Paleoseismic evidence for coseismic growth-fold in the 1999 Chichi earthquake and earlier earthquakes, central Taiwan

Wen-Shan Chen, Kun-Jie Lee, Long-Sheng Lee, et.al.
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Date : 2022/05/13

Outline

- **Introduction**
  - * Motivation and Purpose
  - * Characteristics of Chelungpu fault
- **Methodology**
  - * Paleoseismologic study by trench-wall observation
- **Results**
- **Discussion**
- **Conclusions**

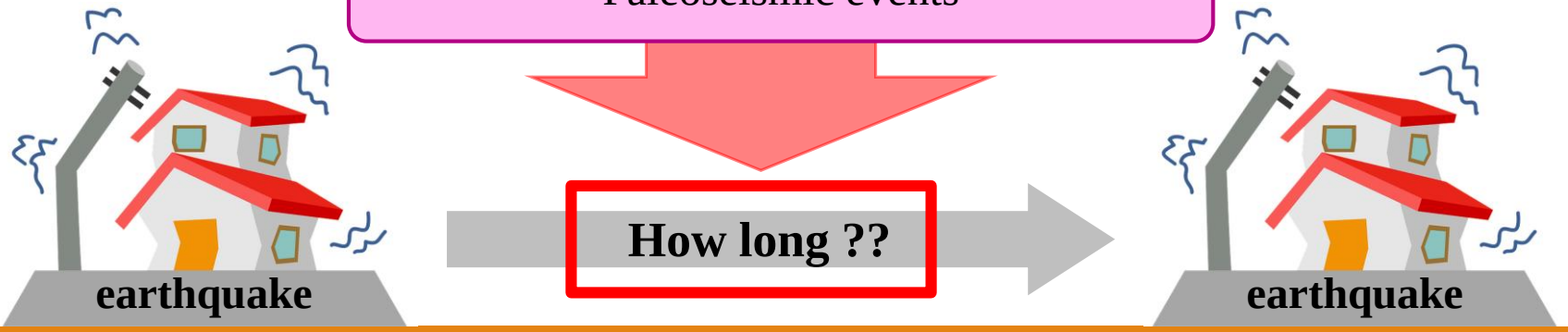
Motivation and Purpose

When the earthquake will repeat?

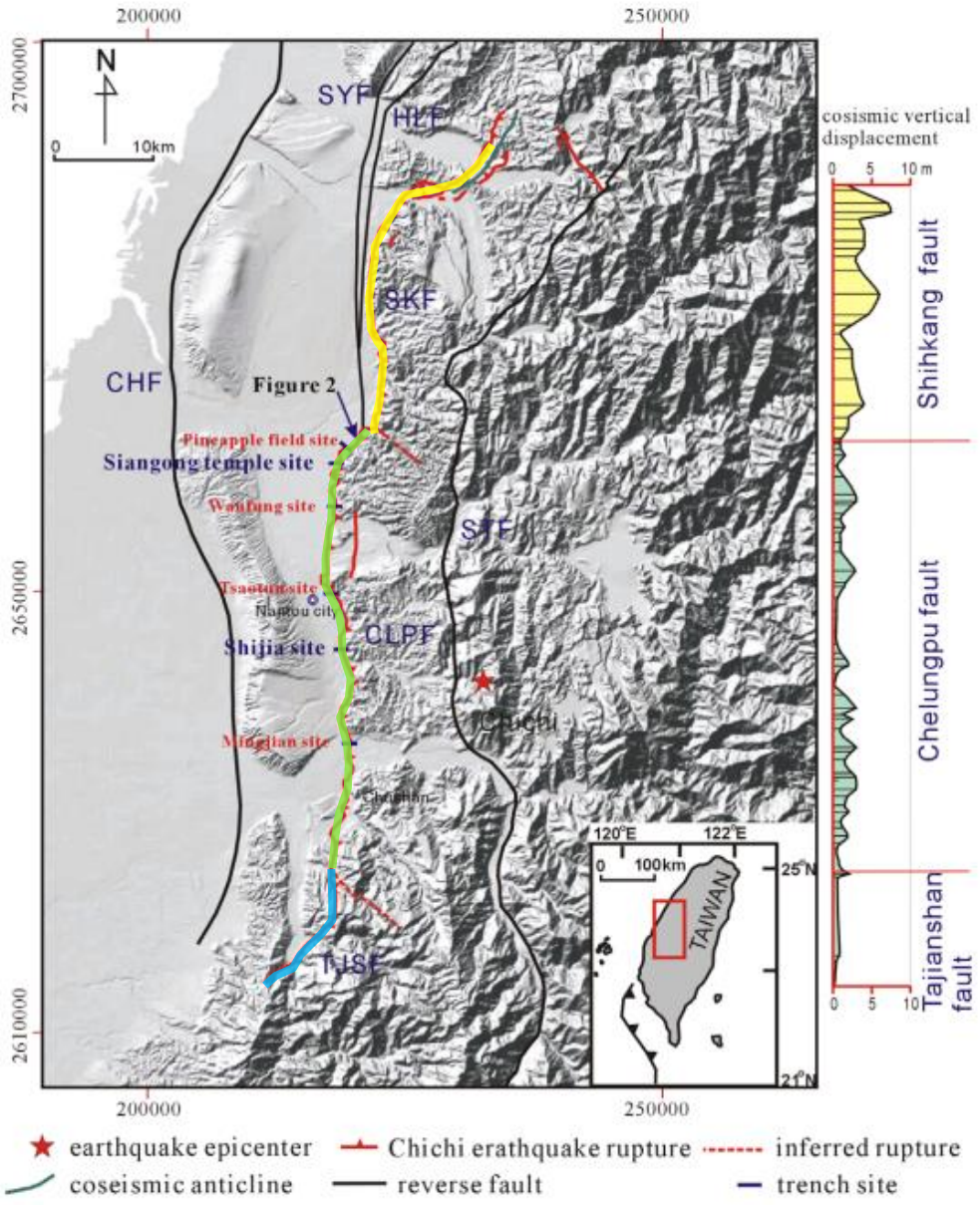
Understanding the fault activity is important

How to know the fault activity?

Paleoseismic events



Motivation and Purpose



The 1999 Chichi earthquake surface rupture dividing three segments with different slip directions and vertical displacements.

Shihkang fault (SKF) :
N30°~40°W, 3~8m

Chelungpu fault (CLPF) :
N70°~90°W, 0.2~4m

Tajianshan fault (TJSF) :
N50°E (strike slip fault), 0.2~1m

(Chen et al., 2001)

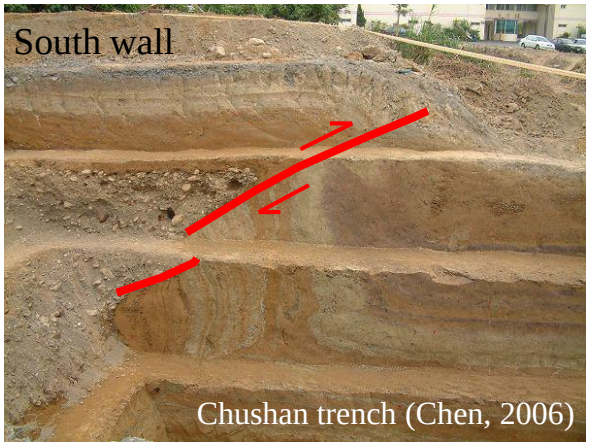
Paleoseismologic study

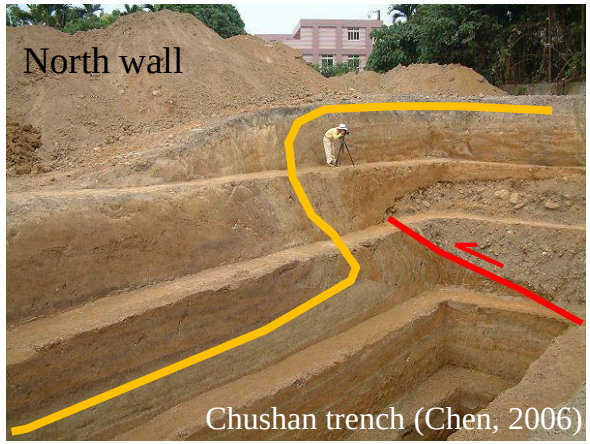
Repeated coseismic displacements commonly displace Holocene sediments forming a scarp.

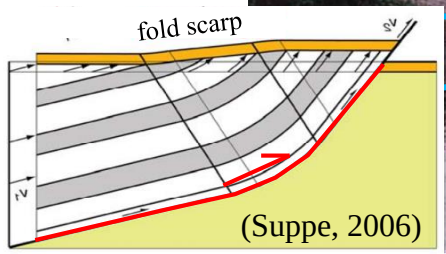
Fault scarp

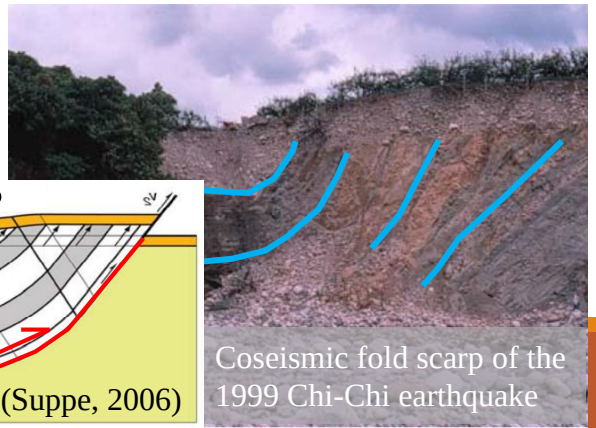
Fault/Fold scarp?

Fold scarp









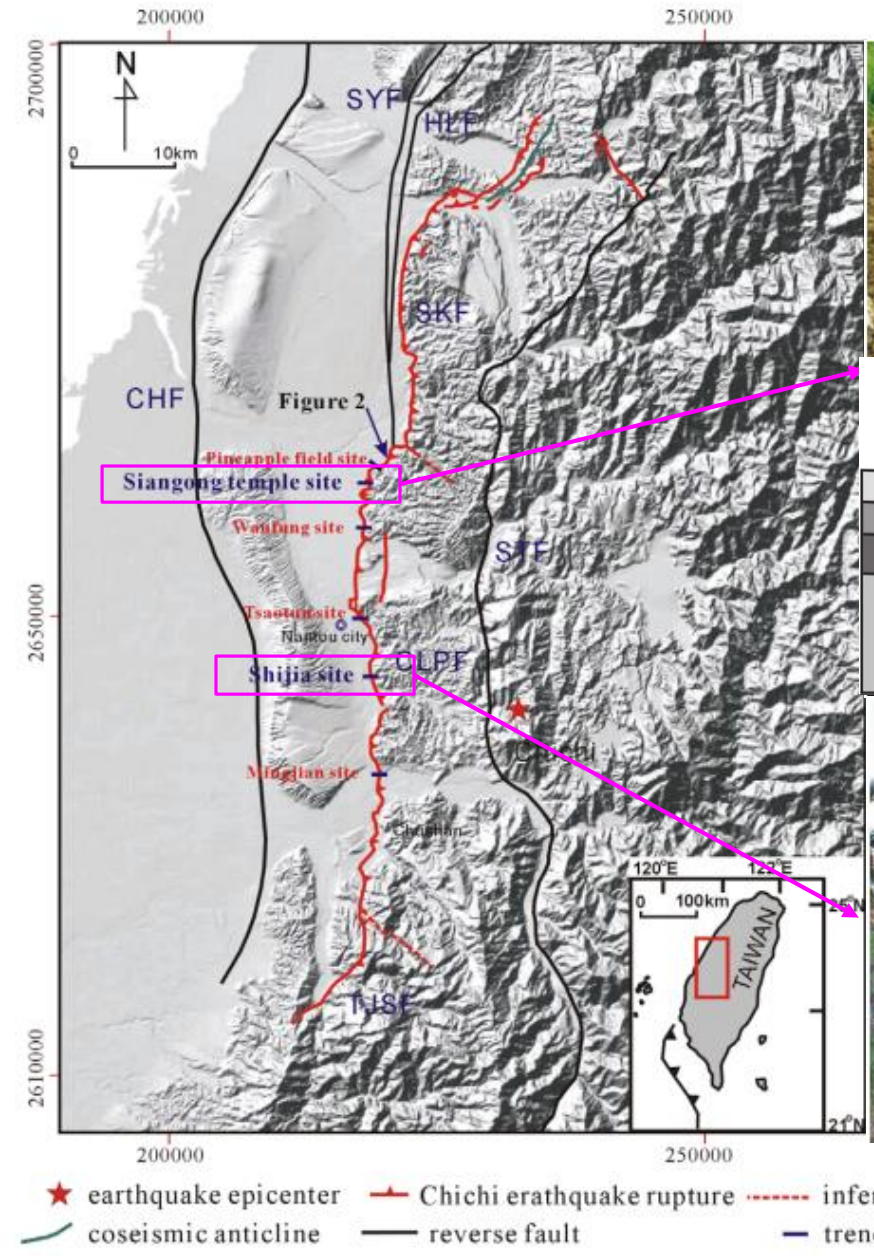
However, it was difficult to determine if these scarps were fault or fold related.

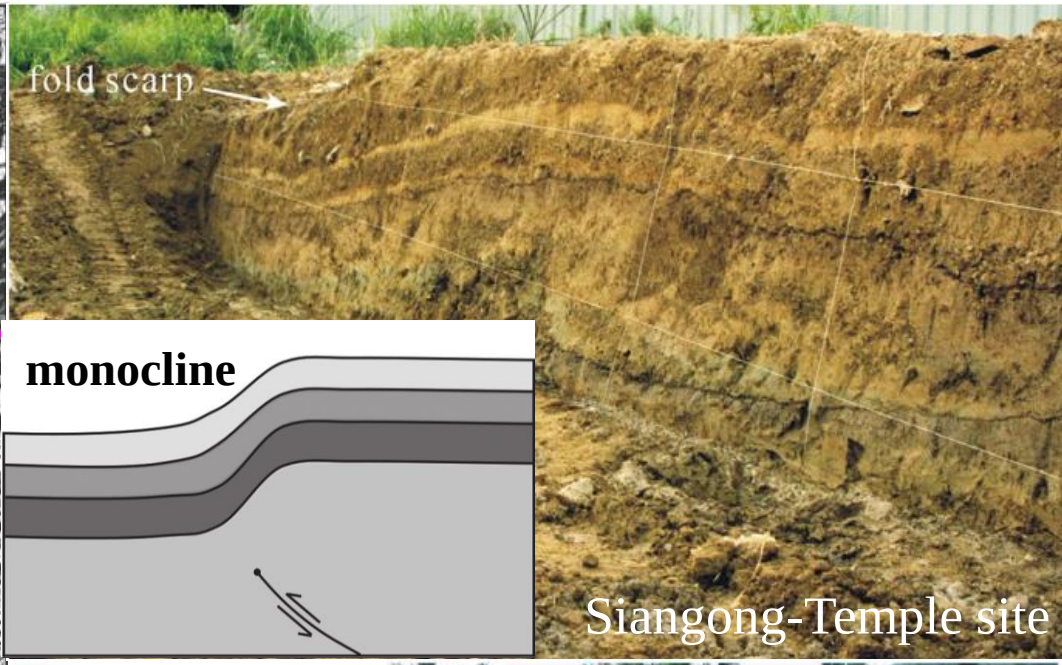
Paleoseismologic study

Repeated coseismic displacements commonly displace Holocene sediments forming a scarp.

However, it was difficult to determine if these scarps were fault or fold related.

- trench-wall observations
- Relationship between structures and sediments
- Radiocarbon dating of the disturbed sediments
- Paleoseismic events


200000
250000
2700000
2650000
2610000
N
0
10km
SYF
HLF
SKF
CHF
Figure 2
Pineapple field site
Siangong temple site
Wanfang site
SYF
Tsaotun site
Nantou city
CLPF
Shijia site
Minglian site
Chushan
TJSF
120°E
122°E
0
100km
TAIWAN
25°N
21°N
200000
250000
earthquake epicenter
Chichi erathquake rupture
inferred rupture
coseismic anticline
reverse fault
trench site

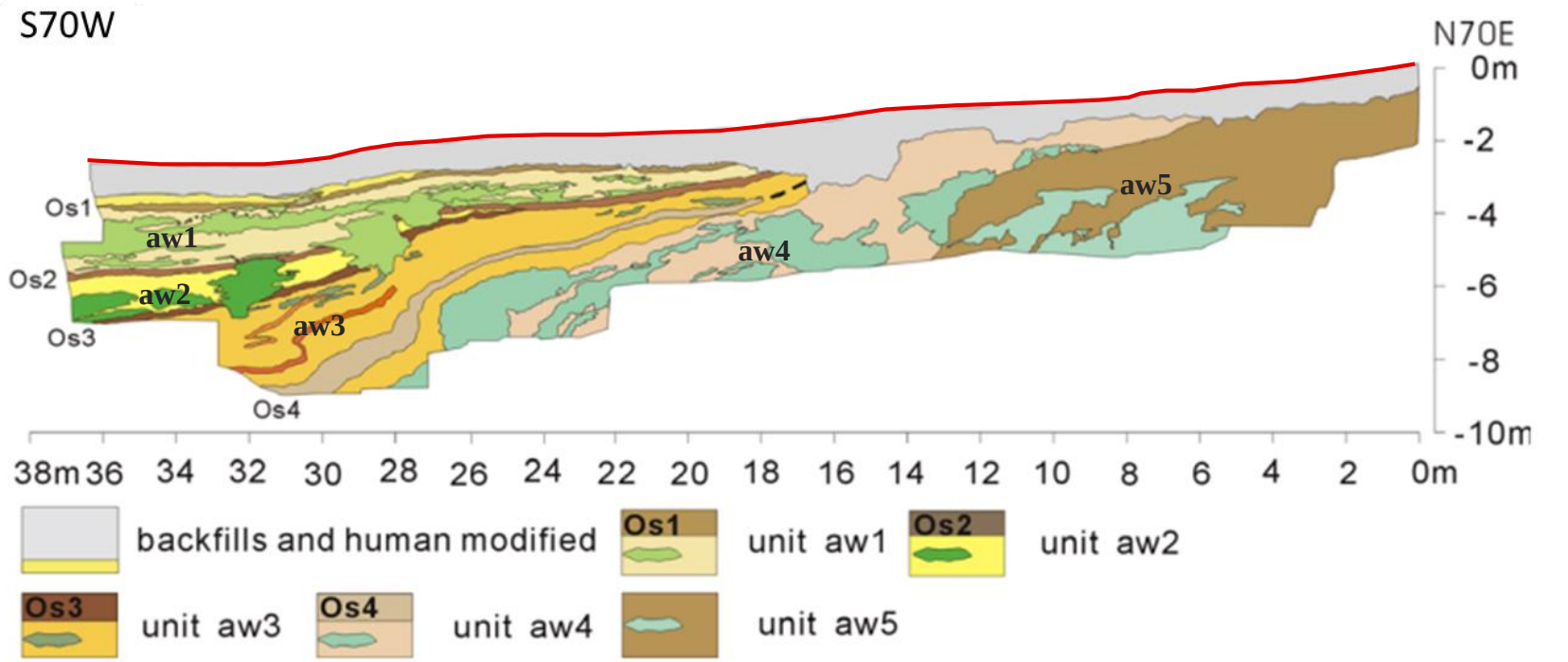

fold scarp
monocline
Siangong-Temple site


west
east
fold scarp
Shijia site

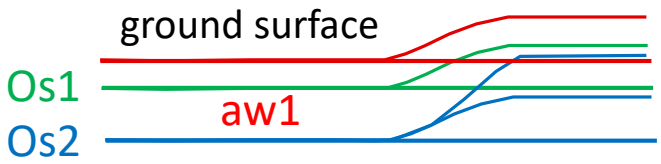
Siangong-Temple site

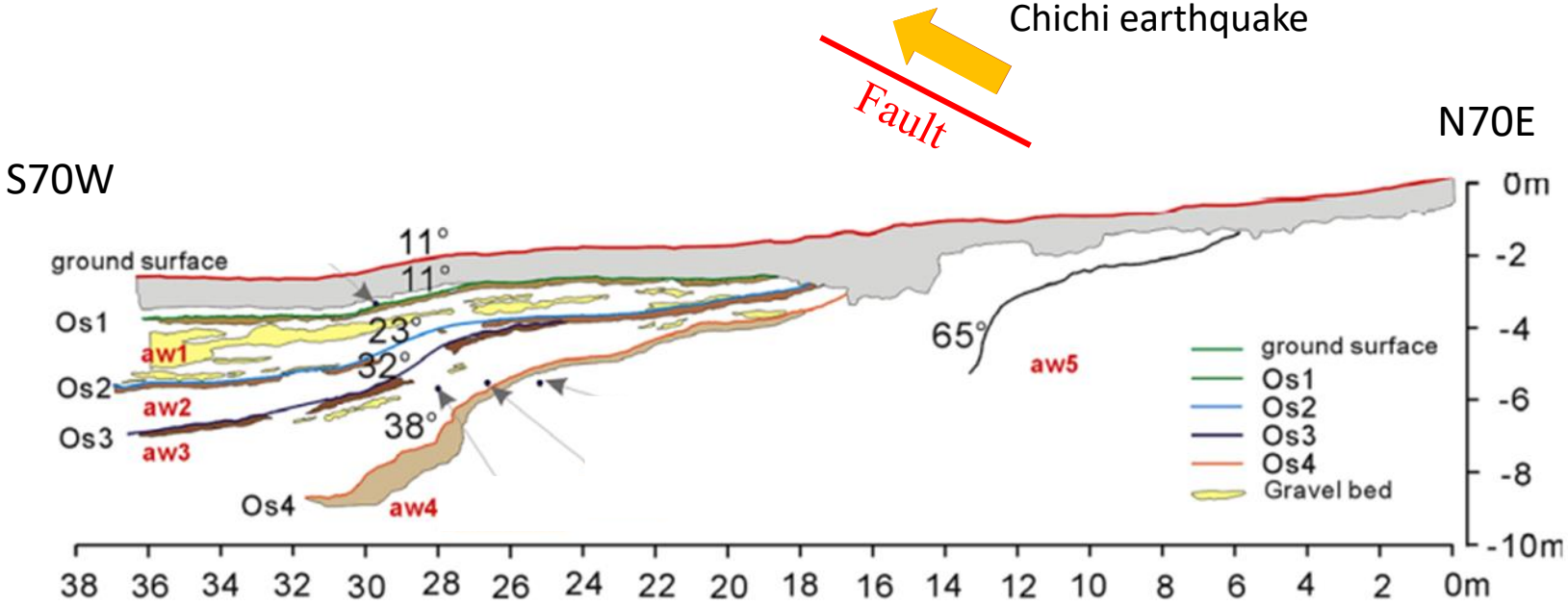
Trench-wall exposures consist of five alluvial units that formed a wedge-shaped deposit (aw1, aw2, aw3, aw4 and aw5).

In this trench-wall, four distinctive paleosoils (Os1, Os2, Os3, and Os4) which bound three alluvial wedges (aw1,aw2, and aw3) can represent three episodic seismic events.



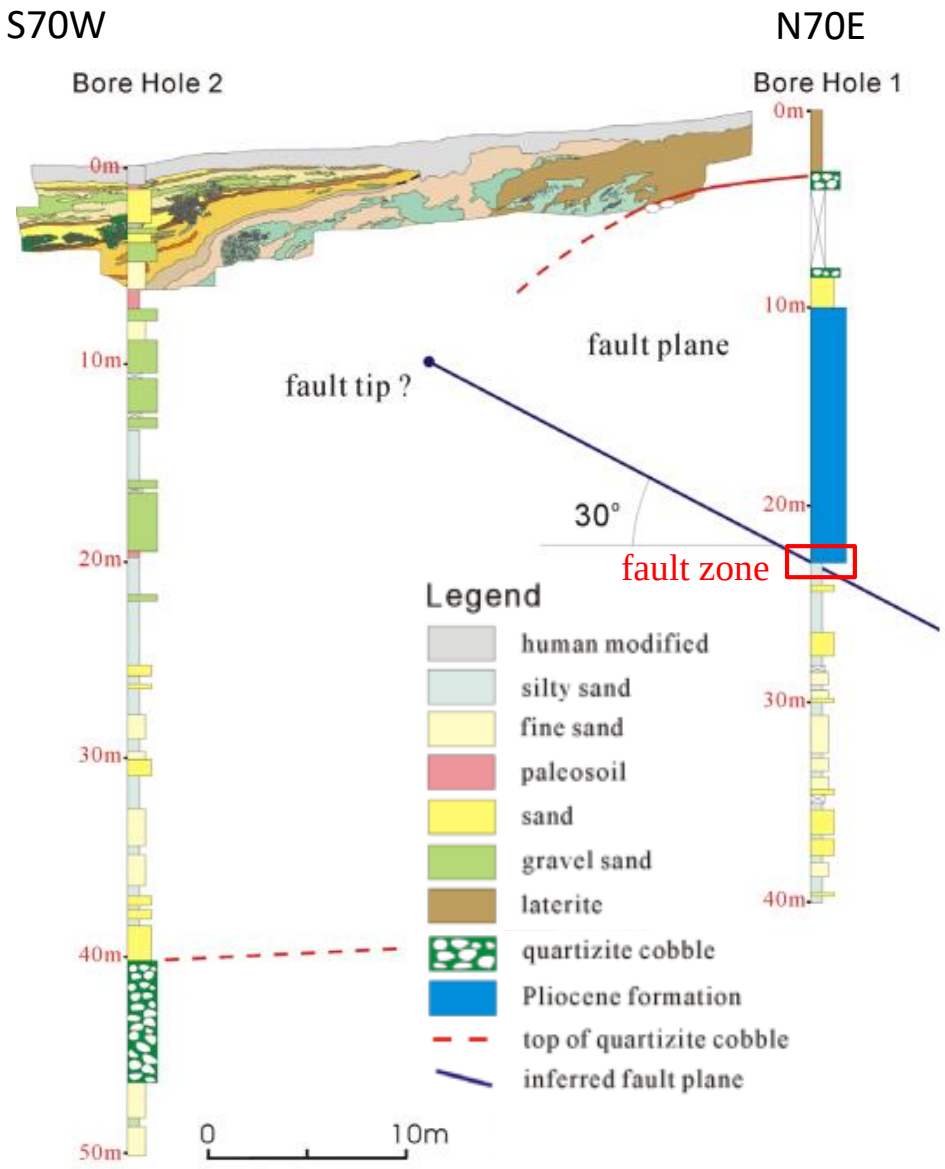
The dips of paleosoil layers in the forelimb increase from 11° at the ground surface to 38° at the lower paleosoil layer (Os4). ➡ repeated coseismic deformation





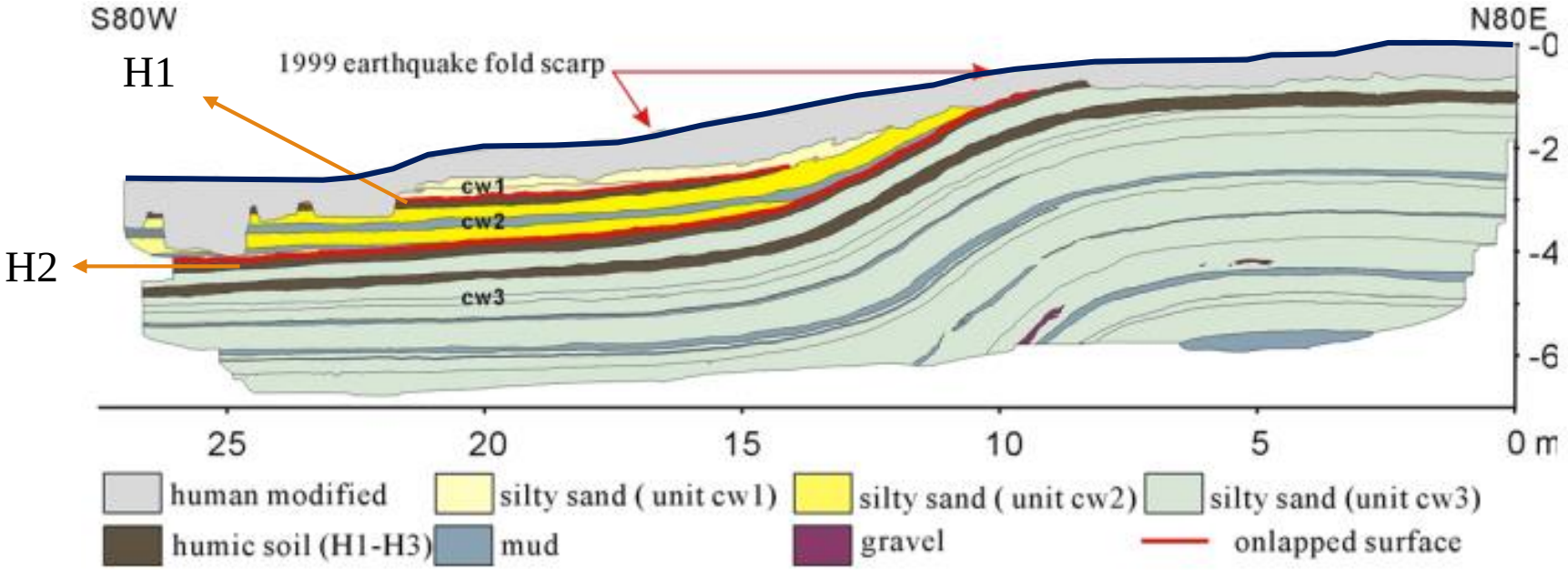
Two continuously cored borings were drilled to depth of 40 m on the hanging wall and 50 m on the footwall.

The cored borings constrain the location of the fault zone on the hanging wall at a depth of 22.8 m between Pliocene shale and late Pleistocene–Holocene alluvial deposits.

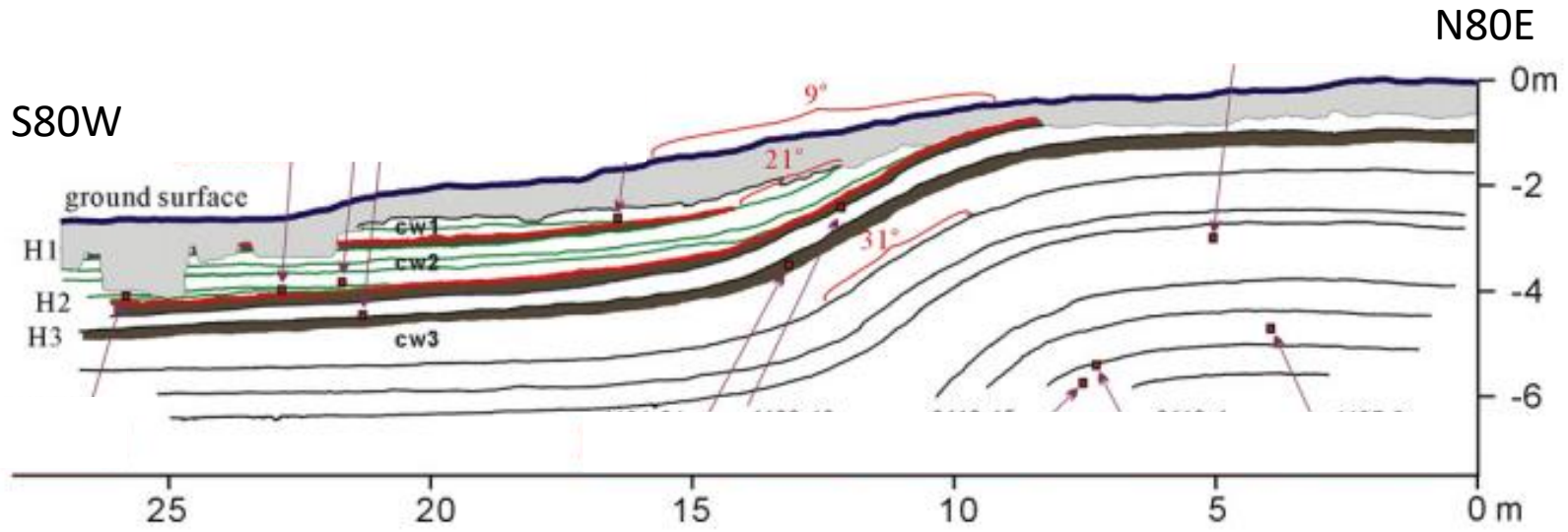


Shijia site

Trench-wall exposures show three depositional units (cw1, cw2, and cw3) defined by onlap of humic paleosoil horizons (H1 and H2).

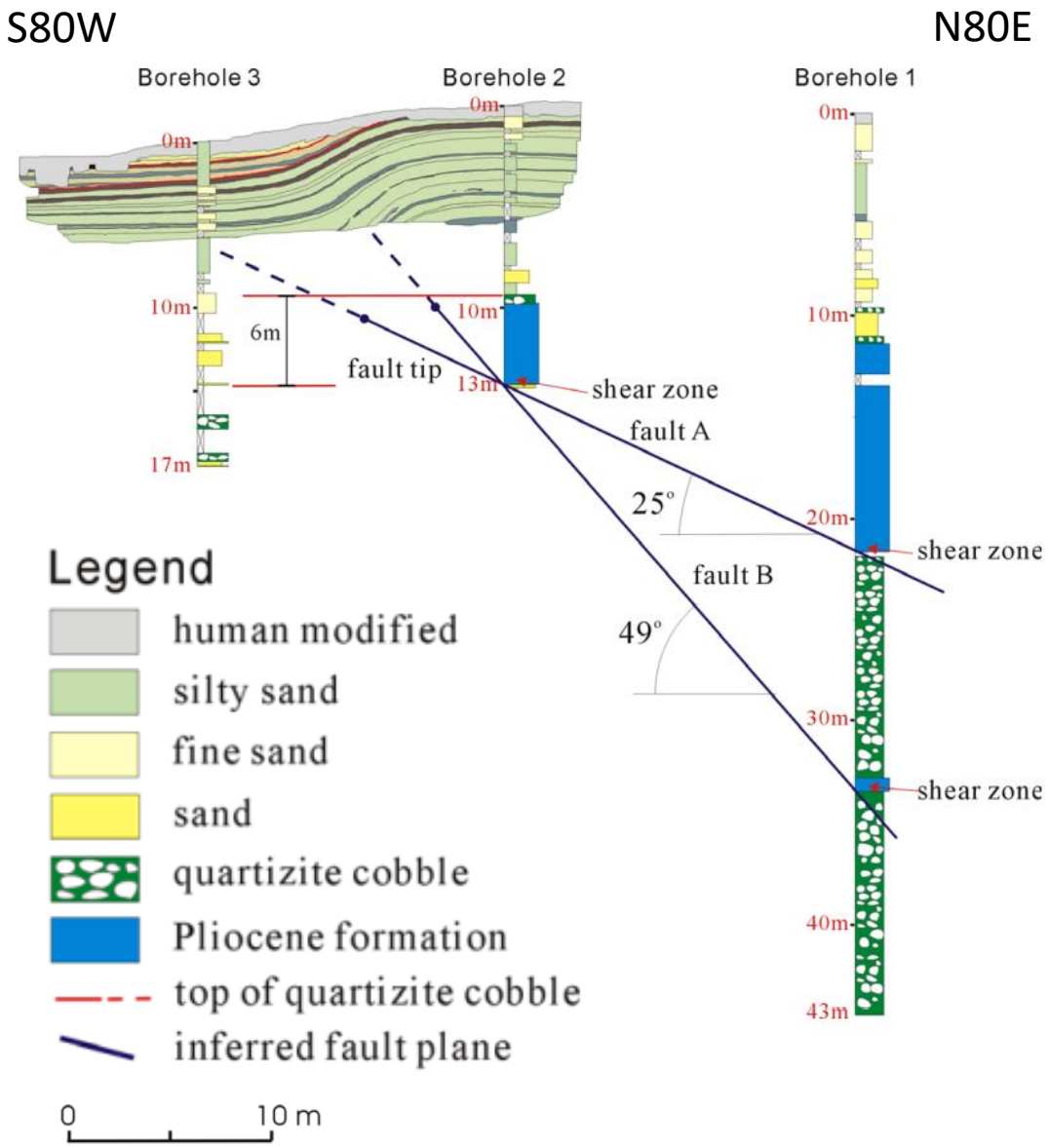


Palesoils dip within the forelimb increases from 9˚ to 31˚.



Three continuously cored borings drilled to depth of 13 and 43 m on the hanging wall and to 17 m on the footwall provide further subsurface constraint.

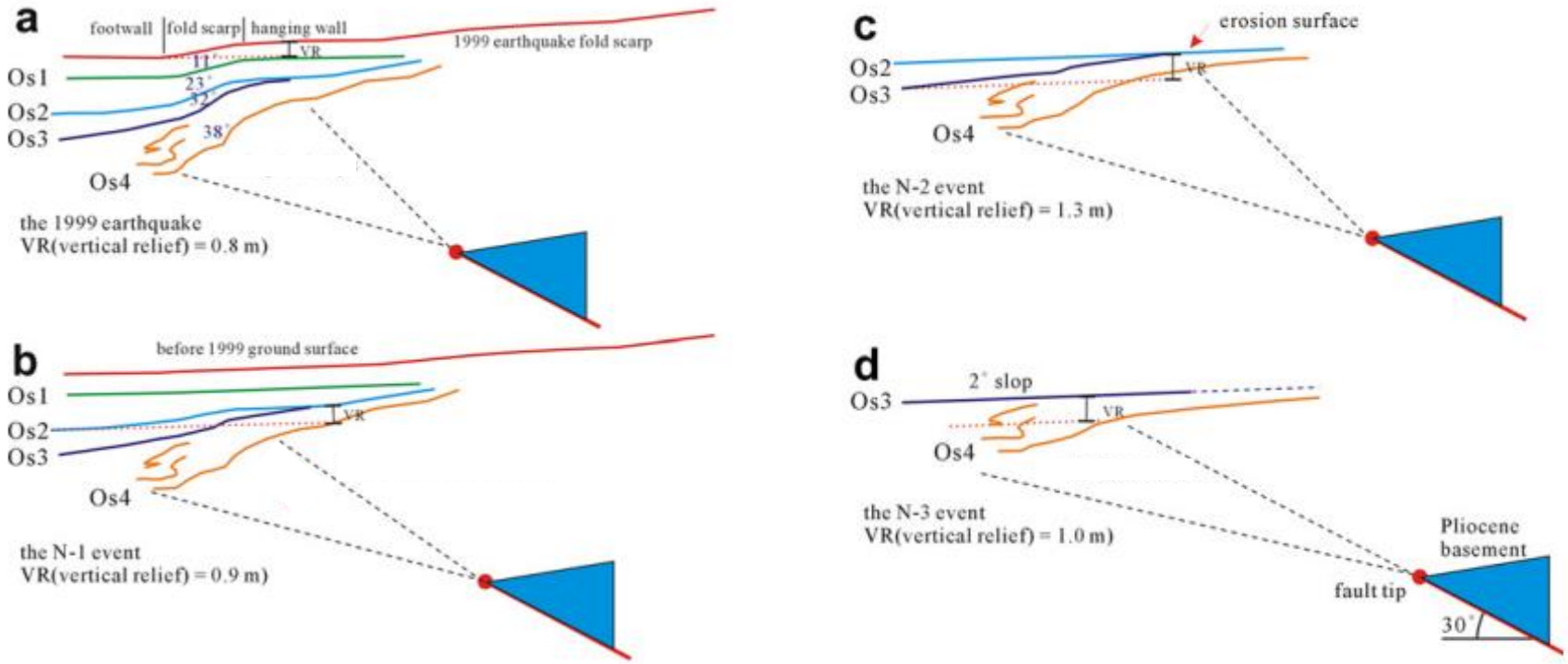
Shear zones are located at a depth of 13 m in borehole 2 and at 20.7 and 33 m in borehole 1.



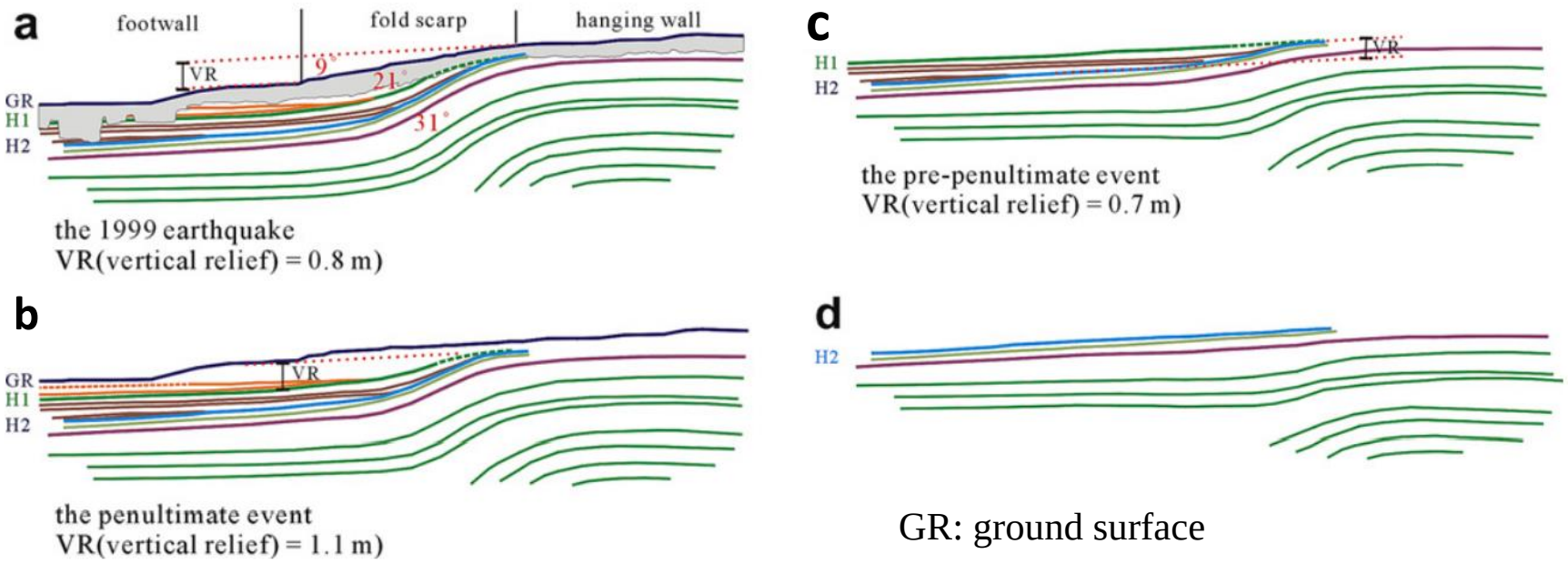
Restoration of fault scarp surface (Siangong-Temple site)

Retrodeformation of the fanning paleosoils (Os1, Os2, Os3, Os4) which dip within the forelimb can provide a record of paleoearthquakes.

1.constant line length
2.constant strata thickness



Restoration of fault scarp surface (Shijia site)

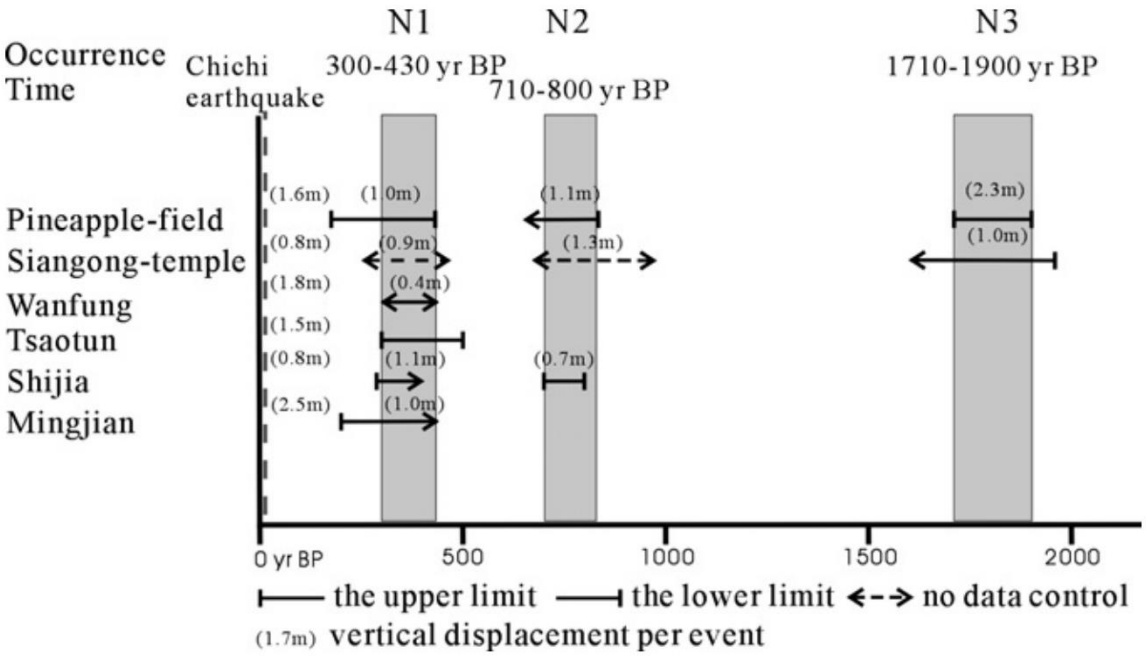


GR: ground surface

H1、H2: paleosoils

Conclusions

Results of the paleoseismological analyses can be identified three large paleoearthquake events occurring 300–430, 710–800, and 1710–1900 yr B.P.



Conclusions

The vertical offsets of Chichi earthquake and three paleoearthquake events

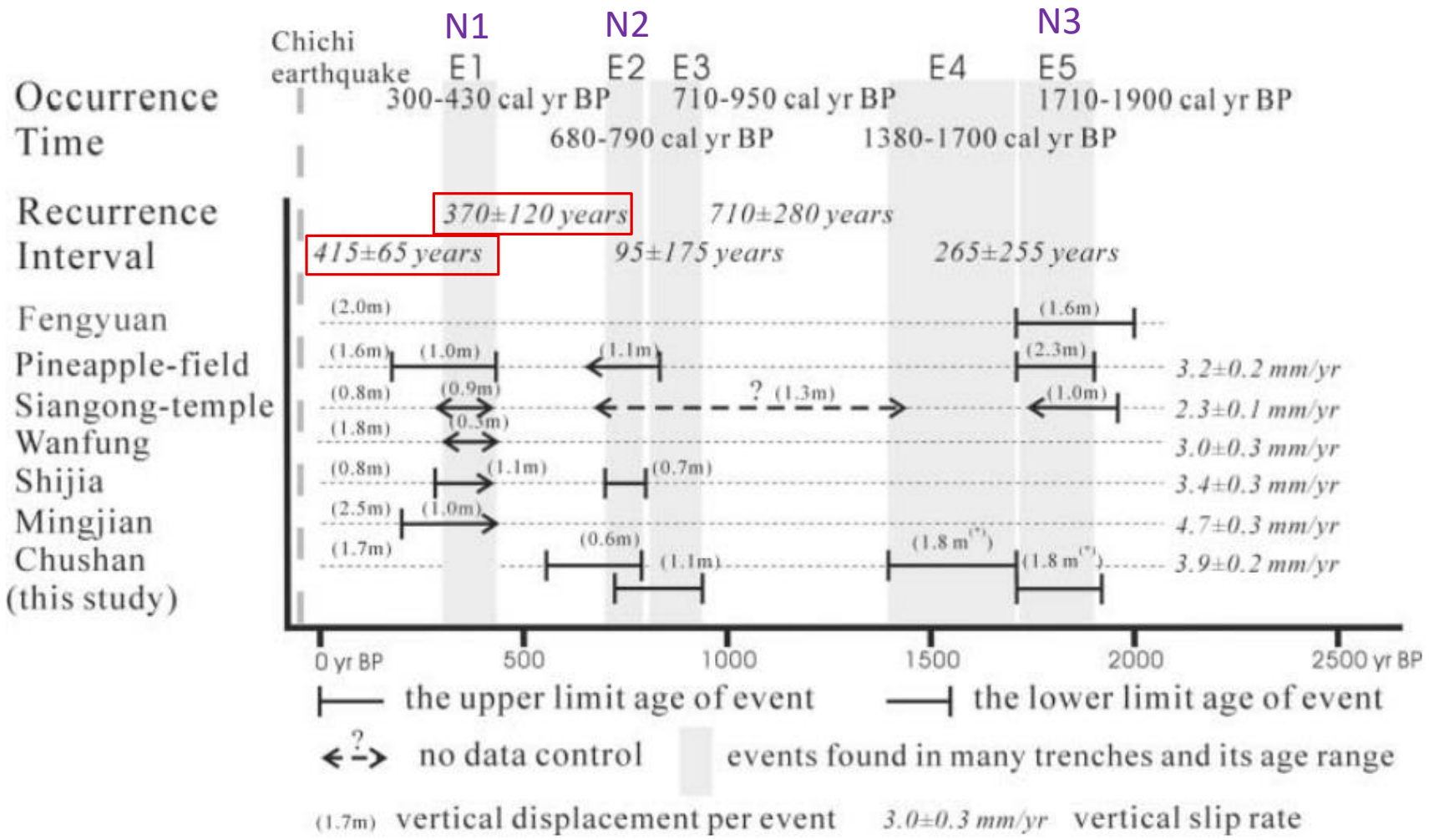
	1999 Chichi earthquake	N1 (300–430 yr B.P.)	N2 (710–800 yr B.P.)	N3 (1710–1900 yr B.P.)
Siangong-Temple	0.8m	0.9m	1.3m	1.0m
Shijia	0.8m	1.1m	0.7m	

The slip rate on the Siangong-Temple and Shijia sites is thus 4.2 and 4.5 mm/yr, respectively.

Time during N1 and N2 event ≈ 400 yr
Fault dip angle : 30°

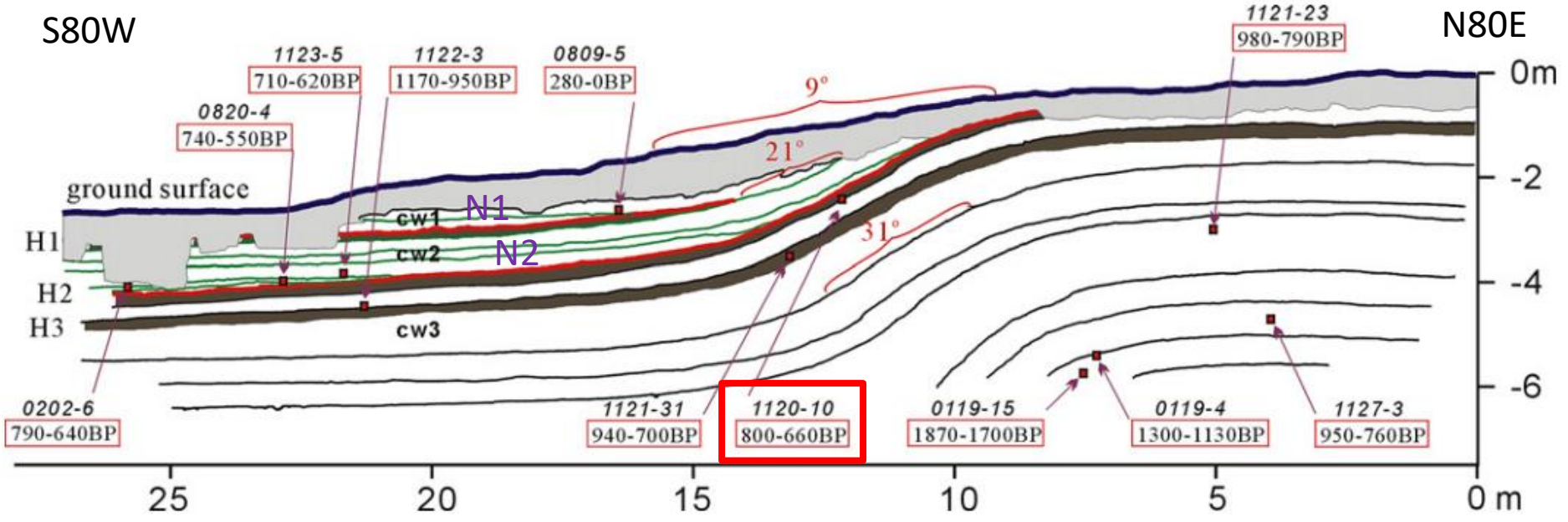
→ Estimated vertical offset in N1 event
= 4.2*400*sin30° = 840mm = 0.84m

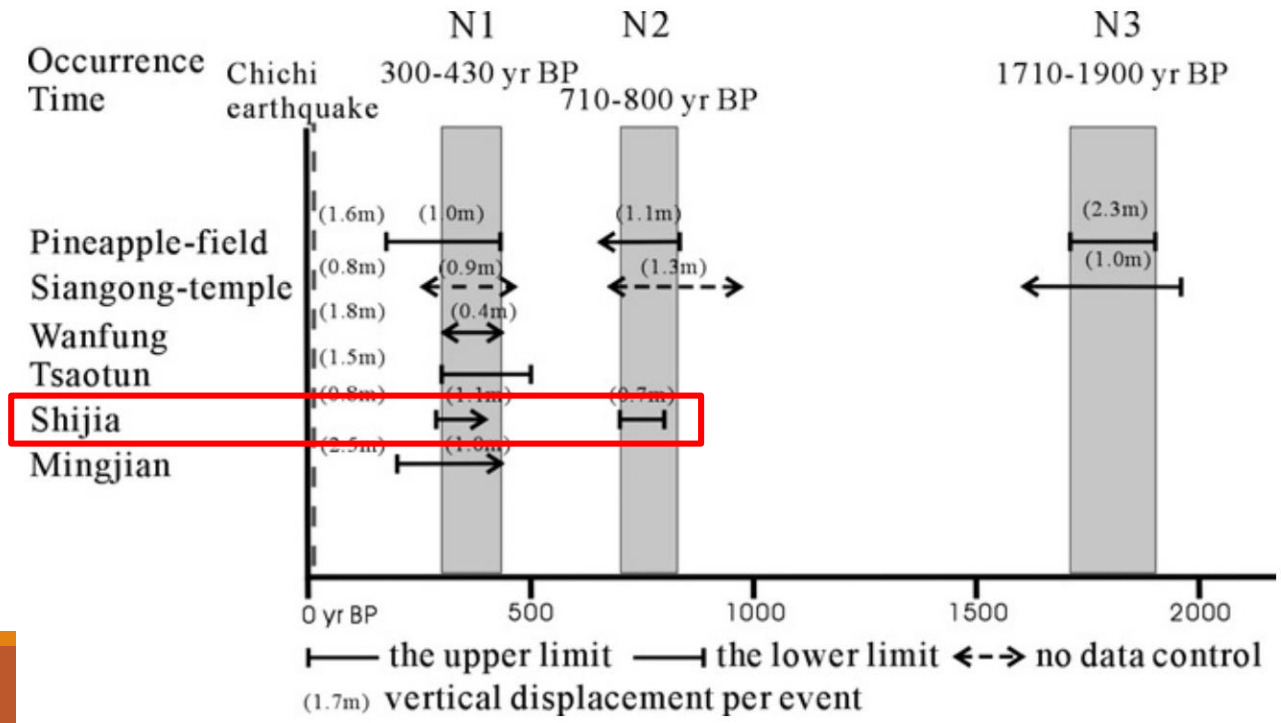
Thanks for your attention ~

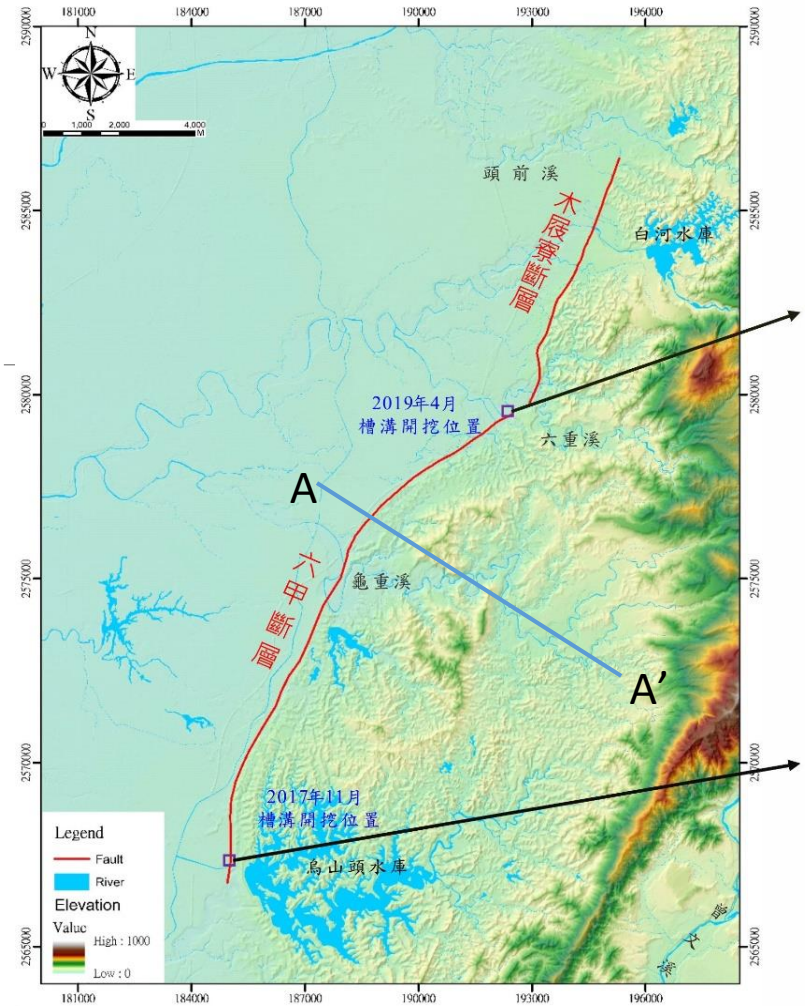


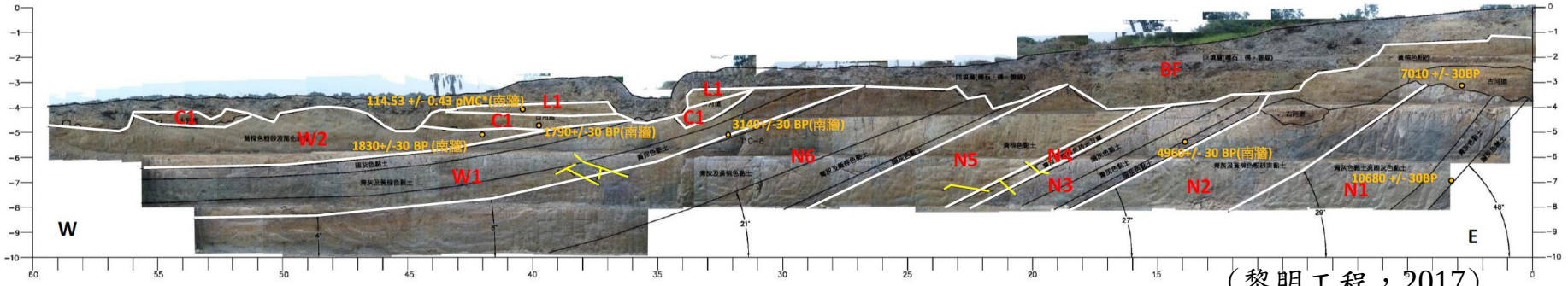
The intervals in the past 2 ka have a maximum of about 700 years and a minimum of about 100 years.

The long-term vertical slip rate of the Chelungpu fault has been estimated as 2.8–5.0 mm/yr in the past 67 ka (Y. G. Chen et al., 2003).


S80W
N80E
1123-5
710-620BP
1122-3
1170-950BP
0809-5
280-0BP
1121-23
980-790BP
0820-4
740-550BP
9°
21°
31°
ground surface
N1
N2
cw1
cw2
cw3
H1
H2
H3
0m
-2
-4
-6
0202-6
790-640BP
1121-31
940-700BP
1120-10
800-660BP
0119-15
1870-1700BP
0119-4
1300-1130BP
1127-3
950-760BP
25
20
15
10
5
0 m


N1
N2
N3
Occurrence Time
Chichi earthquake
300-430 yr BP
710-800 yr BP
1710-1900 yr BP
Pineapple-field
Siangong-temple
Wanfung
Tsaotun
Shijia
Mingjian
(1.6m)
(1.0m)
(1.1m)
(2.3m)
(0.8m)
(0.9m)
(1.3m)
(1.0m)
(1.8m)
(0.4m)
(1.5m)
(0.7m)
0 yr BP
500
1000
1500
2000
the upper limit
the lower limit
no data control
(1.7m) vertical displacement per event

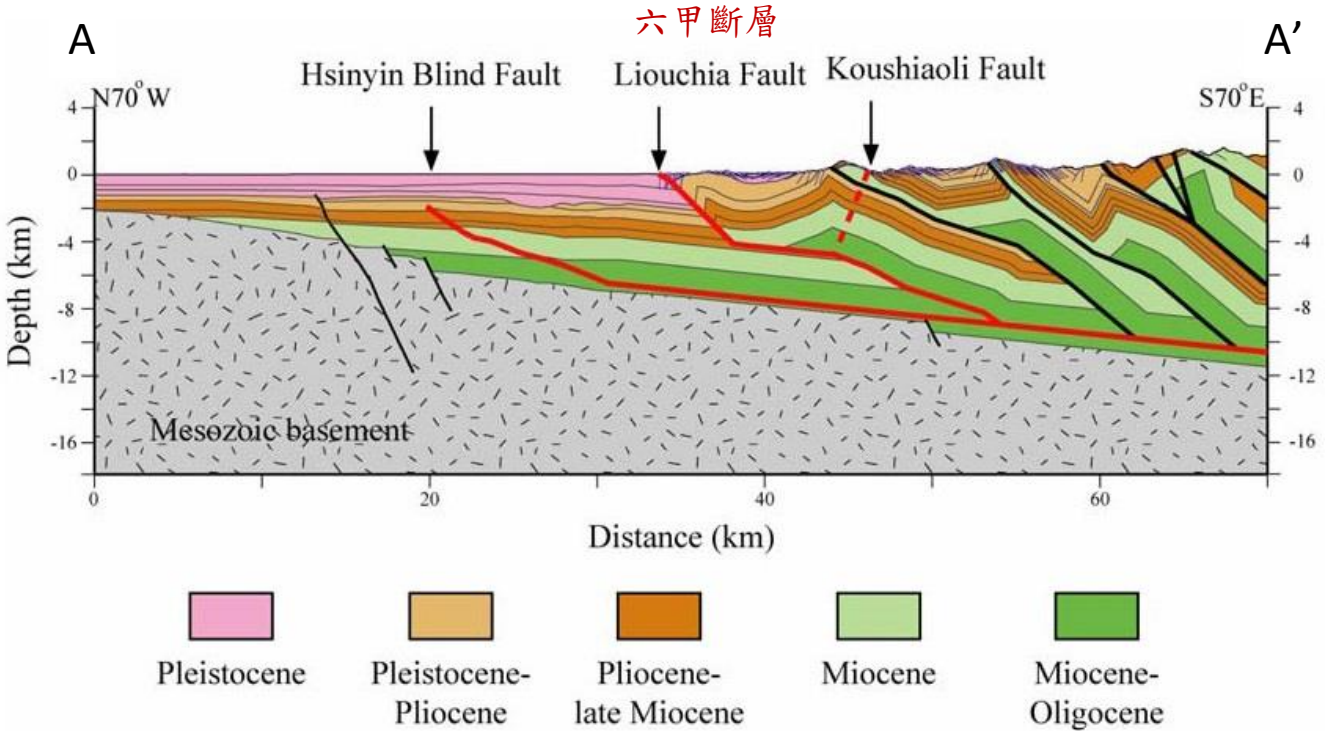




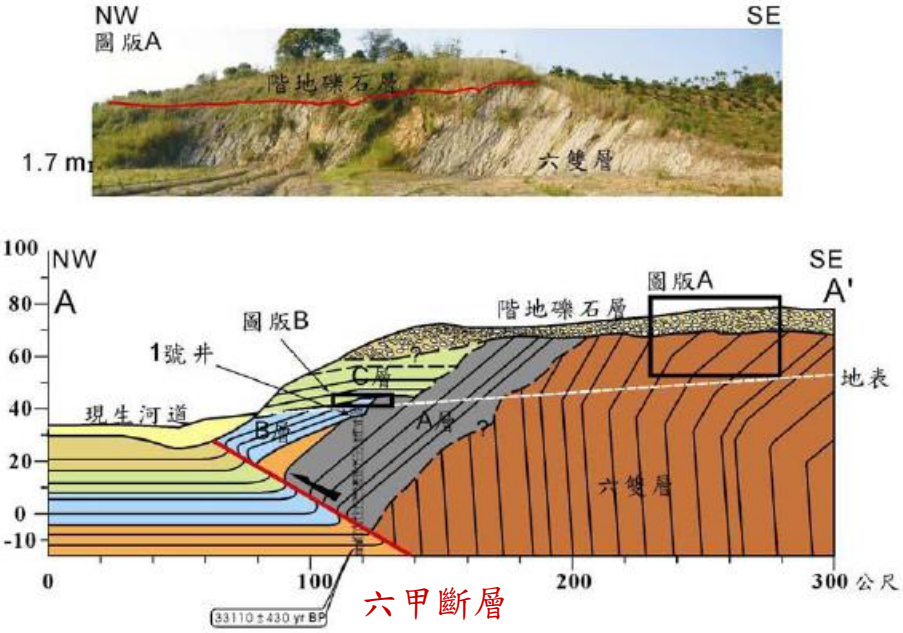
（黎明工程，2017）

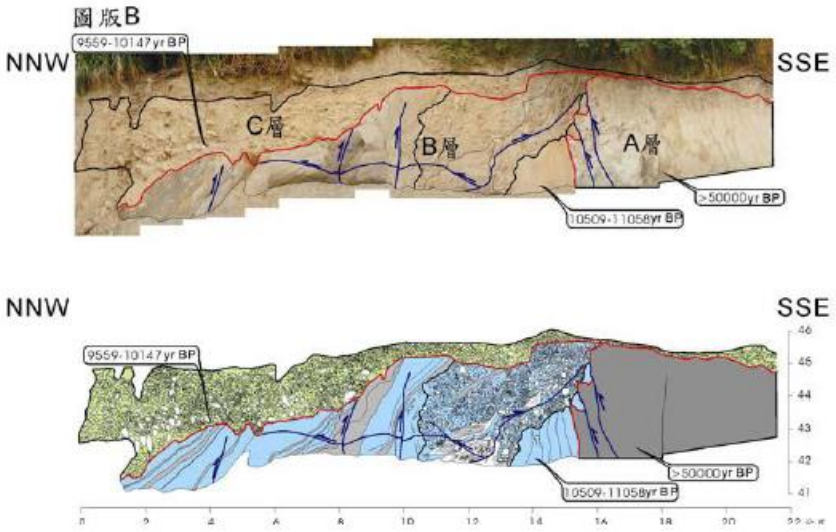
圖 3-7-6 烏山頭電廠槽溝地層剖面圖

❑ 東西向剖面



❑ 六重溪莉桐崎





(楊志成等，2005)