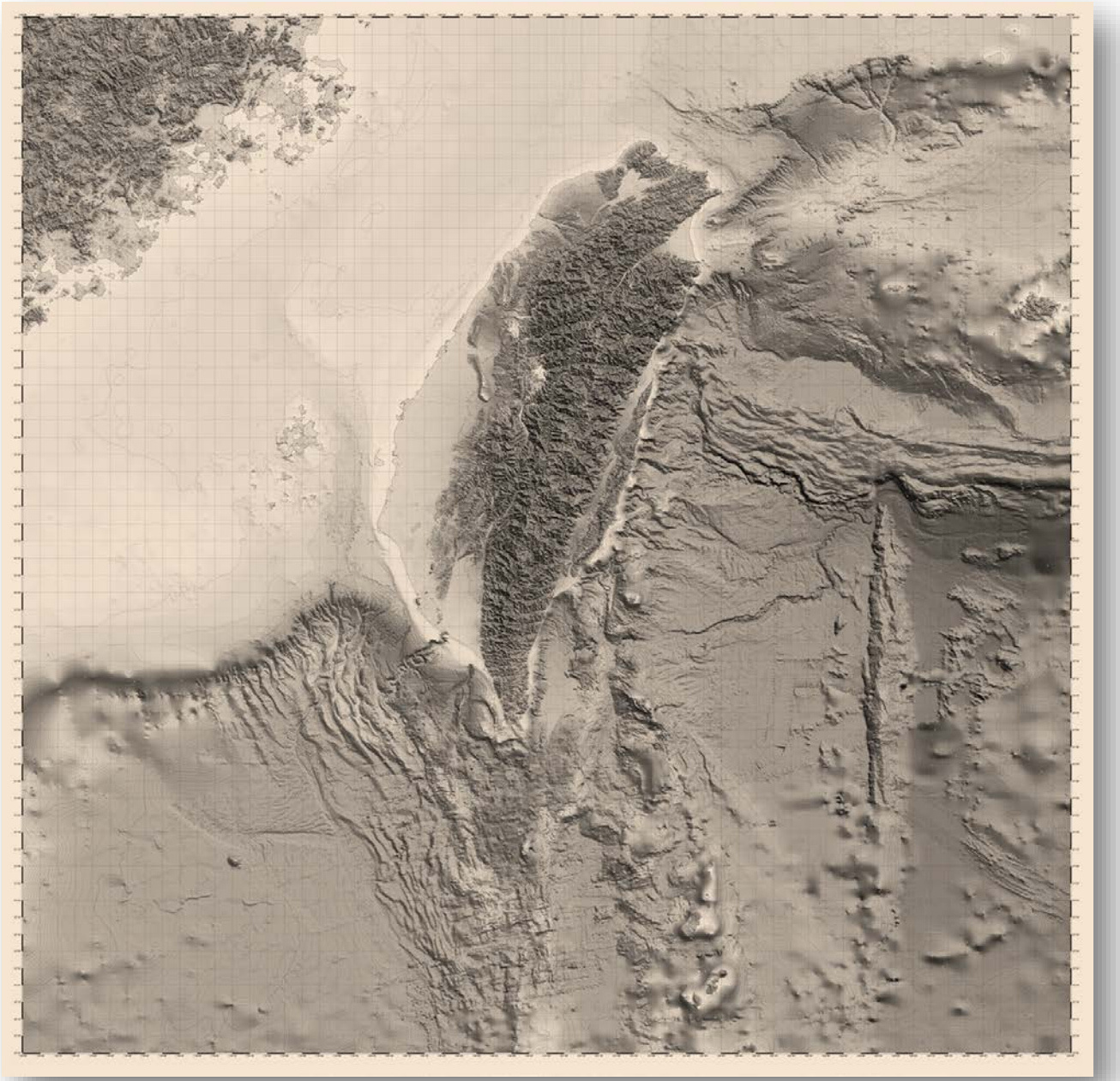
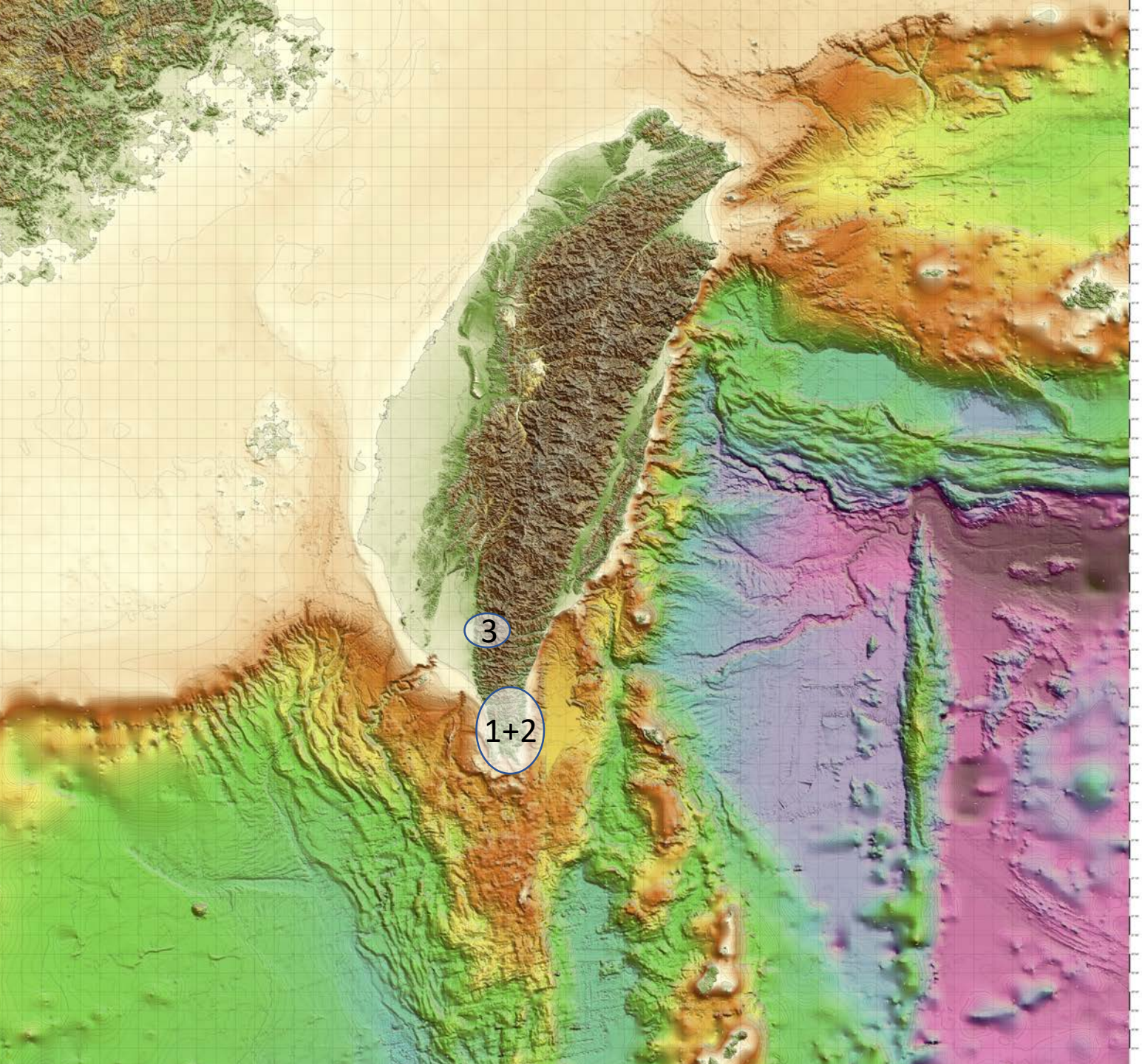


Geomorphic Landscapes Reorganization in Emerging Orogens

Jack Giletycz

張文和

Department of Earth Sciences
National Central University, Taiwan



Geomorphic Landscapes Reorganization in Emerging Orogens

(recent surveys and results)

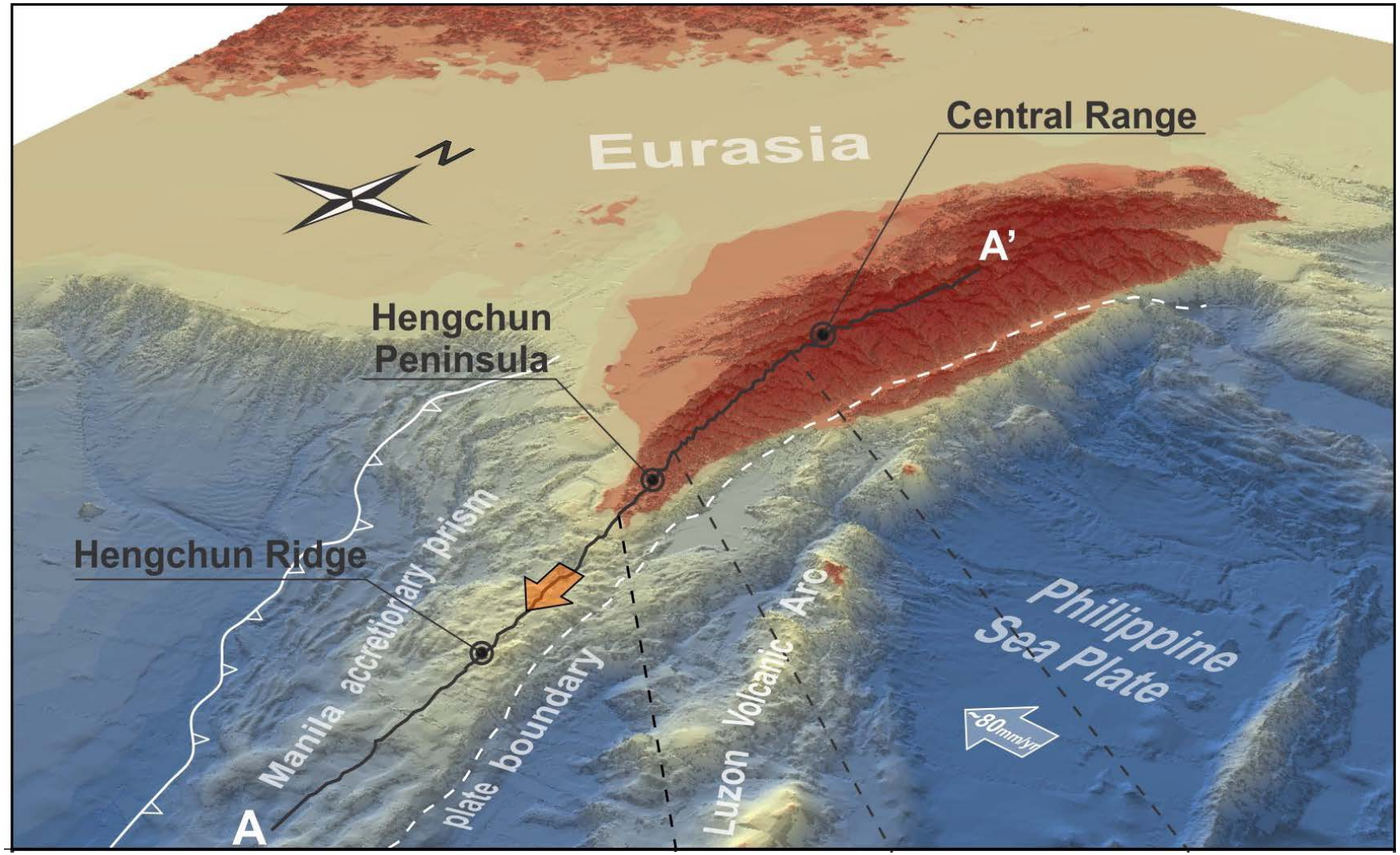
- upcoming scientific questions
- research plans
- teaching ideas

1-2. Hengchun Peninsula 恆春半島

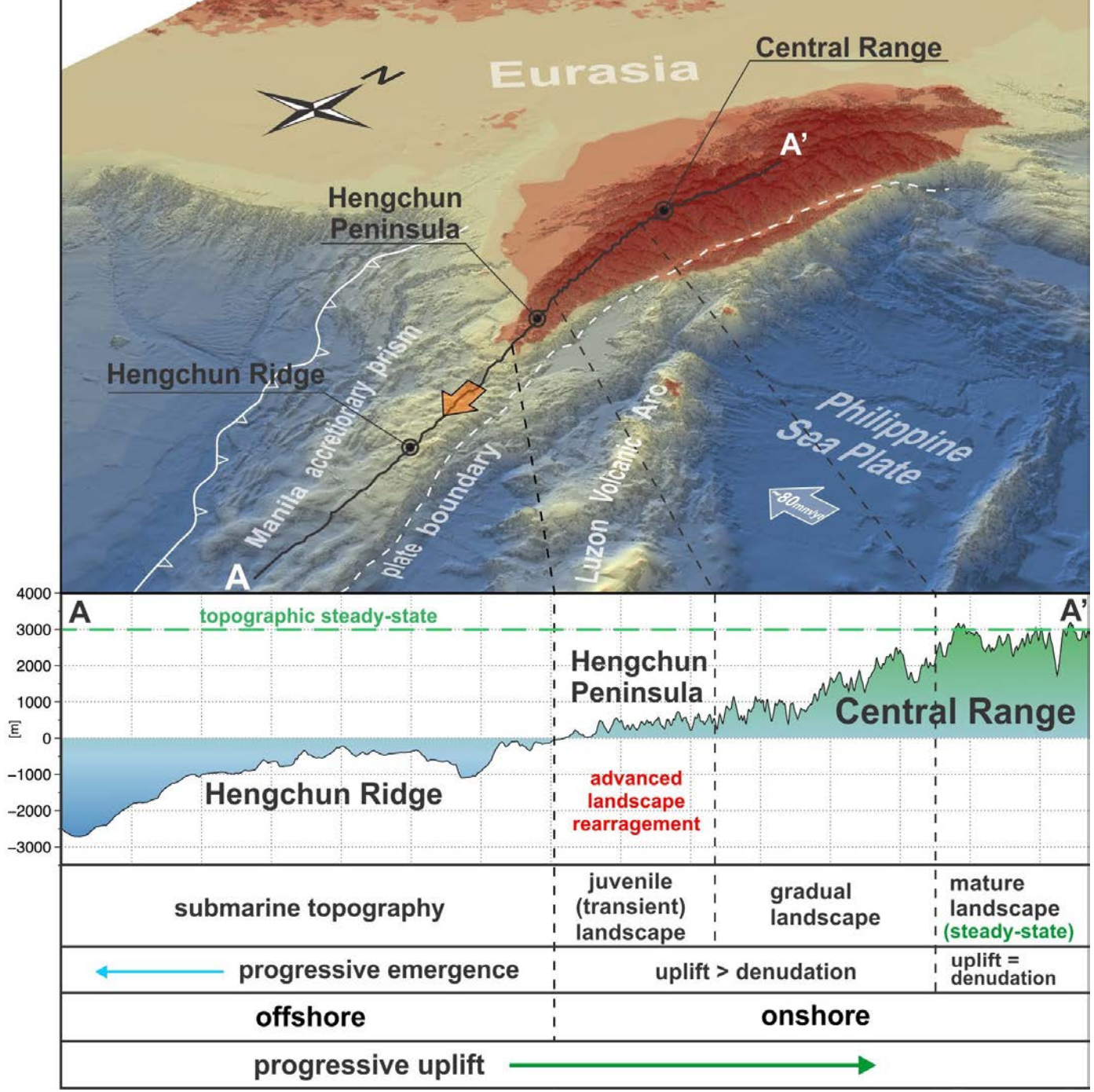
3. Sandimen/Wutai 三地門/霧台

1

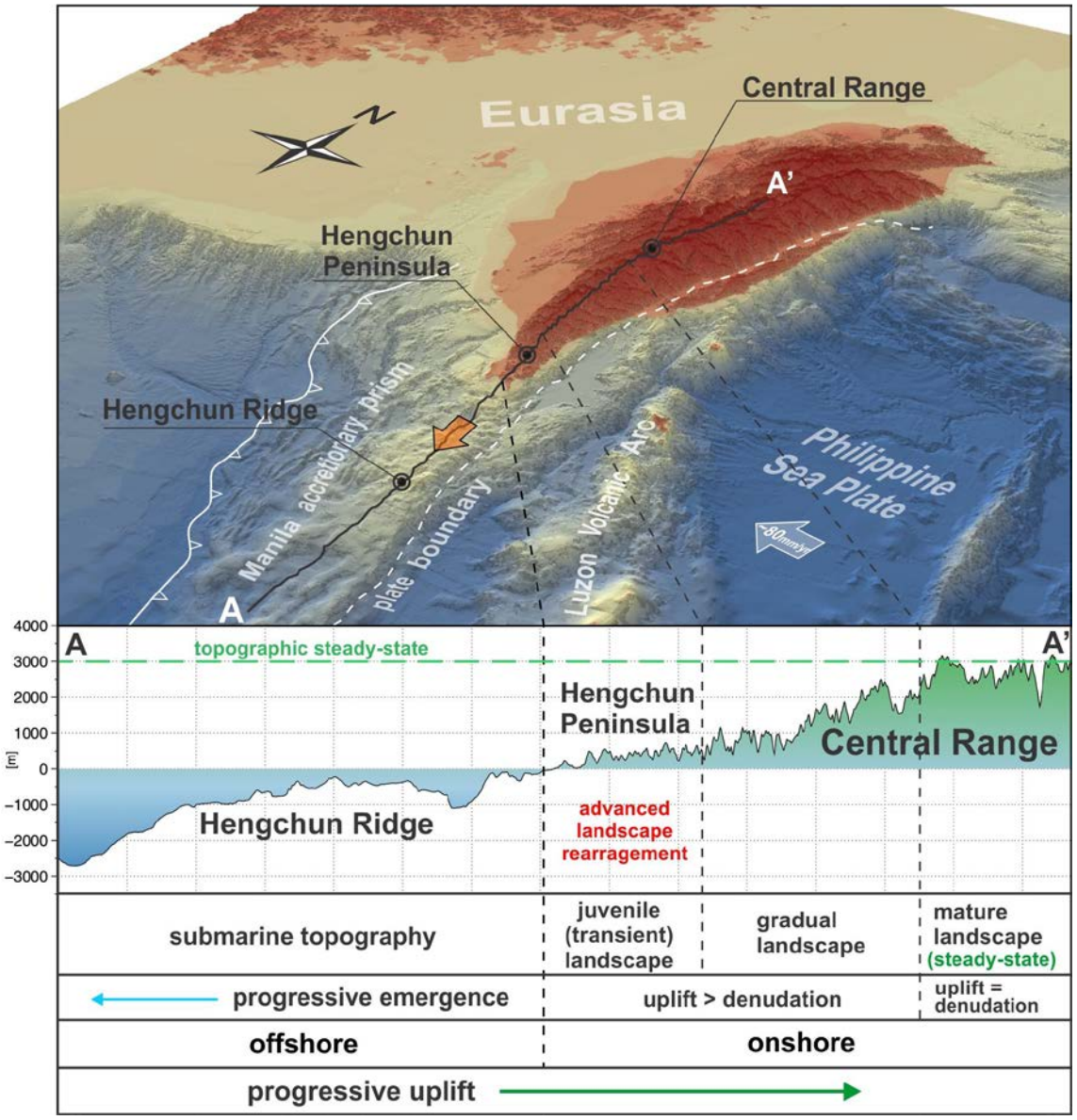
Paleoenvironmental reconstruction of a newly emerged geomorphic system.

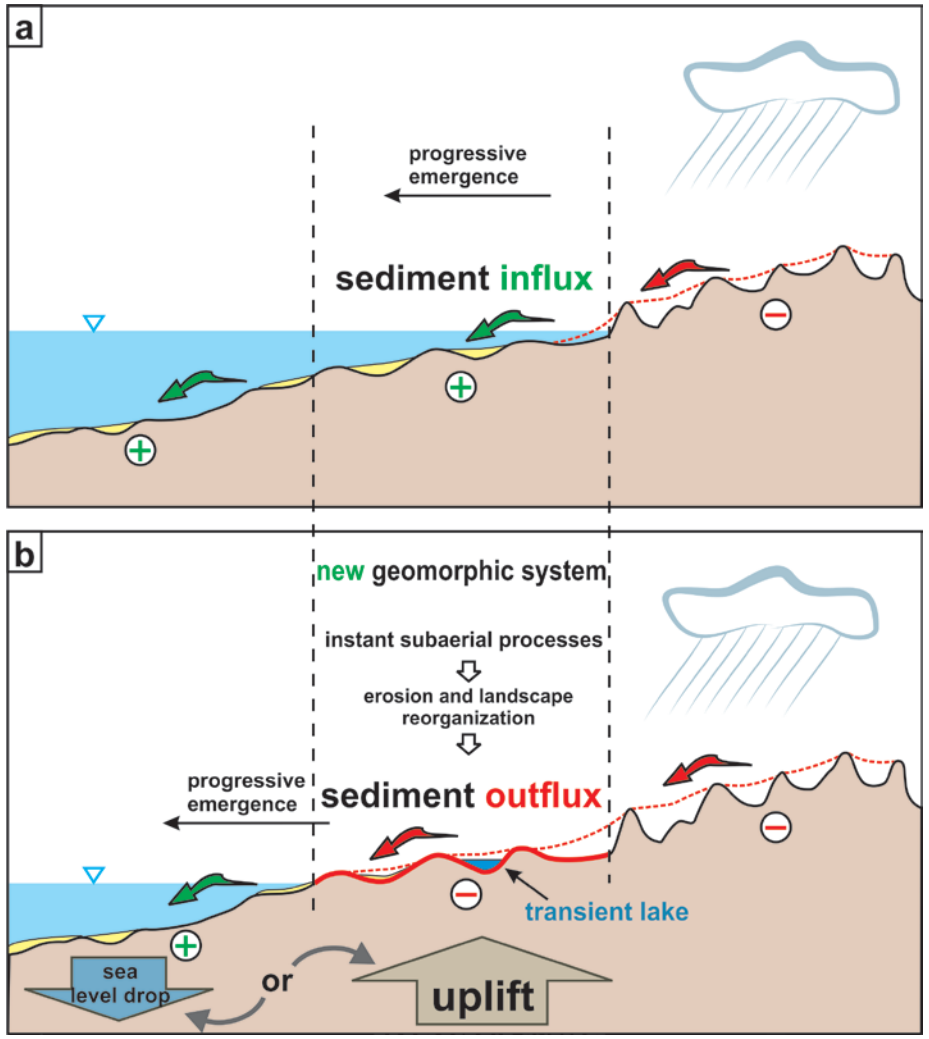


Taiwan orogen topography


Eurasia
N
Central Range
A'
Hengchun
Peninsula
Hengchun Ridge
Manila accretionary prism
plate boundary
Luzon Volcanic Arc
Philippine
Sea Plate
80mm/yr
A
4000
3000
2000
1000
0
−1000
−2000
−3000
[m]
A
topographic steady-state
A'
Hengchun
Peninsula
Central Range
Hengchun Ridge
advanced
landscape
rearragement
submarine topography
juvenile
(transient)
landscape
gradual
landscape
mature
landscape
(steady-state)
progressive emergence
uplift > denudation
uplift =
denudation
offshore
onshore
progressive uplift

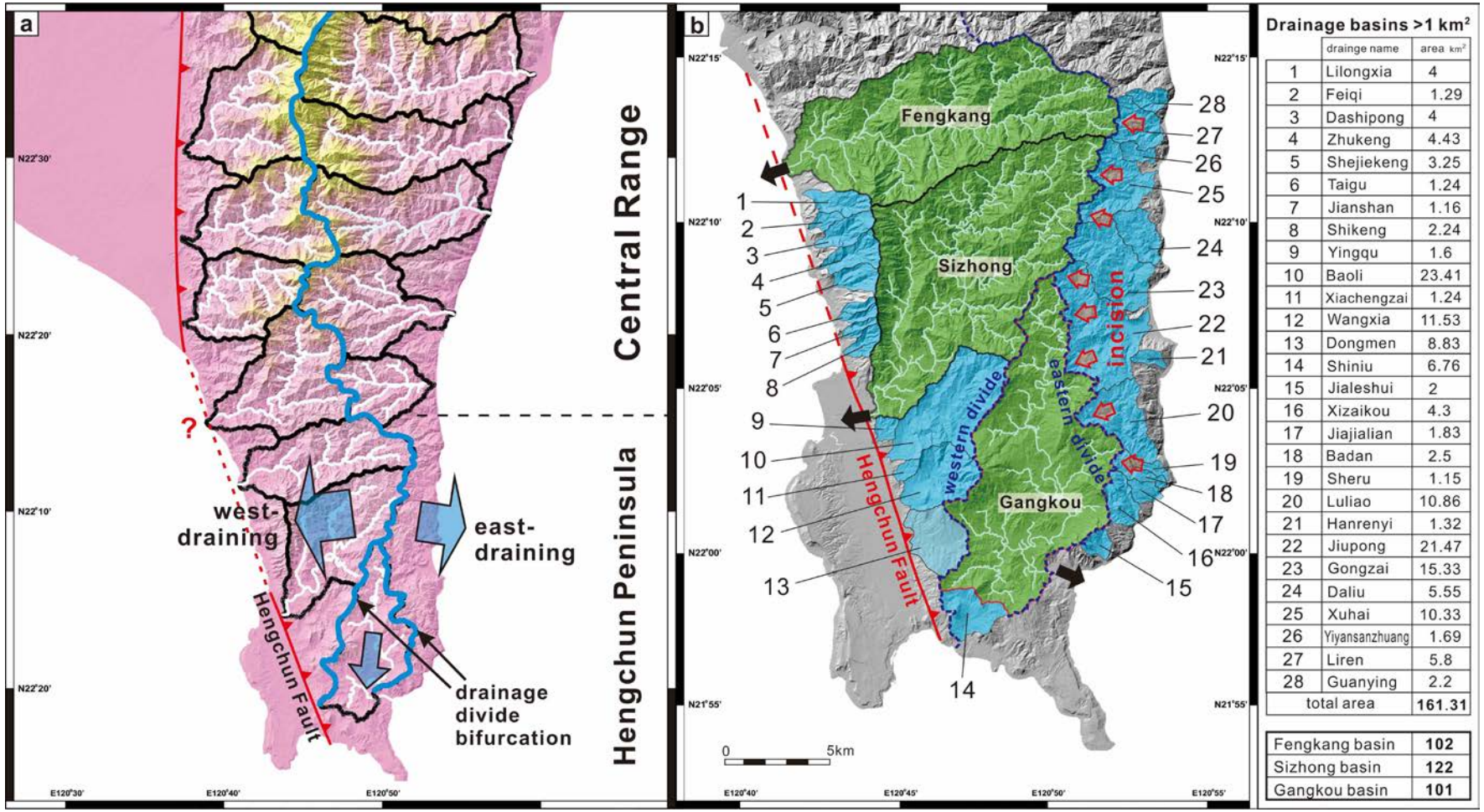
New geomorphic system emerged above sea level





The juvenile topography can lead to build enclosed water bodies as lakes.

Asymmetrical pattern of newly emerged geomorphic system (Hengchun Peninsula)



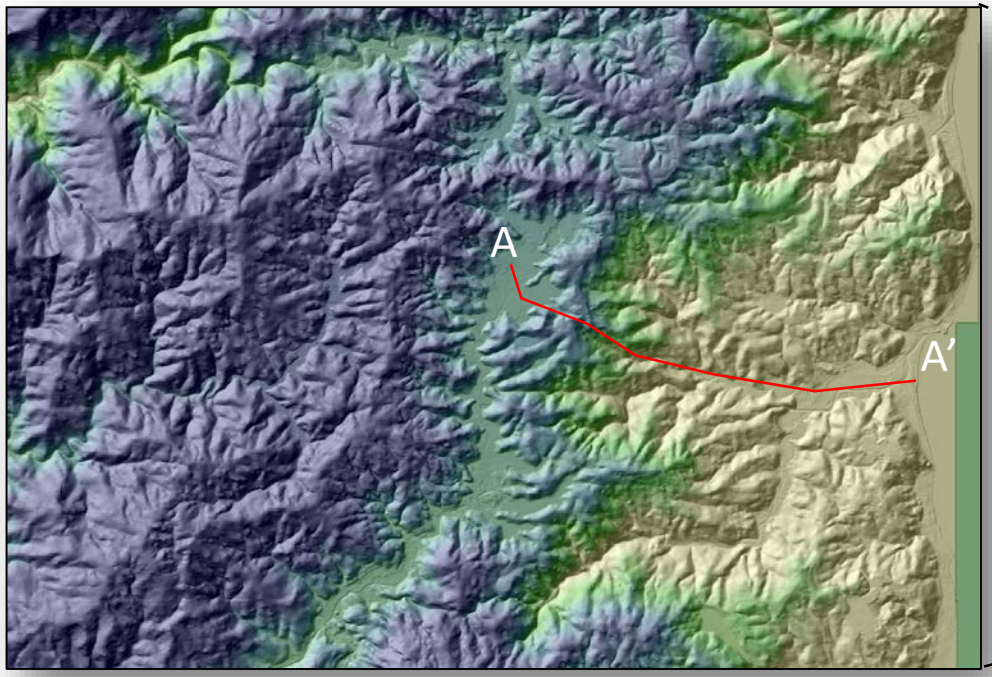
Drainage basins >1 km²

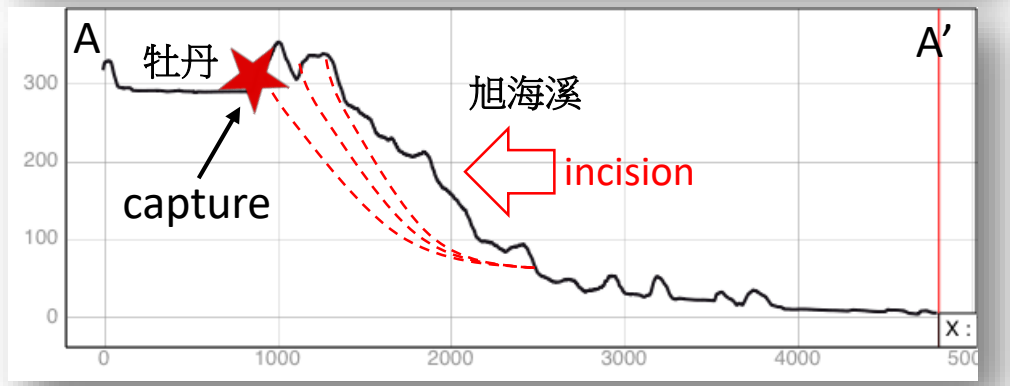
	drainge name	area km²
1	Lilongxia	4
2	Feiqi	1.29
3	Dashipong	4
4	Zhukeng	4.43
5	Shejiekeng	3.25
6	Taigu	1.24
7	Jianshan	1.16
8	Shikeng	2.24
9	Yingqu	1.6
10	Baoli	23.41
11	Xiachengzai	1.24
12	Wangxia	11.53
13	Dongmen	8.83
14	Shiniu	6.76
15	Jialeshui	2
16	Xizaikou	4.3
17	Jiajialian	1.83
18	Badan	2.5
19	Sheru	1.15
20	Luliao	10.86
21	Hanrenyi	1.32
22	Jiupong	21.47
23	Gongzai	15.33
24	Daliu	5.55
25	Xuhai	10.33
26	Yiyansanzhuang	1.69
27	Liren	5.8
28	Guanying	2.2
total area		161.31

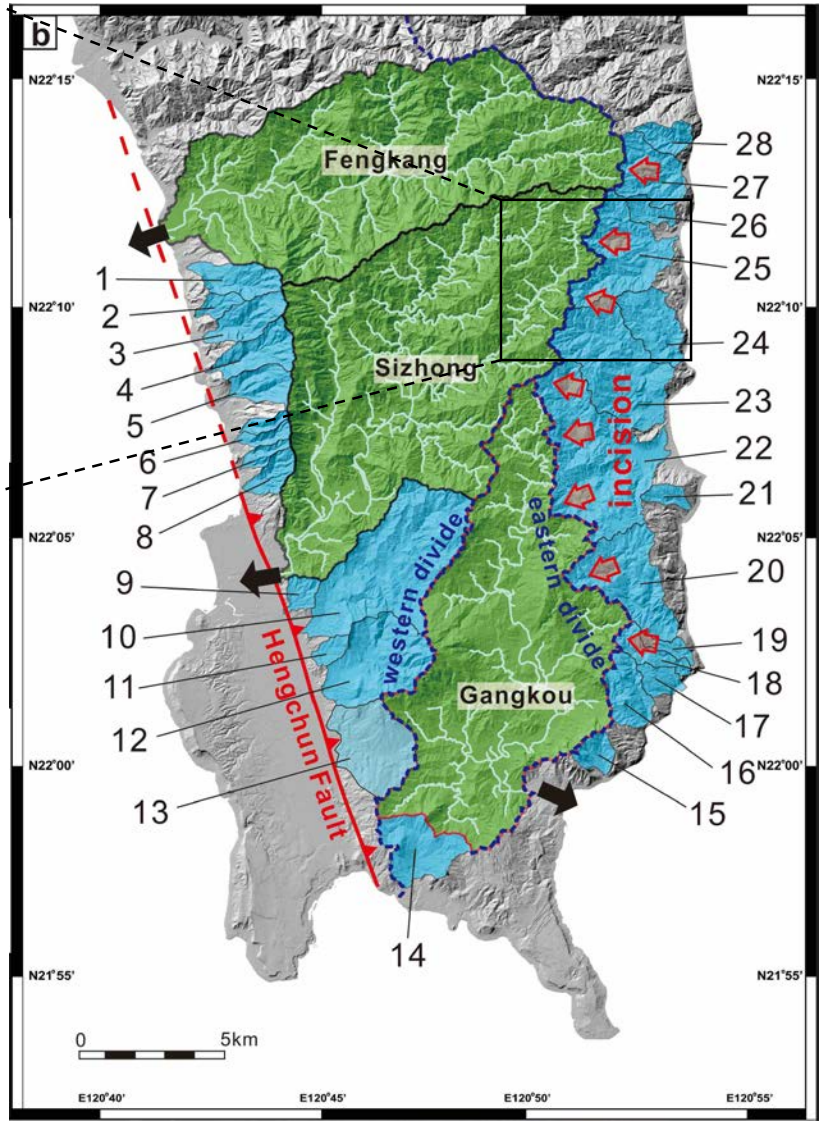
Fengkang basin	102
Sizhong basin	122
Gangkou basin	101

A) Juvenile landscape may by characterized by an anomalous pattern of drainage system…

B) …where drainage divides may not correlate to topographic highs as they are under constant migration or abrupt shifts due to incision and river captures (Huggett, 1988).

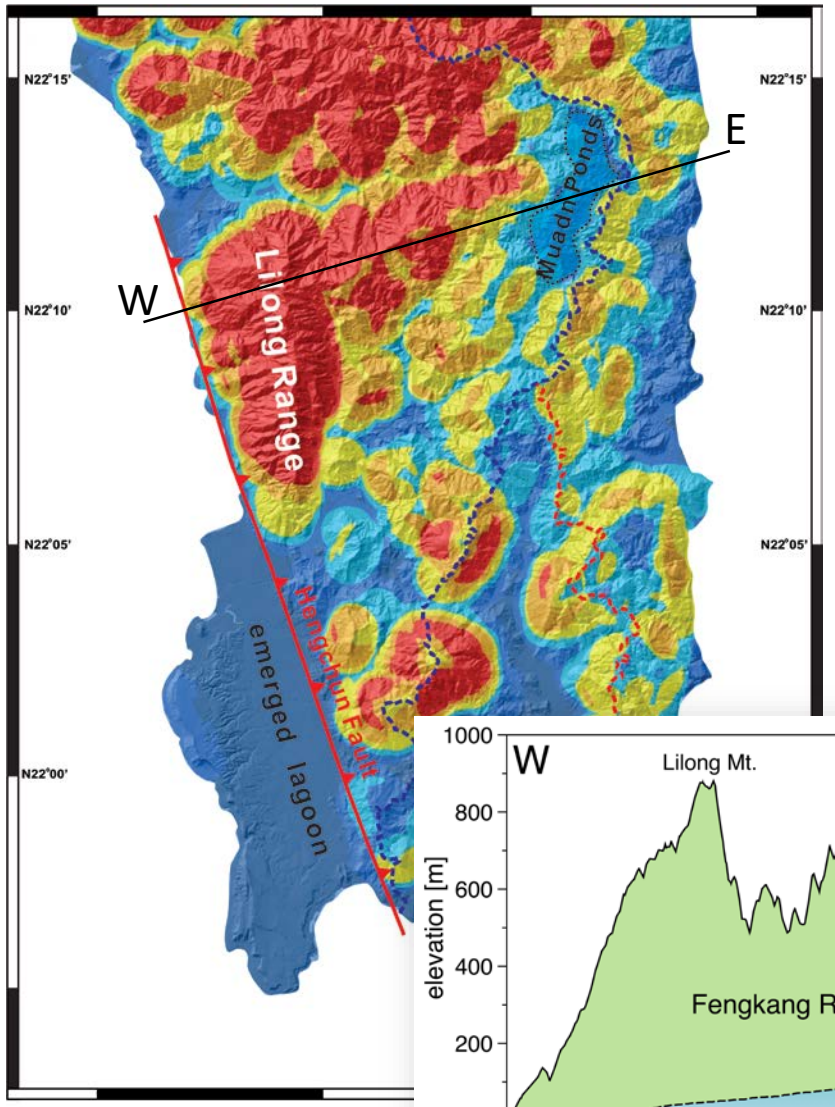




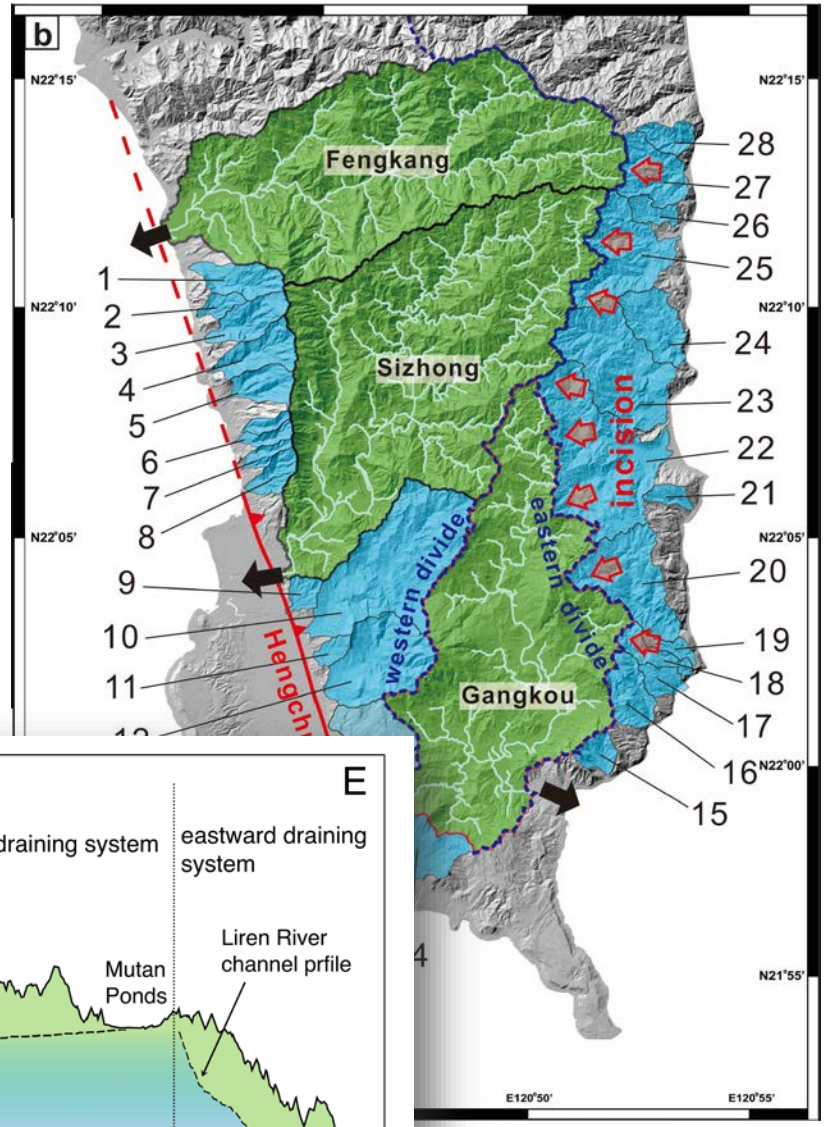


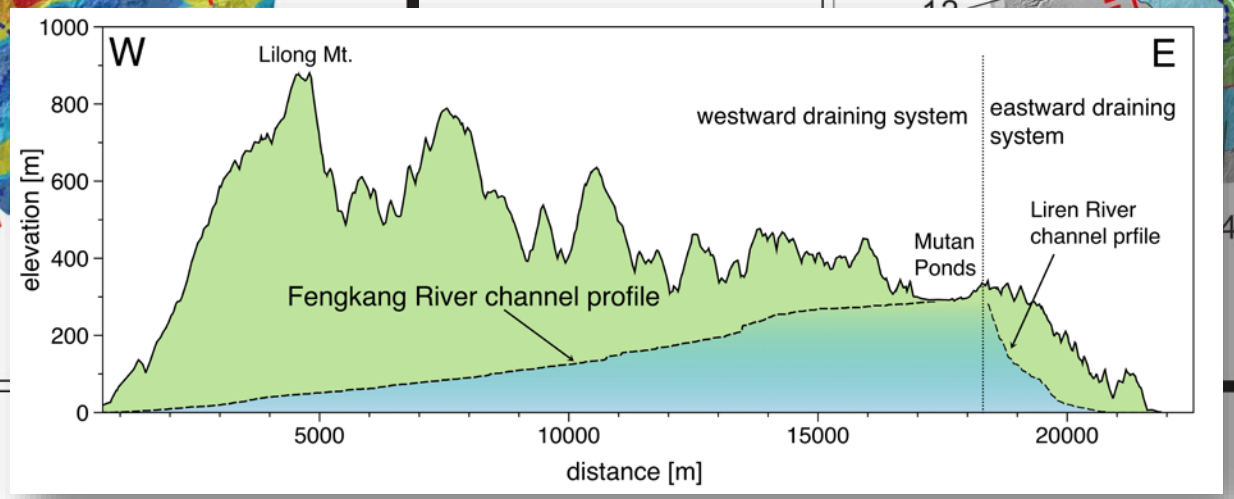
Incision from the east (Ramsey, 2006; Giletycz et al., 2015)

Local relief map (5km sliding window)



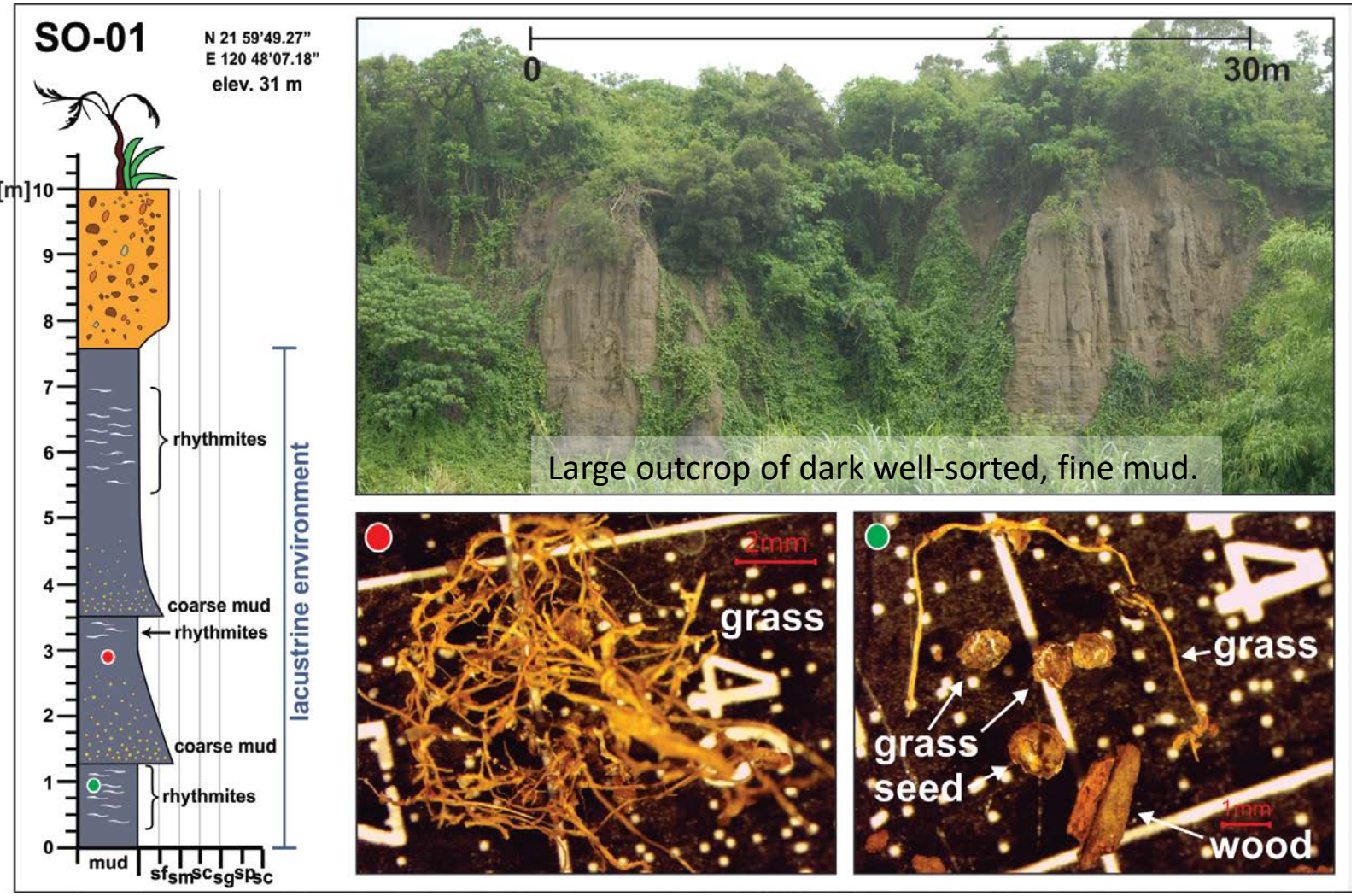
Drainage system of Hengchun Peninsula

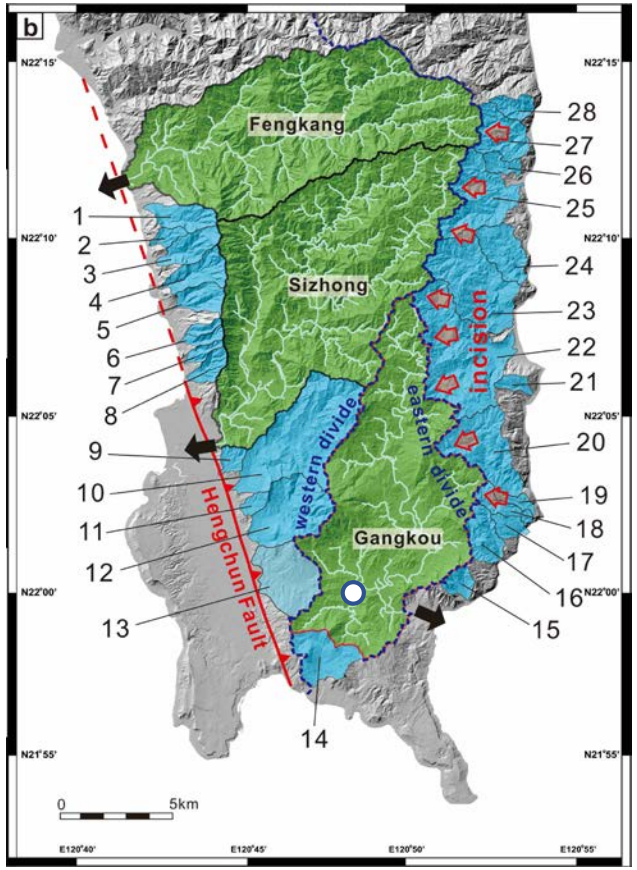




Outcrop SO-01

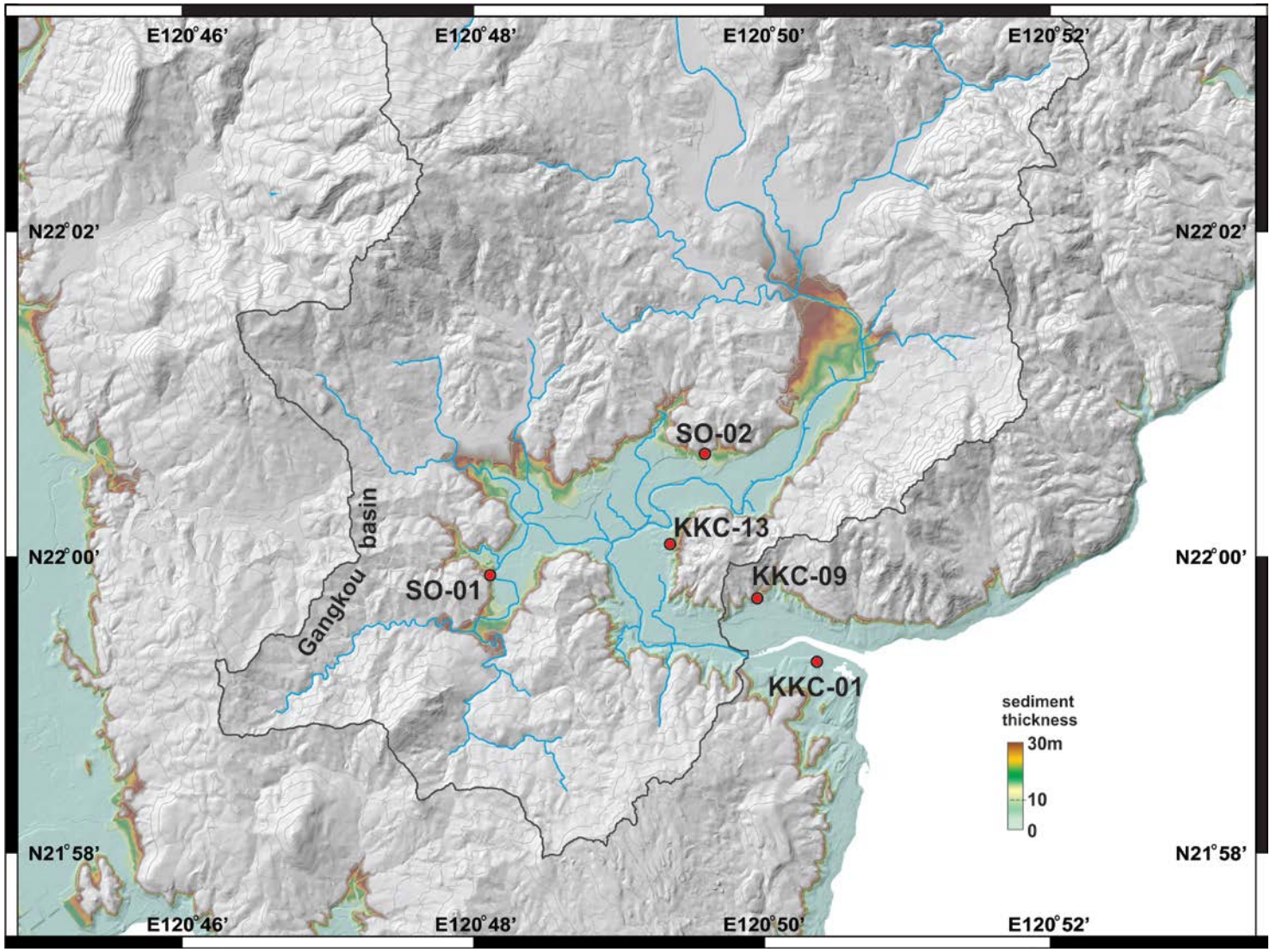
N 21°59’48.8’’ **E** 120°48’06.79’’

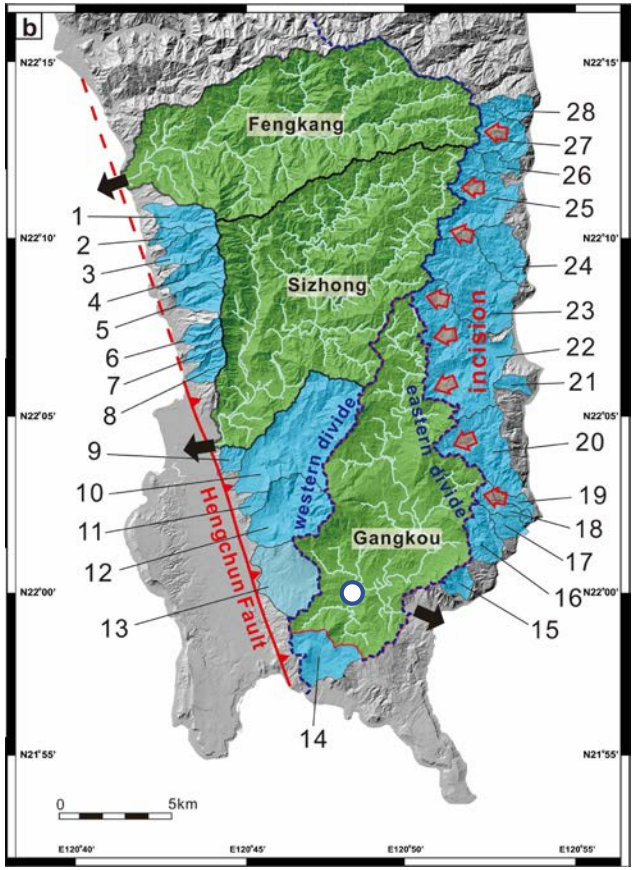




Pollen and grass fossils.

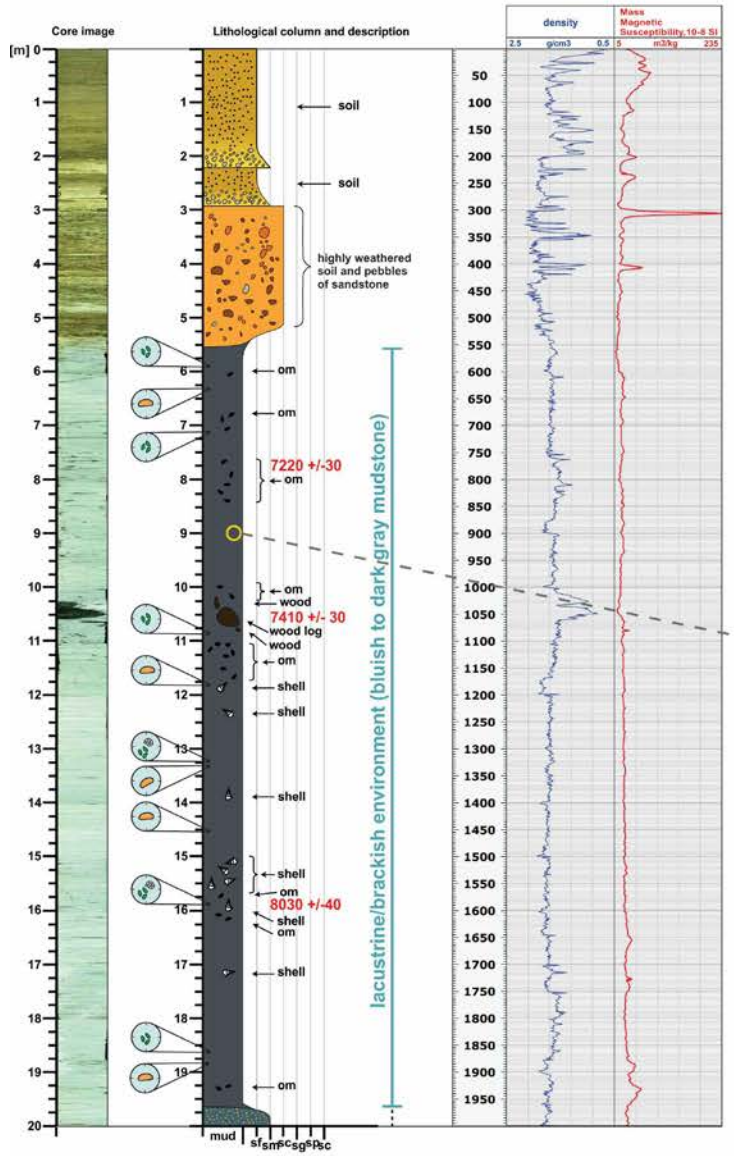
Drilling sites and outcrops.





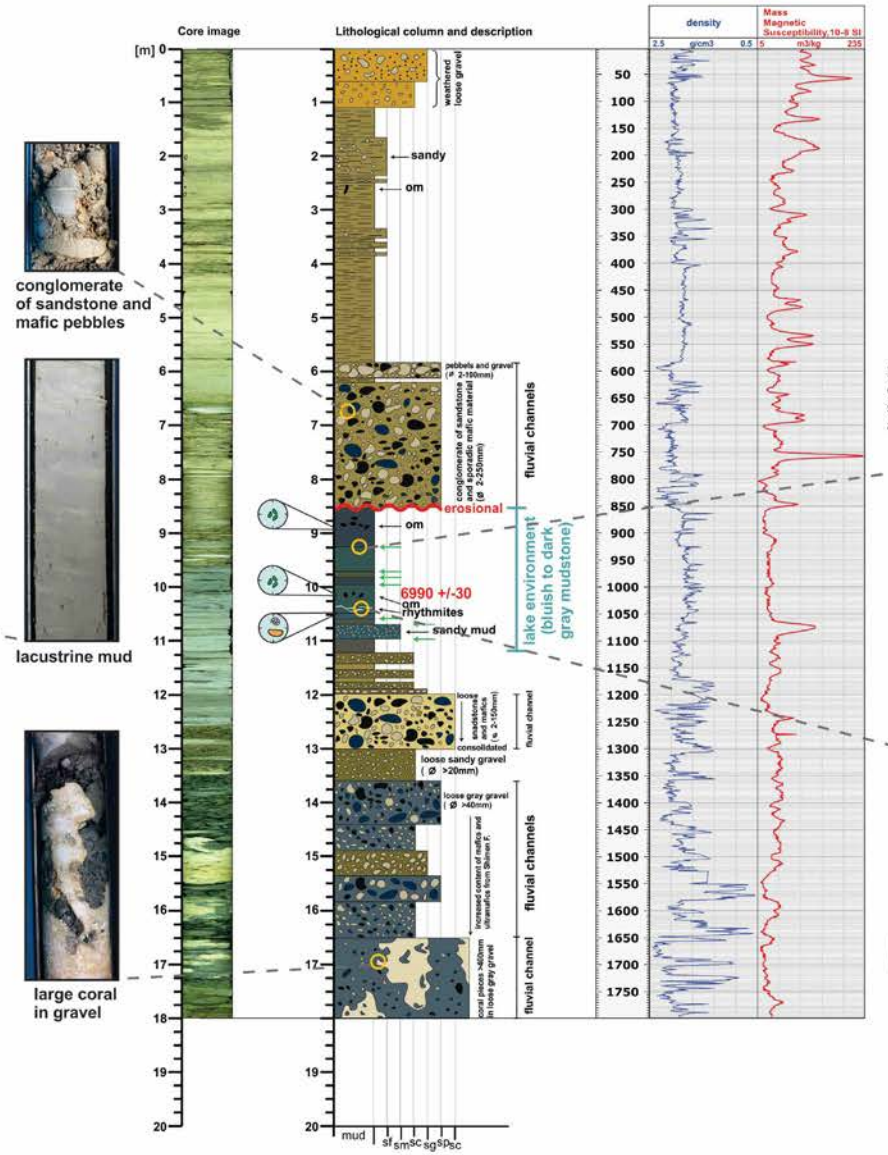
KKC-01

elev. 12 m N 21 59'07.94" E 120 50'23.83"



KKC-09

elev. 10 m N 21 59'29.38" E 120 49'54.30"



conglomerate of sandstone and mafic pebbles

lacustrine mud

large coral in gravel



lacustrine mud covered by sandstone gavels and weathered soil



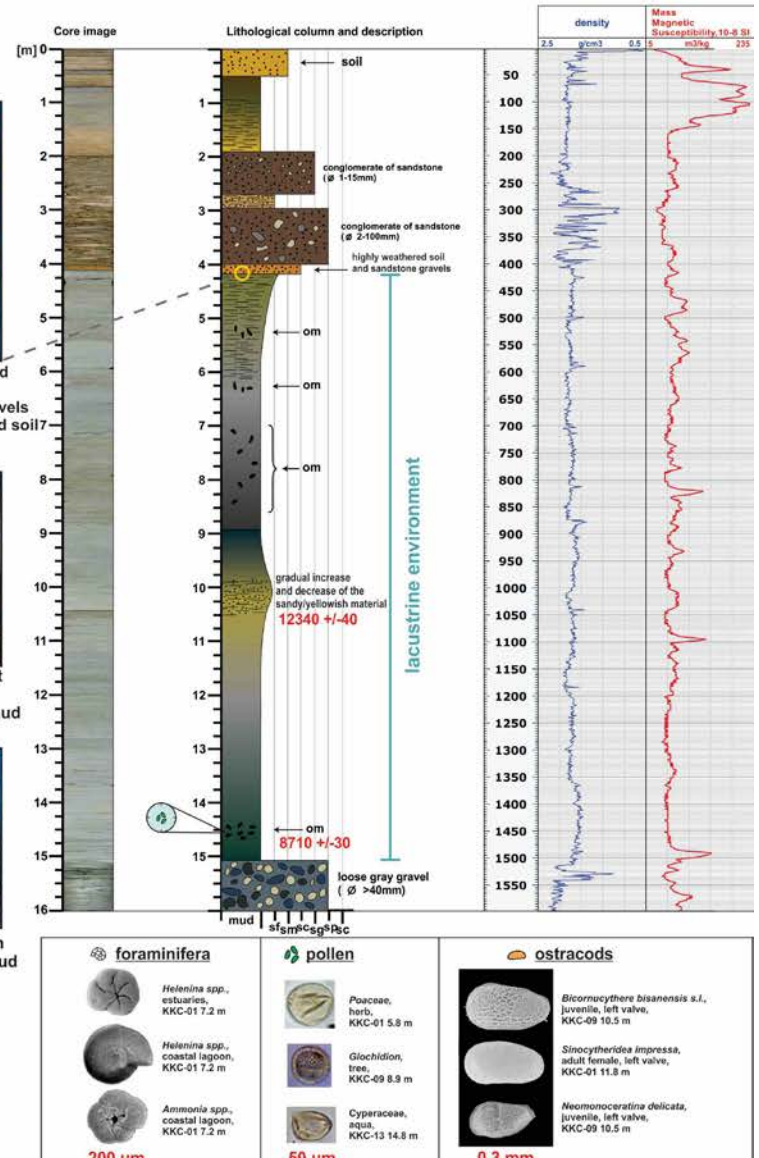
environment change in lacustrine mud

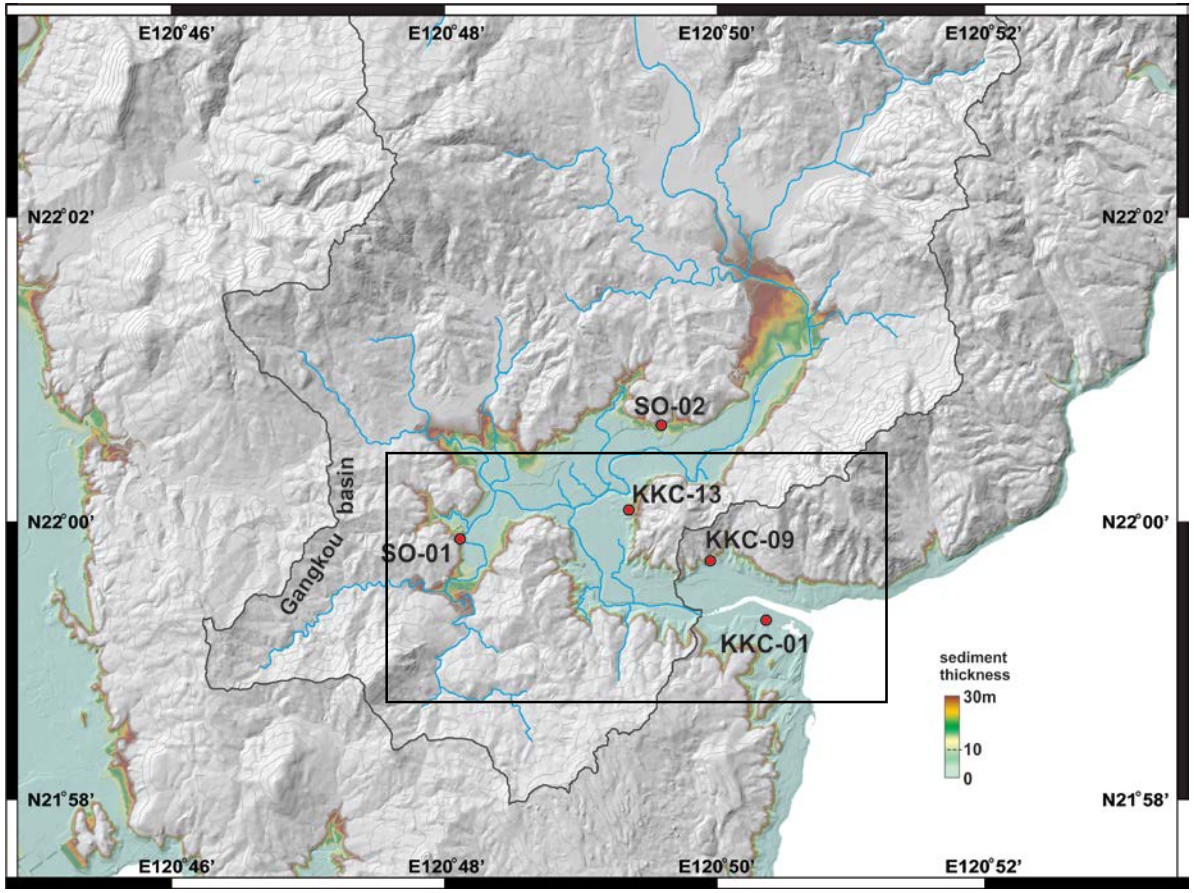


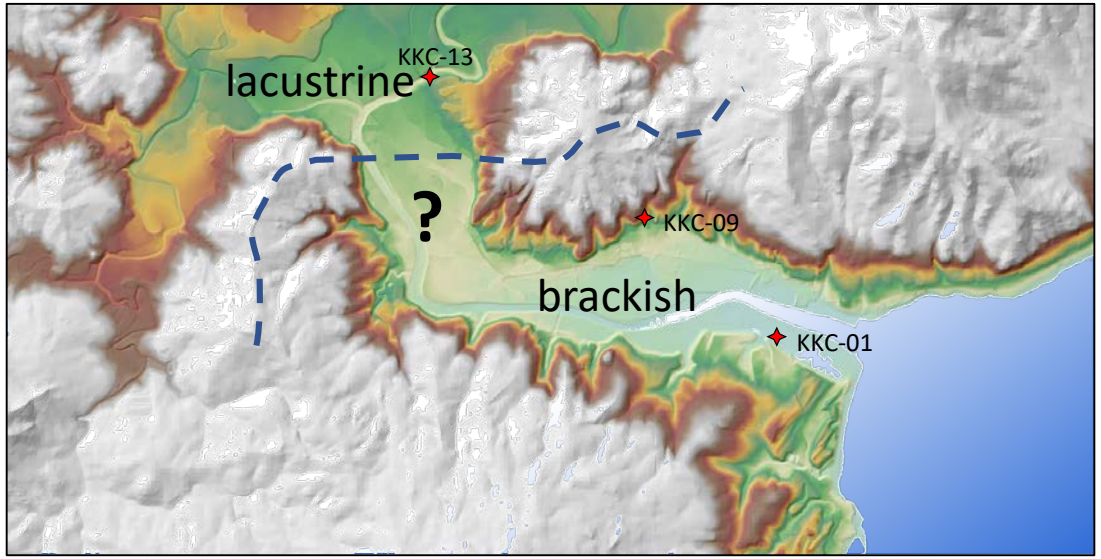
rhythmites in lacustrine mud

KKC-13

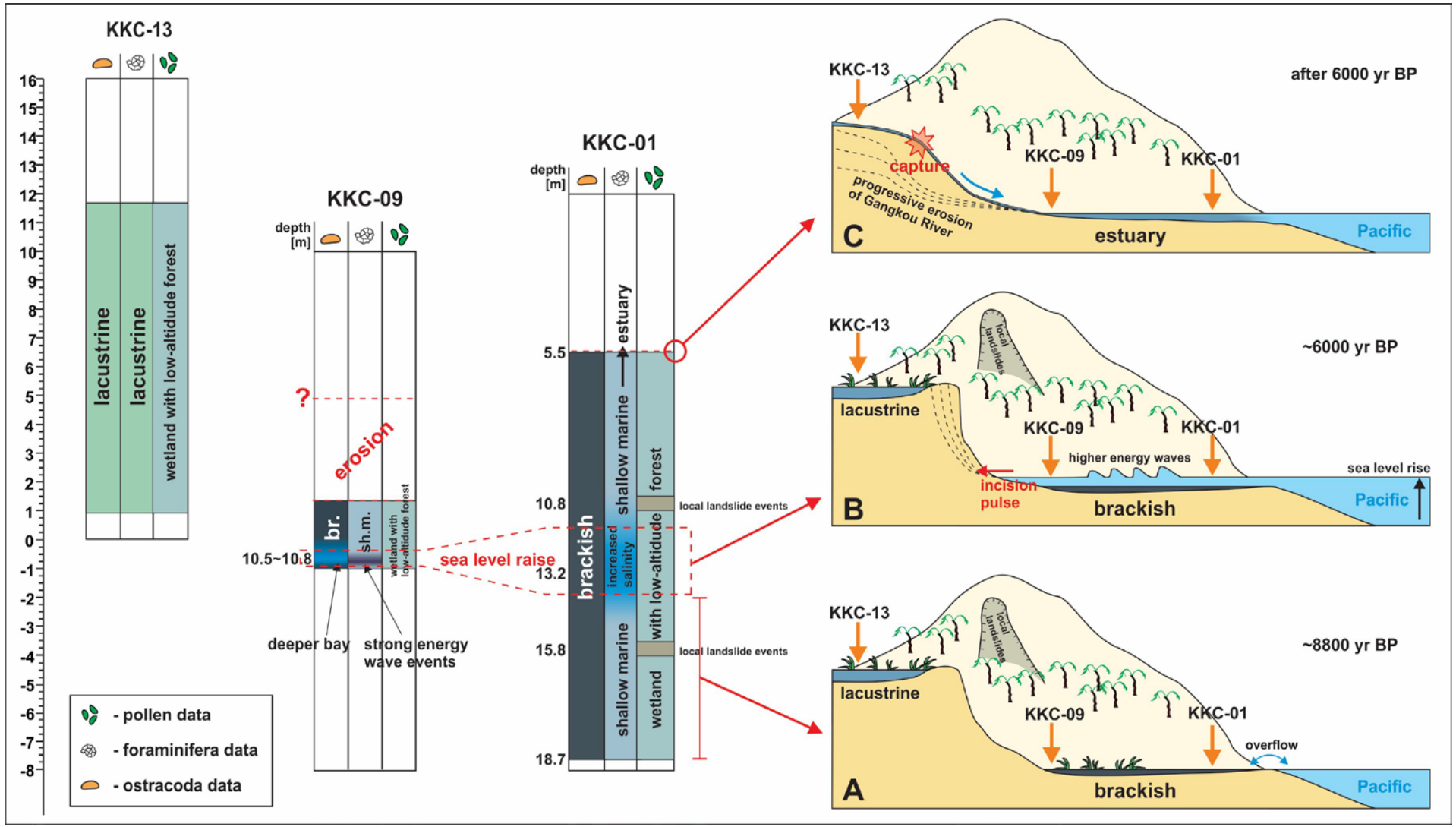
elev. 16 m N 22 00'04.56" E 120 49'09.94"



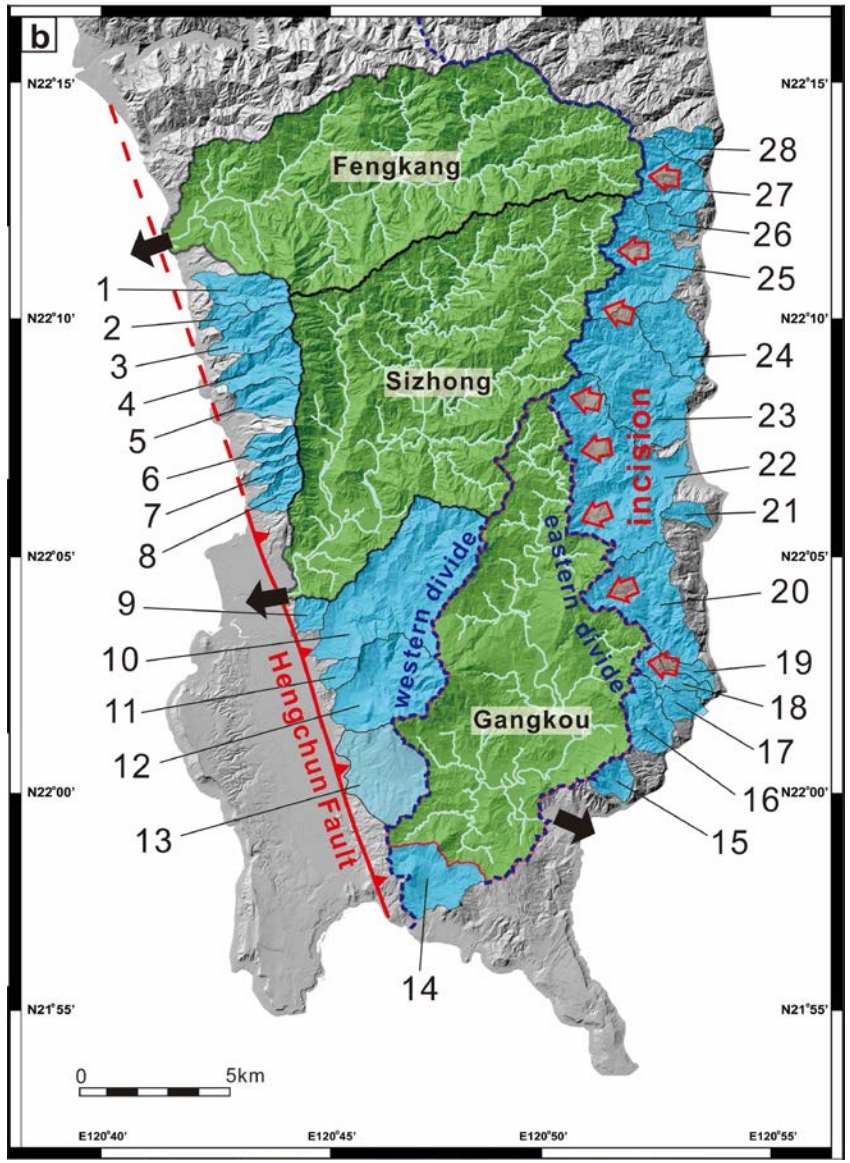

E120°46'
E120°48'
E120°50'
E120°52'
N22°02'
N22°00'
N21°58'
SO-02
KKC-13
KKC-09
SO-01
KKC-01
Gangkou basin
sediment thickness
30m
10
0


lacustrine
KKC-13
?
KKC-09
brackish
KKC-01

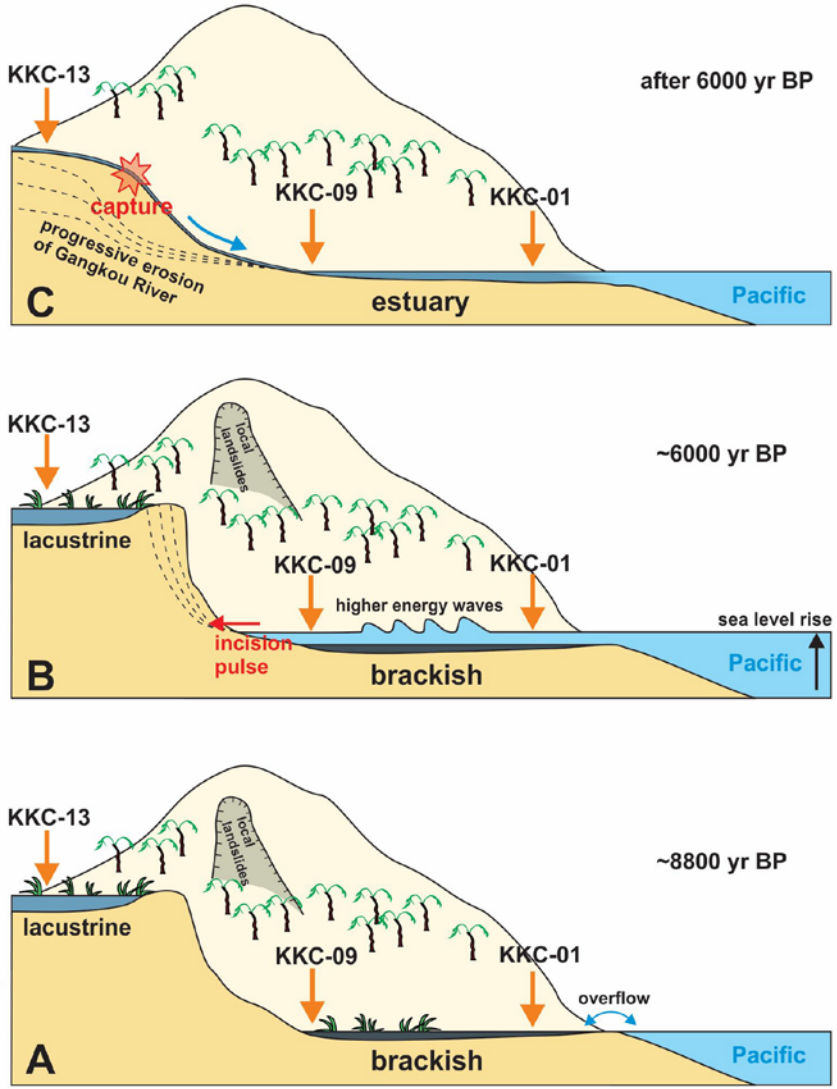
Evolutionary model of brackish waters into Gangkou estuary



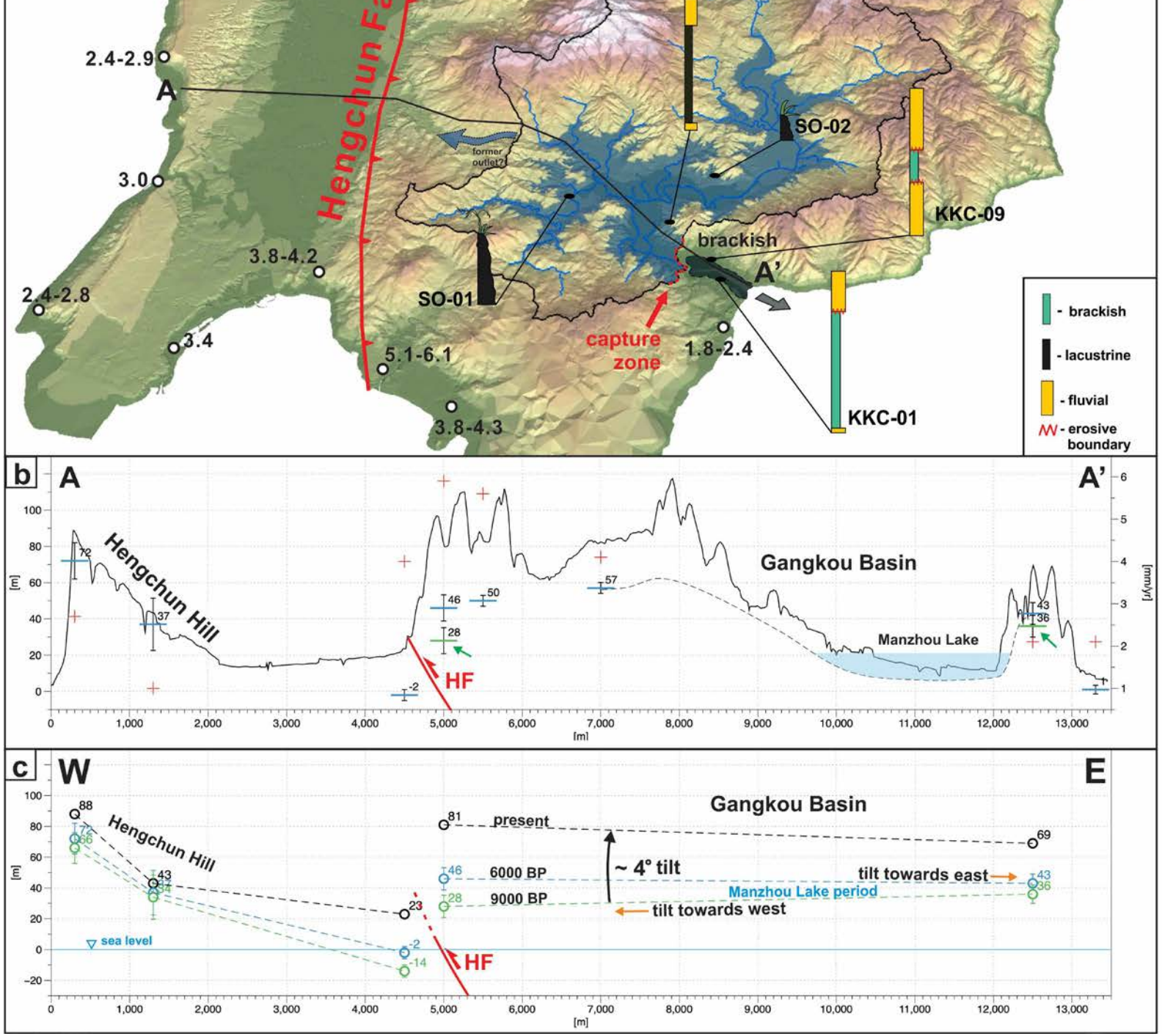
Incision as along the eastern Coast



Evolutionary model of brackish waters into Gangkou estuary

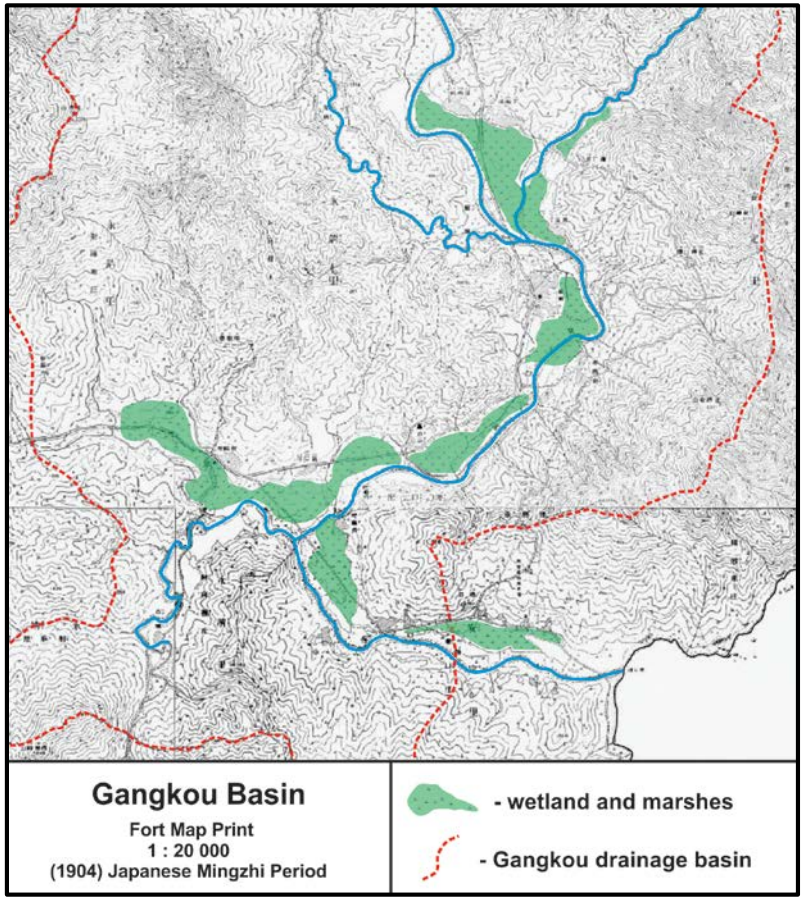


Lake simulation and tectonic deformation across the Hengchun Peninsula.



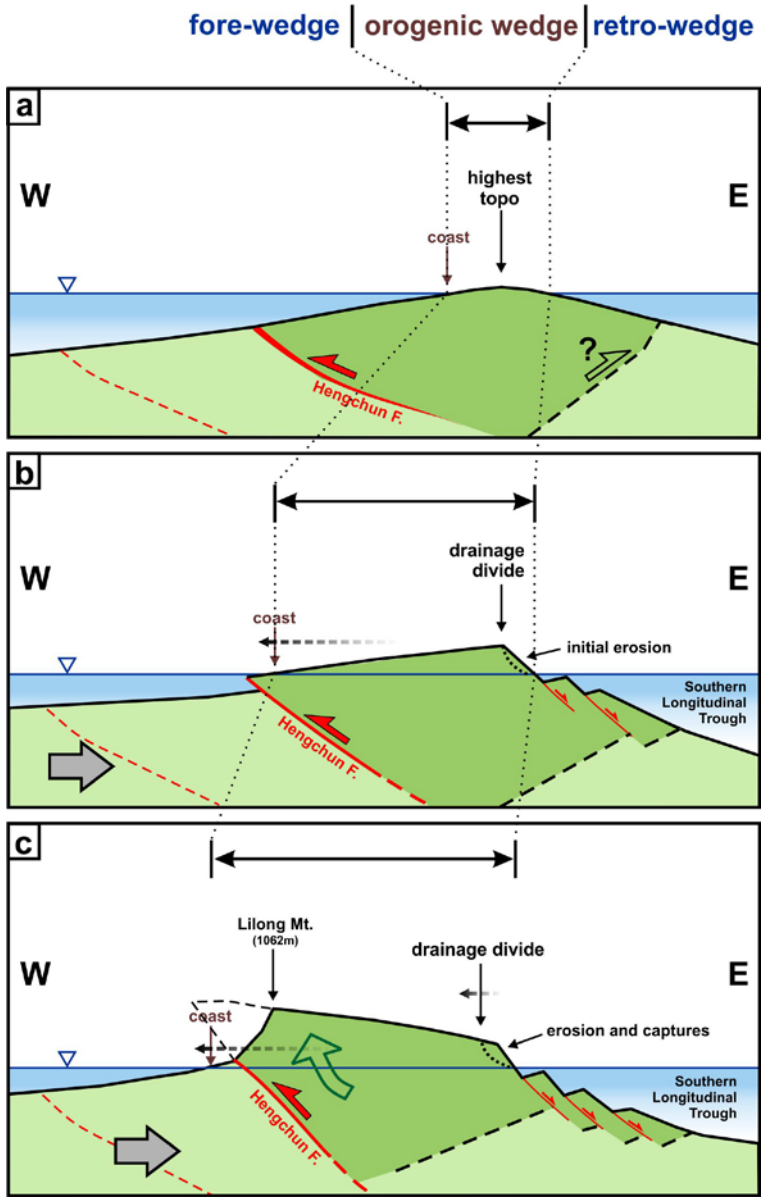
(*submitted*, Giletycz et al.)

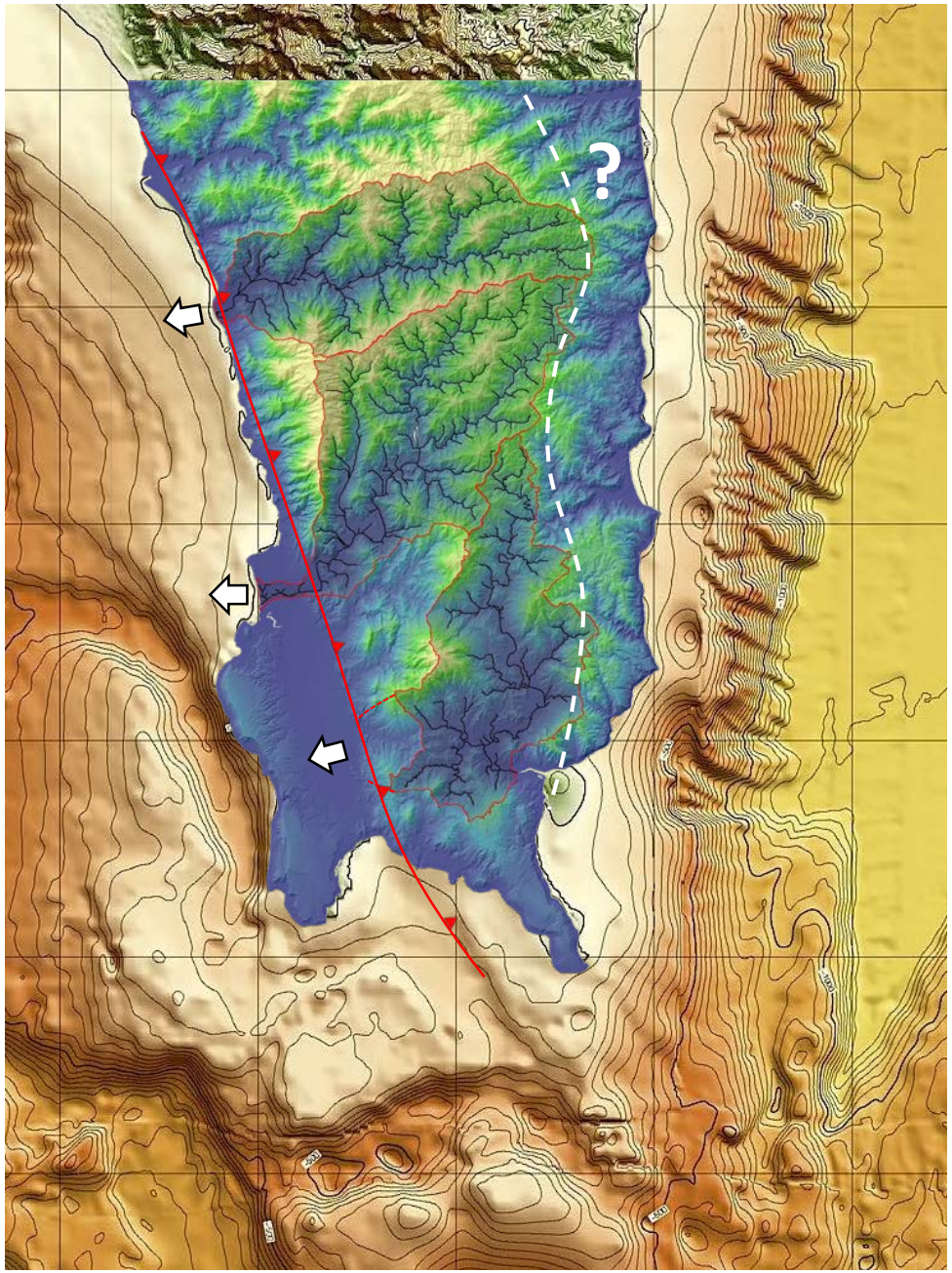
Draining Manzhou Lake into Pacific



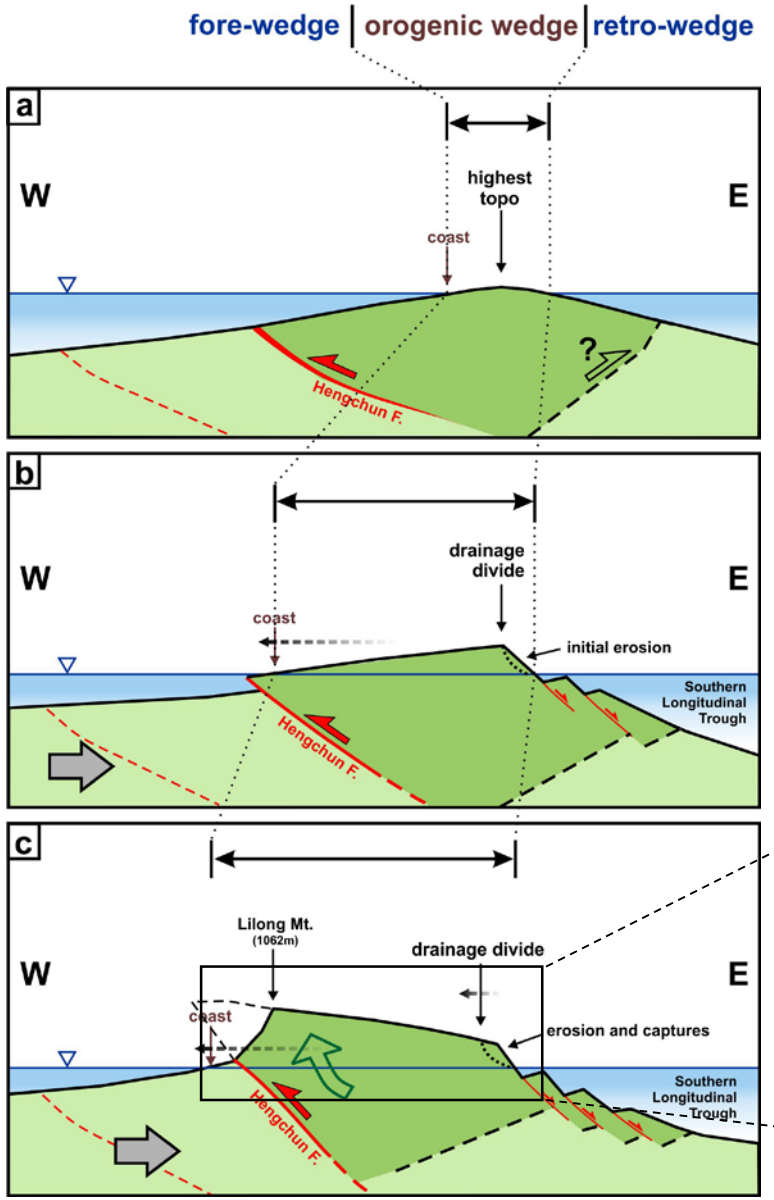
Post-Japanese map of the Gangkou Basin from 1904 (Mingzhi Period)

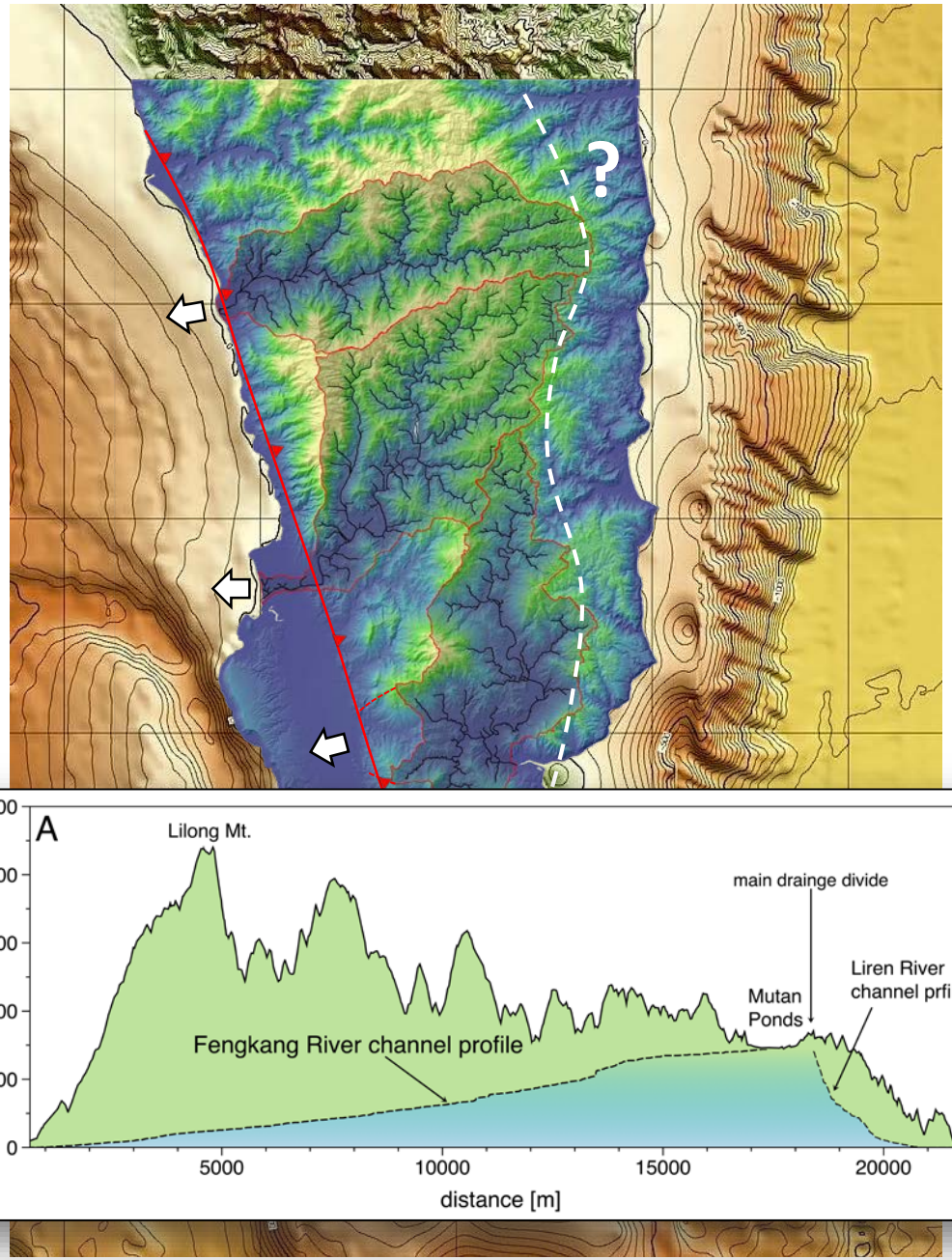
Evolutionary model of Hengchun Peninsula.



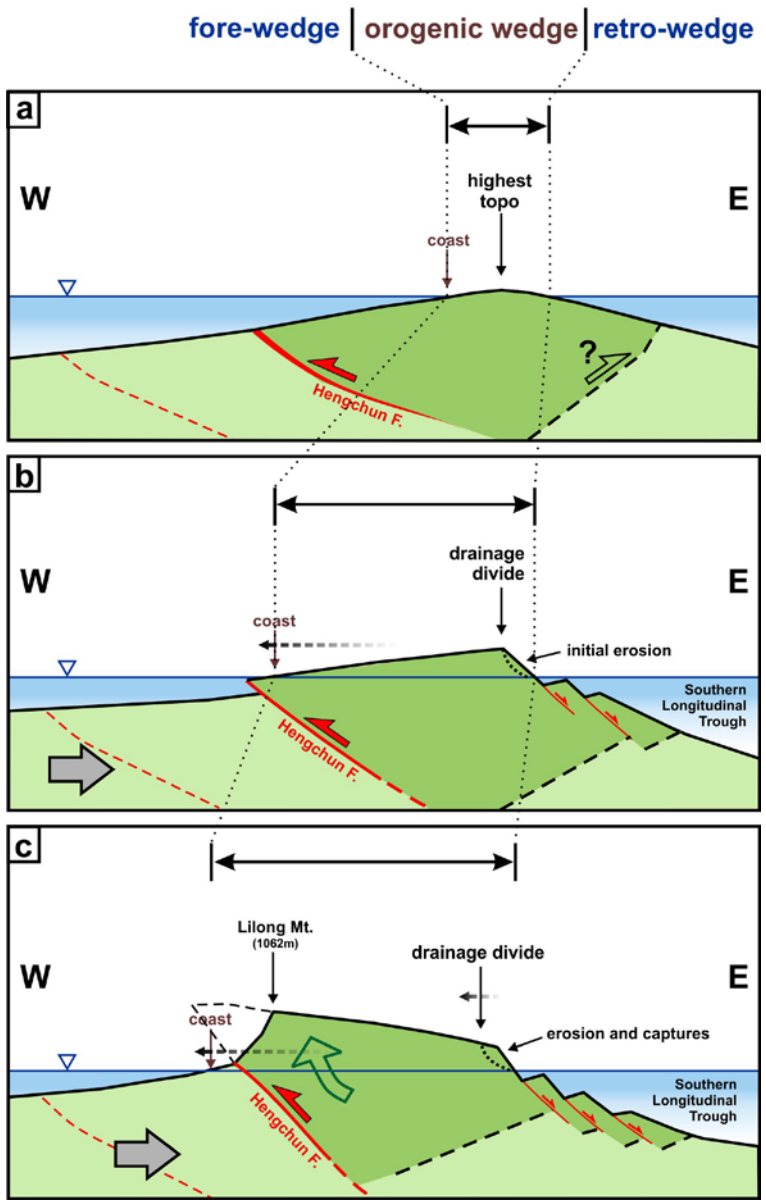


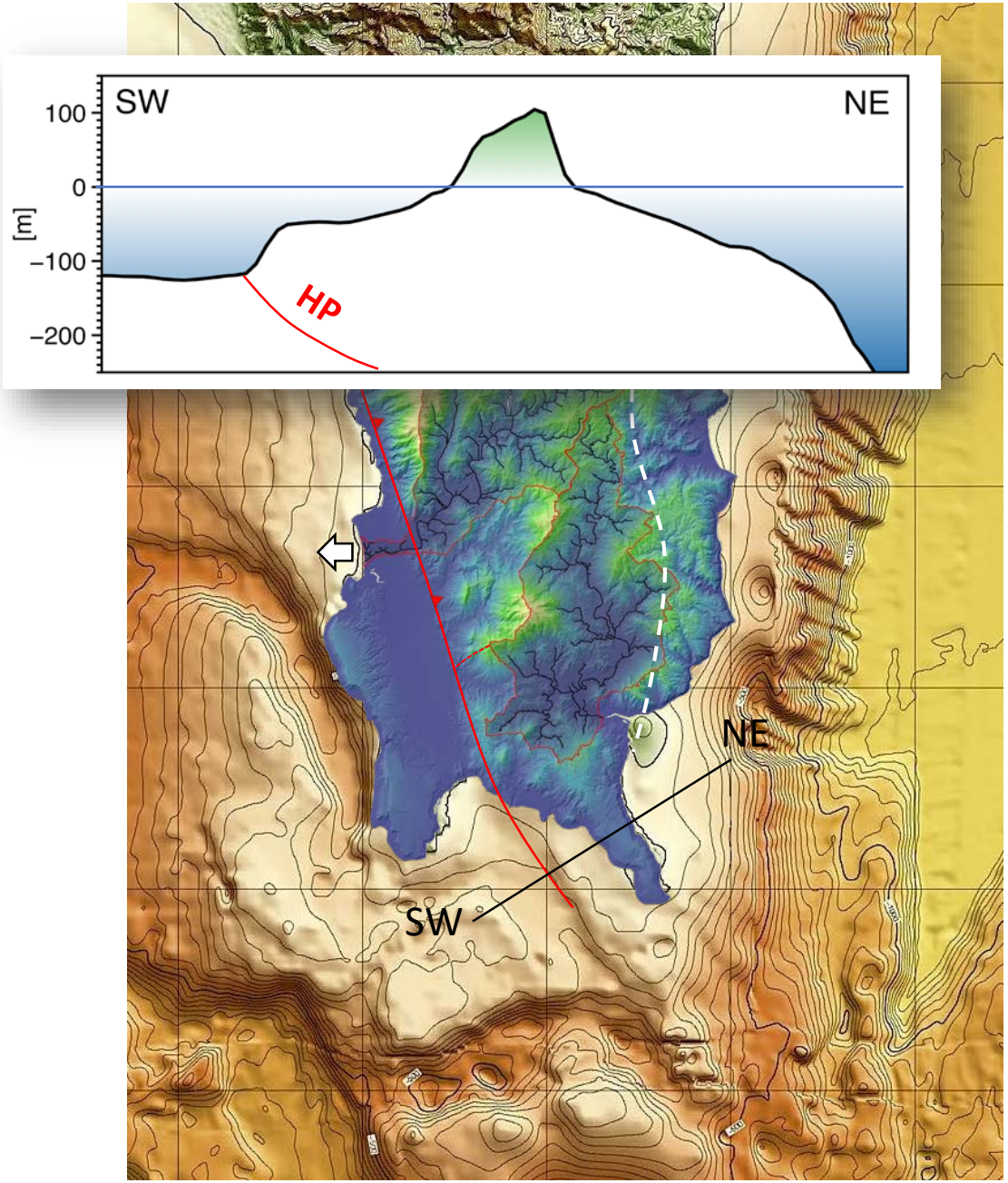
Evolutionary model of Hengchun Peninsula.

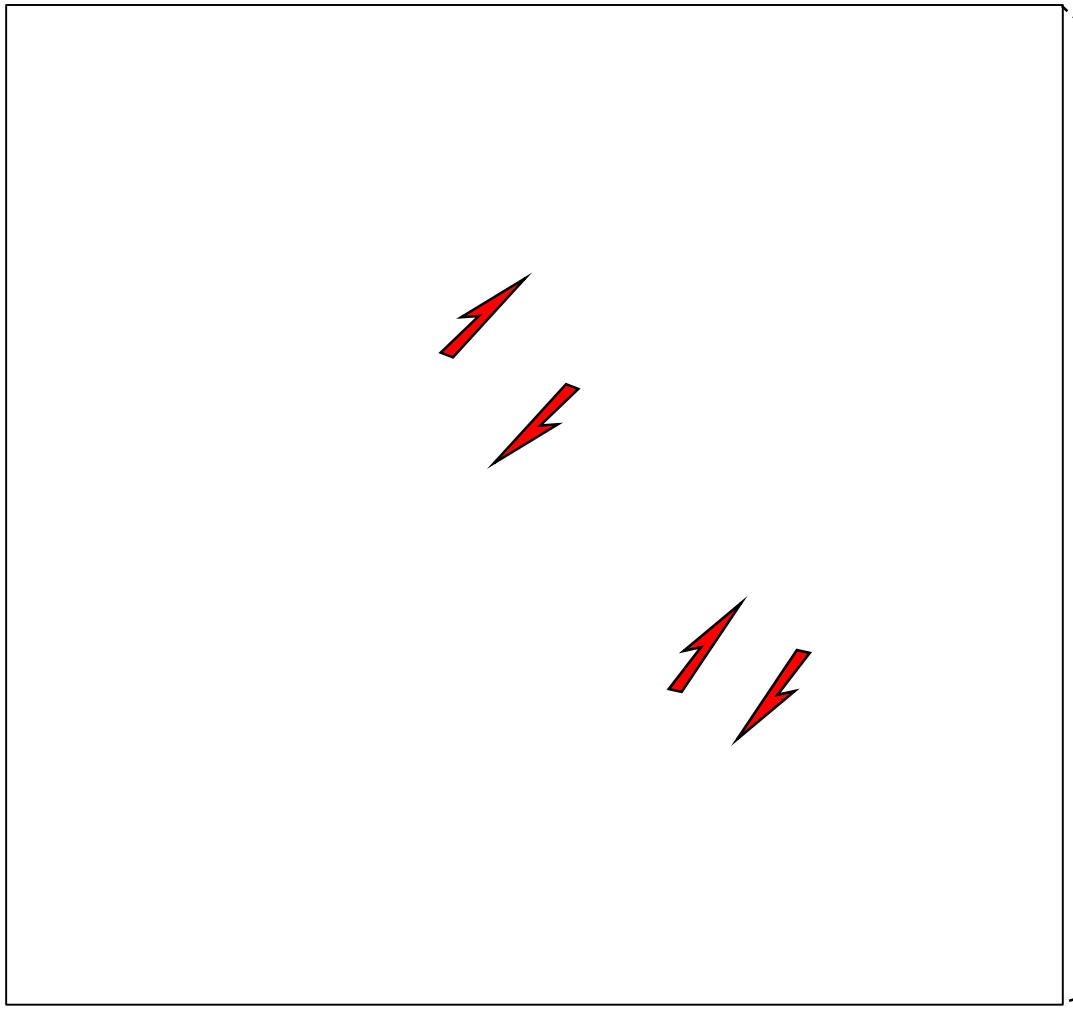


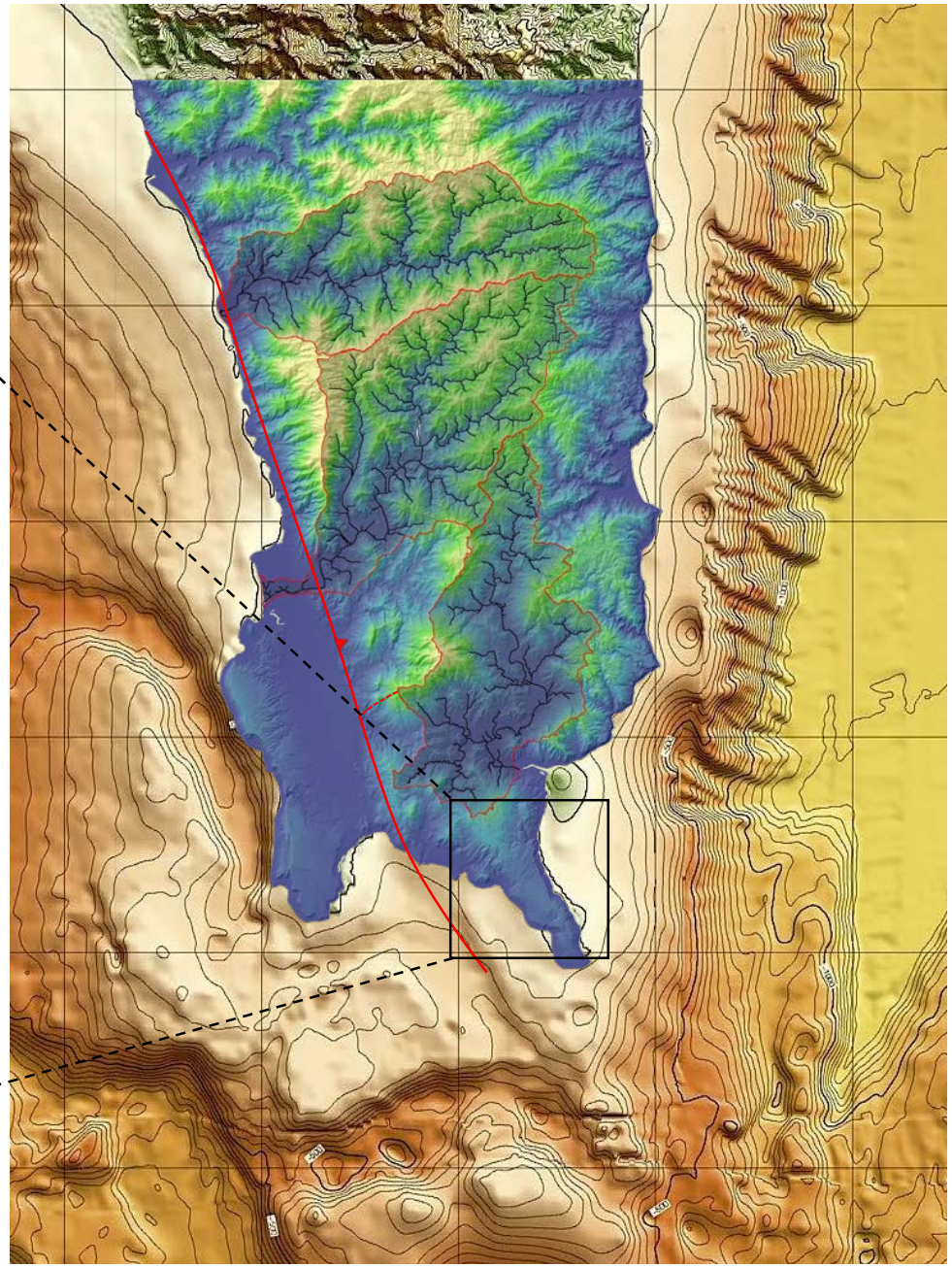


Evolutionary model of Hengchun Peninsula.





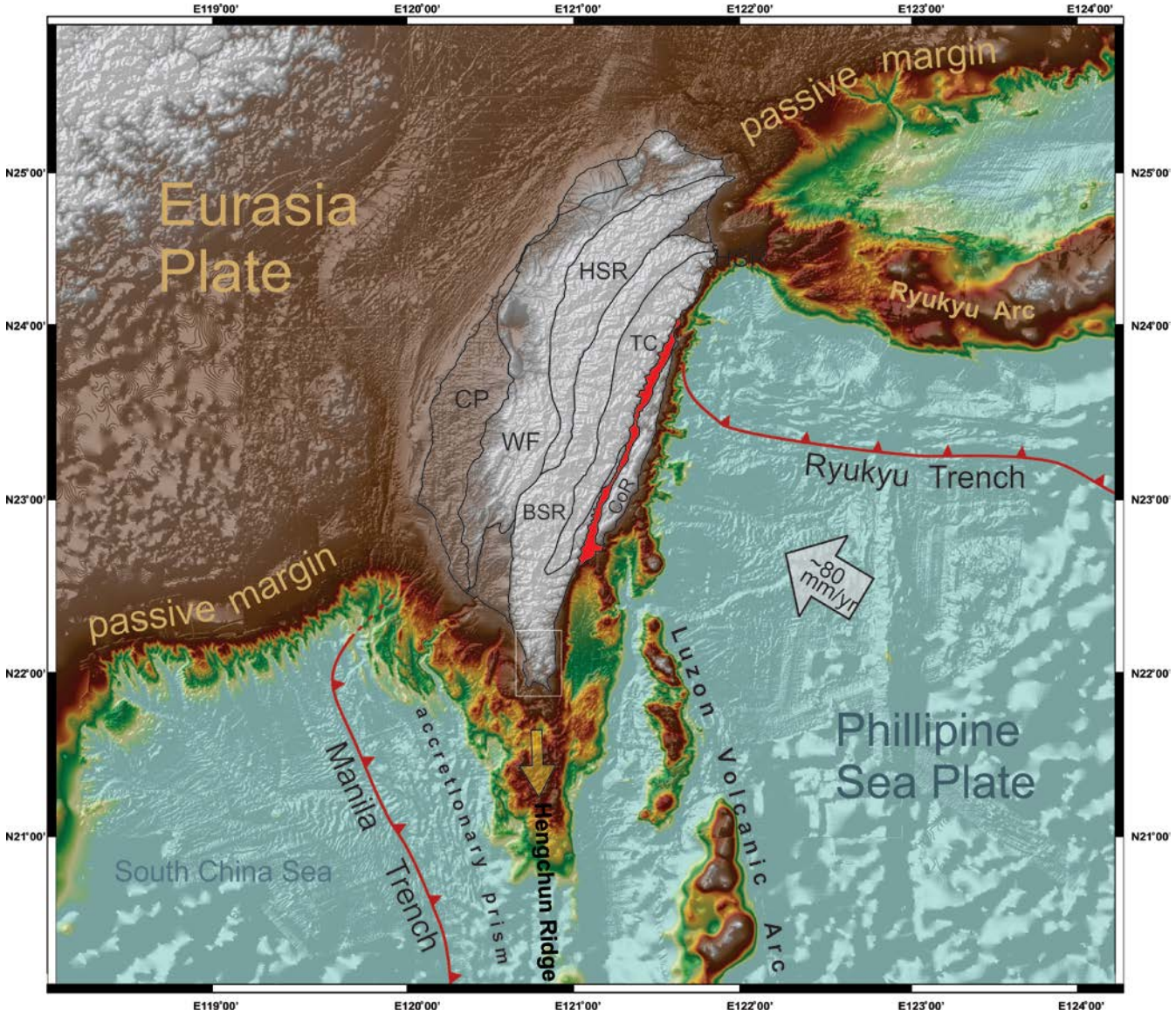




Strike-slip faults in Oluanpi ‘sub-peninsula’

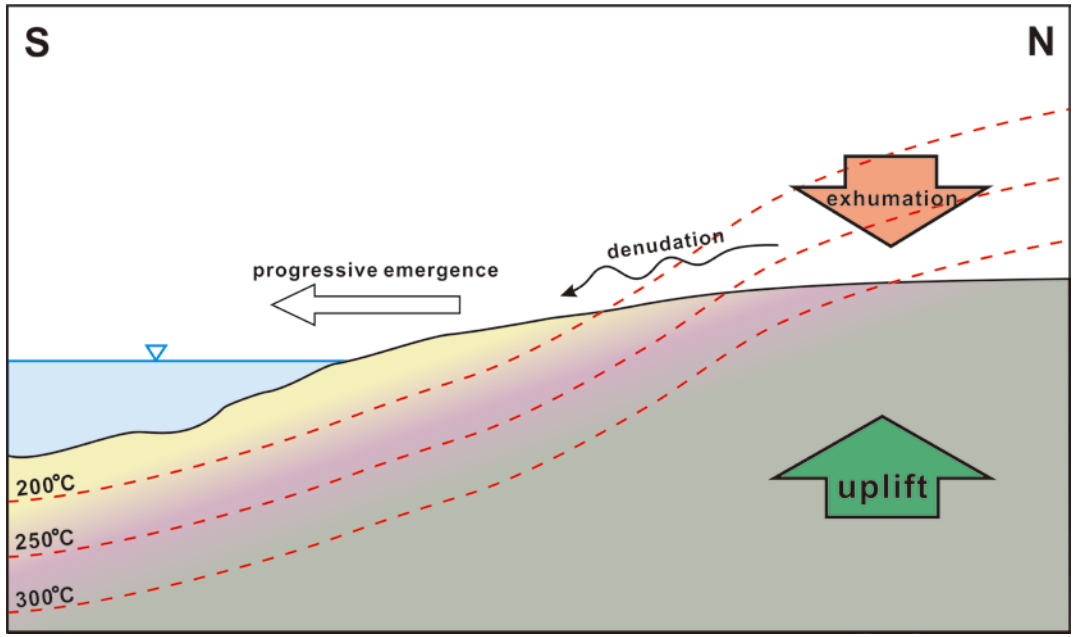
2

Exhumation patter in emerging topography

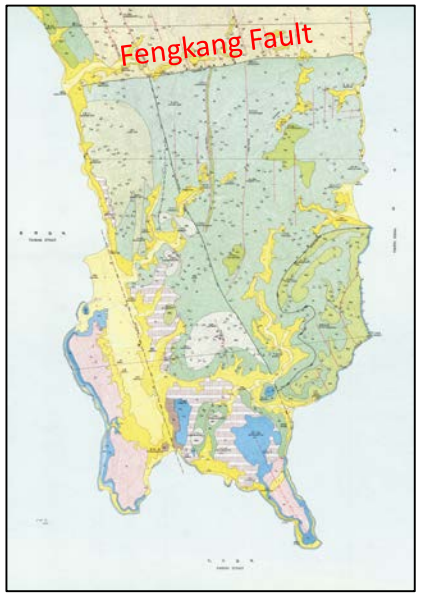


(*in prep.*, Giletycz et al.)

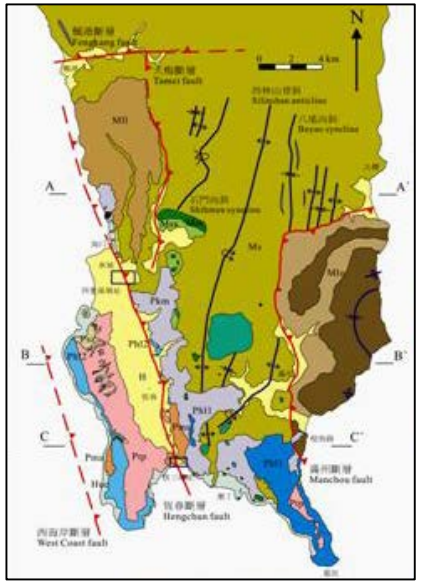
Transition from diagenesis to low-metamorphism grade.



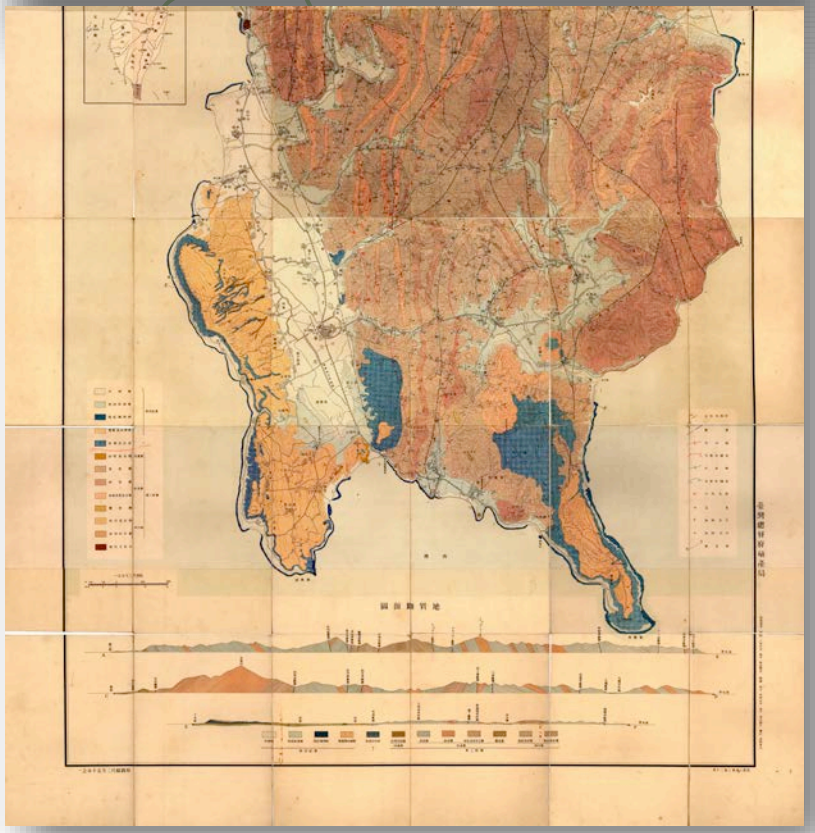
What is the exhumation pattern of the Hengchun Peninsula?



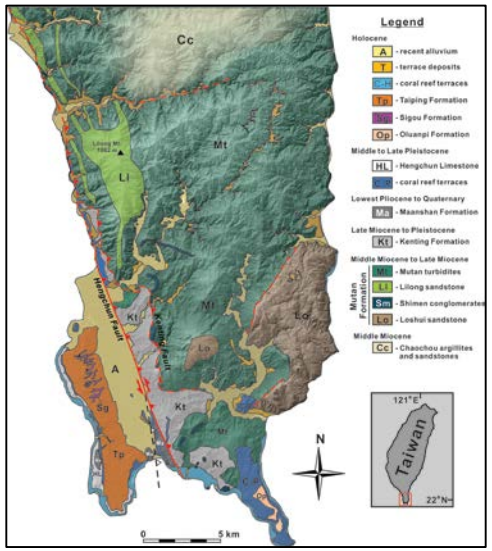
(CGS, 1997)



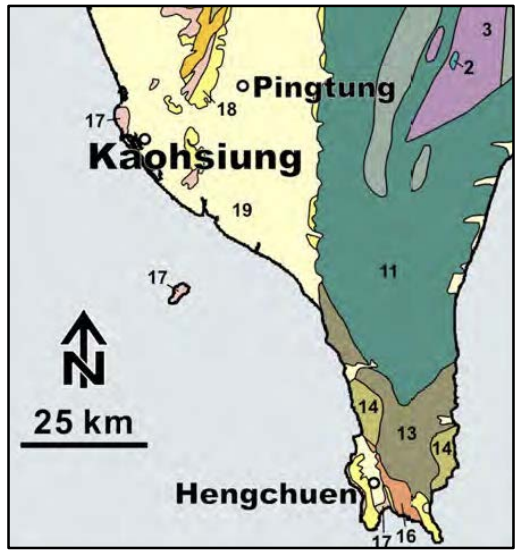
(陳文山, 1999)



First geological map of the Hengchun Peninsula
(Rokkaku and Makiyama; 1934- 昭和9年)



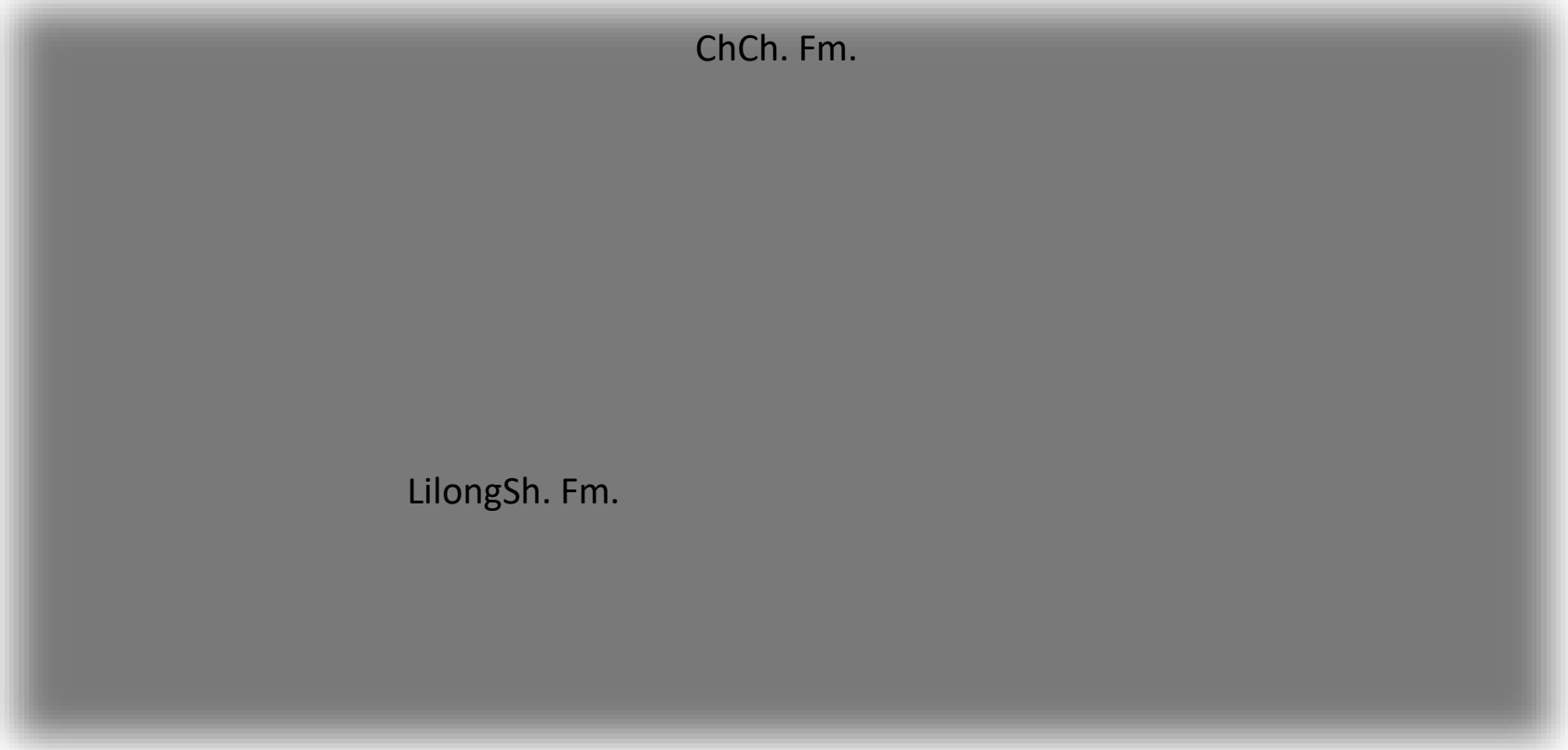
(Giletycz et al., 2015)



(Angelier et al., 2008)

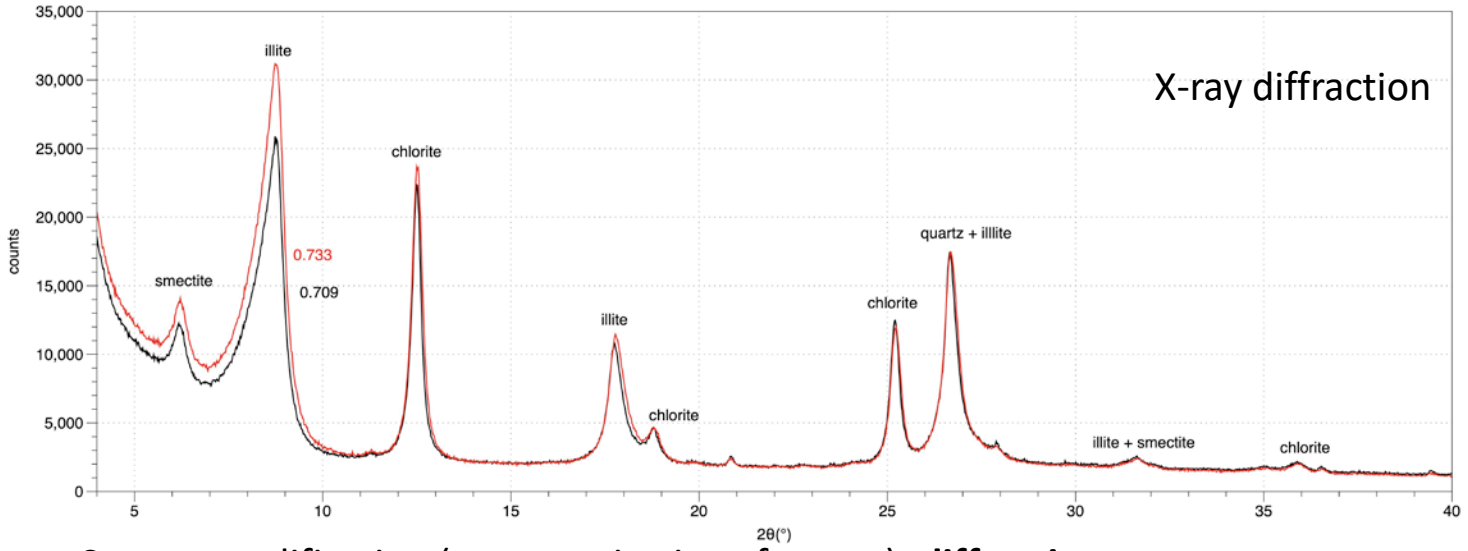
1) No Fengkang Fault,

2) Never found any indication in the field.

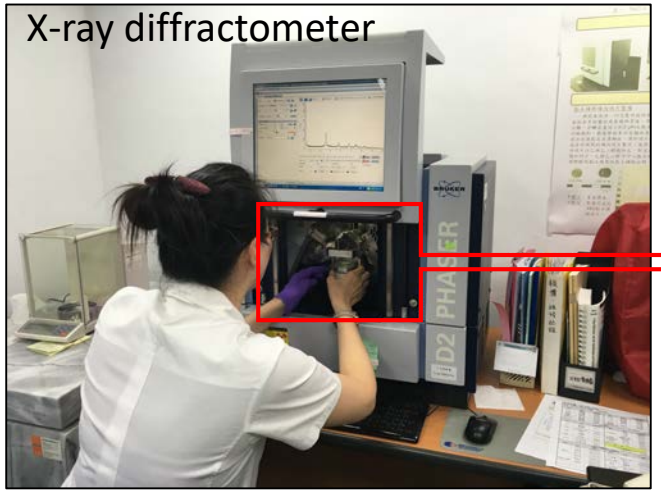


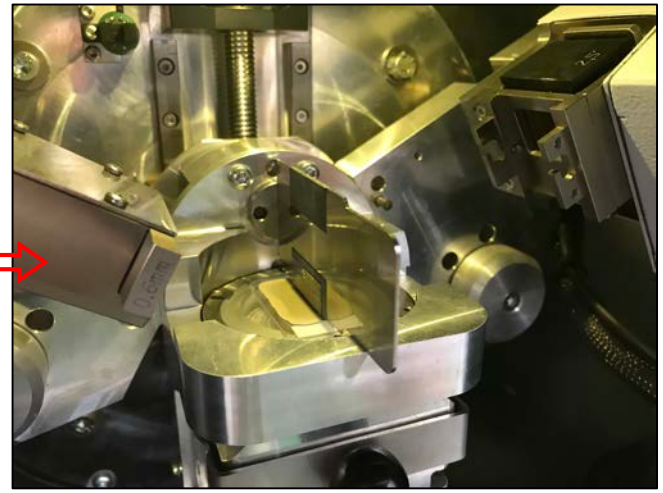
First geological map of the Hengchun Peninsula
(Rokkaku and Makiyama; 1934- 昭和9年)

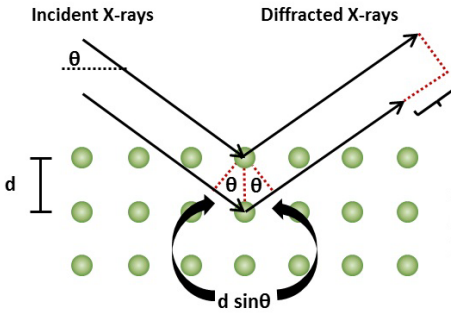
Illite crystallinity



Strong amplification (constructive interference): **diffraction**
– that characterize atomic crystal structure of minerals that the sample is made.







Constructive interference when

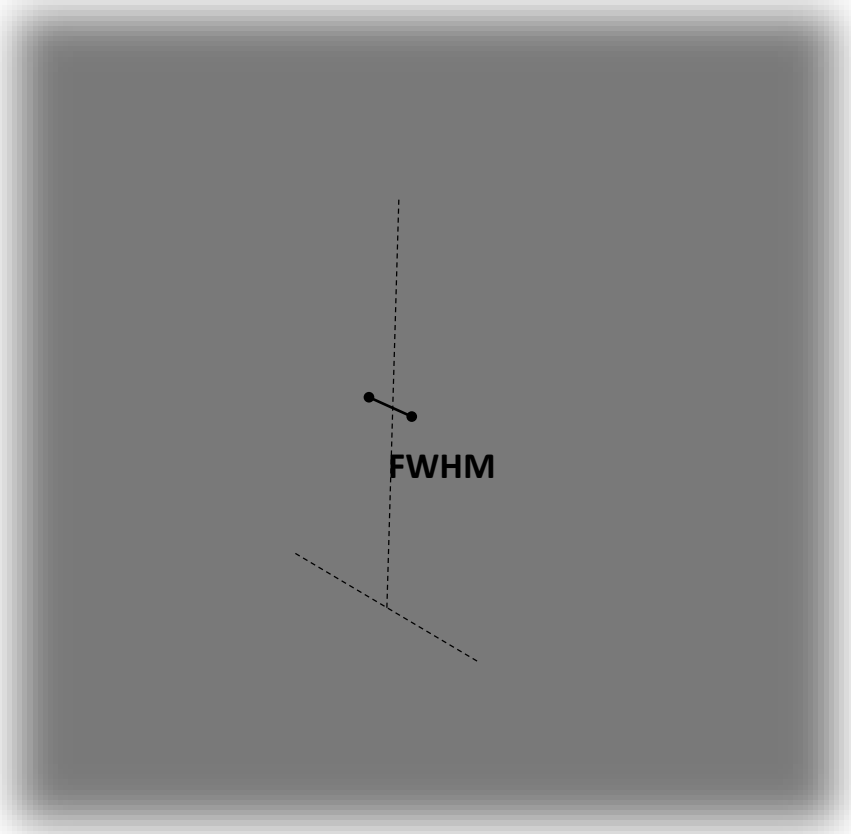
$n\lambda = 2d \sin\theta$

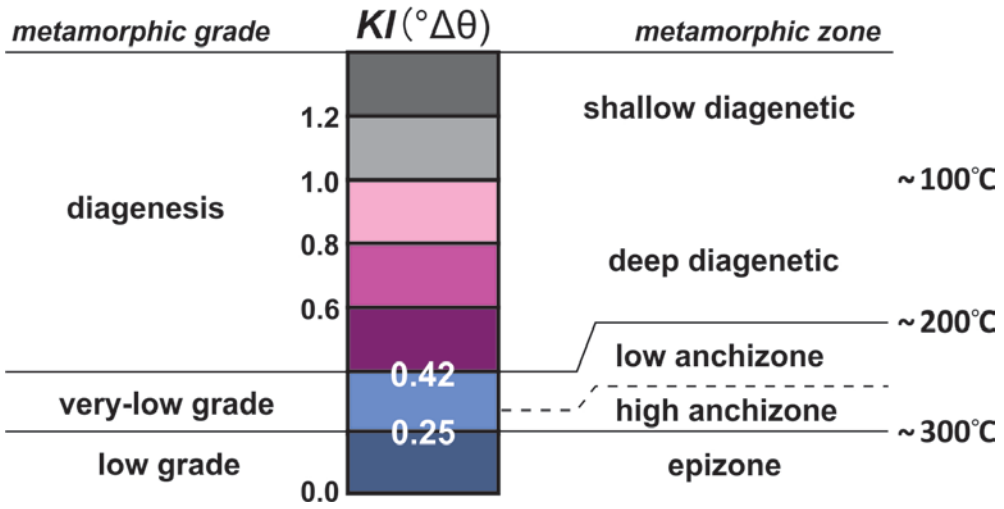
Bragg's Law

Each of the crystals is composed of the regular arrangement of atoms.

Measure of the full width at maximum (**FWHM**) (~10Å) – **Kübler Index**

of the first illite diffraction peak.



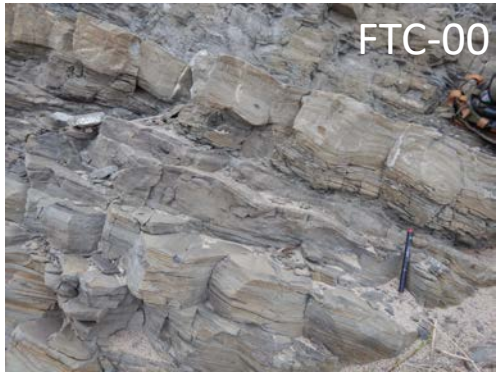


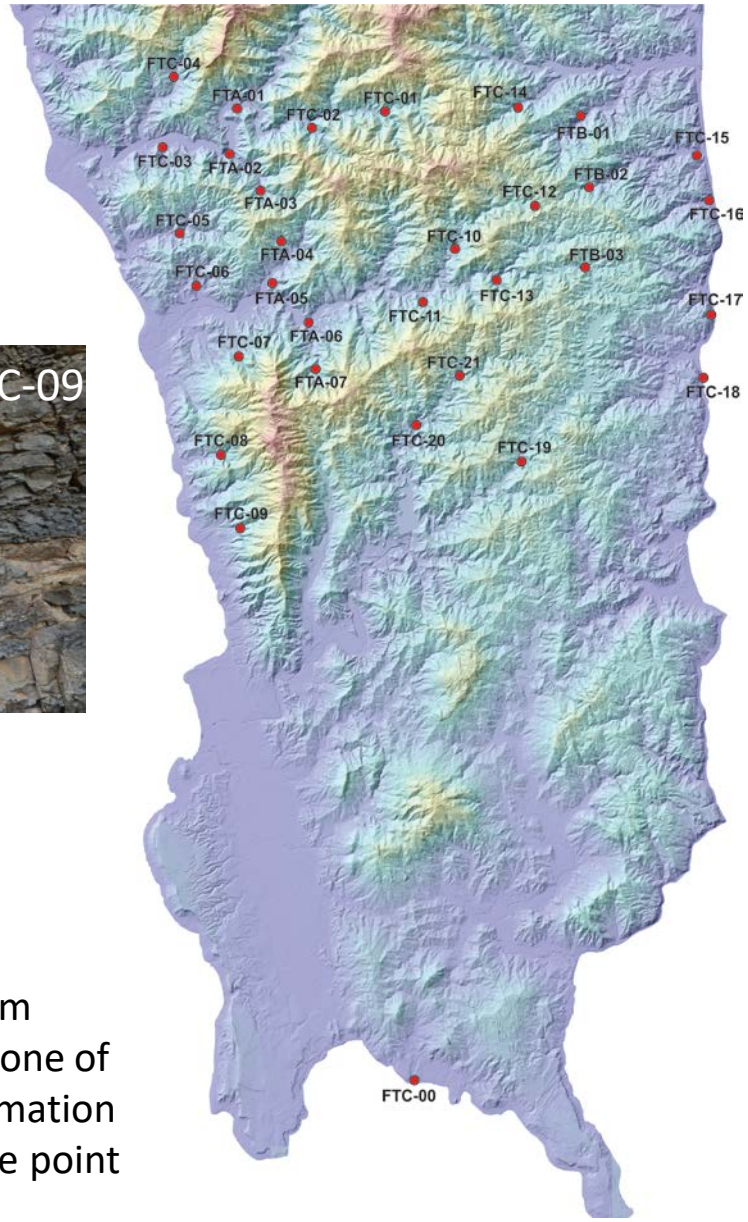
standardized values

Sampling locations and outcrops for illite crystallinity surveys.



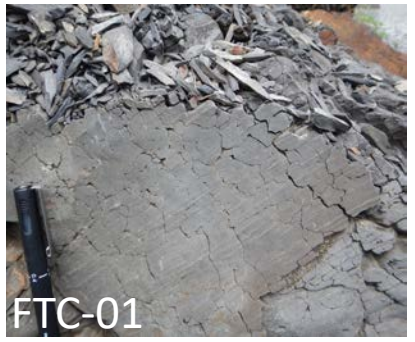










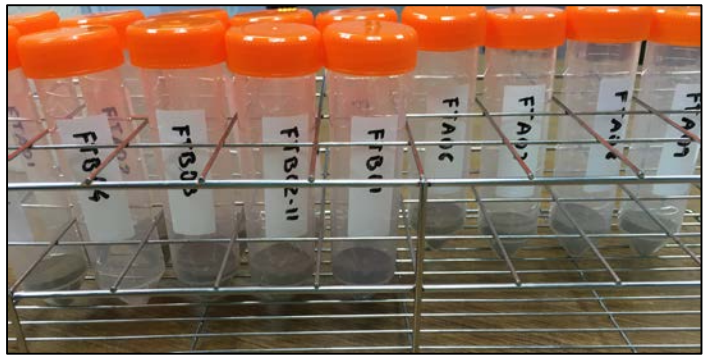


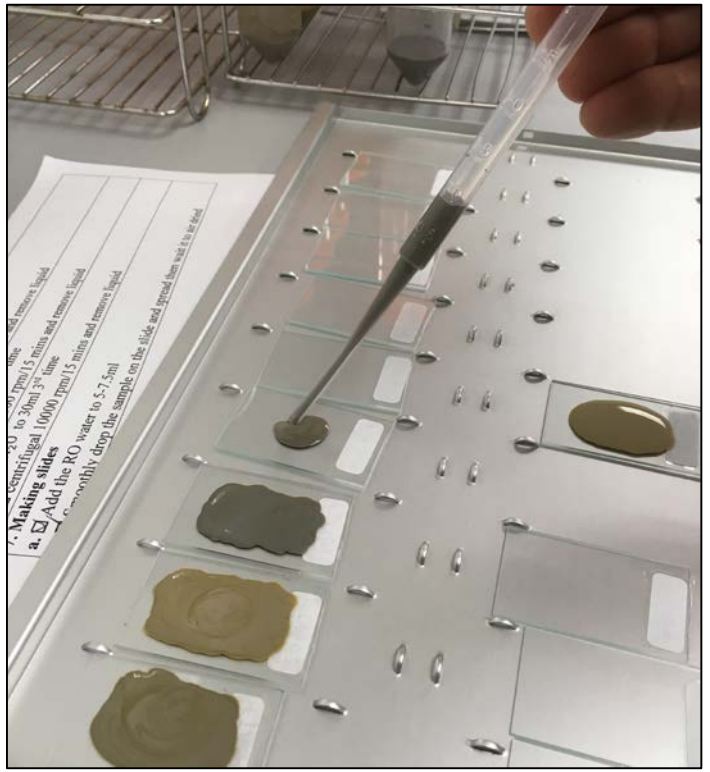


31 samples from argillite/mudstone of the Mutan Formation + 1 as reference point



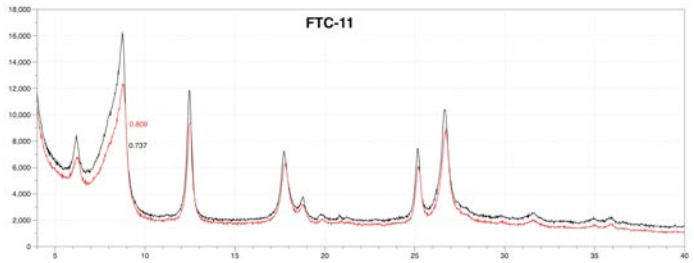


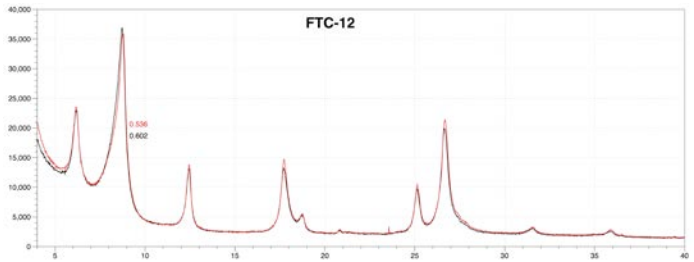


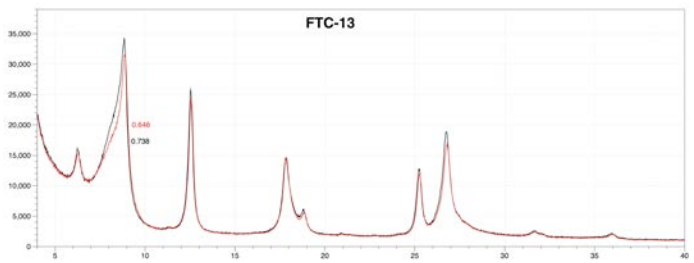


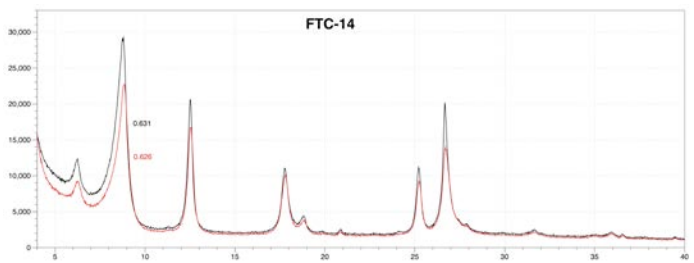
(sea salt removal, carbonate removal, organics removal, separation of clay minerals, magnesium saturation, etc.)

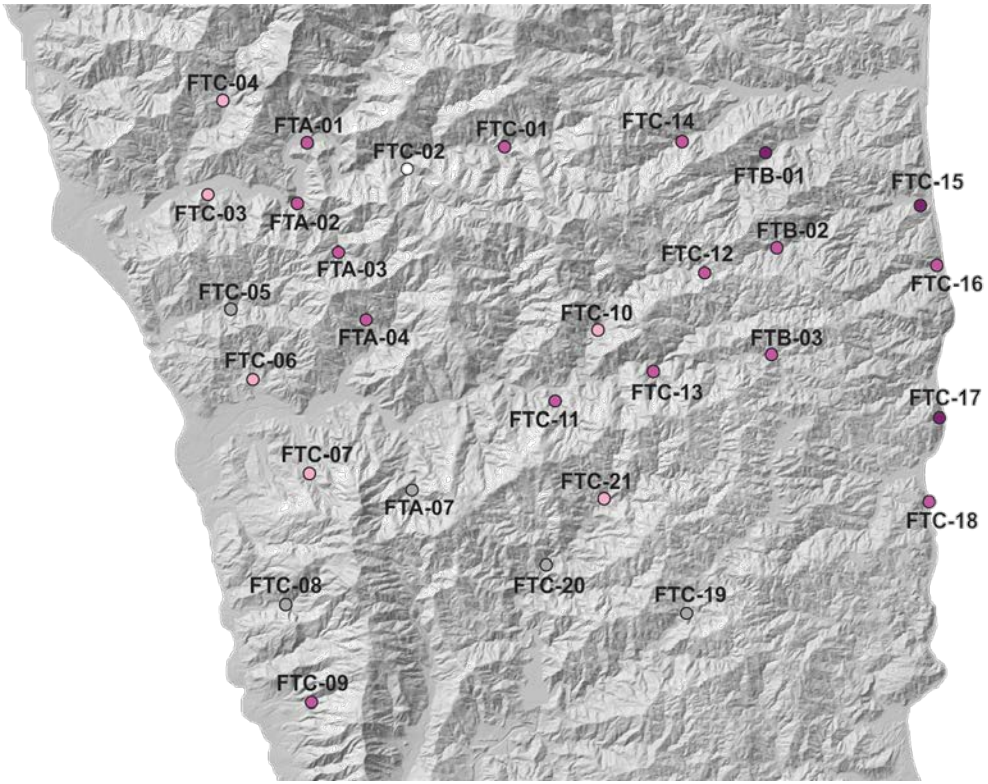
Preliminary results for illite crystallinity in Hengchun Peninsula.

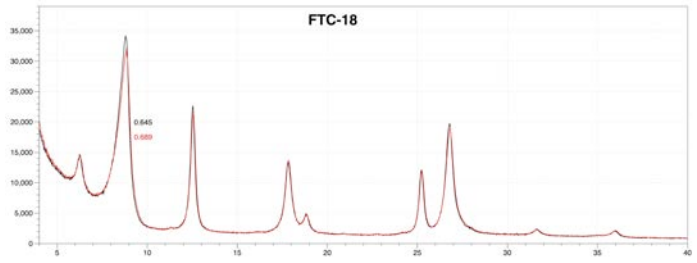


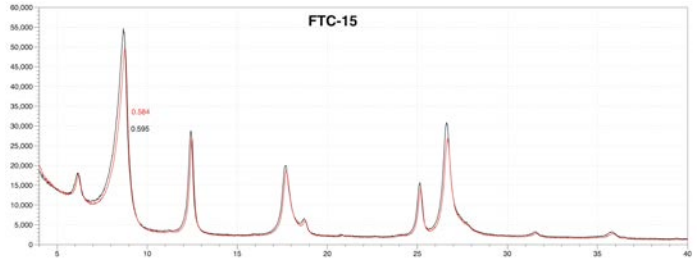


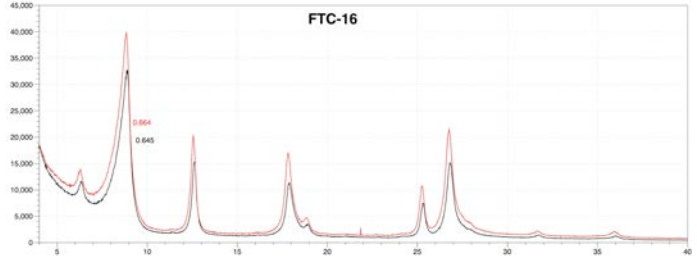


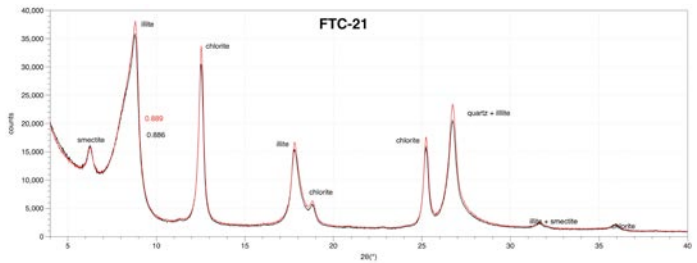






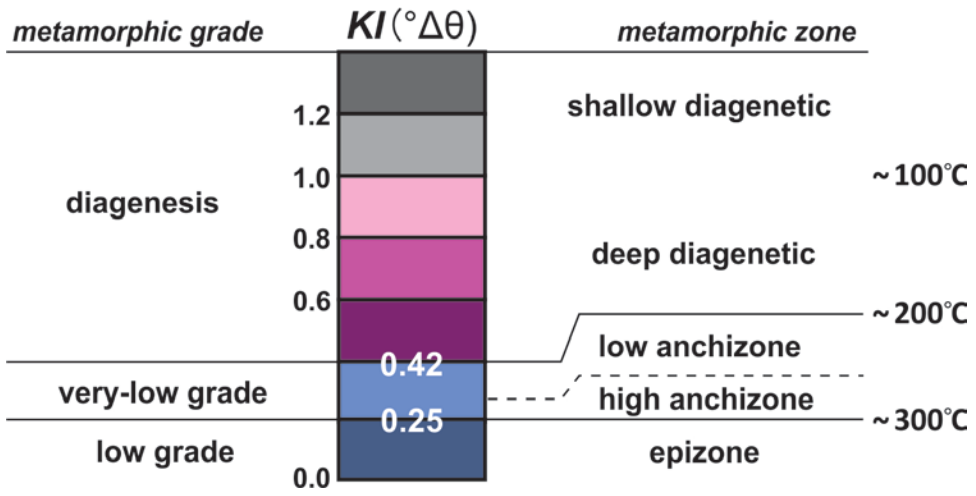




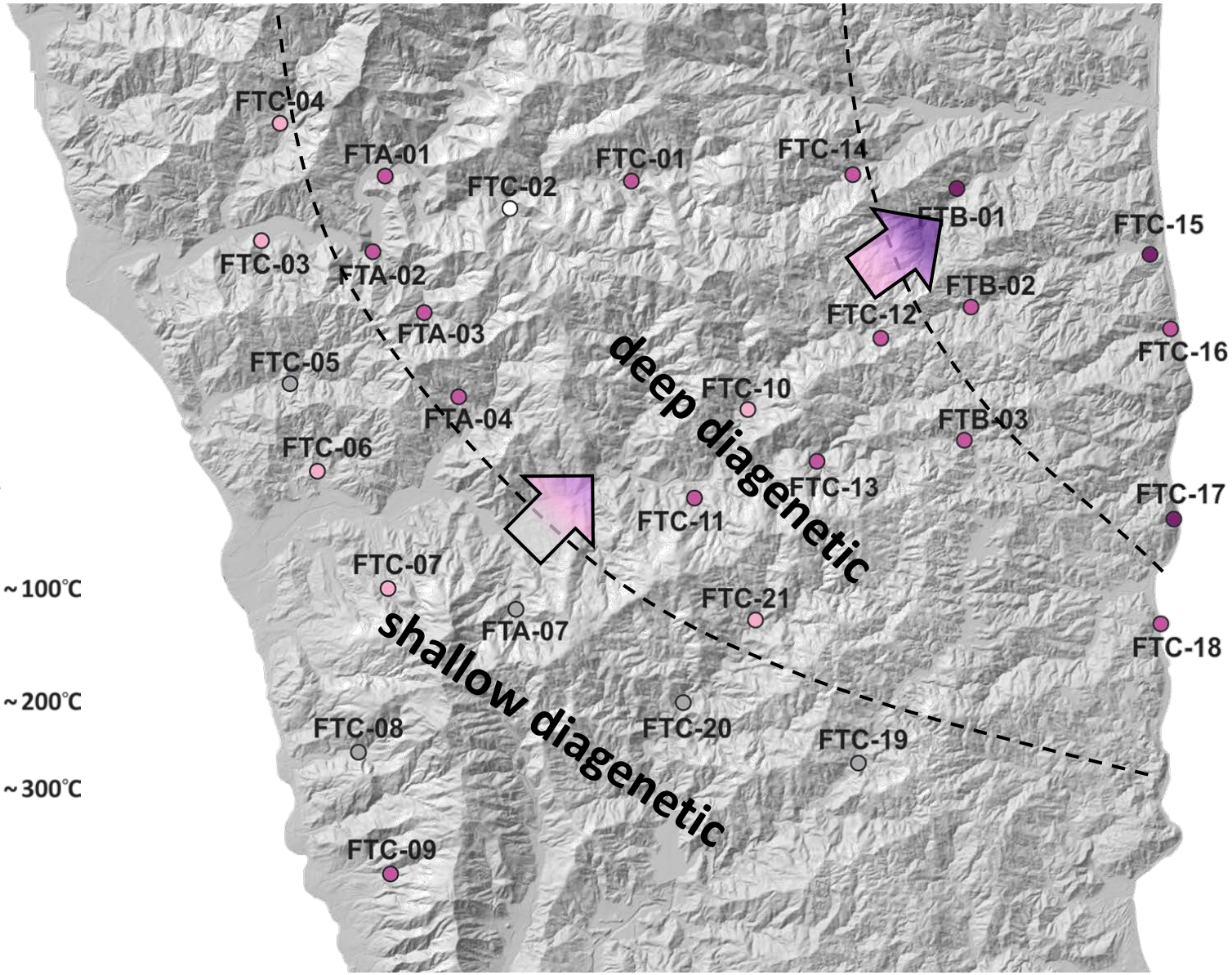


(*in prep.*, Giletycz et al.)

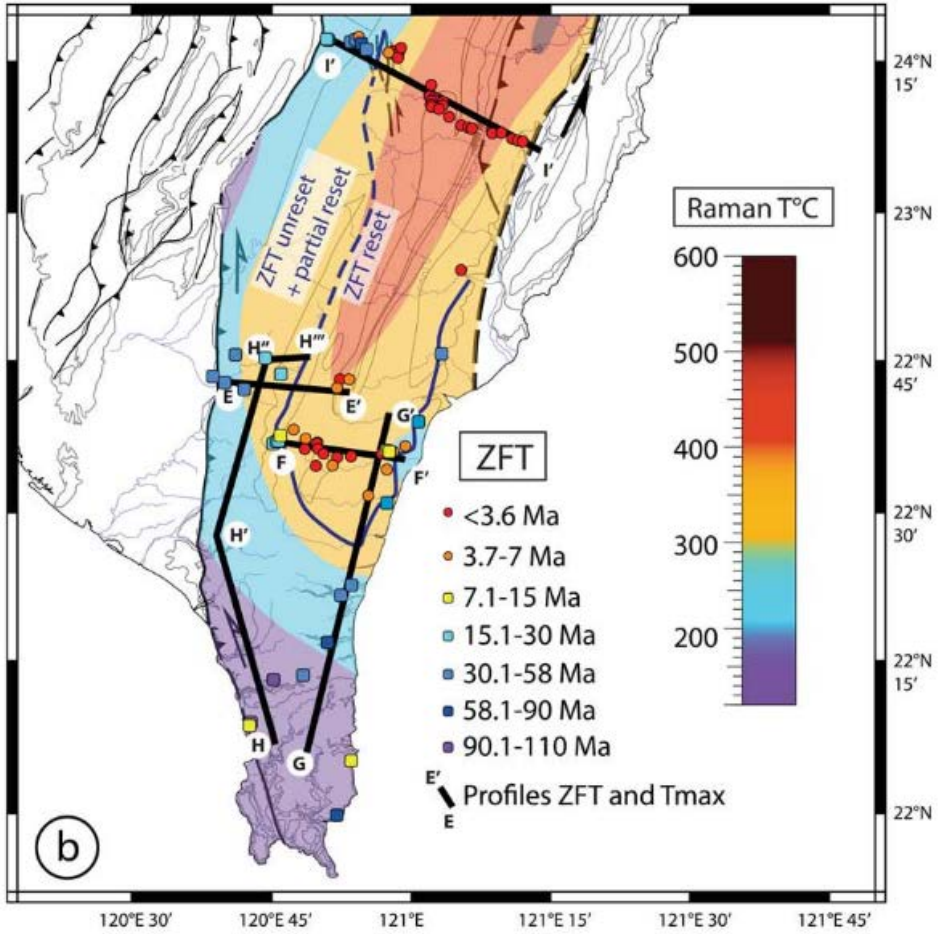
Diagenesis and very-low grade metamorphism in Hengchun Peninsula



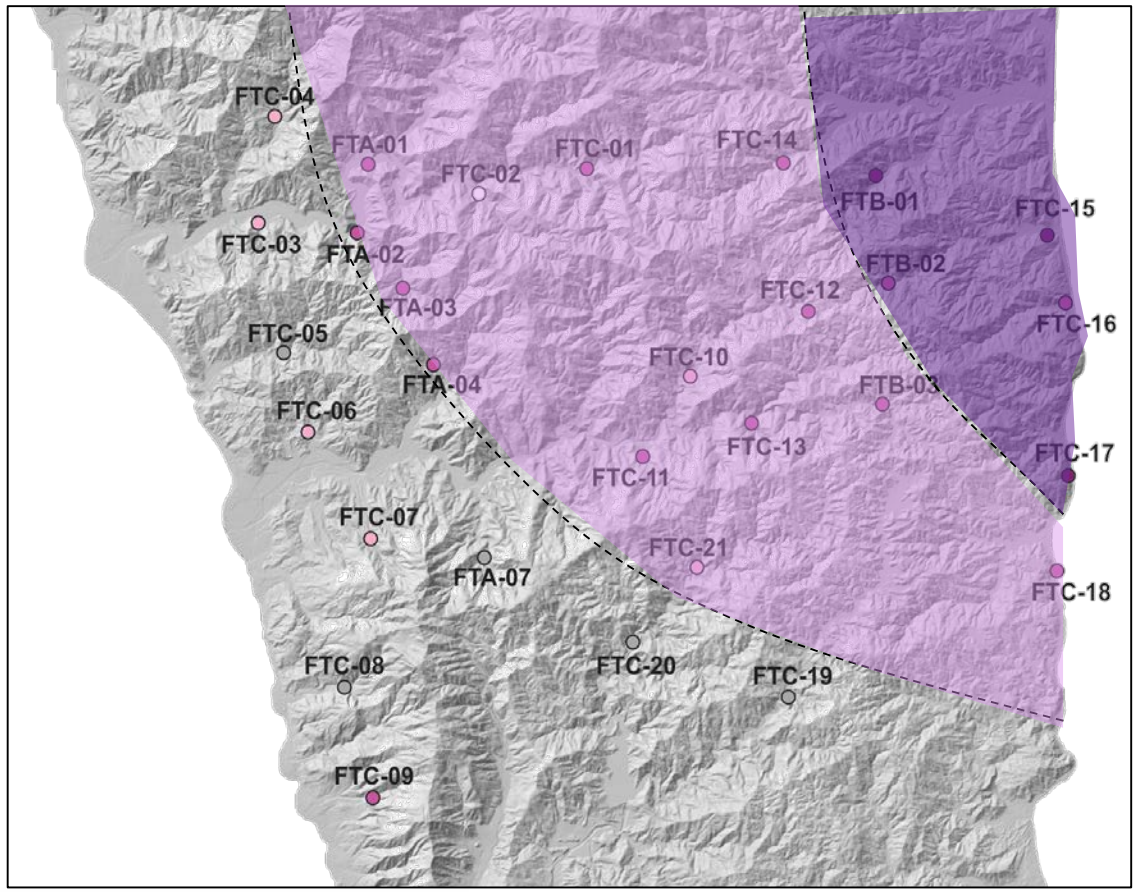
standardized values



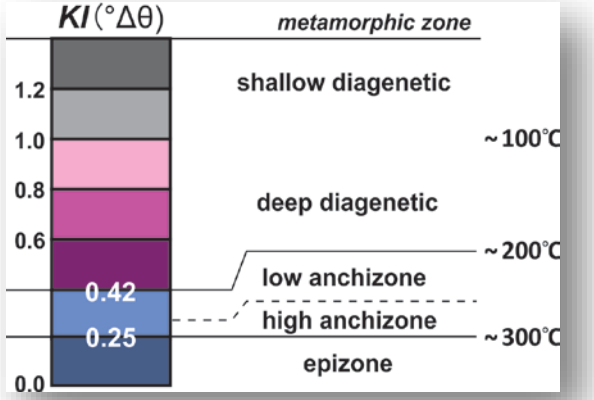
Raman dating of the southern Central Range.



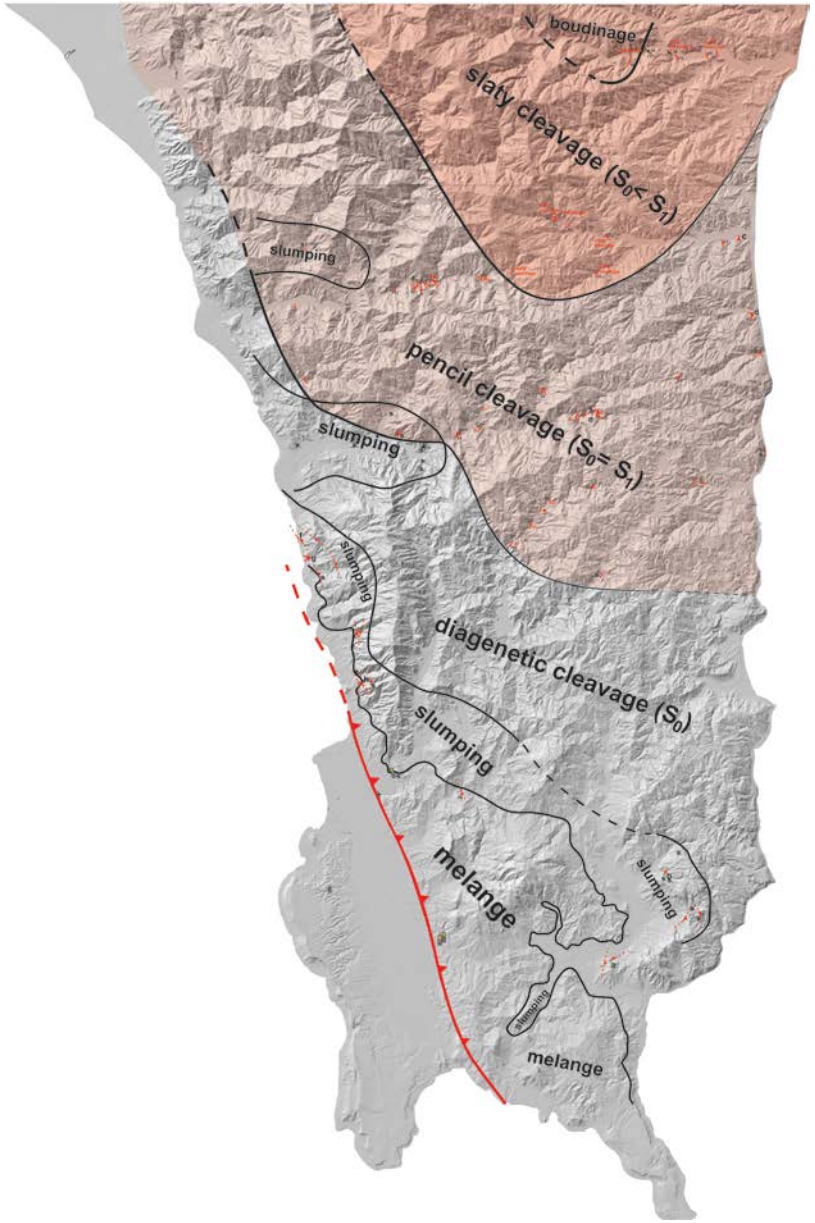
Conand Clement et al., 2020

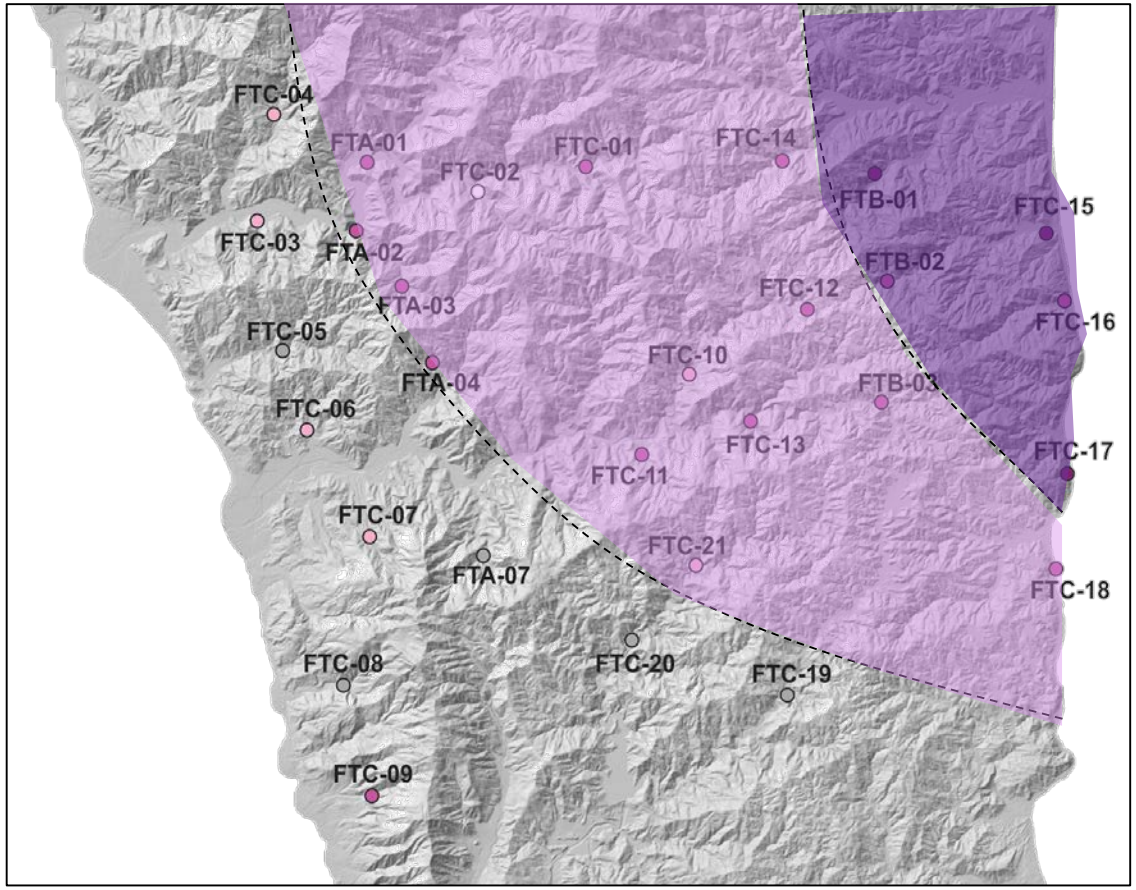


(*in prep.*, Giletycz et al.)

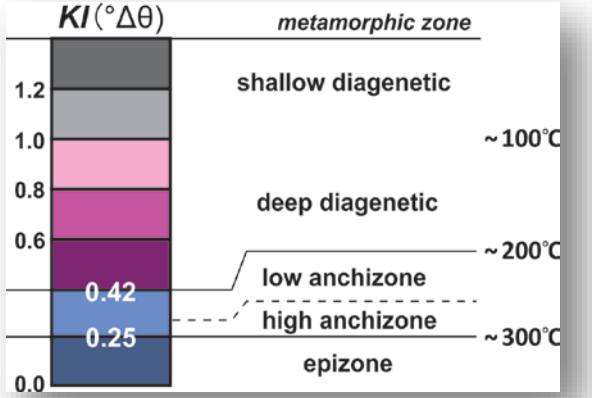


Structural geology of the HP

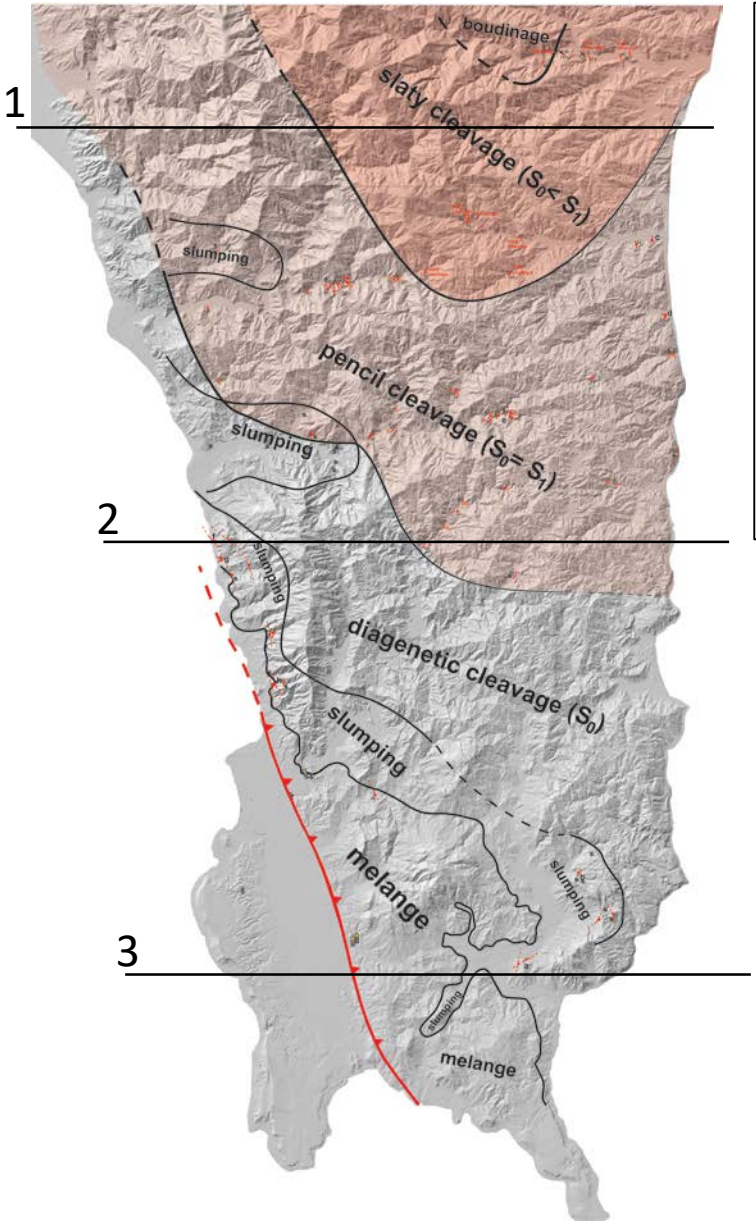


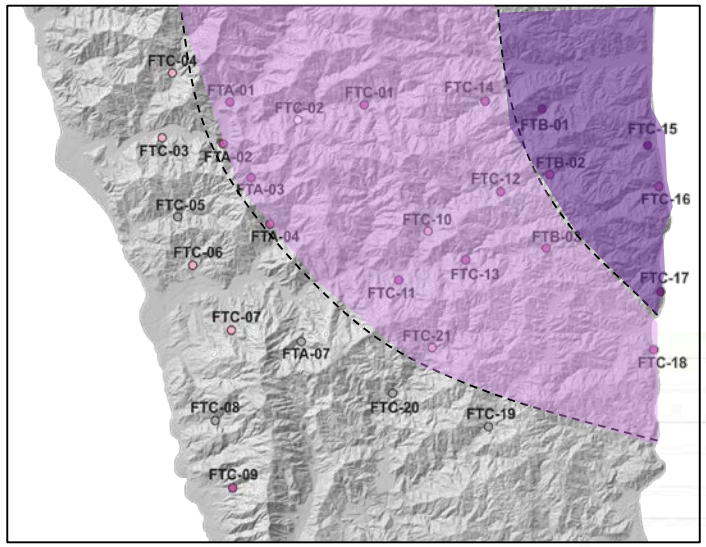


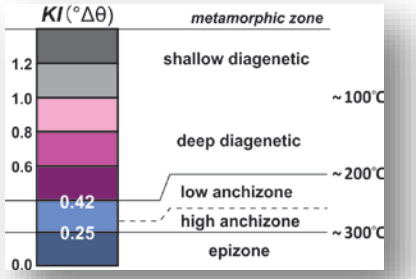
(*in prep.*, Giletycz et al.)



Structural geology of the HP

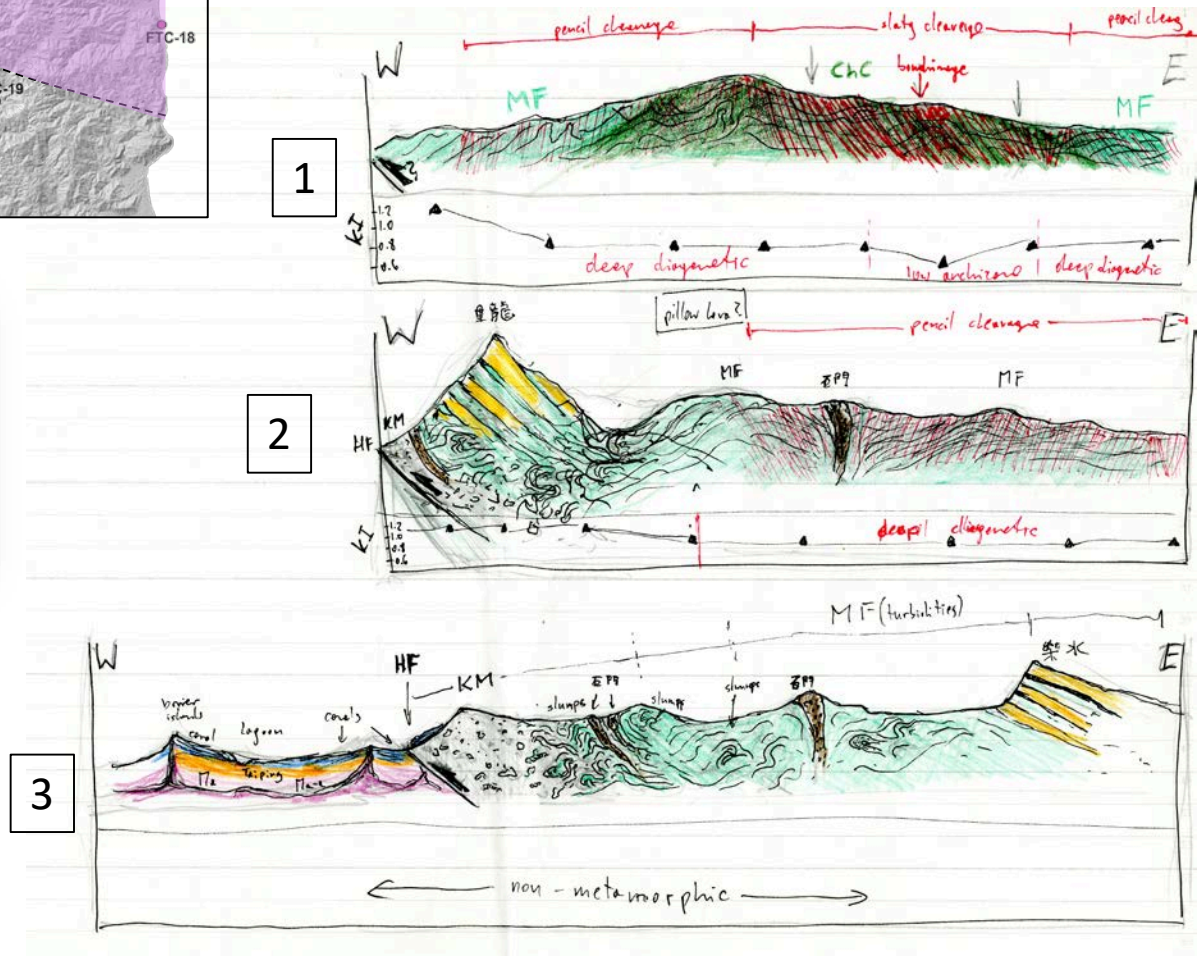






Updated Geological Map of HP





3

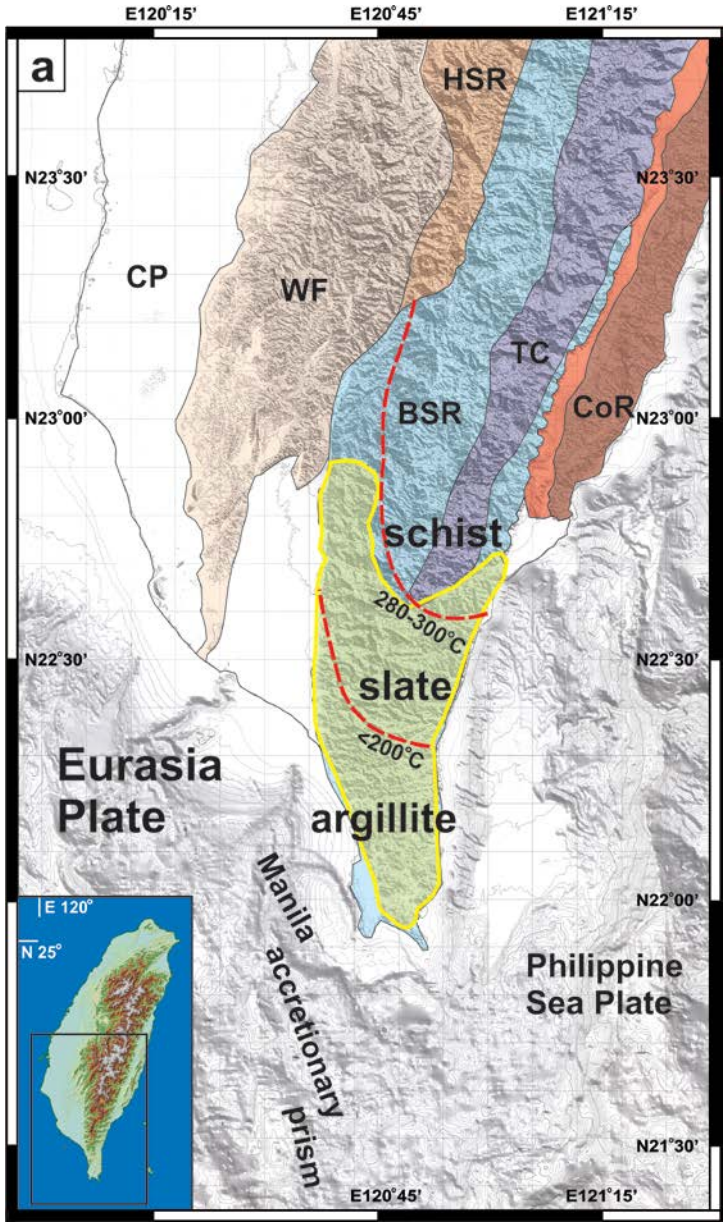
Regional Geology, Extreme Weather and Natural Disasters: Forced Migrations of the Indigenous People of Taiwan

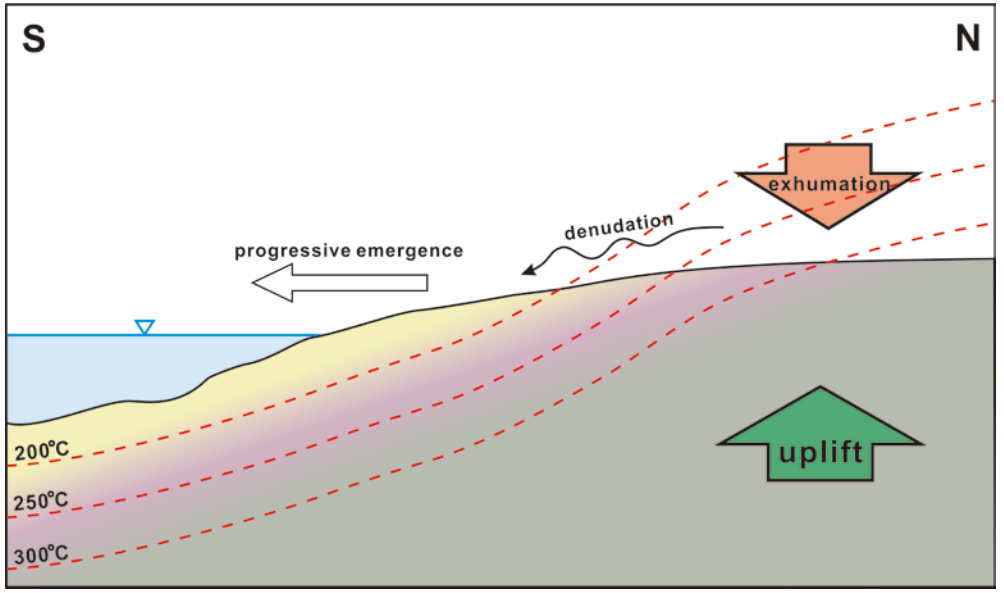


In collaboration with:

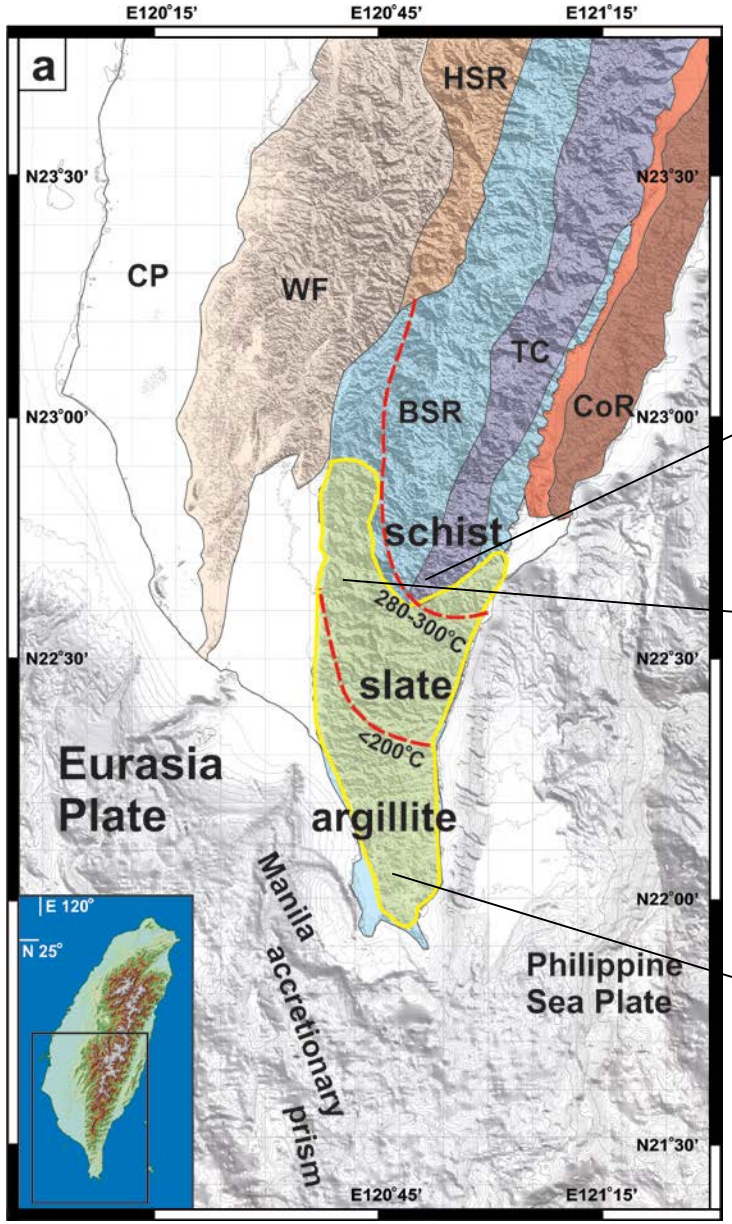
Olimpia Kot-Giletycz
國立清華大學 人類學研究所

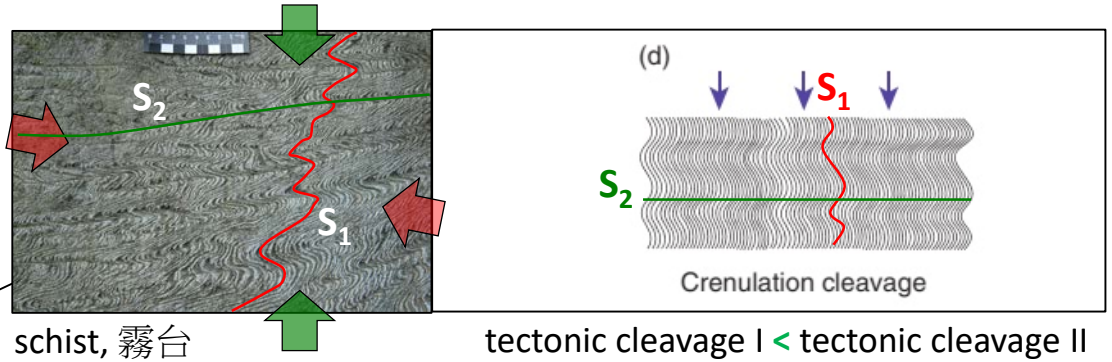
Dennis Brown
Inst. of Earth Sciences, CSIS
Barcelona, Spain





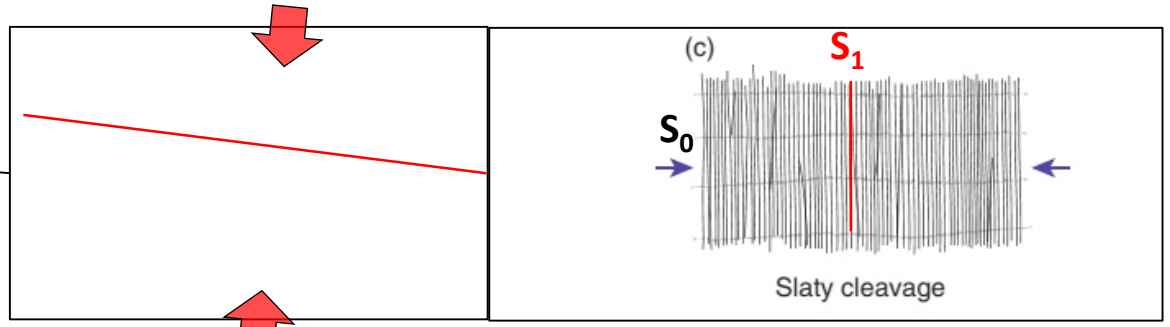
gradual increase of metamorphism





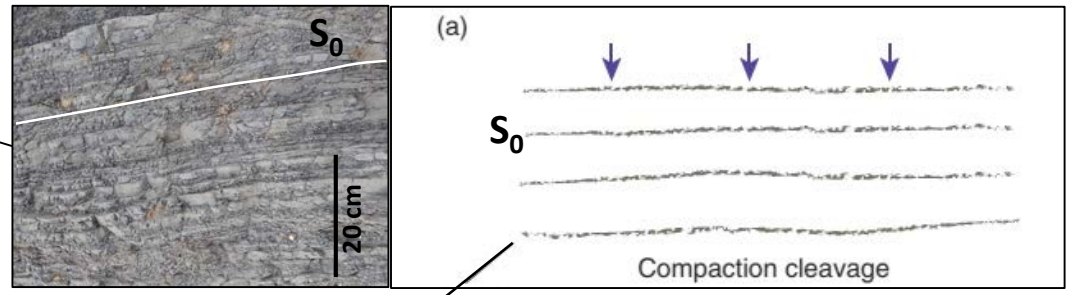
schist, 霧台

tectonic cleavage I < tectonic cleavage II



slate, 大社

diagenetic cleavage < tectonic cleavage



argillite, 恆春

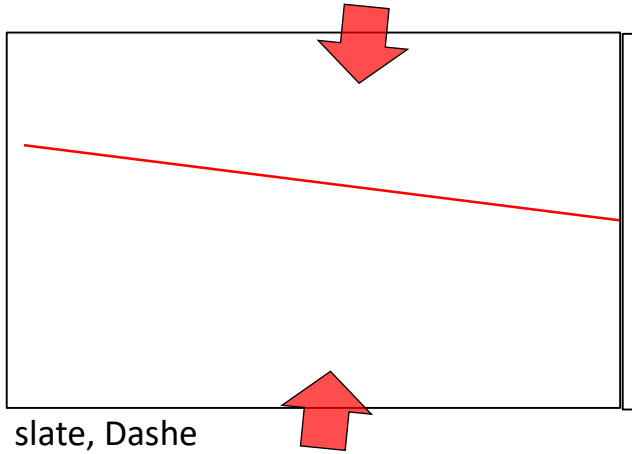
bedding

diagenetic cleavage (gravity)

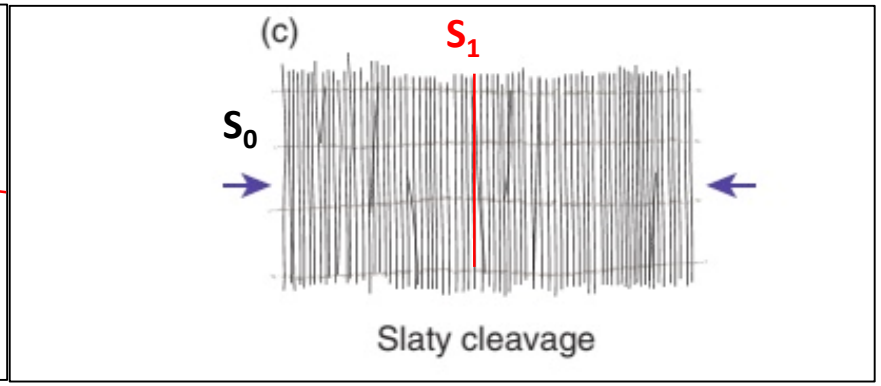
(H. Fossen 2010)



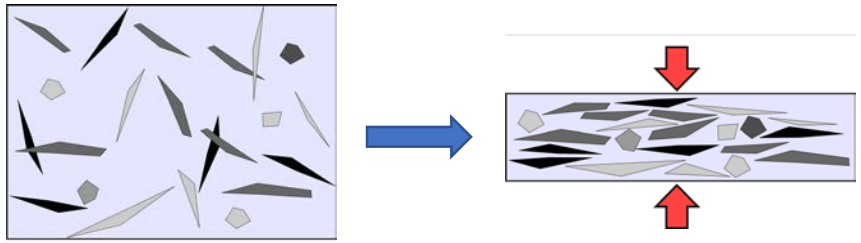
significant accumulation of shortening
(+/- 75%)



slate, Dashe



diagenetic cleavage < tectonic cleavage

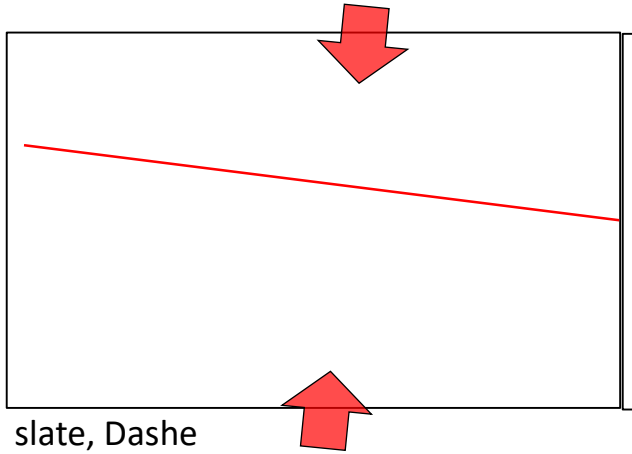


a) parallel ('preferred') orientation of minerals
b) flake minerals: muscovite or illite, often along with biotite, chlorite

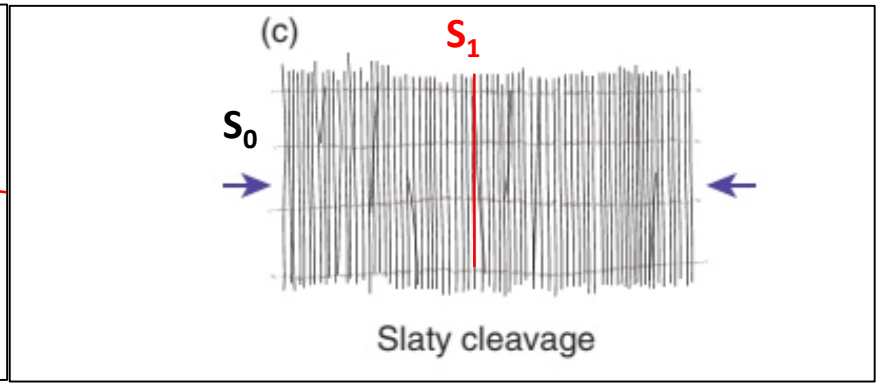


significant accumulation of shortening
(+/- 75%)



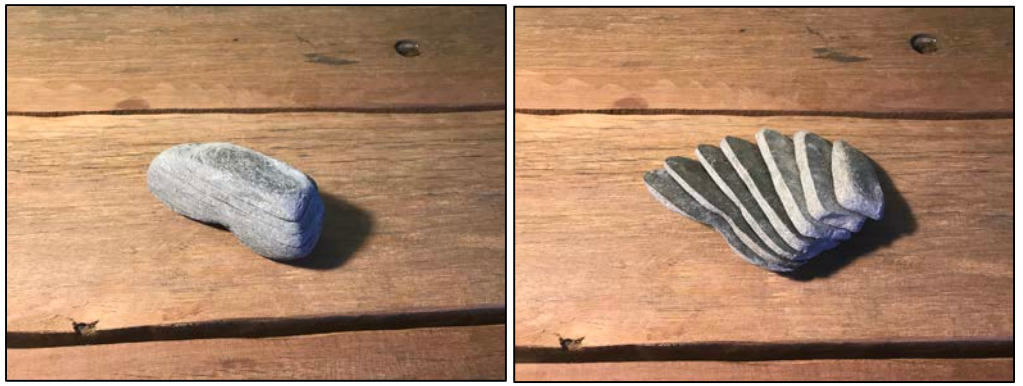


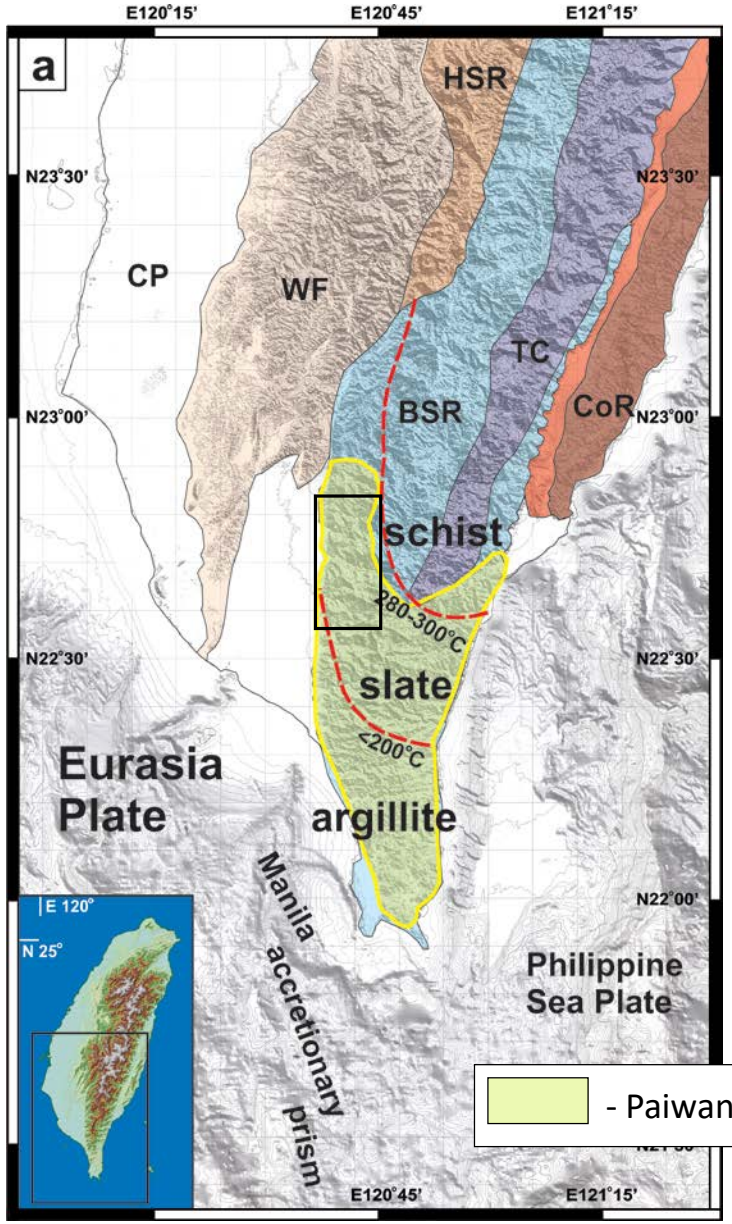
slate, Dashe

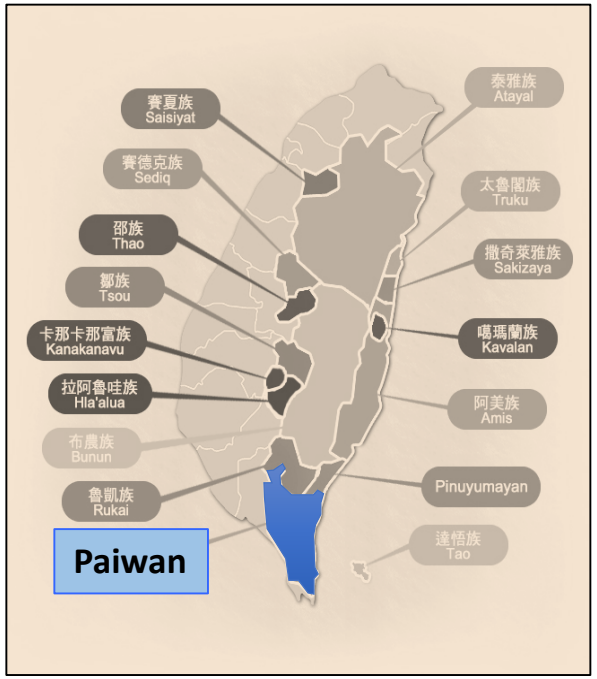


diagenetic cleavage < tectonic cleavage

slaty cleavage




a
E120°15'
E120°45'
E121°15'
N23°30'
N23°00'
N22°30'
N22°00'
HSR
CP
WF
TC
BSR
CoR
schist
280-300°C
slate
<200°C
Eurasia Plate
argillite
Manila accretionary prism
Philippine Sea Plate
E 120°
N 25°
- Paiwan Group


賽夏族 Saisiyat
賽德克族 Sediq
邵族 Thao
鄒族 Tsou
卡那卡那富族 Kanakanavu
拉阿魯哇族 Hla'alua
布農族 Bunun
魯凱族 Rukai
泰雅族 Atayal
太魯閣族 Truku
撒奇萊雅族 Sakizaya
噶瑪蘭族 Kavalan
阿美族 Amis
Pinuyumayan
達悟族 Tao
Paiwan







Slaty cleavage



Prehistoric slate quarry (till 350 years BP)



Traditional ‘slate house’



Slaty cleavage





Traditional ‘slate house’

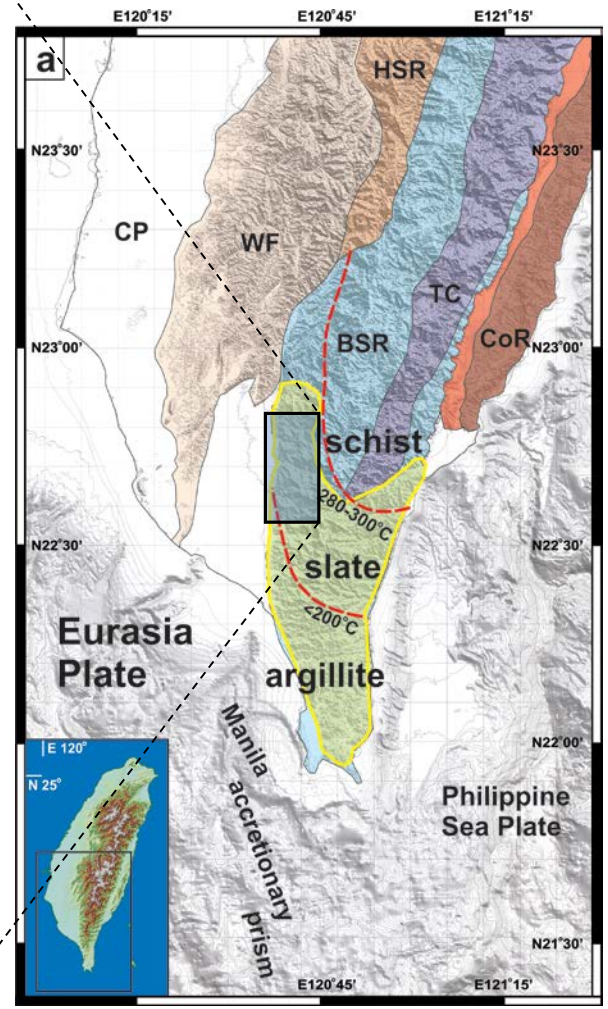


and cons:

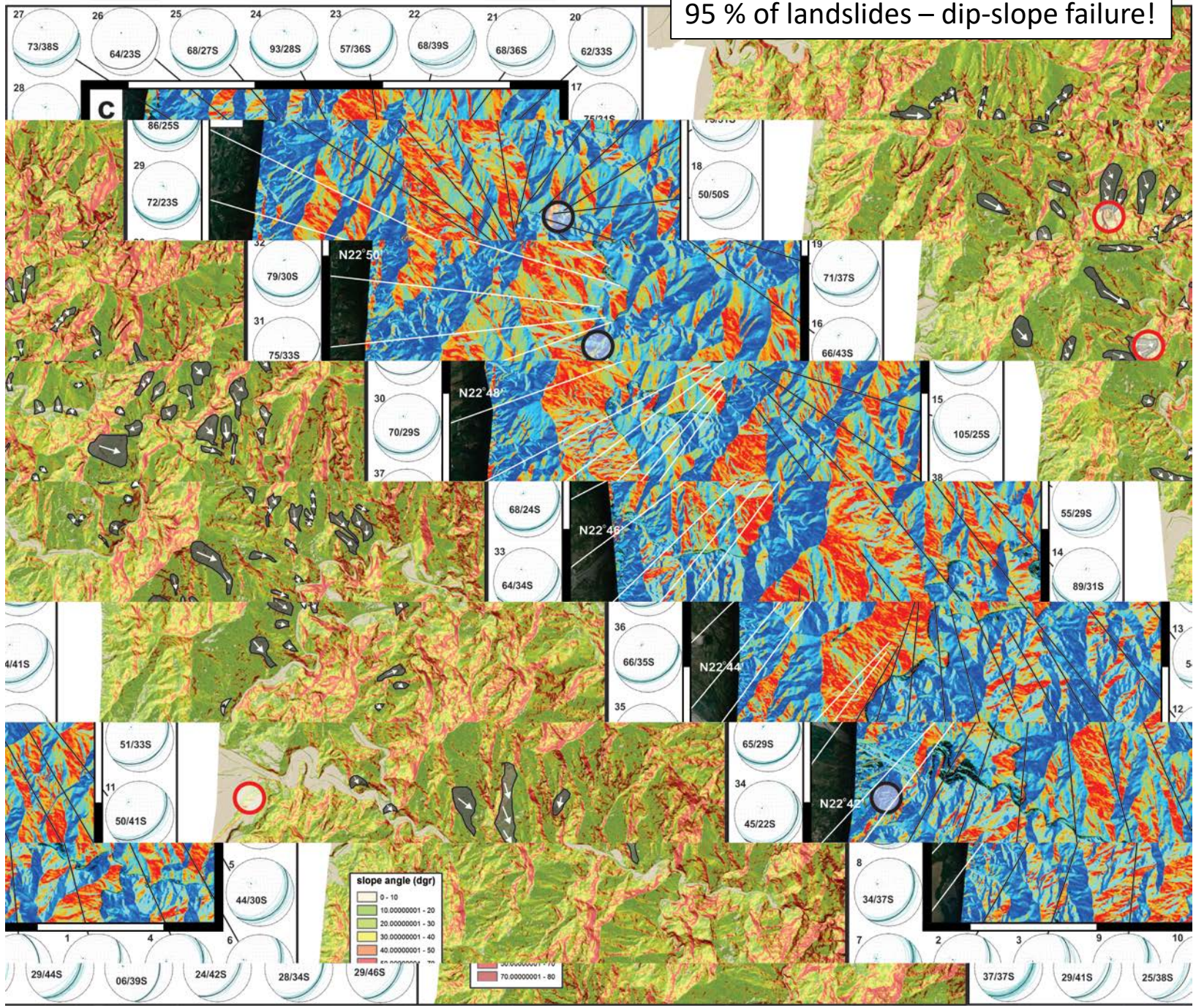


Slaty cleavage leads to dip-slope failure…

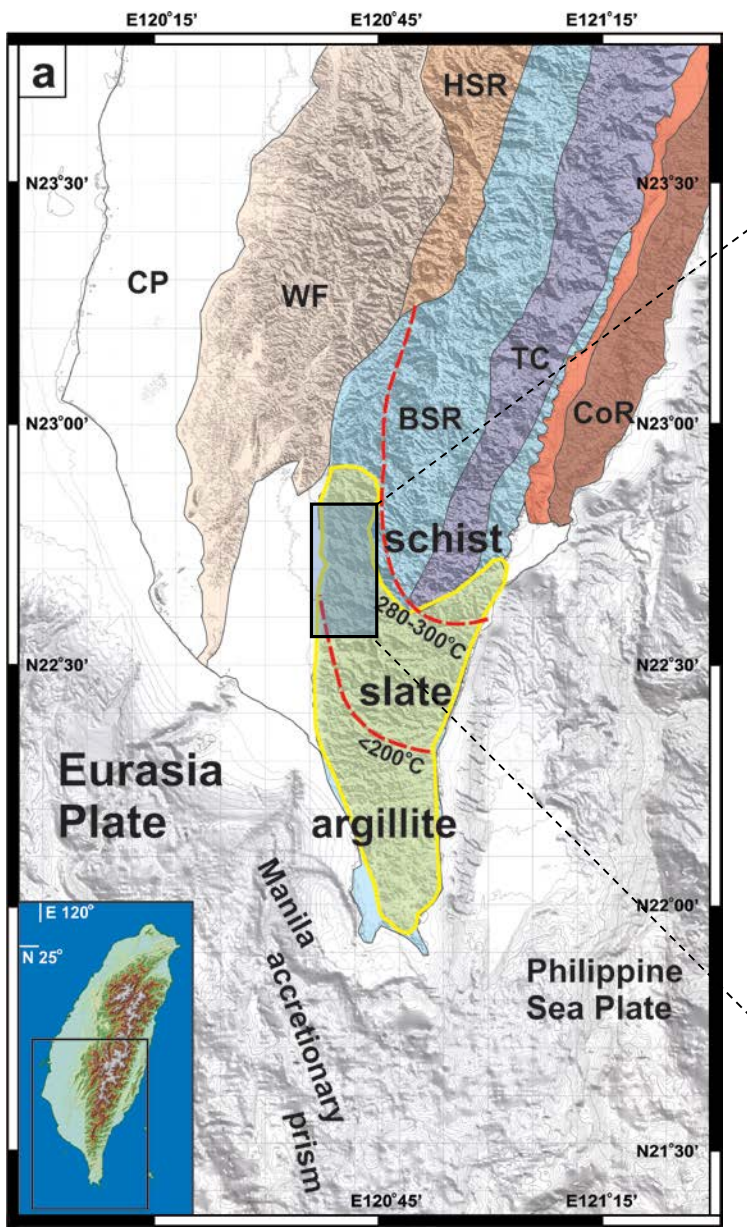
Aspect map od the study area.



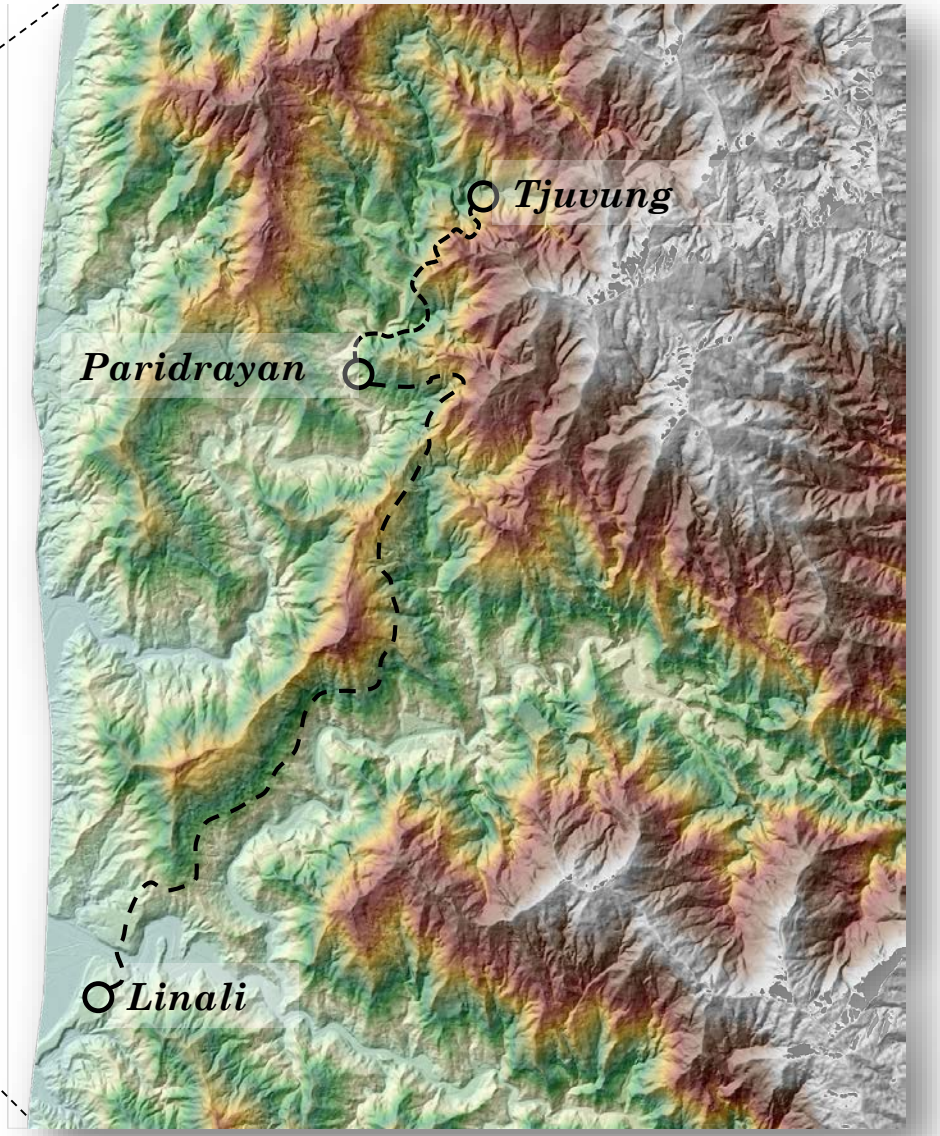
Aspect map od the study area.



Study area.

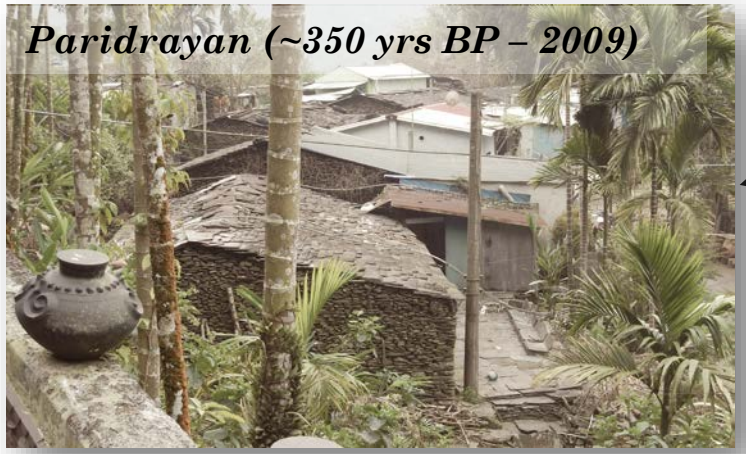


Two resettlements in the village 350 years history.

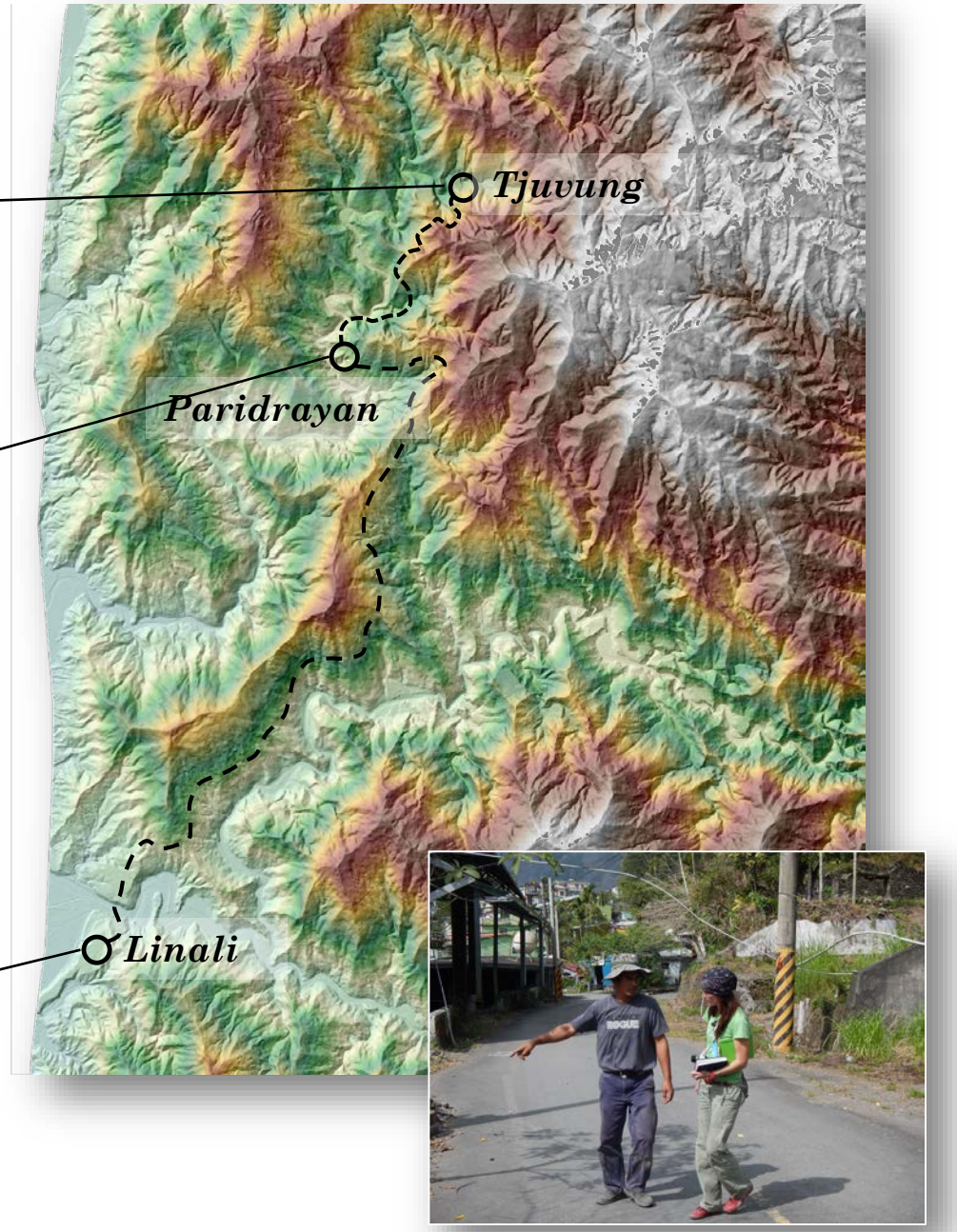


Two migration events due to natural disasters.

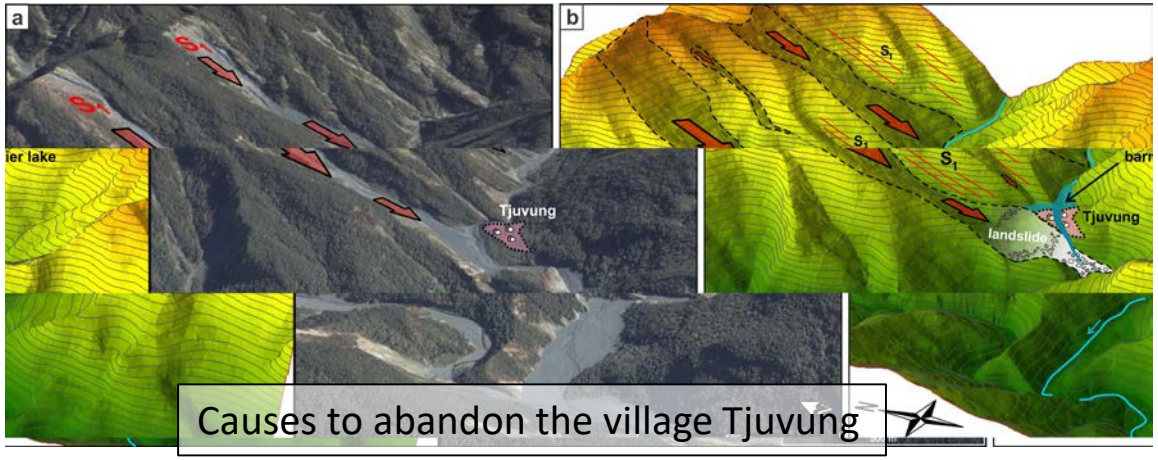




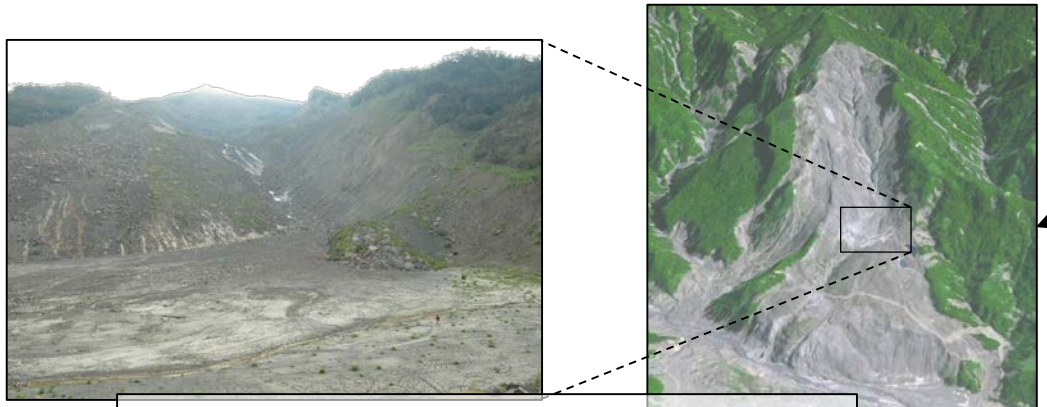




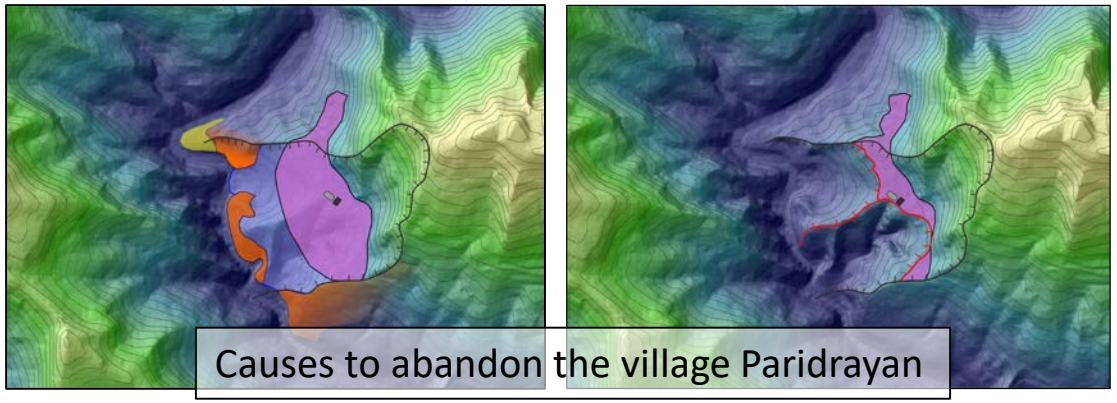
Two migration events due to natural disasters.



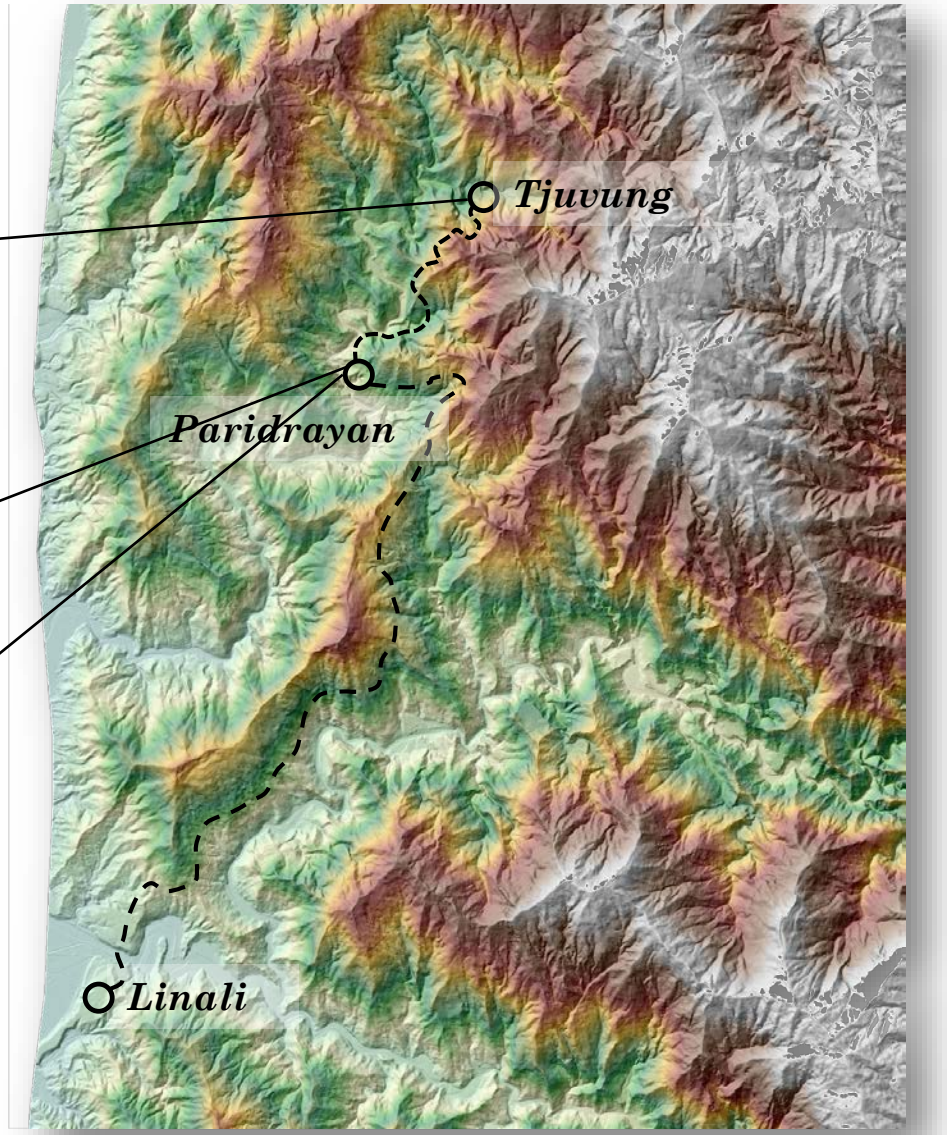
Causes to abandon the village Tjuvung



Causes to settle the village in Paridrayan



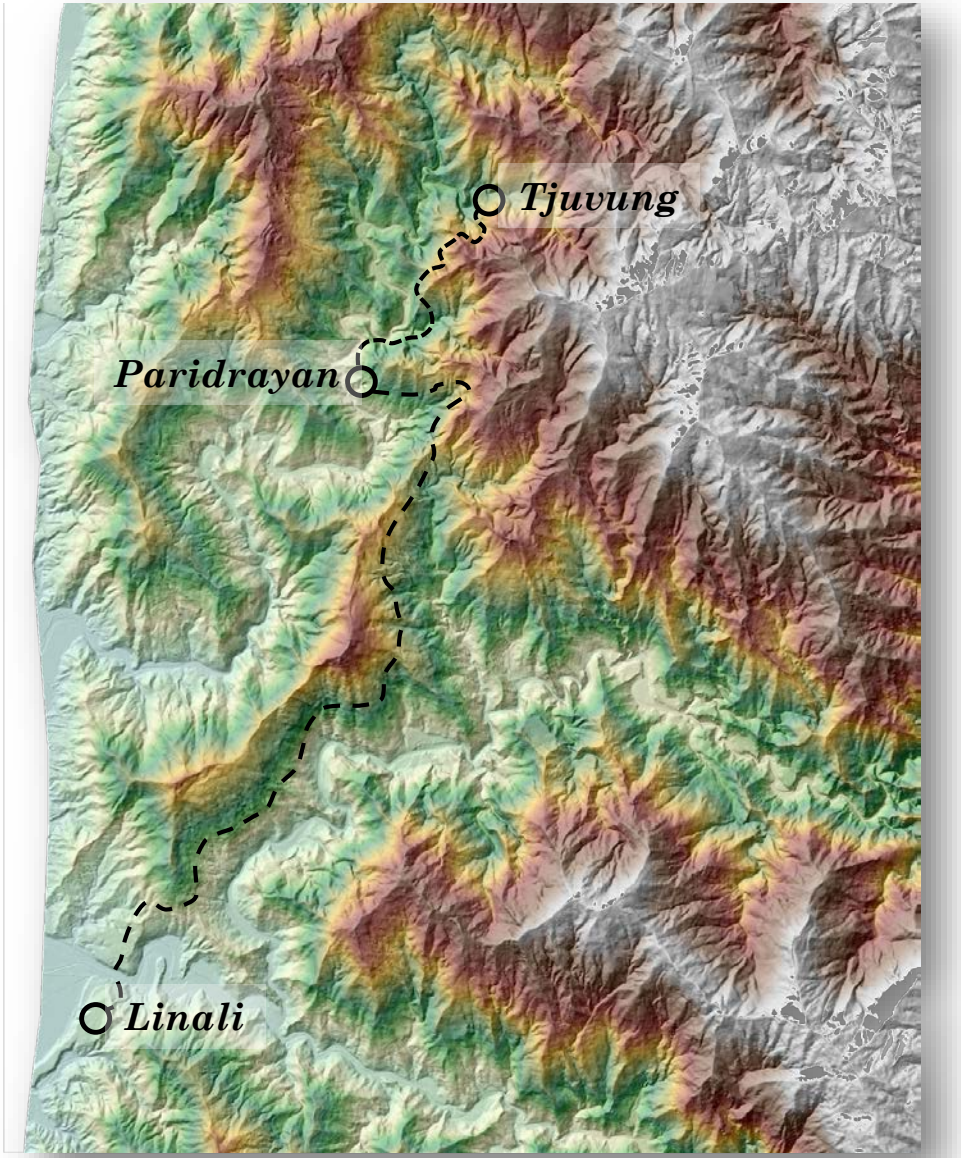
Causes to abandon the village Paridrayan



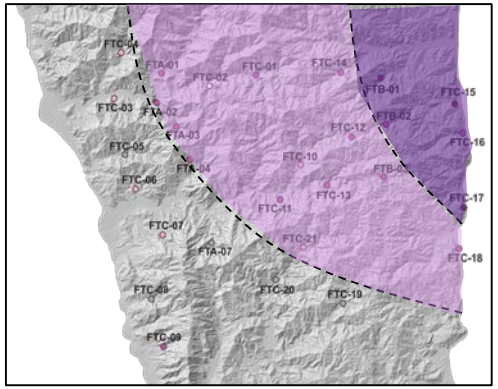
1) The trigger to leave Tjuvung and the cause to settle Paridriayan villages were due to landslides probably triggered by the same extreme event.

2) The slaty-cleavage is the crucial factor leading to landslides occurrence in the Paiwan Group area.

3) Natural disasters are inherited in the social structure of indigenous people as a repetedly occurring phenomenon.



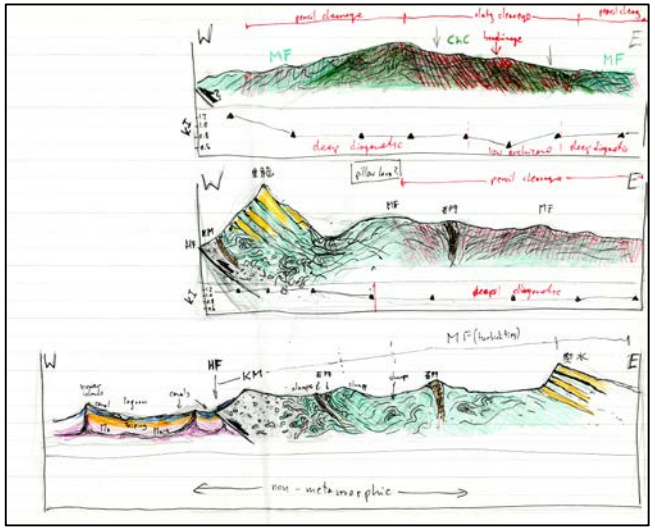
Upcoming scientific questions.



Wrap-up metamorphic grade pattern of the Hengchun Peninsula and update geological map.



Continue surveys over Kenting Mélange.



Hengchun Peninsula geology and tectonics.

correlate offshore-onland data

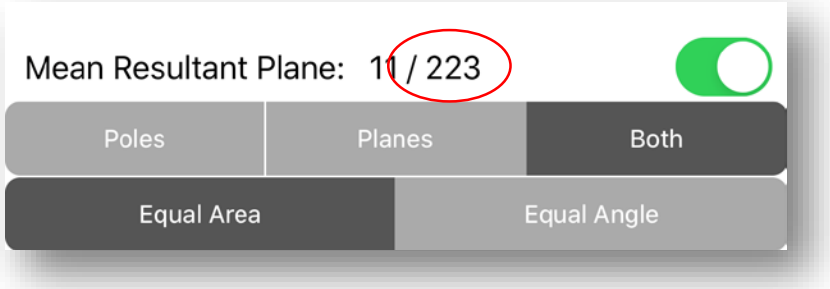
My research plans.

Field geology/Structural geology.





Topography evolution and landscape rearrangement.



My research plans.

Field geology/Structural geology.



Missile crater

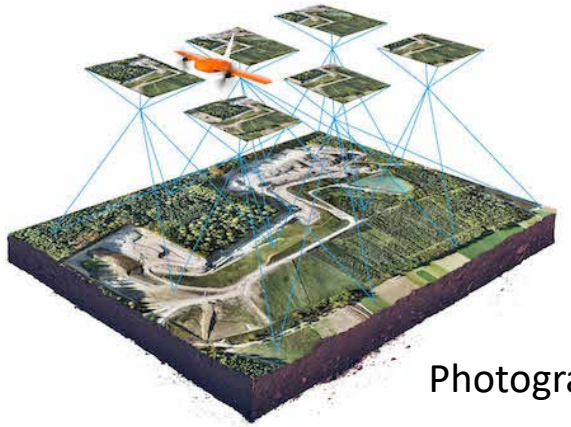




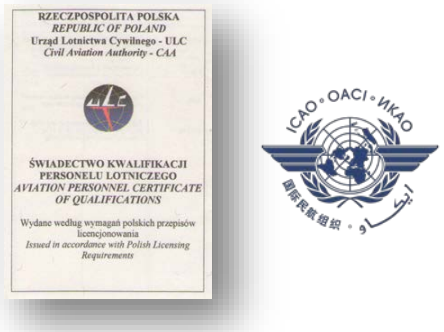
My research plans.



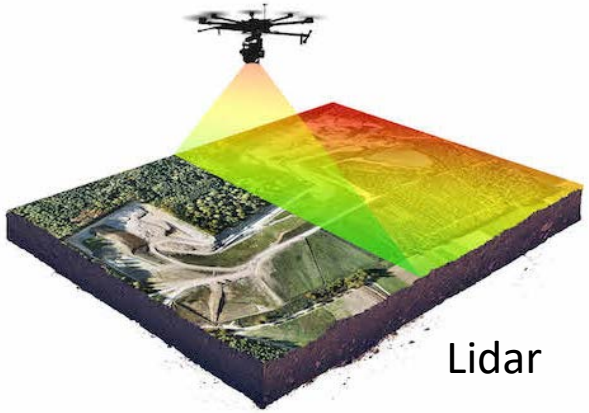
Surveys using UAV systems for structural geology, geomorphology, paleoenvironment reconstruction and other earth-scientific applications.



Photogrammetry



UAV license pilot in ICAO
(International Civil Aviation Organization)

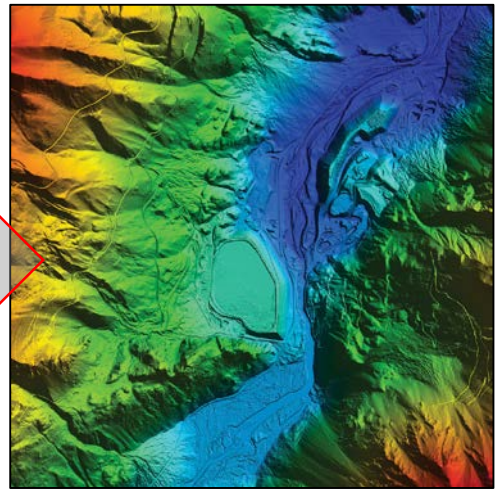


Lidar

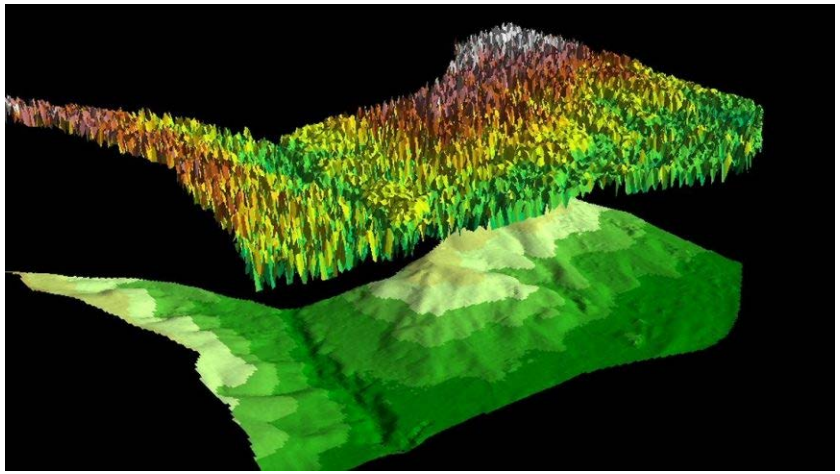
My research plans.



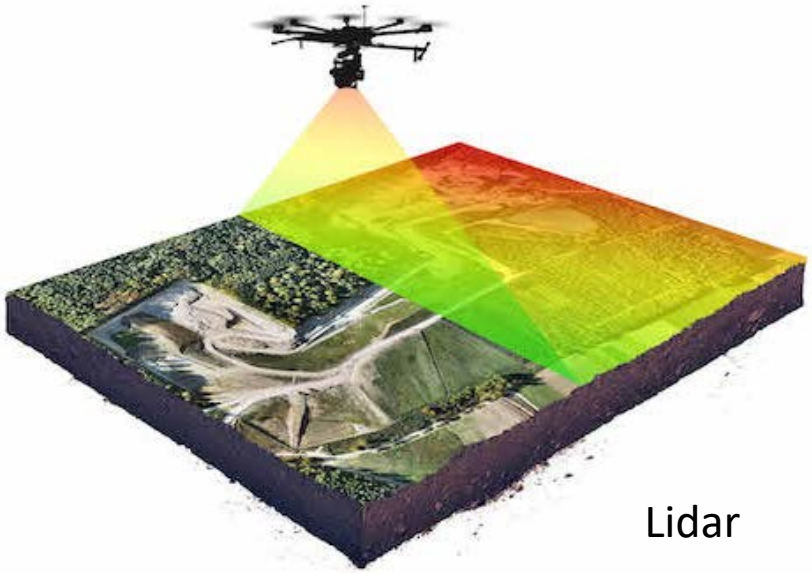
Very fast in high precision.



High-resolution DEM.



No vegetation cover.



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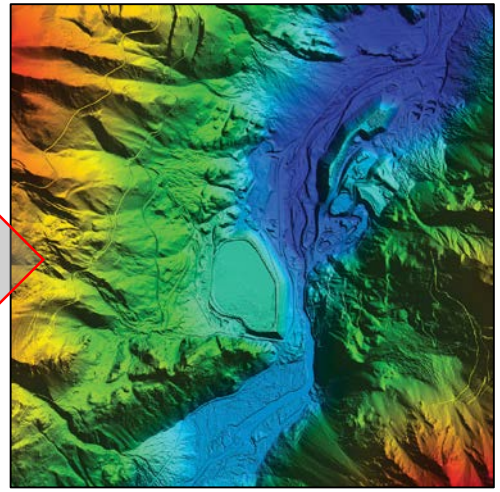
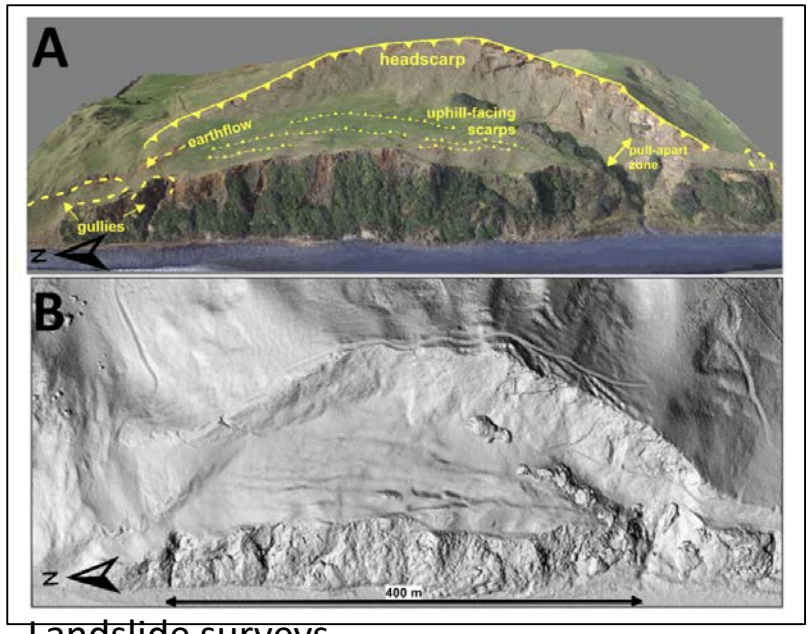
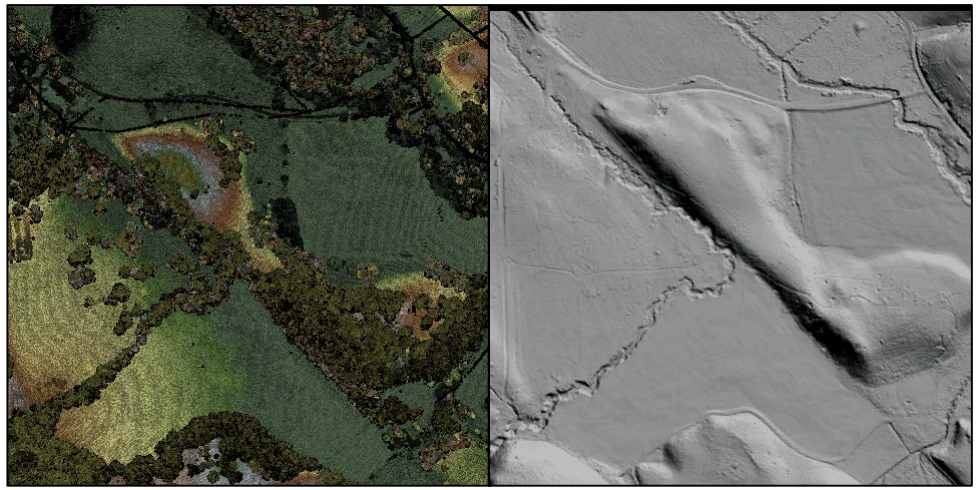


High-resolution DEM.



Landslide surveys



Monitoring active fault scarps

My research plans.



Lidar on UAV



Magnetometer on UAV platform



Biodegradable geophones deployed by UAV to remote/not accessible areas (including Arctic Circle)

Coupling surveys with offshore data/surveys.



Lidar on UAV

Collaborate with ‘shallow marine geology’ surveys.



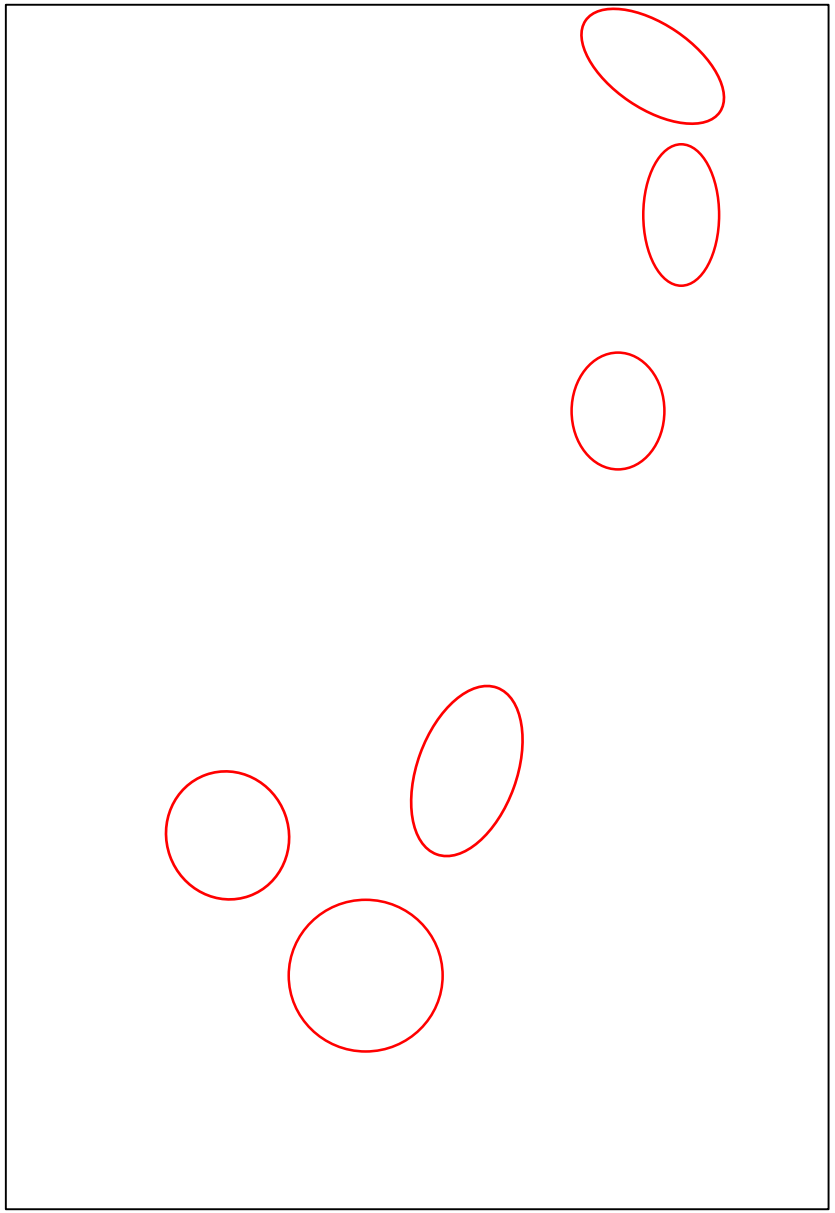
Coupling surveys with offshore data/surveys.



Lidar on UAV

Collaborate with ‘shallow marine geology’ surveys.



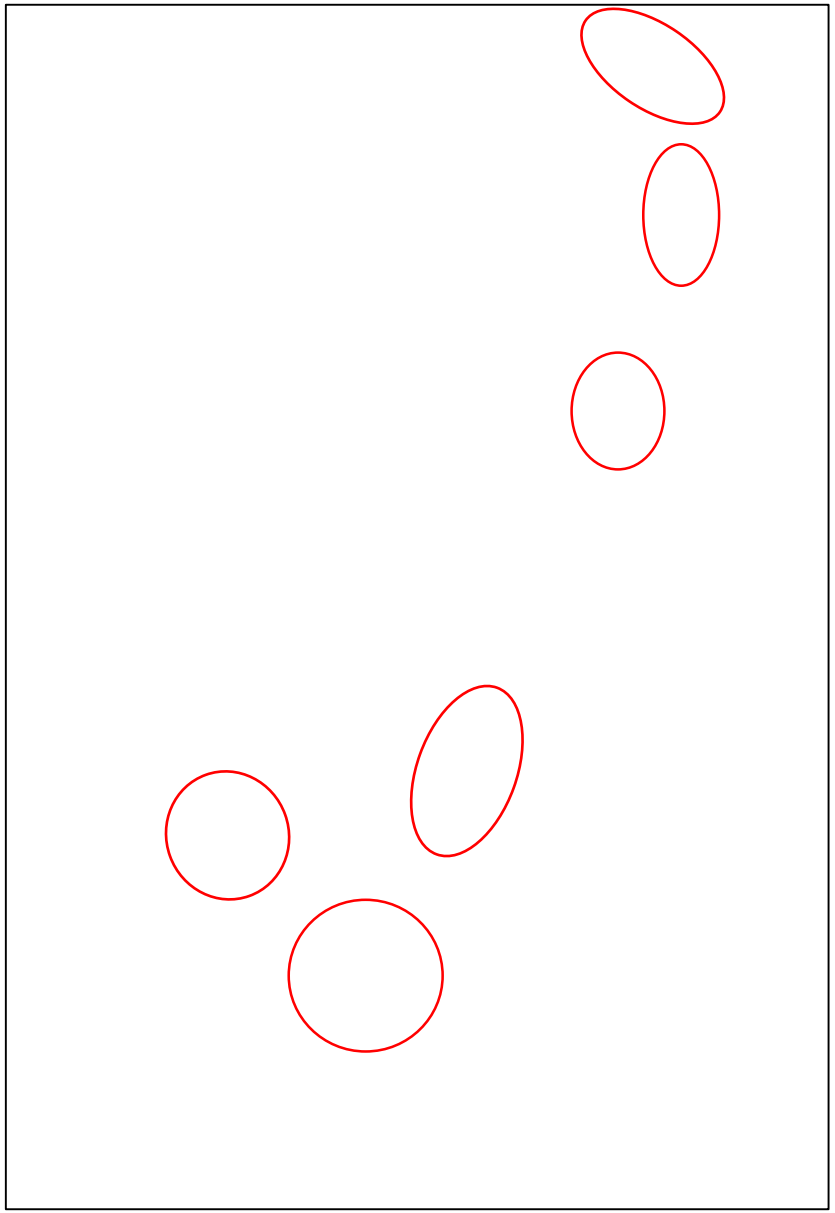




- depth limit min – 18m
- fishery activities

Collaborate with ‘shallow marine geology’ surveys.







Possible long-term plan.

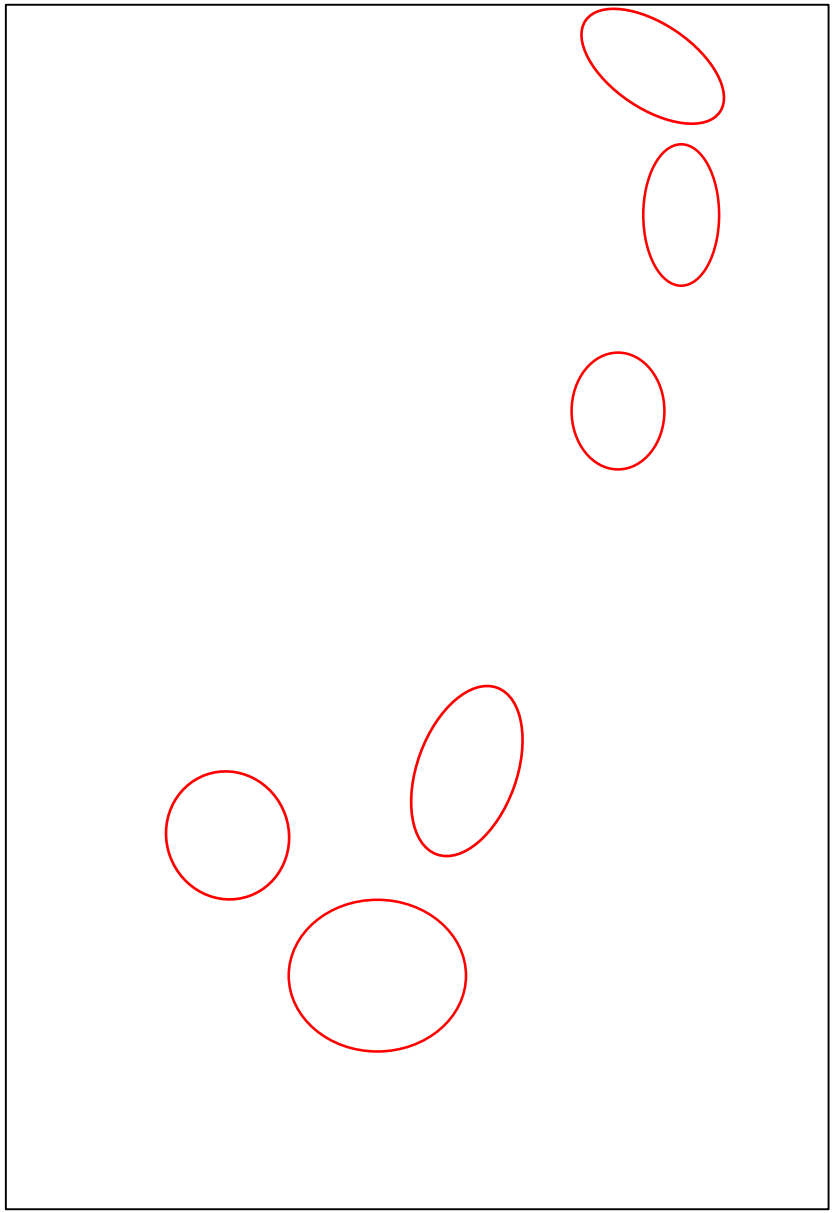


Open Water Diver license
In PADI

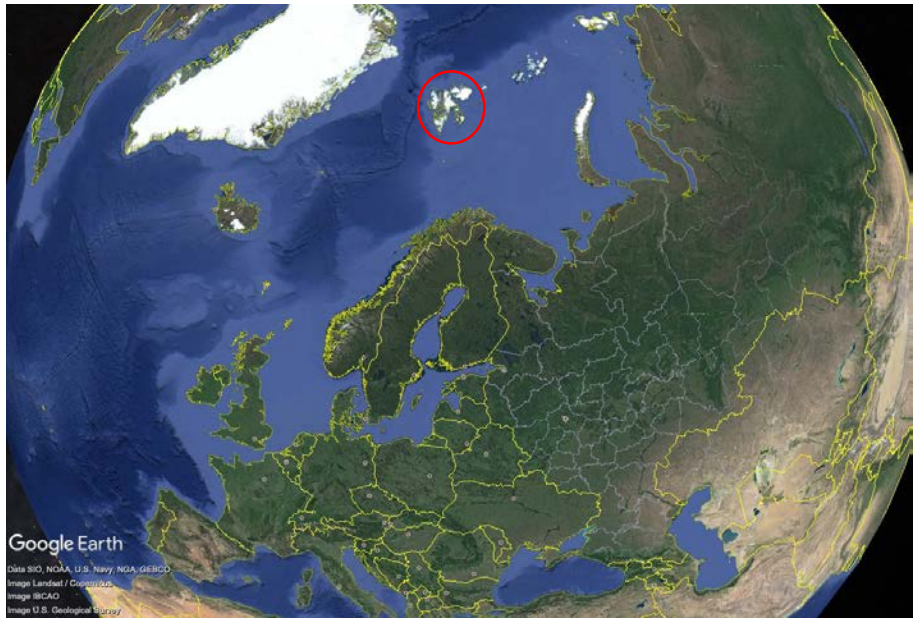
(Professional Association
Of Diving Instructors)

Collaborate with ‘shallow marine geology’ surveys.





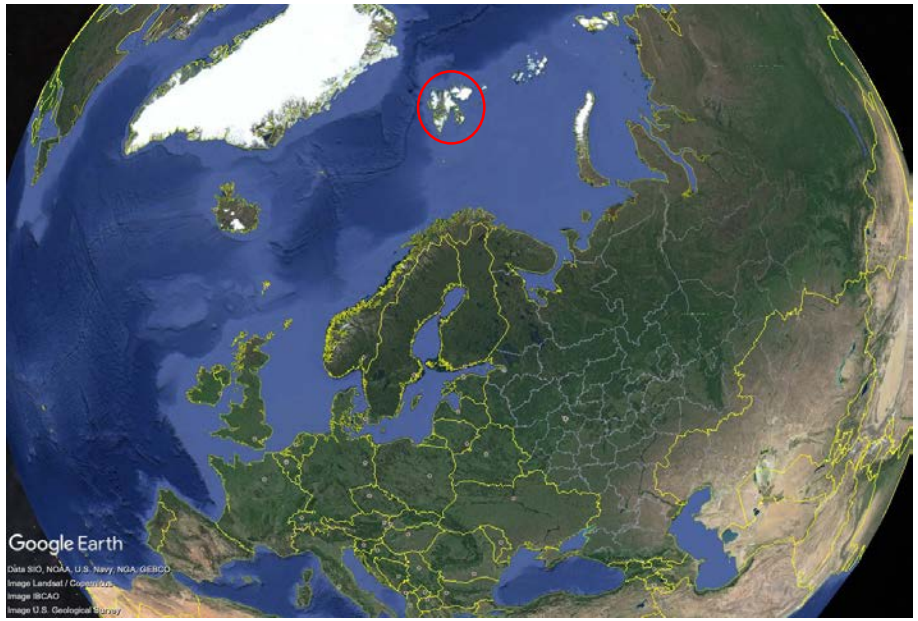
Polar Station in Svalbard







Polar Station in Svalbard







波蘭臺北辦事處
Polish Office in Taipei



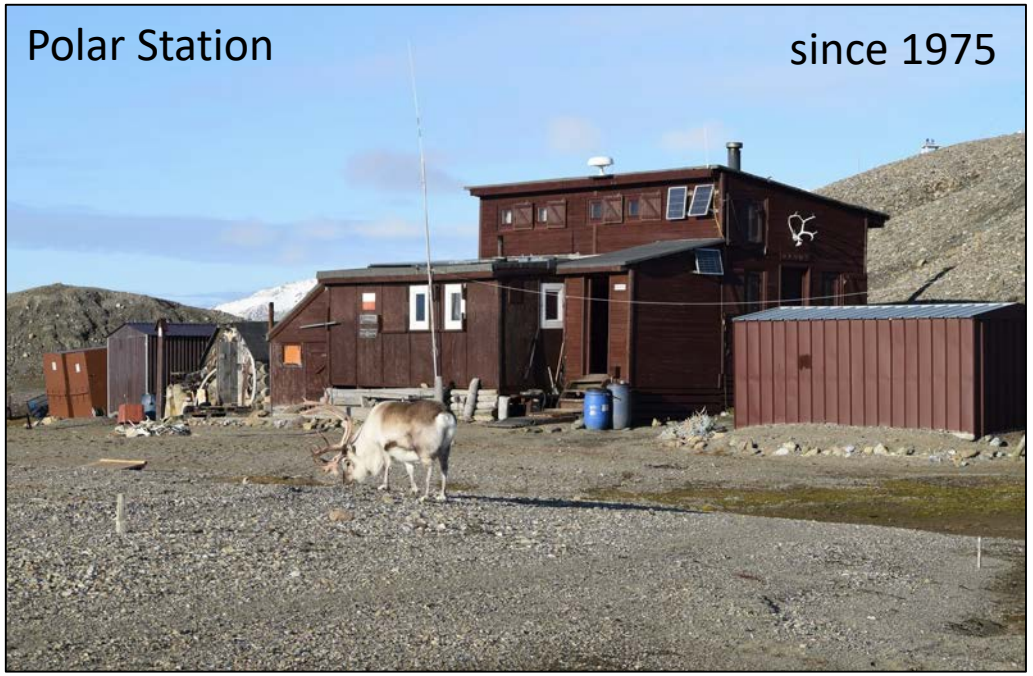
歐洲經貿辦事處
European Economic and Trade Office







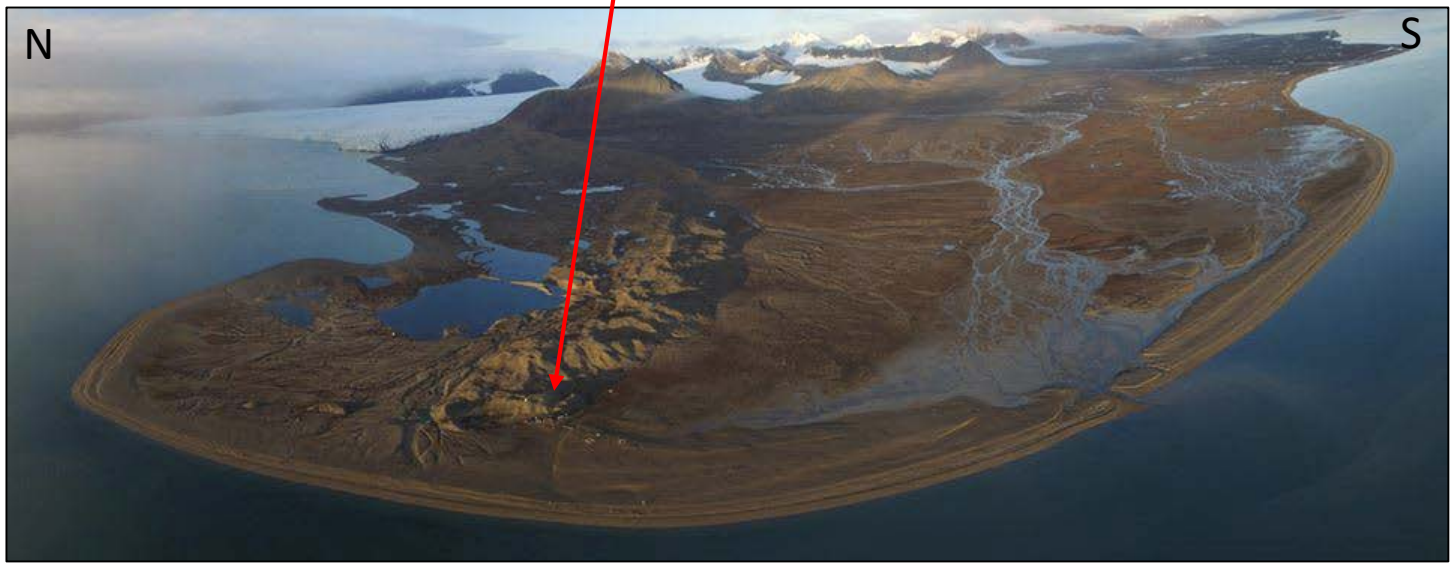
Nicolaus Copernicus University, Department of the Earth Sciences
Toruń, Poland





(17-21 November 2019)

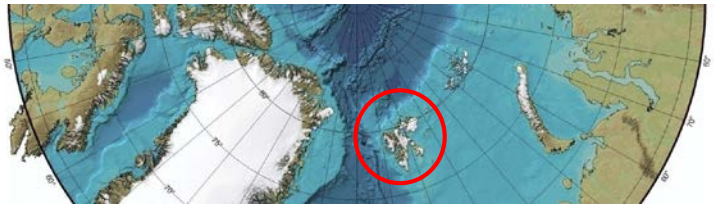



N
S


B
10°E
20°E
50 km
Seven Islands
Hinlopen Strait
80°N
Wijdefjorden
Nordaustlandet
Wahlenbergfjorden
Spitsbergen Coastal Current
Woodfjorden
79°N
Kongsfjorden
Dicksonfjorden
St. Jonsfjorden
Barentsøya
Billefjorden
Isfjorden
Tempelfjorden
Edgeøya
Spitsbergen
Prins Karls Forland
78°N
Grønfjorden
West Spitsbergen Current
Van Mijenfjorden
Van Keulenfjorden
Storfjorden
Hornsund
A
B

Research







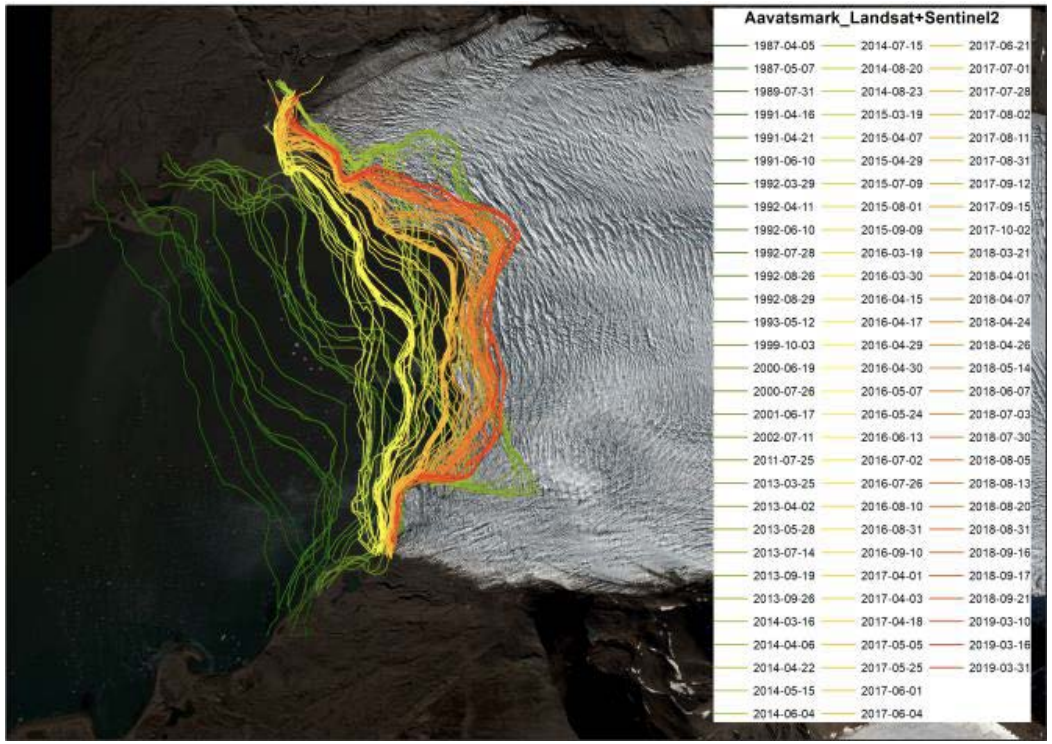




Prof. Sobota

- Global environmental changes,
- Glaciology and cryosphere studies,
- Glacial geomorphology, dynamics, geometry, interaction with climate,
- Permafrost and periglacial processes,
- Climatological studies,
- Changes in cryosphere and climate conditions,
- Photogrammetry for glaciers and hydrological processes,
- Physiochemical water surveys,
- Water movement through glaciers,
- Thermal structure.

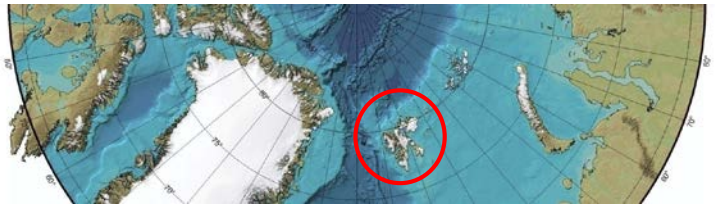
some of the data since 1975



Glacier retreat 53m/year!

Research







Open to any earth-scientific approach and/or field for survey at the Polar Station.

- Global environmental changes,
- Glaciology and cryosphere studies,
- Glacial geomorphology, dynamics, geometry, interaction with climate,
- Permafrost and periglacial processes,
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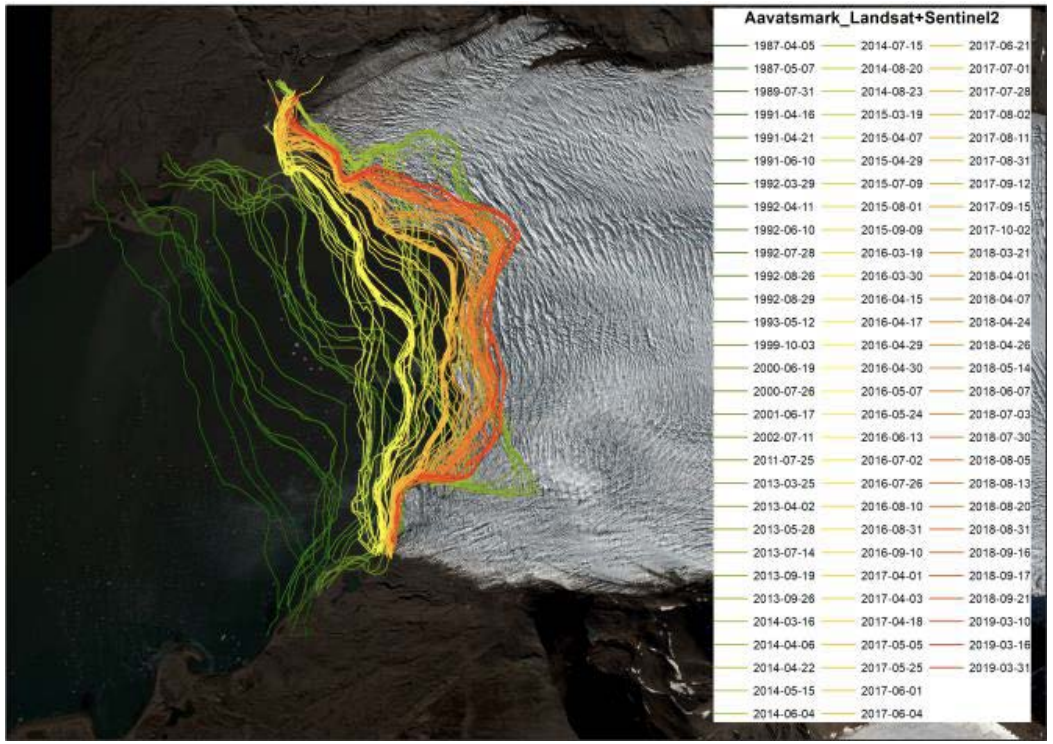

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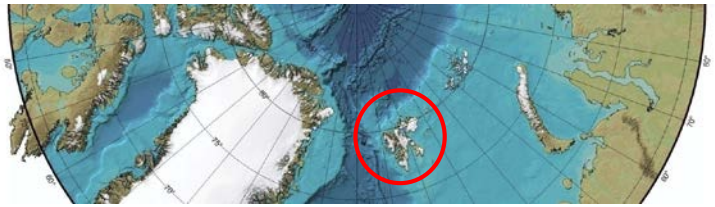




New geomorphic systems due to retreating glaciers:

- Surface deformation (uplift, rebound),
- New fluvial systems,
- Very new structural geology and geology mapping.



Initial UAV surveys over topography and fieldwork as geological mapping and reconnaissance.

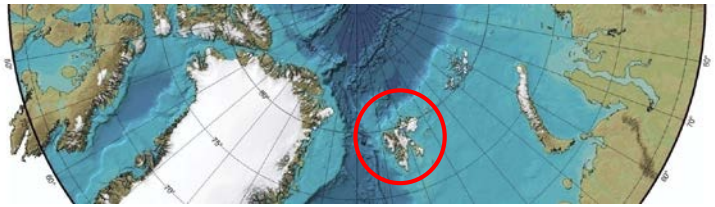
But also long-term collaboration.



New landscapes, new outcrops, new surveys…

Research







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Initial UAV surveys over topography and fieldwork as geological mapping and reconnaissance.

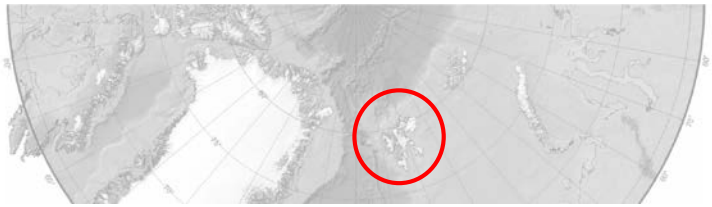
August 2020

(August 09 to September 09)



Research







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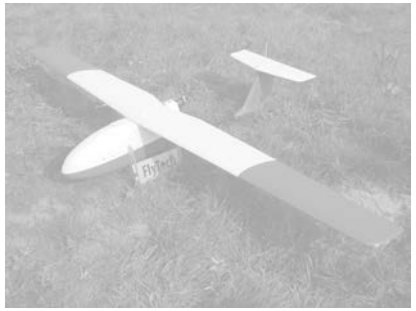

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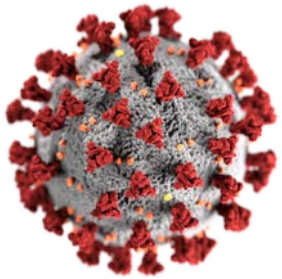


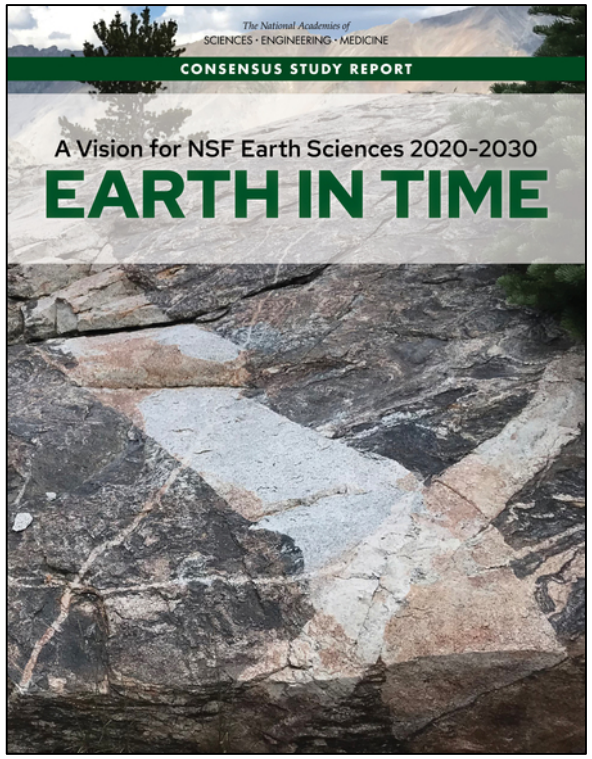
COVID-19 !

August 2020

(August 09 to September 09)



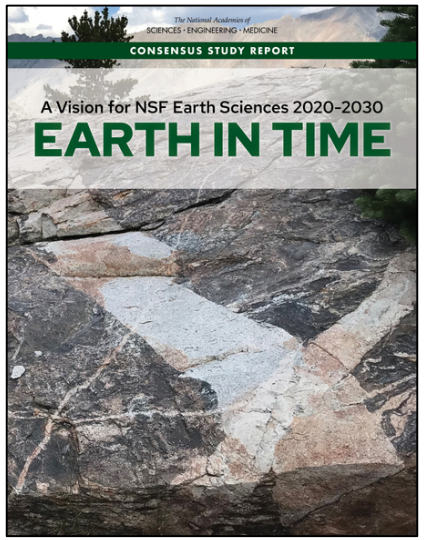
All the initial projects are postponed and collaboration is still a go.



Committee on Catalyzing Opportunities
for Research in the Earth Sciences (CORES):
A Decadal Survey for NSF's Division of Earth Sciences

Science Priority Questions for the upcoming decade.

4) Landscape evolution and development and its impact on inhabitants/society.



6. What are the causes and consequences of topographic change?

Great progress over the past two decades has been made in linking climate, tectonics, and erosion processes to understand how they shape and are dynamically influenced by Earth's surface topography. This progress has brought into focus key scientific questions concerning the role of rock mechanical properties, short-term actors such as storms, and the rheology and dynamics of Earth's interior in landscape evolution, and the co-evolution of landscapes with the atmosphere, cryosphere, sea level, and life. New technology for measuring topography over geologic to human time scales now makes it possible to address these key questions, and their implications for urgent societal challenges related to geologic hazards, resources, and climate change (NRC, 2015; Davis et al., 2016; McGuire et al., 2017; Barnhart et al., 2018; Huntington and Klepeis, 2018; NASEM, 2018).



Svalbard



Taroko Gorge landslide, Taiwan

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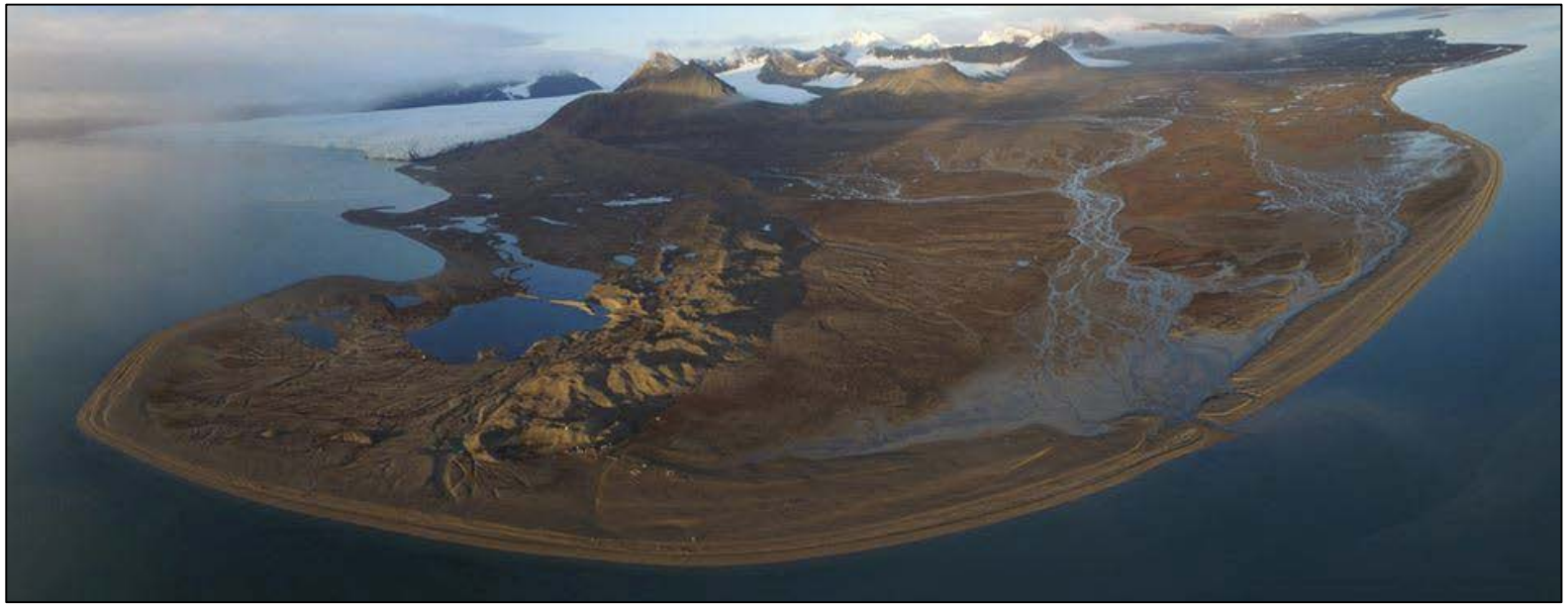
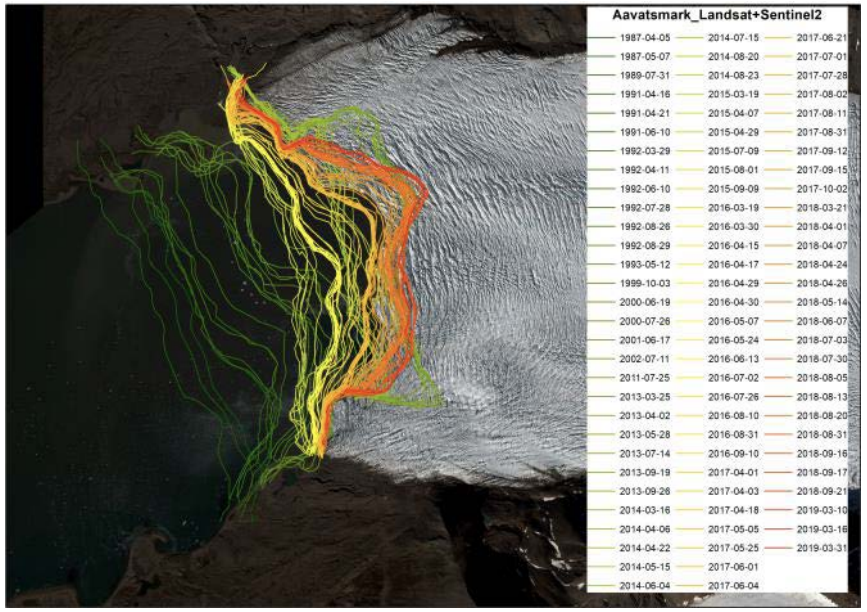
Newly exposed Earth's surface!





Teaching ideas.

1. Special Topics in Remote Sensing Geology (地質遙測專題)

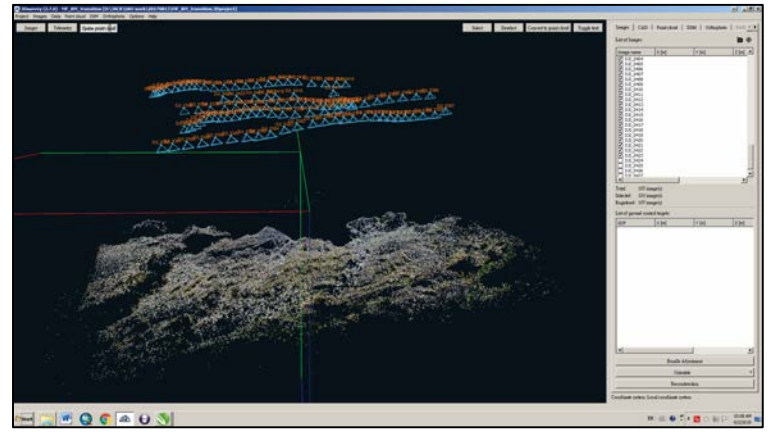


2. Fieldwork- techniques and methodology.



3. Piloting UAV for earth sciences.





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5. Structural Geology and/or Tectonic Geomorphology.



4. Geomorphology/Marine Geomorphology.

Teaching ideas.

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3. Piloting UAV for earth sciences.
4. Geomorphology/Marine Geomorphology.
5. Structural Geology and/or Tectonic Geomorphology.

6. GeoEnglish.

English in earth sciences – academic level



- Preparing and giving oral presentations,
- Reading scientific publications,
- Writing manuscripts,
- Writing thesis.

Specific topics:

1) Photogrammetry and Lidar surveying and processing (UAV).

2) Very-low and low metamorphic grade formations.

Teaching ideas.

1. Special Topics in Remote Sensing Geology (地質遙測專題)
2. Fieldwork- techniques and methodology.
3. Piloting UAV for earth sciences.
4. Geomorphology/Marine Geomorphology.
5. Structural Geology and/or Tectonic Geomorphology.
6. GeoEnglish.
7. Specific topics.

Taiwanese students in Svalbard.

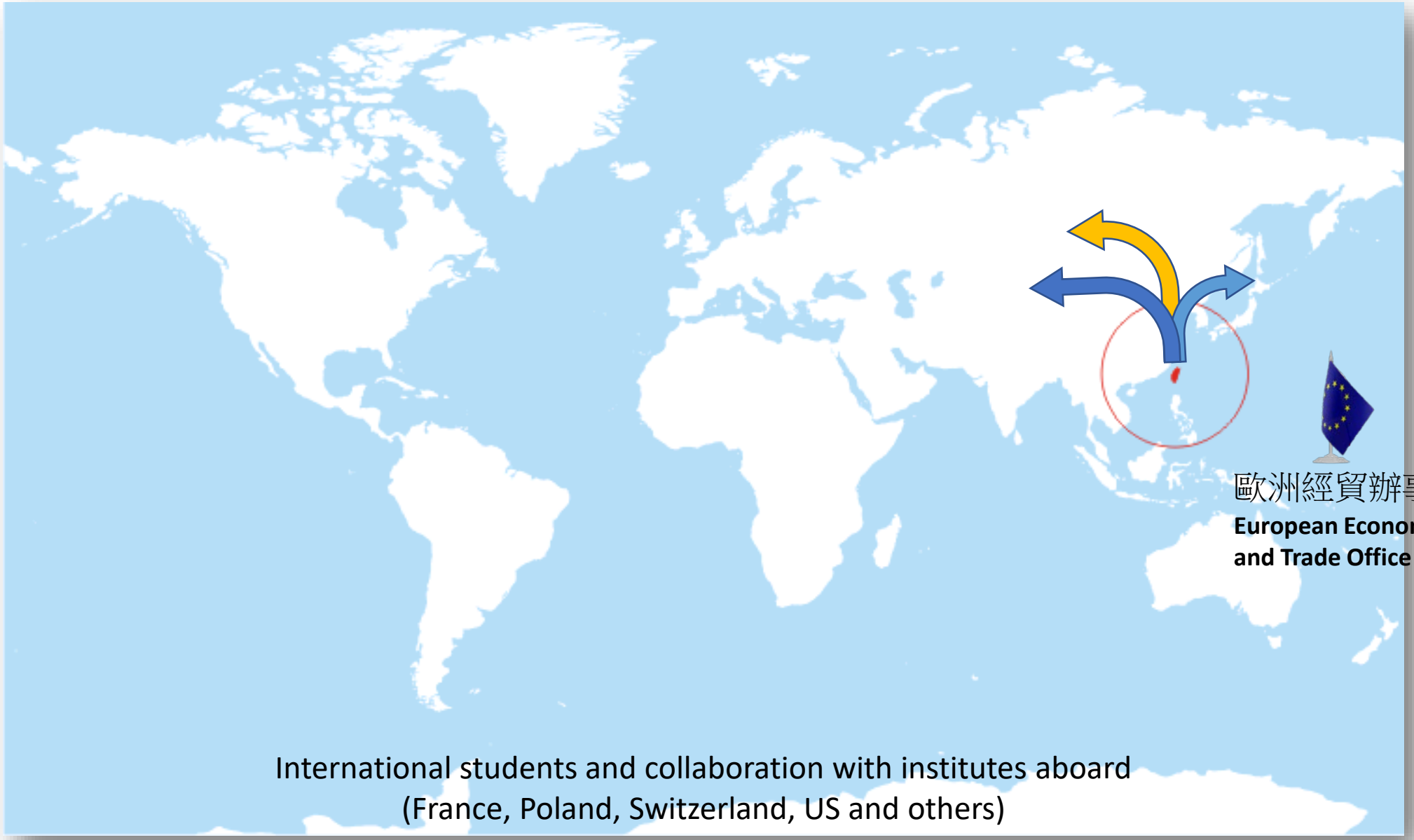


Thin-skinned shortening
Decollement folds at Midterhuken, Svalbard

International students in Taiwan (field and scholarships).



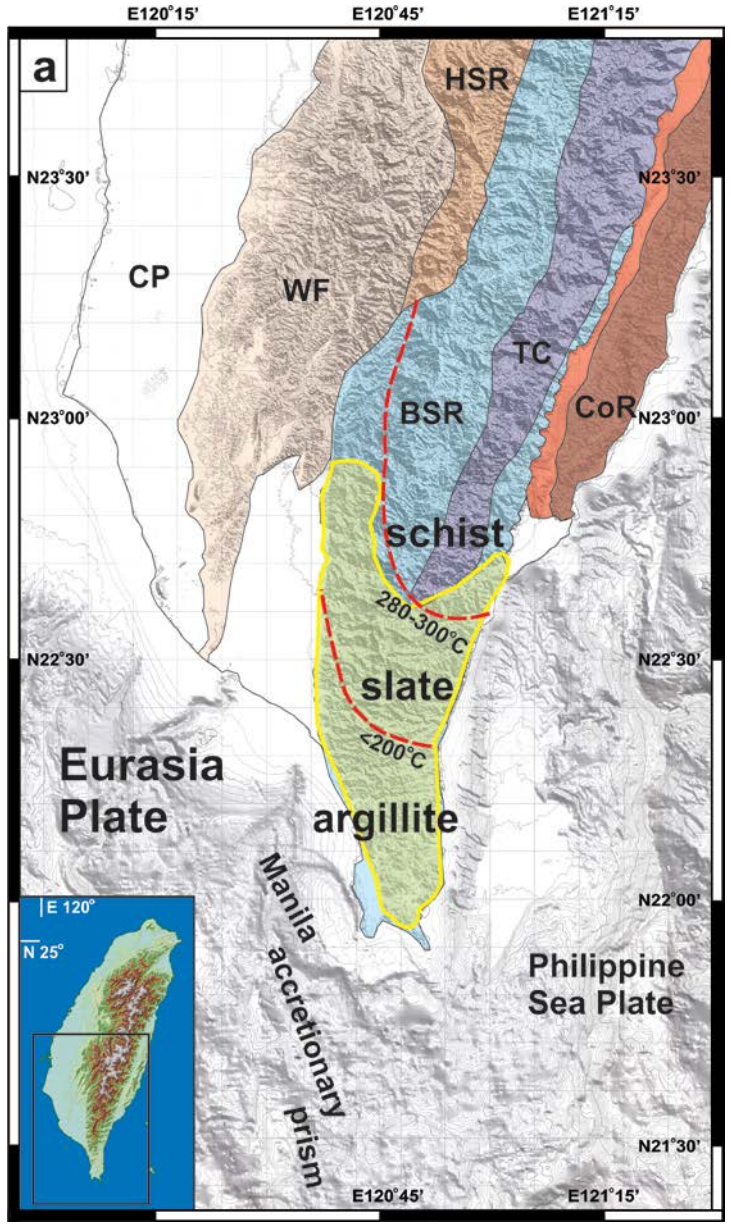
太麻里, Taiwan

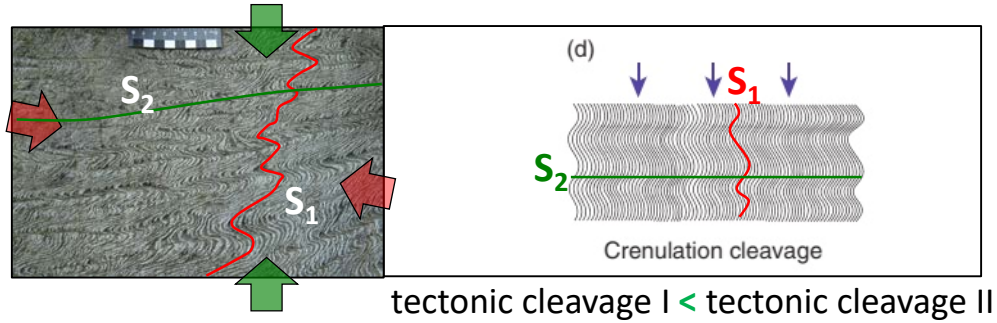


歐洲經貿辦事處
European Economic and Trade Office

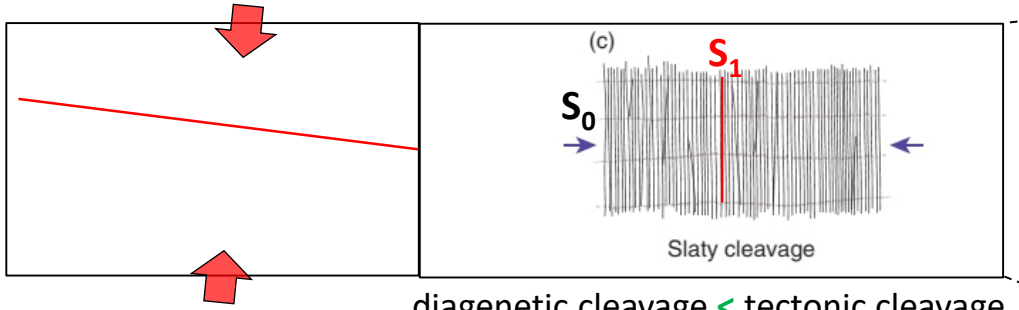
International students and collaboration with institutes aboard
(France, Poland, Switzerland, US and others)


Thank you

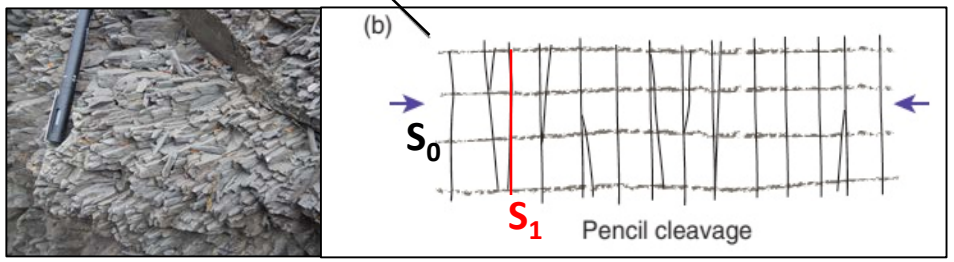




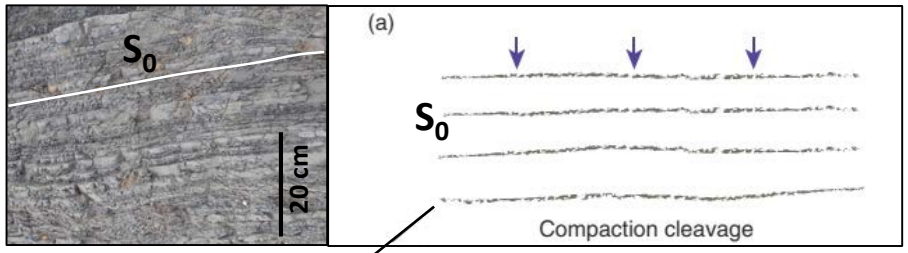
tectonic cleavage I < tectonic cleavage II



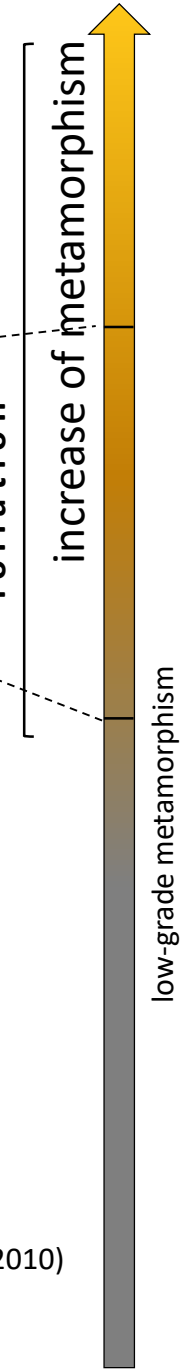
diagenetic cleavage < tectonic cleavage



diagenetic cleavage = tectonic cleavage



diagenetic cleavage (gravity)



(H. Fossen 2010)

Transportation





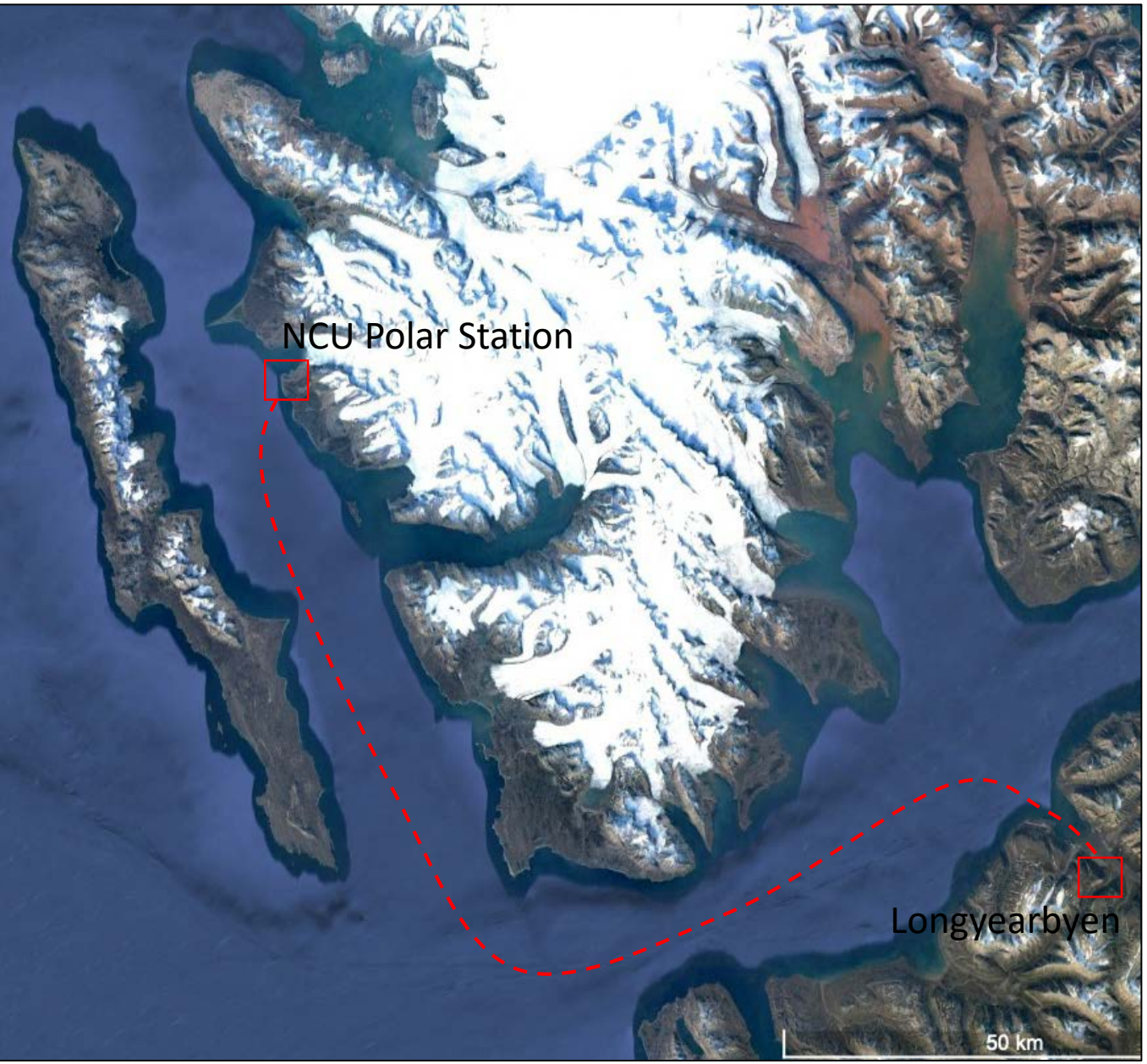




Longyearbyen



Svalbard Global Seed Vault







Transportation on land in winter.

Polar Station

Daytime 24 hours in summer time.











Polar Bears!



Real fieldwork













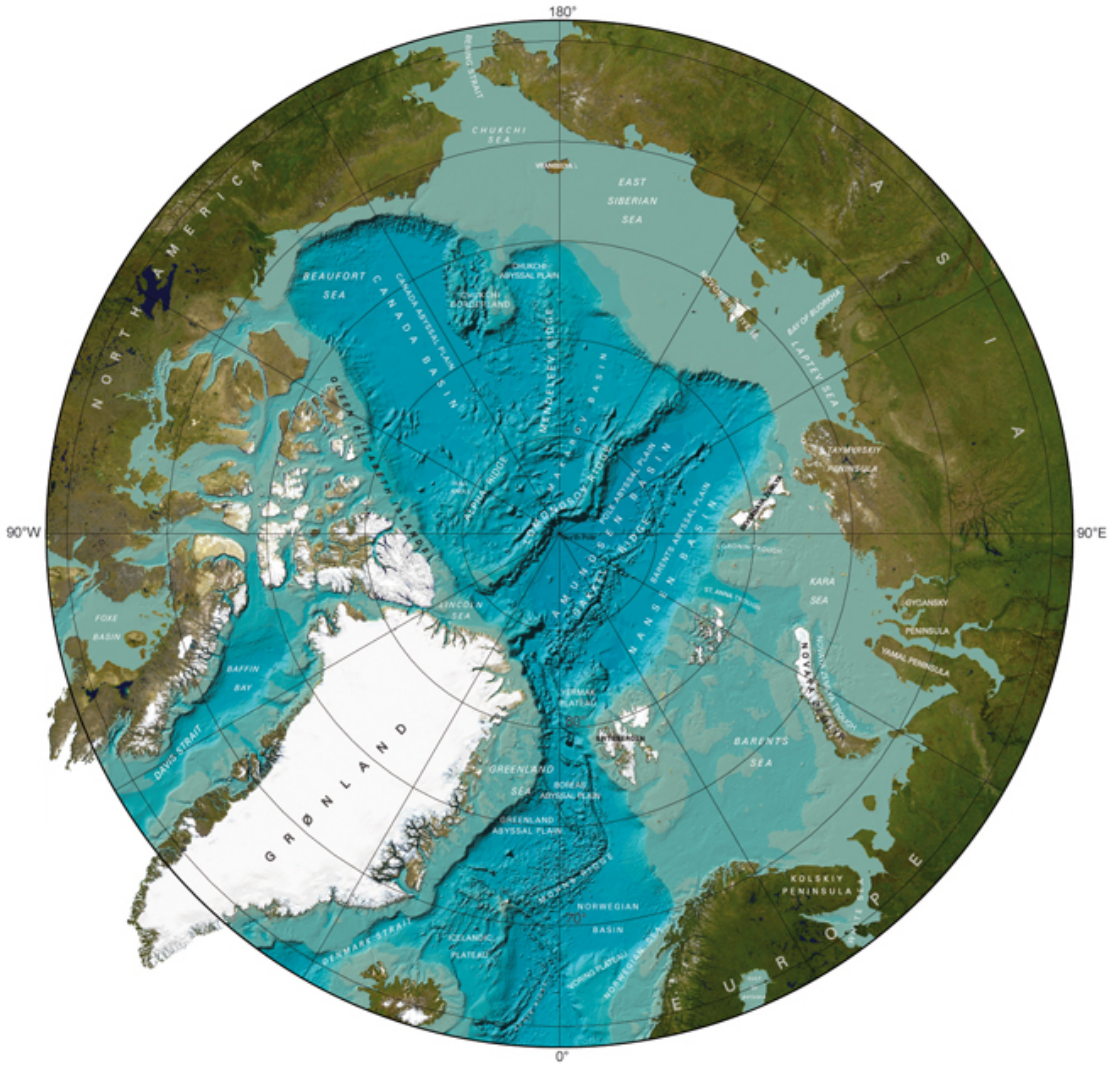


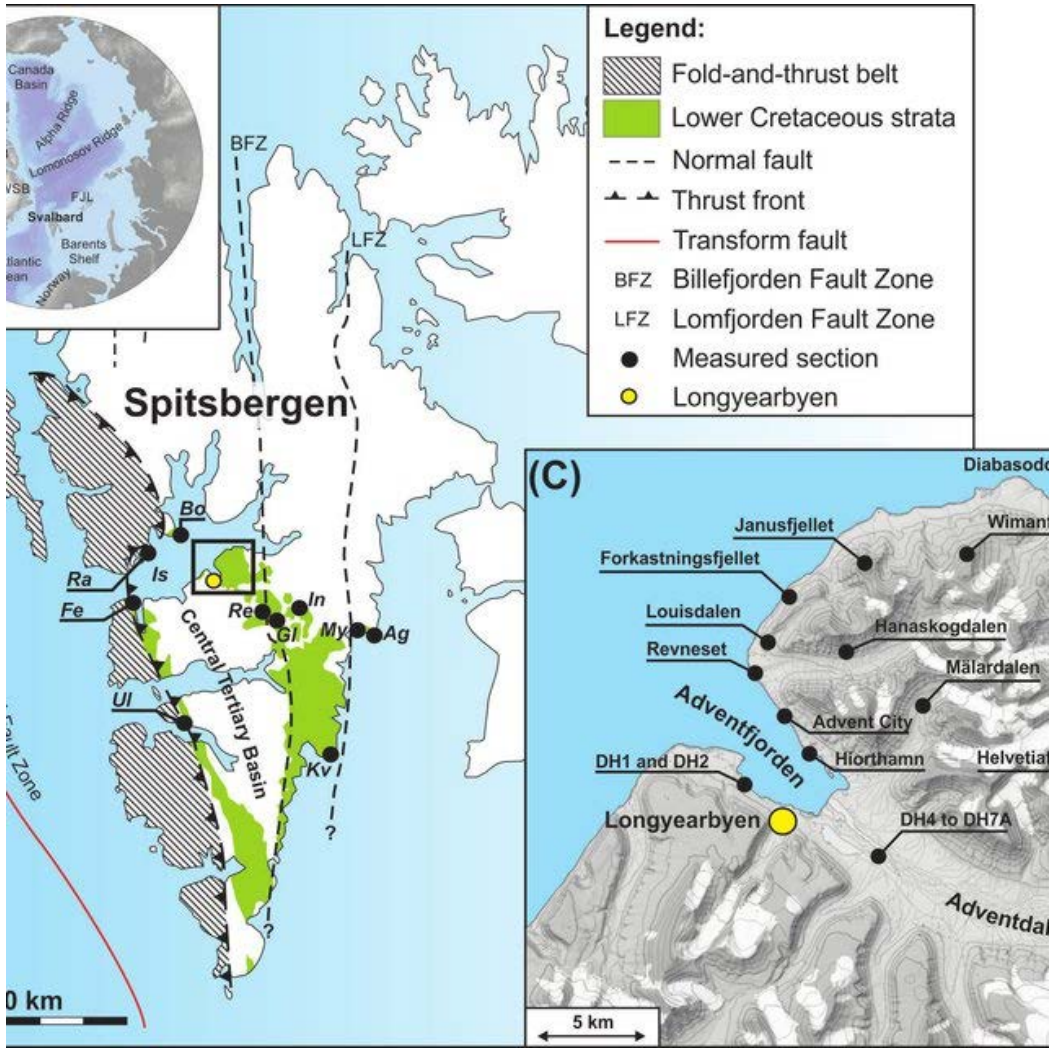
Wildlife and Landscapes





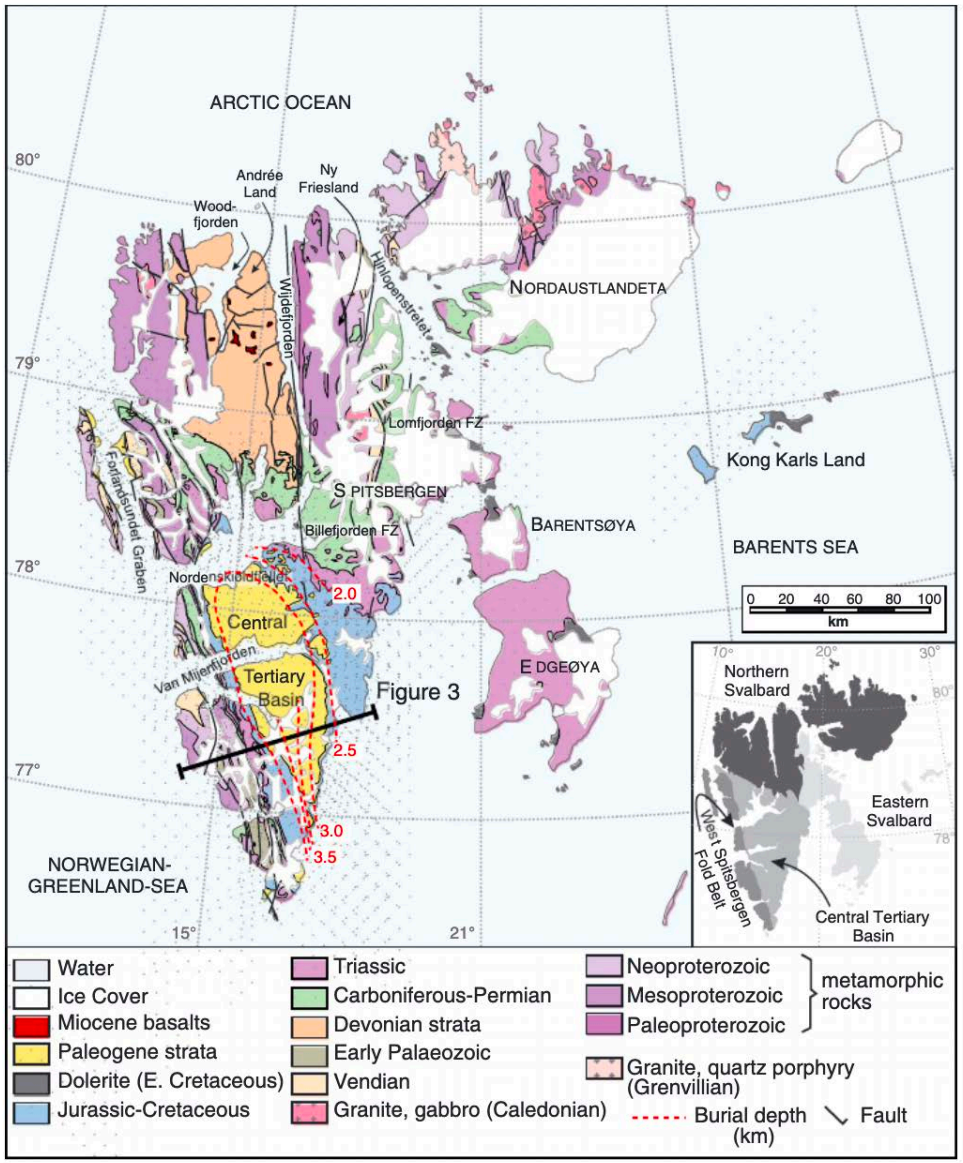


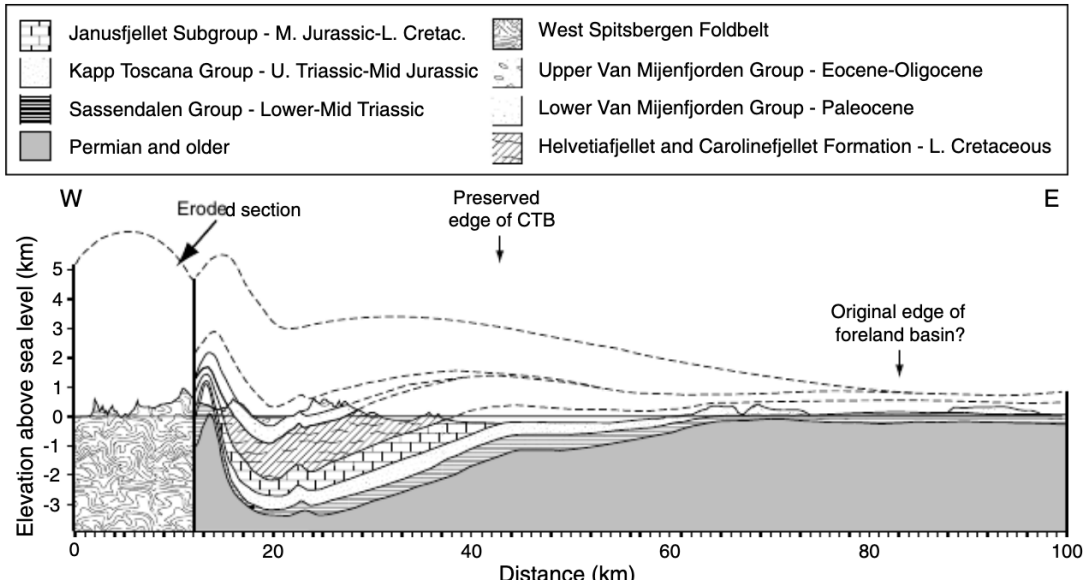




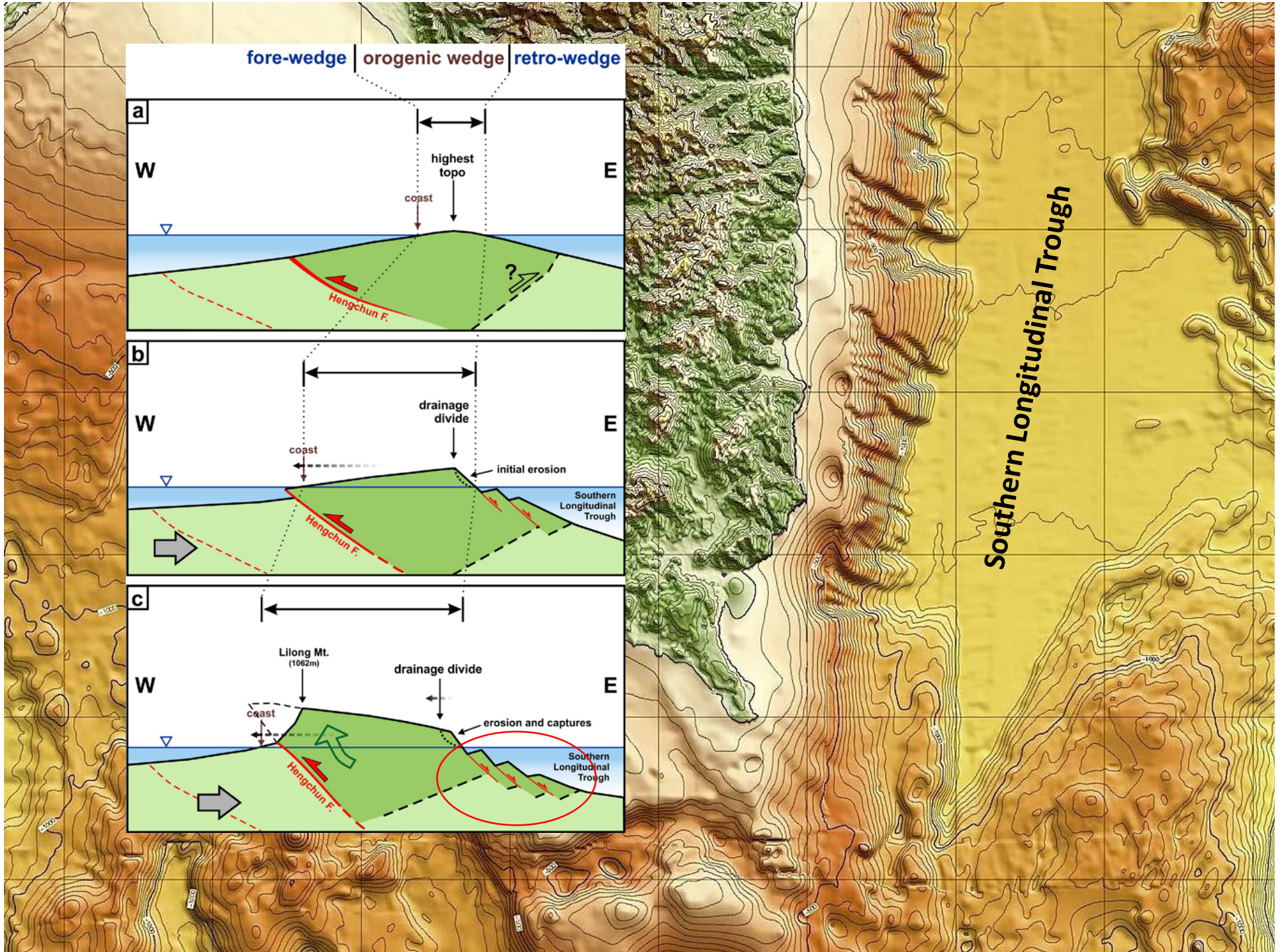
Grundvåg et al., 2019

Geological units of Svalbard





(N. Dörr et al., 2013)


fore-wedge
orogenic wedge
retro-wedge
a
W
E
highest topo
coast
?
Hengchun F.
b
W
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drainage divide
coast
initial erosion
Southern Longitudinal Trough
Hengchun F.
c
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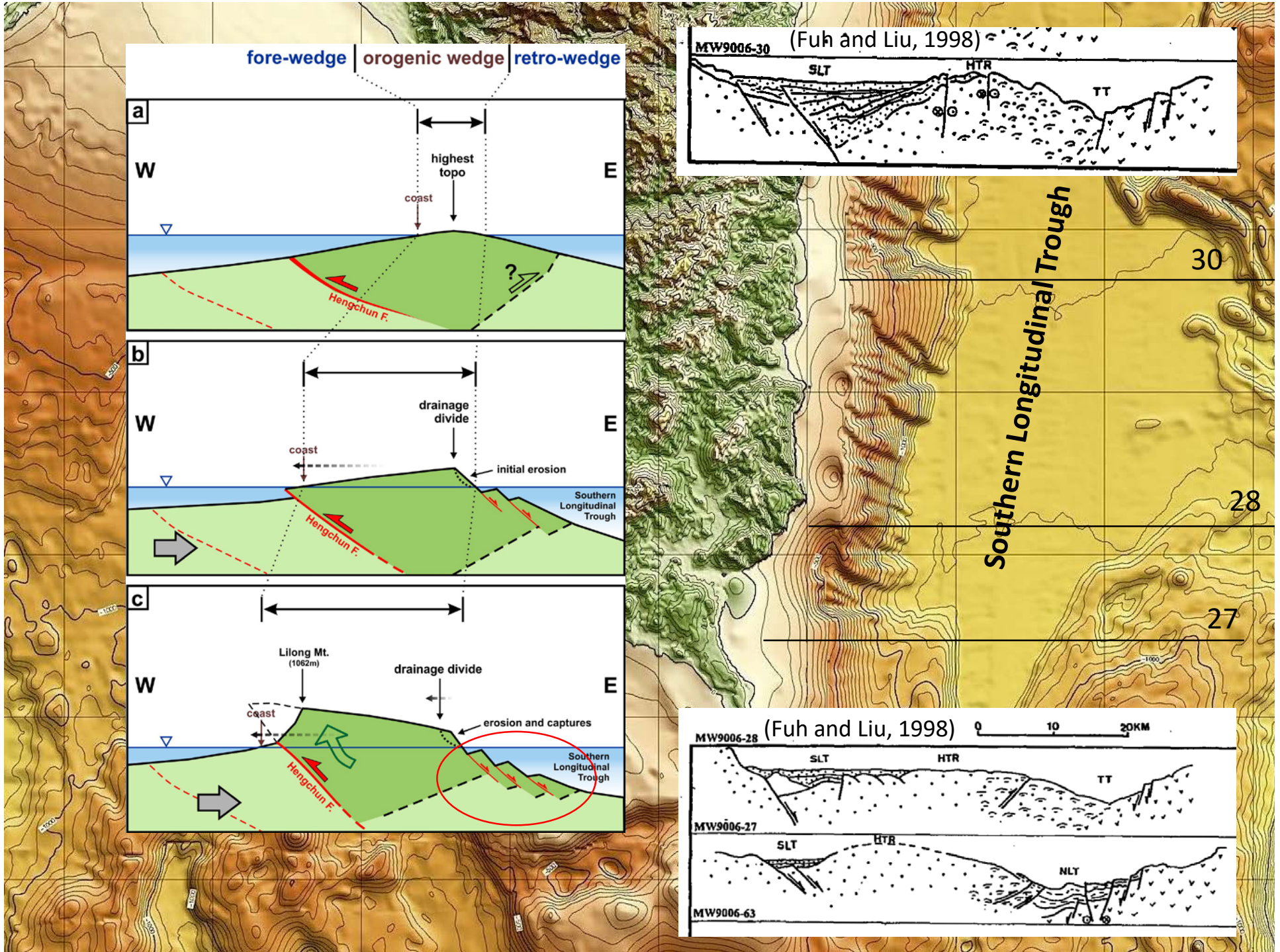
E
Lilong Mt. (1062m)
drainage divide
coast
erosion and captures
Southern Longitudinal Trough
Hengchun F.
Southern Longitudinal Trough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coast
initial erosion
Southern Longitudinal Trough
Hengchun F.
c
W
E
Lilong Mt. (1062m)
drainage divide
coast
erosion and captures
Southern Longitudinal Trough
Hengchun F.
(Fuh and Liu, 1998)
MW9006-30
SLT
HTR
TT
Southern Longitudinal Trough
30
28
27
(Fuh and Liu, 1998)
MW9006-28
0
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SLT
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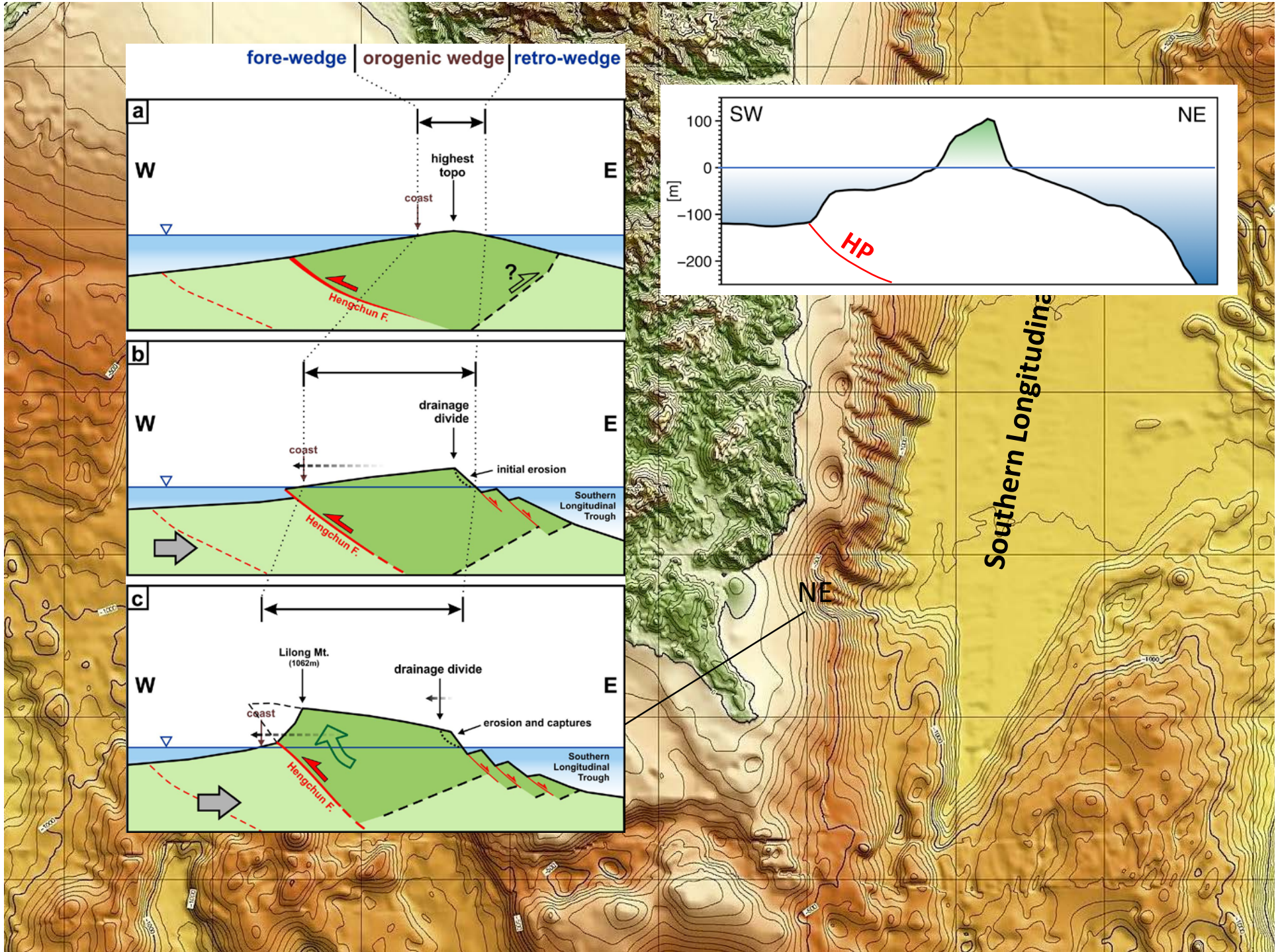
NLT
MW9006-63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drainage divide
coast
initial erosion
Southern Longitudinal Trough
Hengchun F.
c
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Lilong Mt. (1062m)
drainage divide
coast
erosion and captures
Southern Longitudinal Trough
Hengchun F.
SW
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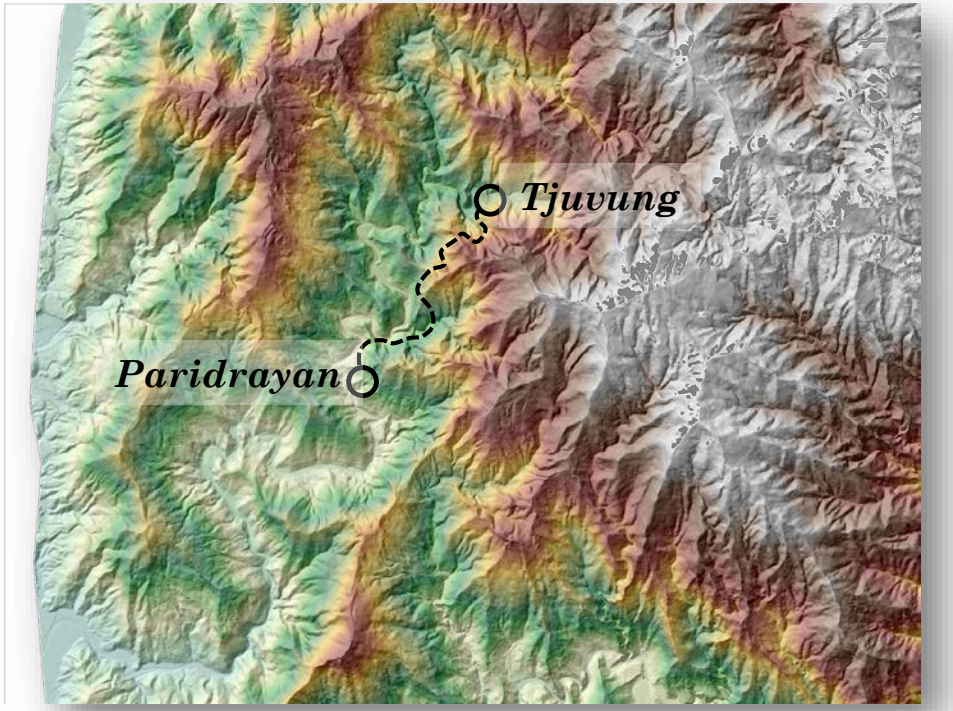
HP
Southern Longitudina
NE

1) Reasons for relocations,

2) Conditions to settle.



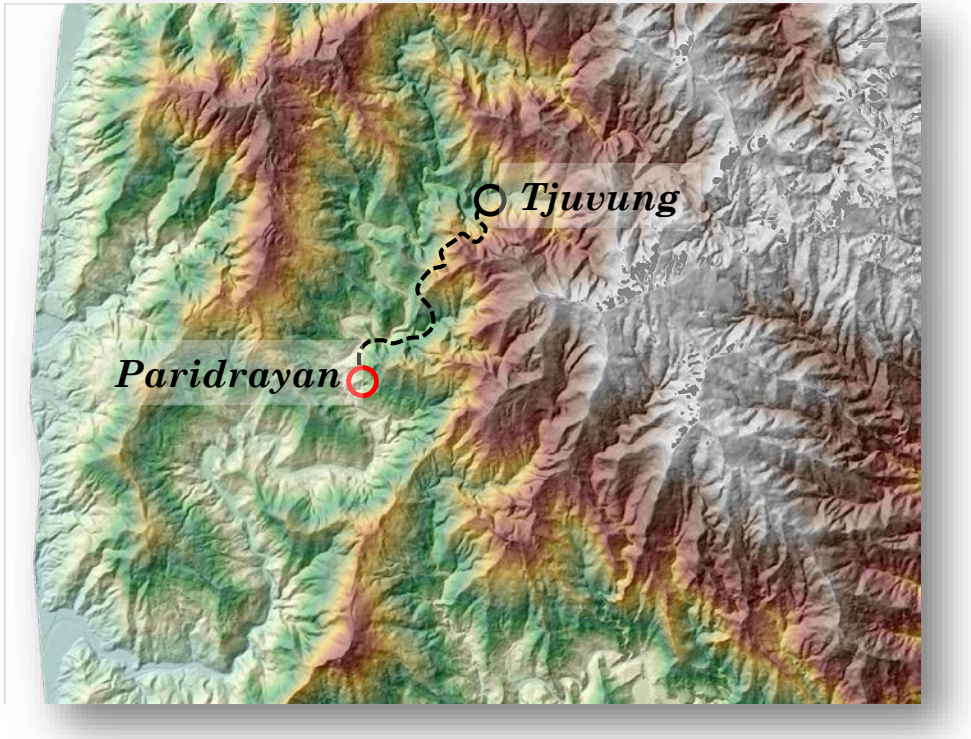
~ 350 years BP

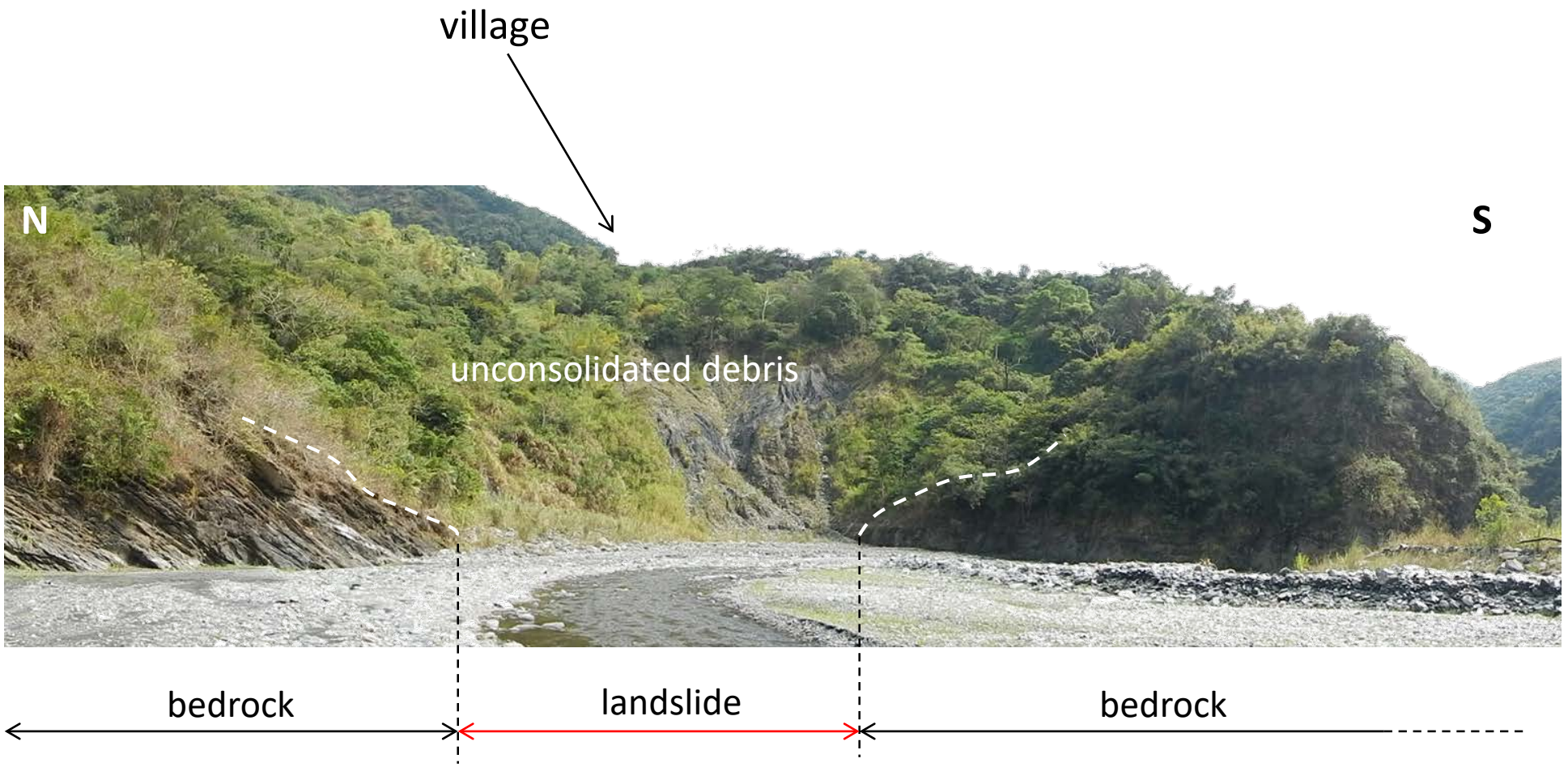


The village is located on a prehistoric landslide!



~ 350 years BP




village
N
S
unconsolidated debris
bedrock
landslide
bedrock

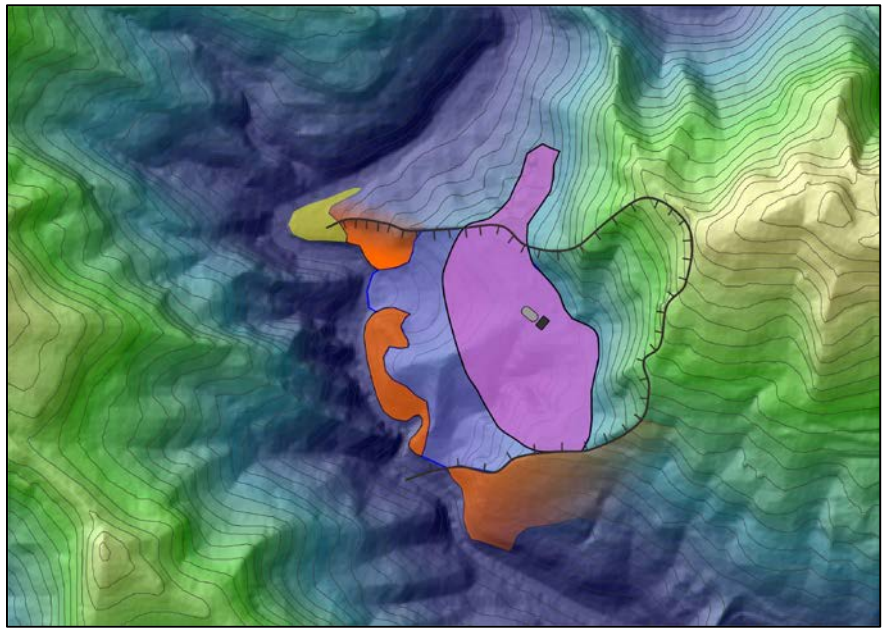
Paridraian - present



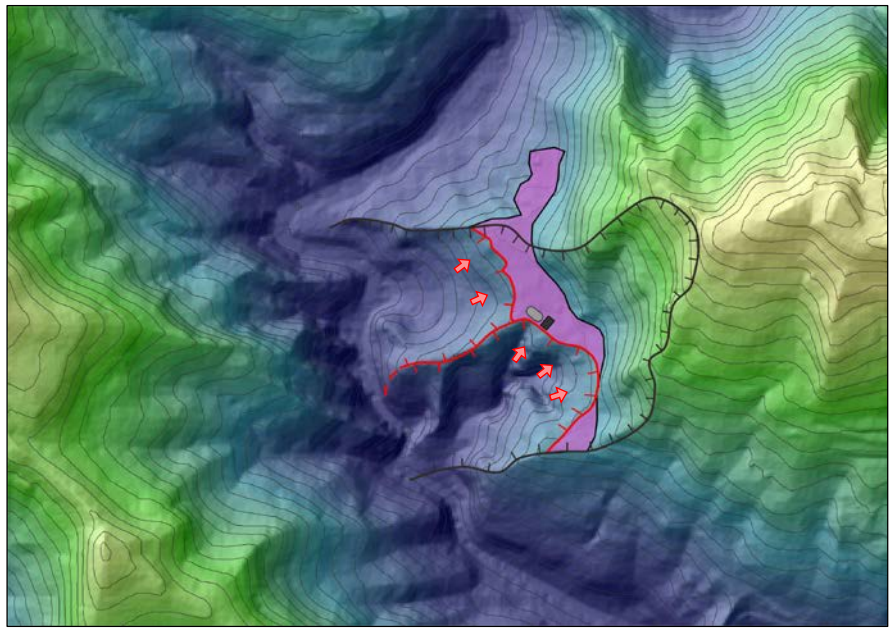
school over the cliff
(abandoned)



Paridrayan right after the landslide



Paridrayan Village in present.

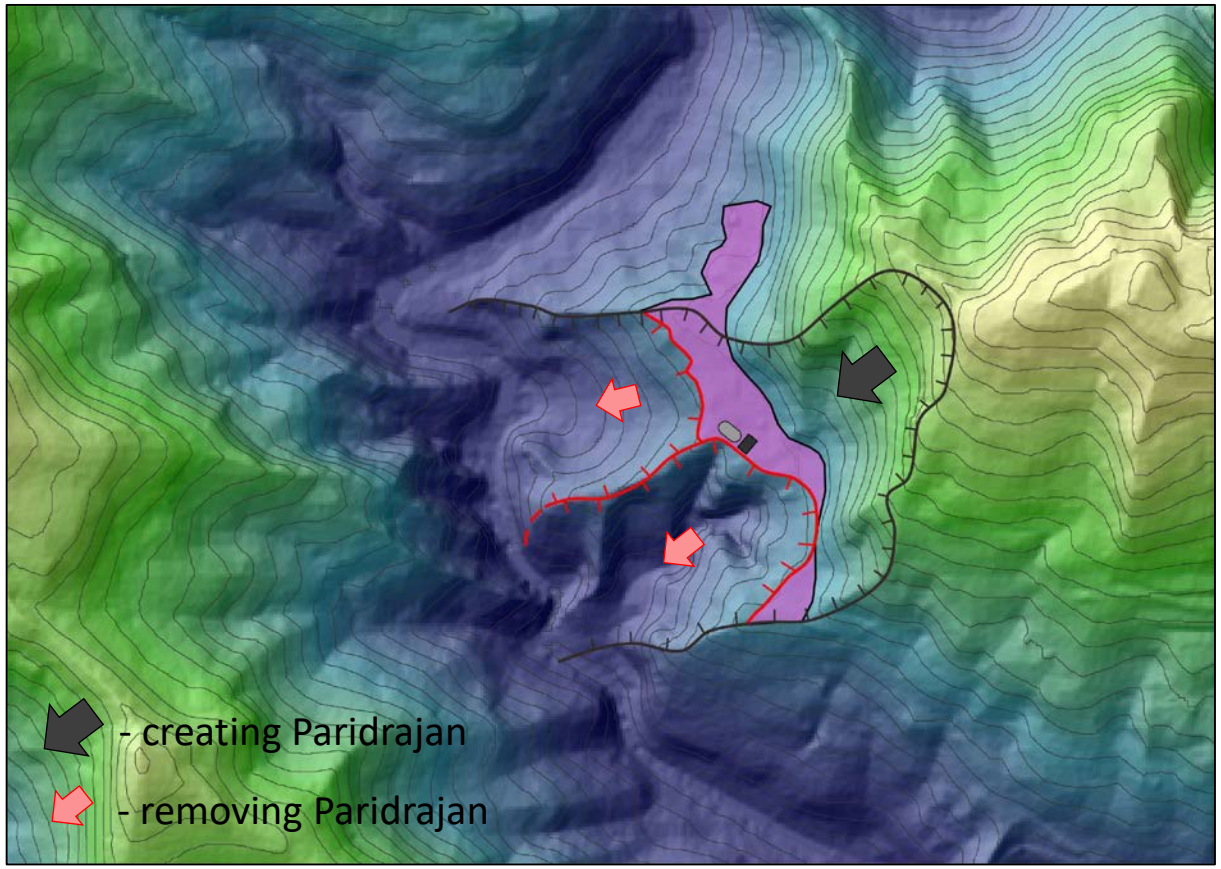


(5m DEM)

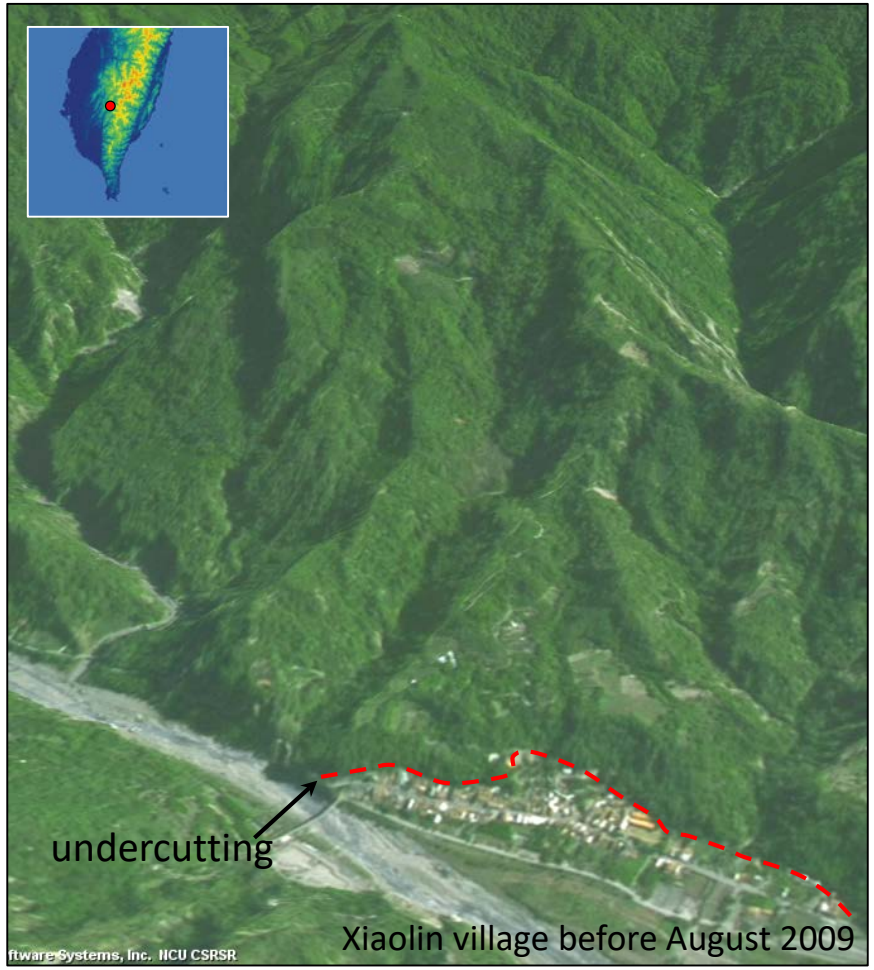
- bedrock

- original village area

Two generations of landslides



Typhoon Morakot August 2009



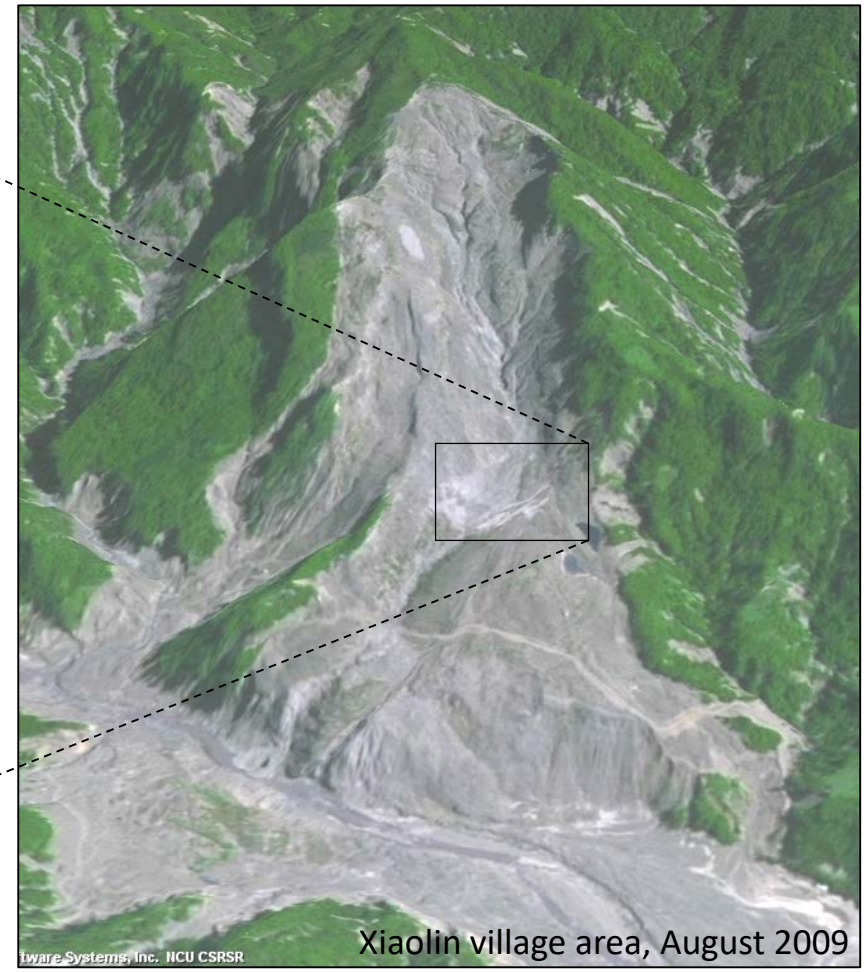
Xiaolin village before August 2009



Xiaolin village area, August 2009

Depletion zone of the Xiao Lin village.





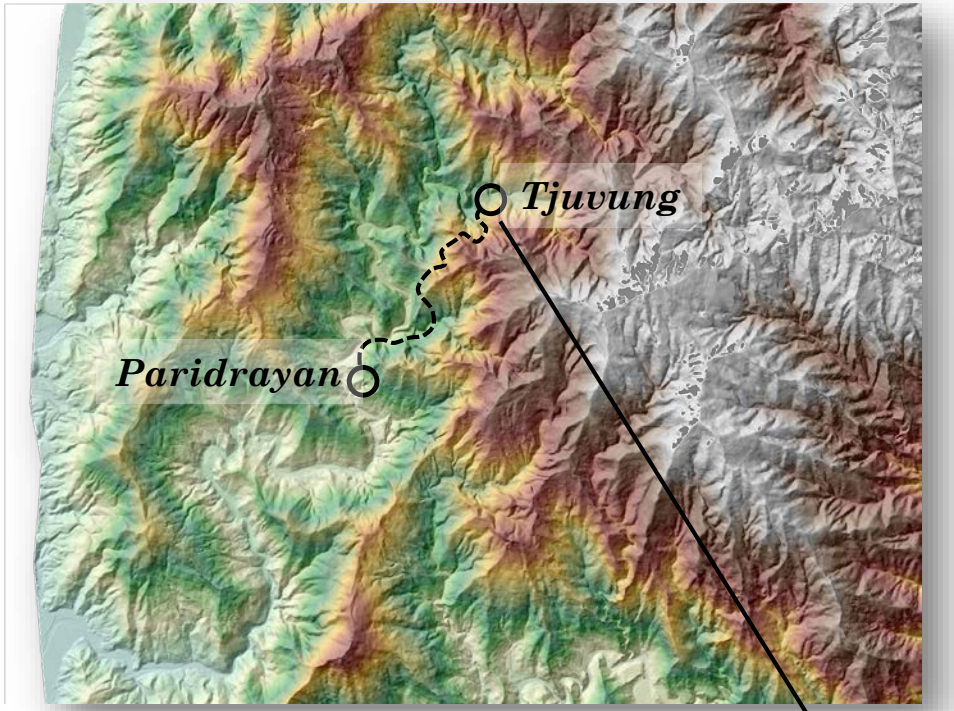
Xiaolin village area, August 2009

1) Reasons for relocations,

2) Conditions to settle.



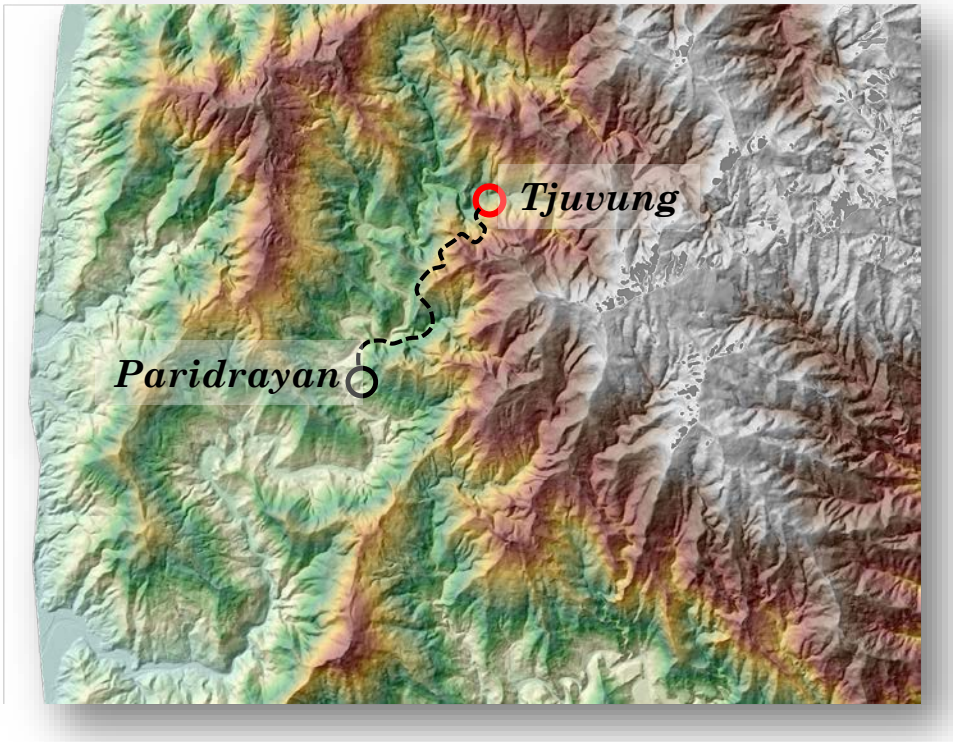
~ 350 years BP



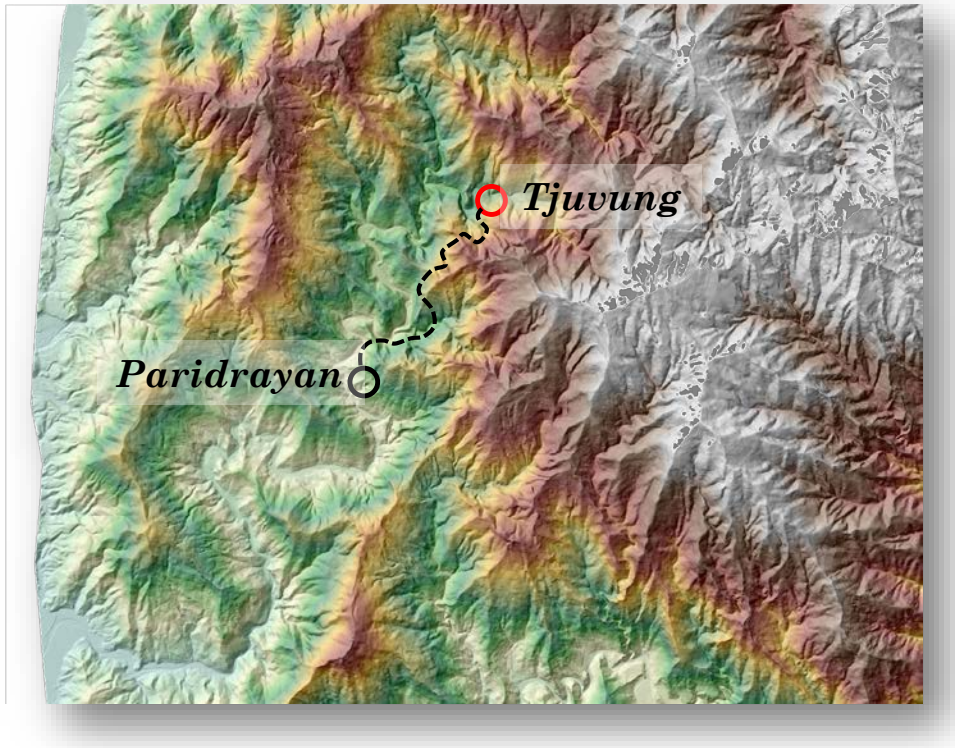
"flood.." (?!)


Tiuvung (~350 yrs BP)



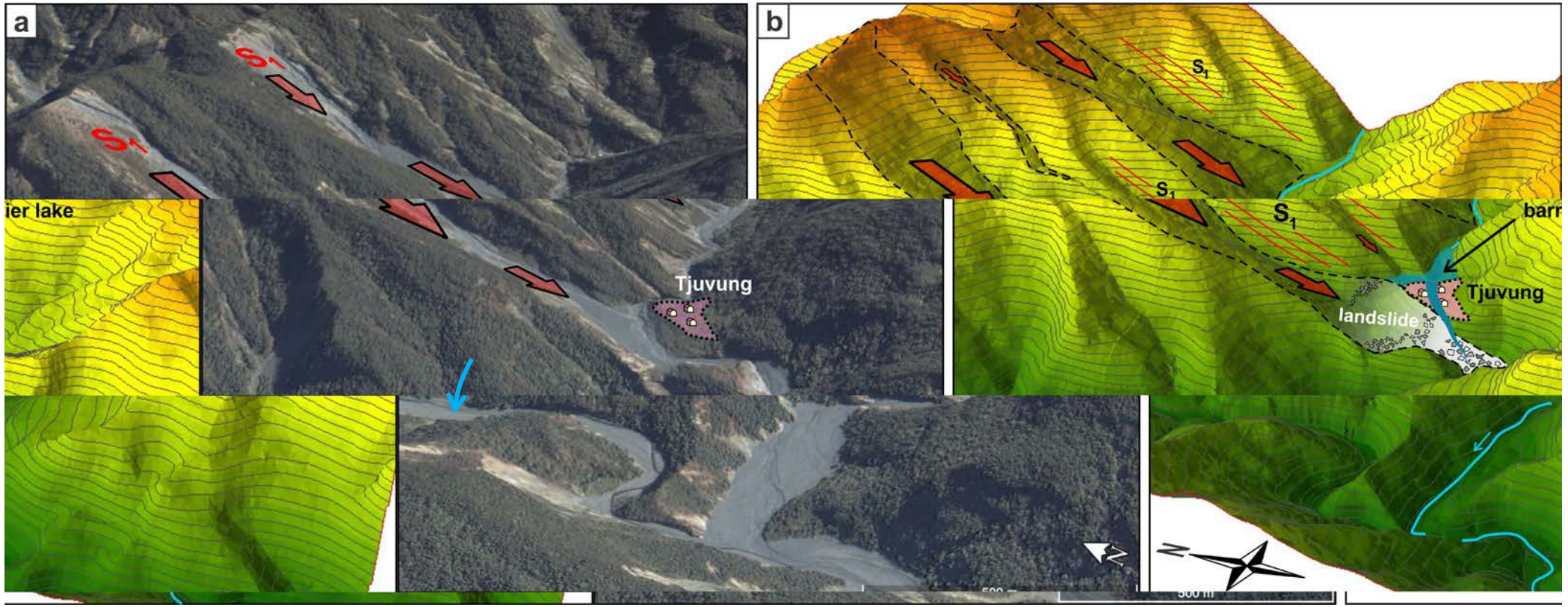

Tjuvung
Paridrayan

Dip-slope failure



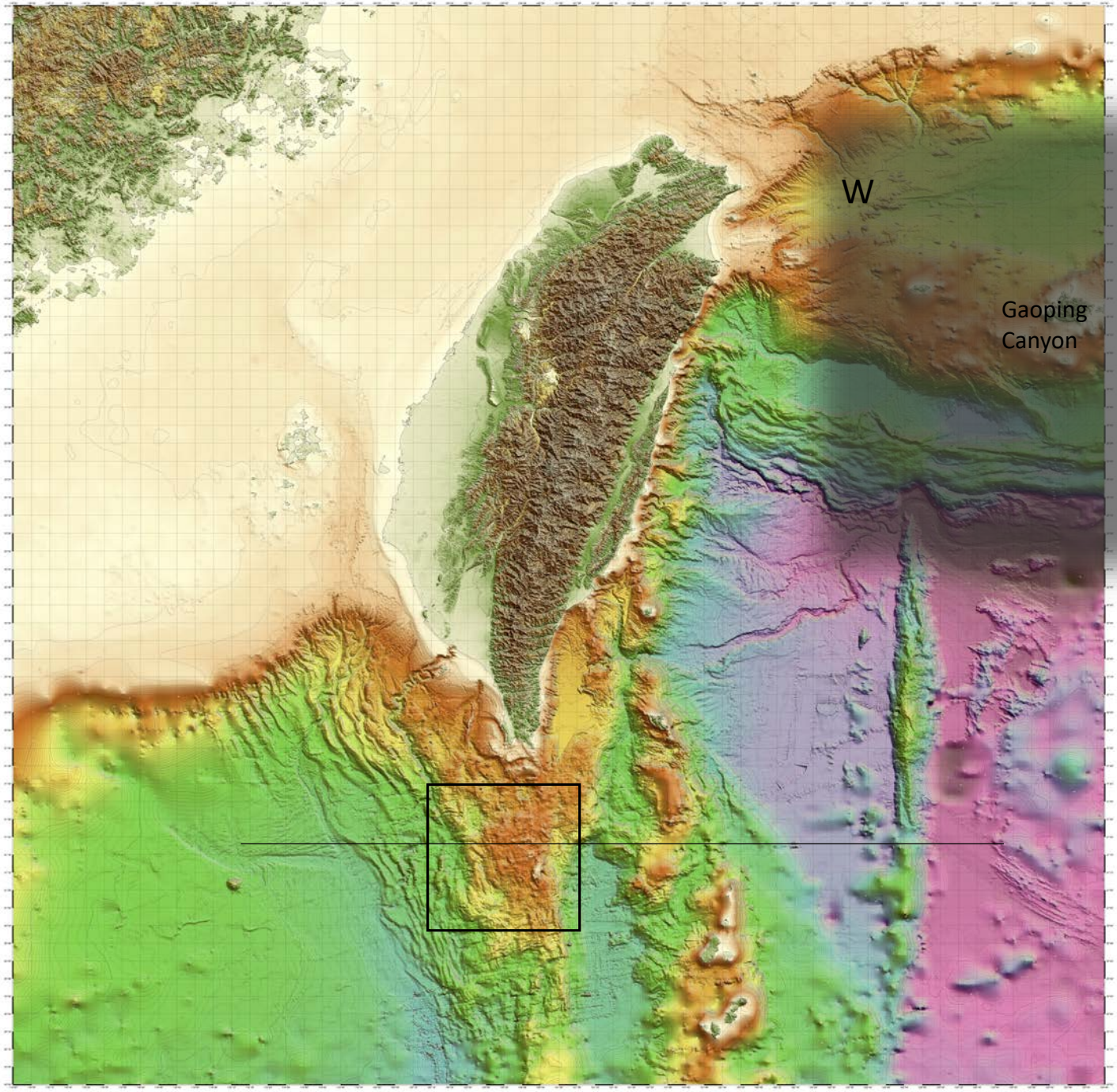
Dip-slope failure

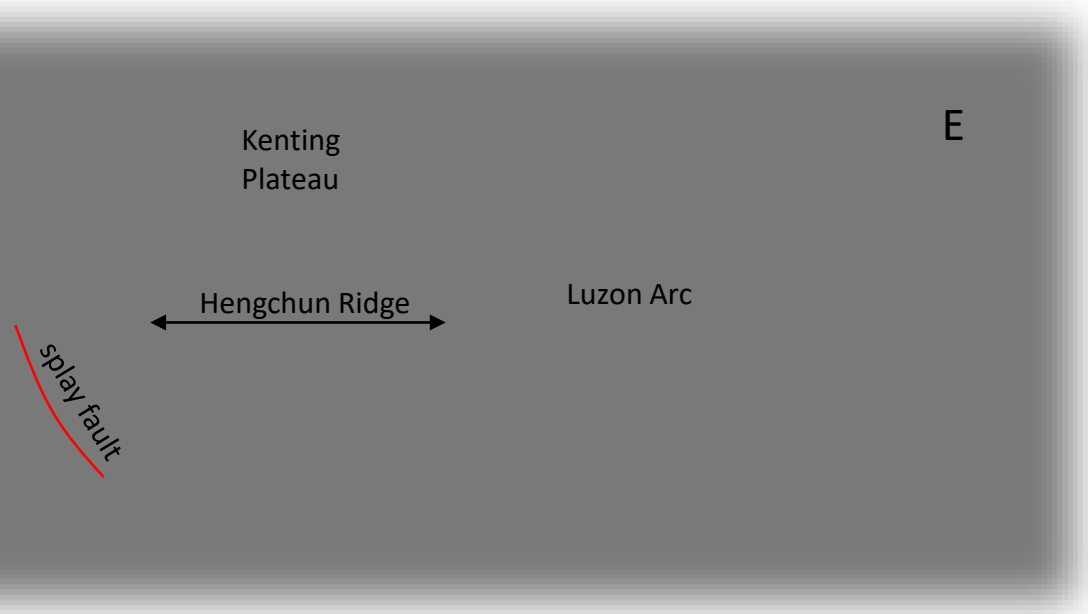
…led to the barrier lake that flood the village.





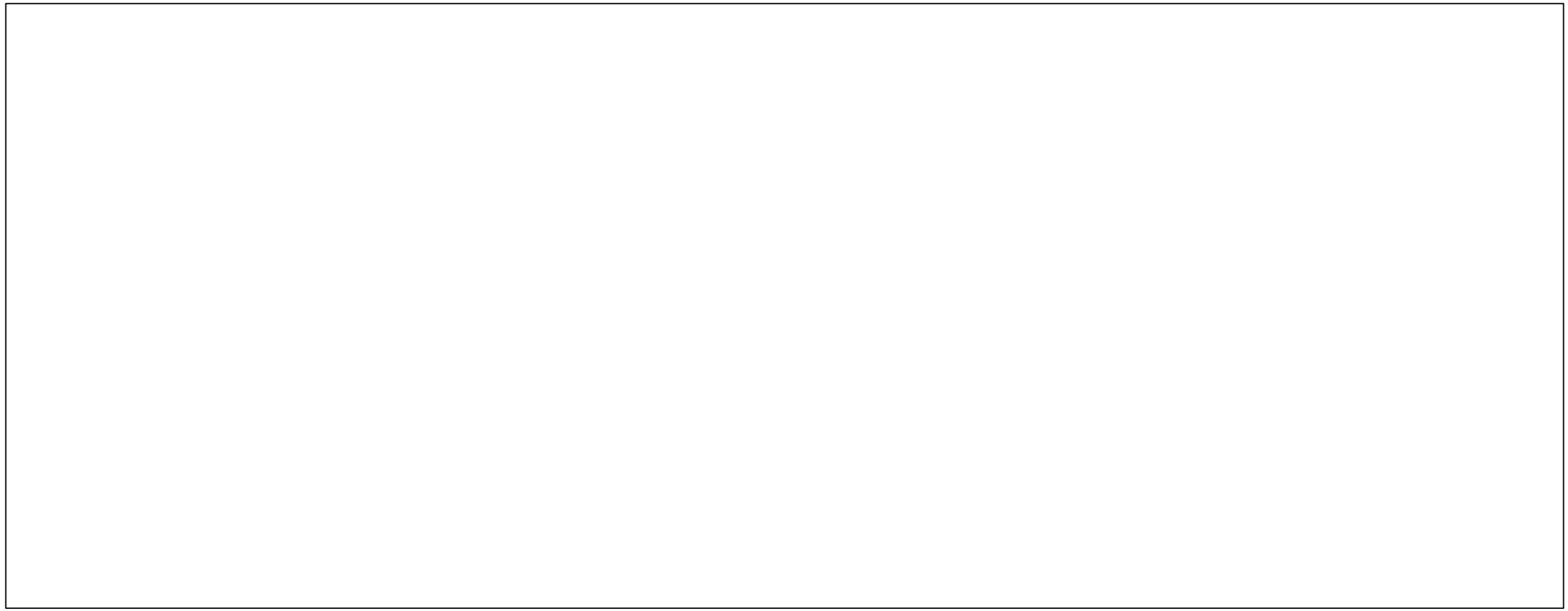
Environmental refugees





Kenting Plateau



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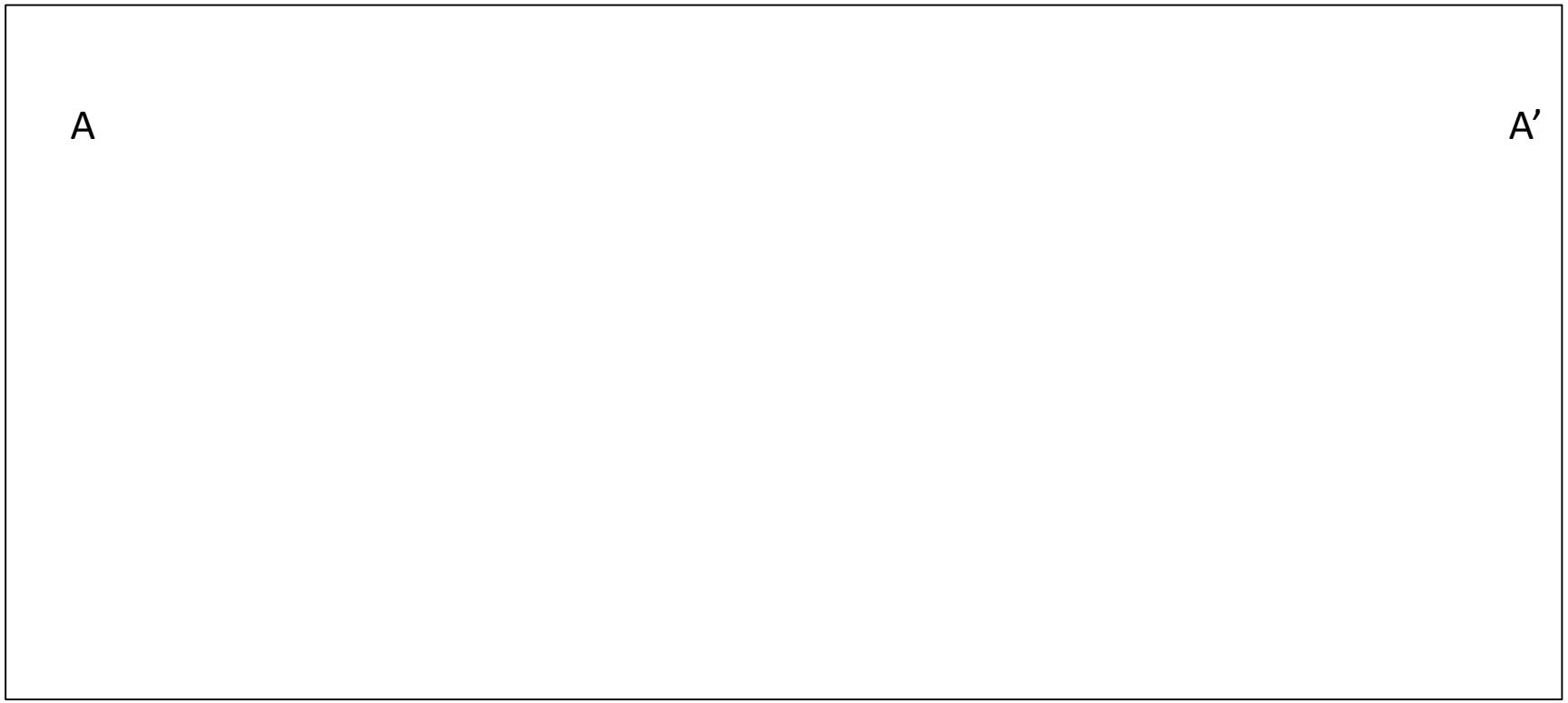
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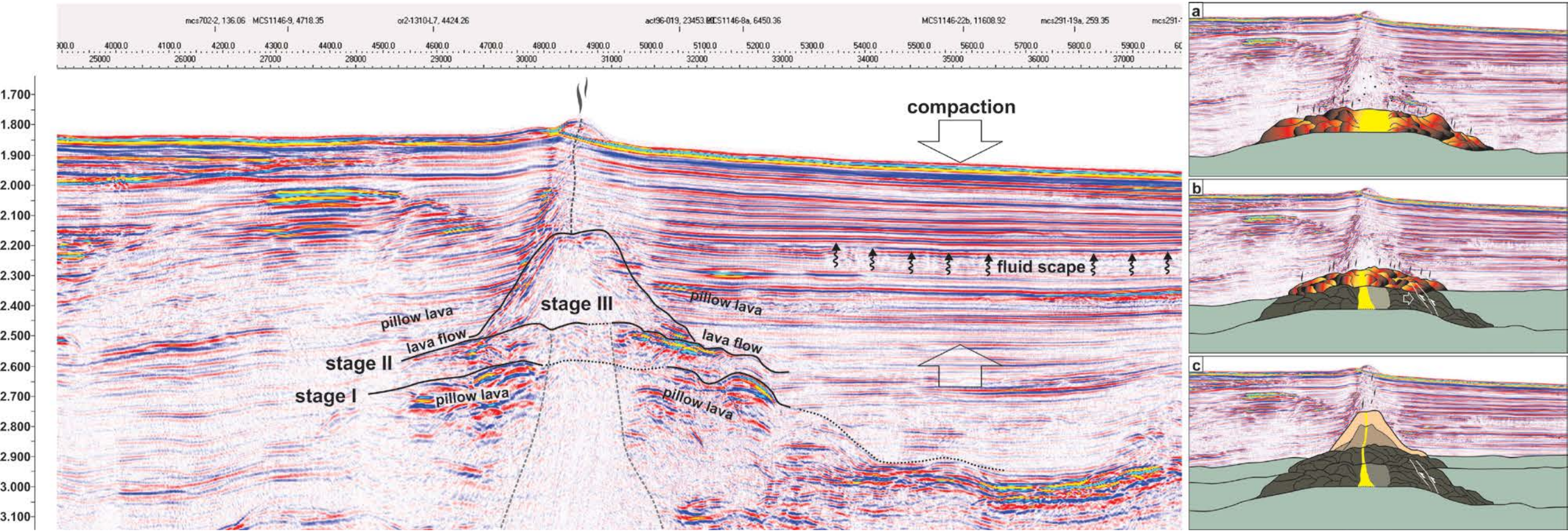
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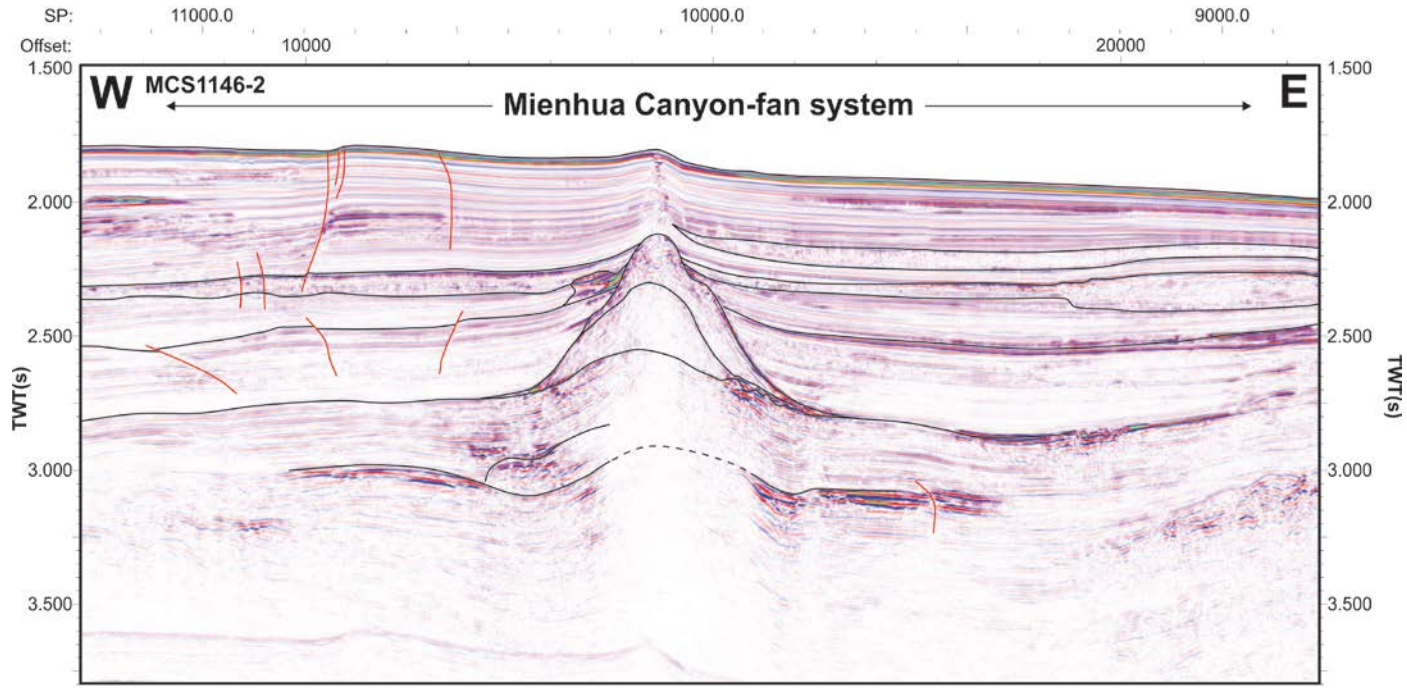
compaction
fluid scape
stage III
stage II
stage I
pillow lava
lava flow
pillow lava
lava flow
pillow lava
pillow lava
a
b
c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Mienhua Canyon-fan system
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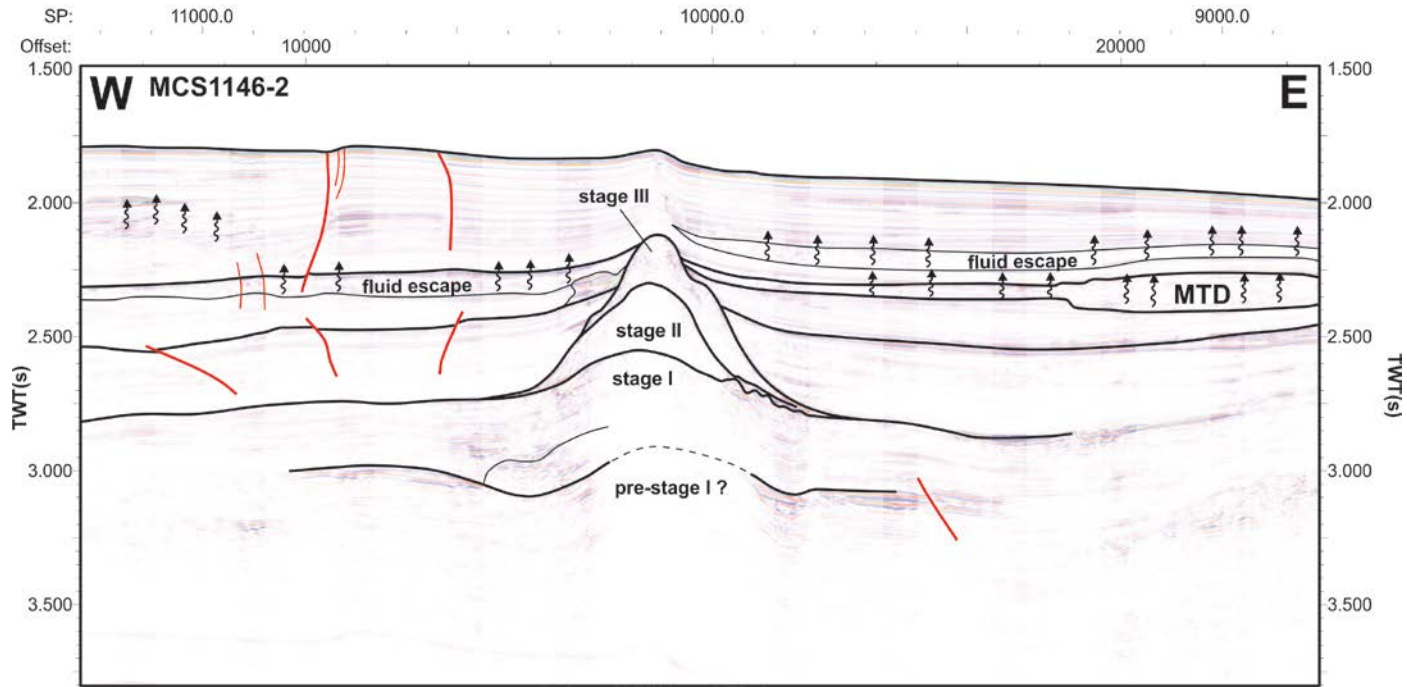
TWT(s)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fluid escape
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MTD
stage II
stage I
pre-stage I ?
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2.500
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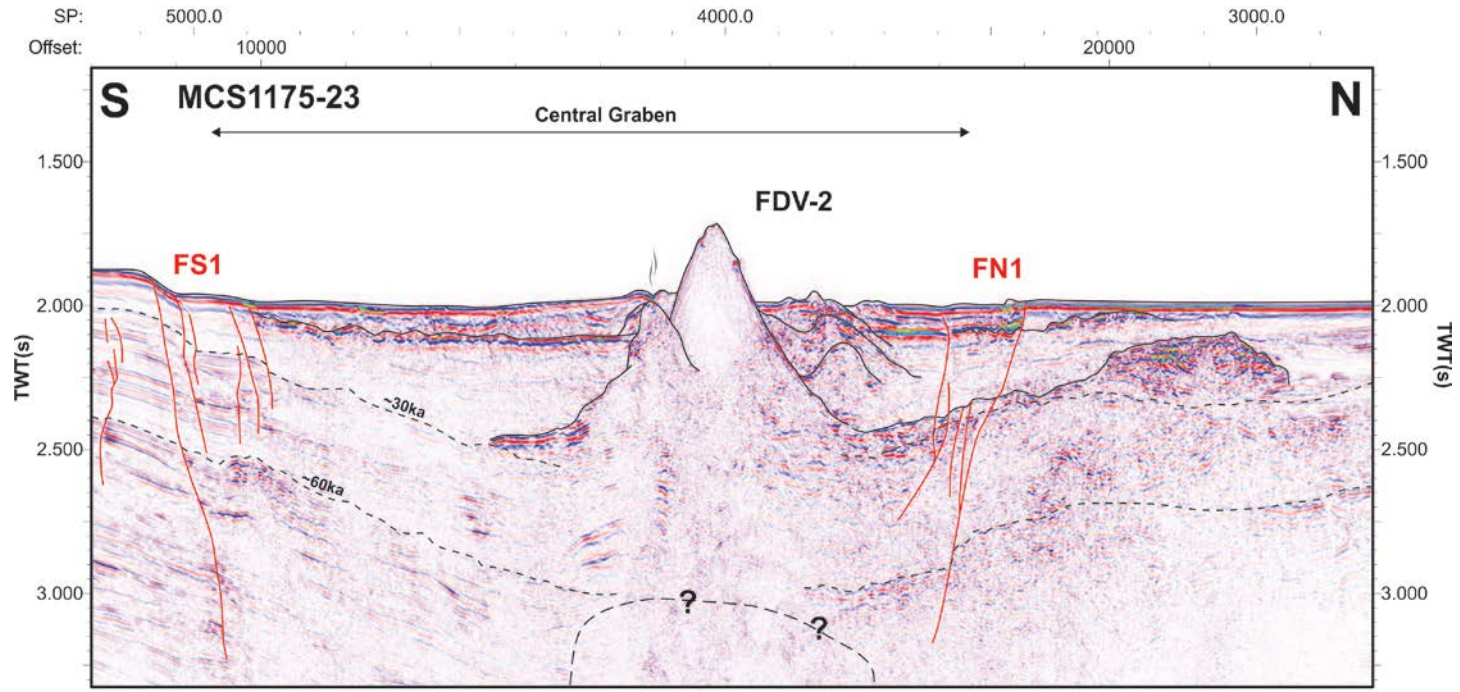
3.500
TWT(s)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Central Graben
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TWT(s)
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FN1
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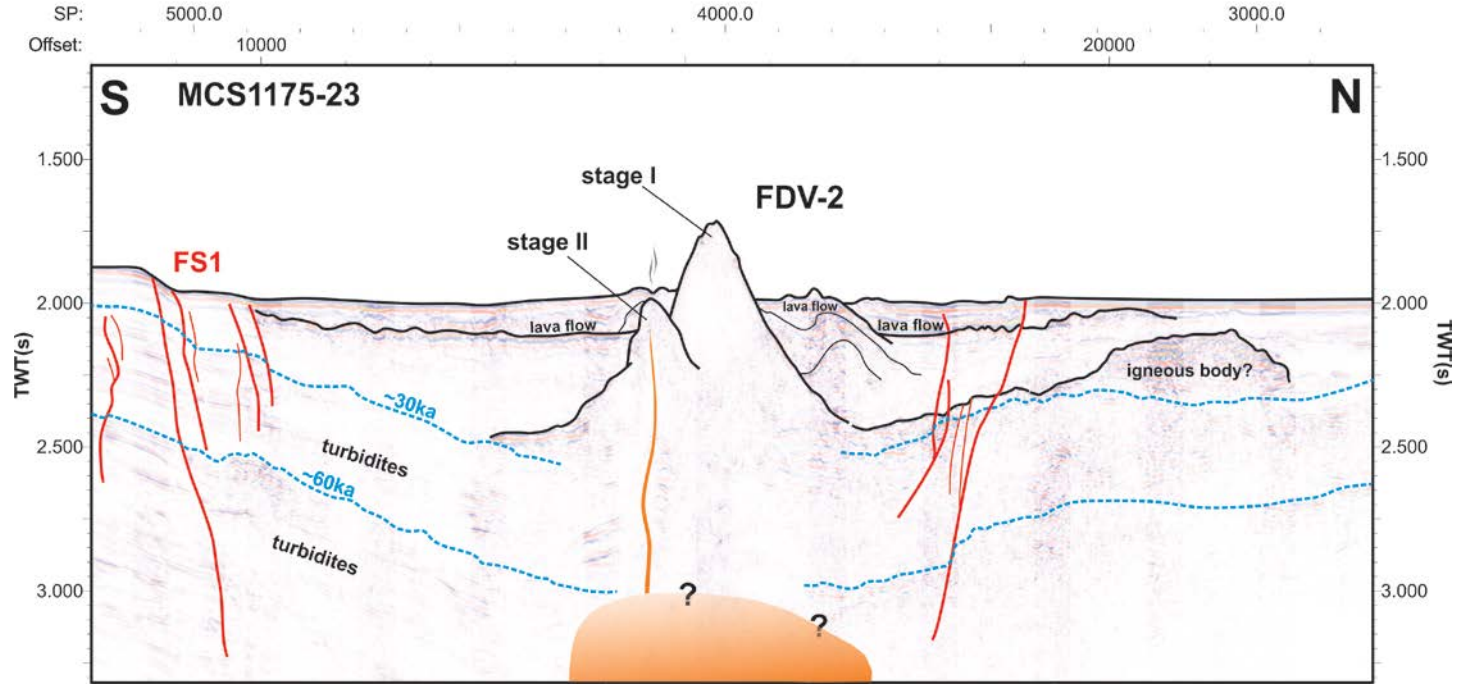
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TWT(s)
stage I
stage II
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