Introduction of Logic trees Principles for Weighting Scaling Law

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Taiwan SSHAC Level 3 PSHA Study
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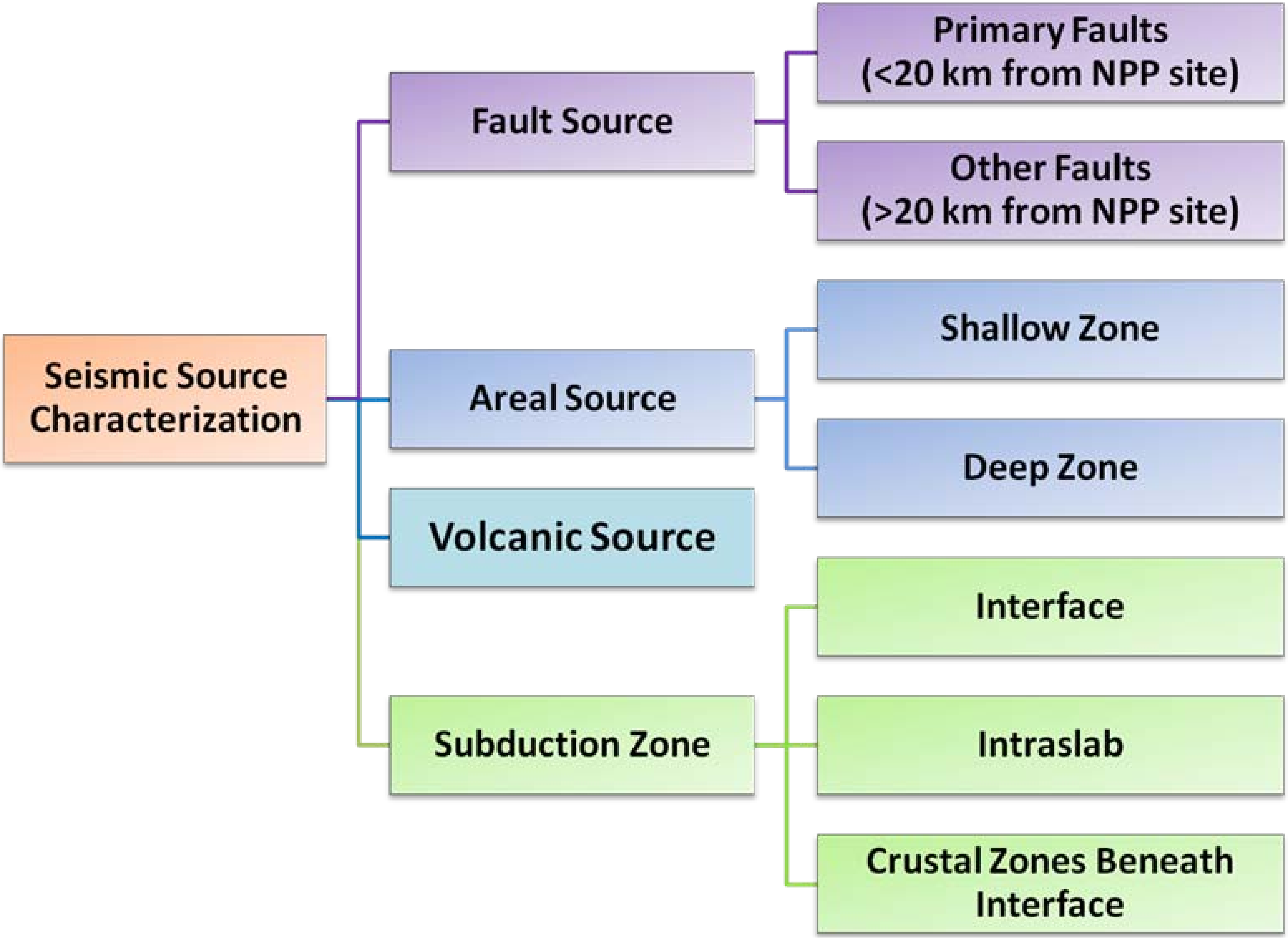
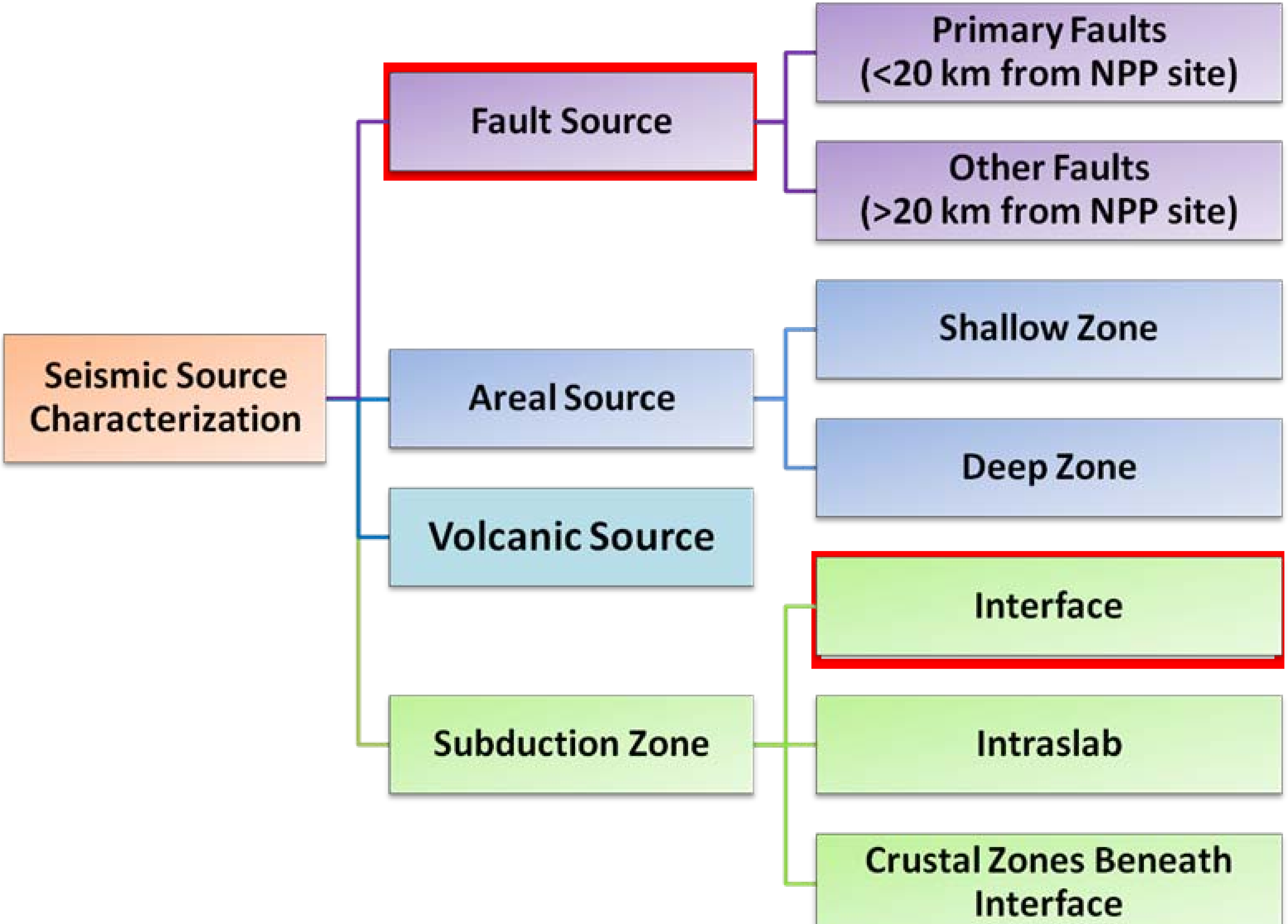
Taipei, Taiwan

Seismic Source Characterization in Taiwan



Seismic Source Characterization in Taiwan

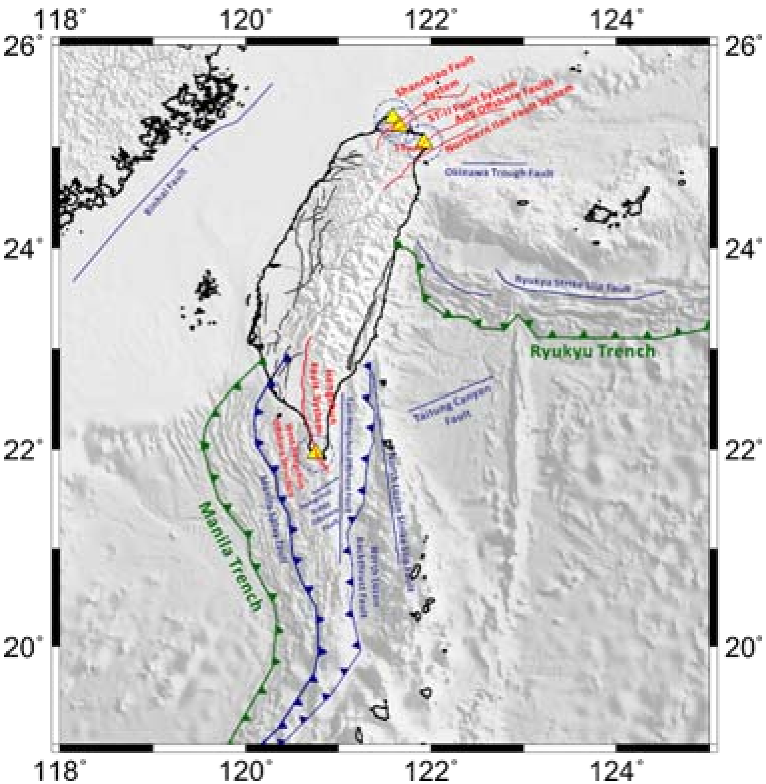


7 Primary Faults

P1	Shanchiao Fault System
P2	ST-II Fault System
P3	S Fault
P4	Aoti Offshore Faults
P5	Northern Ilan Fault System
P6	Hengchun Fault System
P7	West Hengchun Offshore Structure

2 Subduction Interfaces

1	Ryukyu Trench
2	Manila Trench



48 Other Faults

Onshore Offshore

1t	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 Trough Fault
24	Houchiali fault		
25	Chishan fault		

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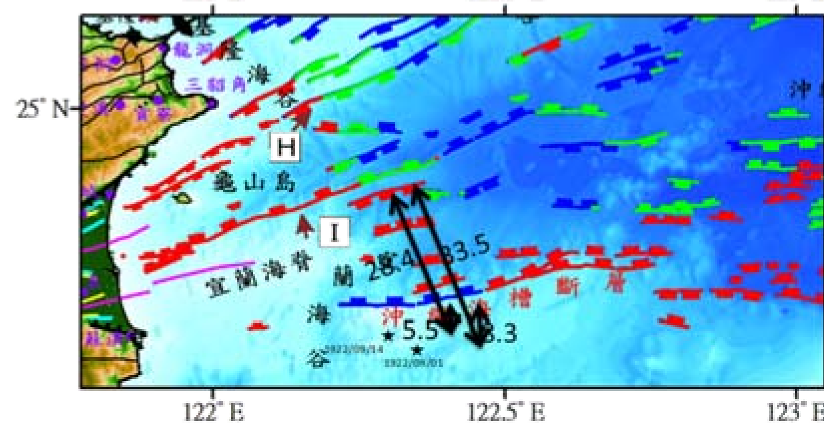
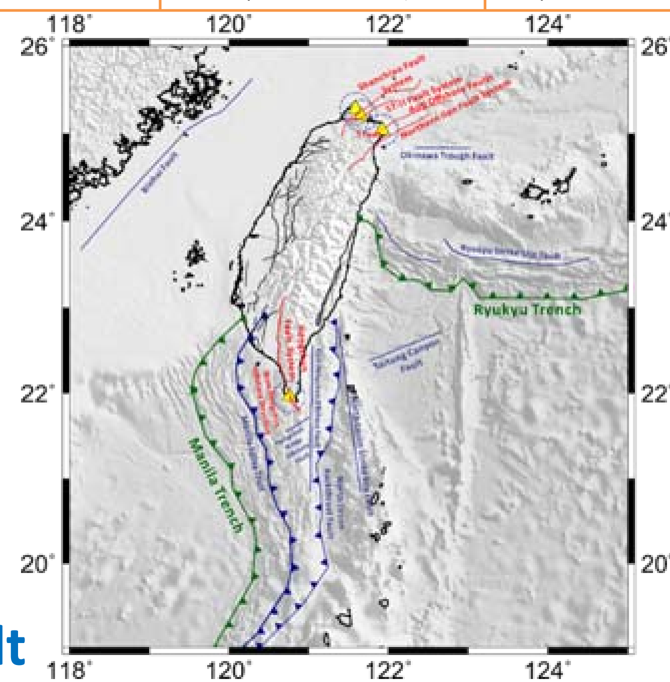
- **48 Other Faults**

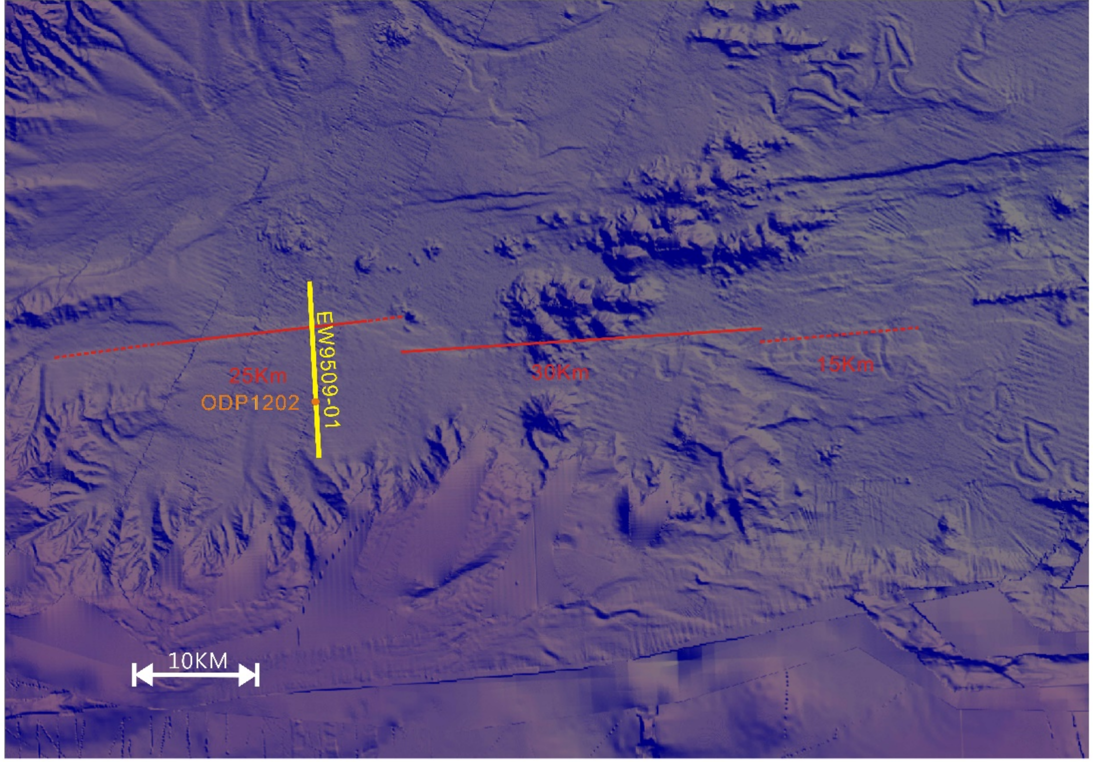
add **Okinawa Trough fault**



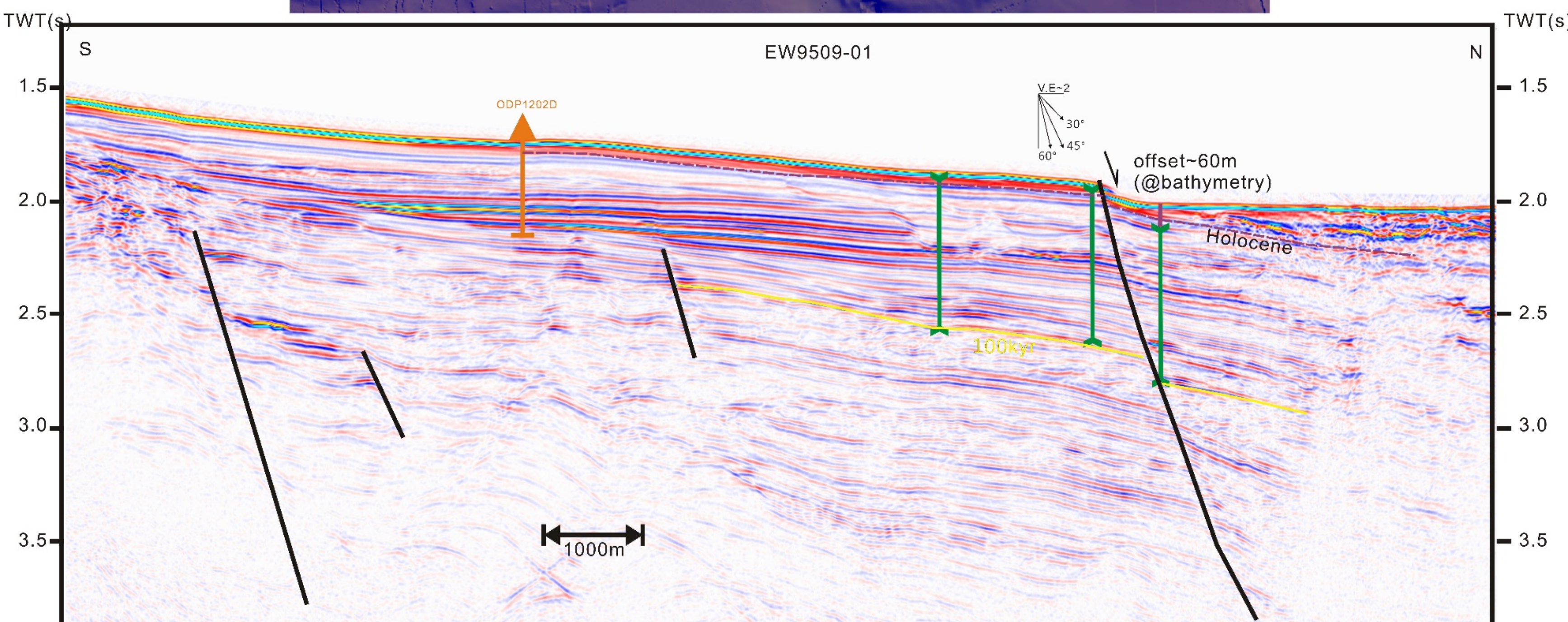
Num	event	Distance to Okinawa trough fault (Dip N50°)	DIstance to I fault (Dip N55°)
a	1922/9/1 M7.7 9km depth	8.3 km (horizontal distance from epicenter to fault)	33.5 km (horizontal distance from epicenter to fault)
b	1922/9/14 M7.3 20km depth	5.5 km (horizontal distance from epicenter to fault)	28.4 km (horizontal distance from epicenter to fault)

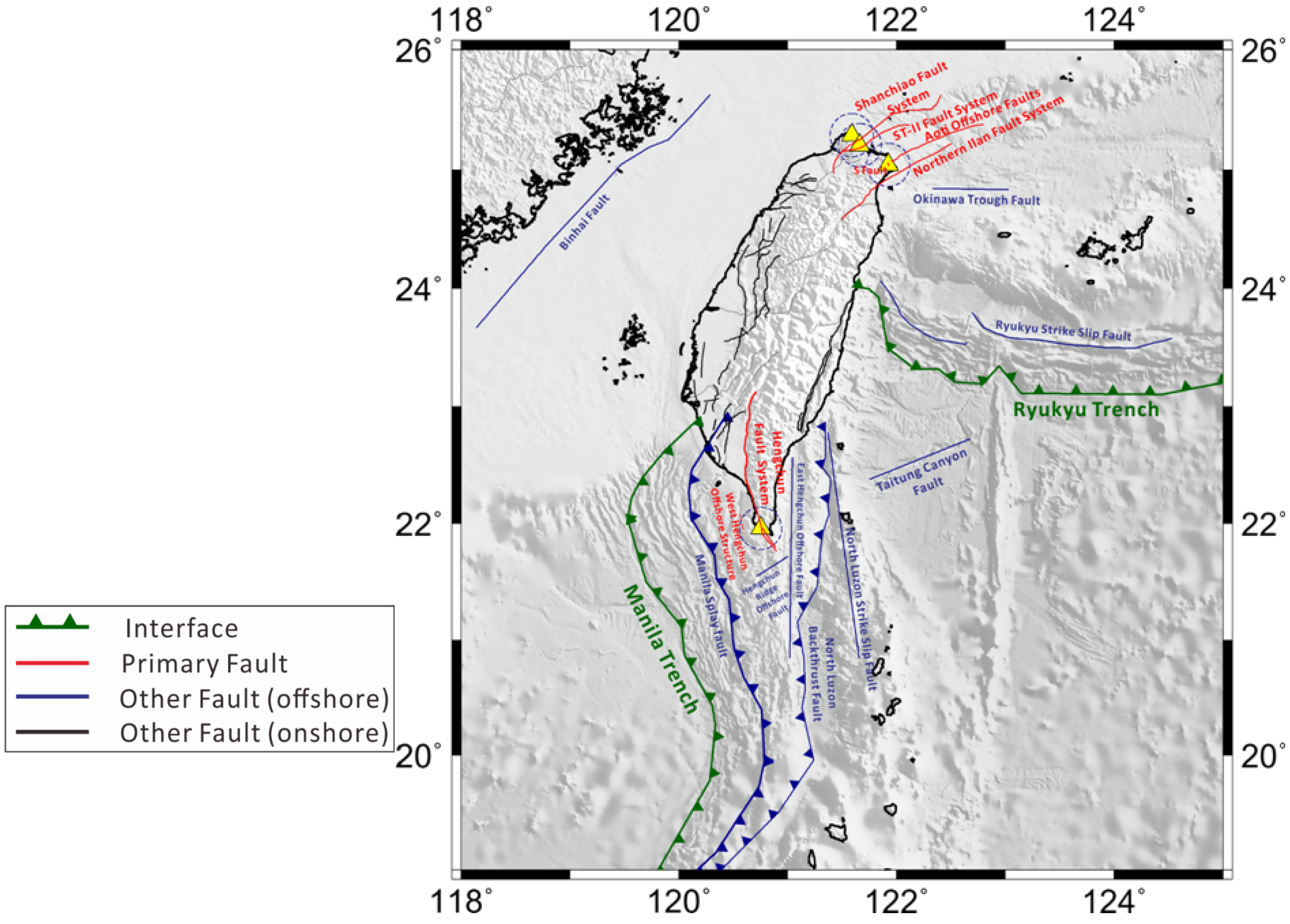


Okinawa Trough fault



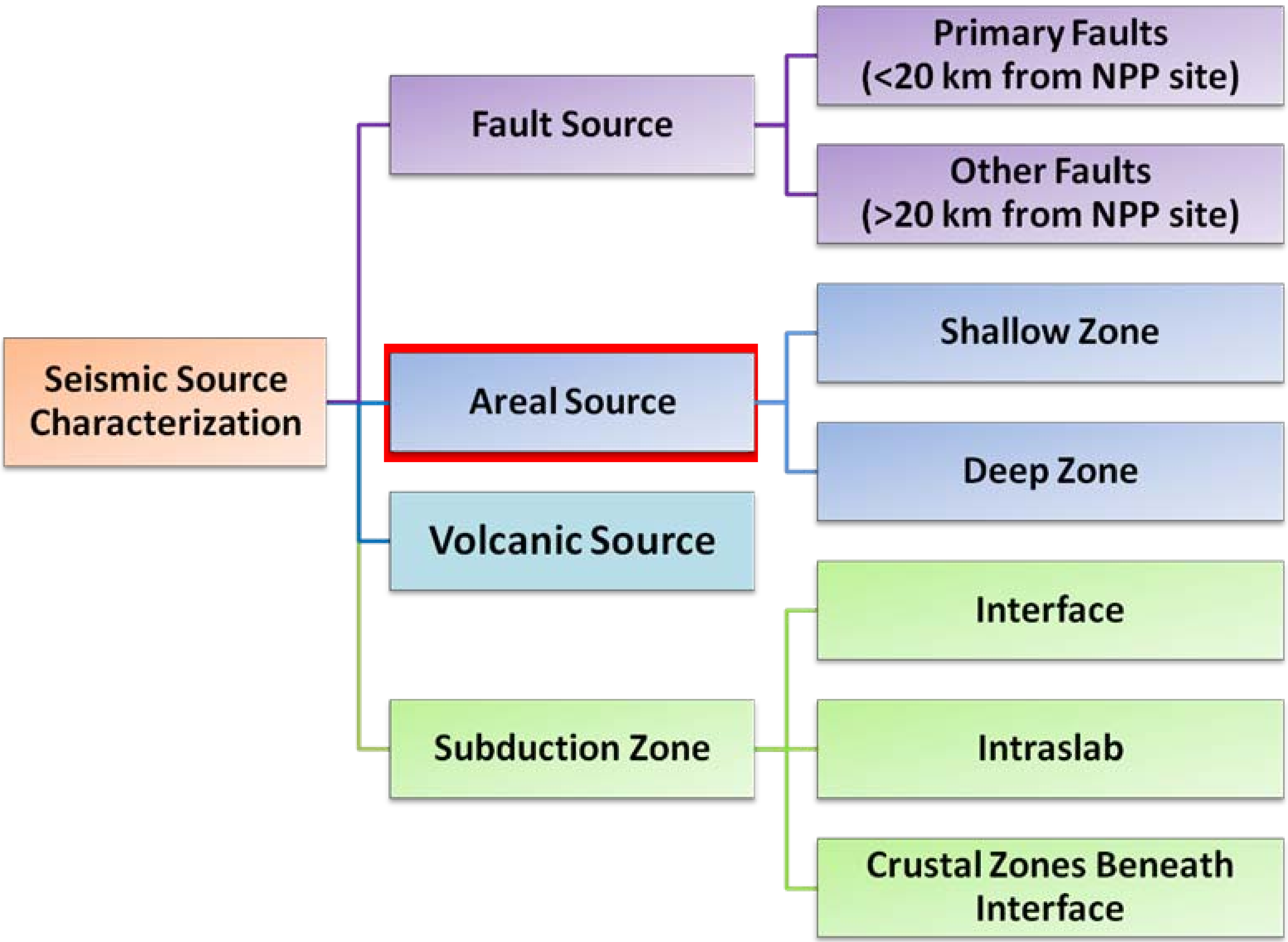
S N



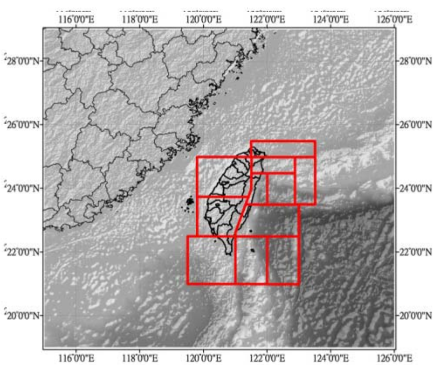
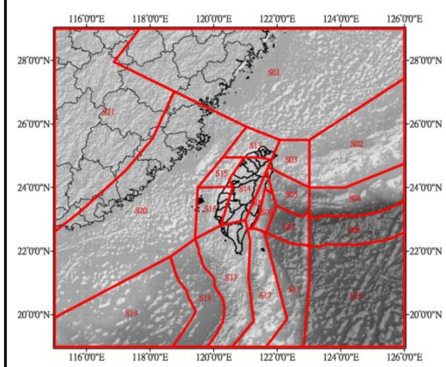
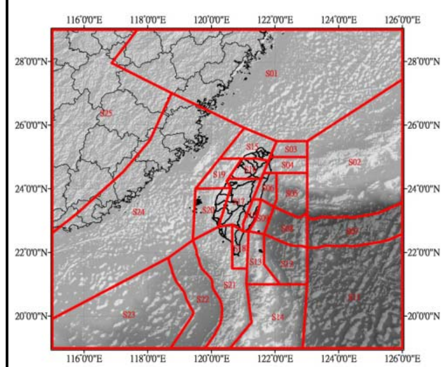
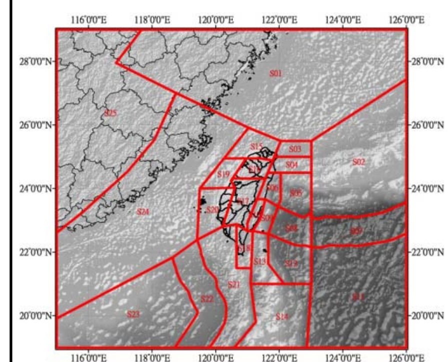
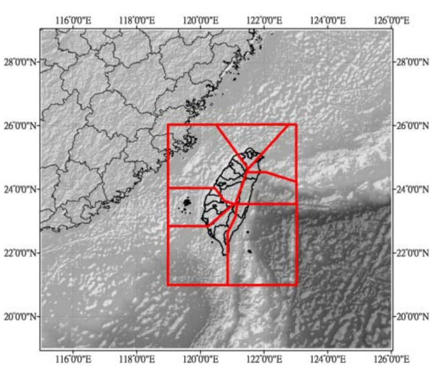
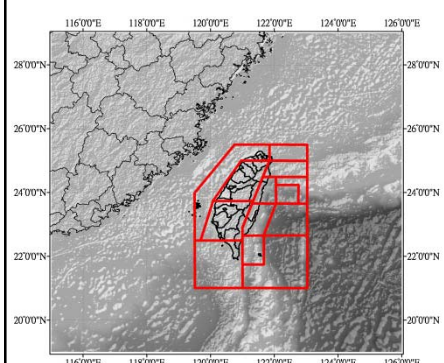
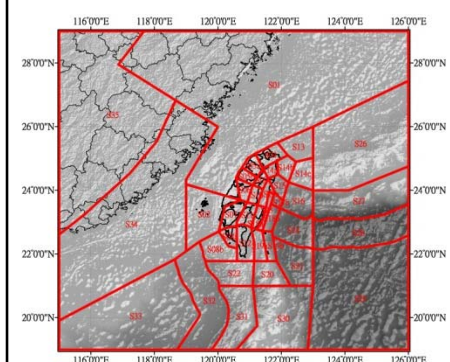
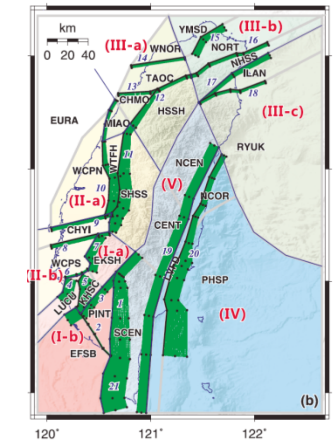


118°
120°
122°
124°
26°
24°
22°
20°
Shanchiao Fault System
ST-II Fault System
Aoti Offshore Faults
Northern Ilan Fault System
S Fault
Okinawa Trough Fault
Binhai Fault
Ryukyu Strike Slip Fault
Ryukyu Trench
Hengchun Fault System
West Hengchun Offshore Structure
East Hengchun Offshore Fault
Taitung Canyon Fault
Hengchun Ridge Offshore Fault
Manila Splay fault
North Luzon Backthrust Fault
North Luzon Strike Slip Fault
Manila Trench
Interface
Primary Fault
Other Fault (offshore)
Other Fault (onshore)

Seismic Source Characterization in Taiwan

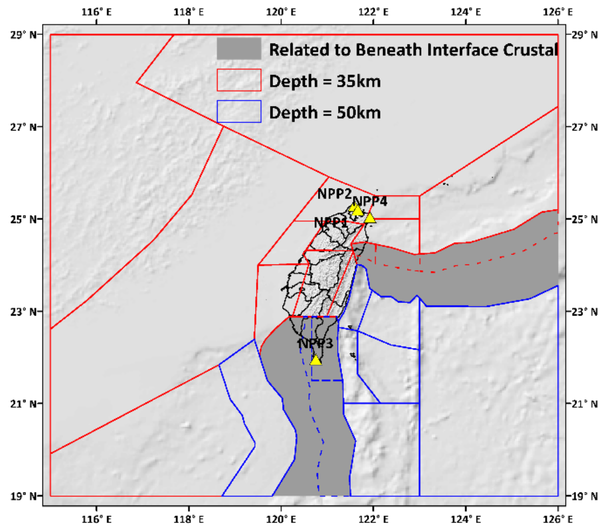


Areal Zoning Schemes Considered

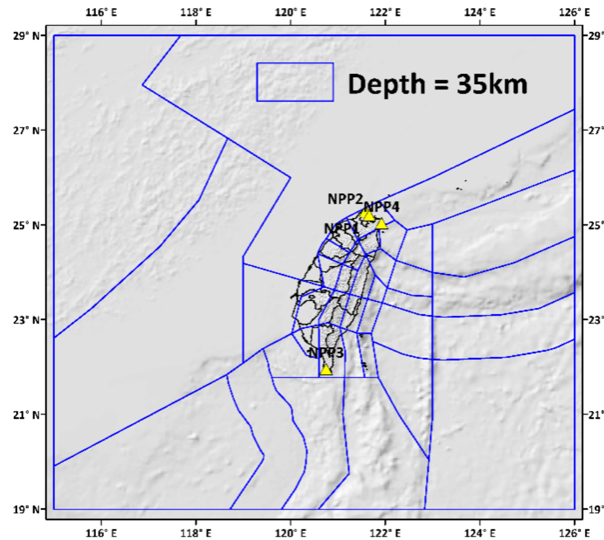
Tsai et al., 1987	Zoning Scheme A	Zoning Scheme B	Zoning Scheme C
Depth: 0~35 km 	Depth: 0~35 km 	Depth: 0~35 km 	Depth: 0~35 km 
CWB	**Zoning Scheme D**	**Zoning Scheme S**	**Block Model**
Depth: 0~35 km 	Depth: 0~35 km 	Depth: 0~35 km 	

Seismic Source Characterization in Taiwan

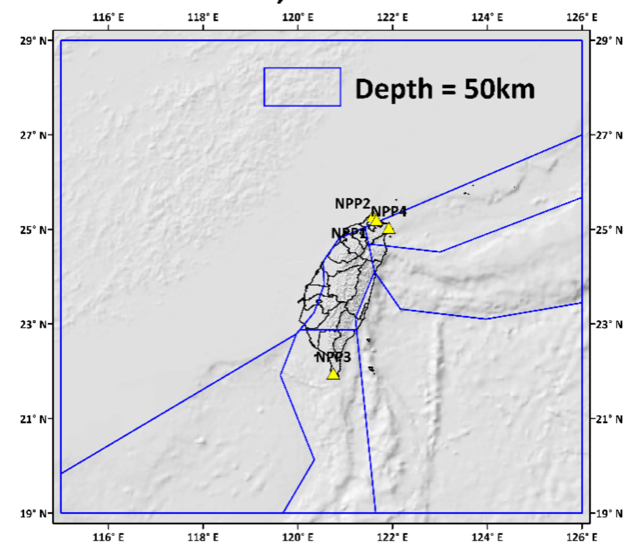
Zoning Scheme B, Shallow Zone



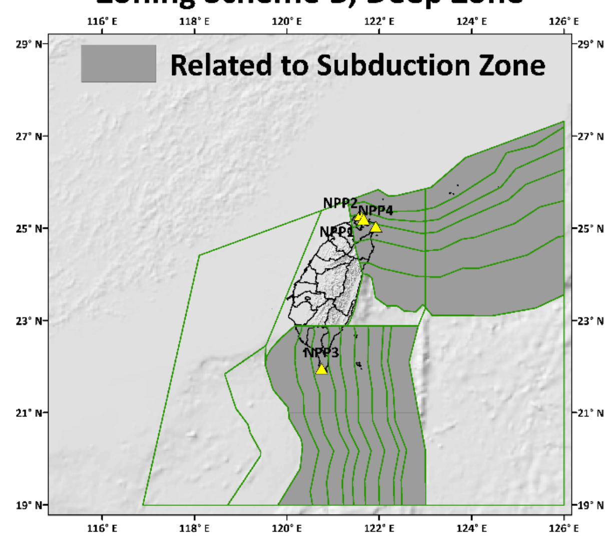
Zoning Scheme S, Shallow Zone



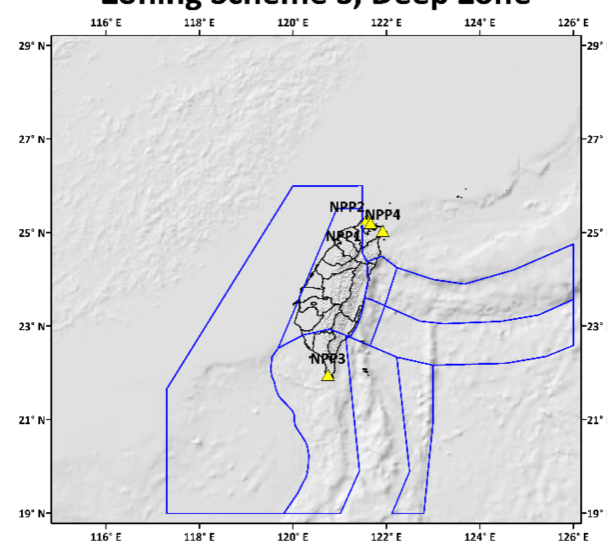
Zoneless, Shallow Zone



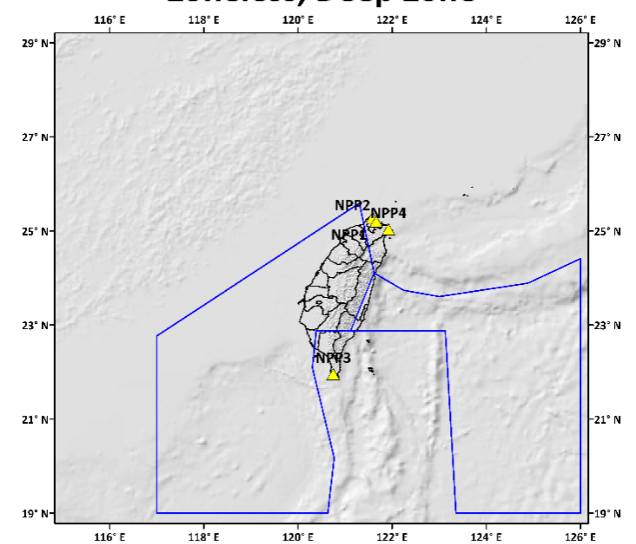
Zoning Scheme B, Deep Zone



Zoning Scheme S, Deep Zone



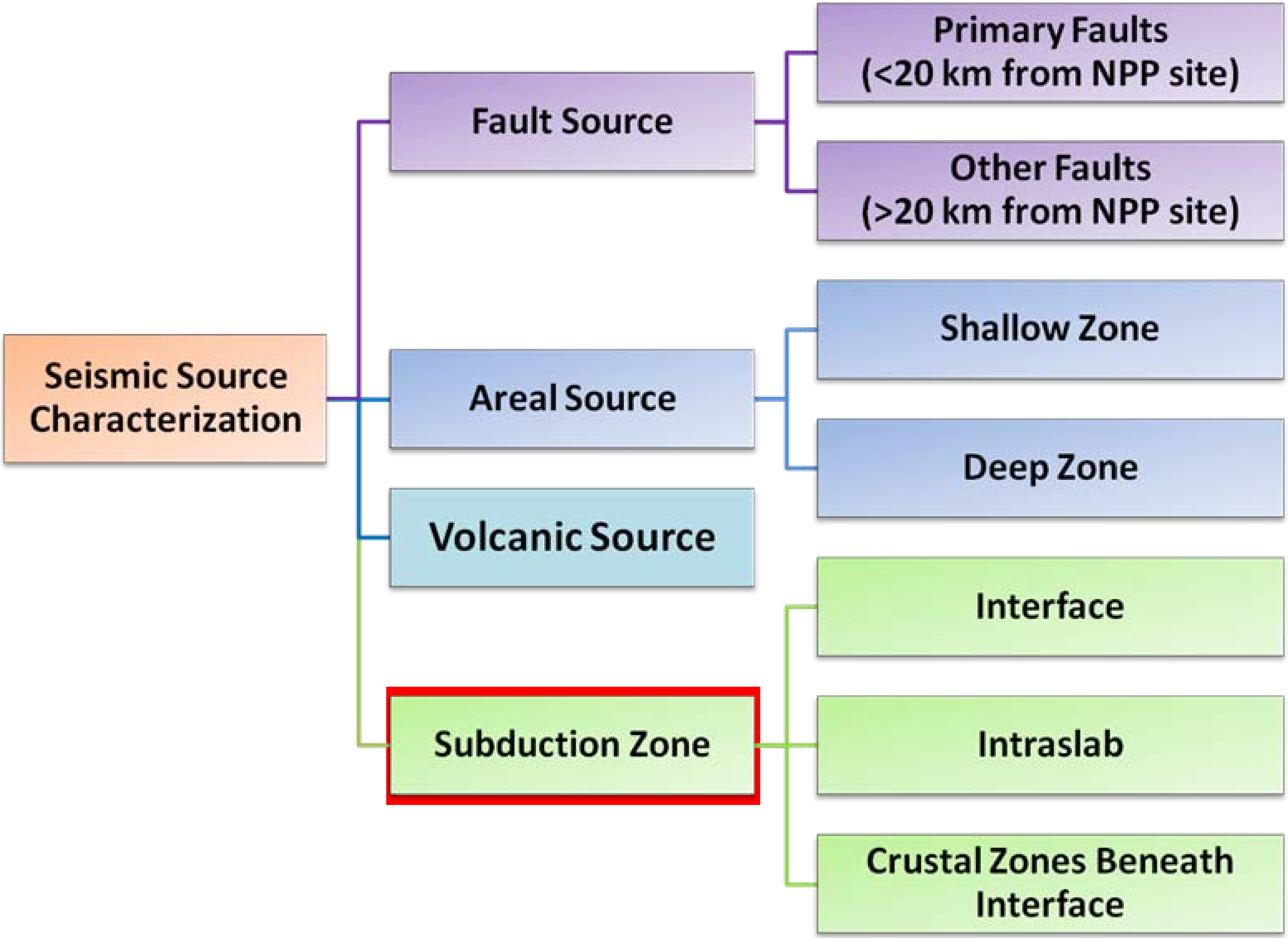
Zoneless, Deep Zone



Zoning Schemes Overview

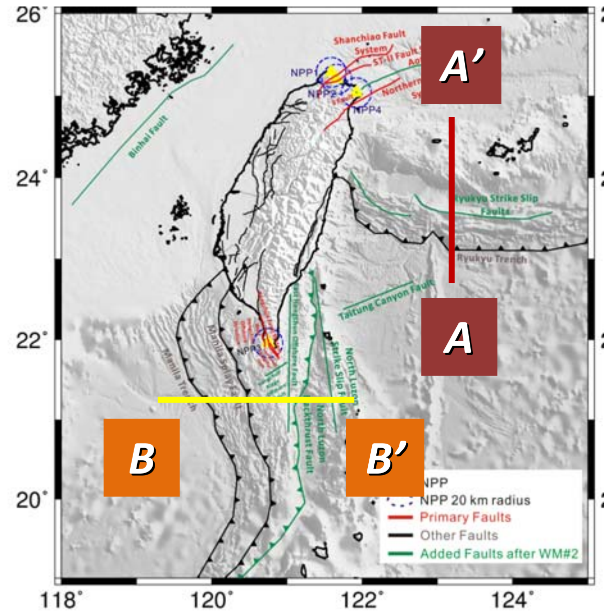
Zoning Scheme	Scheme B	Scheme S	Scheme Z
Boundary Reference	NPPs' PSHA Report (1994)	C.T. Cheng, 2002	New Creation (H.J. Liu)
Seismic Source Classification	• Shallow zones • Beneath Interface crustal zones • Deep zones • Intraslab zones • Volcanic zones	• Shallow zones • Deep zones • Intraslab zones • Volcanic zones	• Shallow zones • Beneath Interface crustal zones • Deep zones • Intraslab zones • Volcanic Zones
Depth Ranges of Shallow Zones	0 – 35km 0 – 50km	0 – 35km	0 – 35km 0 – 50km
No. of Shallow Zones	25	38	6
No. of Beneath Interface Crustal Zones	4	N/A	2
No. of Intraslab Zones	19	11	6
No. of Deep Zones	20	8	6

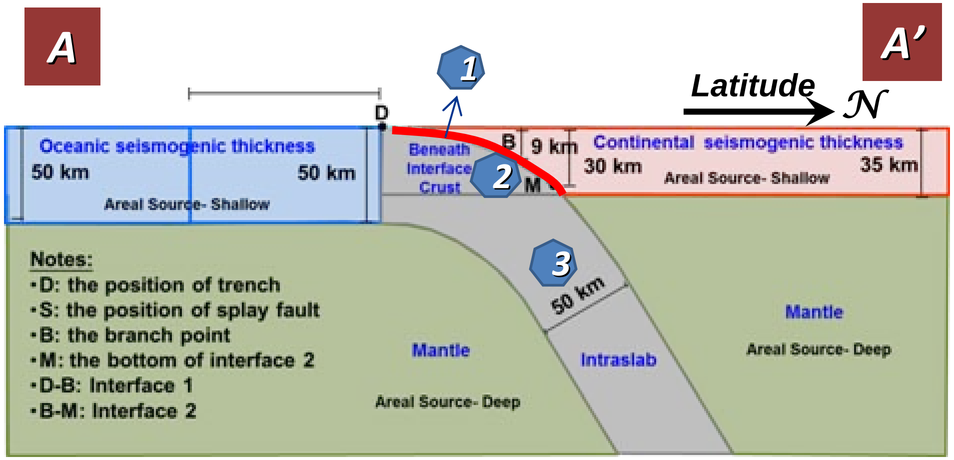
Seismic Source Characterization in Taiwan



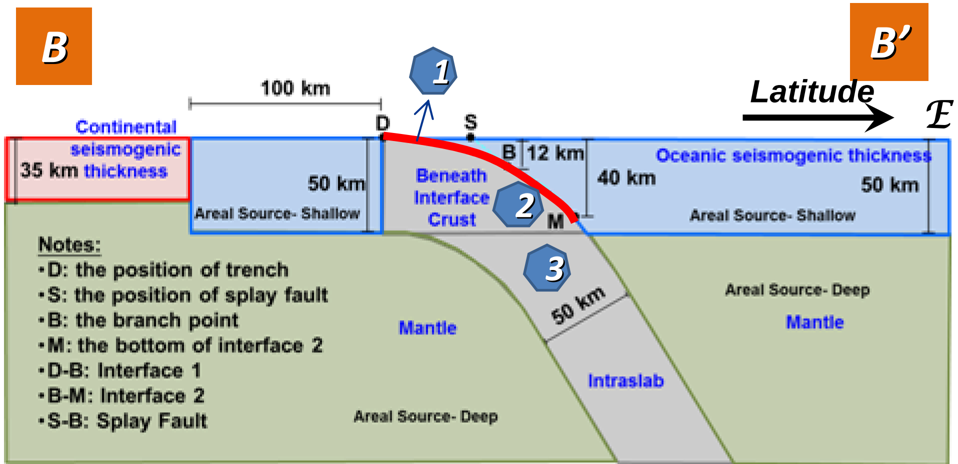
Subduction - Source type

- **Ryukyu Subduction Zone (A – A’)**
  1) Interface (Depth: 0 ~ 35km)
  2) Beneath Interface Crustal (Depth: 0 ~ 35km)
  3) Intraslab (35km ~)
- **Manila Subduction Zone (B – B’)**
  1) Interface (0 ~ 50km)
  2) Beneath Interface Crustal (Depth: 0 ~ 50km)
  3) Intraslab (50km ~)





Ryukyu Subduction Zone



Manila Subduction Zone

Classification of logic tree styles

- **Fault source**
  - ✓ Northern primary faults
  - ✓ Southern primary faults
  - ✓ Other faults : Onshore & Offshore
- **Subduction zone**
  - ✓ Ryukyu subduction
  - ✓ Manila subduction
- **Areal source**
  - ✓ Scheme B
  - ✓ Scheme S
  - ✓ Zoneless

Fault Source & Interface Style of Logic Tree Node

- **Geometry**

Style of Faulting	Rupture Model	Rupture Source	Fault Geometry Model: Dip	Fault Geometry Model: Seismogenic Depth

- **Activity**

Seismogenic Probability	Vertical Rate	Magnitude Distribution Model: Max. Magn.	Magnitude Distribution Model: Magnitude pdf

*__Max Magn.__ :
•Max Magn. = Char. Magn. + 0.25
•Char. Magn. is calculated from Magnitude Scaling Law: Wells and Coppersmith (1994), Yen and Ma (2011) and Blaser et al (2010).

Areal Source Style of Logic Tree Node

- **Geometry**

  Areal Zoning Schemes

- **Activity**

  b-value & Activity Rate

  Max Magnitude (for TE model)

  Focal Mechanism

*Note:
•Method of estimating b-value and activity rate: Maximum Likelihood Estimation
•Magnitude pdf Model: G-R Truncated Exponential Model
•Depth pdf Model: Normal Distribution for Shallow Zones Triangular Distribution for Deep Zones
•Crustal GMPE: NGA-West2 (for Shallow Zones)
•Intraslab GMPE: BCHydro, LL08 (for Deep Zones)
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Principle of Weighting-I

- **3 branches**

1. The weighting of Min. and Max. must be smaller than the weighting of Med., in other words, the weighting of the Med. is the highest unless there is definitive evidence otherwise.

2. If the range of uncertainty is wide or the median is lacking evidence, the weighting would be given almost equal weighting as [0.3] [0.4] [0.3] and be given like normal distribution.

3. If the middle branch is derived from direct measurement and reliable, the weighting would be given as normal distribution with small standard deviation such as [0.2] [0.6] [0.2].

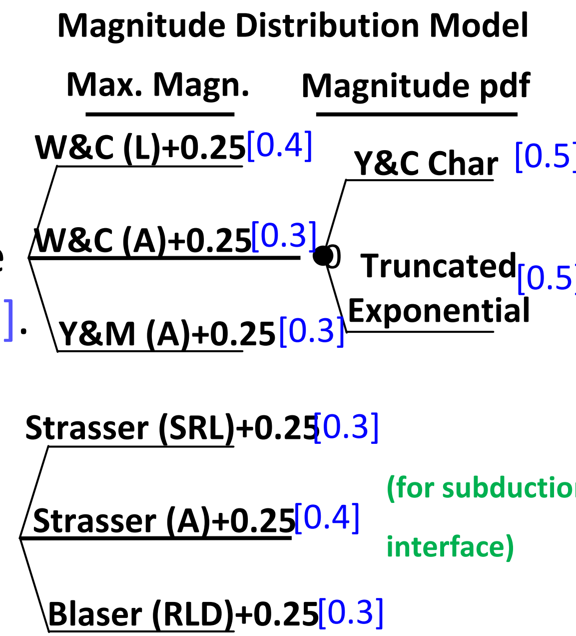
- **2 branches**

1. If the range of uncertainty is wide and/or lacking evidence, the weighting is given as equivalence [0.5] [0.5].

Principle of Weighting-II

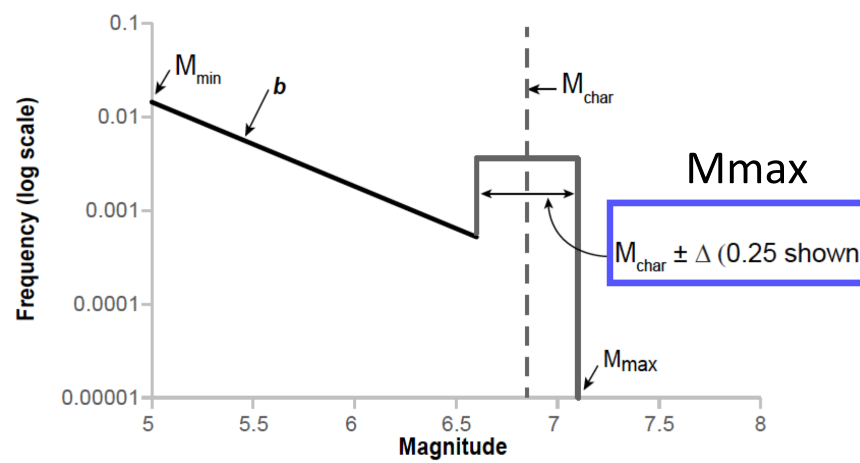
▪ Max. Magnitude

1. The values are derived from Wells and Coppersmith(1994) & Yen and Ma(2011).
2. Both W&C A and Yen&Ma use the fault rupture area, so we give them a total weighting of [0.6] and spilt equally as [0.3].
3. The first branch, W&C L, considers the fault rupture length, and we give it a weighting of [0.4].
4. Strasser A considers the fault rupture area, we give it a weighting of [0.4], while both Strasser SRL and Blaser(RLD) consider rupture length, we give each of them a weighting of [0.3].



▪ Magnitude pdf

1. Characteristic earthquake model (Y&C) and truncated exponetial model, we give equal weighting as [0.5] [0.5].



Char. Magnitude and PDF

Char. Eqk. Magnitude
Scaling law for Crustal faults

- **Wells and Coppersmith (1994)[Surface Rupture Length]**

SS	Mw = 5.16 + 1.12Log(SRL)
RV	Mw = 5.00 + 1.22Log(SRL)
NM	Mw = 4.86 + 1.32Log(SRL)

- **Wells and Coppersmith (1994)[Rupture Area]**

SS	Mw = 3.98 + 1.02Log(A)
RV	Mw = 4.33 + 0.90Log(A)
NM	Mw = 3.93 + 1.02Log(A)

- **Yen and Ma (2011)[Area]**

DS	Log(Ae) = -12.45 + 0.80Log(Mo), Log(Mo) = 9.05 + 1.5Mw
SS	Log(Ae) = -14.77 + 0.92Log(Mo), Log(Mo) = 9.05 + 1.5Mw

Char. Eqk. Magnitude
Scaling law for subduction zone

- **Strasser et al. (2010)**

interface	Mw = 4.441 + 0.846Log(A)
	Mw = 4.868+1.392*log10(SRL)

- **Blaser et al. (2010)**

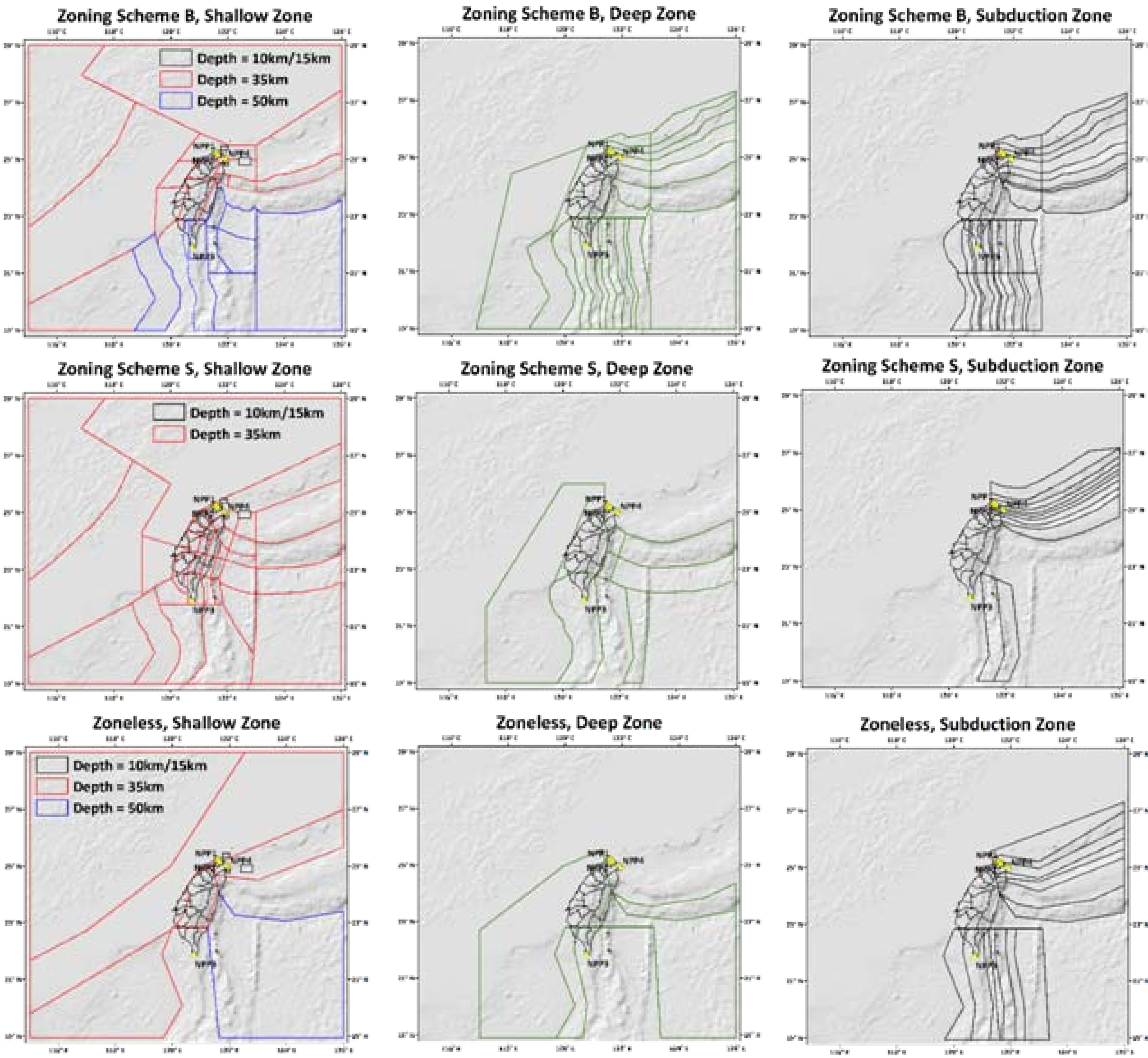
subduction	Log(L) = -2.81 + 0.62Mw

Magnitude PDF

- **Fault source**
  - Characteristic earthquake model (Youngs and Coppersmith,1985)
  - Truncated Exponential model (Cornell and Vanmarcke, 1968)
- **Areal source**
  - Truncated Exponential model (Cornell and Vanmarcke, 1968)
- **Subduction zone source**
  - Interface
    - Characteristic earthquake model (Youngs and Coppersmith,1985)
    - Truncated Exponential model (Cornell and Vanmarcke, 1968)
  - Beneath interface crust and Intraslab
    - Truncated Exponential model (Cornell and Vanmarcke, 1968)

Areal Sources

Zoning Variation



Boundary of shallow and deep zone of Zone B is following the source type. Boundary of shallow and deep zone of Zone S is constant depth at 35km.

Areal Source Style of Logic Tree Node

- **Geometry**

Areal Zoning Schemes

- **Activity**

b-value & Activity Rate

Max Magnitude (for TE model)

Focal Mechanism

*Note:
- Method of estimating b-value and activity rate: Maximum Likelihood Estimation
- Magnitude pdf Model: G-R Truncated Exponential Model
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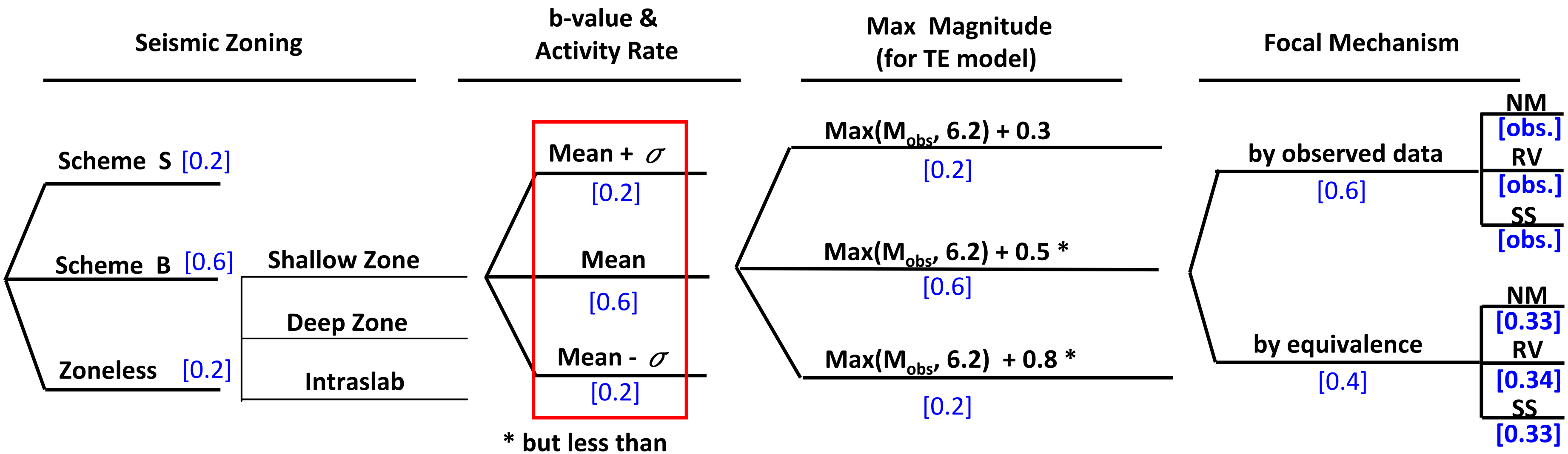
Areal Source Logic Tree



* but less than

7.7 (7.4+0.3) for China Region,

7.7 (7.4+0.3) for Taiwan Region, and

8.3 (8.0+0.3) for Pacific Region

*Note:

- Method of estimating b-value and activity rate: Maximum Likelihood Estimation
- Magnitude pdf Model: G-R Truncated Exponential Model
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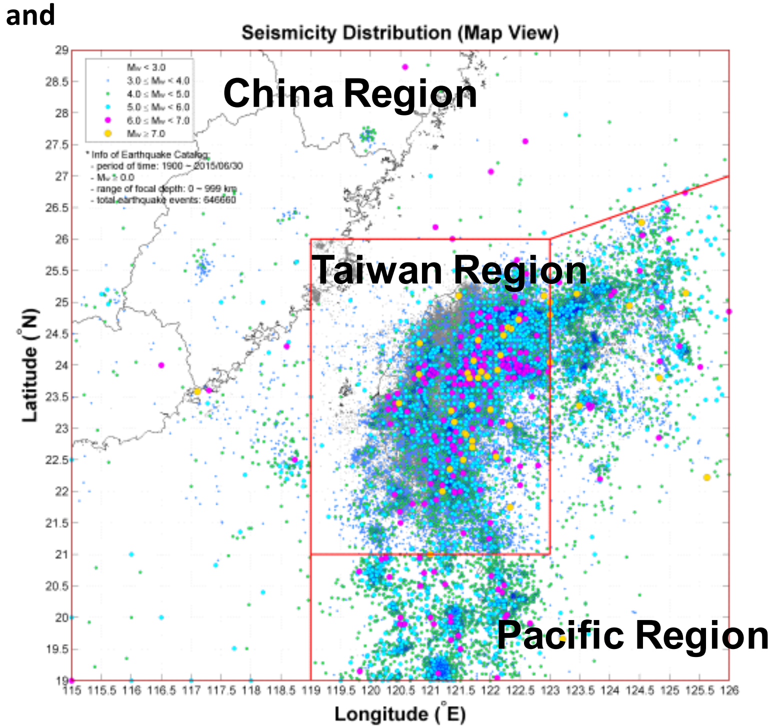
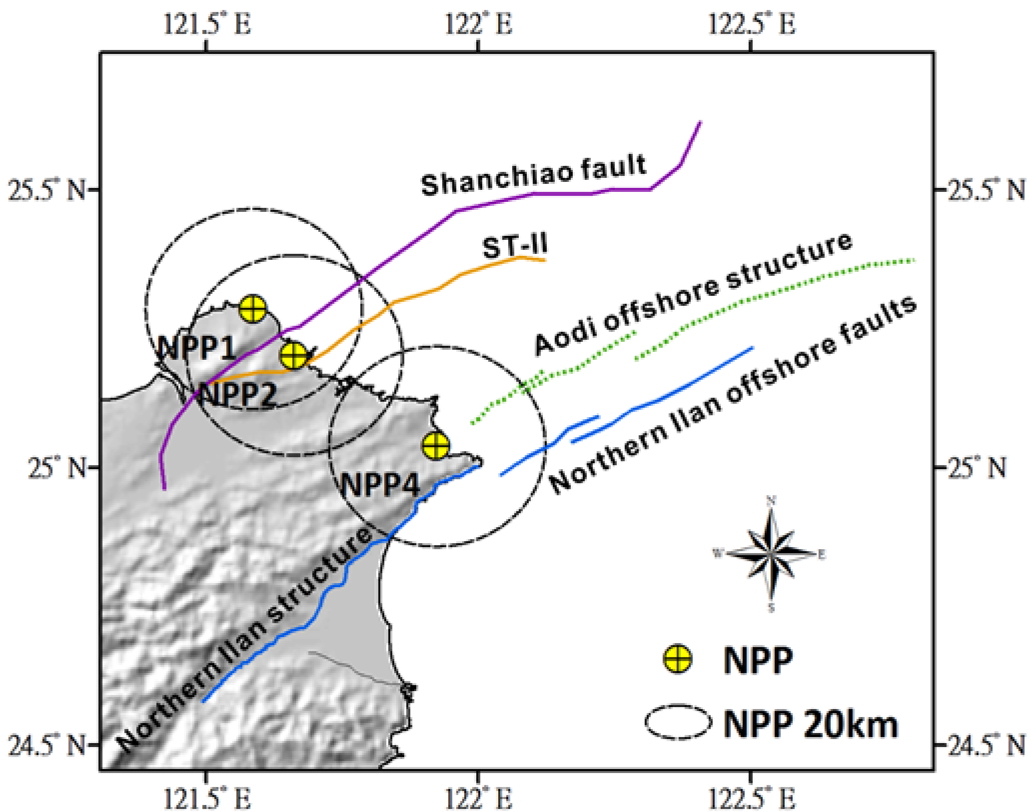
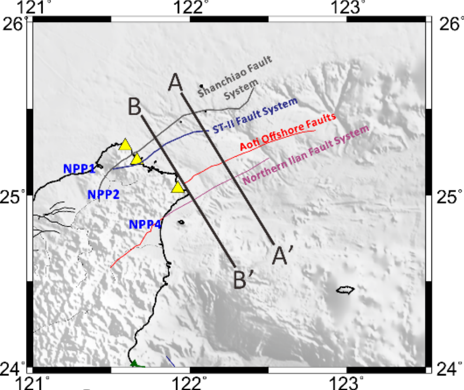
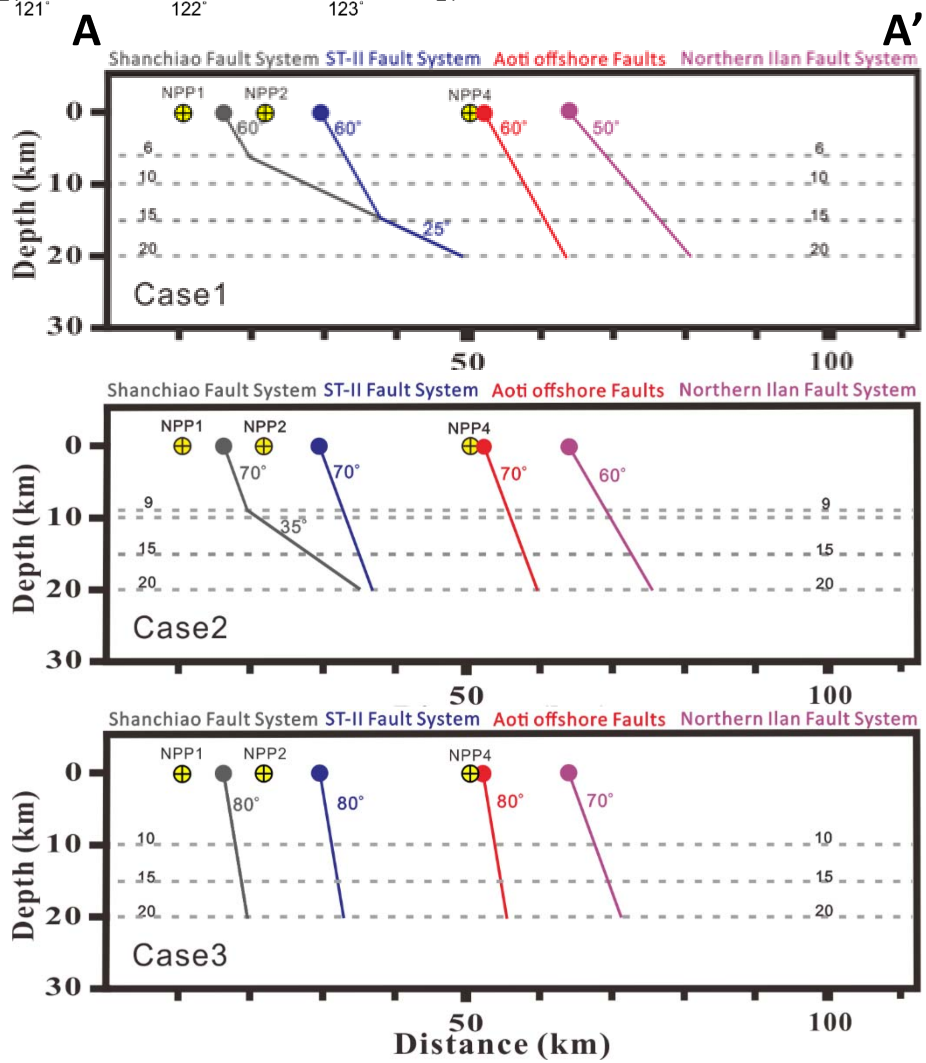


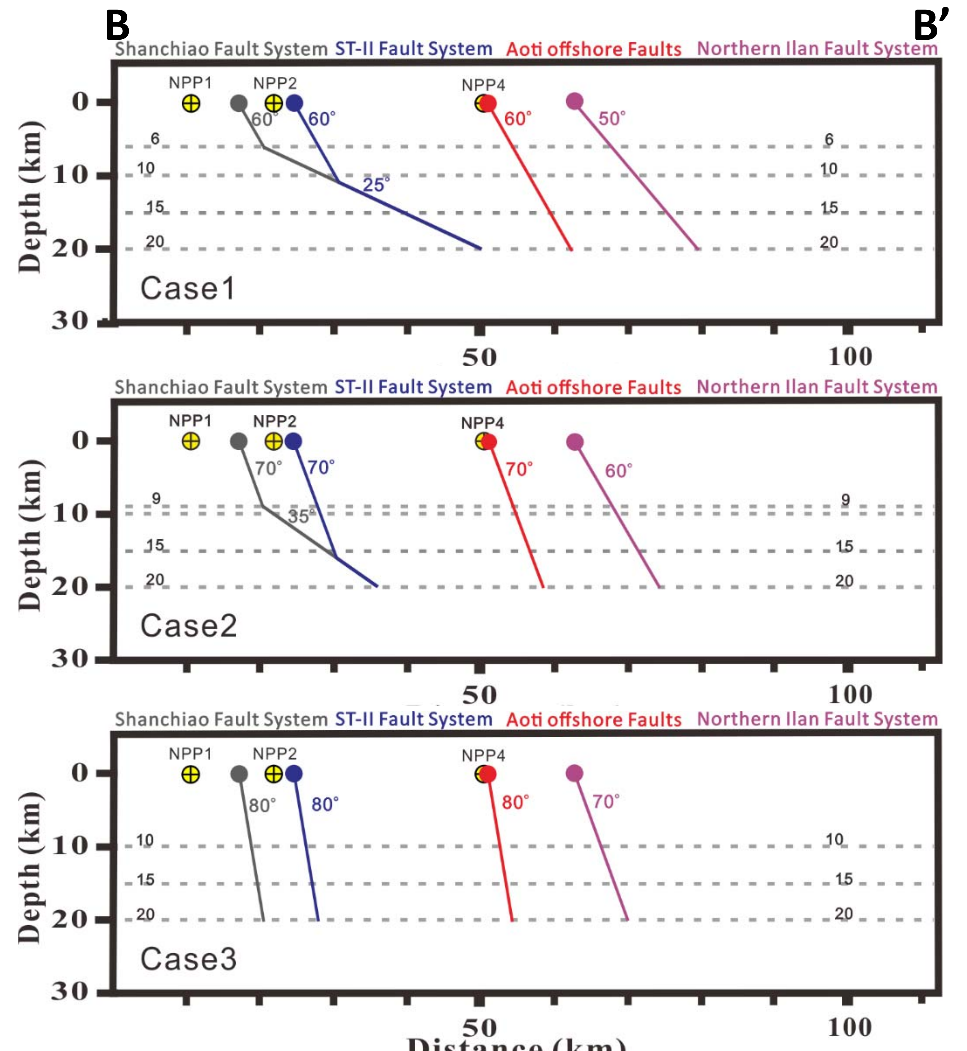
Northern primary faults



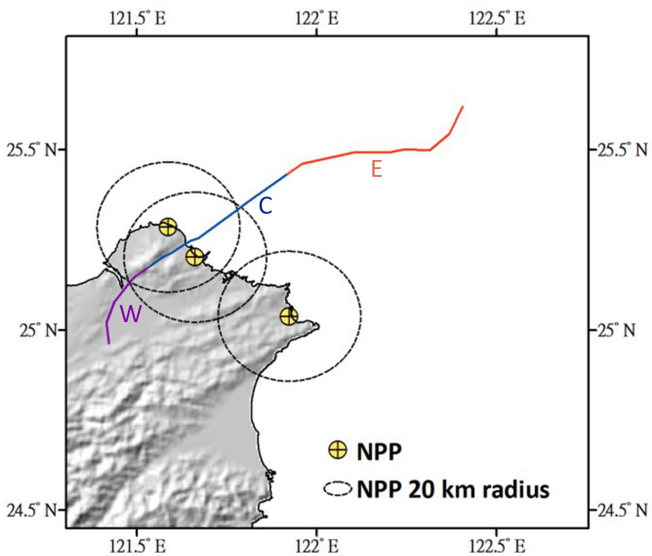


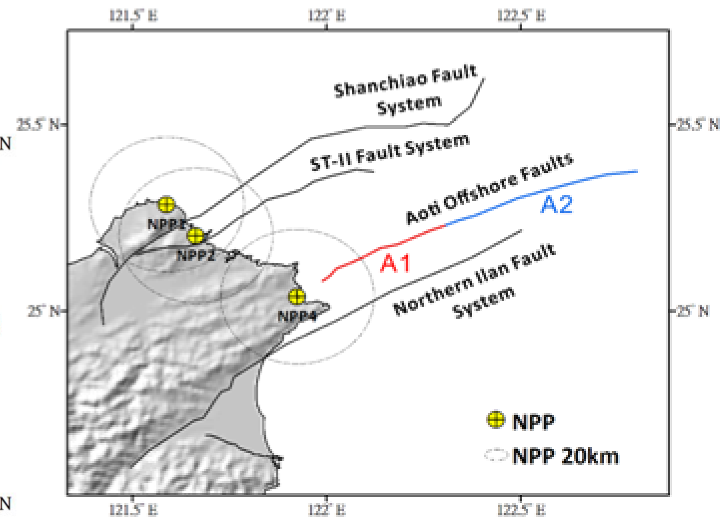
Northern primary faults

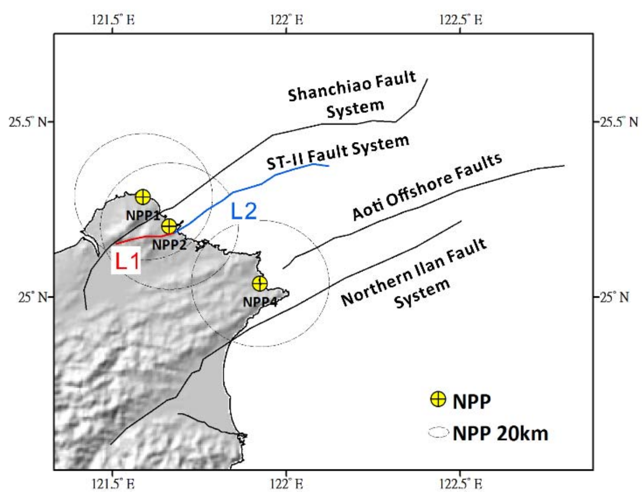


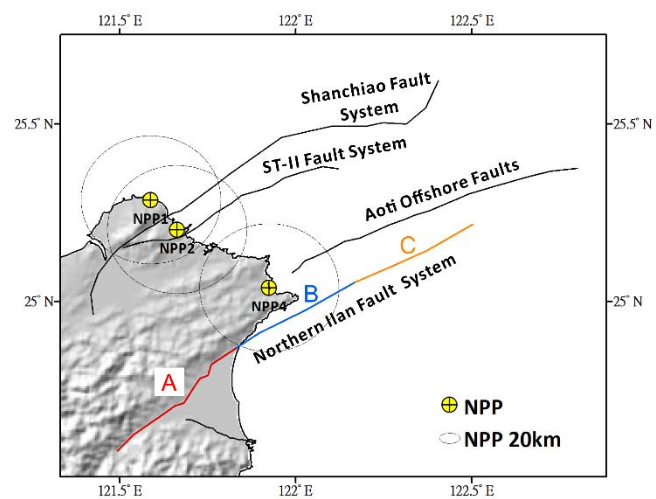


Northern primary faults



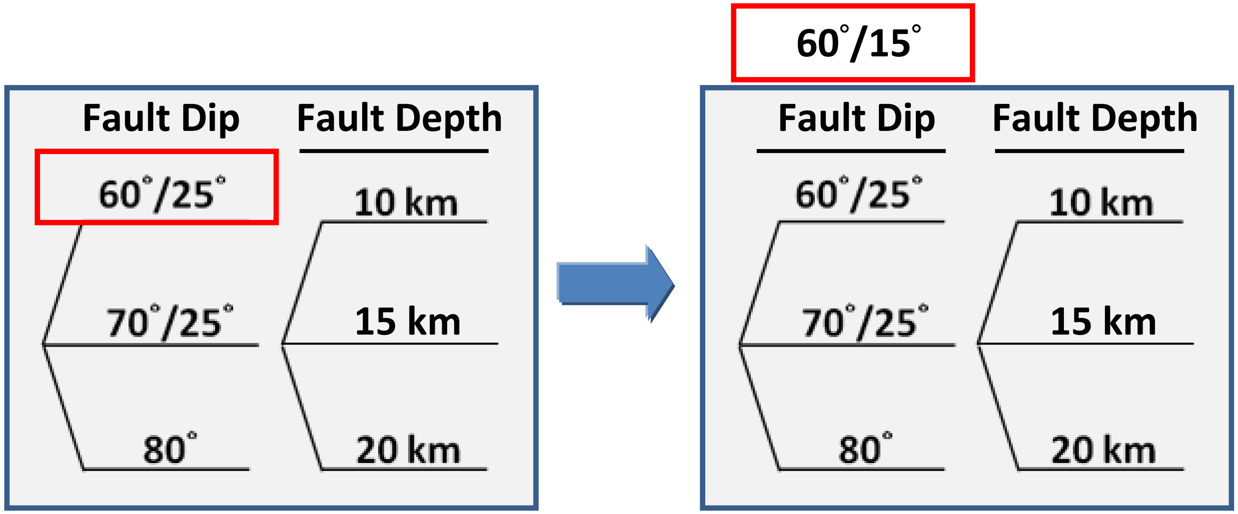




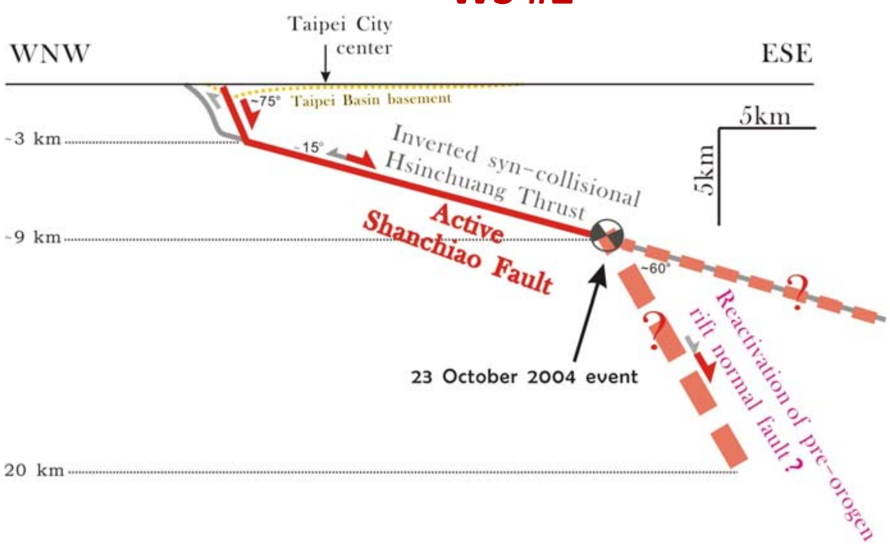


Shanchiao Fault System

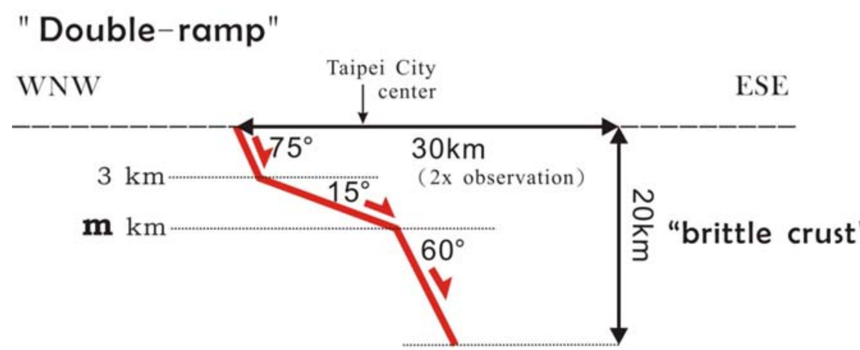
Shallow Dips Proposed by PE in WS#2



WS #2



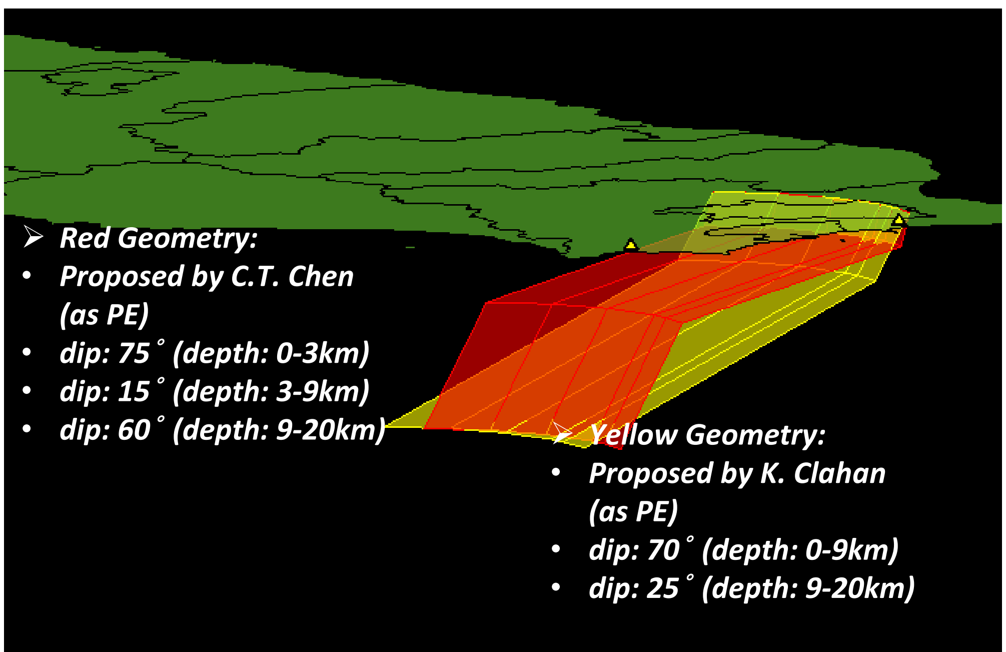
陳致同等人(Chen et al., 2014)

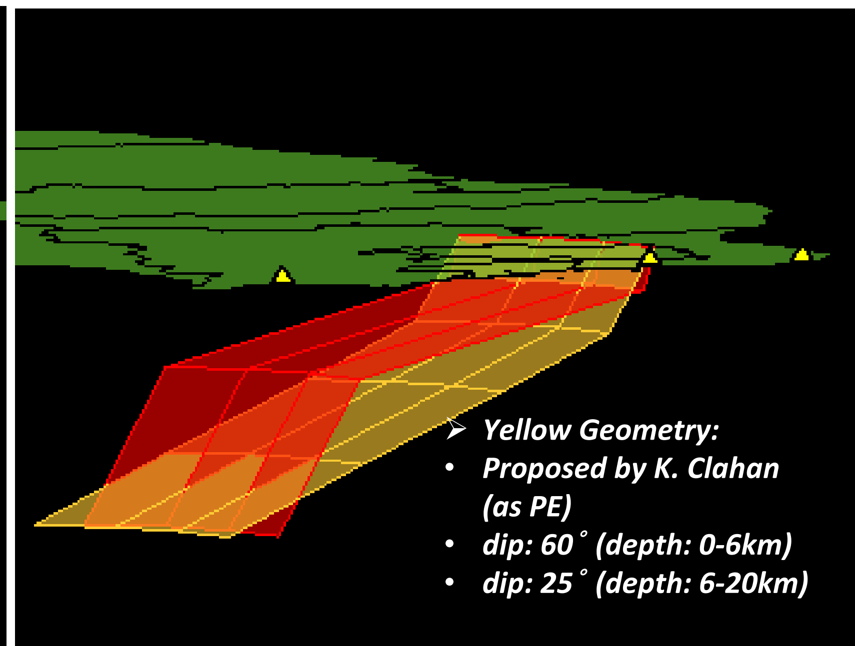


Shanchiao Fault System

Sensitivity Study for Dip Changes in W section

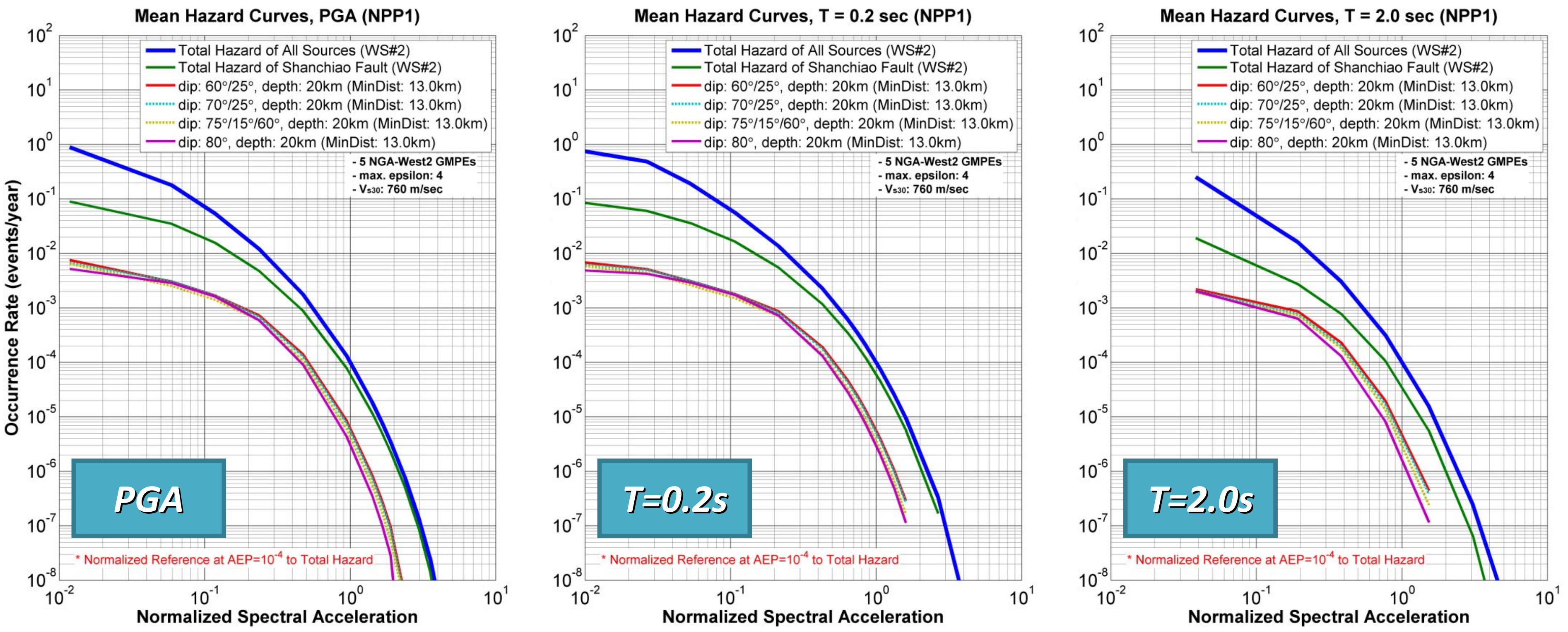
Proponent Expert	Geometry				Activity		Min. Distance (km)		
	Focal Mech.	Length (km)	Depth (km)	Dip	Slip Rate (mm/yr)	Max. Magnitude	NPP1	NPP2	NPP4
K. Clahan	NM	29	0-6-20	60˚/25˚	1.73	6.98	13.0	12.7	30.7
K. Clahan			0-9-20	70˚/25˚	1.60	6.95	13.0	12.8	31.3
K. Clahan			0-20	80˚	1.52	6.75	13.0	12.9	41.5
C. T. Chen			0-3-9-20	75˚/15˚/60˚	1.55	6.99	13.0	12.4	26.9





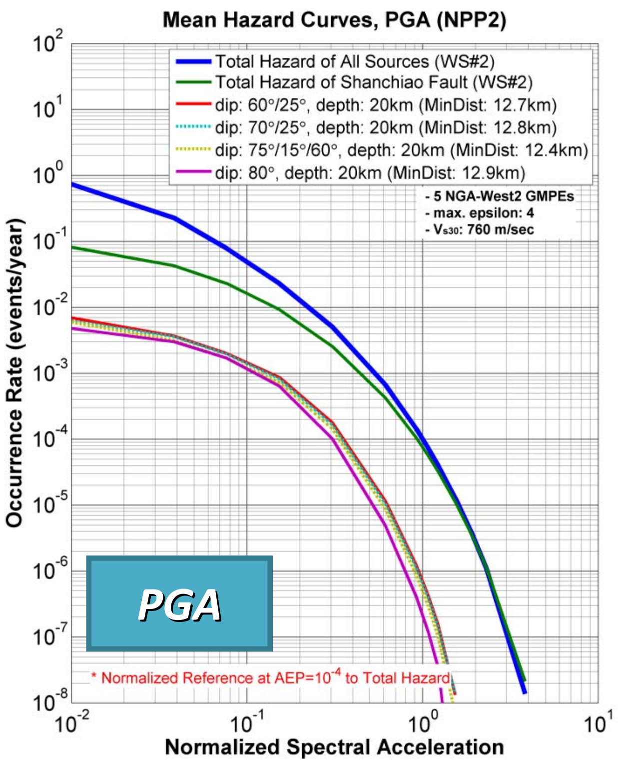
Shanchiao Fault System

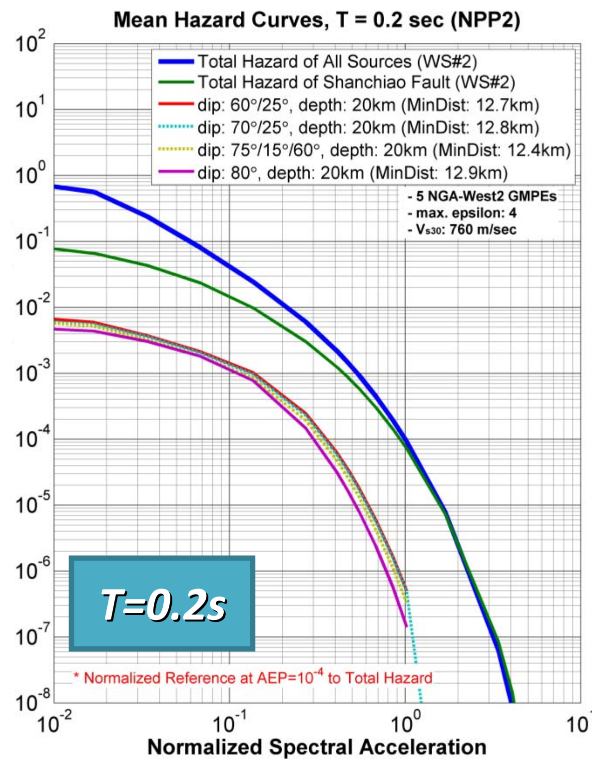
Hazard Sensitivity to NPP1 by W Section

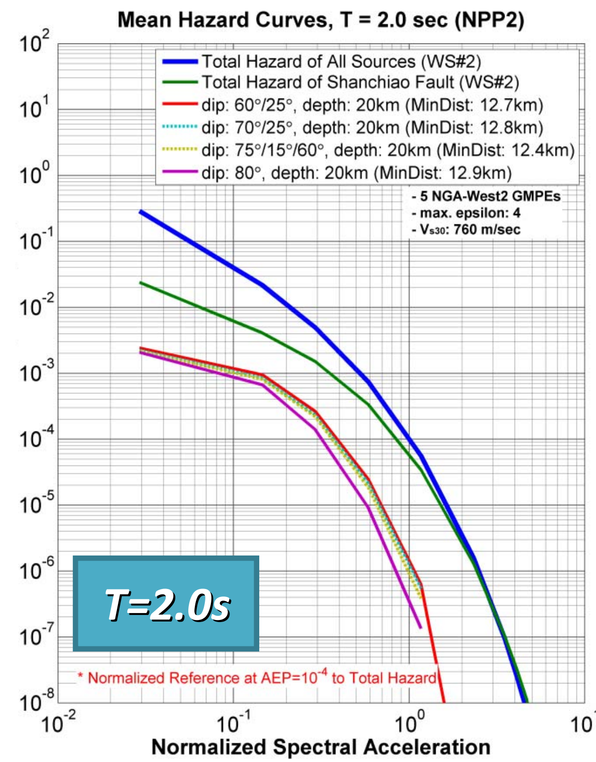


Shanchiao Fault System

Hazard Sensitivity to NPP2 by W Section

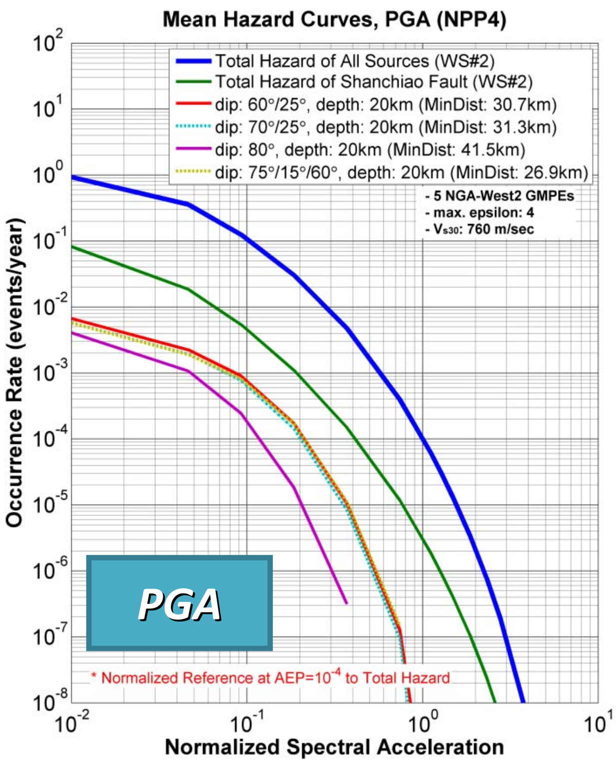


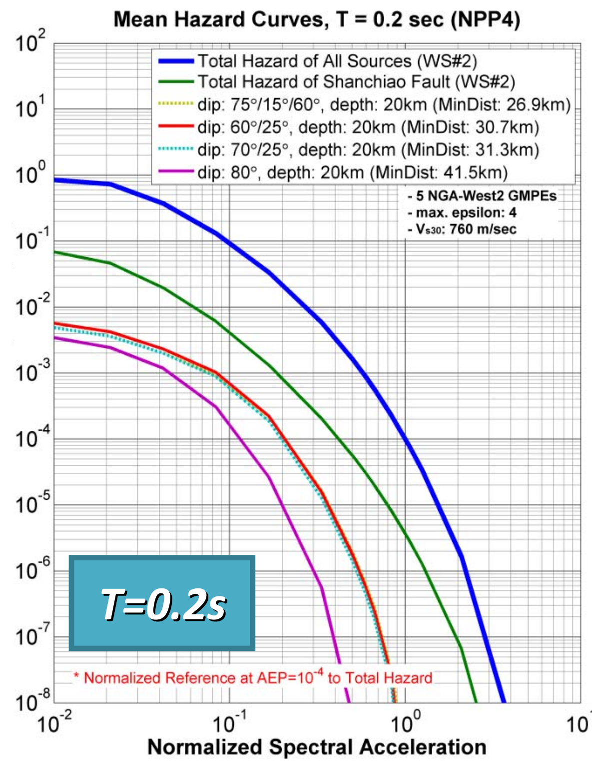


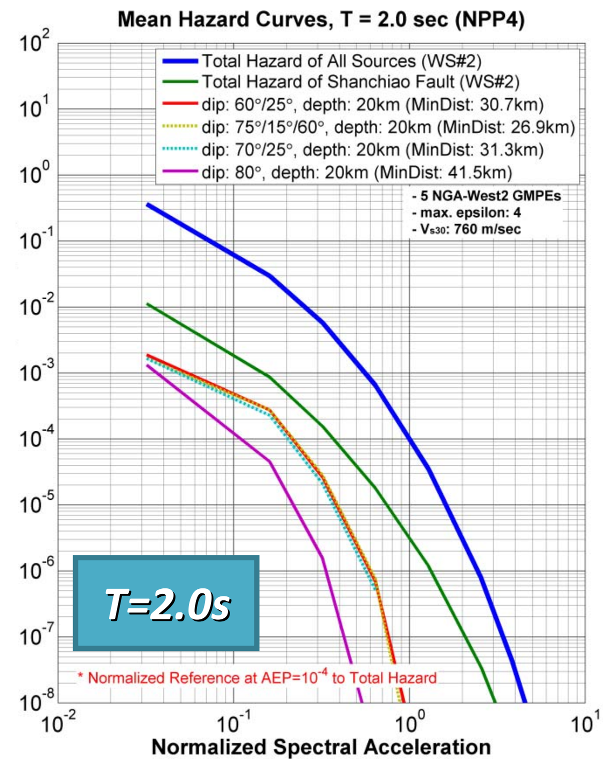


Shanchiao Fault System

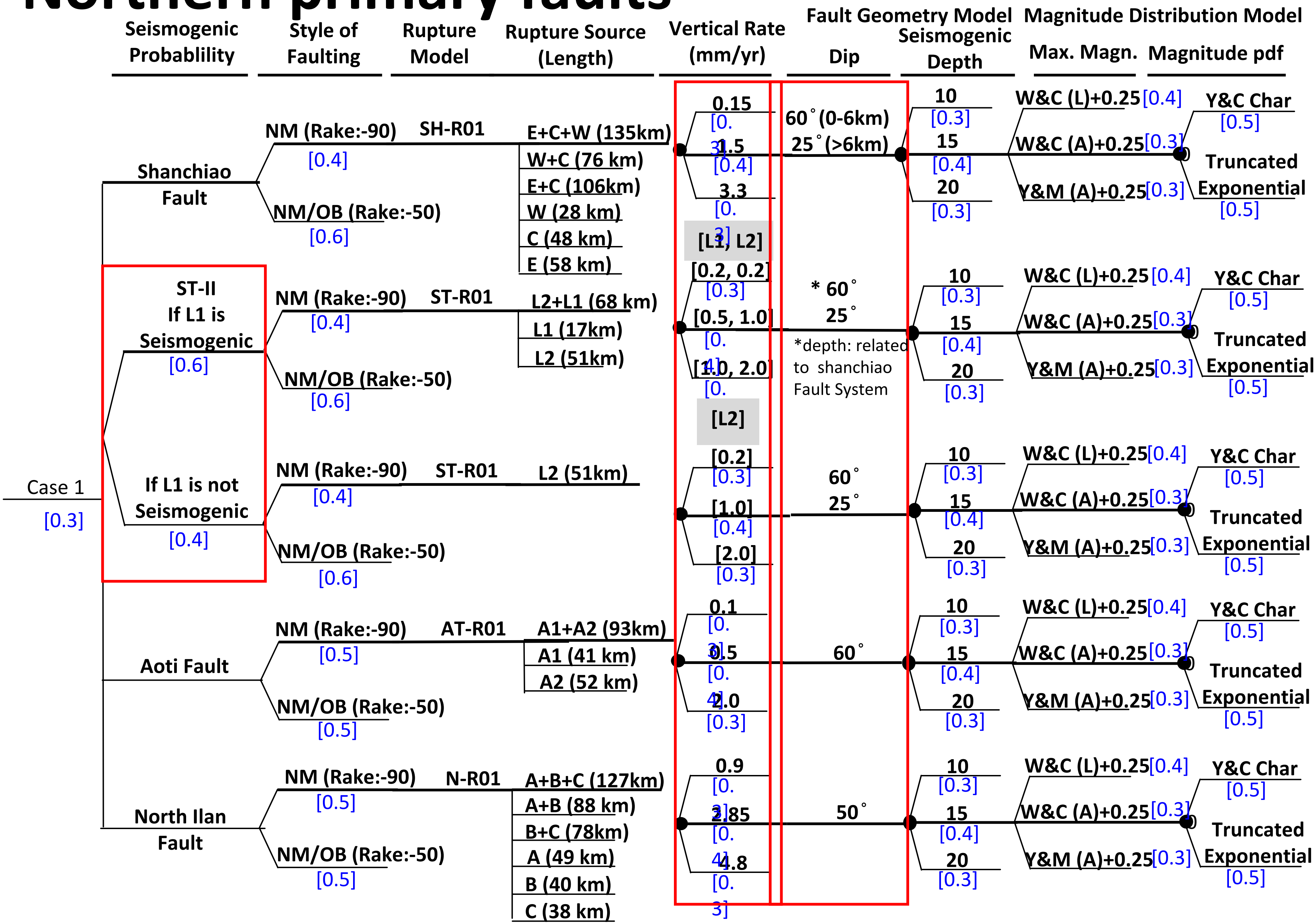
Hazard Sensitivity to NPP4 by W Section



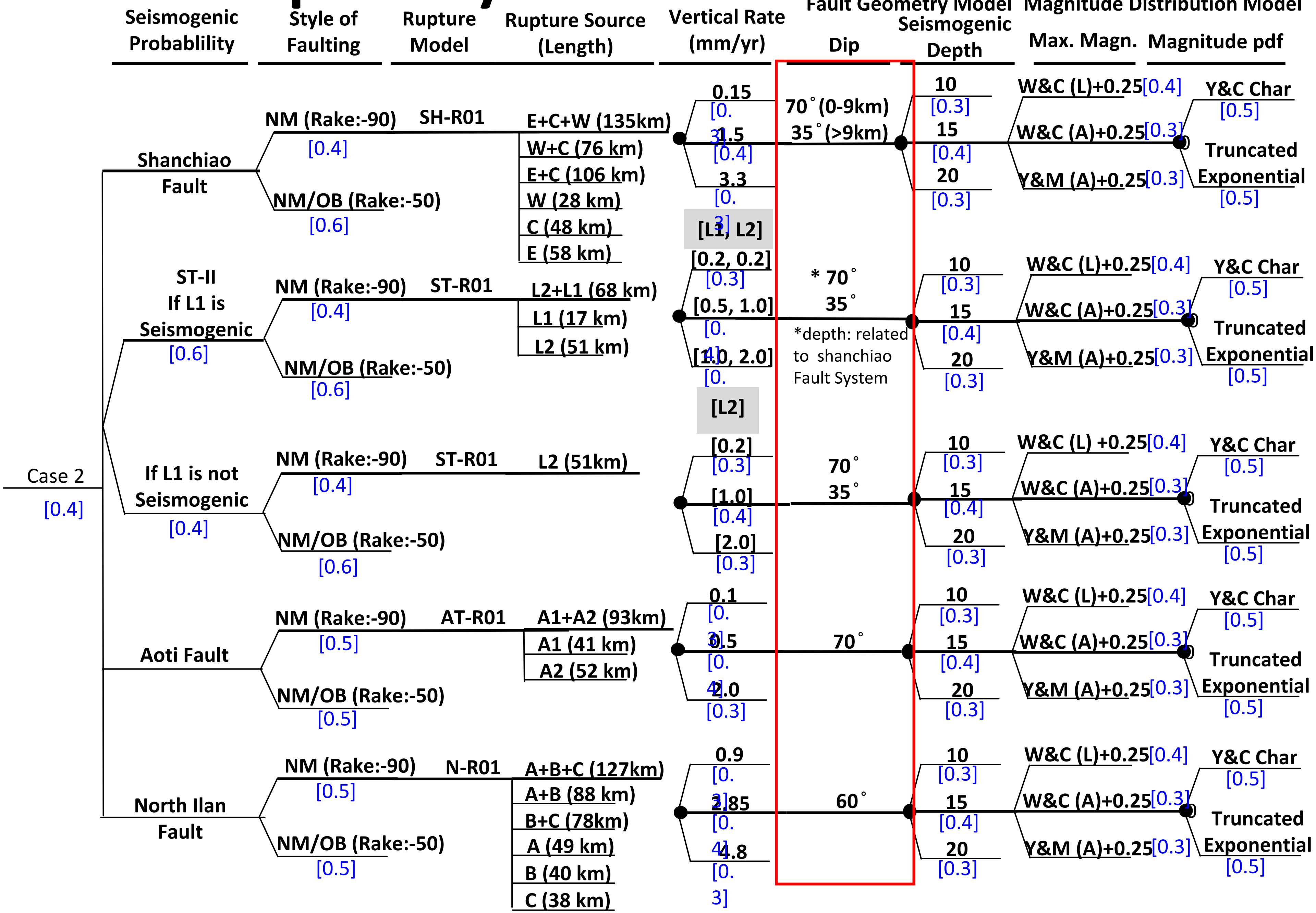




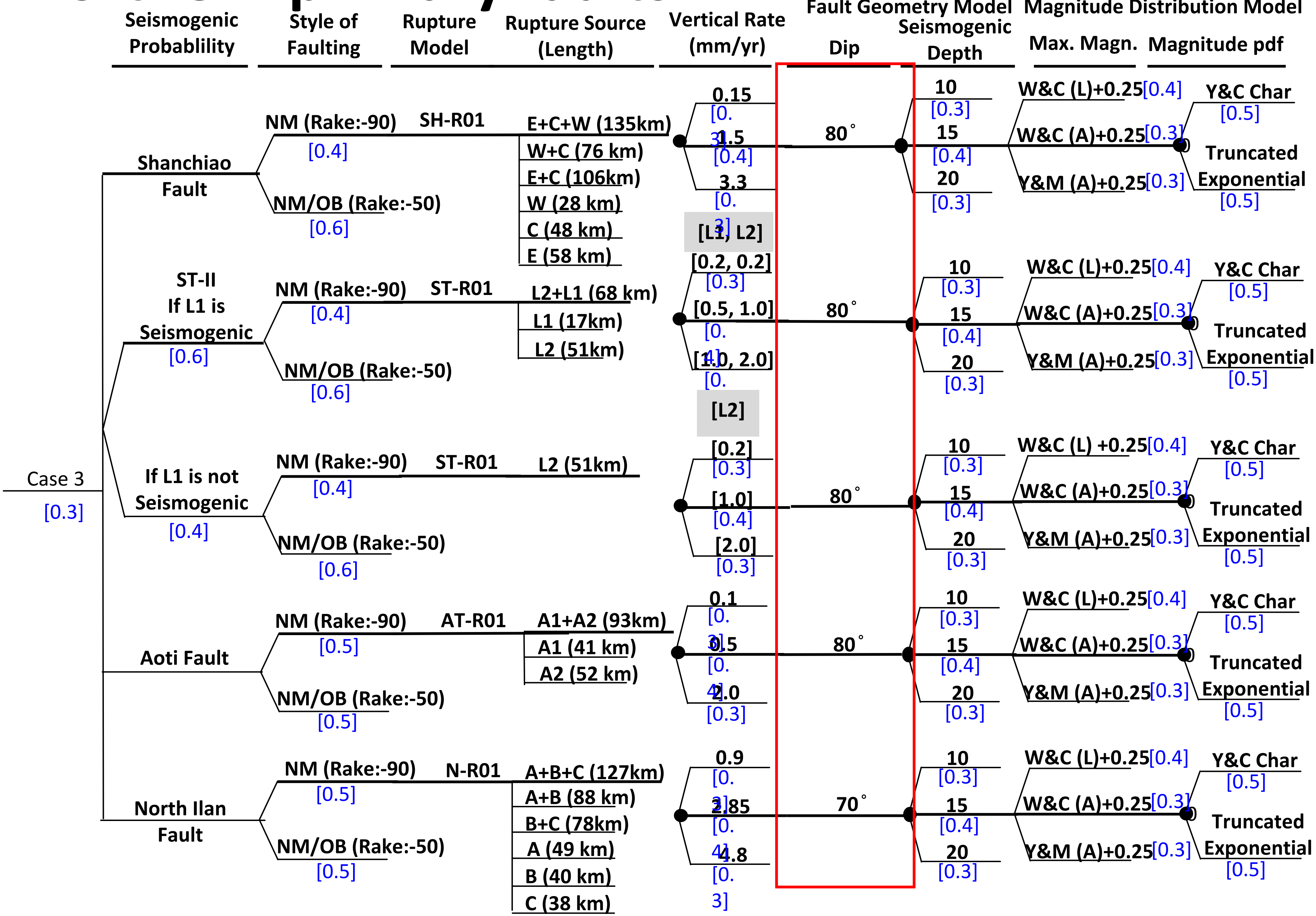
Northern primary faults



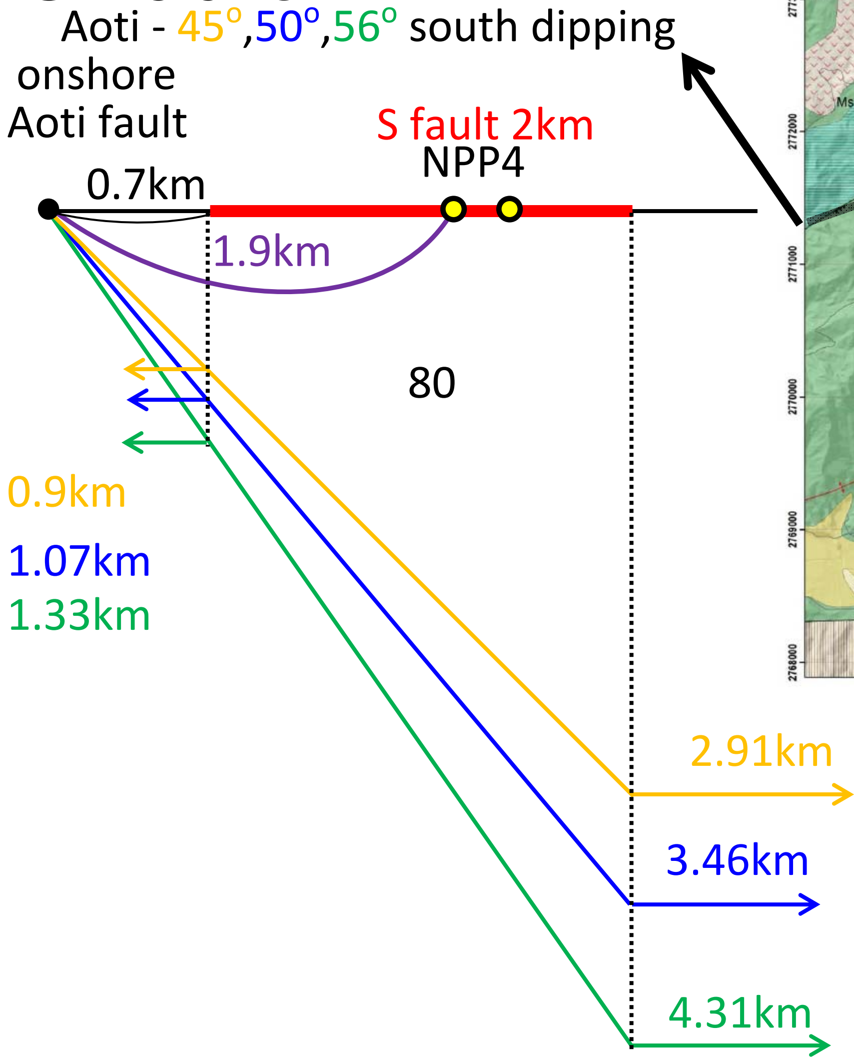
Northern primary faults

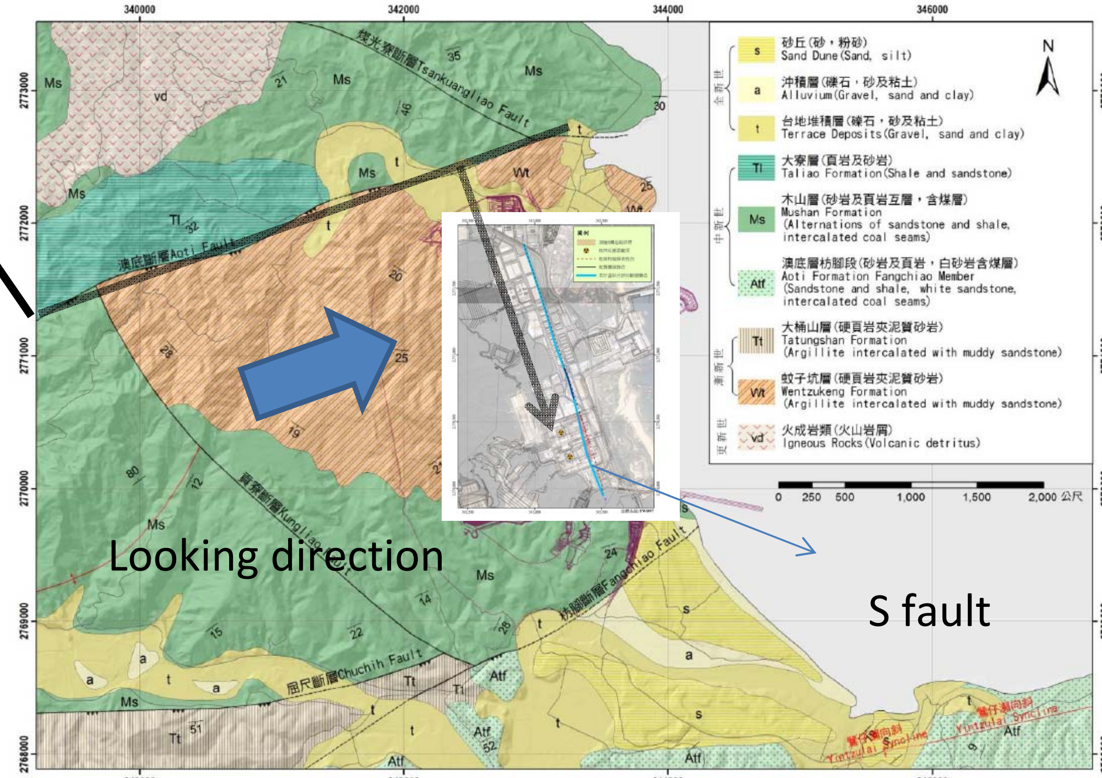


Northern primary faults



S Fault





(摘自中興公司，2013)

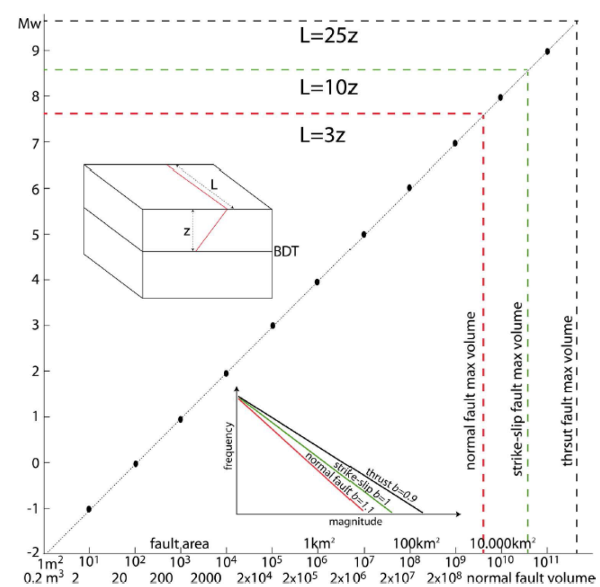
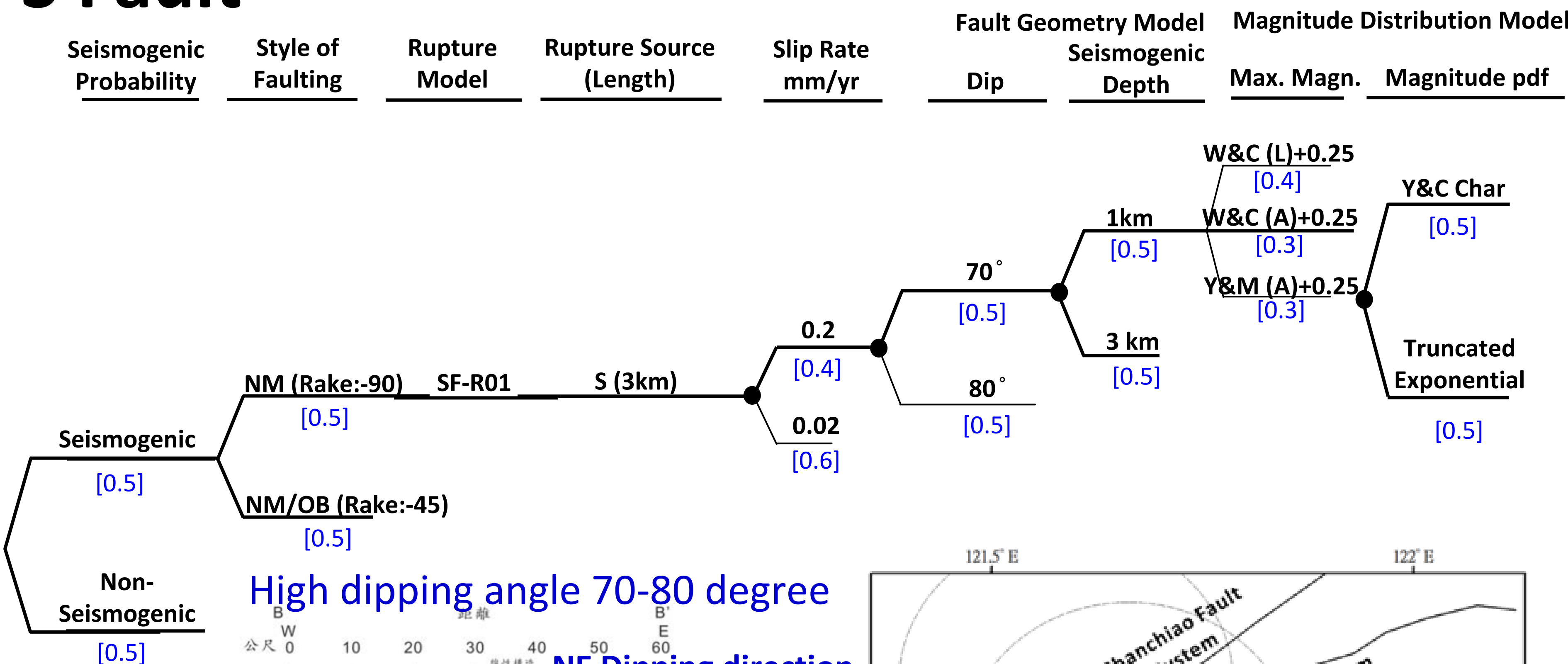


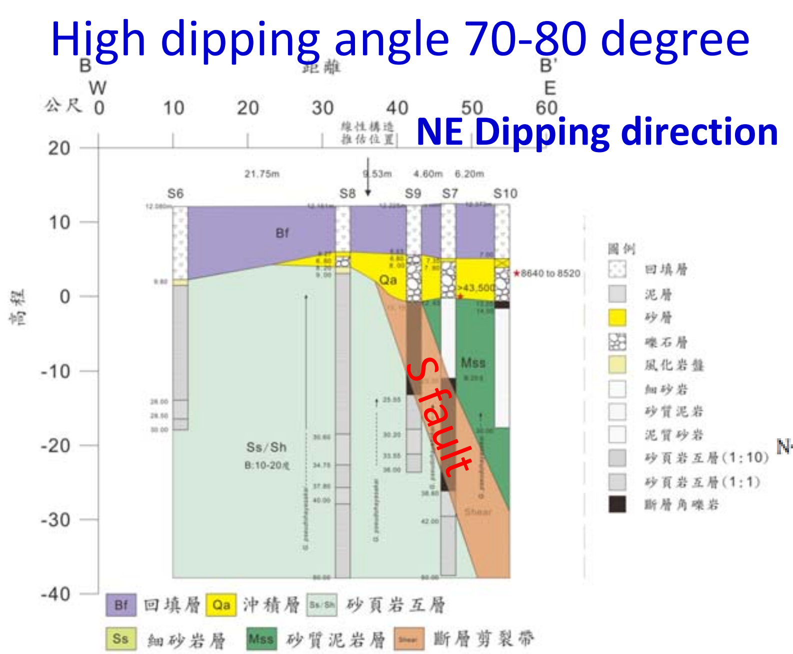
Figure 6. Empirical relationship between earthquake magnitude and fault rupture area. The volume involved by normal faulting is added below. Each type of tectonic setting has its own involved volumes, i.e., determining the maximum expected magnitude. The maximum volumes are computed assuming L = 3z (normal faulting), L = 10z (strike-slip fault) and L = 25z (thrust fault), where L is the fault length and z the involved volume depth. The different types of faulting have also different *b*-value of the Gutenberg-Richter relation[9], supporting that besides the different involved volumes, earthquakes may have different mechanisms.

Doglioni et al., 2015 Normal fault earthquakes or gravity quakes

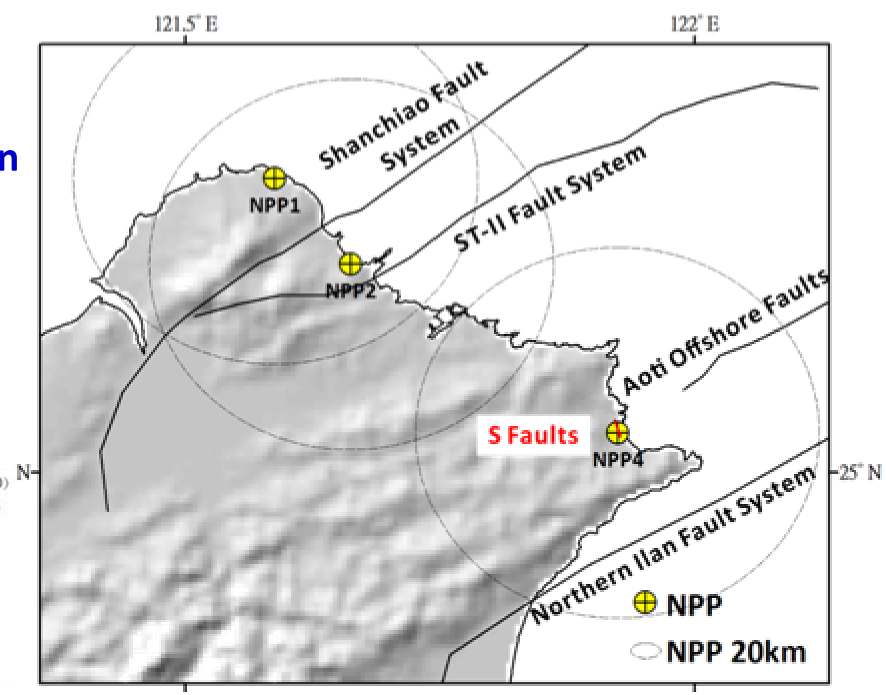
S Fault



Seismogenic Probability
Style of Faulting
Rupture Model
Rupture Source (Length)
Slip Rate mm/yr
Fault Geometry Model
Dip
Seismogenic Depth
Magnitude Distribution Model
Max. Magn.
Magnitude pdf
Seismogenic
[0.5]
Non-Seismogenic
[0.5]
NM (Rake:-90)
[0.5]
NM/OB (Rake:-45)
[0.5]
SF-R01
S (3km)
0.2
[0.4]
0.02
[0.6]
70°
[0.5]
80°
[0.5]
1km
[0.5]
3 km
[0.5]
W&C (L)+0.25
[0.4]
W&C (A)+0.25
[0.3]
Y&M (A)+0.25
[0.3]
Y&C Char
[0.5]
Truncated Exponential
[0.5]

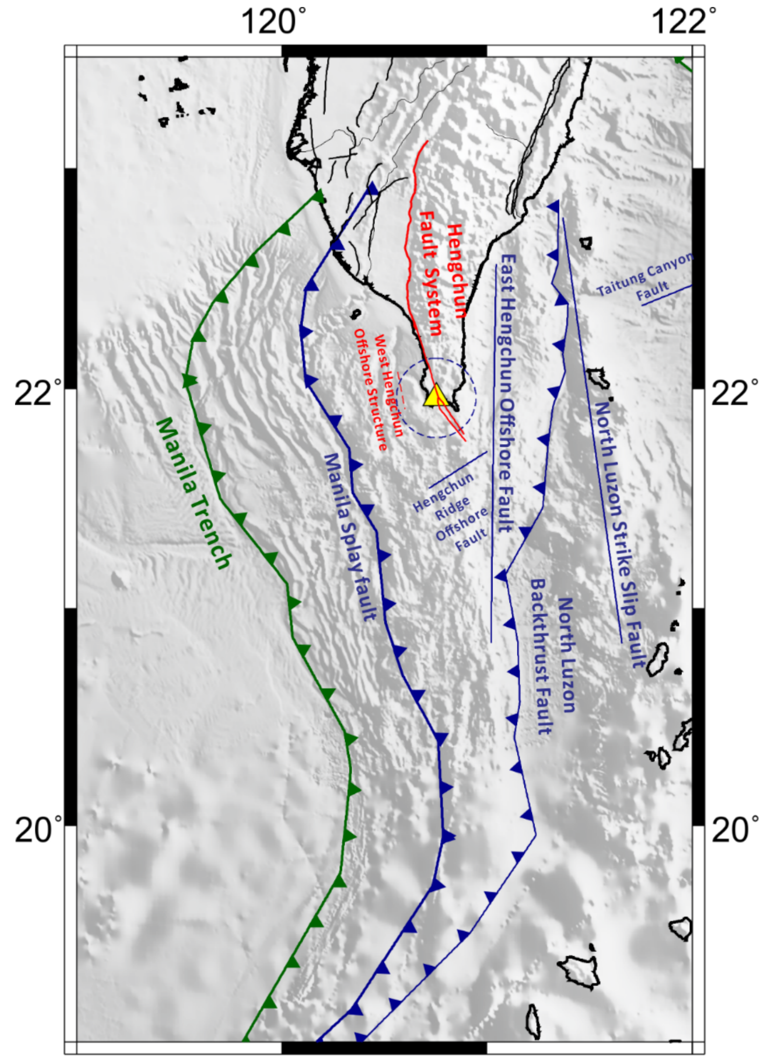


High dipping angle 70-80 degree
NE Dipping direction
B
W
B'
E
距離
公尺
0
10
20
30
40
50
60
20
10
0
-10
-20
-30
-40
S6
S8
S9
S7
S10
Bf
Qa
Ss/Sh
Mss
S fault
Bf 回填層
Qa 沖積層
砂頁岩互層
Ss 細砂岩層
Mss 砂質泥岩層
斷層剪裂帶

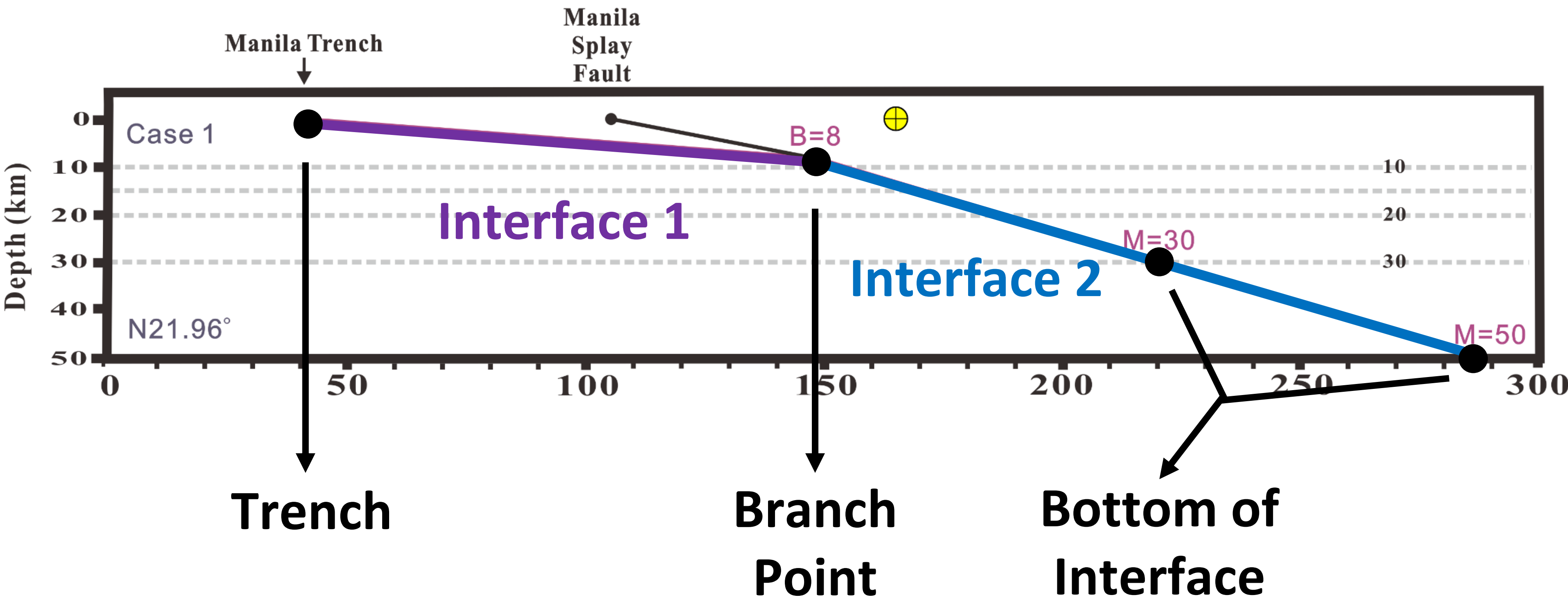


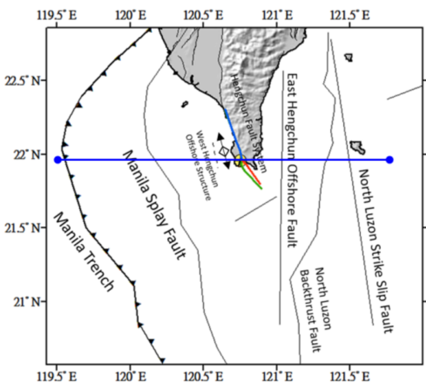
121.5° E
122° E
25° N
Shanchiao Fault System
ST-II Fault System
Aoti Offshore Faults
Northern Ilan Fault System
S Faults
NPP1
NPP2
NPP4
NPP
NPP 20km

Southern primary faults

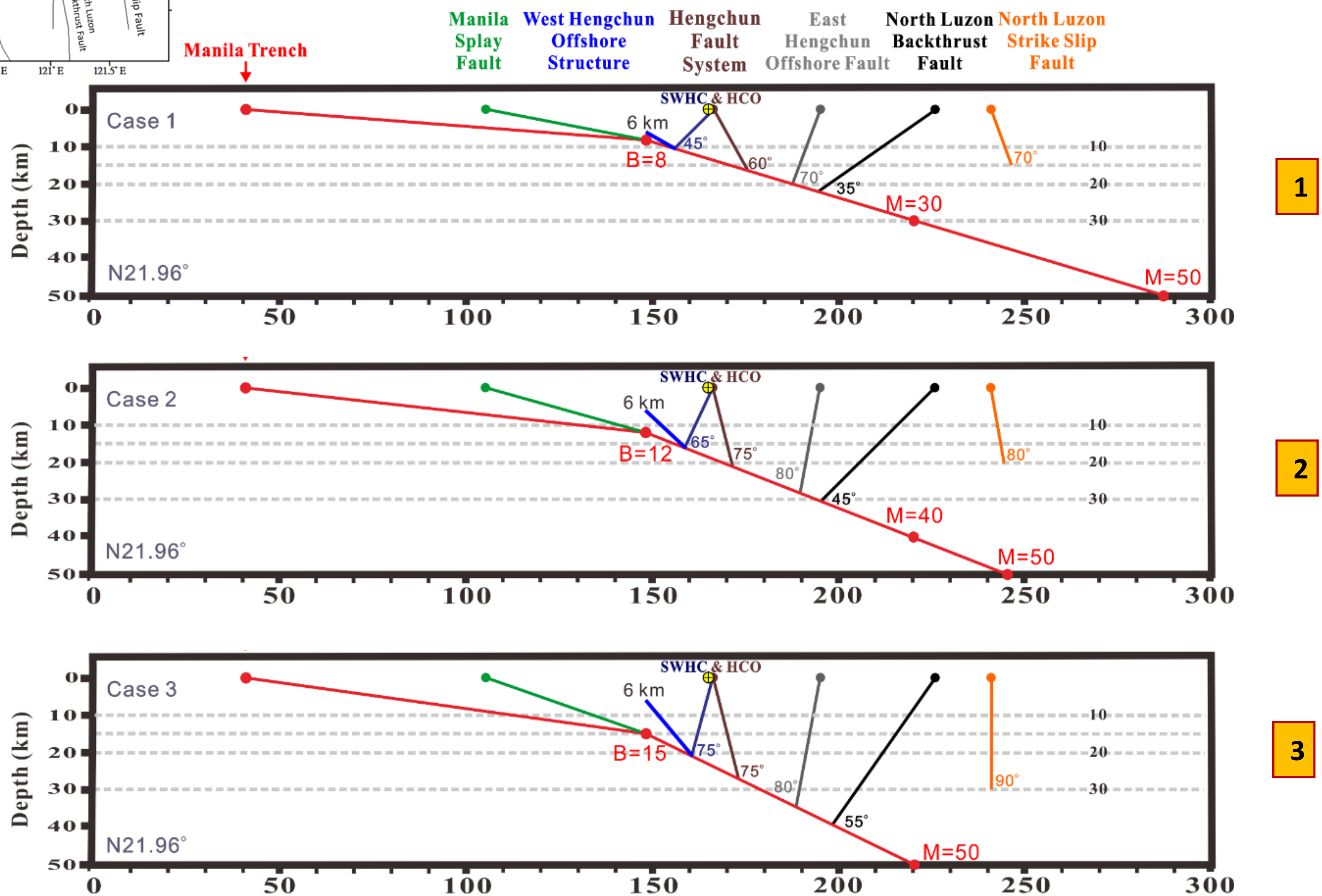


Manilla Subduction Zone Interface Geometry Setting

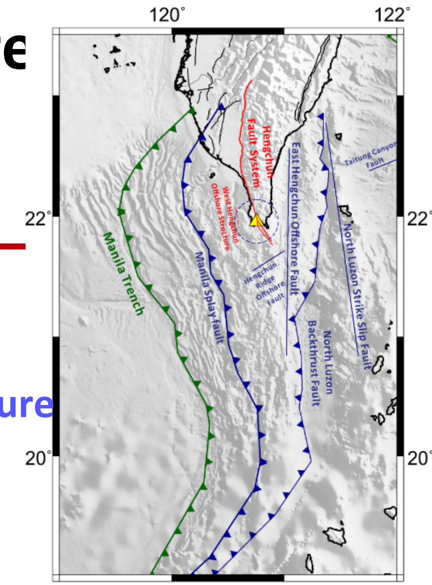




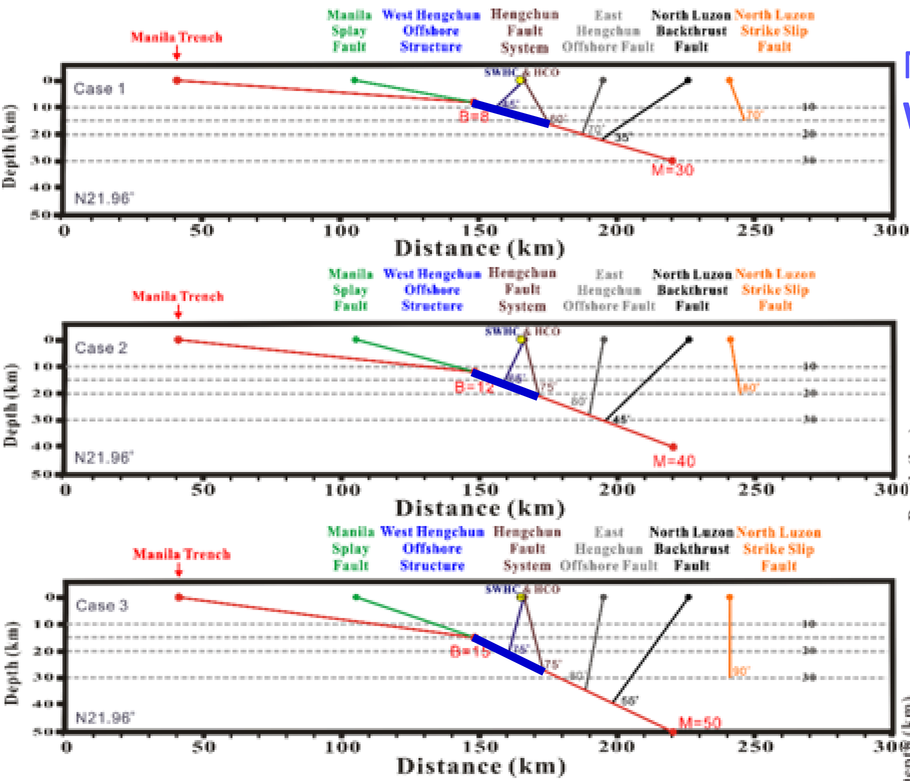
Southern primary faults



Fault geometry -West Hengchun Offshore Structure



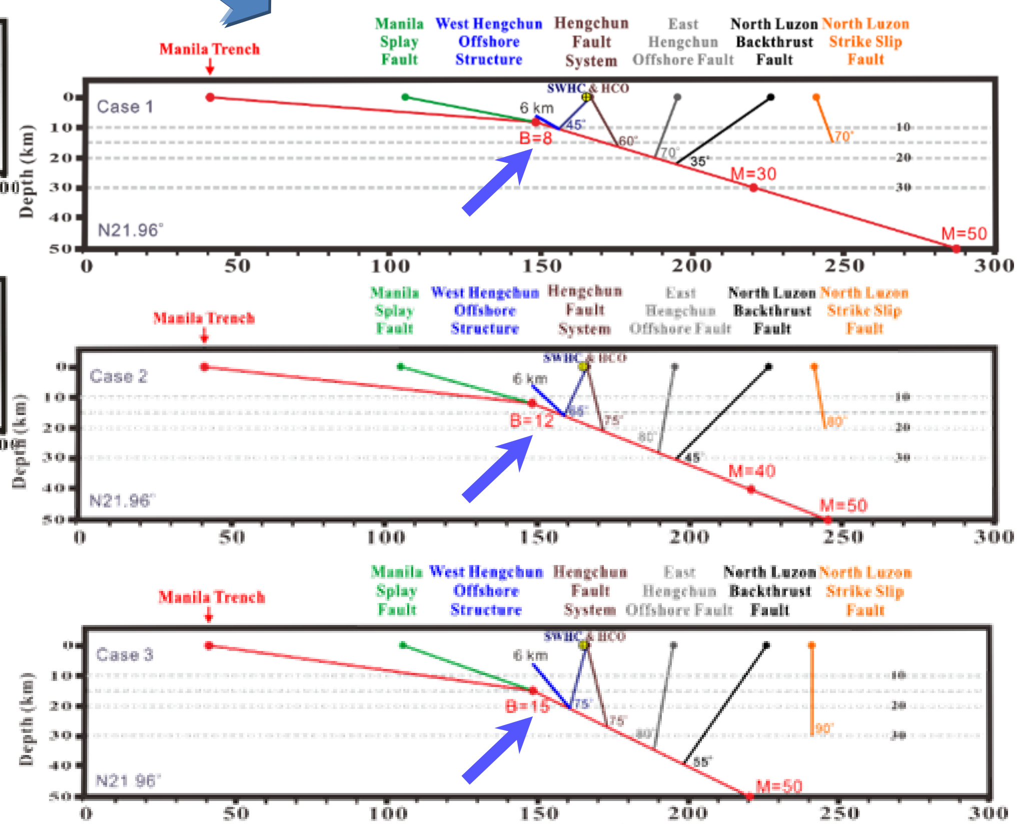
WM #3



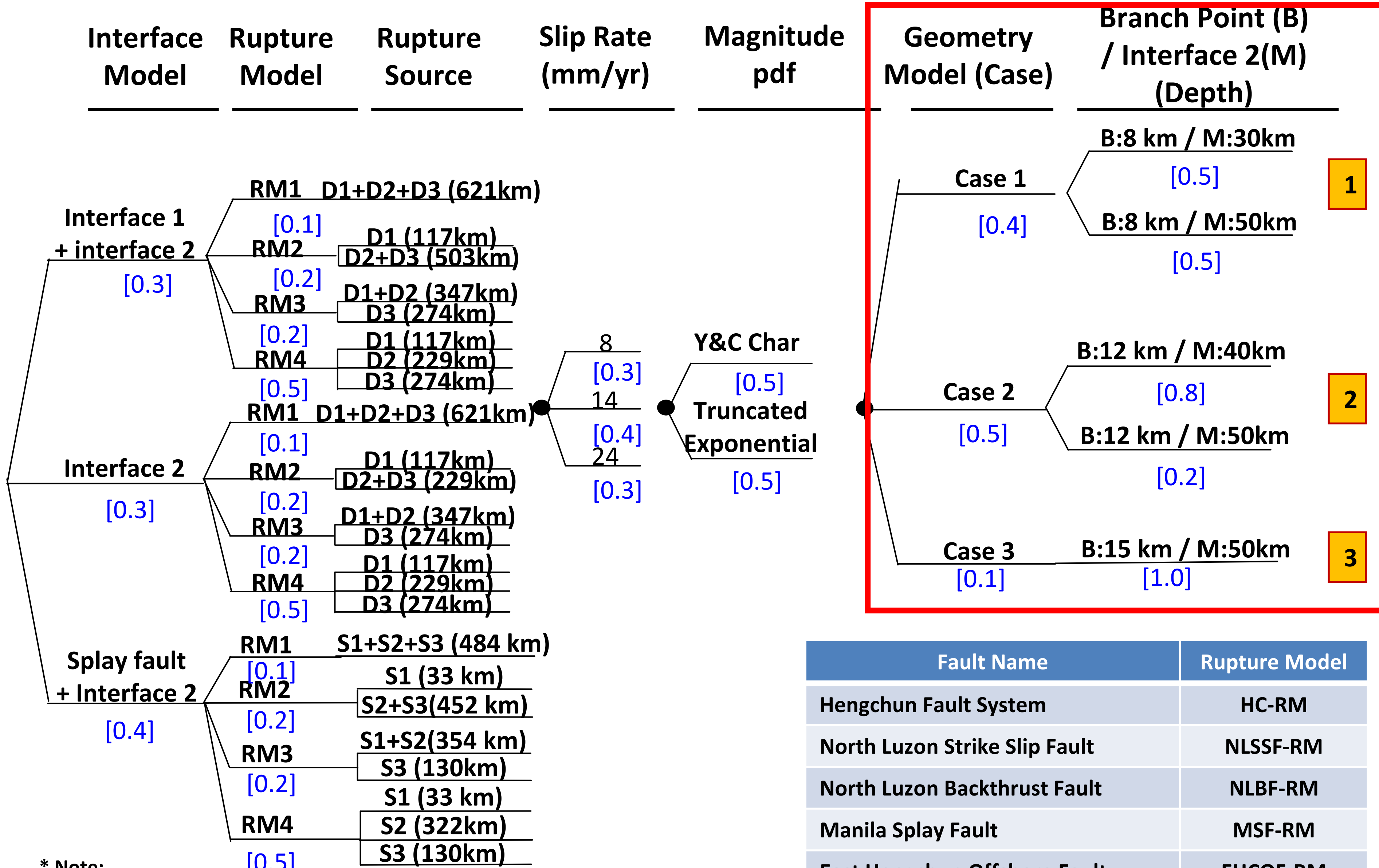
Modify the geometry of

West Hengchun Offshore Structure

WS #3



Southern primary faults & Manila subduction interface



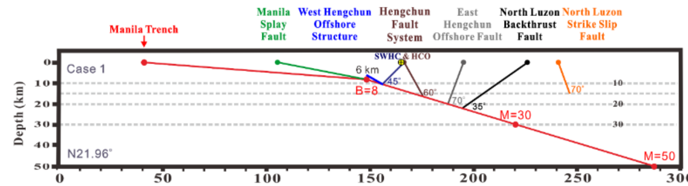
Fault Name	Rupture Model
Hengchun Fault System	HC-RM
North Luzon Strike Slip Fault	NLSSF-RM
North Luzon Backthrust Fault	NLBF-RM
Manila Splay Fault	MSF-RM
East Hengchun Offshore Fault	EHCOF-RM
West Hengchun Offshore Structure	WHCOS-RM

* Note:
•Max Magn. = Char. Magn. + 0.25
•Char. Magn. is calculated from Magnitude Scaling Law: Wells and Coppersmith (1994), Yen and Ma (2011) .

Southern primary faults & Manila subduction interface

Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Fault Geometry Model: Dip	Fault Geometry Model: Seismogenic Depth	Magnitude Distribution Model: Max. Magn.	Magnitude Distribution Model: Magnitude pdf
Seismogenic	RV (90) [0.4] RV/OB (45) [0.6]	HC-RM	CC+HC+SWHC (144 km) CC+HC+HCO (140 km) CC+HC (117 km) HC+HCO (63 km) HC+SWHC (70 km) SWHC (27 km) CC (77 km) HC (40 km) HCO (23 km)	[0.4, 1,0.5] [0.2] [1.6, 4,1.4] [0.6] [2.4, 6,2.3] [0.2] [SWHC, HC, CC]	60°	(Stop at Manila interface)	W&C (L)+0.25 [0.4] W&C (A)+0.25 [0.3] Y&M (A)+0.25 [0.3]	Y&C Char [0.5] Truncated Exponential [0.5]
Seismogenic	RV/OB (45)	NLSSF-RM	(216 km)	4* [0.3] 6 * [0.4] 8* [0.3]	70°	(Stop at Manila interface)	W&C (L)+0.25 [0.4] W&C (A)+0.25 [0.3] Y&M (A)+0.25 [0.3]	Y&C Char [0.5] Truncated Exponential [0.5]
Seismogenic	RV (90)	NLBF-RM	(593 km)	5* [0.3] 8* [0.4] 12* [0.3]	35°	(Stop at Manila interface)	W&C (L)+0.25 [0.4] W&C (A)+0.25 [0.3] Y&M (A)+0.25 [0.3]	Y&C Char [0.5] Truncated Exponential [0.5]
Seismogenic	RV (90)	MSF-RM1 [0.1] MSF-RM2 [0.2] MSF-RM3 [0.2] MSF-RM4 [0.5]	S1+S2+S3 (484 km) S1 (33 km), S2+S3(452 km) S1+S2(354 km), S3 (130km) S1 (33 km), S2 (322km), S3 (130km)	4* [0.3] 9* [0.4] 15* [0.3]	11°	(Stop at Manila branch point (8 km))	W&C (L)+0.25 [0.4] W&C (A)+0.25 [0.3] Y&M (A)+0.25 [0.3]	Y&C Char [0.5] Truncated Exponential [0.5]
Seismogenic	RV (90)	EHCOF-RM	(190 km)	5 [0.3] 7 [0.4] 9 [0.3]	70°	(Stop at Manila interface)	W&C (L)+0.25 [0.4] W&C (A)+0.25 [0.3] Y&M (A)+0.25 [0.3]	Y&C Char [0.5] Truncated Exponential [0.5]
Seismogenic [0.5] Non-Seismogenic [0.5]	RV (90)	WHCOS-RM	(19 km)	1.2 [0.2] 1.6 [0.6] 2.4 [0.2]	30°	(branch fault off interface)	W&C (L)+0.25 [0.4] W&C (A)+0.25 [0.3] Y&M (A)+0.25 [0.3]	Y&C Char [0.5] Truncated Exponential [0.5]

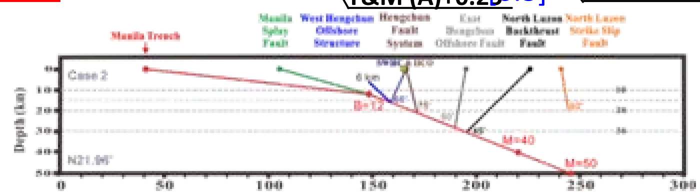
* Means constant slip rate



Southern primary faults & Manila subduction interface

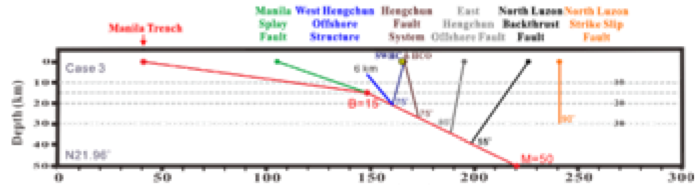
Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Fault Geometry Model: Dip	Seismogenic Depth	Magnitude Distribution Model: Max. Magn.	Magnitude pdf
Seismogenic	RV (90) [0.4]; RV/OB (45) [0.6]	HC-RM	CC+HC+SWHC (144 km); CC+HC+HCO (140 km); CC+HC (117 km); HC+HCO (63 km); HC+SWHC (70 km); SWHC (27 km); CC (77 km); HC (40 km); HCO (23 km)	[0.4, 1,0.5] [0.2]; [1.6, 4,1.4] [0.6]; [2.4, 6,2.3] [0.2]; [SWHC, HC, CC]	75°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]; W&C (A)+0.25 [0.3]; Y&M (A)+0.25 [0.3]	Y&C Char [0.5]; Truncated Exponential [0.5]
Seismogenic	RV/OB (45)	NLSSF-RM	(216 km)	4* [0.3]; 6 * [0.4]; 8* [0.3]	80°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]; W&C (A)+0.25 [0.3]; Y&M (A)+0.25 [0.3]	Y&C Char [0.5]; Truncated Exponential [0.5]
Seismogenic	RV (90)	NLBF-RM	(593 km)	5* [0.3]; 8* [0.4]; 12* [0.3]	45°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]; W&C (A)+0.25 [0.3]; Y&M (A)+0.25 [0.3]	Y&C Char [0.5]; Truncated Exponential [0.5]
Seismogenic	RV (90)	MSF-RM1 [0.1]; MSF-RM2 [0.2]; MSF-RM3 [0.2]; MSF-RM4 [0.5]	MSF-RM1: S1+S2+S3 (484 km); MSF-RM2: S1 (33 km), S2+S3(452 km); MSF-RM3: S1+S2(354 km), S3 (130km); MSF-RM4: S1 (33 km), S2 (322km), S3 (130km)	4* [0.3]; 9* [0.4]; 15* [0.3]	15°	(Stop at Manila branch point (12 km))	W&C (L)+0.25 [0.4]; W&C (A)+0.25 [0.3]; Y&M (A)+0.25 [0.3]	Y&C Char [0.5]; Truncated Exponential [0.5]
Seismogenic	SS (0)	EHCOF-RM	(190 km)	5 [0.3]; 7 [0.4]; 9 [0.3]	80°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]; W&C (A)+0.25 [0.3]; Y&M (A)+0.25 [0.3]	Y&C Char [0.5]; Truncated Exponential [0.5]
Seismogenic [0.5]	RV (90)	WHCOS-RM	(19 km)	1.2 [0.2]; 1.6 [0.6]; 2.4 [0.2]	40°	(branch fault off interface)	W&C (L)+0.25 [0.4]; W&C (A)+0.25 [0.3]; Y&M (A)+0.25 [0.3]	Y&C Char [0.5]; Truncated Exponential [0.5]
Non-Seismogenic [0.5]								

* Means constant slip rate



Southern primary faults & Manila subduction interface

Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Fault Geometry Model: Dip	Fault Geometry Model: Seismogenic Depth	Magnitude Distribution Model: Max. Magn.	Magnitude Distribution Model: Magnitude pdf
Seismogenic	RV (90) [0.4]	HC-RM	CC+HC+SWHC (144 km)	[0.4, 1,0.5] [0.2]	75°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]	Y&C Char [0.5]
	RV/OB (45) [0.6]		CC+HC+HCO (140 km)	[1.6, 4,1.4] [0.6]			W&C (A)+0.25 [0.3]	Truncated Exponential [0.5]
			CC+HC (117 km)	[2.4, 6,2.3] [0.2]			Y&M (A)+0.25 [0.3]	
			HC+HCO (63 km)	[SWHC, HC, CC]				
			HC+SWHC (70 km)					
			SWHC (27 km)					
			CC (77 km)					
			HC (40 km)					
			HCO (23 km)					



Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Dip	Seismogenic Depth	Max. Magn.	Magnitude pdf
Seismogenic	RV/OB (45)	NLSSF-RM	(216 km)	4* [0.3]	90°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]	Y&C Char [0.5]
				6 * [0.4]			W&C (A)+0.25 [0.3]	Truncated Exponential [0.5]
				8* [0.3]			Y&M (A)+0.25 [0.3]	

Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Dip	Seismogenic Depth	Max. Magn.	Magnitude pdf
Seismogenic	RV (90)	NLBF-RM	(593 km)	5* [0.3]	55°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]	Y&C Char [0.5]
				8* [0.4]			W&C (A)+0.25 [0.3]	Truncated Exponential [0.5]
				12* [0.3]			Y&M (A)+0.25 [0.3]	

Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Dip	Seismogenic Depth	Max. Magn.	Magnitude pdf
Seismogenic	RV (90)	MSF-RM1 [0.1]	S1+S2+S3 (484 km)	4* [0.3]	18°	(Stop at Manila branch point (15 km))	W&C (L)+0.25 [0.4]	Y&C Char [0.5]
		MSF-RM2 [0.2]	S1 (33 km)	9* [0.4]			W&C (A)+0.25 [0.3]	Truncated Exponential [0.5]
			S2+S3(452 km)	15* [0.3]			Y&M (A)+0.25 [0.3]	
		MSF-RM3 [0.2]	S1+S2(354 km)					
			S3 (130km)					
		MSF-RM4 [0.5]	S1 (33 km)					
			S2 (322km)					
			S3 (130km)					

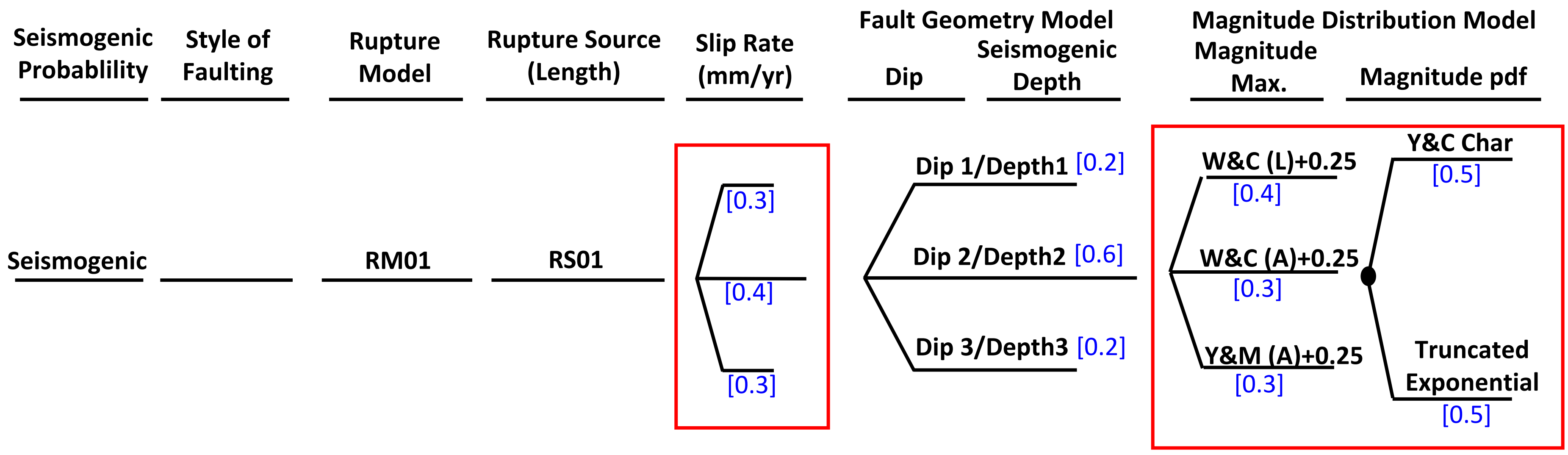
* Means constant slip rate

Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Dip	Seismogenic Depth	Max. Magn.	Magnitude pdf
Seismogenic	SS (0)	EHCOF-RM	(190 km)	5 [0.3]	80°	(Stop at Manila interface)	W&C (L)+0.25 [0.4]	Y&C Char [0.5]
				7 [0.4]			W&C (A)+0.25 [0.3]	Truncated Exponential [0.5]
				9 [0.3]			Y&M (A)+0.25 [0.3]	

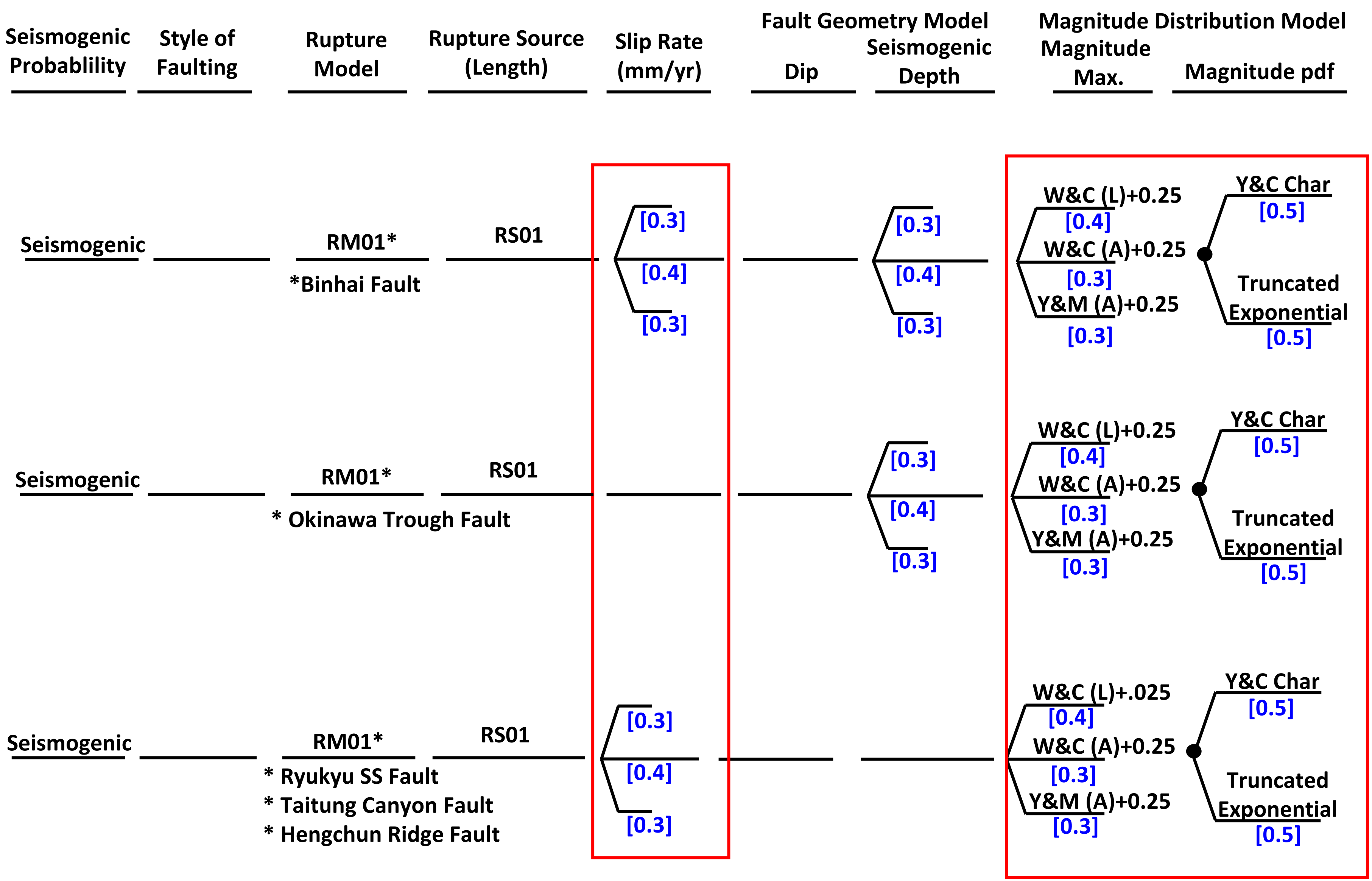
Seismogenic Probablility	Style of Faulting	Rupture Model	Rupture Source (Length)	Vertical Rate (mm/yr)	Dip	Seismogenic Depth	Max. Magn.	Magnitude pdf
Seismogenic [0.5]	RV (90)	WHCOS-RM	(19 km)	1.2 [0.2]	50°	(branch fault off interface)	W&C (L)+0.25 [0.4]	Y&C Char [0.5]
Non-Seismogenic [0.5]				1.6 [0.6]			W&C (A)+0.25 [0.3]	Truncated Exponential [0.5]
				2.4 [0.2]			Y&M (A)+0.25 [0.3]	

Other faults

Other faults - Onshore



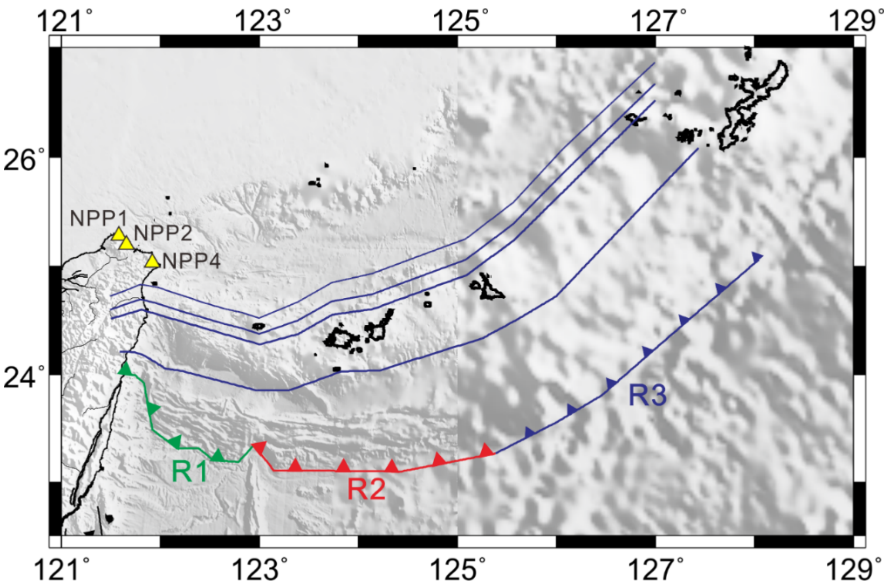
Other faults - Offshore



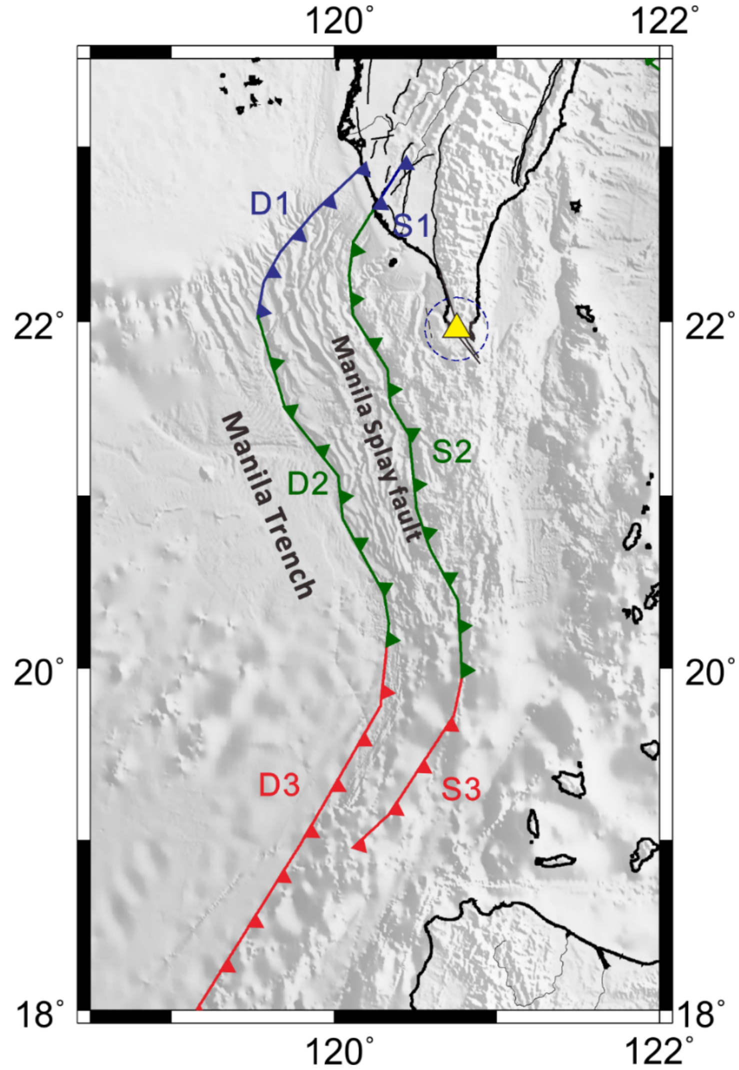
Subduction Zones

Subduction zone map

Ryukyu Trench

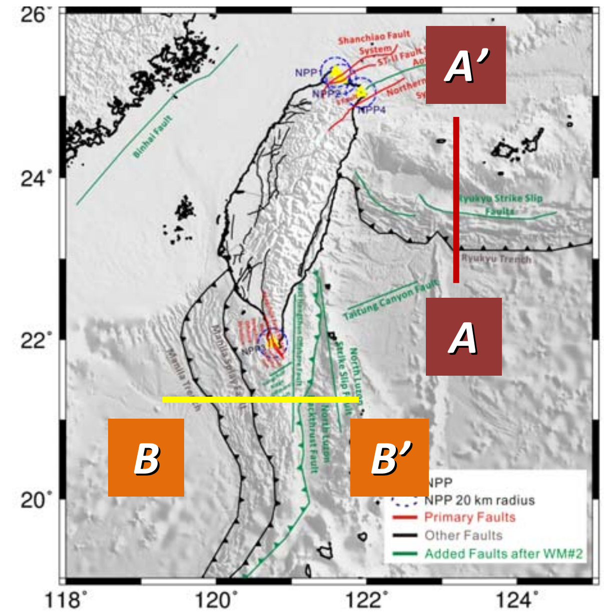


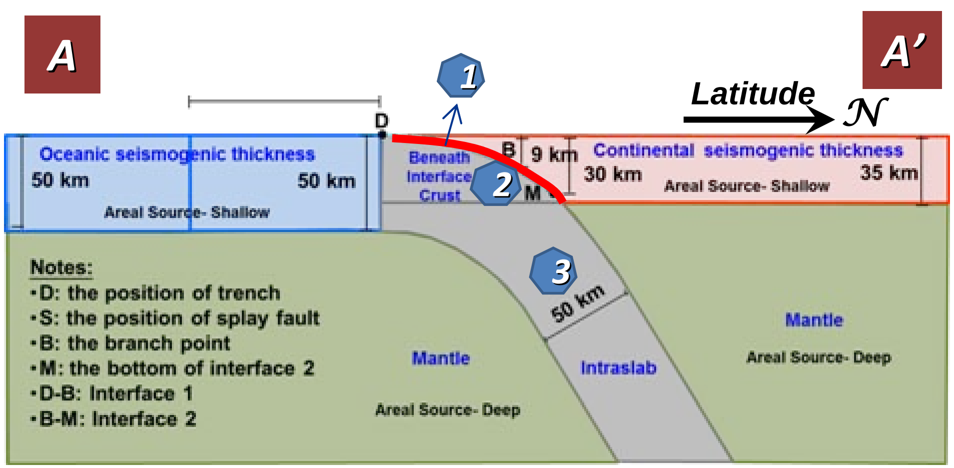
Manila Trench



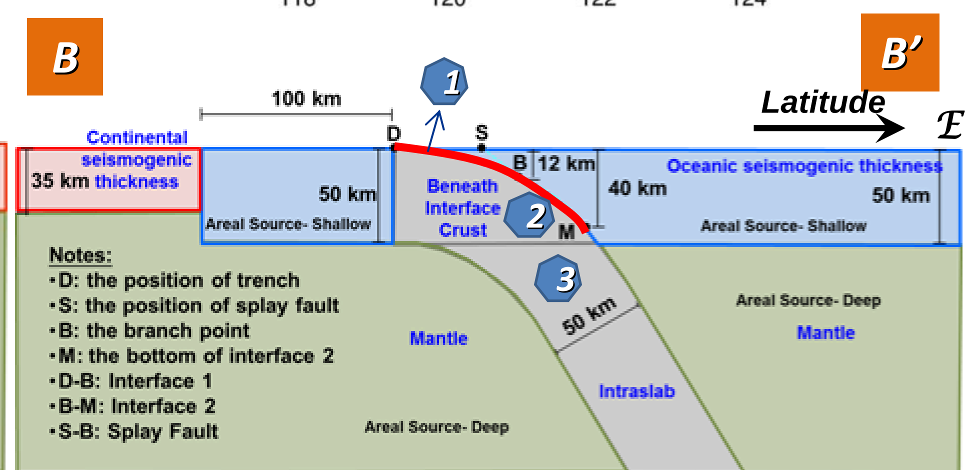
Subduction - Source type

- **Ryukyu Subduction Zone (A – A')**
  1) Interface (Depth: 0 ~ 35km)
  2) Beneath Interface Crustal (Depth: 0 ~ 35km)
  3) Intraslab (35km ~)
- **Manila Subduction Zone (B – B')**
  1) Interface (0 ~ 50km)
  2) Beneath Interface Crustal (Depth: 0 ~ 50km)
  3) Intraslab (50km ~)





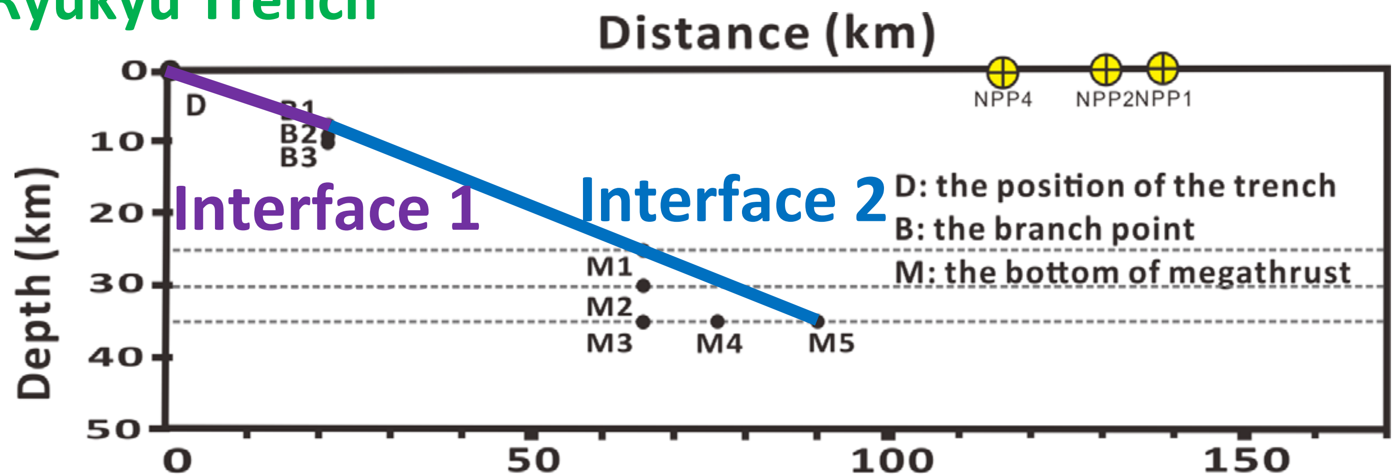
Ryukyu Subduction Zone



Manila Subduction Zone

Subduction interface Geometry Setting

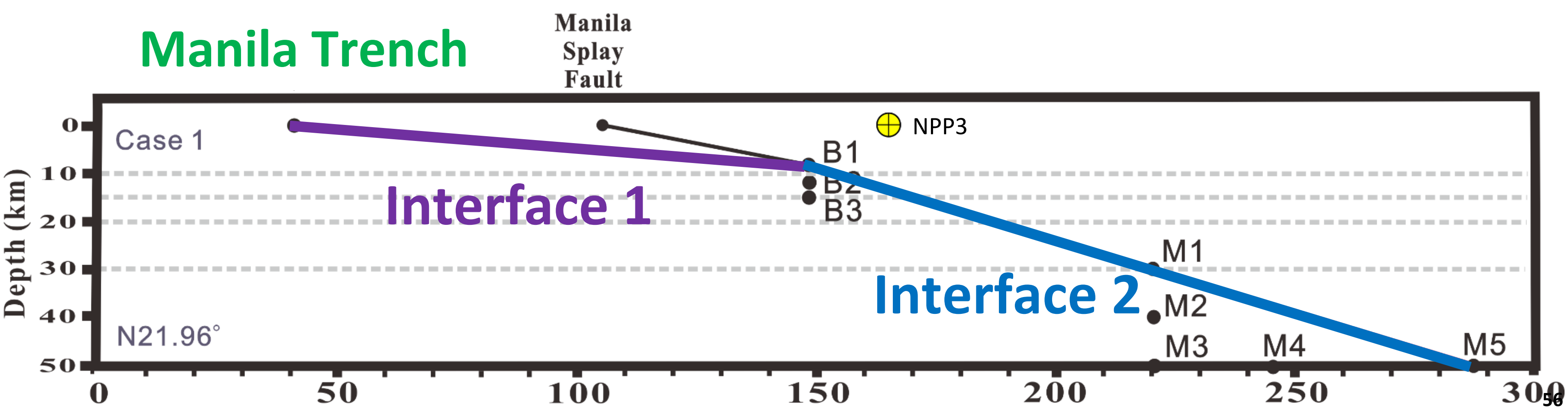
Ryukyu Trench



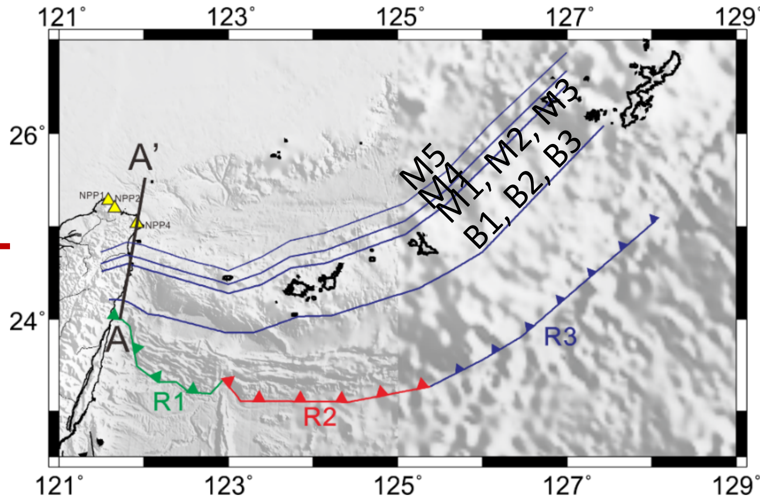
B: Branch Point

M: Bottom of interface

Manila Trench



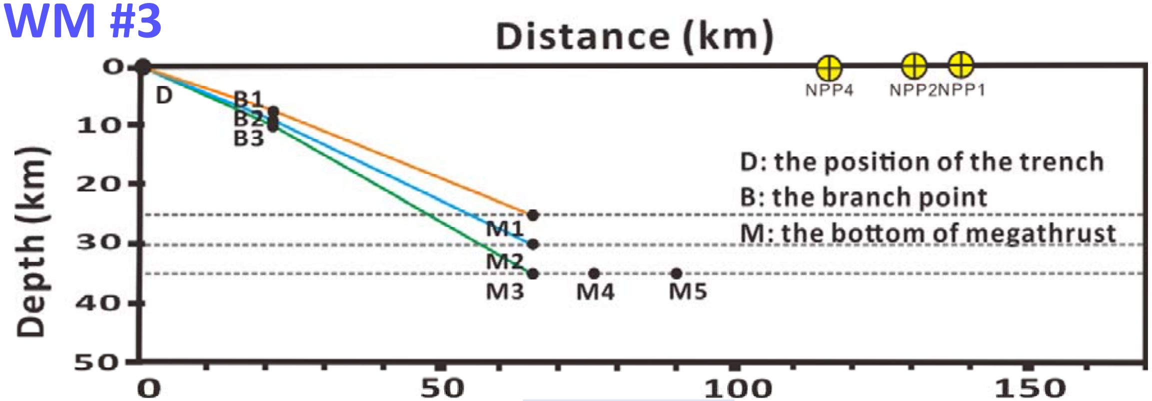
Ryukyu subduction Interface – Fault Geometry model



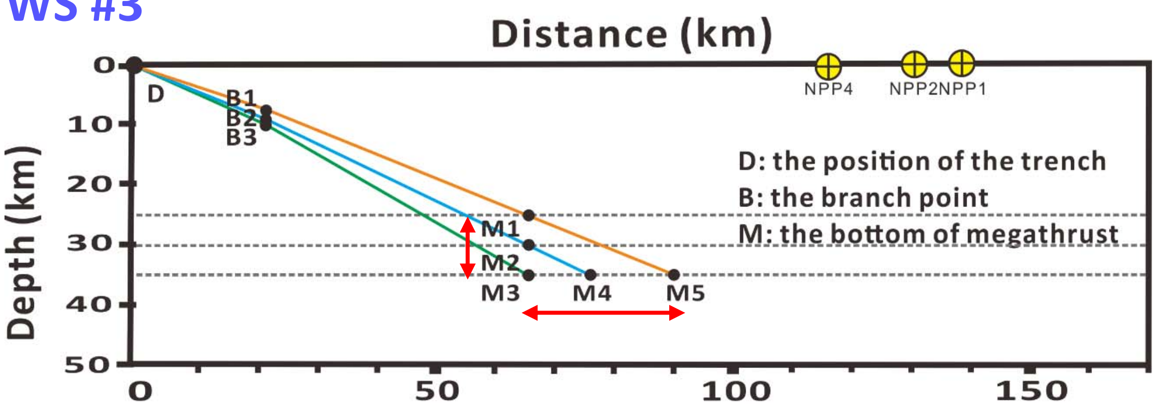
To extend the interface to depth of 35 km will influence the seismic hazard contribution.

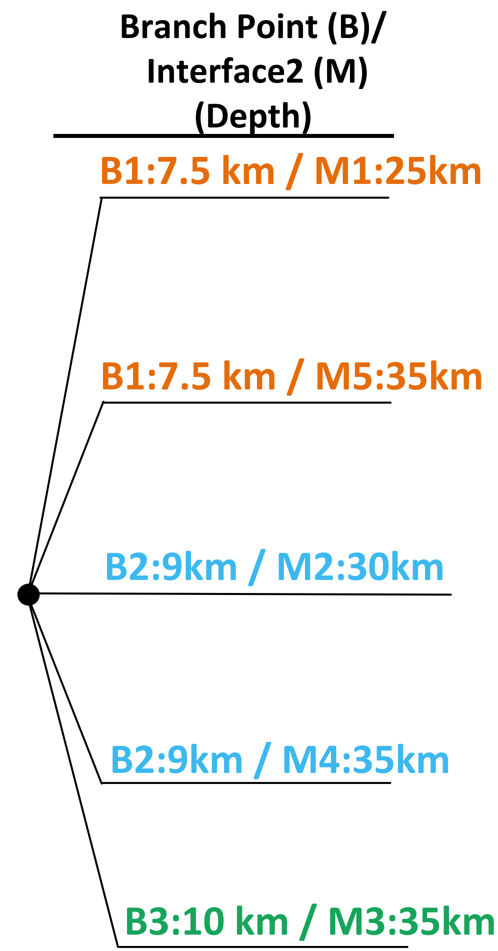
Fault Geometry Model

WM #3

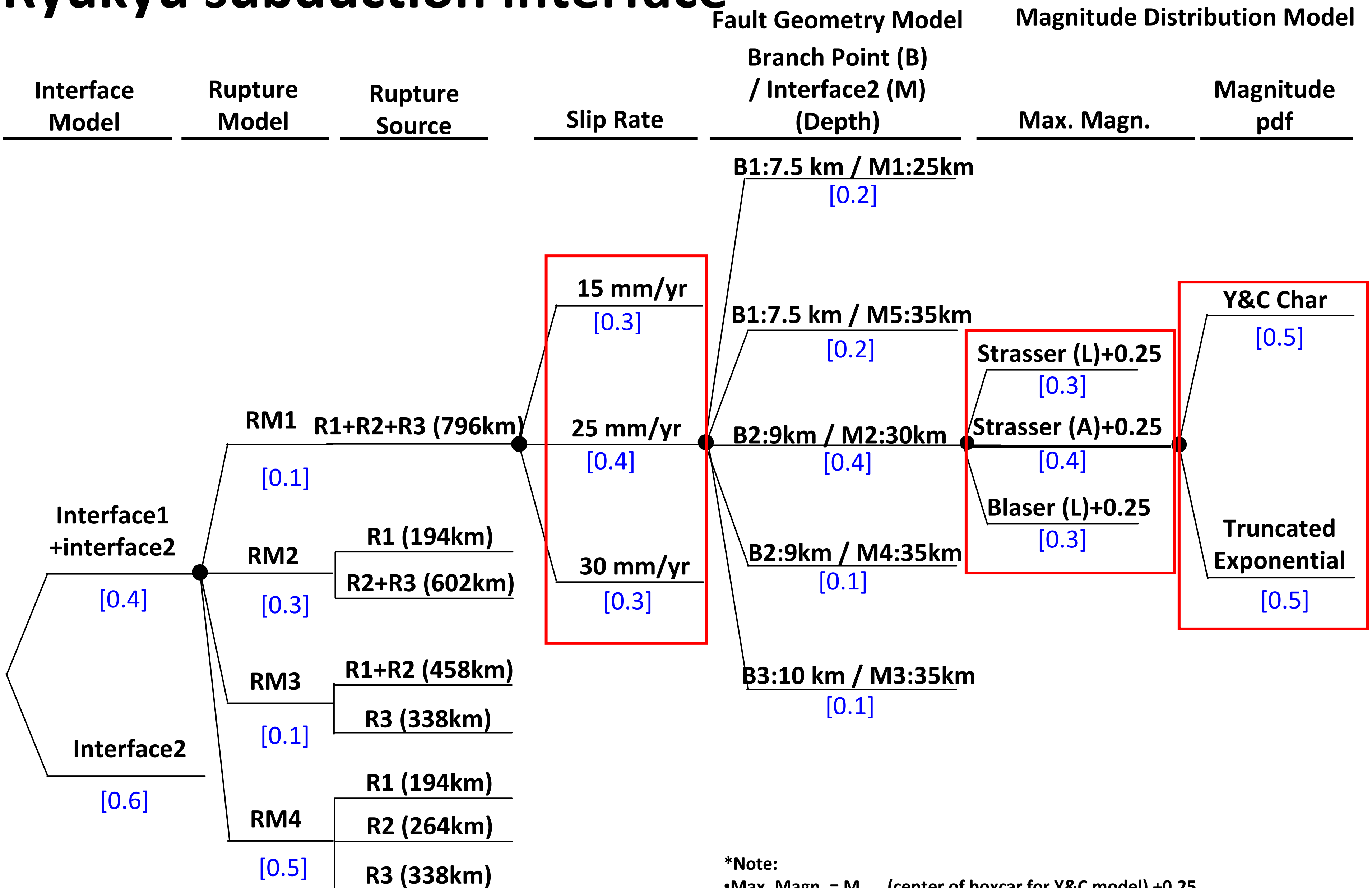


WS #3





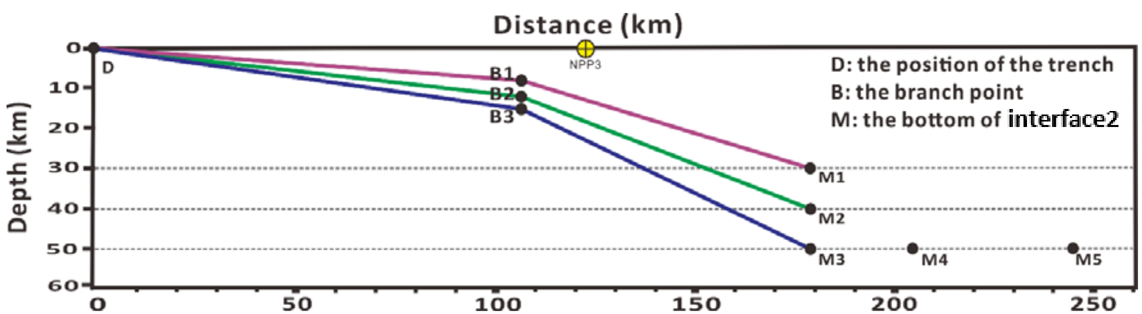
Ryukyu subduction interface



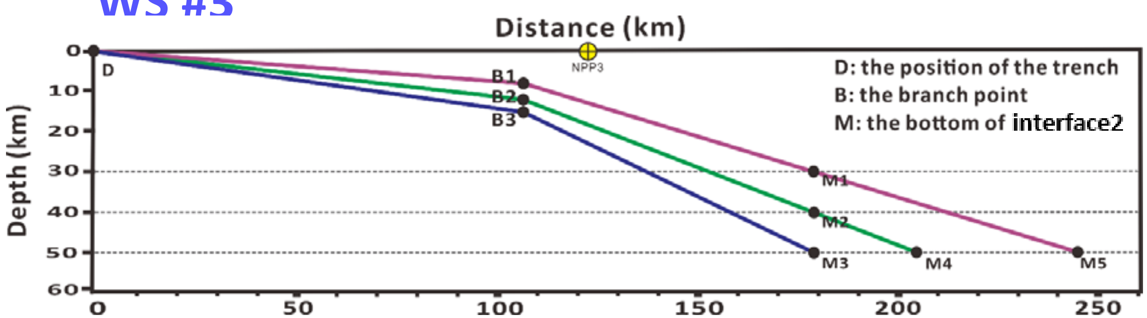
*Note:
- Max. Magn. = M_{char} (center of boxcar for Y&C model) +0.25
- Magnitude Scaling Law: Strasser et al., 2010 and Blaser et al (2010)
- Subduction zone interface GMPE

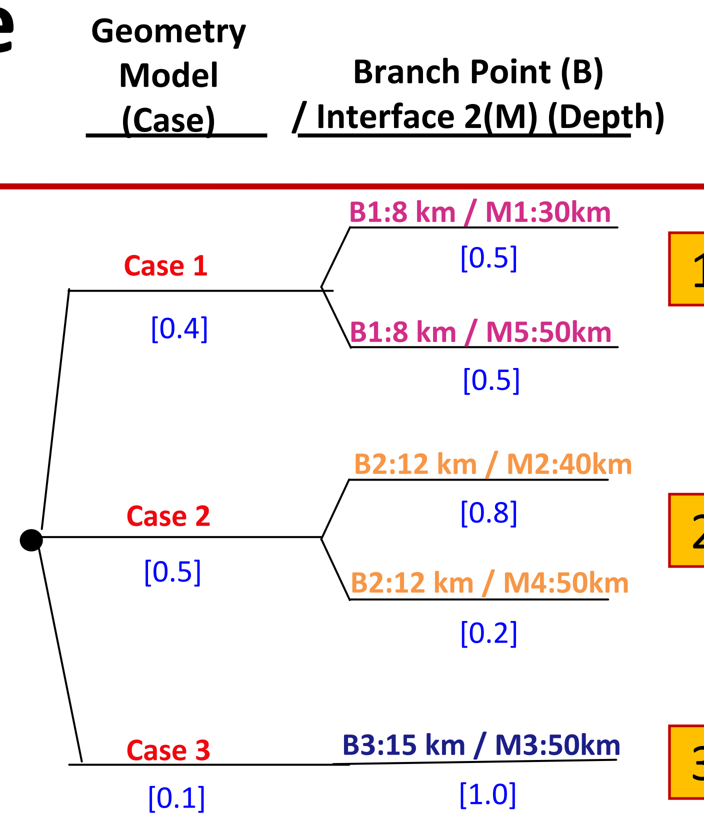
Manila Subduction interface Geometry model

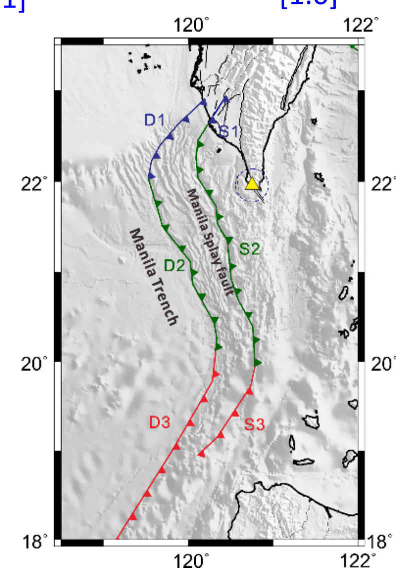
WM #3



WS #3

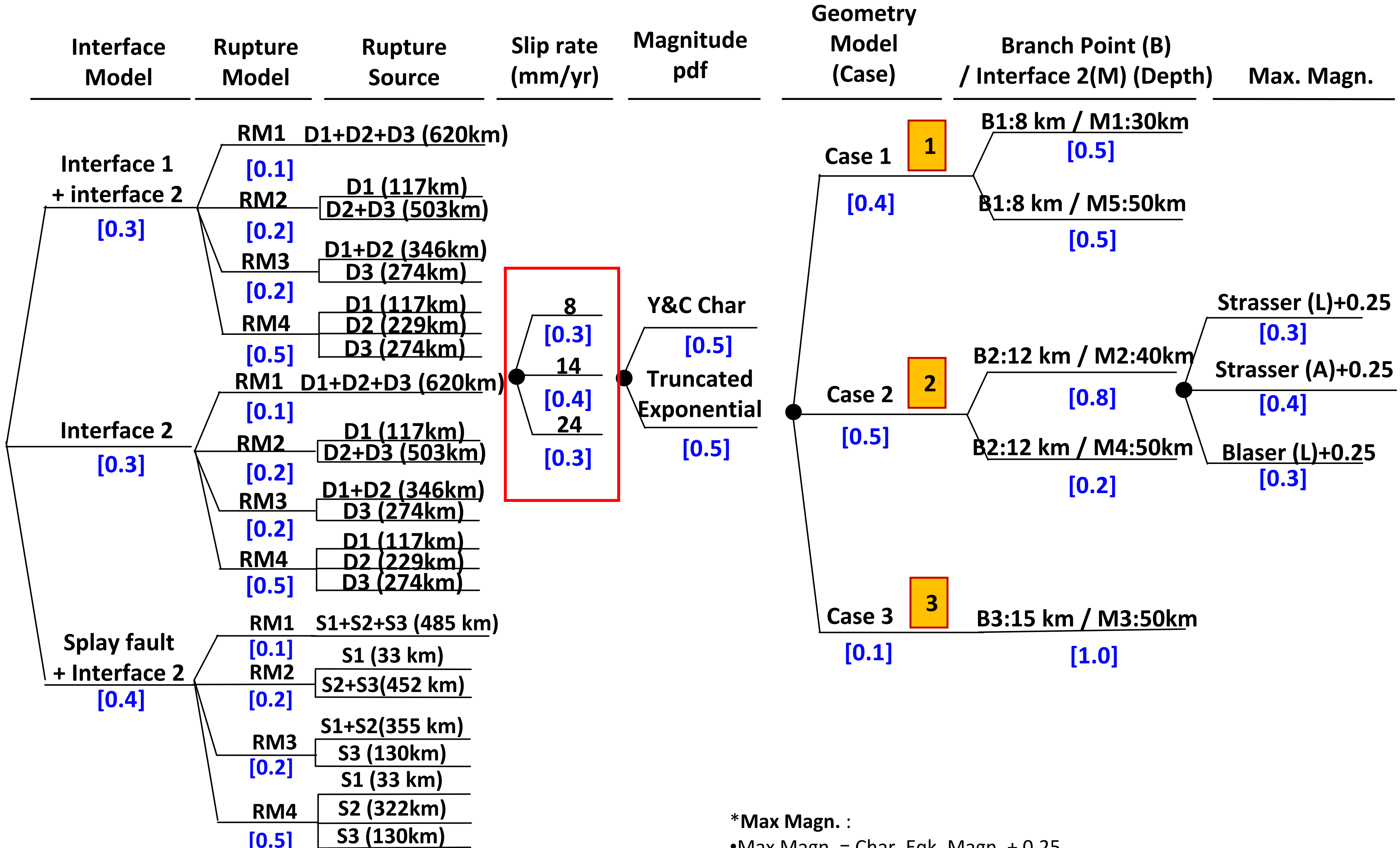






* Extend the interface of depth to 50 km, the rupture area and the maximum magnitude will increase.

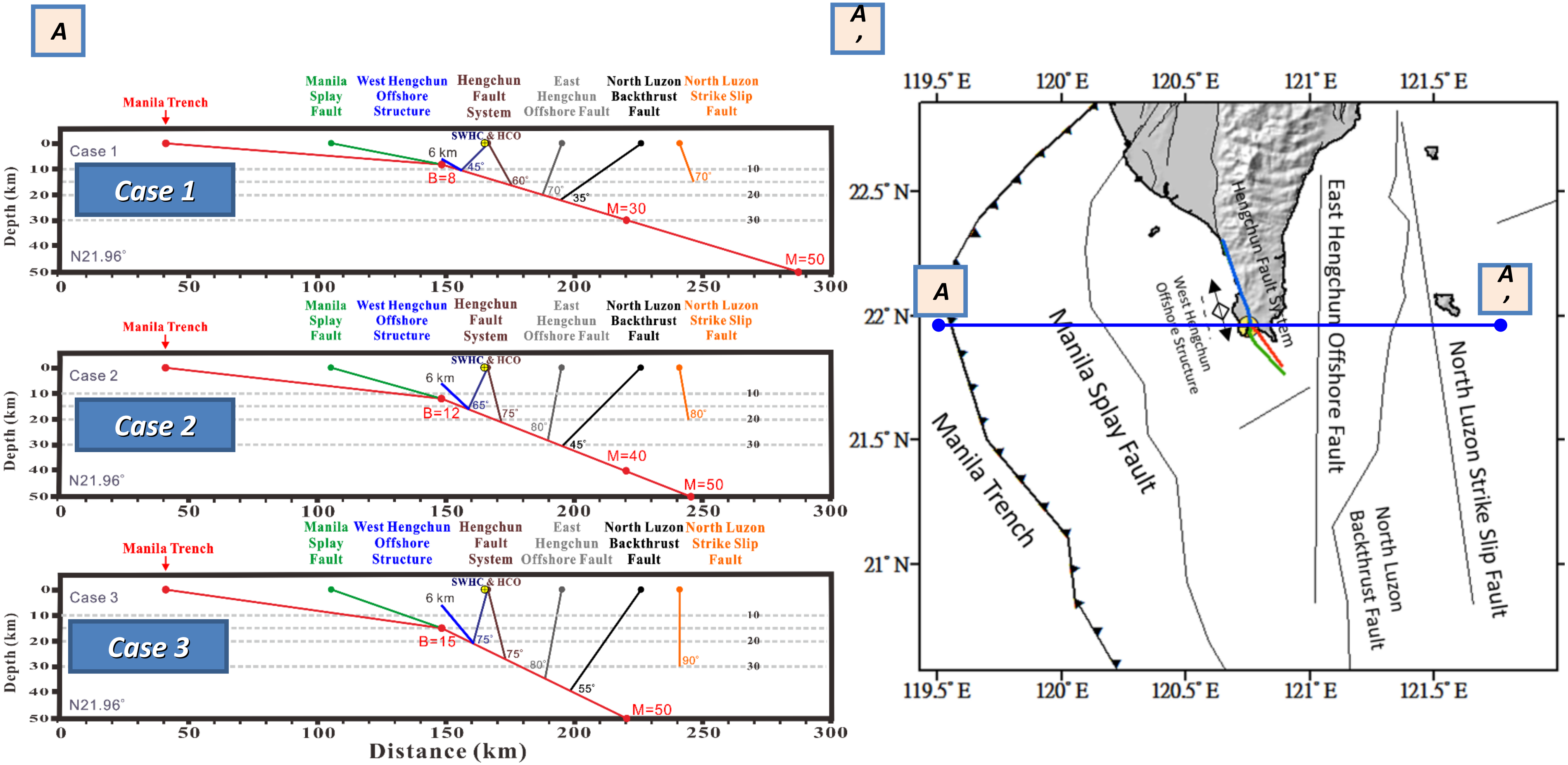
Manila subduction interface



***Max Magn.** :

- Max Magn. = Char. Eqk. Magn. + 0.25
- Char. Eqk. Magn. is calculated from Magnitude Scaling Law:
  - For Fault source: Wells and Coppersmith (1994), Yen and Ma (2011)
  - For interface source: Strasser et al (2010) and Blaser et al (2010)

Related Geometry Modeling in Southern Taiwan



Construction of three Geometry Modeling Cases for the fault systems around NPP3 in consideration of the Uncertainties.

Cumulative geologic slip rate across the entire southern region

WS# 2	Manila Trench (mm/yr)	%	Manila Splay Fault (mm/yr)	%	Other Faults (%)	Total slip rate (mm/yr)
Case 1	8	16-25	4	10-13	62	31.60
	10		6		70	54.18
	12		8		73	74.77
Case 2	8	17-25	4	11-13	62	31.74
	10		6		69	52.21
	12		8		72	71.63
Case 3	8	19-28	4	13-14	58	28.50
	10		6		66	46.80
	12		8		69	63.70

WM# 3	Manila Trench (mm/yr)	%	Manila Splay Fault (mm/yr)	%	Other Faults (%)	Total slip rate (mm/yr)
Case 1	8	22-25	4	12-15	63	32.30
	14		9		63	62.10
	20		15		62	91.20
Case 2	8	24-26	4	13-18	61	30.80
	14		9		60	57.90
	20		15		59	84.70
Case 3	8	24-27	4	13-18	60	30.10
	14		9		59	55.90
	20		15		57	81.80

WS# 3	Manila Trench (mm/yr)	%	Manila Splay Fault (mm/yr)	%	Other Faults (%)	Total slip rate (mm/yr)
Case 1	8	23-25	4	12-16	63	32.30
	14		9		63	62.10
	24		15		59	95.20
Case 2	8	24-27	4	13-17	61	30.80
	14		9		60	57.90
	24		15		56	88.70
Case 3	8	25-28	4	13-18	60	30.10
	14		9		59	55.90
	24		15		55	85.80

Other Faults include West Hengchun Offshore Structure, Hengchun Fault, East Hengchun Offshore Fault, North Luzon Backthrust Fault, North Luzon Strike Slip Fault, Soutwest Hengchun Fault.

WS# 2

- The slip rate of Manila trench accounts for 20-30 percent of the slip rate of southern region of Taiwan.
- Consider the plate convergence rate (86/mm/yr) Modify the slip rate of manila trench and splay fault.

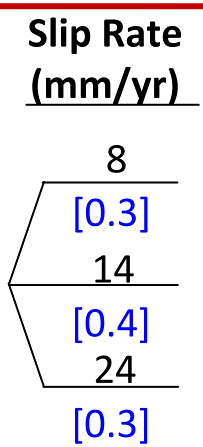
WM# 3

- Modify the slip rate of manila trench.

WS# 3

Manila Trench Slip Rate (mm/yr)			
	Max.	Medium	Min.
WS#2	12	10	8
WM#3	20	14	8
WS#3	24	14	8

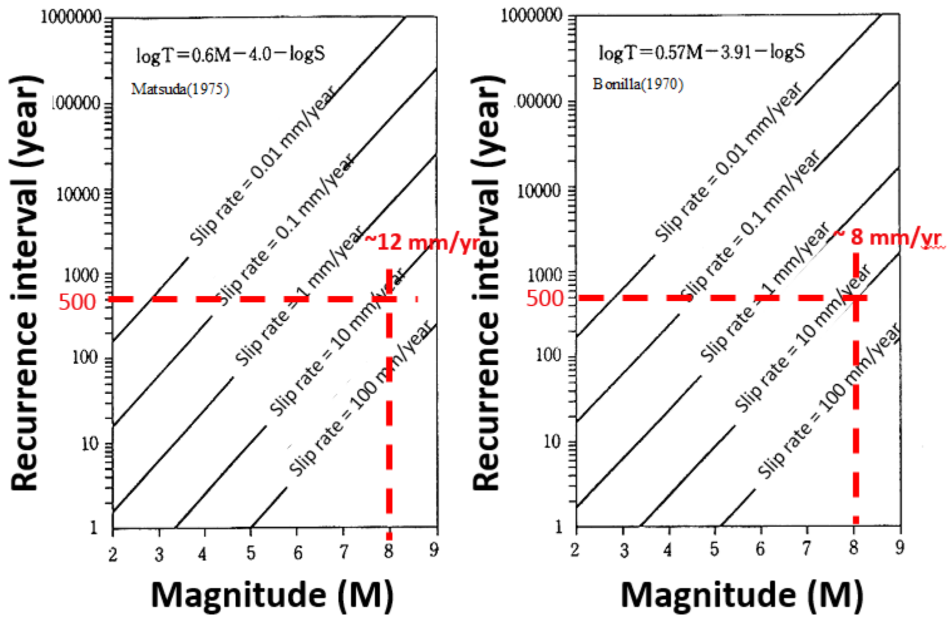
Manila Subduction Interface – Slip Rate



- The range of uncertainty is wide and the median is lacking evidence, so we give almost equal weighting as [0.3] [0.4] [0.3].

	Slip Rate (mm/yr)		
	Max.	Medium	Min.
WS#2	12	10	8
WM#3	20	14	8
WS#3	24	14	8

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)



Min slip rate: 8~12 mm/yr

Thank You for Your Attention