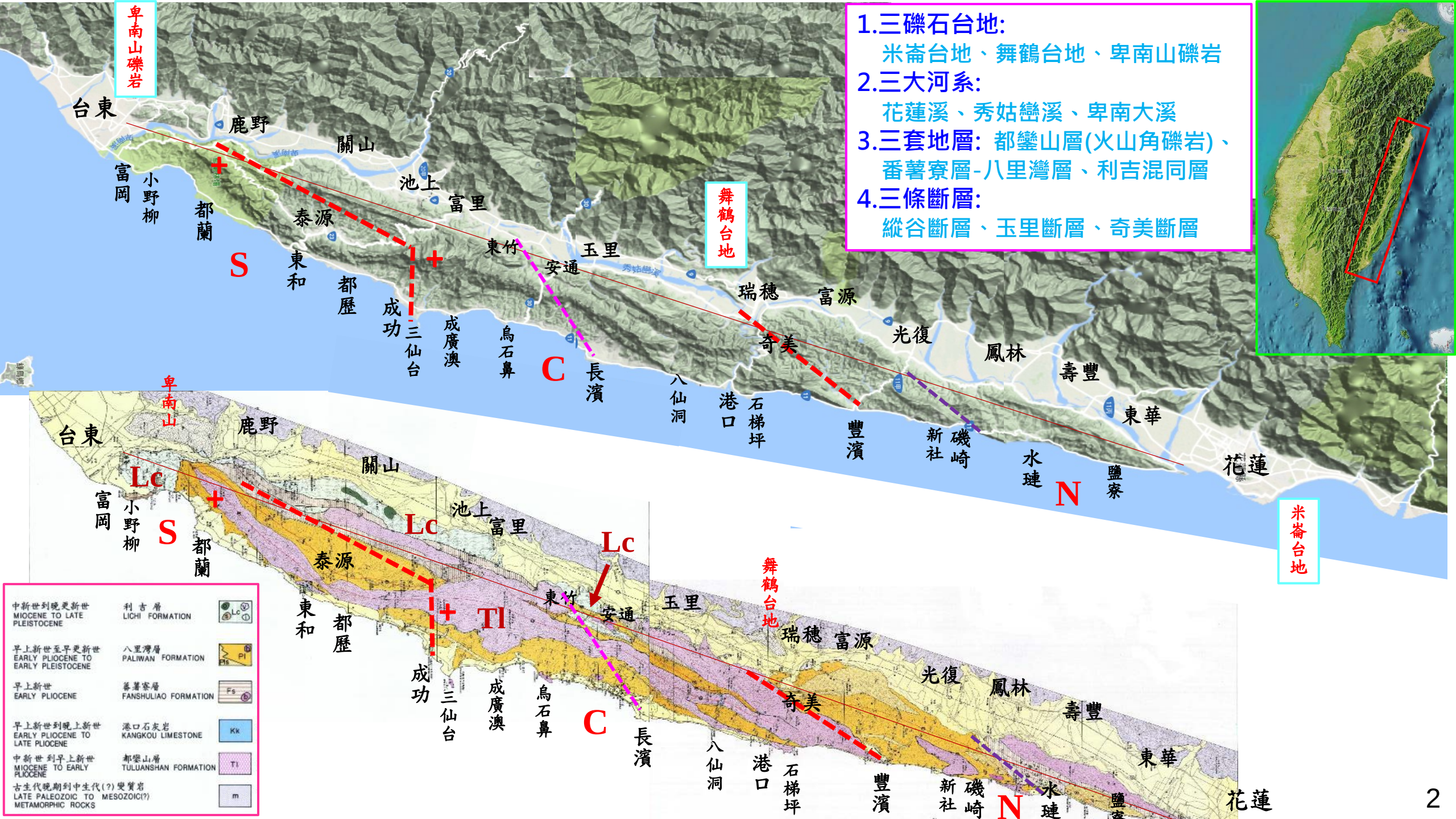
從南北十條橫跨花東縱谷震測剖面
看海岸山脈造山

Examining Costal Range Mountain Building from 10 Seismic Profiles across the Longitudinal Valley

王乾盈

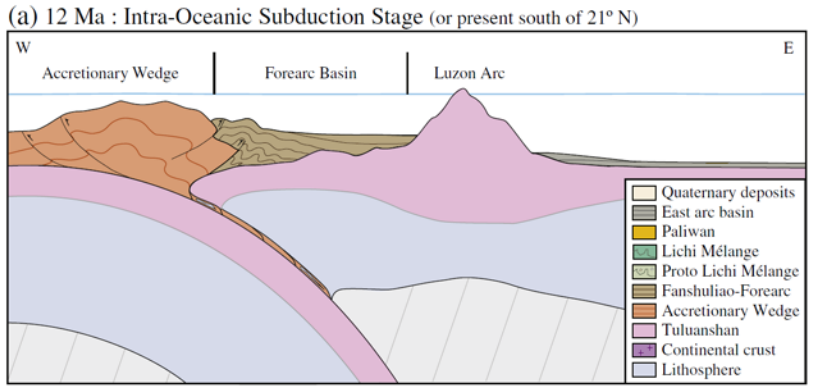
團隊: 郭陳澔、張文彥[2]、郭炫佑、管卓康、孫維芳[2]、謝一銘、賴思穎

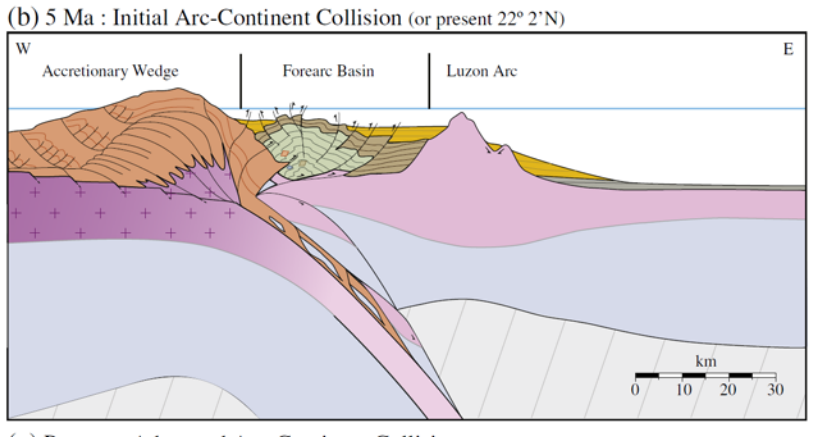
中央大學地球物理所　[2]東華大學環境學院

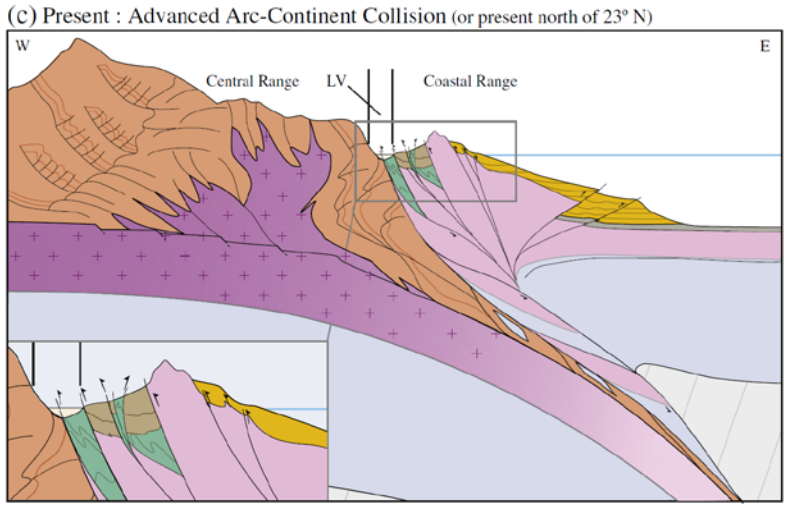

卑南山礫岩
台東
鹿野
關山
富岡
小野柳
都蘭
泰源
池上
富里
東竹
安通
玉里
舞鶴台地
東和
都歷
成功
三仙台
成廣澳
烏石鼻
長濱
八仙洞
瑞穗
富源
奇美
光復
鳳林
壽豐
港口
石梯坪
豐濱
新社
磯崎
東華
水璉
鹽寮
花蓮
米崙台地
S
C
N
Lc
Tl
1.三礫石台地:
米崙台地、舞鶴台地、卑南山礫岩
2.三大河系:
花蓮溪、秀姑巒溪、卑南大溪
3.三套地層: 都鑾山層(火山角礫岩)、
番薯寮層-八里灣層、利吉混同層
4.三條斷層:
縱谷斷層、玉里斷層、奇美斷層
中新世到晚更新世 MIOCENE TO LATE PLEISTOCENE
利吉層 LICHI FORMATION
早上新世至早更新世 EARLY PLIOCENE TO EARLY PLEISTOCENE
八里灣層 PALIWAN FORMATION
早上新世 EARLY PLIOCENE
番薯寮層 FANSHULIAO FORMATION
早上新世到晚上新世 EARLY PLIOCENE TO LATE PLIOCENE
港口石灰岩 KANGKOU LIMESTONE
中新世到早上新世 MIOCENE TO EARLY PLIOCENE
都鑾山層 TULUANSHAN FORMATION
古生代晚期到中生代(?)變質岩 LATE PALEOZOIC TO MESOZOIC(?) METAMORPHIC ROCKS

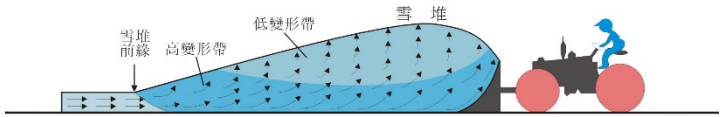
1. 海岸山脈與造山運動(mountain building)
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面
6. 構造模型
7. 2018花蓮地震與米崙斷層
8. 結論

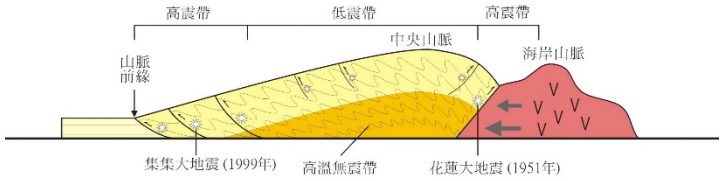
海岸山脈是造山主角之說

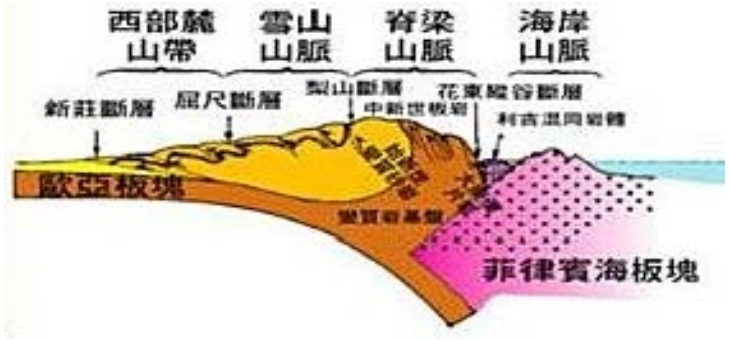












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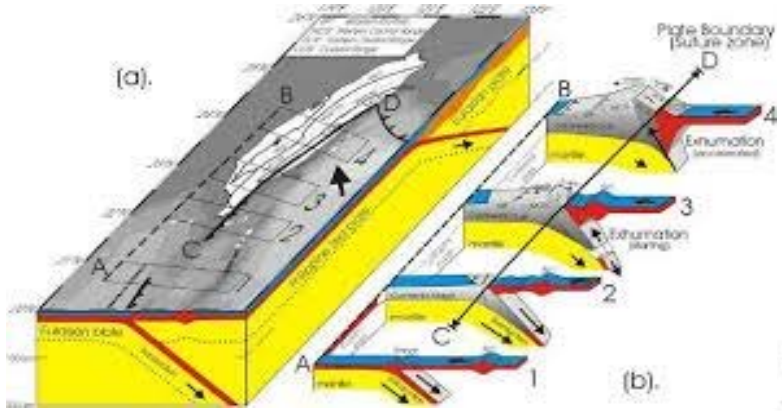
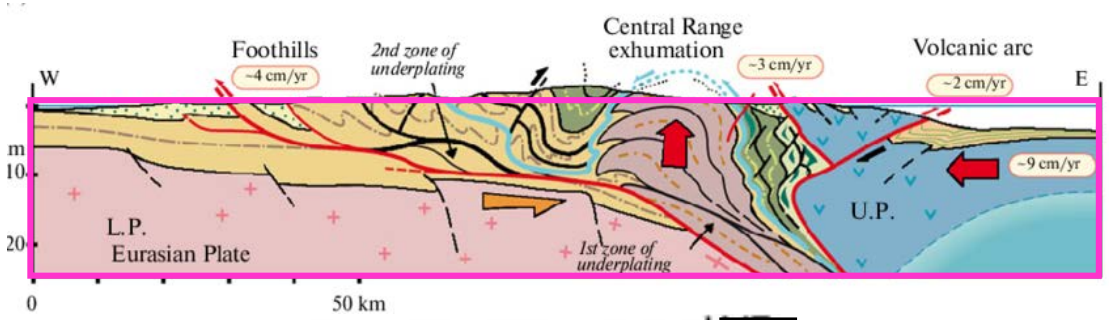
(Thomas, et al., 2014)

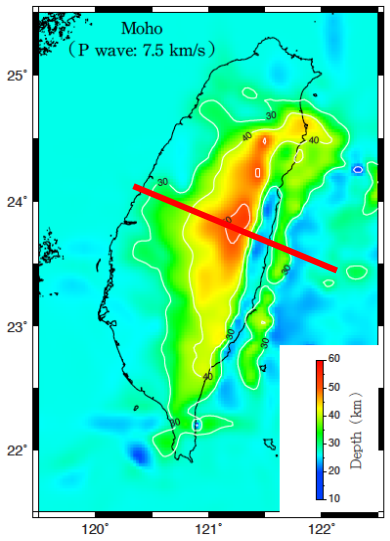
中央山脈是造山主角之說

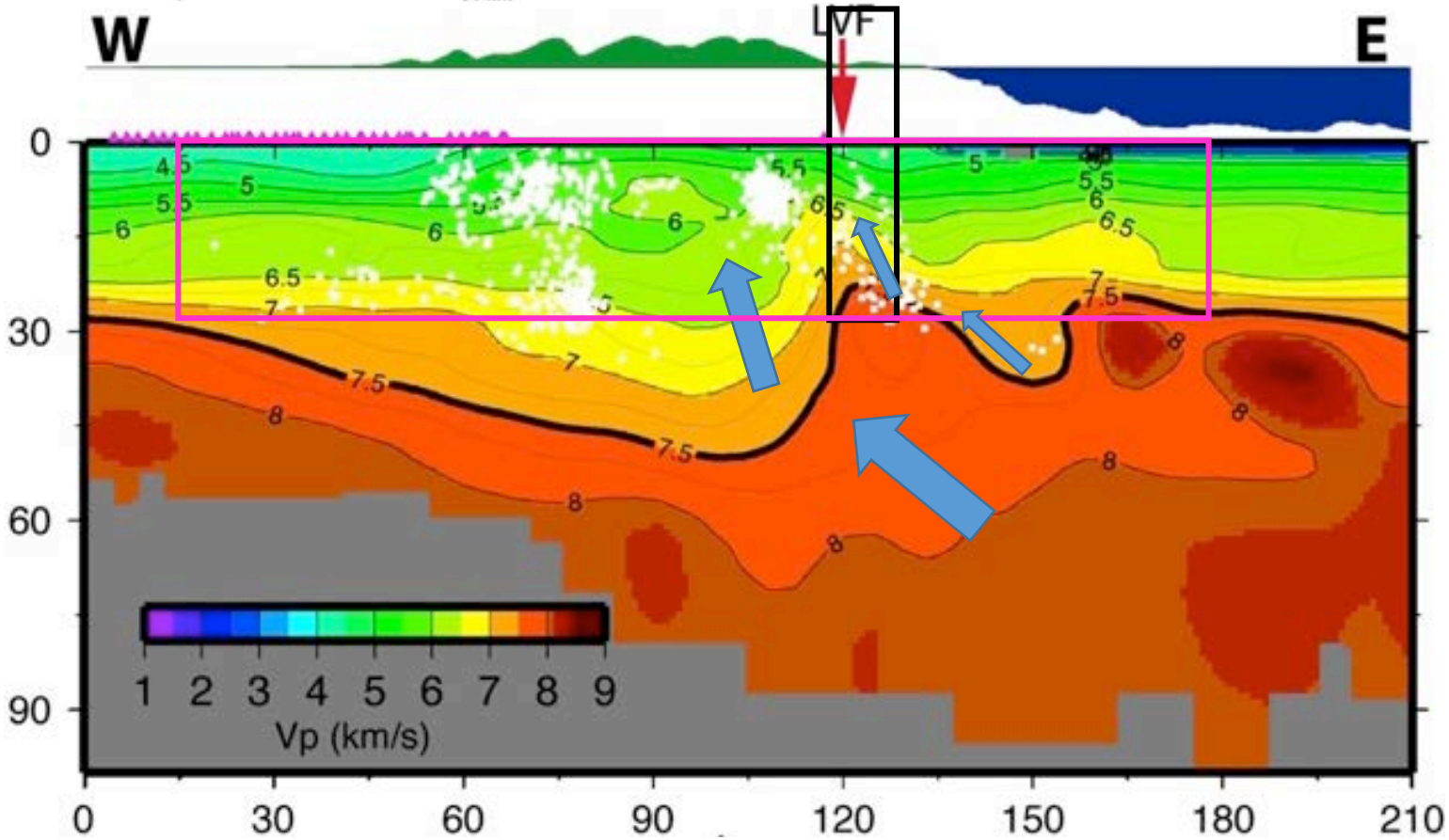
Exhumation Model





Thin Skin





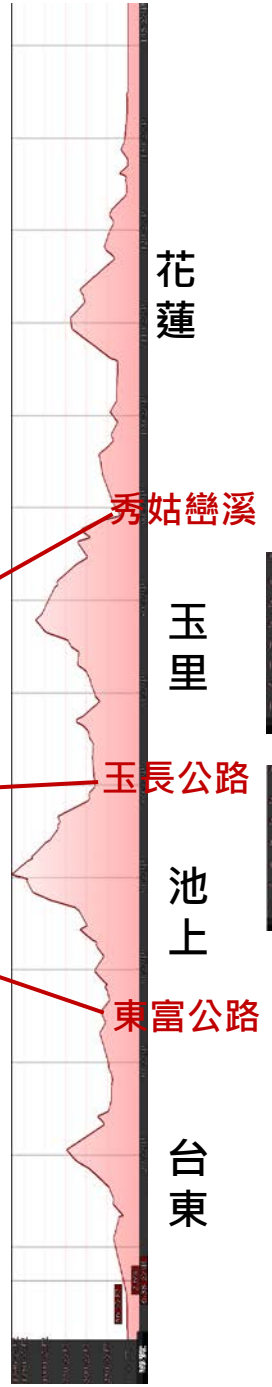
Thick Skin

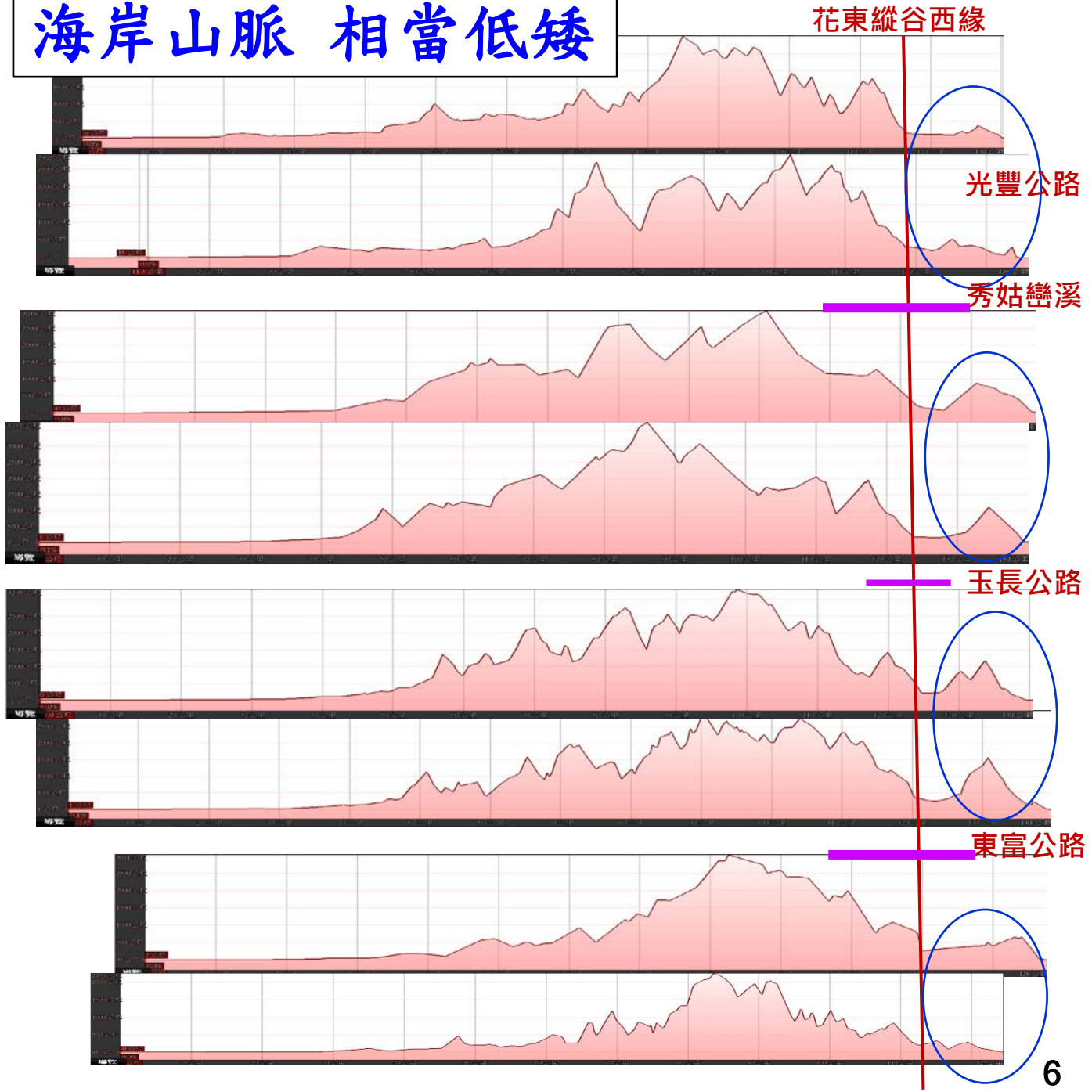
Lithosphere Collision

(KuoChen et al., 2012)

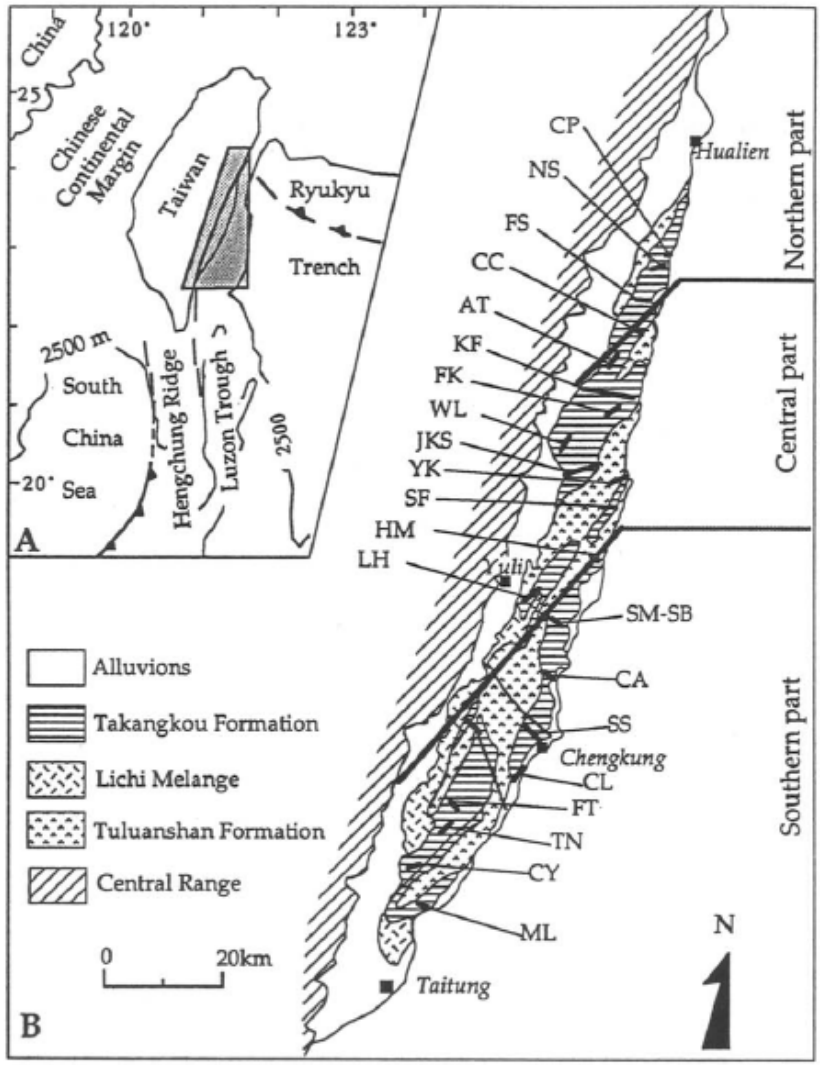
5

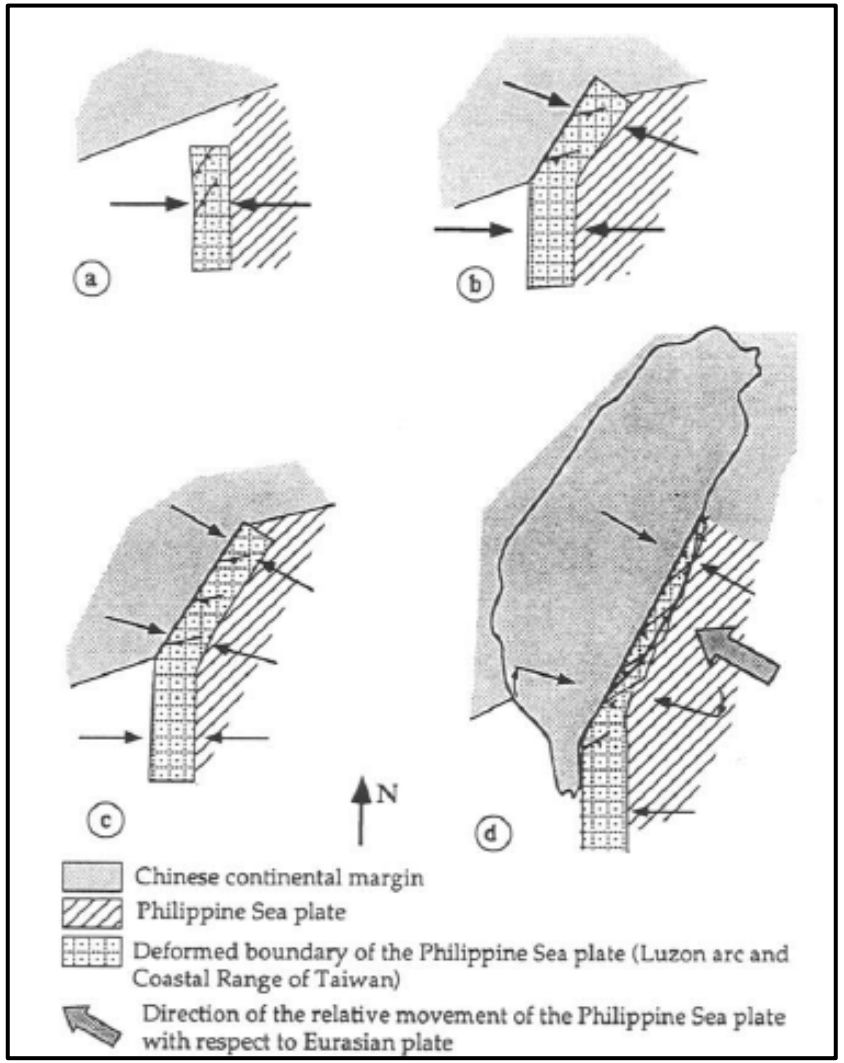
海岸山脈 相當低矮





海岸山脈分次碰撞

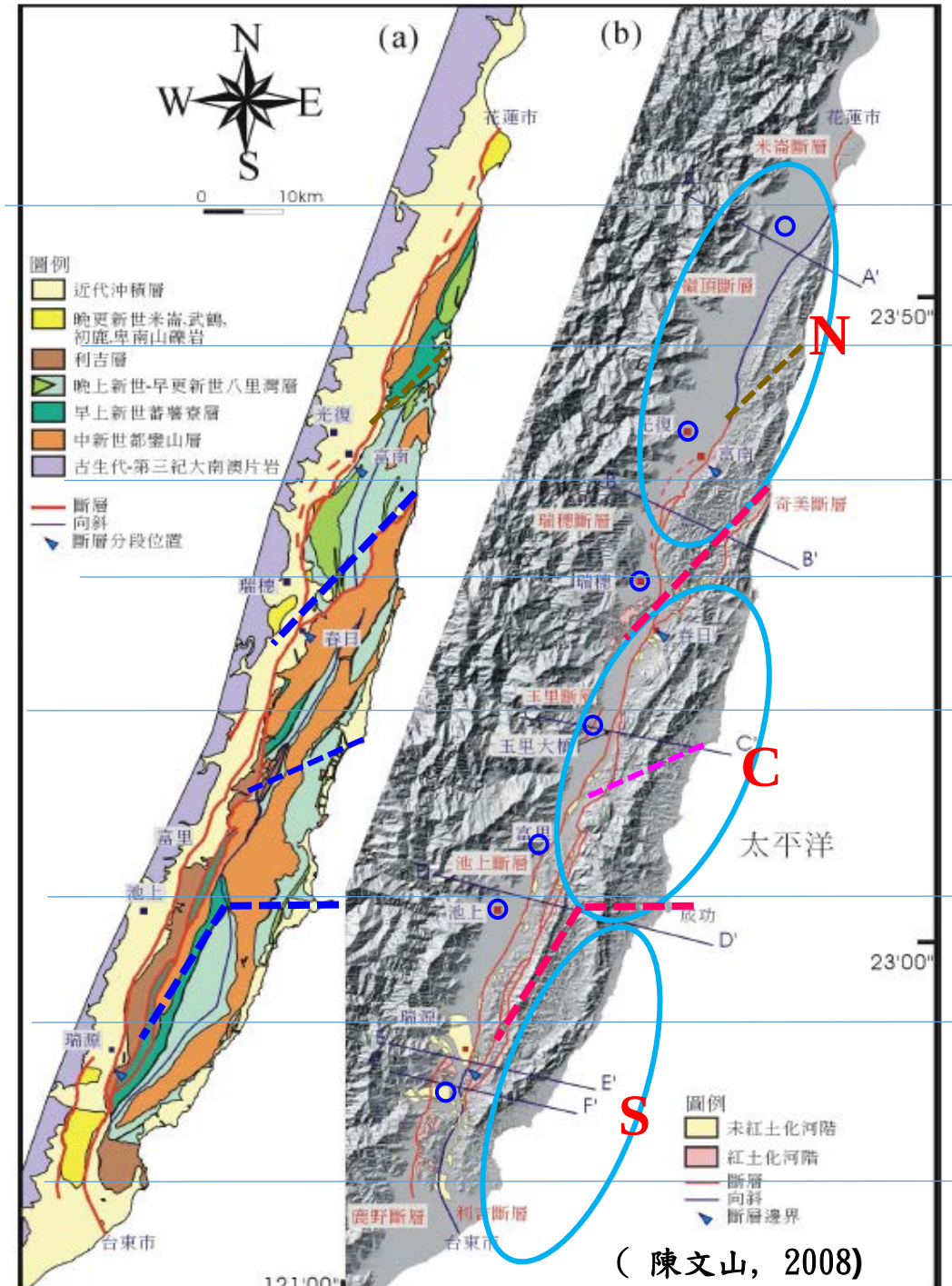




由北而南
依次碰撞

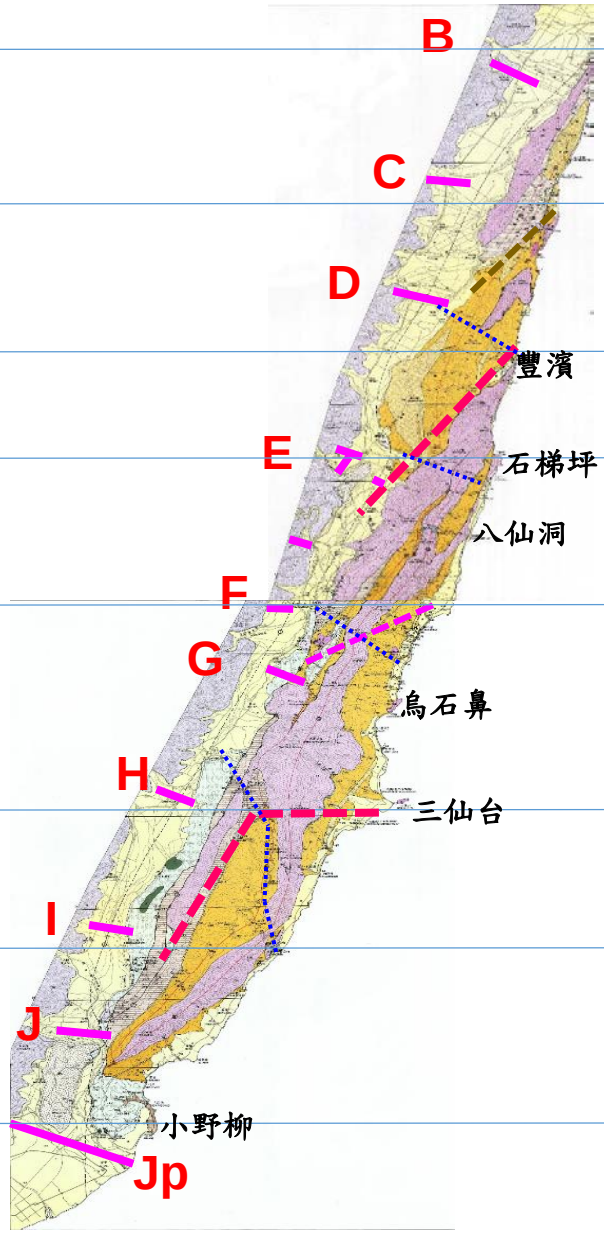
順時針轉30度

(Lee et al., 1991)

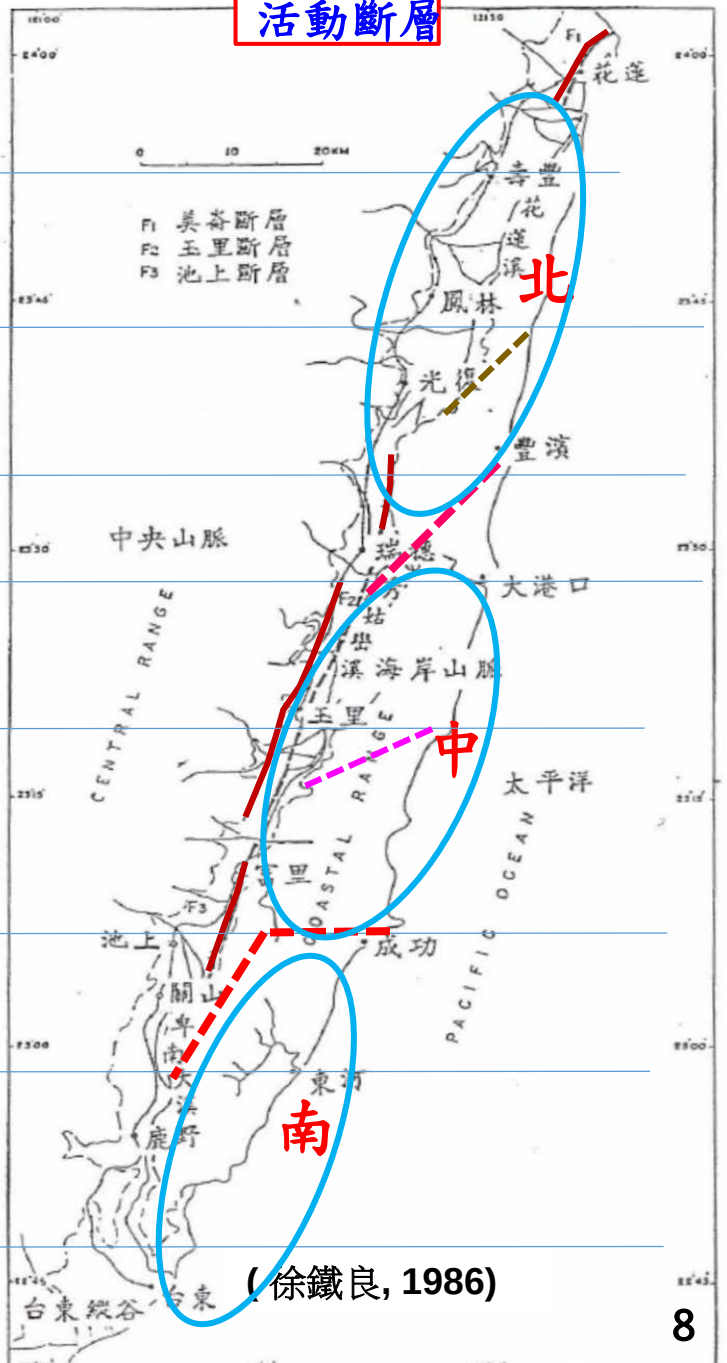


(陳文山, 2008)

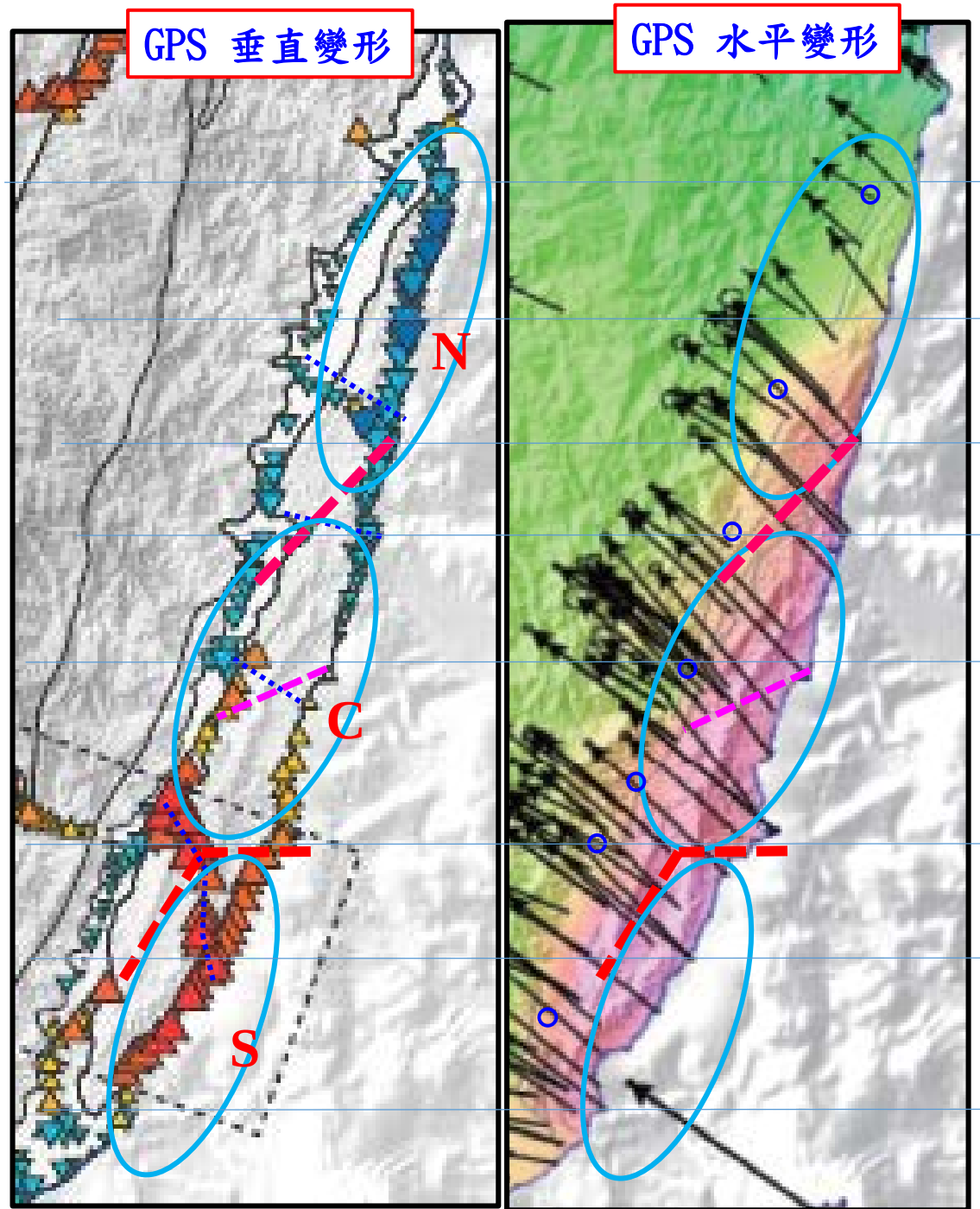
地質圖



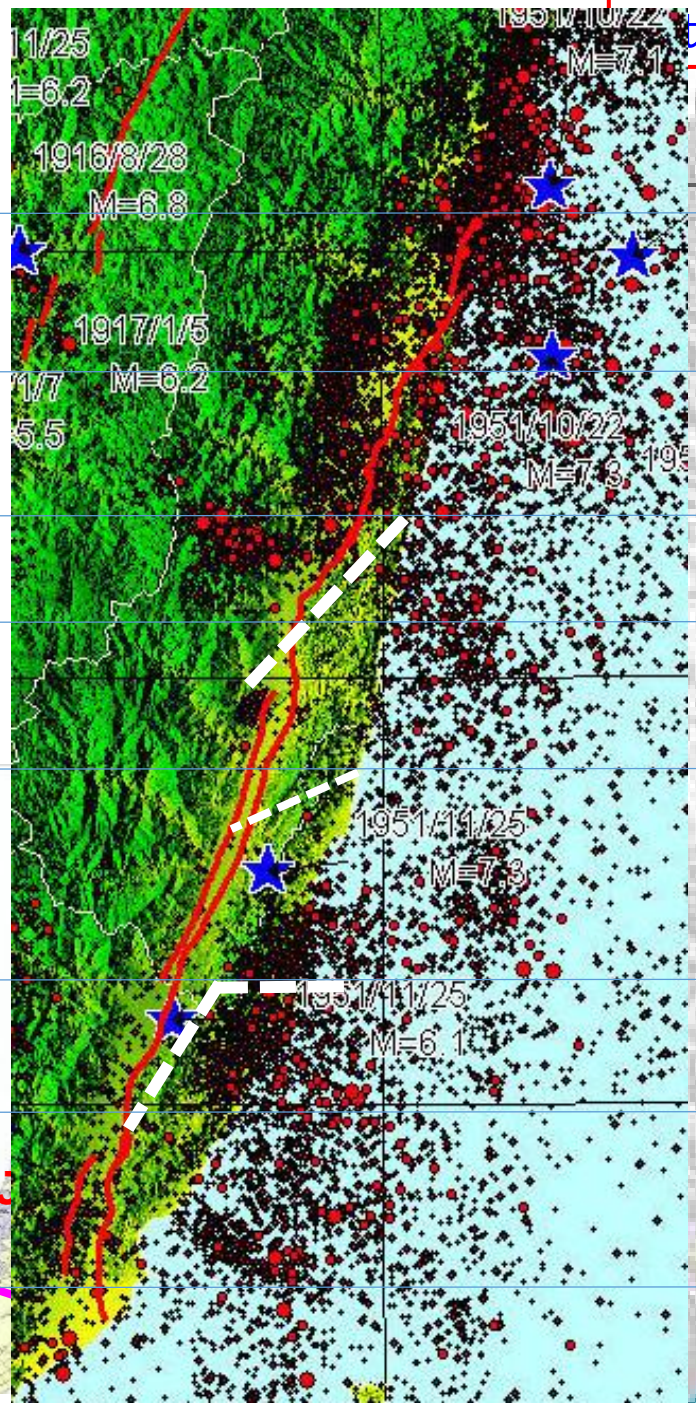
活動斷層

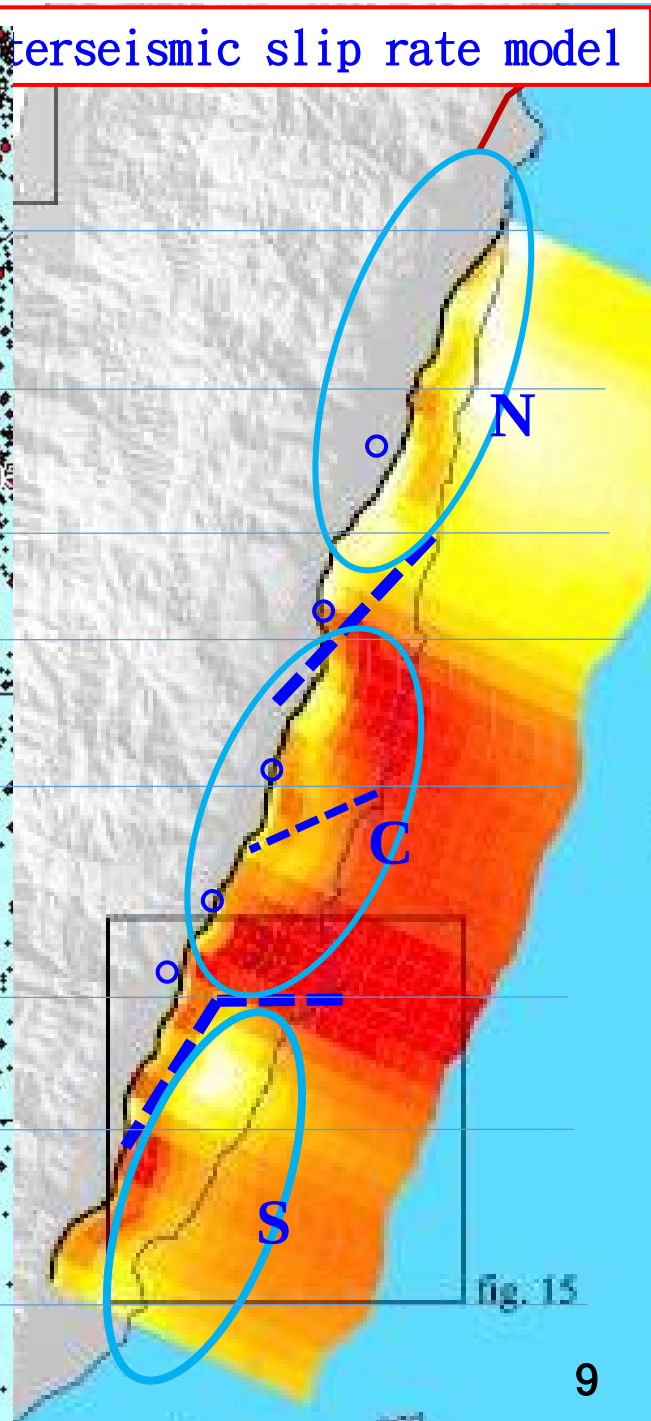


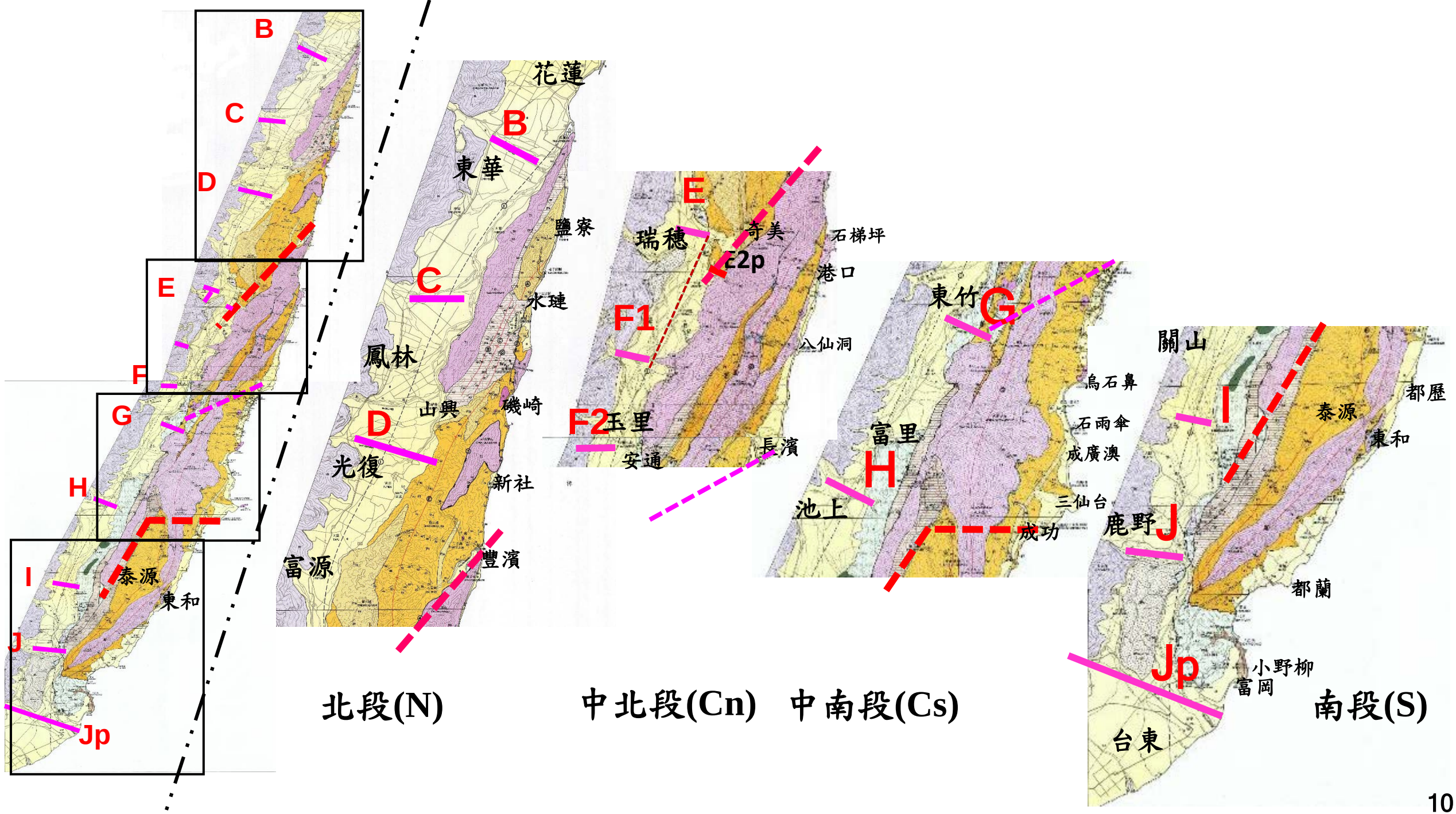
(徐鐵良, 1986)


GPS 垂直變形
N
C
S

GPS 水平變形


1916/8/28
M=6.8
1917/1/5
M=6.2
1951/10/22
M=7.3
1951/11/25
M=7.3
M=6.1


terseismic slip rate model
N
C
S
fig. 15

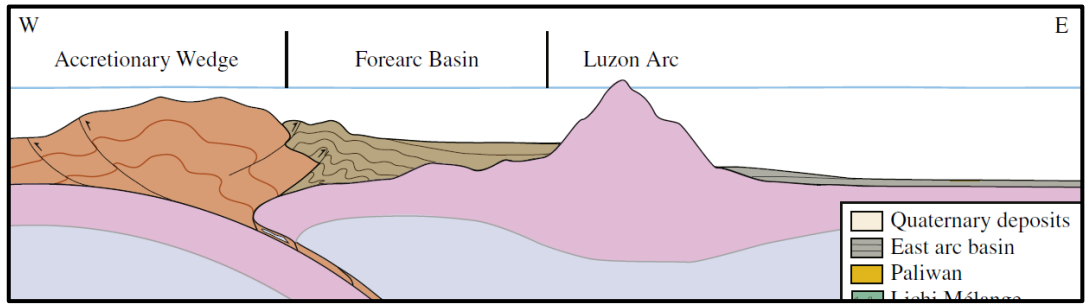

B
C
D
E
F
G
H
I
J
Jp
花蓮
東華
鹽寮
水璉
鳳林
山興
磯崎
光復
新社
富源
豐濱
泰源
東和
瑞穗
奇美
石梯坪
港口
八仙洞
玉里
安通
長濱
東竹
烏石鼻
富里
石雨傘
成廣澳
池上
三仙台
成功
關山
都歷
鹿野
都蘭
小野柳
富岡
台東
F1
F2
E2p
北段(N)
中北段(Cn)
中南段(Cs)
南段(S)

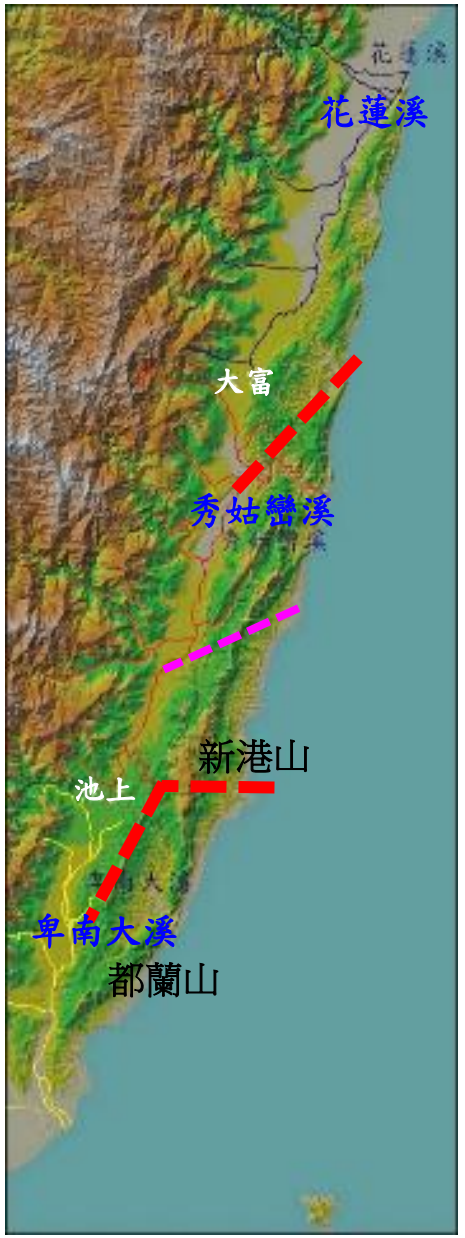
台灣省地形。林朝棨。P. 159

海岸山脈 與 花東縱谷河系

現在的海岸山脈以台東縱谷平原，與中央山脈隔離，但過去之海岸山脈與中央山地東坡，連結呈該東坡之東端，上列許多平行河流乃並列向東流出東海岸，呈完整之順向河道。海岸山脈東側海崖附近河階砂礫層中之礫石，均由大南澳片岩類被侵蝕又搬運而來者，而海岸山脈東側之太平洋岸附近，有此等平行順向河之舊河口，沉沒於海中，呈溺谷(Drowned valley)，其規模比現在海岸山脈東坡之河谷，大許多倍。海岸山脈之分水嶺亦有舊河流之遺跡，呈風口(Wind gap)。此等事實均為上述諸並行順向河群曾經向東流入太平洋之明證。

唯更新世中壢期，斷層作用造成台東縱谷平原，河系遂受其影響，改向北方或南方流出，經爭奪合併等現象發生後，始分成現在三大河系。

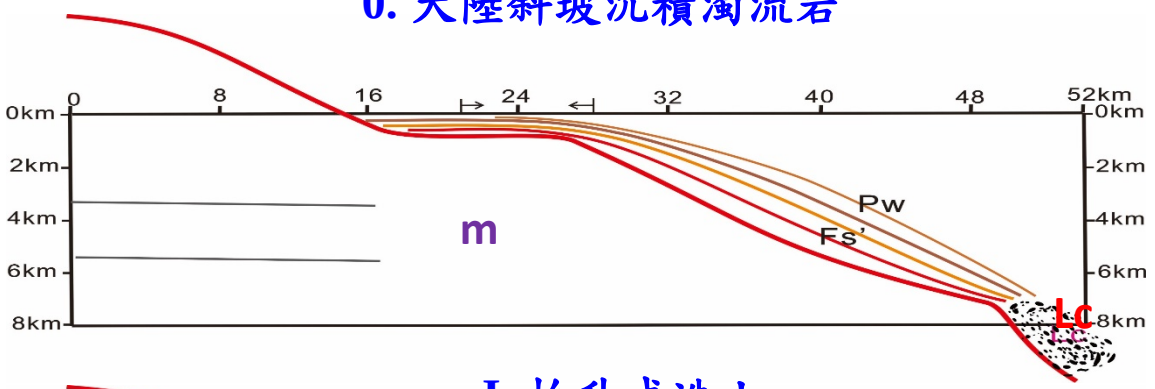




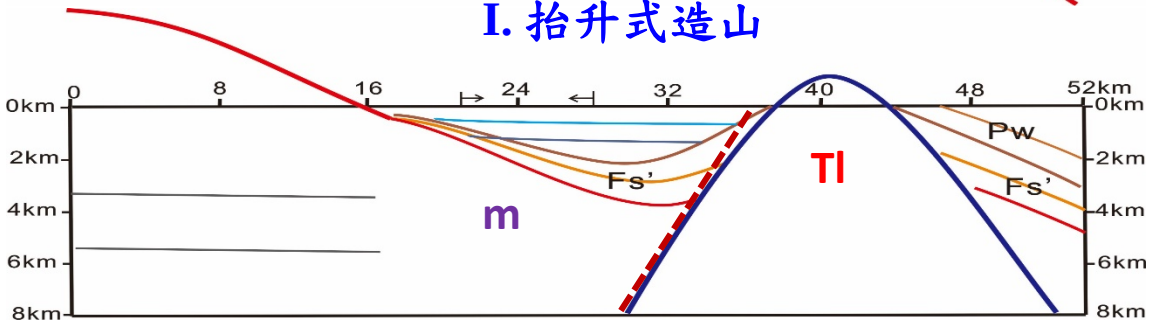
海岸山脈地層

全新世 HOLOCENE	冲積層 ALLUVIUM	a	礫石，砂，黏土 Gravel, sand and clay
晚更新世 LATE PLEISTOCENE	卑南山礫岩 PEINANSHAN CONGLOMERATE 舞鶴礫岩 WUHO CONGLOMERATE	Pn Wh	礫岩夾砂岩 Conglomerate intercalated with sandstone
中新世到晚更新世 MIOCENE TO LATE PLEISTOCENE	利吉層 LICHI FORMATION	Lc	泥岩夾各種不同外來岩塊；o：蛇綠岩岩塊；s：沈積岩岩塊；i：石灰岩岩塊；v：安山岩岩塊 Mudstone with various exotic blocks ; o : ophiolite ; s : sedimentary blocks ; i : limestone blocks ; v : andesitic blocks
早上新世至早更新世 EARLY PLIOCENE TO EARLY PLEISTOCENE	八里灣層 PALIWAN FORMATION	Pl Pls	砂岩與砂頁岩互層；Pl s：礫岩；b：安山岩質崩移岩塊 Sandstone, alternations of sandstone and shale; Pls:conglomerate; b : transported blocks
早上新世 EARLY PLIOCENE	蕃薯寮層 FANSHULIAO FORMATION	Fs	泥岩與砂頁岩互層；b：安山岩質崩移岩塊 Mudstone, alternations of sandstone and shale b : transported andesitic blocks
早上新世到晚上新世 EARLY PLIOCENE TO LATE PLIOCENE	崁口石灰岩 KANGKOU LIMESTONE	Kk	藻球藻，有孔蟲與珊瑚石灰岩 Rodolith, foraminifera, coal limestone
中新世到早上新世 MIOCENE TO EARLY PLIOCENE	都巒山層 TULUANSHAN FORMATION	Tl	火山岩流，火山角礫岩與再積性火山碎屑岩 Lava flow, volcanic breccia and epiclastic rocks
古生代晚期到中生代(?)變質岩 LATE PALEOZOIC TO MESOZOIC(?) METAMORPHIC ROCKS		m	板岩及片岩 Slate and schist

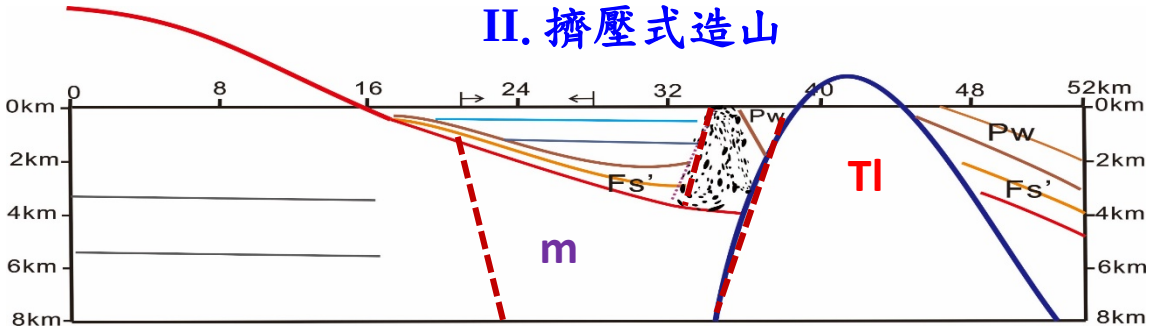
0. 大陸斜坡沉積濁流岩



I. 抬升式造山

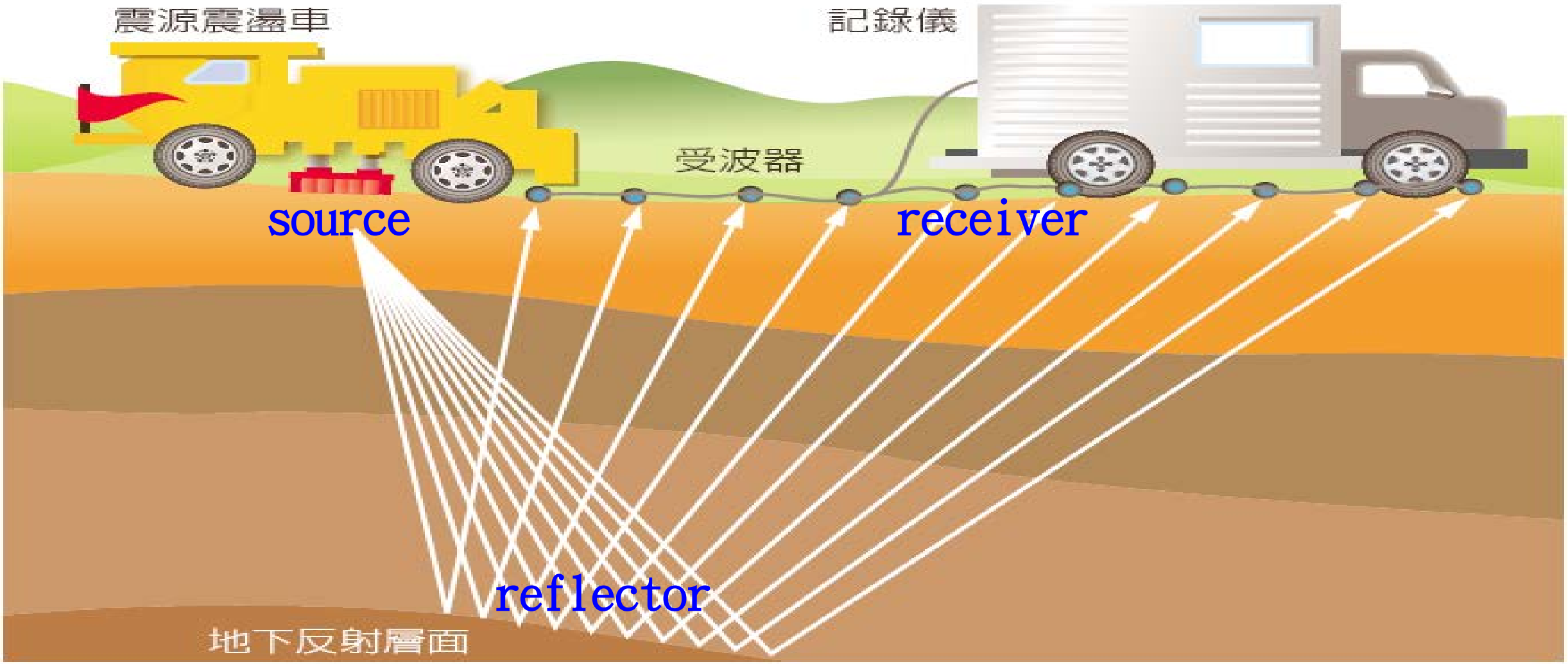


II. 擠壓式造山



高解析反射震測
(high resolution reflection seismics)

反射震測法（reflection seismics）



兩種反射震測
(Two kinds of reflection seismics)

	深度	紀錄時間	間距	展開	頻率	經費
1)高解析度(high resolution):	3km	2 sec	4m	1km	120Hz	20萬/km
2) 探油(oil exploration)：	8km	5 sec	25m	10km	50Hz	80萬/km

1）高解析度： 活動斷層、淺部地層構造
2）探油： 探勘油藏、區域地質構造

高解析度震測（2 sec)

MiniVibe 震盪震源

一次4部

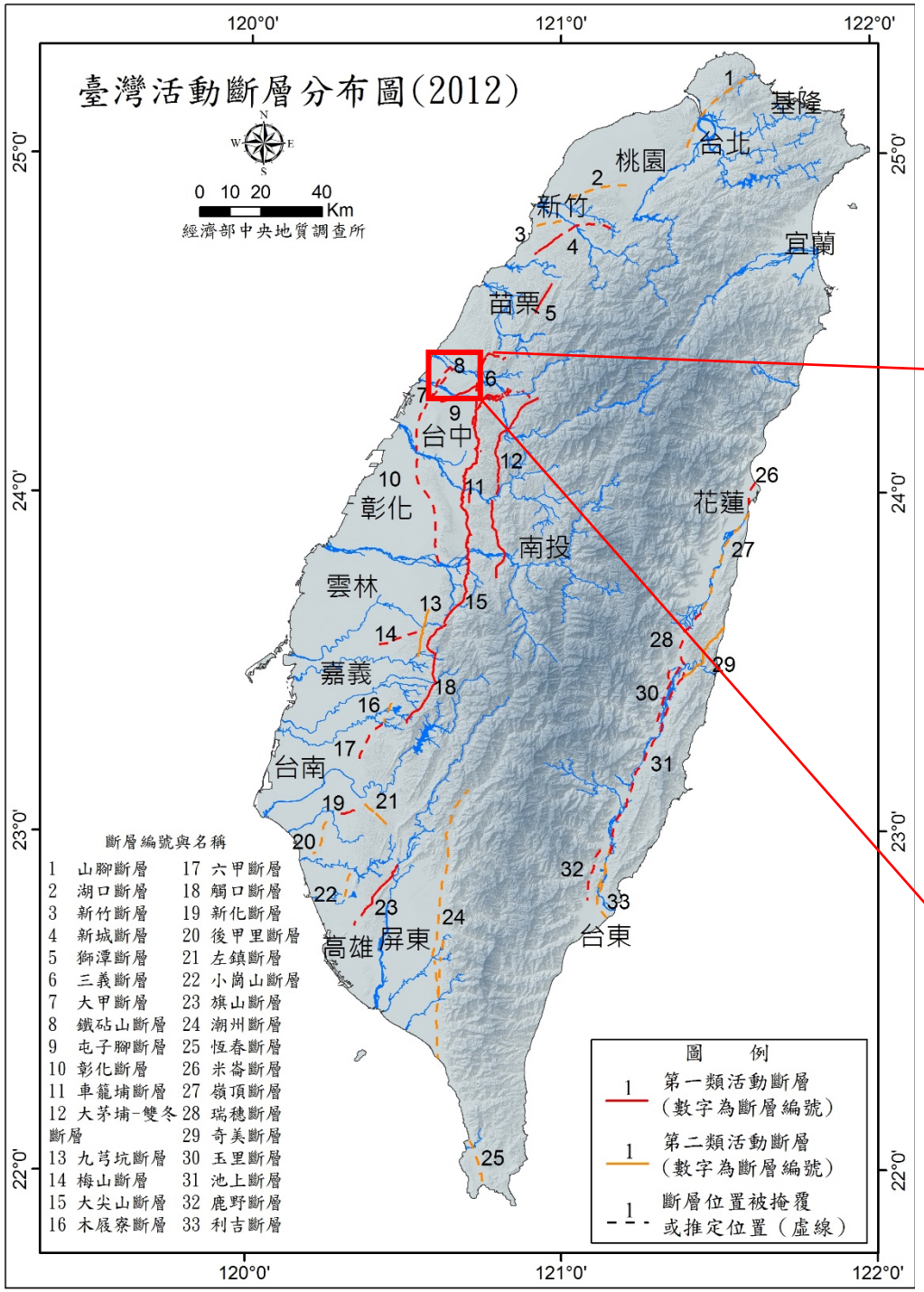
探油震測（5 sec)

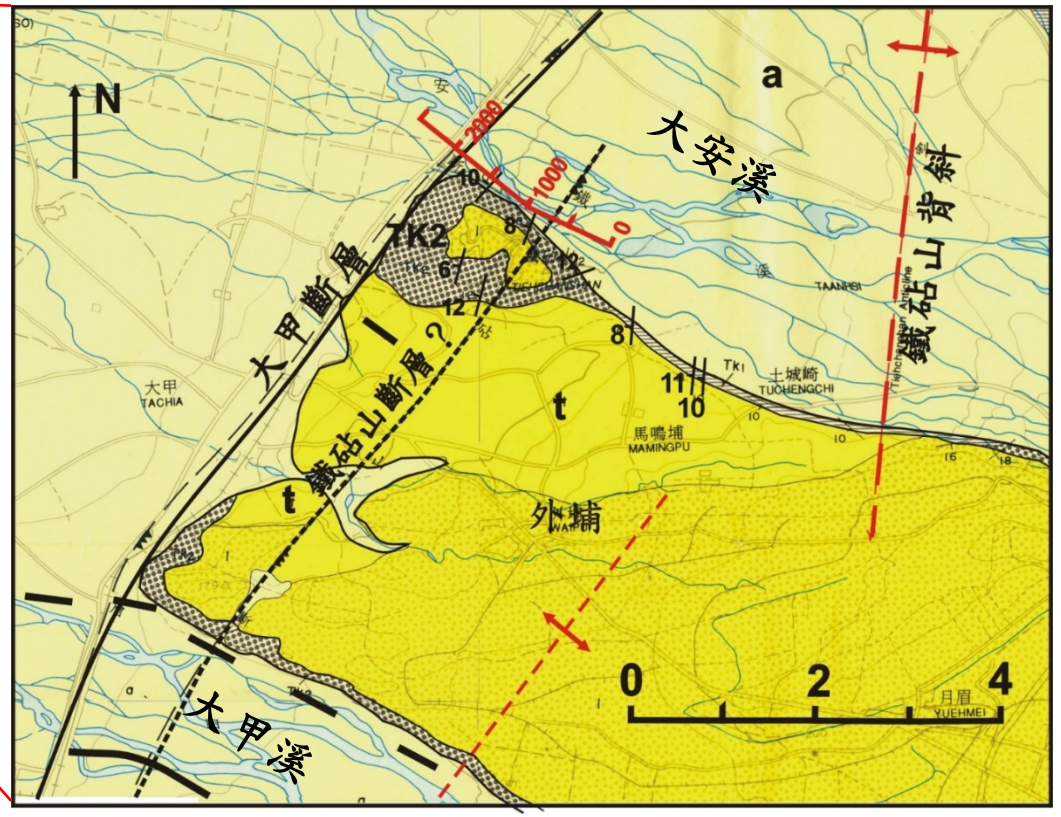
重型震盪震源

receiver(受波器)

recorder(紀錄器)

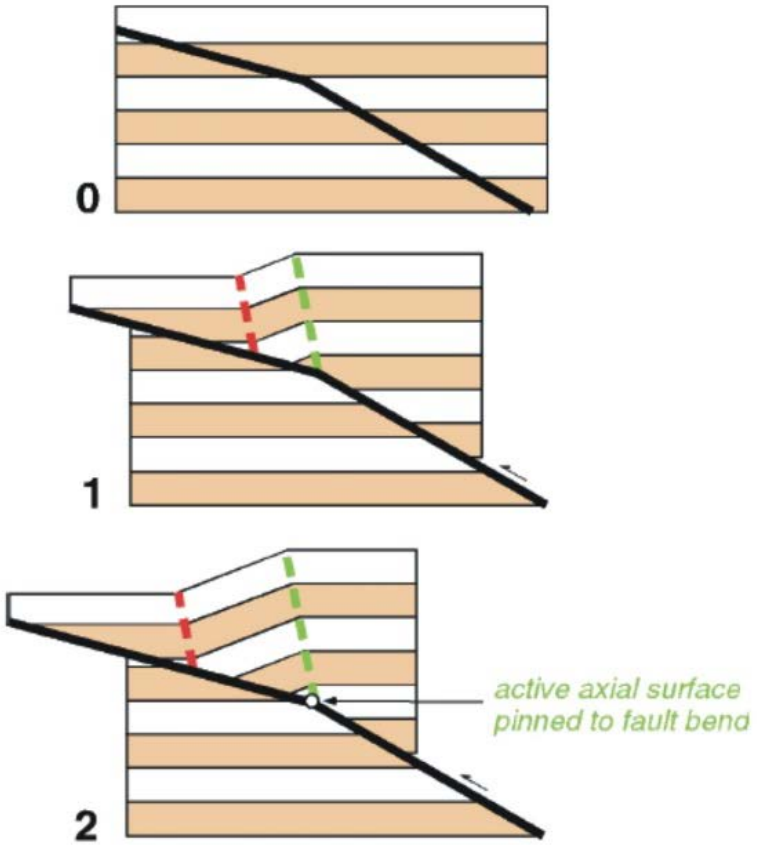
例一(Example 1):
大甲斷層(TaChia Fault)

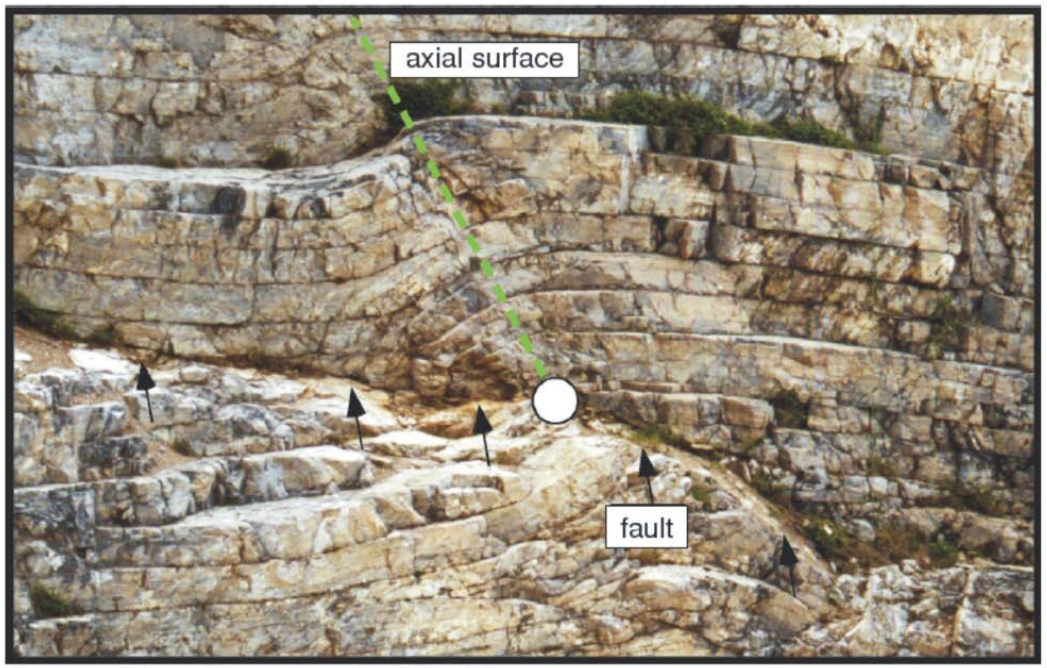




Anticlinal fault-bend folds

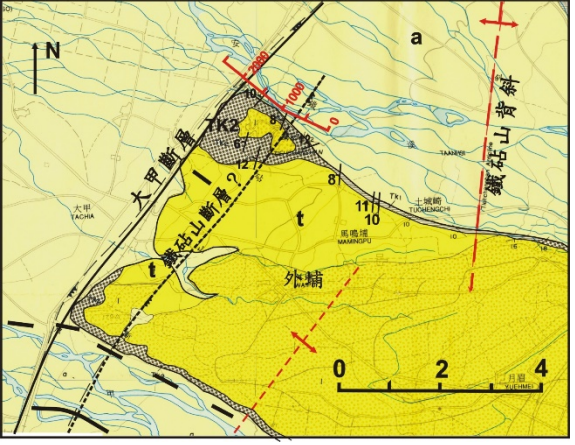
Kinematic Model

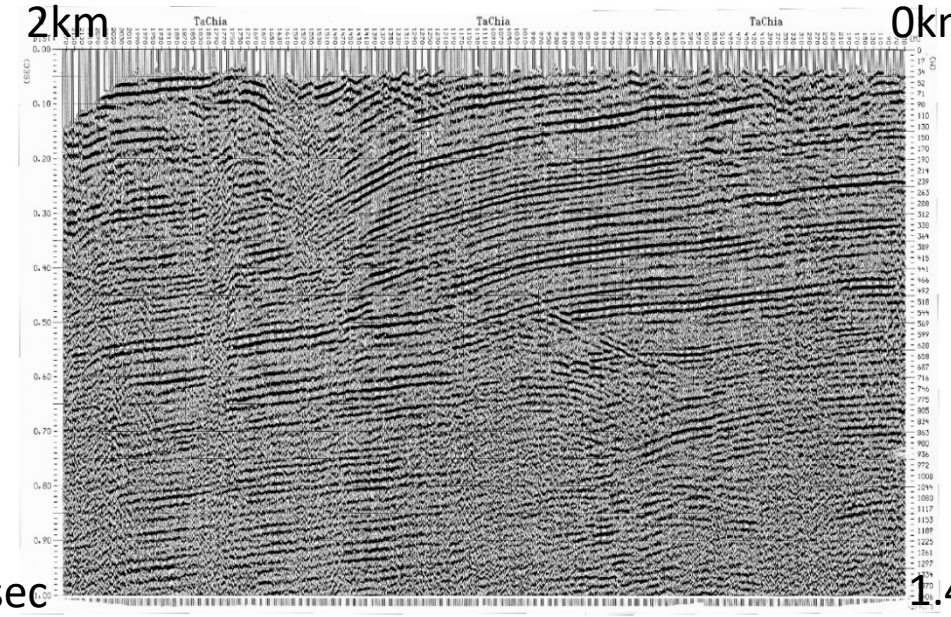




Crows Nest Pass, Alberta, Canada. (JHS/FDB)

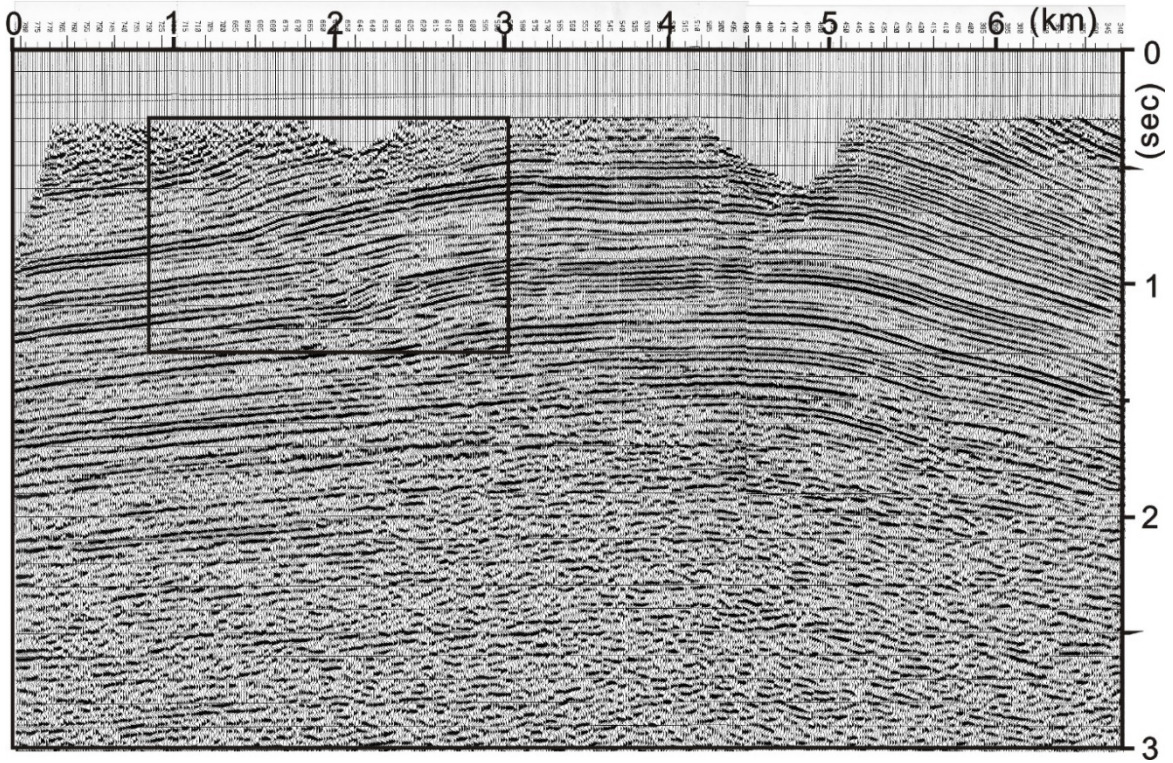
Shaw, J.H., Connors, C., Suppe, J. (2005) Seismic interpretation of contractional fault-related folds. AAPG Studies in Geology no.53.



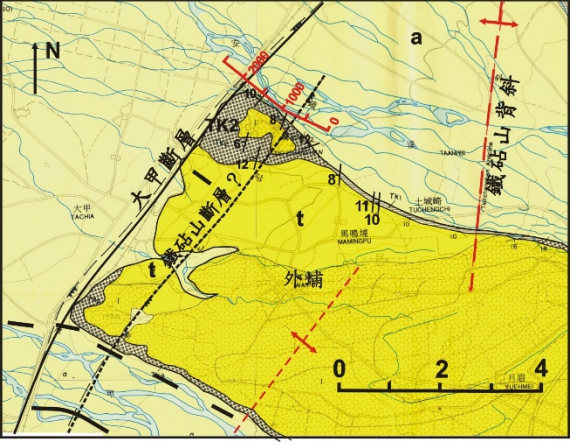


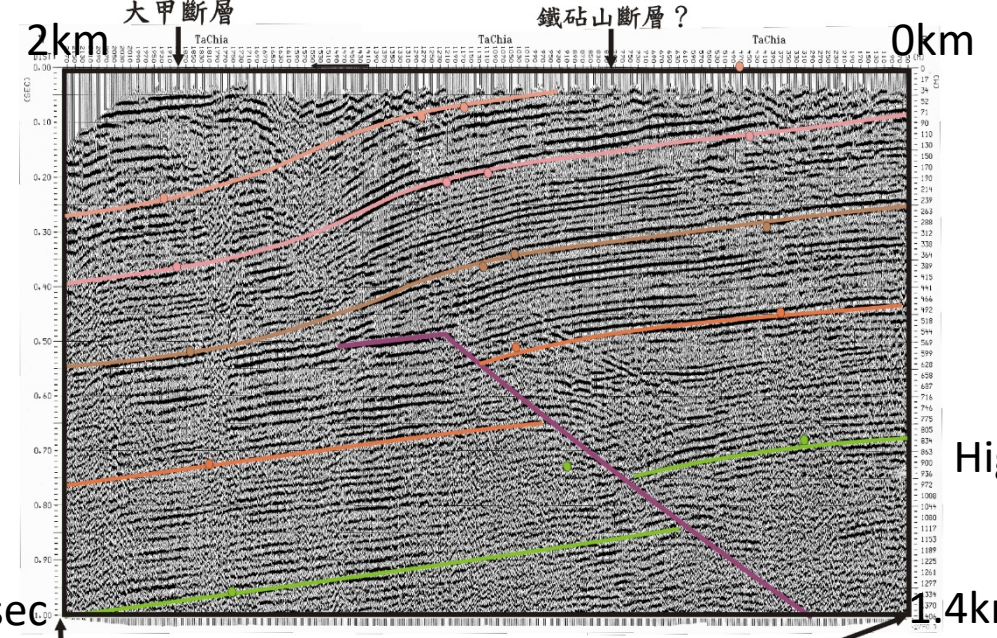
High resolution seismics

（注意：深部測線在淺層測線北方約 1.5 公里處。）



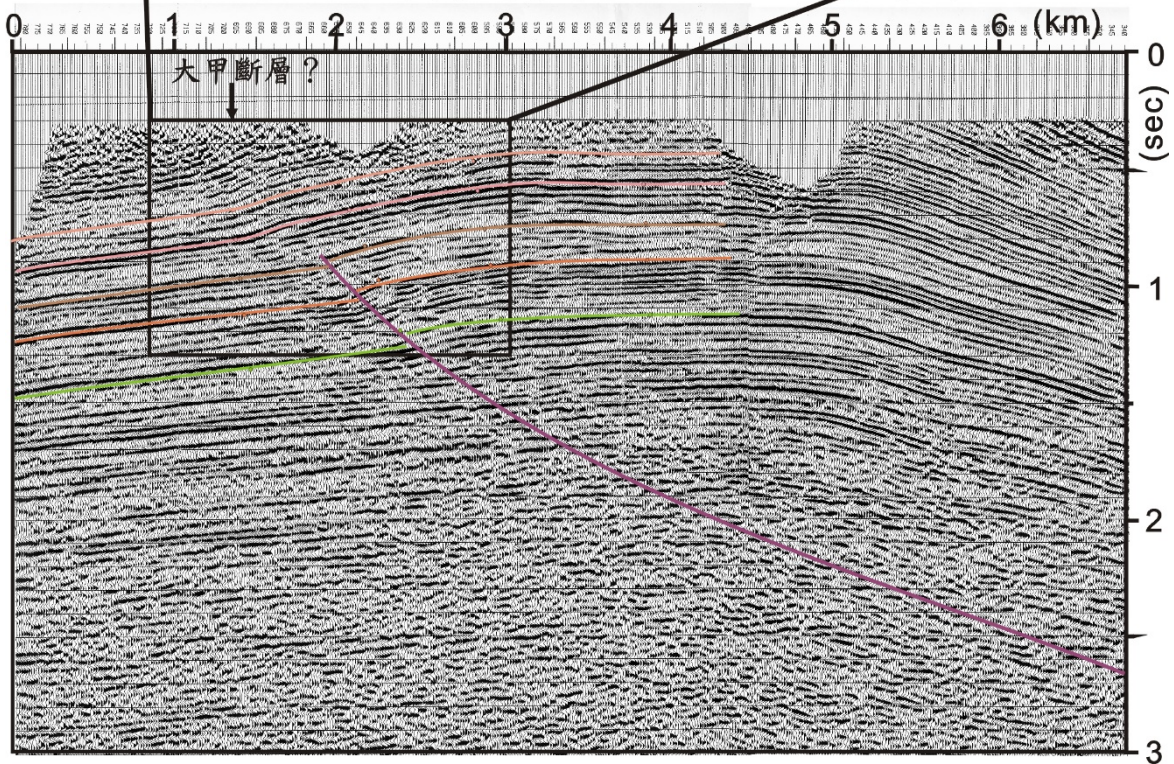
Oil exploration seismics



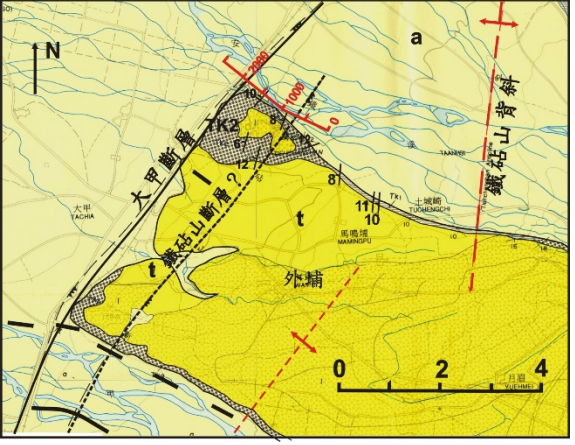


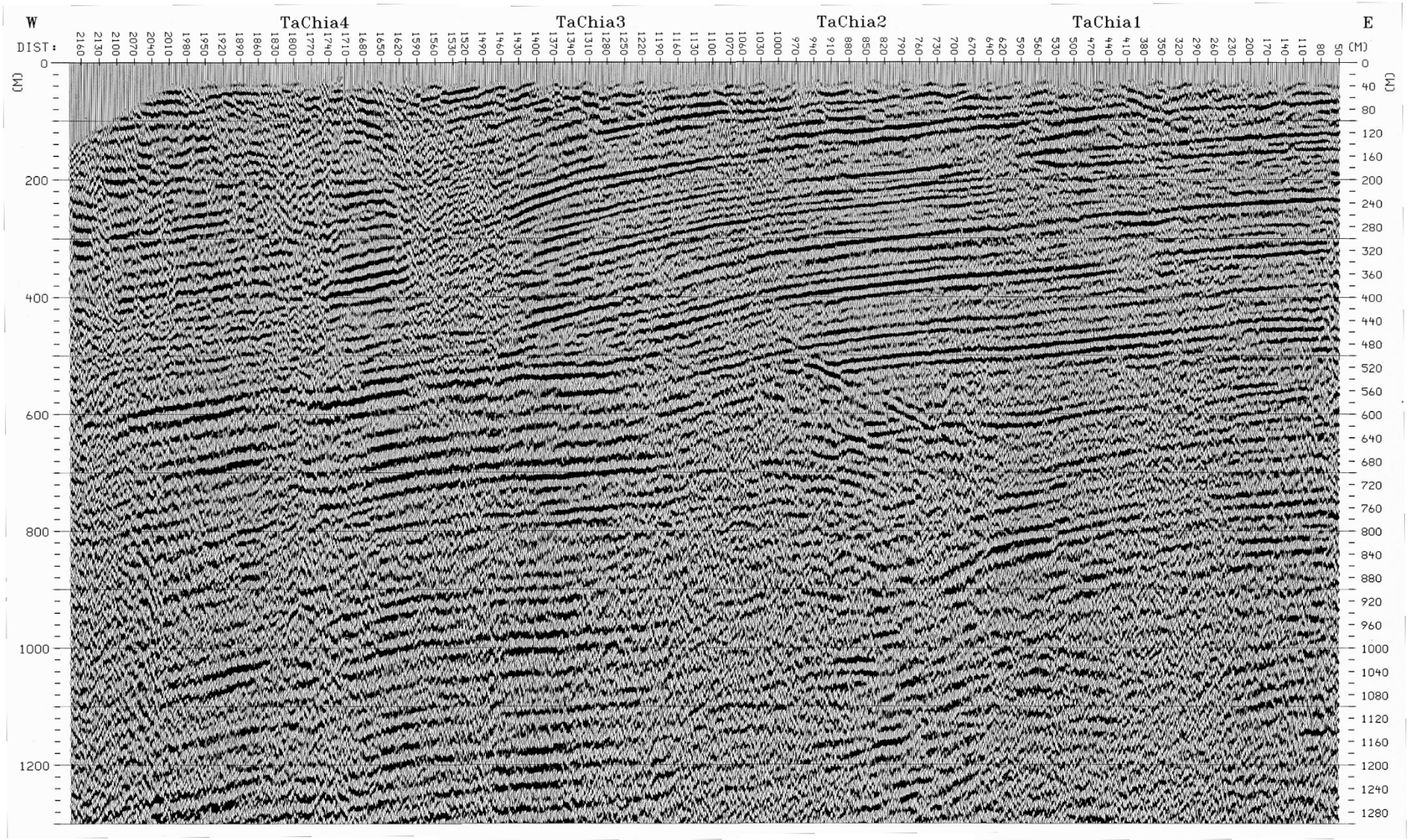
High resolution seismics

（注意：深部測線在淺層測線北方約 1.5 公里處。）

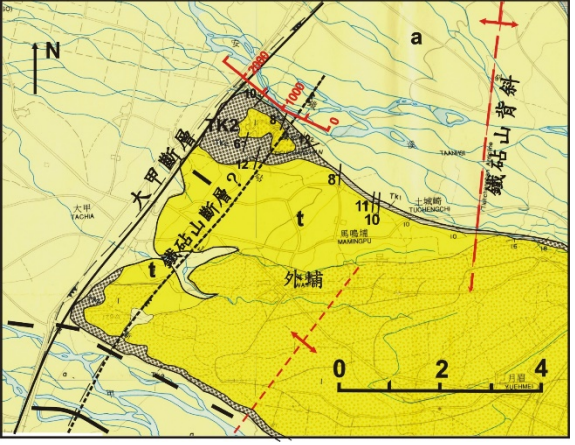


Oil exploration seismics



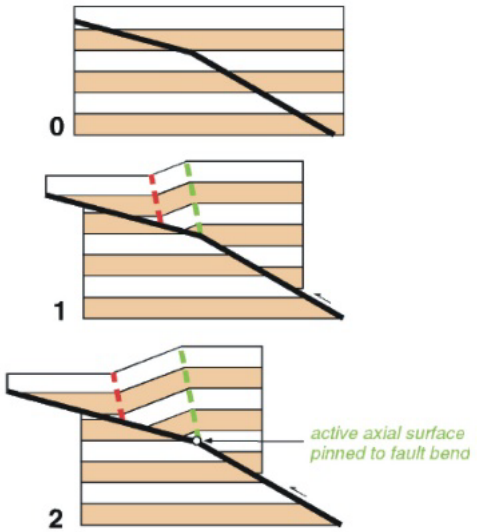


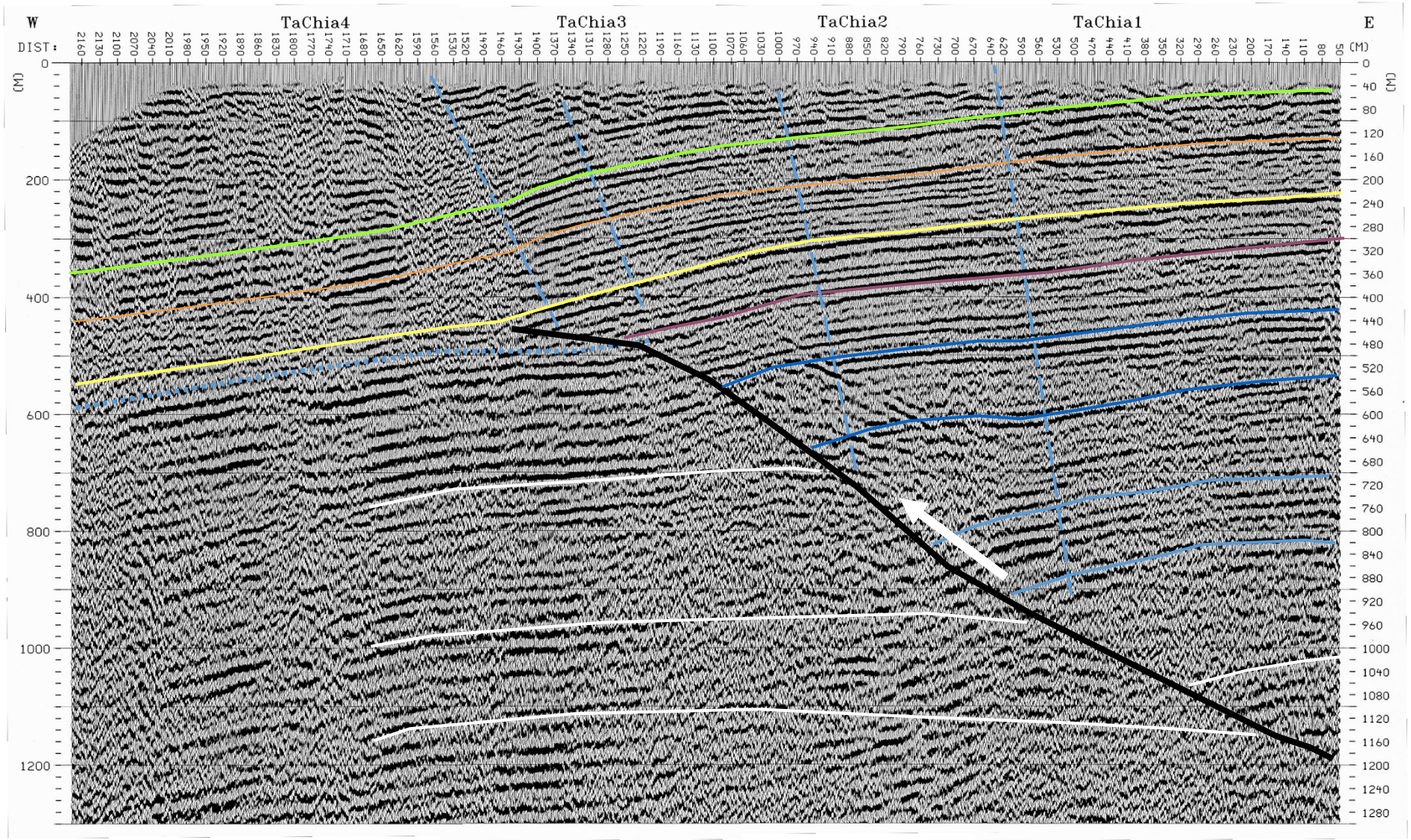
High resolution seismics



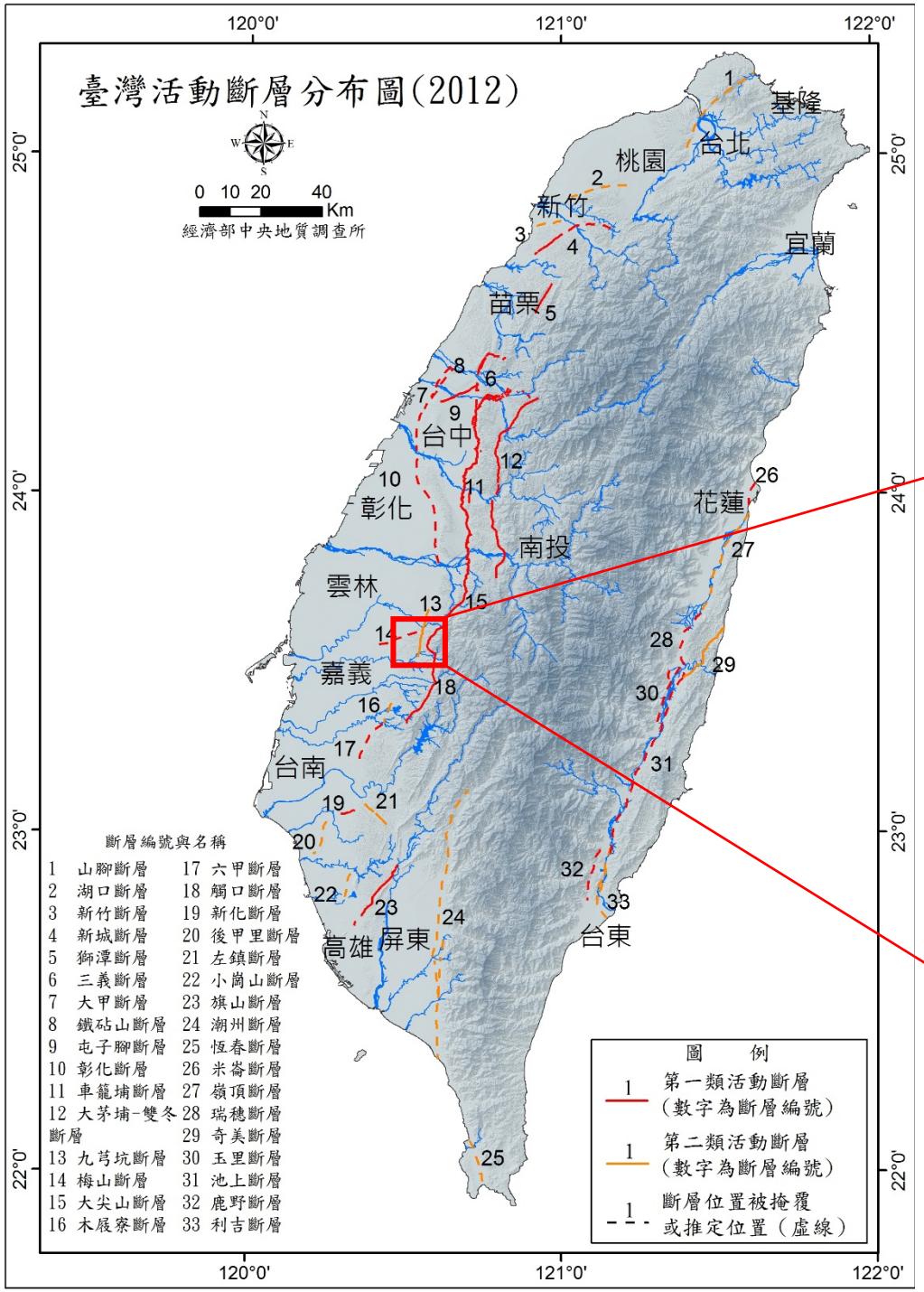
Anticlinal fault-bend folds

Kinematic Model

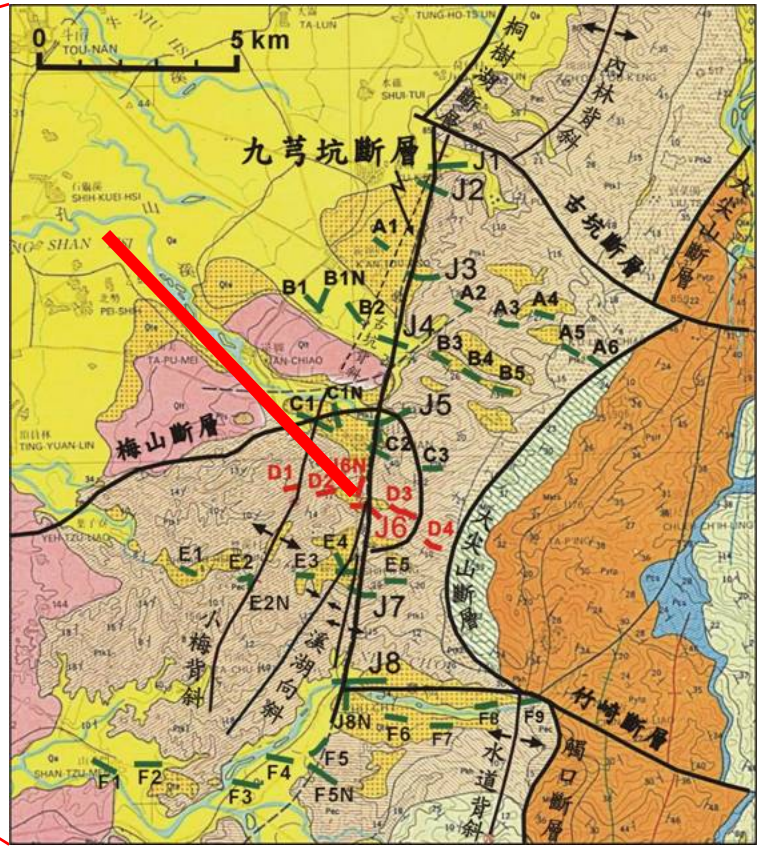


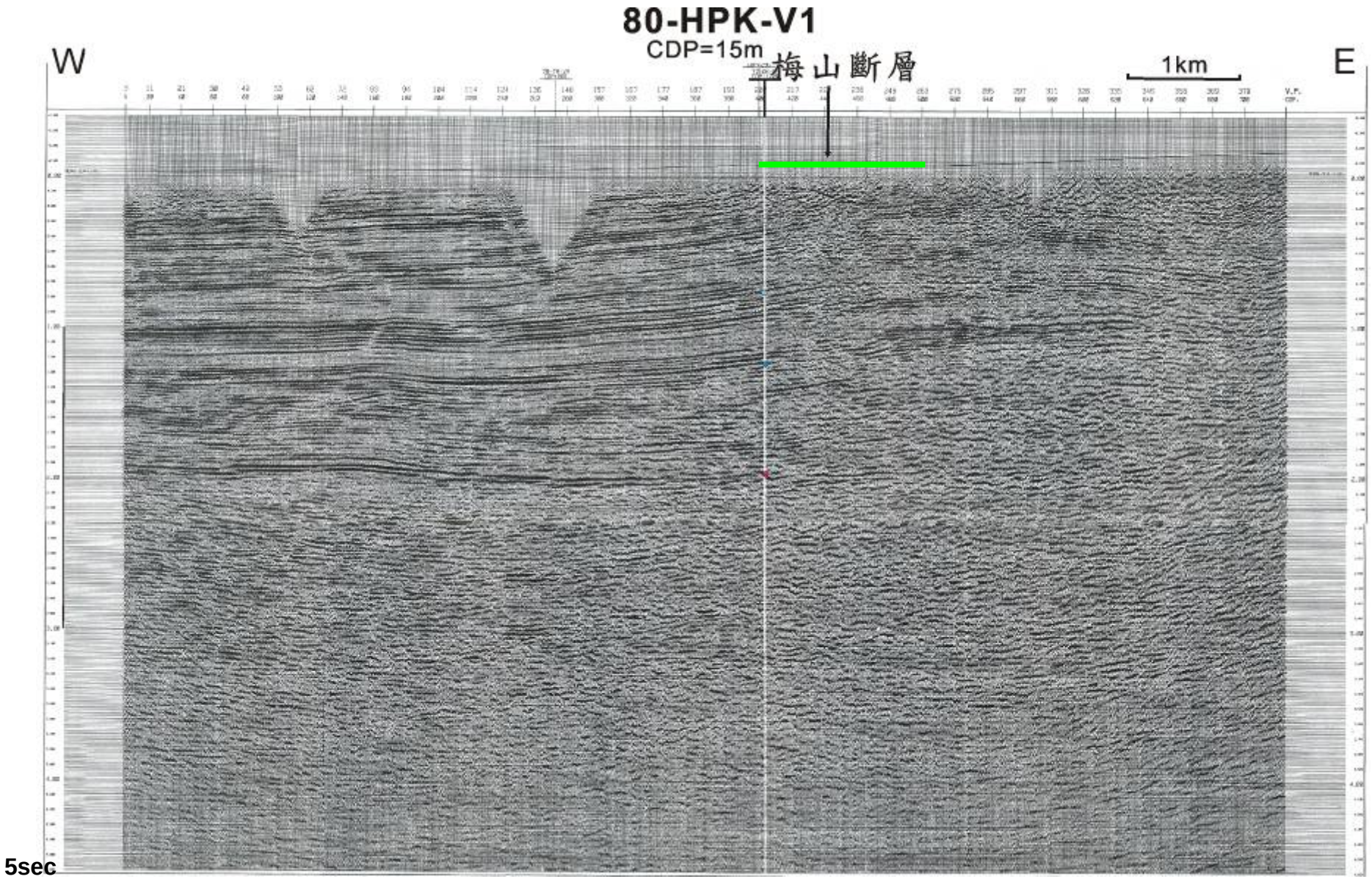


High resolution seismics

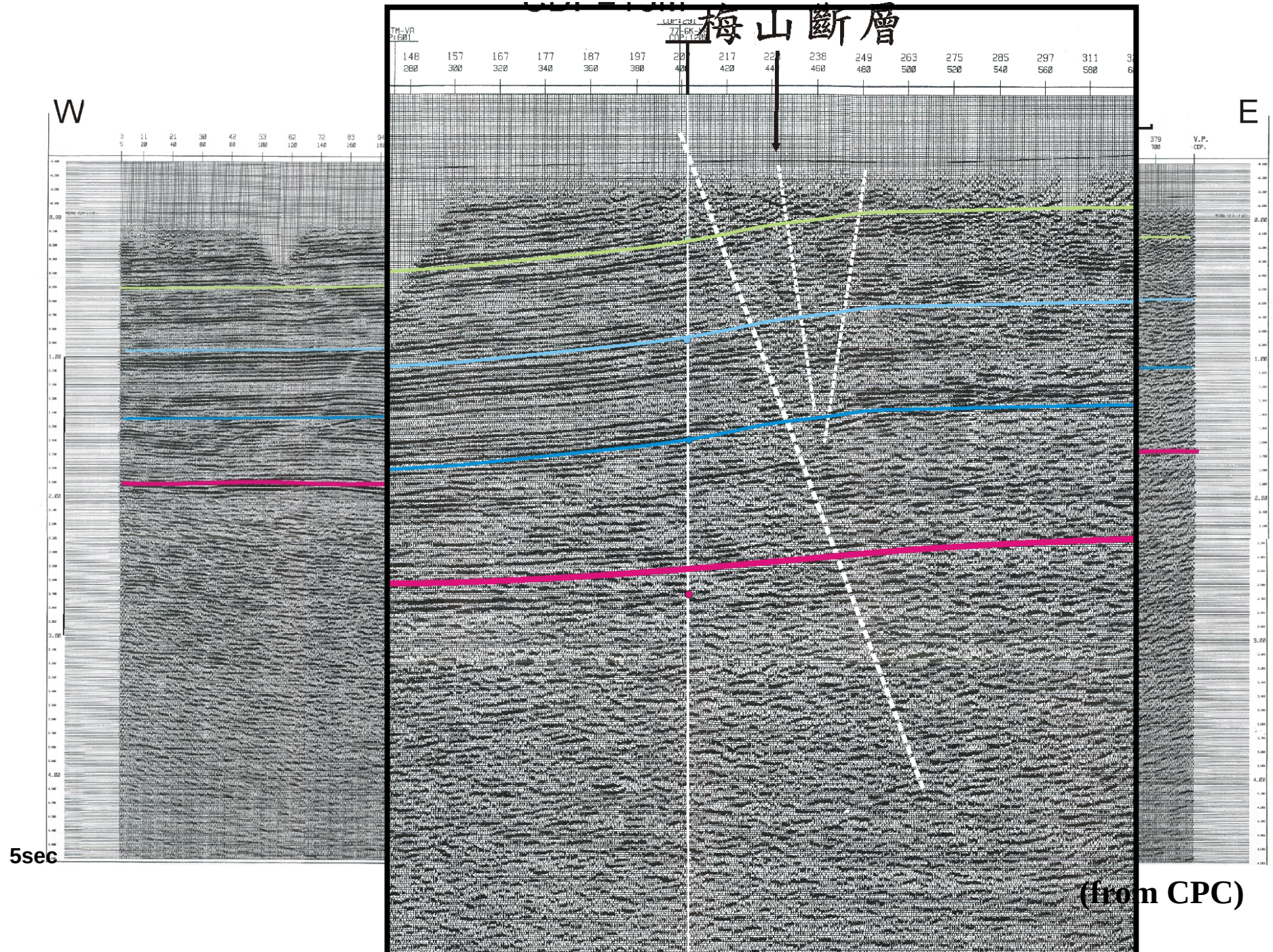


例二（Example 2）：
梅山斷層（MeiSan Fault）

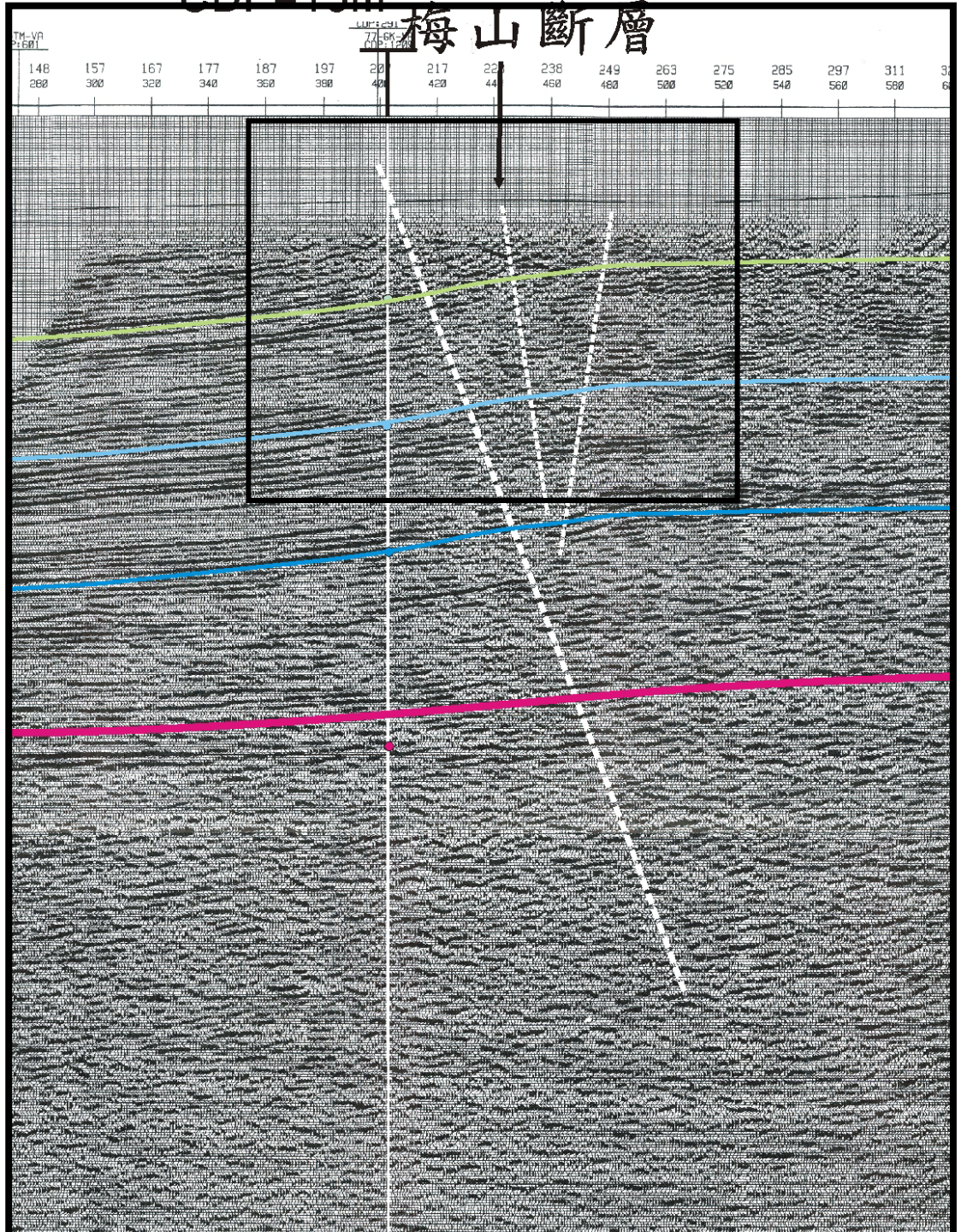


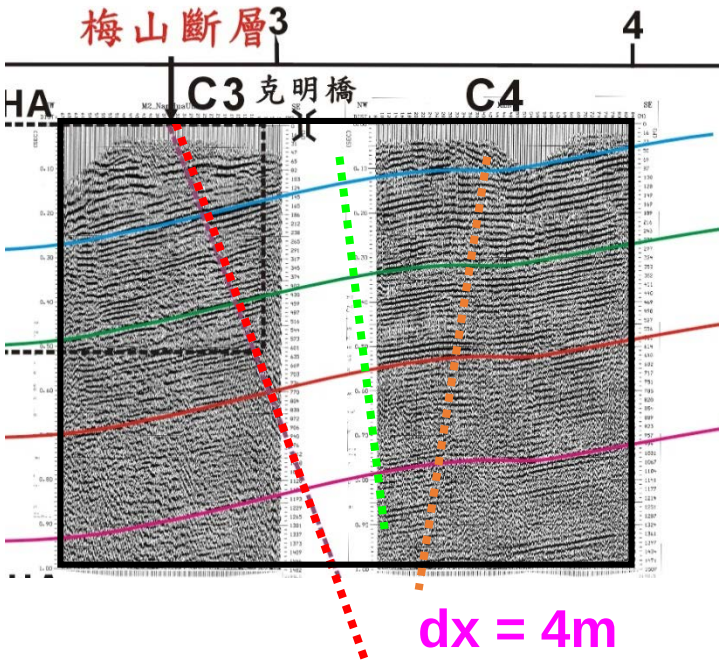


(from CPC)

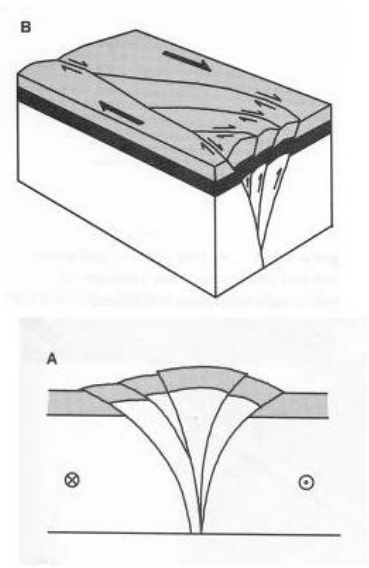


(from CPC)





dx = 4m
freq=100Hz
(high resolution)

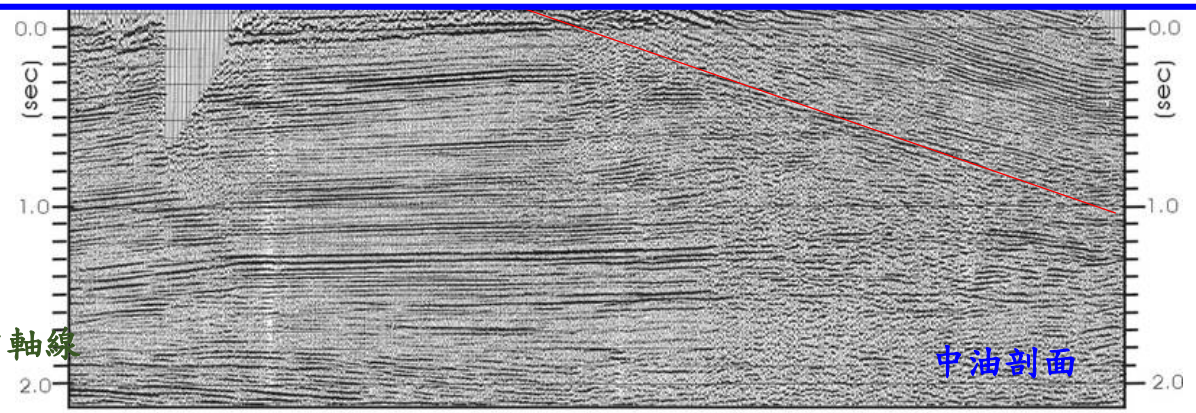


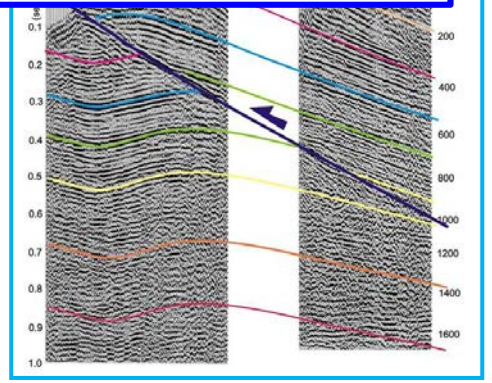
壓縮型：棕櫚樹型
(conpressional flower structure: palm tree)

dx = 25m
freq=50Hz

(from CPC)

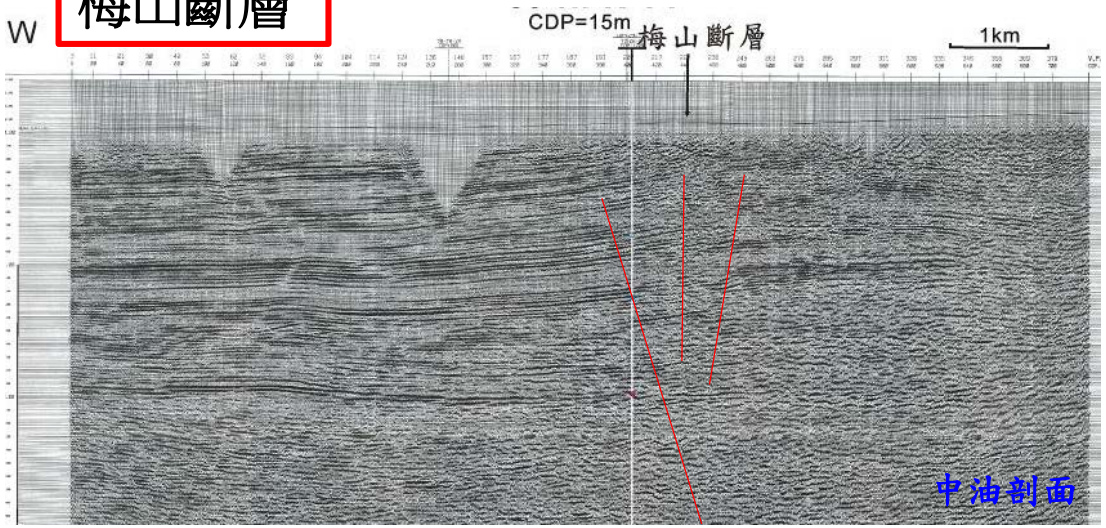
梅山地震: 1792 →1906→2020?





1906梅山地震(M7.1)
Omori原圖之彩繪稿

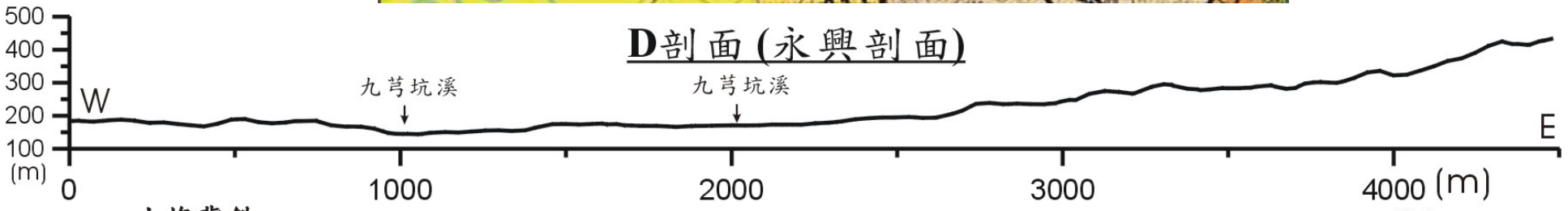
梅山斷層

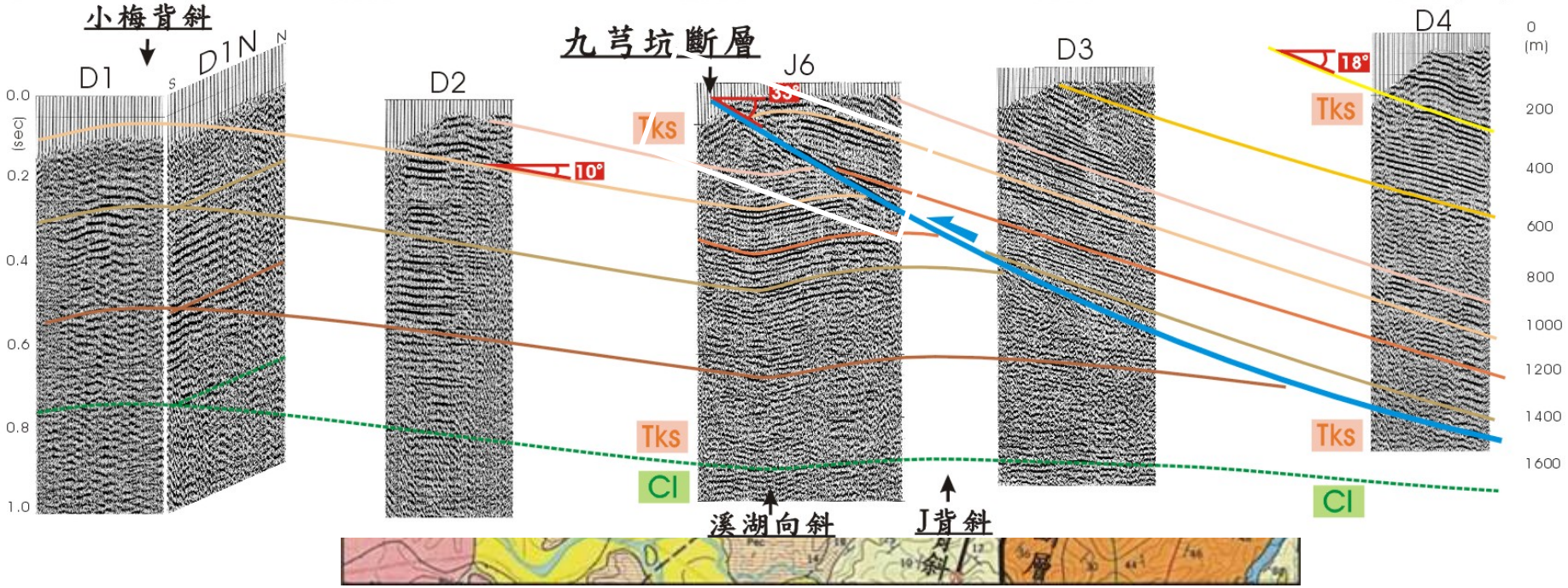


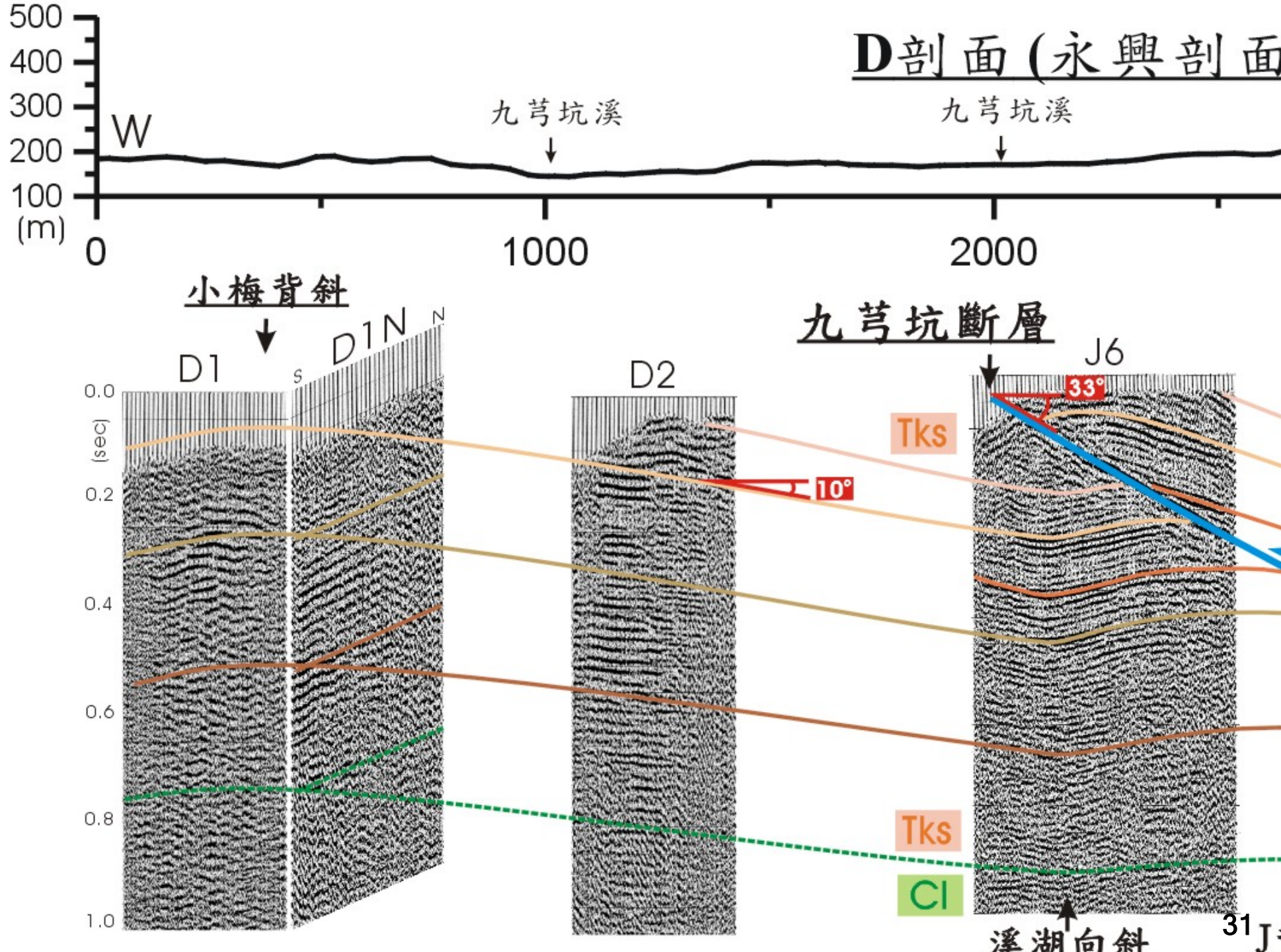
平移斷層花狀造

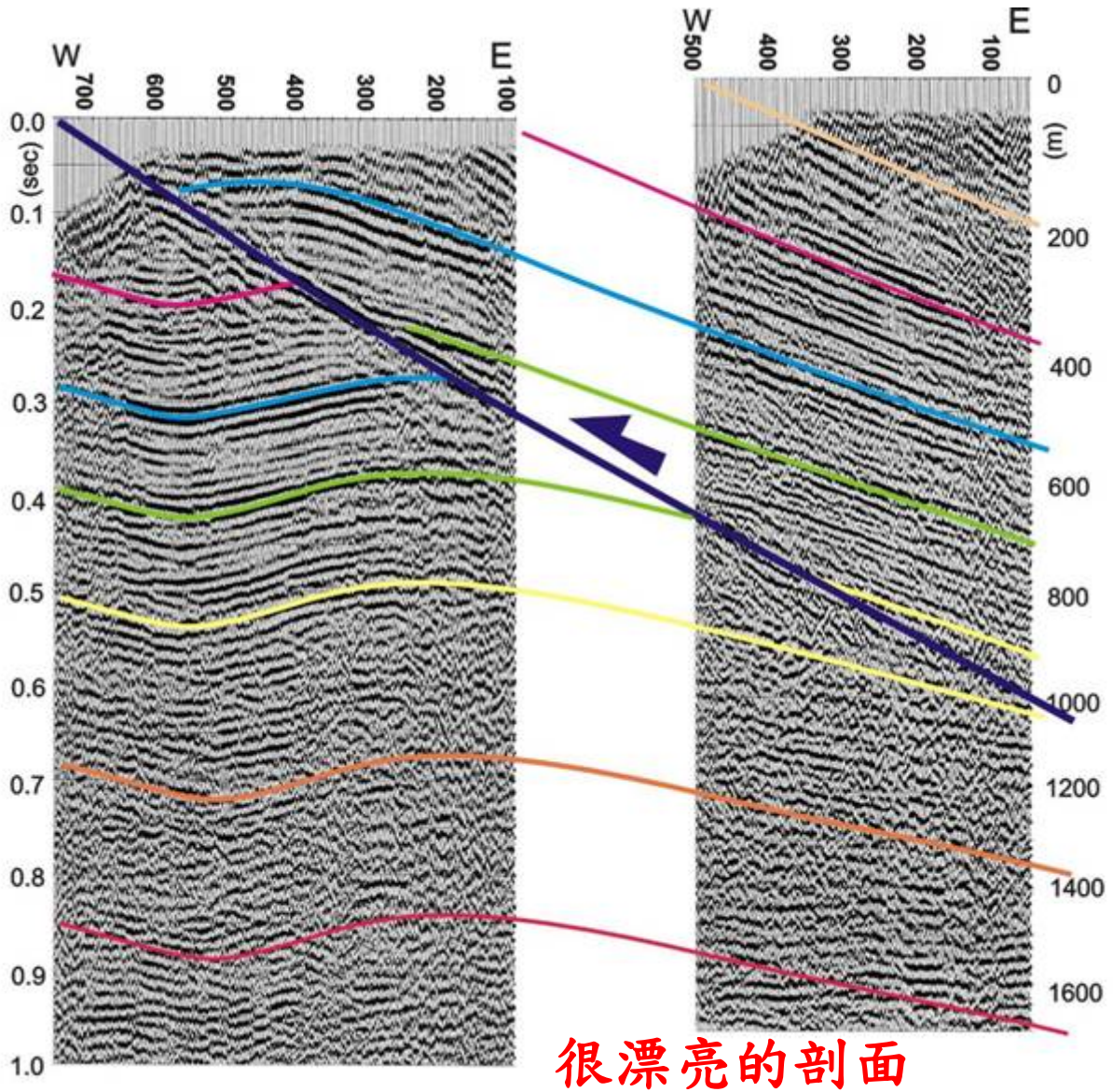
嘉義 九芎坑斷層(D剖面)


0
5 km
TOU-NAN
TA-LUN
TUNG-HO-TSUN
SHUI-TUI
SHIH-KUEI HSI
桐樹湖斷層
內林背斜
九芎坑斷層
J1
J2


D剖面 (永興剖面)
500
400
300
200
100
(m)
W
E
九芎坑溪
九芎坑溪
0
1000
2000
3000
4000 (m)


小梅背斜
九芎坑斷層
D1
D1N
D2
J6
D3
D4
Tks
Cl
10°
18°
0.0
0.2
0.4
0.6
0.8
1.0
(sec)
0
200
400
600
800
1000
1200
1400
1600
(m)
溪湖向斜
J背斜


D剖面(永興剖面
500
400
300
200
100
(m)
W
九芎坑溪
九芎坑溪
0
1000
2000
小梅背斜
九芎坑斷層
D1
S
D1N
N
D2
J6
33°
10°
Tks
Tks
Cl
0.0
(sec)
0.2
0.4
0.6
0.8
1.0
溪湖向斜

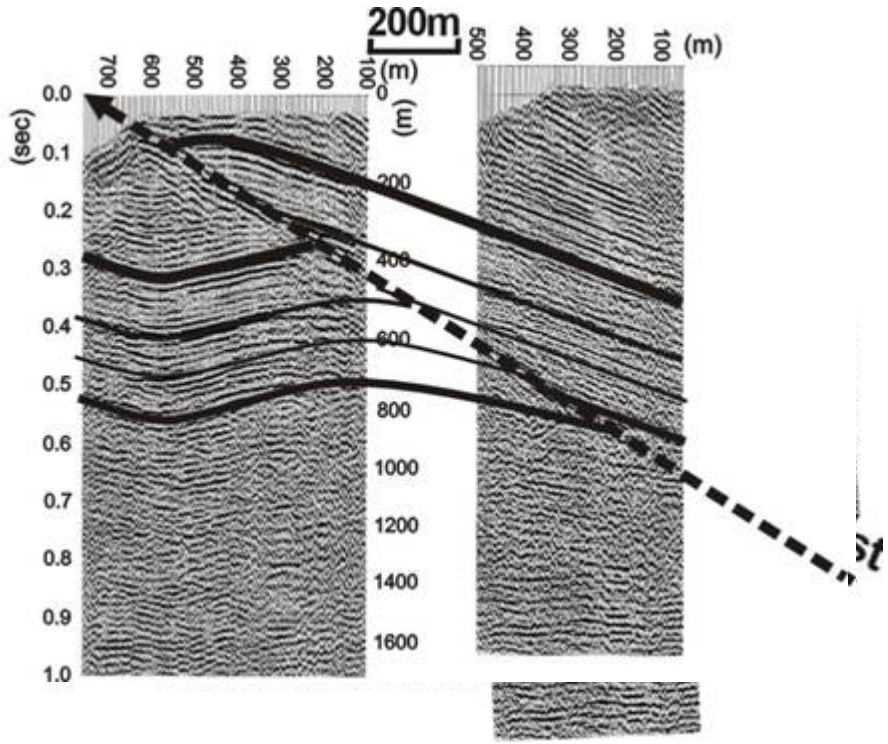

W
700
600
500
400
300
200
E
100
0.0
(sec)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
W
500
400
300
200
100
E
0
(m)
200
400
600
800
1000
1200
1400
1600

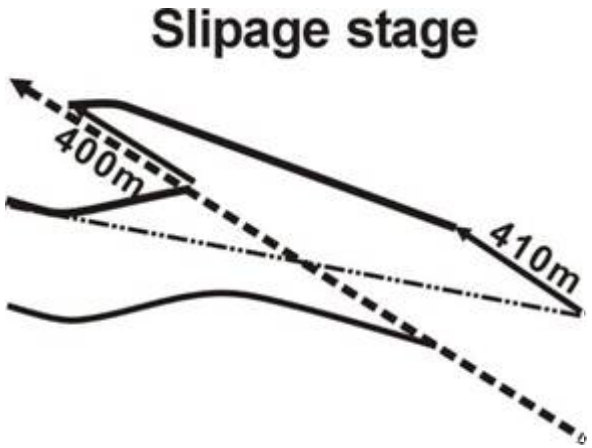
很漂亮的剖面

D剖面之斷層構造演化推論

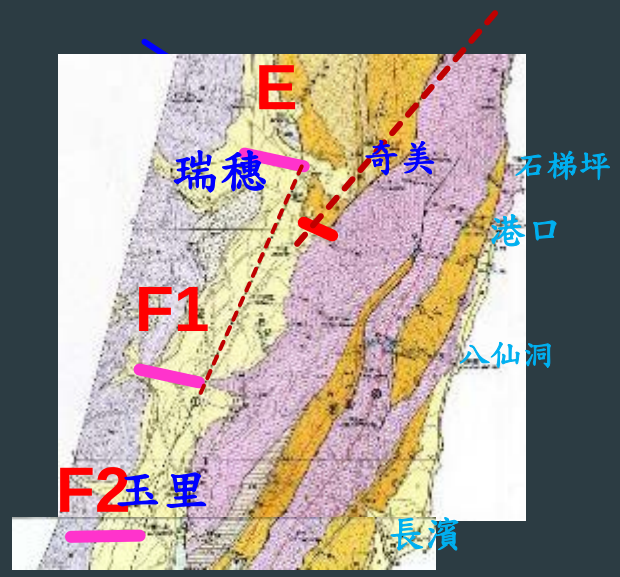
Fault-propagation Folding

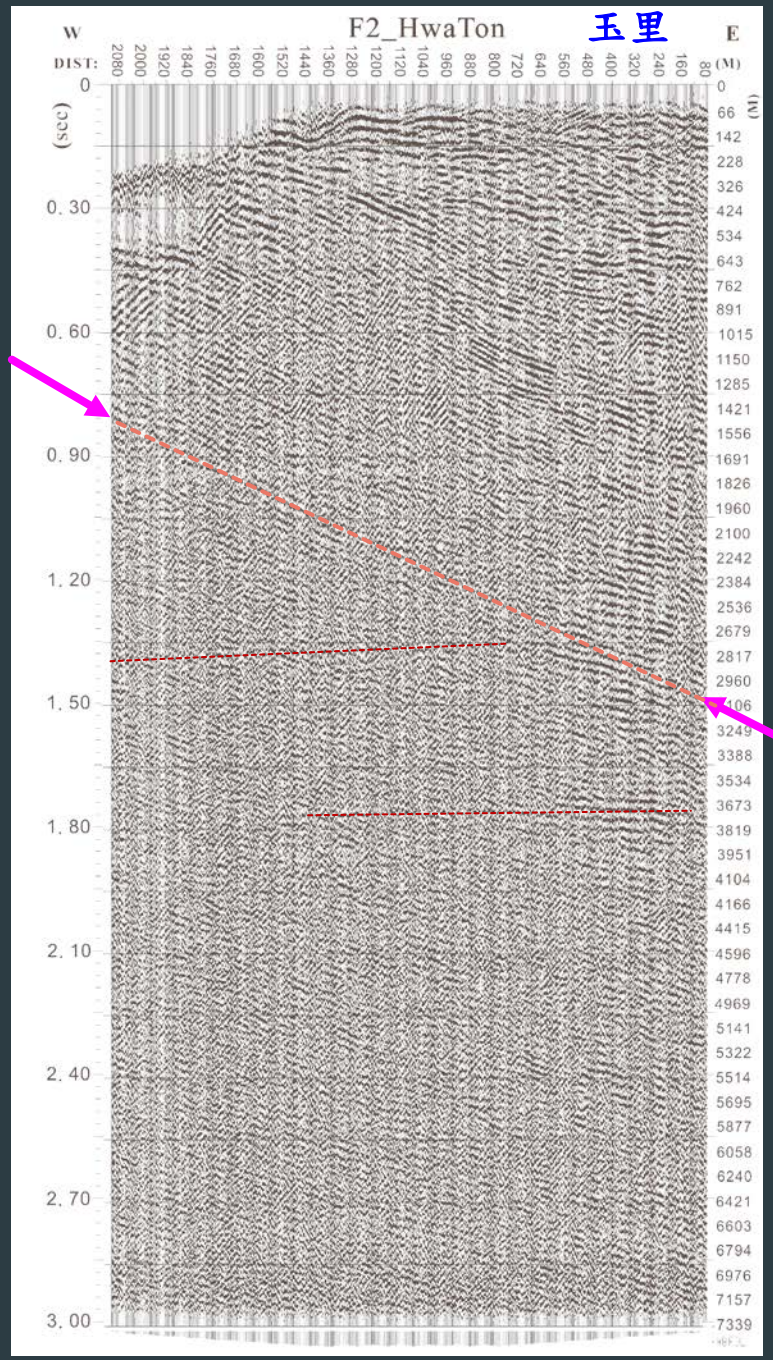
5

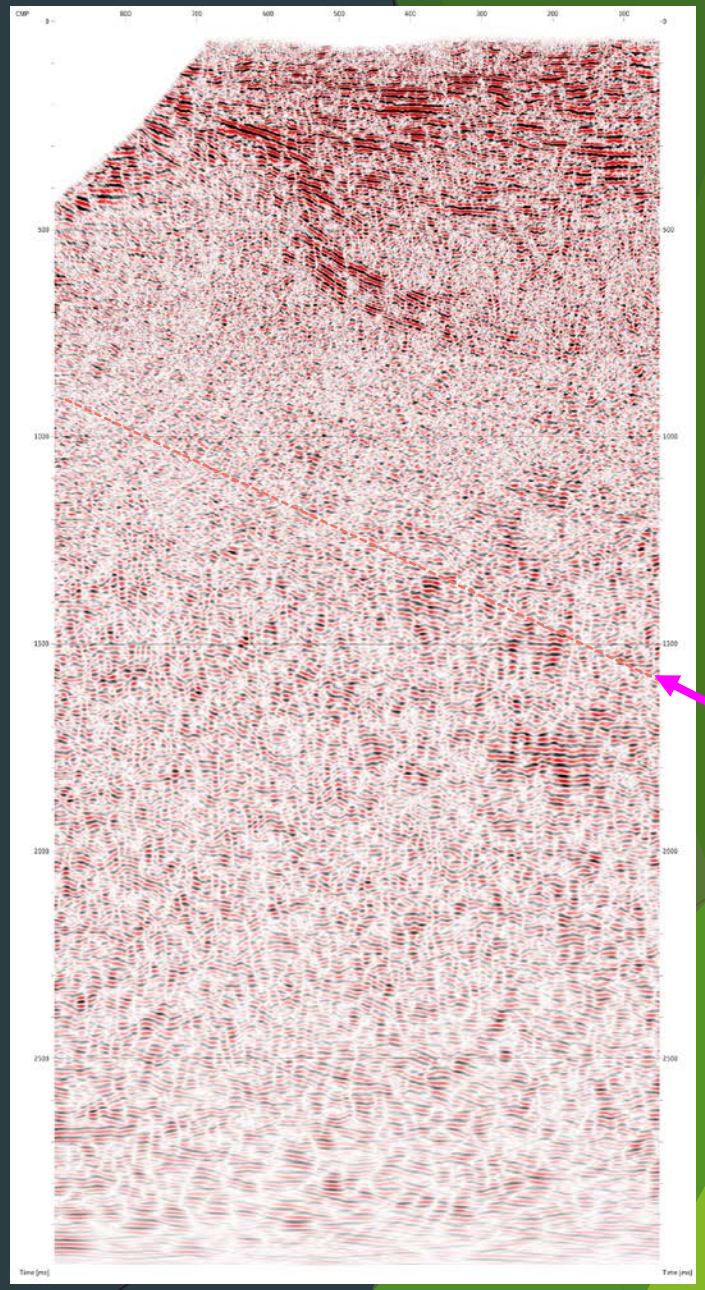


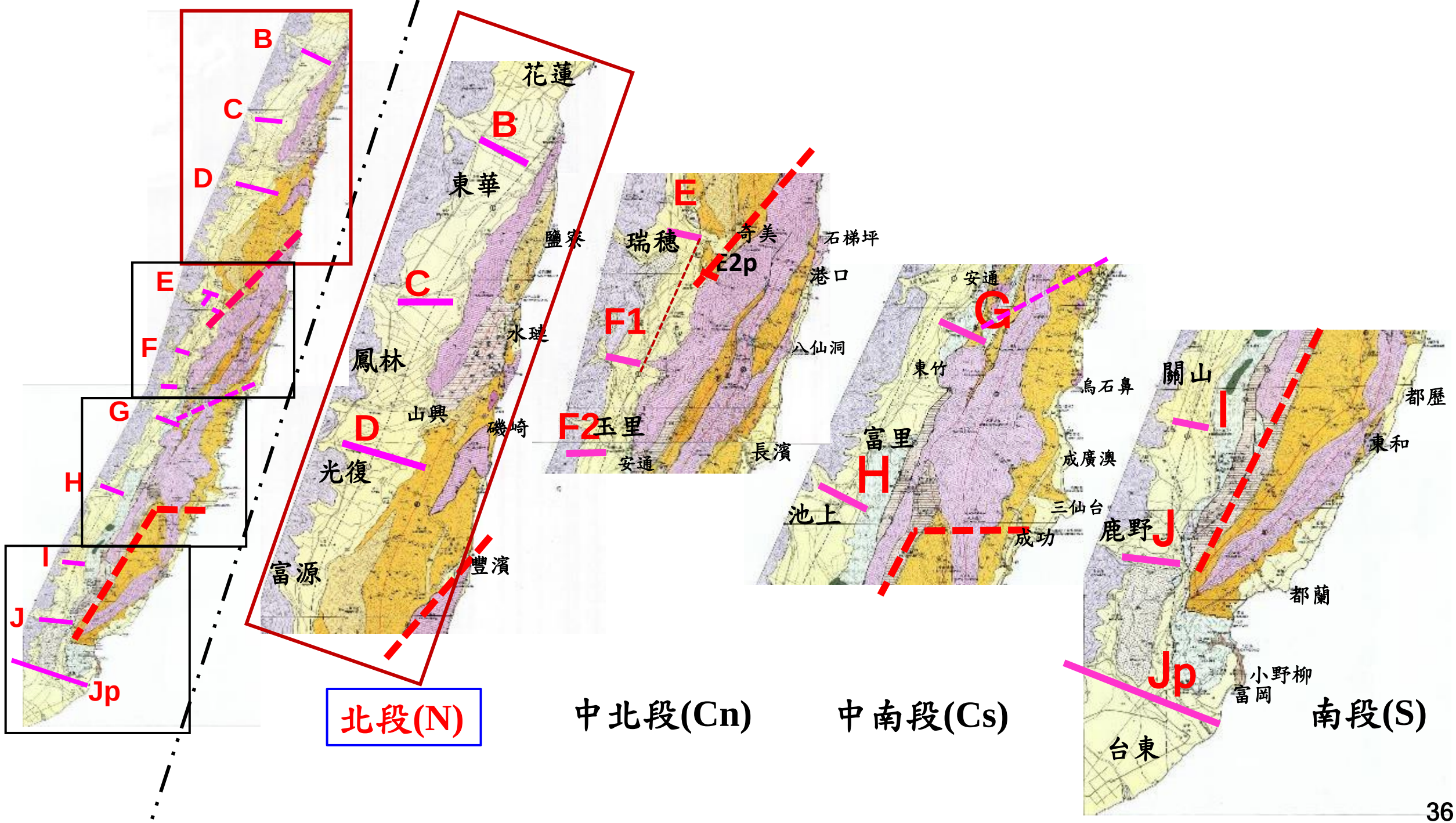


1. 海岸山脈與造山運動
2. 縱谷北段震測剖面(N)
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面
6. 構造模型
7. 2018花蓮地震與米崙斷層
8. 結論

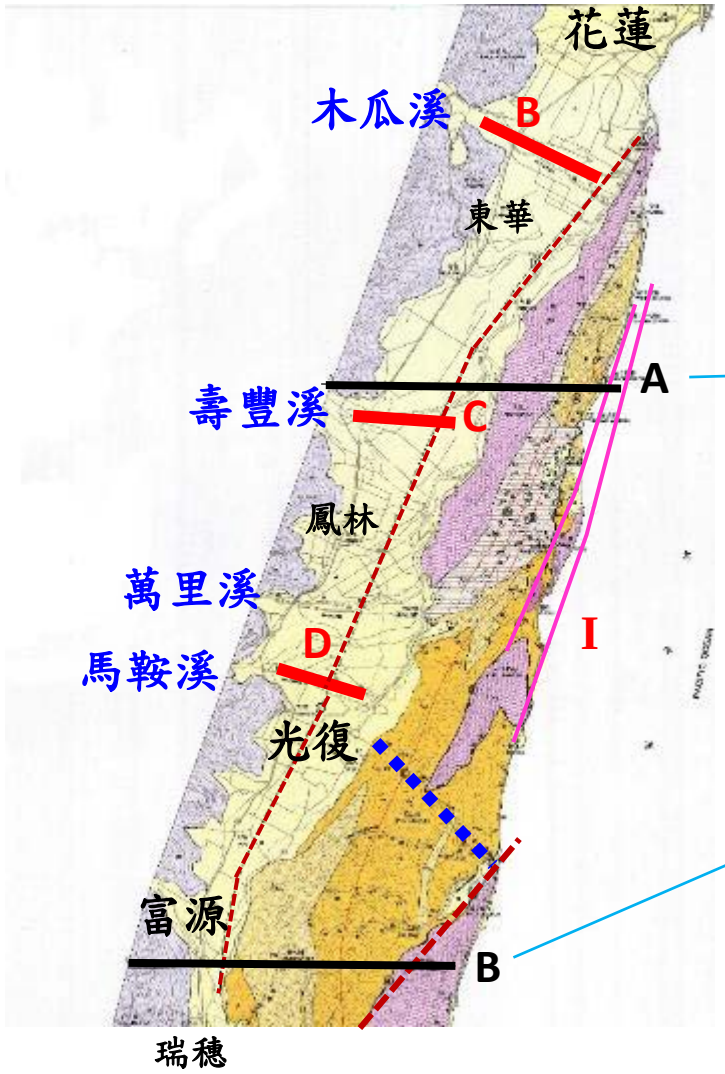

E
瑞穗
奇美
石梯坪
花口
F1
八仙洞
F2玉里
長濱

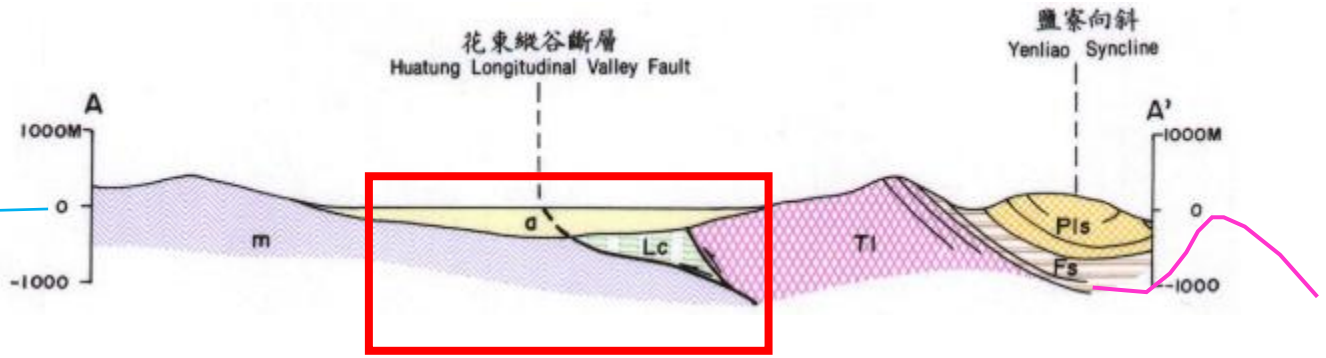

W
F2_HwaTon
玉里
E
DIST:
(SEC)
(M)
(M)
0
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
3.00

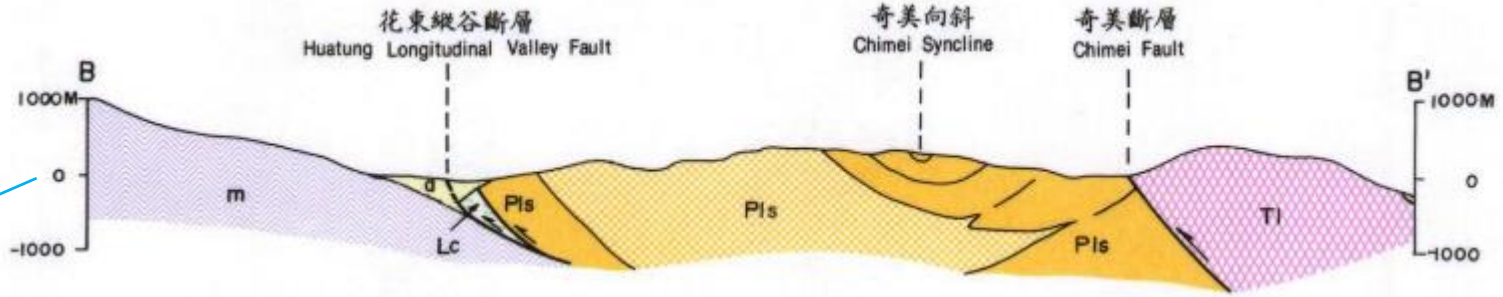



B
C
D
E
F
G
H
I
J
Jp
花蓮
東華
鹽寮
瑞穗
奇美
石梯坪
港口
八仙洞
水璉
鳳林
山興
磯崎
光復
富源
豐濱
玉里
安通
長濱
富里
東竹
烏石鼻
池上
成廣澳
三仙台
成功
關山
都歷
東和
鹿野
都蘭
小野柳
富岡
台東
F1
F2
ε2p
北段(N)
中北段(Cn)
中南段(Cs)
南段(S)

縱谷北段(N) 推測地質剖面(Geology Profile)

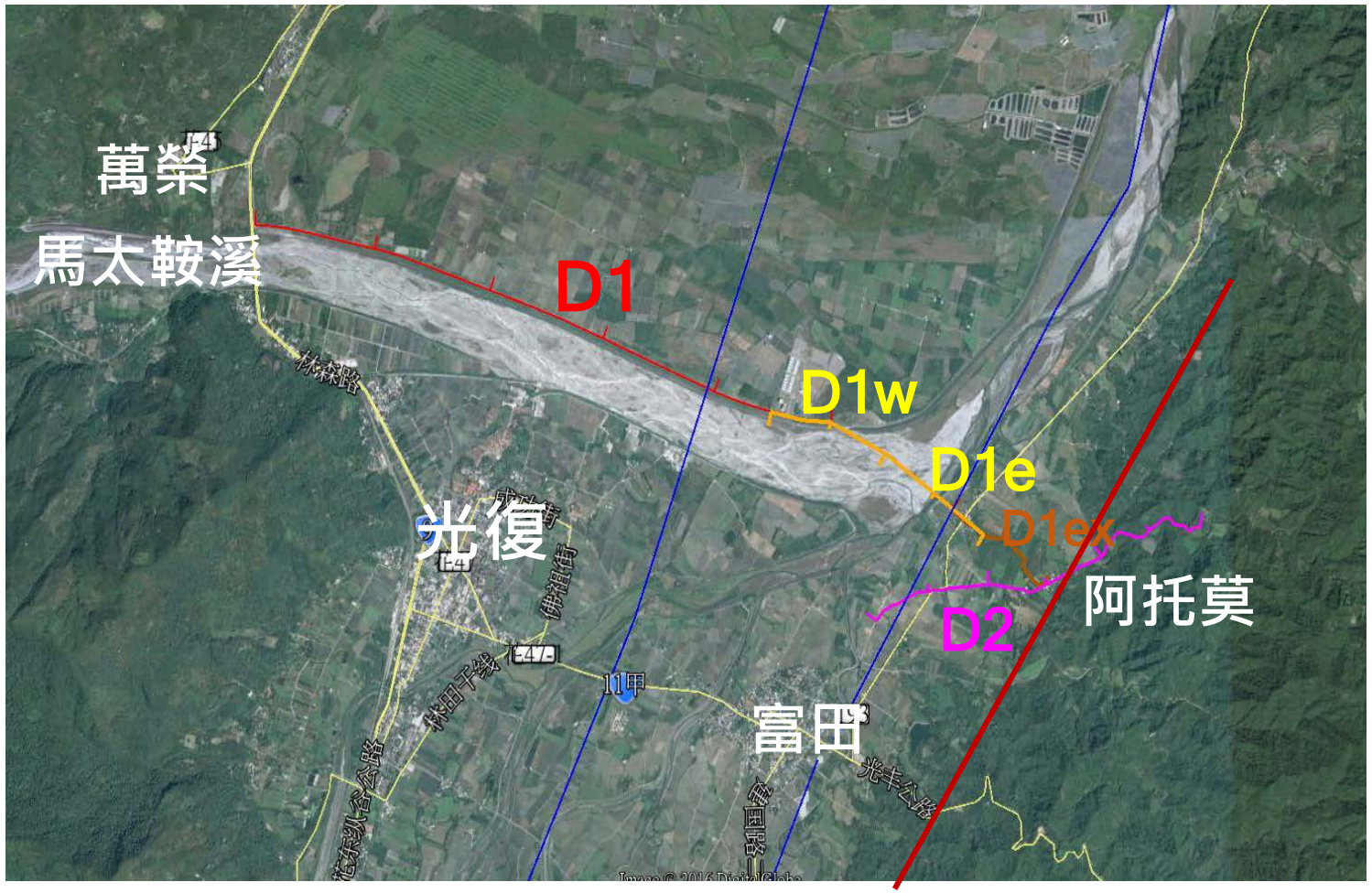


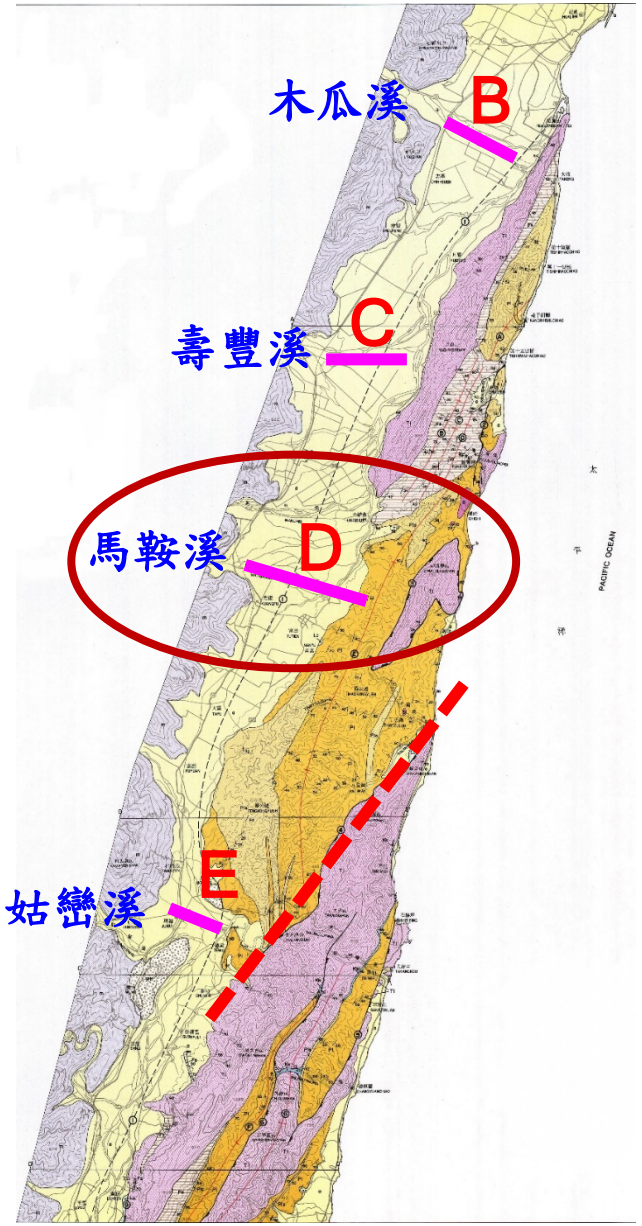




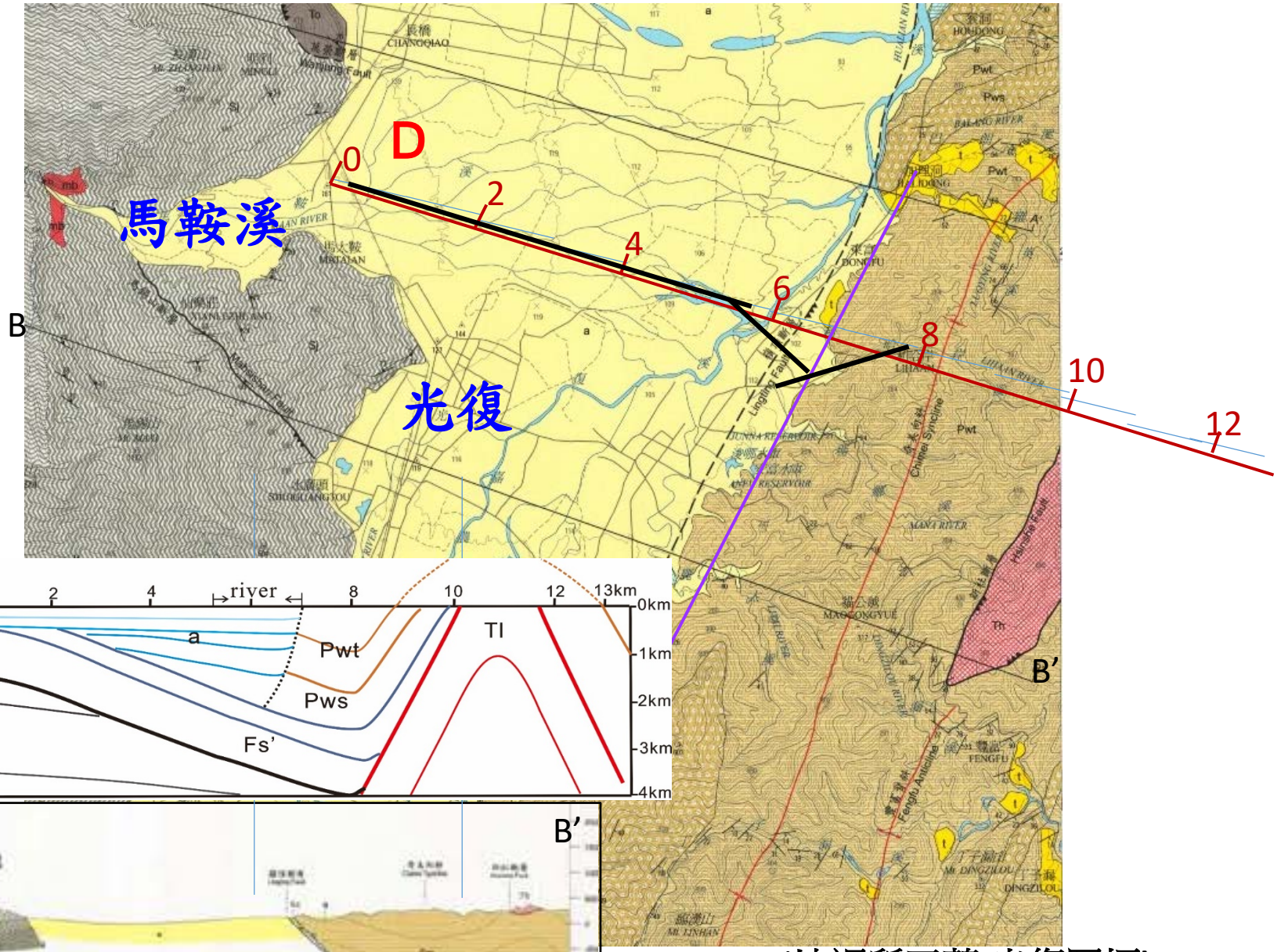
(地調所地質圖)

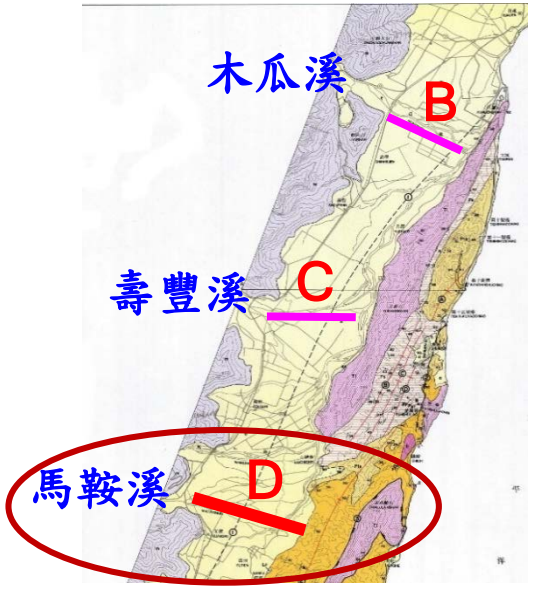
D_HwaTon


萬榮
馬太鞍溪
D1
D1w
D1e
D1ex
D2
光復
阿托莫
富田
林森路
光丰公路

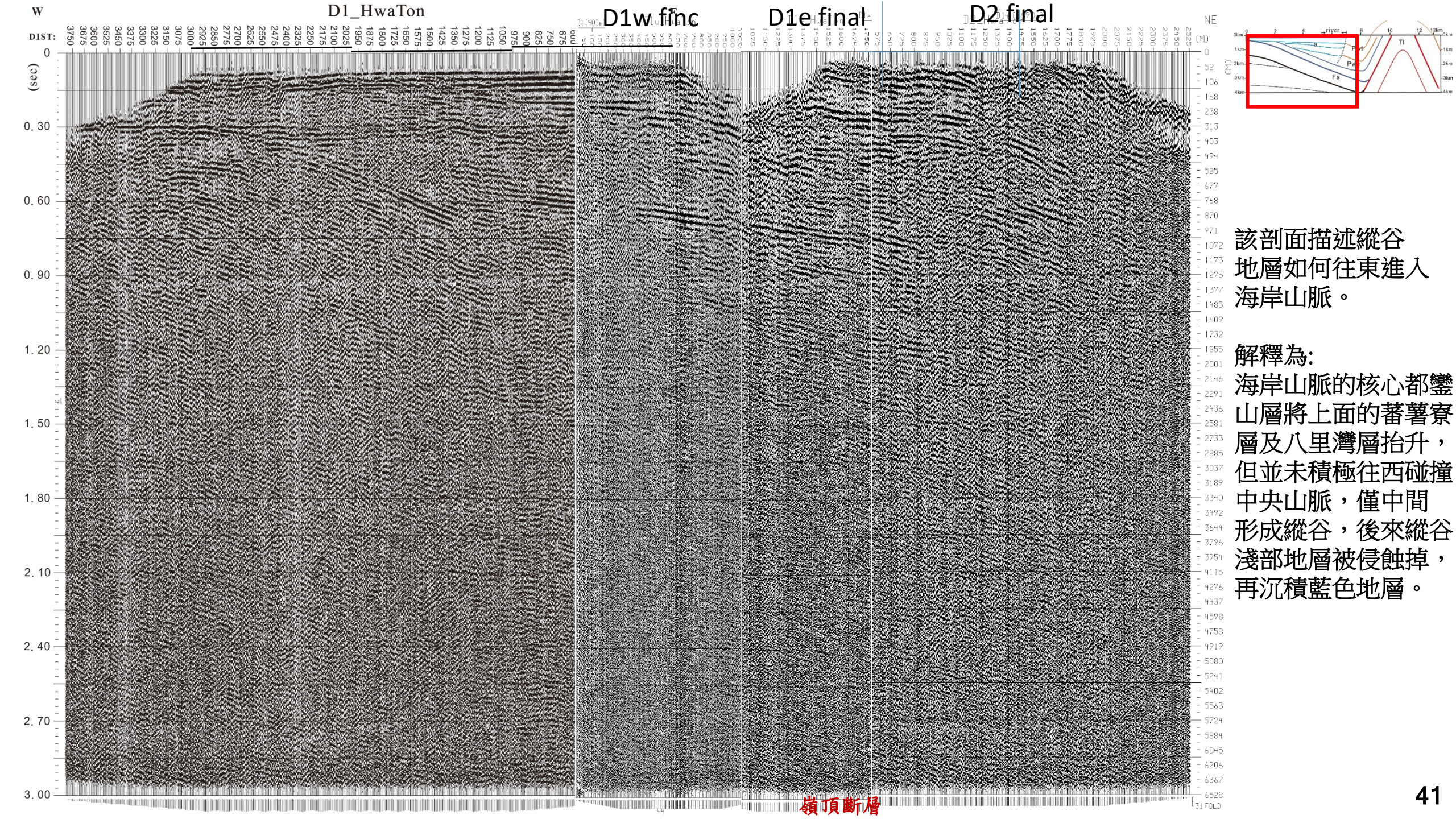

木瓜溪
B
壽豐溪
C
馬鞍溪
D
秀姑巒溪
E

強渡溪流(across river)


馬鞍溪
光復
D
0
2
4
6
8
10
12
B
B'
Pwt
Pws
Fs'
TI
a
river
0km
1km
2km
3km
4km
13km

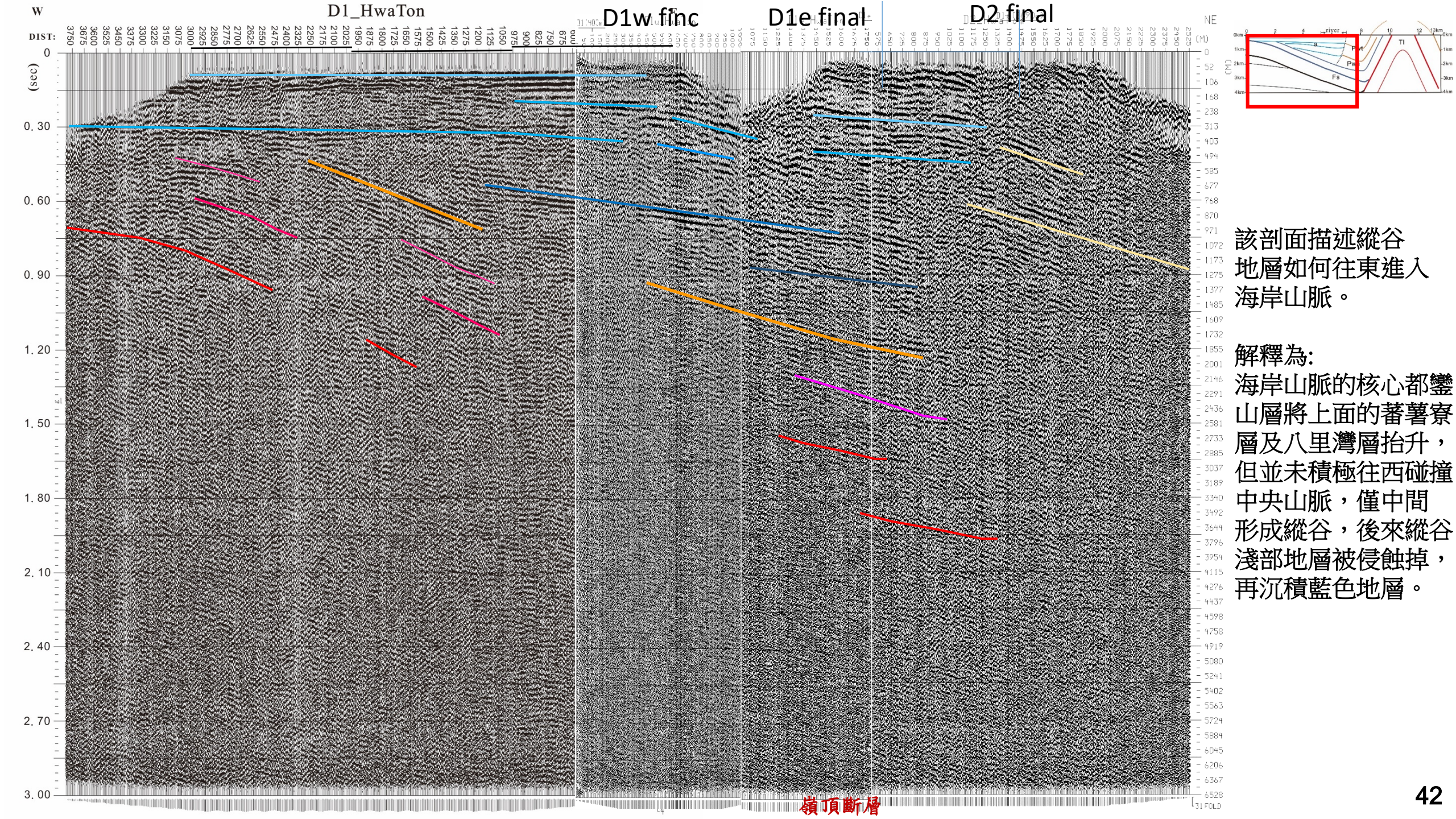

木瓜溪
B
壽豐溪
C
馬鞍溪
D

(地調所五萬:光復圖幅)



該剖面描述縱谷地層如何往東進入海岸山脈。

解釋為:
海岸山脈的核心都鑾山層將上面的蕃薯寮層及八里灣層抬升，但並未積極往西碰撞中央山脈，僅中間形成縱谷，後來縱谷淺部地層被侵蝕掉，再沉積藍色地層。



該剖面描述縱谷地層如何往東進入海岸山脈。

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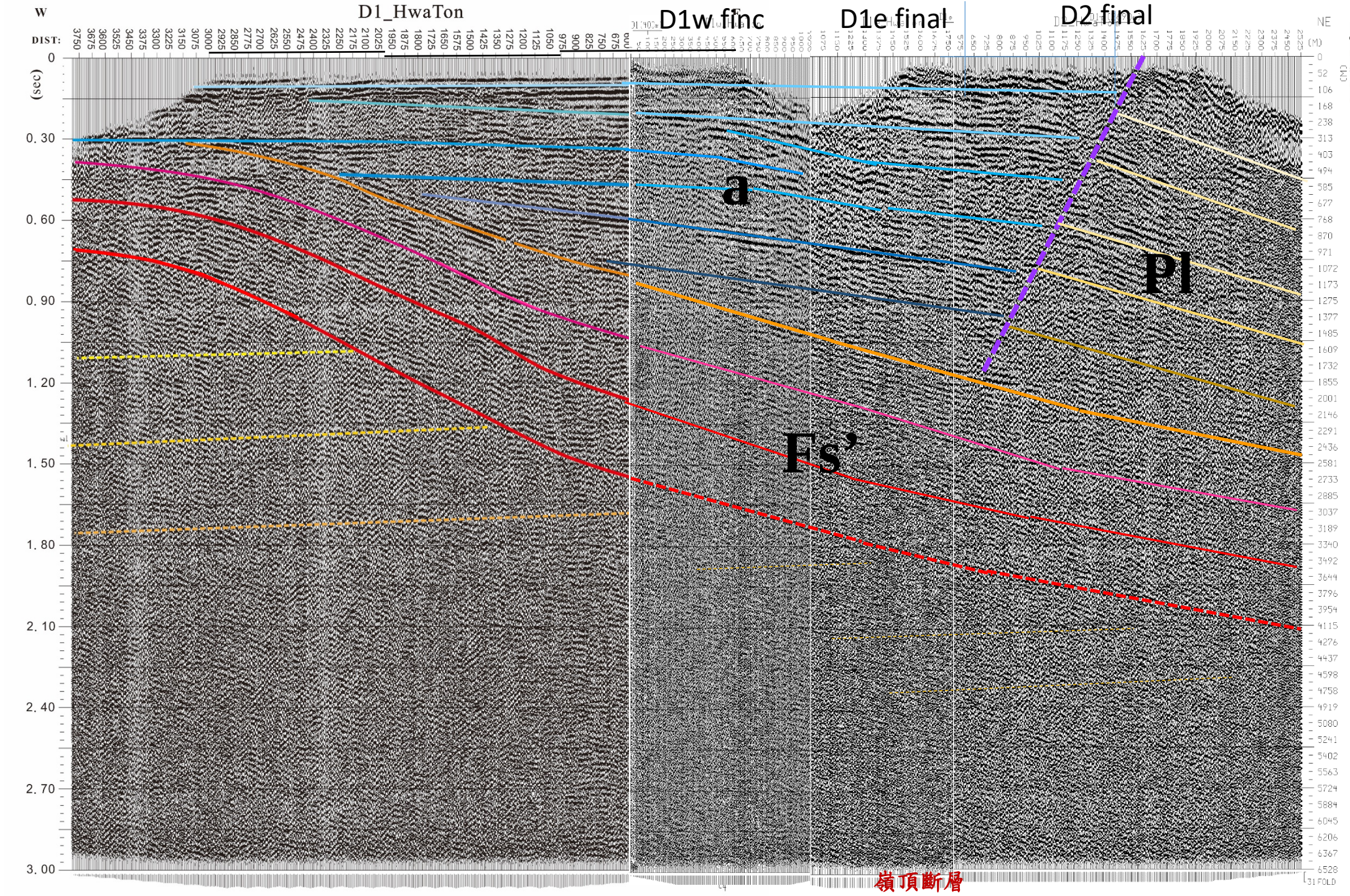
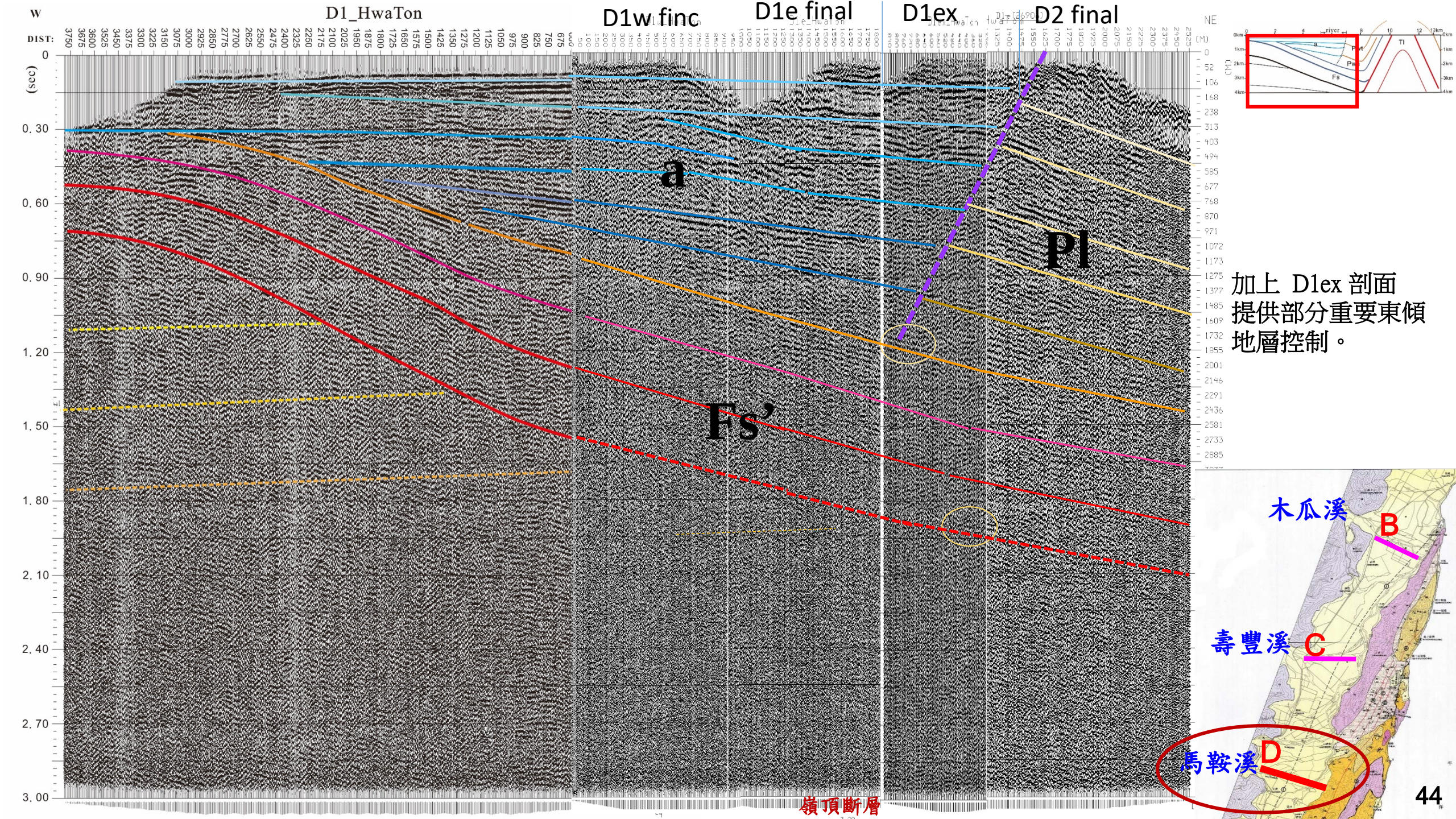
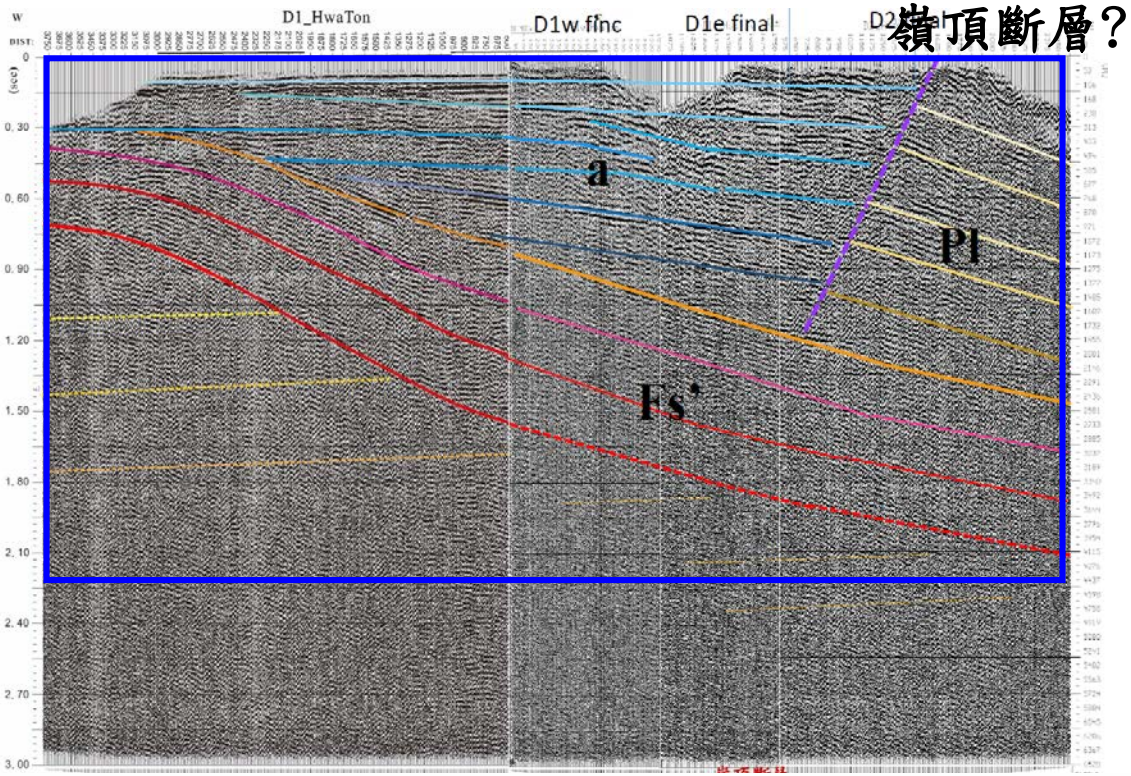


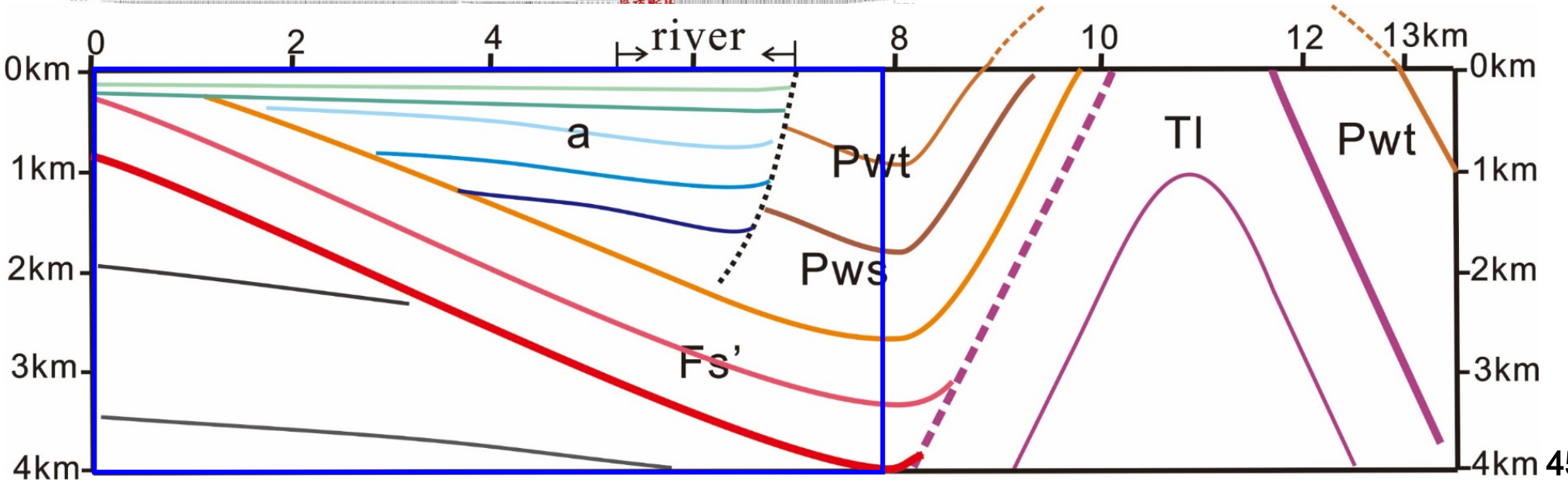
該剖面描述縱谷地層如何往東進入海岸山脈。

解釋為:
海岸山脈的核心都鑾山層將上面的蕃薯寮層及八里灣層抬升，但並未積極往西碰撞中央山脈，僅中間形成縱谷，後來縱谷淺部地層被侵蝕掉，再沉積藍色地層。

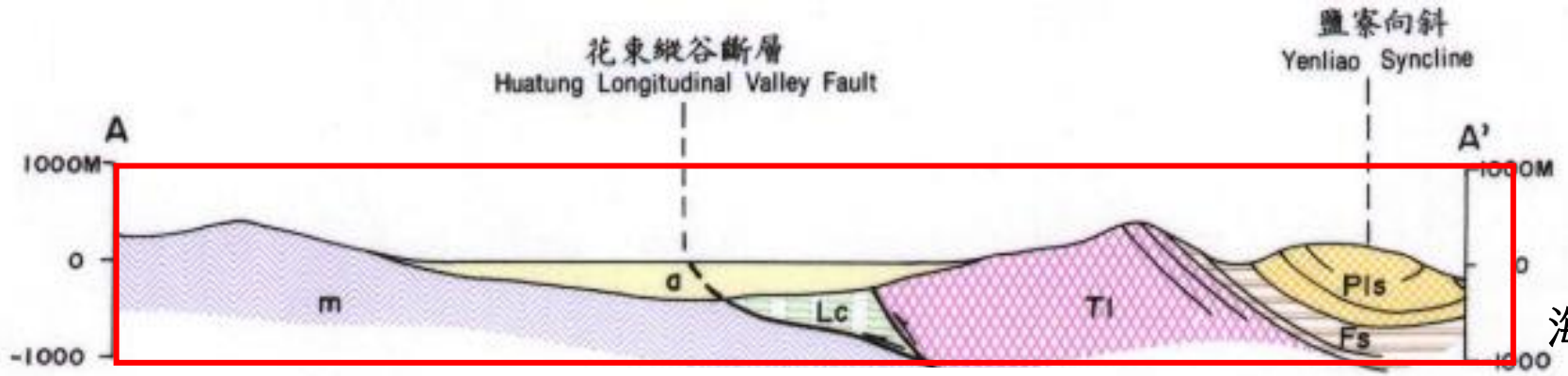

D1_HwaTon
D1w finc
D1e final
D1ex
D2 final
W
NE
DIST:
(sec)
a
Pl
Fs'
崁頂斷層
加上 D1ex 剖面
提供部分重要東傾
地層控制。
木瓜溪
B
壽豐溪
C
馬鞍溪
D

光復
(馬鞍溪剖D)


D1_HwaTon
D1w finc
D1e final
嶺頂斷層？
a
Pl
Fs'

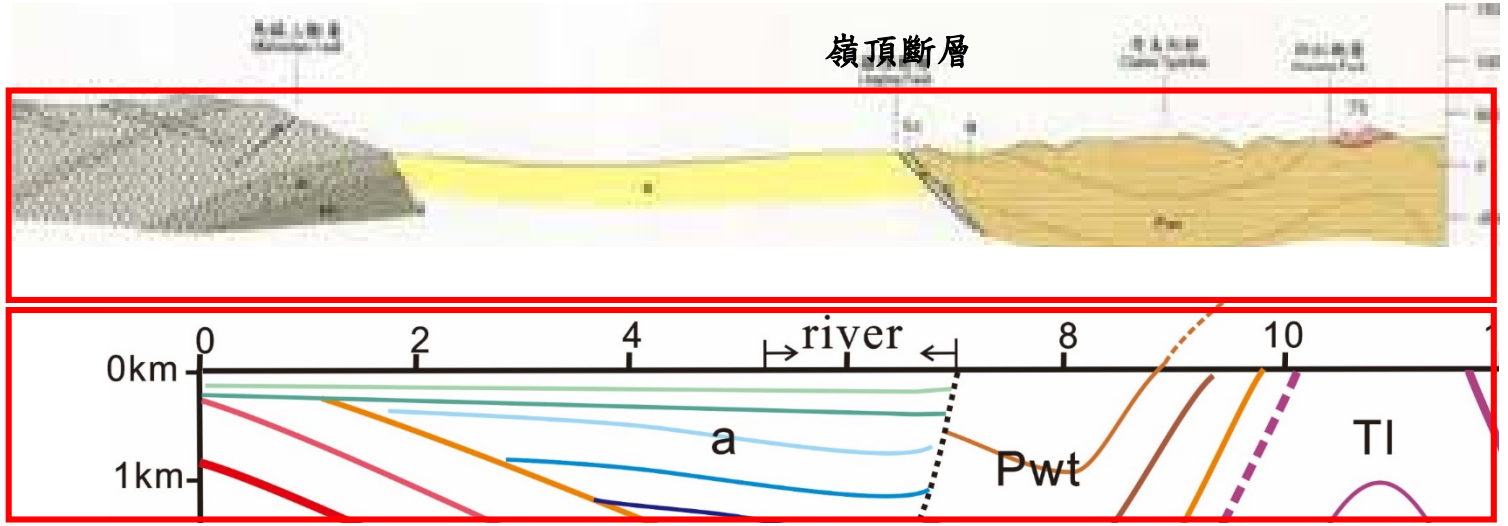

0
2
4
river
8
10
12
13km
0km
1km
2km
3km
4km
a
Pwt
Pws
Fs'
Tl
Pwt

壽豐溪剖面



海岸山脈圖幅

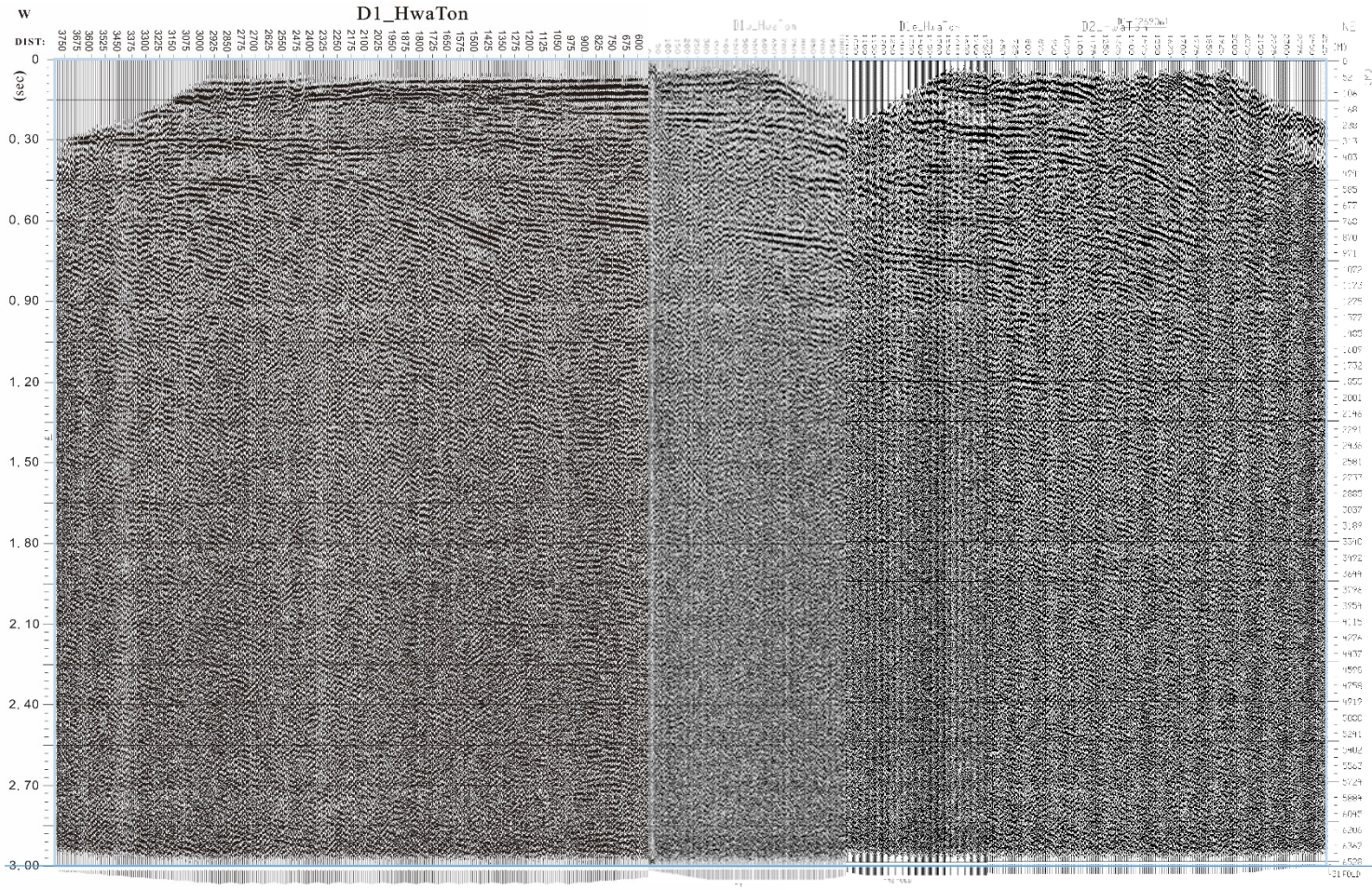
光復
(馬鞍溪剖面D)



光復圖幅

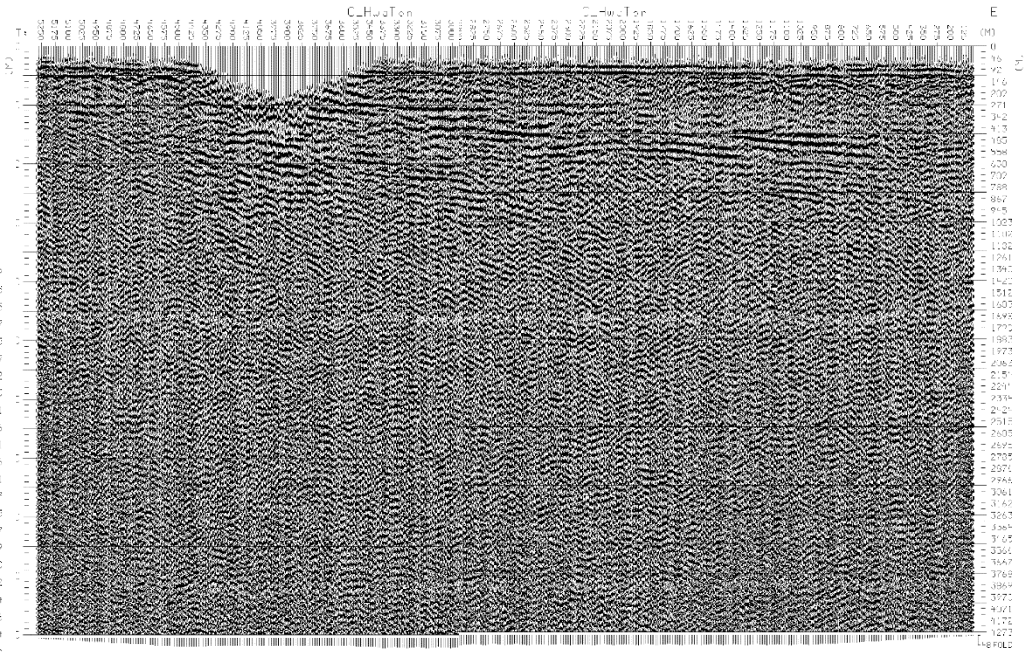
馬太鞍溪(光復)

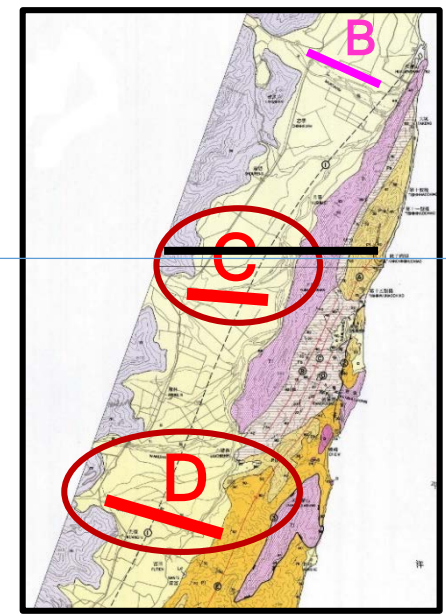
D final



壽豐溪(鳳林)

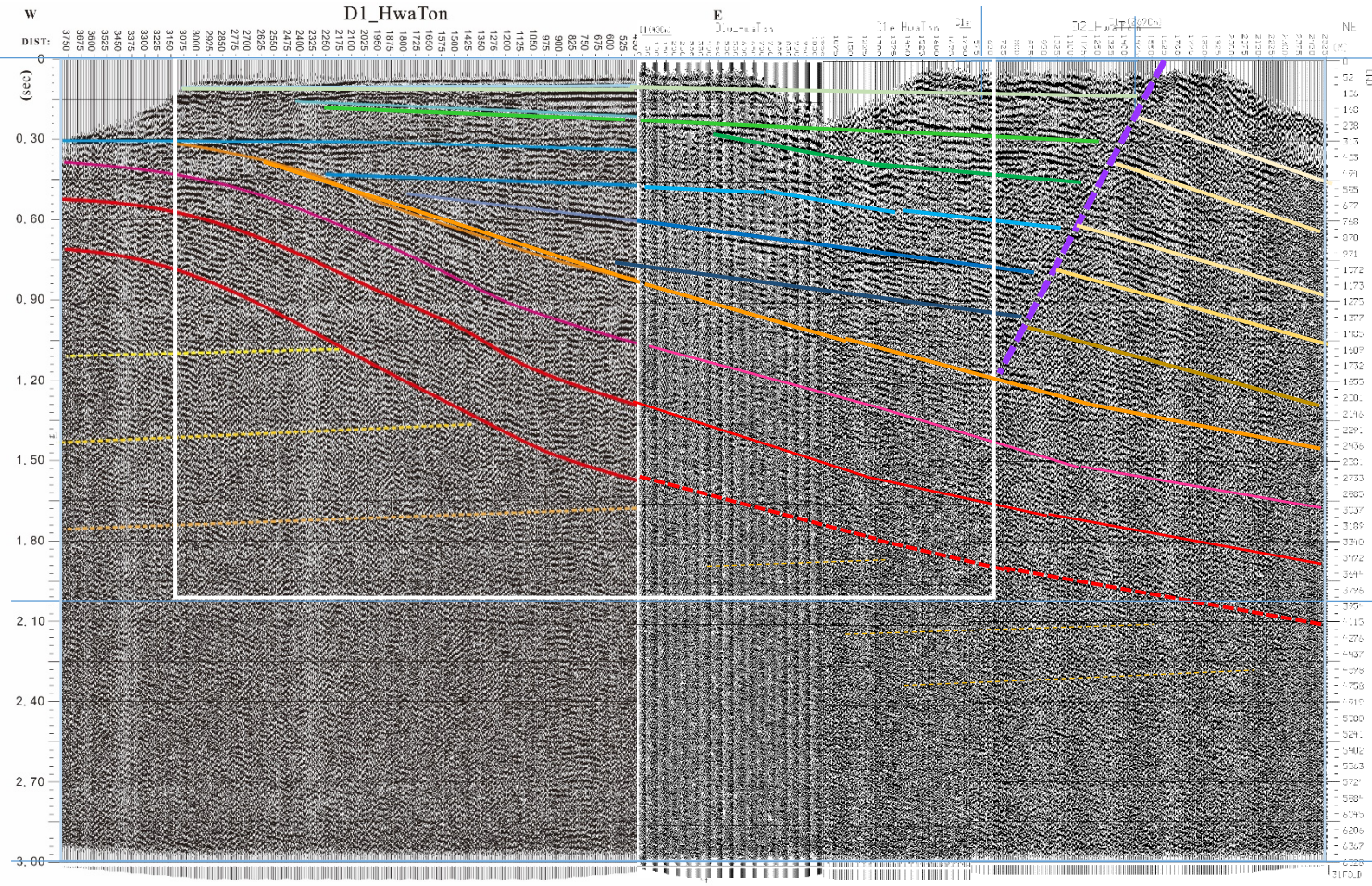
C final





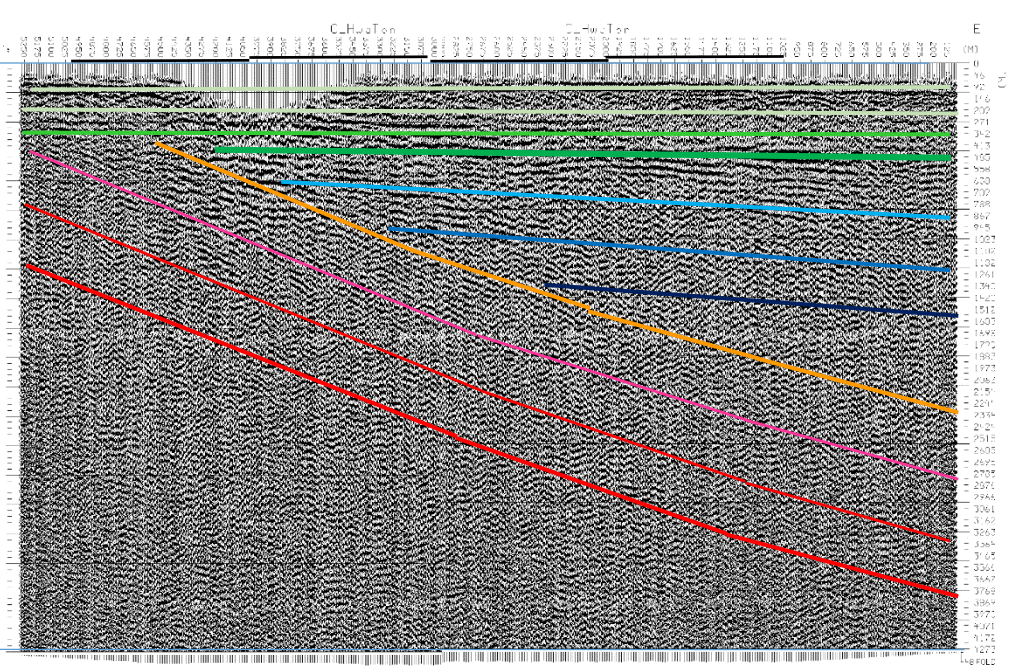
馬太鞍溪(光復)

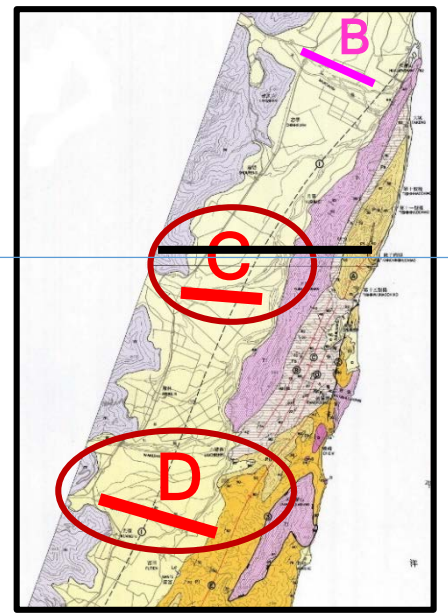
D final



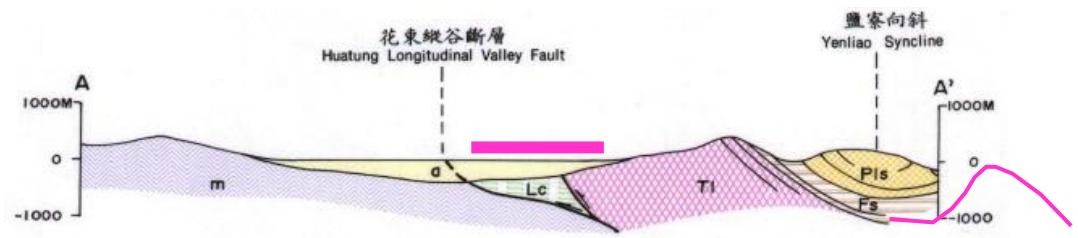
壽豐溪(鳳林)

C final



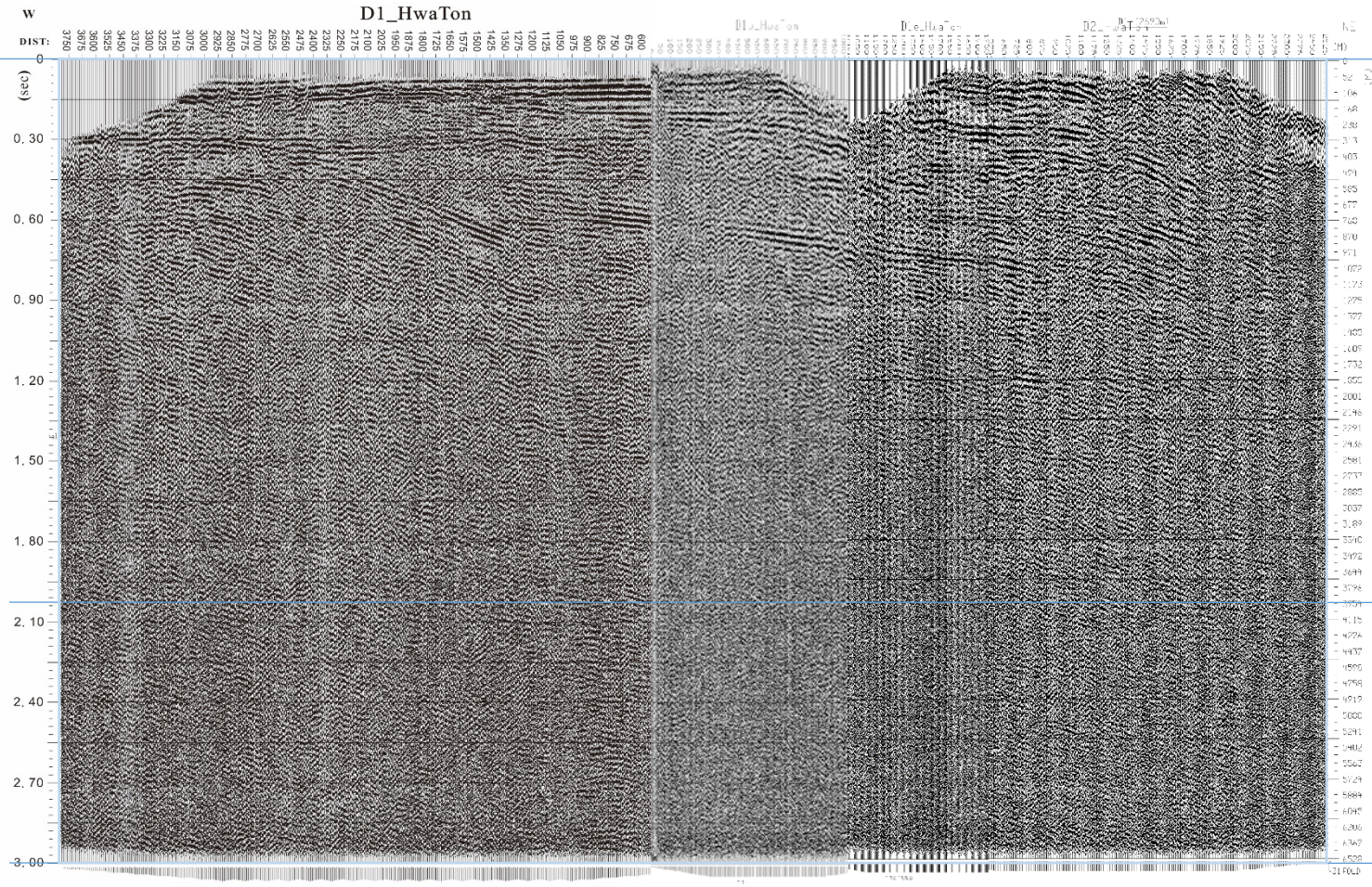


嶺頂斷層?



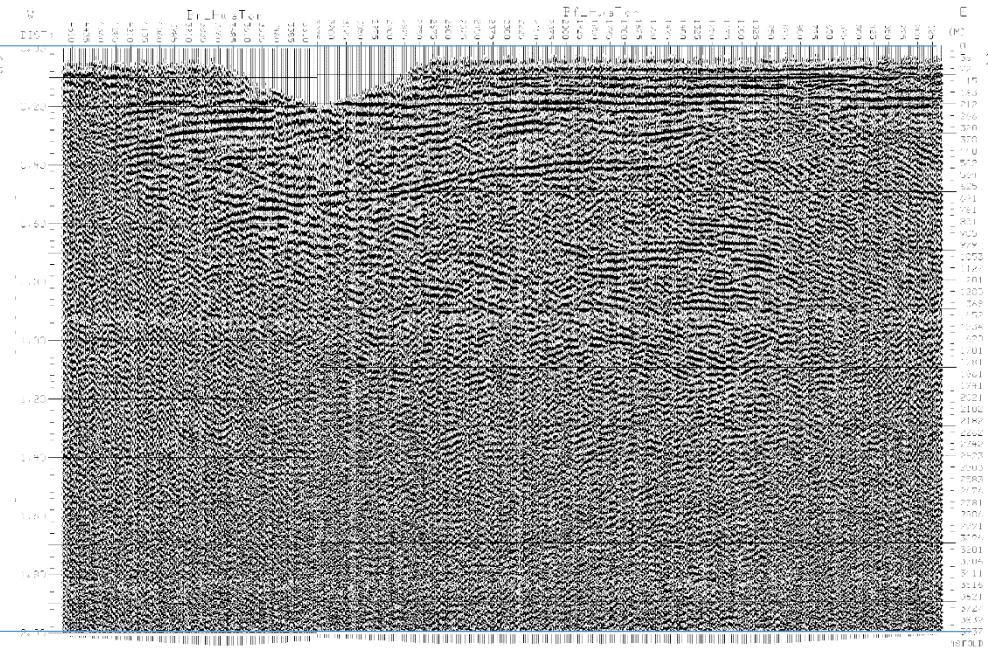
馬太鞍溪(光復)

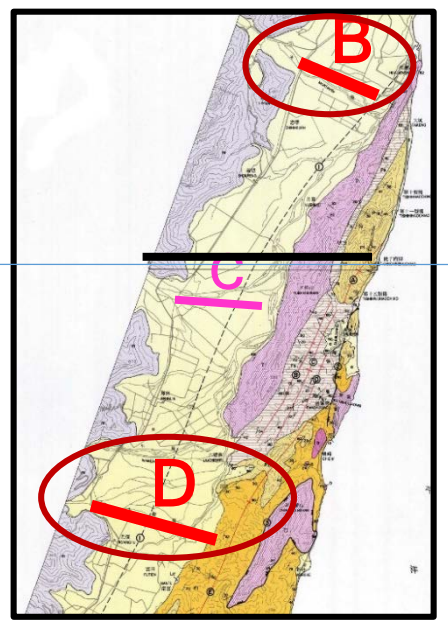
D final



木瓜溪(東華)

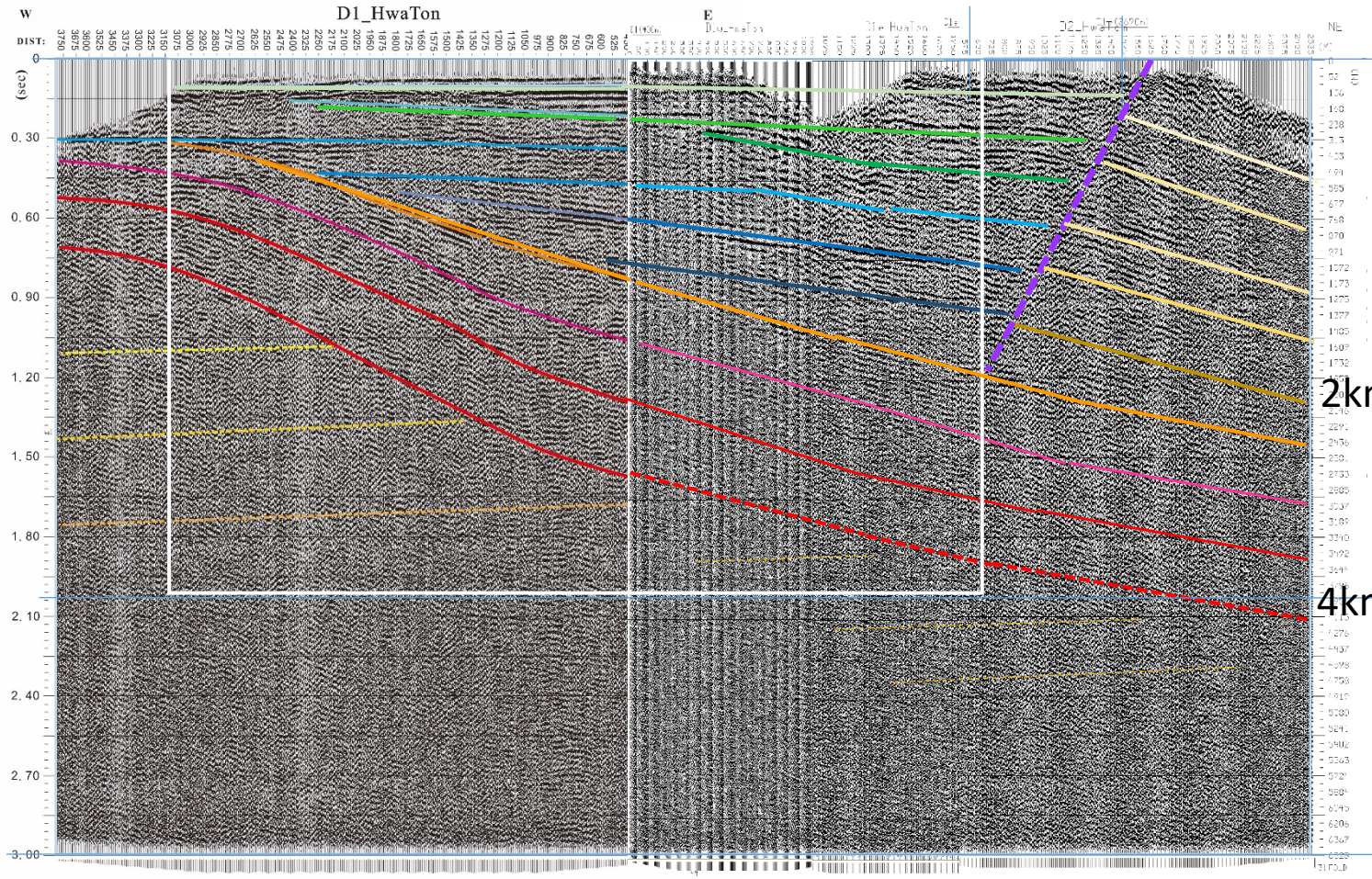
B final





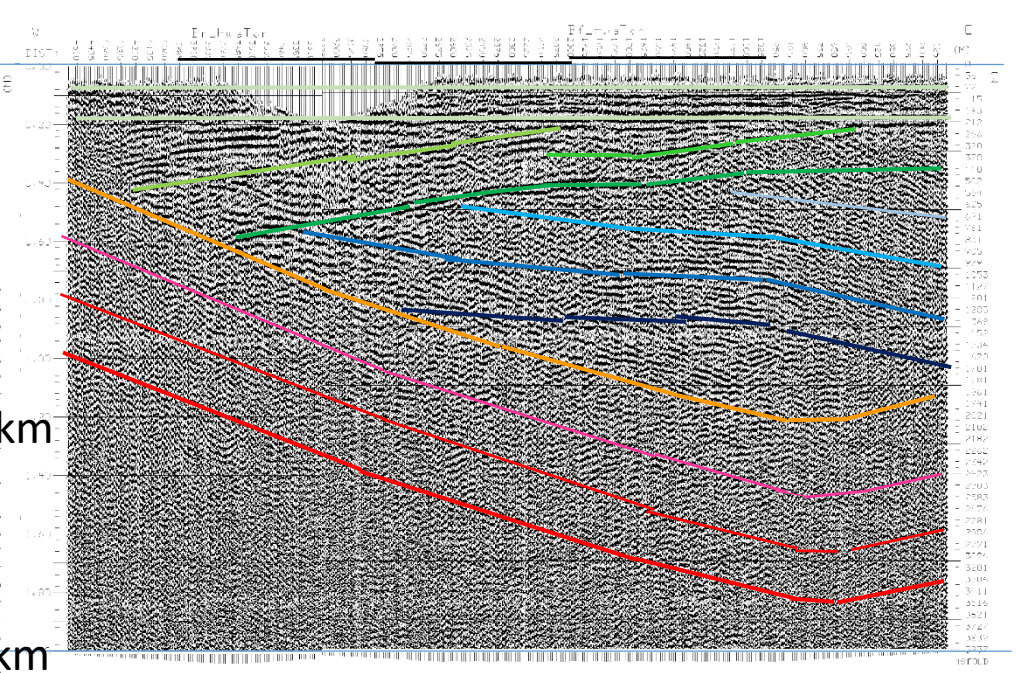
馬太鞍溪(光復)

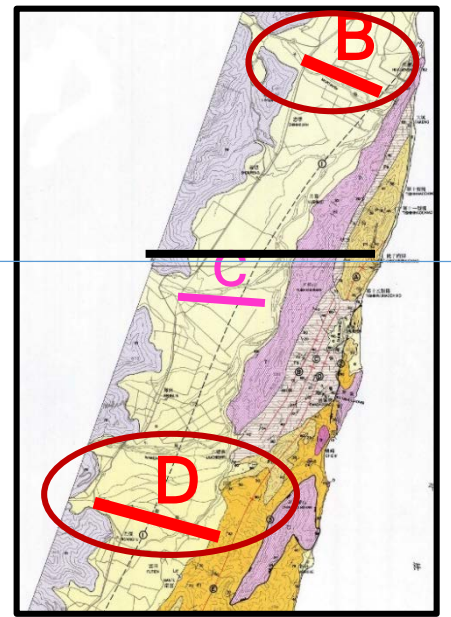
D final



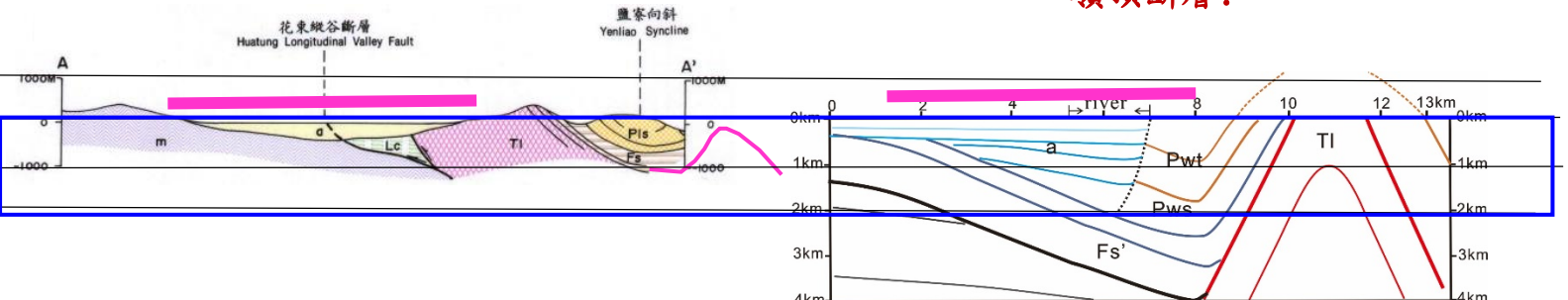
木瓜溪(東華)

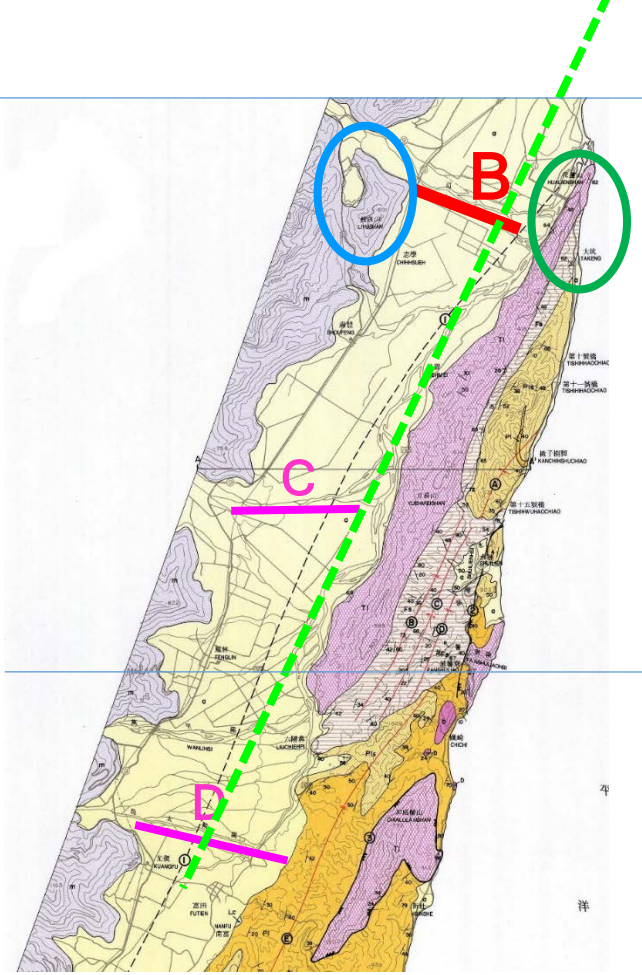
B final

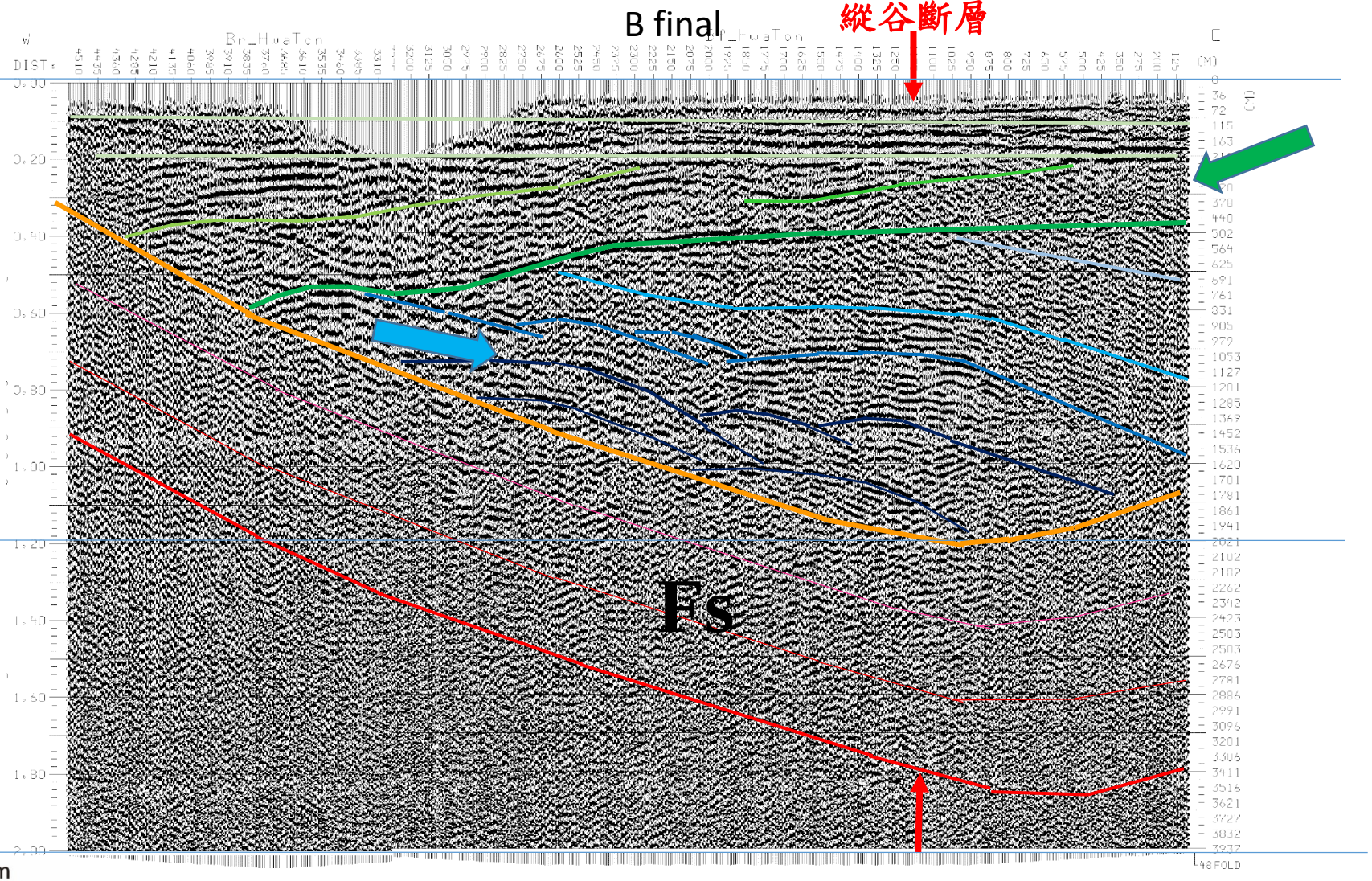


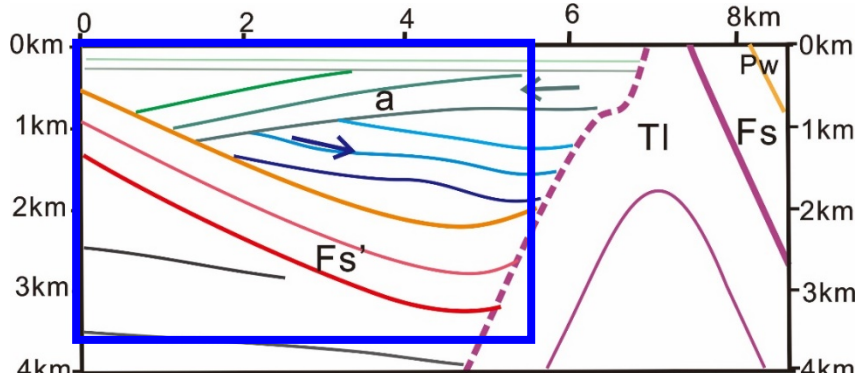


嶺頂斷層?







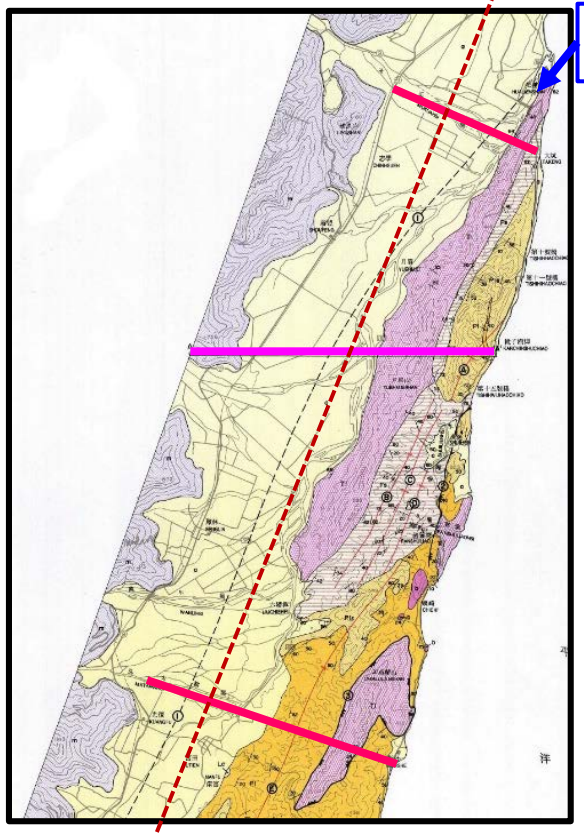


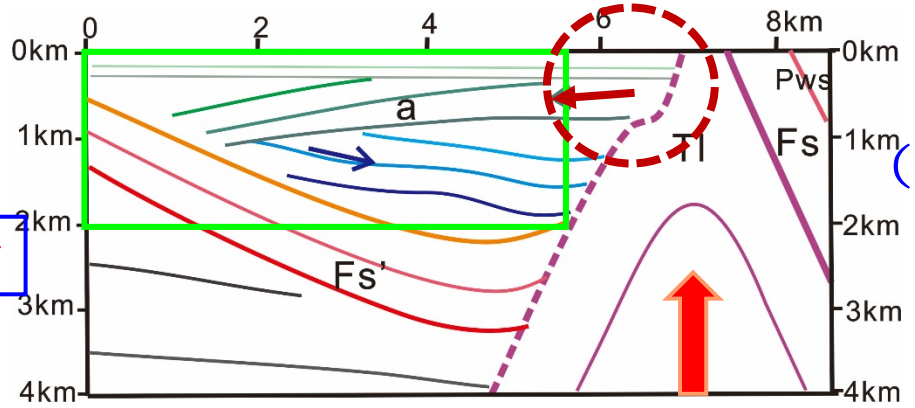
沖積層有三次沈積

淺部西傾的沖積層(綠色)顯示: 該層沉積時，東邊的海岸山脈是在附近，後來才東退。

縱谷斷層

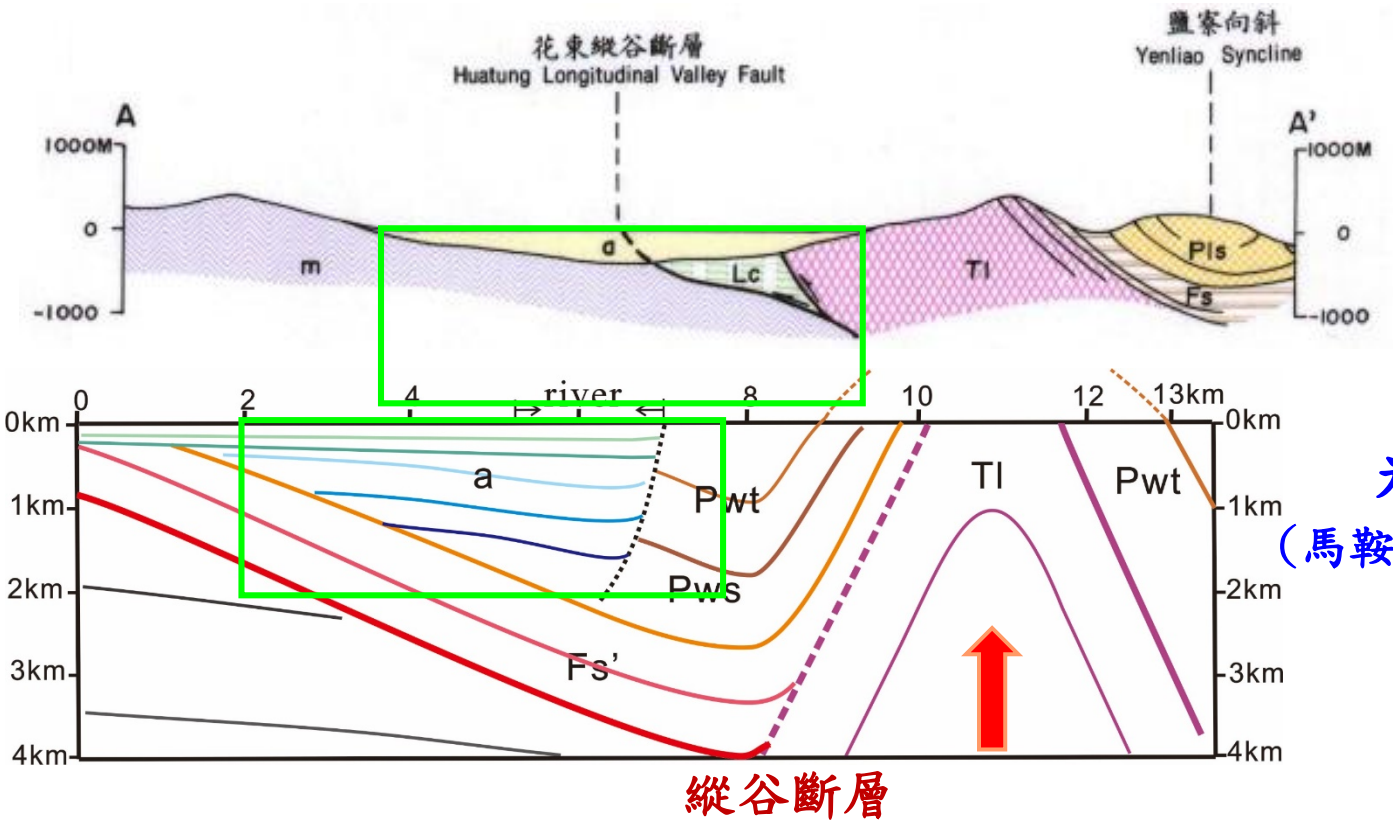
嶺頂斷層不存在





東華

(木瓜溪剖面B)

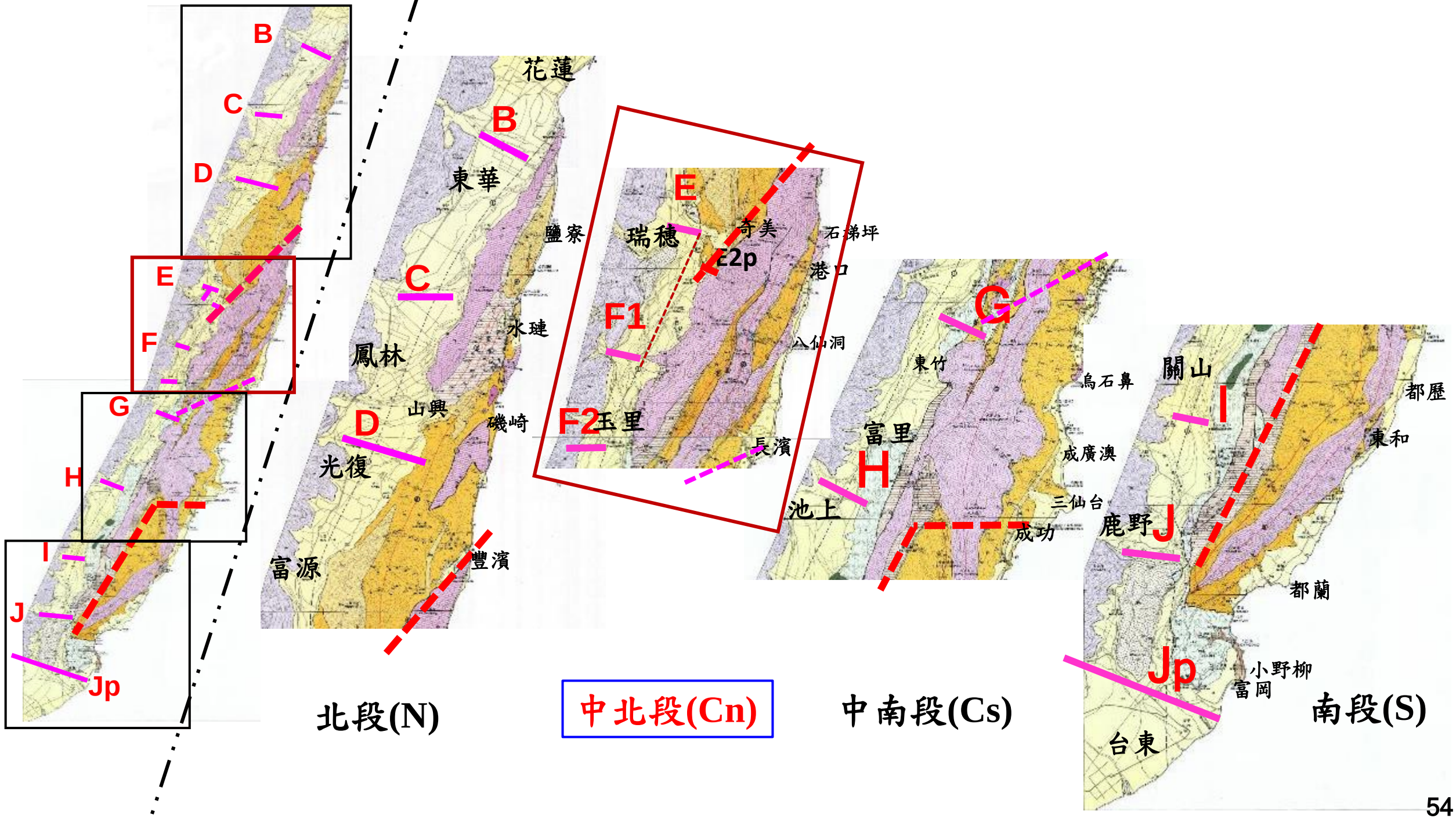


光復

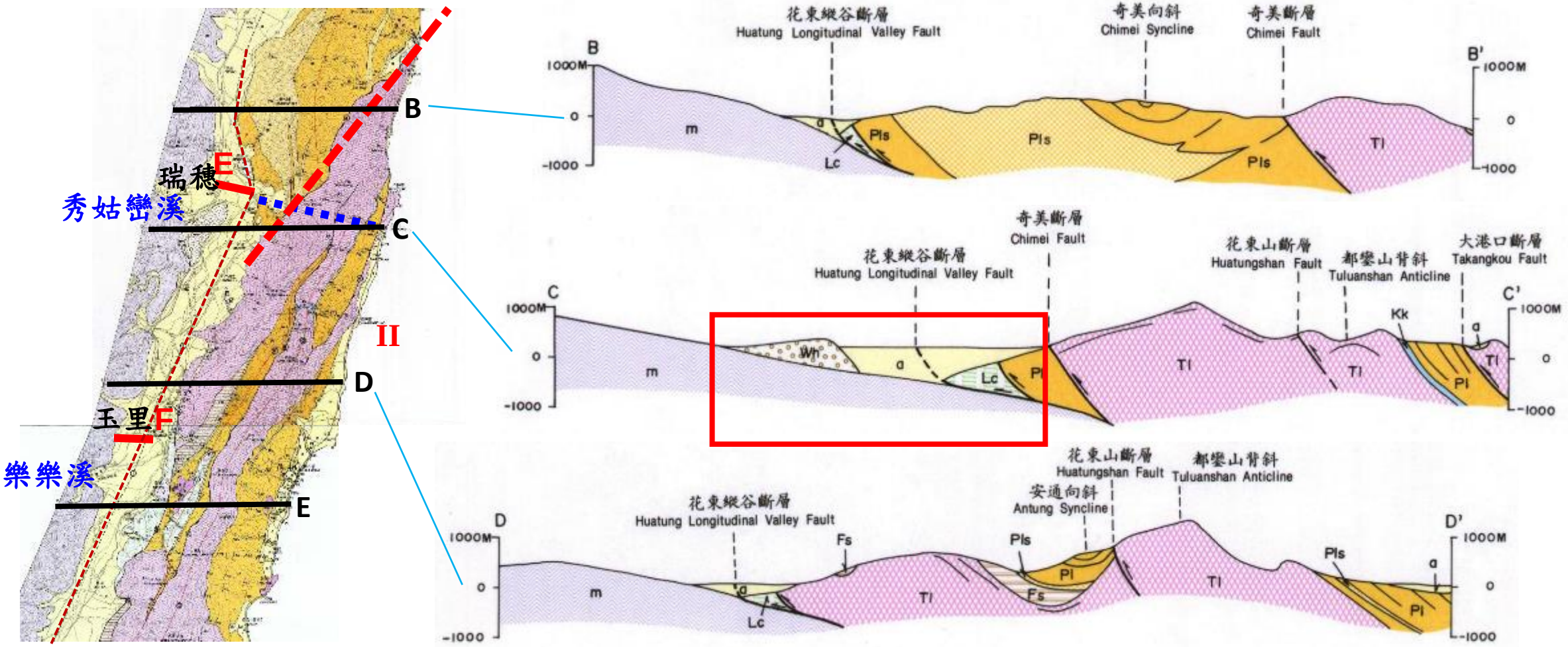
(馬鞍溪剖面D)

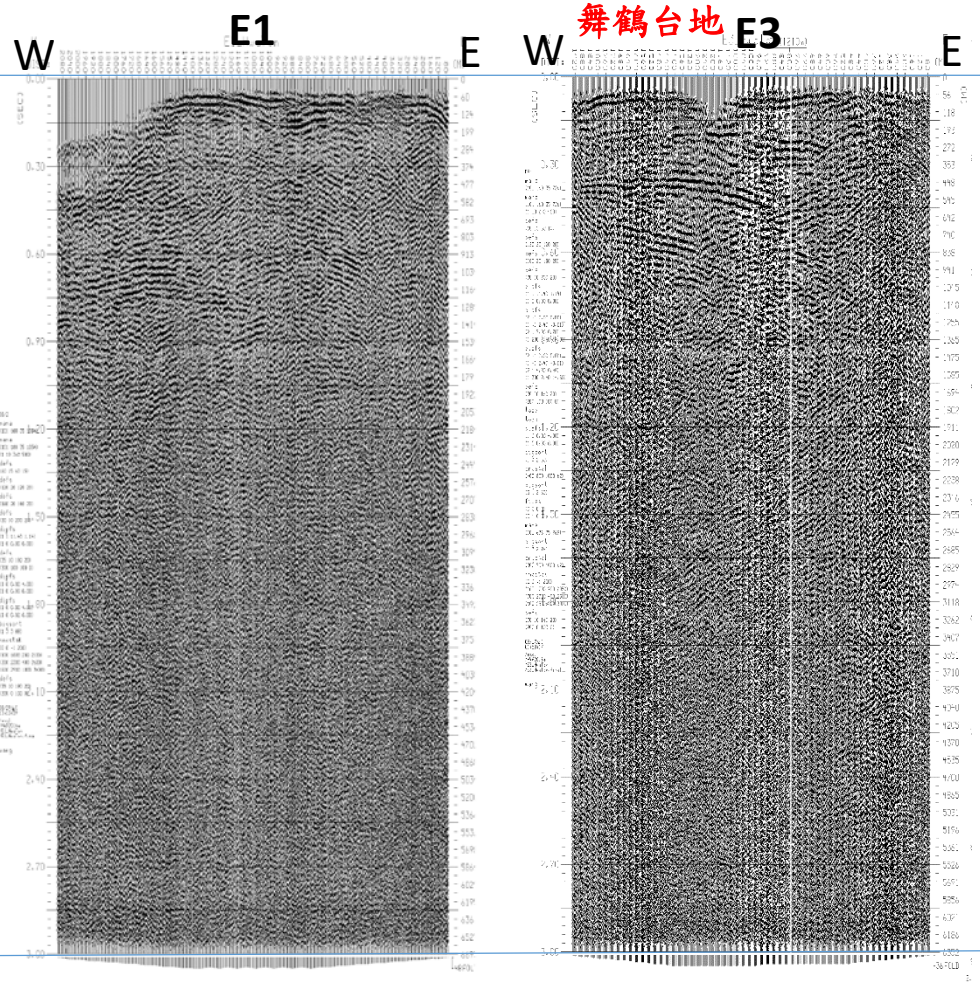
縱谷斷層

1. 海岸山脈與造山運動
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面(Cn)
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面
6. 構造模型
7. 2018花蓮地震與米崙斷層
8. 結論

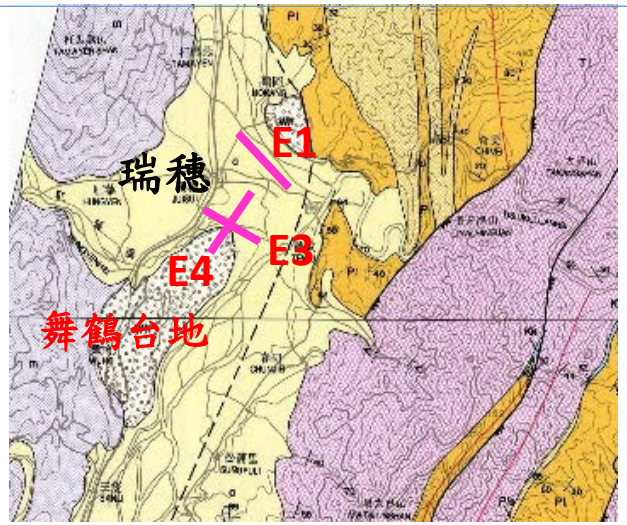

B
C
D
E
F
G
H
I
J
Jp
花蓮
東華
鹽寮
鳳林
山興
磯崎
光復
富源
豐濱
水璉
瑞穗
奇美
石梯坪
港口
八仙洞
玉里
長濱
富里
東竹
烏石鼻
池上
成廣澳
三仙台
成功
關山
都歷
東和
鹿野
都蘭
小野柳
富岡
台東
北段(N)
中北段(Cn)
中南段(Cs)
南段(S)

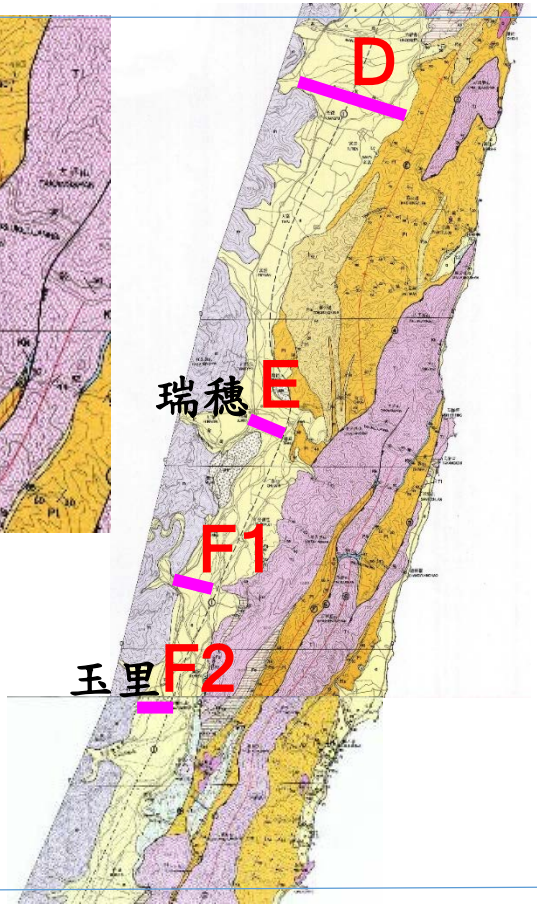
縱谷中北段(Cn) 推測地質剖面(Geology Profile)

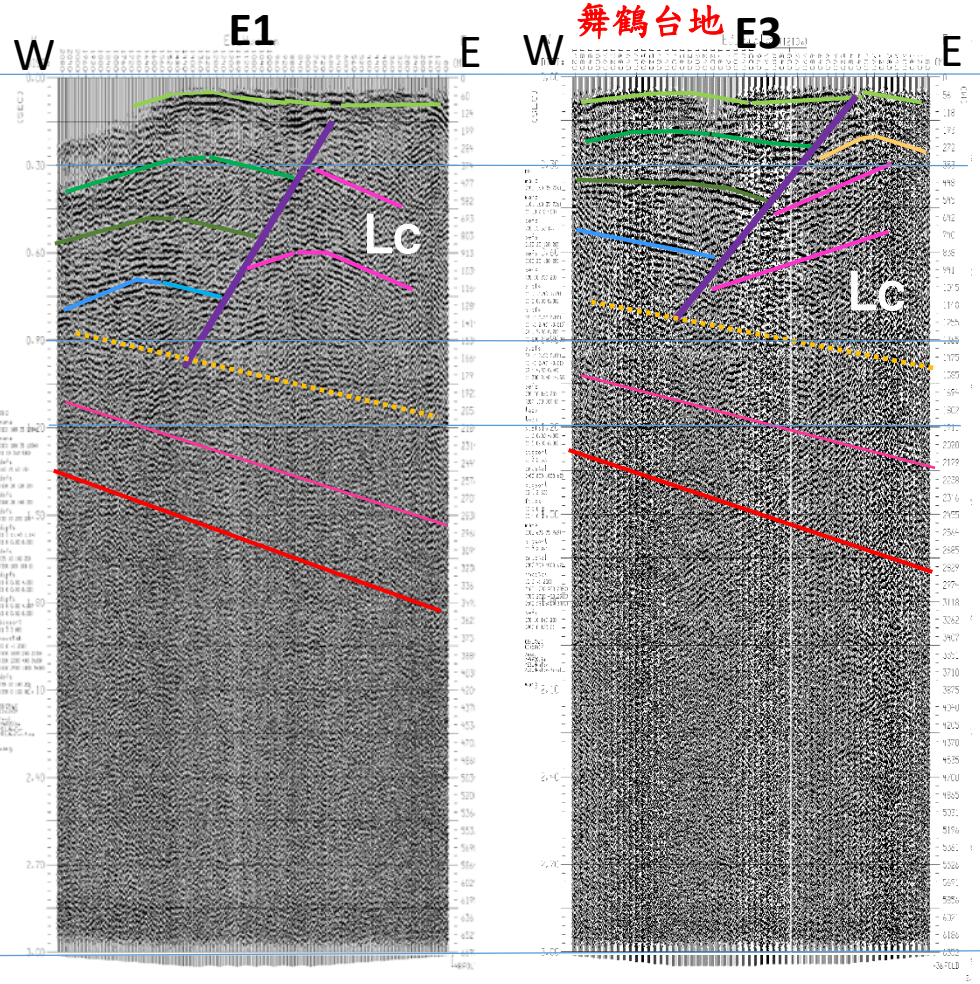




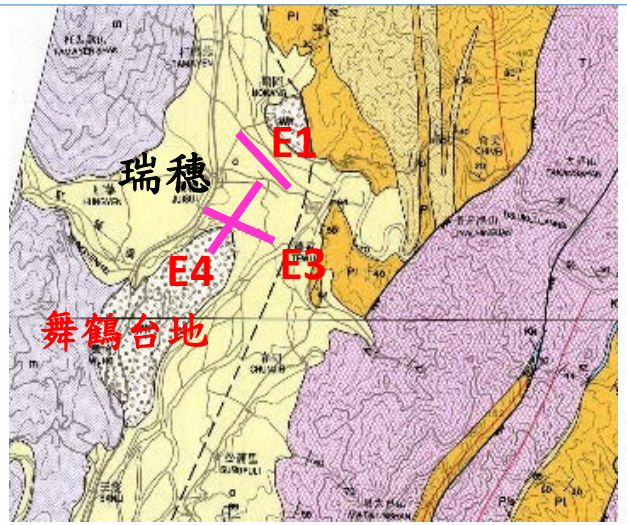
富源溪(瑞穗)

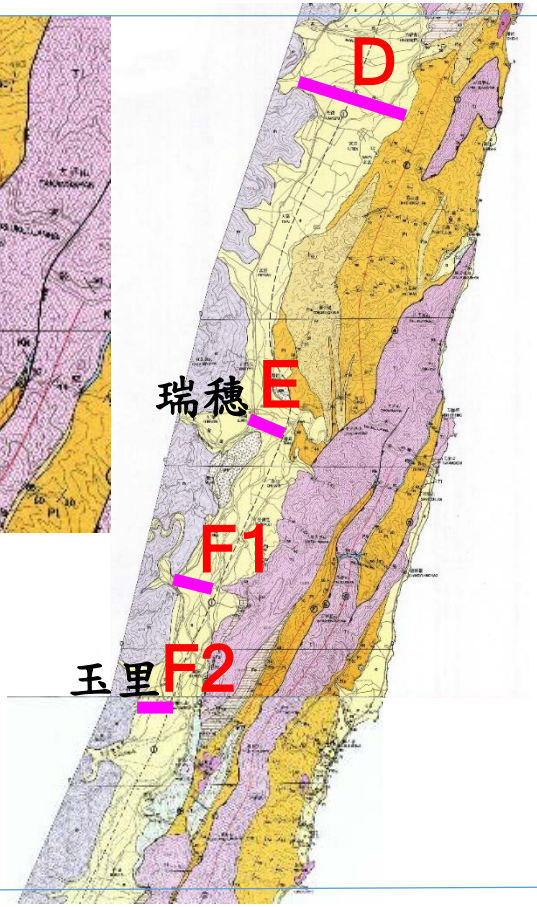


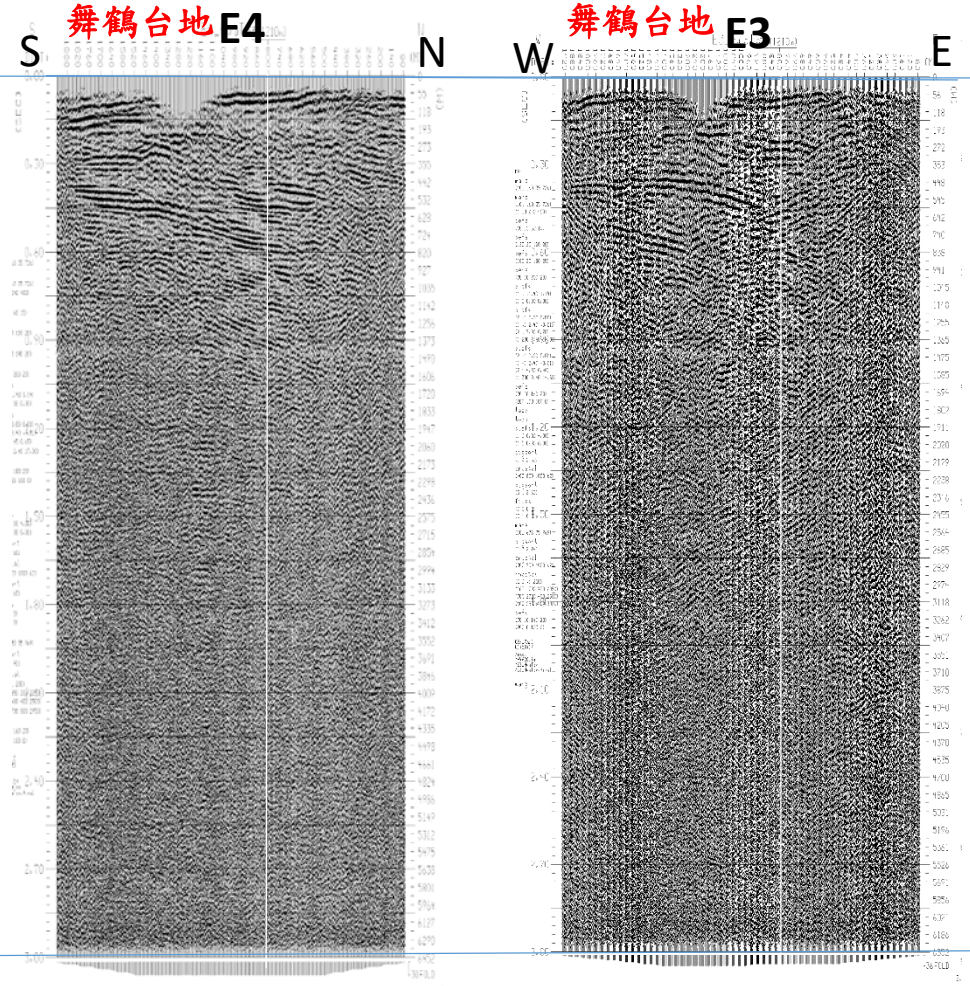




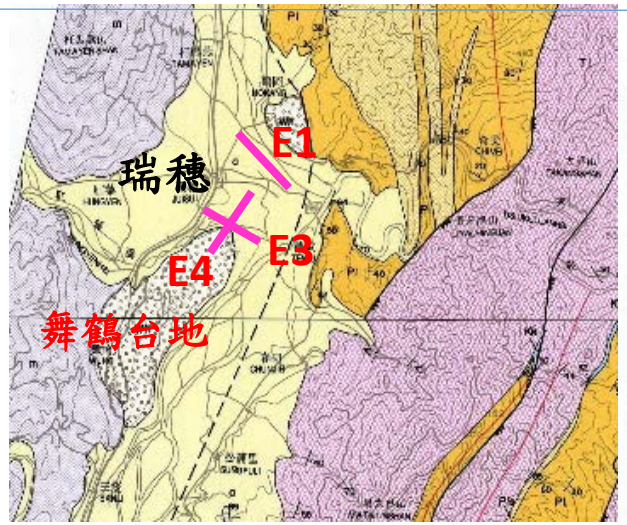
富源溪(瑞穗)

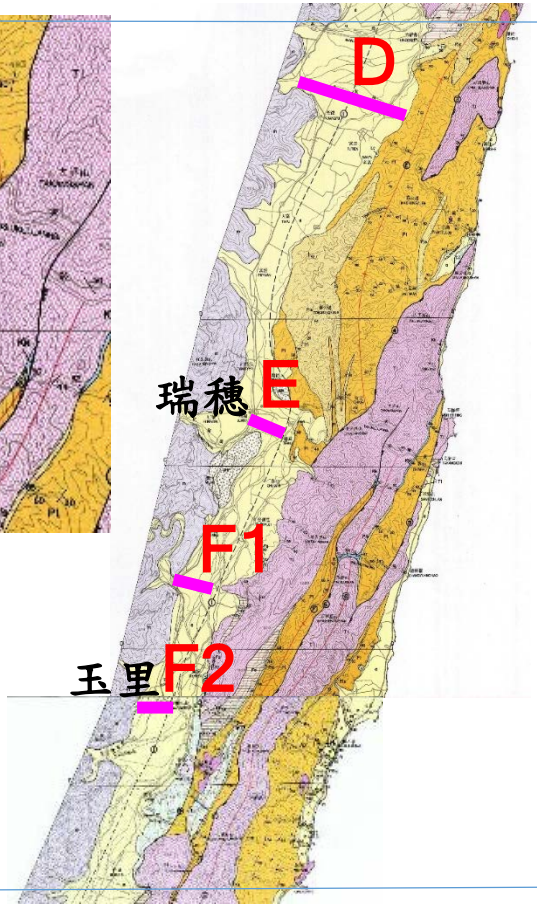


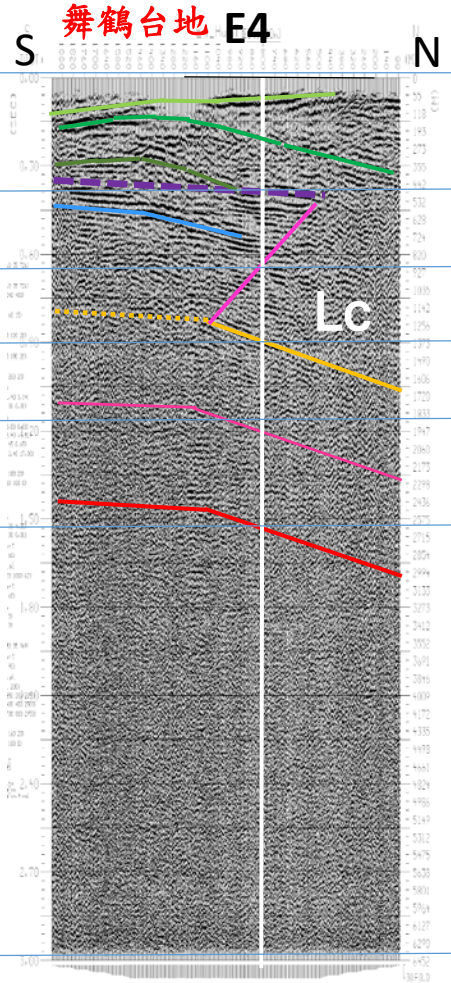


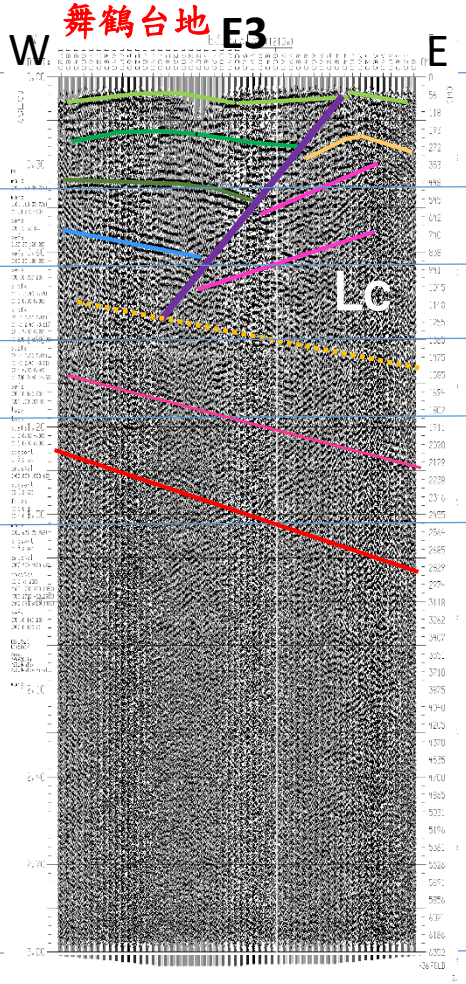


富源溪(瑞穗)

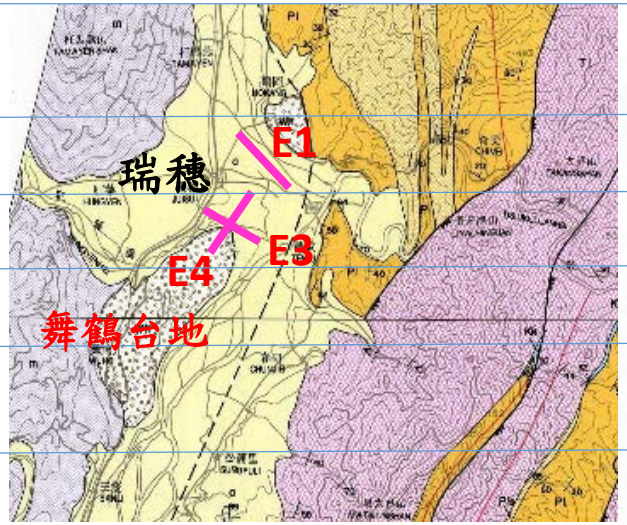


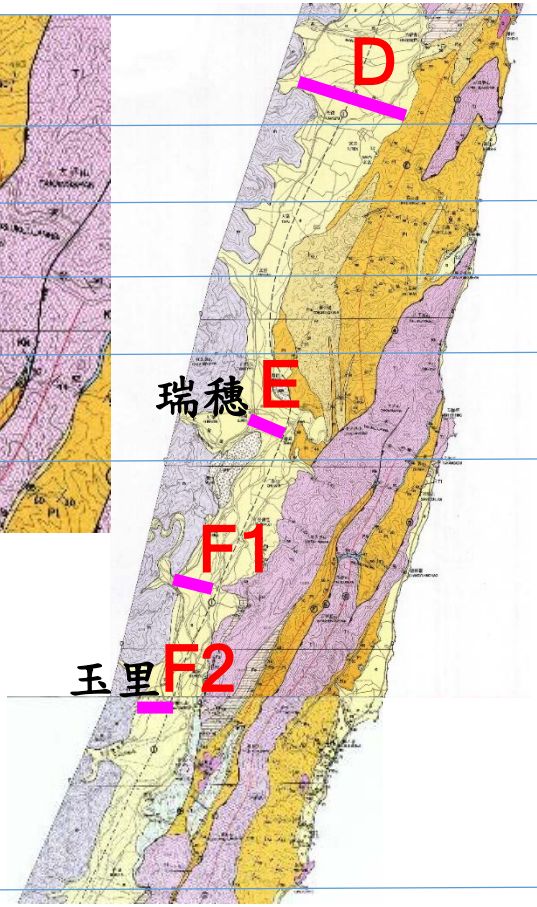




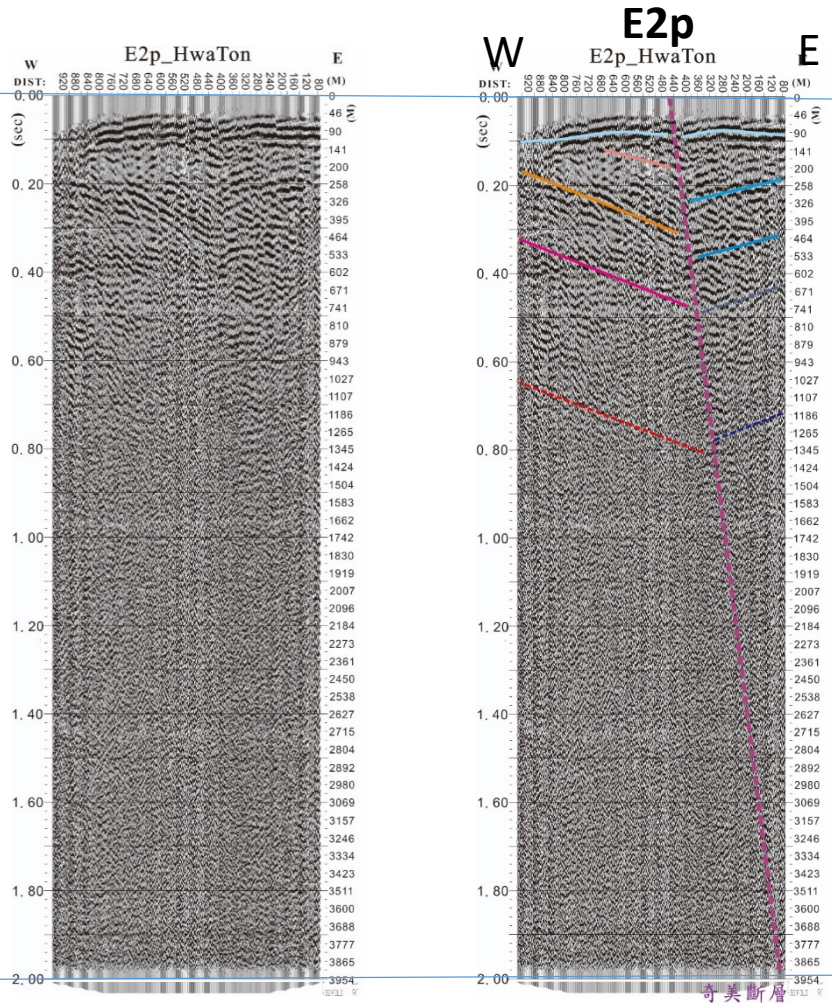


富源溪(瑞穗)

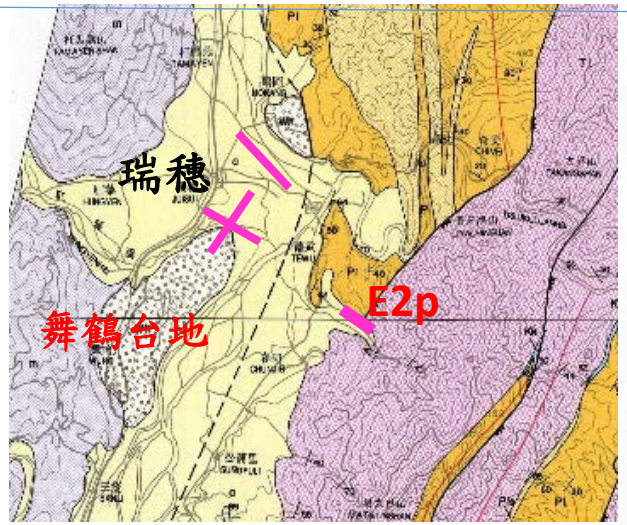


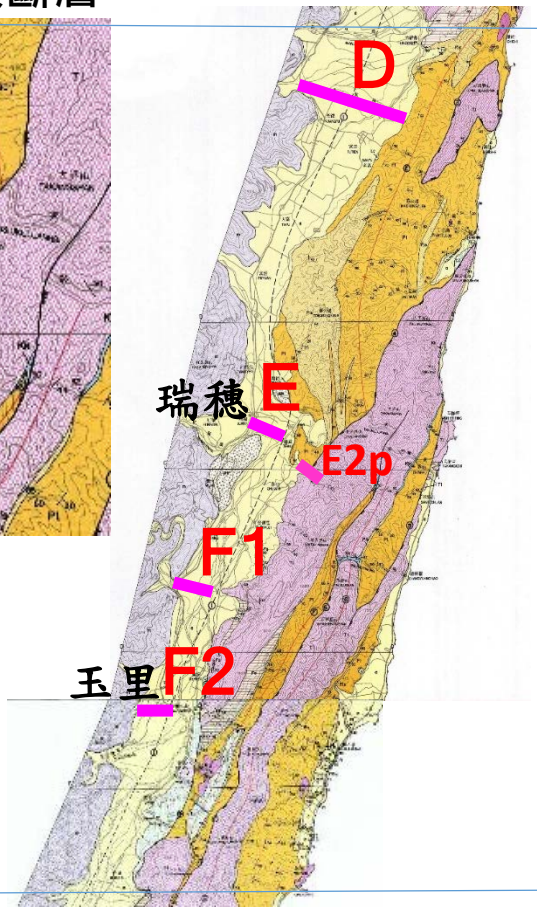


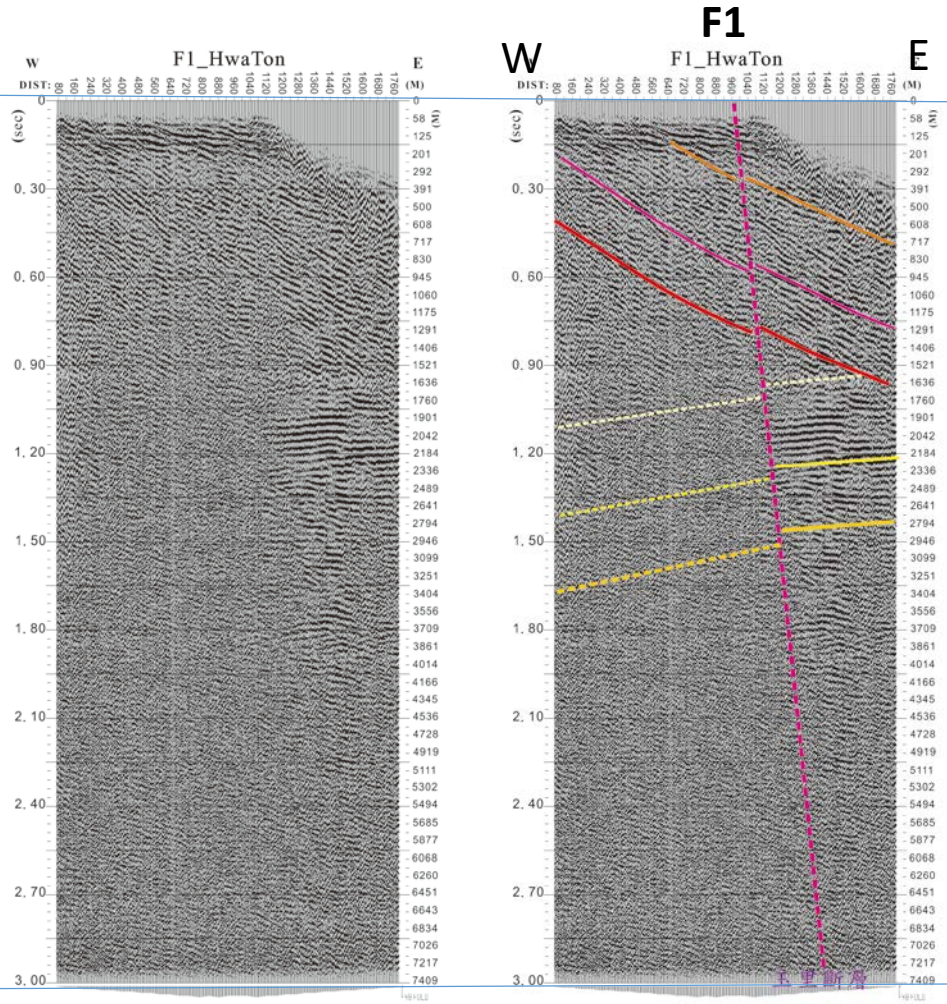
奇美斷層

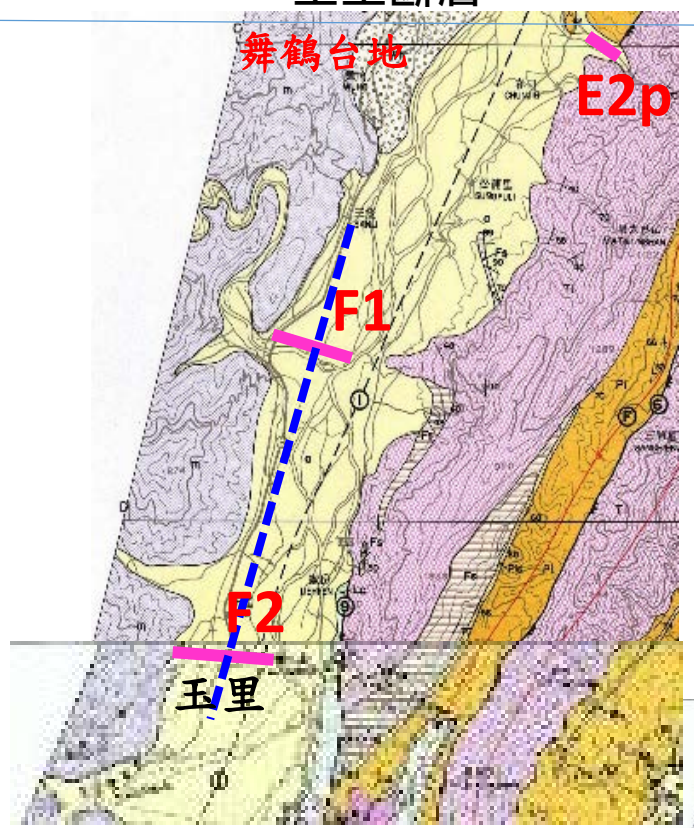


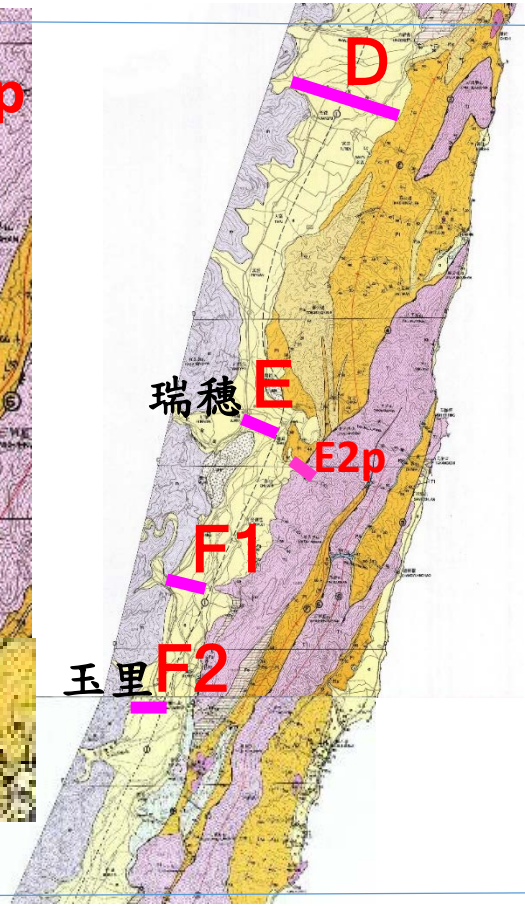
奇美斷層

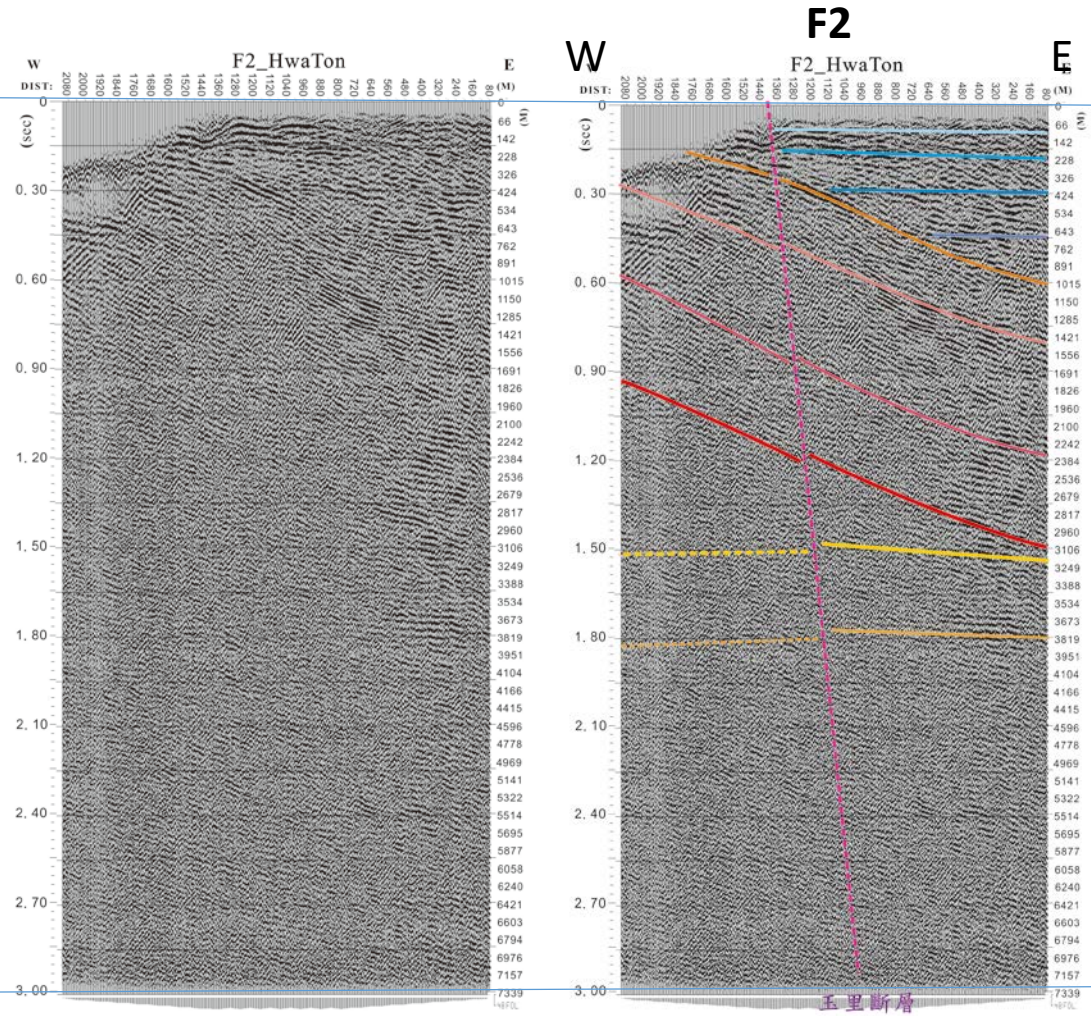


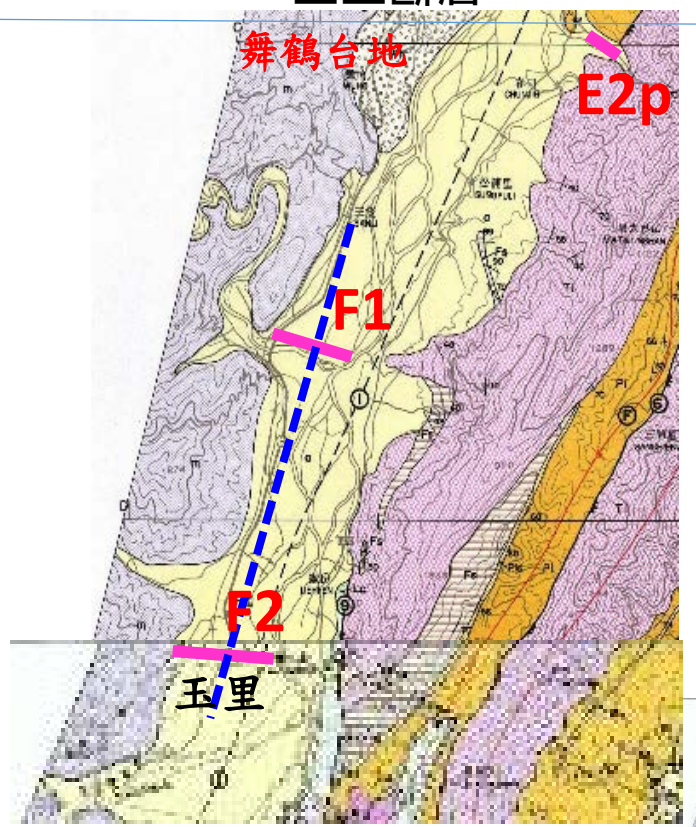


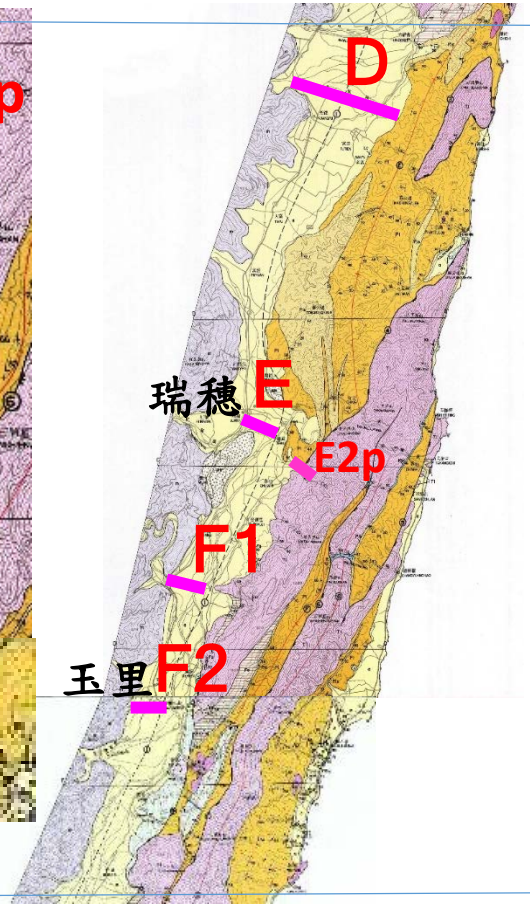

F1
W
F1_HwaTon
E
DIST:
(SEC)
(M)
玉里斷層

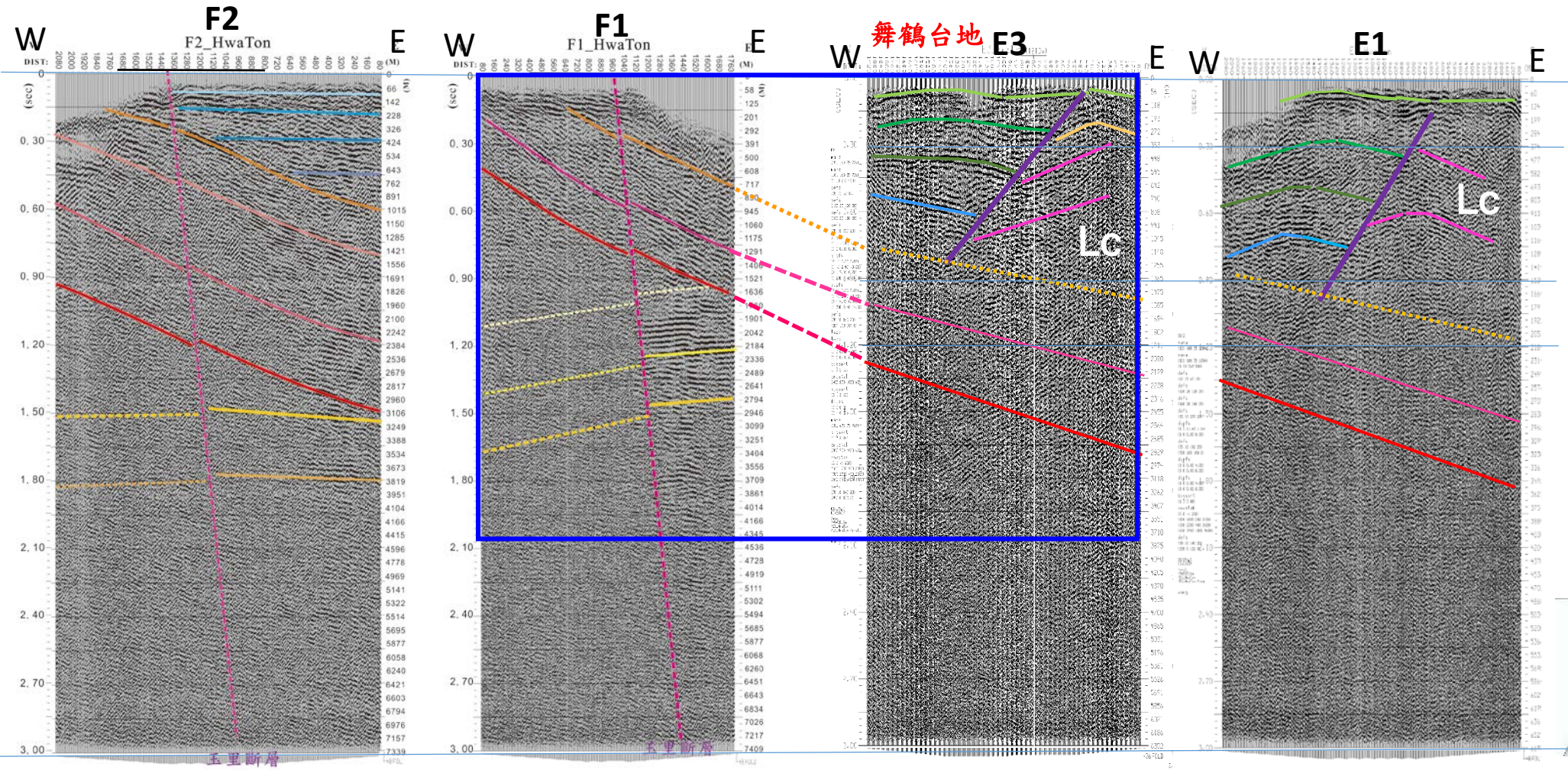

玉里斷層
舞鶴台地
E2p
F1
F2
玉里

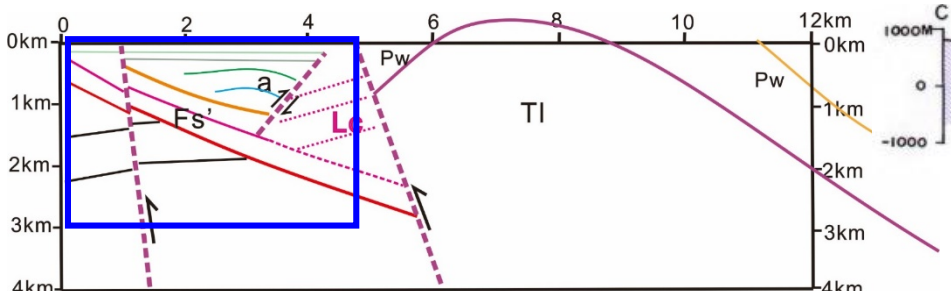

D
瑞穗
E
E2p
F1
玉里
F2

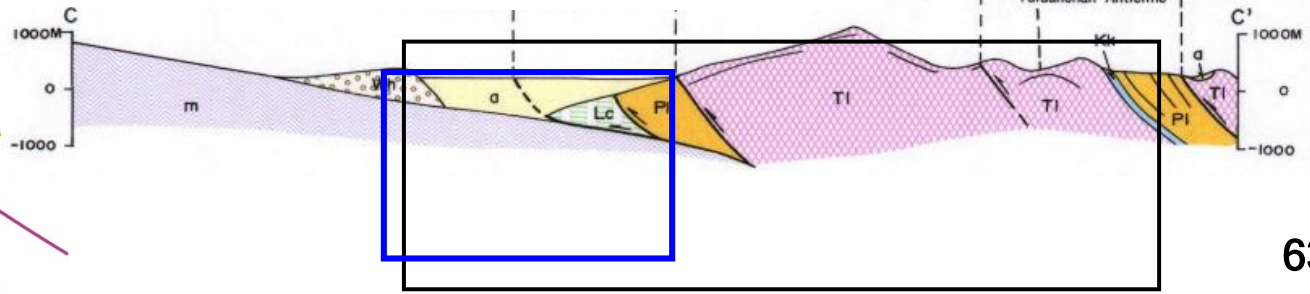

F2
W
E
F2_HwaTon
F2_HwaTon
玉里斷層


玉里斷層
舞鶴台地
E2p
F1
F2
玉里

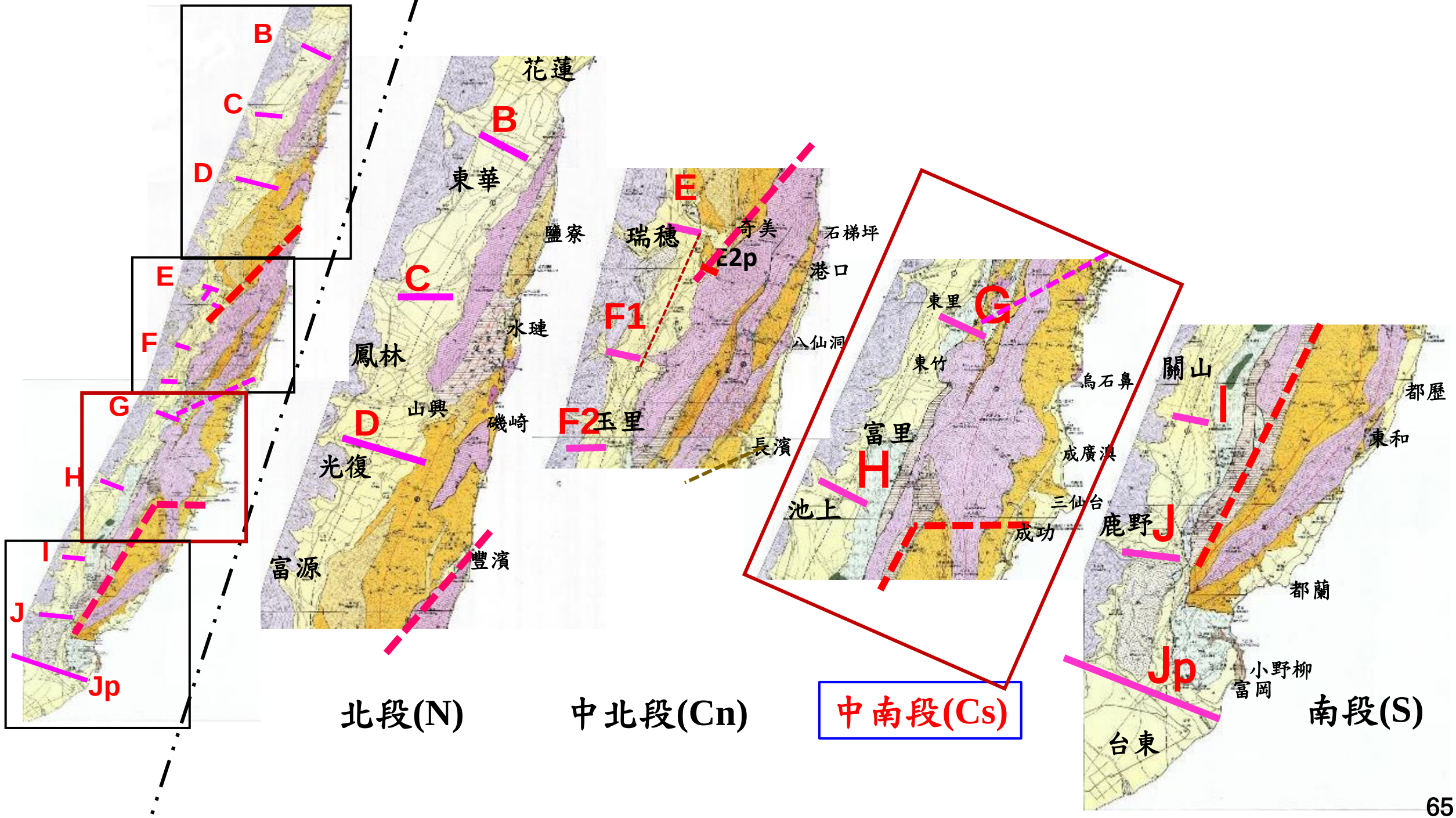

D
瑞穗
E
E2p
F1
玉里
F2


F2
F2_HwaTon
W
E
F1
F1_HwaTon
舞鶴台地
E3
Lc
E1
玉里斷層
D
瑞穗
E
F2p
F1
玉里
F2
花東山斷層
Huatungshan Fault
鹿鑾山背斜
Tuluanshan Anticline
大港口斷層
Takangkou Fault

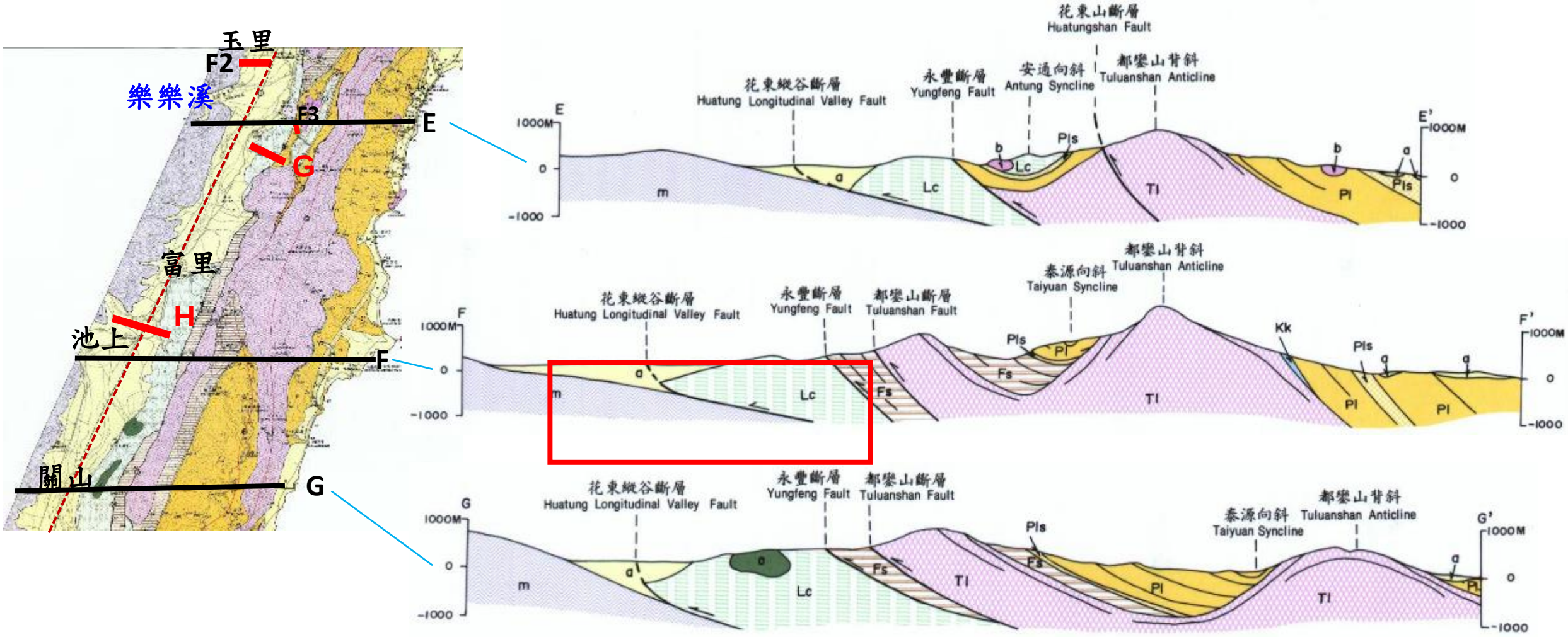

0km
1km
2km
3km
4km
Pw
Fs'
Lc
TI

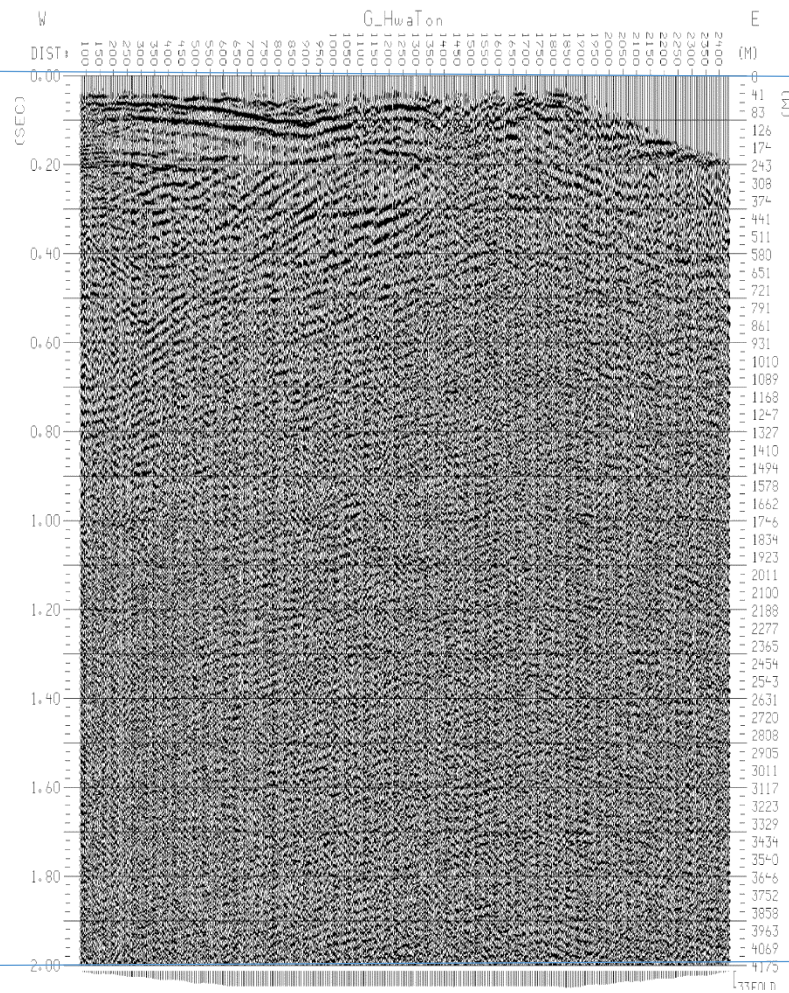

C
C'
1000M
0
-1000
m
a
Lc
Pl
TI
Kk

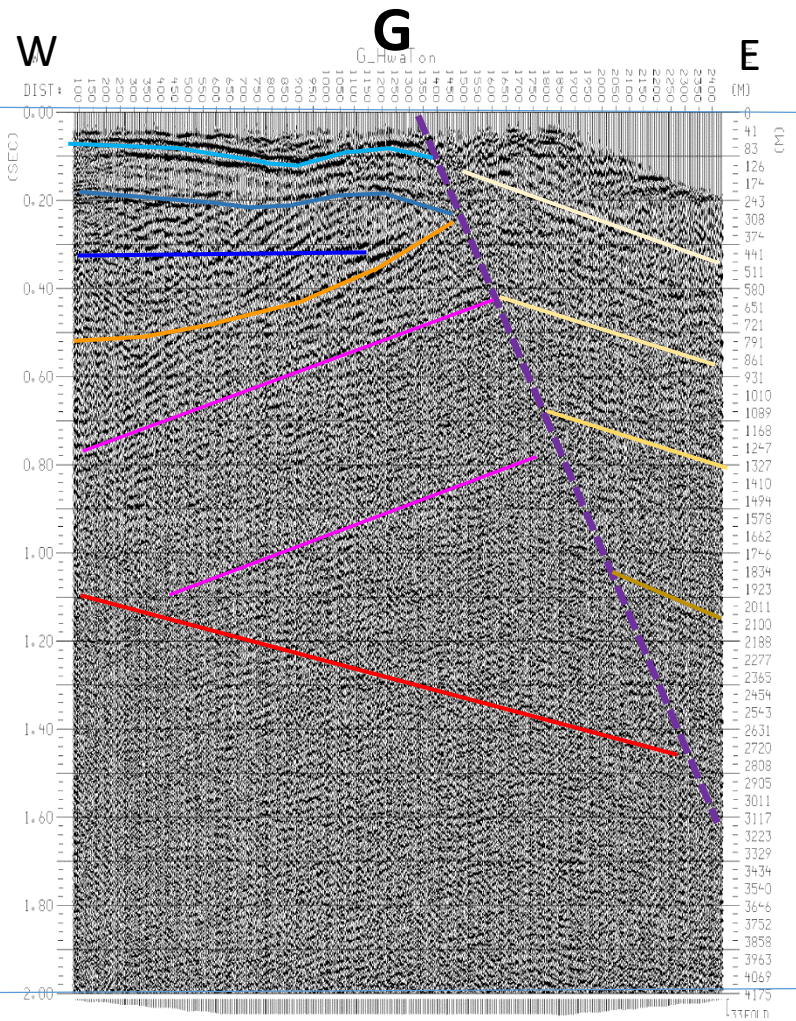
1. 海岸山脈與造山運動
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面(Cs)
5. 縱谷南段震測剖面
6. 構造模型
7. 2018花蓮地震與米崙斷層
8. 結論

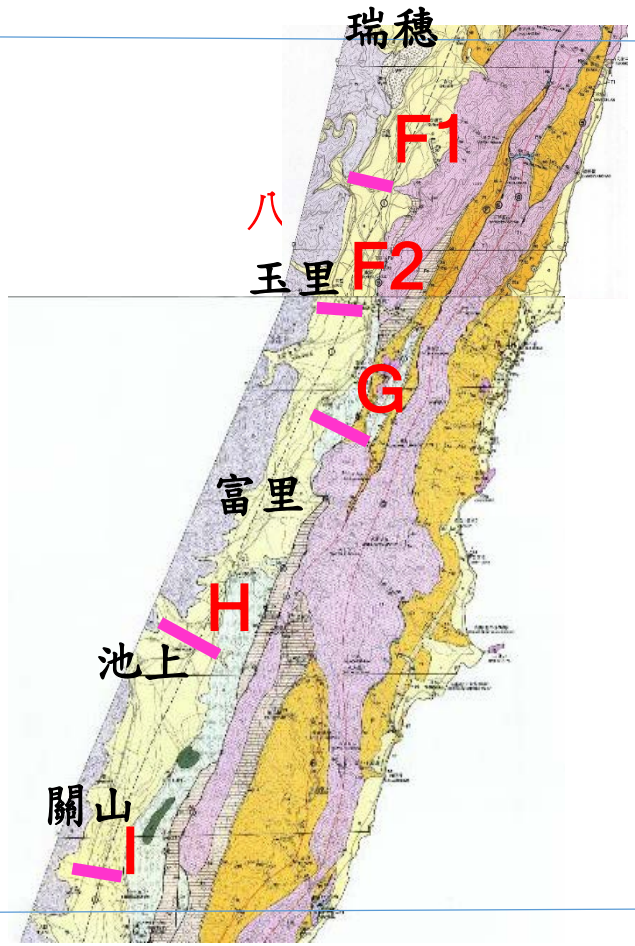

B
C
D
E
F
G
H
I
J
Jp
花蓮
東華
鹽寮
鳳林
水璉
山興
磯崎
光復
富源
豐濱
瑞穗
奇美
石梯坪
港口
八仙洞
F1
F2
玉里
長濱
東里
東竹
烏石鼻
富里
池上
成廣澳
三仙台
成功
關山
都歷
東和
鹿野
都蘭
小野柳
富岡
台東
北段(N)
中北段(Cn)
中南段(Cs)
南段(S)

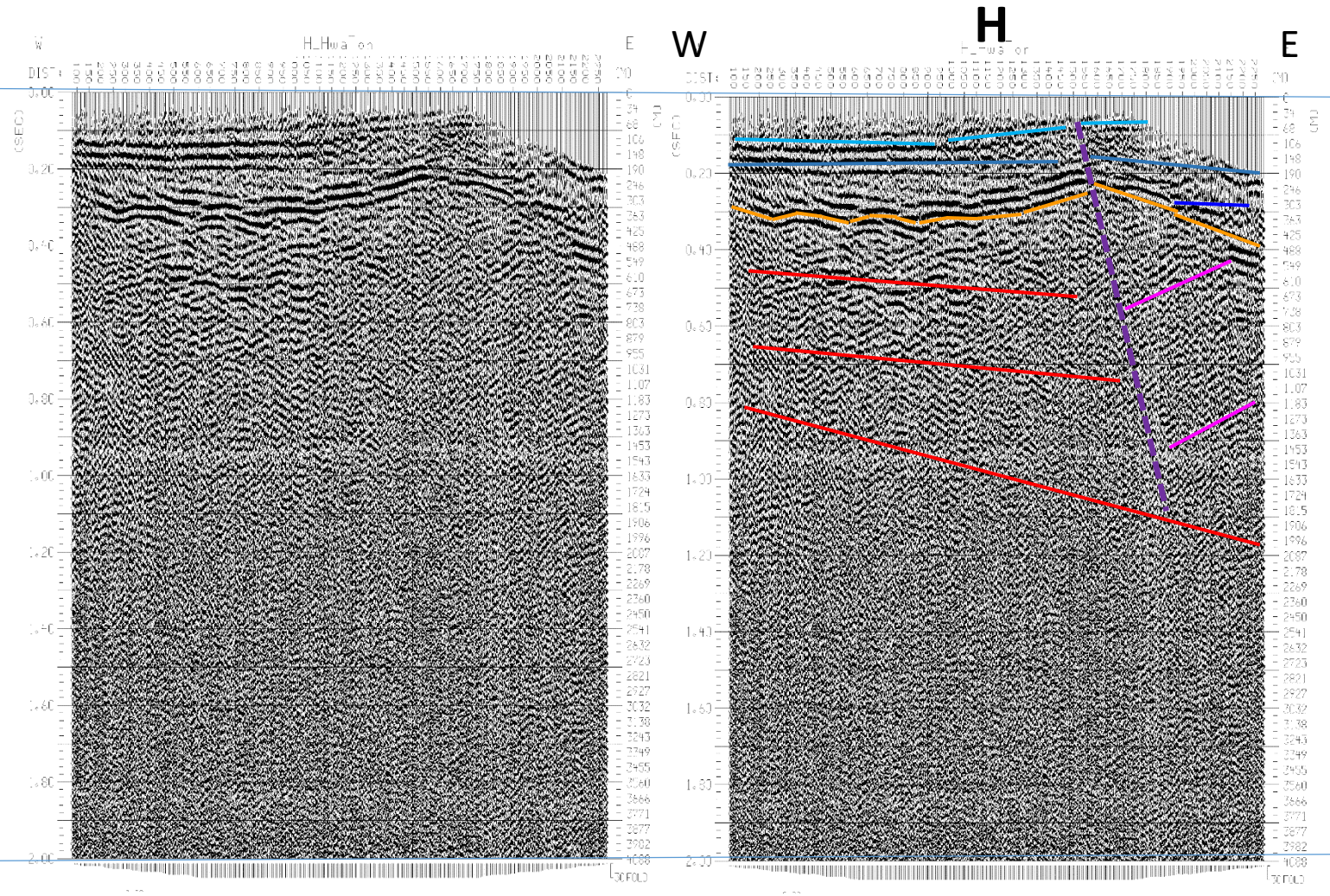
縱谷中南段(Cs) 推測地質剖面(Geology Profile)

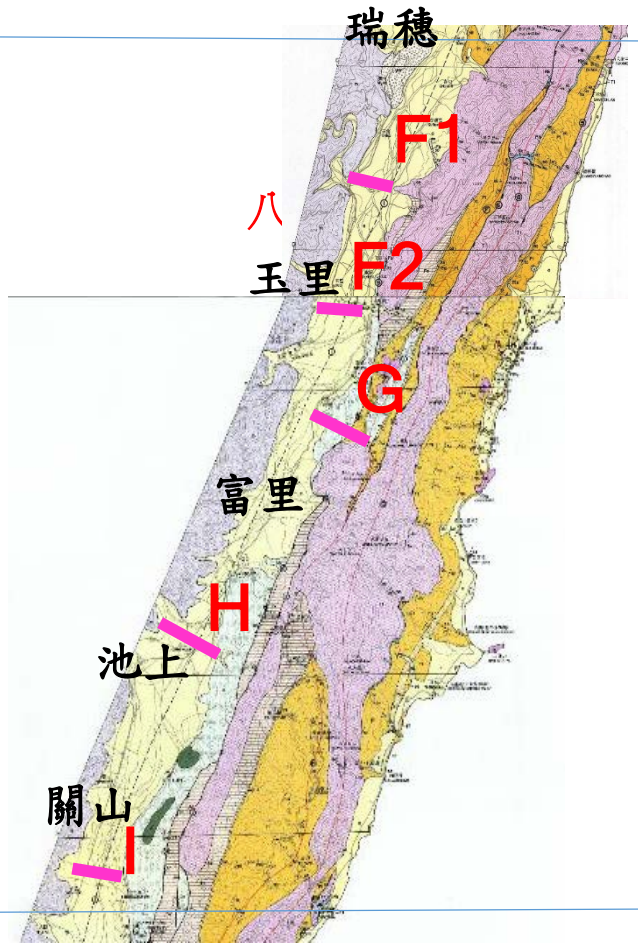


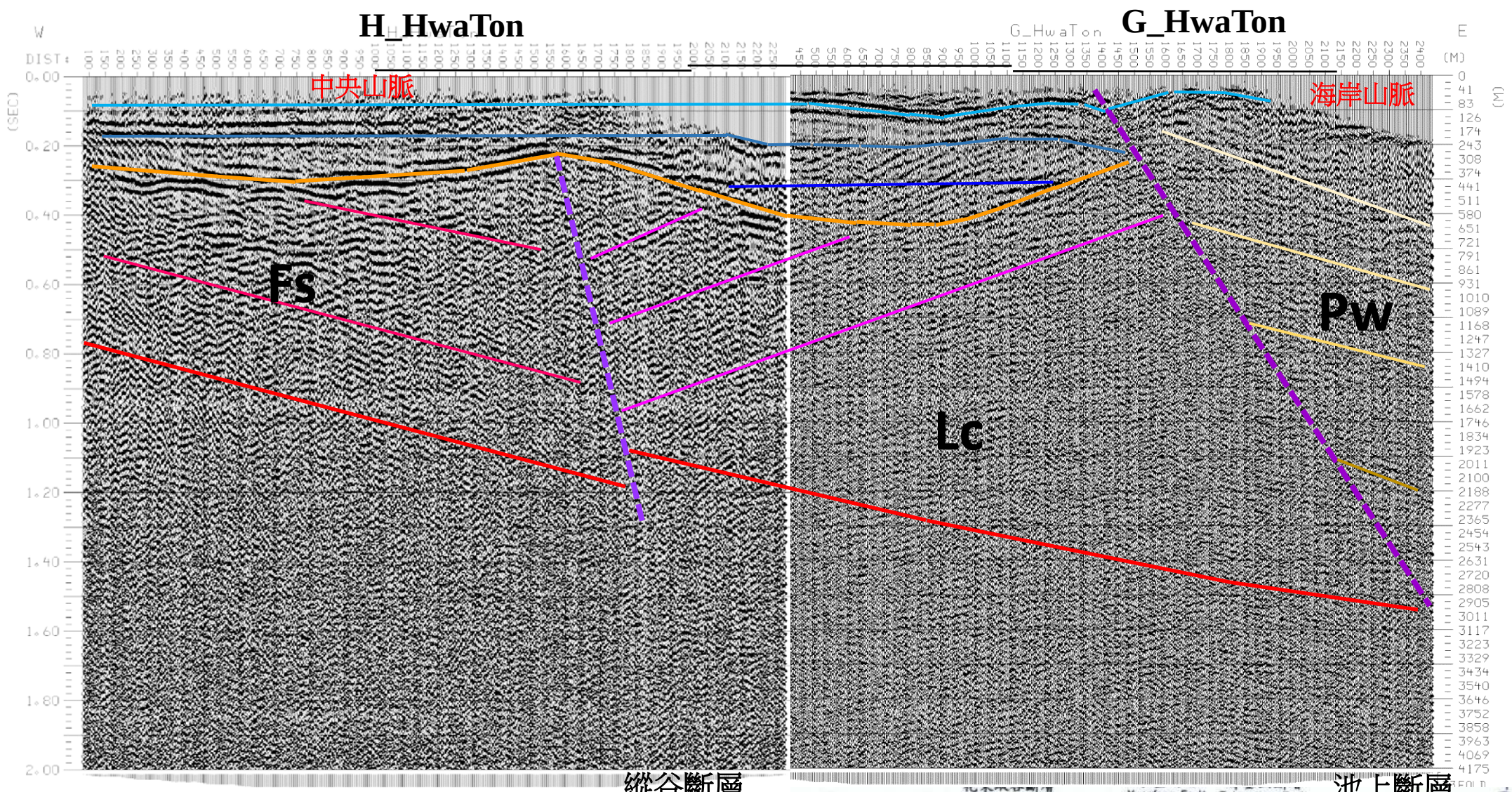

W
G_HwaTon
E
DIST:
(SEC)
(M)


G
W
G_Hwaton
E
DIST:
(SEC)
(M)

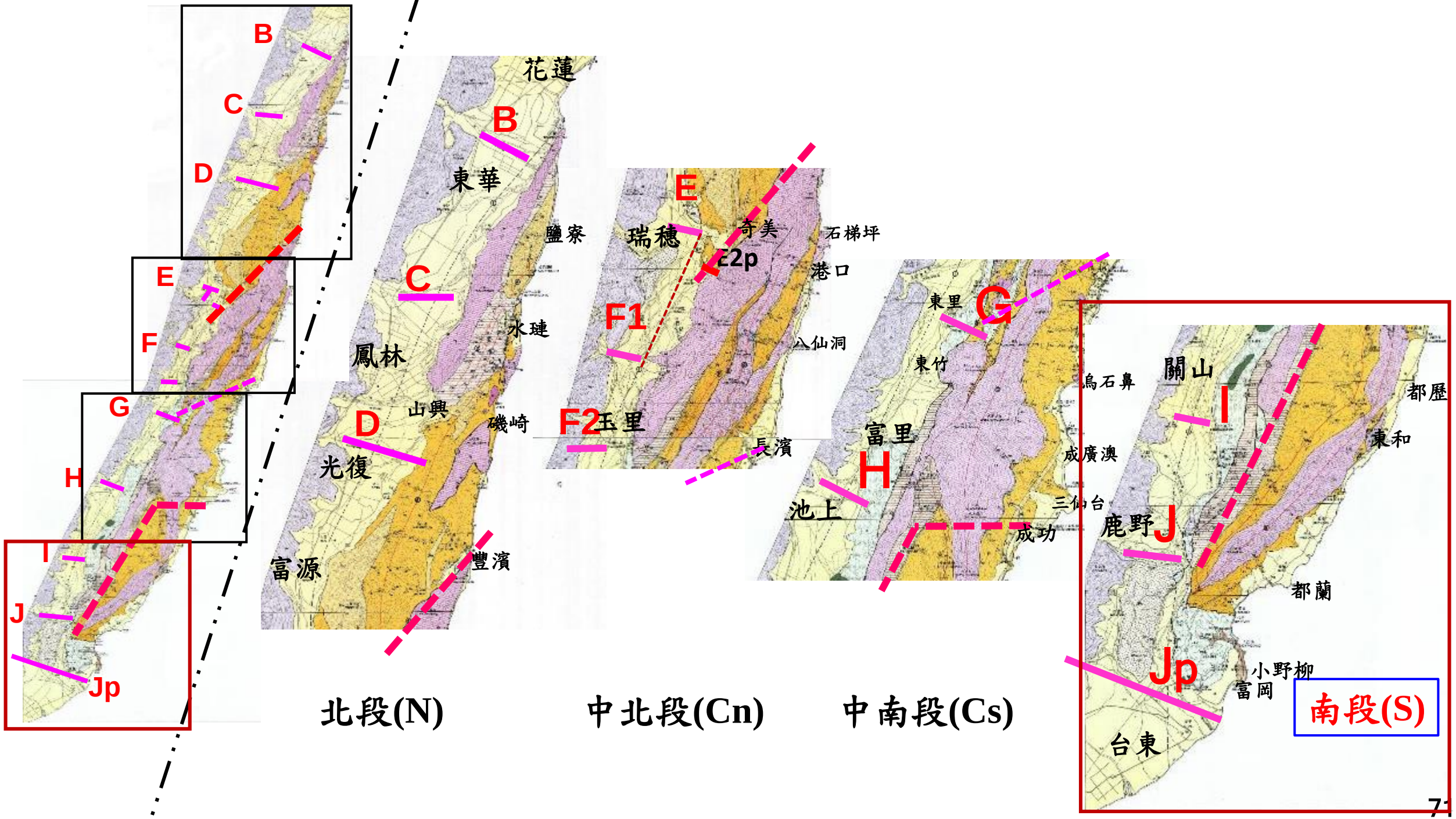

瑞穗
F1
八
玉里
F2
G
富里
H
池上
關山


W
H
E

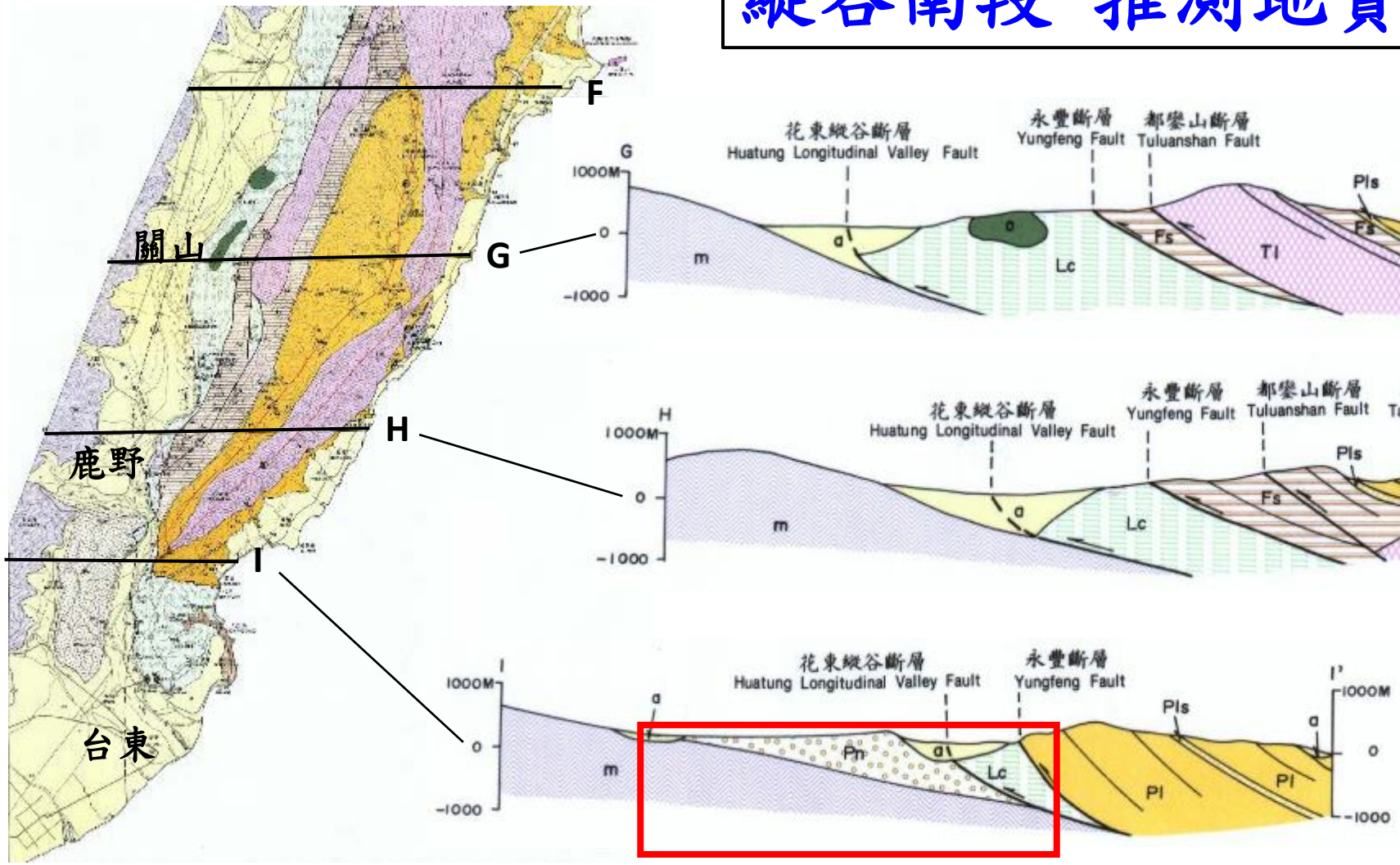

瑞穗
F1
八
玉里
F2
G
富里
H
池上
關山


H_HwaTon
G_HwaTon
中央山脈
海岸山脈
Fs
Lc
Pw
縱谷斷層
池上斷層
Fs'
a
Pw
Tl
Lc
Huatung Longitudinal Valley Fault
Yungfeng Fault
Tuluanshan Fault
m
Fs
Pl
Tl

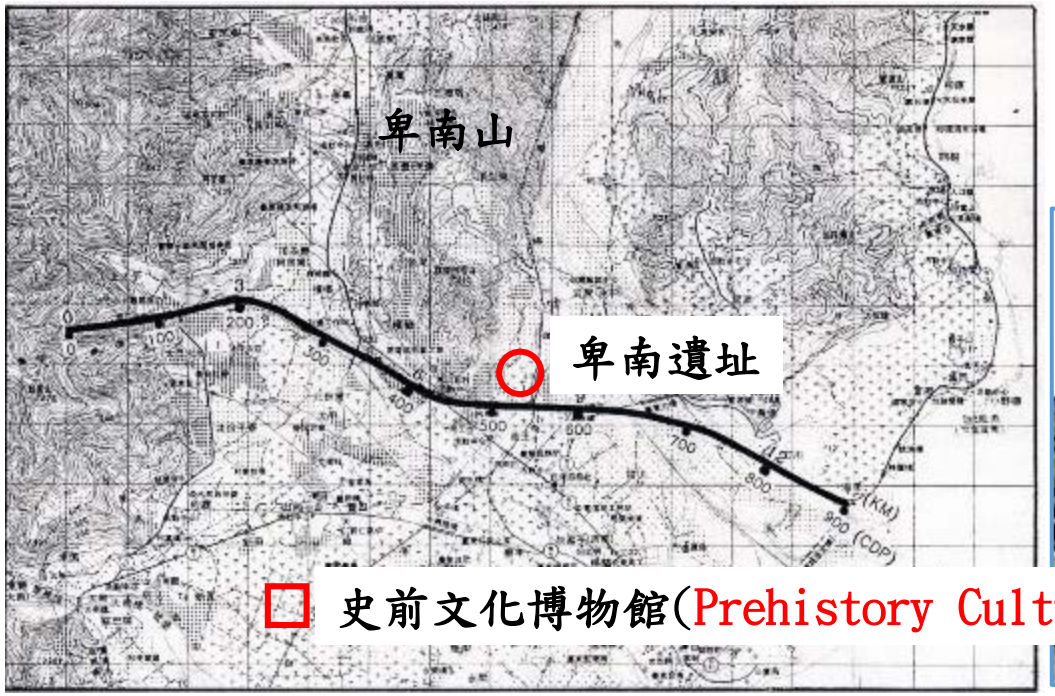
1. 海岸山脈與造山運動
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面(S)
6. 構造模型
7. 2018花蓮地震與米崙斷層
8. 結論


B
C
D
E
F
G
H
I
J
Jp
花蓮
東華
鹽寮
鳳林
水璉
山興
磯崎
光復
富源
豐濱
瑞穗
奇美
石梯坪
港口
八仙洞
長濱
玉里
富里
東里
東竹
池上
成功
三仙台
烏石鼻
關山
都歷
東和
成廣澳
鹿野
都蘭
小野柳
富岡
台東
北段(N)
中北段(Cn)
中南段(Cs)
南段(S)

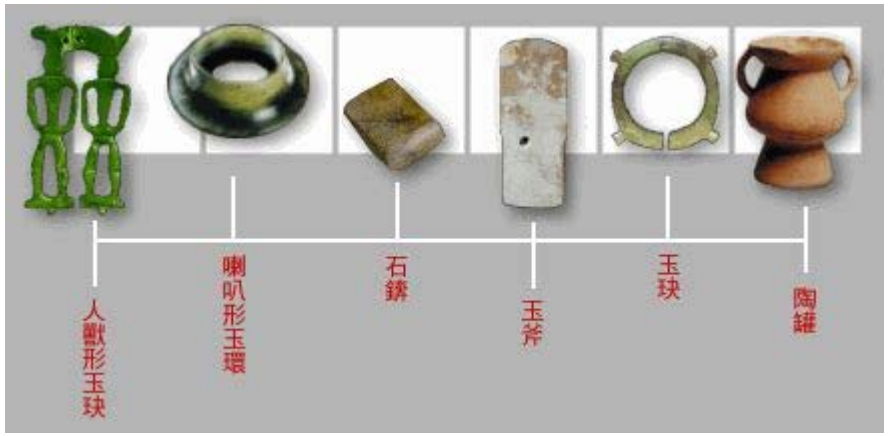
縱谷南段 推測地質剖面


F
G
H
I
關山
鹿野
台東
G
G'
H
H''
I
I'
1000M
0
-1000
花東縱谷斷層
Huatung Longitudinal Valley Fault
永豐斷層
Yungfeng Fault
都巒山斷層
Tuluanshan Fault
泰源向斜
Taiyuan Syncline
都巒山背斜
Tuluanshan Anticline
m
a
Lc
Fs
Pls
Pl
Tl
Pn

1990年 卑南山測線 (王執明教授委託中油執行，史前博物館計畫)

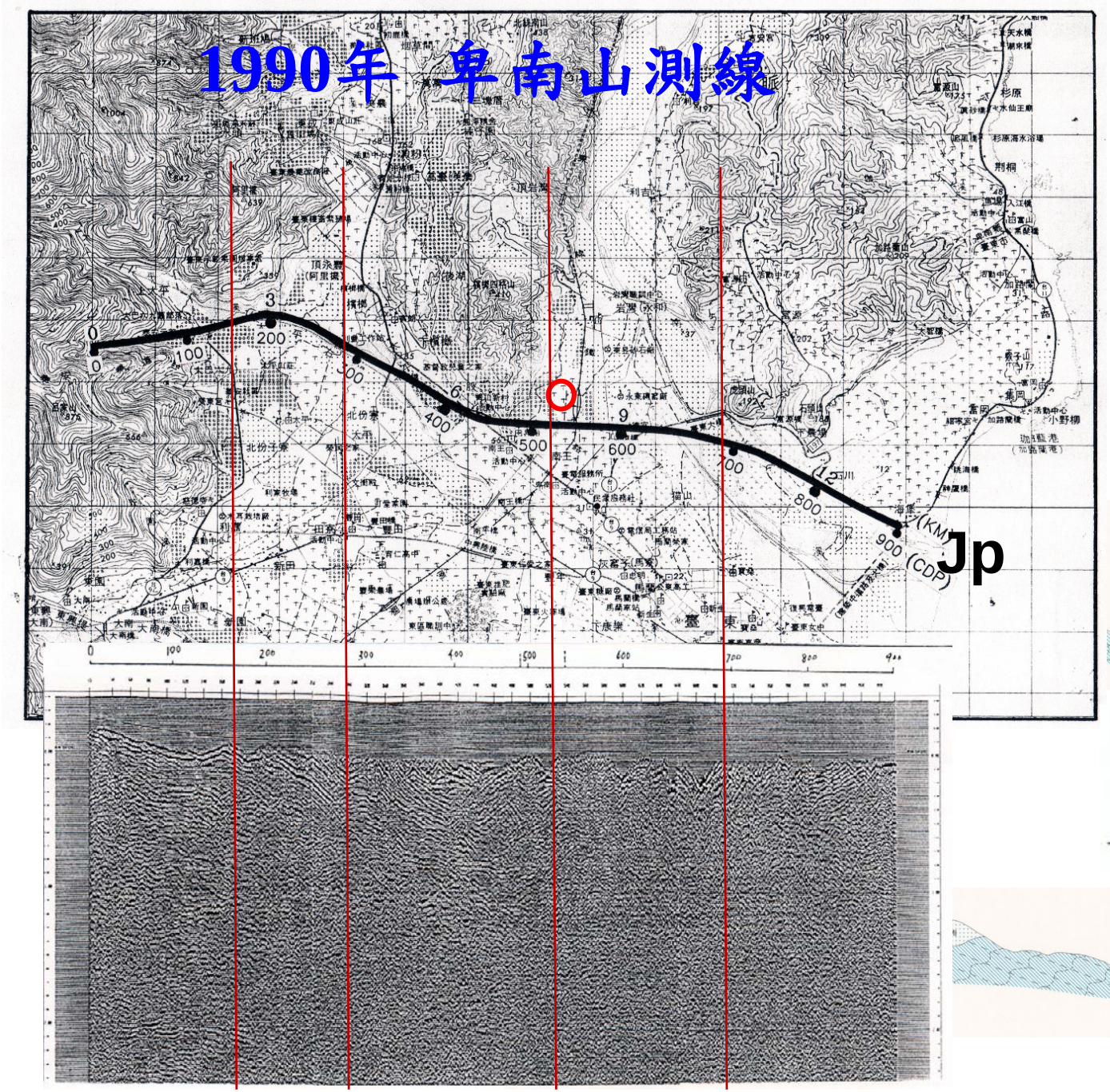


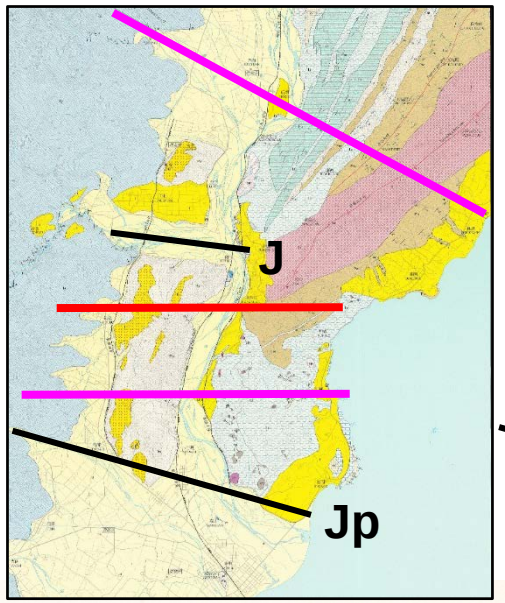
皆朝向都蘭山

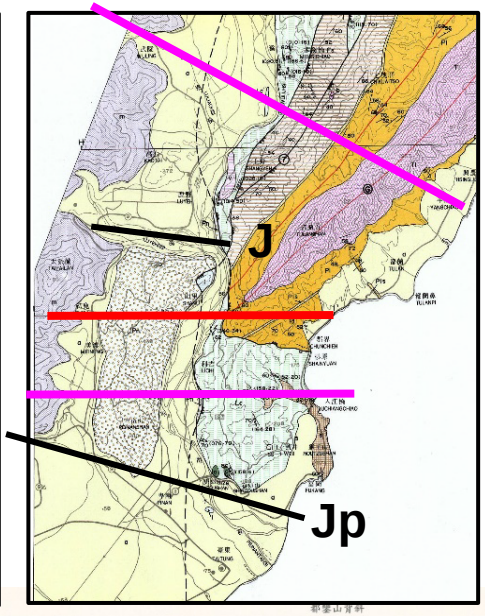


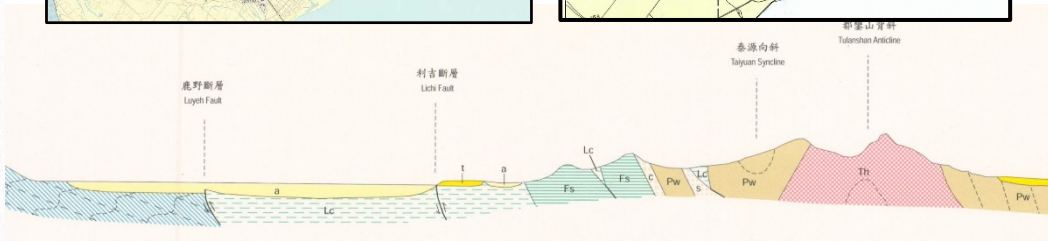
Prehistoric Culture Museum

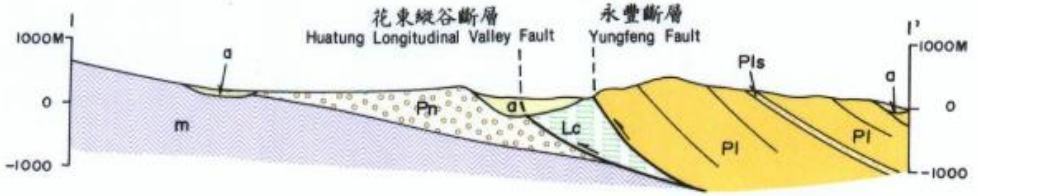
1990年 卑南山測線

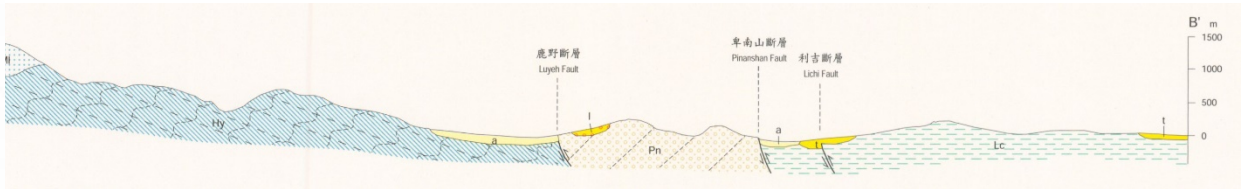

Jp
(KM)
(CDP)


J
Jp

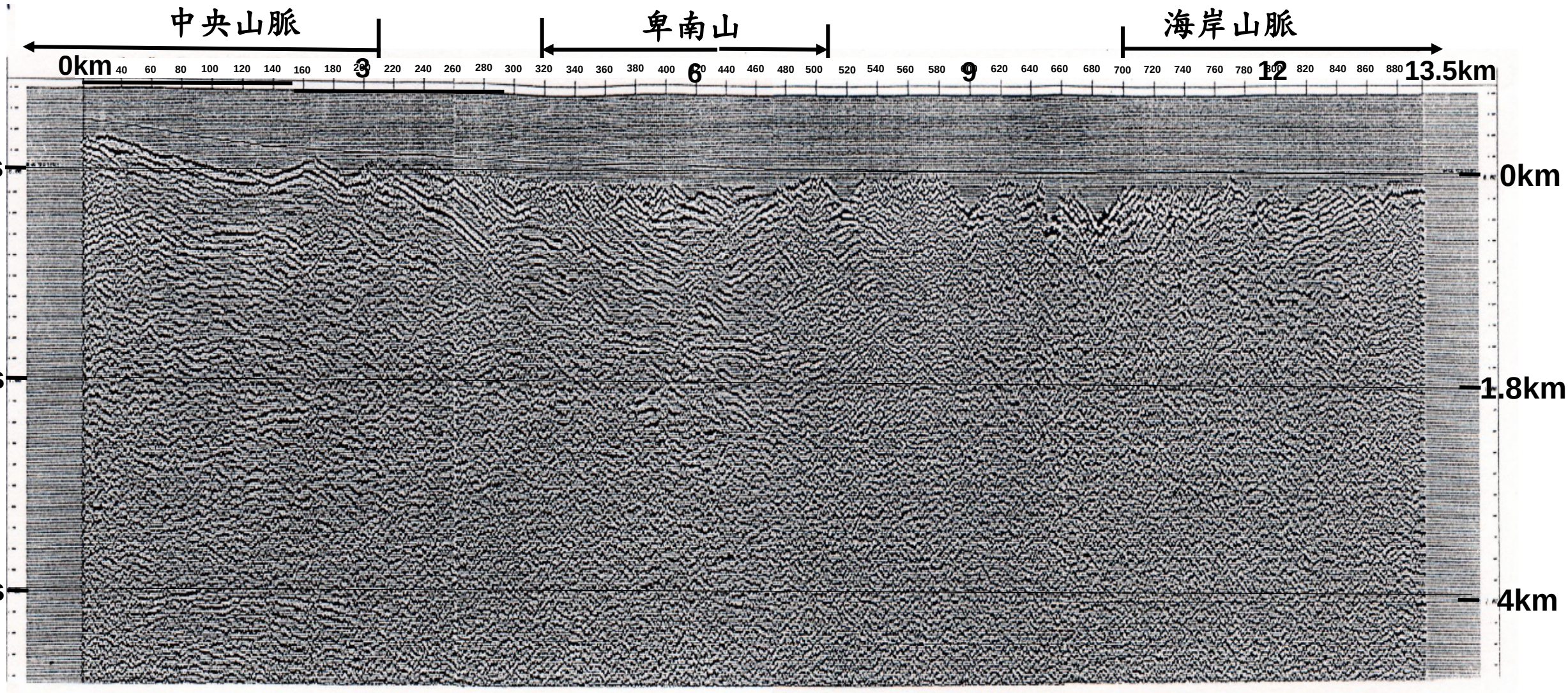

J
Jp



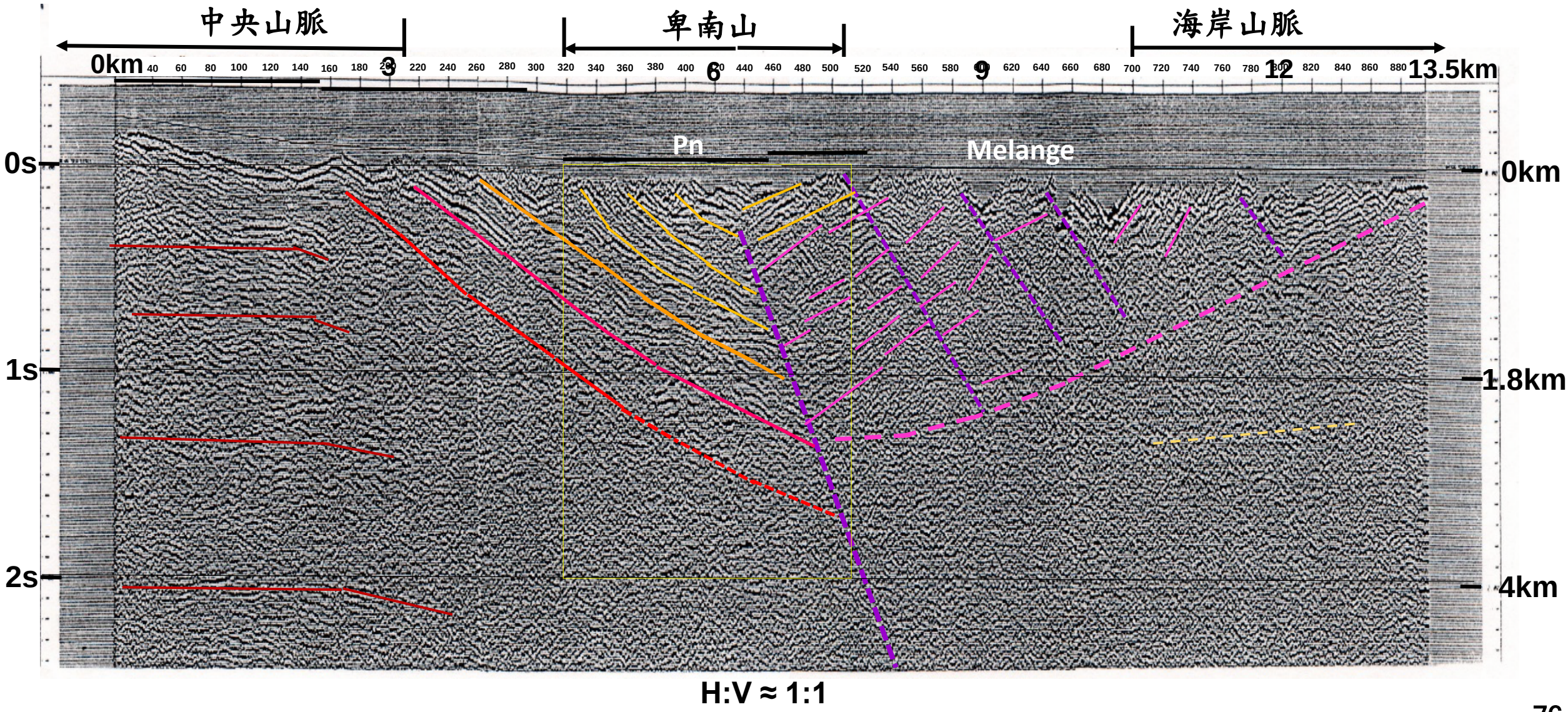

花東縱谷斷層
Huatung Longitudinal Valley Fault
永豐斷層
Yungfeng Fault
1000M
0
-1000

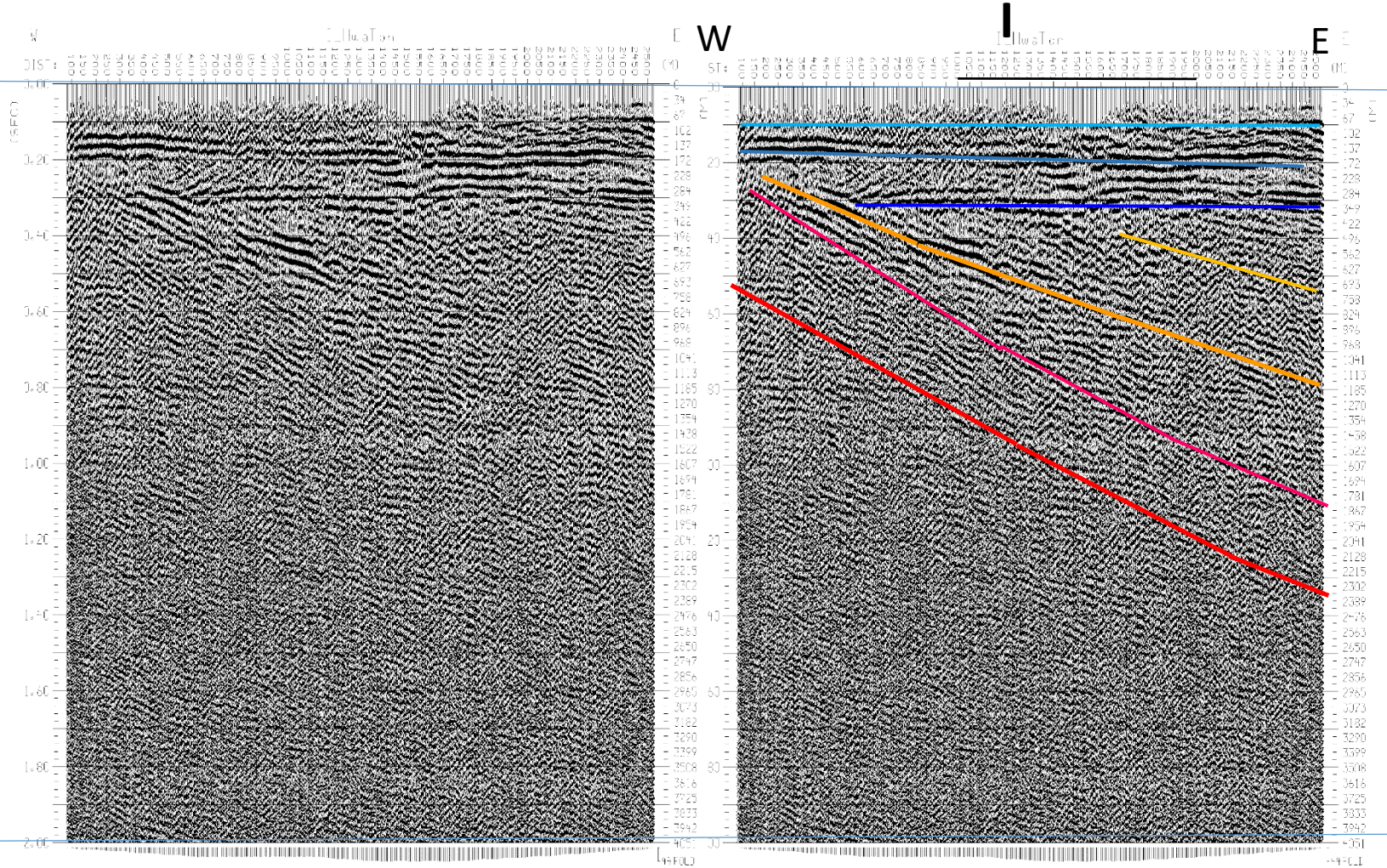


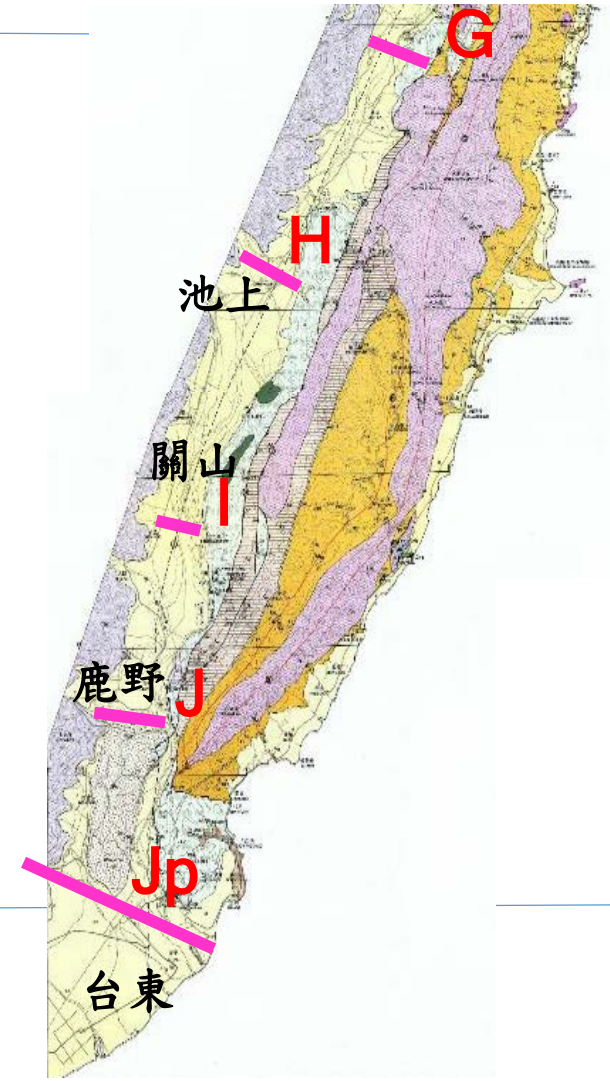
1990年 中油 卑南山測線

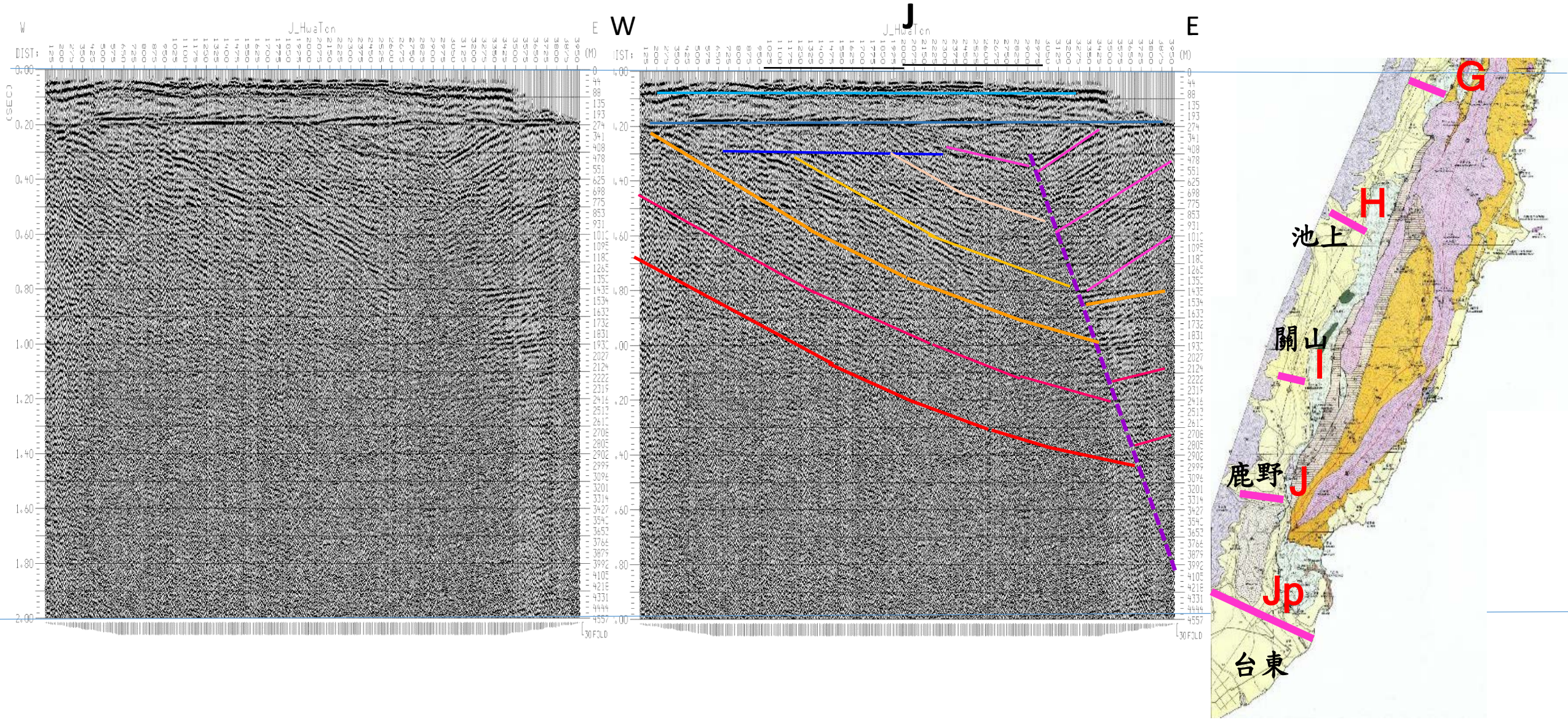


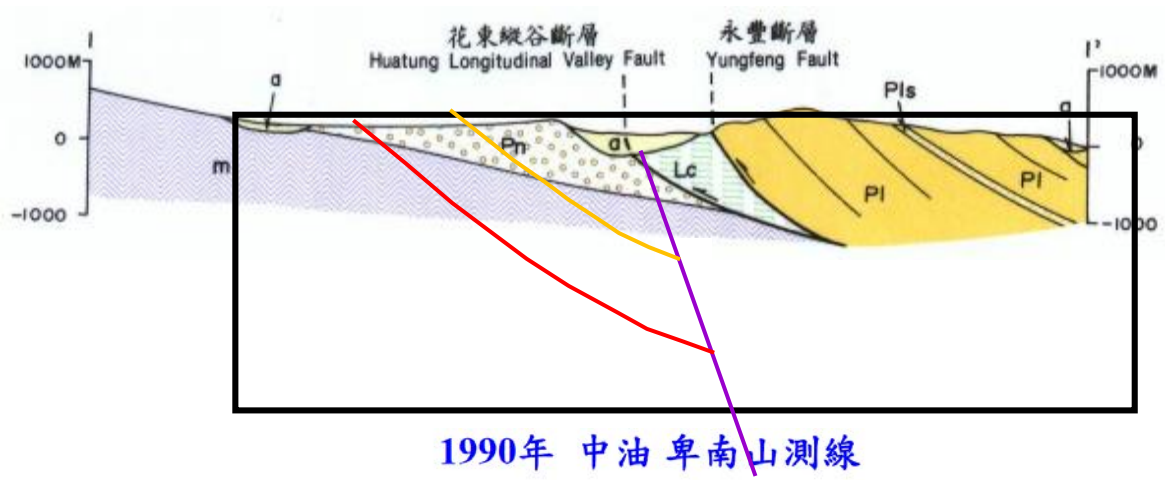
1990年 中油 卑南山測線



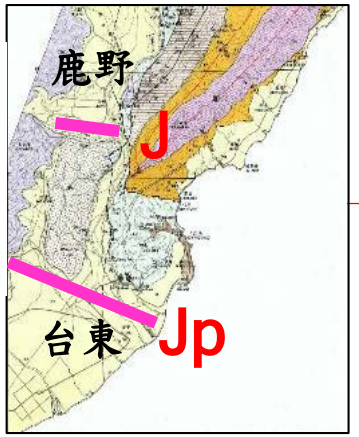

W
I
E

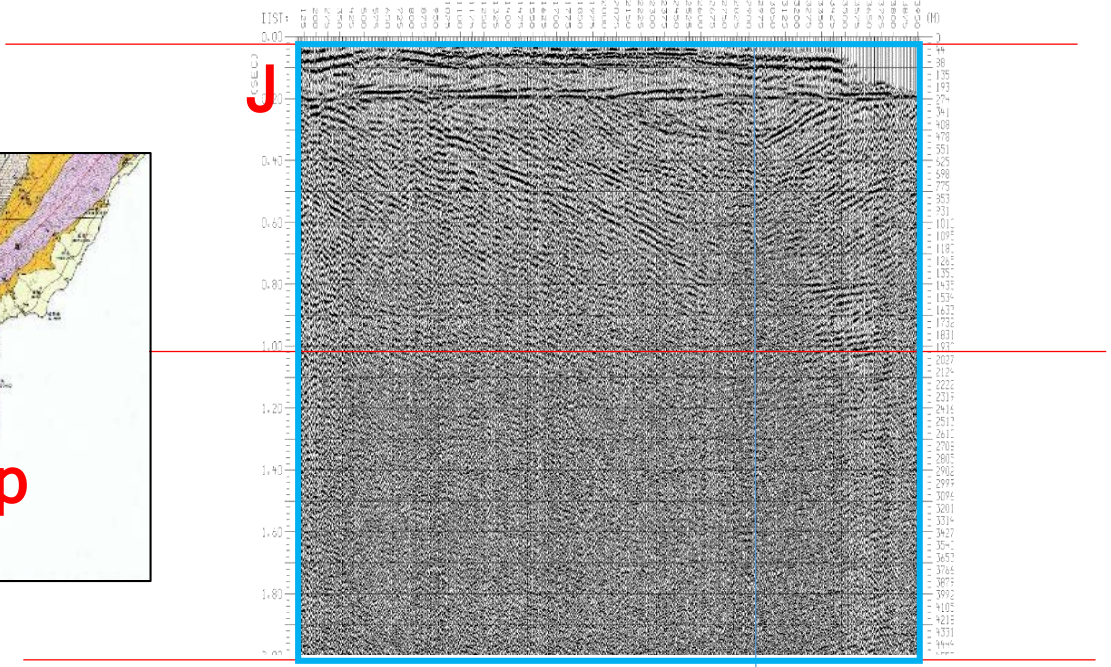

G
H
池上
關山
I
鹿野
J
Jp
台東

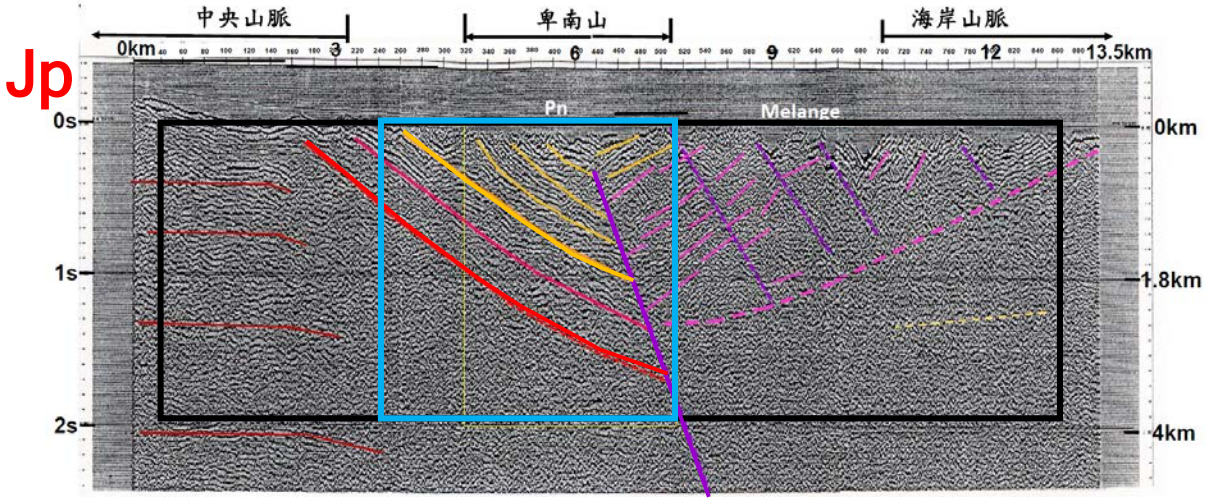

W
J
E
G
H
池上
關山
I
鹿野
J
Jp
台東



1990年 中油 卑南山測線







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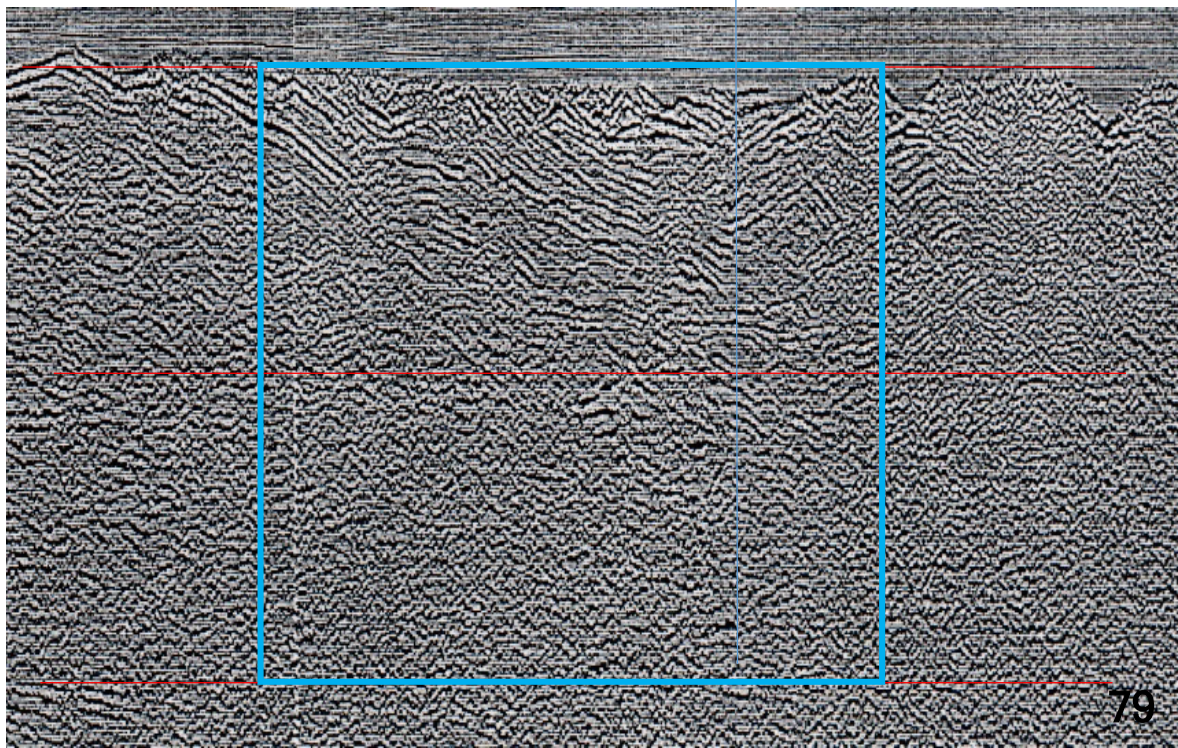
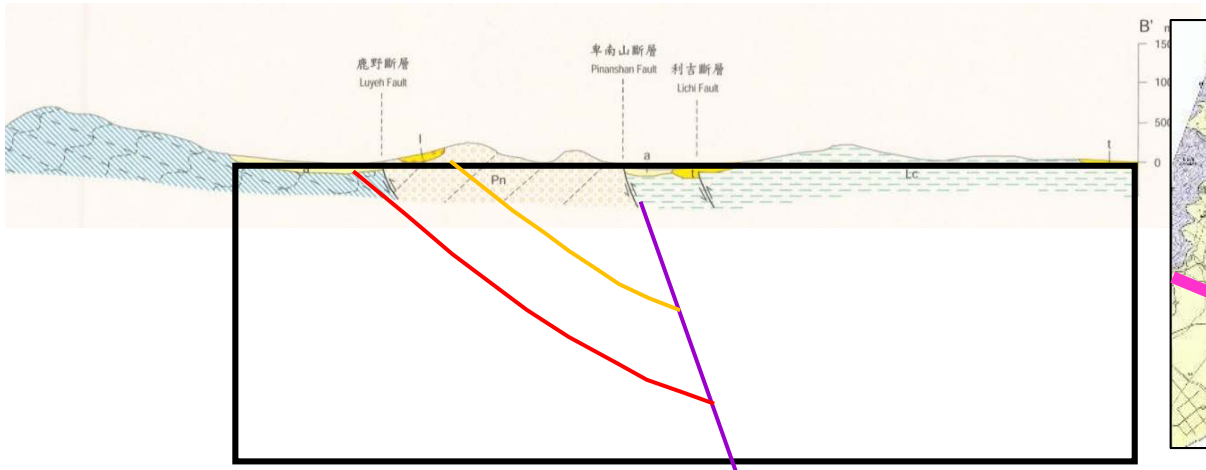
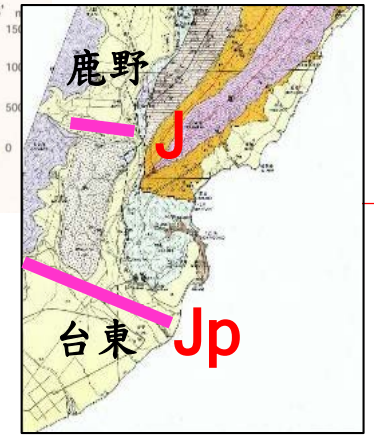
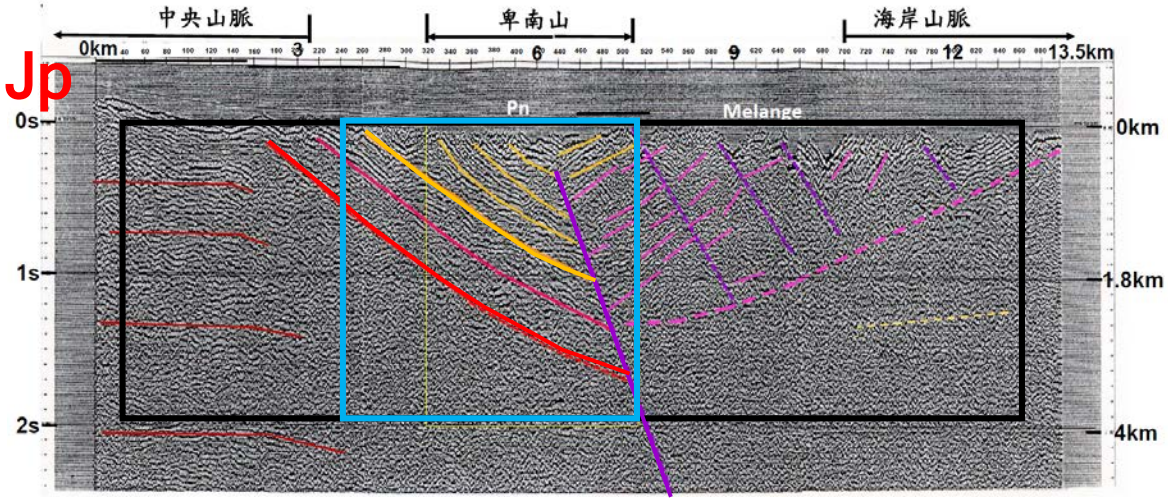
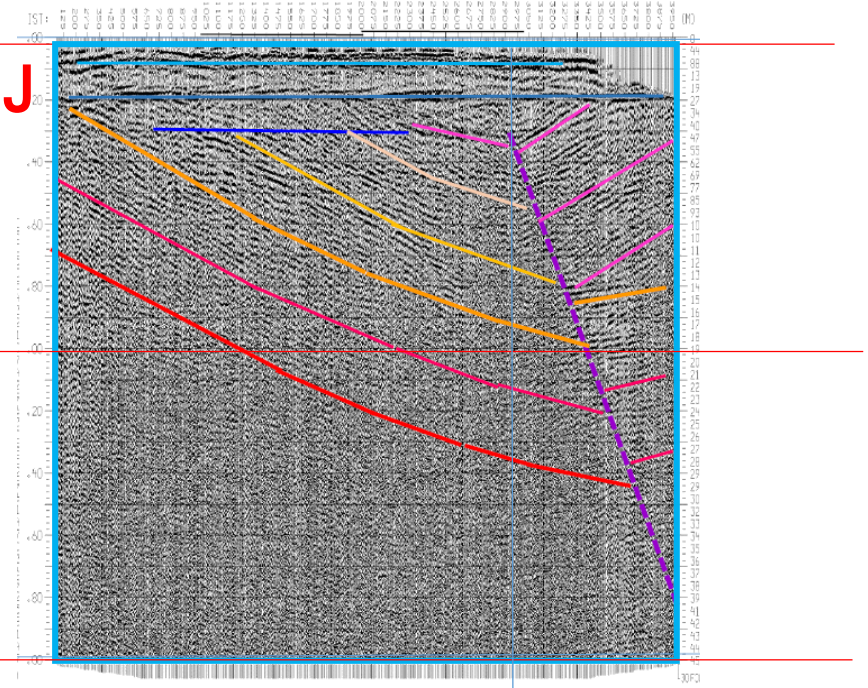


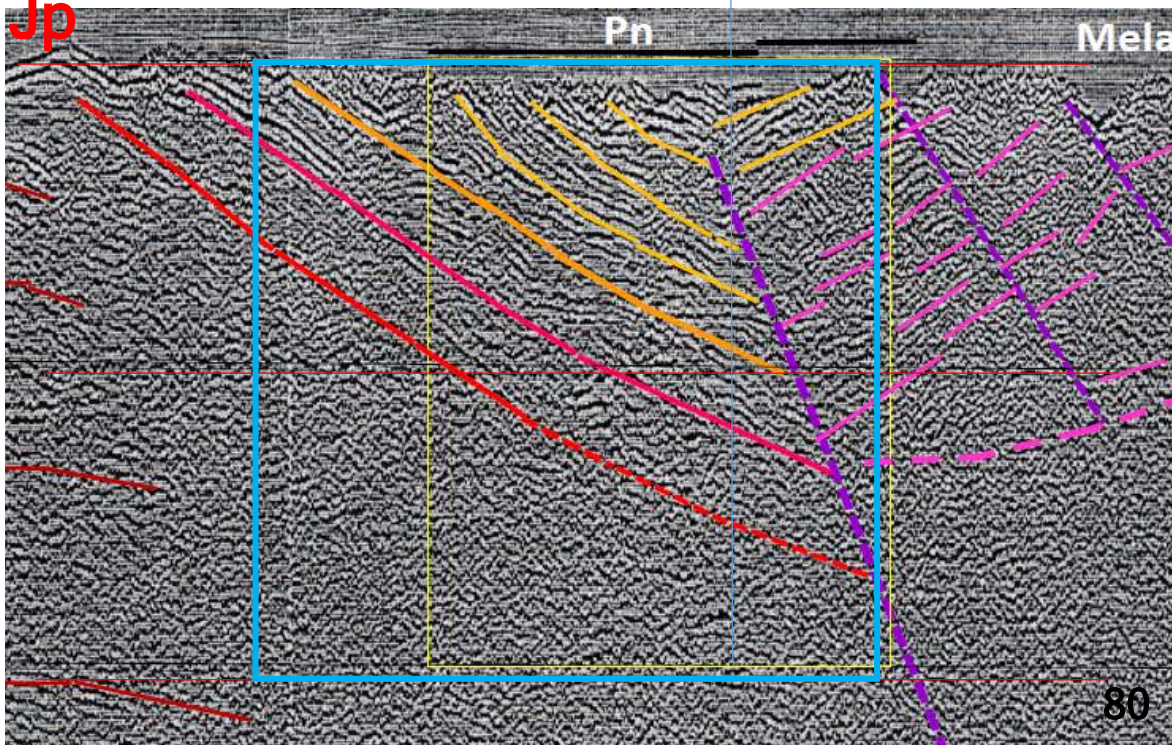




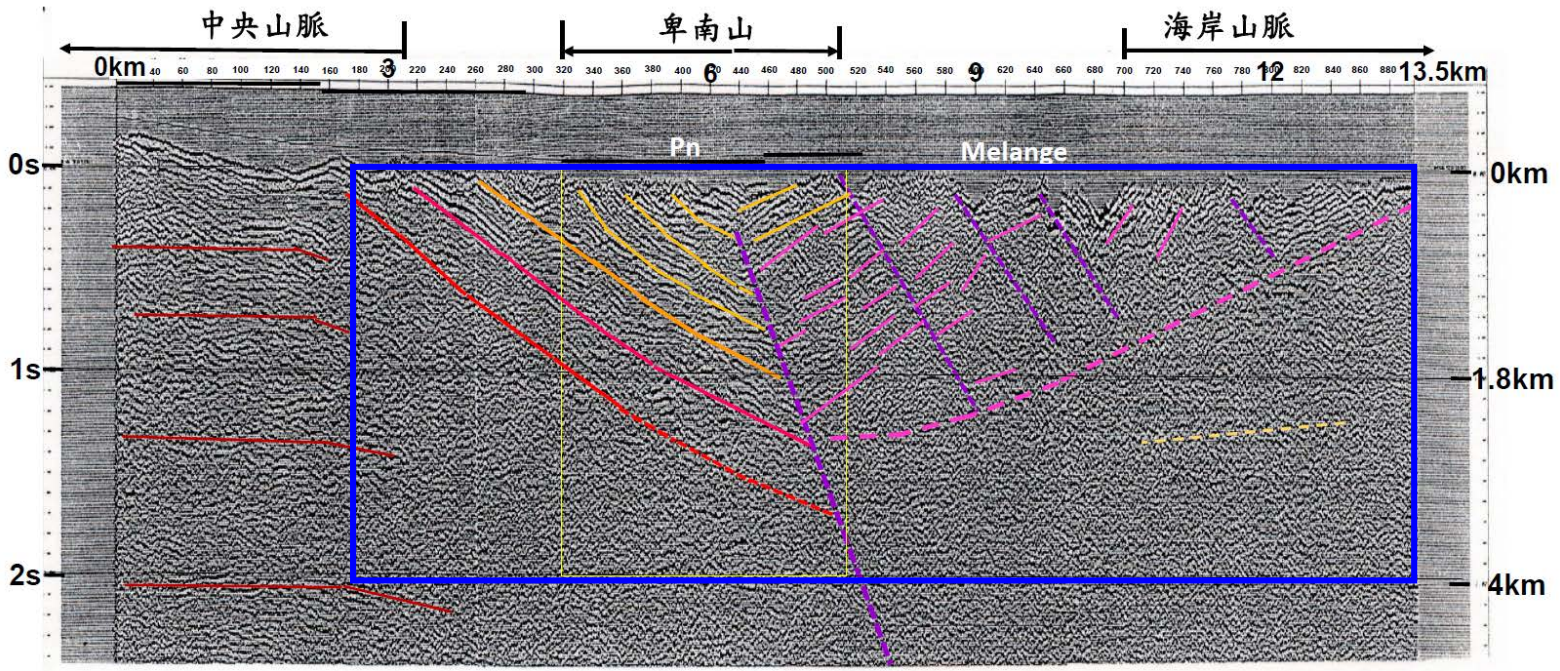
1990年 中油 卑南山測線

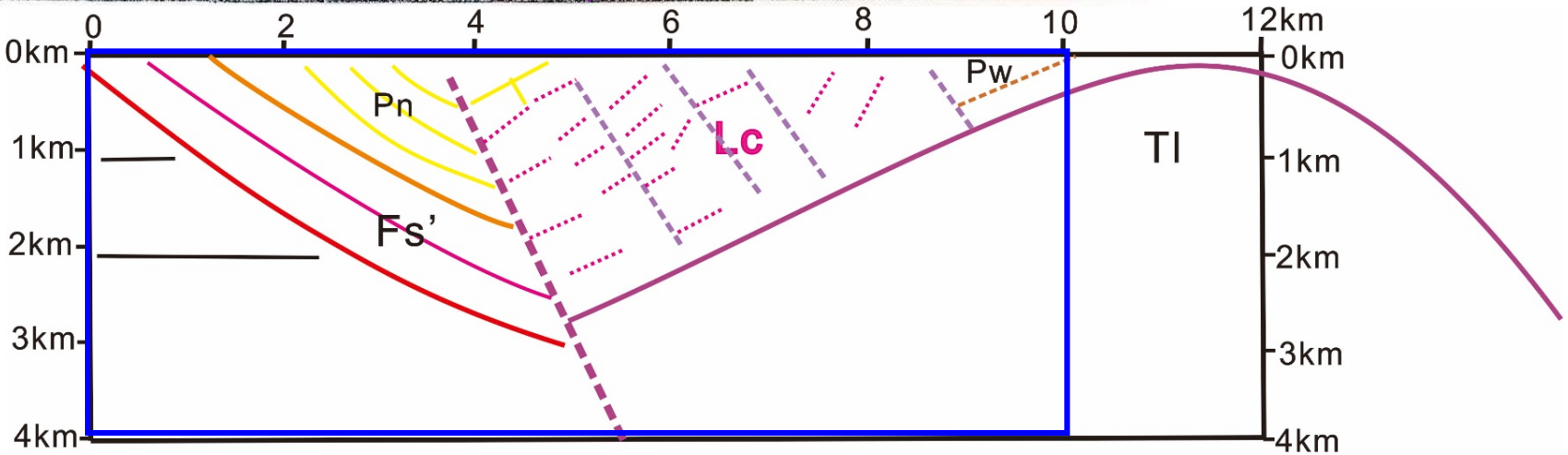




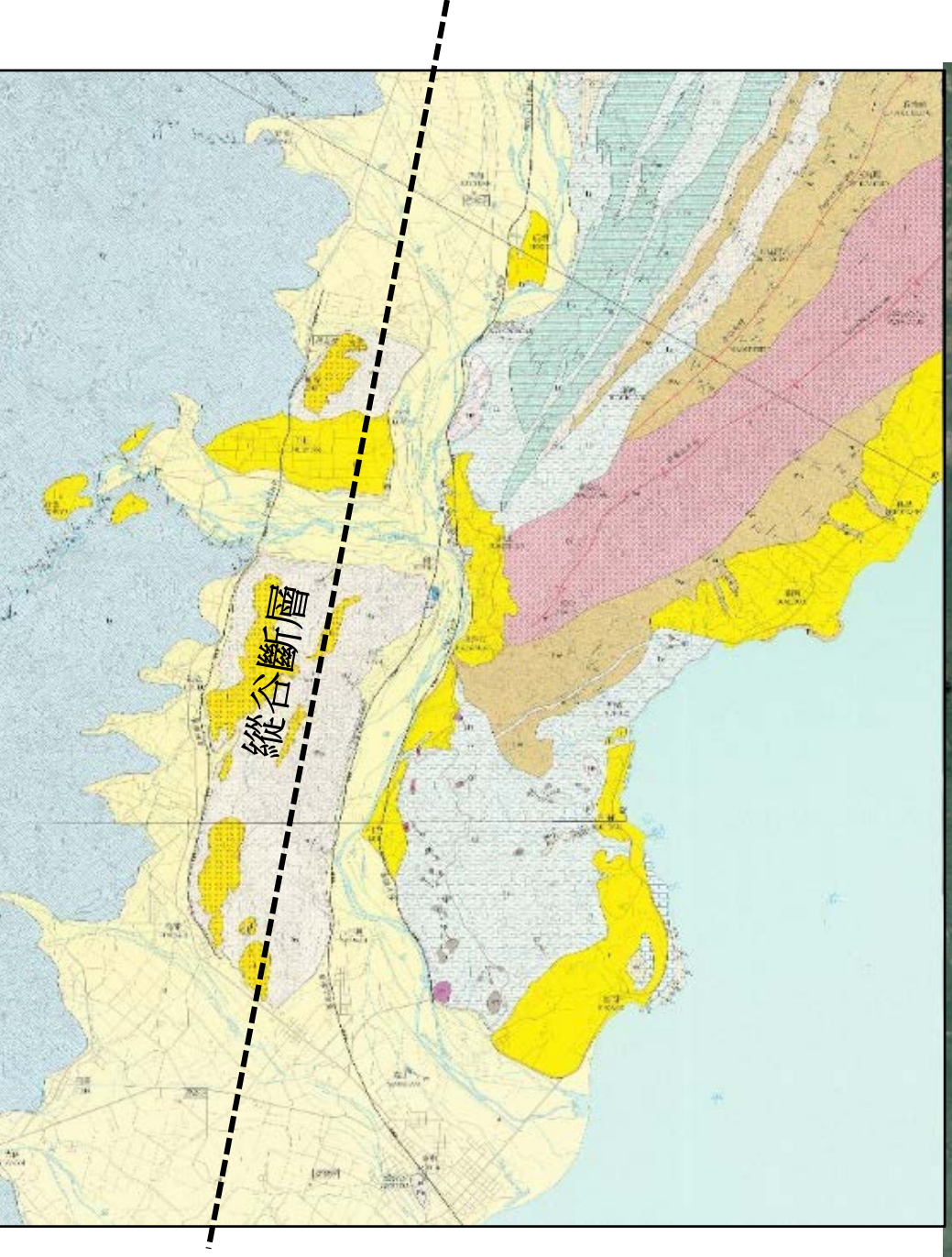


1990年 中油 卑南山測線



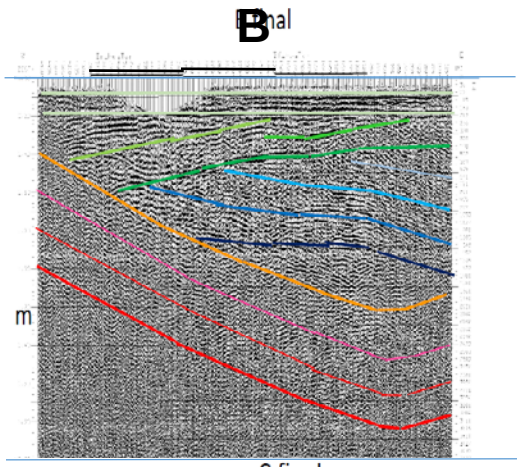


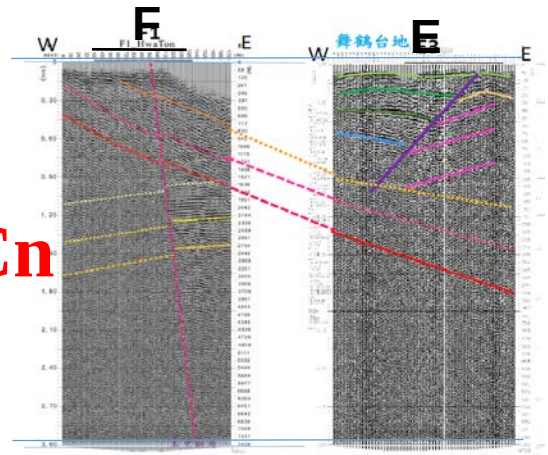
縱谷斷層


縱谷斷層


J
縱谷斷層
Jp
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2017 DigitalGlobe
Image © 2017 CNES / Airbus

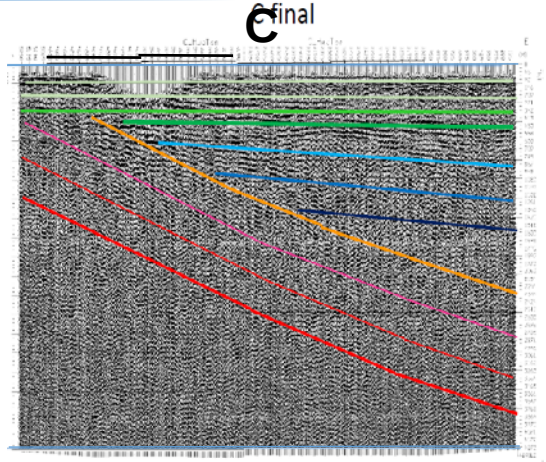
1. 海岸山脈與造山運動
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面
6. **構造模型 (Structure Pattern)**
7. 2018花蓮地震與米崙斷層
8. 結論

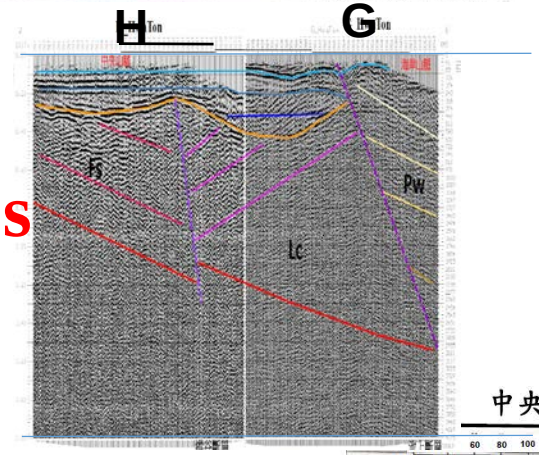




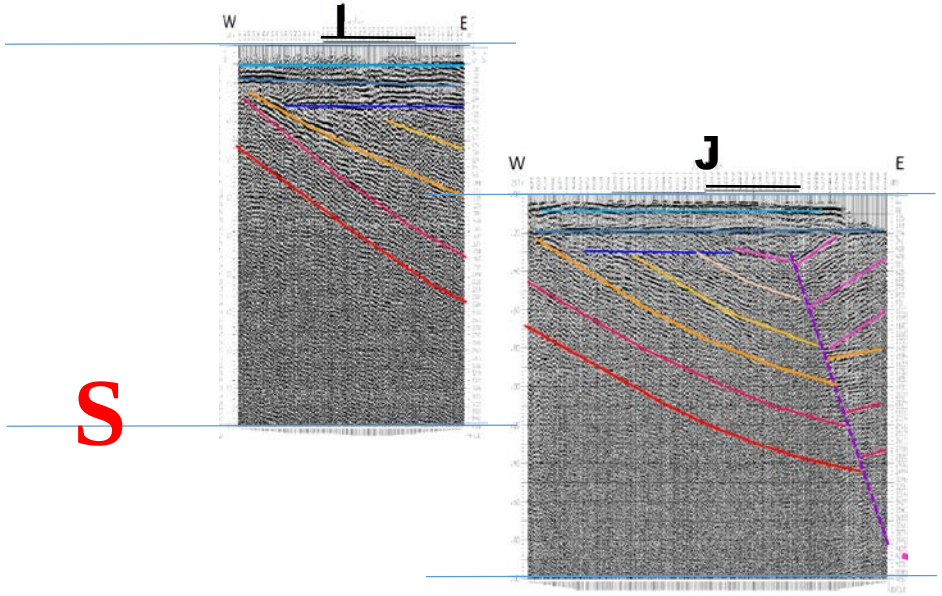
Cn

N





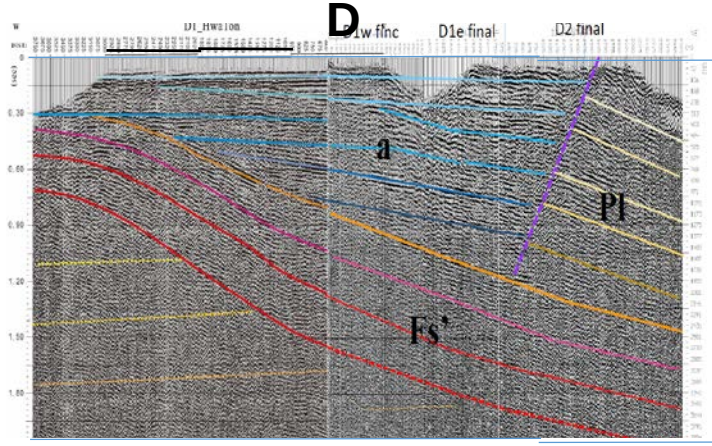
Cs

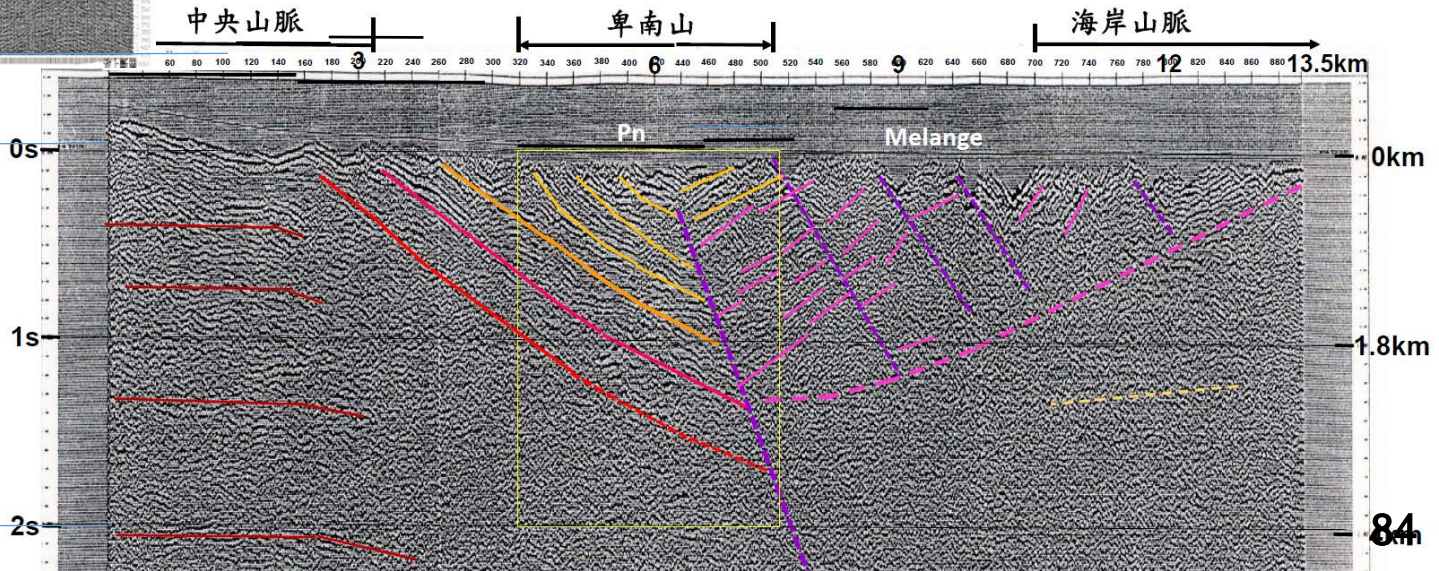


S

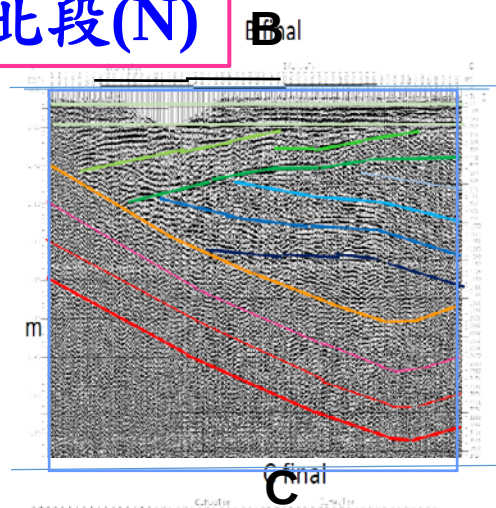
1990年 中油 卑南山測線

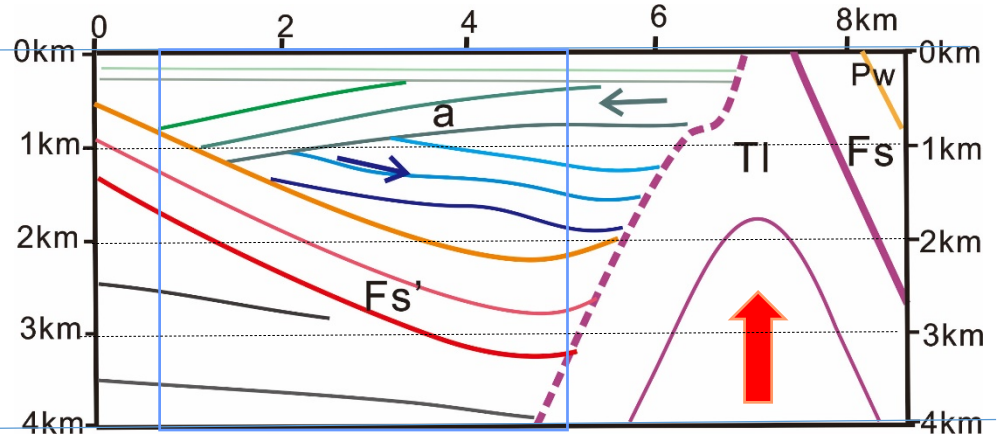
Jp

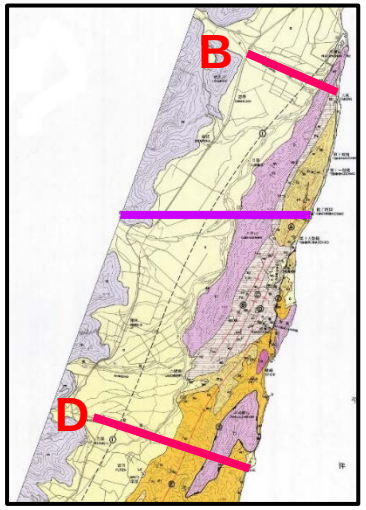


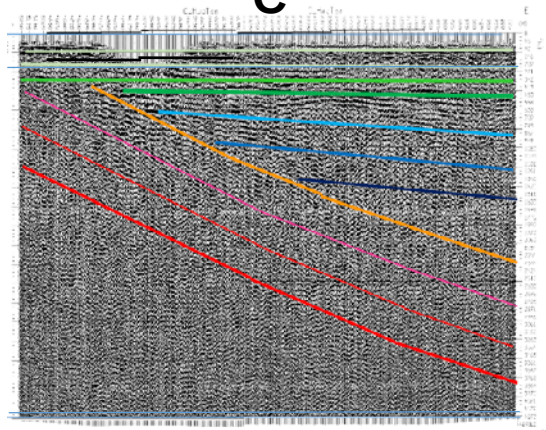


縱谷北段(N)


B
m


0
2
4
6
8km
0km
1km
2km
3km
4km
a
Fs'
Tl
Pw
Fs


B
D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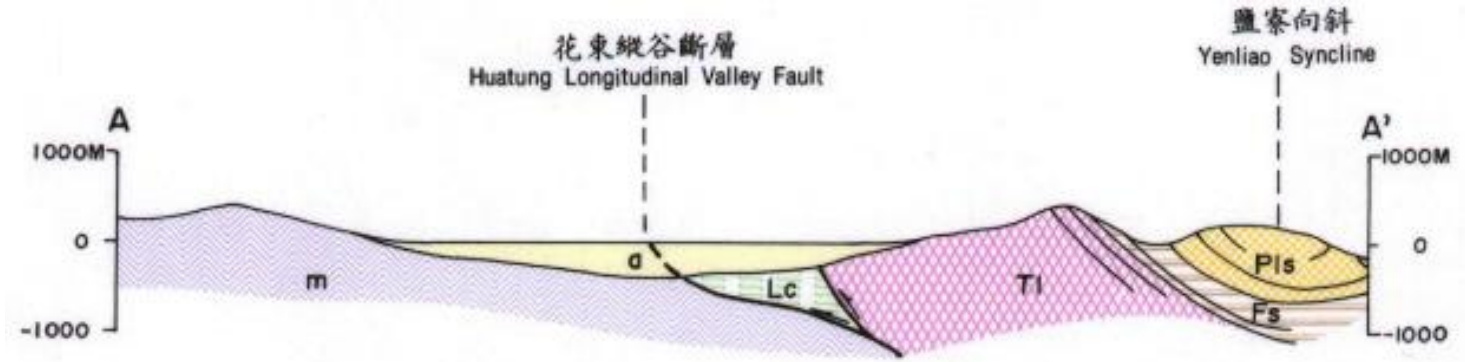
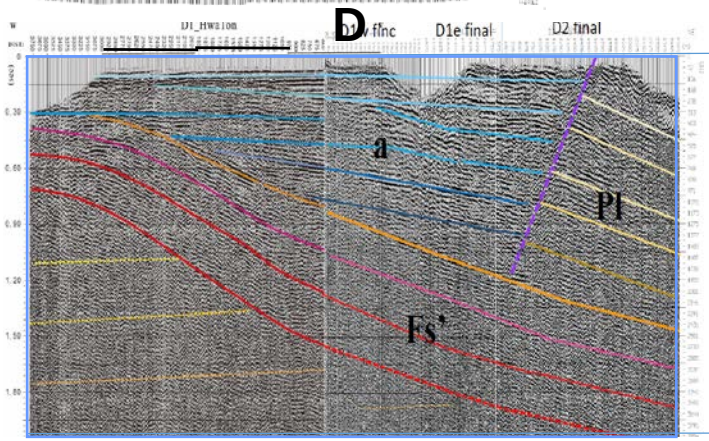
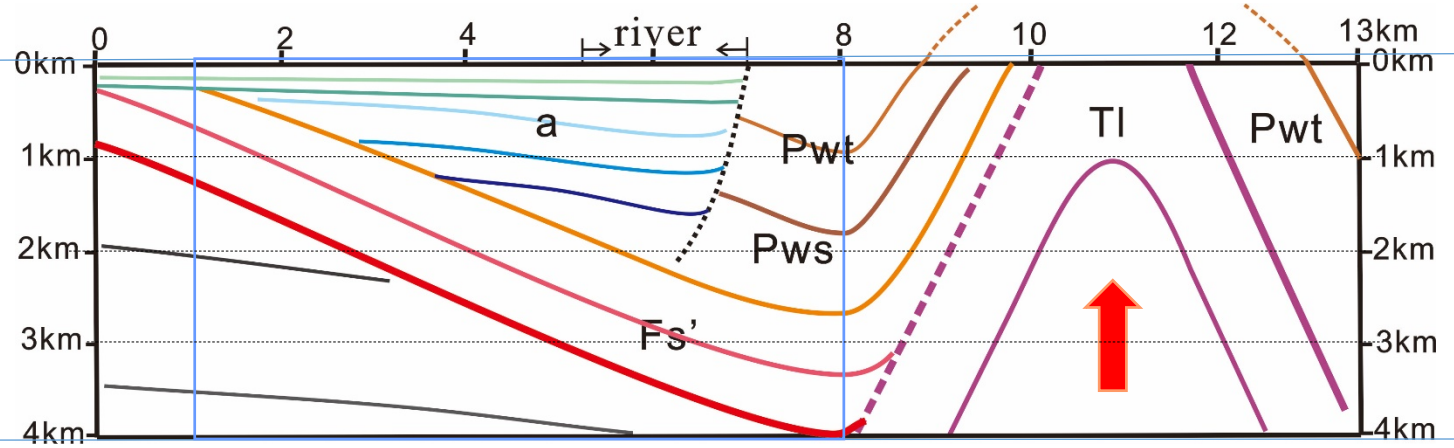
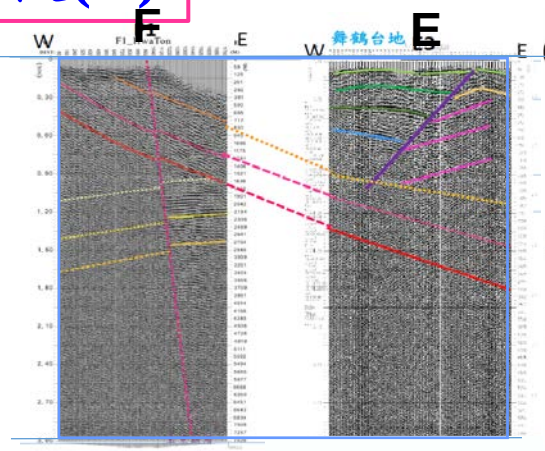

花東縱谷斷層
Huatung Longitudinal Valley Fault
鹽寮向斜
Yenliao Syncline
A
A'
1000M
0
-1000
m
a
Lc
Tl
Pls
Fs

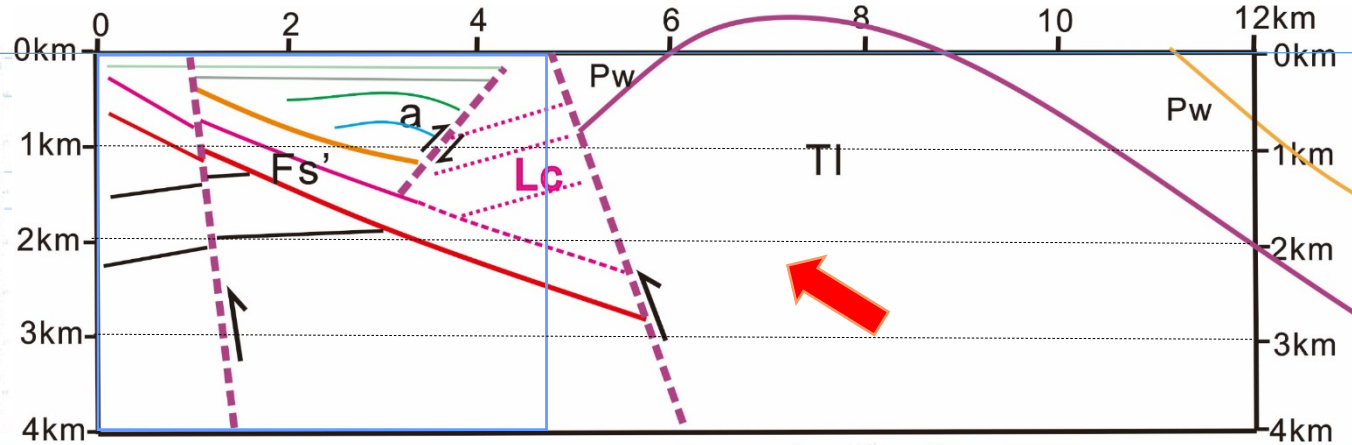

D
a
Pl
Fs'

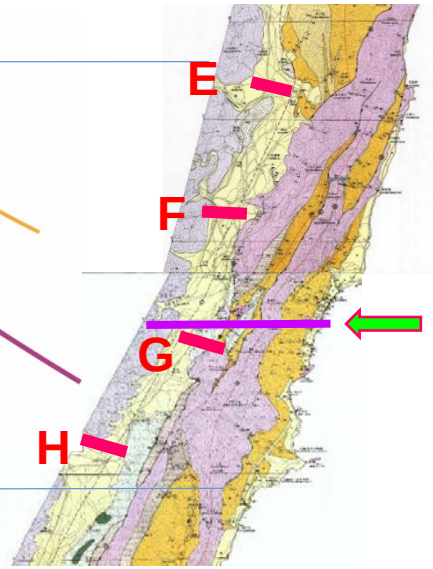

0
2
4
river
8
10
12
13km
0km
1km
2km
3km
4km
a
Pwt
Pws
Fs'
Tl
Pwt

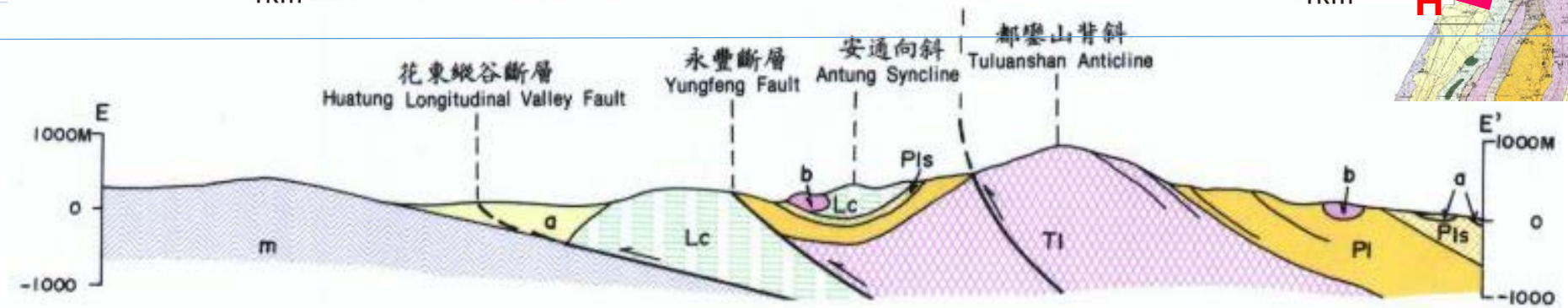
縱谷中段(C)

(Cn)

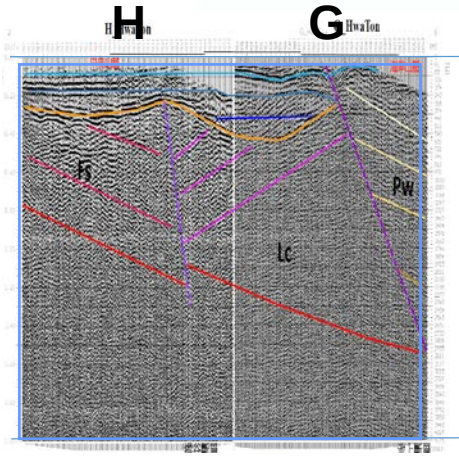

F
E
W
E
舞鶴台地

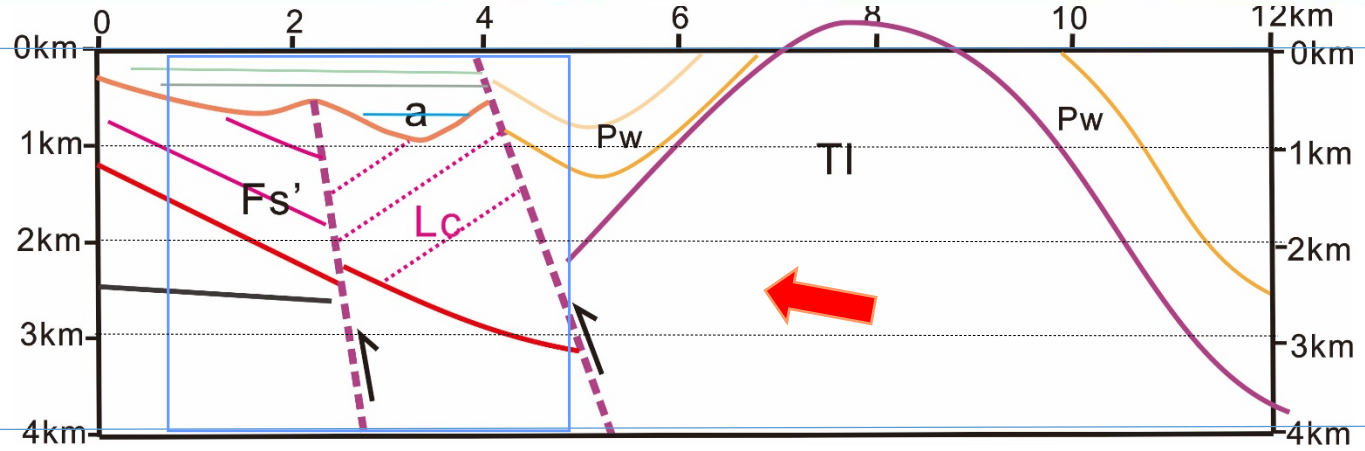

0
2
4
6
8
10
12km
0km
1km
2km
3km
4km
Pw
Pw
a
Fs'
Lc
Tl


E
F
G
H

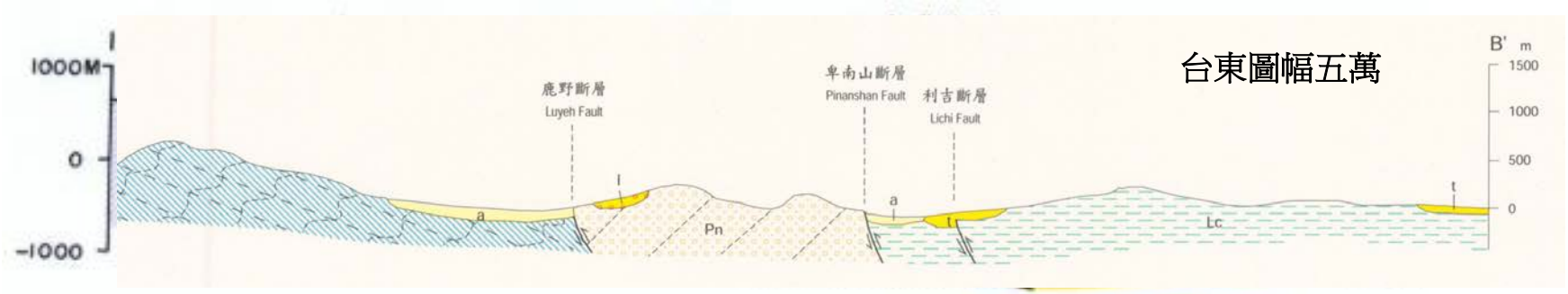

花東縱谷斷層
Huatung Longitudinal Valley Fault
永豐斷層
Yungfeng Fault
安通向斜
Antung Syncline
鹿鑾山背斜
Tuluanshan Anticline
E
E'
1000M
0
-1000
m
a
Lc
b
Pls
Tl
Pl

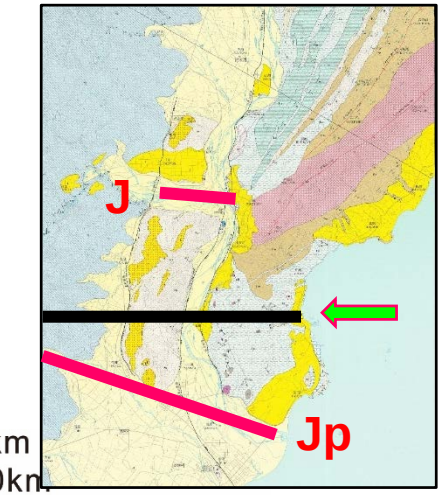
(Cs)

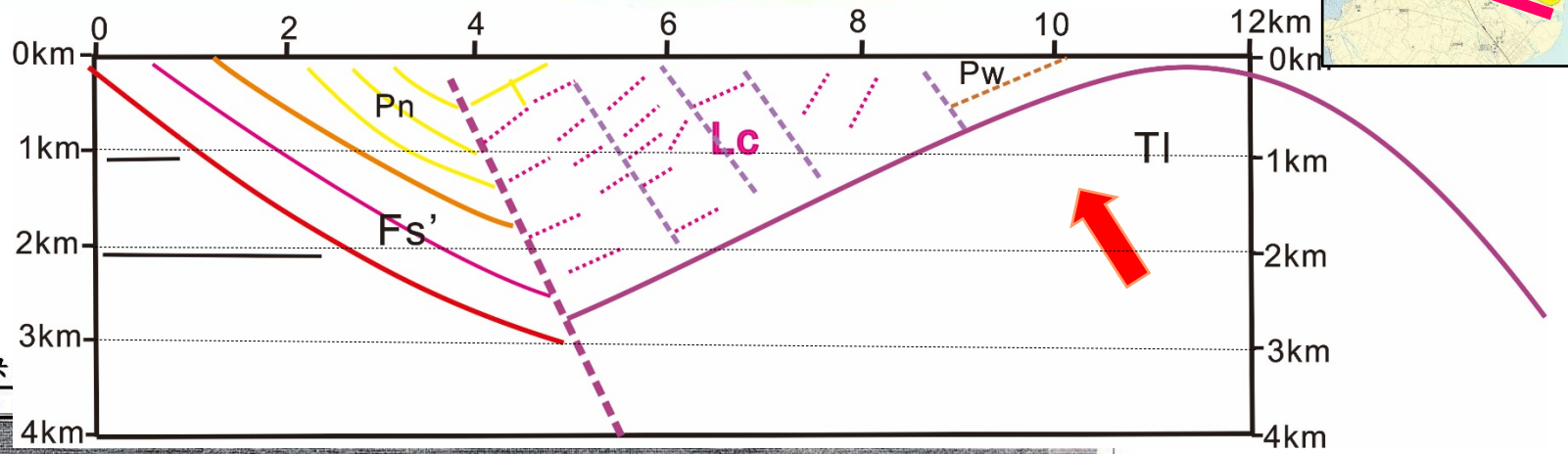

H
G
Pw
Lc

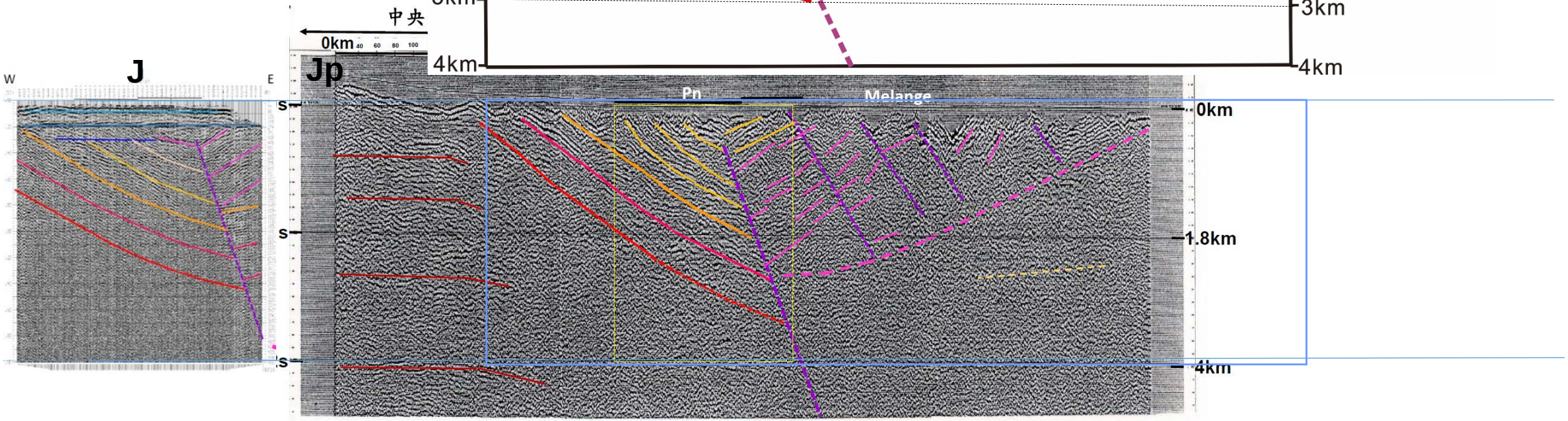

0
2
4
6
8
10
12km
0km
1km
2km
3km
4km
a
Pw
Pw
Tl
Fs'
Lc

縱谷南段(S)

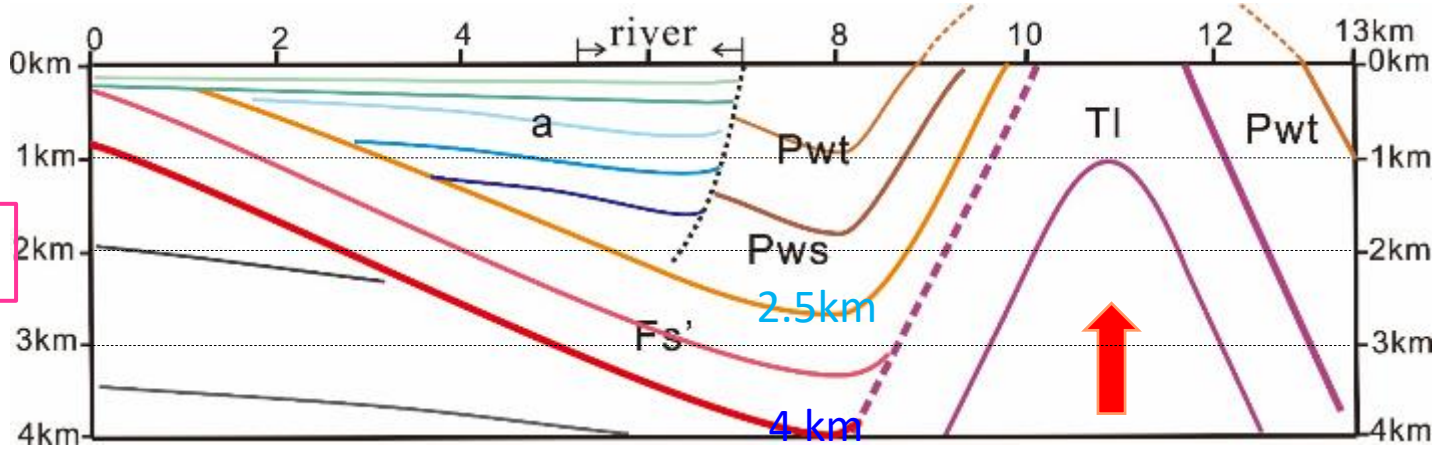

台東圖幅五萬
1000M
0
-1000
鹿野斷層
Luyeh Fault
卑南山斷層
Pinanshan Fault
利吉斷層
Lichi Fault
Pn
Lc
B'
m
1500
1000
500
0


J
Jp


0
2
4
6
8
10
12km
0km
1km
2km
3km
4km
Pn
Lc
Pw
TI
Fs'


W
J
E
中央
0km
Jp
Pn
Melange
0km
1.8km
4km

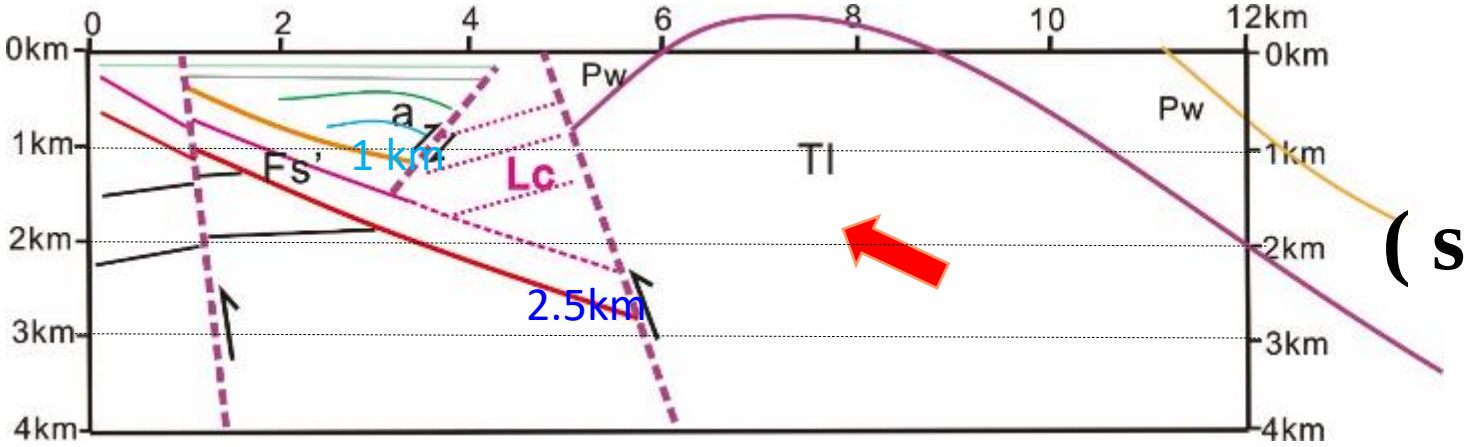
縱谷北段



頂
(lift)

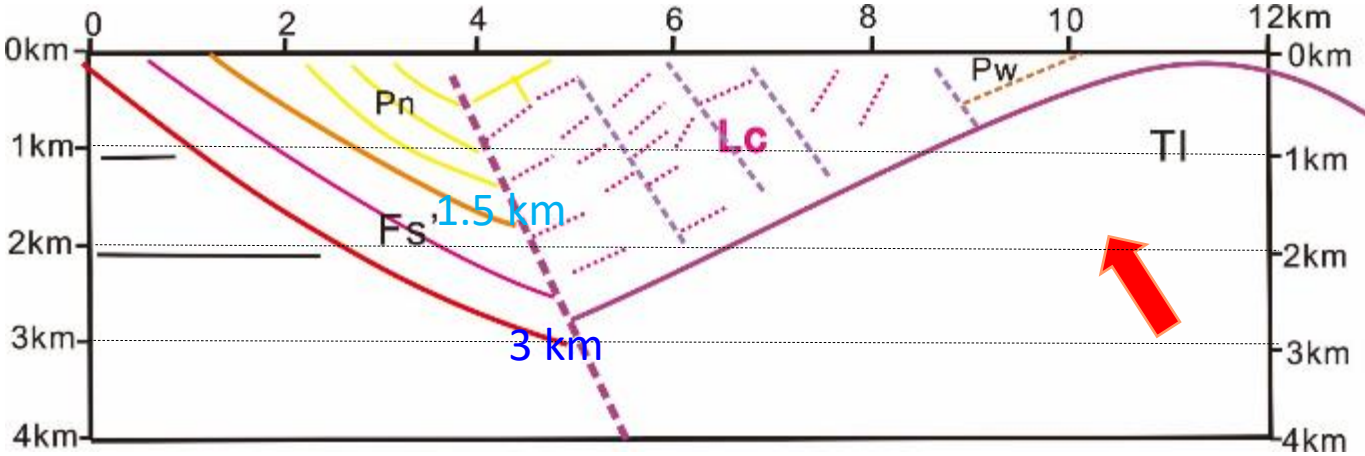
北
中
南

縱谷中段



擠
(squeeze)

縱谷南段

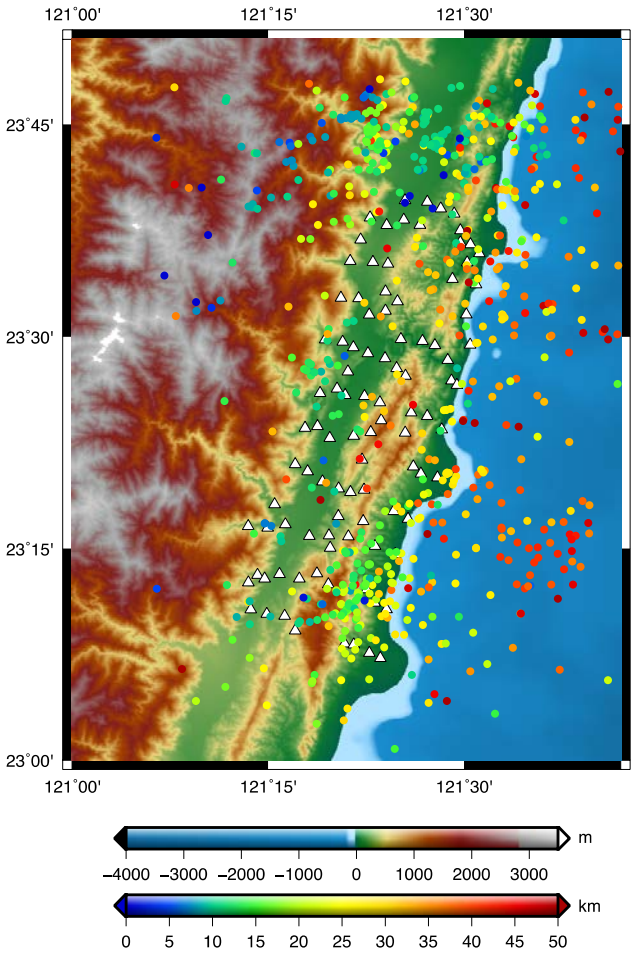


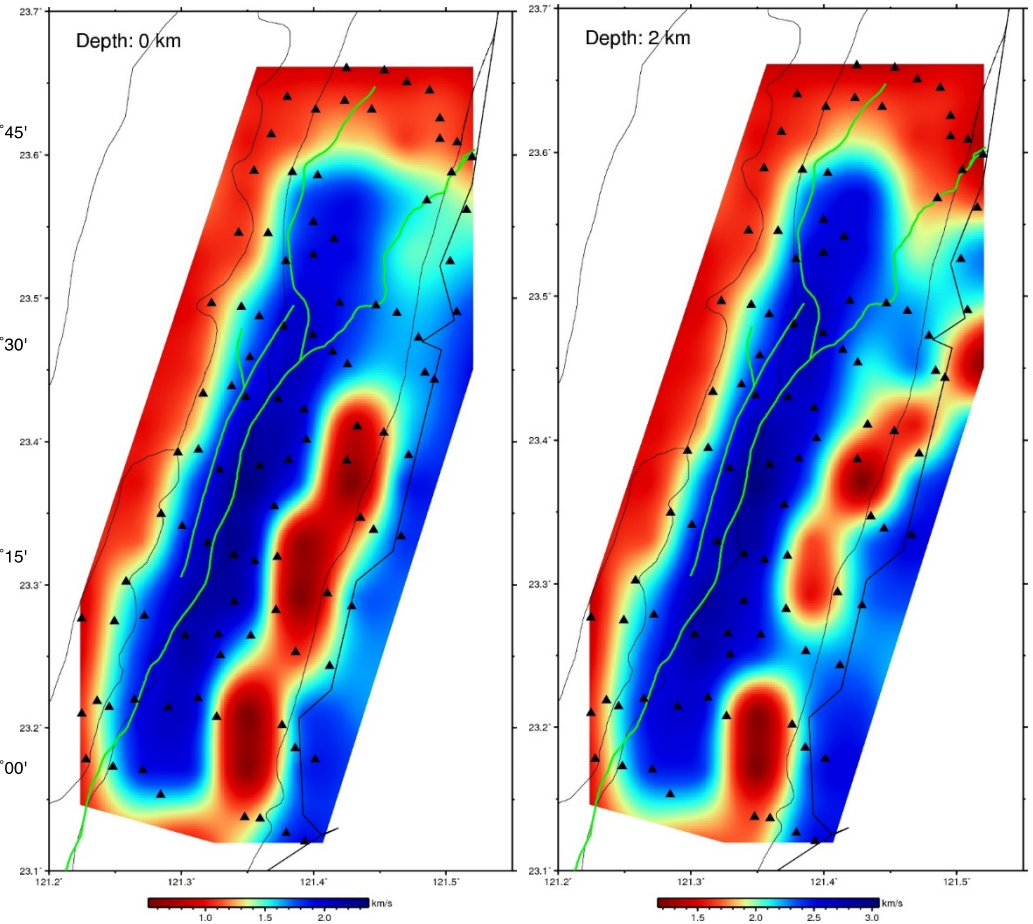
推
(push)

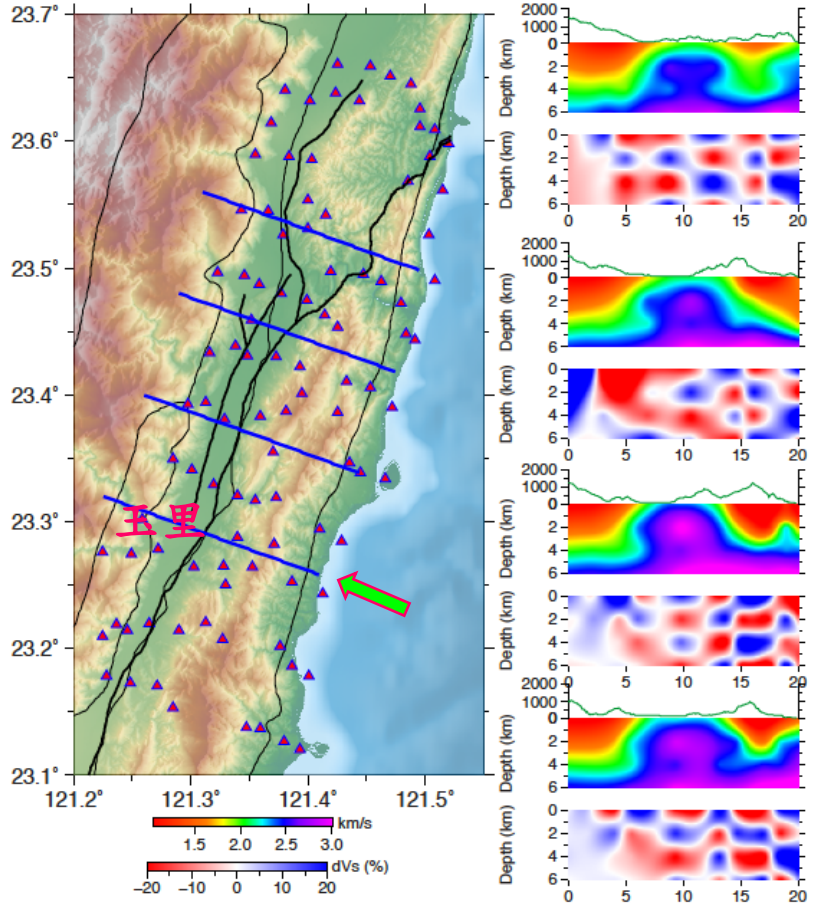
Joint inversion with surface and body waves:

High quality travel-time data

High quality surface wave data







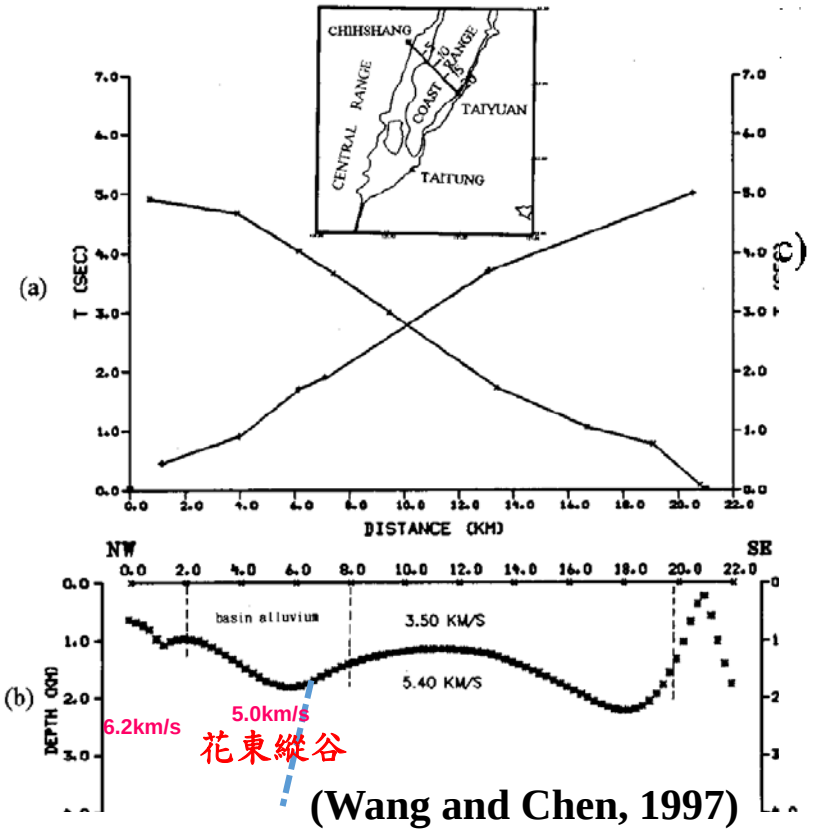
(郭陳澔與鄭璟郁，2018)

Prof. Y. B. Tsai

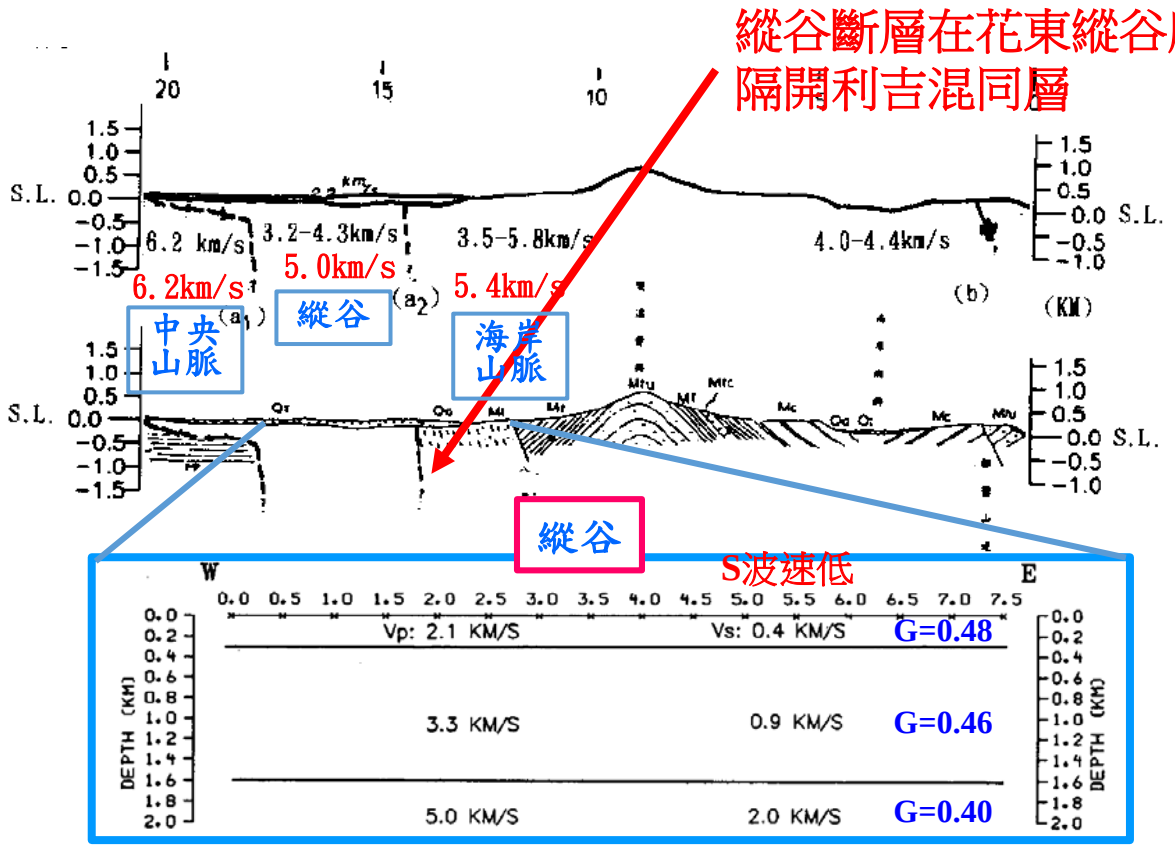
蔡義本教授1974年，利用炸藥震源，進行橫跨花東縱谷及海岸山脈的折射震測研究

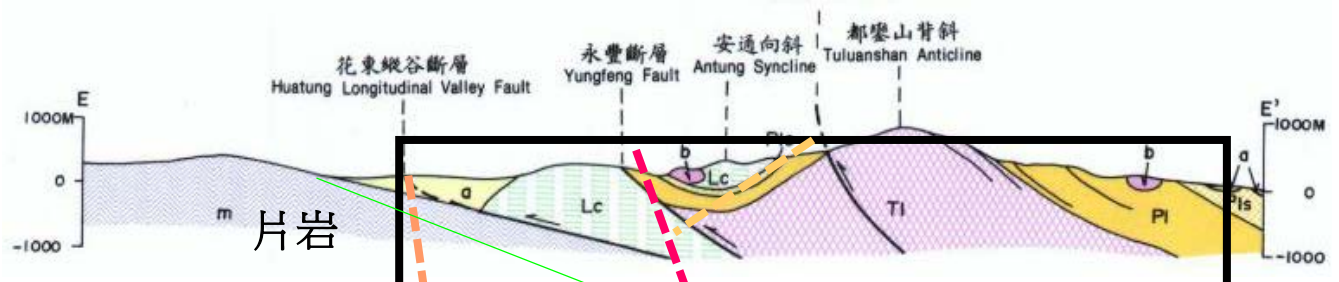
Tsai, Y. B., Y. M. Hsiung, H. B. Liaw, H. P. Lueng, T. H. Yao, Y. H. Yeh and Y. T. Yeh, 1974: A seismic refraction study of eastern Taiwan. *Petrol. Geol. Taiwan*, **11**, 165-182.

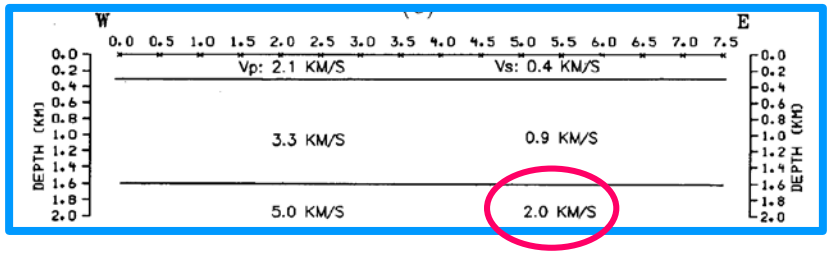
Wang,C.Y. and K. P. Chen, 1997: A seismic refraction profile across the Longitudinal Valley near Hualien, Taiwan. *Terr. Atmo. Ocean*, 8, 295-312.

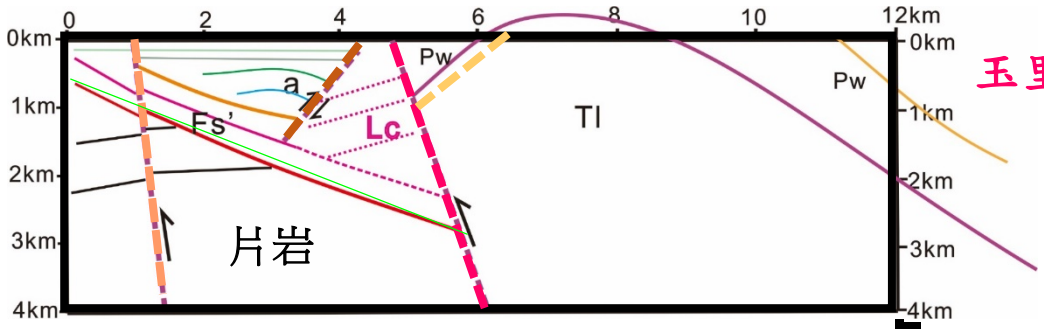


(Wang and Chen, 1997)

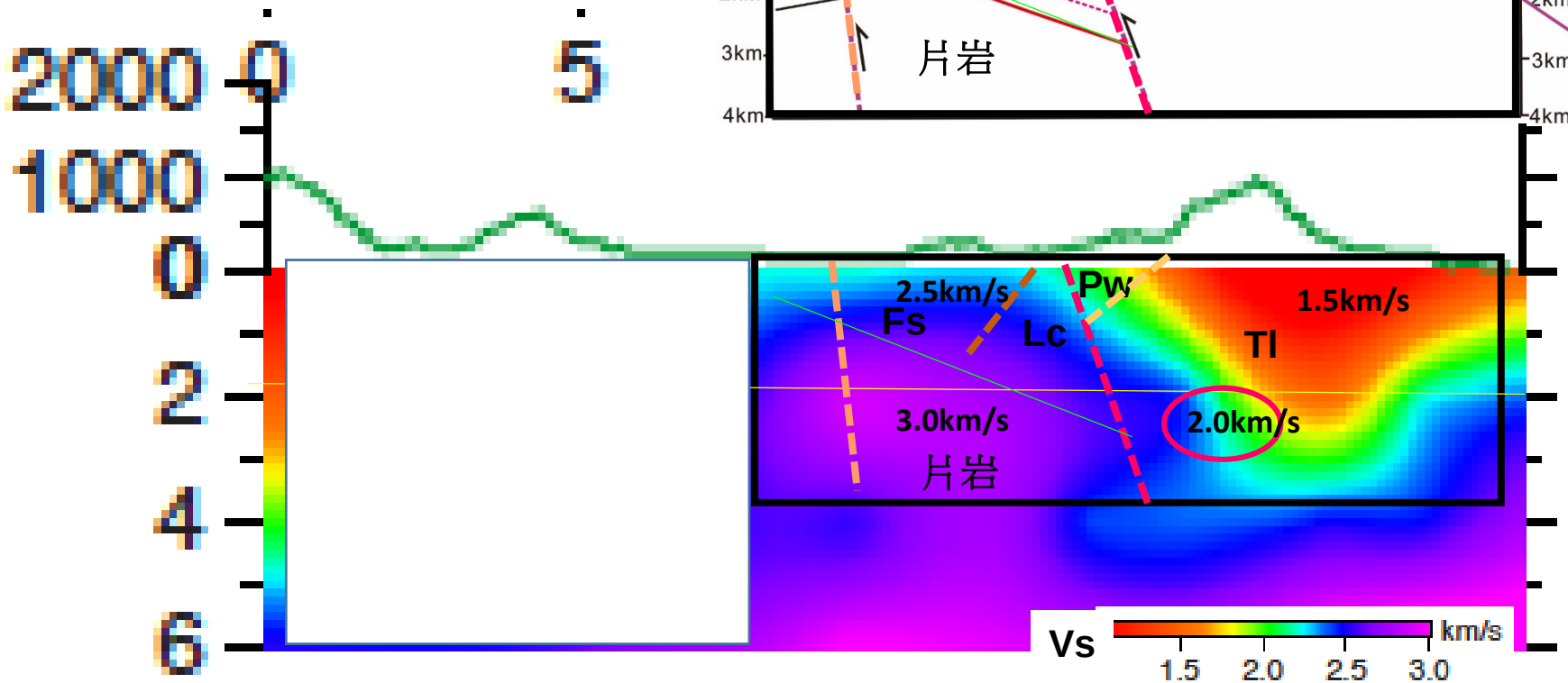








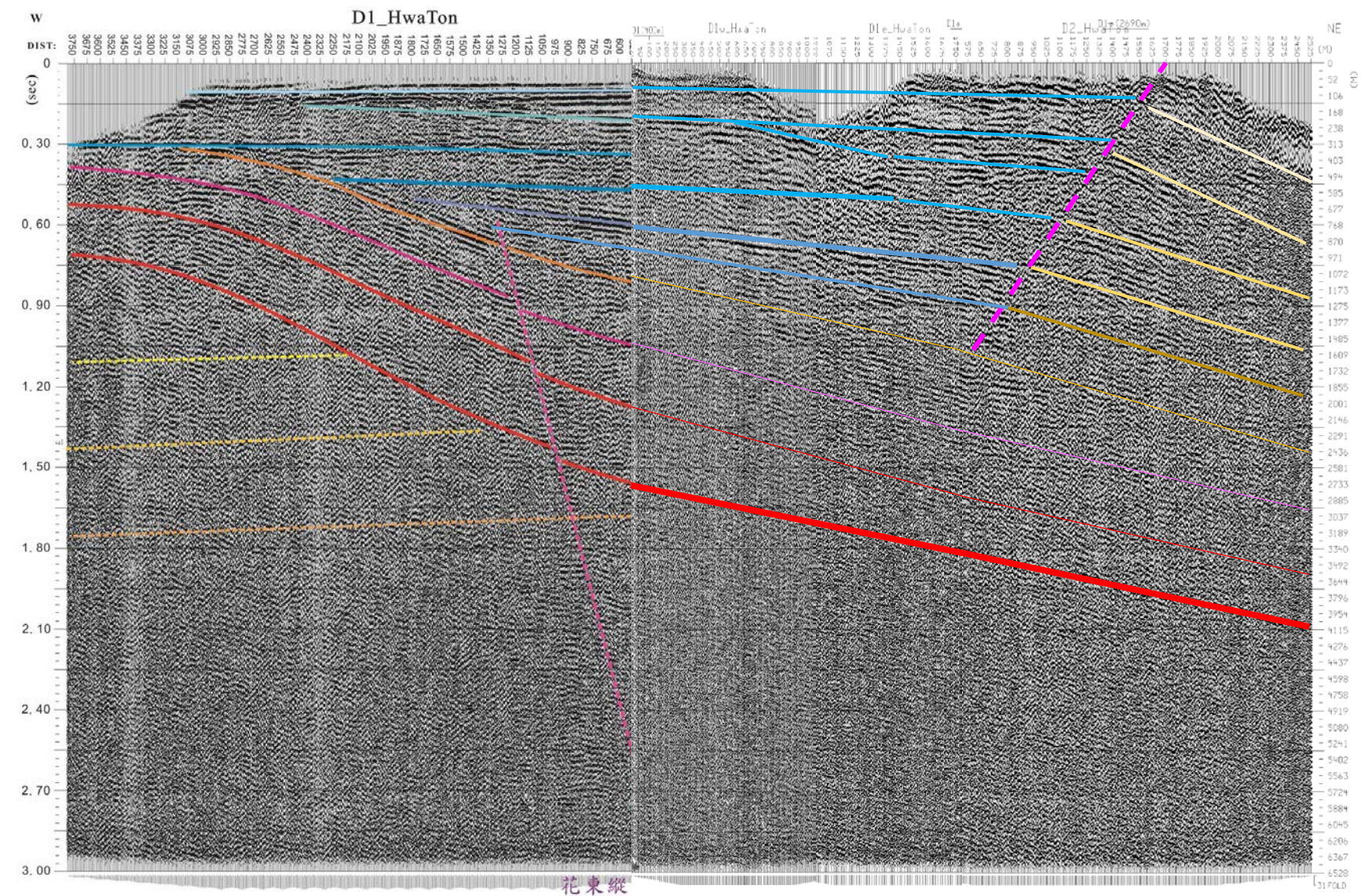
玉里剖面

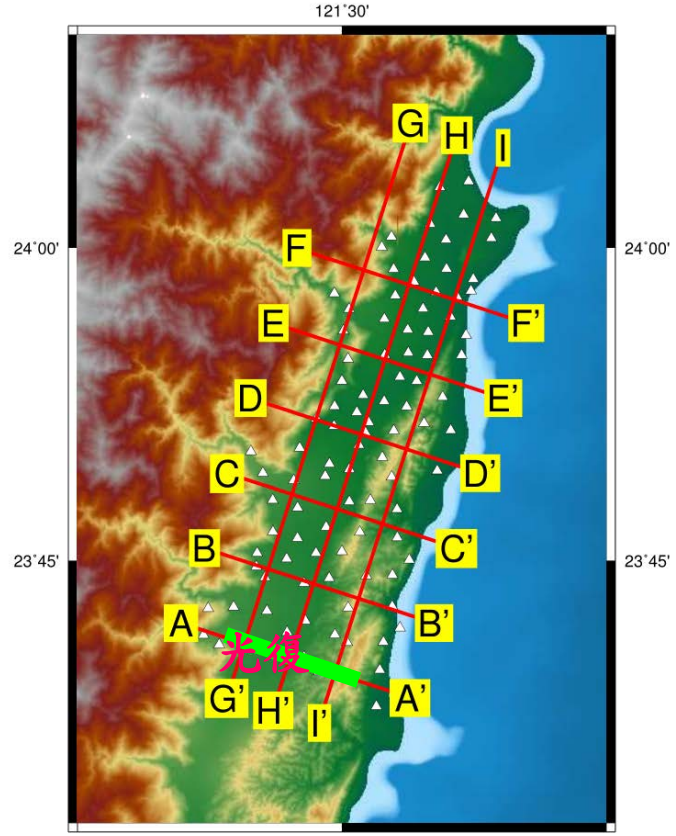


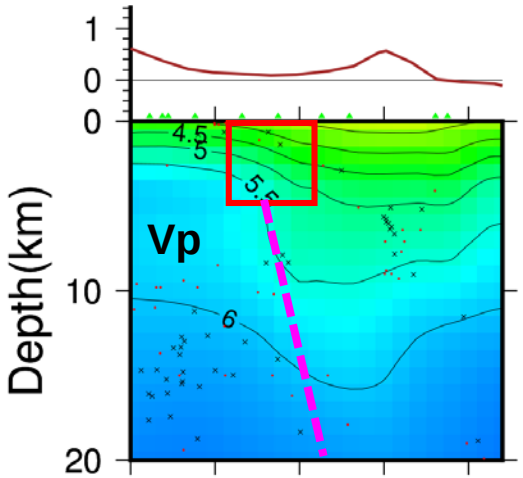
(郭陳澔與鄭璟郁，2018)

Seismic Reflection:

光復剖面







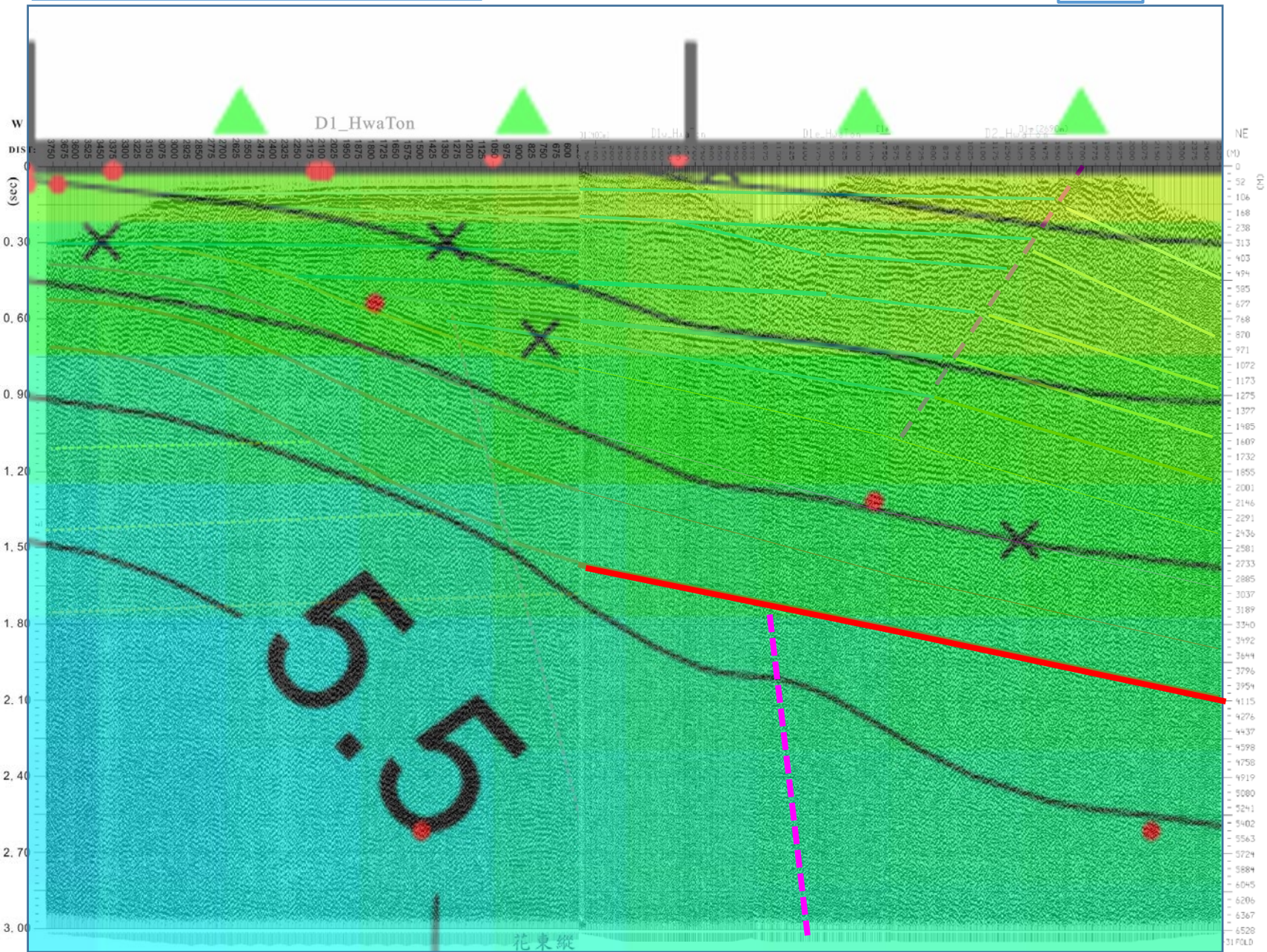
(郭陳澔、管卓康、孫維芳，2018)

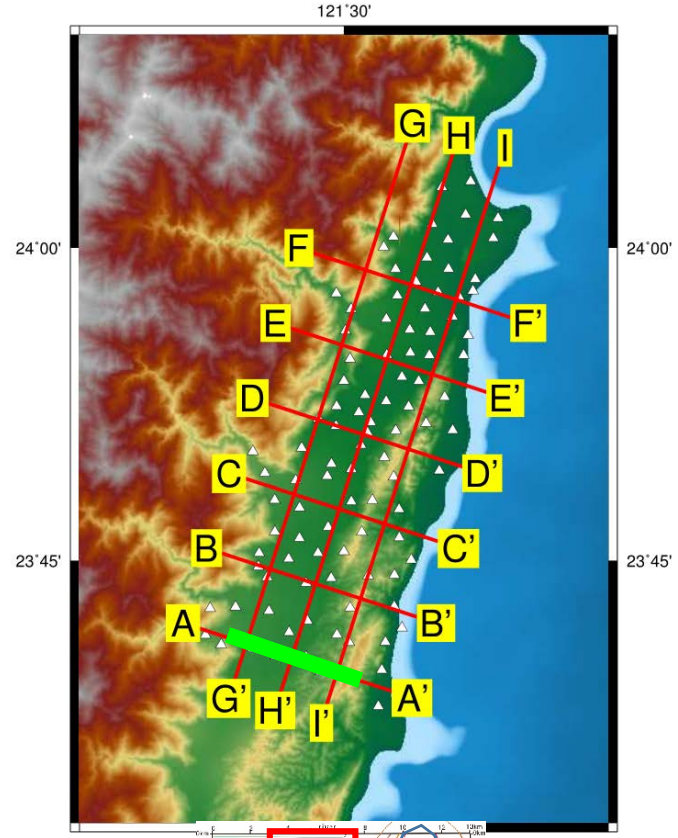
Seismic Reflection:

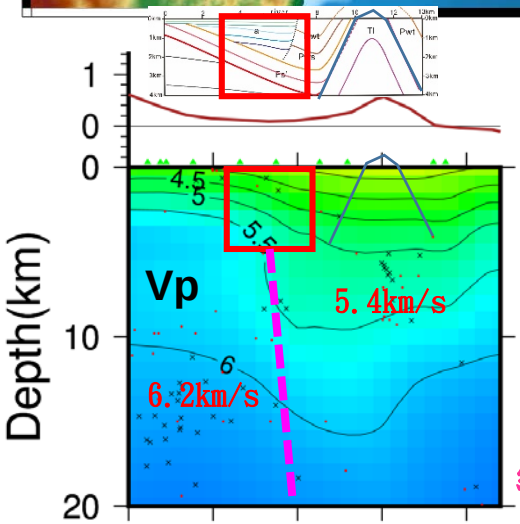
6.2km/s 中央山脈

5.0km/s 縱谷

5.4km/s 海岸山脈





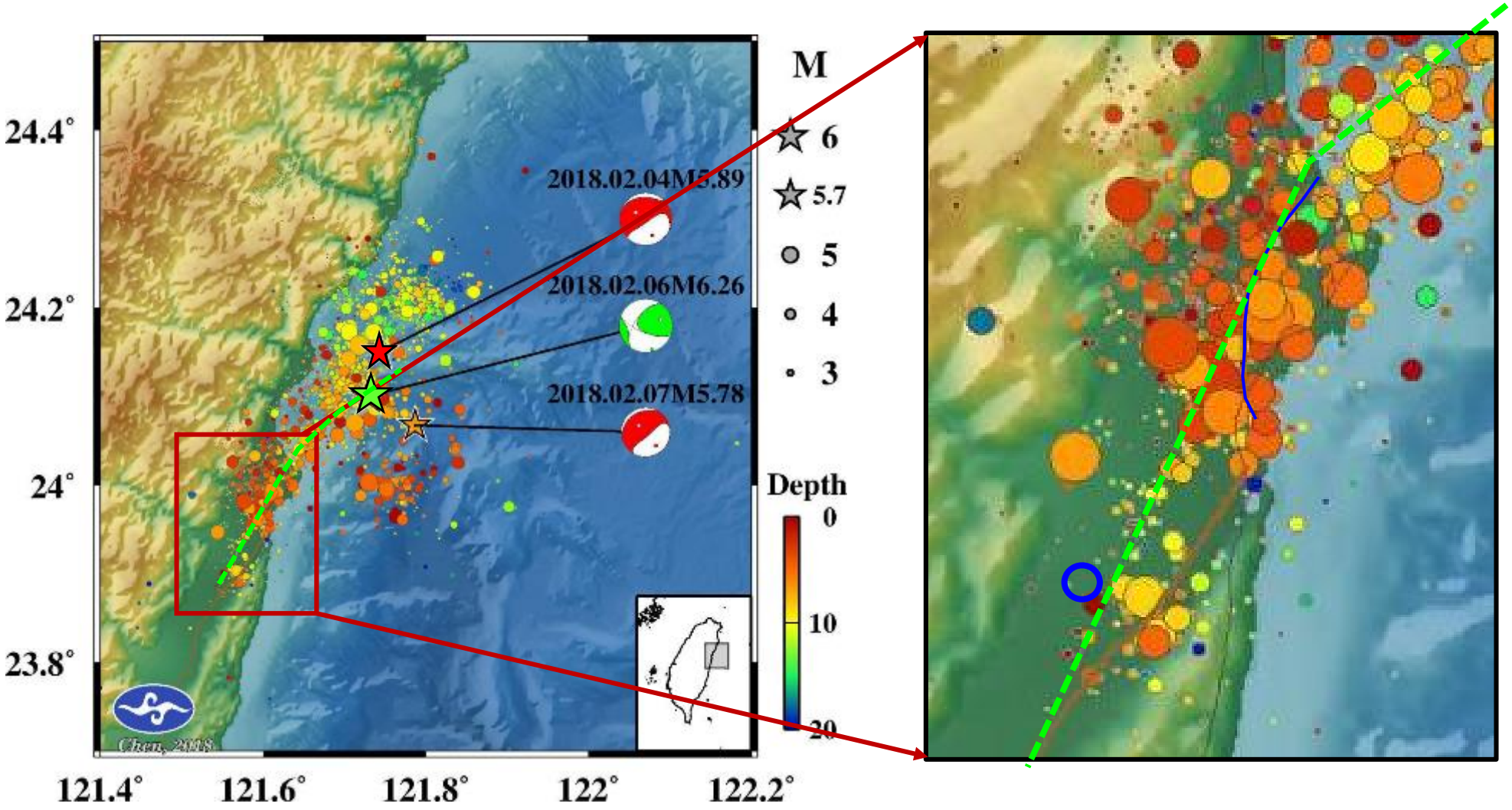


縱谷斷層

(郭陳澔、管卓康、孫維芳，2018)

1. 海岸山脈與造山運動
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面
6. 構造模型
7. 2018花蓮地震與米崙斷層(Milun Fault)
8. 結論

2018/04/02,06 花蓮地震（ML=5.9 及 6.3）



damage

Where is Milun fault?

2018 HuaLien Earthquake (M_L=6.3, M_w=6.4, depth=10.6km)

before earthquake

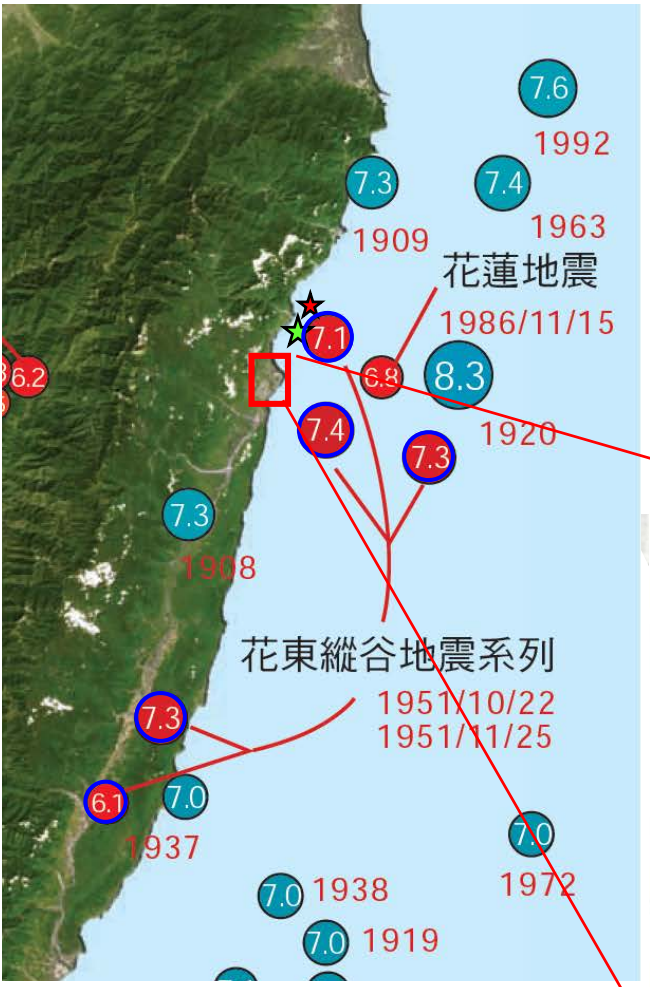
after earthquake

雲門翠堤大樓

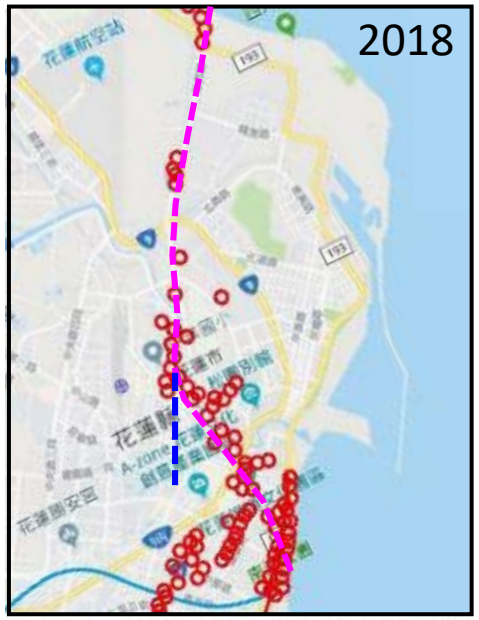
統帥飯店

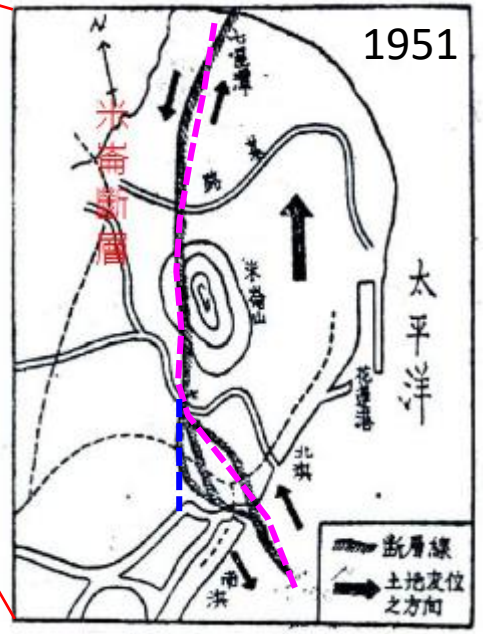
1951 HuaLien-TaiTon Sequence Earthquakes

發震時間	緯度 (°N)	經度 (°E)	震源深度 (km)	地震規模 (ML)
1951/10/22 05:34	23.875	121.725	4.0	7.4
1951/10/22 11:29	24.075	121.725	1.0	7.1
1951/10/22 13:43	23.825	121.950	18.0	7.3
1951/11/25 02:47	23.100	121.225	16.0	6.1
1951/11/25 02:50	23.275	121.350	36.0	7.3



米崙斷層



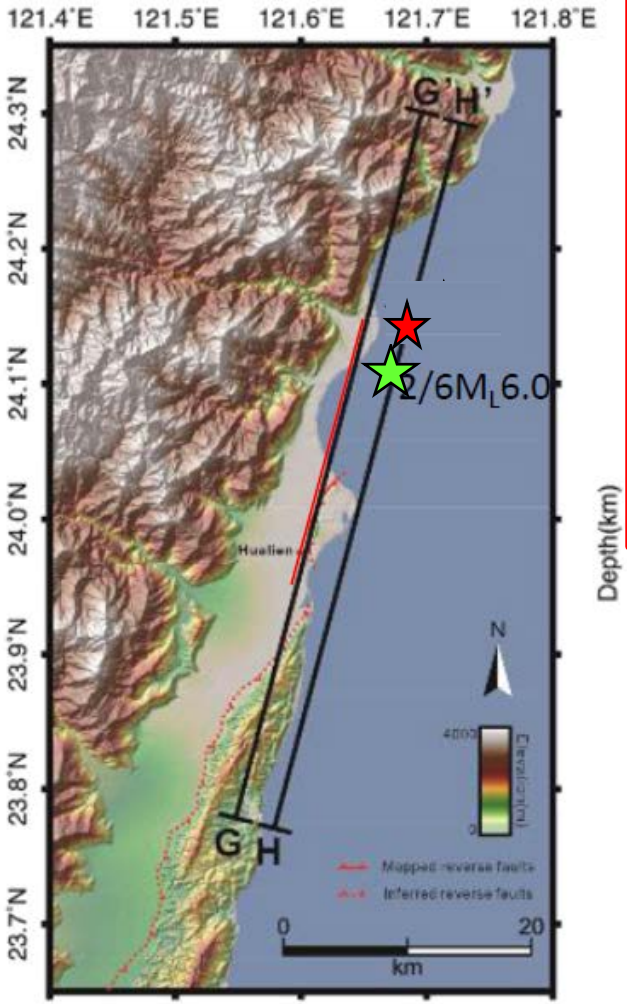


火車站前

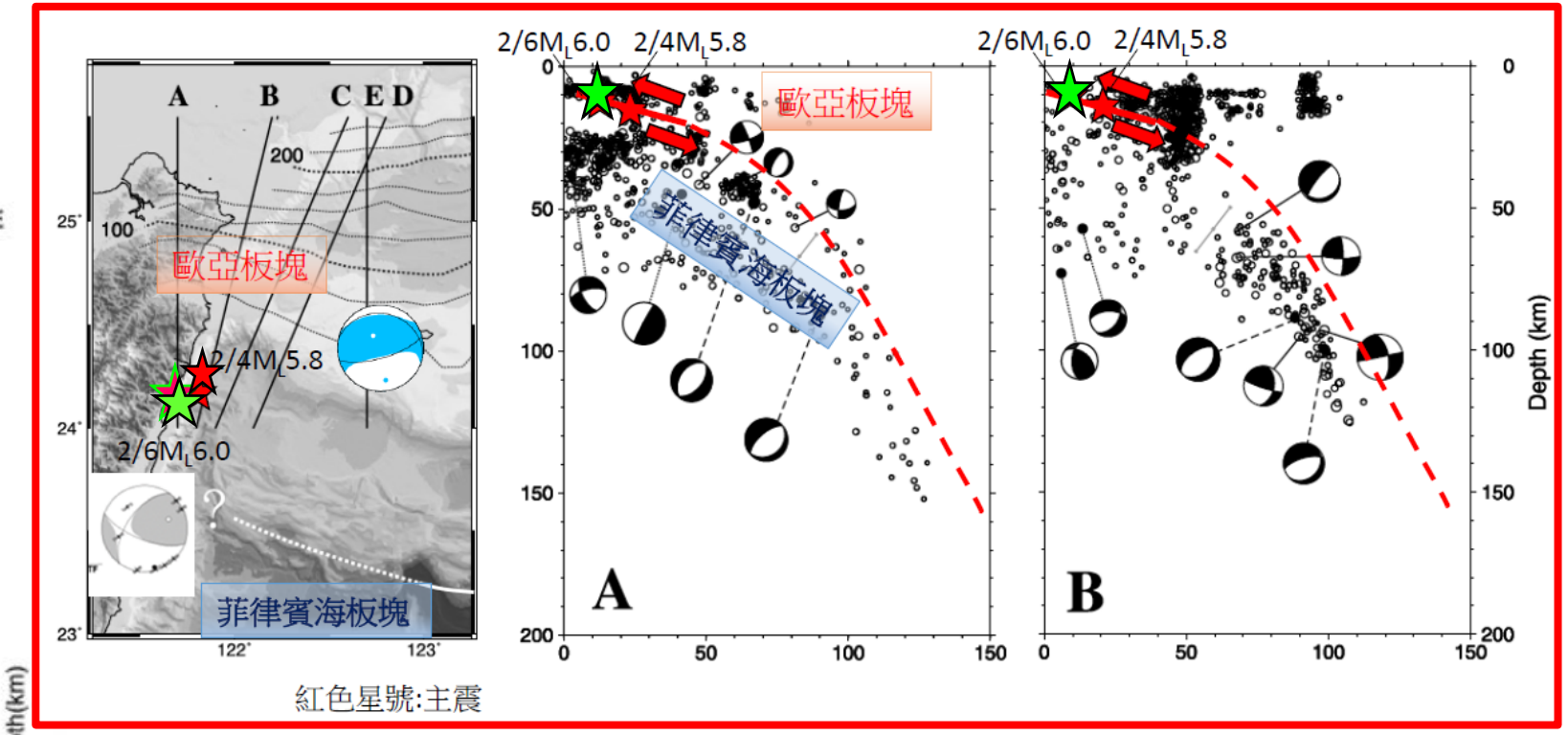
明禮國小

中正路

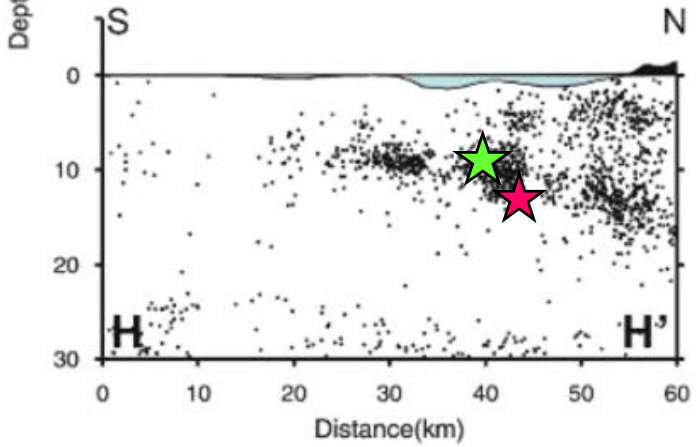
中華路

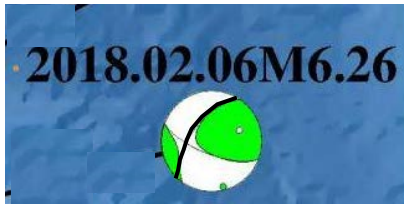


(Shyu et al., 2016)



紅色星號:主震

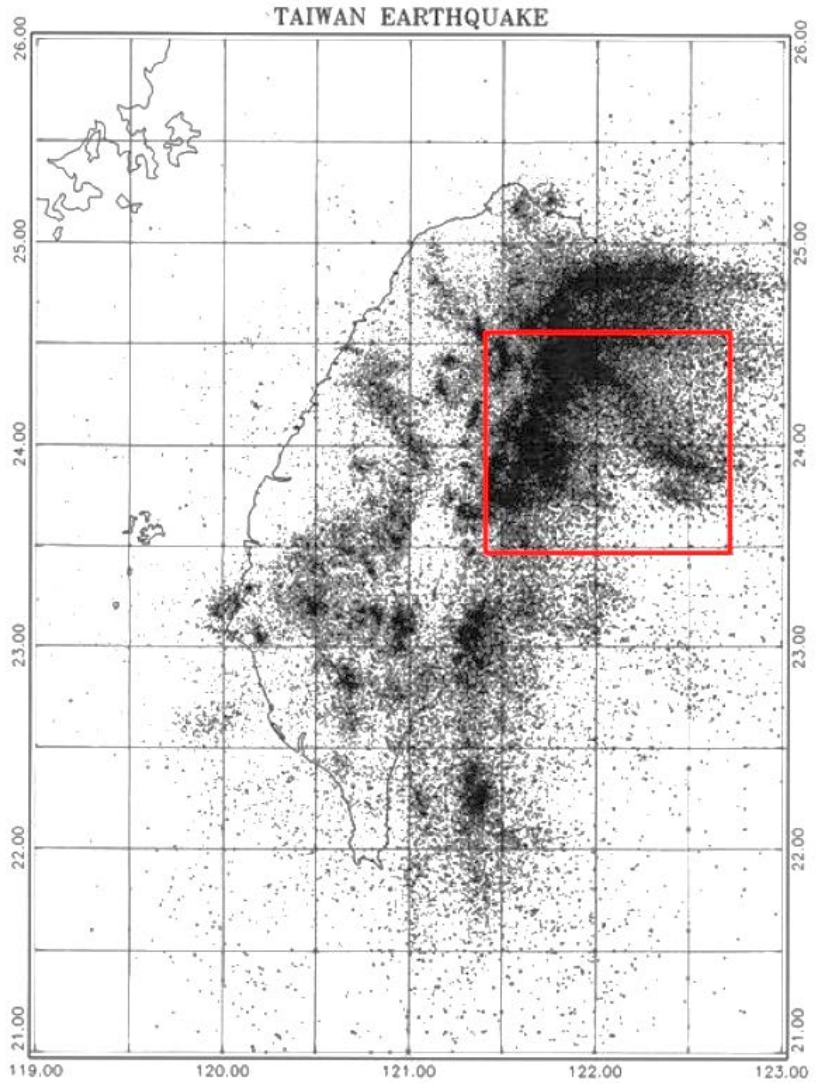


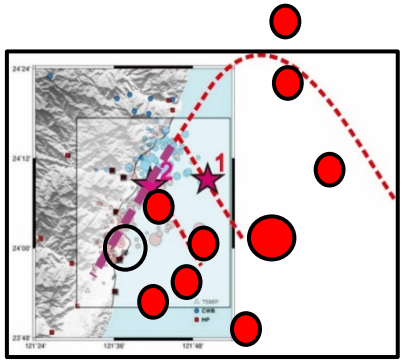


side collision
(strike slip)

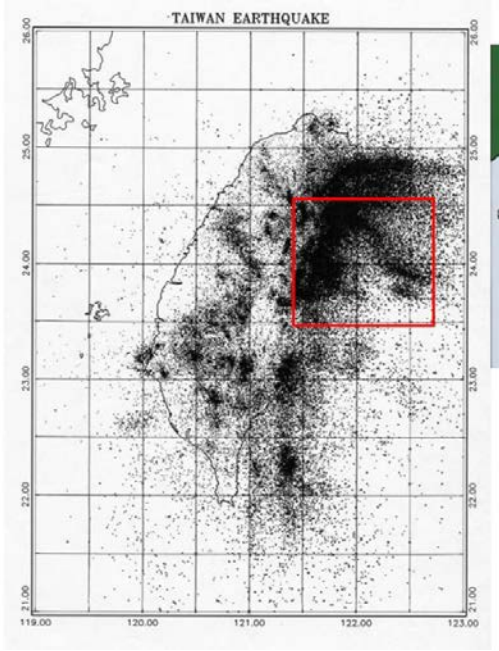
Subduction
(thrust)

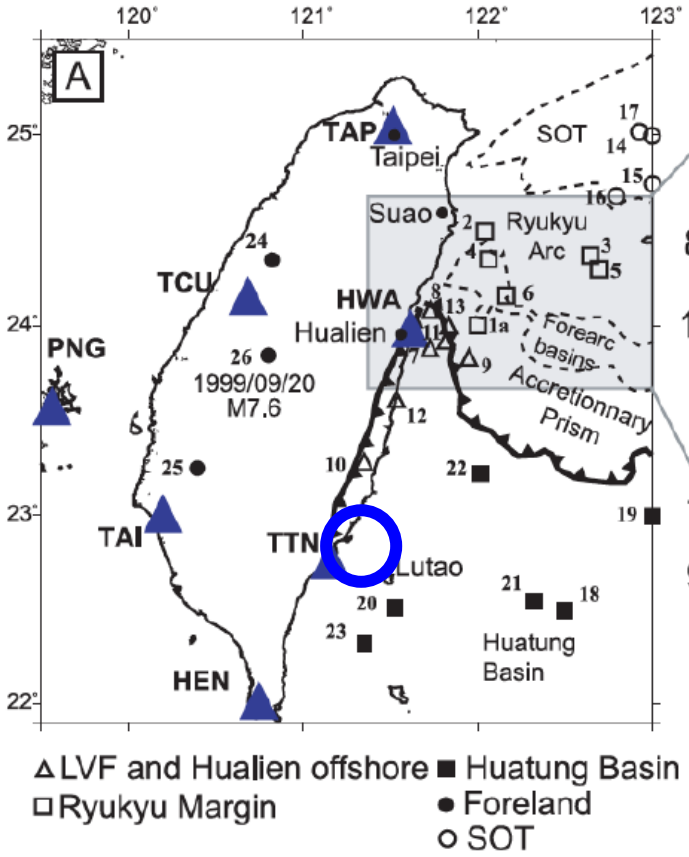
花蓮-蘇澳外海（台灣地震最密集帶）

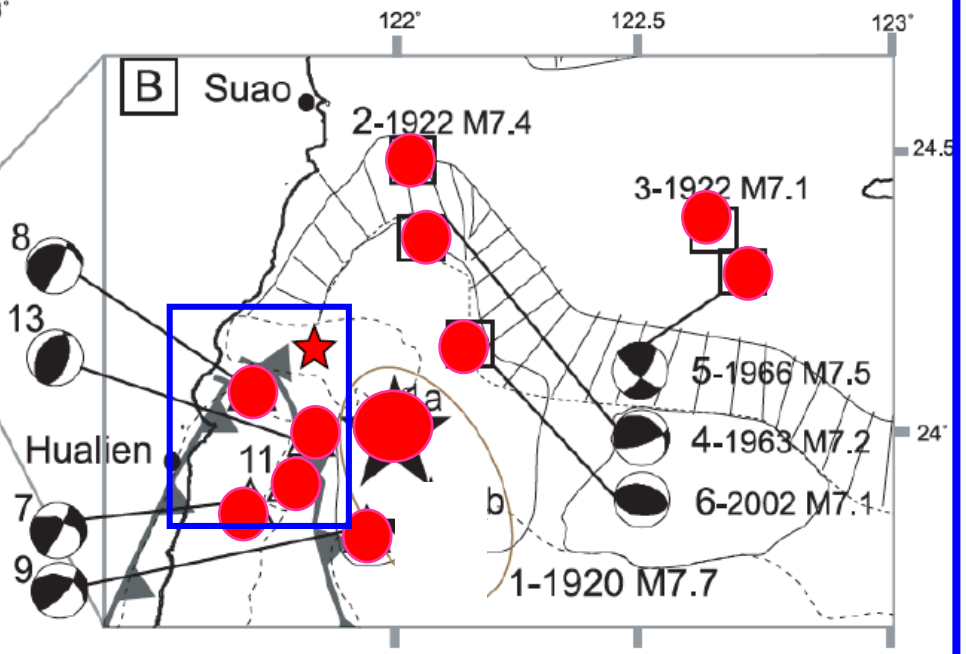




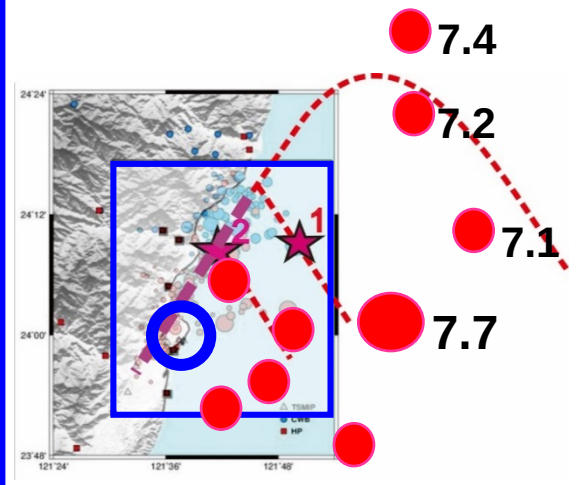
終端扇型壓縮帶

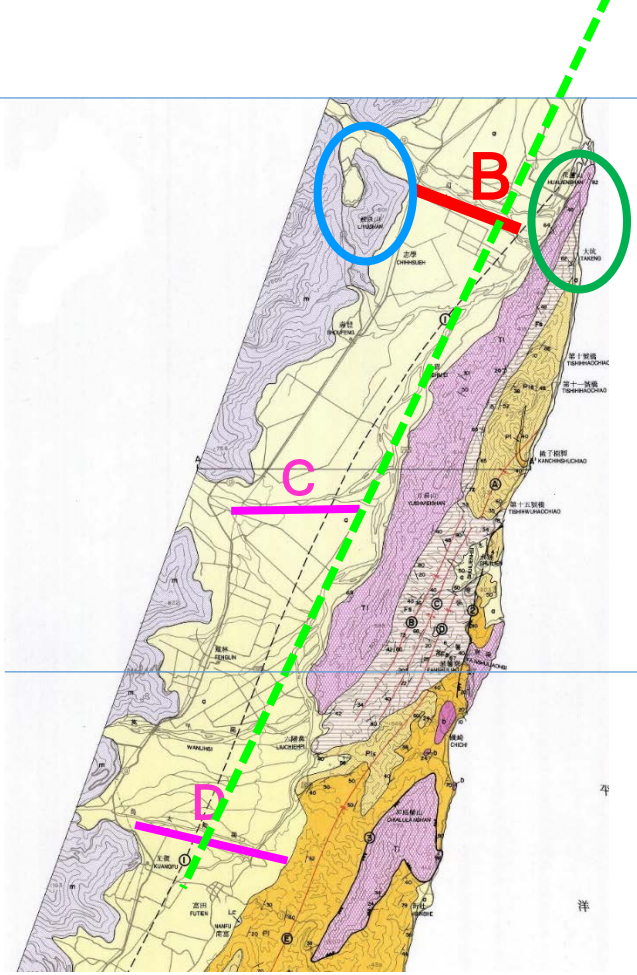


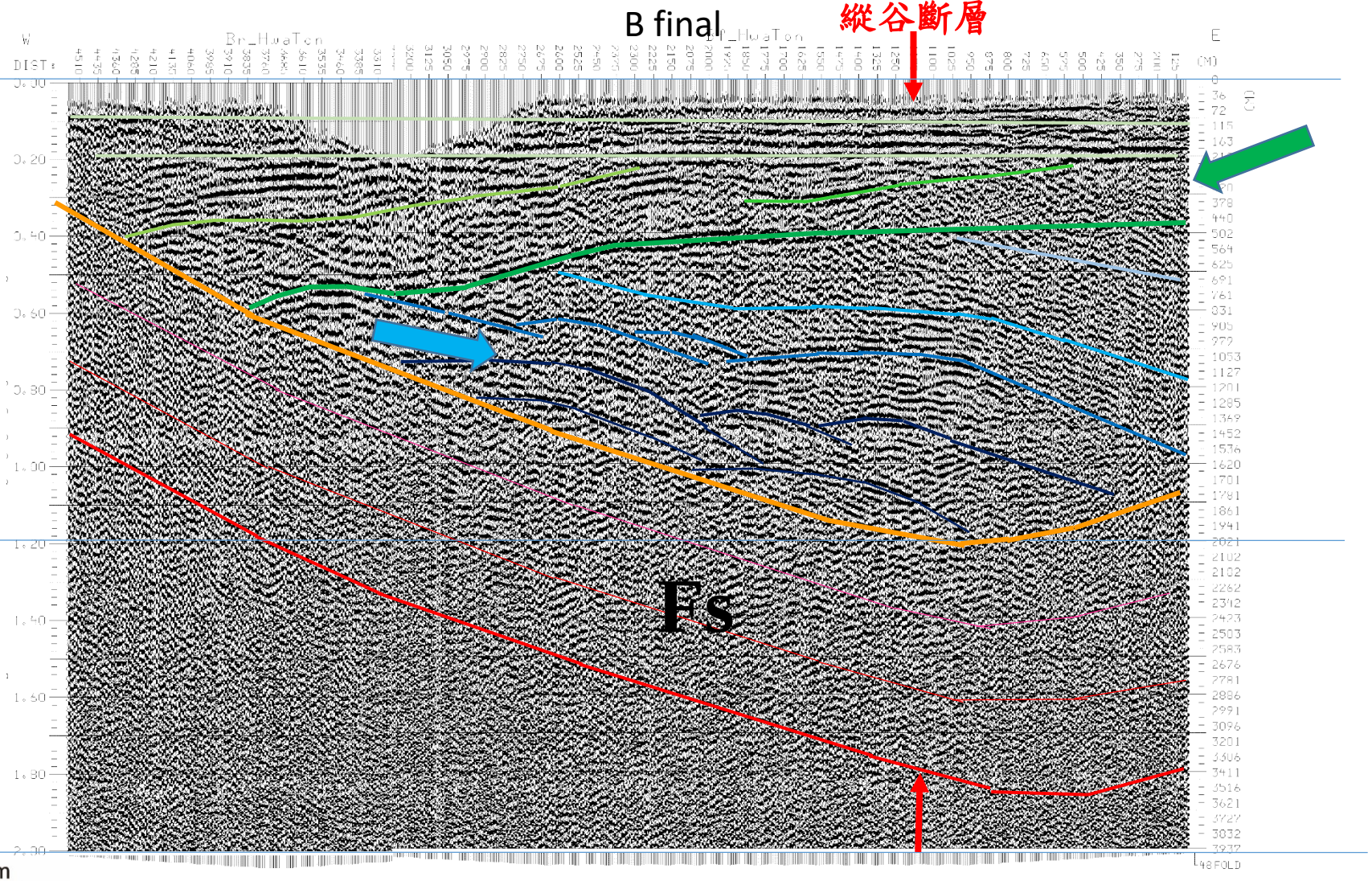


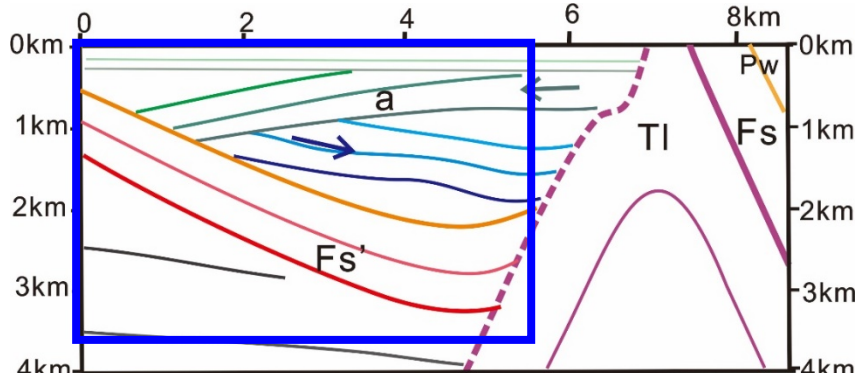


紅色星號:主震





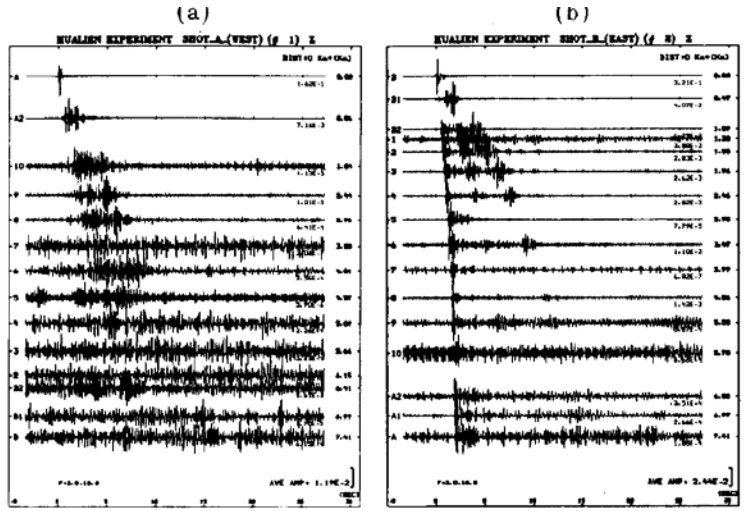


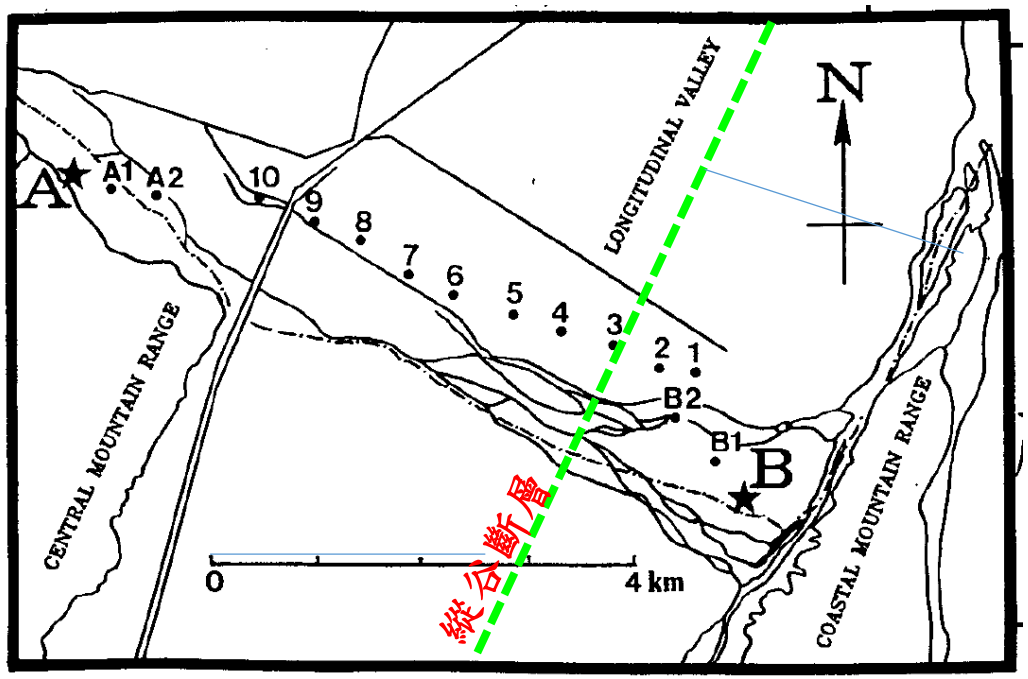


沖積層有三次沈積

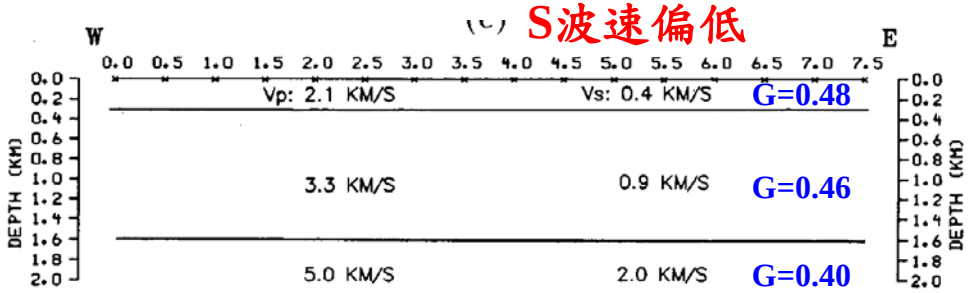
淺部西傾的沖積層(綠色)顯示: 該層沉積時，東邊的海岸山脈是在附近，後來才東退。

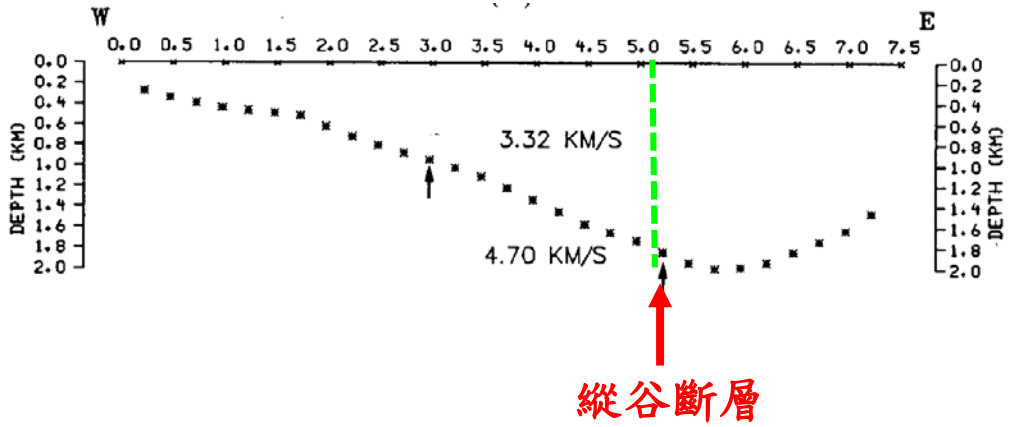
木瓜溪折射震測 (Wang and Chen, 1997)

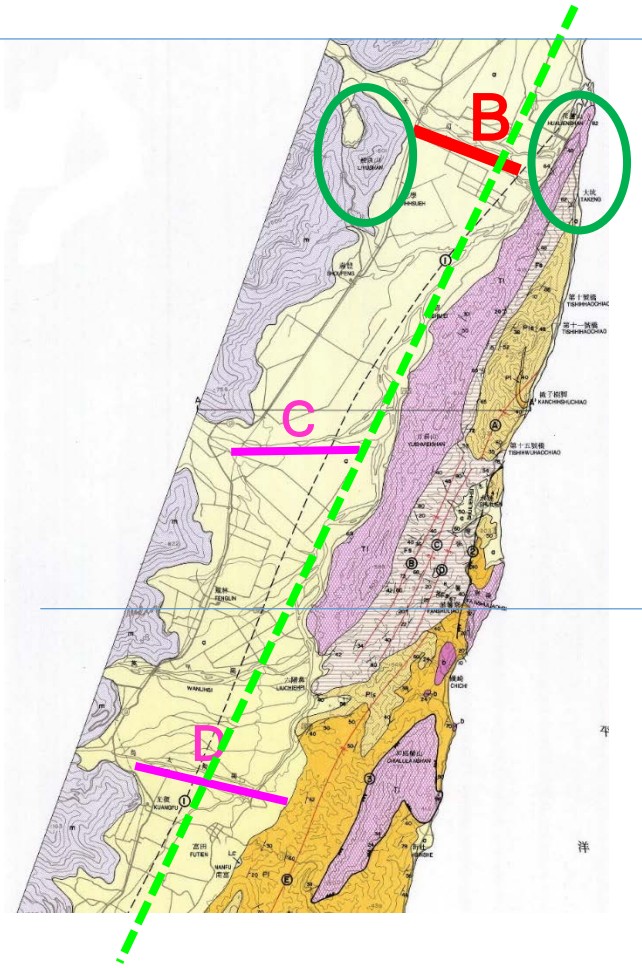




50kg

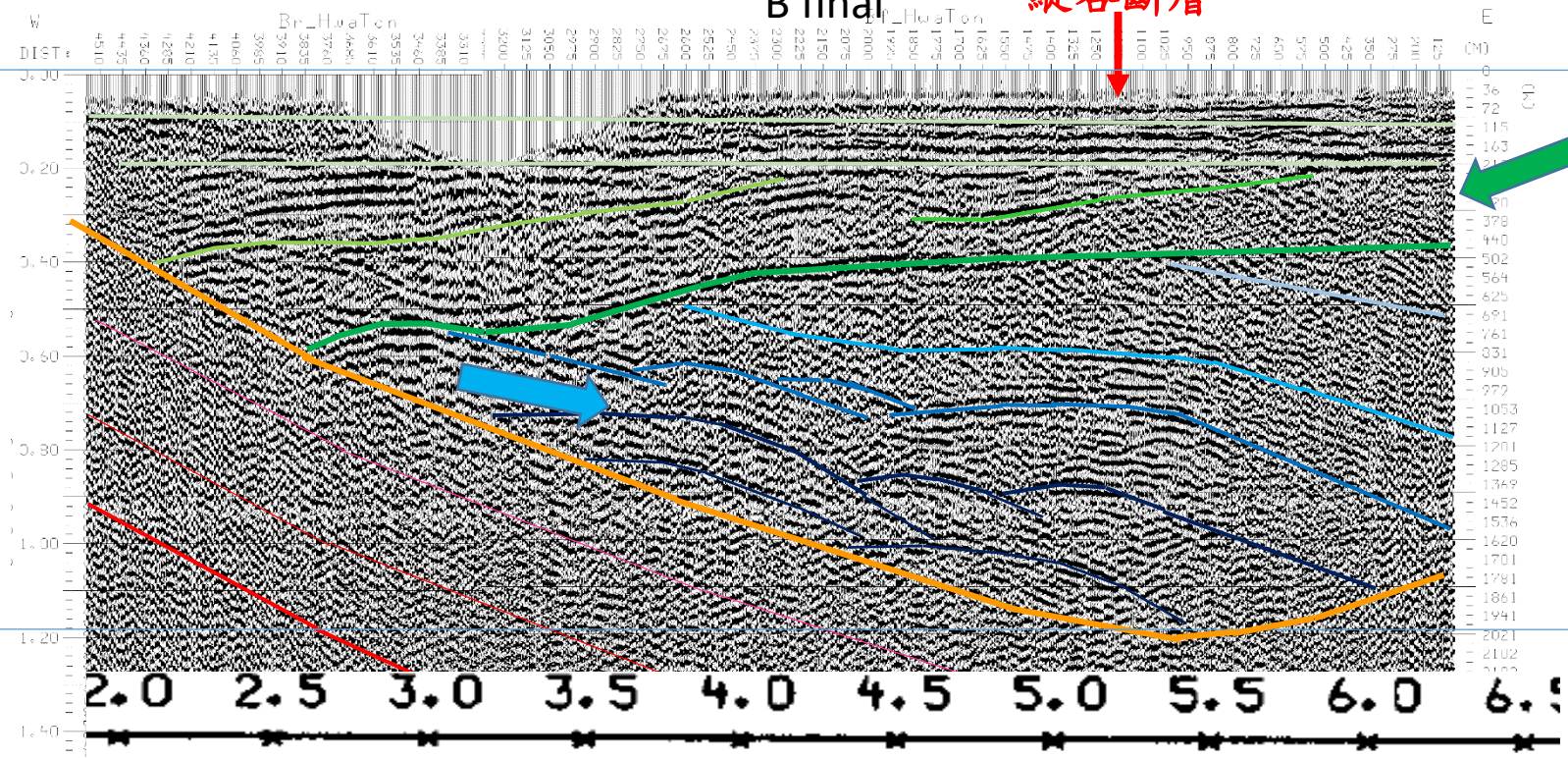




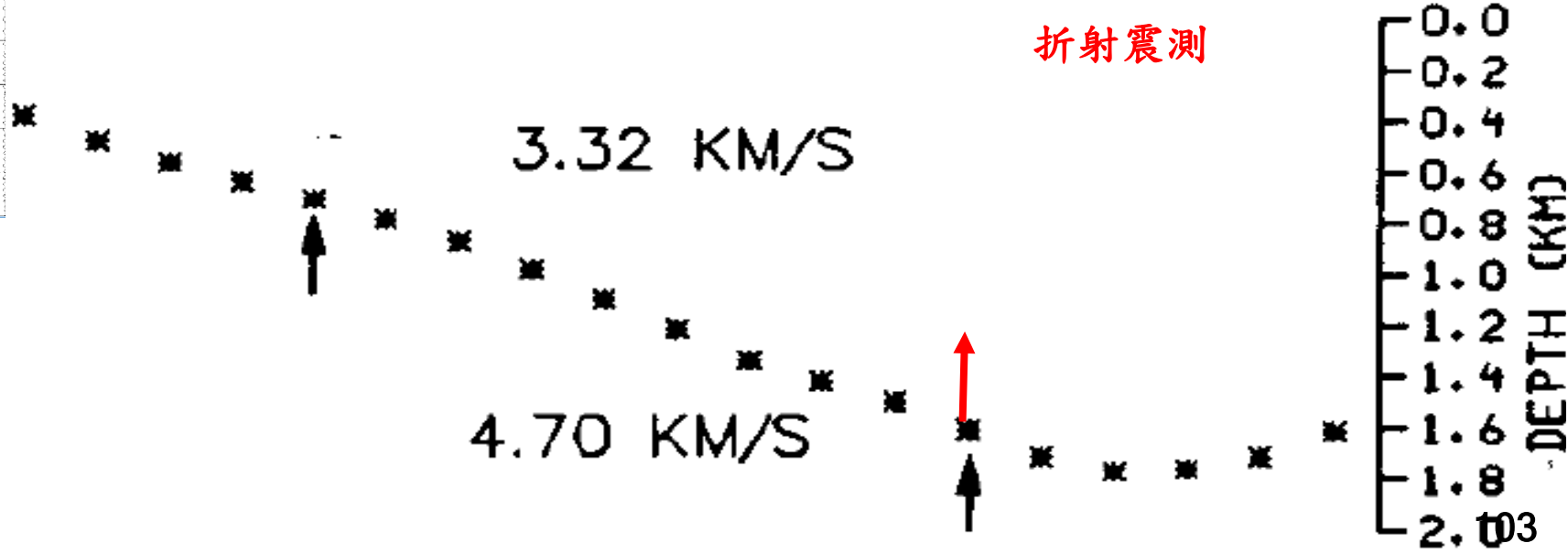


B final

縱谷斷層



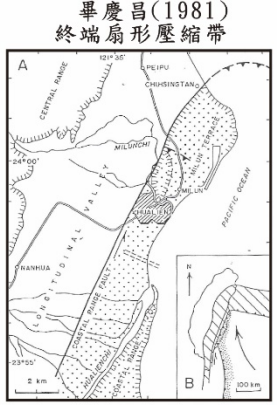
折射震測



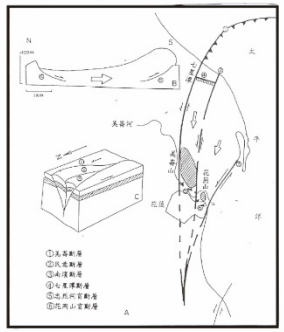
七星潭測線

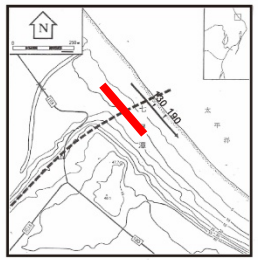
(Wang and Chang, 1994)

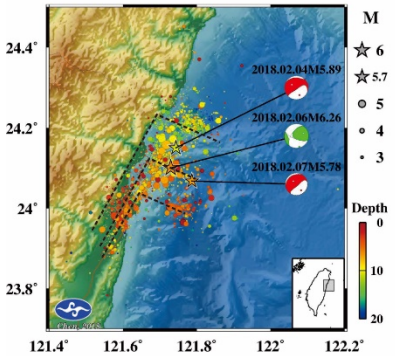
畢慶昌(1981)
終端扇形壓縮帶

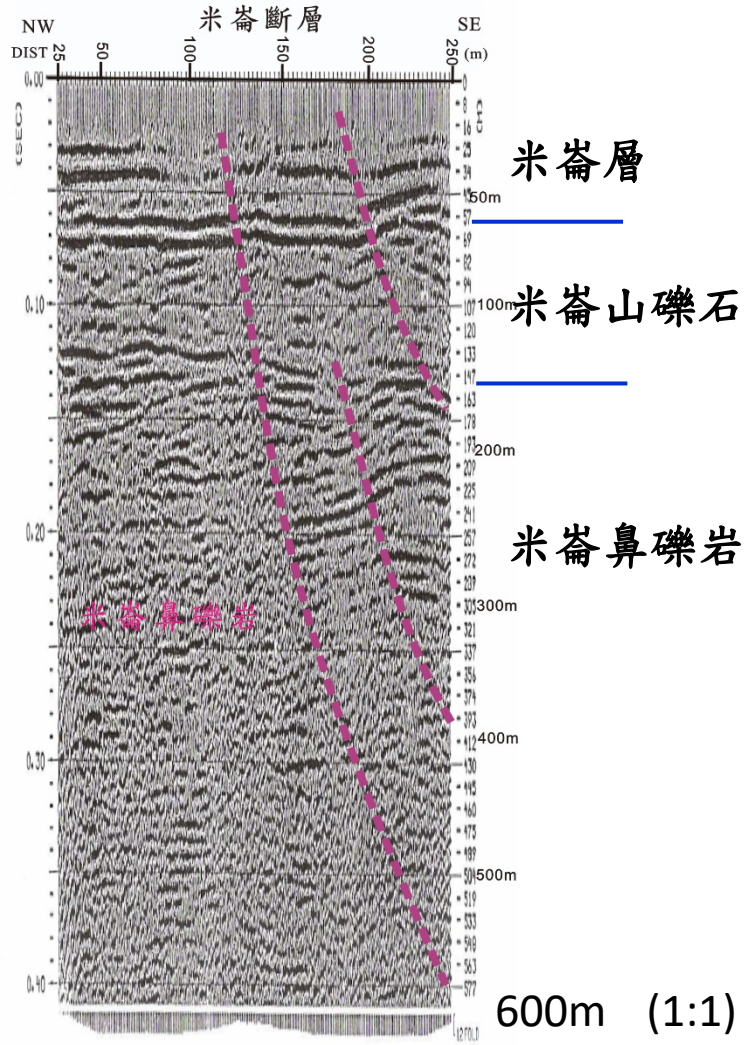


游明聖(1996)
紅燈右轉

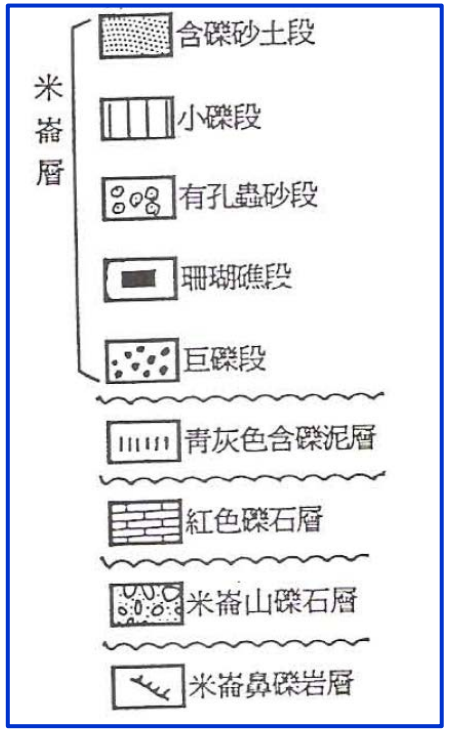




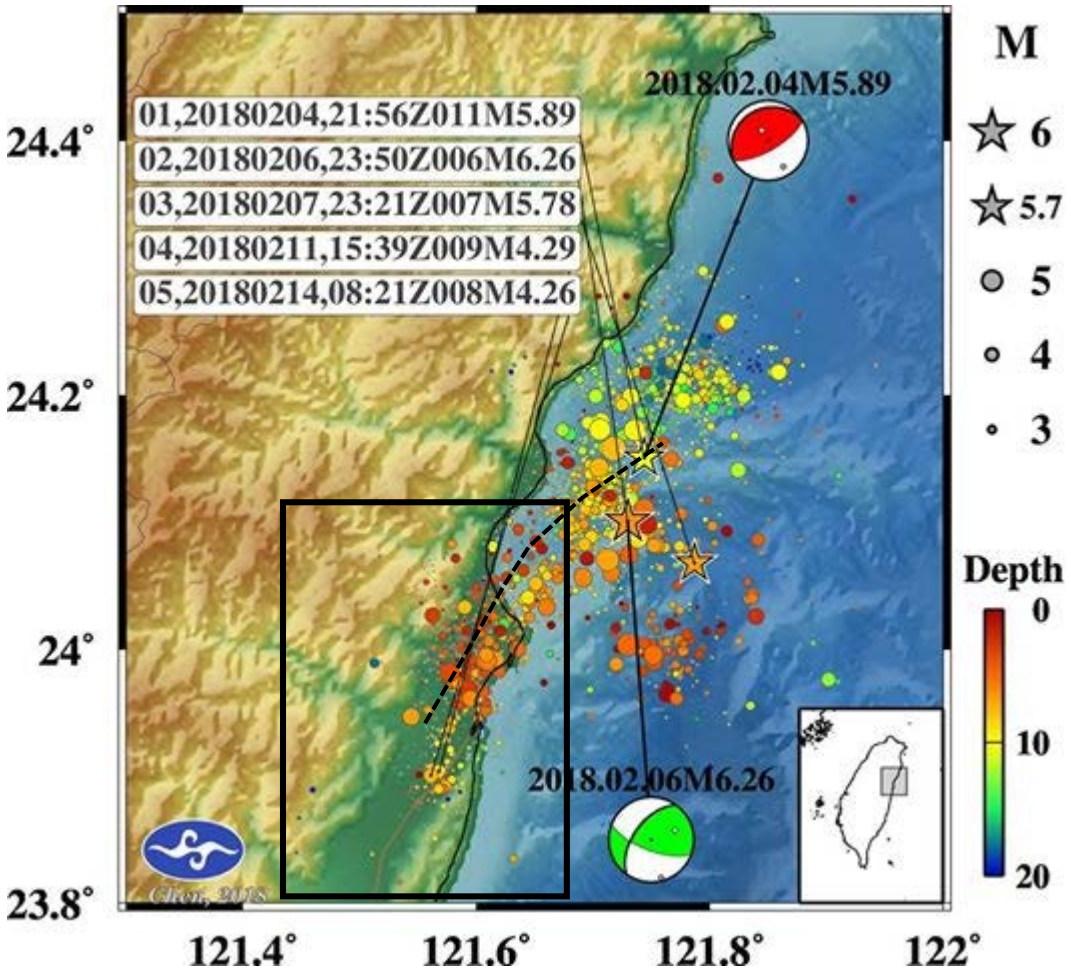




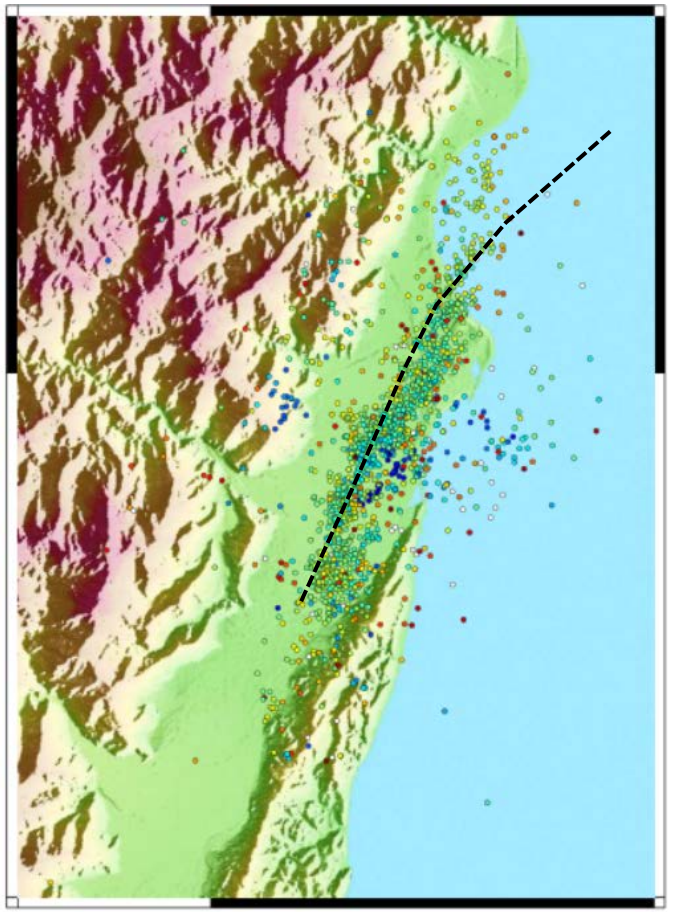
一序列高解度
東傾之斷層帶



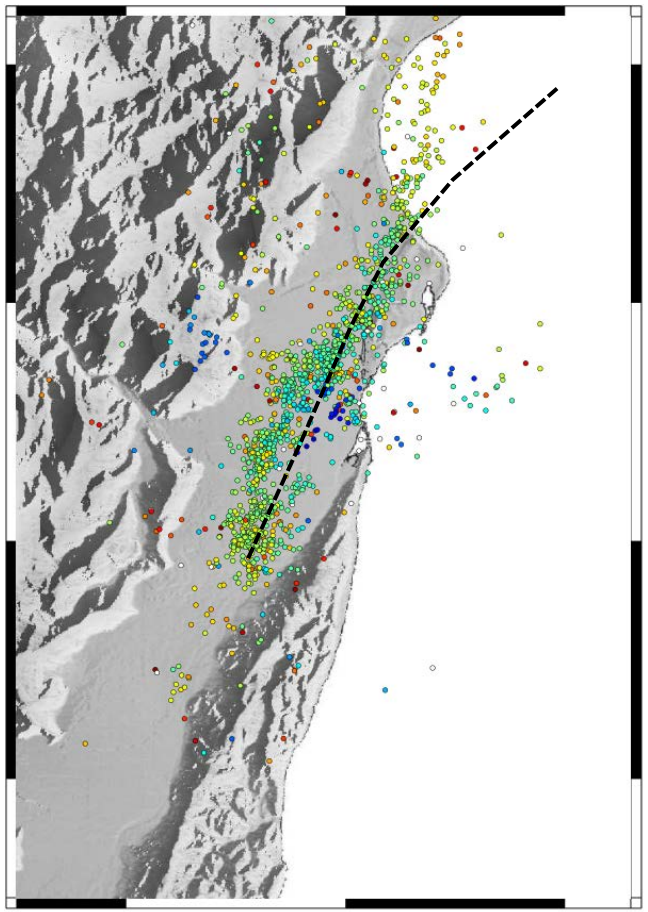
20180206 花蓮地震



臨時站
餘震分布

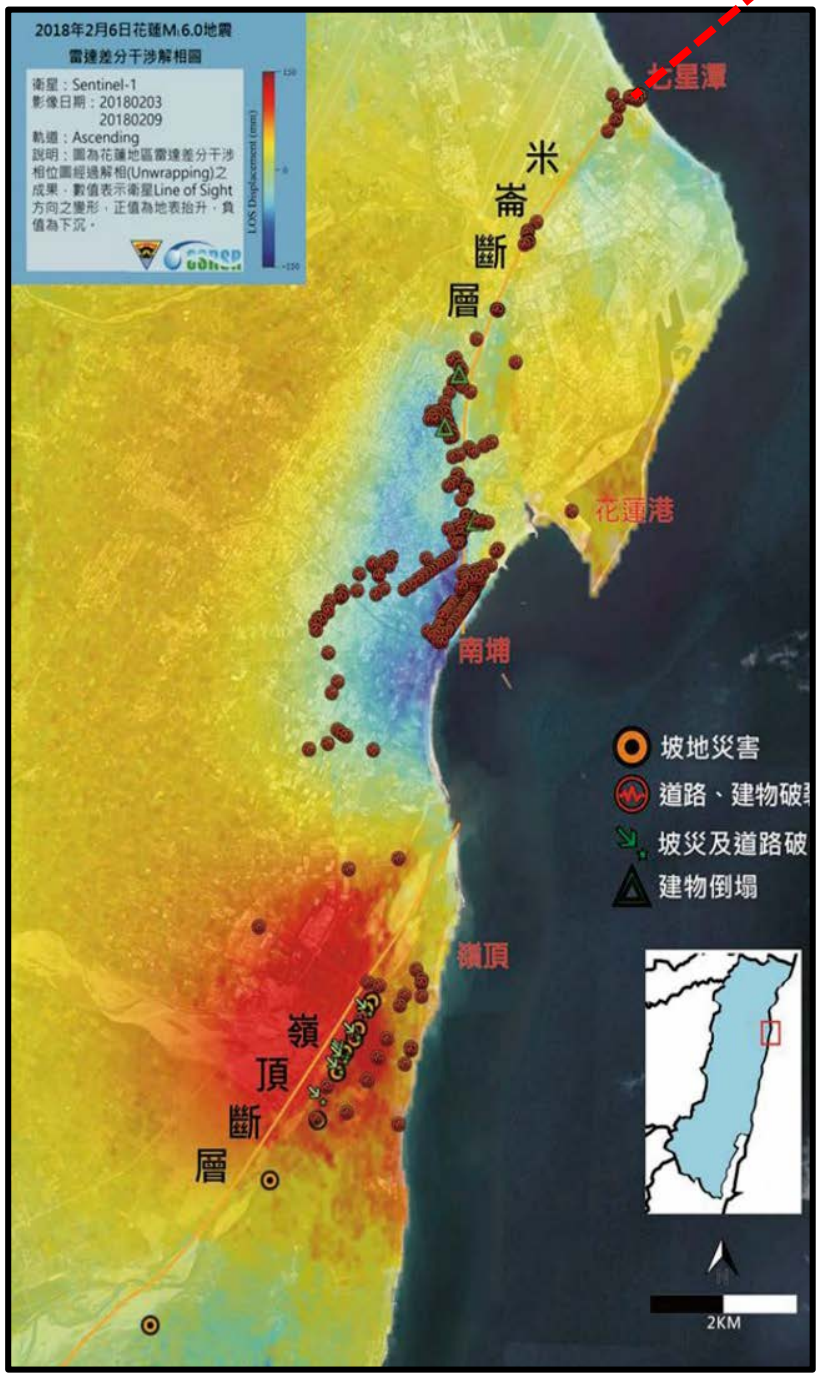


臨時站
餘震分布(最佳1500個)

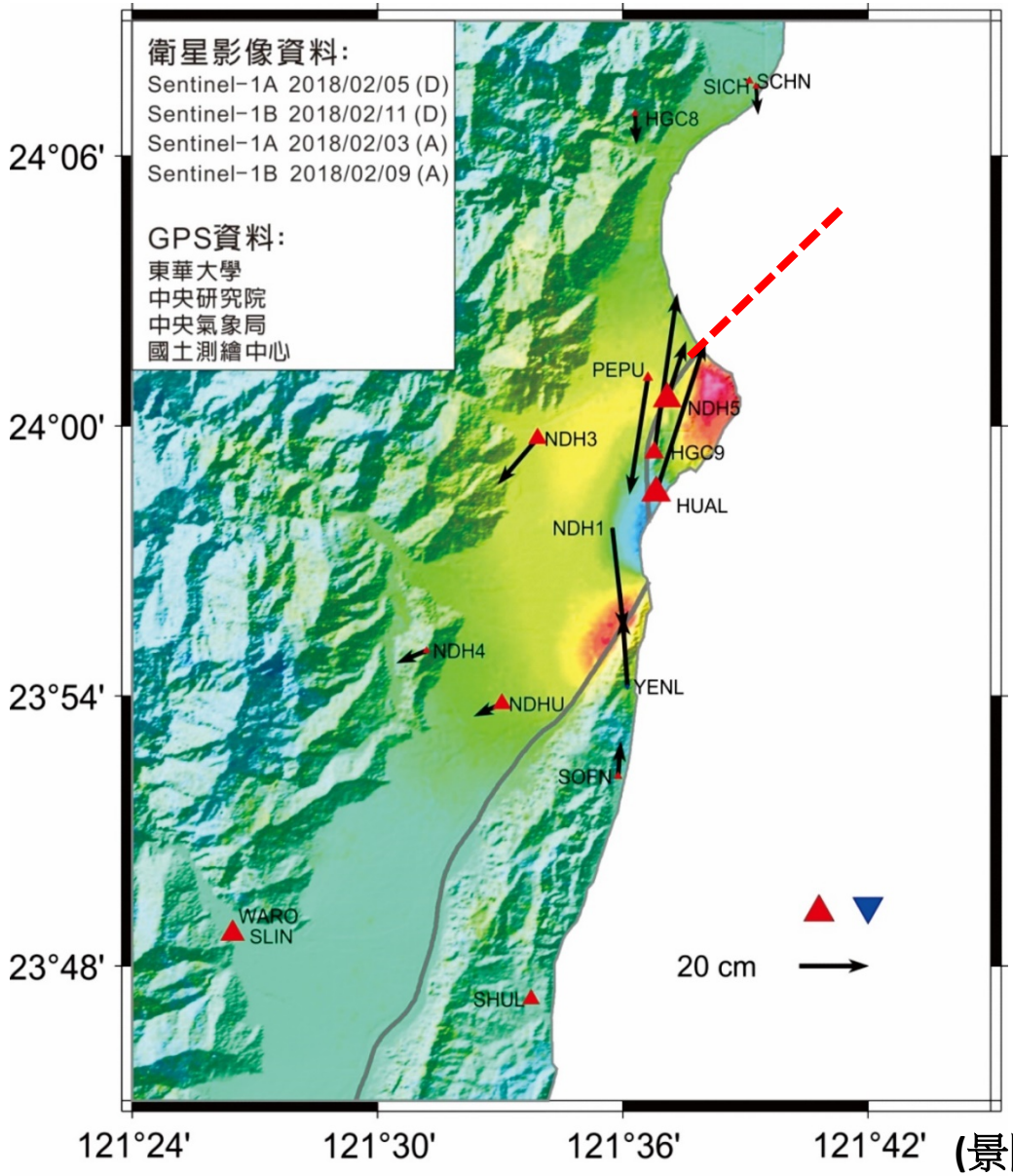


(郭陳澔、管卓康、孫維芳，2018)

同震變形

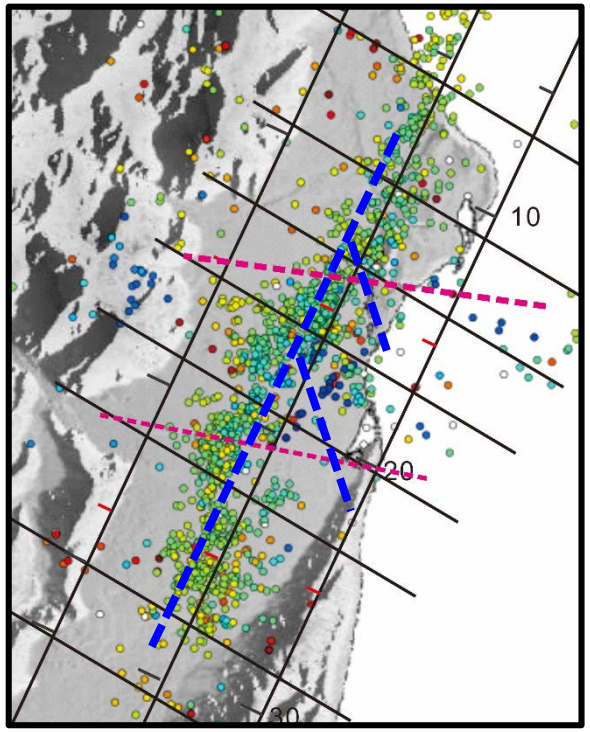


(張中白與
顏君毅，2018)

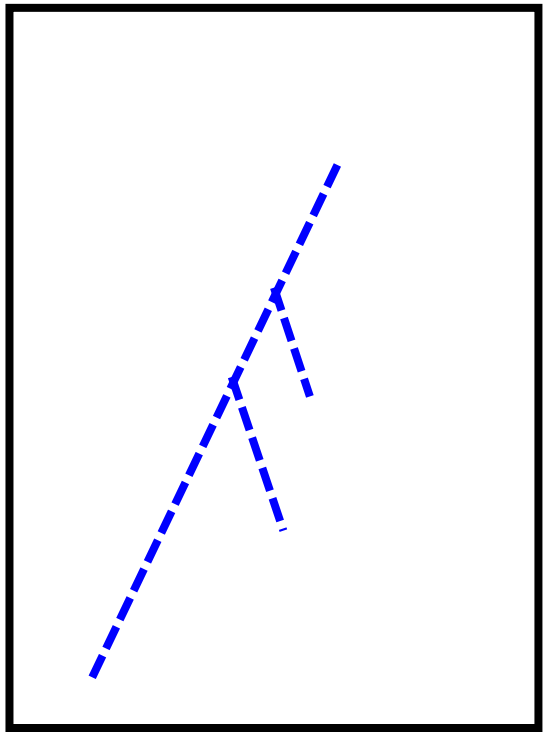


(景國恩，2018)

20180206地震
餘震分布

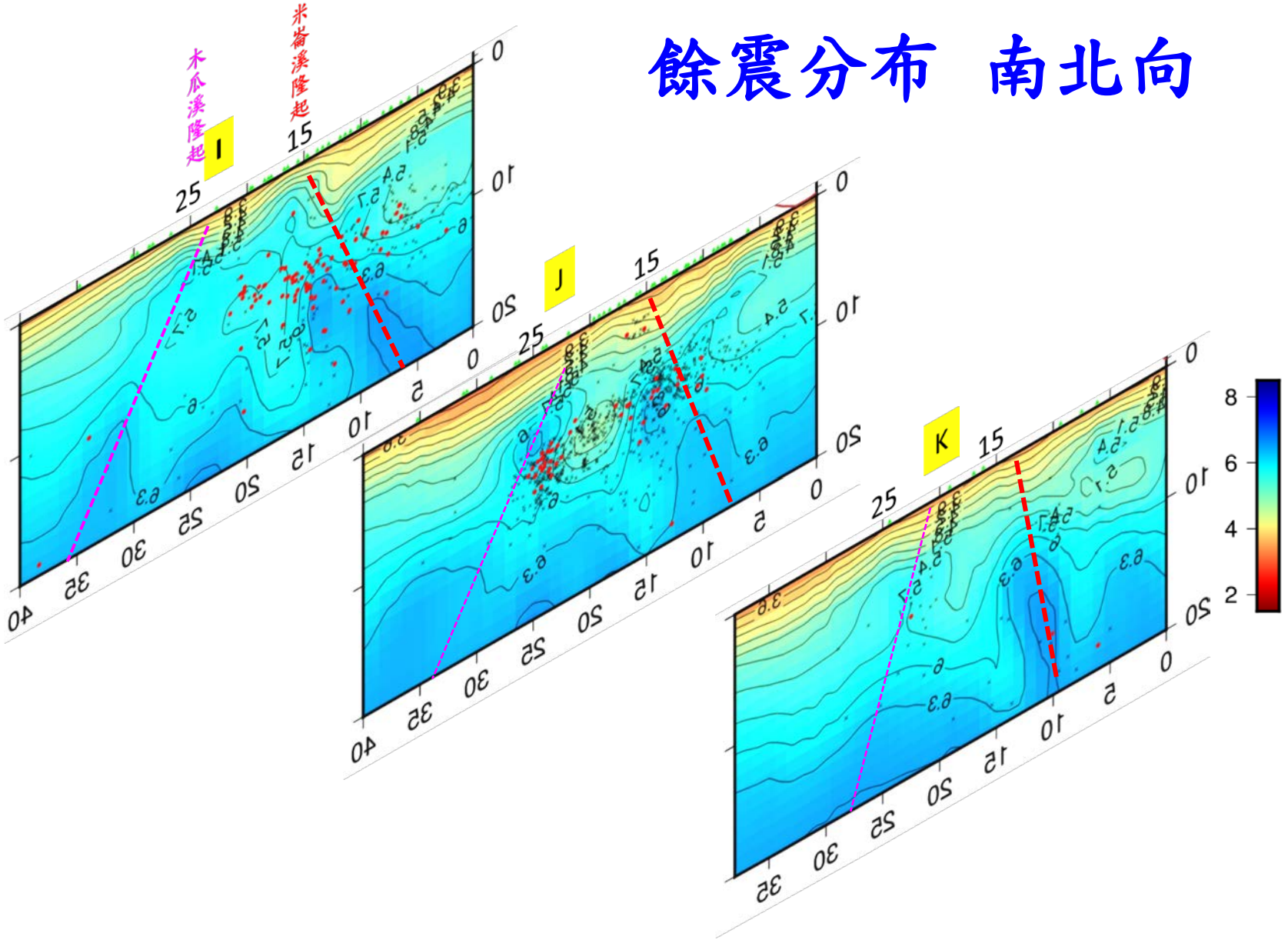


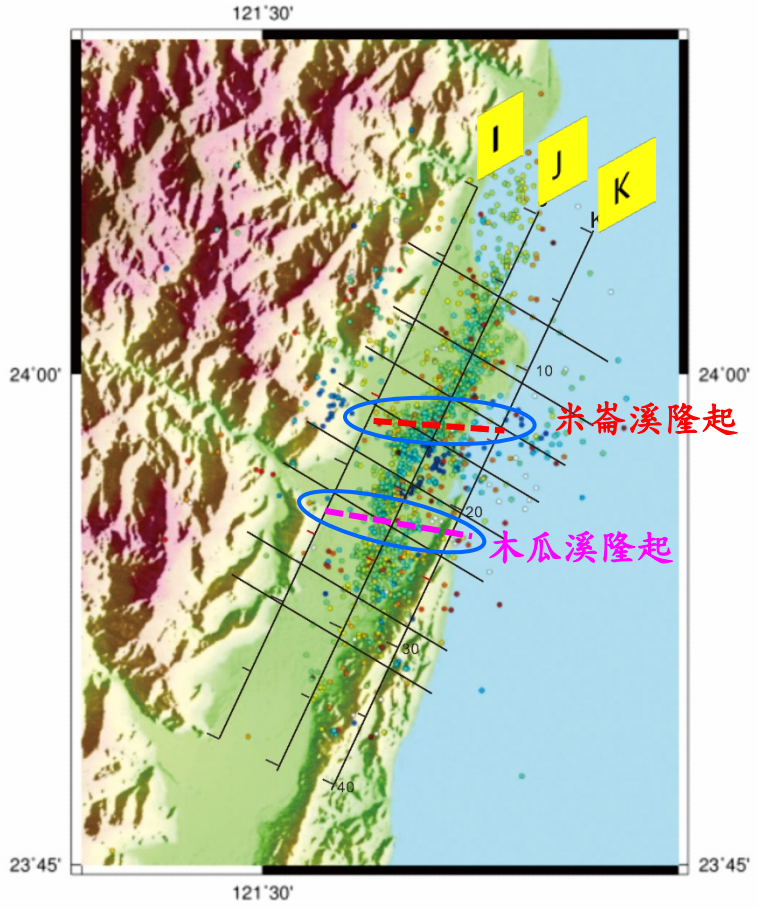
徐鐵良(1962)
縱谷斷層說



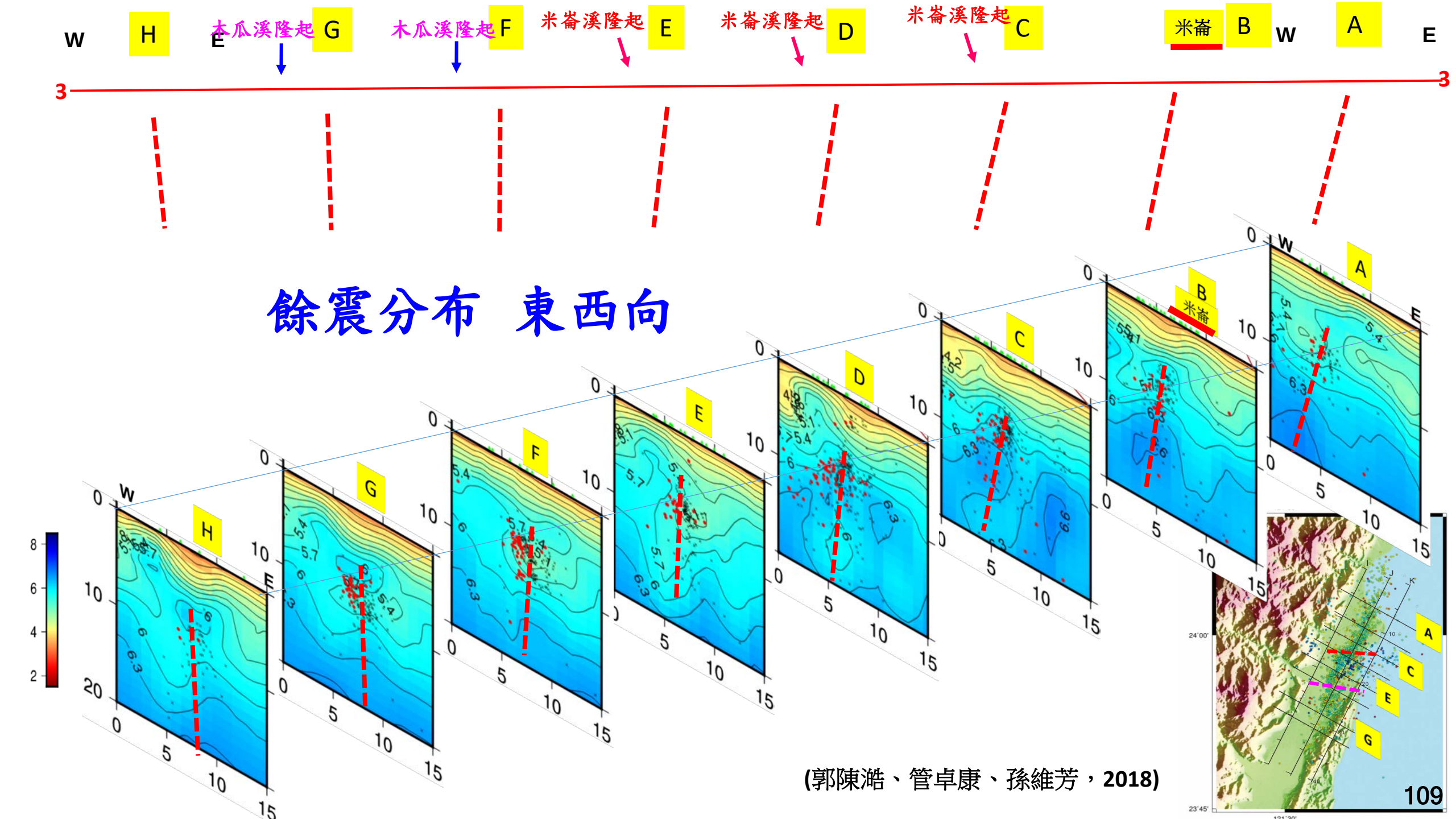
20180206地震
地表破裂

餘震分布 南北向





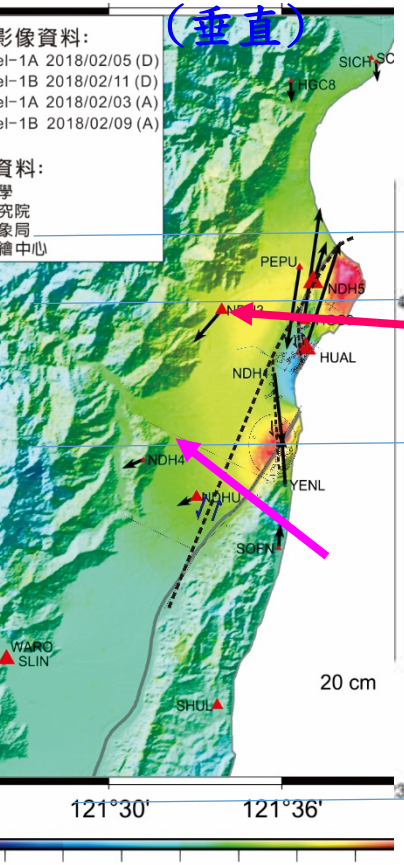
(郭陳澔、管卓康、孫維芳，2018)



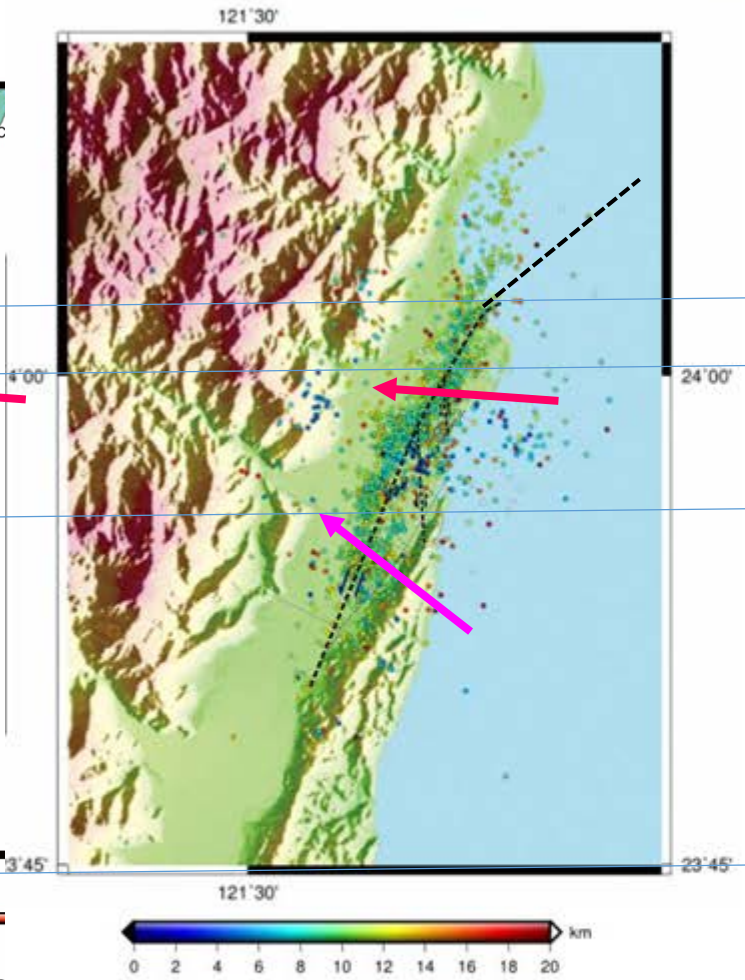
(郭陳澔、管卓康、孫維芳，2018)

餘震分布

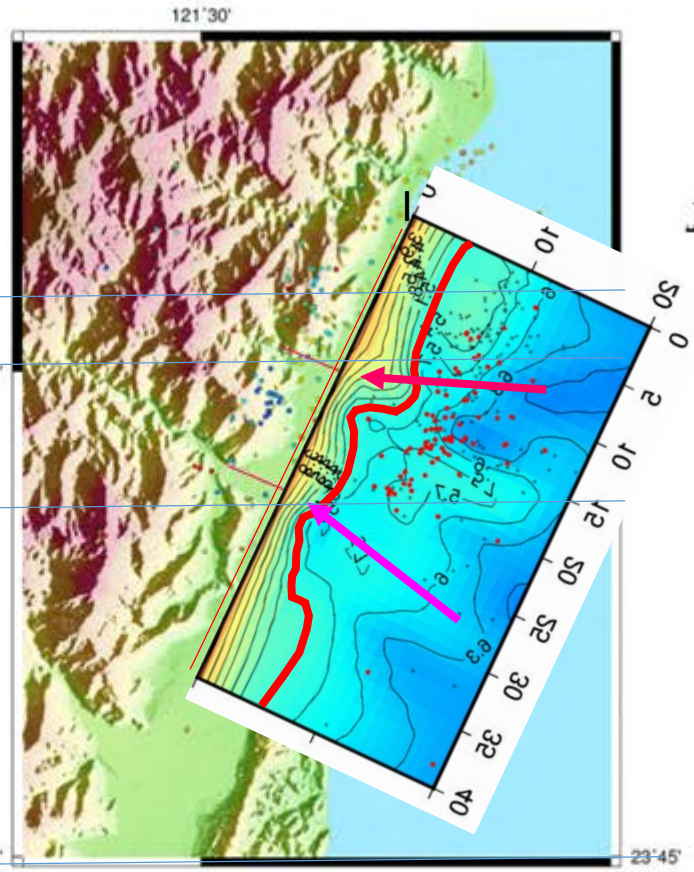
同震變形（垂直）

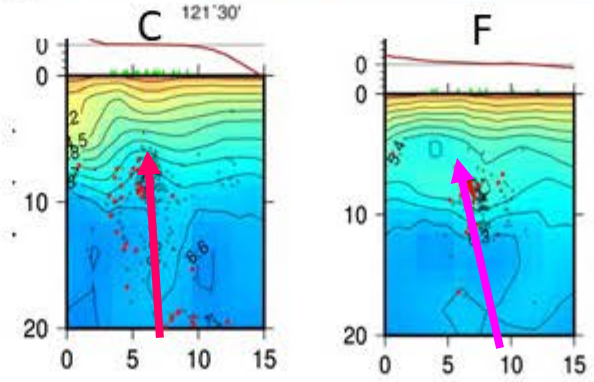


景國恩(2018)



郭陳澔(2018)

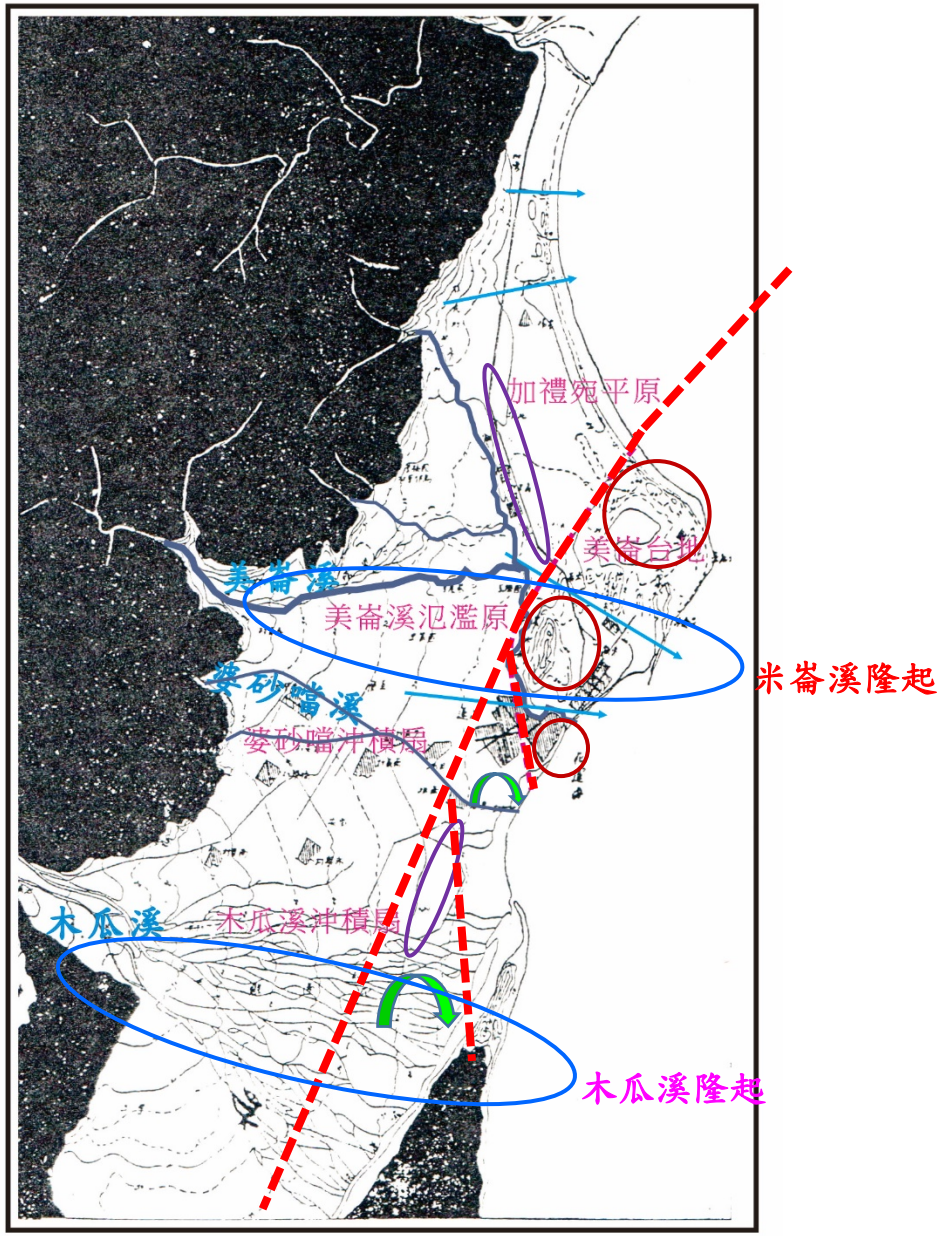




台灣省地形。林朝棨。P. 335
花蓮隆起海岸平原

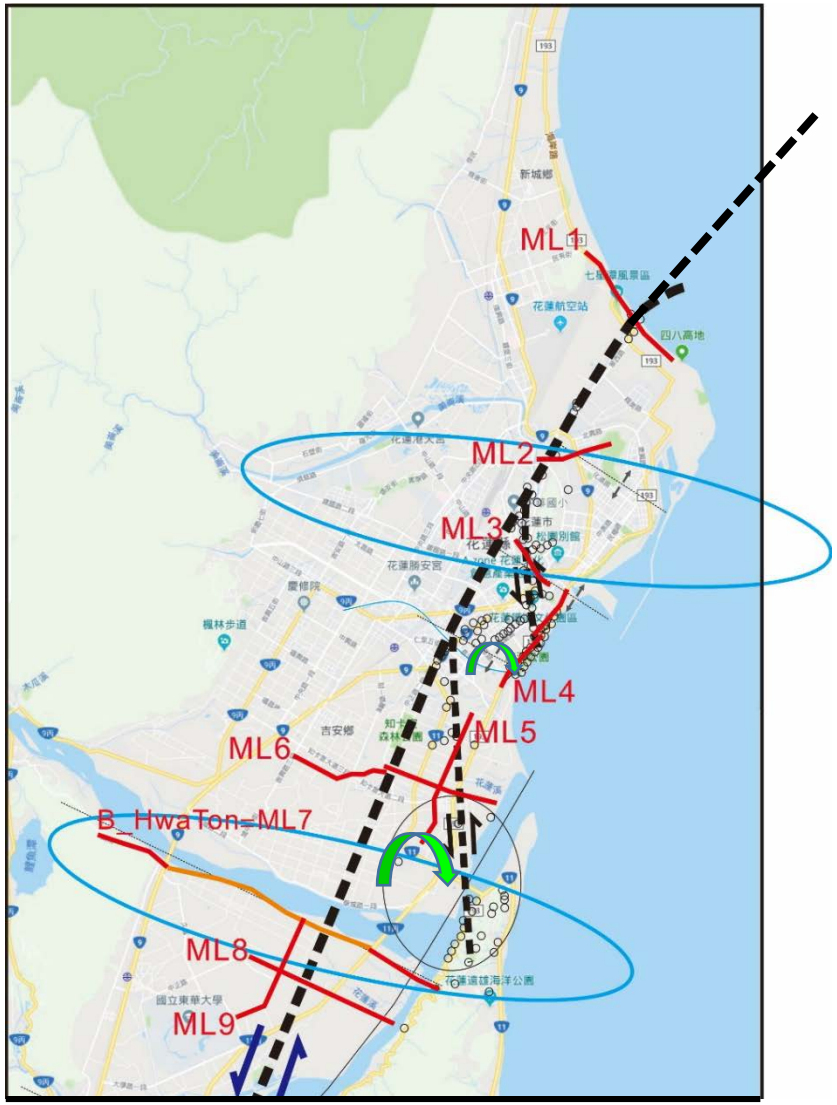
北米崙台地
米崙山
花崗山
嘉里隆起
(北埔斷層)
吉安隆起
米崙溪隆起
木瓜溪隆起

台灣省地形。林朝棨。P. 335
花蓮隆起海岸平原

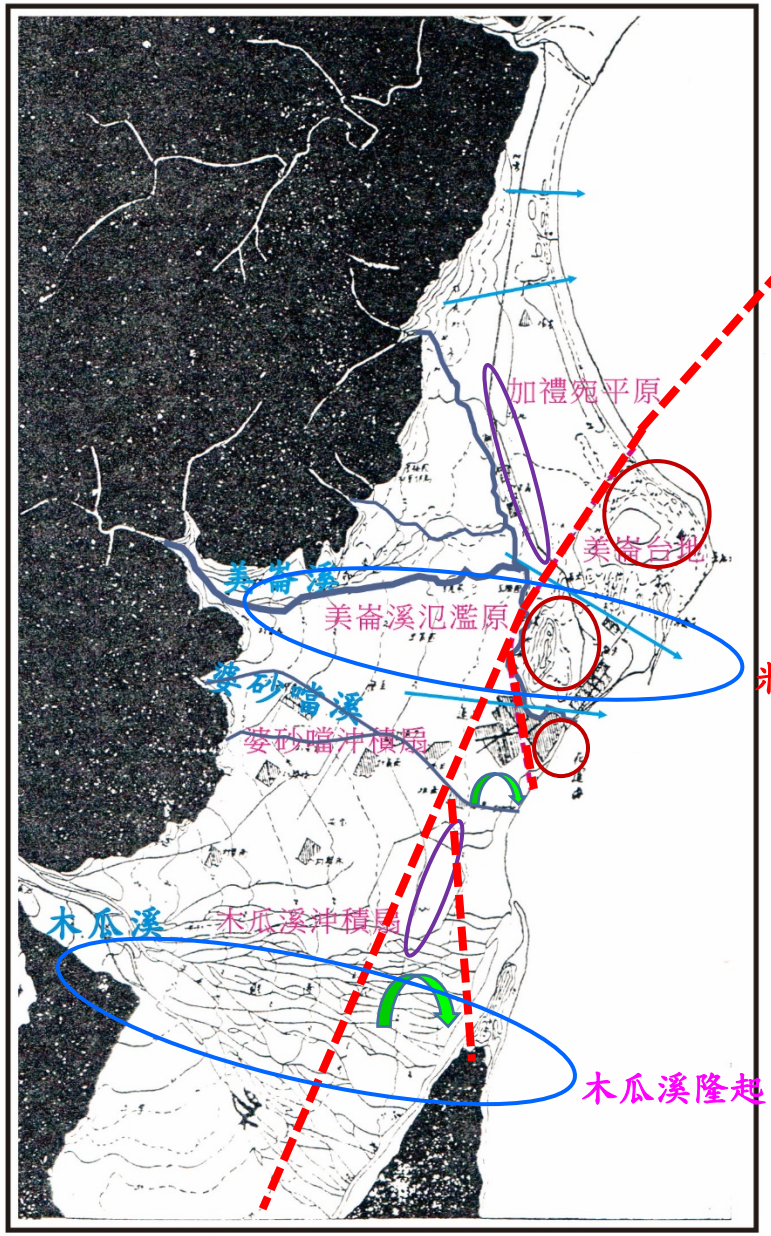


台灣省地形。林朝棨。P. 335

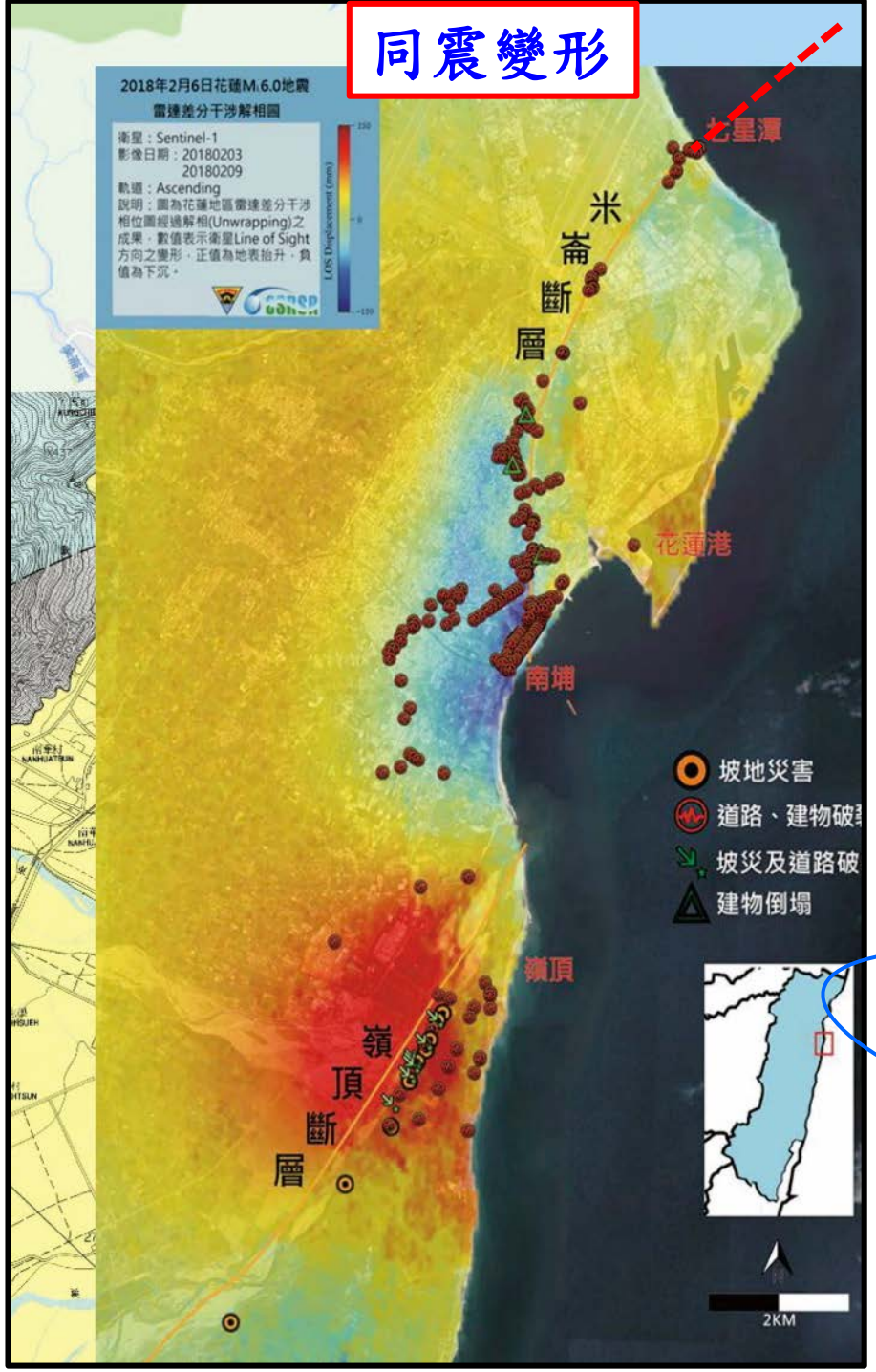
花蓮隆起海岸平原

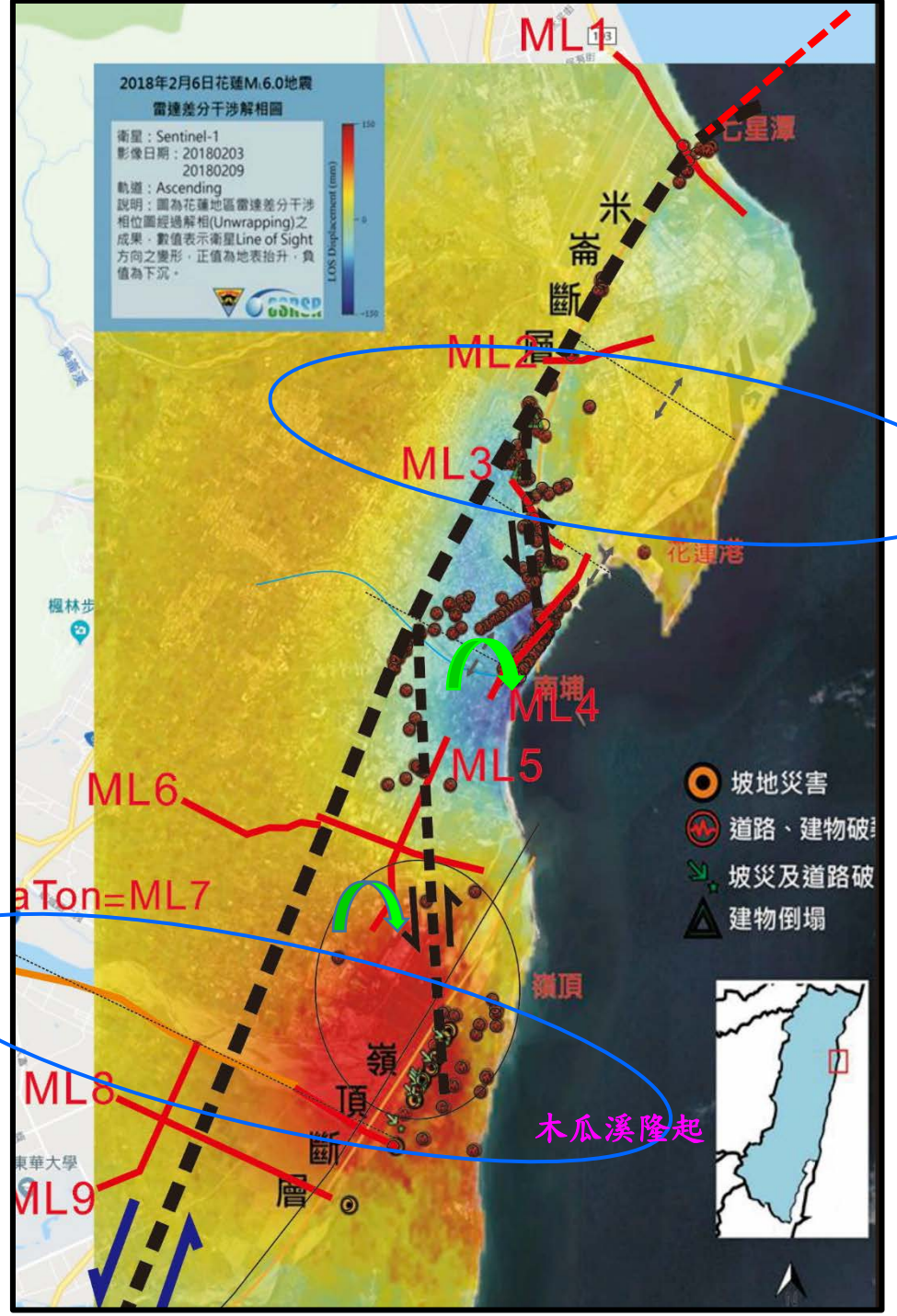


北米崙台地
米崙山
花崗山
嘉里隆起
(北埔斷層)
吉安隆起
米崙溪隆起
木瓜溪隆起



同震變形





中大太遙(2018)

餘震複合斷層面解

正斷層(東昇西降)

27°

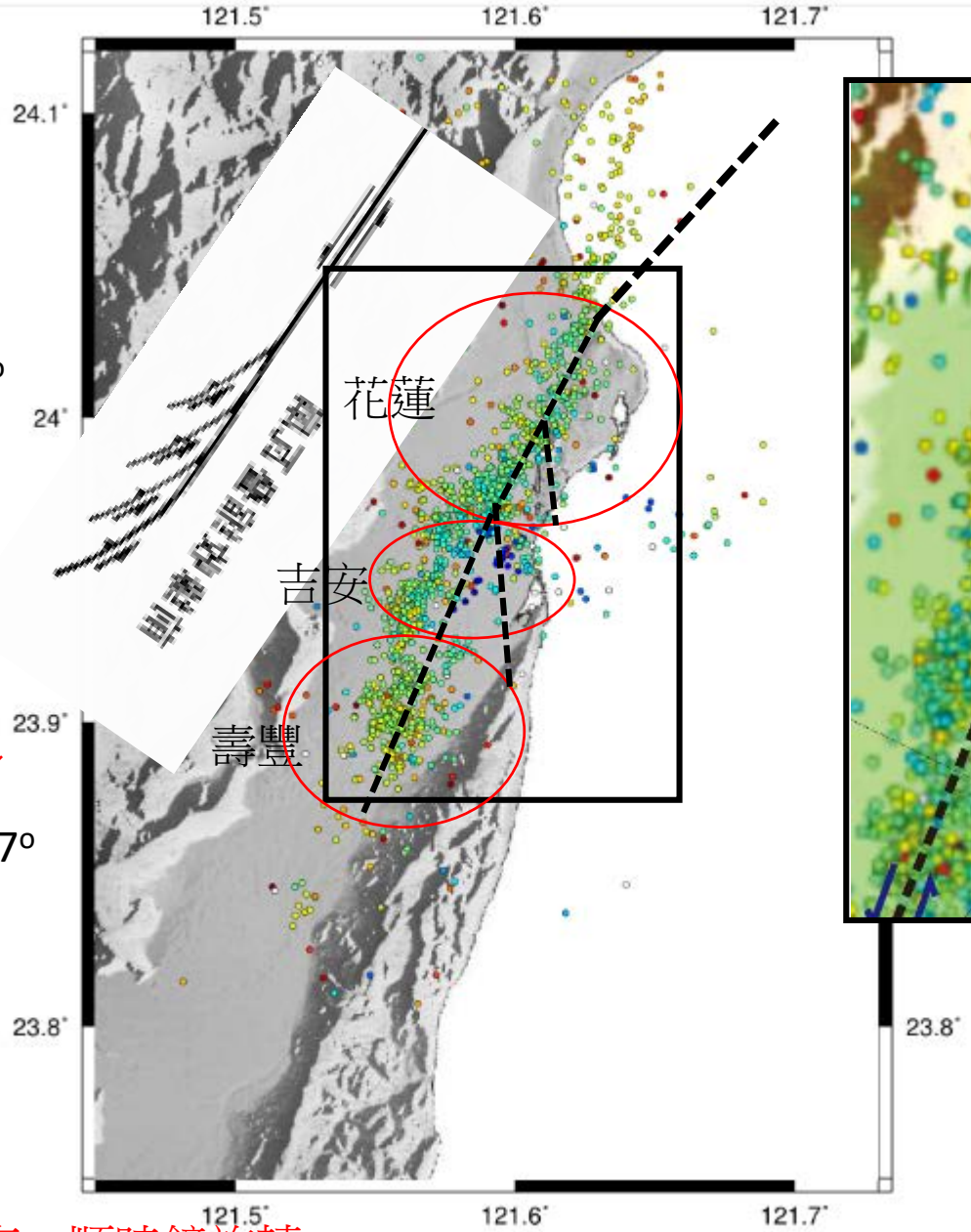
花蓮

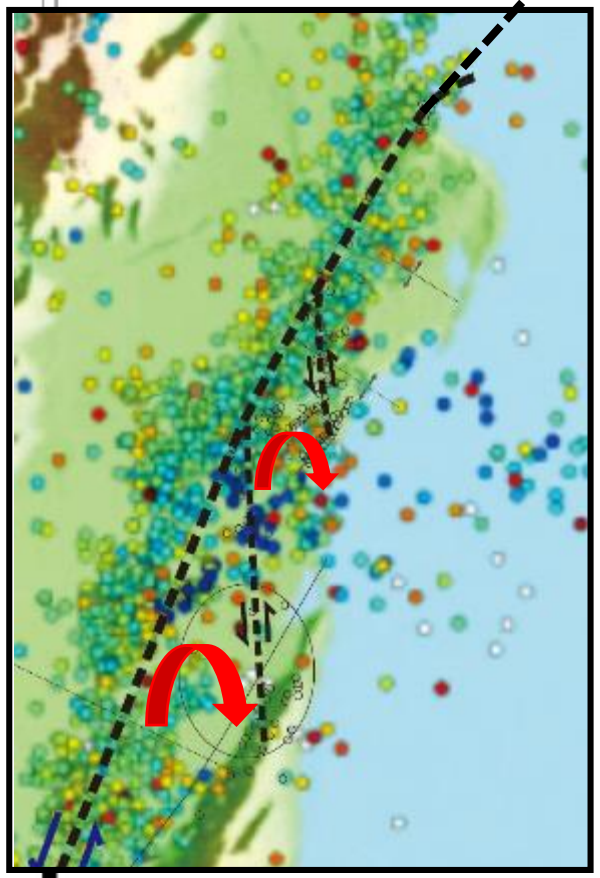
38°

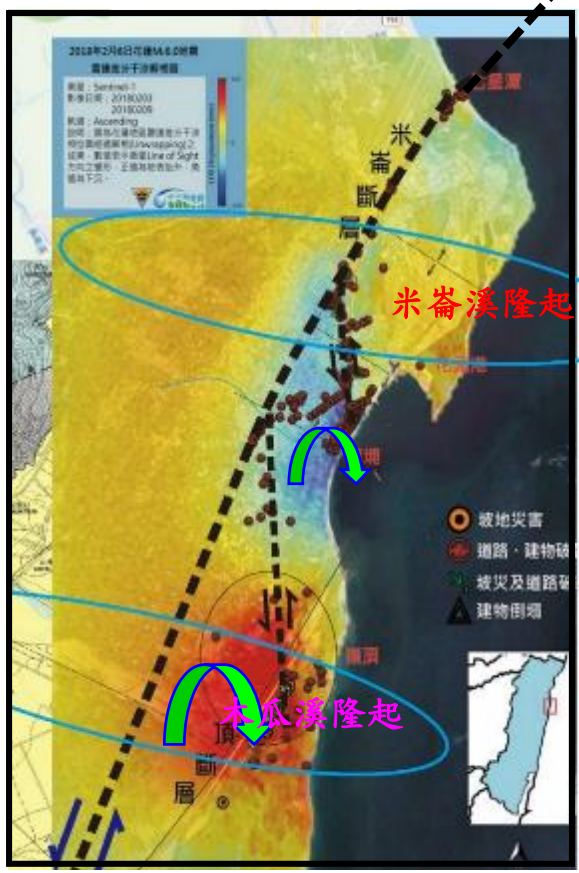
吉安

47°

壽豐

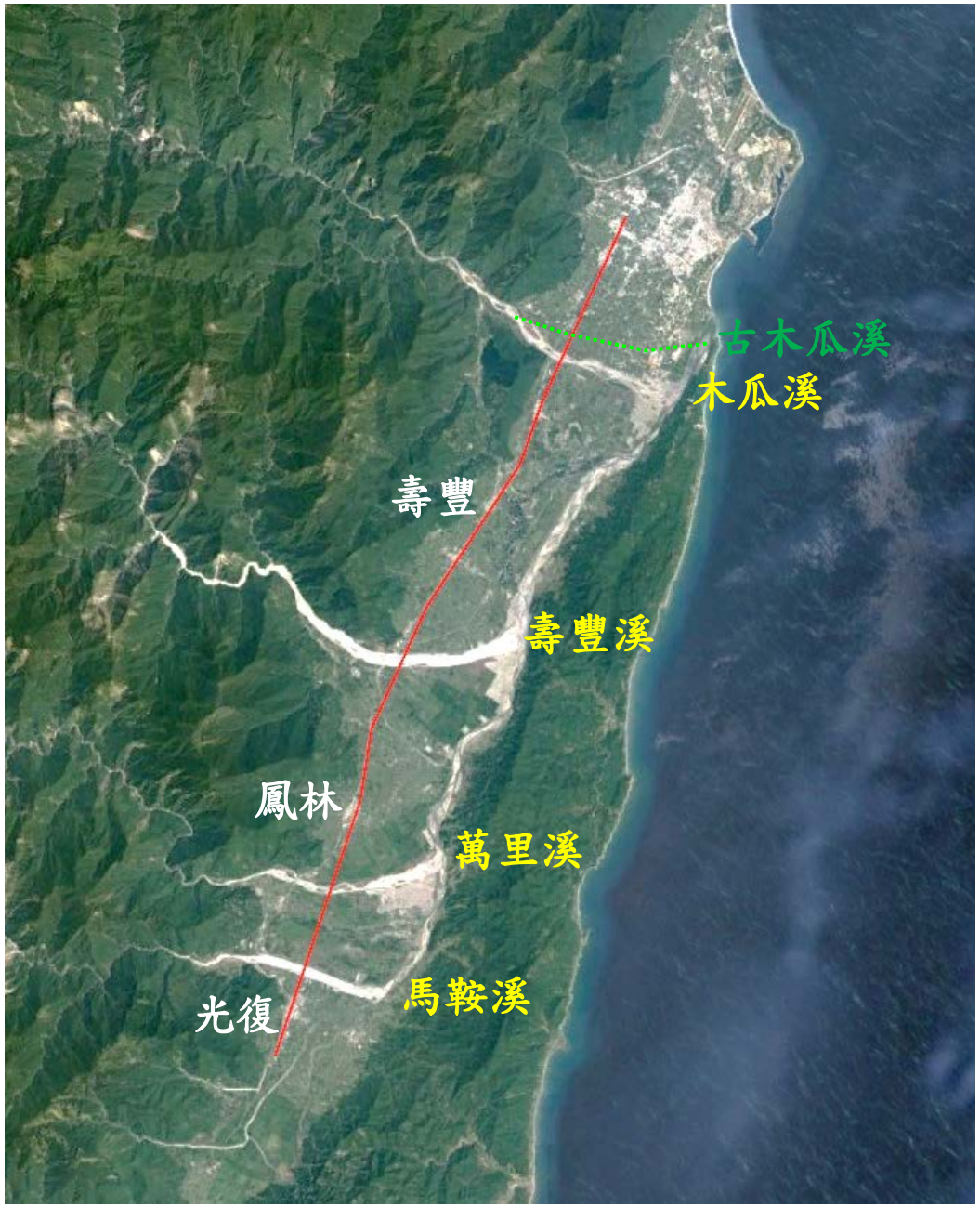




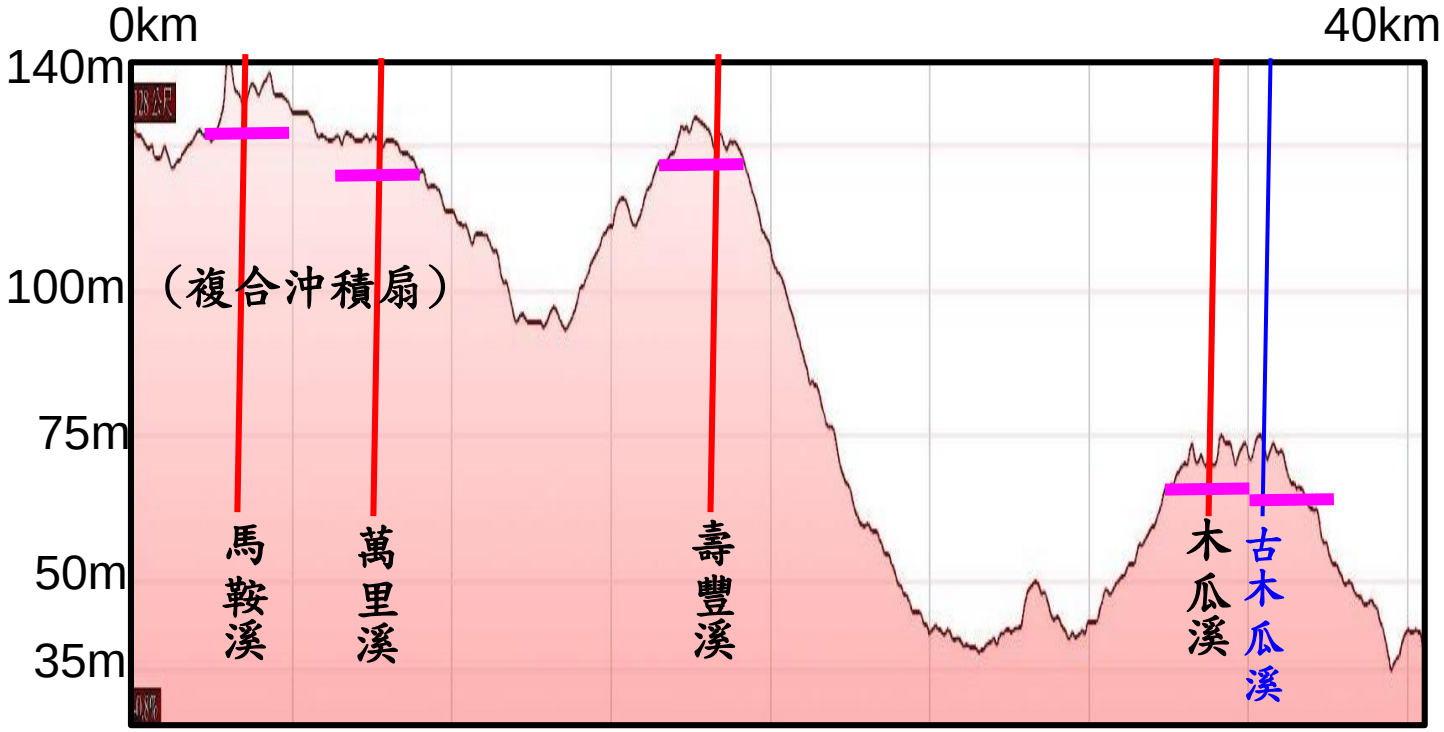


應力方向由北而南，順時鐘旋轉

(郭陳澔、管卓康、孫維芳，2018)

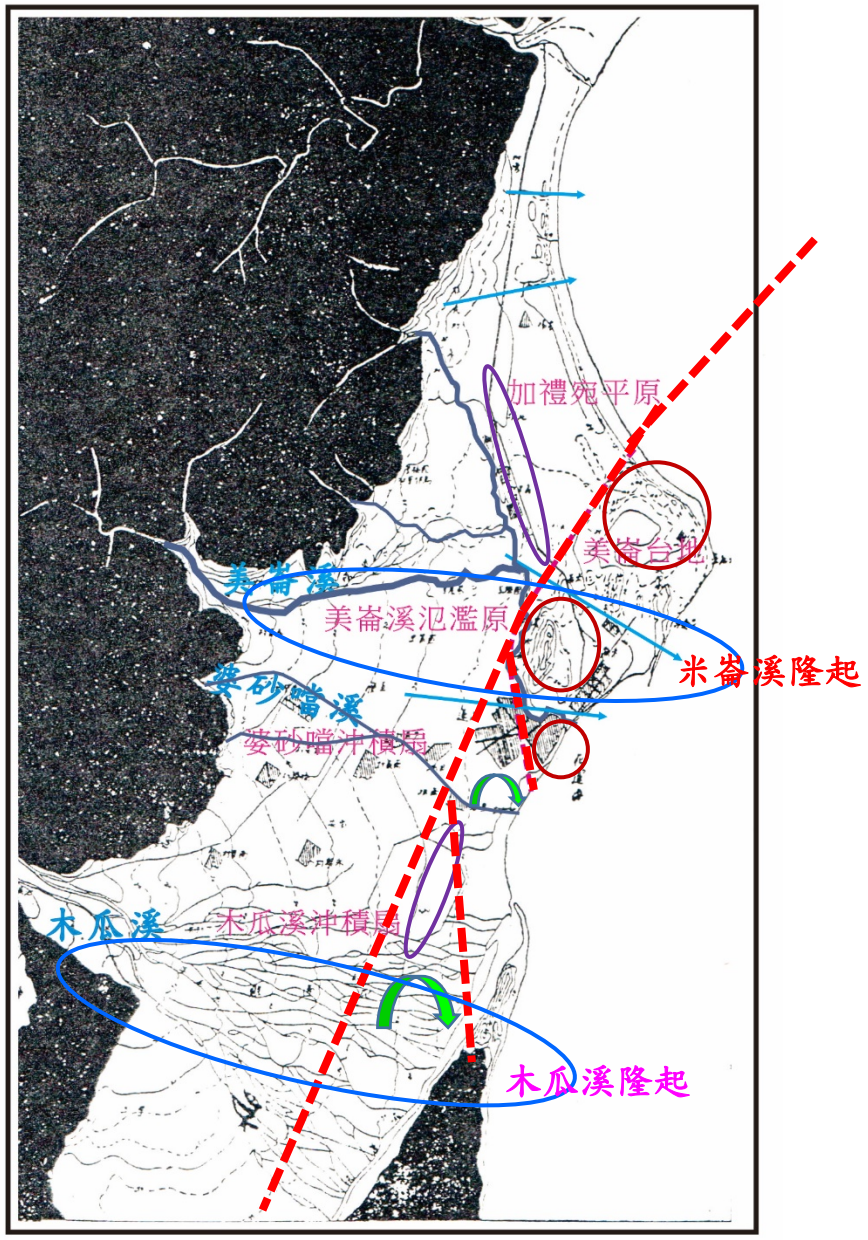

古木瓜溪
木瓜溪
壽豐
壽豐溪
鳳林
萬里溪
光復
馬鞍溪

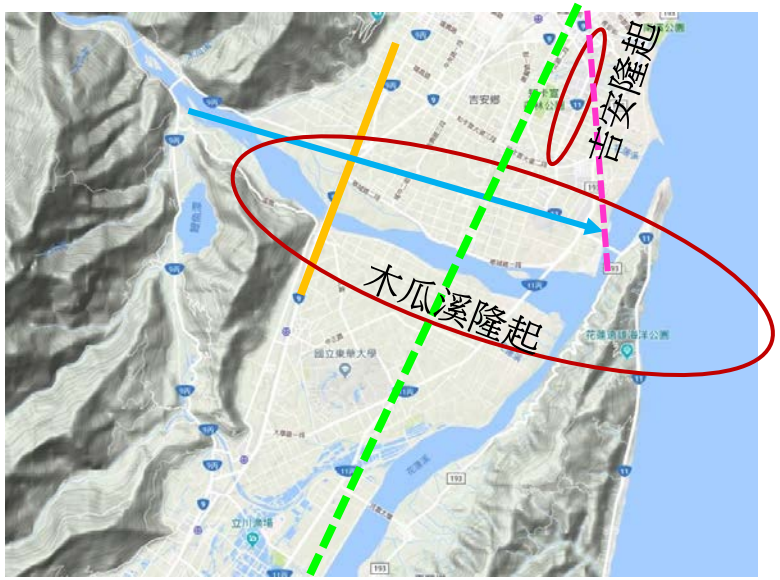
木瓜溪 偽複合沖積扇

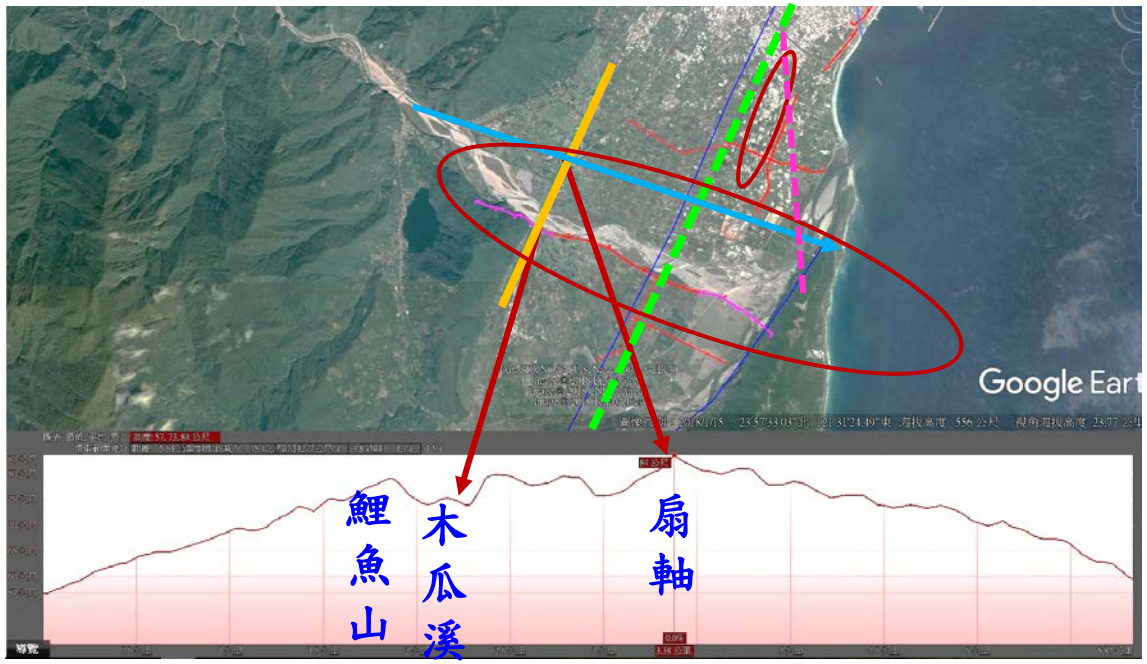

0km
40km
140m
100m
75m
50m
35m
（複合沖積扇）
馬鞍溪
萬里溪
壽豐溪
木瓜溪
古木瓜溪

木瓜溪隆起造成 木瓜溪沖積扇往南遷移

北米崙台地
米崙山
花崗山
嘉里隆起
吉安隆起
米崙溪隆起
木瓜溪隆起



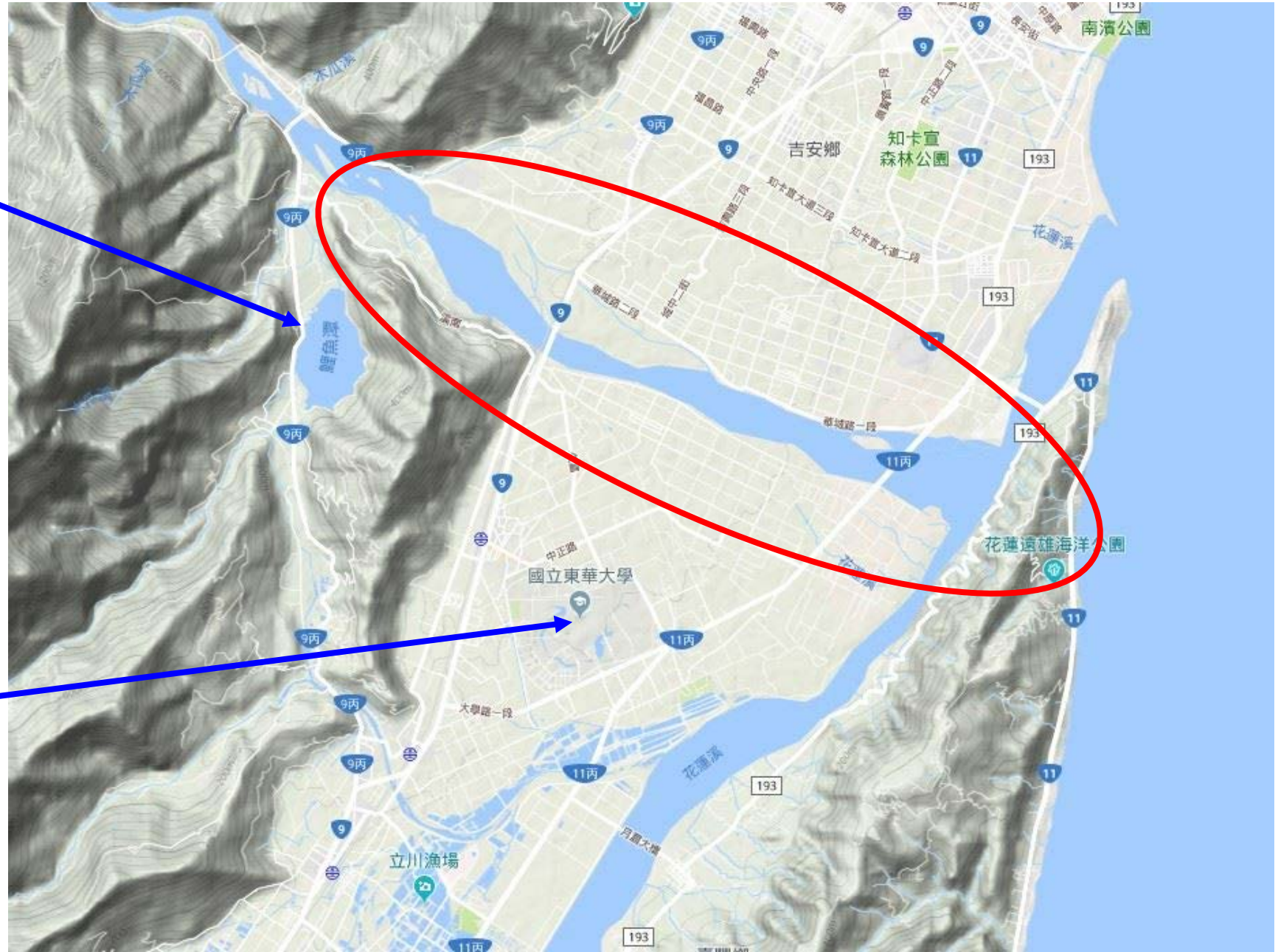


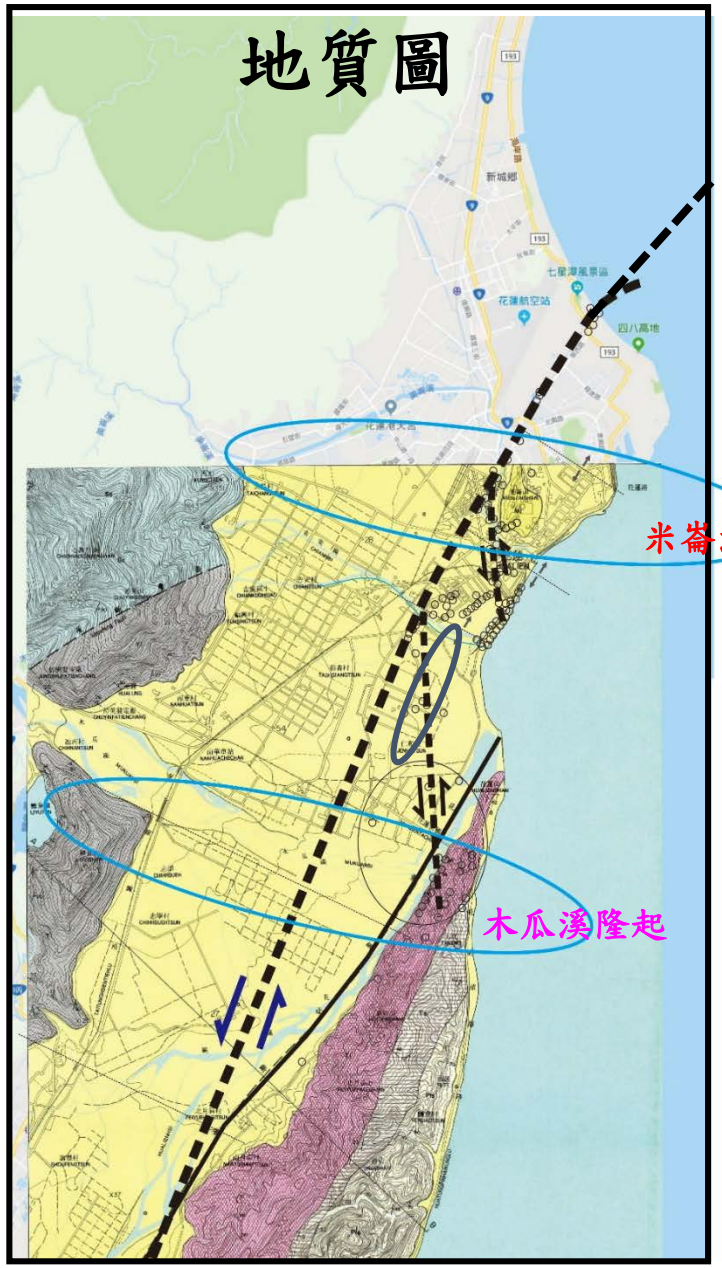


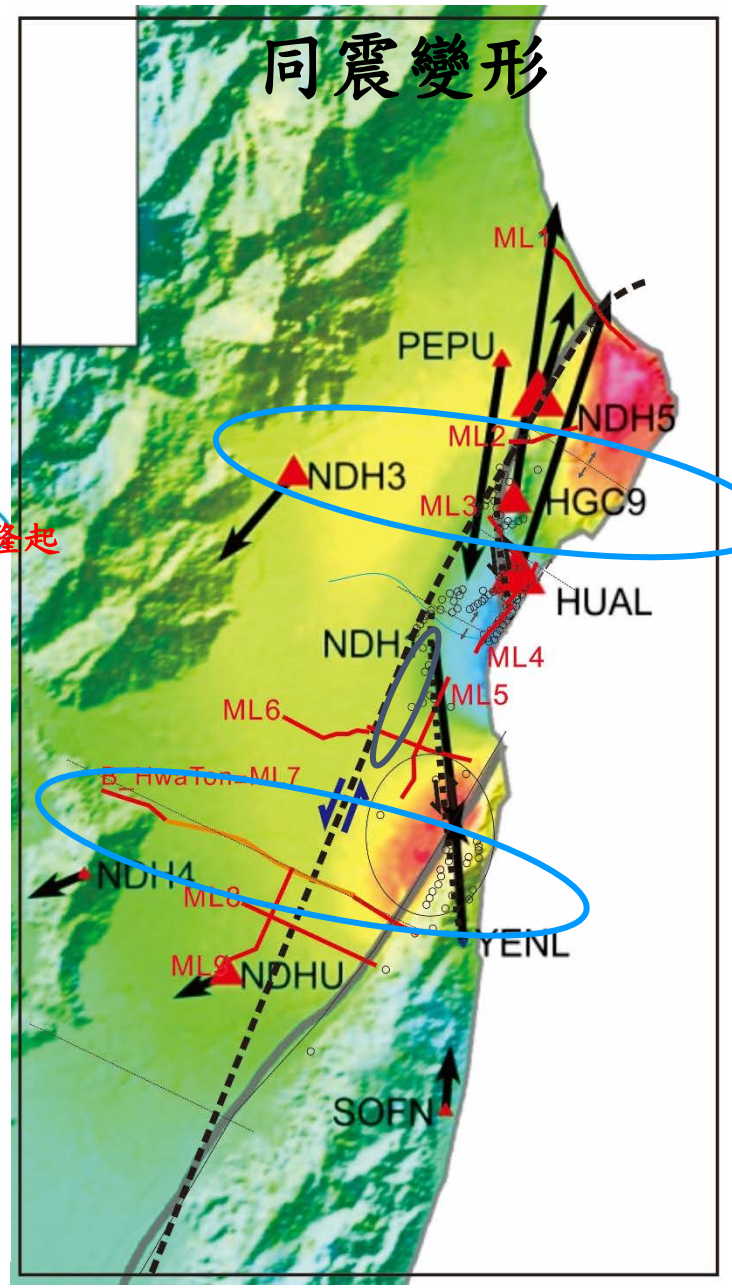
木瓜溪隆起造成 鯉魚潭堰塞湖

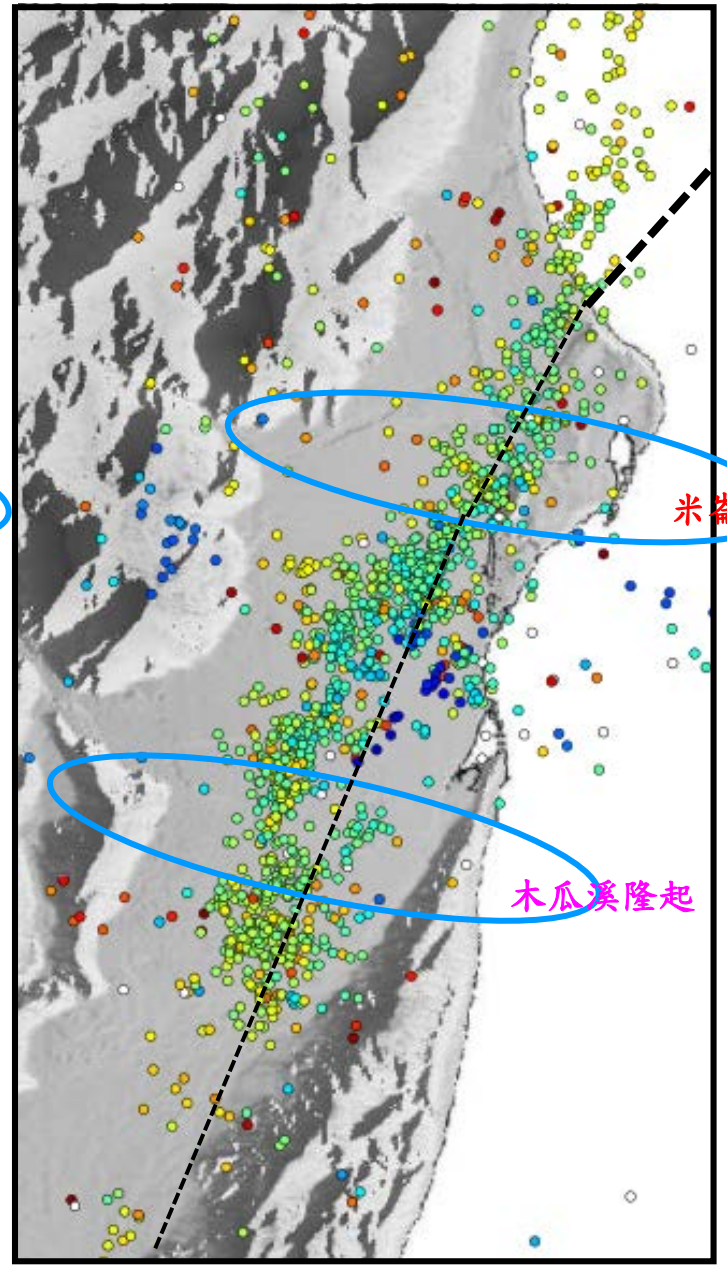
鯉魚潭

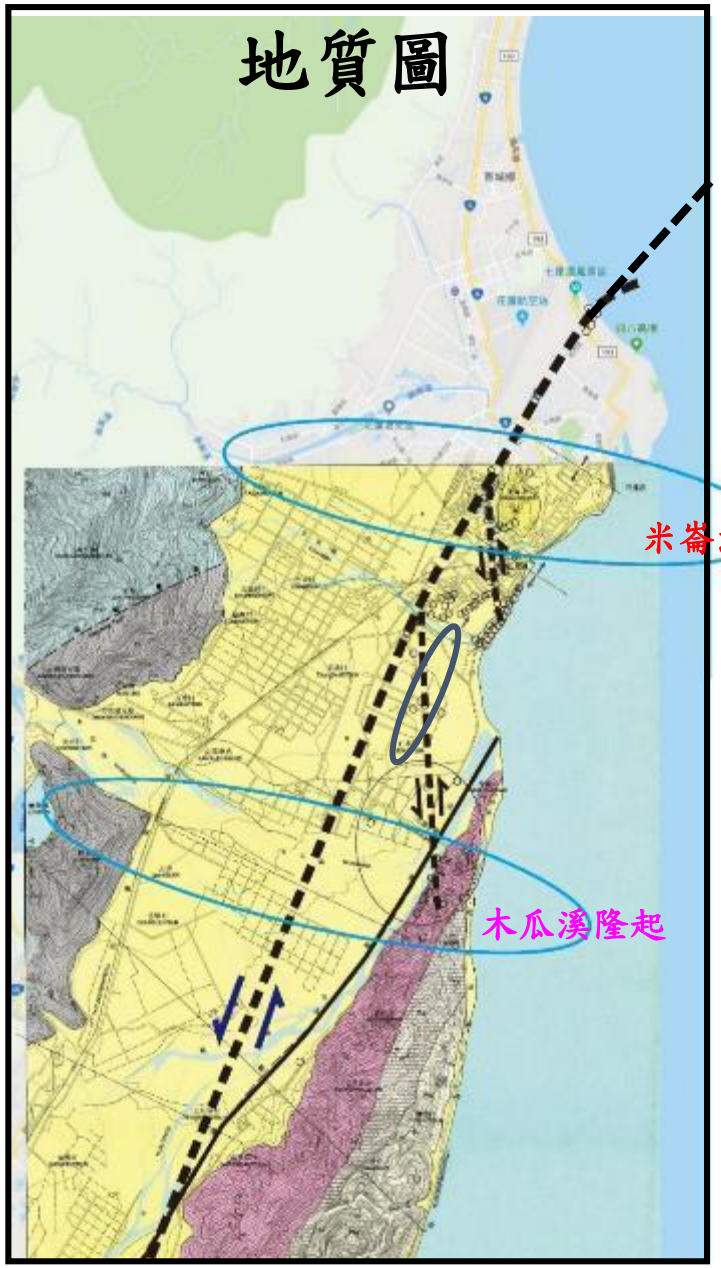
東華大學

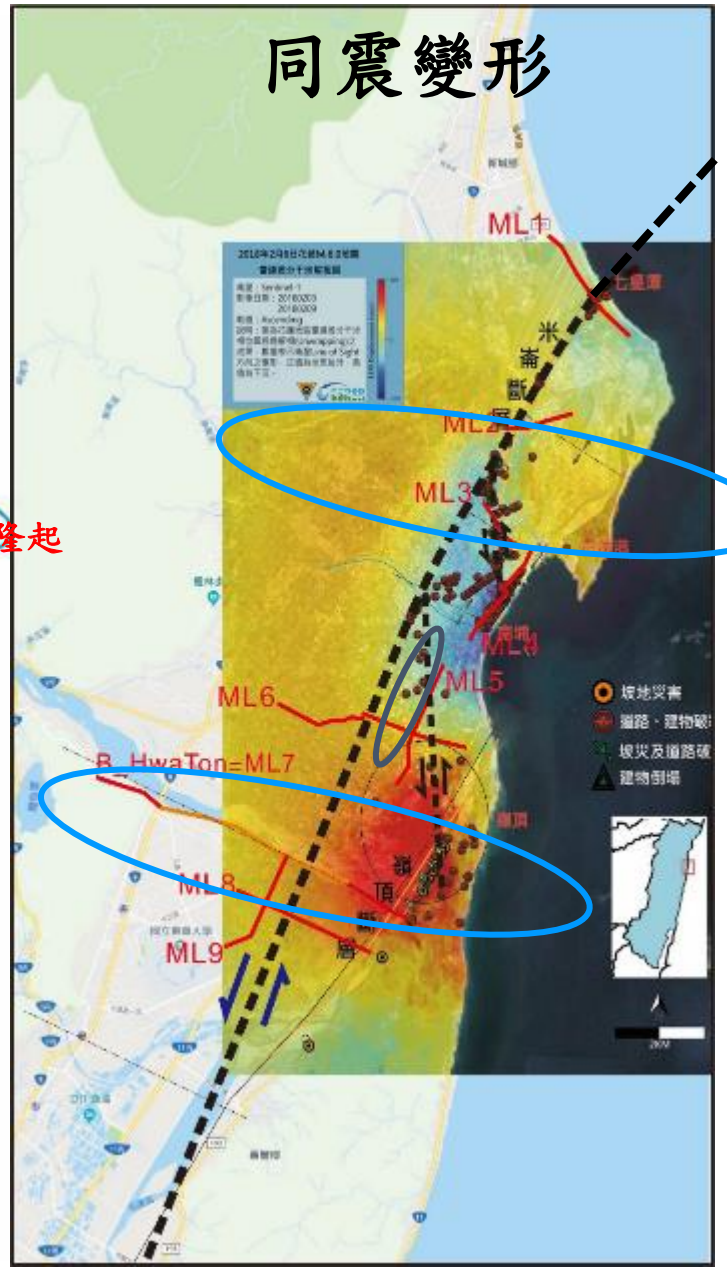


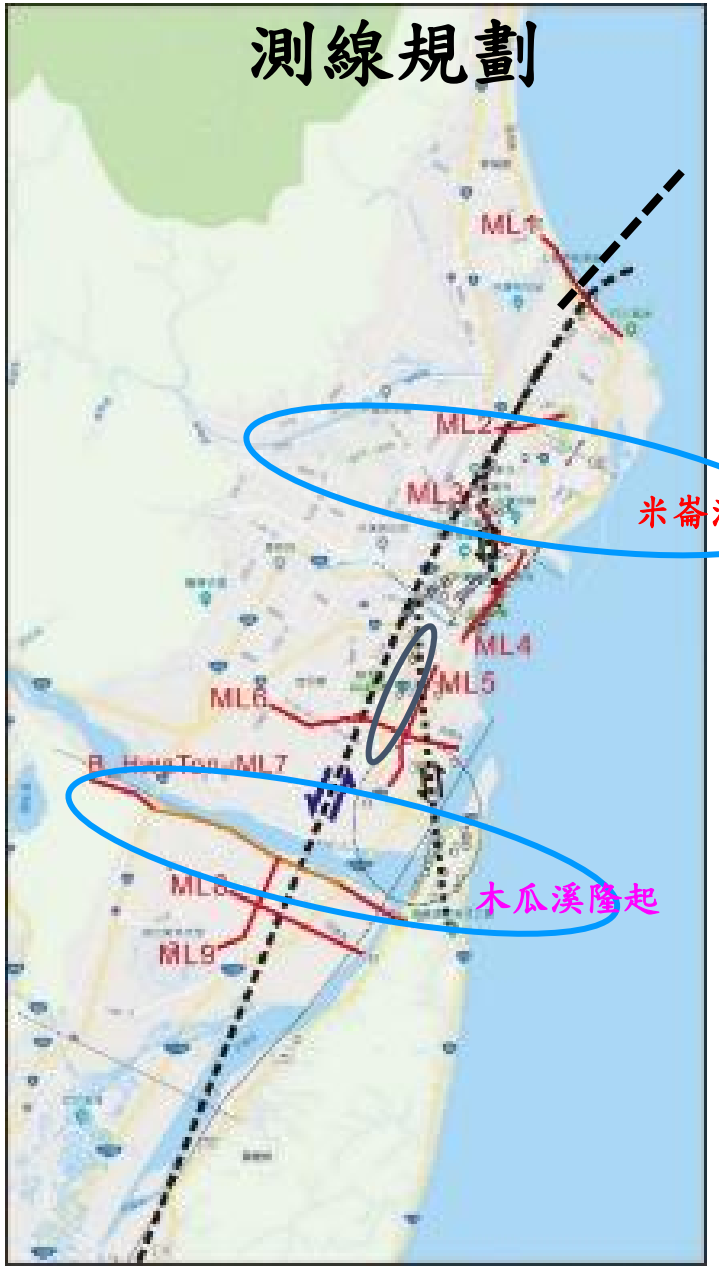

地質圖
米崙溪隆起
木瓜溪隆起


同震變形
ML1
PEPU
NDH5
ML2
NDH3
ML3
HGC9
HUAL
NDH
ML4
ML5
ML6
ML7
NDH4
ML8
ML9
NDHU
YENL
SOFN

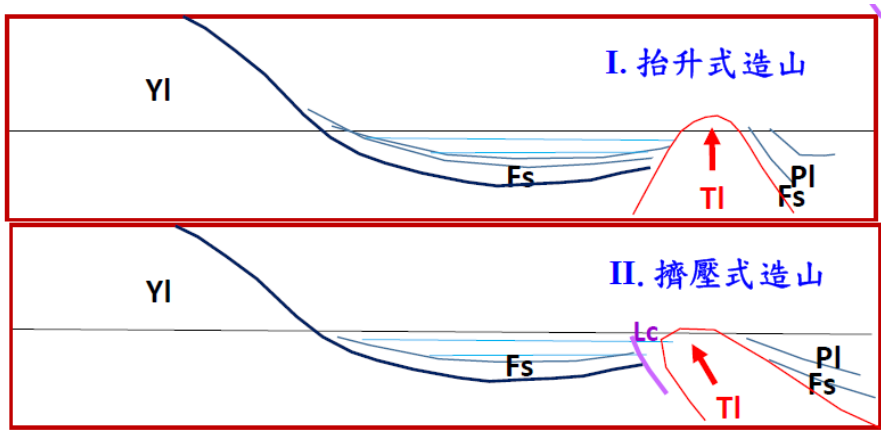

米崙溪隆起
木瓜溪隆起


地質圖
米崙溪隆起
木瓜溪隆起


同震變形
ML1
ML2
ML3
ML4
ML5
ML6
ML7
ML8
ML9
坡地災害


測線規劃
ML1
ML2
ML3
ML4
ML5
ML6
ML9
米崙溪隆起
木瓜溪隆起

1. 海岸山脈與造山運動
2. 縱谷北段震測剖面
3. 縱谷中北段震測剖面
4. 縱谷中南段震測剖面
5. 縱谷南段震測剖面
6. 構造模型
7. 米崙斷層
8. **結論 (Conclusion)**



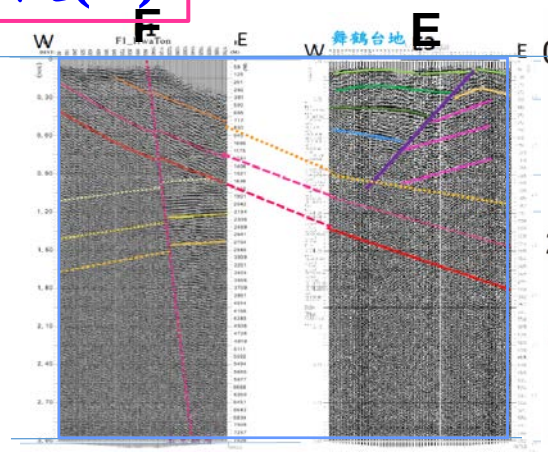
結論

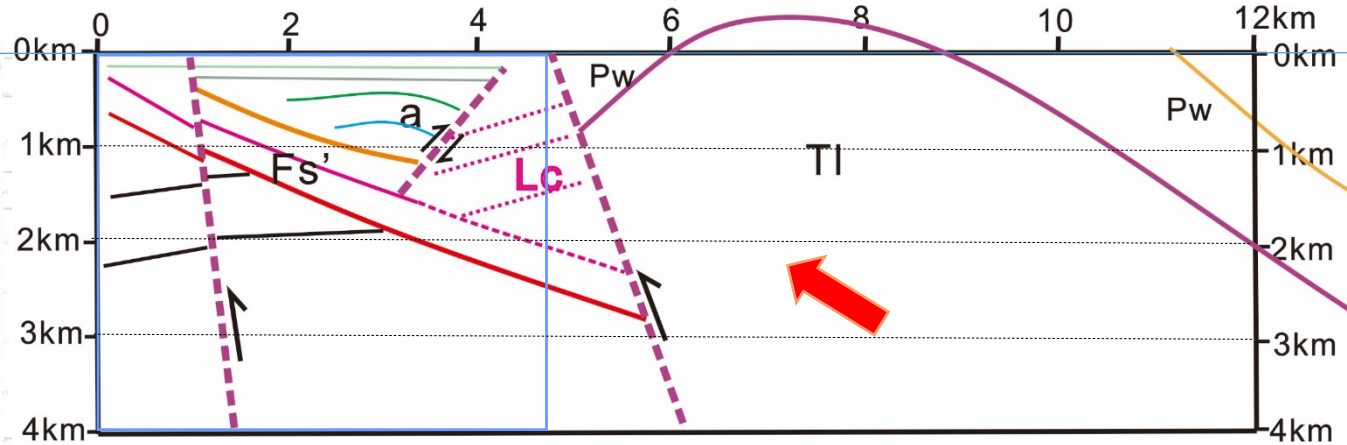
1. 海岸山脈分三段造山(北、中、南)。
2. 海岸山脈未見明顯推擠「中央山脈之造山」。
3. 縱谷北段為抬升式造山，<u>嶺頂斷層不存在</u>。
4. 縱谷中段為擠壓式造山，利吉混同層擠進縱谷底下，沖積層薄於1公里。
5. 縱谷南段為推併式造山，大量利吉混同層併入縱谷地層。
6. 縱谷斷層埋於厚(<2公里)之沖積層及厚1.5公里之上新世地層的下方，為海岸山脈都蘭山層與中央山脈變質岩地層之交界，斷層面近乎垂直。
7. 米崙斷層即縱谷斷層，南北走向，為高角度斷層，微西傾。
8. 花蓮隆起海岸平原有數處東西向長條隆起，與板塊向下隱沒之彎曲帶有關。

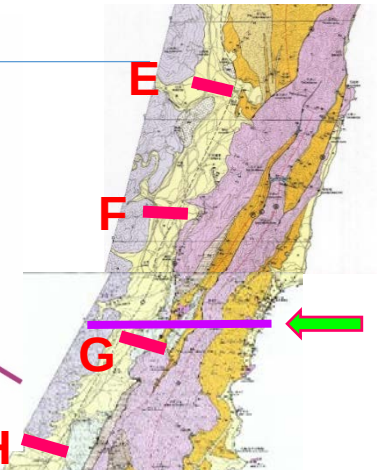
THANKS!

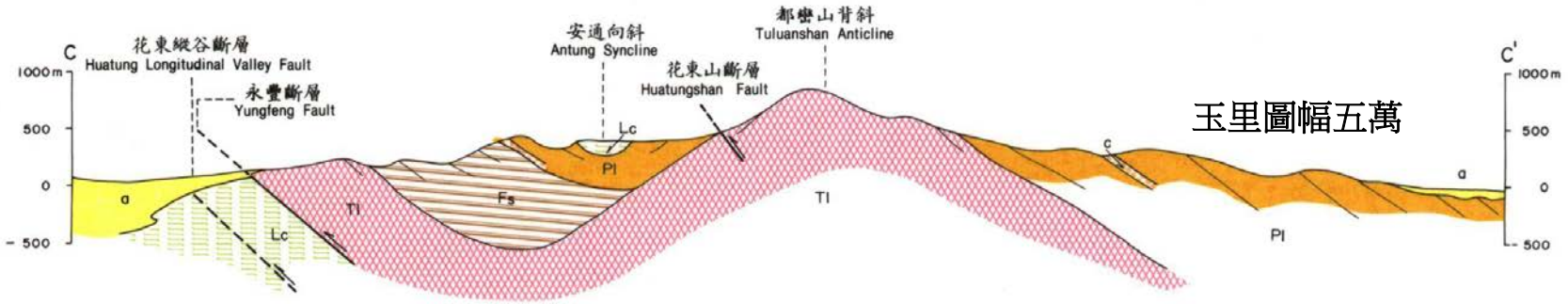
縱谷中段(C)

(Cn)



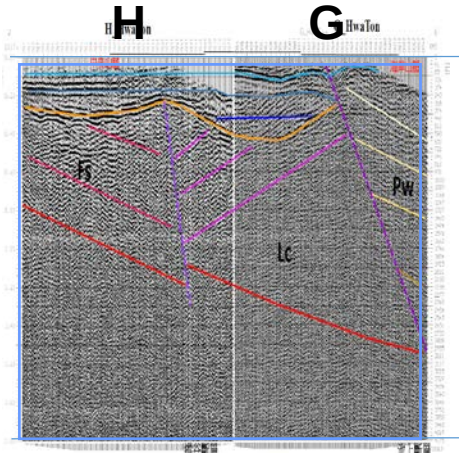


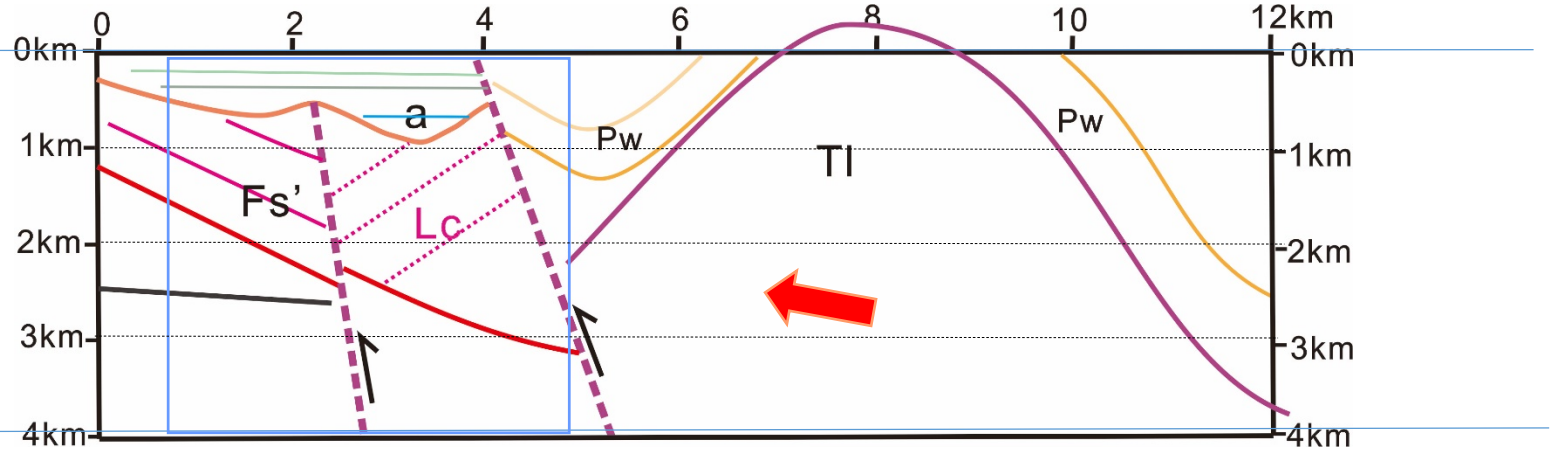


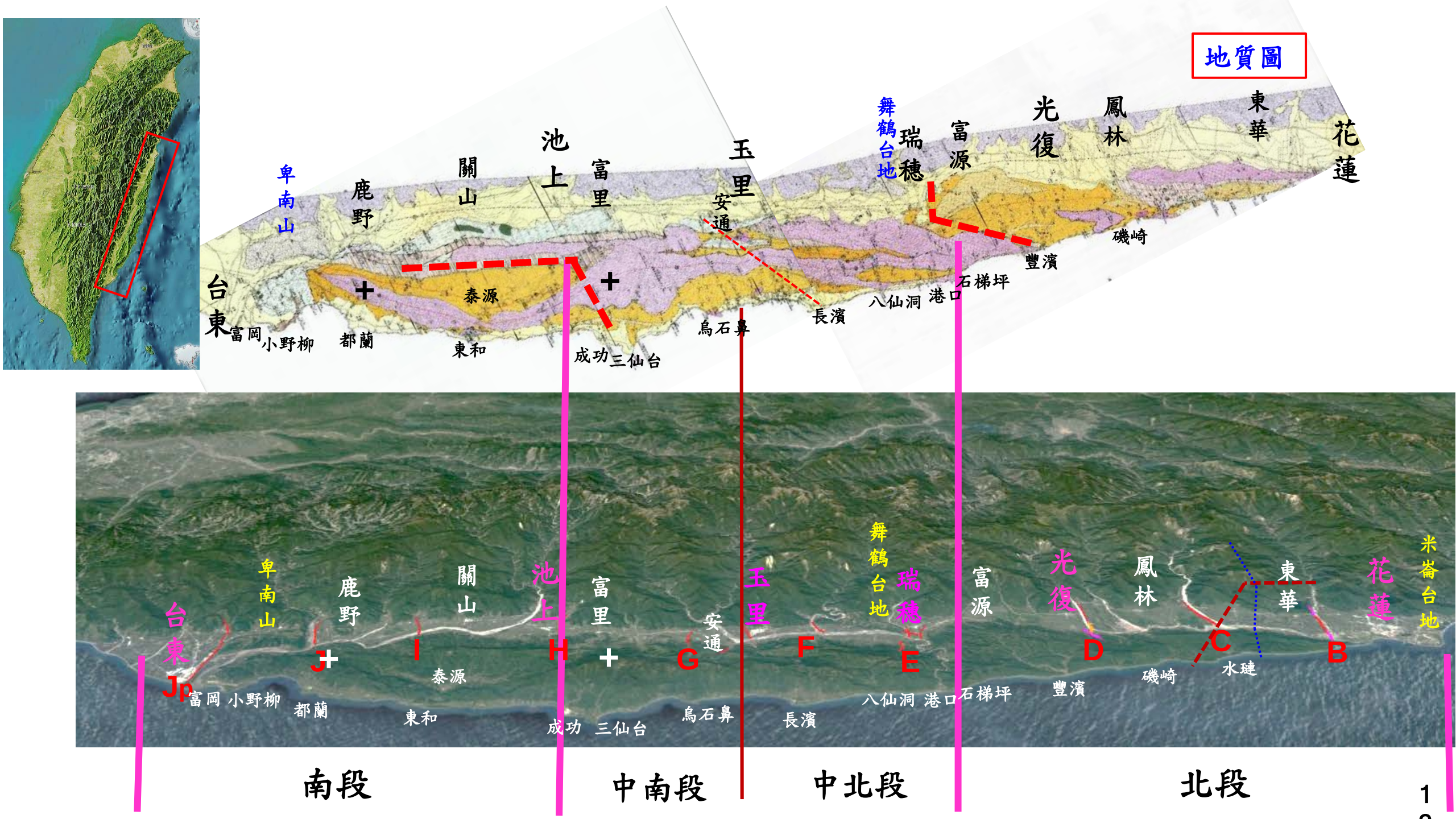


玉里圖幅五萬

(Cs)

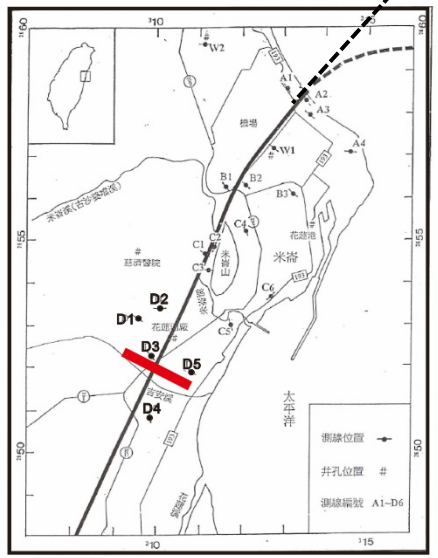


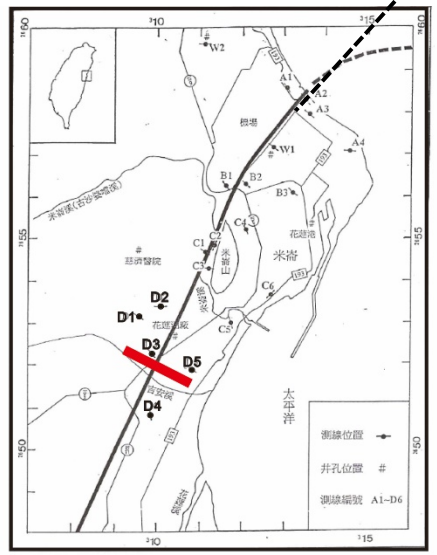


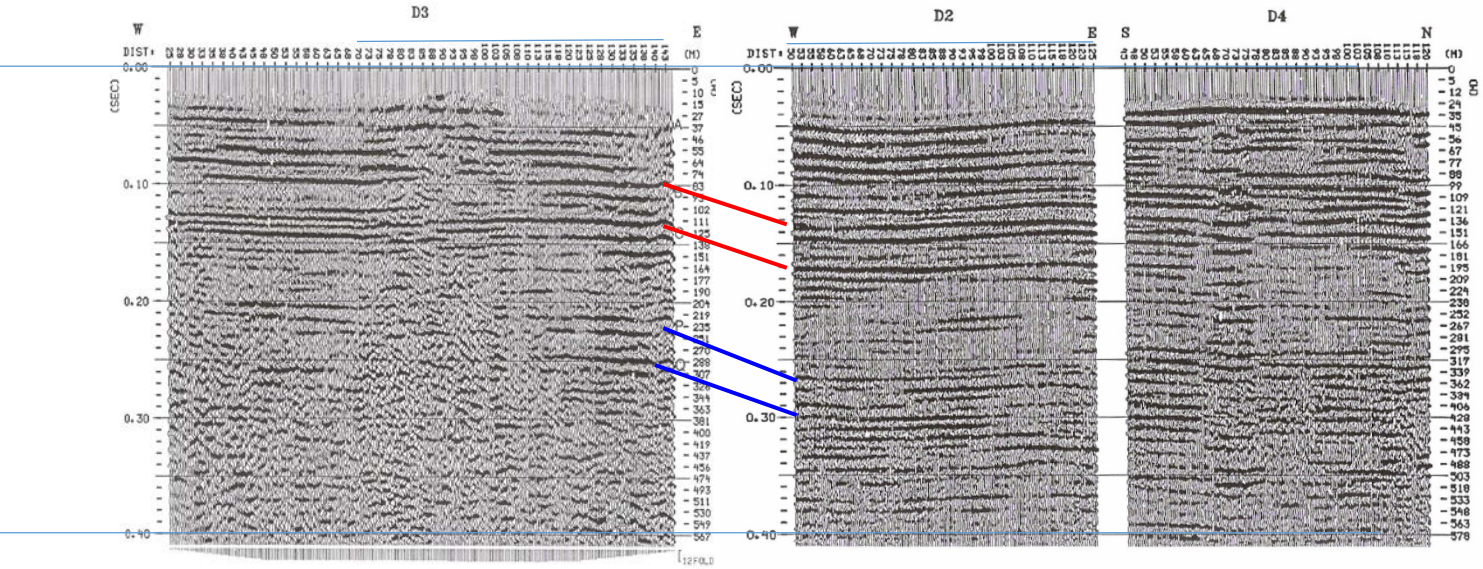

地質圖
台東
卑南山
鹿野
關山
池上
富里
玉里
舞鶴台地
瑞穗
富源
光復
鳳林
東華
花蓮
富岡
小野柳
都蘭
泰源
東和
成功
三仙台
安通
烏石鼻
長濱
八仙洞
港口
石梯坪
豐濱
磯崎
水璉
米崙台地
Jp
J
I
H
G
F
E
D
C
B
南段
中南段
中北段
北段

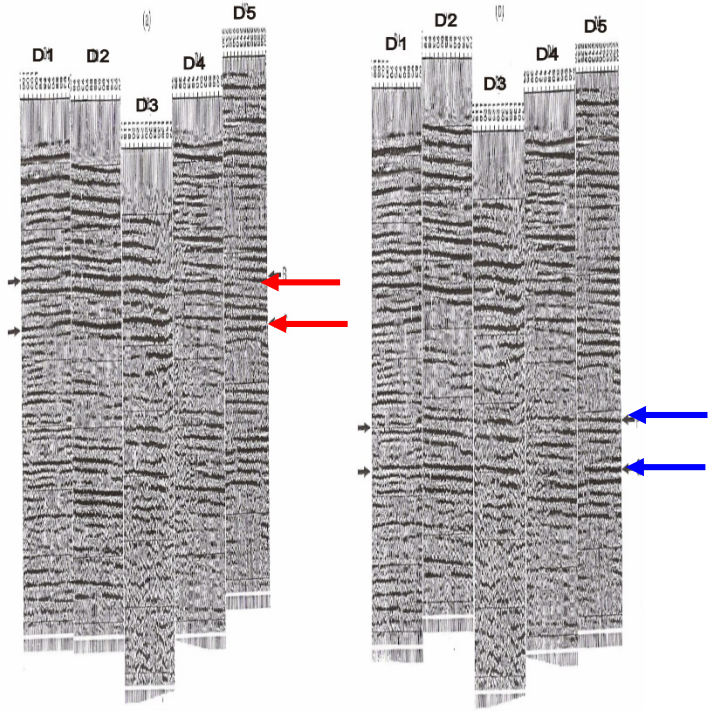
吉安鄉測線

(Wang and Chang, 1994)

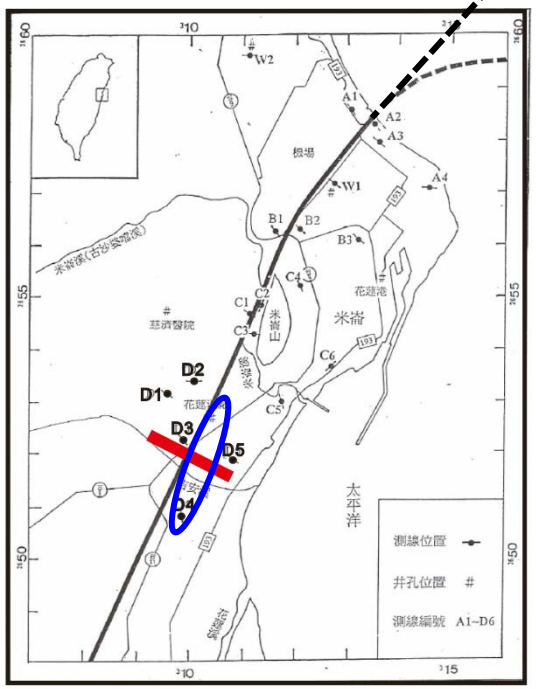


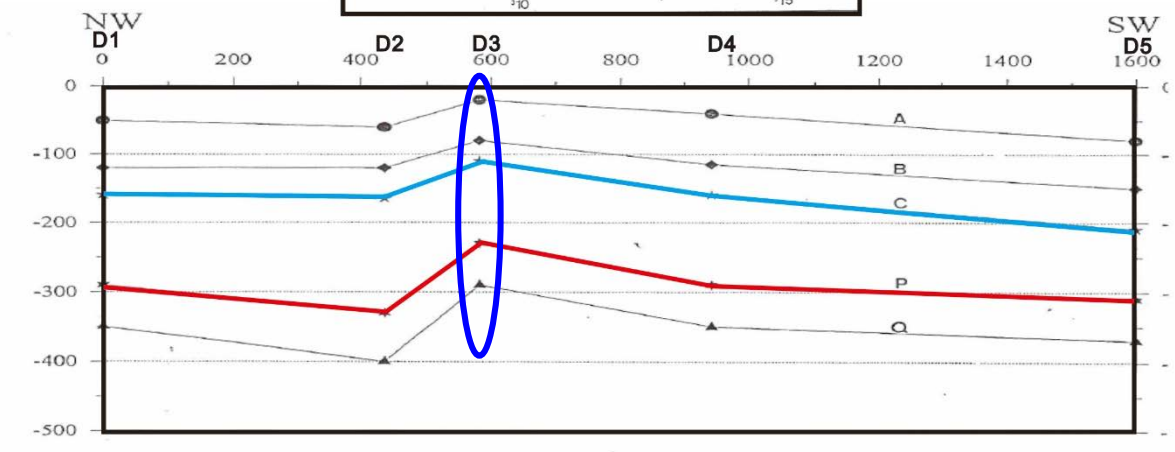


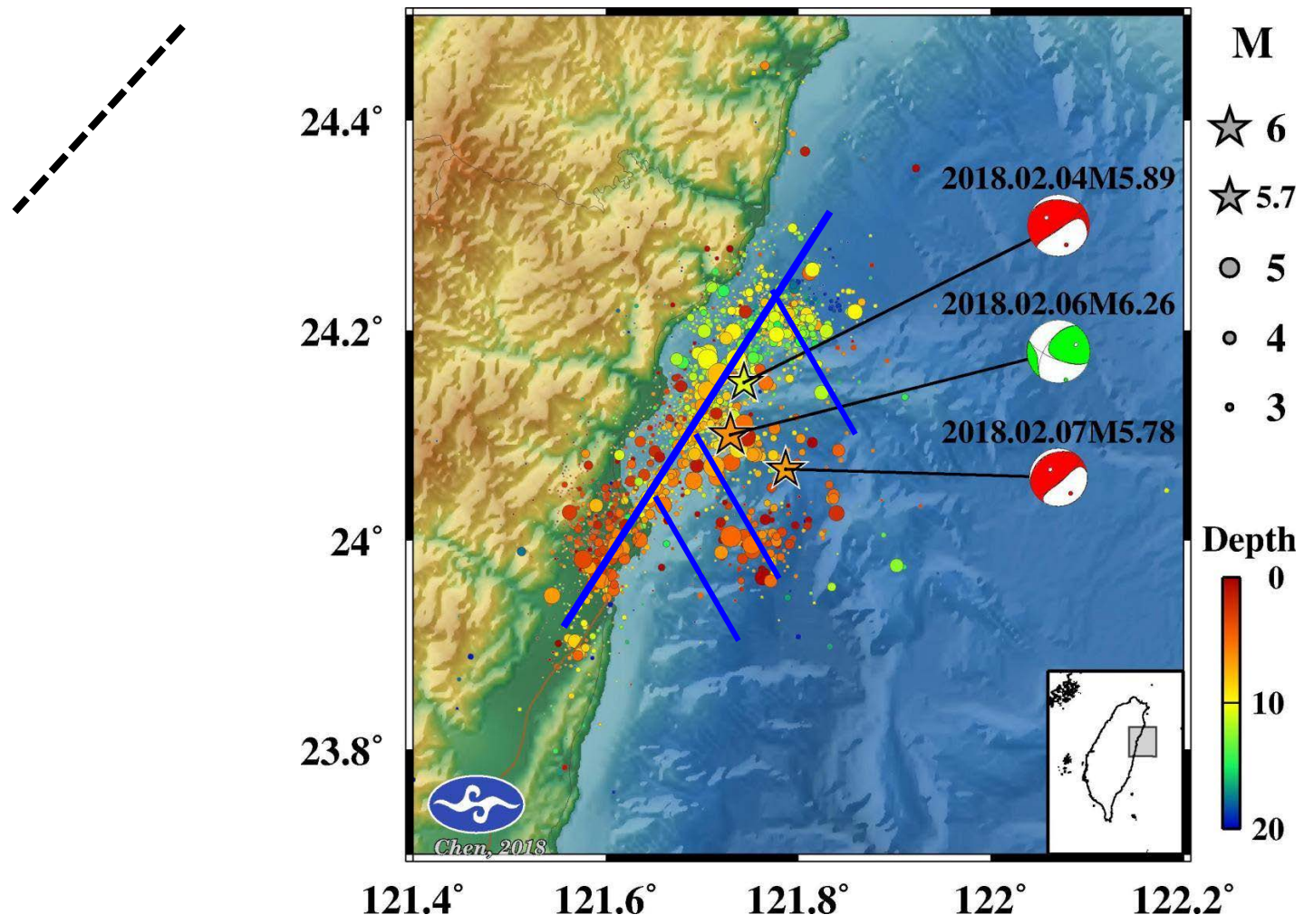




吉安隆起 見東側地層抬起





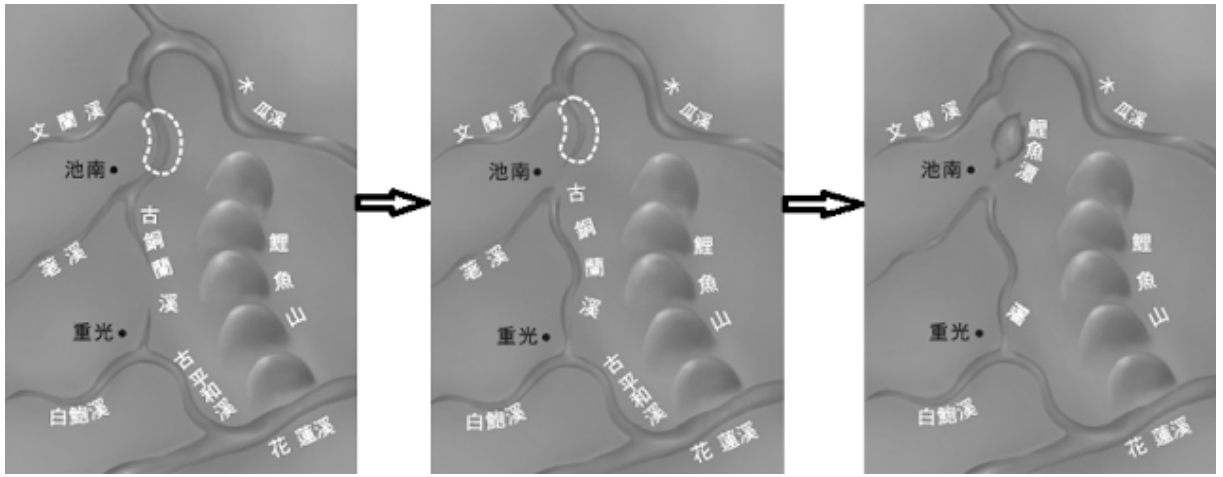

M
6
5.7
5
4
3
2018.02.04M5.89
2018.02.06M6.26
2018.02.07M5.78
Depth
0
10
20
24.4°
24.2°
24°
23.8°
121.4°
121.6°
121.8°
122°
122.2°
Chen, 2018

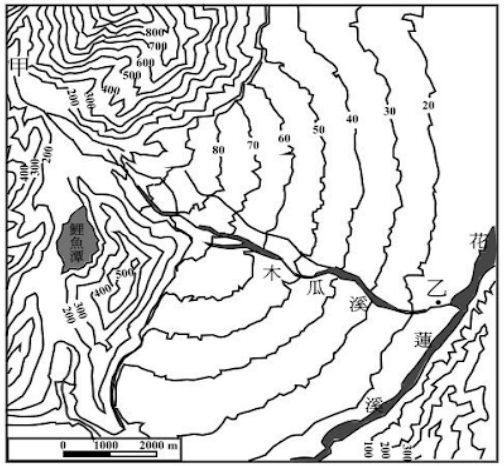
花蓮 鯉魚潭

木瓜溪隆起造成 鯉魚潭堰塞湖

鯉魚潭位於花蓮壽豐鄉池南村鯉魚山腳下，距花蓮市僅18公里。鯉魚潭南北最長處約1.6公里，東西最寬處約930公尺，最深處15公尺，為木瓜溪及花蓮溪支流所形成的堰塞湖，湖的面積約 104 公頃，湖水來自地底湧泉，終年清澈， 是花蓮縣內最大的內陸湖泊，地質上屬於中央山脈系統，東有鯉魚山、西有銅門。當地人原稱之為「大陂」，阿美族人則稱之為「巴鬧」，後因東傍鯉魚山而被命名為鯉魚潭。

根據地質學家的研究，在鯉魚山、銅門山及木瓜山之間，曾有一條古銅蘭溪，鄰近的文蘭溪、荖溪、白鮑溪與平和溪均為古銅蘭溪的支流，而鯉魚潭目前的地點，則是古銅蘭溪一段河面較寬的河面。由於向源侵蝕的作用，平和溪與白鮑溪之間，以及荖溪與白鮑溪之間均曾發生過河川襲奪現象，造成荖溪的流向改變，古銅蘭溪的水量驟減。加上鯉魚潭北側的文蘭溪沖積扇因崩塌淤積，造成鯉魚潭出水口的堵塞，以及荖溪伏流的湧出，形成一處堰塞湖，也就是今日鯉魚潭的雛形。(資料來源：花東縱谷國家風景區官網)





(一)河川襲奪發生前，荖溪、白鮑溪是古銅蘭溪的支流，兩條溪匯集後向北流入木瓜溪，古和平溪則流入花蓮溪

(二)前期襲奪為古和平溪的向源侵蝕，切穿分水嶺，襲奪古銅蘭溪和白鮑溪。

(三)後期襲奪為古銅蘭溪繼續向北侵蝕，襲奪支流荖溪，在池南森林遊樂區東北方形成襲奪灣，荖溪與古銅蘭溪、古和平溪形成今日的荖溪，而池南古銅蘭溪則成斷頭河。

(四)古銅蘭溪因襲奪成為斷頭河後，水量減少，無法沖刷其北方的文蘭溪挾帶而下的泥沙，在今日鯉魚潭的北方行形成沖積扇，逐漸堰塞河道，舊河道積水成湖，形成鯉魚潭這個典型的堰塞湖。