Other faults
Onshore and offshore faults

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Taiwan SSHAC Level 3 PSHA Study

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Taipei, Taiwan

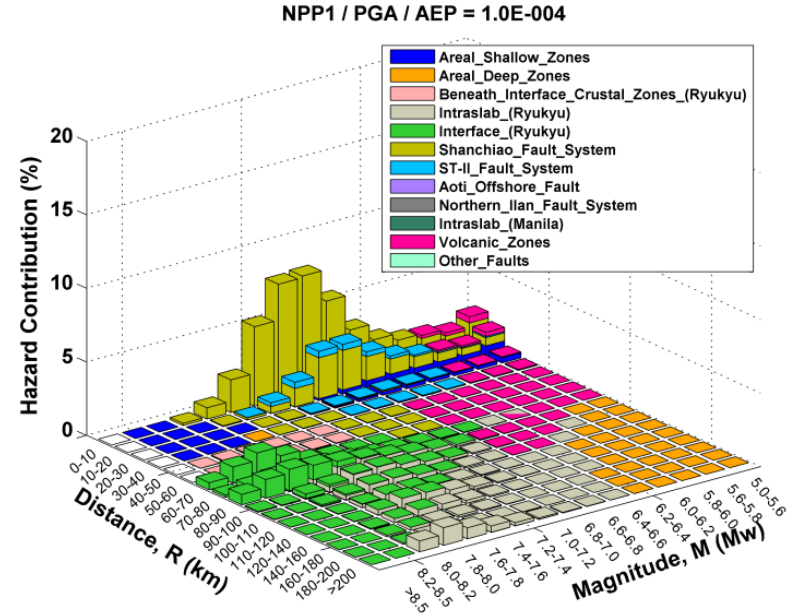
Outline

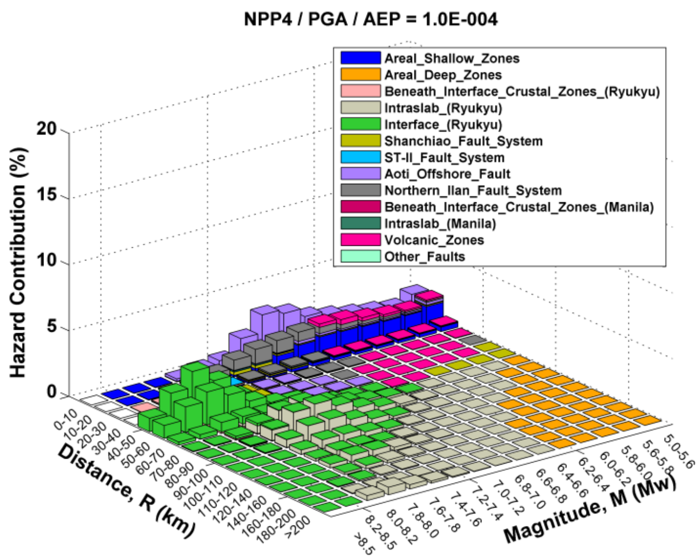
- **Logic tree**
- **Onshore fault**
  - Data collection
  - Geometry
  - Slip rate
- **Offshore faults**
  - Geometry
  - Slip rate

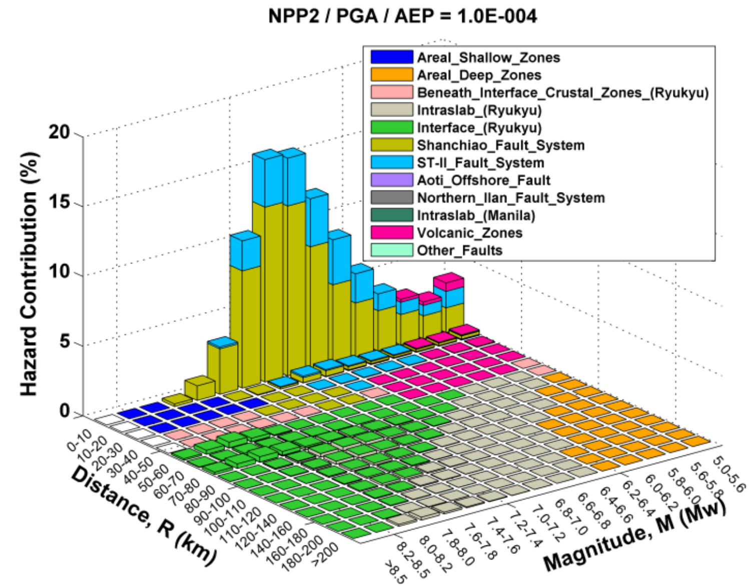
Definition of Primary Faults and Other Faults

- According to hazard deaggregation in PSHA, the major hazards come from the seismic sources within 20 km range of NPP sites

- Primary Faults: ≦ 20 km
- Other Faults: > 20 km
  - Onshore
  - Offshore



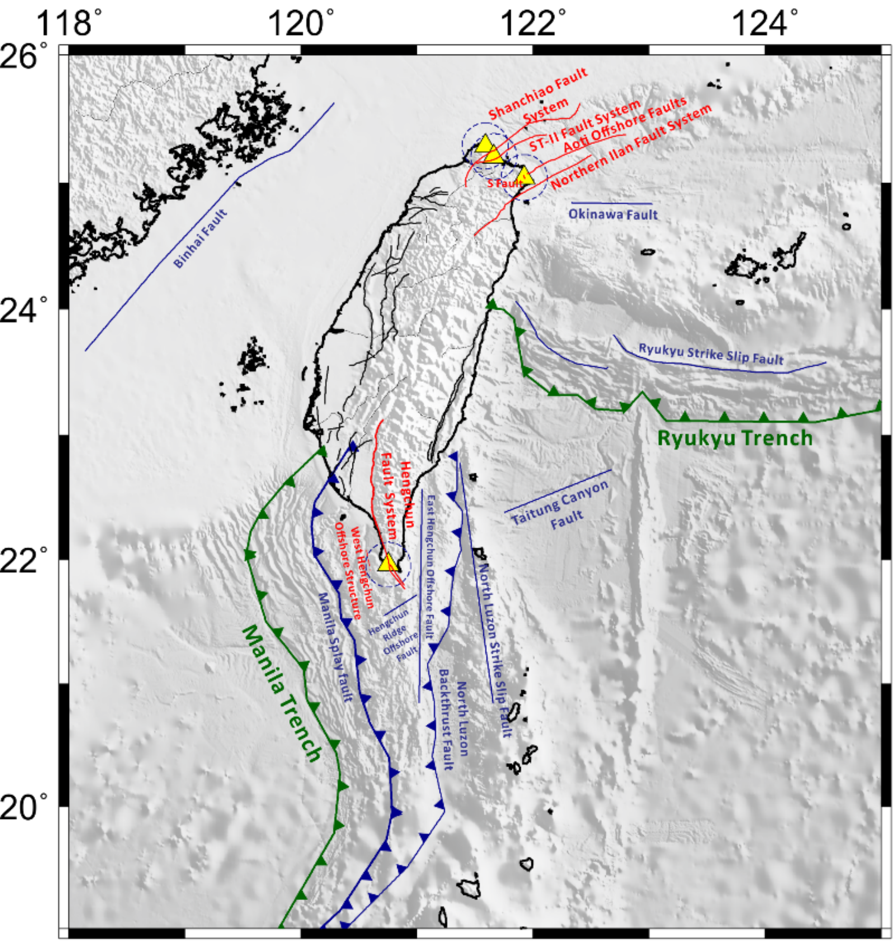




48 Other Faults

Onshore Offshore Interface
Primary fault

39 onshore faults
9 offshore faults



1	Shuanglienpo structure	26	Hsiaokangshan fault
2	Yangmei structure	27	Kaoping River structure
3	Hukou fault	28	Milun fault
4	Fengshan river strike-slip structure	29	Longitudinal Valley fault
5	Hsinchu fault	30	Central Range structure
6	Hsincheng fault	31	Luyeh fault
7	Hsinchu frontal structure	32	Taimali coastline structure
8	Touhuanping structure	33	Southern Ilan structure
9	Miaoli frontal structure	34	Chushiang structure
10	Tunglo structure	35	Gukeng structure
11	East Miaoli structure	36	Tainan frontal structure
12	Shihtan fault	37	Longchuan structure
13	Sanyi fault	38	Youchang structure
14	Tuntzuchiao fault	39	Fengshan hills frontal structure
15	Changhua fault	40	Taitung Canyon Fault
16	Chelungpu fault	41	Binhai Fault
17	Tamaopu - Shuangtung fault	42	North Luzon Strike Slip Fault
18	Chiuchiungkeng fault	43	North Luzon Backthrust Fault
19	Meishan fault	44	East Hengchun Offshore Fault
20	Chiayi frontal structure	45	Hengchun Ridge Offshore Fault
21	Muchiliao - Liuchia fault	46	Manila Splay Fault
22	Chungchou structure	47	Ryukyu Strike Slip Fault
23	Hsinhua fault	48	Okinawa Fault
24	Houchiali fault		
25	Chishan fault		

Investigation data of Other fault onshore Parameters

Investigative Techniques \ Fault Parameters		Segmentation (Length)	Fault Dip	Rupture Depth	Long-term Slip Rate
Structural Geology	Geologic cross-section	●	●	●	●
	Tectonic sequence stratigraphy	●			
	Balanced cross section		●	●	●
	Drilling boreholes	●	●		
Surface Geological Survey	Earthquake surface rupture	●			
	Exploratory trenching		●		●
	Terrace dating				●
Exploration Geophysics	Seismic profile		●	●	
	Resistivity Image Profile	●			
Interpretation of Remote Sensing Image	D-InSAR or PS-InSAR	●			
	Satellite image interpretation	●			
	Aerial photo interpretation	●			
Seismology	Aftershock distribution	●		●	
	Seismicity cross sections		●	●	
	Focal mechanism solution		●		
	Seismic tomography			●	
Geodetic survey	GPS coseismic slip	●			
	GPS block model				●

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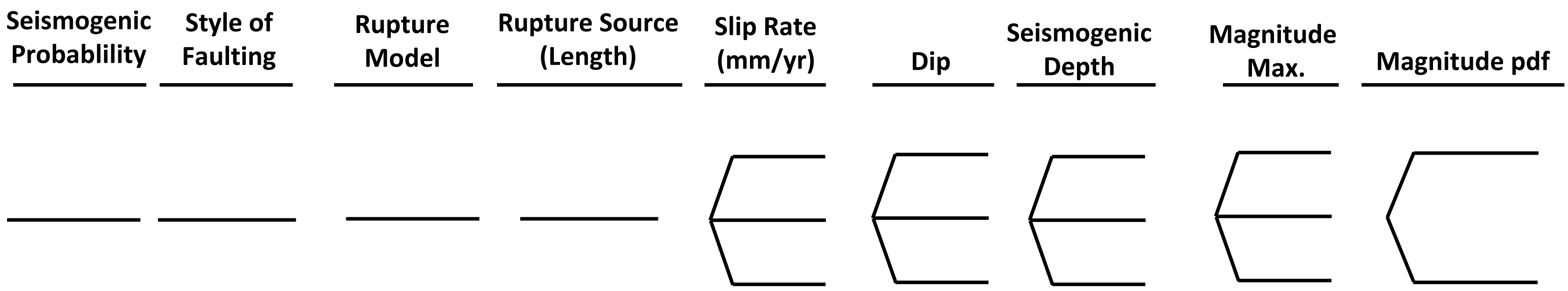
Logic Tree Node of Other Faults



- **The goal of SSHAC is to integrate all possibilities and considerations of faults into the logic tree.**

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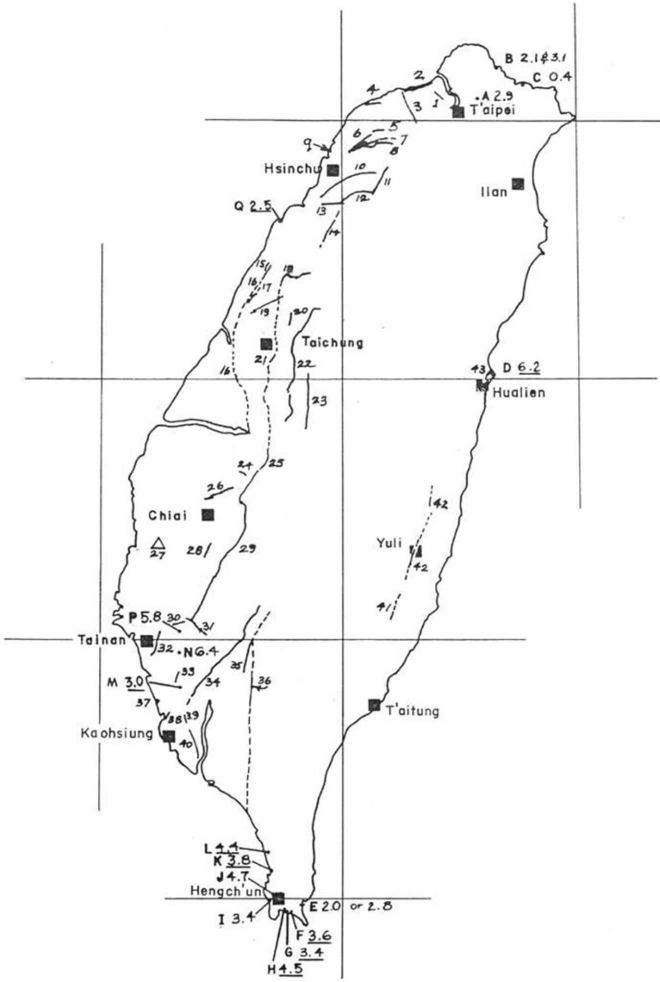
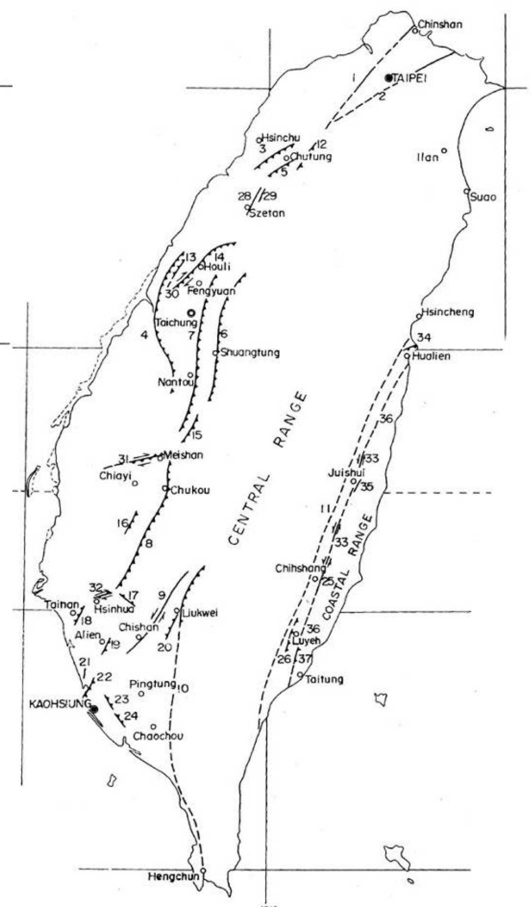
Active Fault Map

Different version in early stages

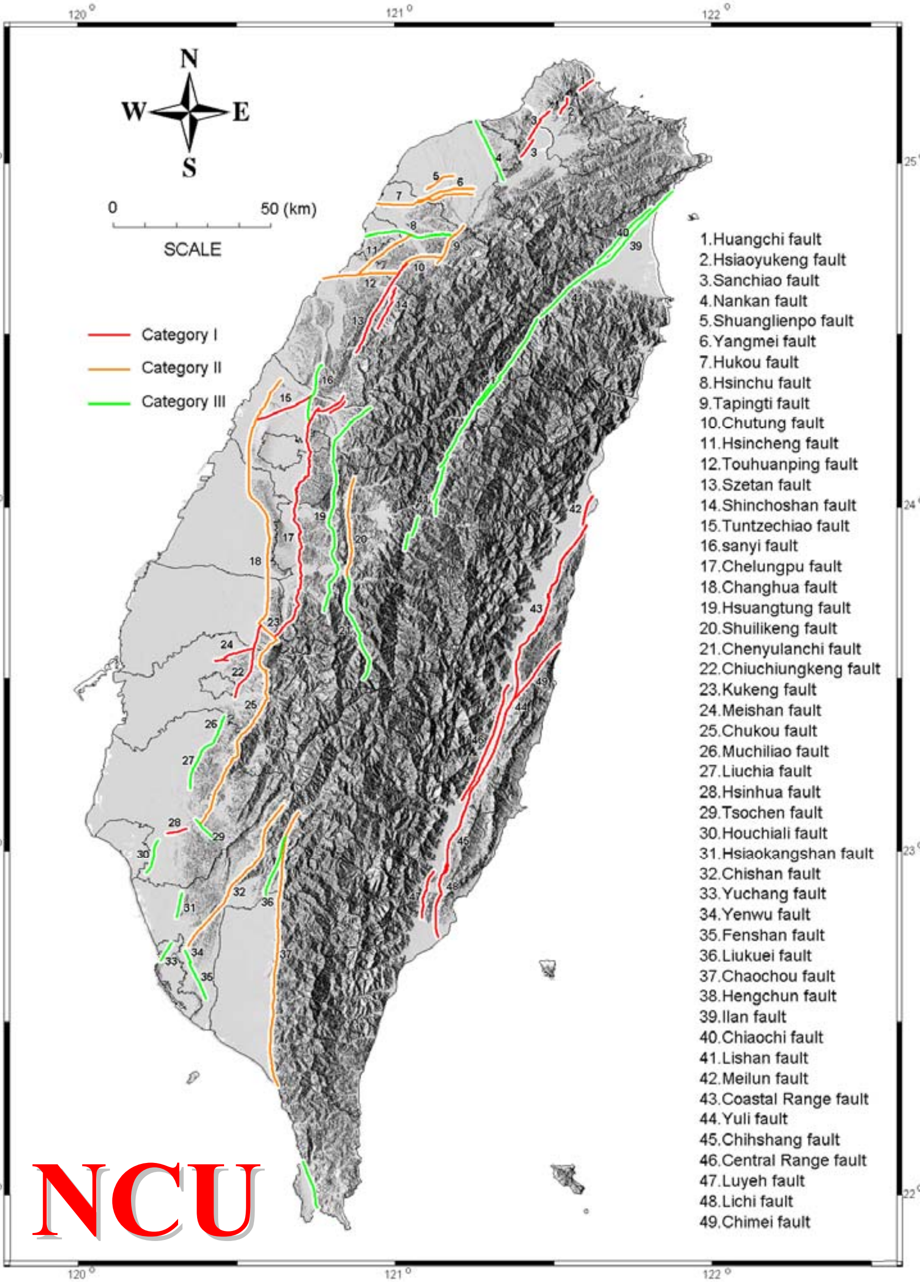


Bonilla, 1975

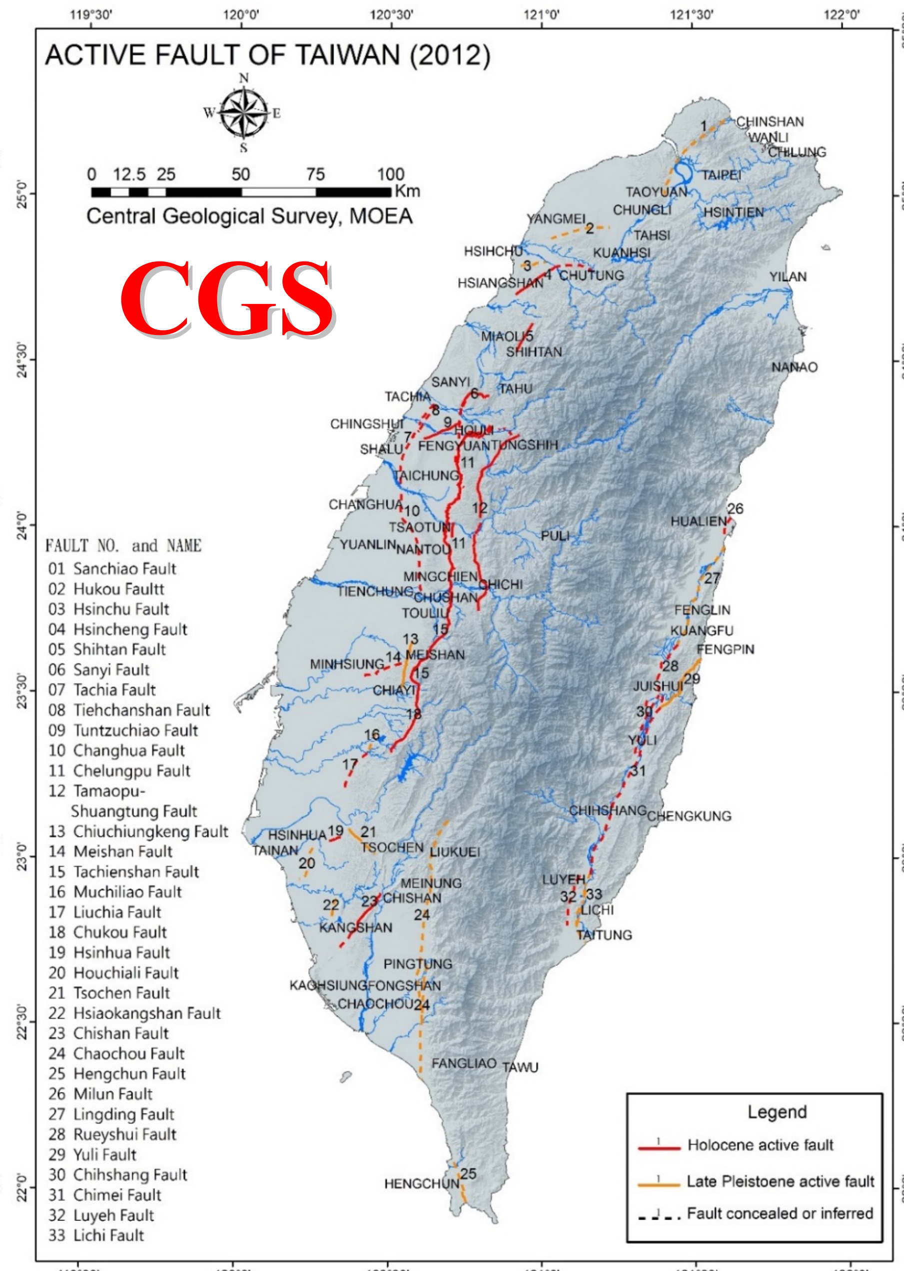


Hsu and Chang, 1979

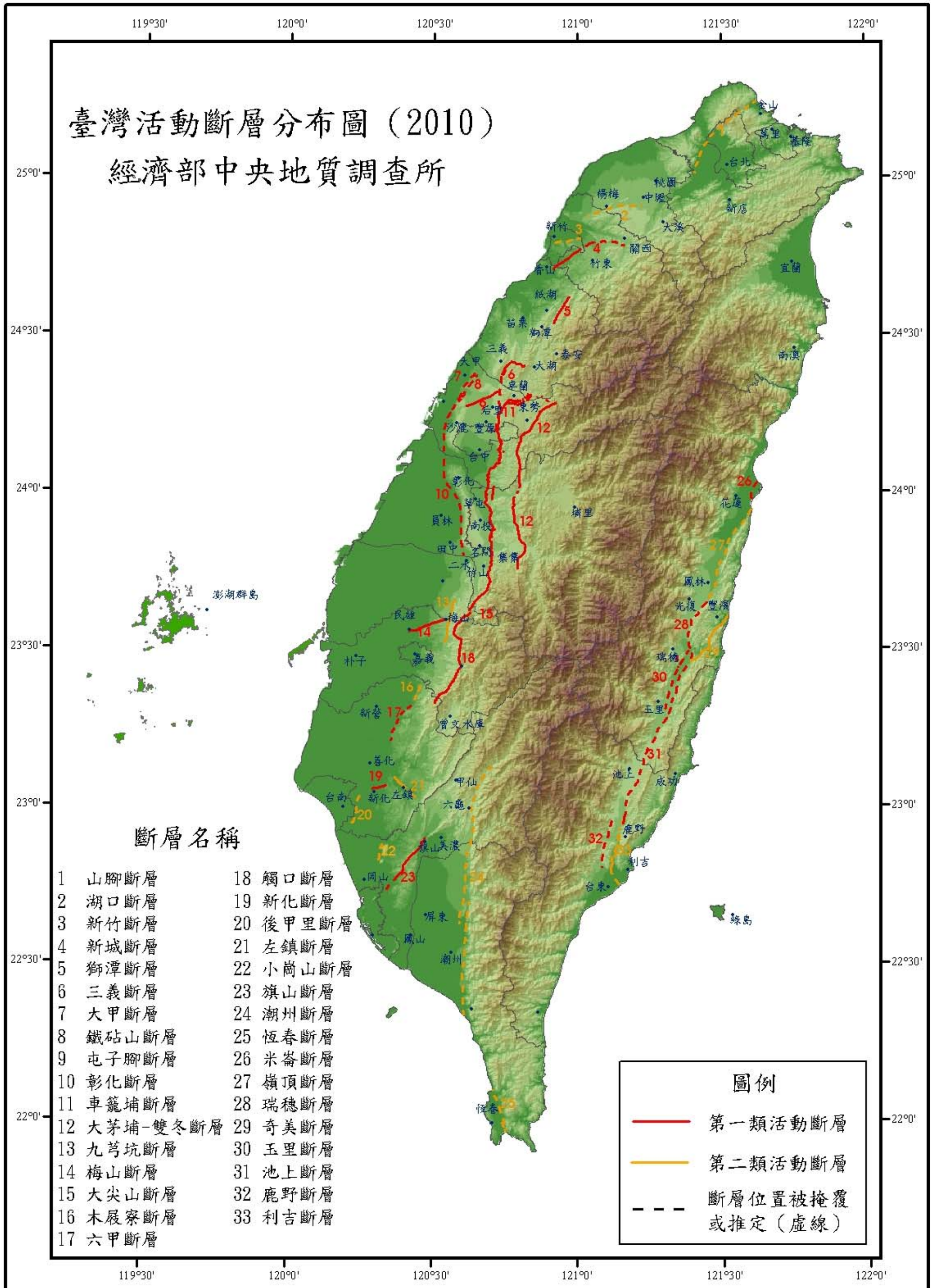
Chang et al., 1998

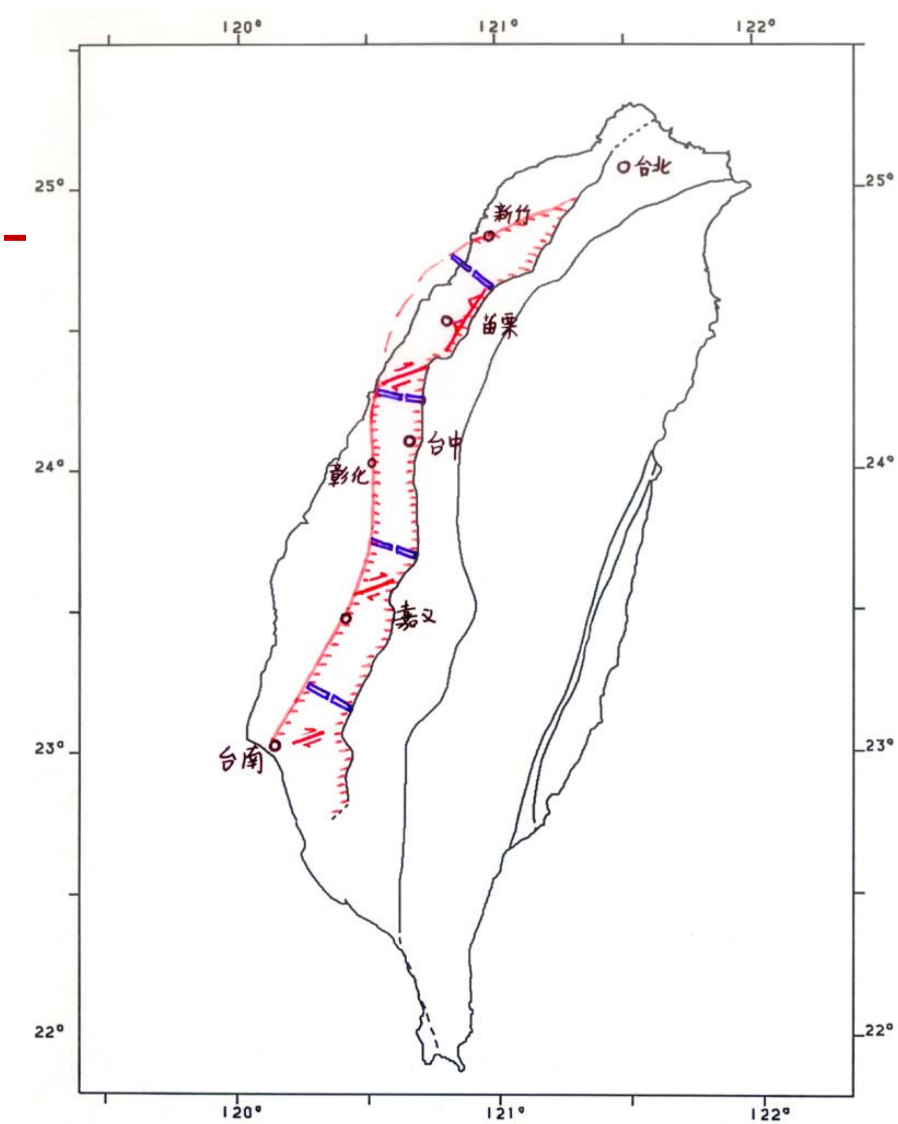


(Modified from Lee, 1999)

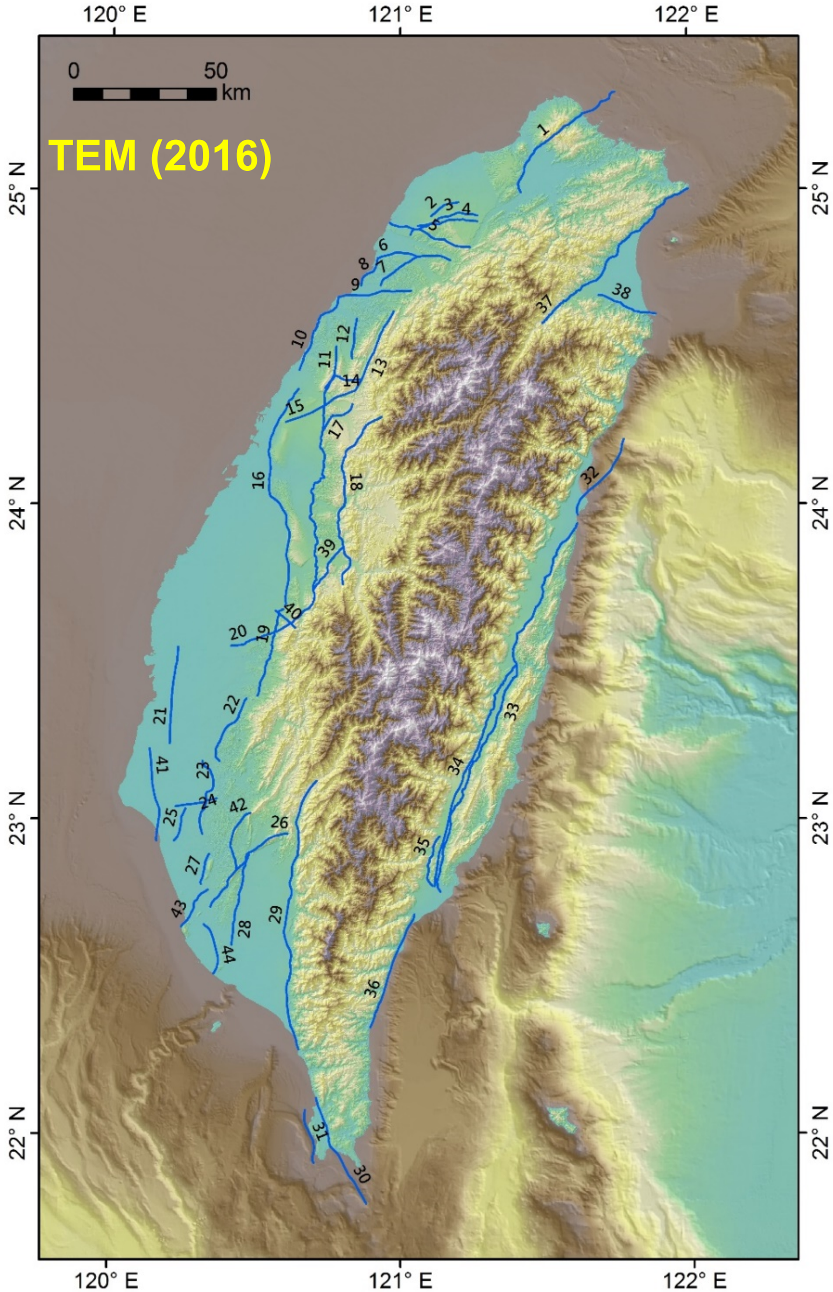


(CGS, 2012)





Sections of Blind Faults in Western Taiwan (Lee, 1992)



ID	Fault Name
1	Shanchiao fault
2	Shuanglienpo structure
3	Yangmei structure
4	Hukou fault
5	Fengshan river strike-slip structure
6	Hsinchu fault
7	Hsincheng fault
8	Hsinchu frontal structure
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17	Chelungpu fault
18	Tamaopu - Shuangtung fault
19	Chiuchiungkeng fault
20	Meishan fault
21	Chiayi frontal structure
22	Muchiliao - Liuchia fault
23	Chungchou structure
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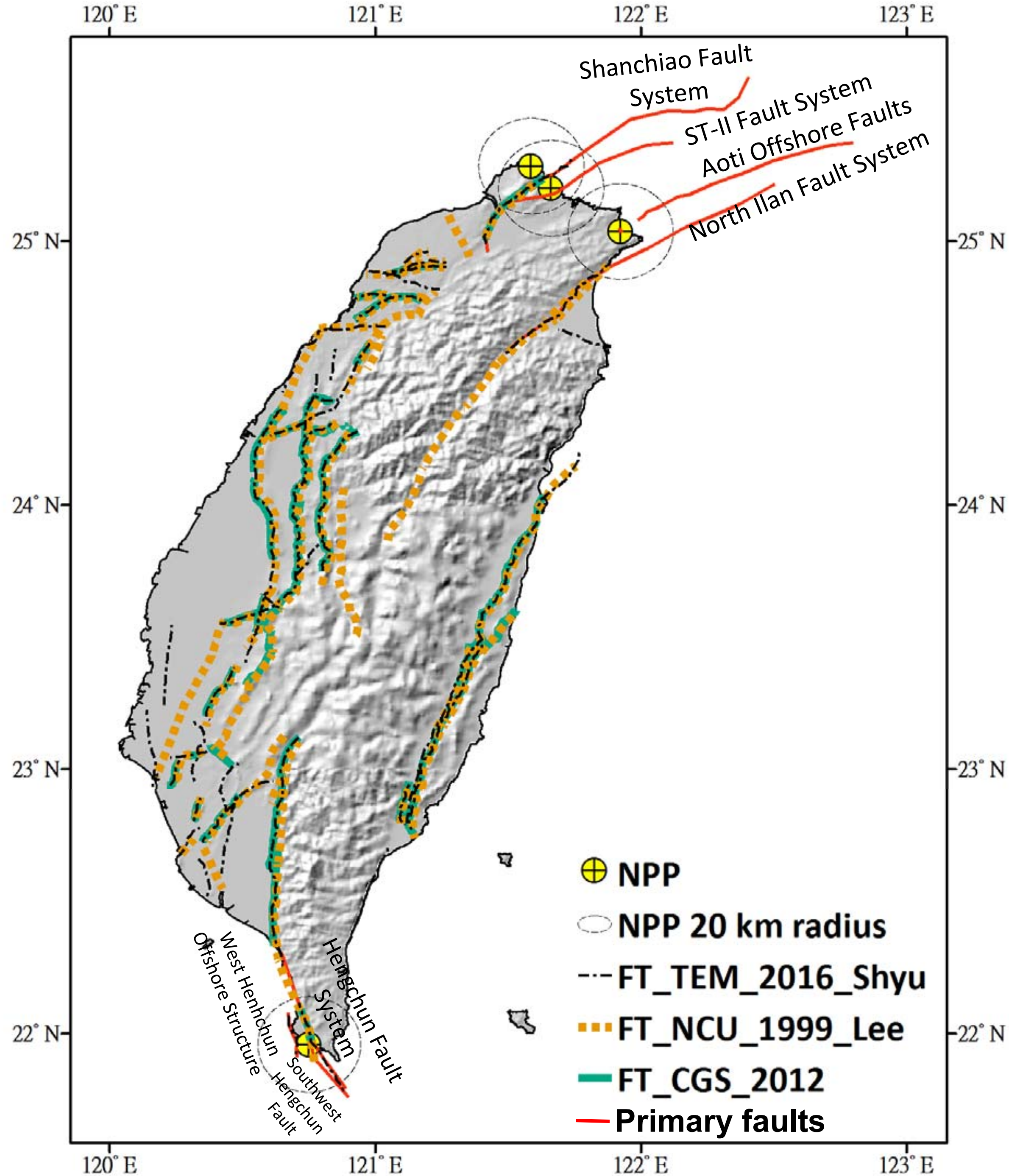
42	Longchuan structure
43	Youchang structure
44	Fengshan hills frontal structure



Summary of Onshore and Primary Active Fault Map

- Overlay active fault maps from TEM, CGS and NCU.
- Identify primary faults which may be composed by onshore and offshore parts

The papameters of other fault

- **The major parameters of other faults in SSHAC is the latest version of TEM because**
  - The parameters in TEM are well established, and
  - TEM has compiled CGS and NCU version.

	Year	Dip		Depth		Slip rate	
		Data	Confidence of Uncertainty	Data	Confidence of Uncertainty	Data	Confidence of Uncertainty
TEM	2016	1*	high	1	high	1	medium
CGS	2012	1	high	1	high	2	medium
NCU	1999	3	medium	3	medium	3	low

*ranking of data abundance

Data Quality of Other Faults

○ data with high confidence would be given the weighting mostly on median branch (e.g 0.2, 0.6, 0.2).
□△ data with larger uncertainty would be given average weight on branches. (e.g. 0.3, 0.4, 0.3)

Onshore faults

Num.	Fault Name	Dip	Depth	Activity
1 - 39	TEM 2016 version	○	□	△

Other offshore faults

Num.	Fault Name	Trace	Geometry	Activity
40	Taitung Canyon fault	△	△	△
41	Binhai Fault	△	△	△
42	North Luzon Strike Slip Fault	△	△	△
43	North Luzon Backthrust Fault	○	□	△
44	East Hengchun Offshore Fault	△	△	△
45	Hengchun Ridge Offshore Fault	△	△	△
46	Manila Splay fault	○	□	△
47	Ryukyu Strike Slip fault	△	△	△
48	Okinawa fault	△	△	△

○	□	△
High confidence	Need more discussion	Have large uncertainty

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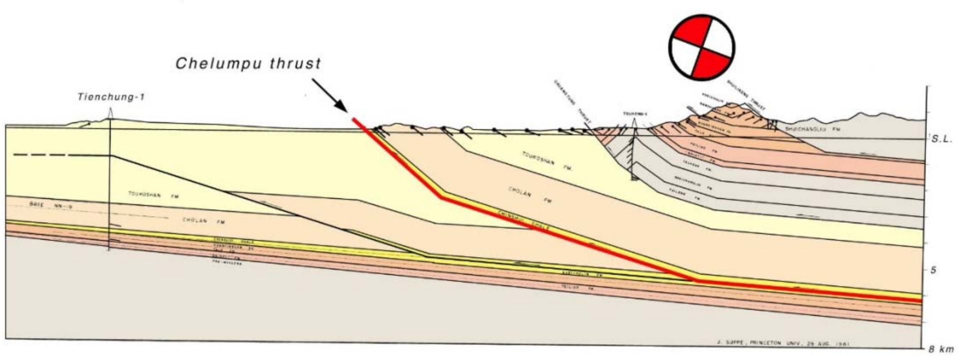
Structure depth

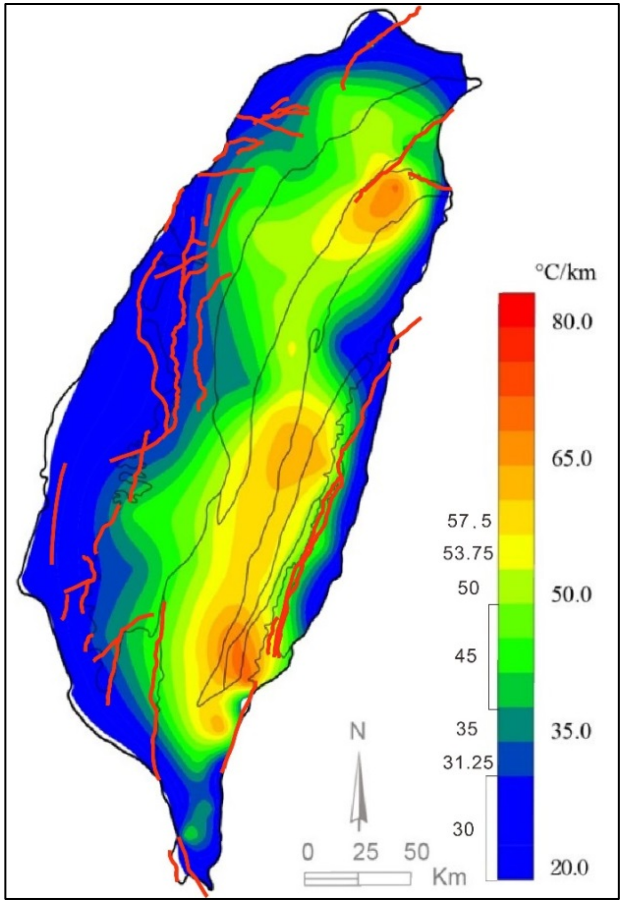
The structure depth are constrained
–by seismic data
(e.g., Miaoli and Hsinchu area in northwestern Taiwan)

–by geothermal data (brittle ductile transition zone depth, ~450°C)

- The depth in **Blue area** would be deeper than the **red area**.
- 450 ℃: A conservative high value of temperature for the brittle-ductile transition zone



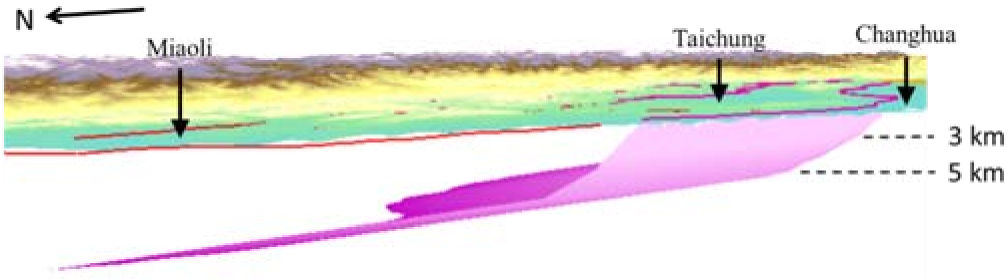
(Suppe, 1981)



Geothermal gradient map
(Liu et al., 2015)

Structures with multiple dips

- **The structures with multiple dips:**
  (1) Shuanglienpo structure
  (2) Changhua fault
  (3) Longitudinal Valley fault
  (4) Luyeh fault



Fault Name	Dip (°)	Depth 1 (km)	Dip (°)	Depth 2 (km)	Dip (°)	Depth 3 (km)
Changhua fault 彰化斷層	45	3	30	5	10	12

The uncertainty/range of geometry in TEM

Onshore

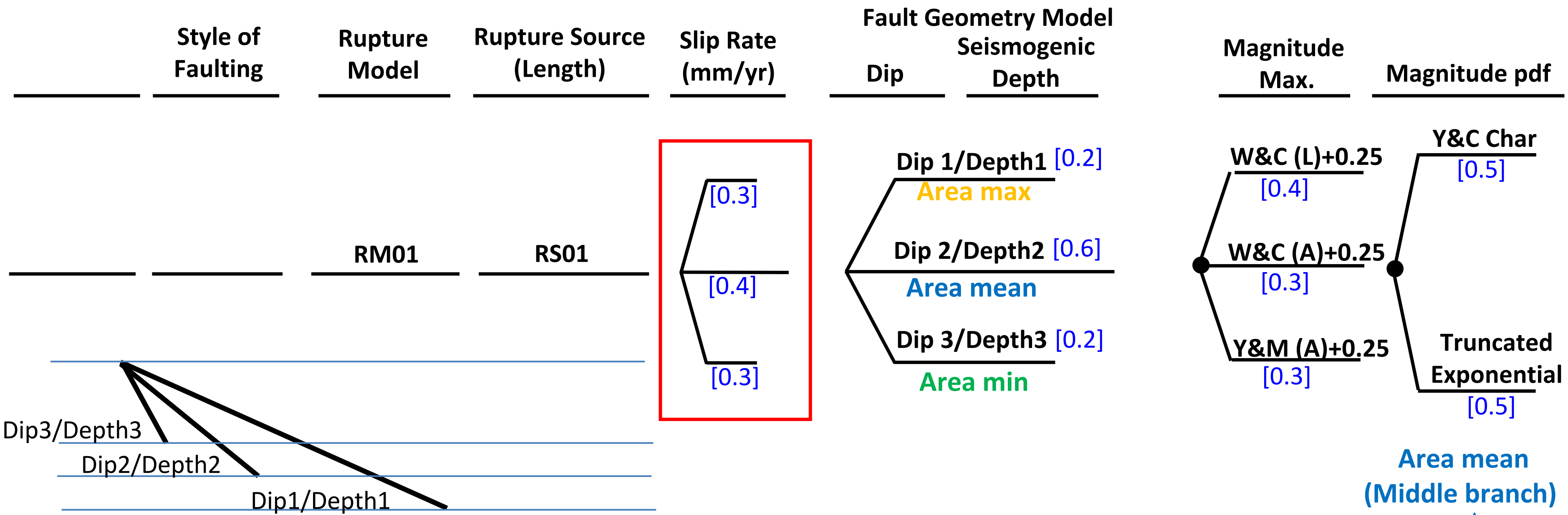
- (1) If the dipping angle is 15°<Dip<85°, then the uncertainty is ±10°.
- (2) If the dipping angle is Dip⩽15° or ⩾85°, then the uncertainty is ±5°.
- (3) If the node depth is Depth>8 km, then the uncertainty is ±2 km.
- (4) If the node depth is Depth⩽8 km, then the uncertainty is ±1 km.

offshore

- (1) If the dipping angle is 15°<Dip<85°, then the uncertainty is ±15°.
- (2) If the dipping angle is Dip⩽15° or ⩾85°, then the uncertainty is ±5°.
- (3) All the depth errors are assumed to be ±5 km because the data in the offshore are less well constrained.

(Shyu et al., 2016)

The Range and Weighting of Logic Tree for Other Fault



Area mean (Middle branch)

ID	Fault name	Type	Length (km)	Depth 0 (km)	Depth 1 (km)			Dip (degree) between depth 0-1			Depth 2 (km)			Dip2 (degree) between depth 1-2			Depth 3 (km)			Dip3 (degree) between depth 2-3			Width (km)			Area (km^2)		
					min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max
16	Changhua fault	R	82.2	0	2.50	3.00	3.50	35	45	55	4.50	5.00	5.50	20	30	40	10.00	12.00	14.00	5	10	15	24.77	48.55	119.21	2036.09	3990.81	9799.06
17	Chelungpu fault	R	91.9	0	10.00	12.00	14.00	10	15	20													29.24	46.36	80.62	2687.16	4260.48	7408.98

Area min (Lower branch)

Area max (Upper branch)

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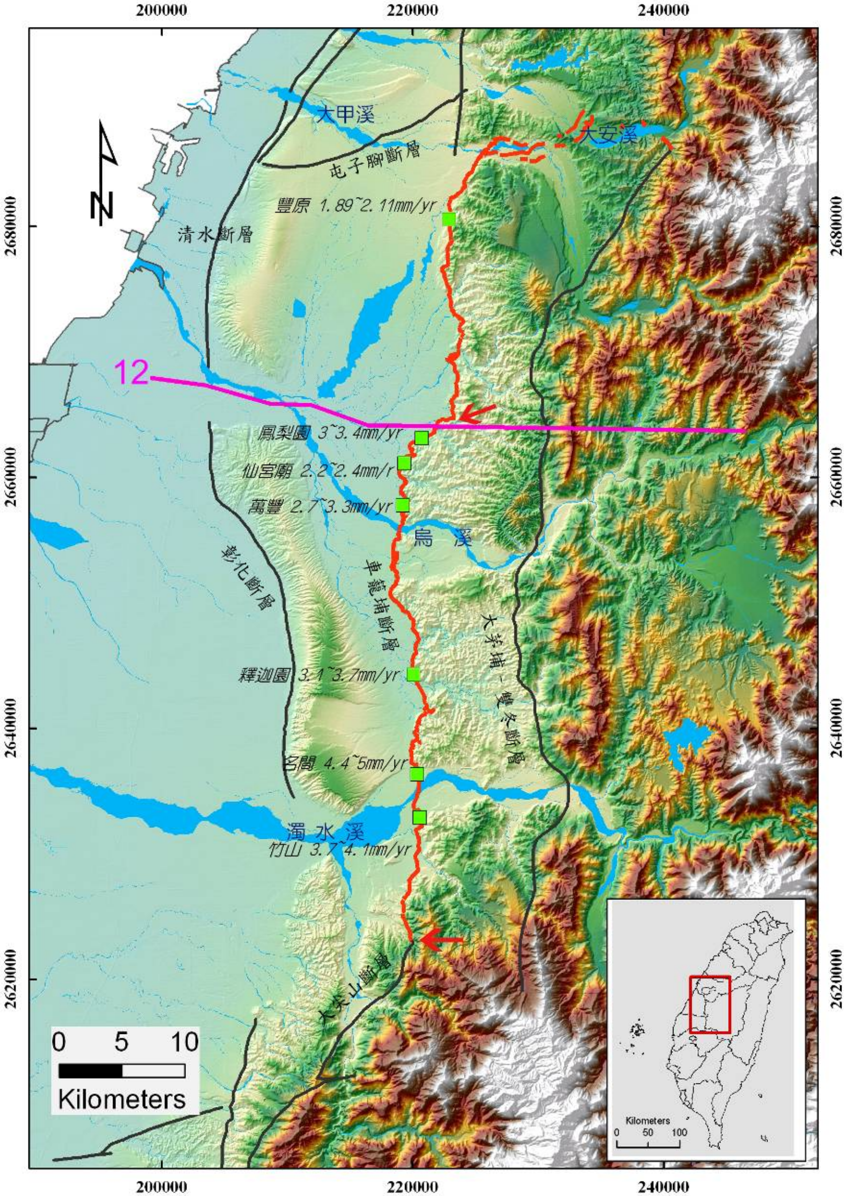
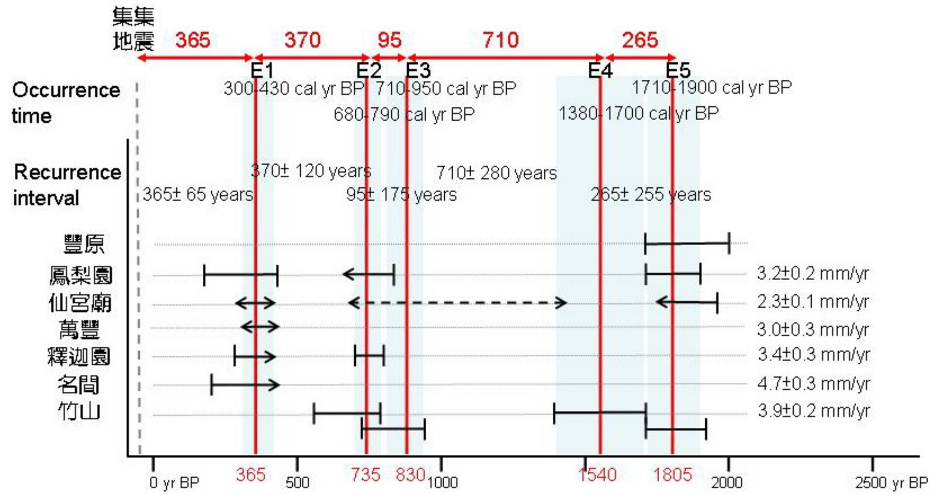
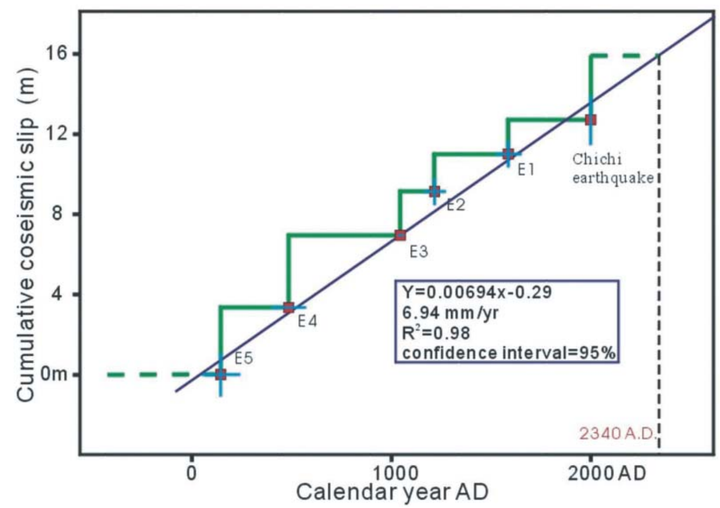
Slip rates of onshore structure

Investigative Techniques \ Fault Parameters		Segmentation (Length)	Fault Dip	Rupture Depth	Long-term Slip Rate
Structural Geology	Geologic cross-section	●	●	●	●
	Balanced cross section		●	●	●
	Drilling boreholes	●	●		●
Surface Geological Survey	Exploratory trenching		●		●
	Terrace dating				●

Previous study of slip rate in Chelungpu fault



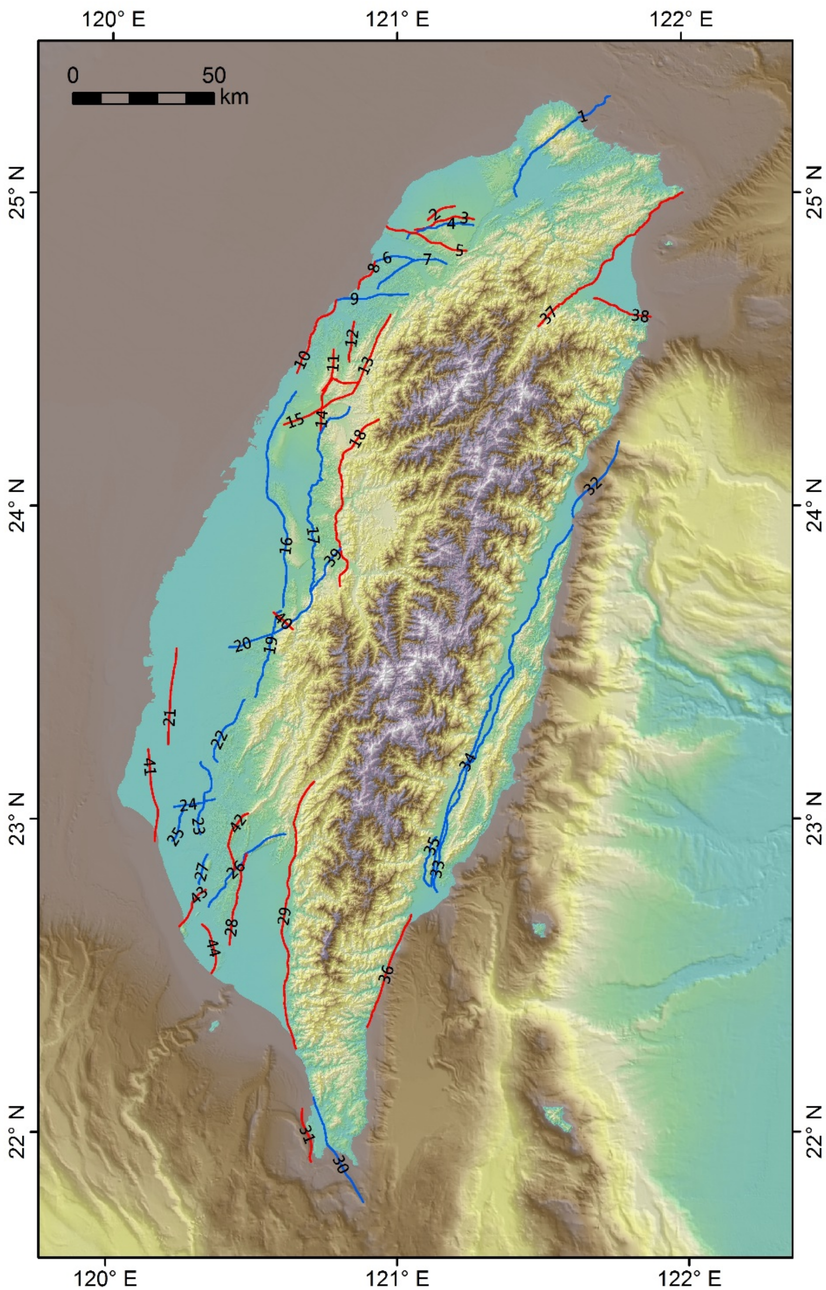




From trenches: slip rate ~ 6.94 mm/yr (Chen et al., 2007)。

Blue lines (21): slip rates can be obtained from previous studies.

Red lines (23): no slip rate data in previous studies.



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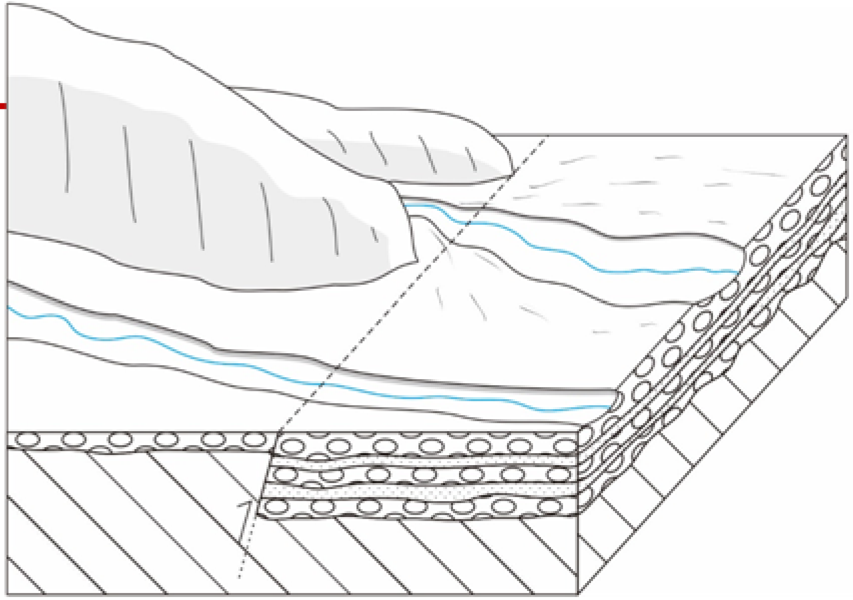
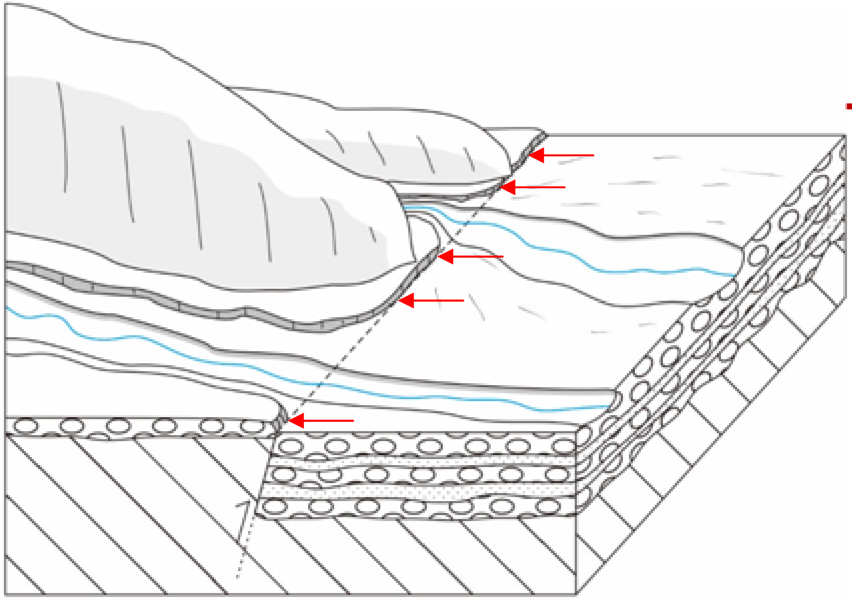
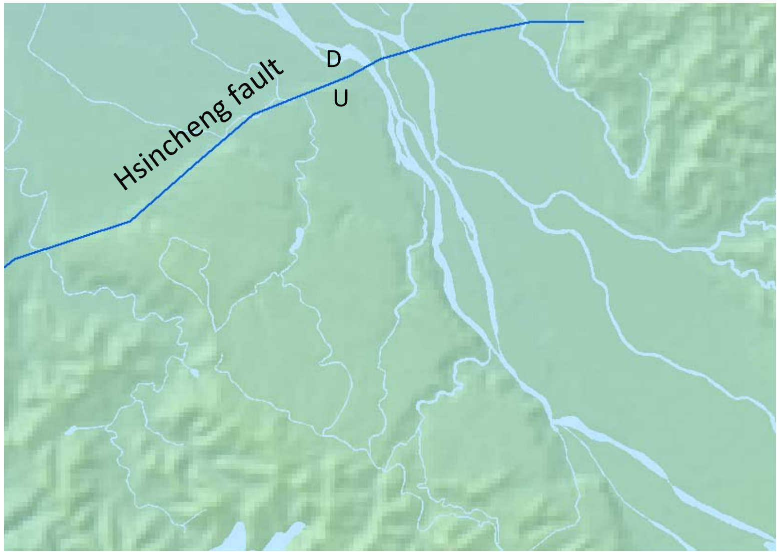
(Slide from Bruce Shyu.)

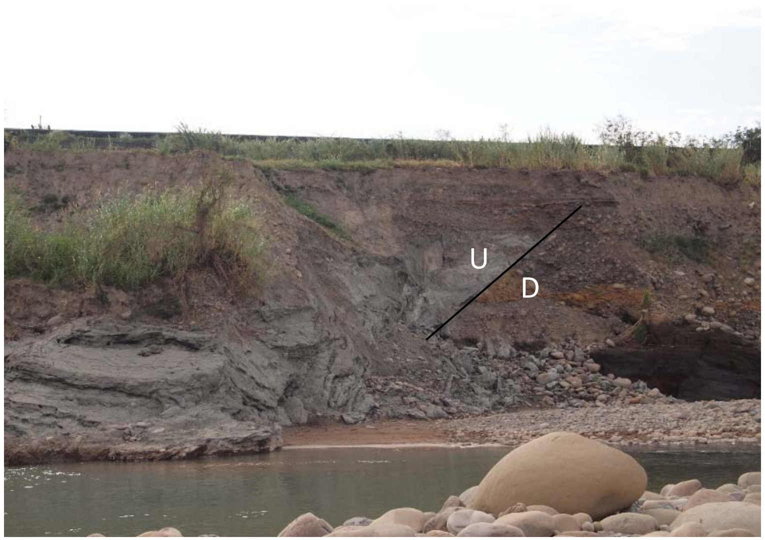
No offset at the surface



Offset of the surface



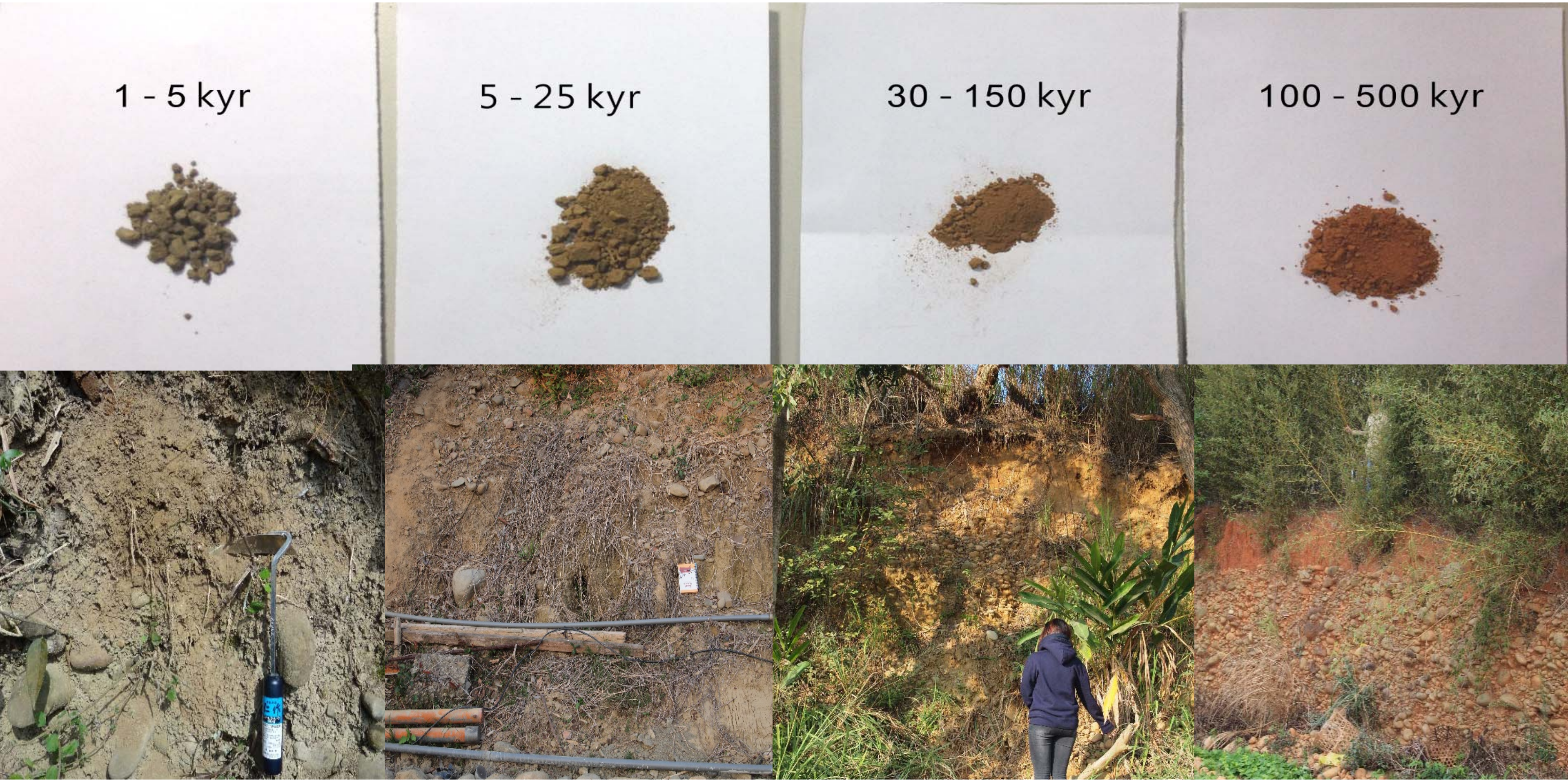




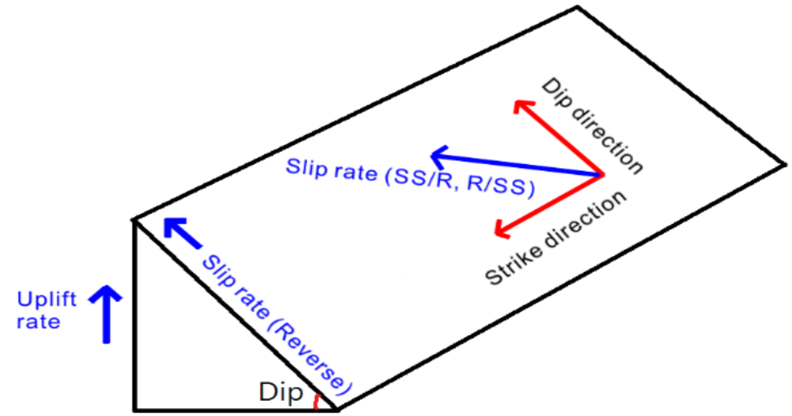
(Slide from Bruce Shyu.)

Soil age classification

Detection limit of C^{14} dating: ~47 kyr BP (BETA)



(Slide from Bruce Shyu.)

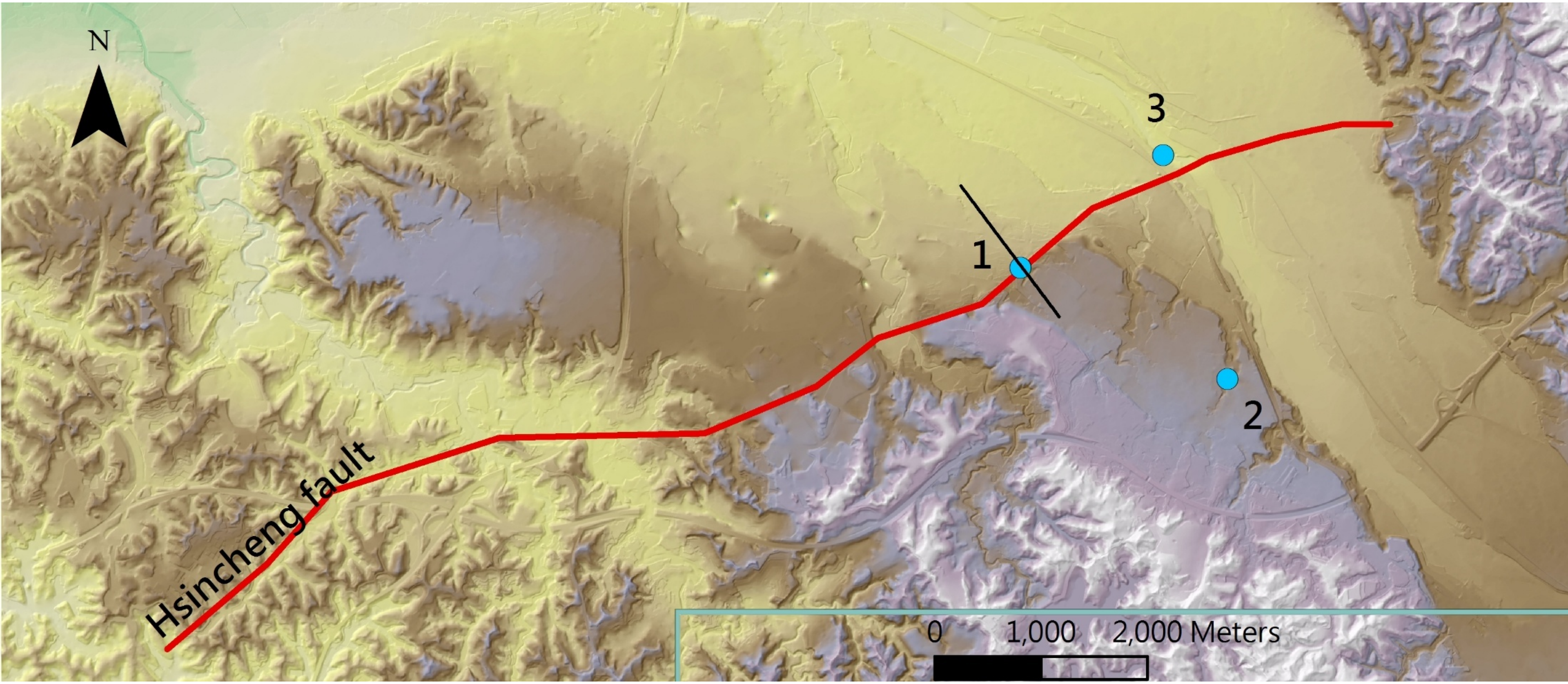


- **Offset and Age:**
  from field survey or previous studies

- **Uplift rate:**
  Offset/Age

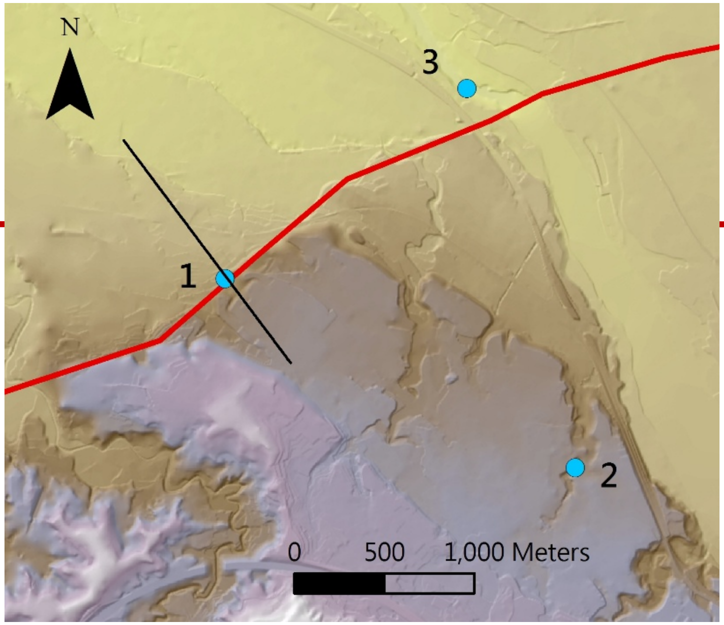
- **Slip rate :**
  - obtained from published data or from this study
    Slip rate = Uplift rate / sin(dip) (R, N)
    Slip rate =√2 *Uplift rate / sin(dip) (R/SS, SS/R), assume the rake is 45 ˙
  - dip=the dip of the uppermost part of the rupture plane
    (SC fault, SLP structure, CH fault, LV fault, LY fault)
  - Slip rate of LVF=1/4 of total slip rate
    (assume 1/4 to 2/4 of slip rate is contribute to the brittle behavior)

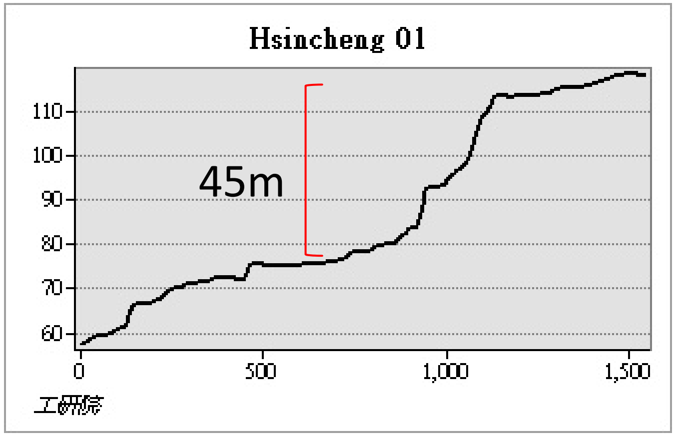
Hsincheng fault



(Slide from Bruce Shyu.)

Site 1

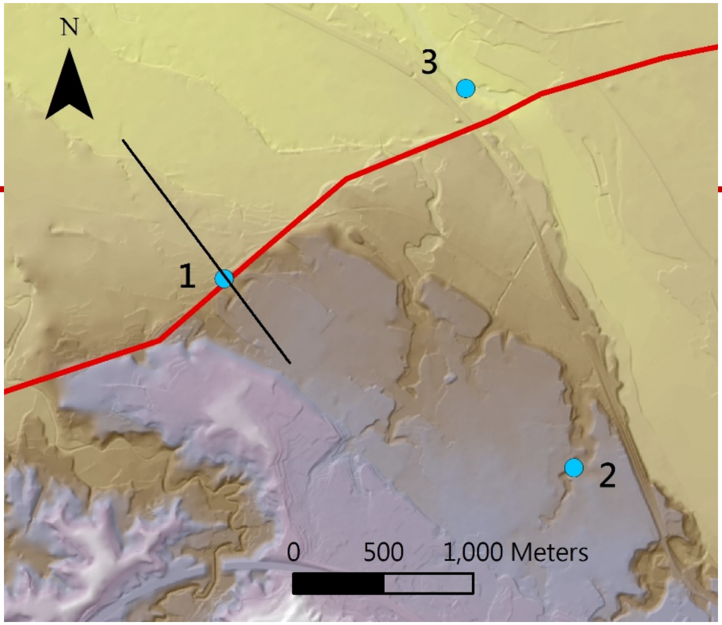


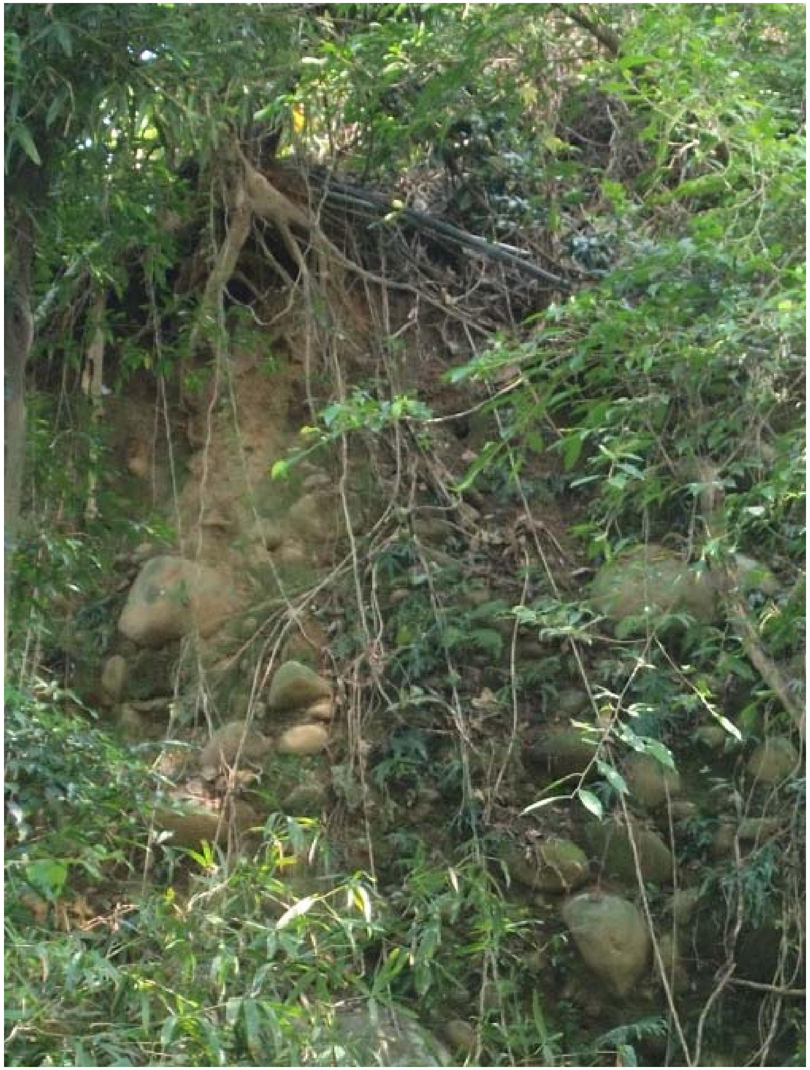


Offset amount
Field survey : 26 m
5m DEM : 45 m

(Slide from Bruce Shyu.)

Site 2





(Slide from Bruce Shyu.)

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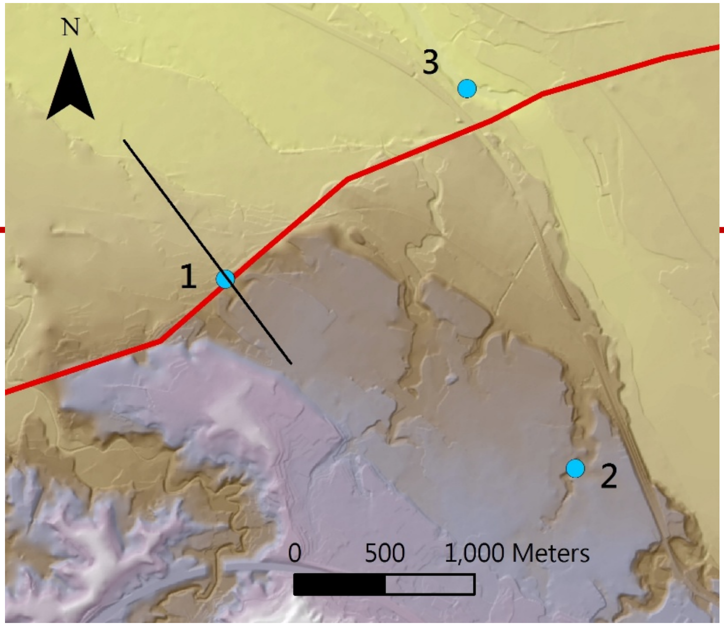


Site 3

Last event was less than 300 yrs old

(Slide from Bruce Shyu.)

Hsincheng fault

Fault type: reverse fault
Length (km): 13.0
Fault dip (°): 30
Depth (km): 12.86 (Geothermal)
Width (km): 25.71
Area (km^2): 334.23
M_w: 6.60
M_0 (10^{25} dyne-cm): 9.89
Displacement (m): 0.99

Vertical offset (m): 45
Age (kyr): 30 – 150
→Uplift rate: 0.30 – 1.50 mm/yr

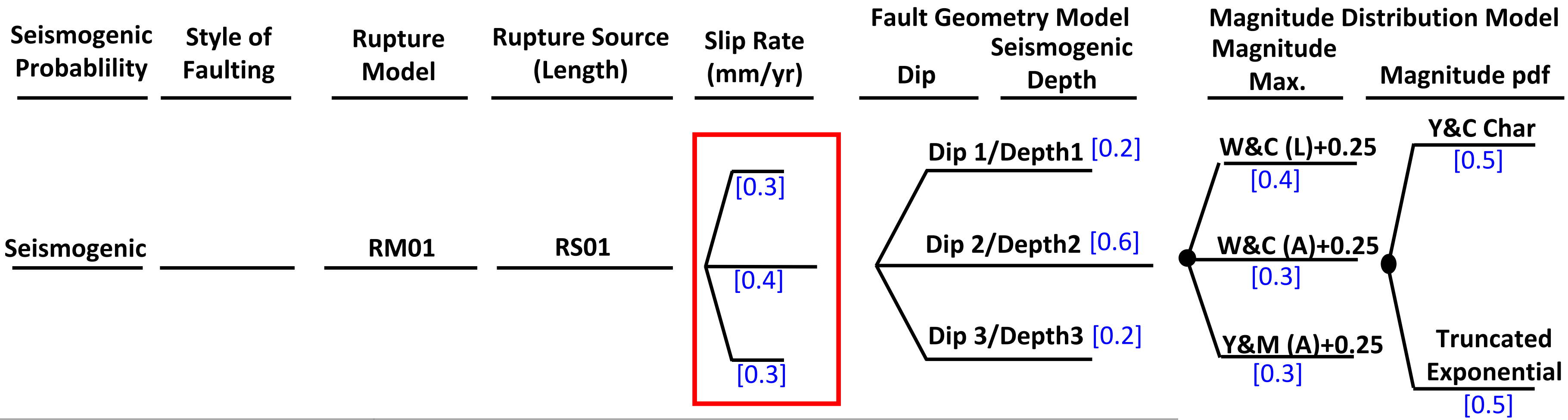
Fault dip (°): 30
→ Slip rate: 0.60 – 3.00 mm/yr

Displacement (m): 0.99
→Recurrence interval: 330 – 1650 yr

Slip rate (mm/yr) : 1.8 ± 1.2
Displacement/Slip rate = Recurrence interval (yr) : 330 – 1650

The weighting of slip rate

- The slip rates are less constrained as the result that terrace ages are less convinced.
- Therefore the weighting of branches are given **0.3, 0.4, 0.3**.



ID	Fault name	Offset (m)			Age (kyr)			Uplift rate (mm/yr)			Long-term slip rate (mm/yr)			
		min	mean	max	min	mean	max	min	mean	max	min	mean	max	
16	Changhua fault	390	395	400	100	300	500	0.78	1.32	4.00	0.95	1.87	6.97	
17	Chelungpu fault										6.94	6.94	6.94	→ 陳文山 (Chen, 2006)
18	Tamaopu - Shuangtung fault	45	47.5	50	30	90	150	0.30	0.53	1.67	0.47	1.06	4.88	
19	Chiuchiungkeng fault	30	35	40	5	15	25	1.20	2.33	8.00	1.87	4.66	23.39	
20	Meishan fault							2.50	2.50	2.50	2.50	2.51	2.54	→ 陳文山等 (Chen et al., 2013)

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- **Logic tree**
- **Onshore fault**
  - Data collection
  - Geometry
  - Slip rate
- **Offshore faults**
  - Geometry
  - Slip rate

Data Collection

Offshore Active Faults

Fault Name	References	Status
(1) Binhai Fault	馬宗晉等，2002	Although the surface traces may be identified, most of the offshore active faults still lack reliable underground geometry and seismic activity
(2) Taitung Canyon fault	Schnurle et al.,1998	
(3) North Luzon Strike Slip Fault	Cheng et al., 1998	
(4) North Luzon Backthrust Fault	Reed et al.,1992	
(5) East Hengchun Offshore Fault	Cheng et al., 1998	
(6) Hengchun Ridge Offshore Fault	Fuh et al., 1997	
(7) Manila Splay fault	Lin et al., 2009	
(8) Ryukyu Strike Slip Fault	Lallemand et al.,1999	
(9) Okinawa Trough fault	CGS ongoing project, since 2017	

Investigation data of Other fault offshore Parameters

Investigative Techniques \ Fault Parameters		Segmentation (Length)	Fault Dip	Rupture Depth	Long-term Slip Rate
Structural Geology	Geologic cross-section	●	●	●	●
	Tectonic sequence stratigraphy	●			
	Balanced cross section		●	●	●
	Drilling boreholes	●	●		
Surface Geological Survey	Earthquake surface rupture	●			
	Exploratory trenching		●		●
	Terrace dating				●
Exploration Geophysics	Seismic profile		●	●	
	Resistivity Image Profile	●			
Interpretation of Remote Sensing Image	D-InSAR or PS-InSAR	●			
	Satellite image interpretation	●			
	Aerial photo interpretation	●			
Seismology	Aftershock distribution	●		●	
	Seismicity cross sections		●	●	
	Focal mechanism solution		●		
	Seismic tomography			●	
Geodetic survey	GPS coseismic slip	●			
	GPS block model				●

(1) Binhai fault
The presence evidences of Binhai fault

Historical earthquake record

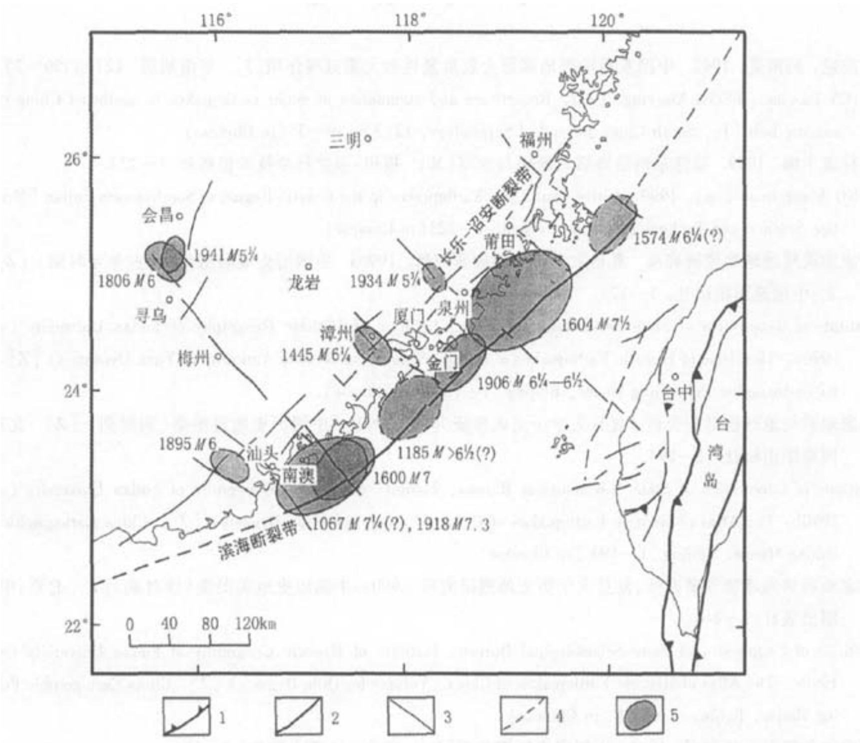


图 4 福建—粤东沿海地区历史及现今 M≥ 5. 7地震震源分布图

Fig 4 Distribution map of hypocenters of the historical and current M≥ 5. 7 earthquakes in the coastal region of Fujian and eastern Guangdong

1 活动逆断层（锯齿示意上盘）；2 旋性不明活断层；3 次级活断层；4 推测断层；5 地震震源区（相对重破坏区）；虚线为推测. 海峡中部及台湾岛的震源区未绘出

(Wen and Xu, 2005) (聞學澤與徐錫偉, 2005)

Seismic data

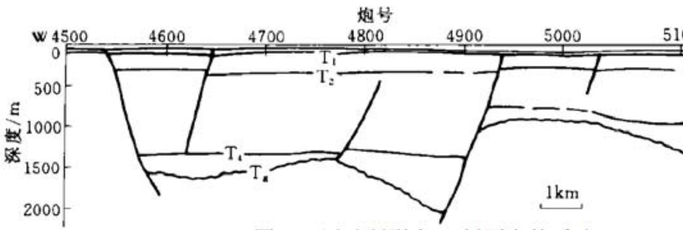


图 3 活动断裂在 L1剖面上的反映

Fig. 3 Active faults shown in L1 seismic profile

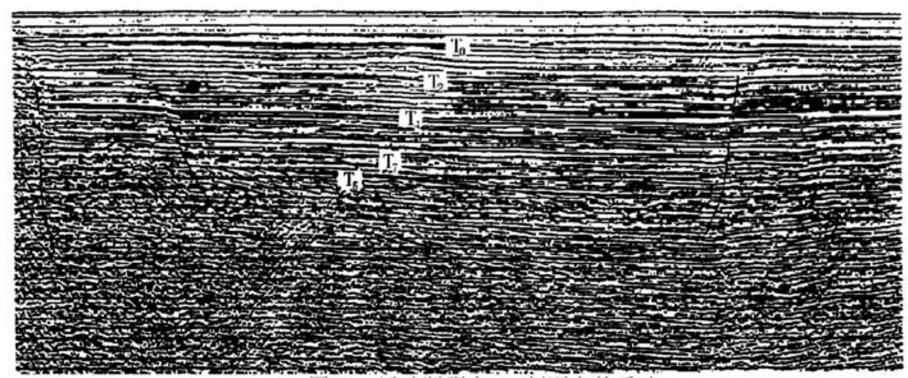


图 4 活动断裂在 L2 剖面上的反映

Fig. 4 Active faults shown in L2 seismic profile

(Zhan et al., 2002) (詹文歡等, 2002)

(1) Binhai fault
Slip rate of Binhai fault

表 1　　闽南粤东沿海地区 ^{14}C 年代测定结果

Table 1　　^{14}C dates from the coastal area of South Fujian and East Guangdong

样品编号野外(实验室)	地　点　与　层　位	试　　料	年　代*（距今计年）	拔海高度**(M)
SF-6(CG-425)	长乐江田海滨海积平原泥炭层	泥　炭	1725±100	3
SF-14(2)(CG-436)	东山宫前村东砂堤	贝 壳 砂	2735±85	6
SF-14(1)(CG-435)	东山宫前村东上升海滩	贝壳砂岩	4110±85	4
SF-9(CG-428)	平潭上板连岛砂坝	贝　壳	5260±90	3
SF-11(CG-431)	龙海角尾河口平原淤泥层	木　头	5660±95	3
0124[1-3](CG-346)	闽侯祥谦邮局钻孔 17 米处淤泥层	淤　泥	8040±110	-14
0124[1-8](CG-349)	闽侯祥谦邮局钻孔32.9米处淤泥层	淤　泥	8790±115	-30
SF-4(1)(CG-422)	闽清(梅埔)东站闽江一级阶地底部	粘　土	1085±85	
SF-4(2)(CG423)	闽清(梅埔)东站闽江下伏石灰华	石 灰 华	12050±175	
SF-16(1)(CG-438)	东山赤山林场连岛砂坝上部淤泥层	泥　炭	6640±105	5
SF-16(2)(CG-439)	东山赤山林场连岛砂坝下部淤泥层	泥　炭	16415±215	4
SF-8(1)(CG-426)	平潭后楼剖面中部	泥　炭	32665±1980	17
SF-8(2)(CG-427)	平潭后楼剖面中下部	泥　炭	>41670	15
SG-4(CG-447)	饶平浒洲盐场贝壳层	*Placuna placenta*	2205±85	1.5
SG-2(1)(CG-442)	饶平黄梦岛黄隆圩南海滨贝壳堤上部	贝壳砂岩	2420±75	4.6
SG-2(3)(CG-444)	饶平黄梦岛黄隆圩南海滨贝壳堤下部	贝壳砂岩	2820±85	1.2
SG-1(1)(CG-440)	澄海樟林贝壳堤上部	贝 壳 砂	2485±70	2.5
SG-1(2)(CG-441)	澄海樟林贝壳堤下部	贝壳砂岩	3265±85	1.8
SG-7(CG-452)	澄海埋美内底贝壳堤	贝壳砂岩	3190±85	3.5
SG-6(1)(CG-450)	潮安梅林湖	*Ostrea sp.*	3545±85	1.5
SG-6(2)(CG-451)	潮安梅林湖	贝 壳 砂	5440±100	1.5
SG-8(CG-453)	陆丰甲子锆矿场东壁	埋藏土壤层	16450±325	0.7

* ^{14}C 半衰期采用 5570 年，计年起点 1950 年。
** 据地形图与目测估计。

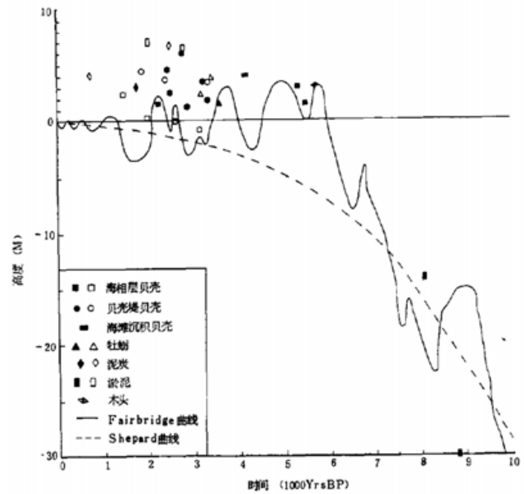


图 5　闽南粤东沿海 ^{14}C 样品的年代与高度及其与已知全新世海面变化代表性曲线的比较（空心符号据黄宝林等）

Fig. 5　The altitudes and ages of ^{14}C samples from the coastal area of South Fujian and East Guangdong and their correlation with the representative curves of Holocene sea level changes.

由图 5 还可看出本区地壳运动的性质、幅度与速率来。如以 Shepard 曲线为准，本区 5500—5000 年的古海面位置要比当时的全球古海面位置高 7—8 米，2300—1500 年前本区古海面位置要比全球古海面高 1—3 米，也就是说，5500 年来平均上升率约达 1—1.5 毫米/年。若以 Fairbridge曲线为准，我们的测年点也基本上位于该曲线上方，但相差的幅度一般只有 1 米左右，时间也稍有错前或推后，也就是说本区属于微弱的上升区，6000 年来的上升率不超过 0.2—0.4 毫米/年。

“This area is a slowly-uplifting area, with an uplift rate less than 0.2-0.4 mm/yr in the last 6000 years.”

(Zhang et al., 1982) (張景文等, 1982)

(1) Binhai fault
The geometry of Binhai fault in TEM

Fault type: Reverse fault

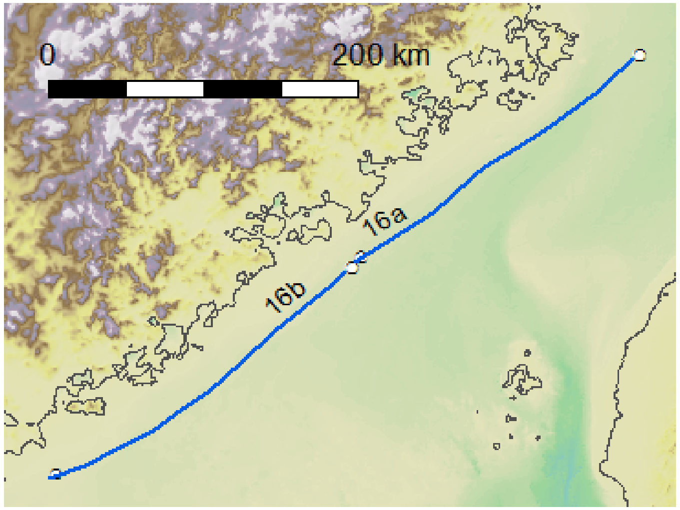
Length (km): 449.74

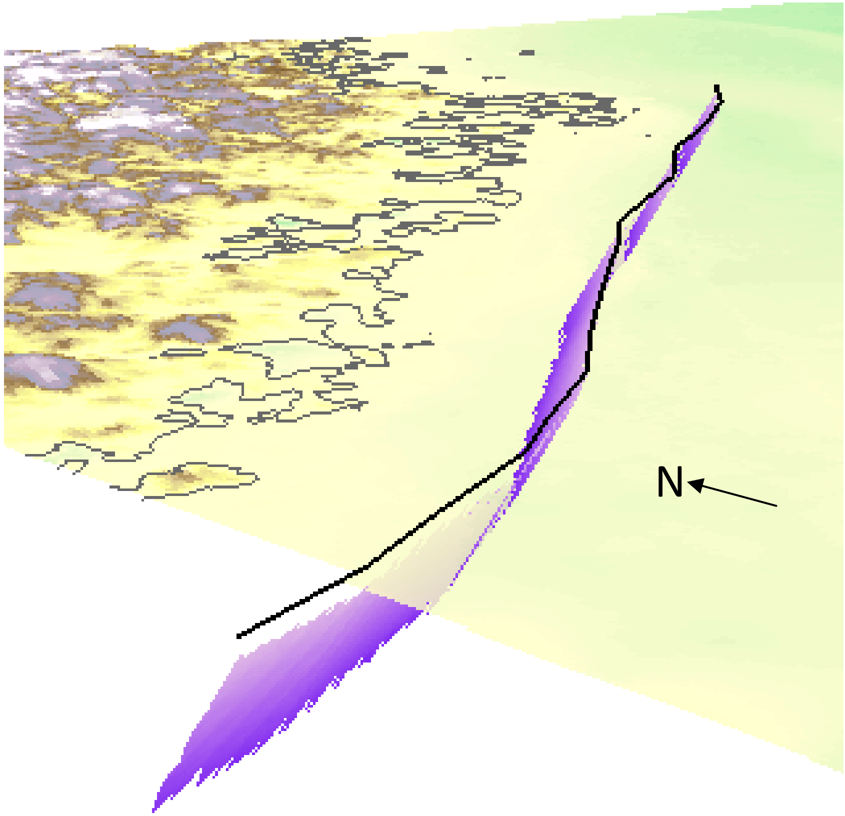
Fault dip (°): 50 – 70 (Xue, 1986)

Depth (km): 10 – 30

Width (km): 10.64 – 39.16

Area (km²): 4785.23 – 17611.82





Slide from Bruce Shyu.

(1) Binhai fault
Slip rate of Binhai fault in TEM

Fault type: Reverse fault

Length (km): 449.74

Fault dip (°): 50 – 70 (Xue, 1986)

Depth (km): 10 – 30

Width (km): 10.64 – 39.16

Area (km²): 4785.23 – 17611.82

M_w: 7.64 – 8.15 (W&C)
7.88 – 8.51 (Y&M)

M_0 (10^{25} dyne-cm): 358.92 – 7244.36

Displacement (m): 2.50 – 13.71

Uplift rate: 0.40 mm/yr (Zhang et al., 1982)

Fault dip (°): 50 – 70

→ Slip rate: 0.43 – 0.52 mm/yr

Displacement (m): 2.50 – 13.71

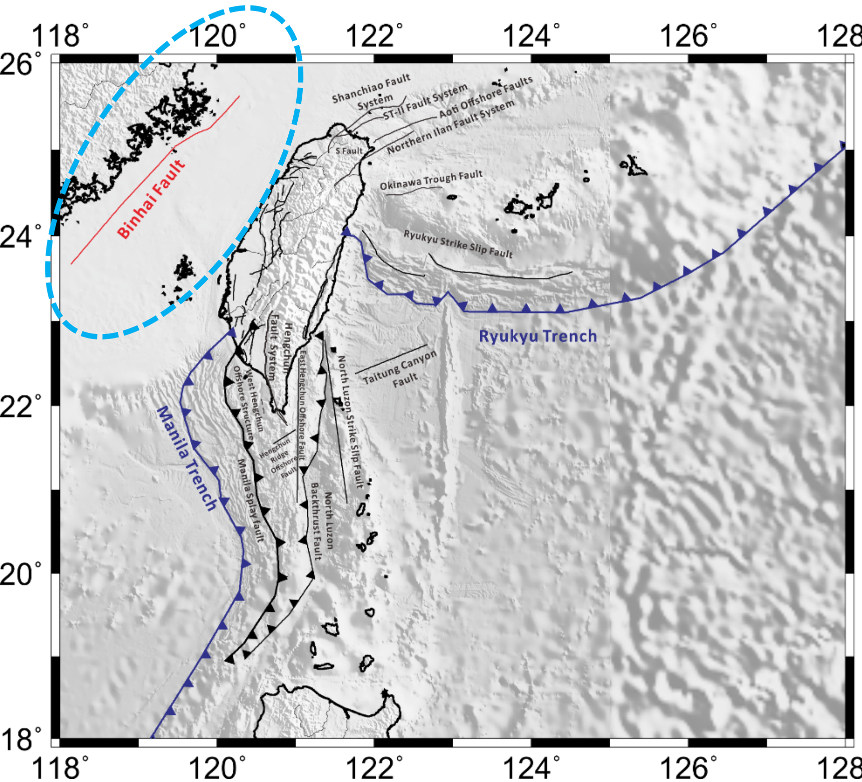
→Recurrence interval: 4810 – 31880 yr

Slip rate (mm/yr): 0.43 – 0.52

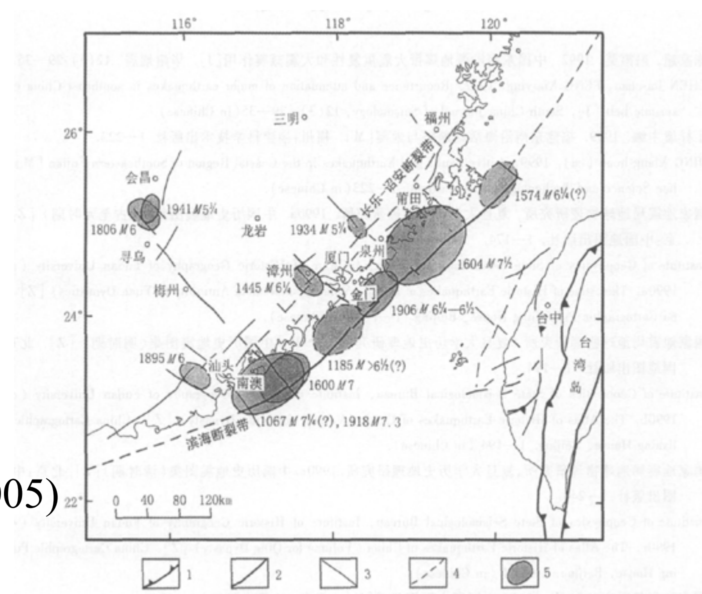
Recurrence interval (yr): 4810 – 31880

(Slide from Bruce Shyu.)

(1) Binhai fault

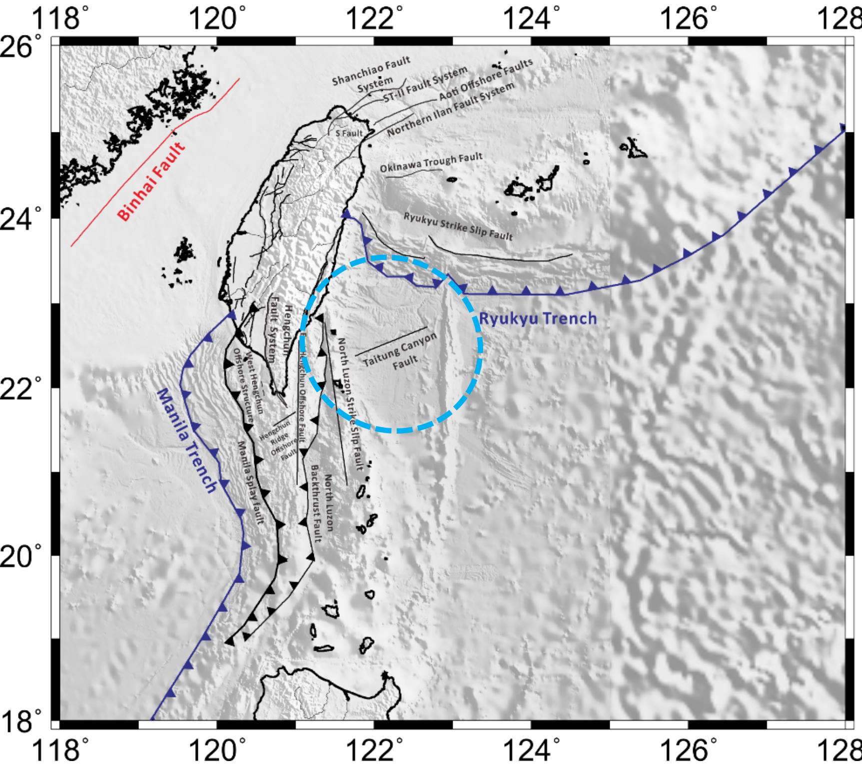


Parameters for Fault Geometry	
Style of Faulting	Reverse + Strike Slip
Length (km)	450
Dip (°)	60
Dip Direction	Westward
Depth (km)	10 / 15 / 20
Parameters for Fault Activity	
Slip-Rate (mm/yr)	0.05 / 0.2 / 0.5
Mag. Scaling Law	W&C, 1994 (SS type)

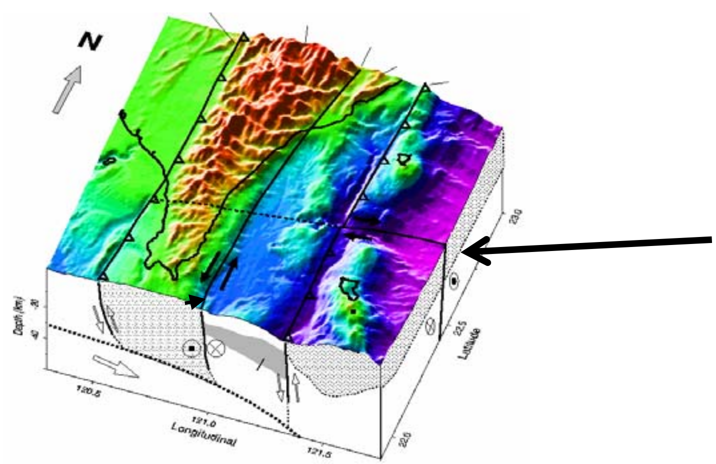


(Wen and Xu, 2005)

(2) Taitung canyon fault

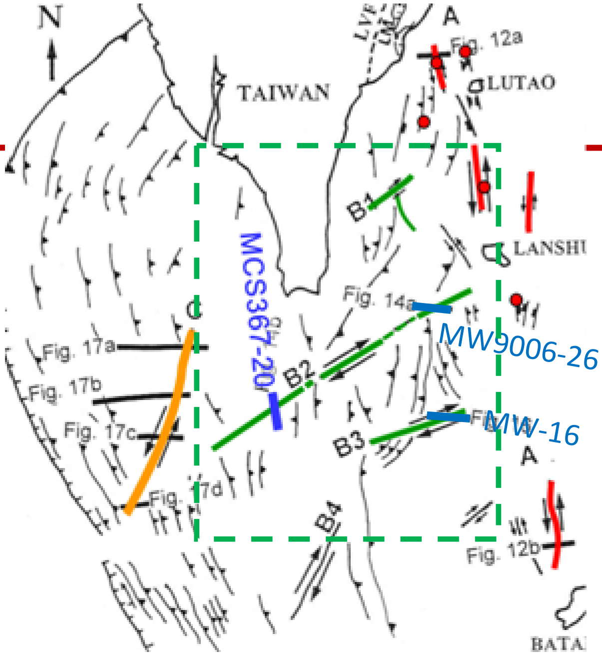


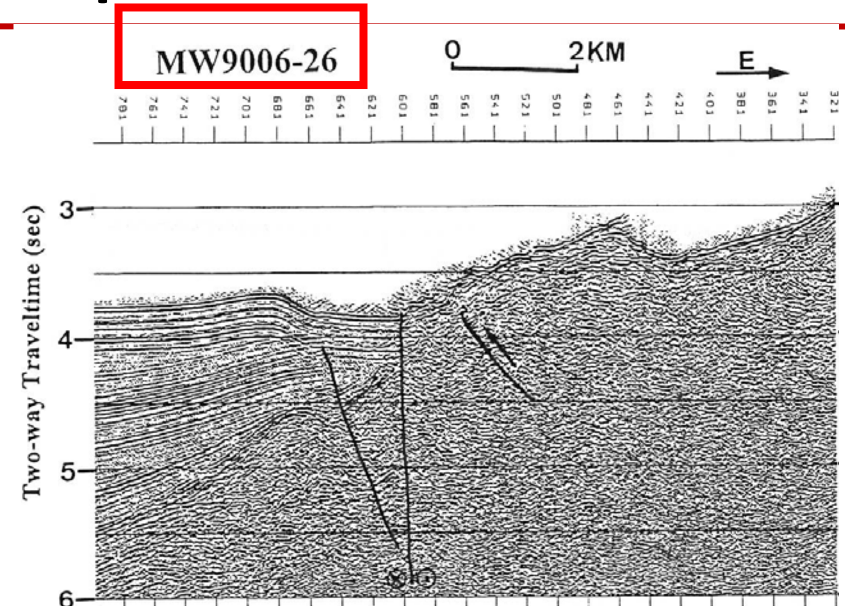
Parameters for Fault Geometry	
Style of Faulting	Strike Slip
Length (km)	102
Dip (˚)	90
Dip Direction	
Depth (km)	10
Parameters for Fault Activity	
Slip-Rate (mm/yr)	4 / 8 / 12
Mag. Scaling Law	W&C, 1994 (SS type)

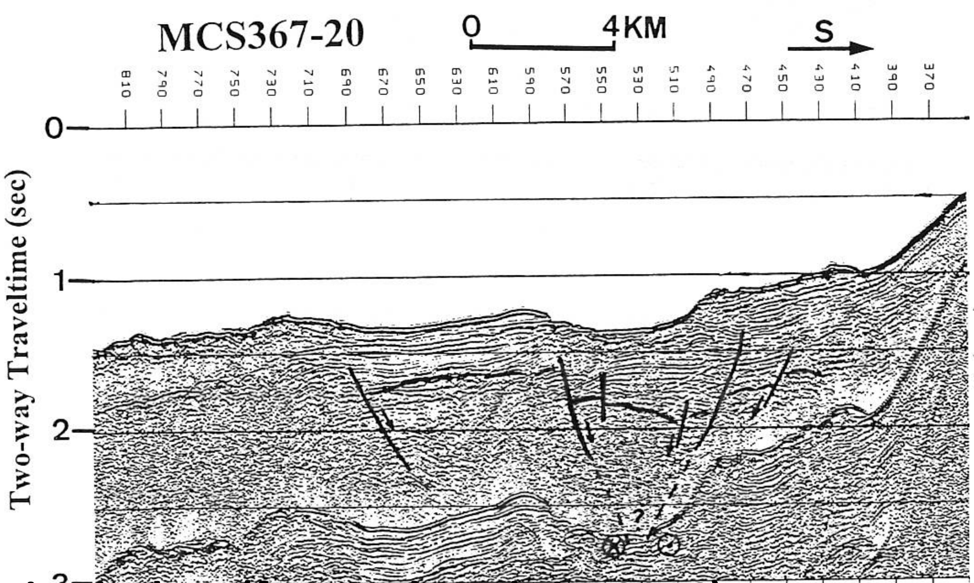


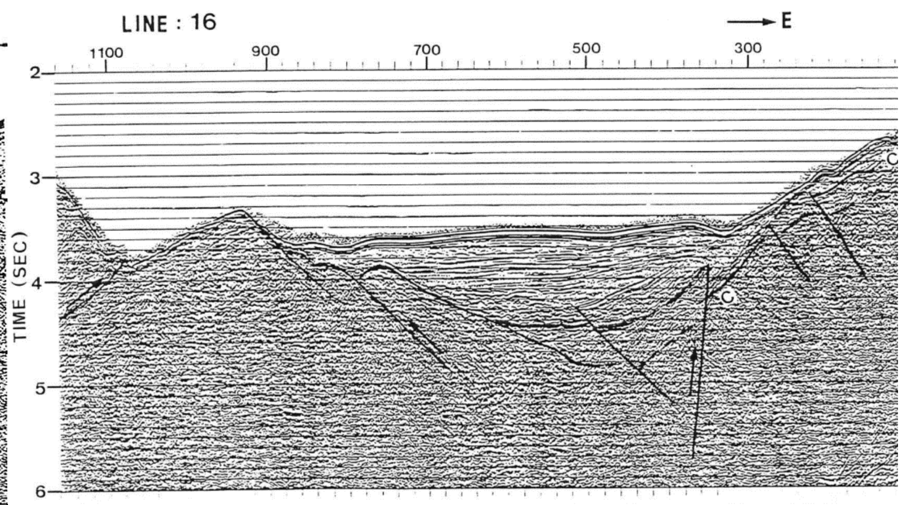
(Cheng et al., 1998)

(3) Henchun Ridge Offshore Fault
The presence evidences



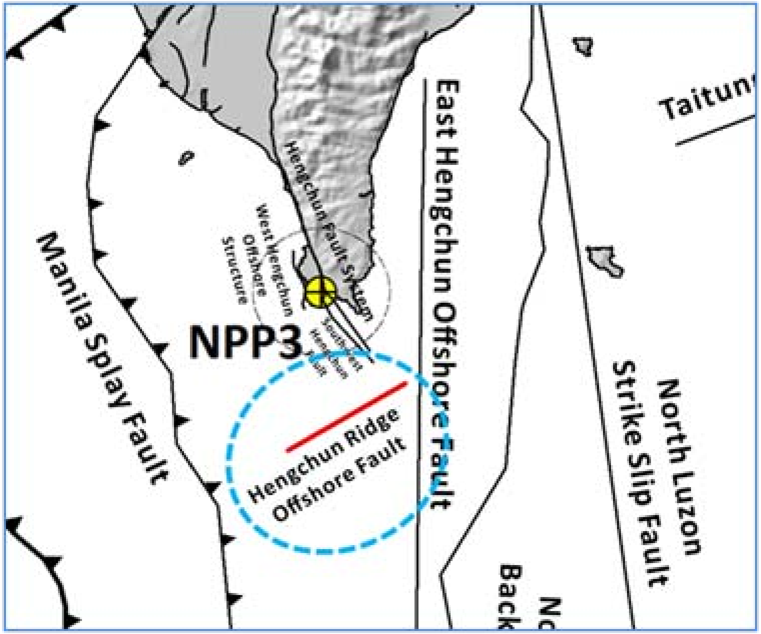




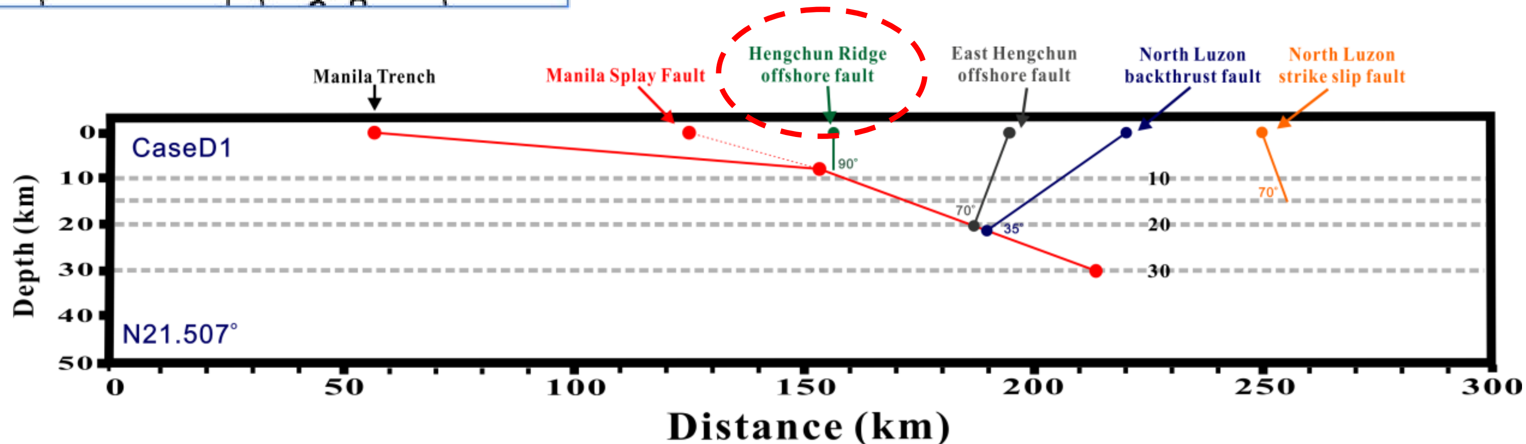


Seismic data (from Fuh and Liu, 2016)

(3) Hengchun Ridge Offshore Fault Geometry

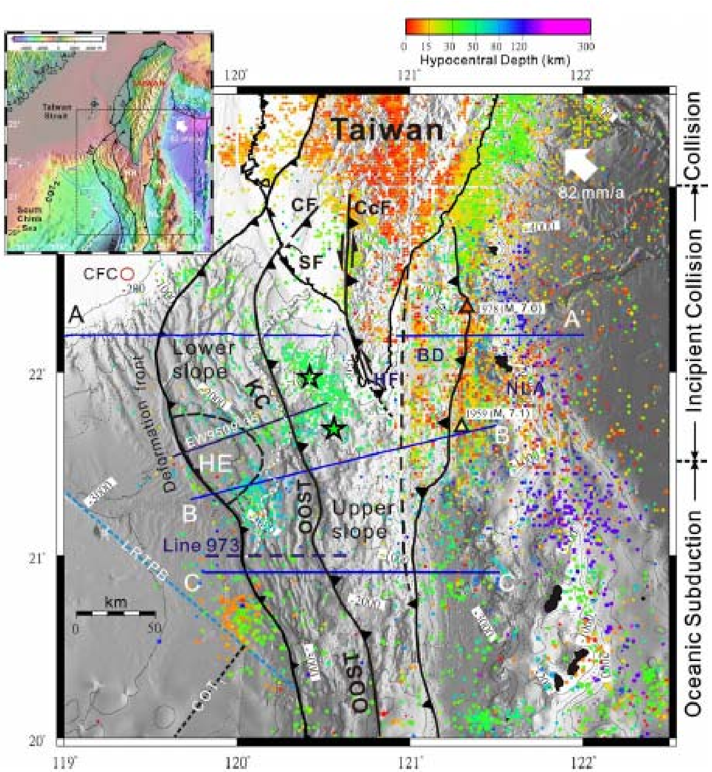


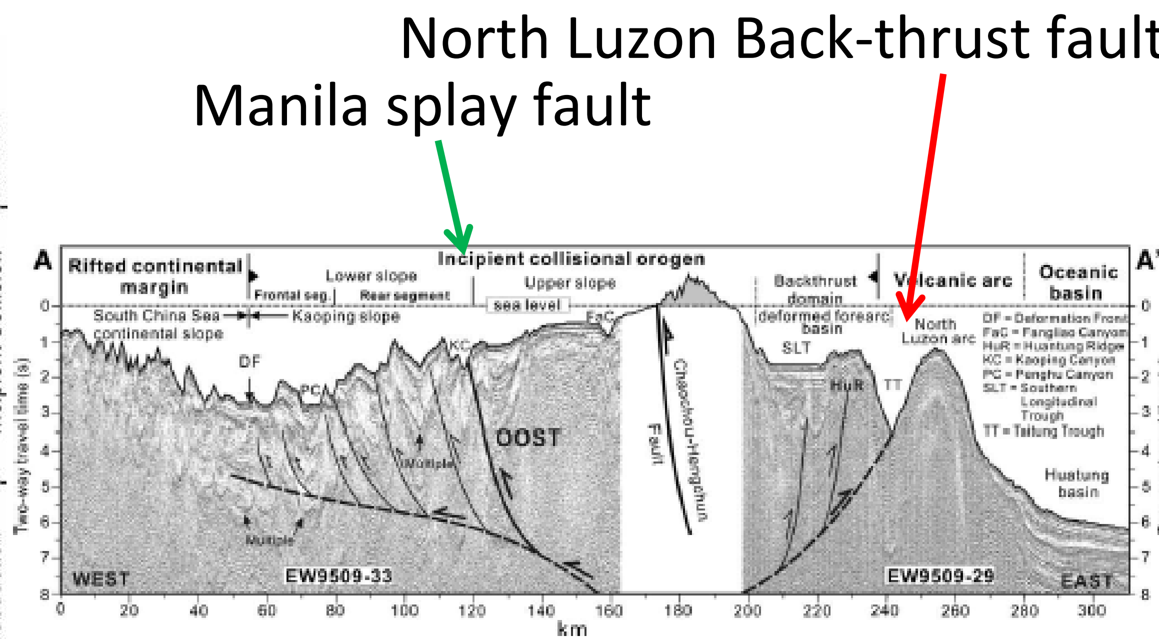
Parameters for Fault Geometry	
Style of Faulting	Strike-Slip
Length (km)	40.0
Dip (°)	90
Dip Direction	-
Depth (km)	8



(4)Manila Splay fault
(5)North Luzon Back thrust fault

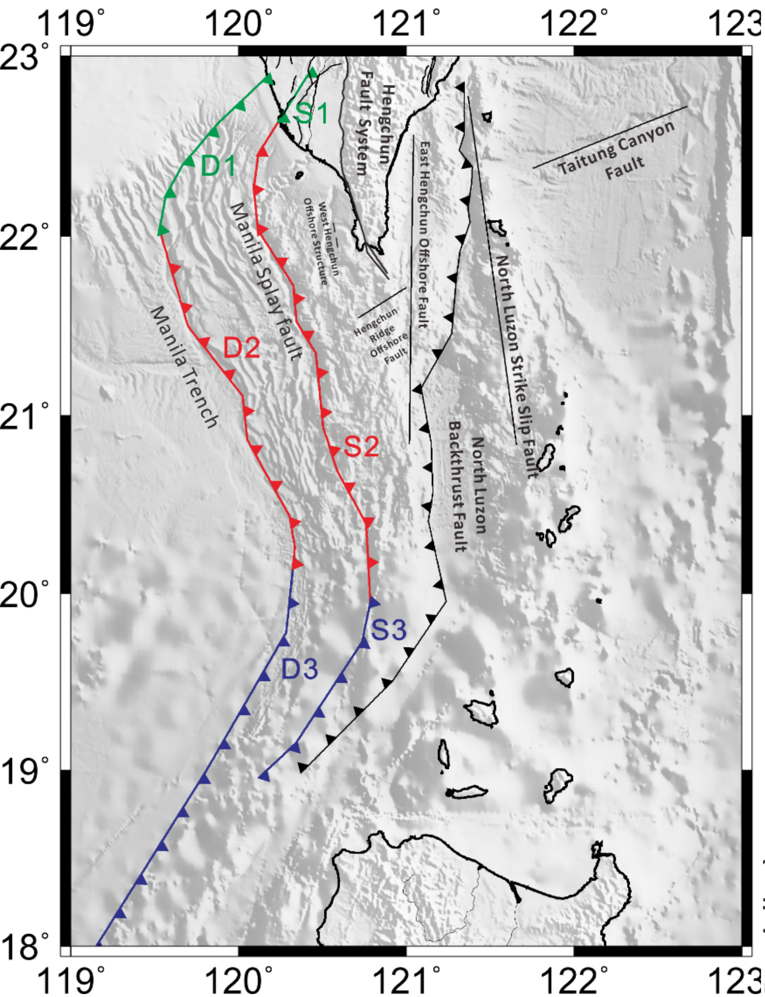
Based on the wide angle seismic refraction result



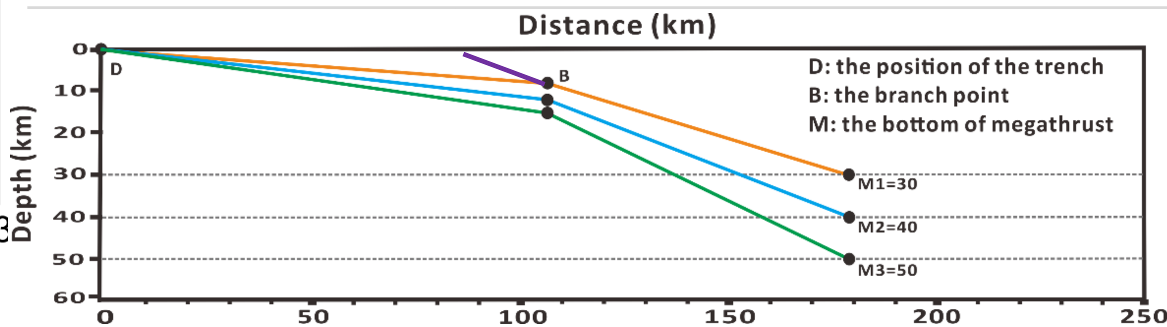


(Lin et al., 2008)

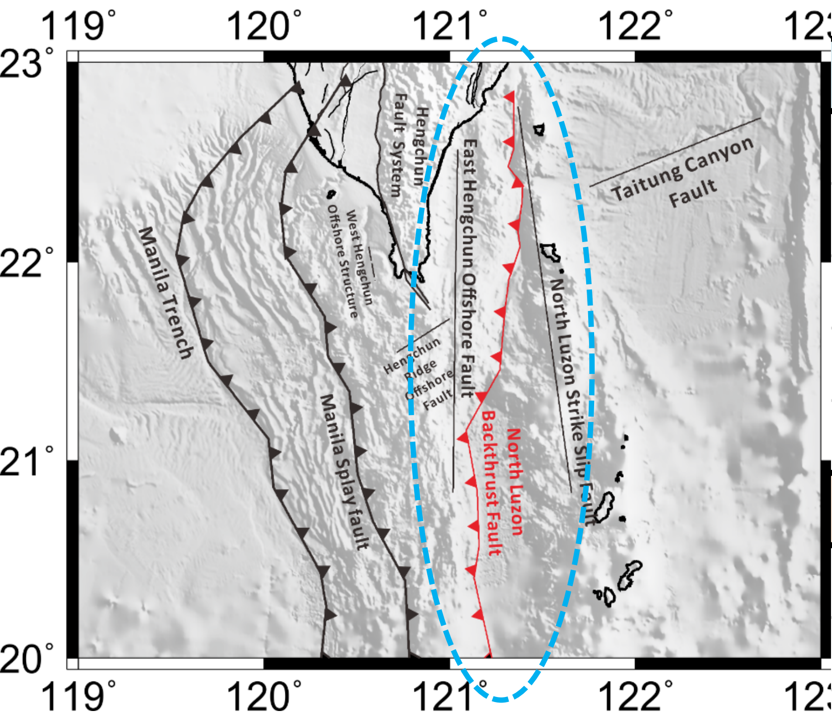
(4) Manila splay fault



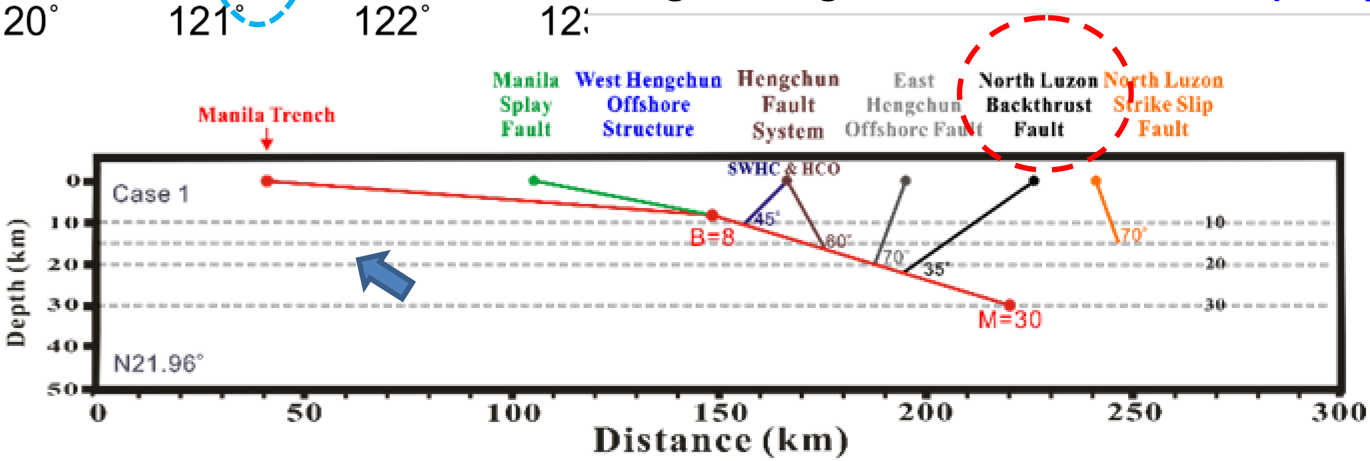
Parameters for Fault Geometry		
Style of Faulting	Reverse	
Length (km)	S1: 50 km S2: 360 km S3: 110 km	S1+S2: 410 km S2+S3: 470 km S1+S2+S3: 520 km
Dip (°)	45-60	
Dip Direction	East	
Depth (km)	8 / 12 / 15	
Parameters for Fault Activity		
Slip-Rate (mm/yr)	4 / 6 / 8	
Mag. Scaling Law	W&C, 1994 (RV type)	



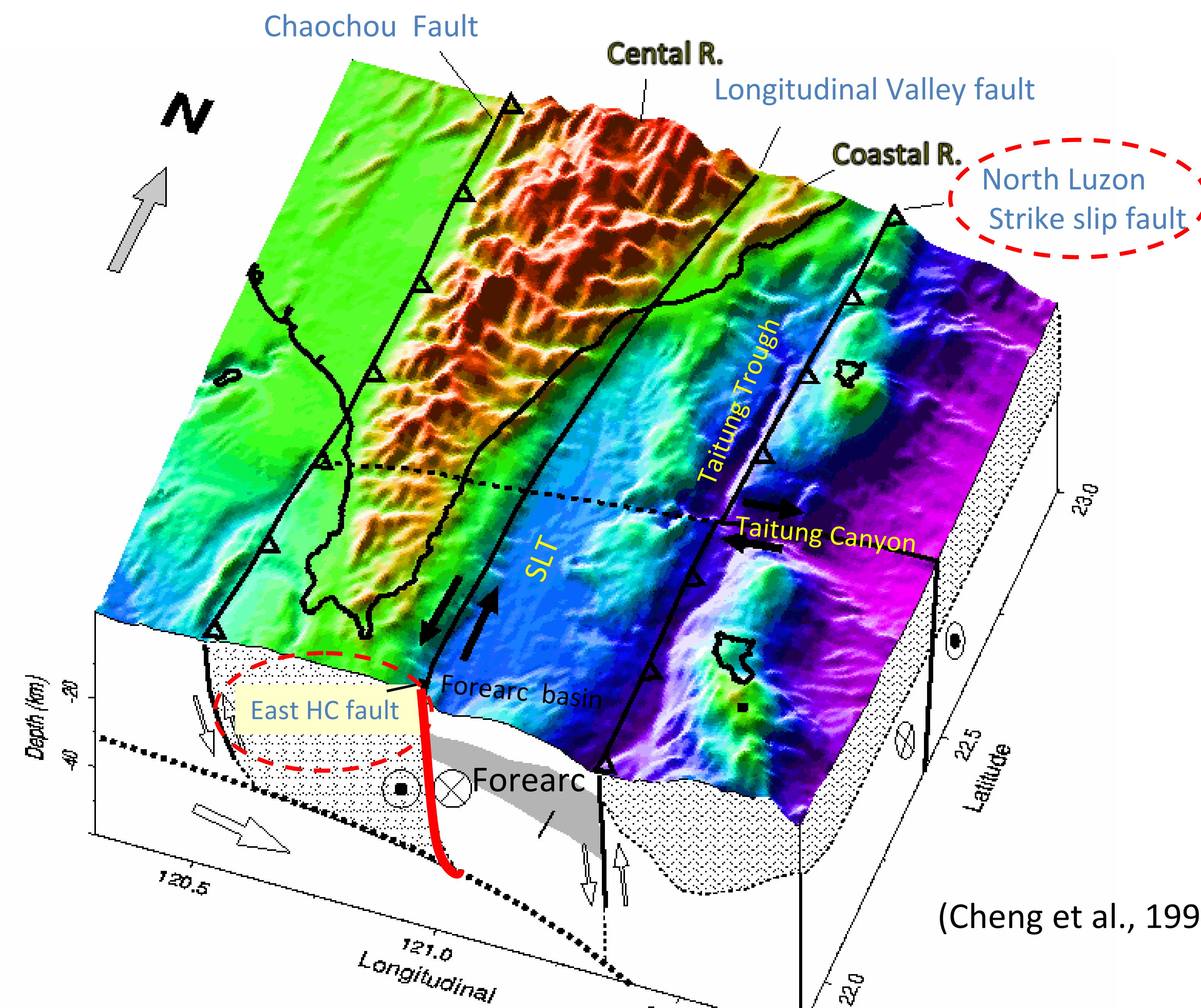
(5) North Luzon Back-thrust fault



Parameters for Fault Geometry	
Style of Faulting	Reverse
Length (km)	540.0
Dip (°)	35 / 45 / 55
Dip Direction	Westward
Depth (km)	Stopped at Manila Interface
Parameters for Fault Activity	
Slip-Rate (mm/yr)	5.0 / 8.0 / 12.0
Mag. Scaling Law	W&C, 1994 (RV type)

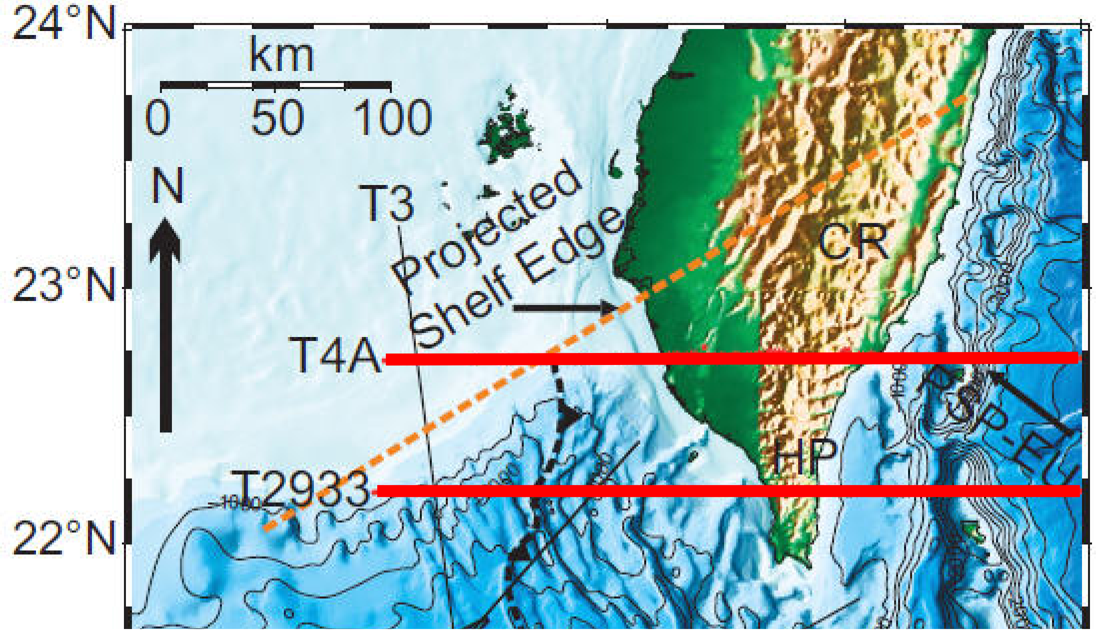


(6) East Hengchun offshore fault
(7)North Luzon strike slip fault



(Cheng et al., 1998)

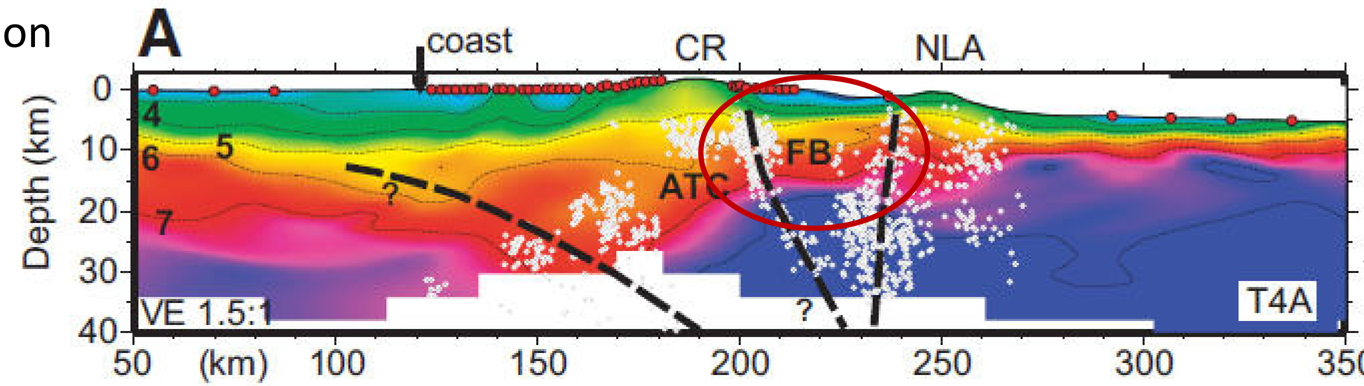
(McIntosh et al., 2014)

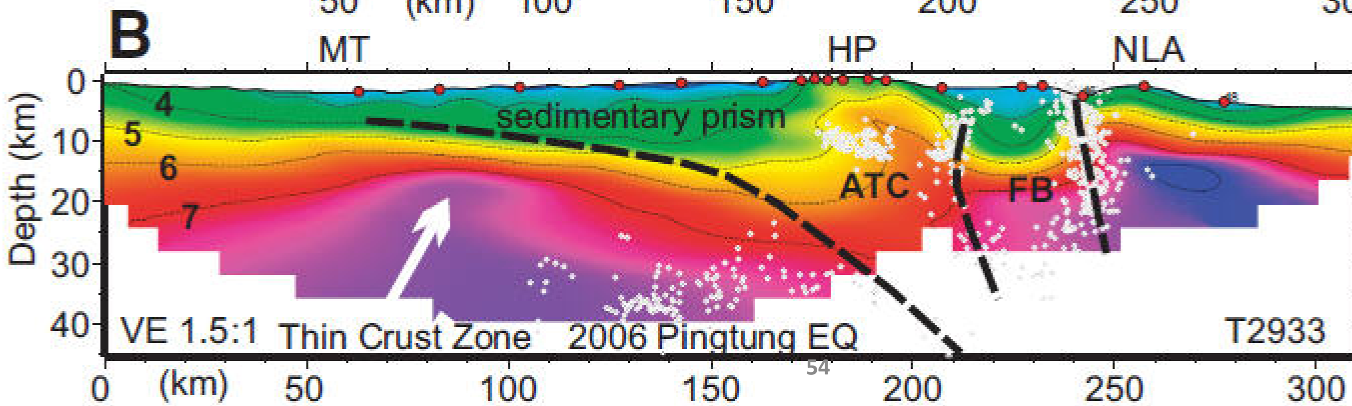


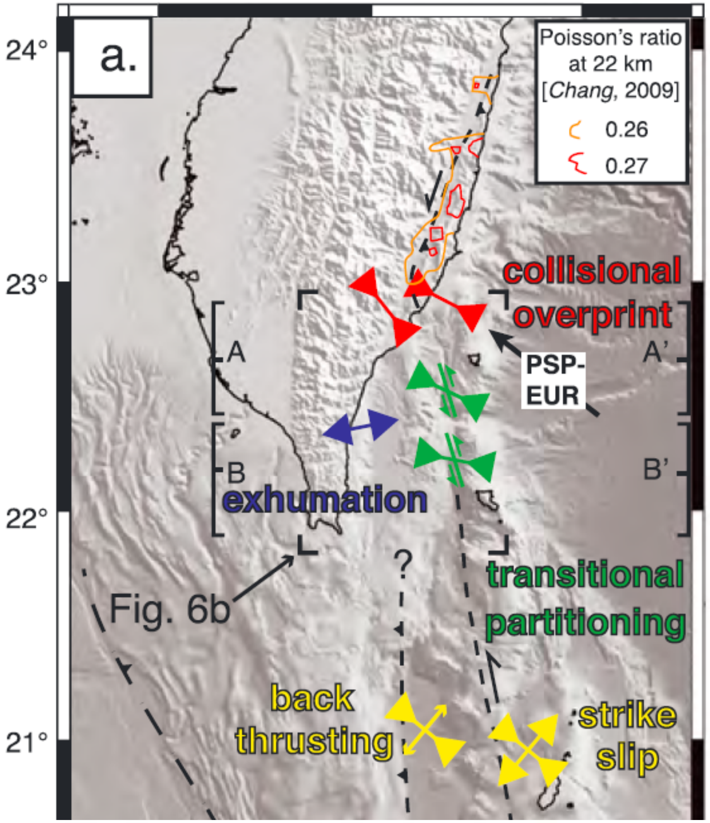
T4A

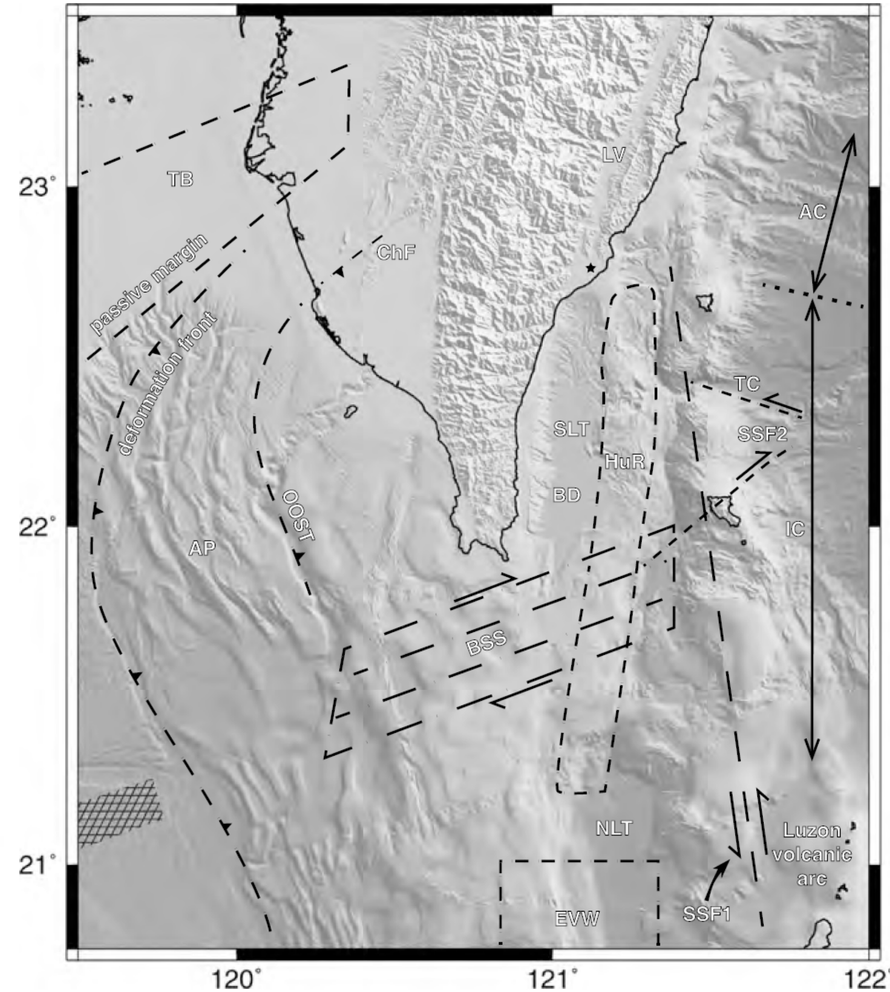
T2933

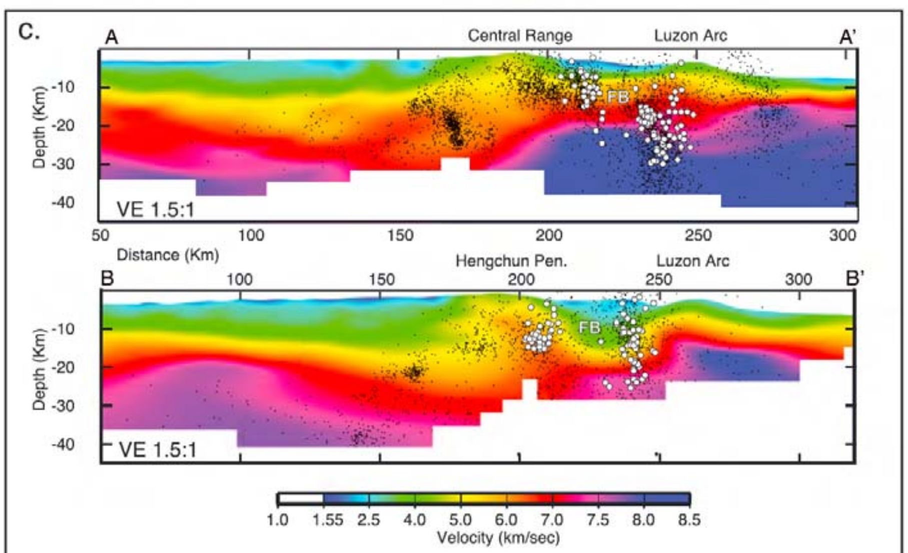
Seismic Refraction





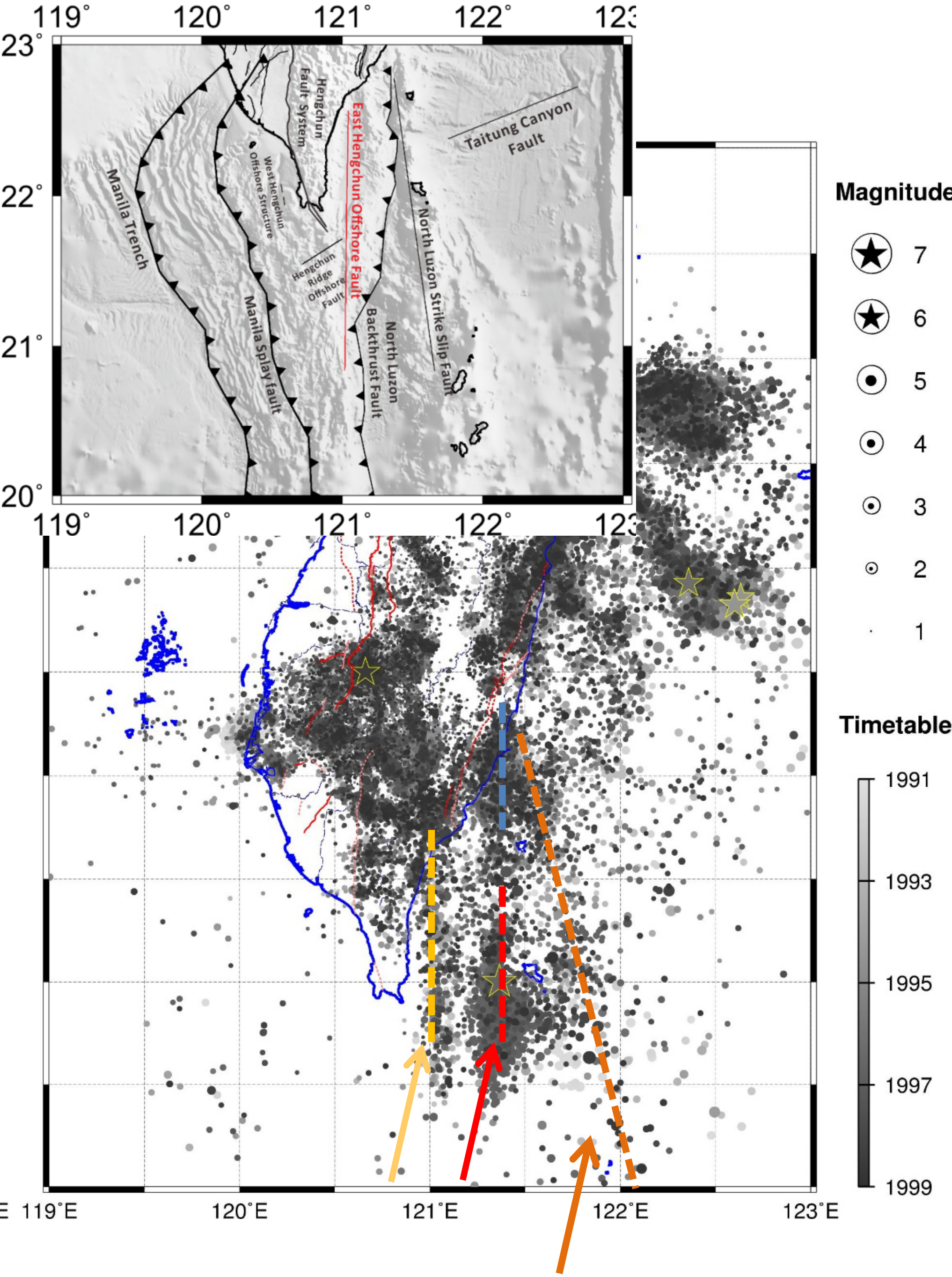






Seismic Refraction

Lewis et al., 2015

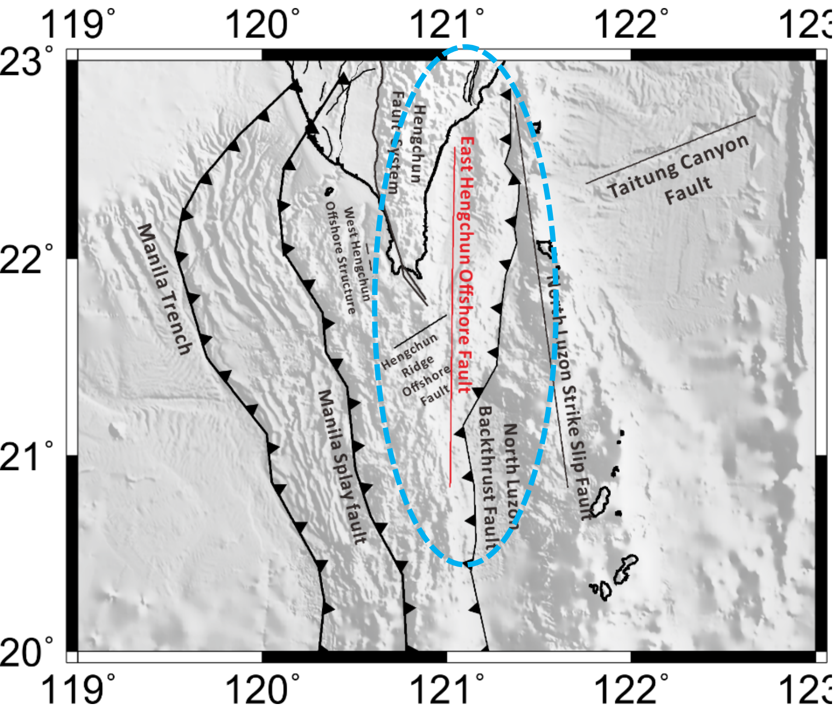


Seismic zone

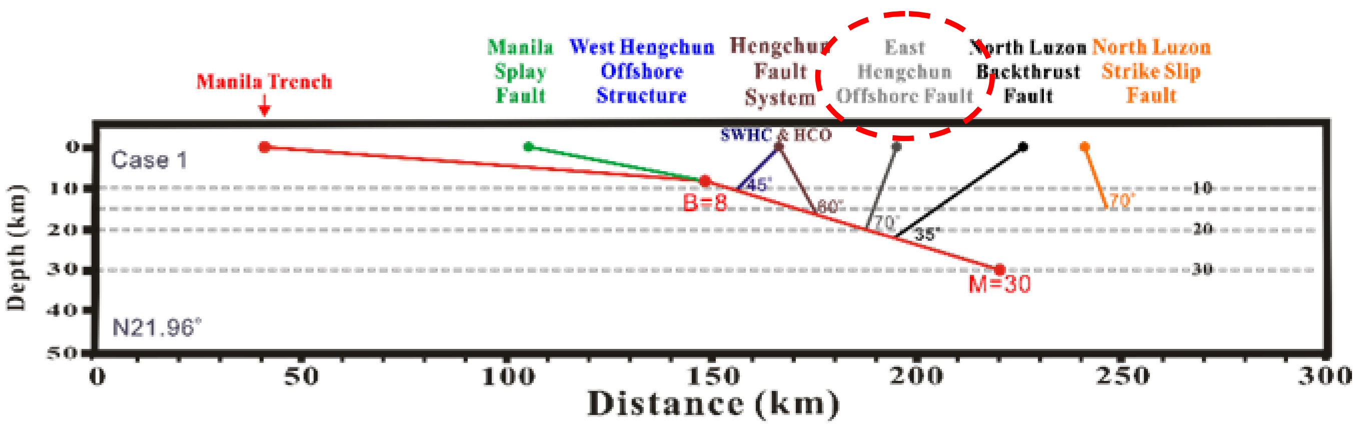
- North Luzon Strike slip seismic zone could be divided into two segments
  - South segment (L~70 km, D~30 km, high-seismicity)
  - North segment (L~60 km, , D~30 km, high-seismicity)
- East HengChun offshore seismic zone
  - (~100 km, D~30 km, low to moderate-seismicity)

Modified from Cheng W.B. Slide

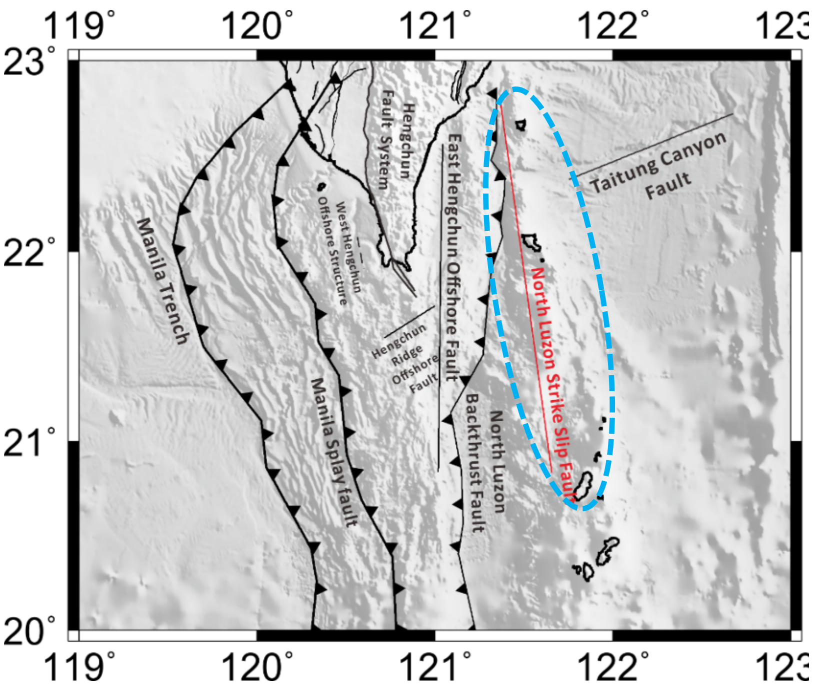
(6) East Hengchun offshore fault



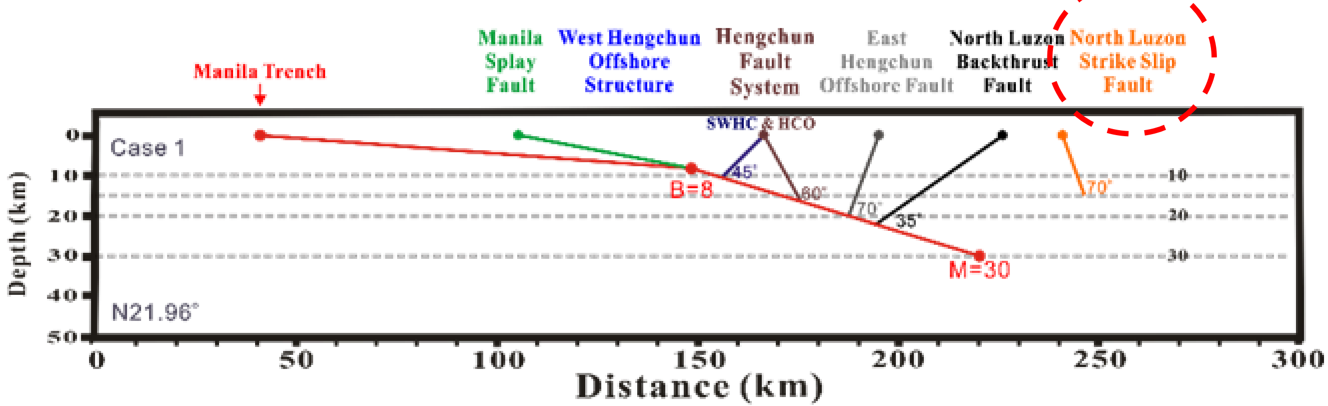
Parameters for Fault Geometry	
Style of Faulting	**Reverse / Strike-Slip**
Length (km)	**173.0**
Dip (°)	**70** (reverse) **/ 80** (strike-slip)
Dip Direction	**Westward**
Depth (km)	**Stopped at Manila Interface**
Parameters for Fault Activity	
Vertical Rate (mm/yr)	**5.0 / 7.0 / 9.0**
Mag. Scaling Law	**W&C, 1994 (RV and SS type)**



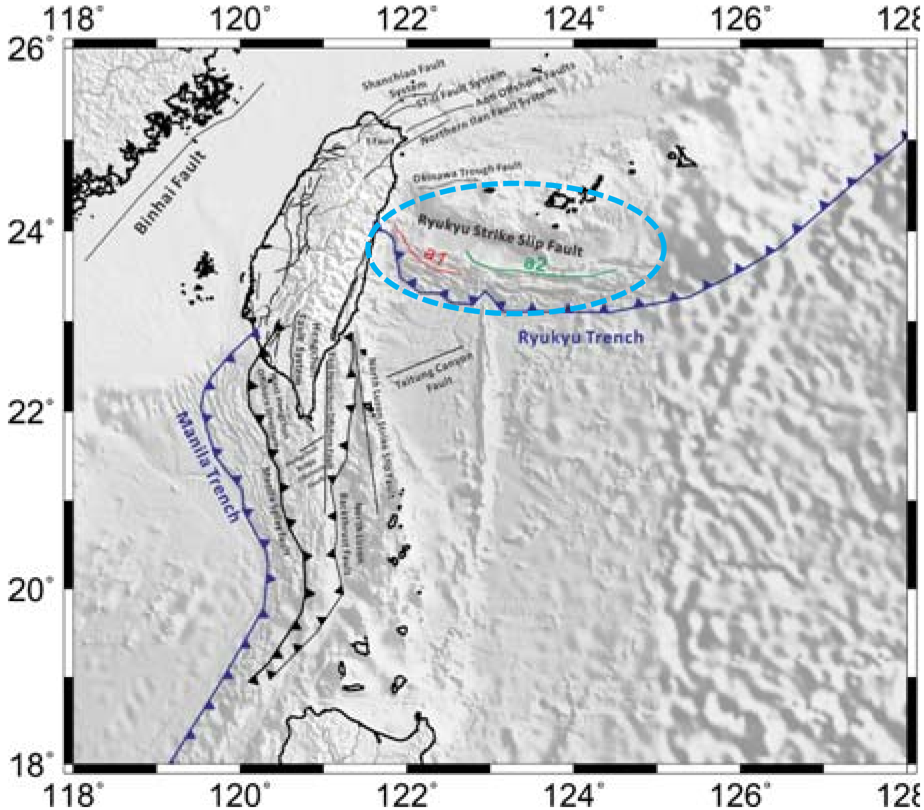
(7) North Luzon Strike slip fault



Parameters for Fault Geometry	
Style of Faulting	Reverse-Oblique
Length (km)	196.0
Dip (°)	70 / 80 / 90
Dip Direction	Eastward
Depth (km)	15 (dip=70°) / 20 (dip=80°) / 30 (dip=90°)
Parameters for Fault Activity	
Slip-Rate (mm/yr)	4.0 / 6.0 / 8.0
Mag. Scaling Law	W&C, 1994 (RV type)

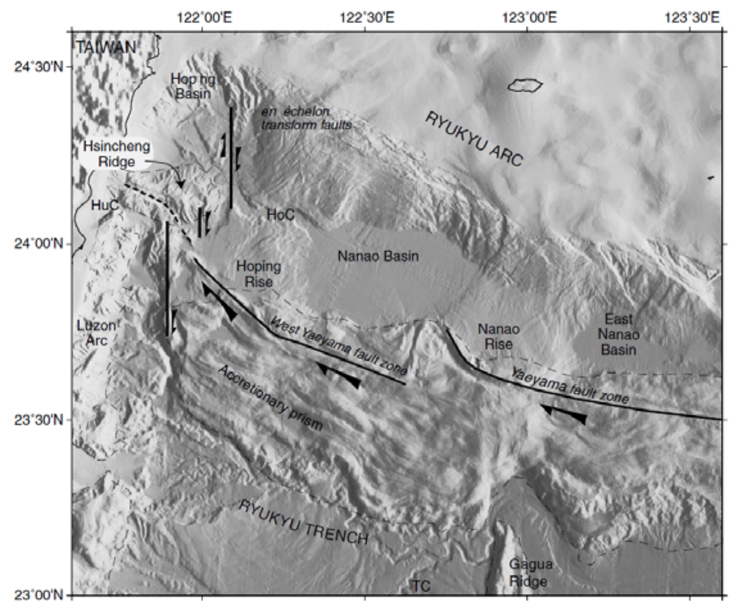


(8) Ryukyu Strike slip fault



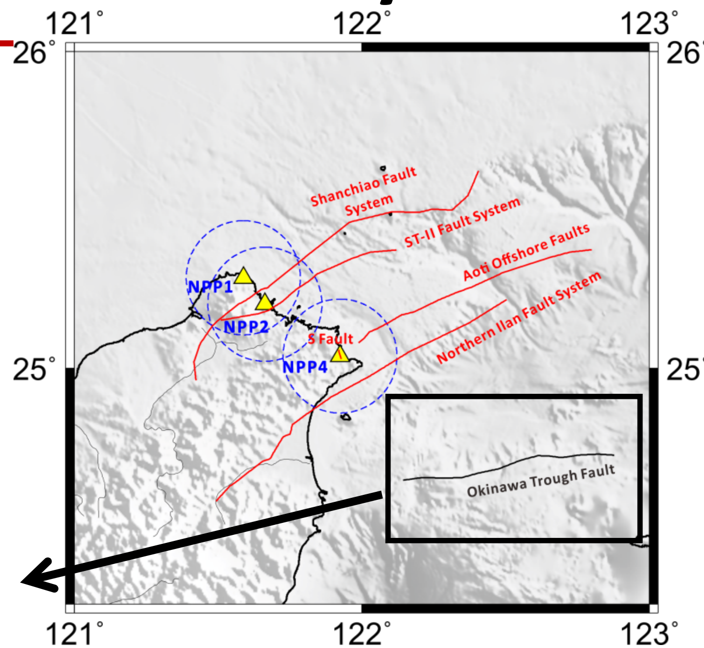
Parameters for Fault Geometry	
Style of Faulting	Strike Slip
Length (km)	a1: 103 / a2: 193
Dip (°)	90
Dip Direction	-
Depth (km)	5
Parameters for Fault Activity	
Slip-Rate (mm/yr)	6 / 8 / 10
Mag. Scaling Law	W&C, 1994 (SS type)

(Font et al., 2001)

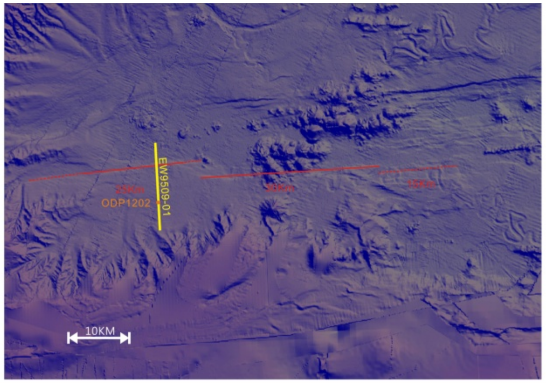


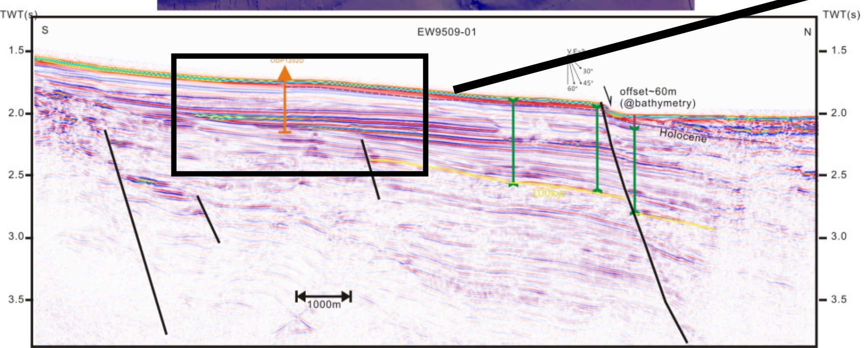
(9) Okinawa Through Fault Geometry

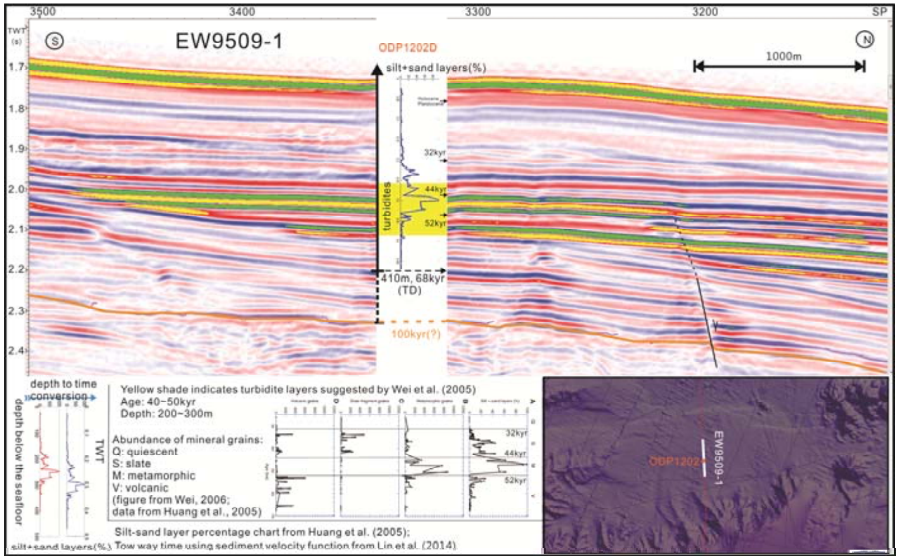
CGS ongoing project, since 2017



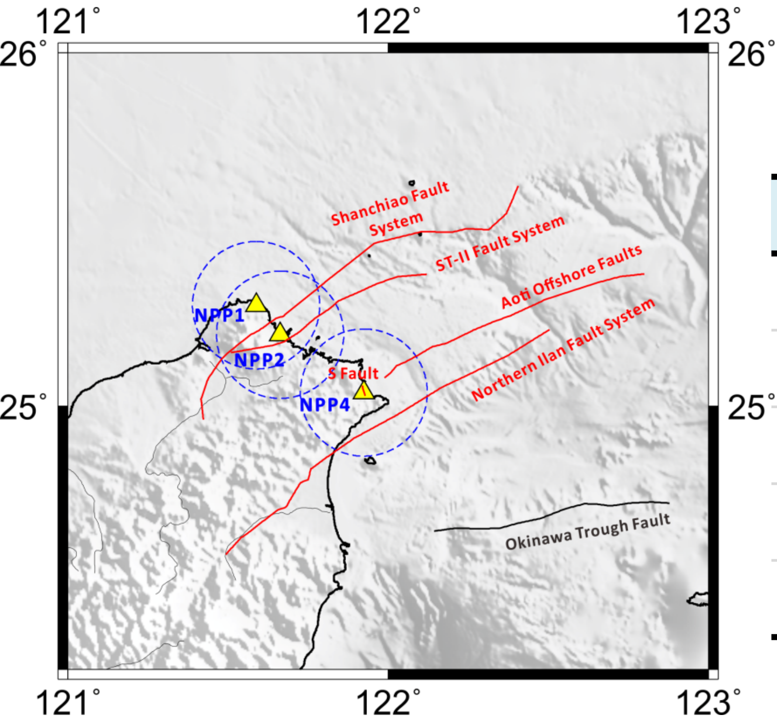
Slip rate: 6mm/yr







(9) Okinawa Through Fault Geometry



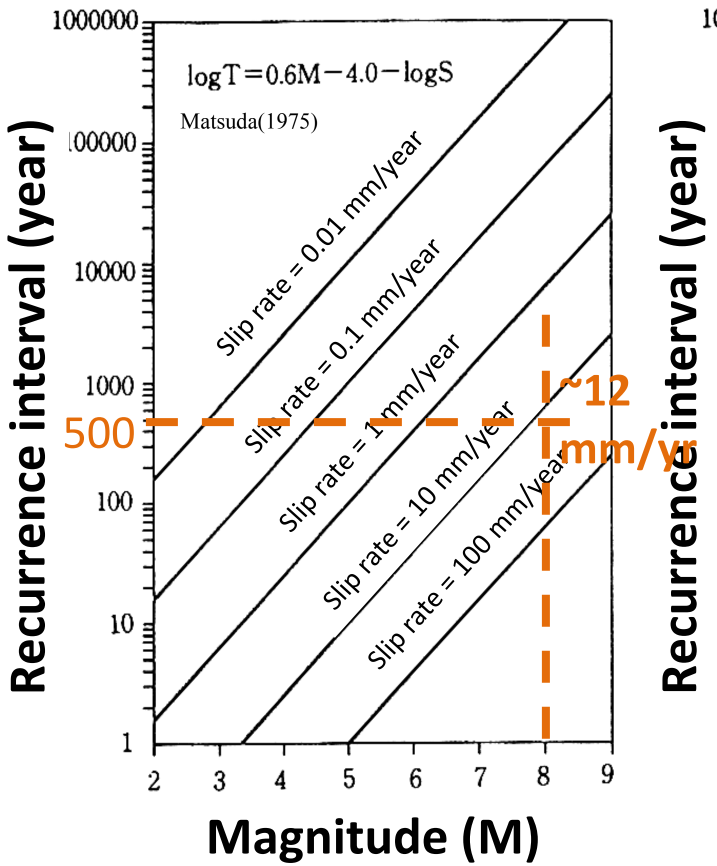
Parameters for Fault Geometry	
Style of Faulting	Normal
Length (km)	77.0
Dip (°)	70
Dip Direction	Northward
Depth (km)	10/15/20

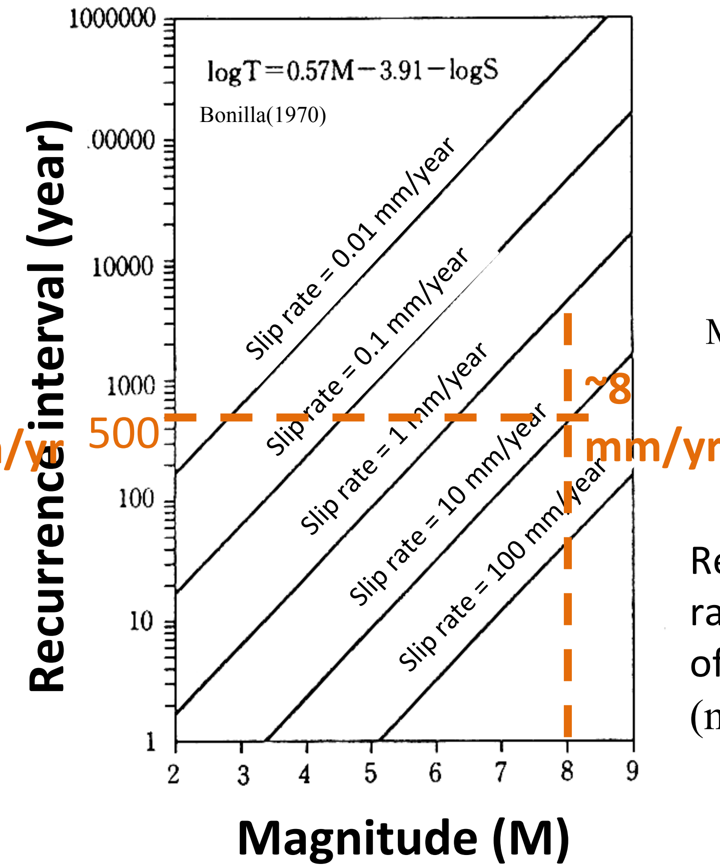
However,
slip rate data is limited for most offshore structures

Therefore,
the relationship between Mw and return period are used to estimate the slip rate.

Offshore fault
Slip rate setting

In Manila Subduction zone, the instrumental catalog does not record any event with Mw > 8 and its aftershocks over the past more 400~500 hundred years (Megawati et al., 2009)



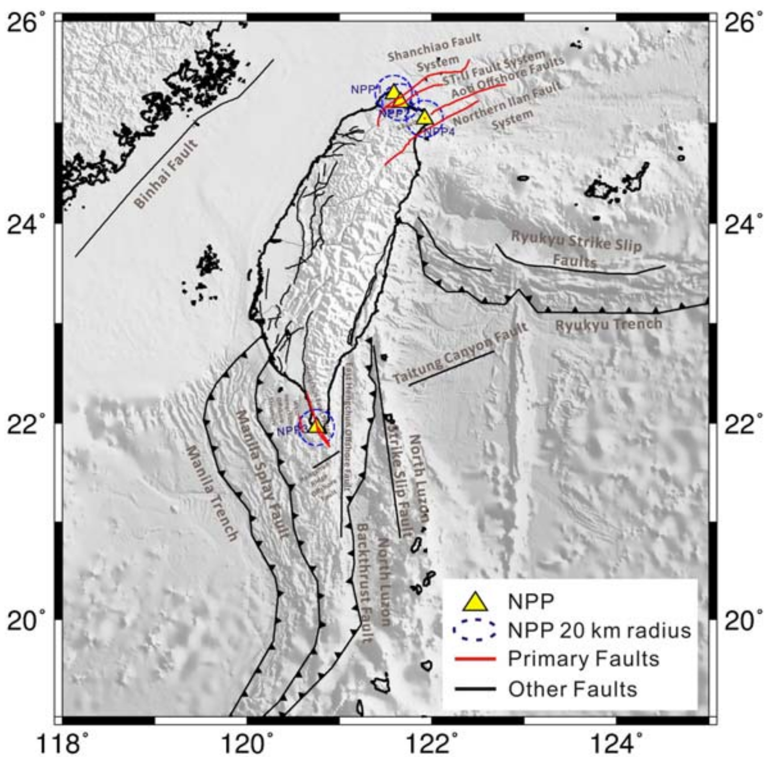


Mw estimated from rupture area

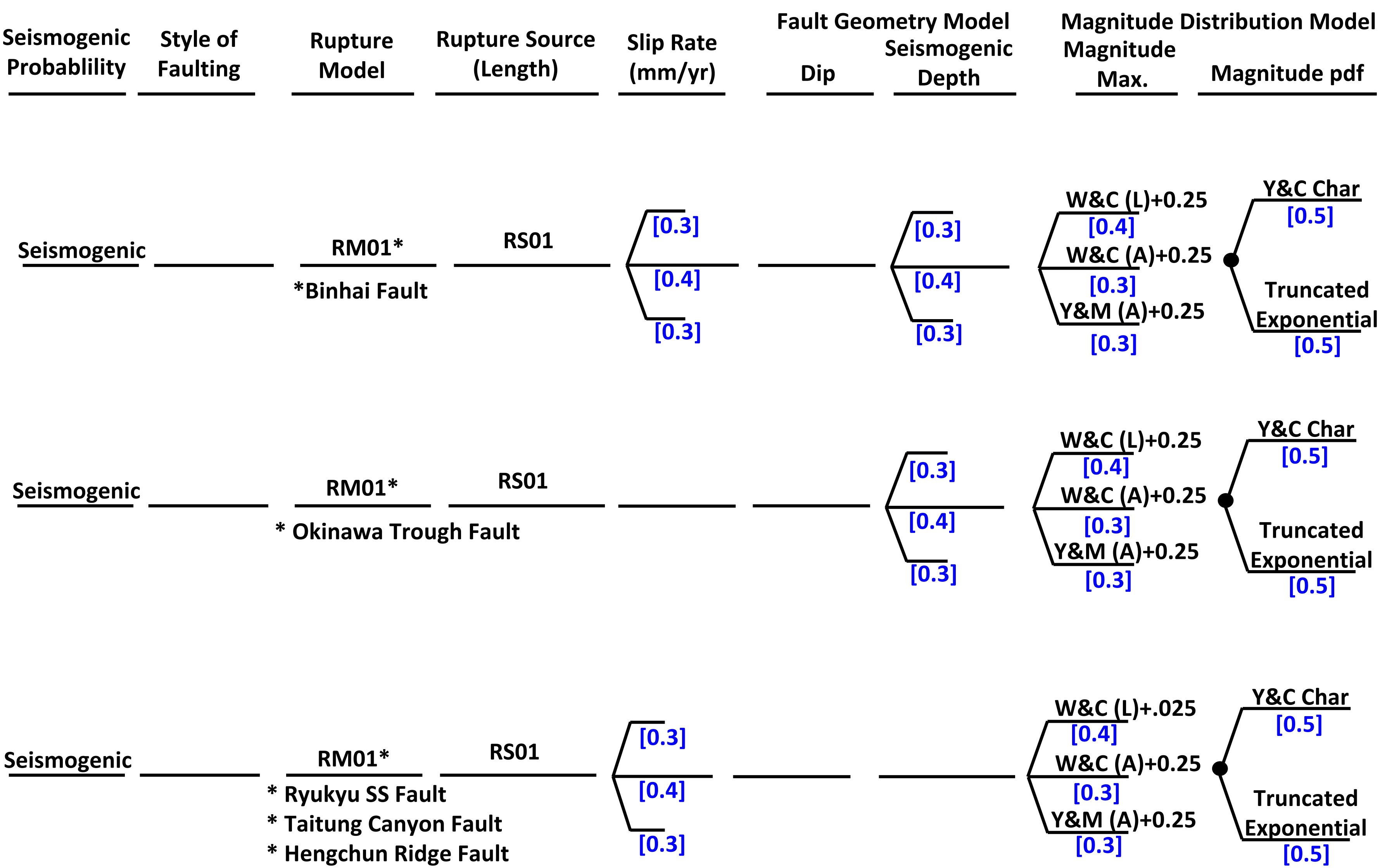
Relationship between slip rate and recurrence interval of characteristic earthquake (modified by Lee et al., 1993)

Logic Tree– Other Faults- Onshore

Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Slip Rate mm/yr	Fault Geometry Model: Dip	Fault Geometry Model: Seismogenic Depth	Magnitude Distribution Model: Magnitude char.	Magnitude Distribution Model: Magnitude pdf
Seismogenic		RM01	RS01	[0.3]		Area max [0.3]	W&C L [0.4]	Y&C Char [0.5]
				[0.4]		Area mean [0.4]	W&C A [0.3]	Truncated Exponential [0.5]
				[0.3]		Area min [0.3]	Yen&Ma A [0.3]	



Logic Tree– Other faults - Offshore



Thank You for Your Attention

Q &A