The relationship between southern Okinawa Trough rifting and extensional tectonics in northeastern Taiwan

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Outline

Geological setting

Formations:

Western Foothill

- Miocene
  - Kce — Kueichoulin formation Erhchiu member
  - Kct — Kueichoulin formation Tapu member
  - Nc — Nanchuang formation
  - Nk — Nankang formation
  - St — Shihti formation
  - Tl — Taliao formation
  - Ms — Mushan formation

Hsuehshan Range

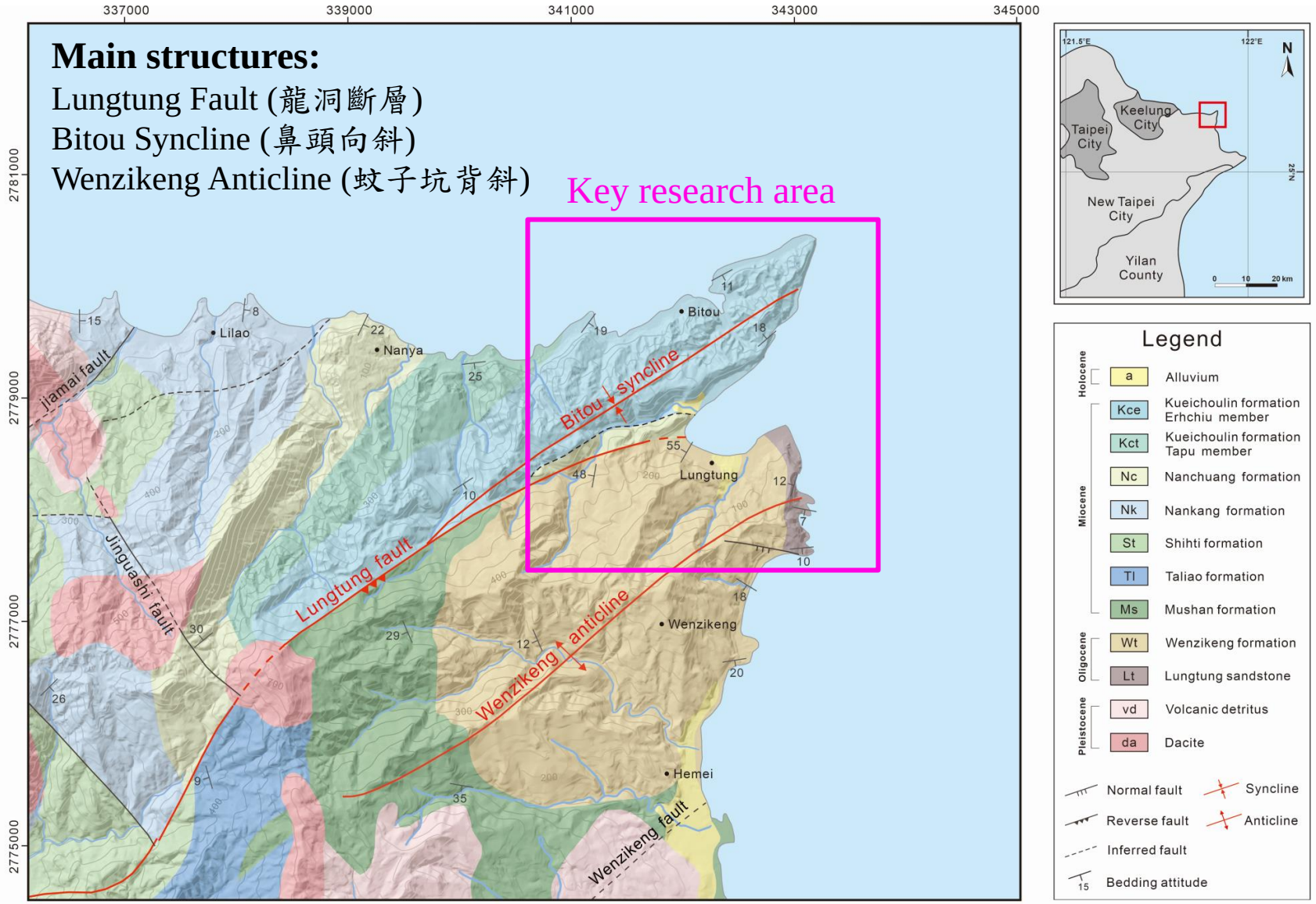
- Oligocene
  - Wt — Wenzikeng formation
  - Lt — Lungtung sandstone

Main structures:

Lungtung Fault (龍洞斷層)

Bitou Syncline (鼻頭向斜)

Wenzikeng Anticline (蚊子坑背斜)



Modified from CGS geological map; Huang et al., 1984

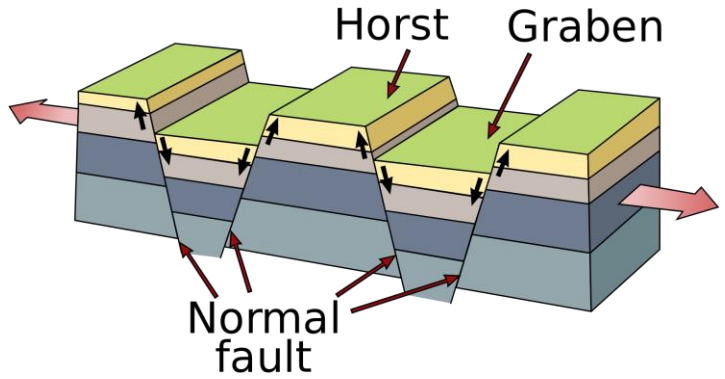
Motivation and Purpose

Motivation:

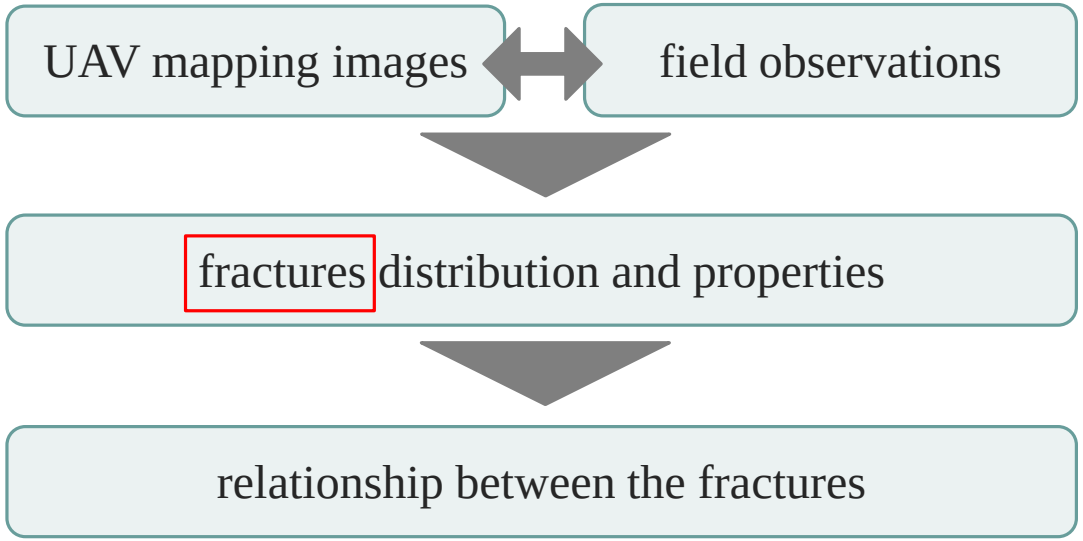
- Complex plate tectonics and the construction of fourth nuclear power plant in northeastern Taiwan have made it important to understand its geological history.
- Northeastern Taiwan has been subjected to post-collisional collapse and rifting in Okinawa Trough. Several previous studies have identified normal fault systems in offshore due to the Okinawa Trough rifting. However, the continuation of these normal faults into onshore is still an open question.
- During field investigation, we have observed series of **horsts** and **grabens** in the well exposed outcrops in Bitou and Lungtung cape area. It will be interesting to know if these normal faults are related to Okinawa Trough rifting.

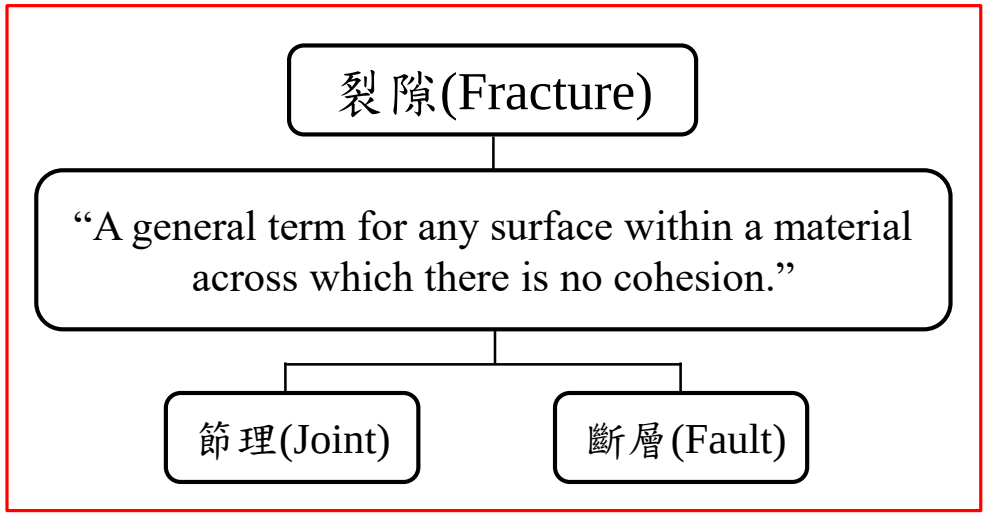
Purposes :

1. To find the relationship between the extensional structures (normal faults) and Okinawa Trough rifting.
2. To conclude the structural evolution.



In this study, I will compare **UAV mapping images** with the **field observations** to know about the fractures distribution and their properties. Understanding the relationship between the fractures can also help understand the timing of their formation and the changes in stress.





UAV mapping and modeling

Orthoimage (map view)

Facade image (elevation view)

UAV mapping:

Take photos in the area

Pix4D model:

1. Orthoimage
2. Facade image
3. 3D model

Analysis:

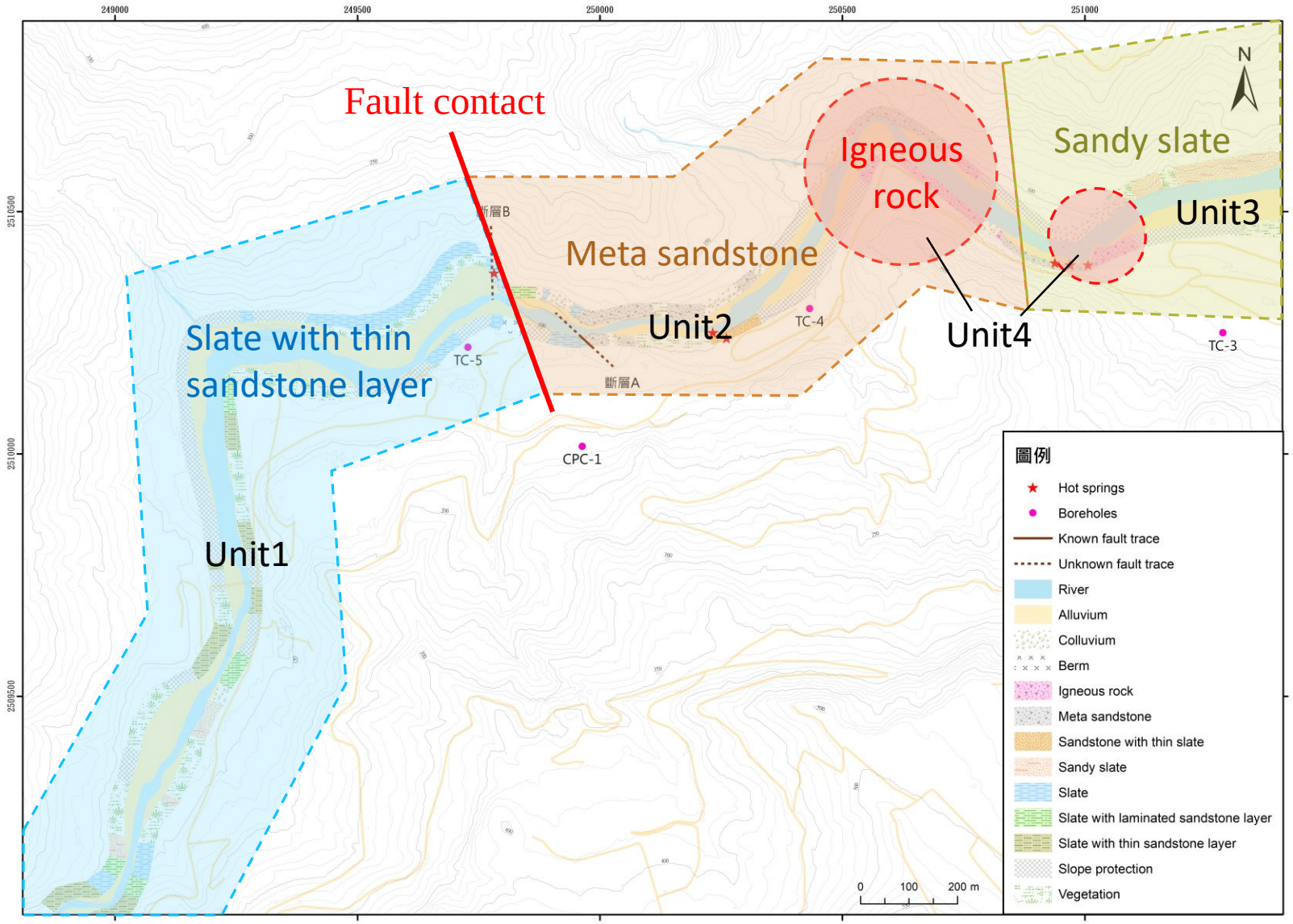
1. fractures distribution

Field investigation

1. Geologic route map

Own geological map

Cross section



Field investigation

2. Structure identification and analysis

Fracture	
Fault	Joint
fault type	joint type
separation	spacing
slip direction	joint sets number
slip amount	mechanics

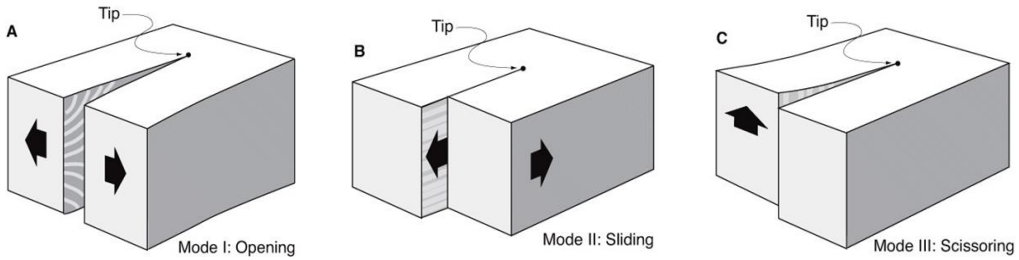


Figure 5.15
Modified from Atkinson (1987), Introduction to fracture mechanics and its geophysical applications.

Field investigation

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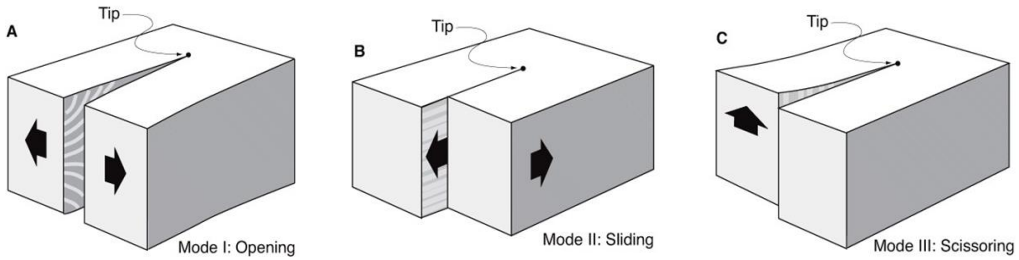

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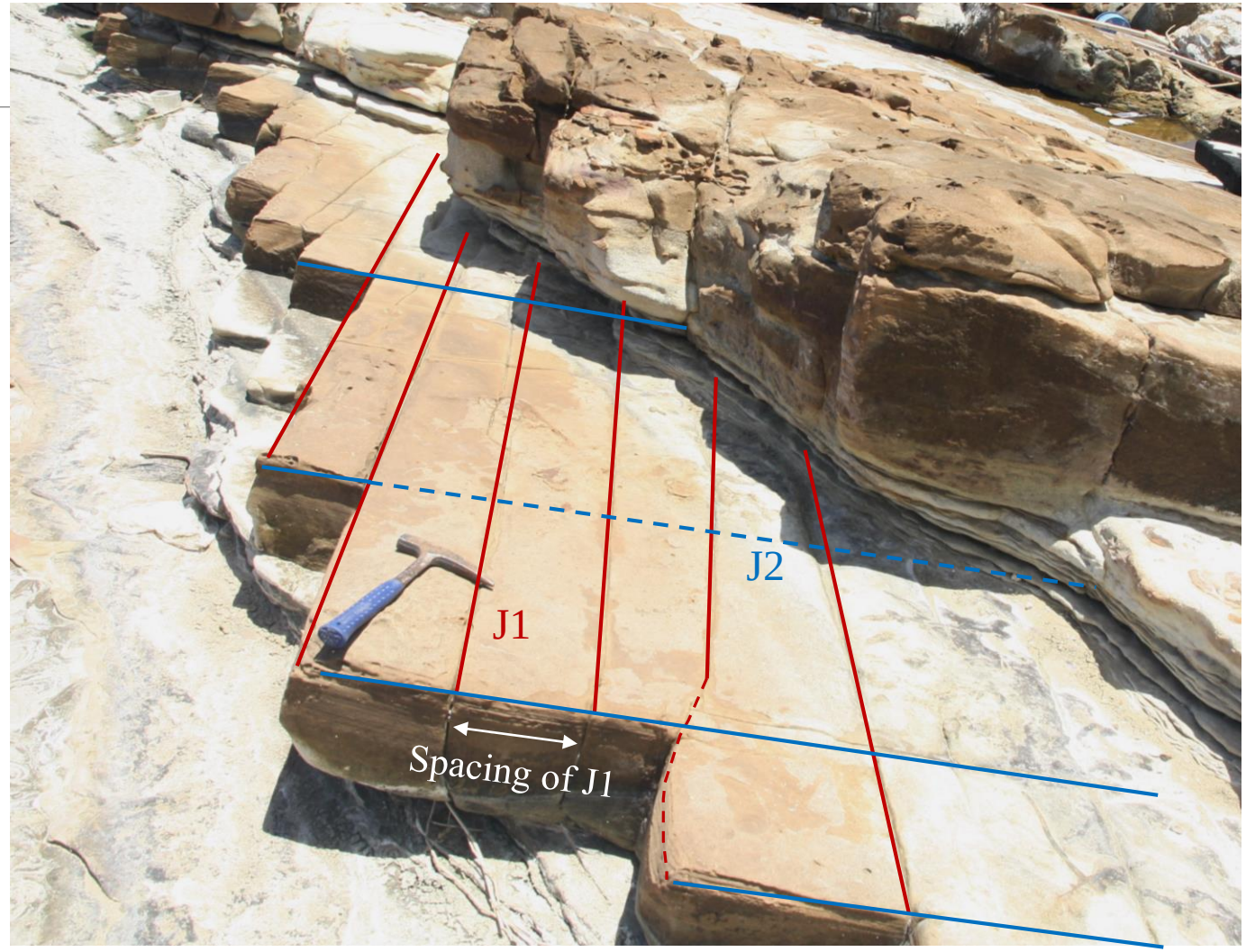

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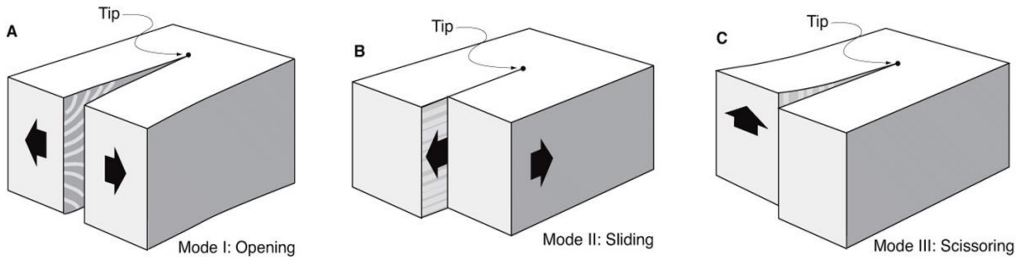

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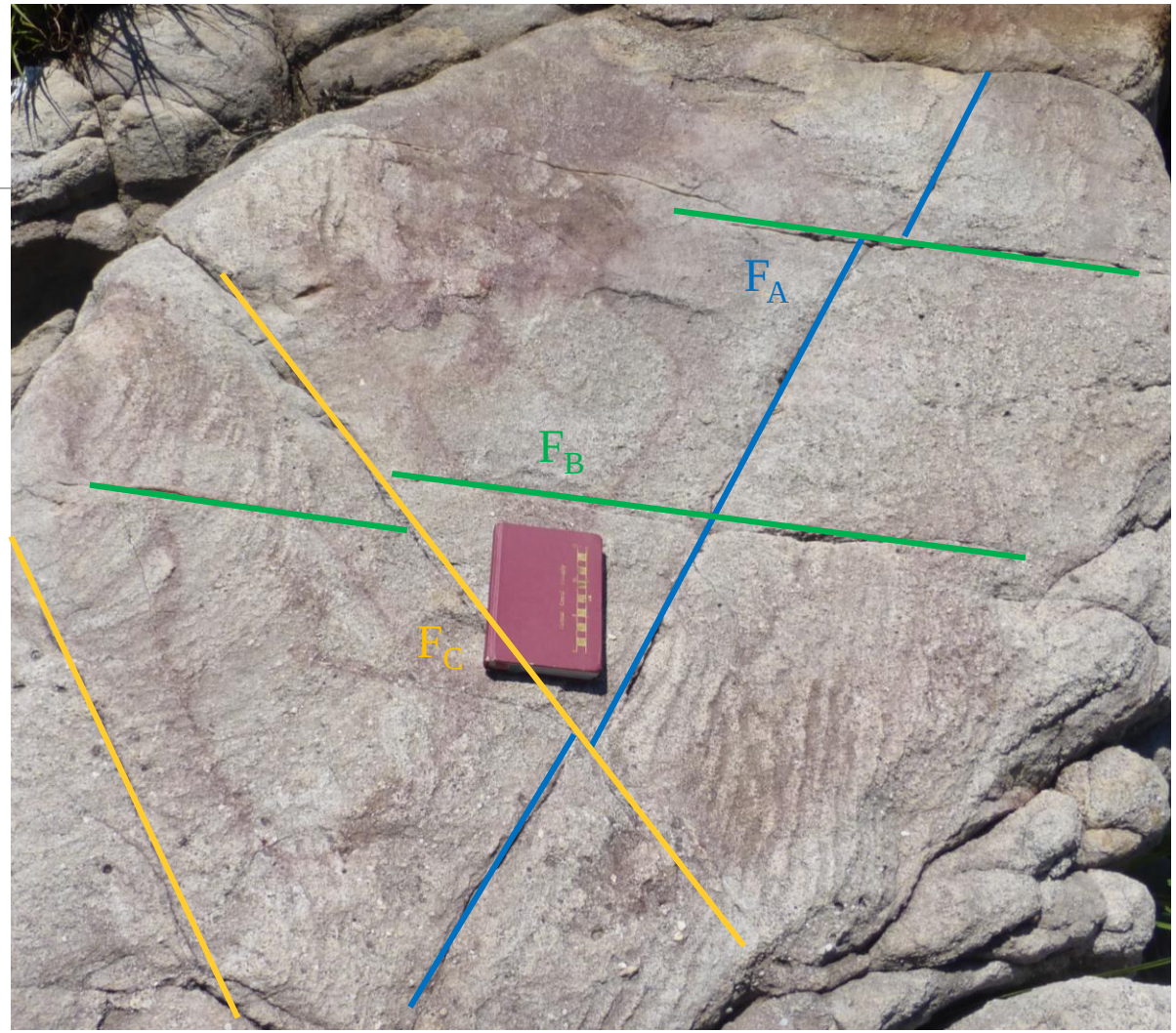
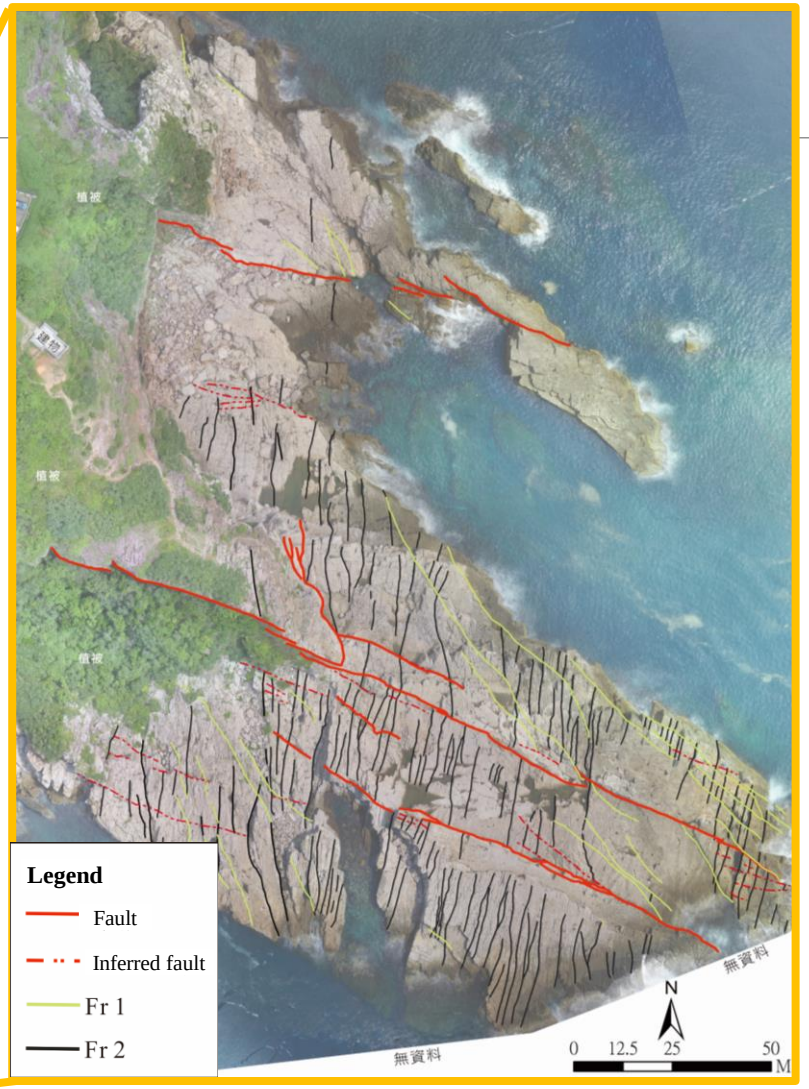


formed order : $F_A > F_B > F_C$

Fractures distribution



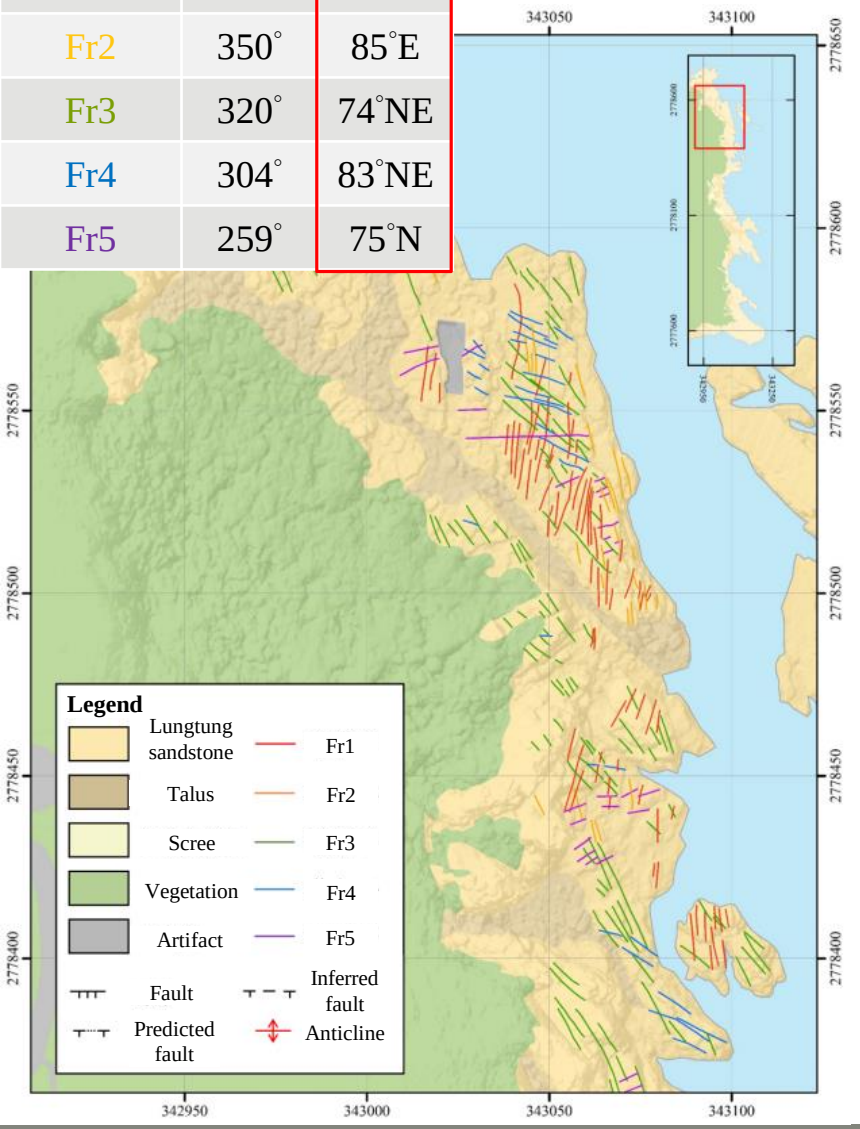
Base on the high resolution (3cm=1pixel) orthoimage, it is very convenient to see the fractures distribution.

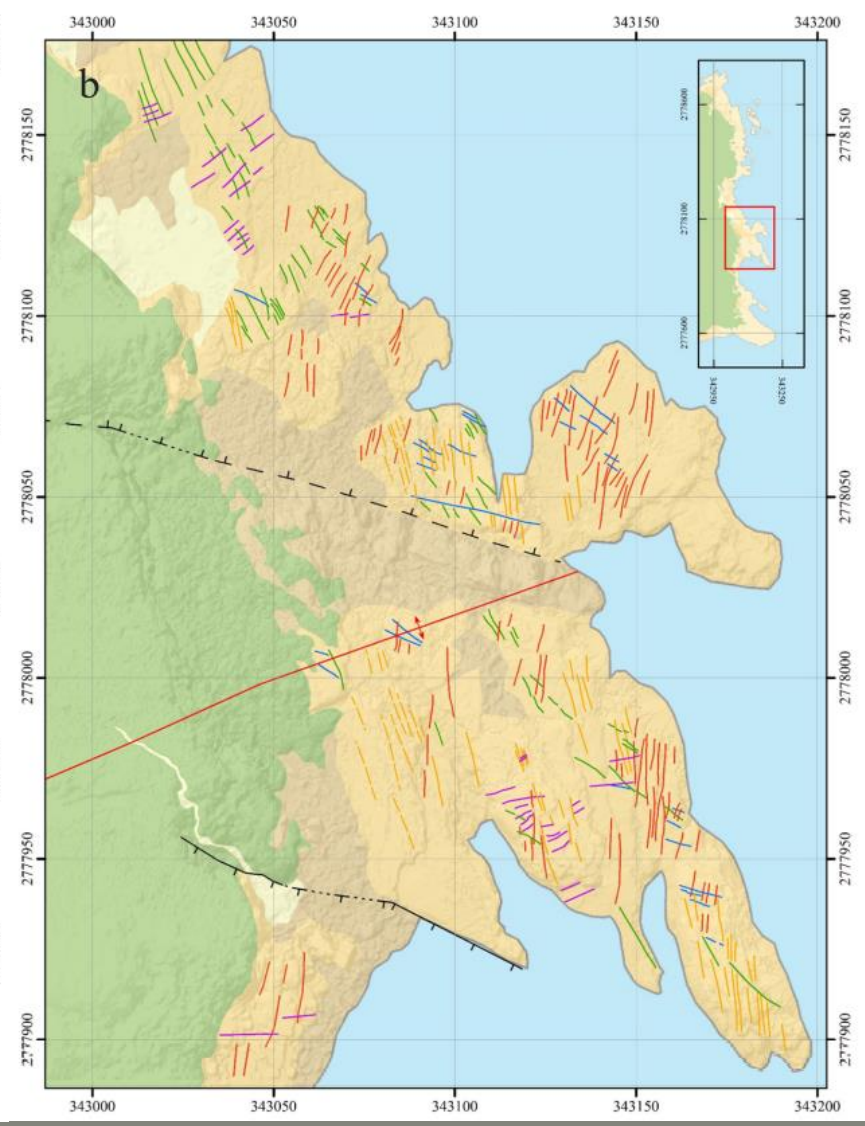
Fracture	Strike	dip
Fr1	190˚	80˚W
Fr2	350˚	85˚E
Fr3	320˚	74˚NE
Fr4	304˚	83˚NE
Fr5	259˚	75˚N

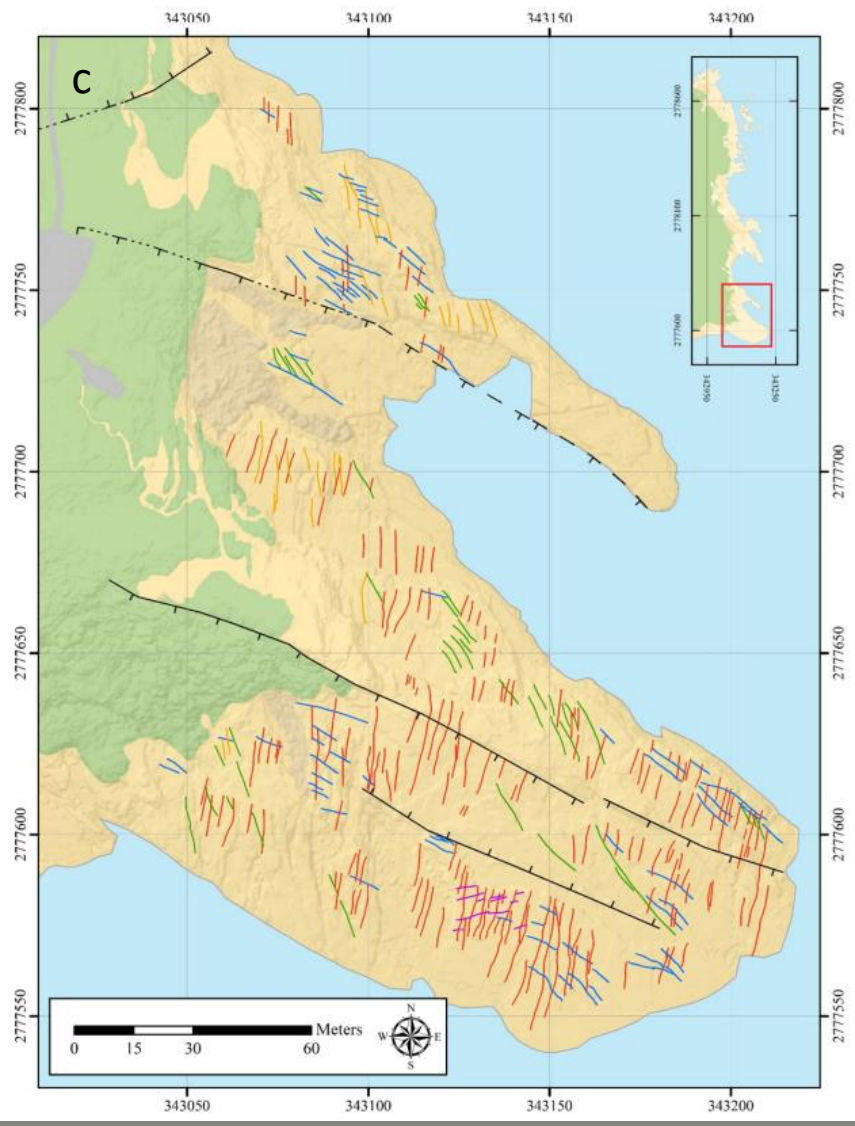
Field investigation

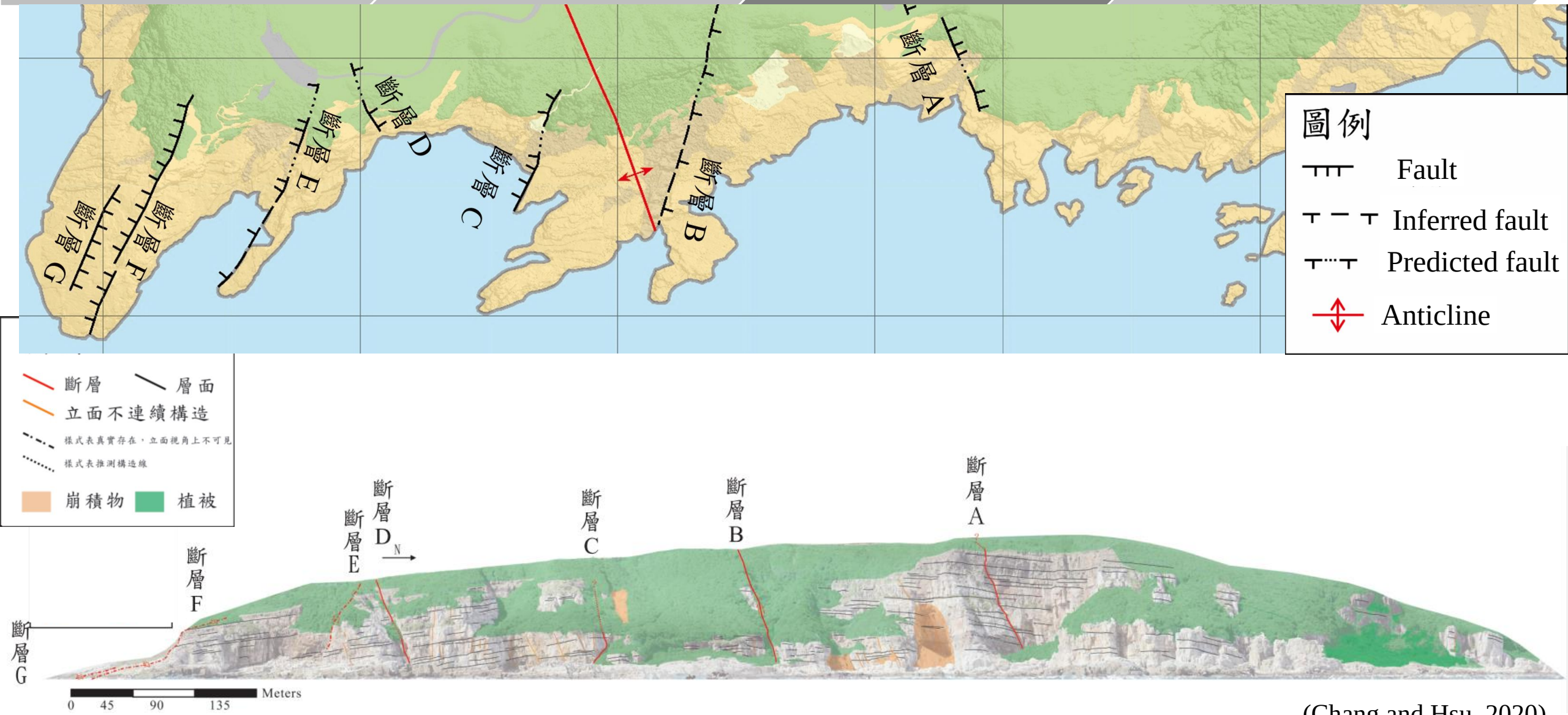
Fractures distribution

(Chang and Hsu, 2020)







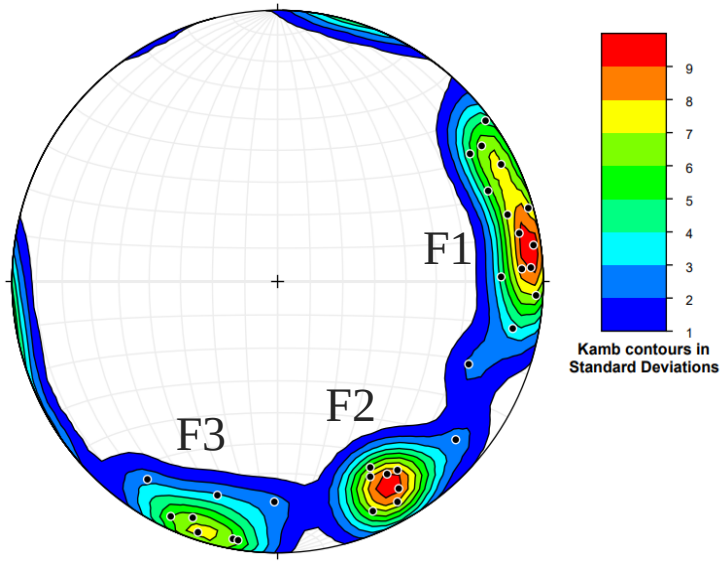


(Chang and Hsu, 2020)

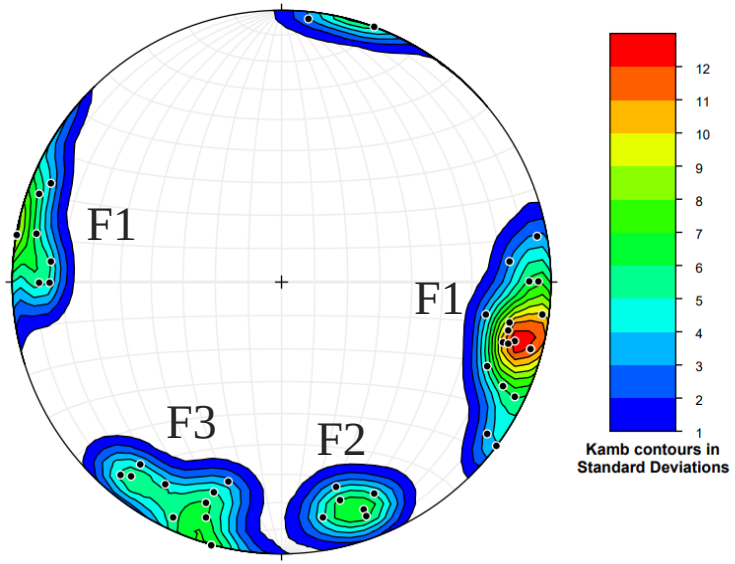
Fracture analysis

The result of fractures distribution in Bitou and Lungtung cape show three fracture sets with similar orientation.

Bitou cape



Lungtung cape



Fracture data were measured in the field

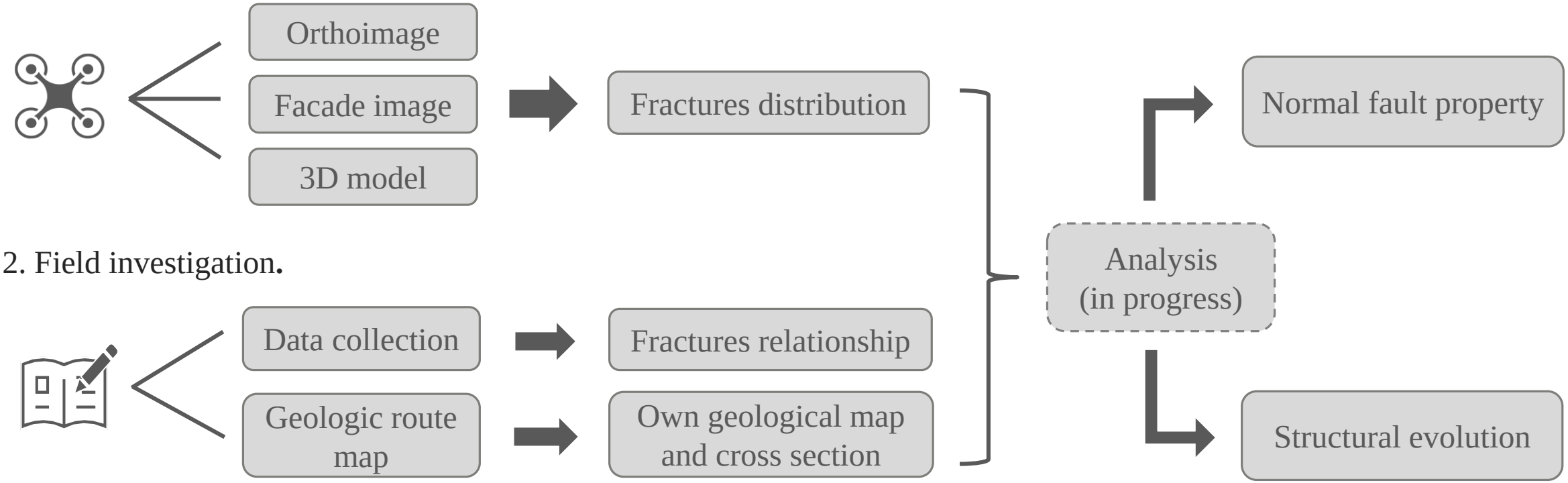
Comparison of mean attitude

	Bitou	Lungtung
F1	172°, 84°	194°, 80°
F2	241°, 74°	252°, 76°
F3	287°, 85°	294°, 78°

Explanation : F1 is older than F2 and F3, It's possible experienced more tectonic activity.

Future work

1. UAV mapping and modeling in the **Bitou area**. (Lungtung area already finished)

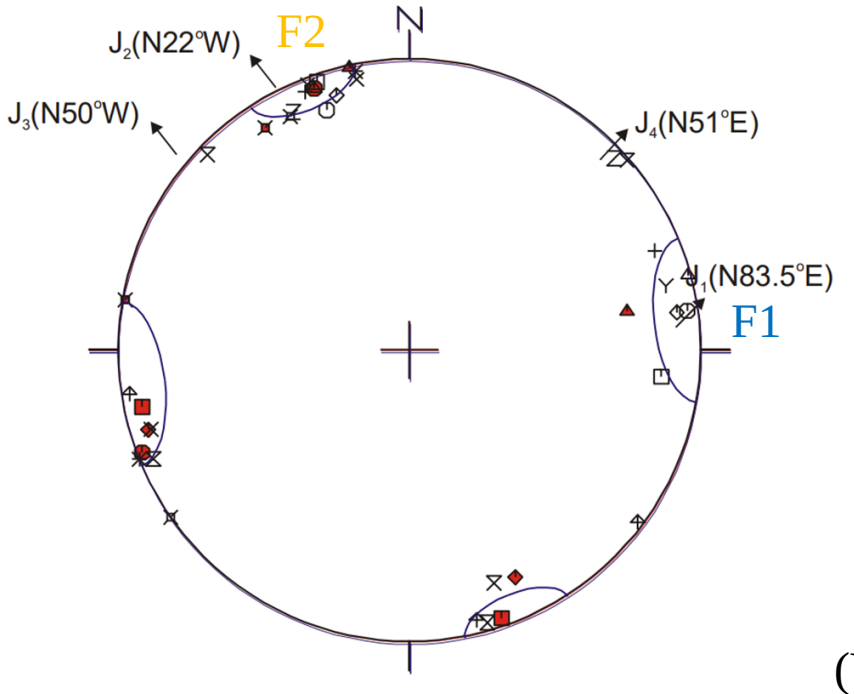


Thanks for your attention ~

F1

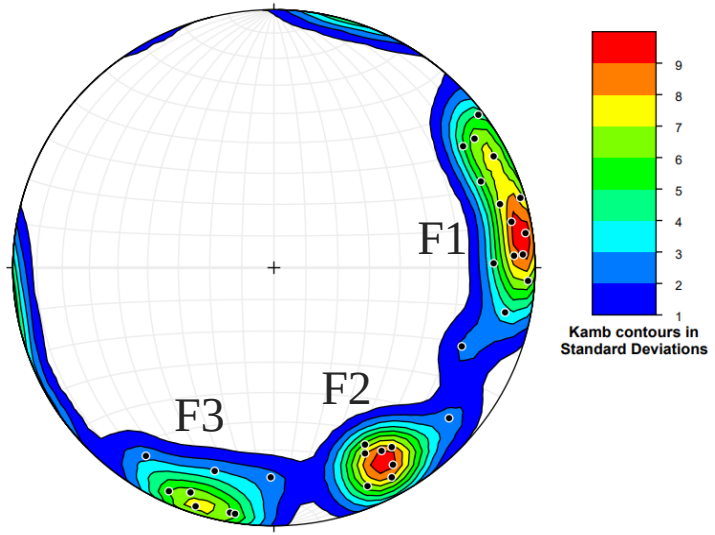
F3

F1 > F3



F1 > F2

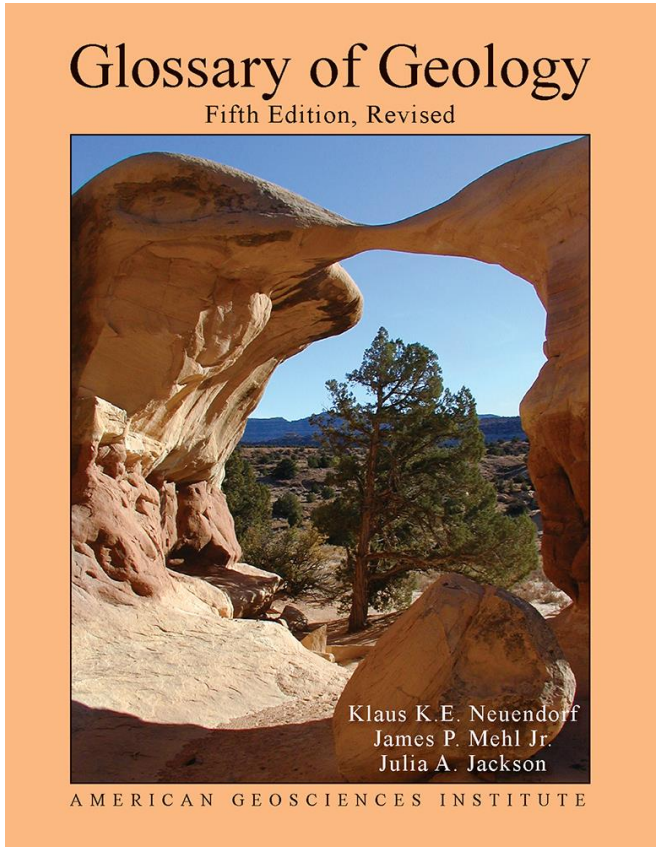
(Yu, 1998)



裂隙(Fracture)

"A general term for any surface within a material across which there is no cohesion."

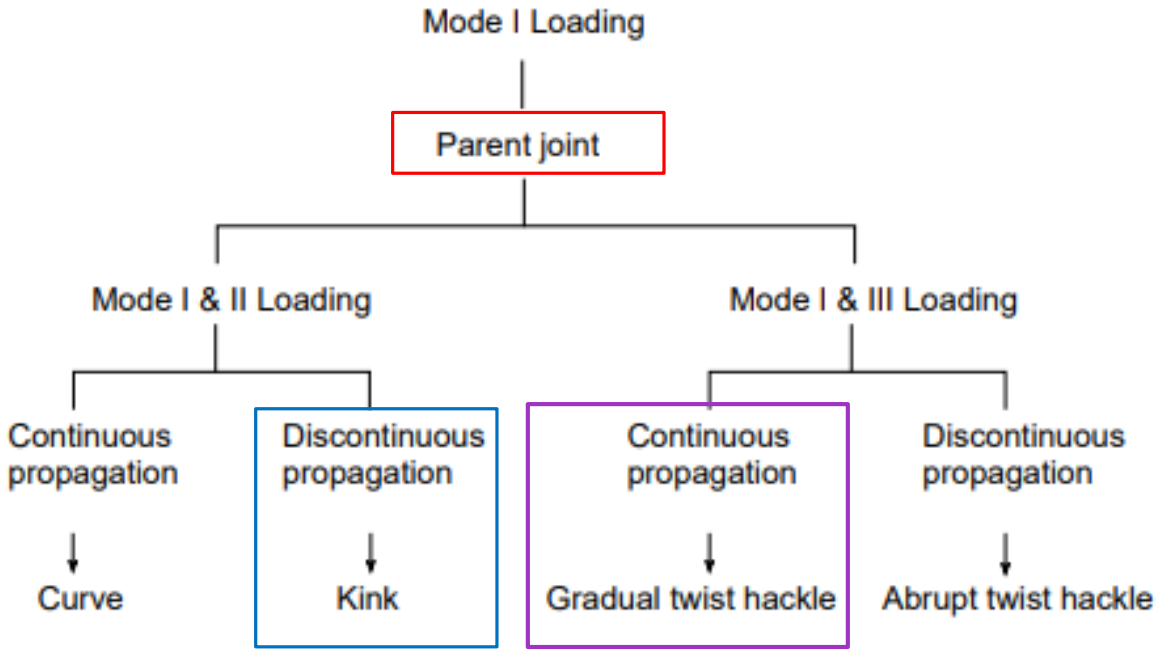
節理(Joint)　　斷層(Fault)

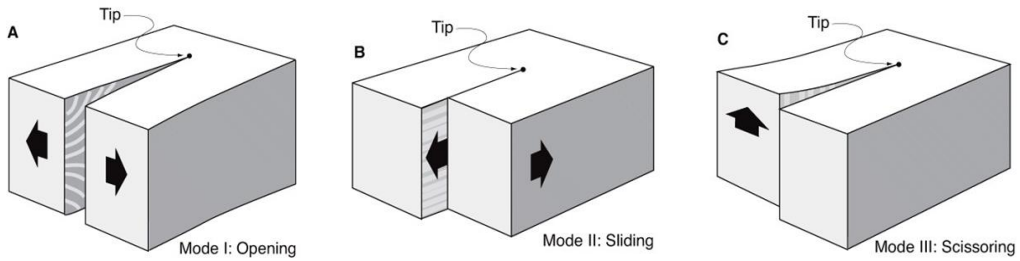


*Cohesion, the component of shear strength(?) of a rock that is independent of interparticle friction.

Joint is a fracture that lacks visible or measurable movement parallel to the surface of the fracture.

Fault is a fractures between two blocks of rock. Faults allow the blocks to move obviously relative to each other.





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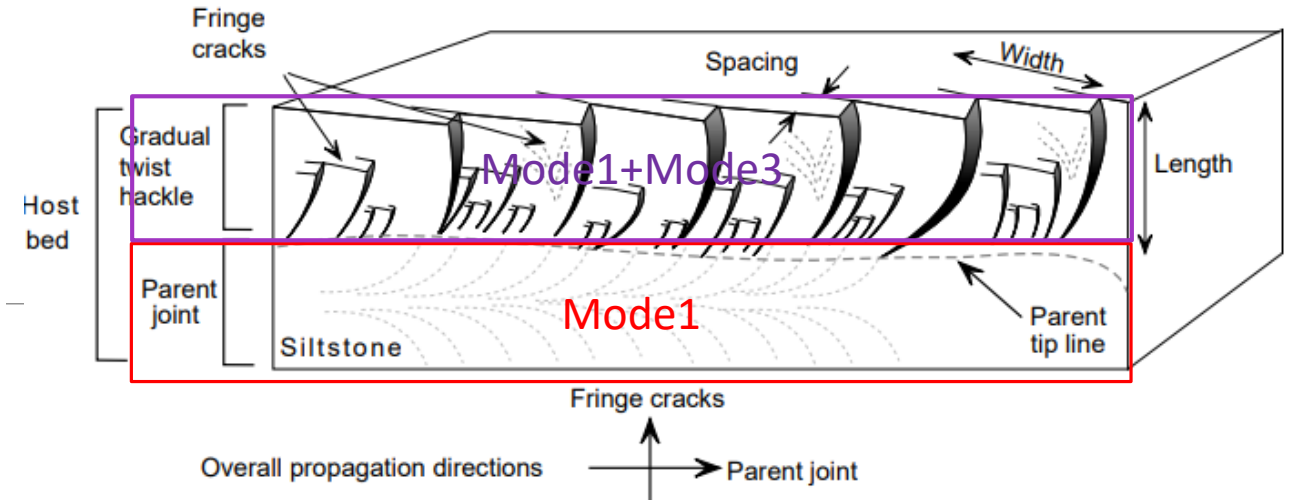
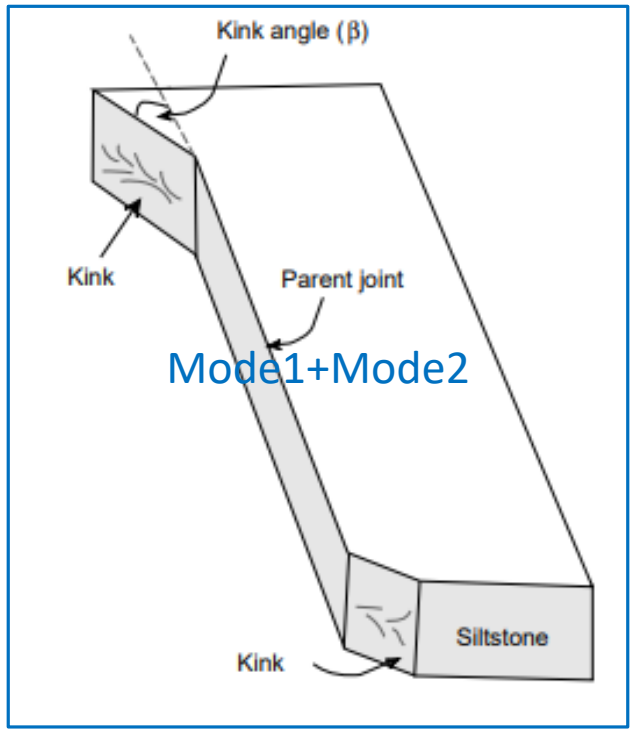
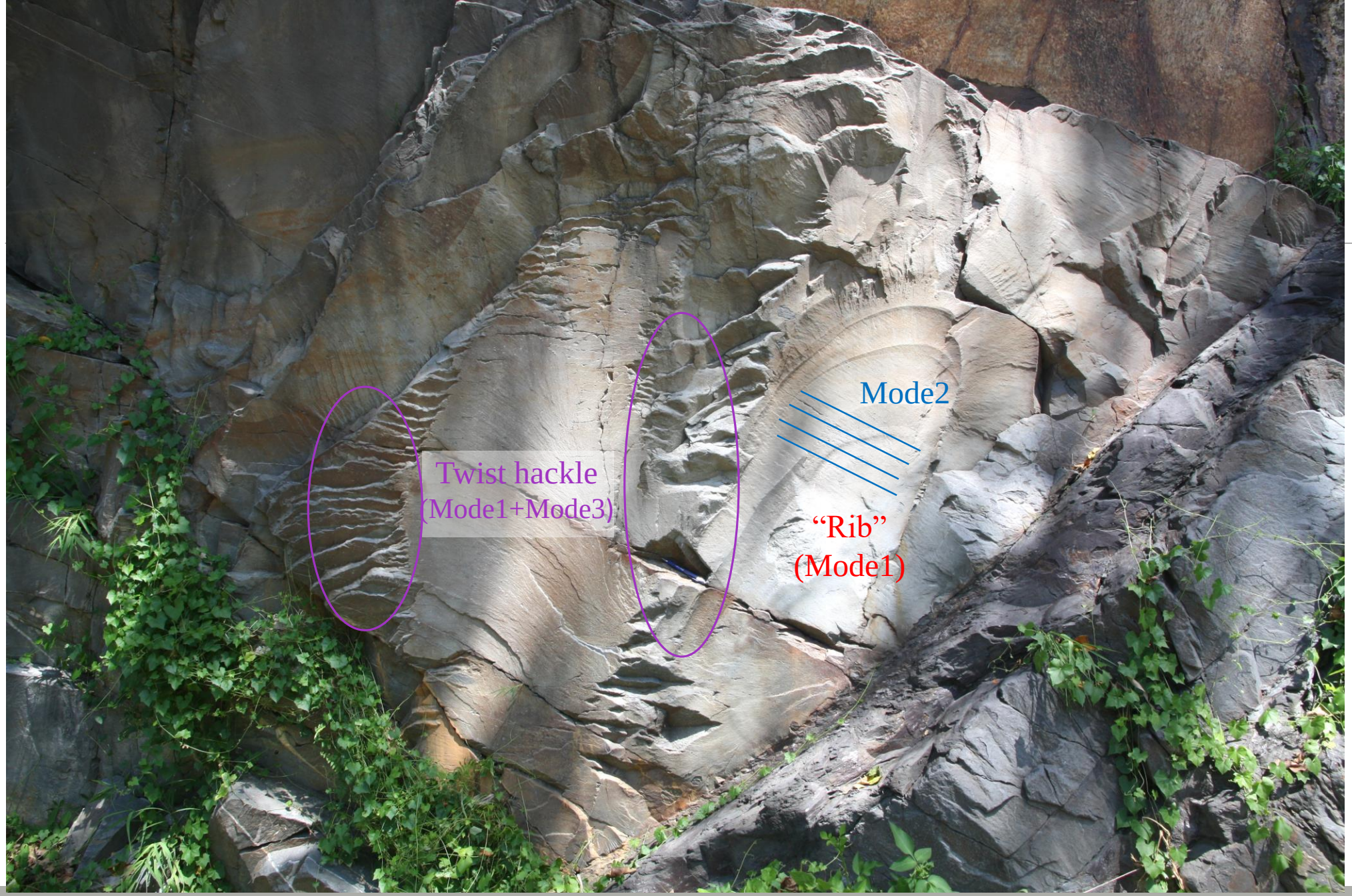
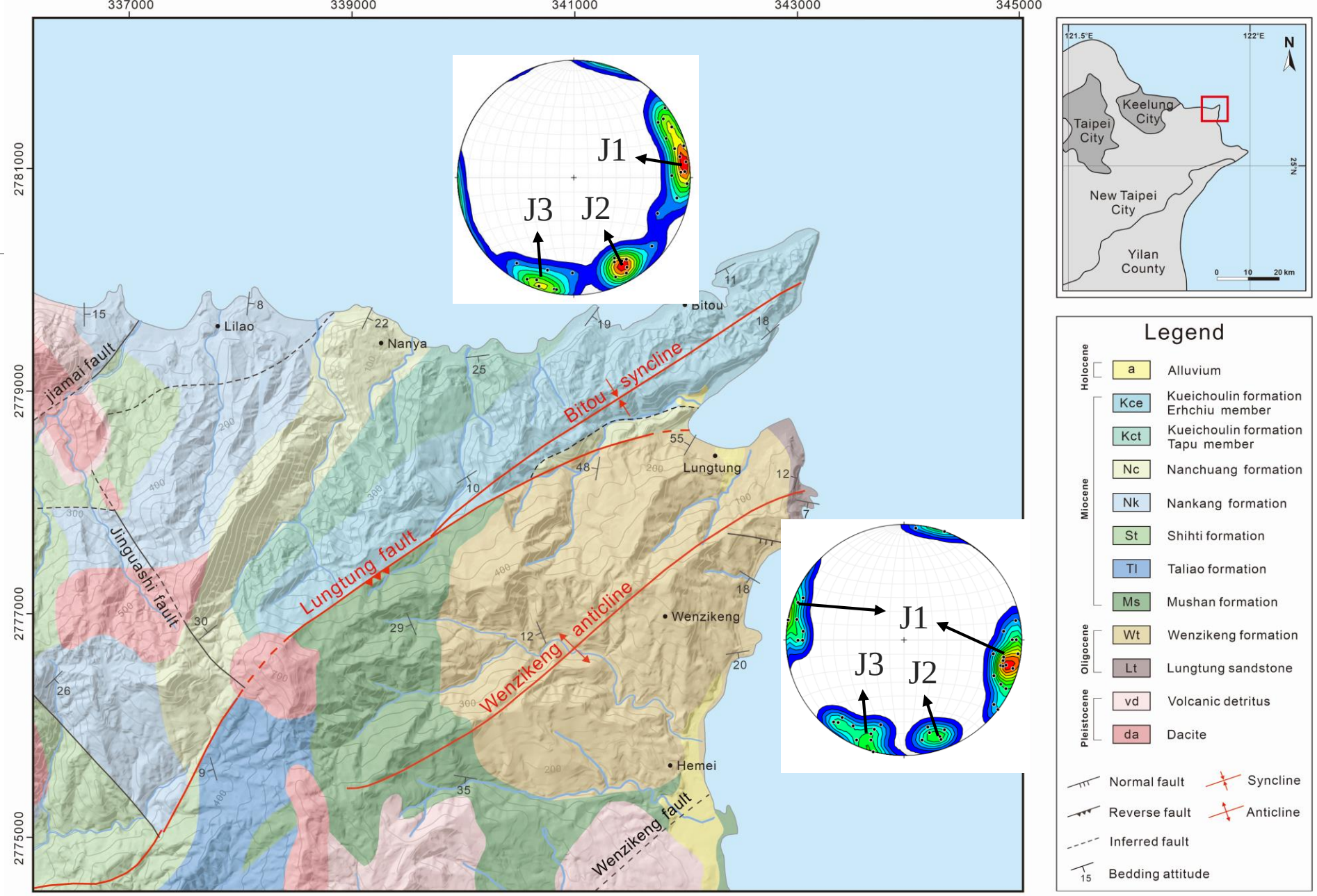




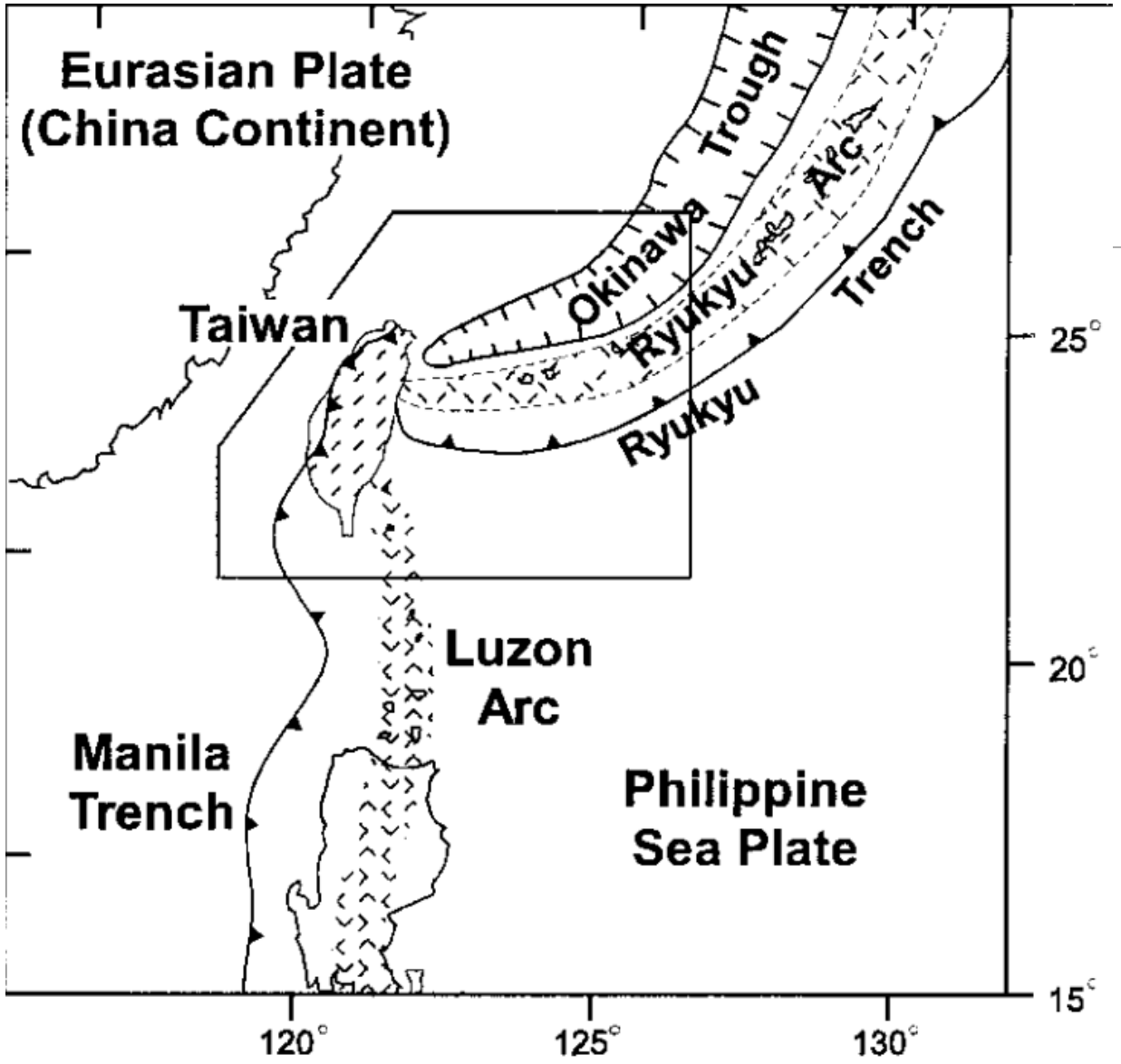

Twist hackle
(Mode1+Mode3)
Mode2
“Rib”
(Mode1)



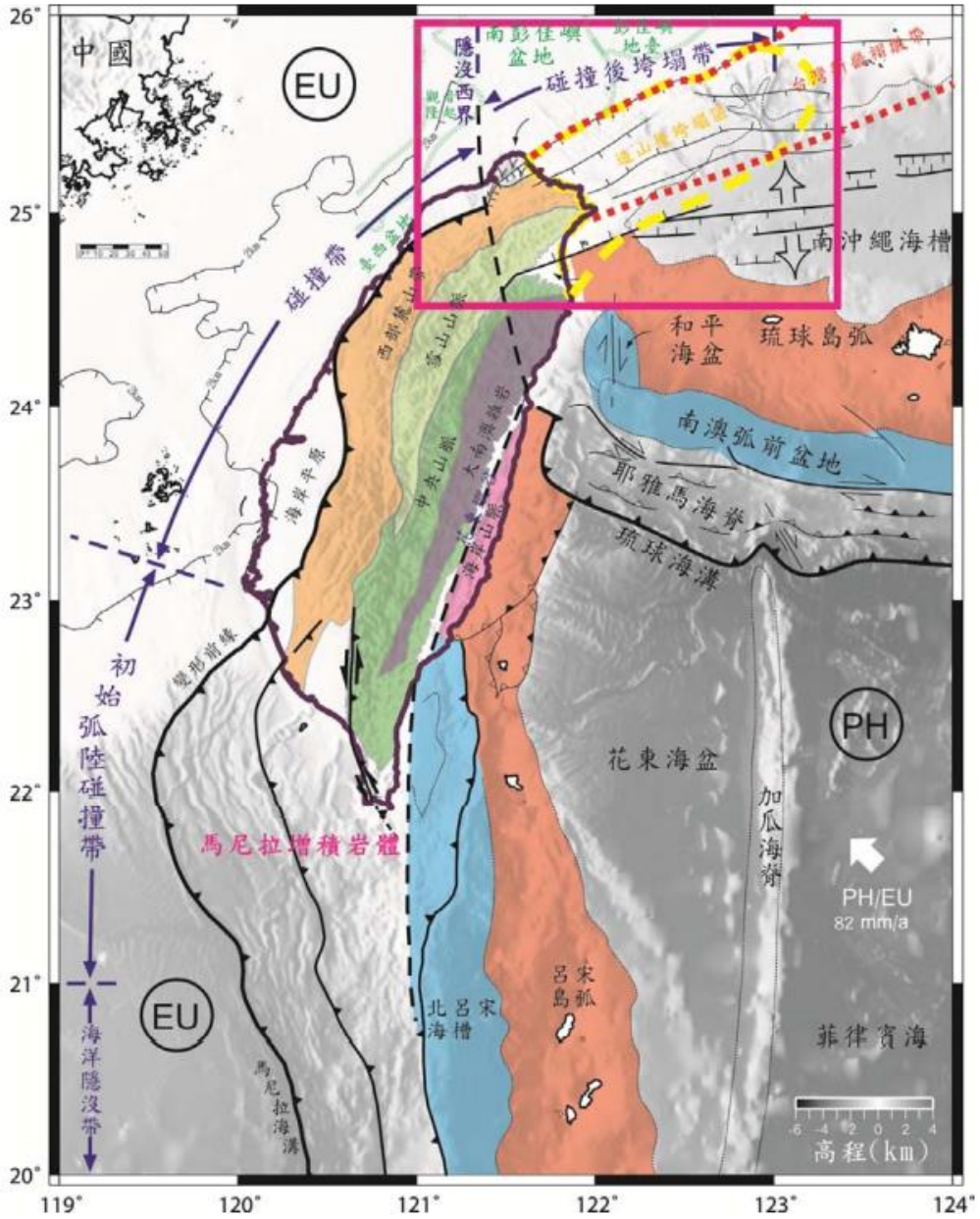
Legend

Holocene	a	Alluvium
Miocene	Kce	Kueichoulin formation Erhchiu member
	Kct	Kueichoulin formation Tapu member
	Nc	Nanchuang formation
	Nk	Nankang formation
	St	Shihti formation
	Tl	Taliao formation
	Ms	Mushan formation
Oligocene	Wt	Wenzikeng formation
	Lt	Lungtung sandstone
Pleistocene	vd	Volcanic detritus
	da	Dacite

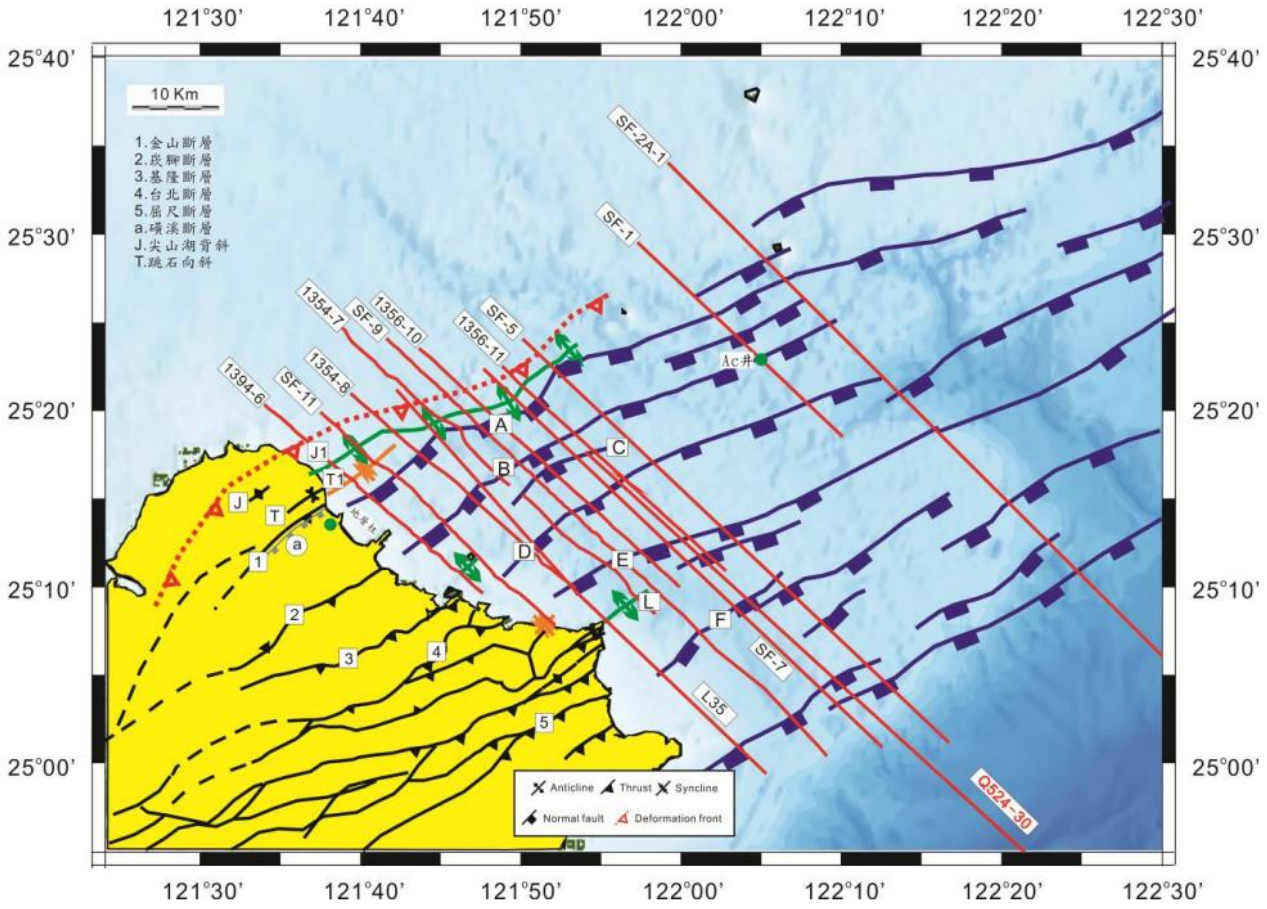
Normal fault
Reverse fault
Inferred fault
15 Bedding attitude
Syncline
Anticline



(Teng, 1996)



(Chen, 2014)



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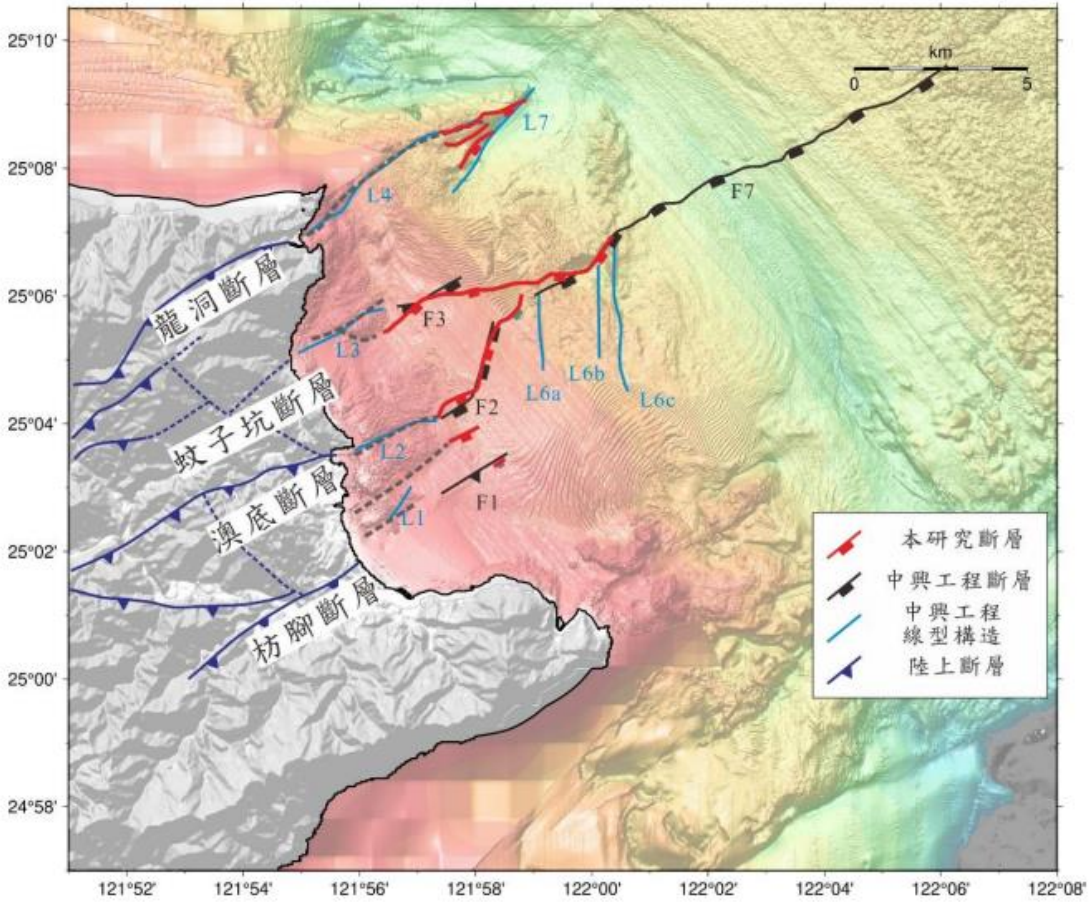
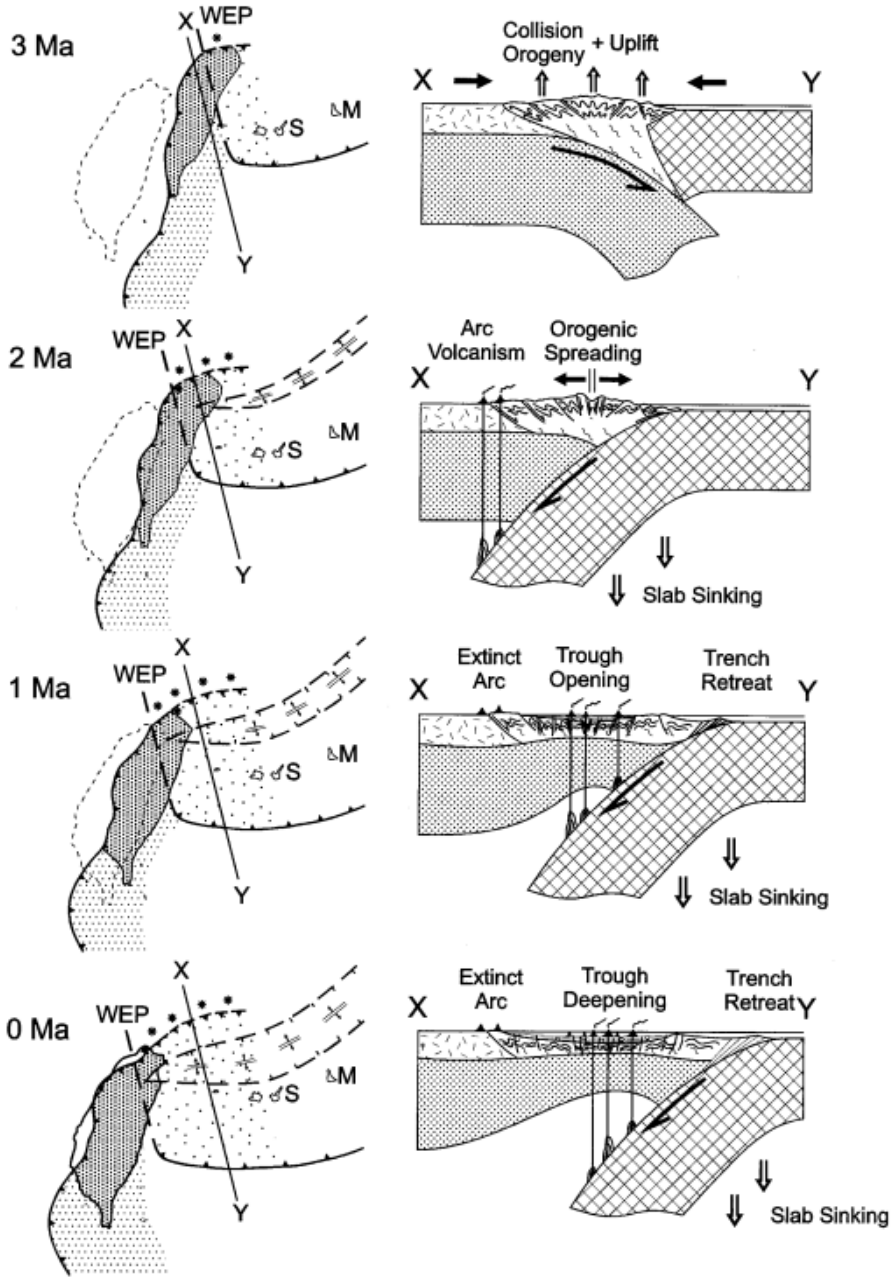
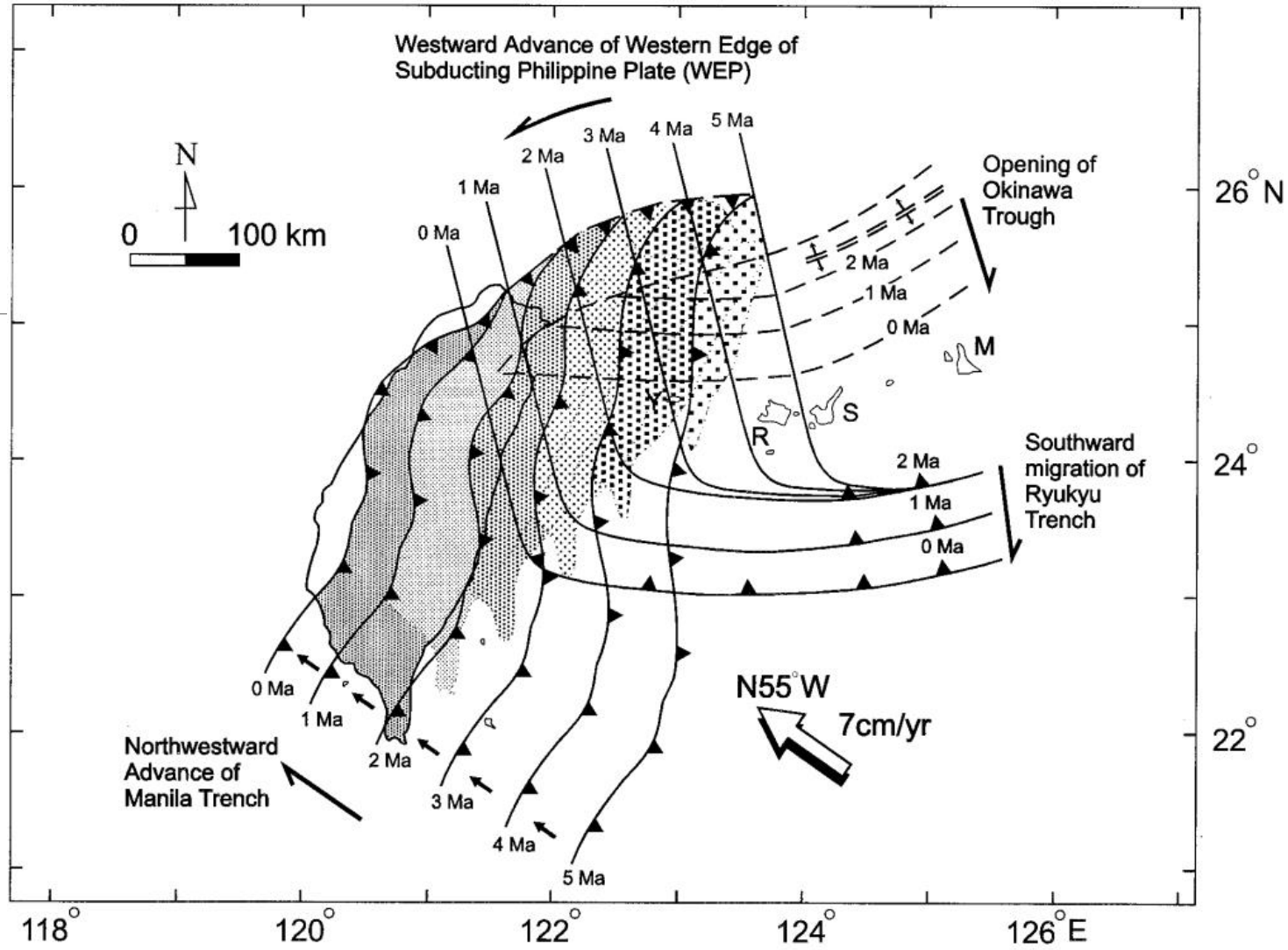


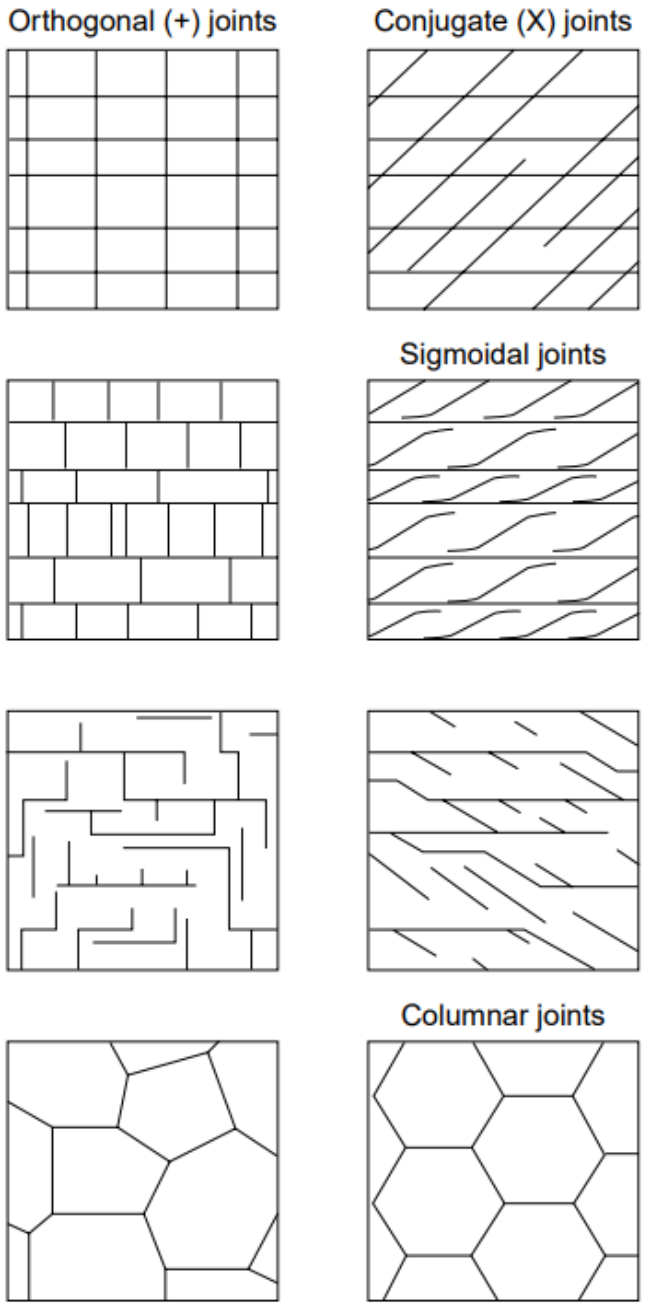
(Lin, 2021)

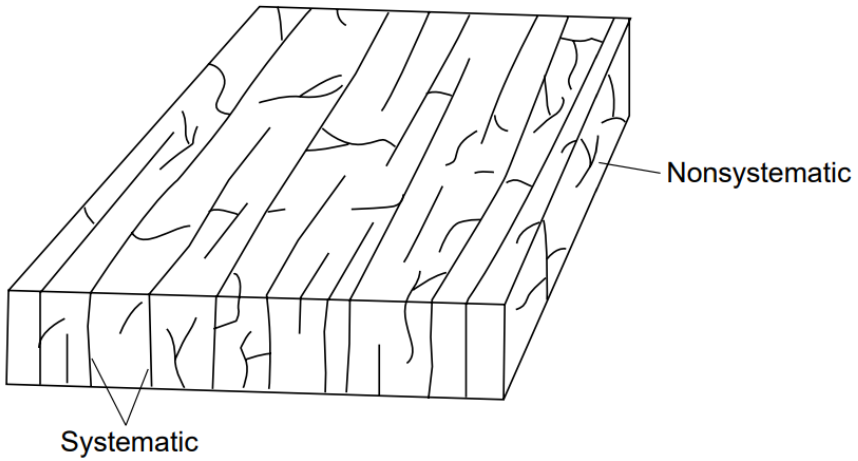

research area
Longmen Nuclear Power Plant
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2022 TerraMetrics
Image © 2022 Maxar Technologies
N
10 km

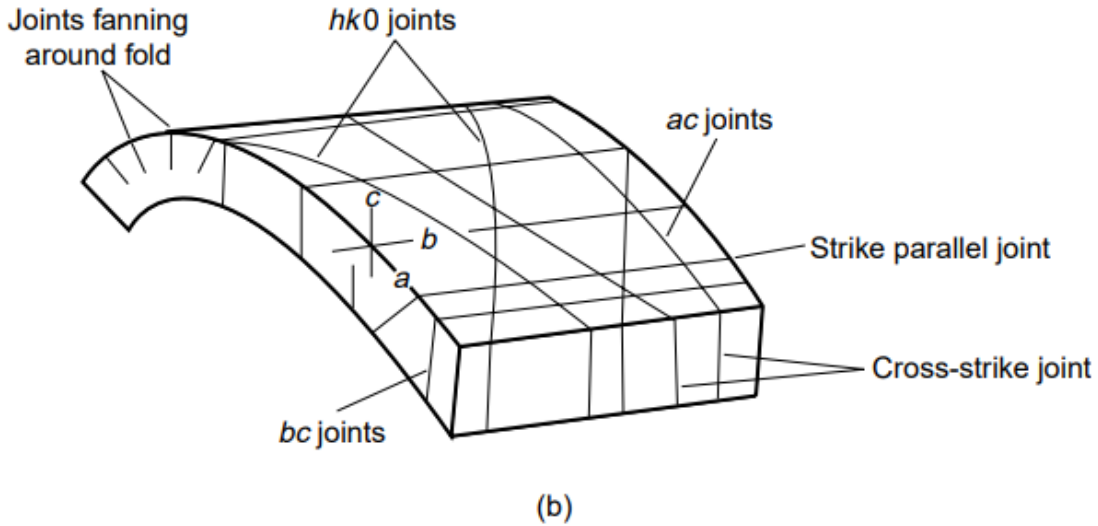

3 Ma
X
WEP
M
S
Y
Collision
Orogeny
+ Uplift
2 Ma
Arc
Volcanism
Orogenic
Spreading
Slab Sinking
1 Ma
Extinct
Arc
Trough
Opening
Trench
Retreat
0 Ma
Trough
Deepening


Westward Advance of Western Edge of
Subducting Philippine Plate (WEP)
N
0
100 km
0 Ma
1 Ma
2 Ma
3 Ma
4 Ma
5 Ma
Opening of
Okinawa
Trough
M
S
R
Southward
migration of
Ryukyu
Trench
N55°W
7cm/yr
Northwestward
Advance of
Manila Trench
26°N
24°
22°
118°
120°
122°
124°
126°E

(Teng, 1996)







From Ben A. Van and Stephen Marshak, 2003, Publish with W.W. Norton, 2004)