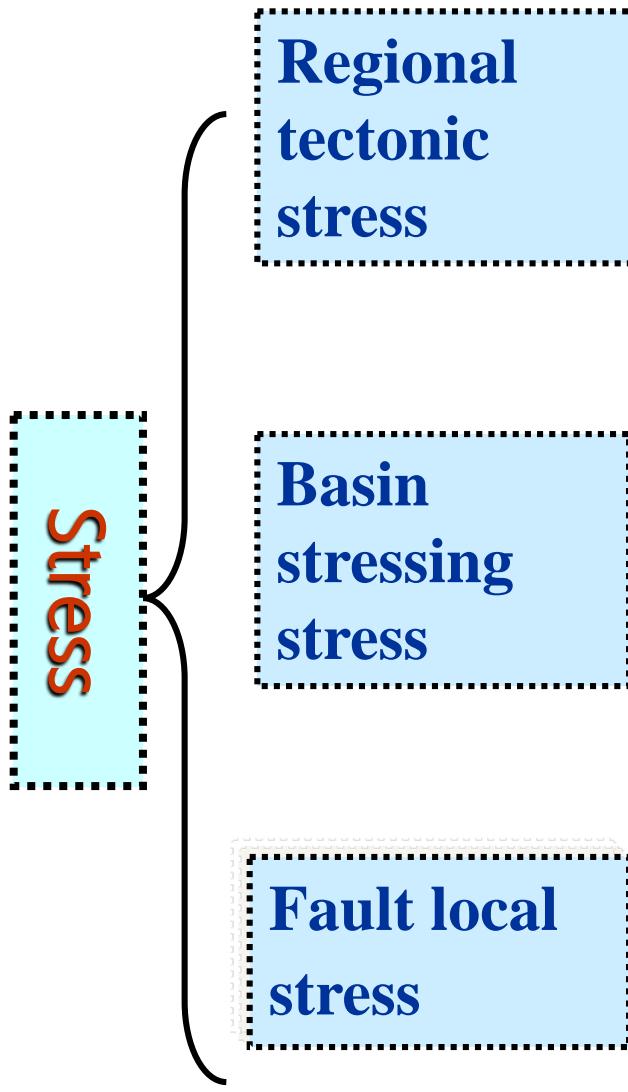
Fault tectonism → location



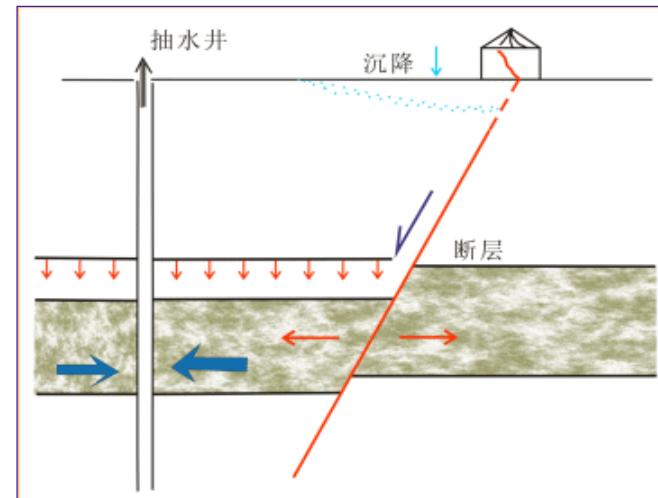
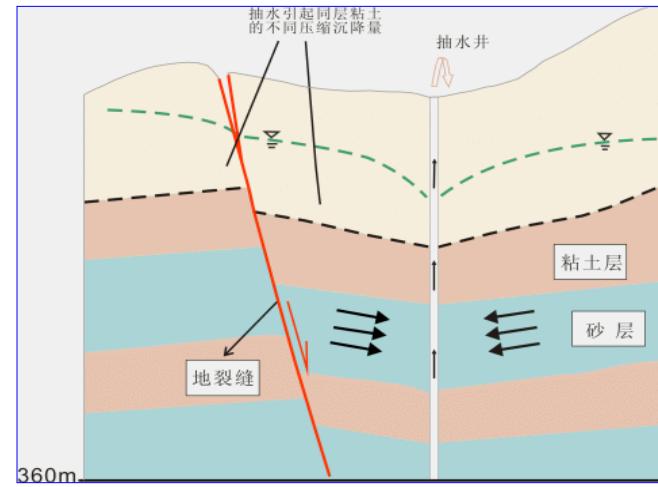
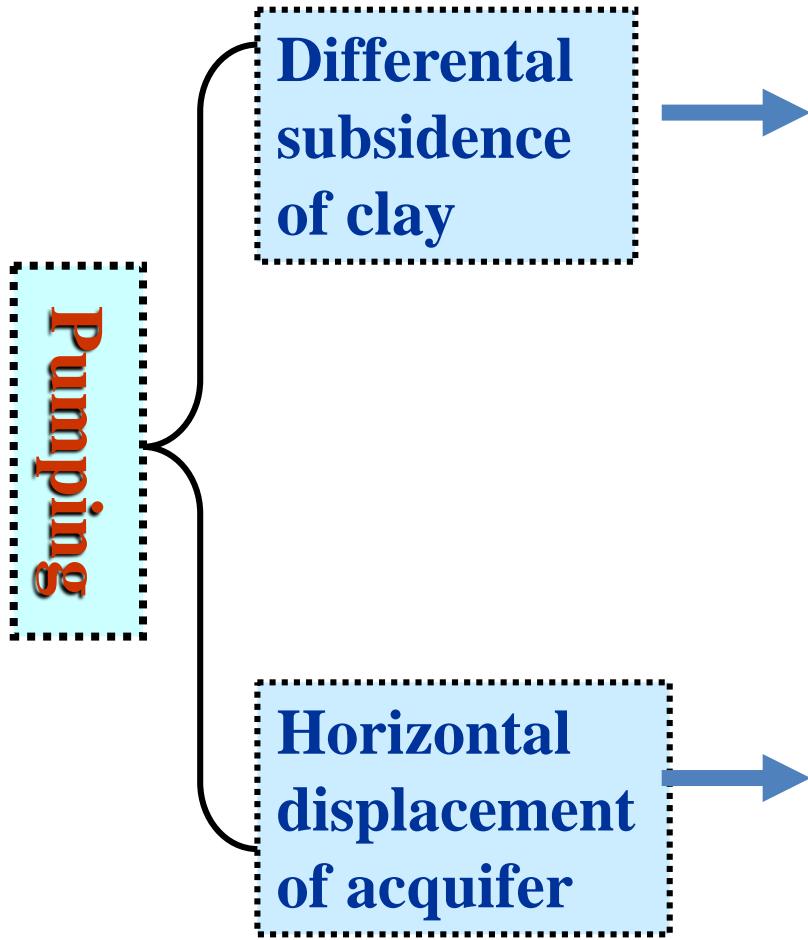
区域拉张应力



Main achievement



Main achievement



Main achievement

