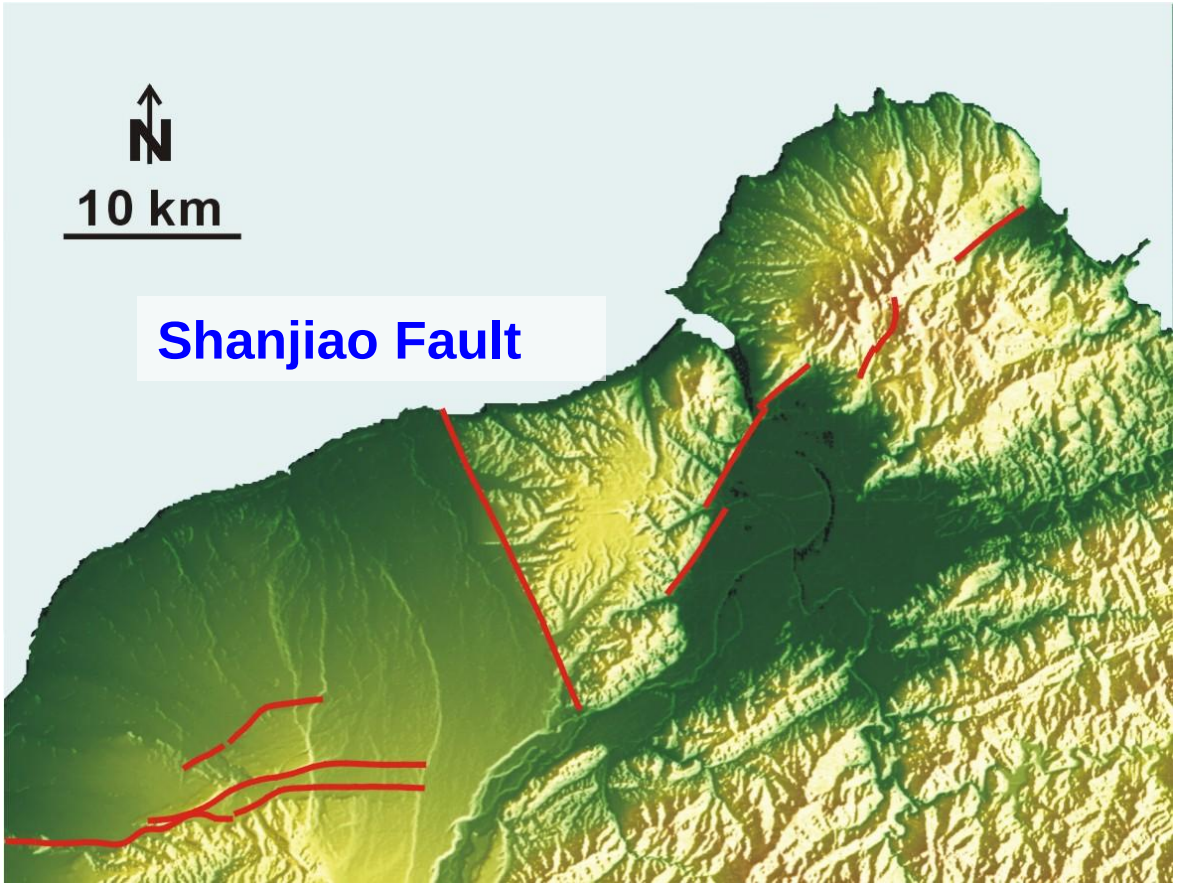
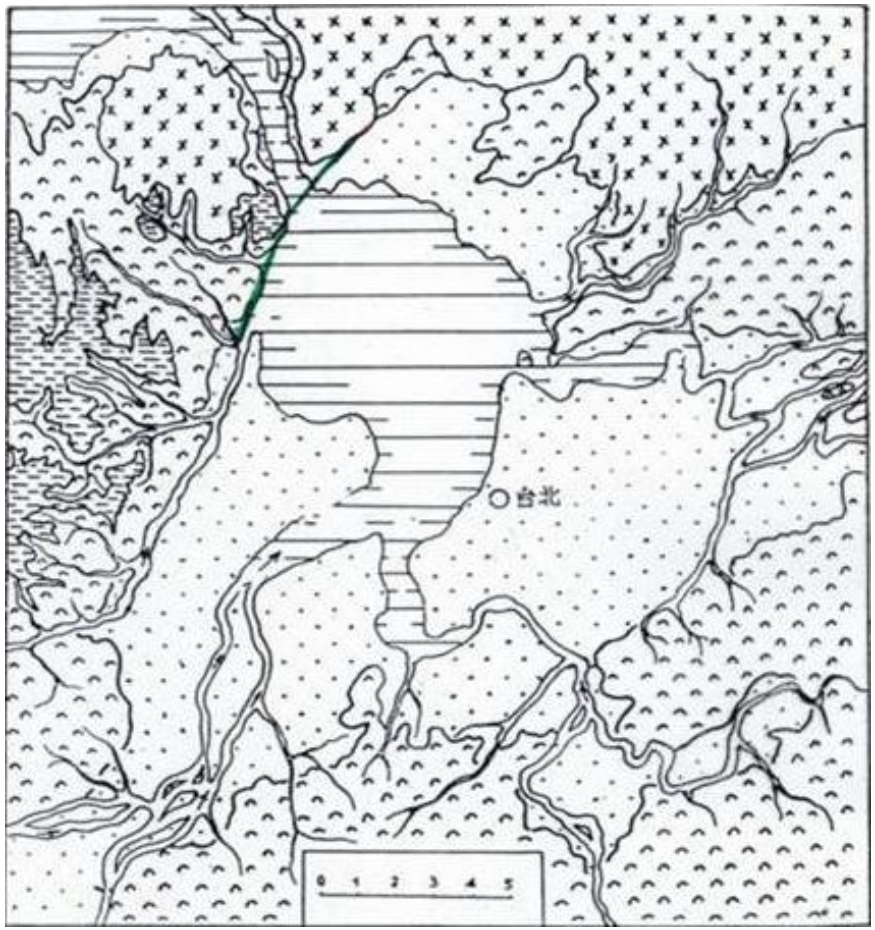
# 台灣山脈內盆地的成因

張中白

# Taipei basin

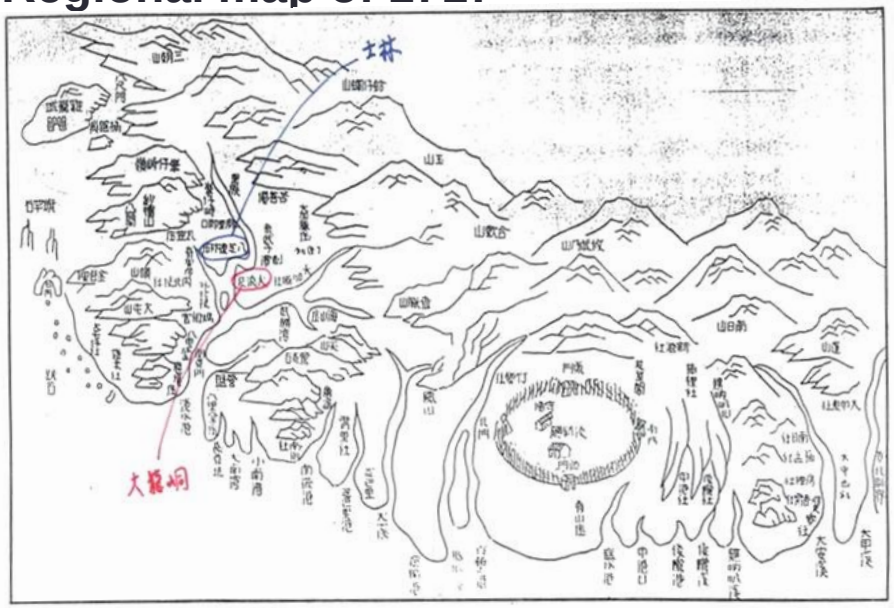



- 243 $Km^2$ in area
- Biggest basin in Taiwan
- Most densely populated metropolitan
- Surrounded by active fault
- Triangular in shaoe



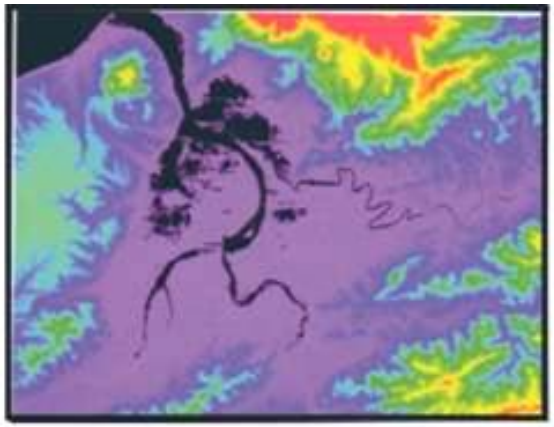

**Reconstructed Taipei Lake**
**- drew by Lin Chao-Chi, 1960**
**- after Yu's record, 1694**

**Regional map of 1717**

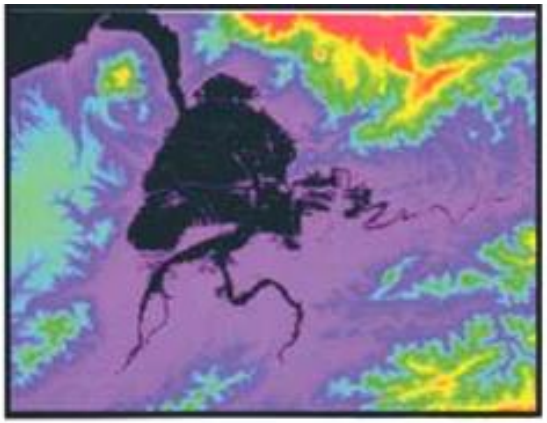



**Regional map of 1741**

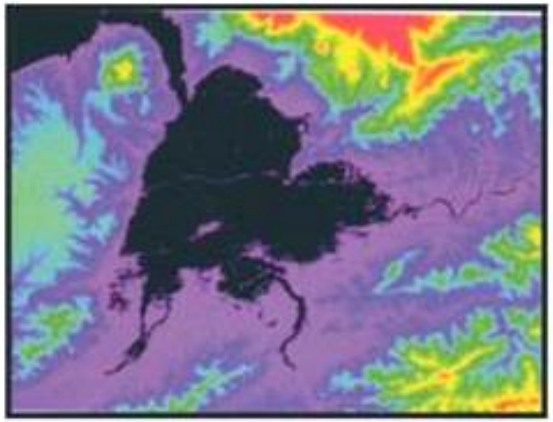
# Inundation model



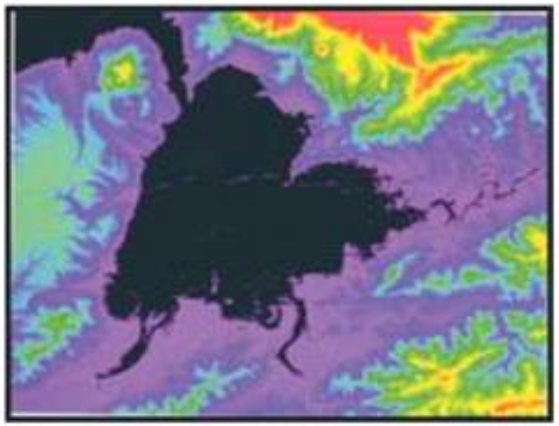
1 meter



3 meters



5 meters



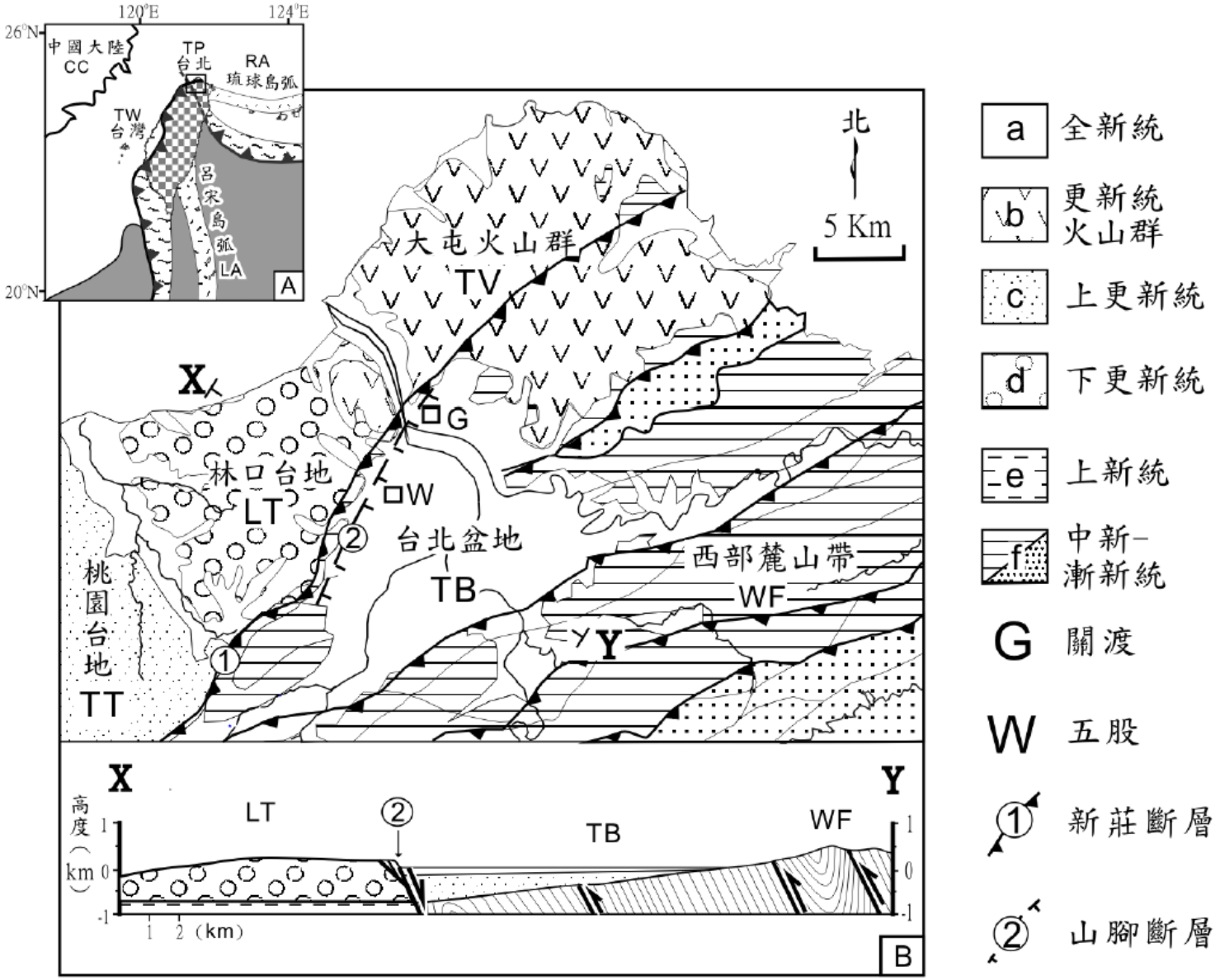
7 meters


DEM of 40m resolution. Data after the Bureau of Agriculture, Taiwan.

In left: the Inundated area is shown by black color.


麻少翁社
（士林區社子）
甘答門（關渡）
觀音山
八里分社
（八里鄉龜崙、米倉）
淡水

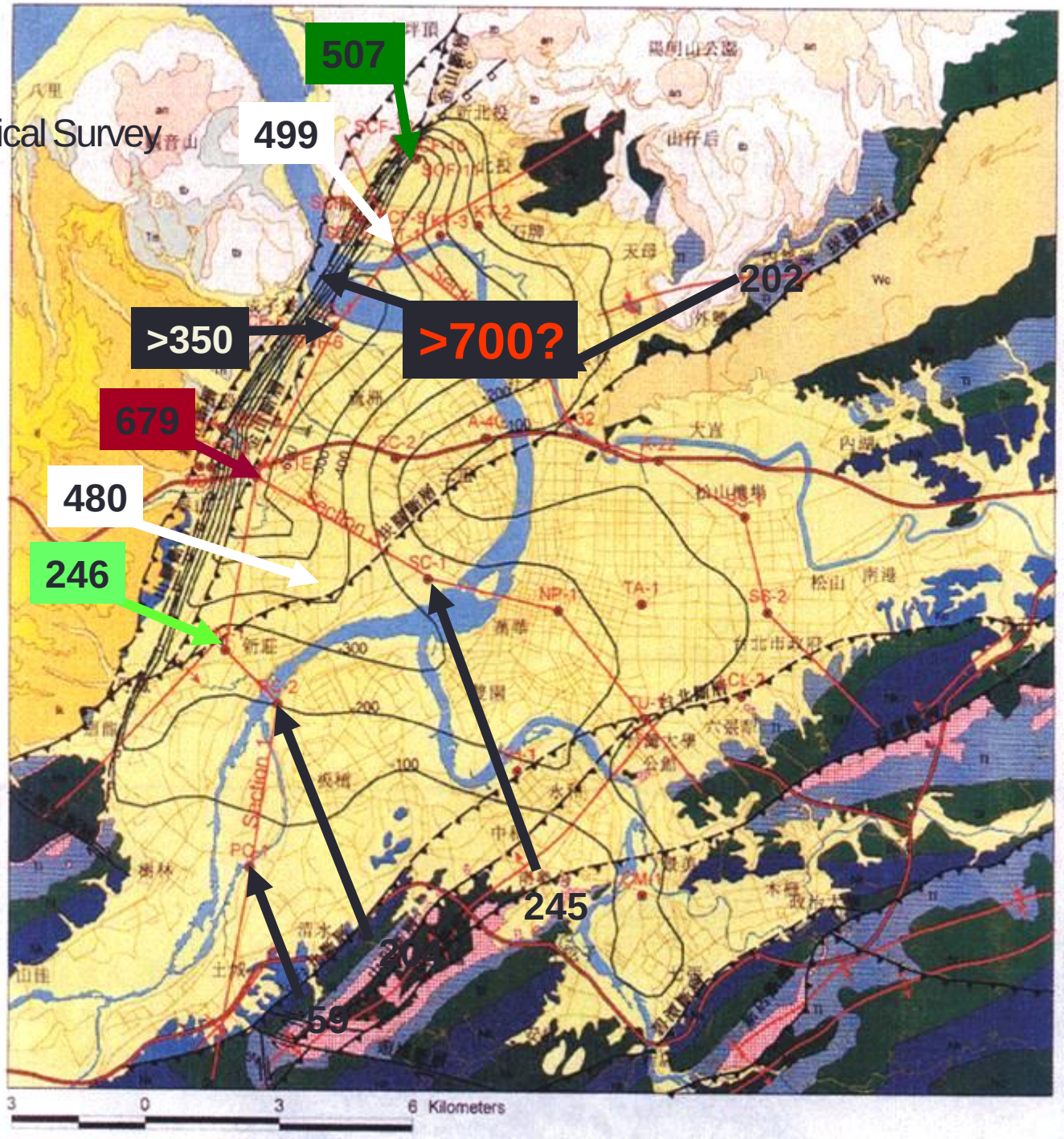
# Geological background



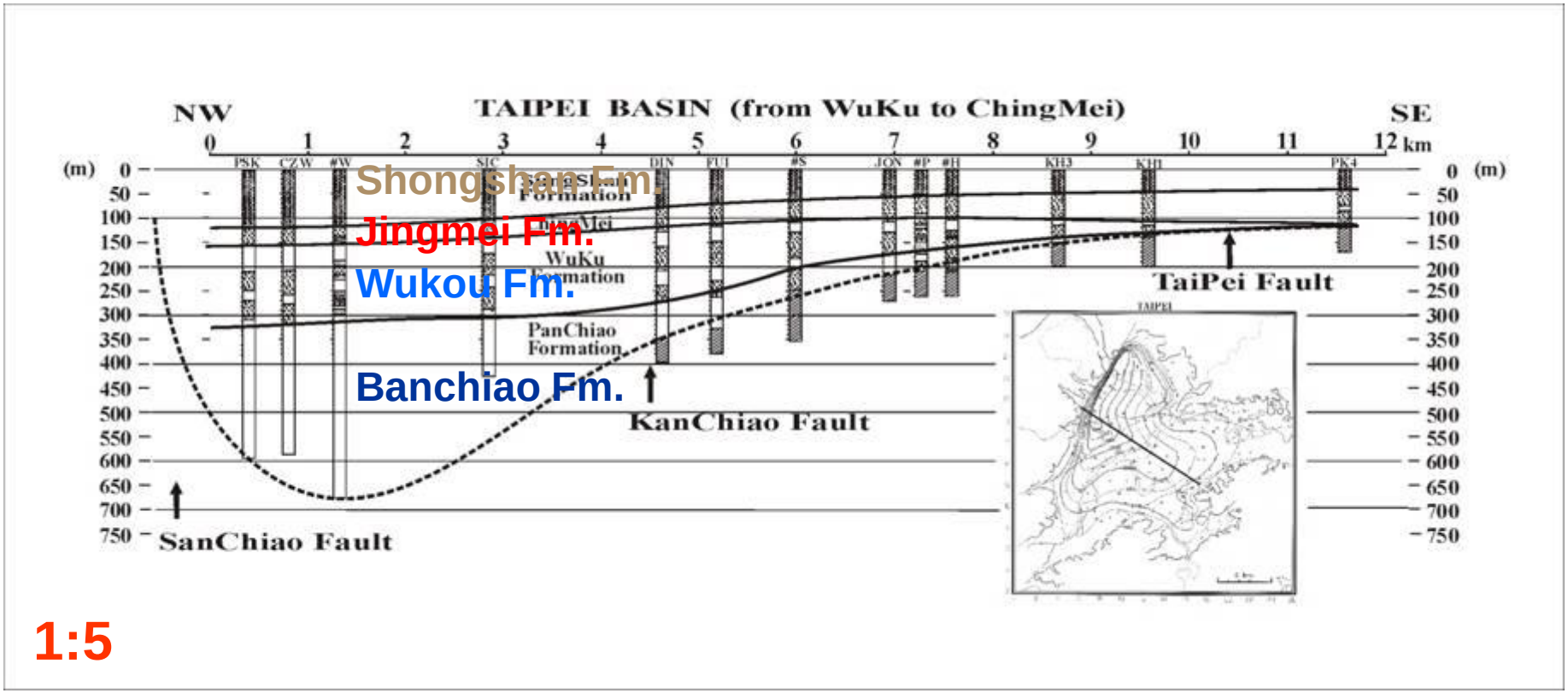

鄧屬予, 2006

# Drilling data

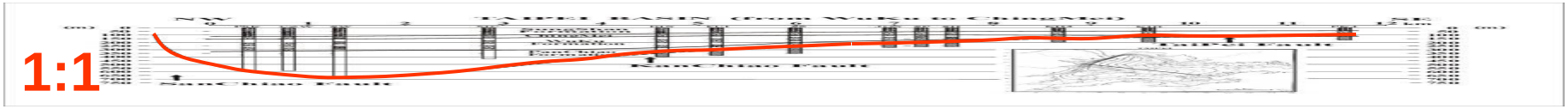
after the Central Geological Survey



# Quaternary Stratigraphical profile cut across the Taipei basin

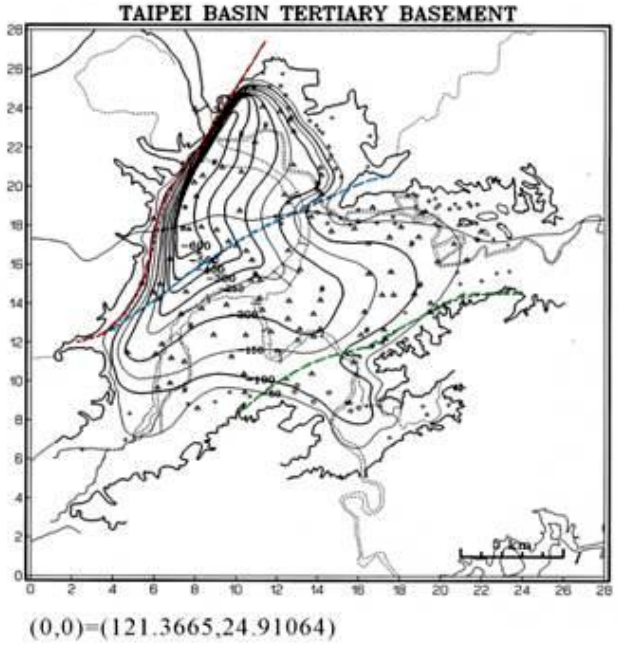



1:5

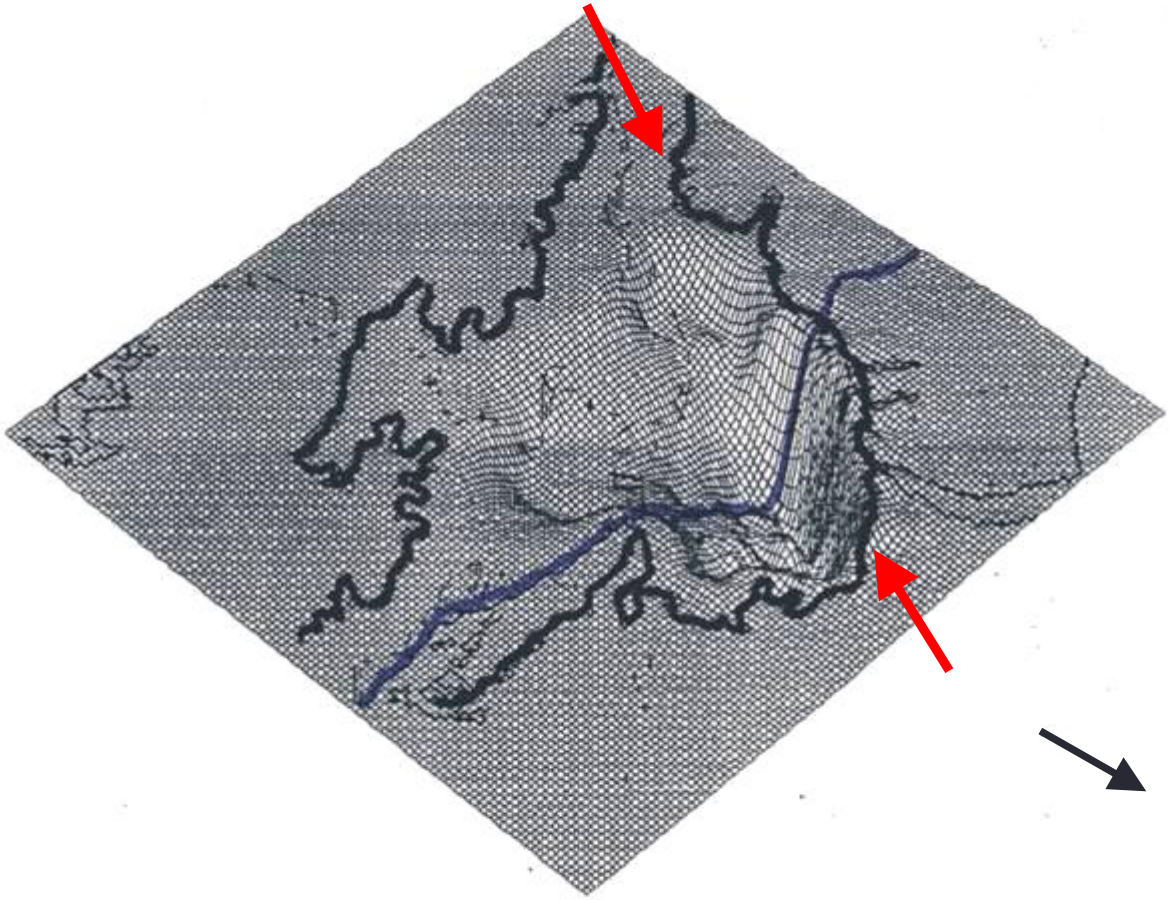


1:1

# Basement of the Taipei basin




Shanjiao Fault

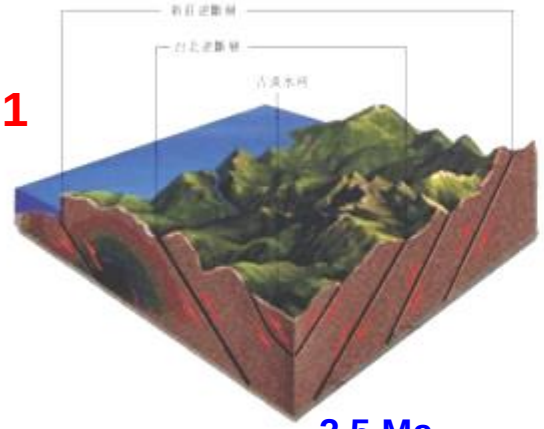


N

TAIPEI BASIN TERTIARY BASEMENT

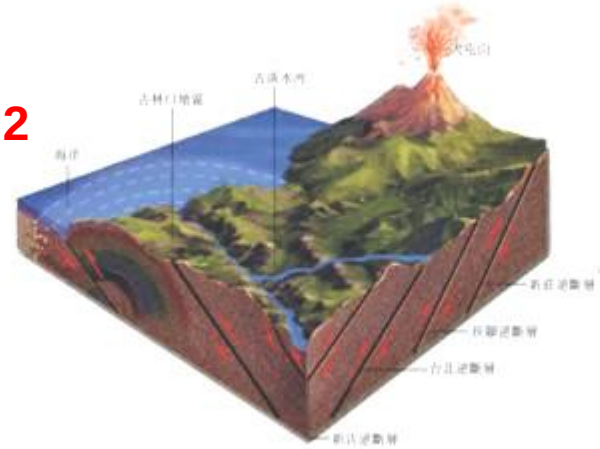
# Tectonic evolution of the Taipei basin

1



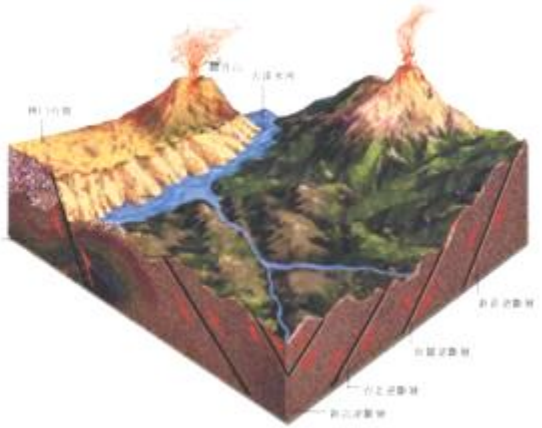
2.5 Ma
Thrusting deformation

2



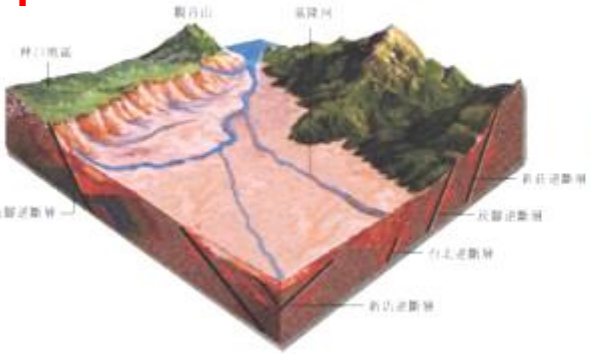
2 Ma
Alluvial fan in Linkou

3



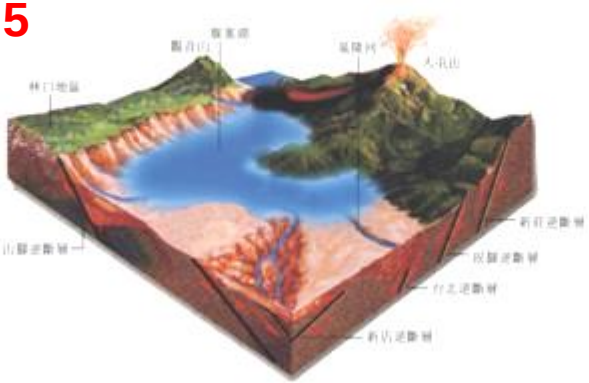
0.40 Ma
Tectonic extension

4



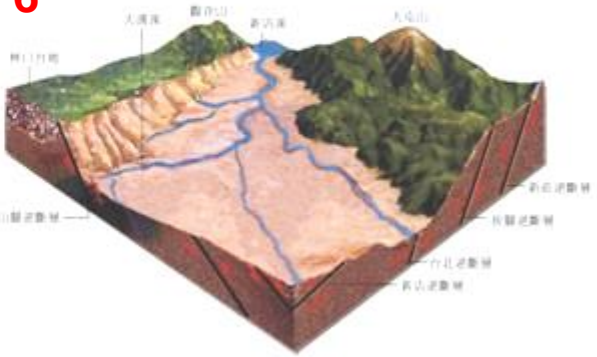
0.3 Ma
Conglomerates into
the Taipei basin

5



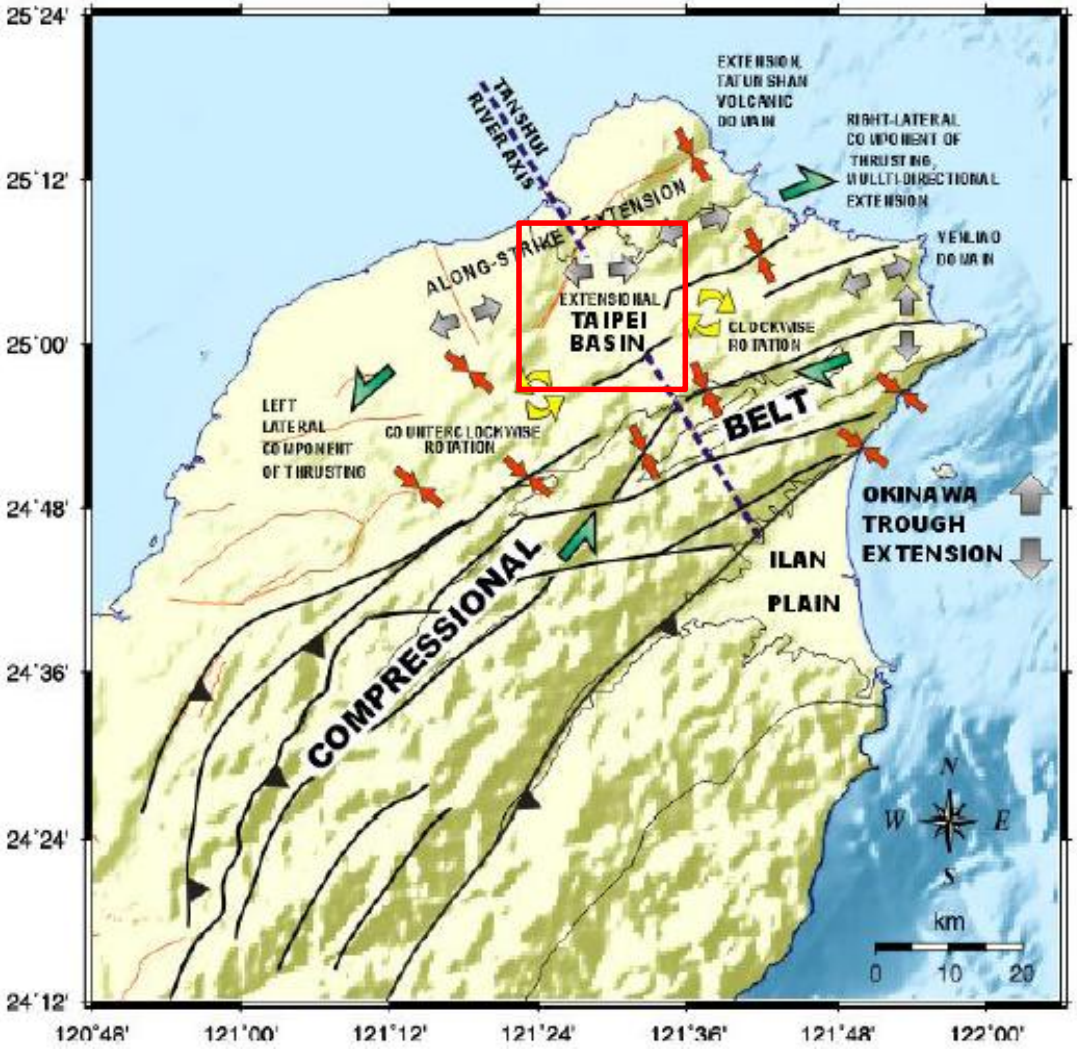
0.2 Ma
Formation of Taipei lake

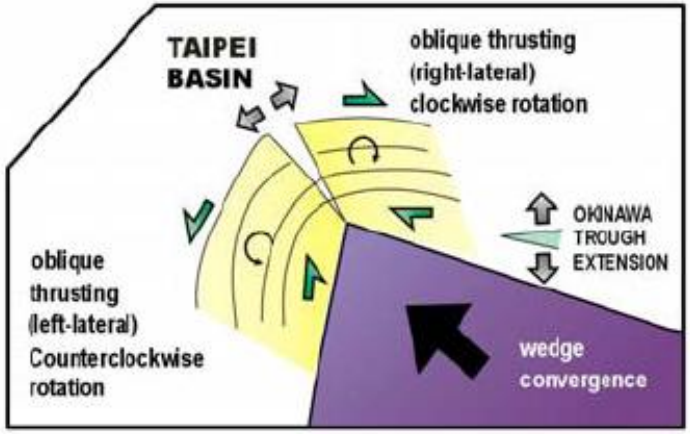
6



30000 yr ago
River change

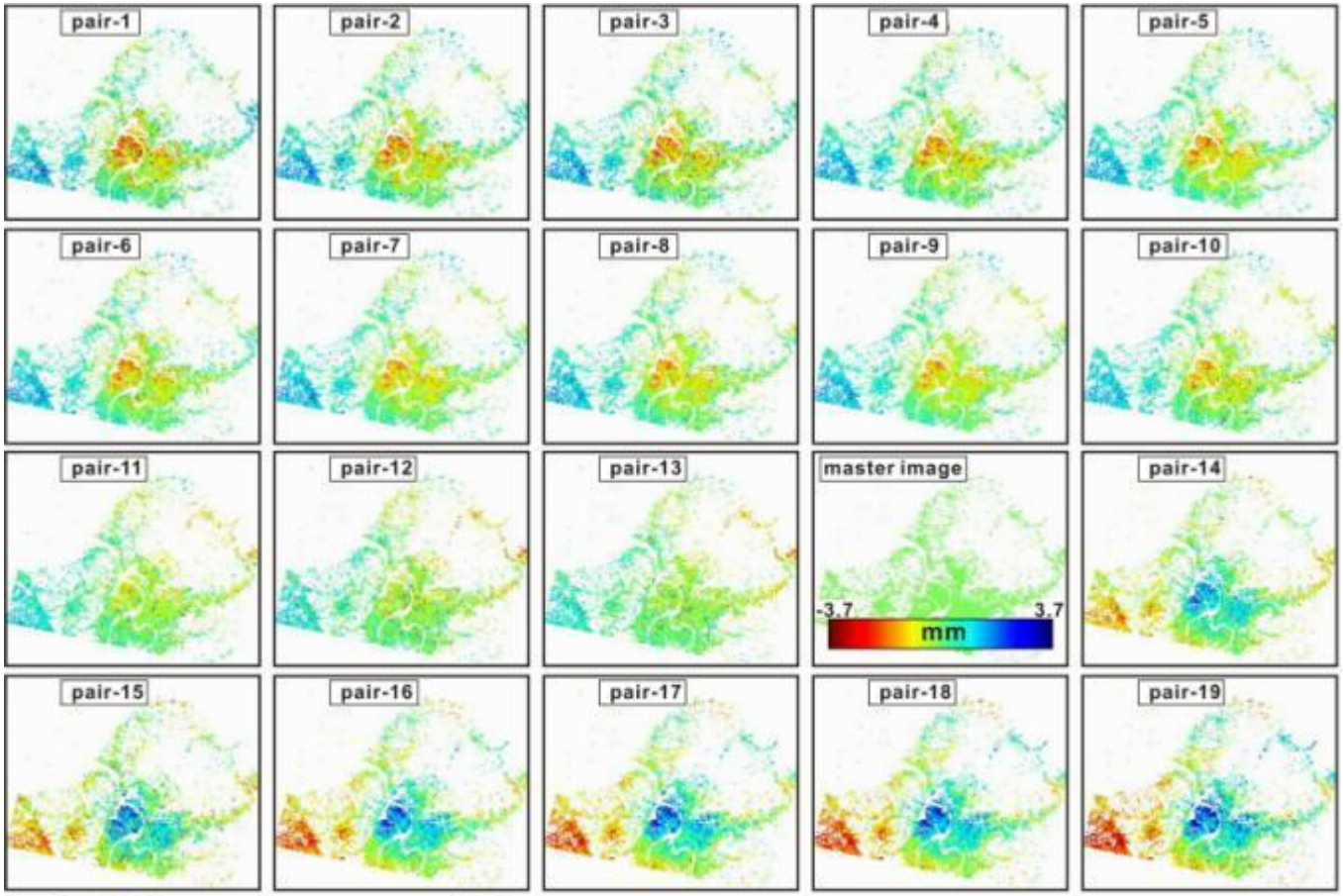
# Extensional tectonics




Lu *et al.* (1995); Hu *et al.* (2002)

# PSInSAR result




Unwrapped phase of PS pixels of each images referenced to the master image.

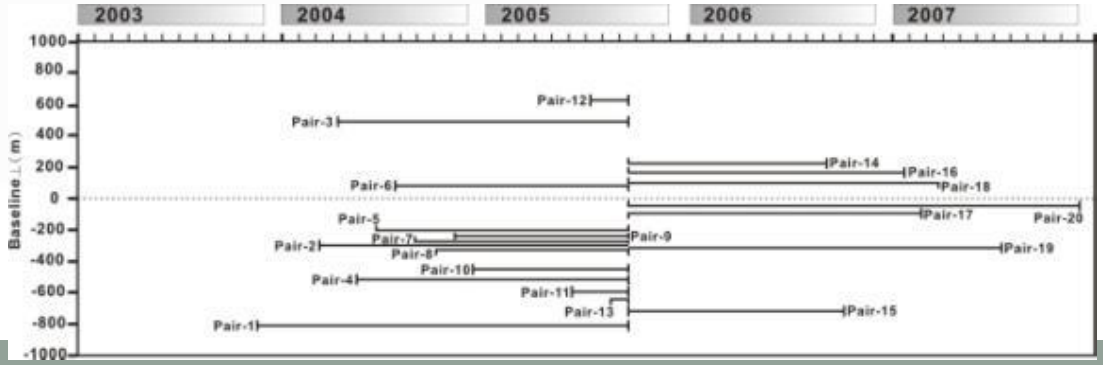
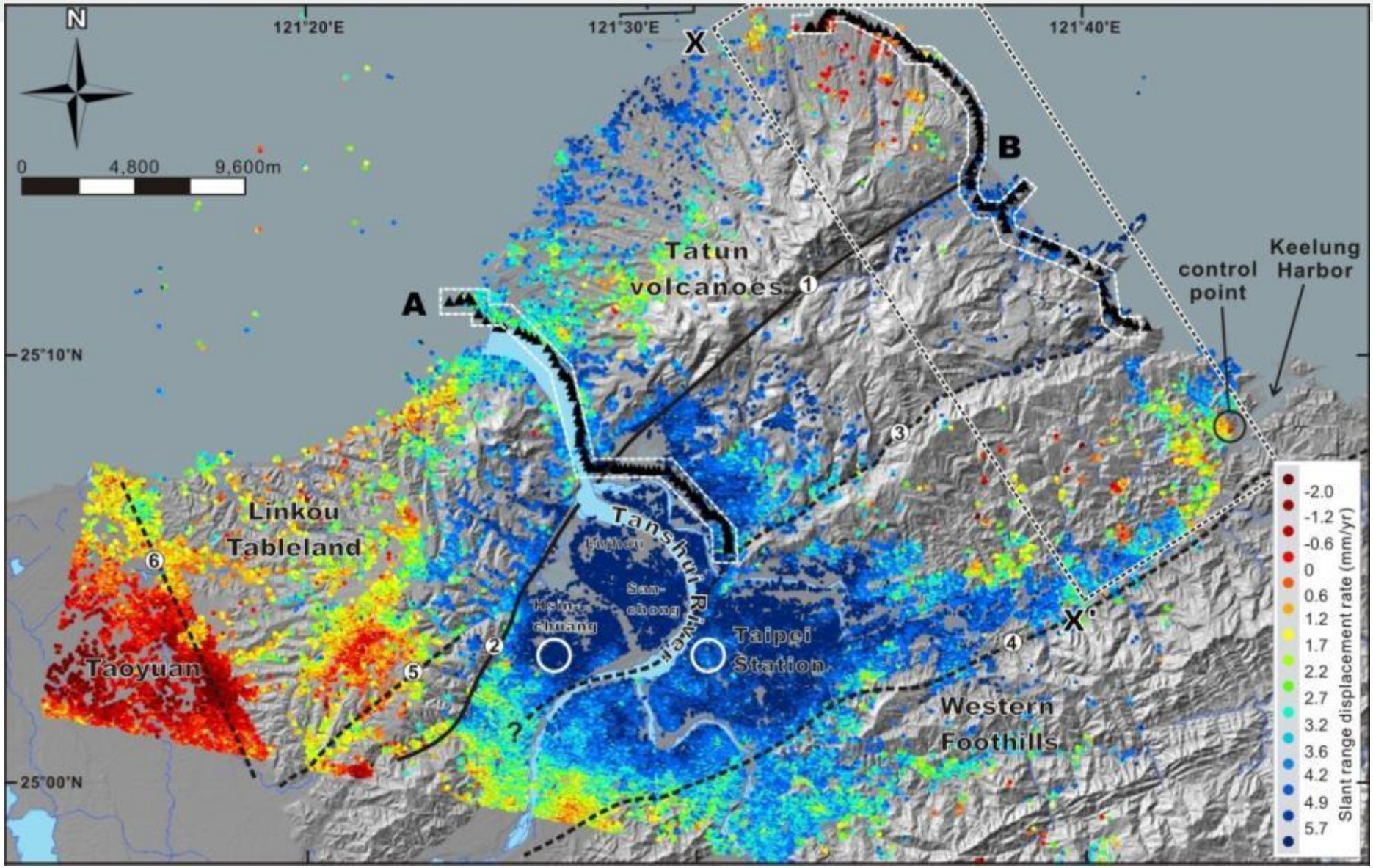
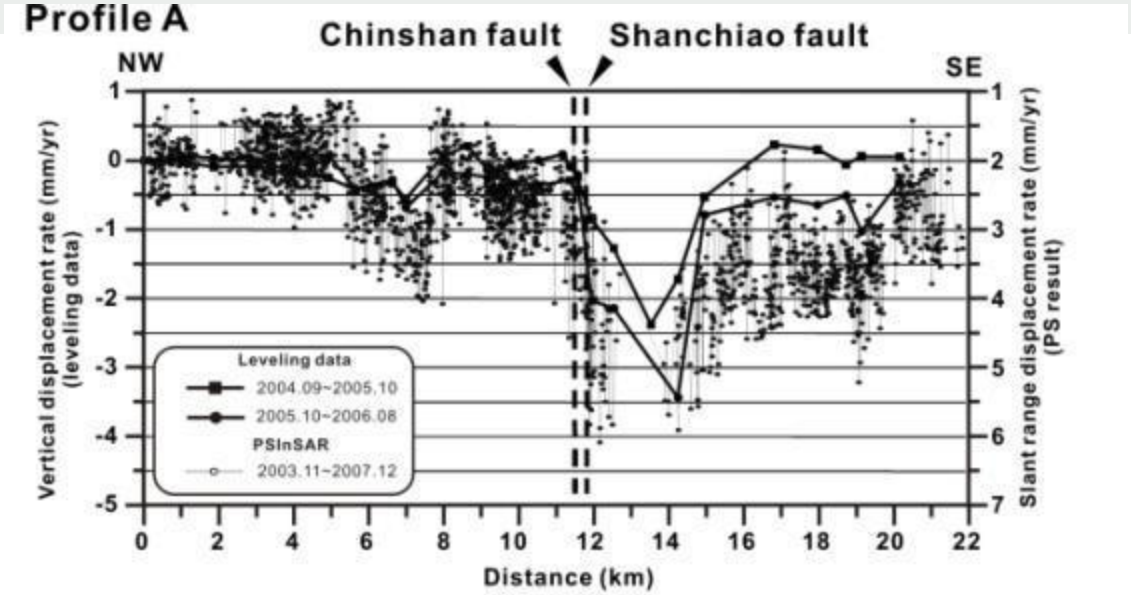
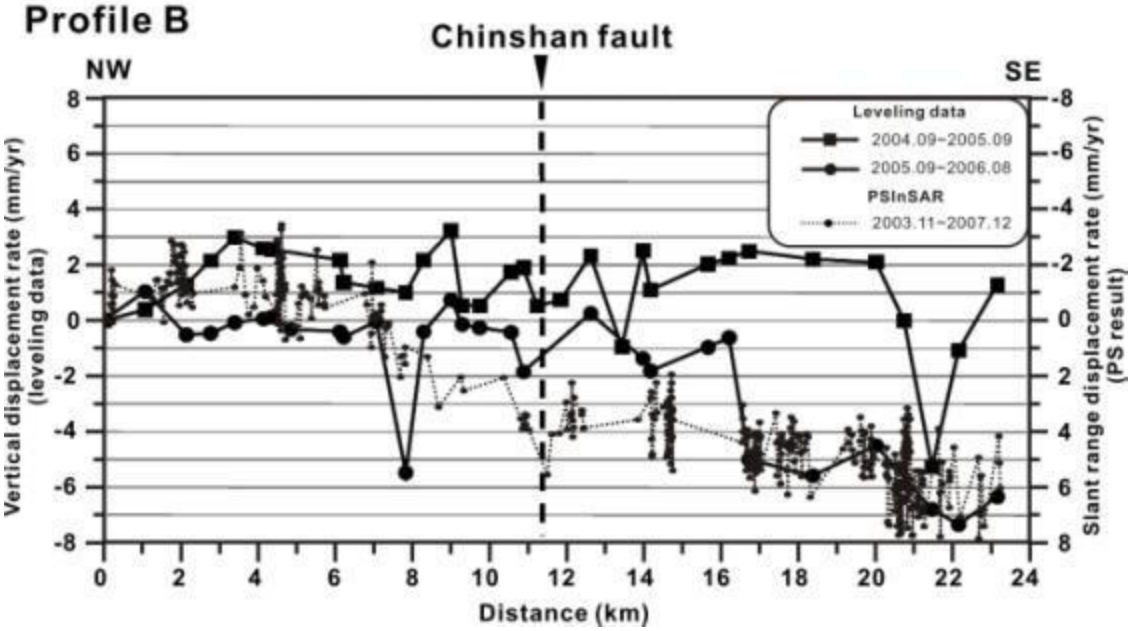




Image pairs used for PSInSAR analysis in this study. All images are acquired by satellite ENVISAT in the descending orbit track 461, frame 3105. The master image is fixed on September 17, 2005.

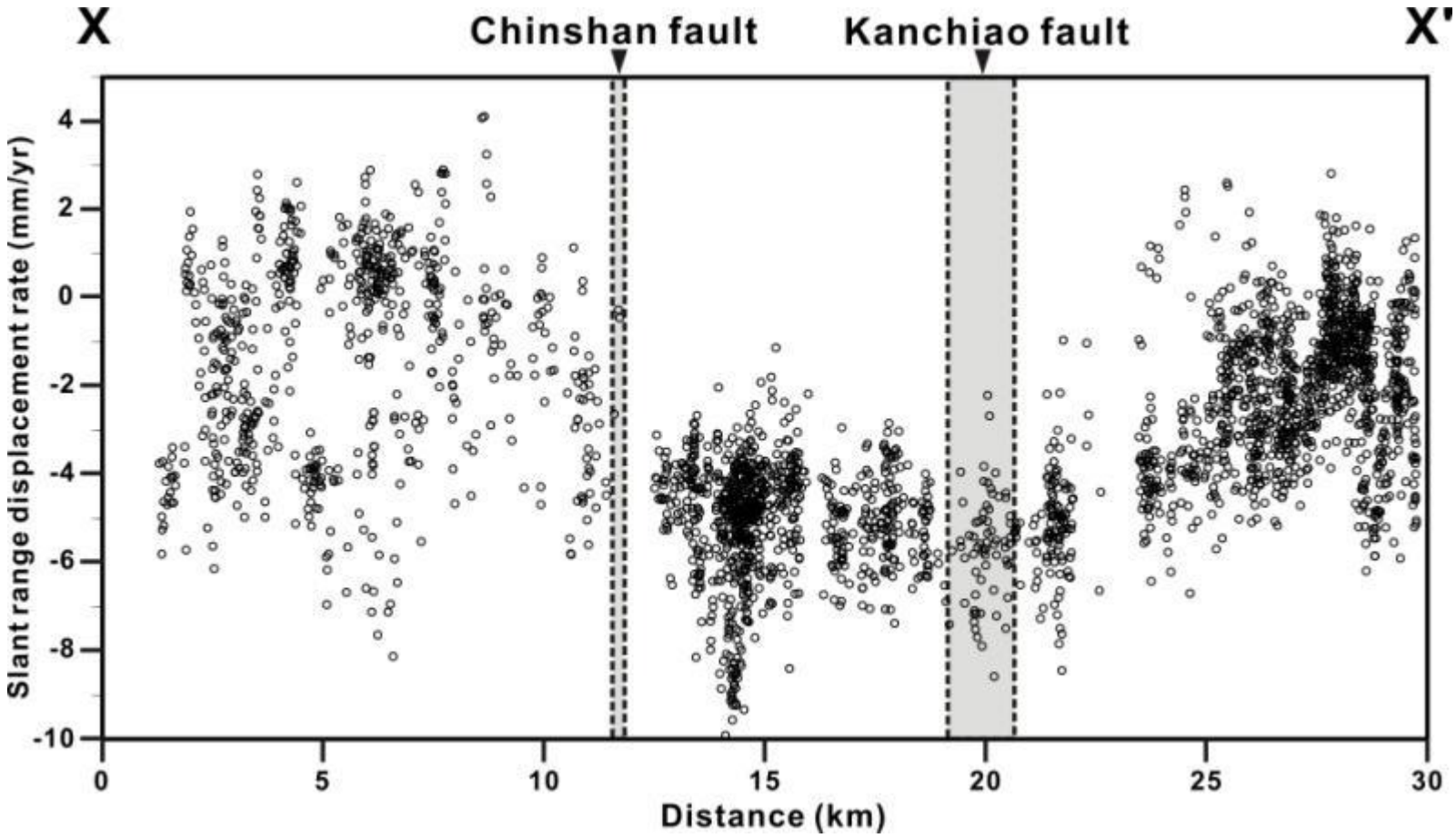



Slant range displacement rate of the processed PSs in the northern Taiwan area. This result has been adjusted by using the base point of “Taiwan Vertical Datum 2001” installed by Ministry of the Interior Bureau in Keelung harbor as the control point. Black triangular: leveling survey points after Hou (2007). White dashed lines encircled the PS pixels that will compare with leveling data along profiles A and B.



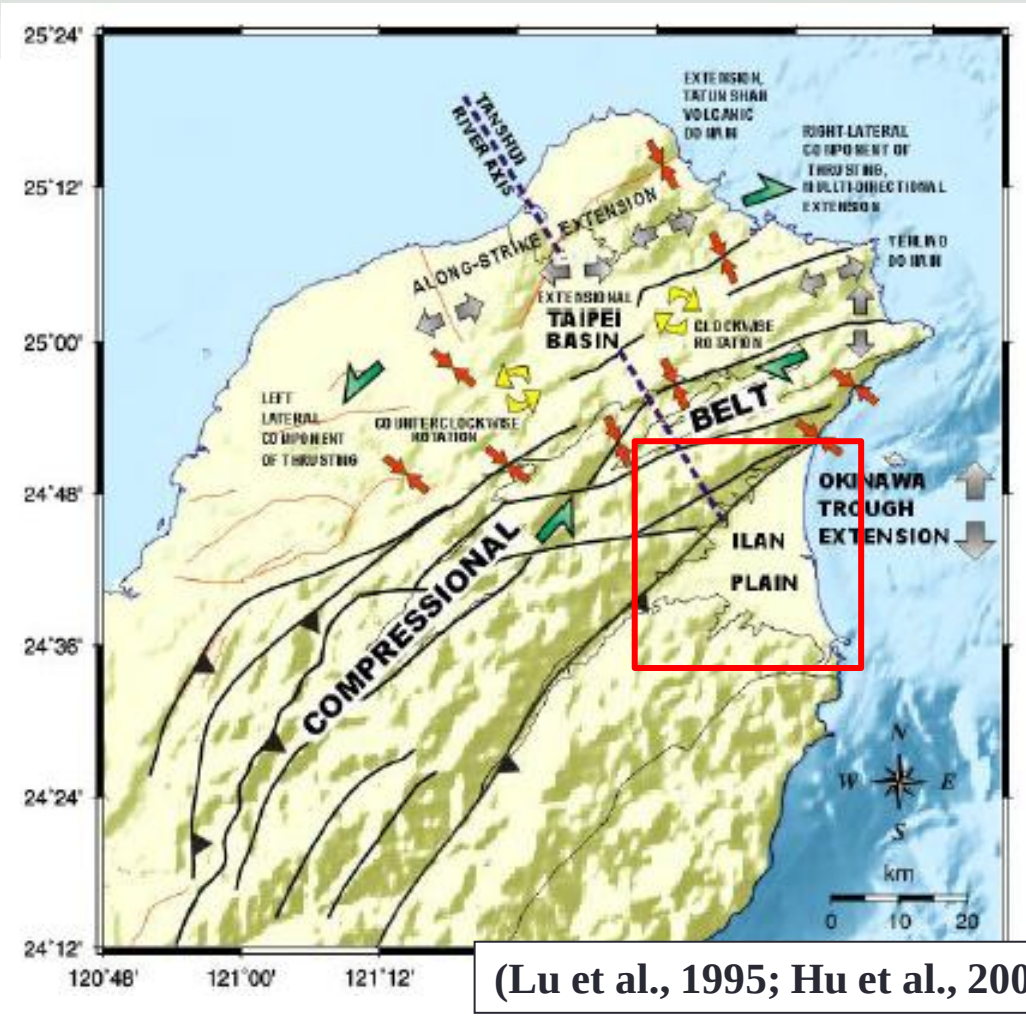




Comparison between the leveling data (Hou, 2007) and PSInSAR result along the northern coastal line (a) and the northern bank of Tanshui River (b). Leveling data are relative to the western most point of the profile, PS displacements are relative to the control point shown in the former figure.




**Slant range displacement of PS pixels in the northern tip of Taiwan Island (in frame XX'). Clear subsidence can be observed in the terrain between the Chinshan and Kanchiao Faults.**

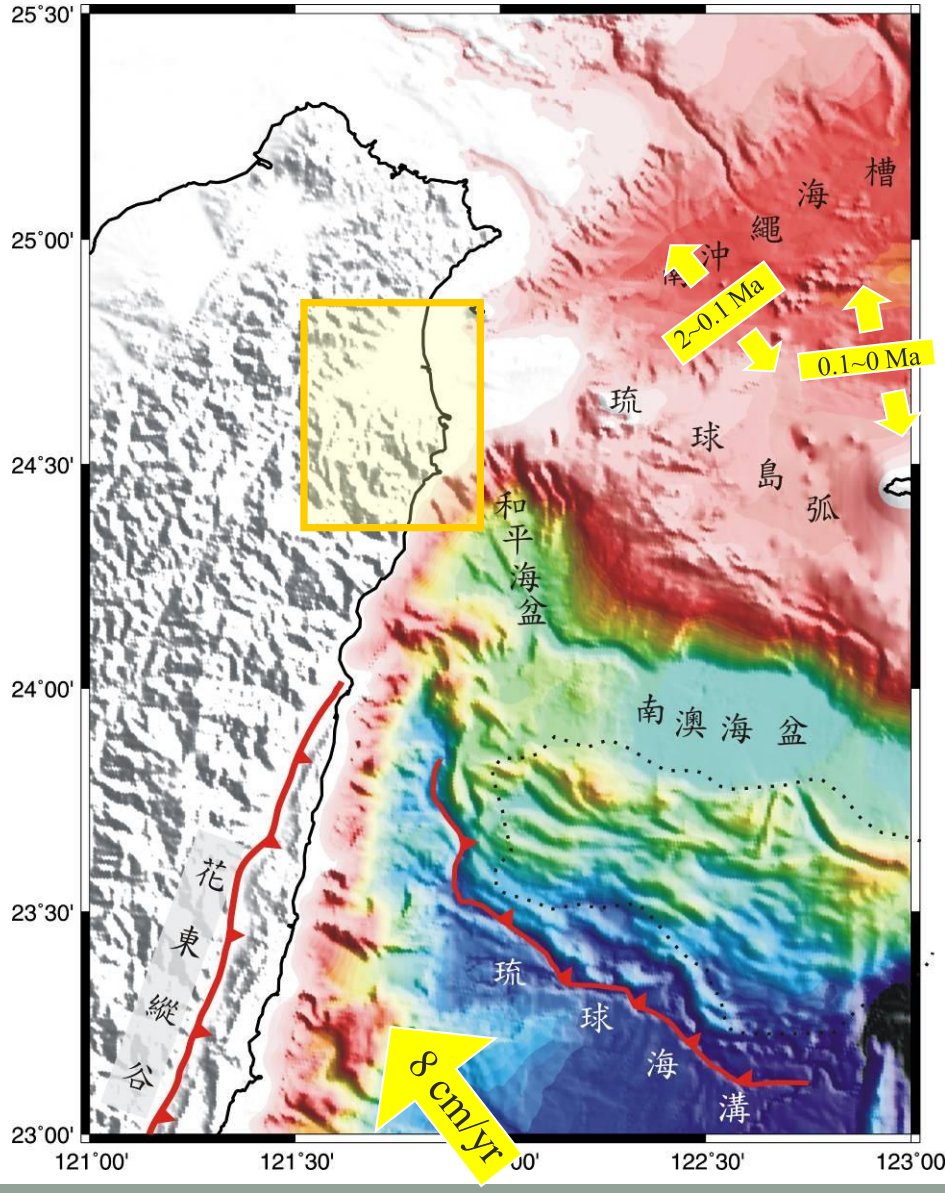
# ILan plain




(Lu et al., 1995; Hu et al., 2002)

- 320 Km$^2$ in area
- Triangular alluvial plain
- Southern tip of the Okinawa Trough

# background




蘭陽平原地區東側之地體構造：

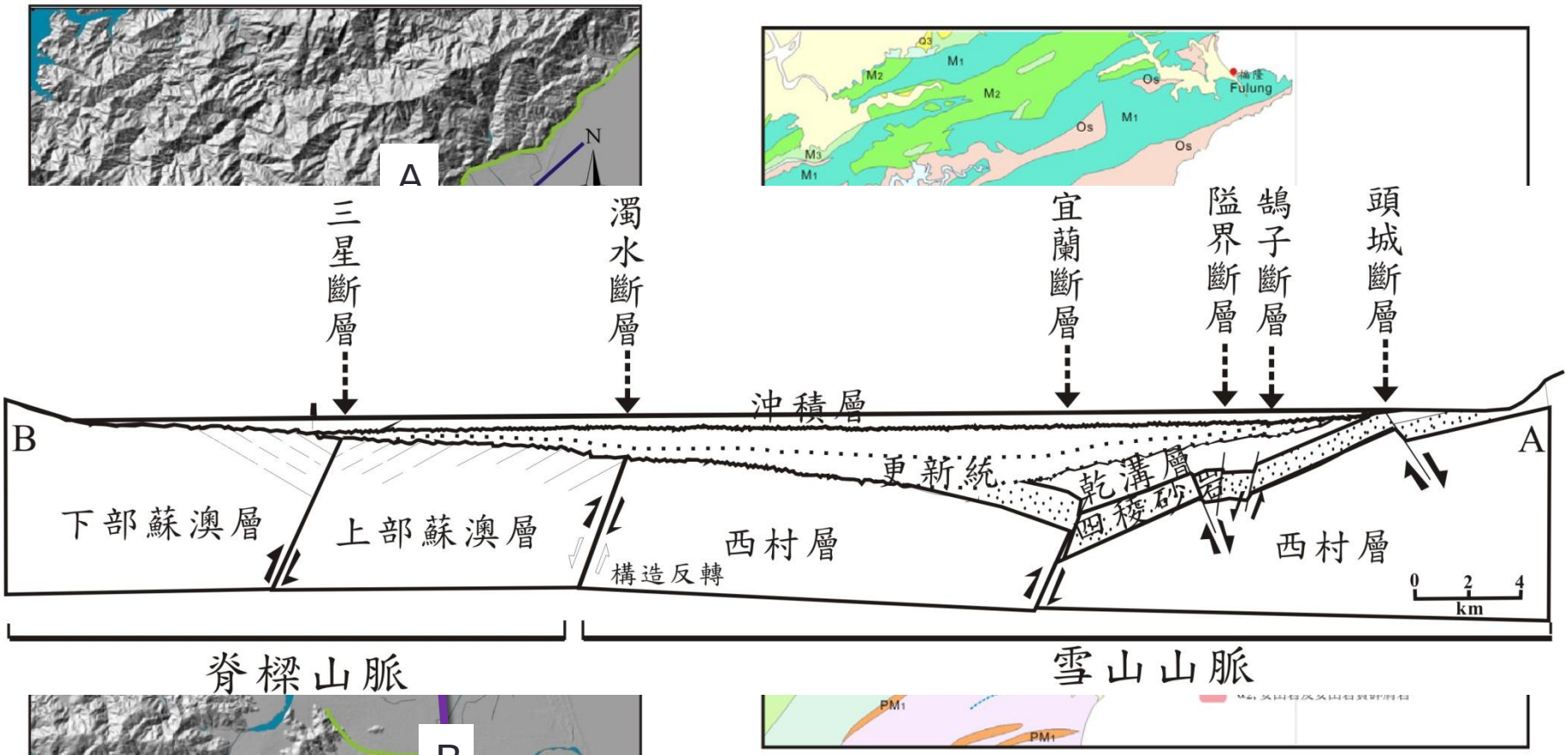
1、南沖繩海槽的張裂

2、琉球海溝之隱沒系統

3、菲律賓海板塊斜向擠壓

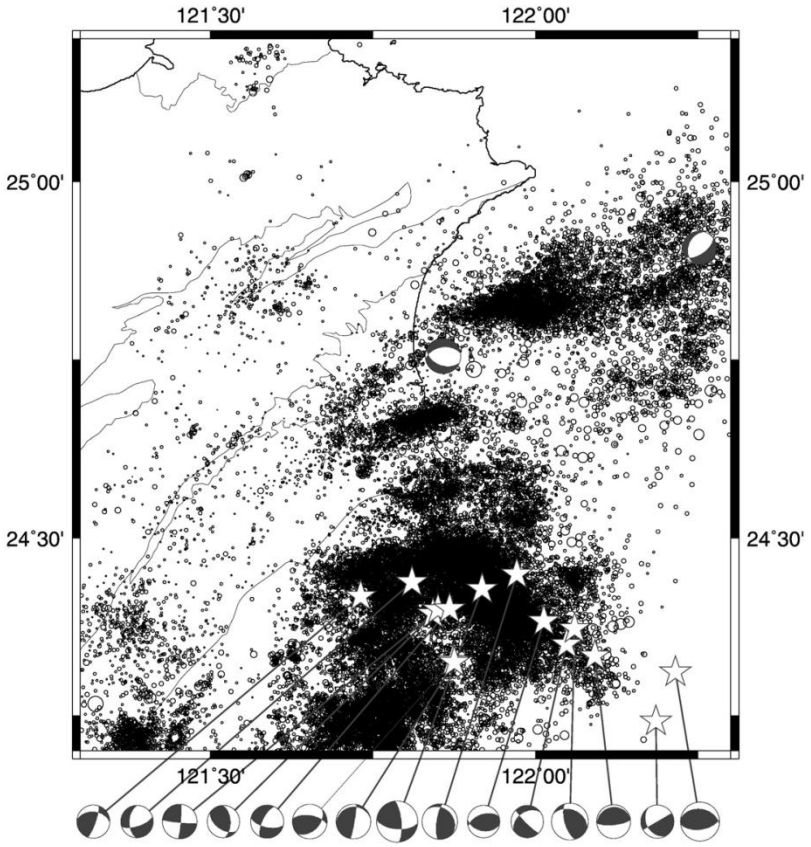
Sibuet et al., 1998

# Geological setting of the Ilan Plain

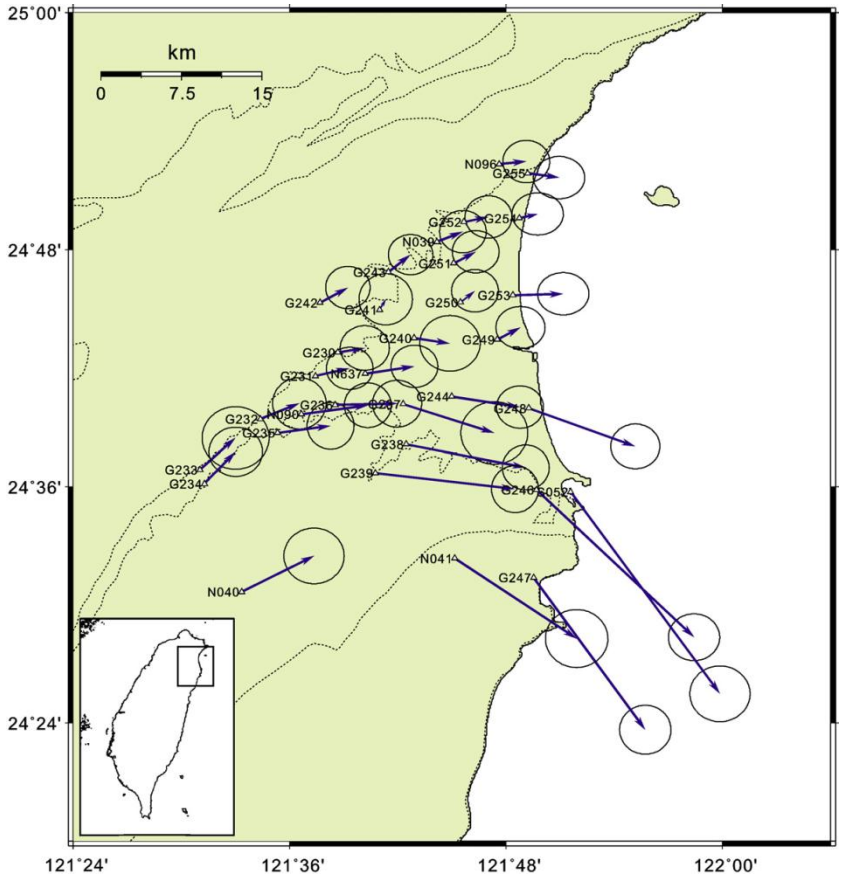



（中央地調查所五十萬分之一地質圖、江新春, 1976）

# Geophysical data



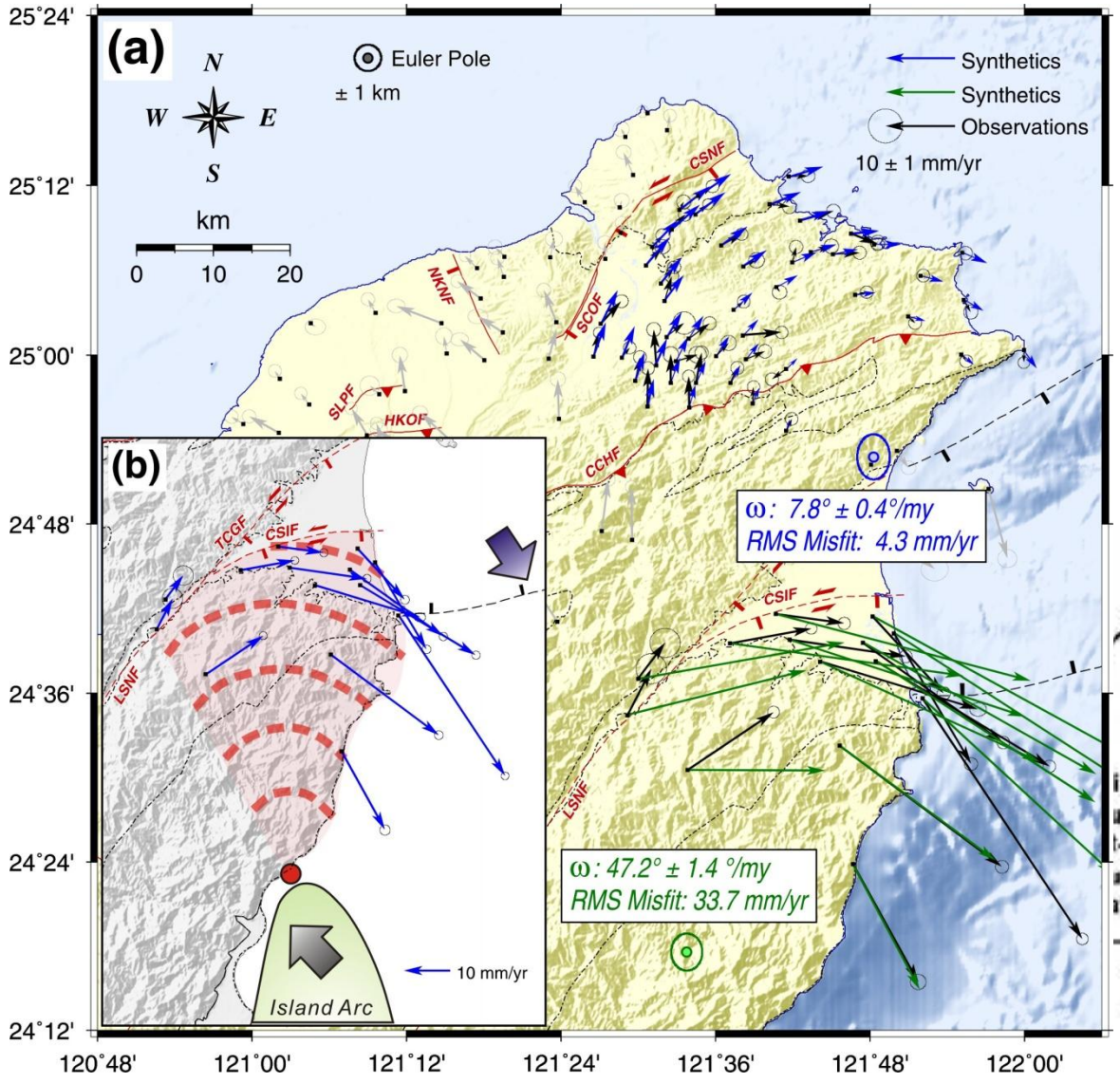

Seismicities of $M_L > 3$ in northeastern Taiwan from 1994 to 2000 based on the Catalog of CWB. The focal mechanisms of magnitude 5.0 to 6.0 are shown.

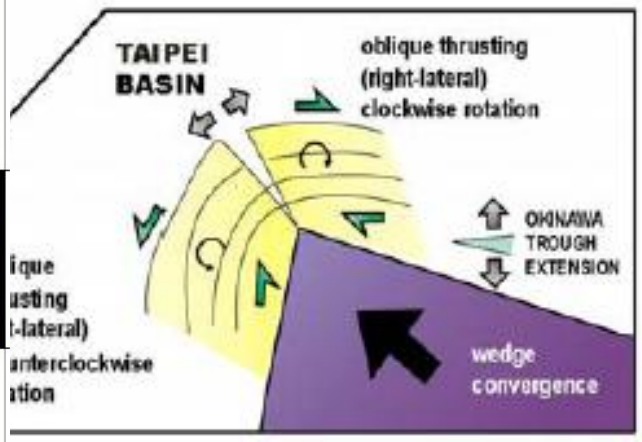



GPS velocity field

(Hou et al., 2009)

# Clockwise rotation

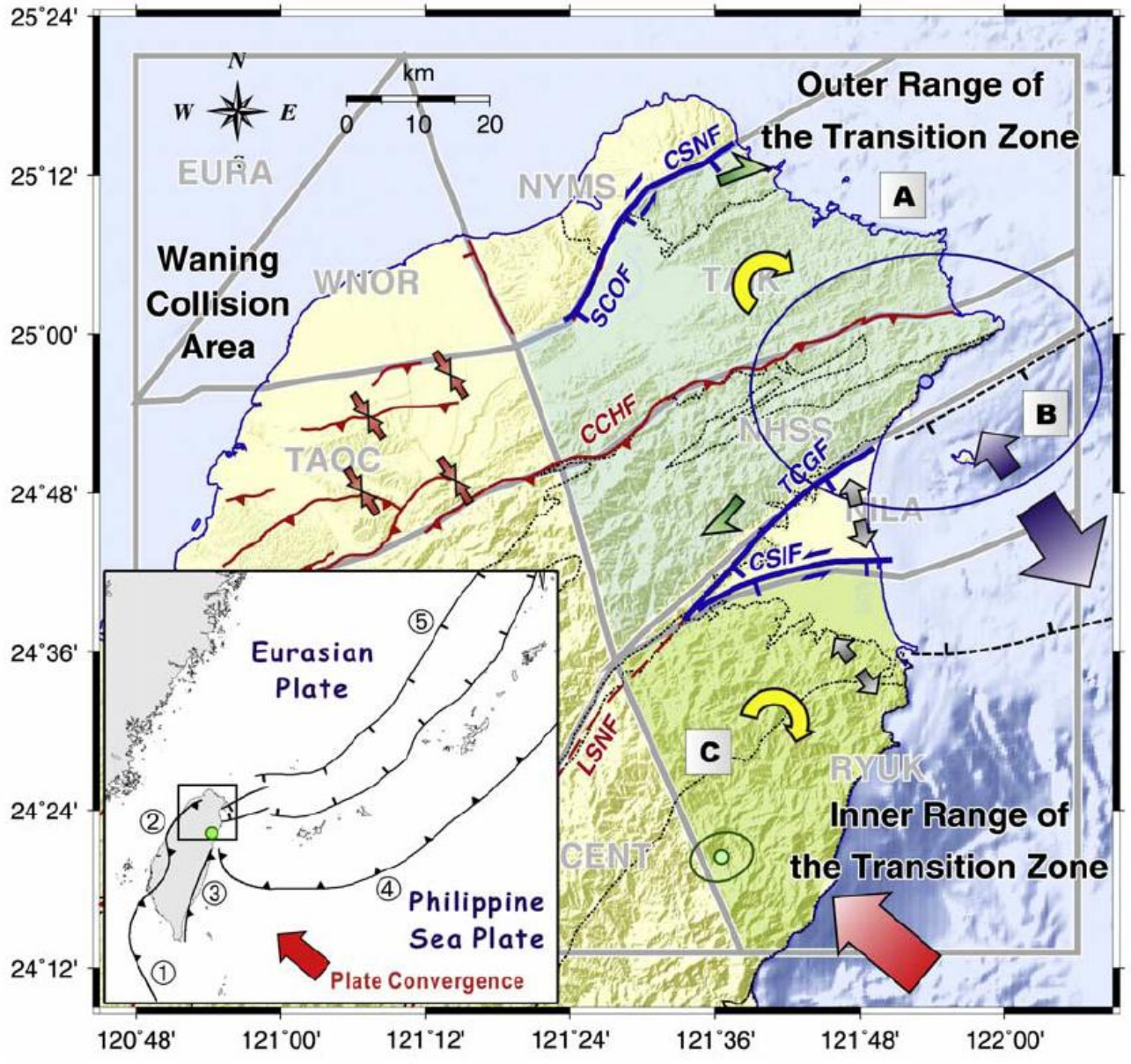



Lu *et al.* (1995); Hu *et al.* (2002)

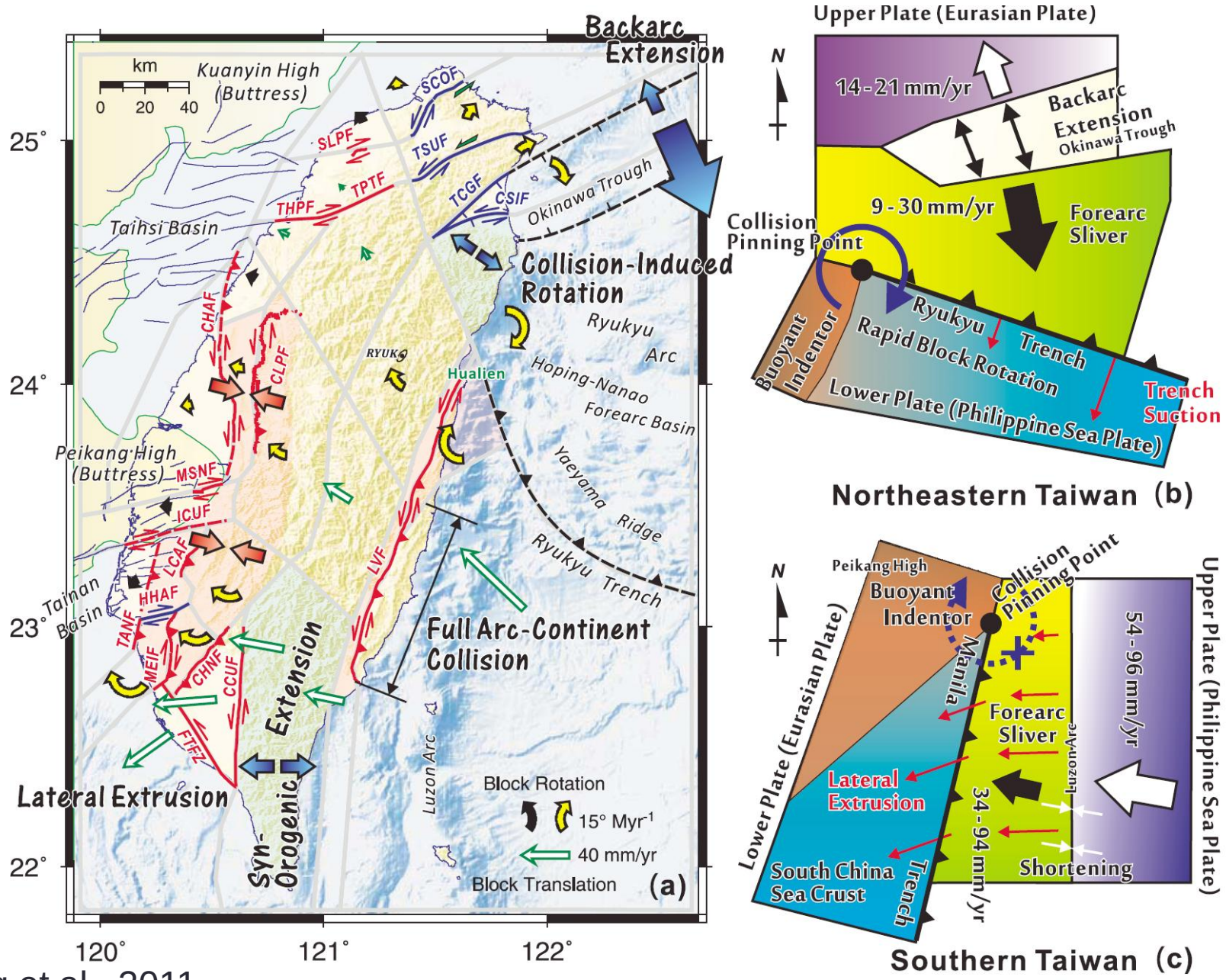
饒瑞鈞,2006

# The tectonic model



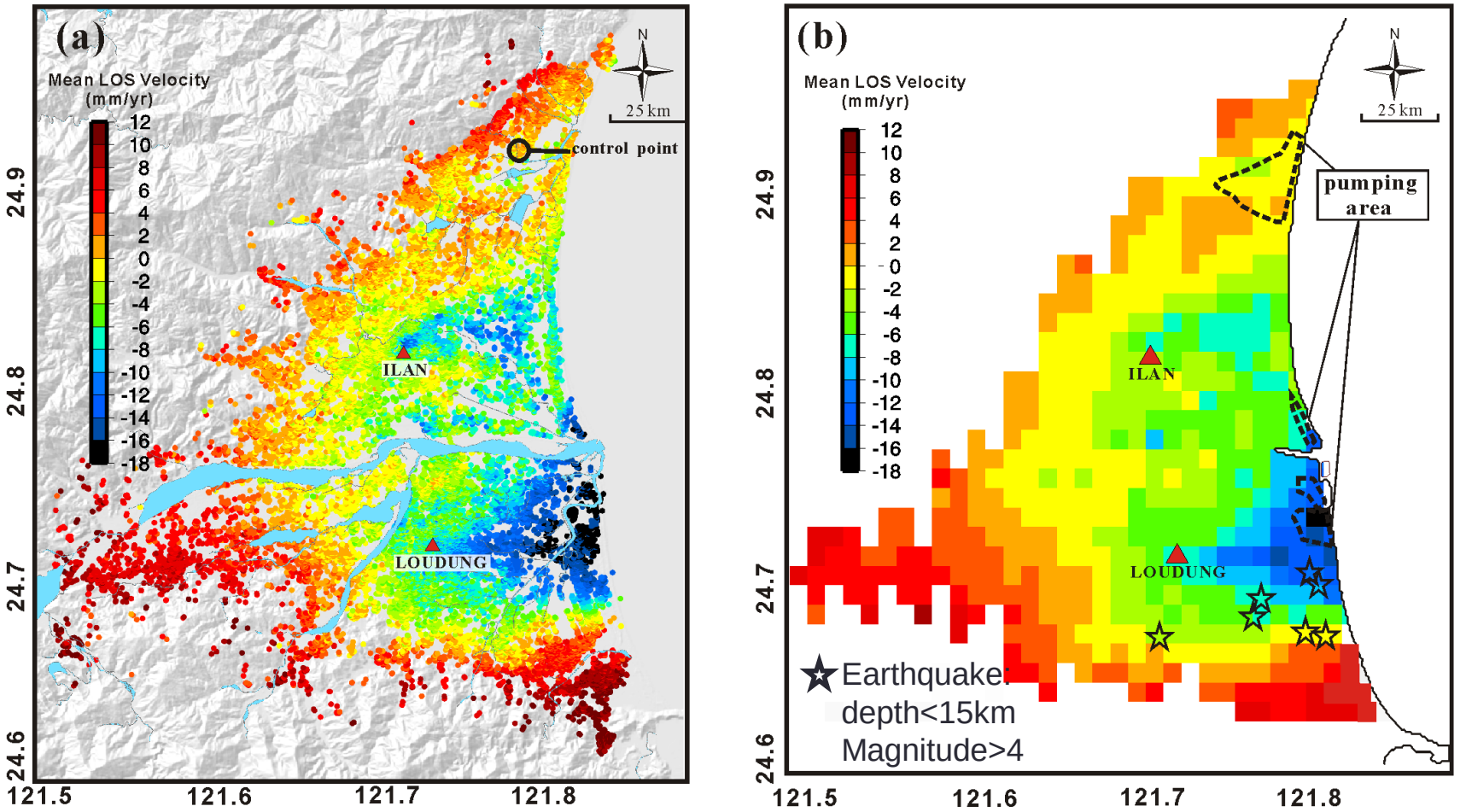

Rau *et al.*, 2008

# Schematic of the strain-partitioning model




Ching et al., 2011

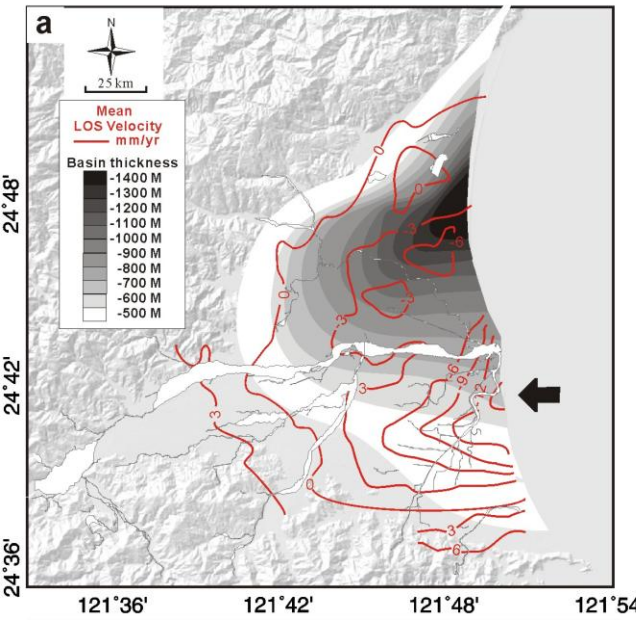
# PSInSAR result



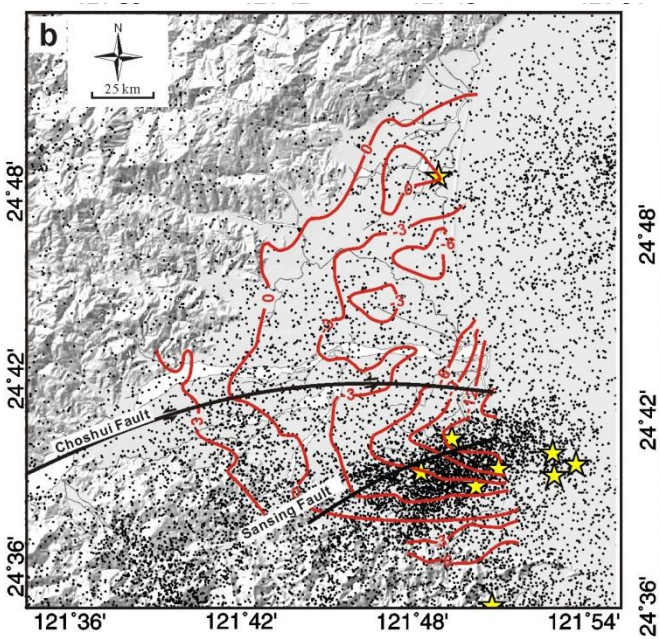

(a) Mean LOS velocity of the processed PS and mound in the Ilan Plain.

(b) Interpolated LOS velocity of the PSI results.

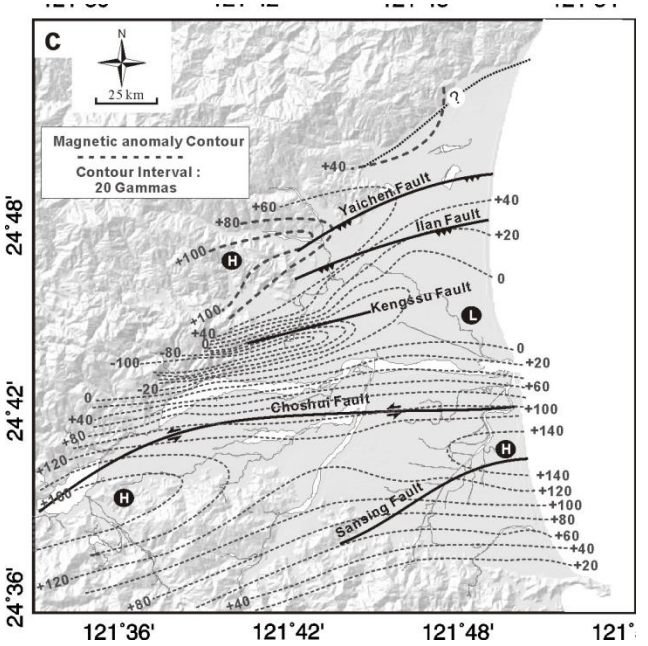
# Relationships between surface deformation and basement structures



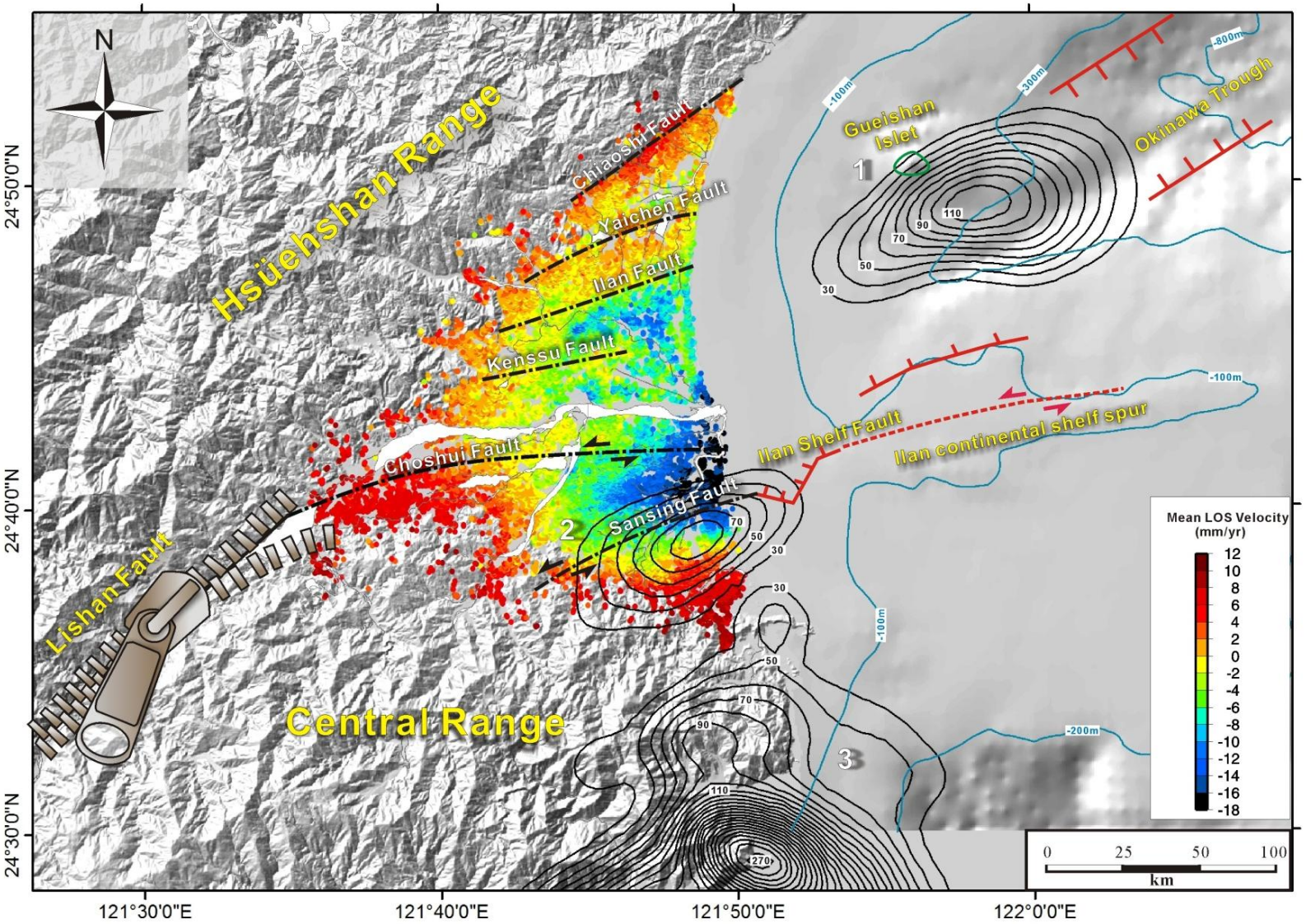

a) Map of the Plio-Quaternary basin thickness in the Ilan Plain (after Jhiang, 1976). Red solid lines show the PSI mean LOS velocity contours and the black arrow highlights the area with the highest subsidence rate.




b) Seismicity distribution map from 1994 to 2008 (Central Weather Bureau Earthquake Catalogue). Yellow stars locate earthquakes with $M_L$ > 3 and depth lower than 30 km. Red solid lines show the PSI mean velocity contour.



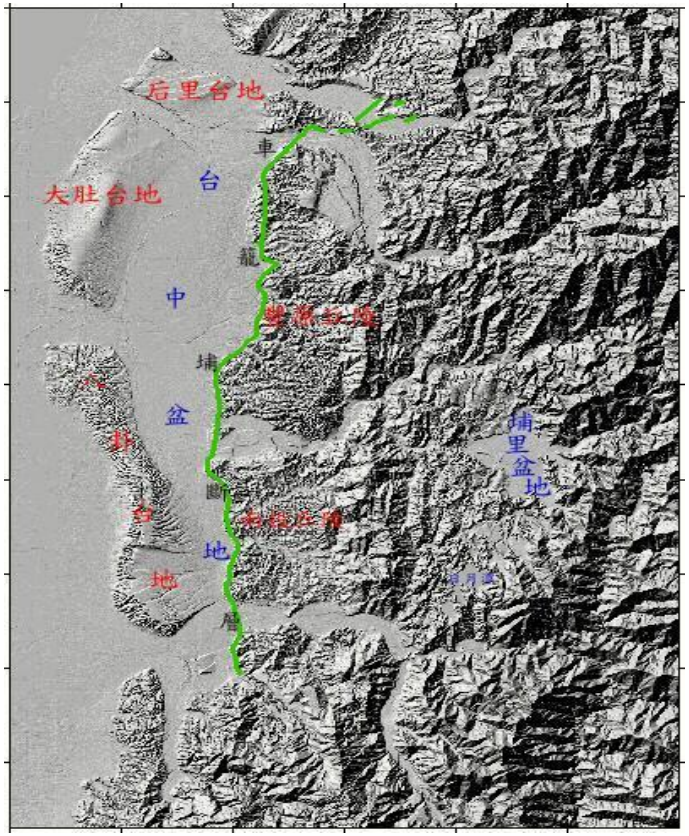

c) Contour map of the magnetic anomalies in the Ilan Plain (after, Yu and Tsai, 1979).




The zipper-liked model for the propagation of the Okinawa Trough through the Taiwan mountain belt, reactivating basement faults that were originally back-thrusting the Hsüeshan Range onto the Central Range (Lishan-Choshui faults).

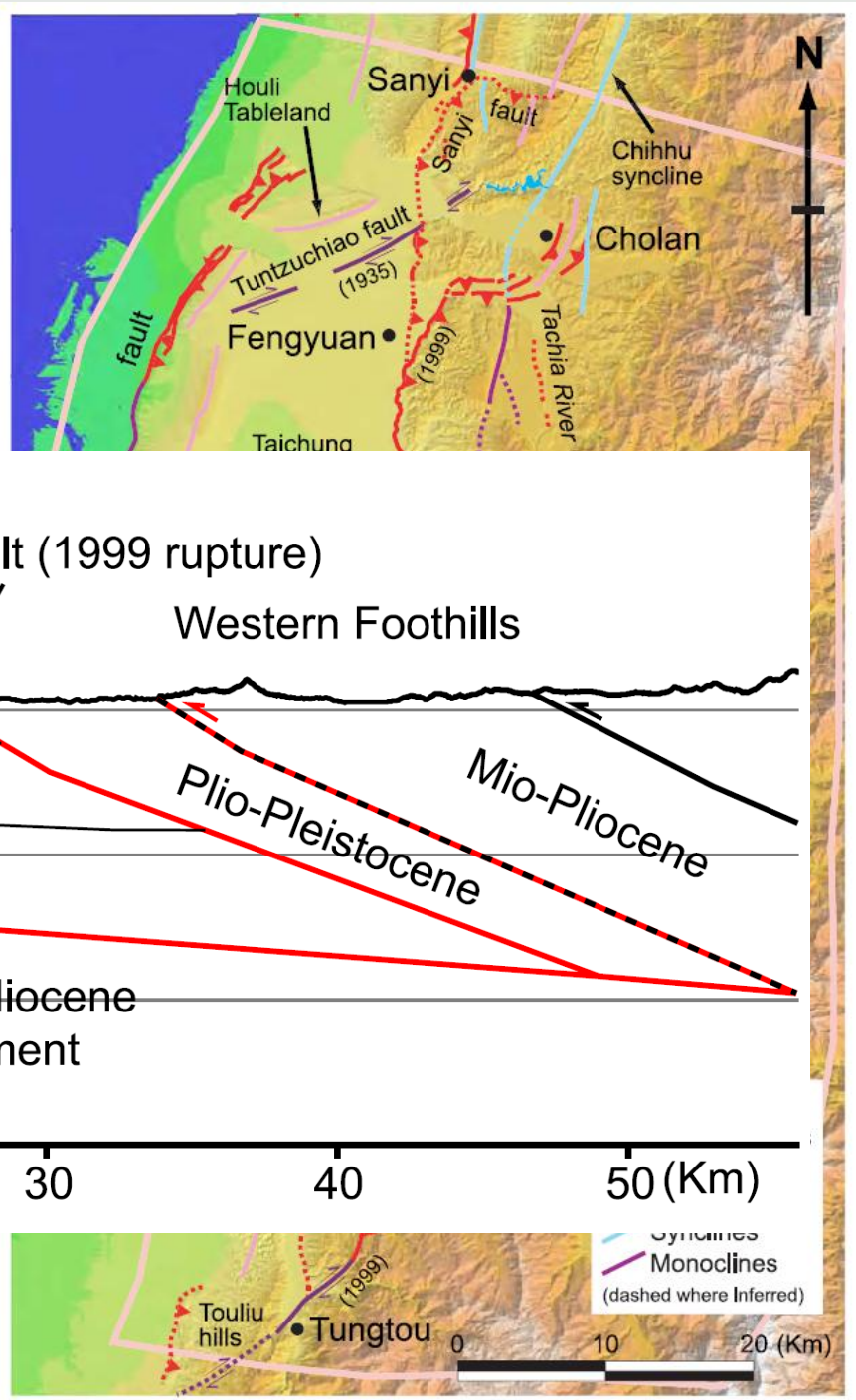
(Jhiang, 1976, Ku et al., 2009)

# Taichung basin




- 370 Km$^2$ in area
- Elongated in shape
- Between two thrusts

# Geotectonic setting

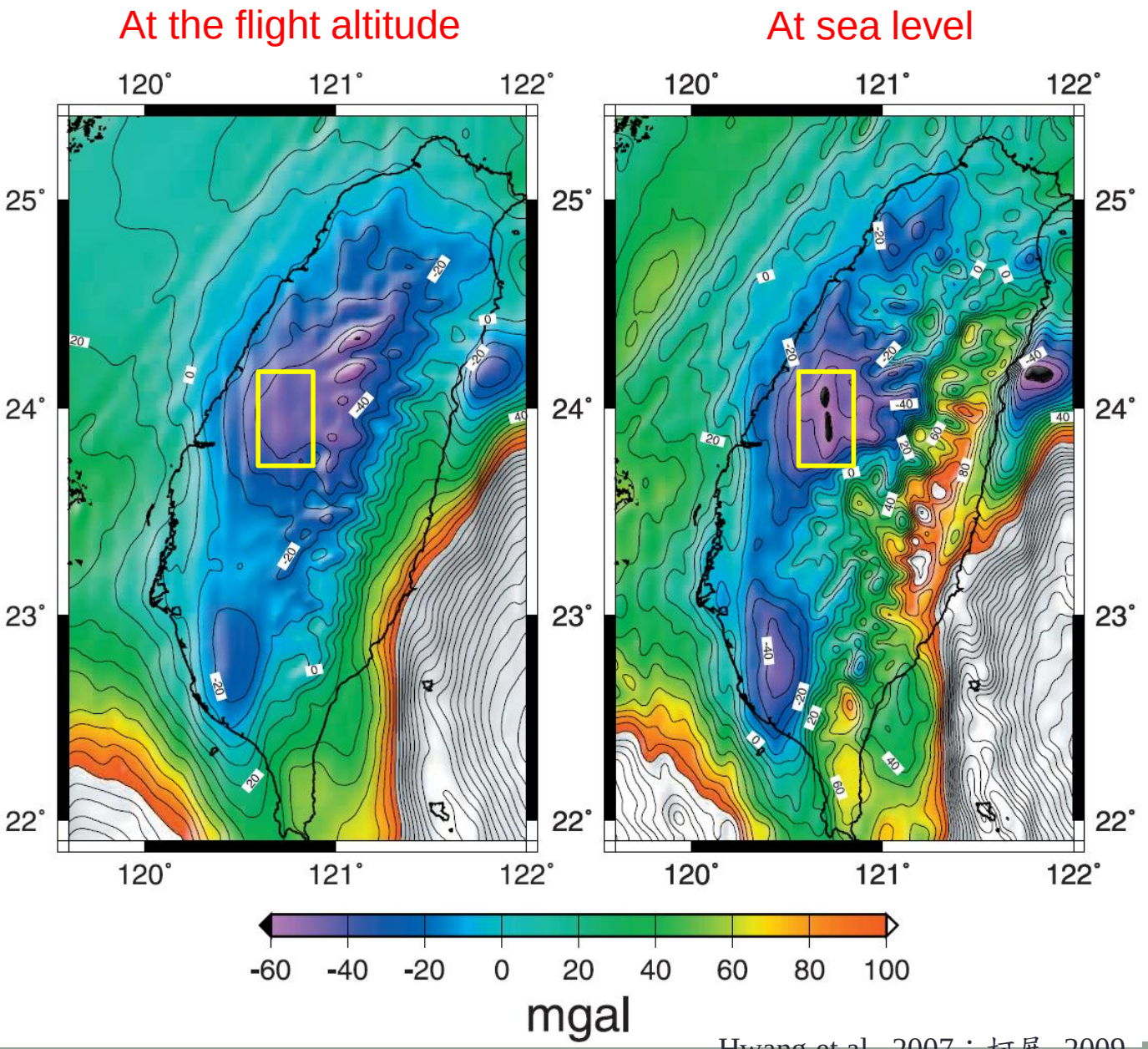



Shyu and Sieh, 2005

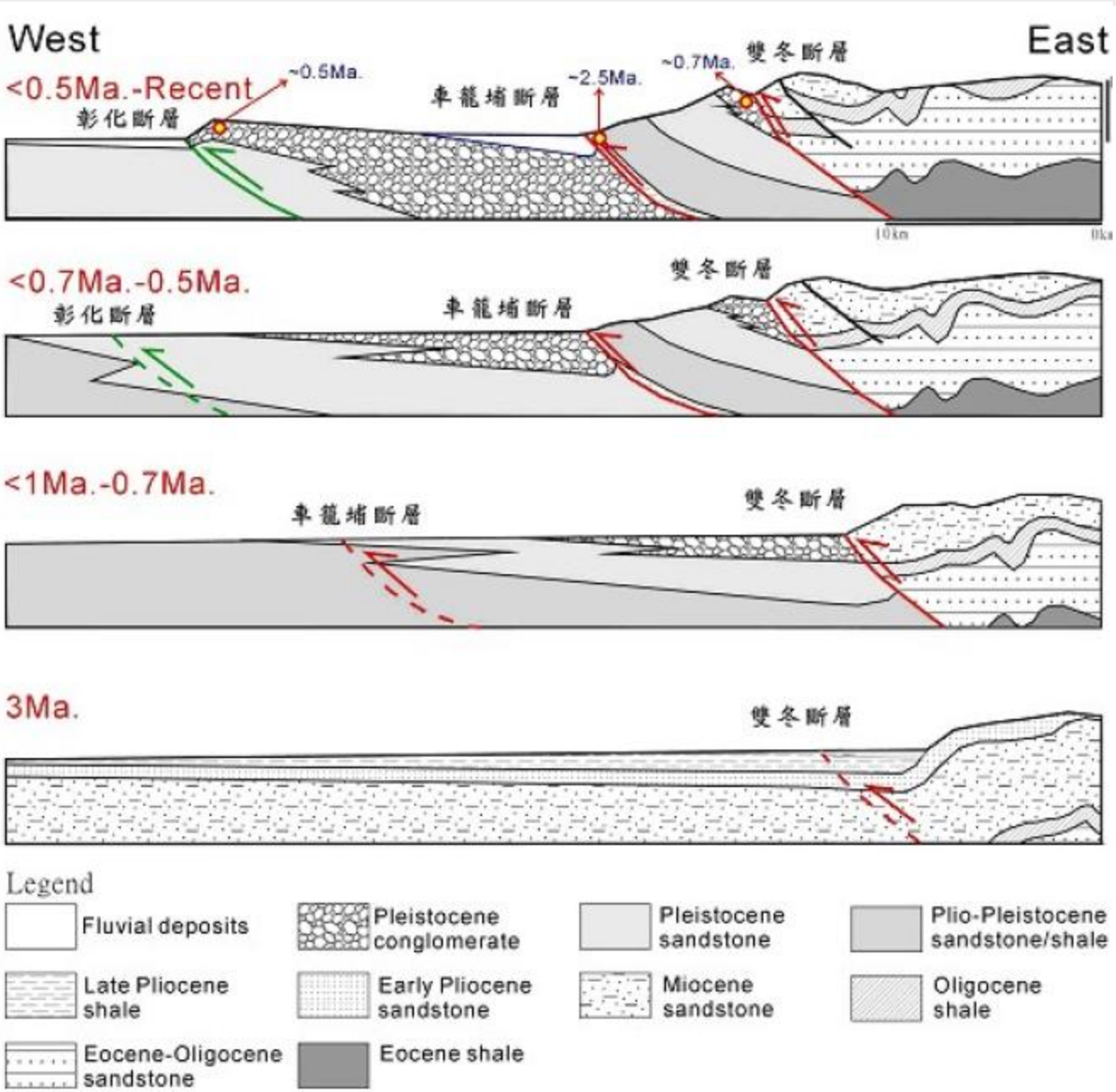
# The Bouguer anomalies

台中盆地的重力低區

- 近地表厚層的沉積層所造成，且有一滑脫面位於深部。




Hwang et al., 2007；柯展, 2009


West
East
<0.5Ma.-Recent
~0.5Ma.
彰化斷層
車籠埔斷層
~2.5Ma.
~0.7Ma.
雙冬斷層
10km
0ka
<0.7Ma.-0.5Ma.
彰化斷層
車籠埔斷層
雙冬斷層
<1Ma.-0.7Ma.
車籠埔斷層
雙冬斷層
3Ma.
雙冬斷層
Legend
Fluvial deposits
Pleistocene conglomerate
Pleistocene sandstone
Plio-Pleistocene sandstone/shale
Late Pliocene shale
Early Pliocene sandstone
Miocene sandstone
Oligocene shale
Eocene-Oligocene sandstone
Eocene shale

陳文山等人,2000a

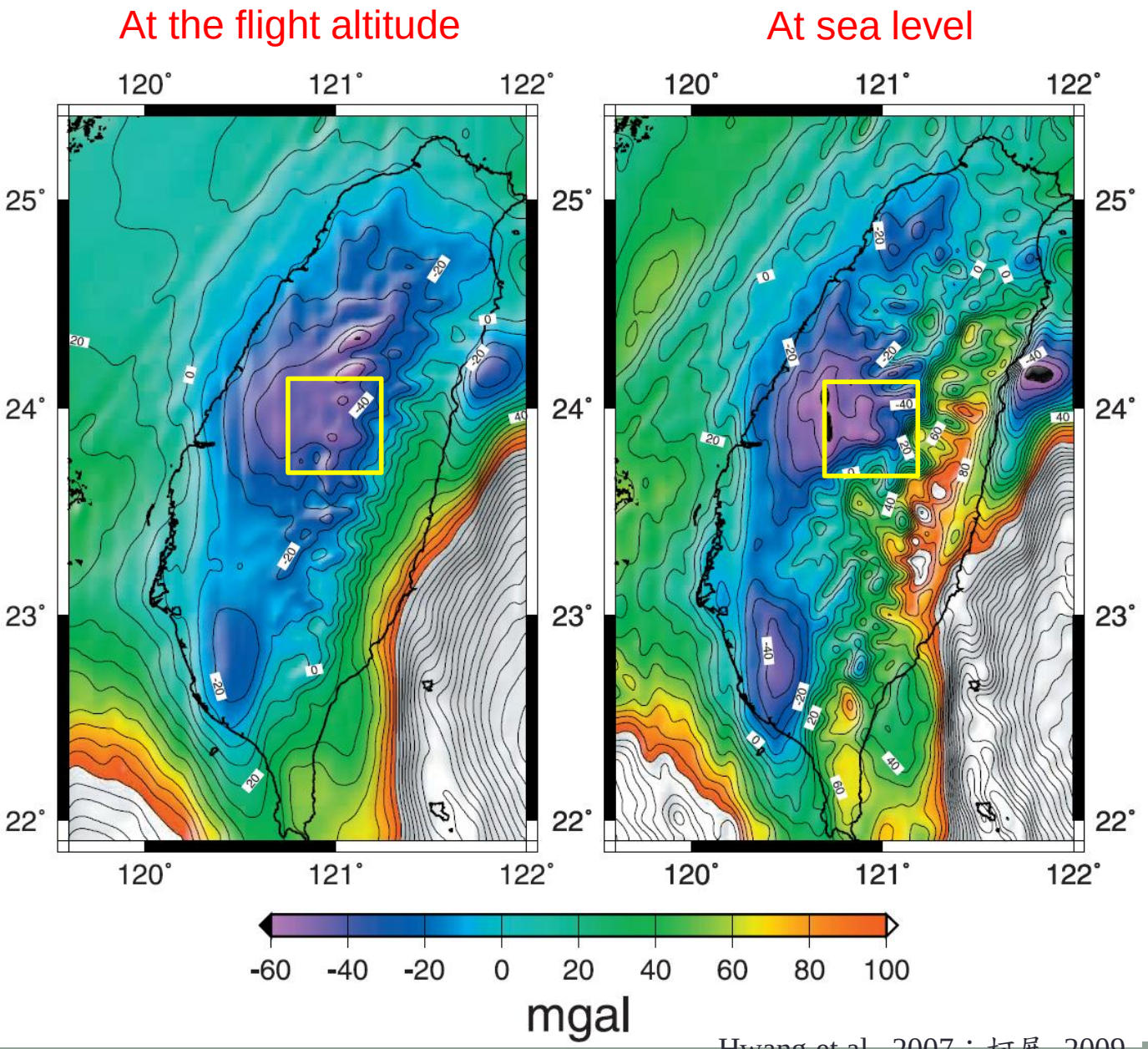
# Puli basin

- 42 km$^2$ in area
- Gravity Low
- A series of basins
- Intra-Mountain basin

# The Bouguer anomalies

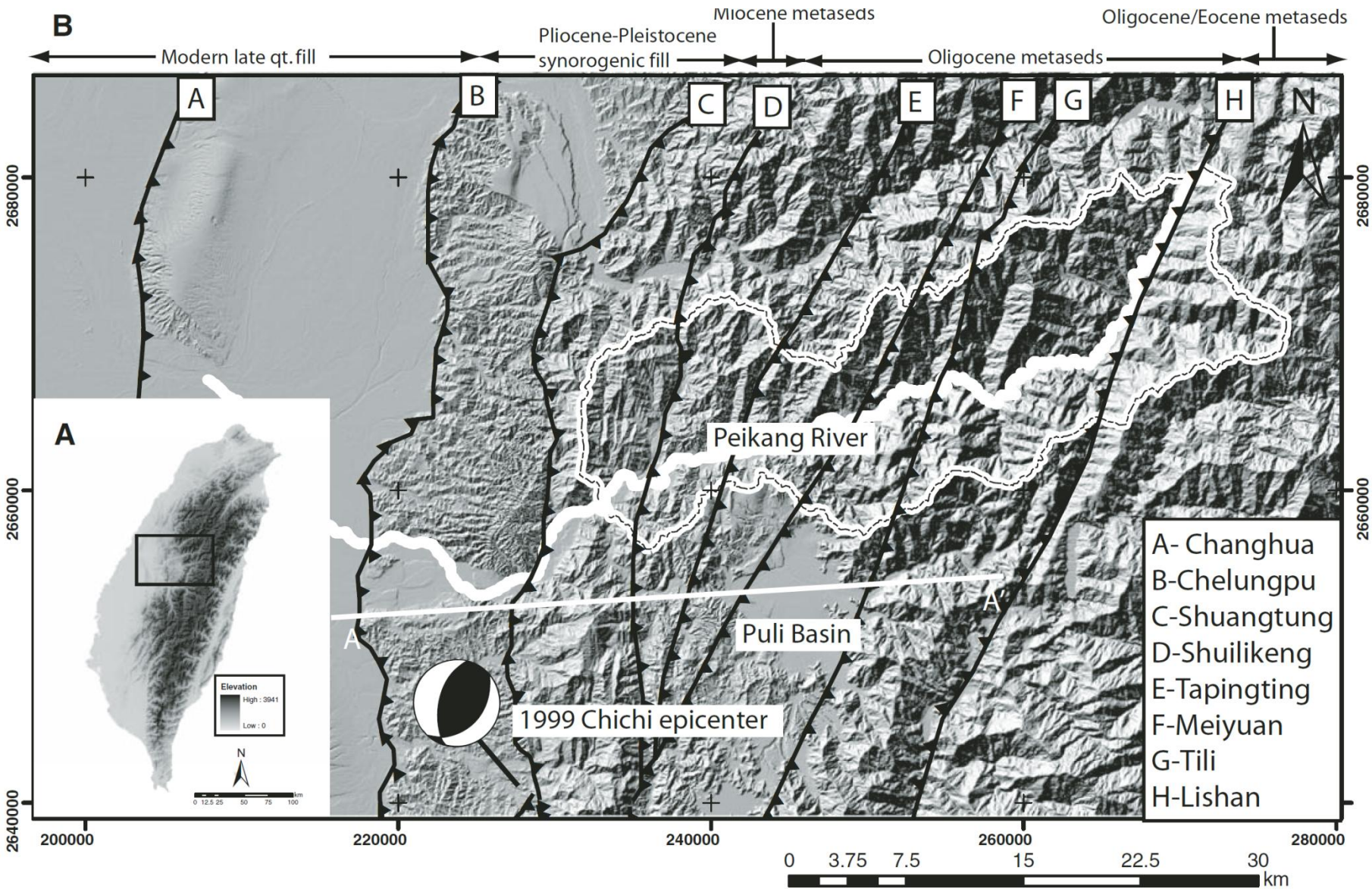
埔里盆地的重力低區

- 為深部堆積著密度較低的上新世晚期-更新世初期地層(頭嵙山層)



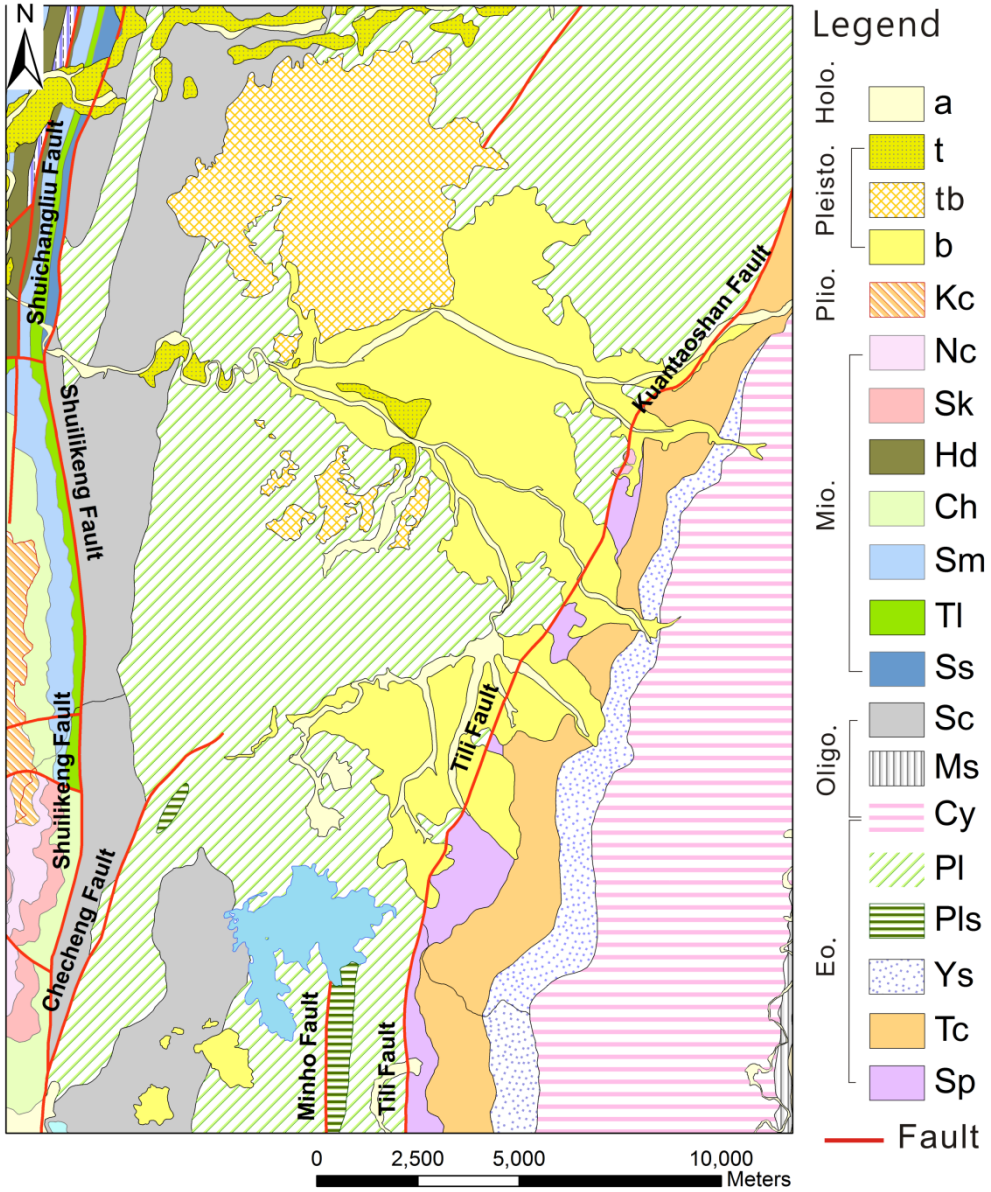

Hwang et al., 2007；柯展, 2009

# Geological background



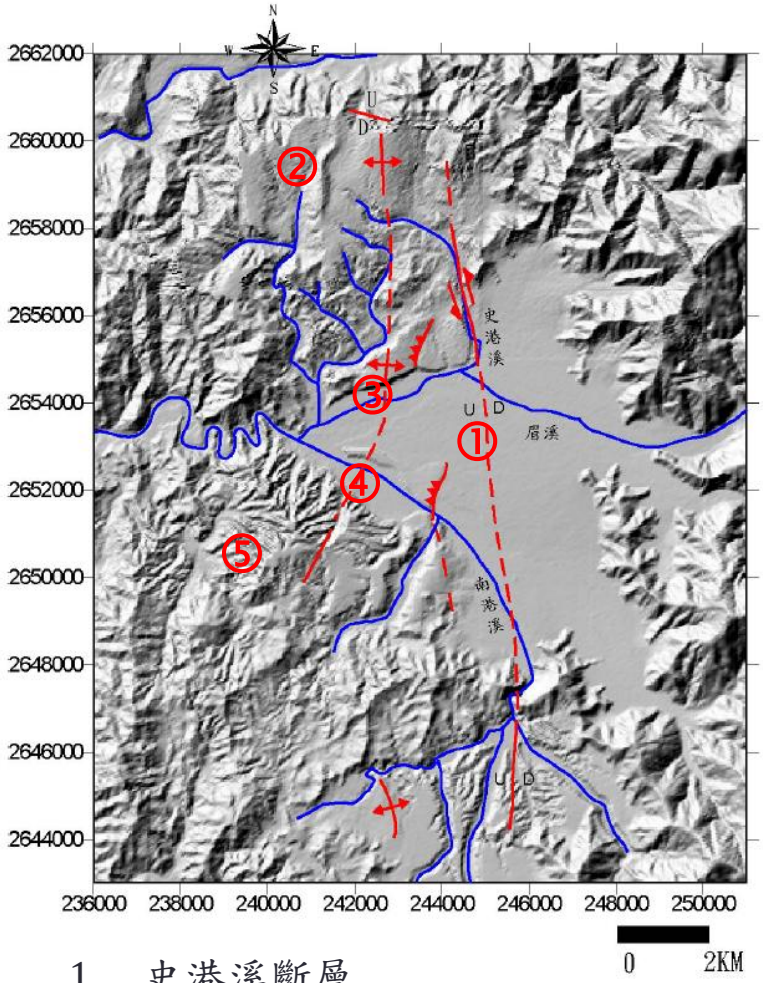

Powell, 2003

# Geological background









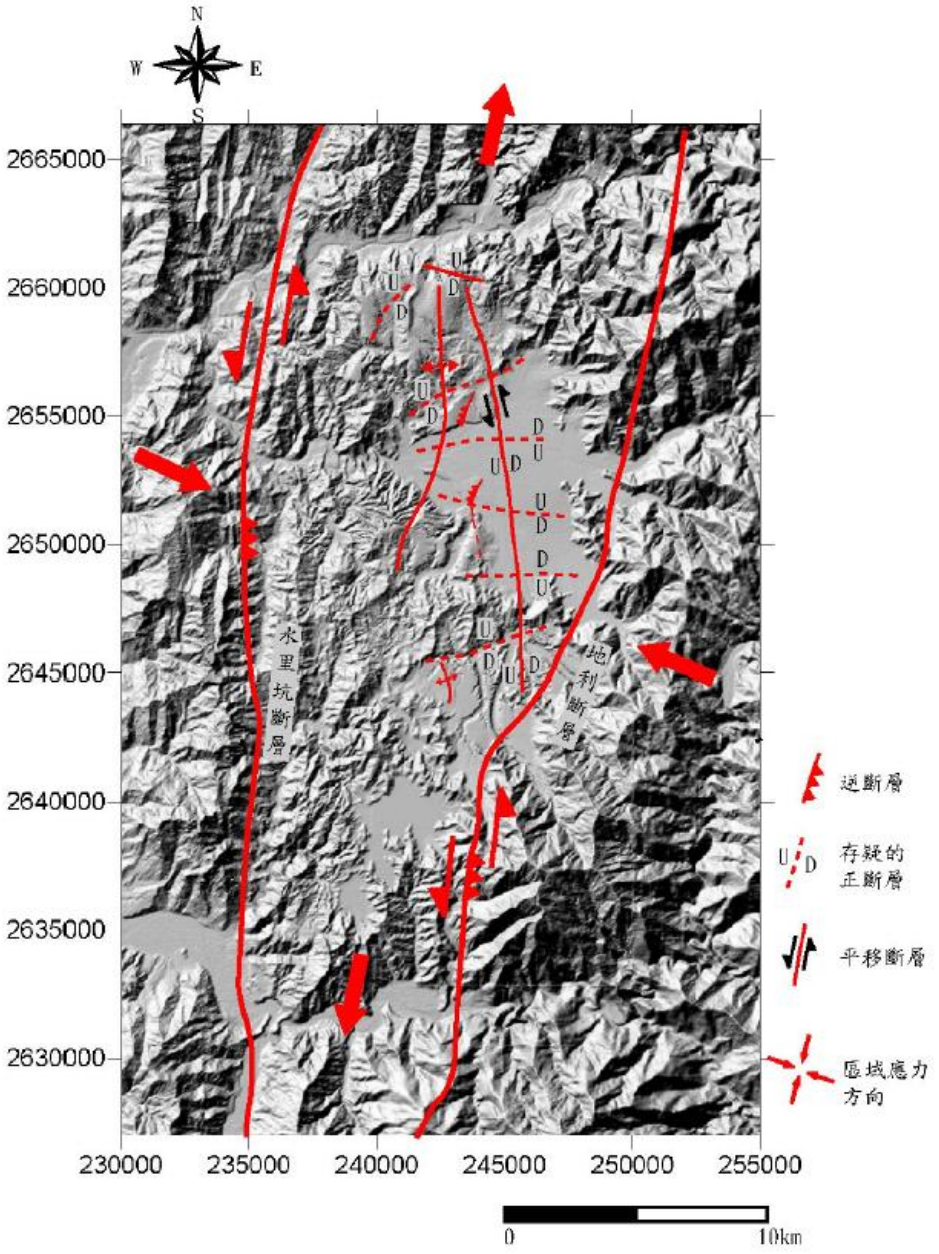

1. 史港溪斷層
2. 大坪頂背斜
3. 赤崁背斜及其東邊的逆斷層
4. 愛蘭逆斷層
5. 桃米坑背斜

（資料來源:中央地質調查所 流域地質圖，2006）

陳炳誠, 2002

# 盆地之成因

1. 曲窪作用(warping)及河流侵蝕作用
2. 背負盆地(piggyback basin)
3. 活動底脫斷層張裂沉陷形成
4. 雪山山脈內的橫移拉張造成(Pull-apart basin)

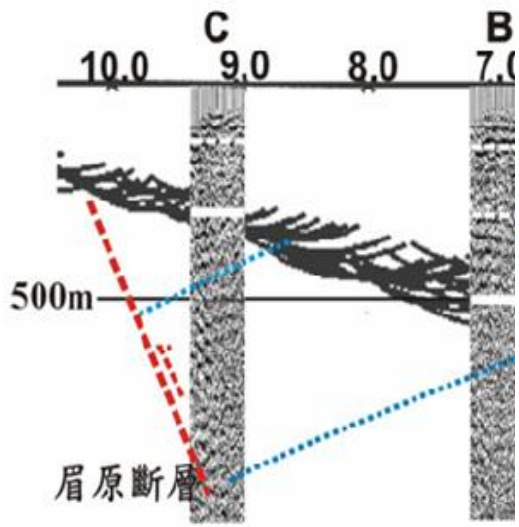


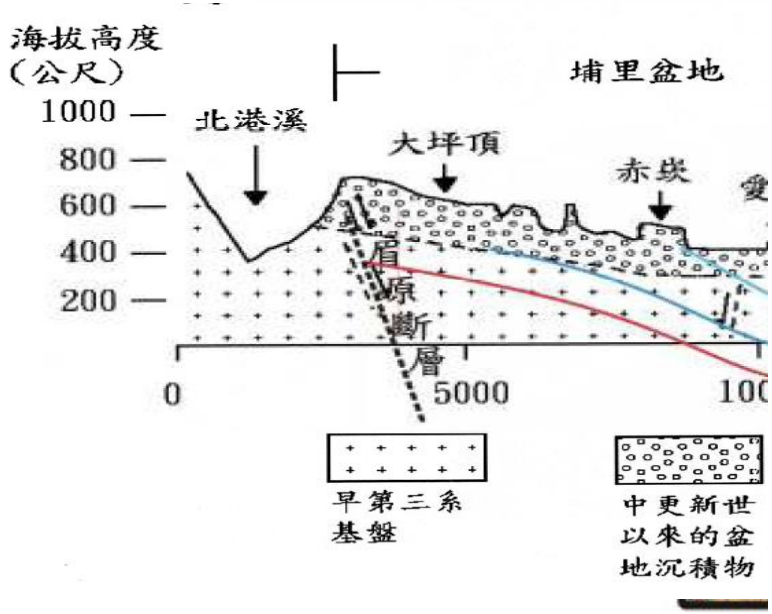

陳炳誠, 2002

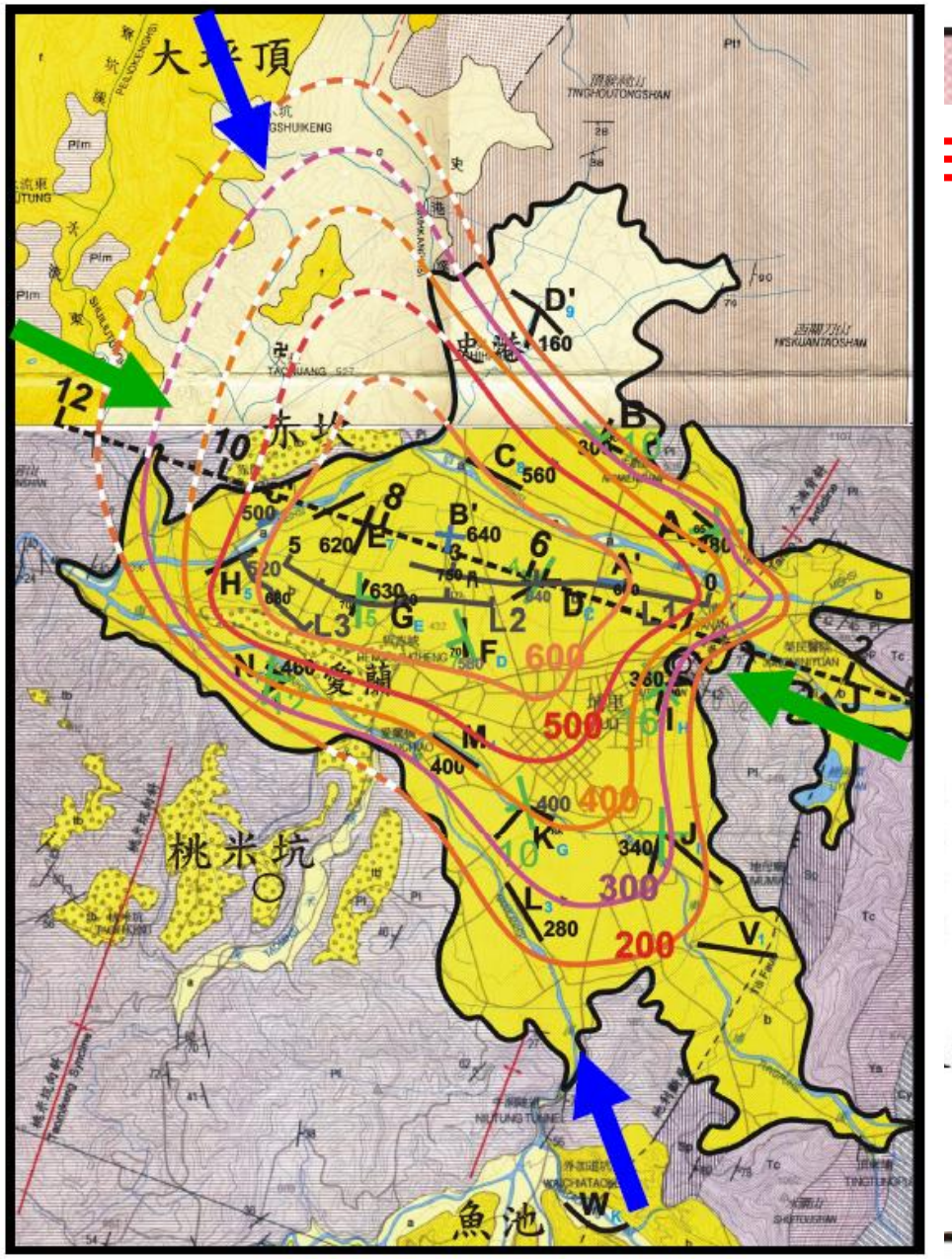
# Shallow Seismic Reflection result

## Down warping basin model

W



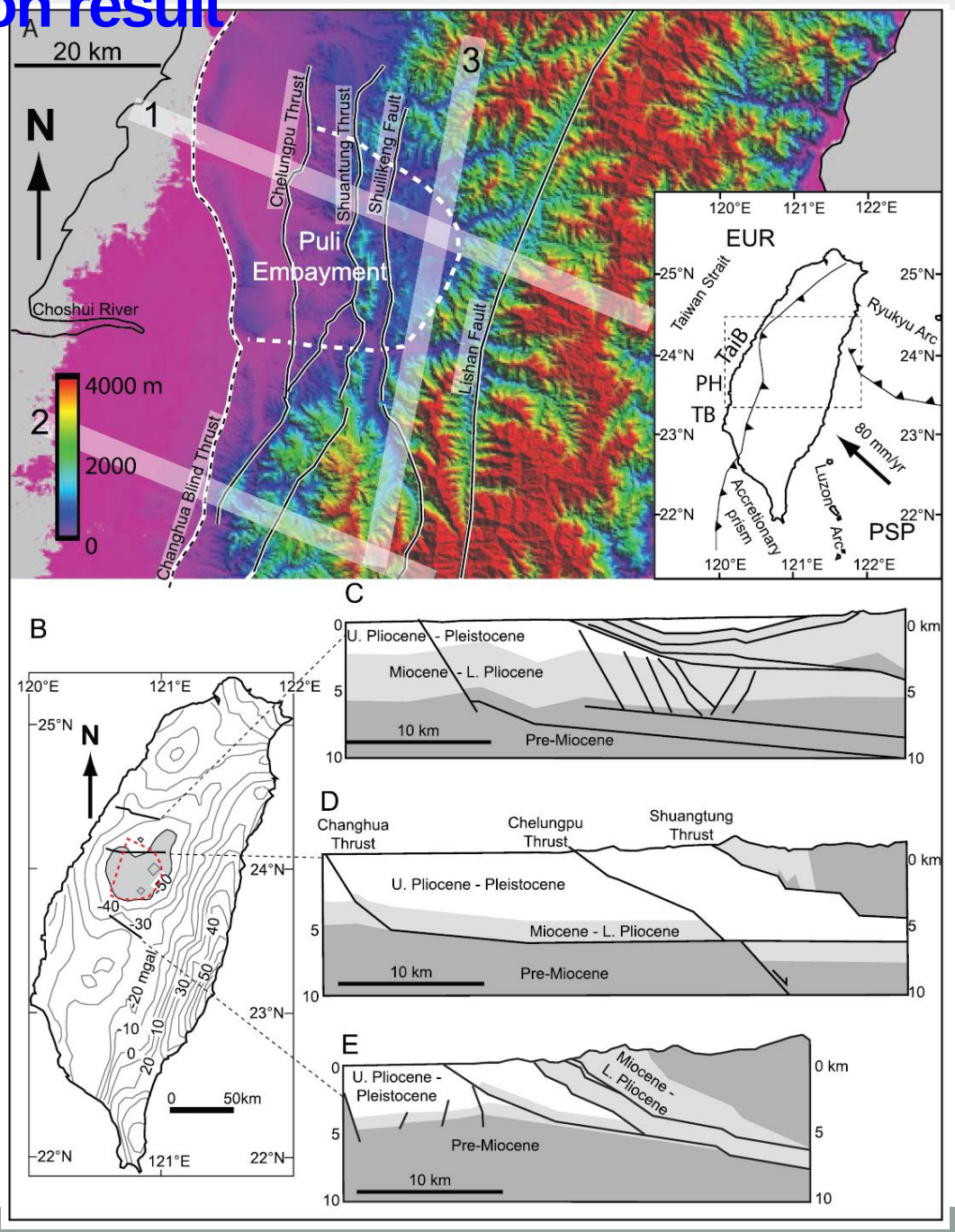




E

黃慶甲, 2007；柯瑞祥, 2009

# Shallow Seismic Reflection result

**piggyback basin**

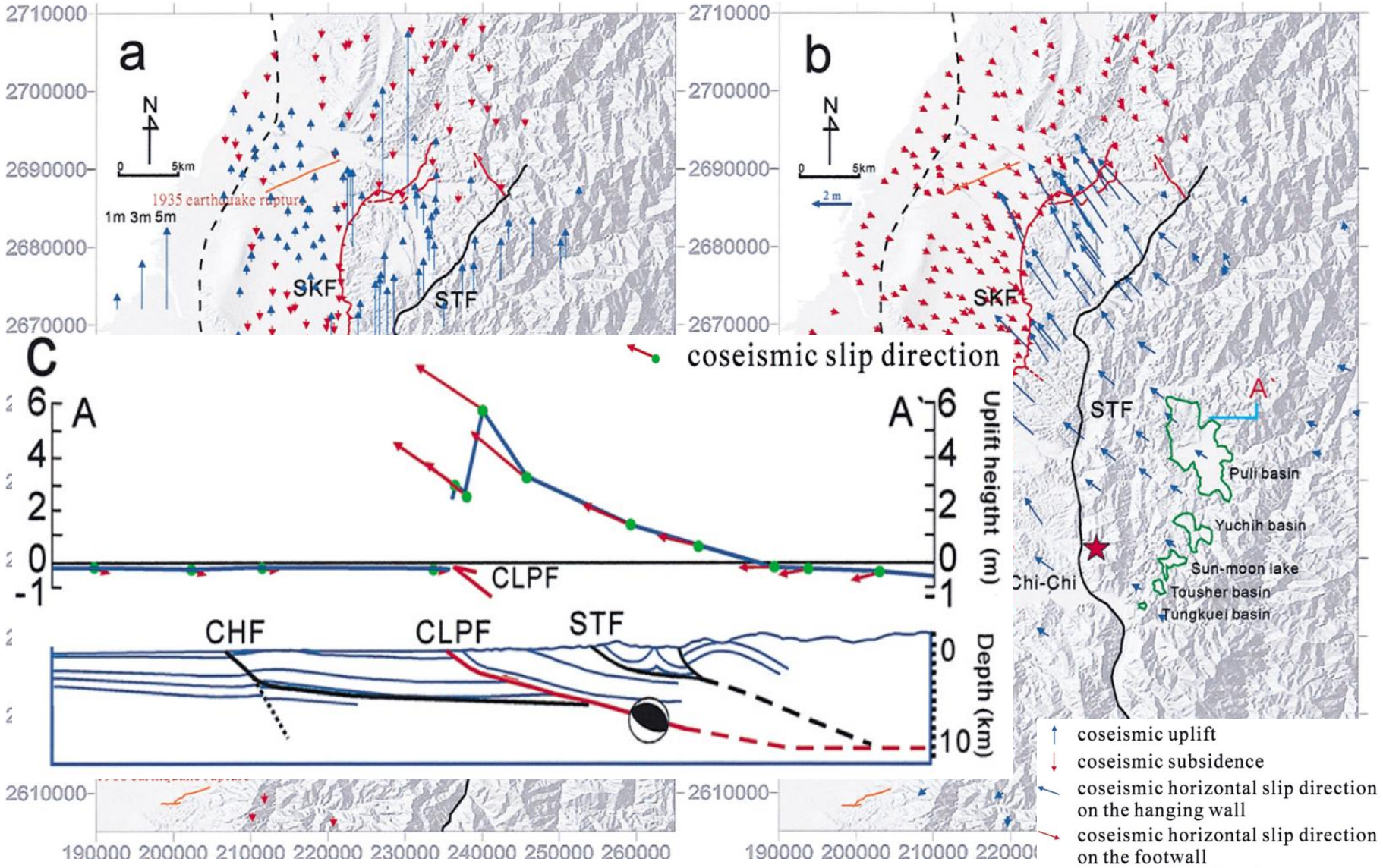



Bouguer anomaly map of Taiwan [after Yeh and Yen, 1992].

Upton et al., 2009

# GPS measurements after the Chi-Chi earthquake

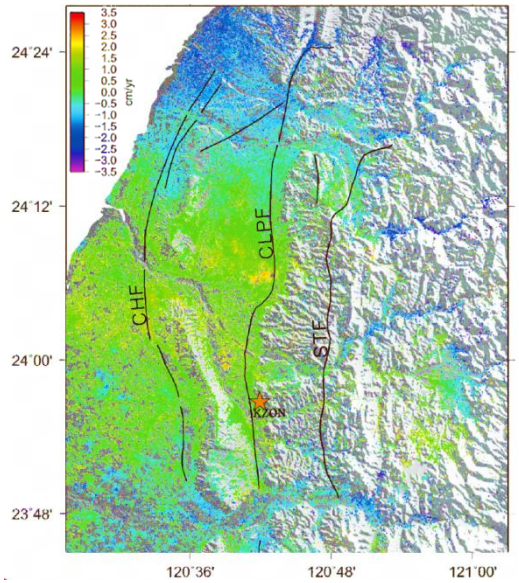
## A detachment under the Puli basin caused the rifting of the basin



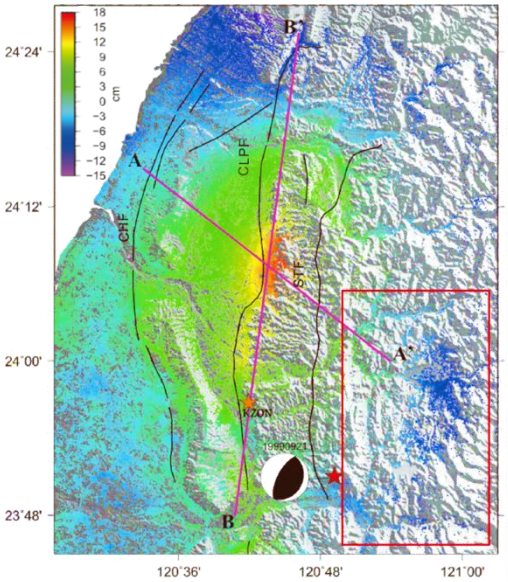

Chen et al., 2001

# PSInSAR result

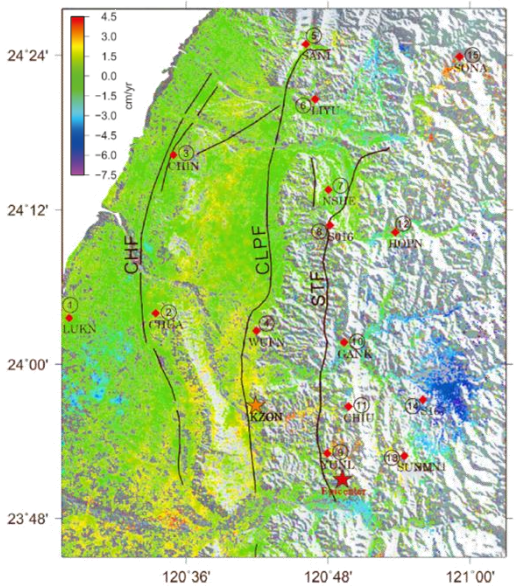
- There is small discrepancy between InSAR results and GPS measurements, however, the total deformation trends are very similar in the post-seismic period.
- Moreover, this study demonstrates that the capability of time series InSAR technique is not only good to monitoring the ground displacement in the subtropical area such as Taiwan, but also to analysis the long-term temporal and spatial deformation.




Pre-seismic Deformation

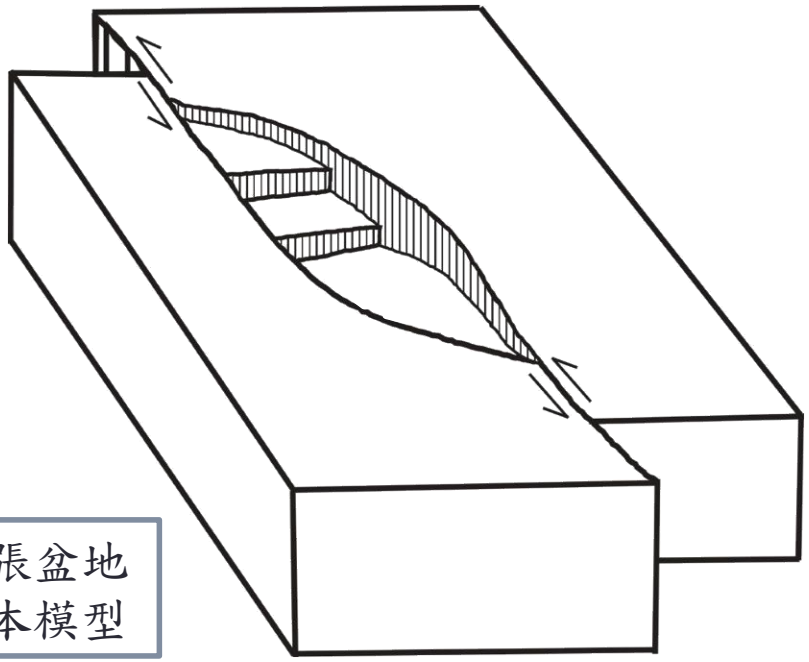



Co-seismic Deformation

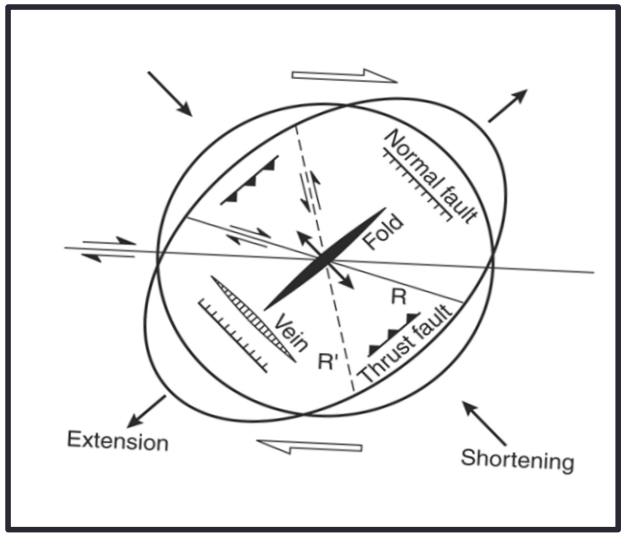


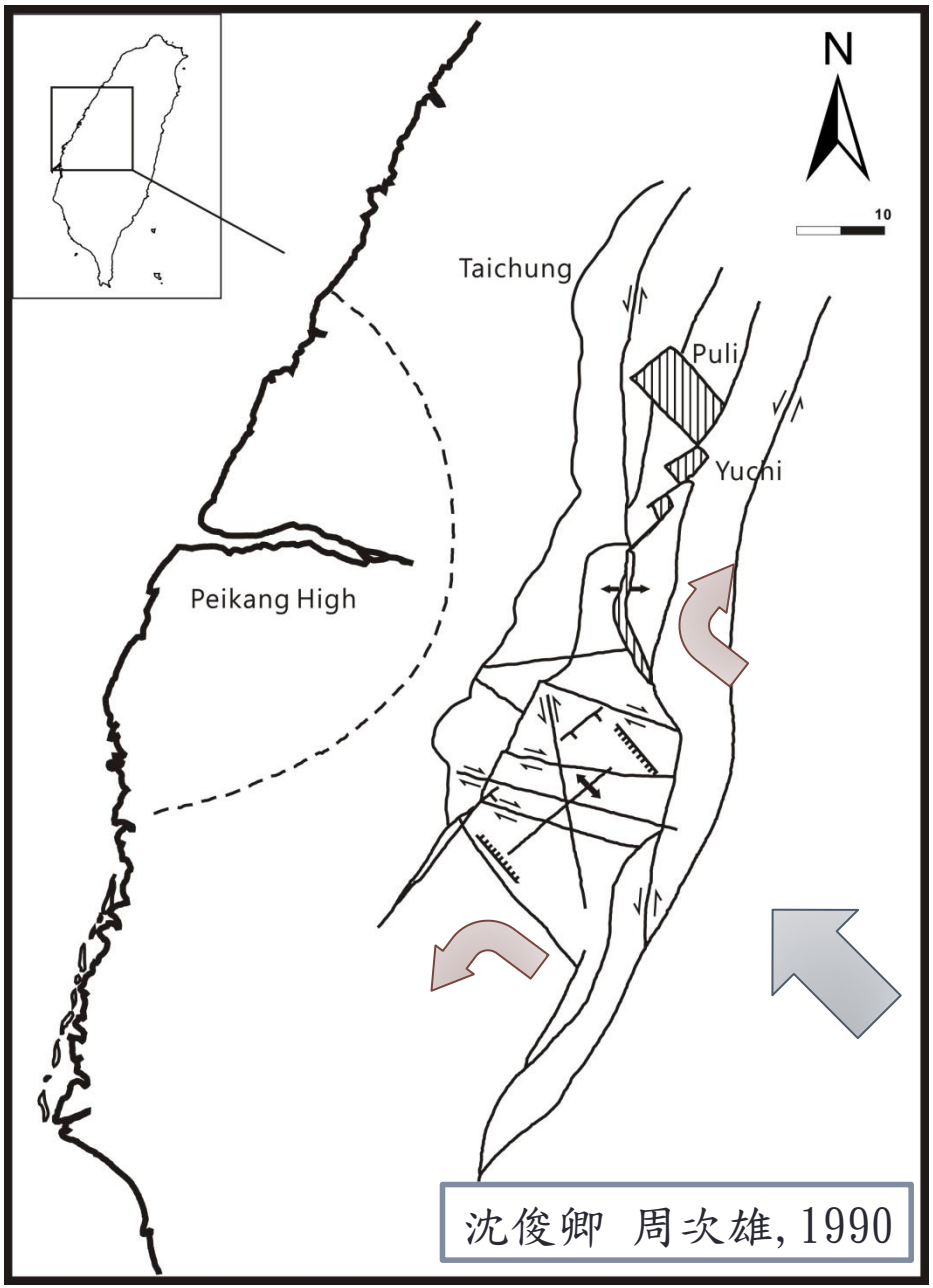

Post-seismic Deformation

# Pull-apart basin



拉張盆地
基本模型



# Oblique convergence, indentation and rotation tectonics in the Taiwan Mountain Belt: Insights from experimental modelling

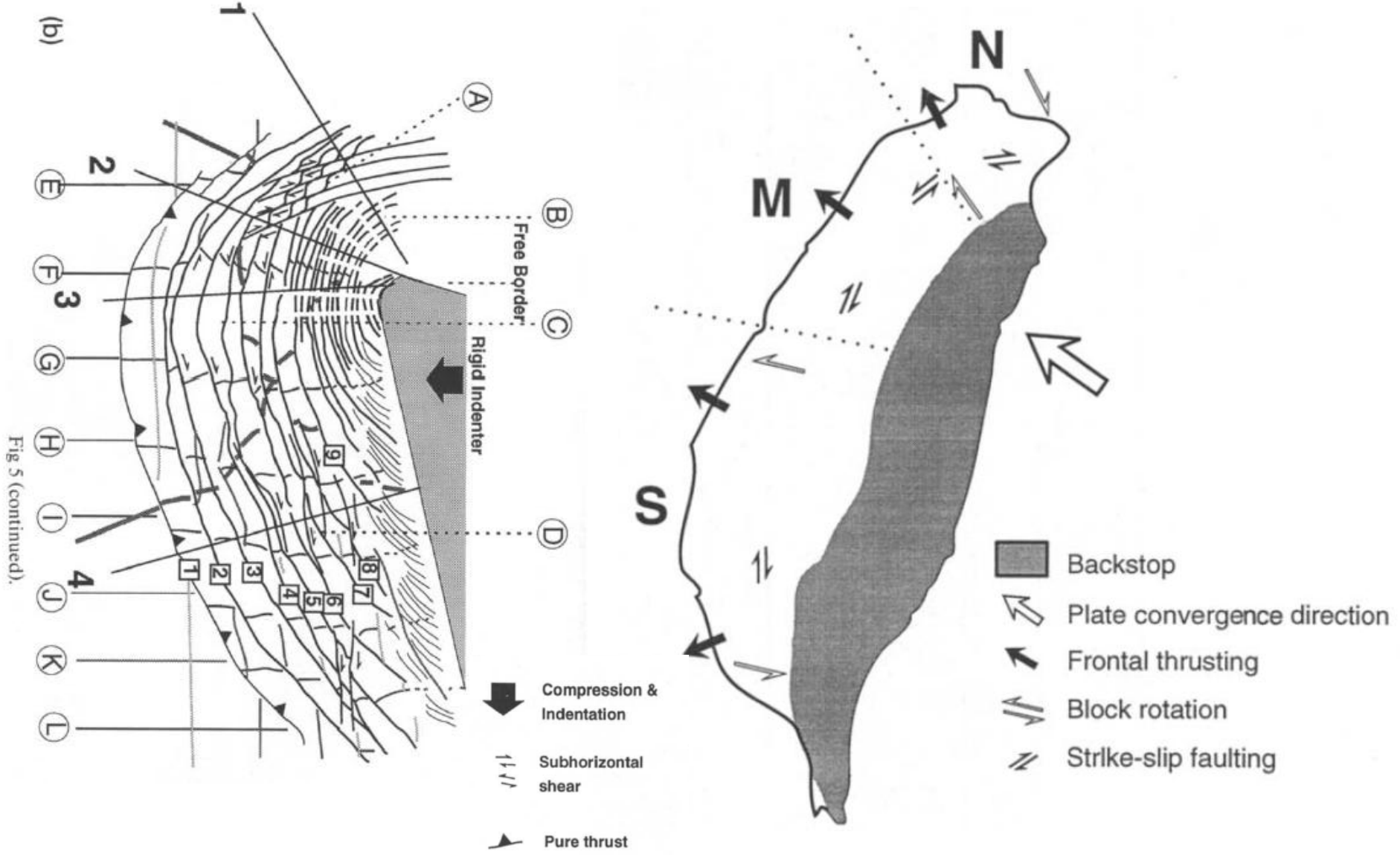
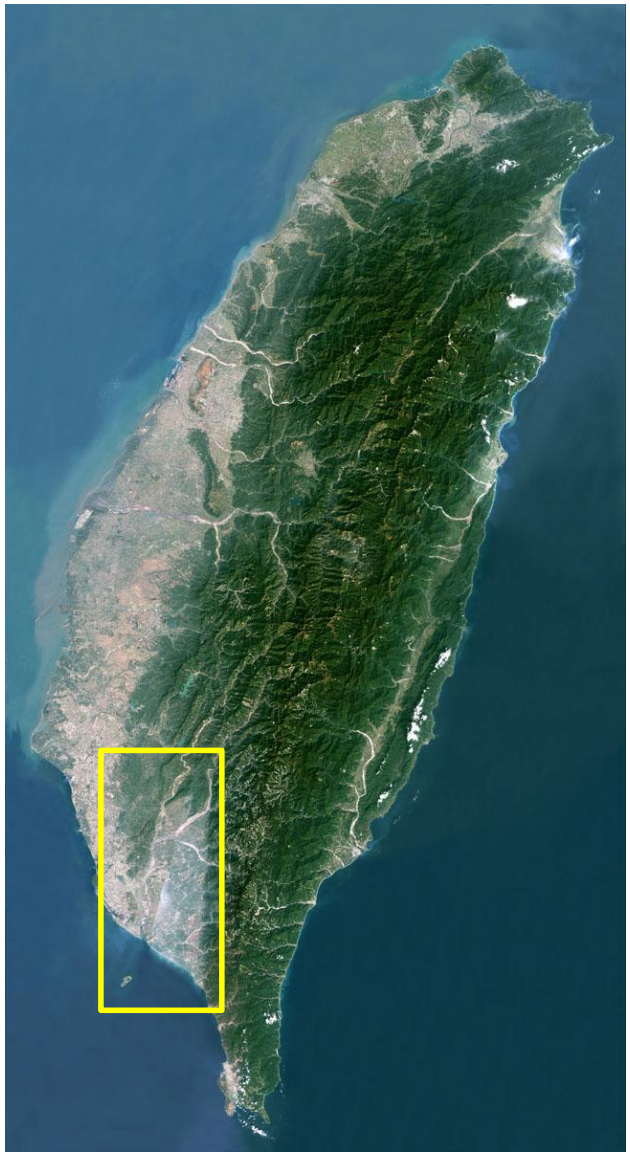


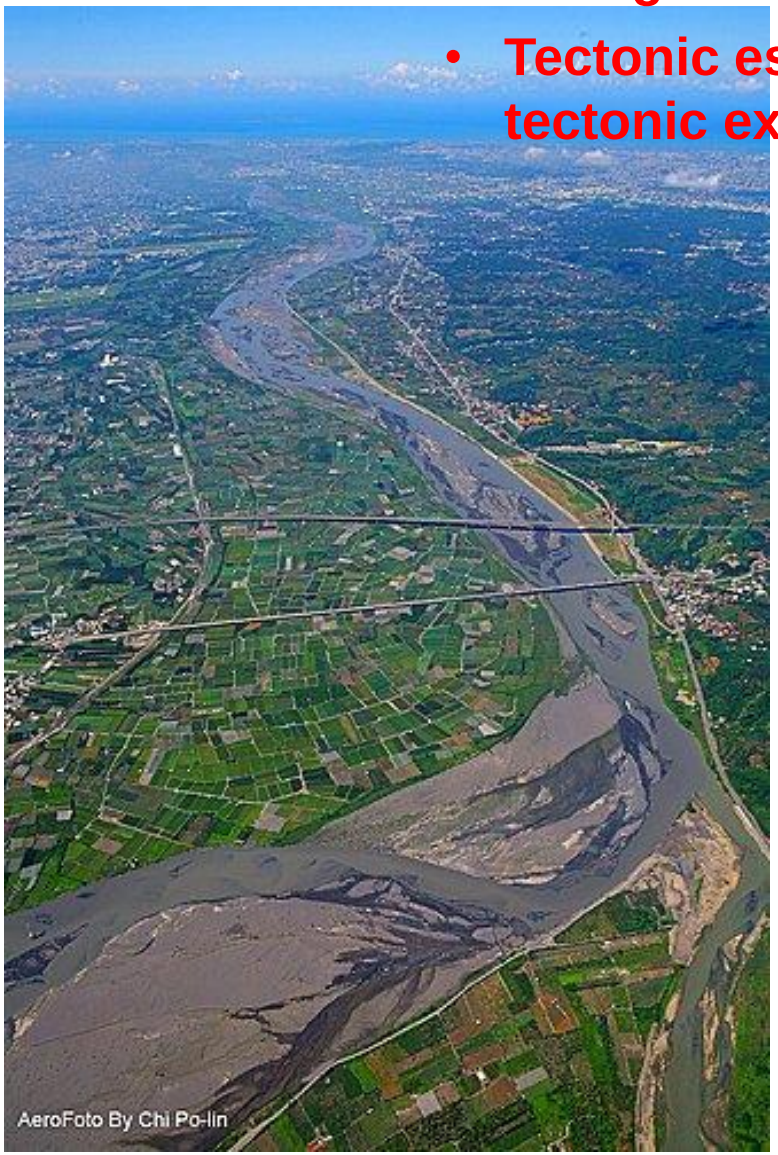

Fig 5 (continued).

Lu and Malavieille, 1994

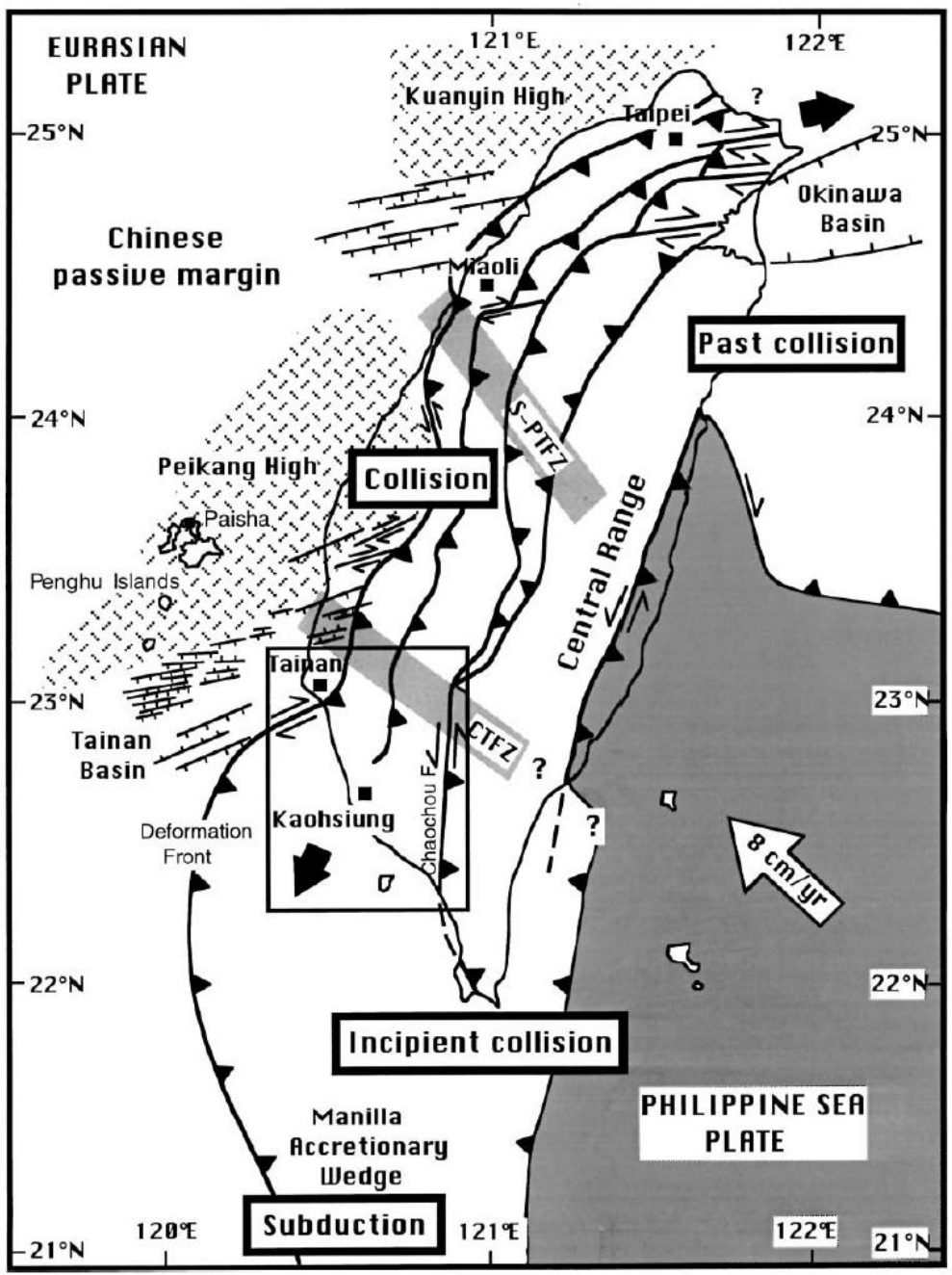
# Pingtung plain

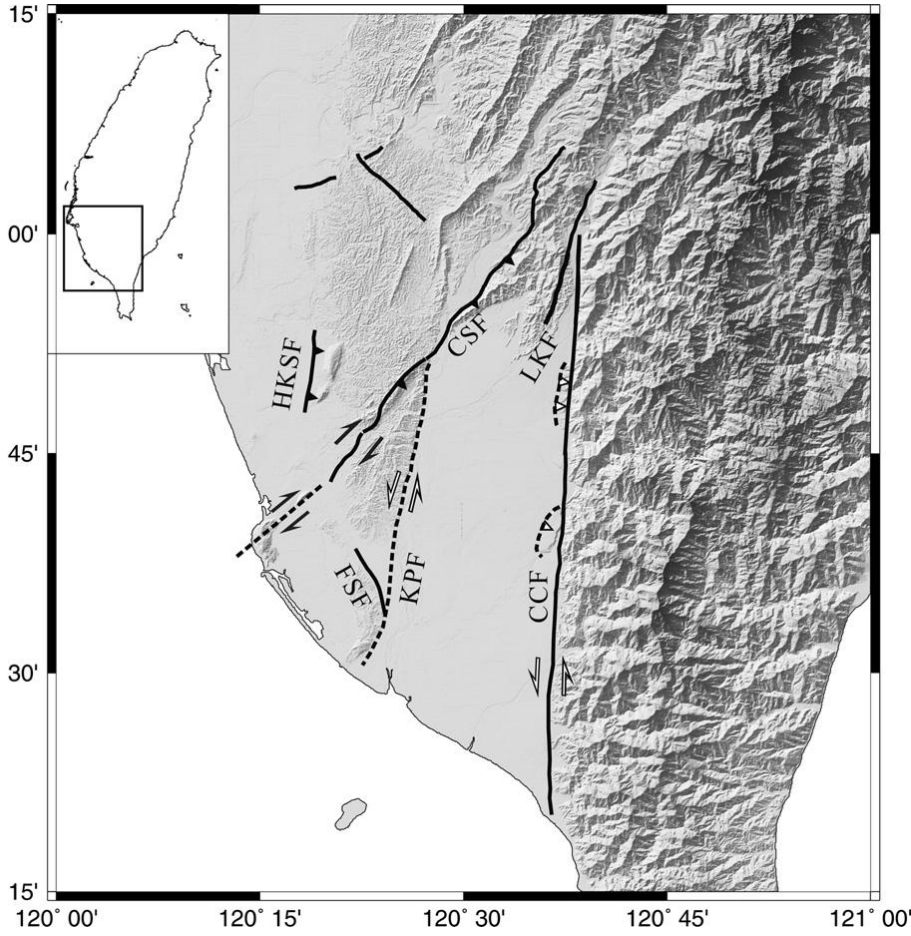
- 1210 $Km^2$ in area
- Triangular alluvial plain
- Tectonic escape or tectonic extrusion





# Geotectonic setting



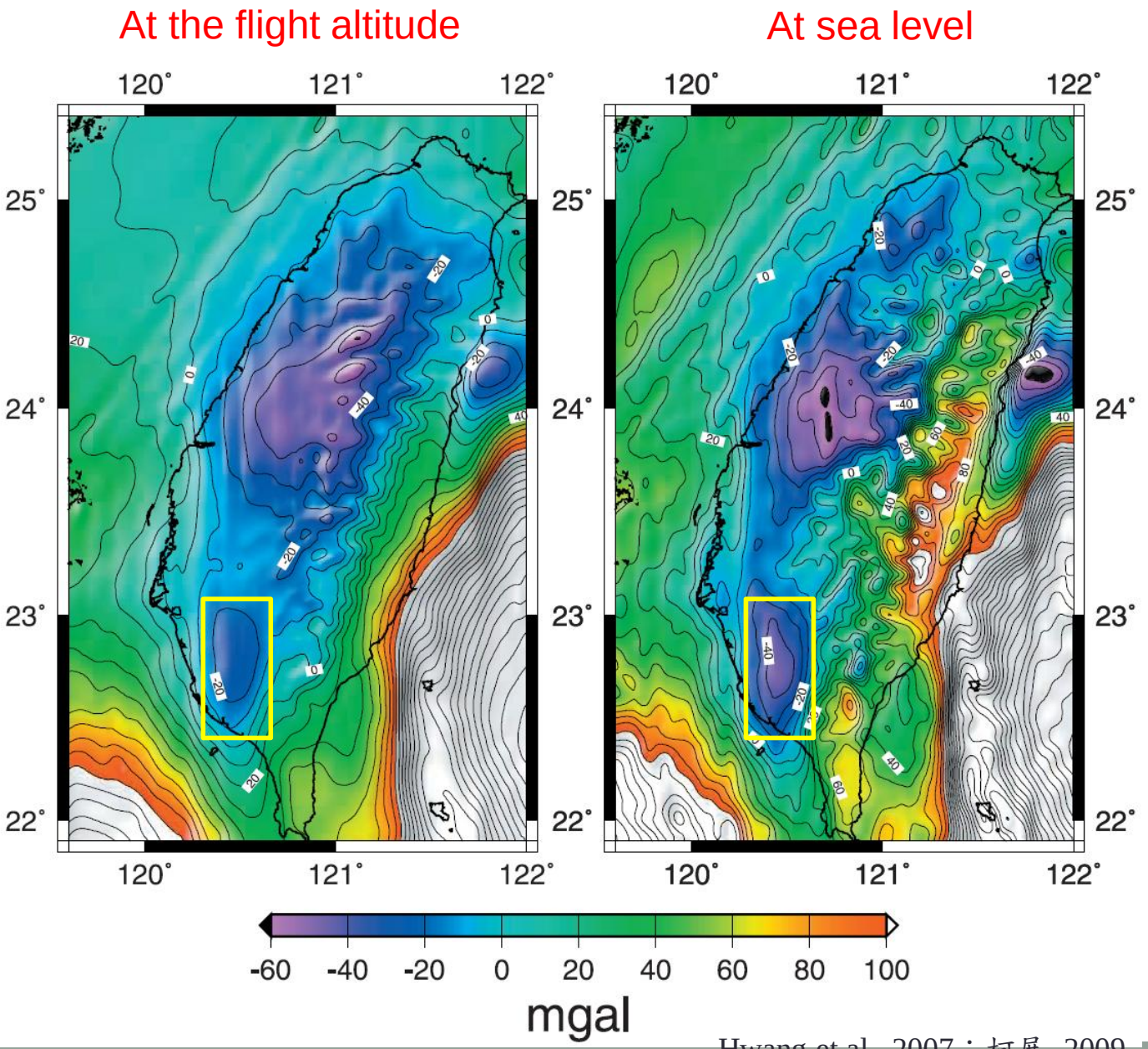




Lacombe et al., 2001

# The Bouguer anomalies

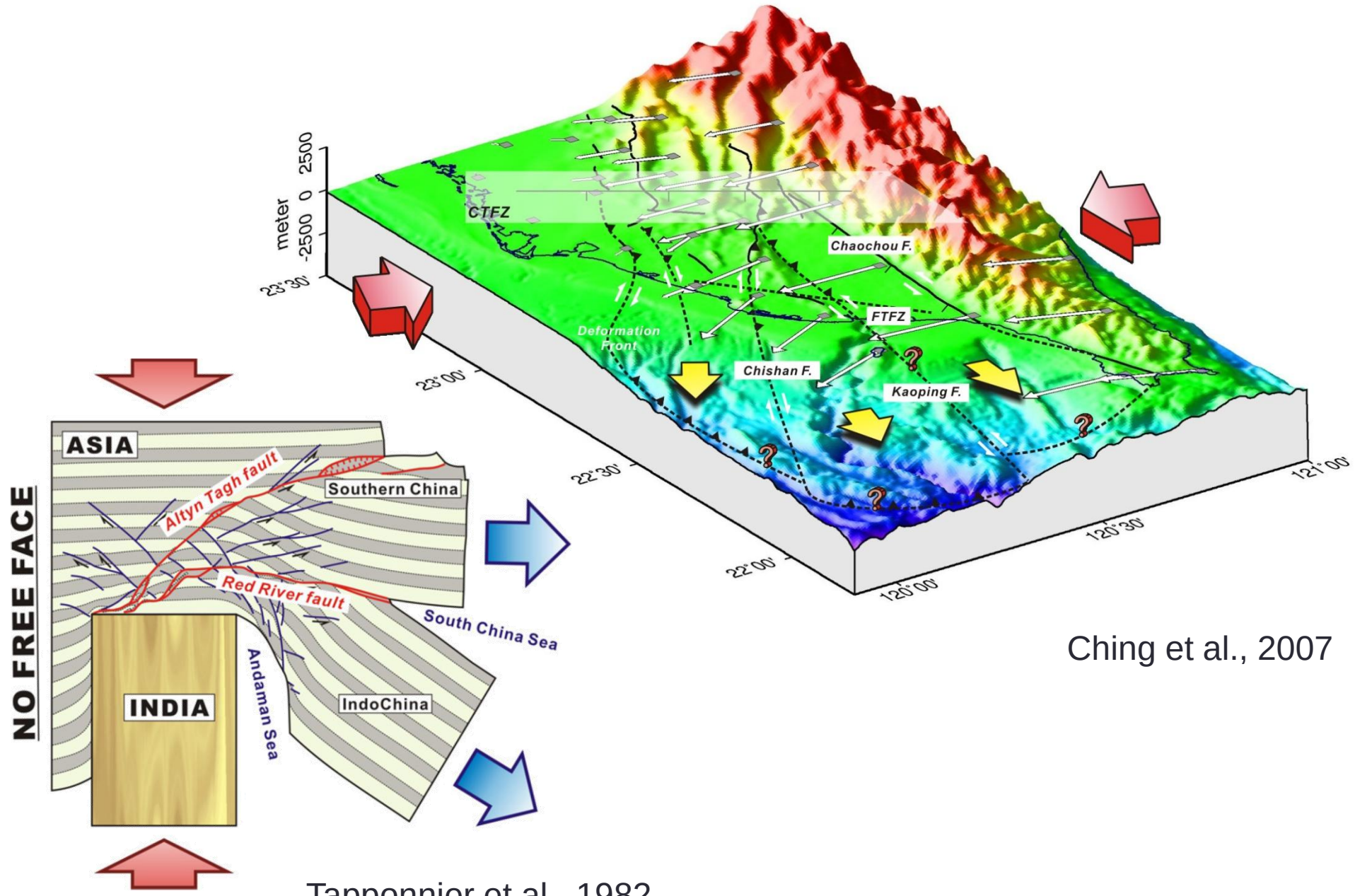
屏東平原的重力低區

- 近地表厚層的沉積層所造成。




Hwang et al., 2007；柯展, 2009

# Tectonic escape or tectonic extrusion

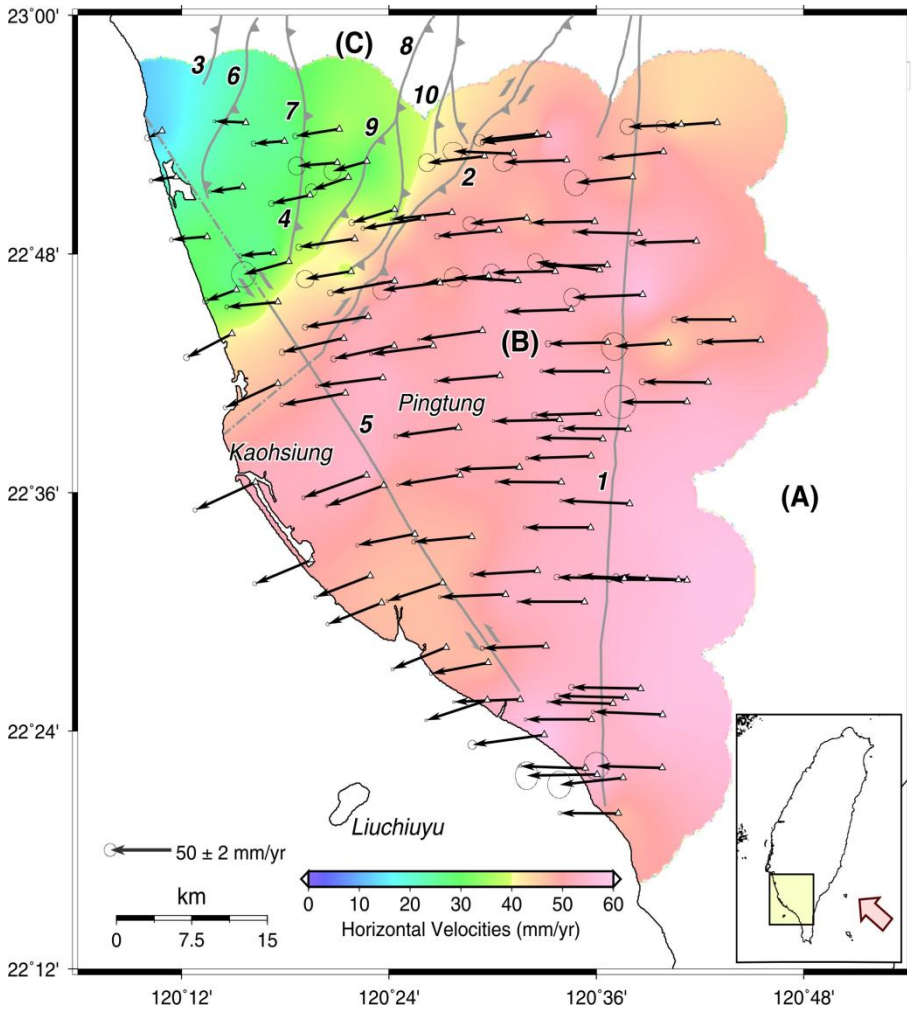



Ching et al., 2007

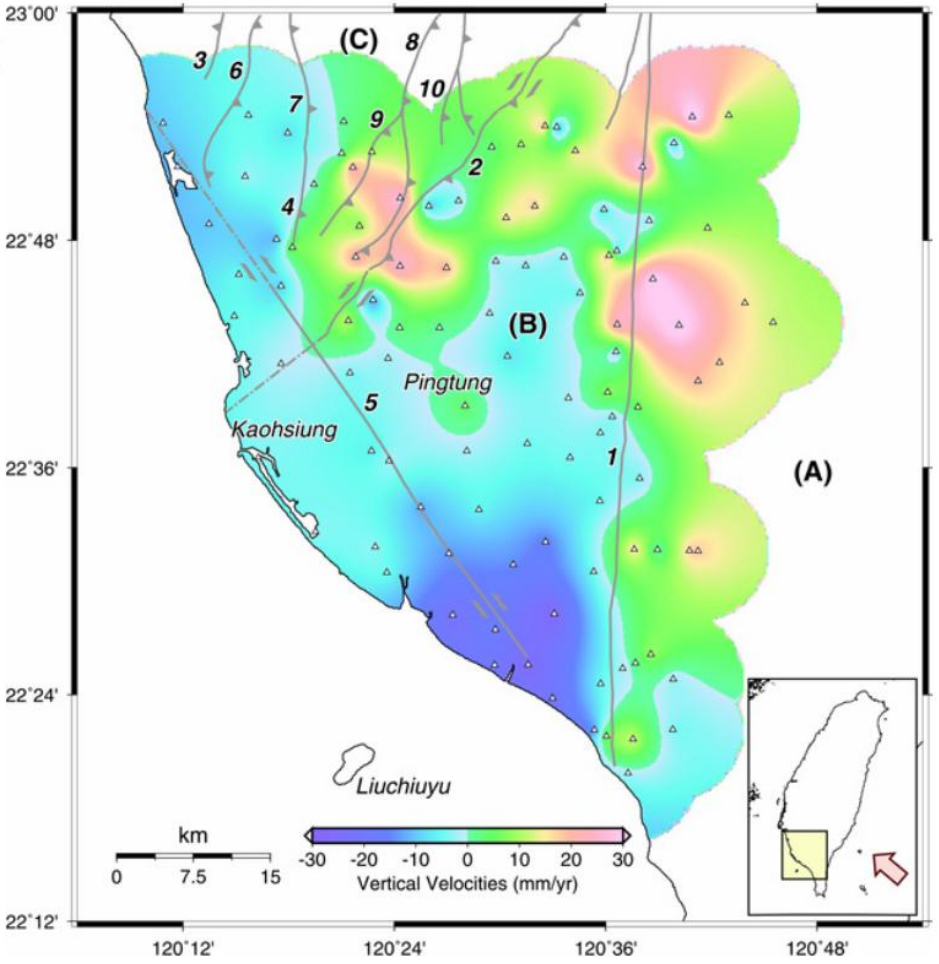
Tapponnier et al., 1982

# GPS measurements from 1995 to 2005

Horizontal velocity field

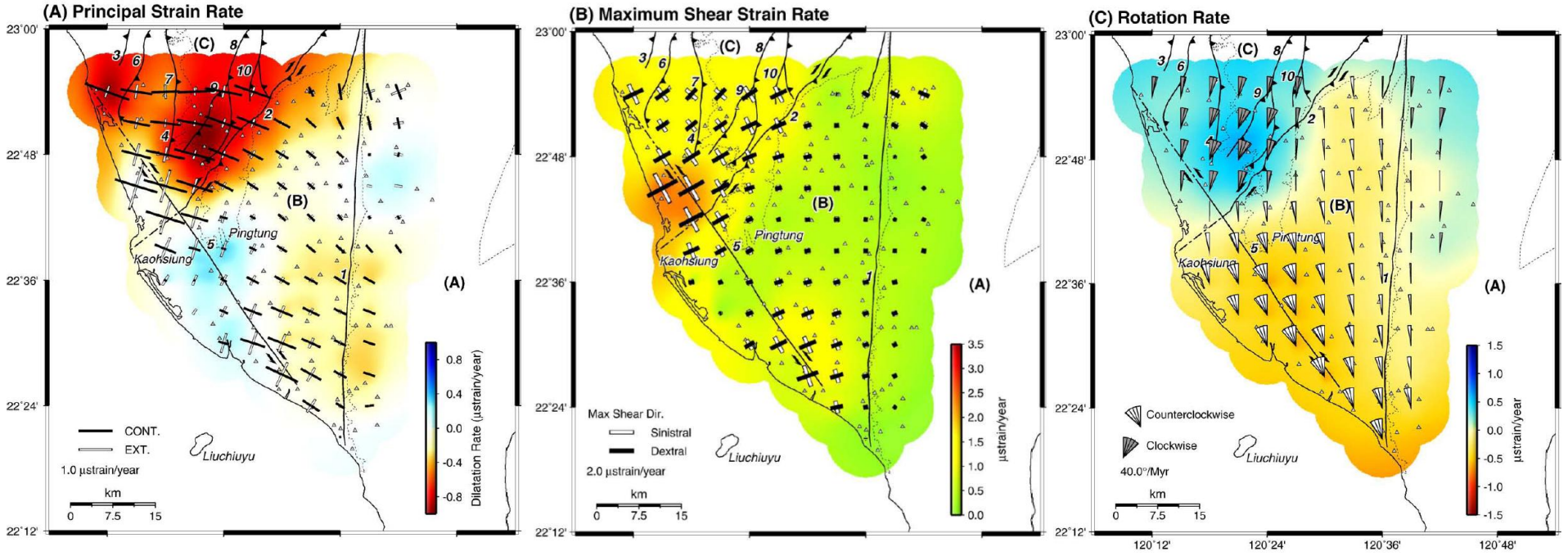



Vertical velocities



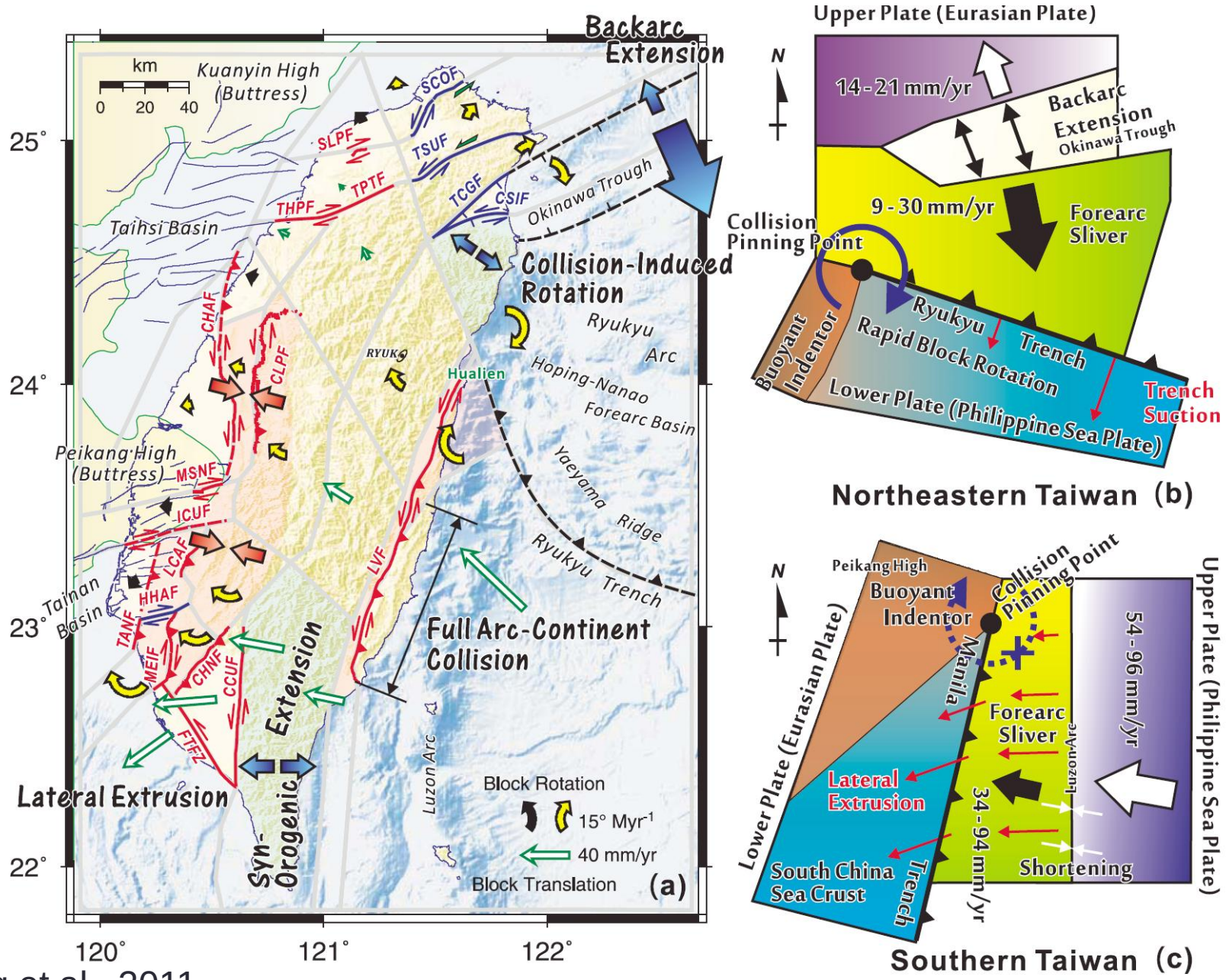

Ching et al., 2007

# Distribution of strain rates in SW Taiwan



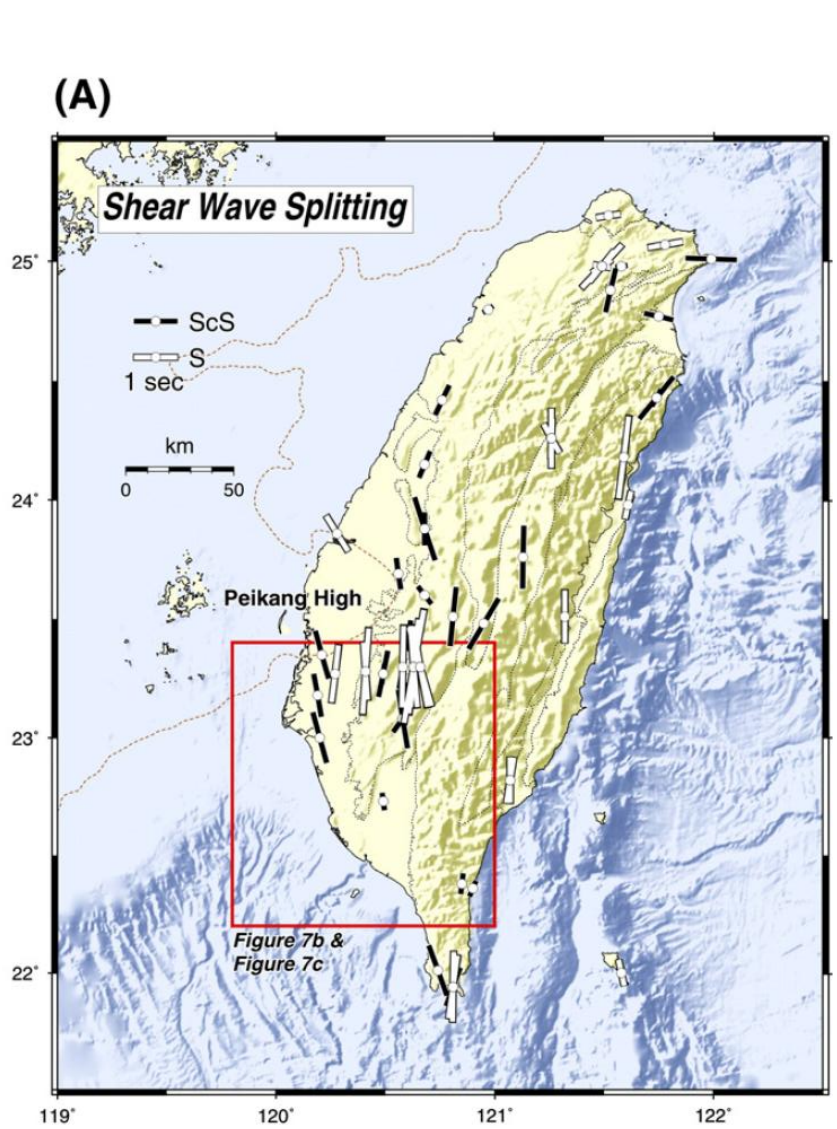

Ching et al., 2007

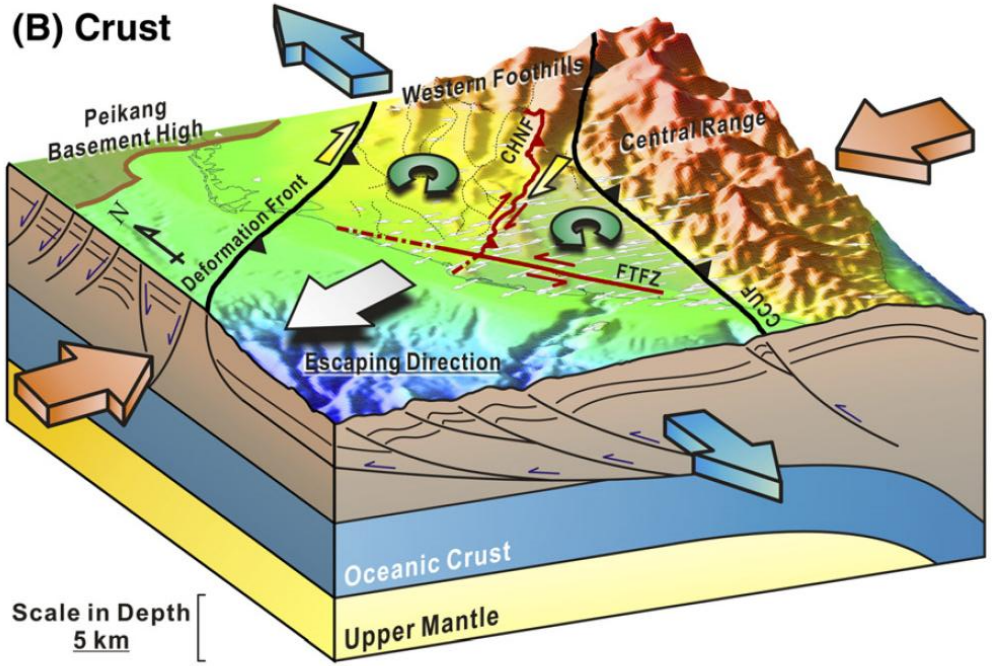
# Schematic of the strain-partitioning model

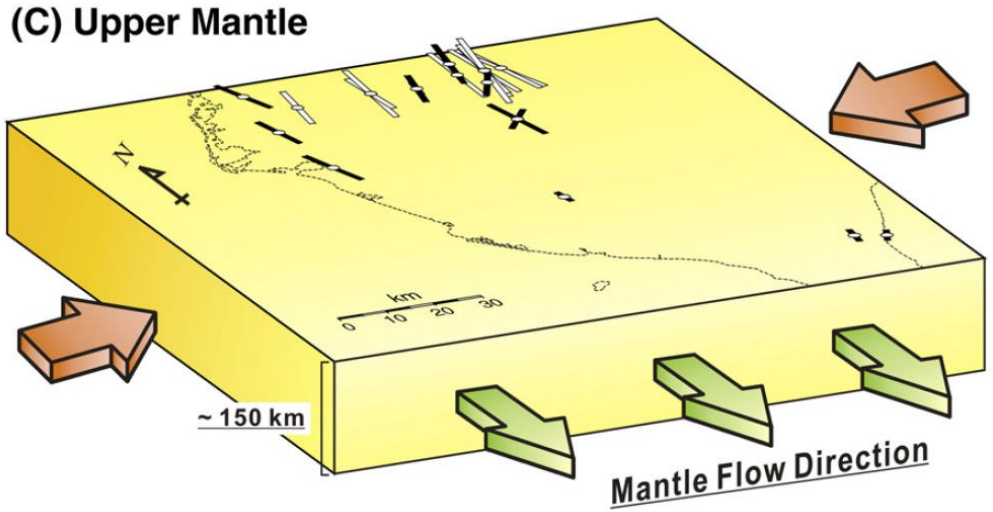



Ching et al., 2011

# The tectonic kinematic model




Ching et al., 2007

# PSInSAR result