

Extensional mountain building along convergent plate boundary: Insights from the active Taiwan mountain belt

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Introduction

- **Motivation:**

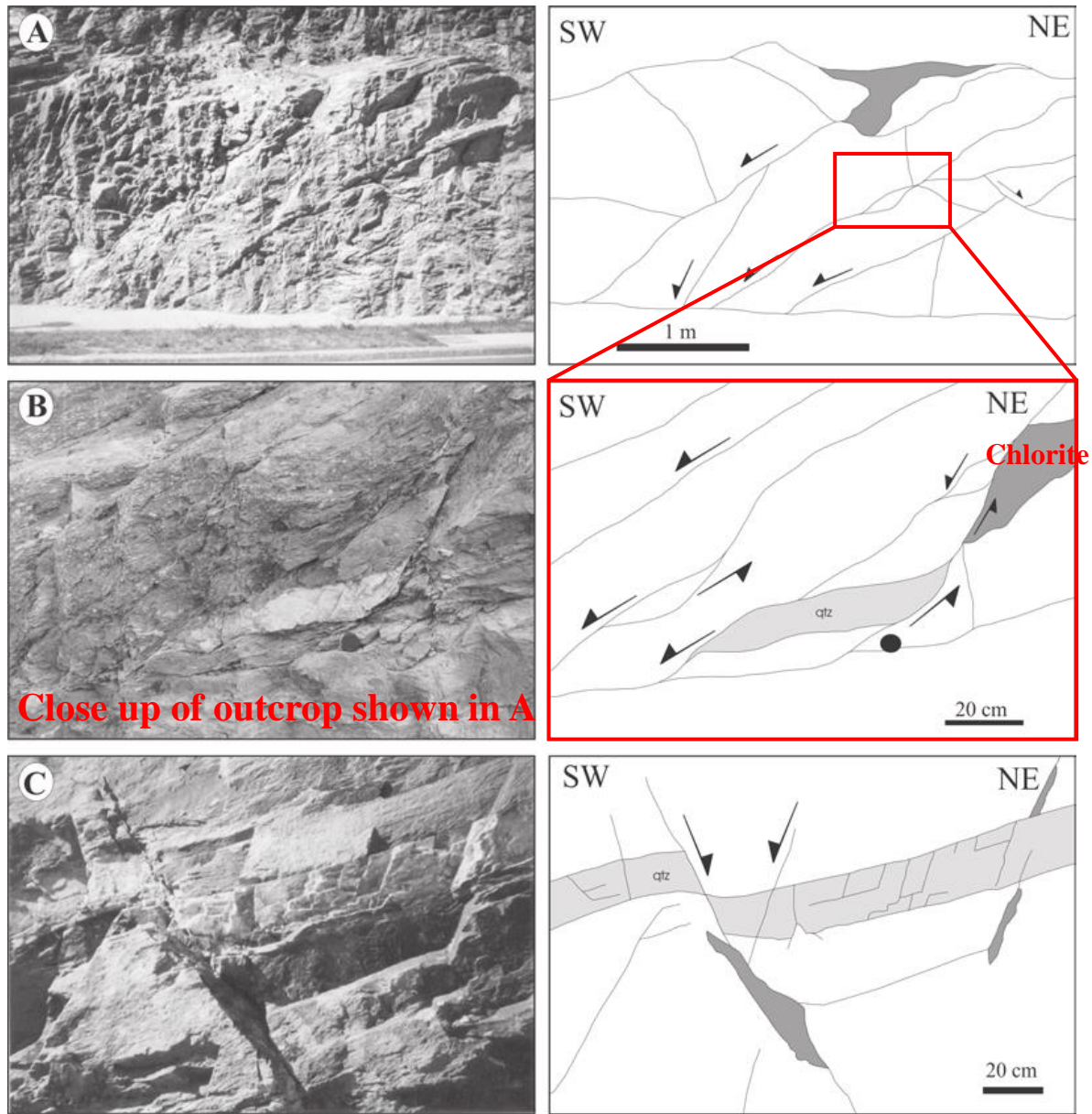
- Brittle extension is a common feature in both active and ancient belts, but its role in mountain building process is still the subject of debate.
- To understand the relationship between extensional deformation and the constructive phase of orogeny.
- To figure out whether brittle extension is a major factor in mountain building process or a near-surface secondary effect.

- **Purpose:**

- To analyze the deformational history on the late brittle extensional system integrated with dating results and foreland sedimentation records to illuminate a direct relationship.

Introduction

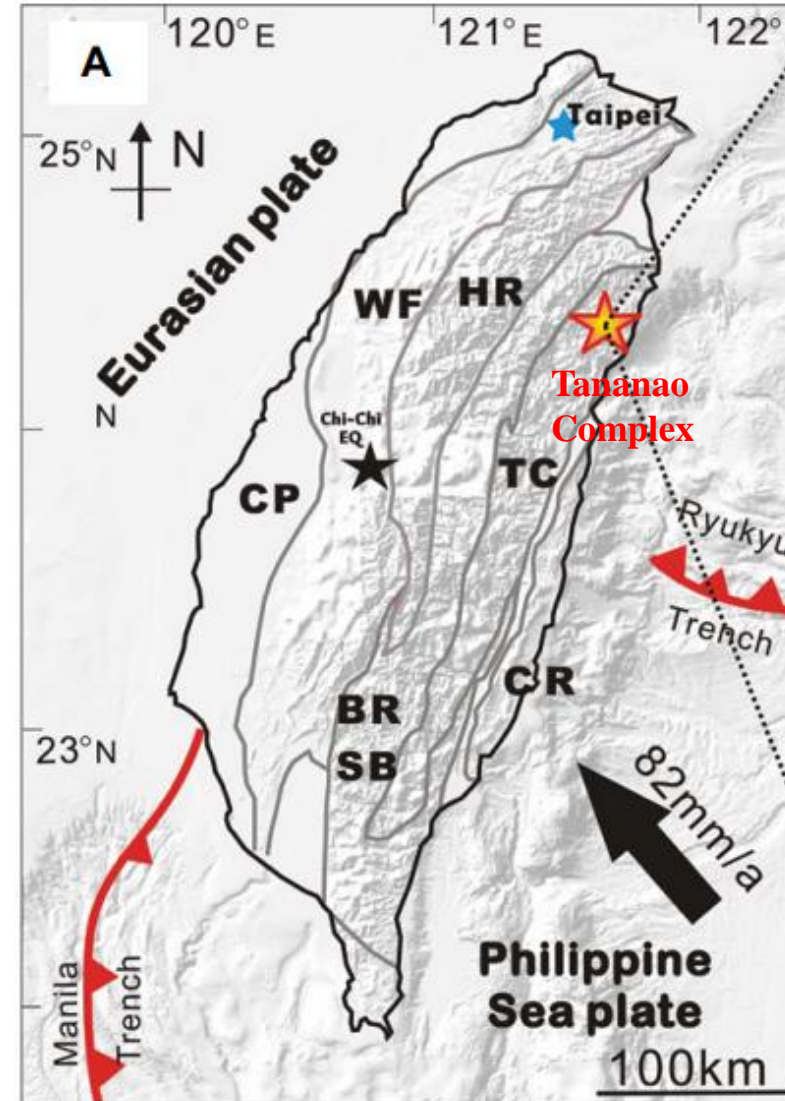
- **Brittle extensional structures**
 - A shallow crustal structures.
 - A series of brittle fractural structures are formed in the horizontal extension system of the crust.
 - The main structure is normal fault.
 - E.g., graben or rift.



Grosjean, Grégory & Sue, Christian & Burkhard, Martin. (2004).

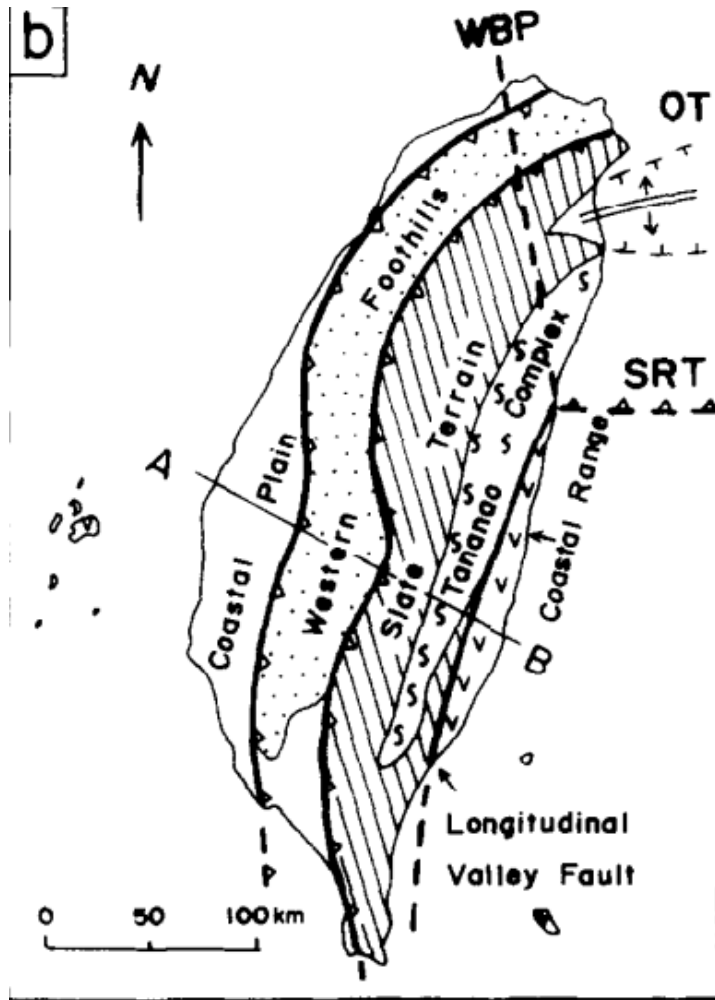
Hoping area

- It located in the east of Taiwan.
- The Hoping region is the brittle extension system within the Tananao Schist basement complex.

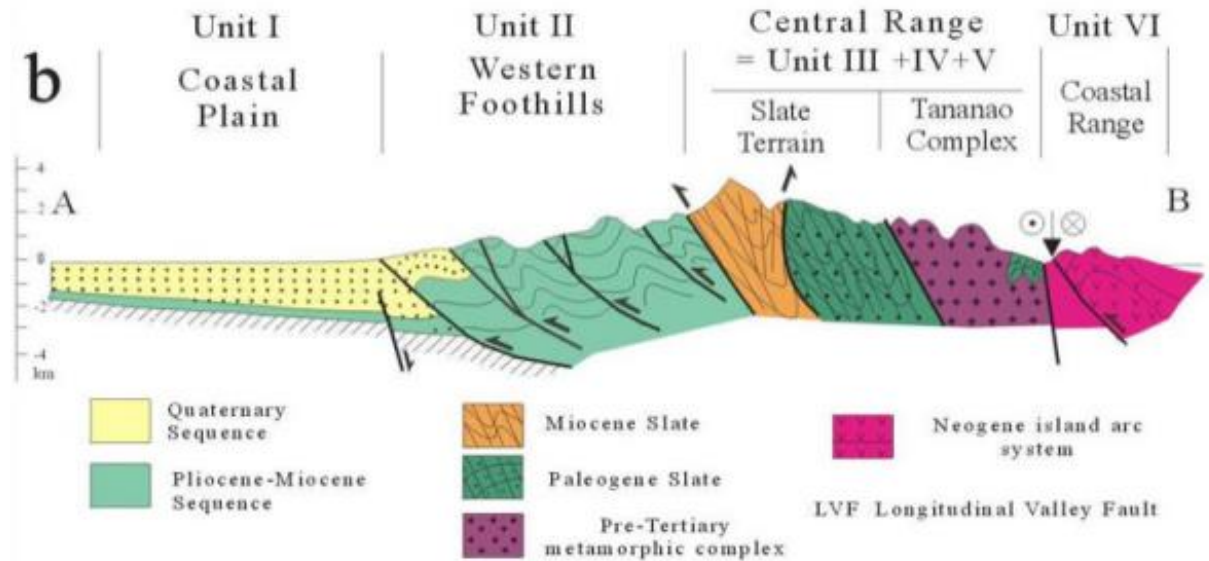


Tectonic framework of the Taiwan mountain belt

Hoping area



Teng, 1990



modified after Teng, 1990

Methods

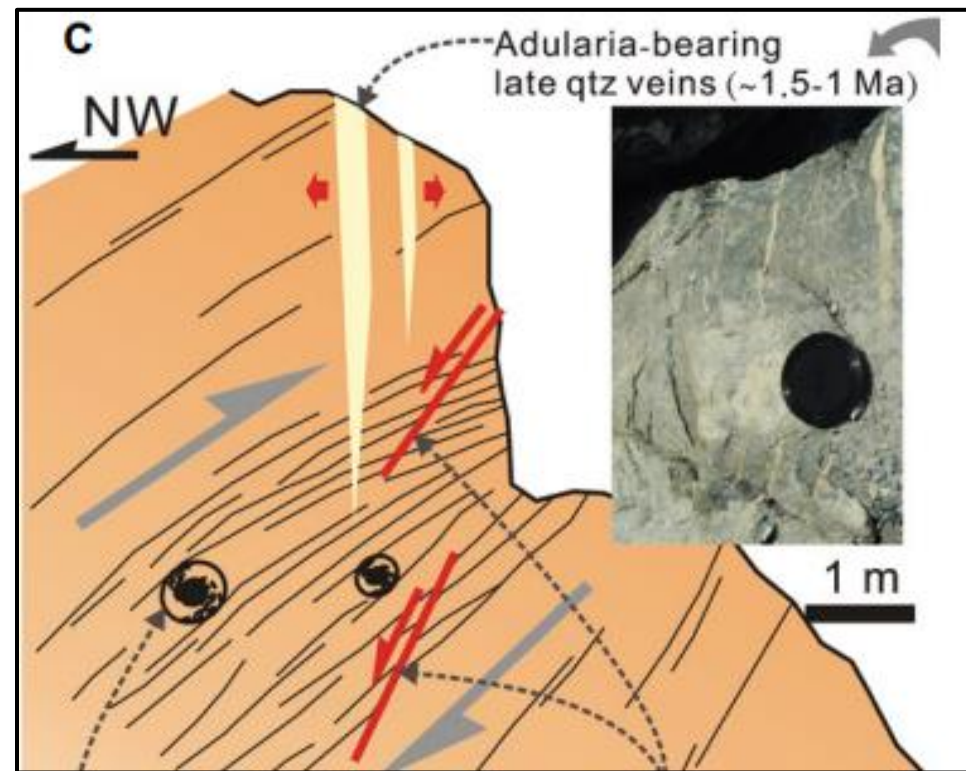
- $^{40}\text{Ar}/^{39}\text{Ar}$ step-heating analysis :

- $$\text{Age} = \frac{1}{\lambda} \ln \left(1 + J \frac{^{40}\text{Ar}^*}{^{39}\text{Ar}_K} \right)$$

- $\lambda = (5.5305 \pm 0.0134) * 10^{-10} \text{ yr}^{-1}$

- J = The constant varies with the standard mineral of known age.

- $\frac{^{40}\text{Ar}^*}{^{39}\text{Ar}_K}$ = The isotope ratio of the sample.



Schematic structural diagram of the Hoping structural complex with field photos

Methods

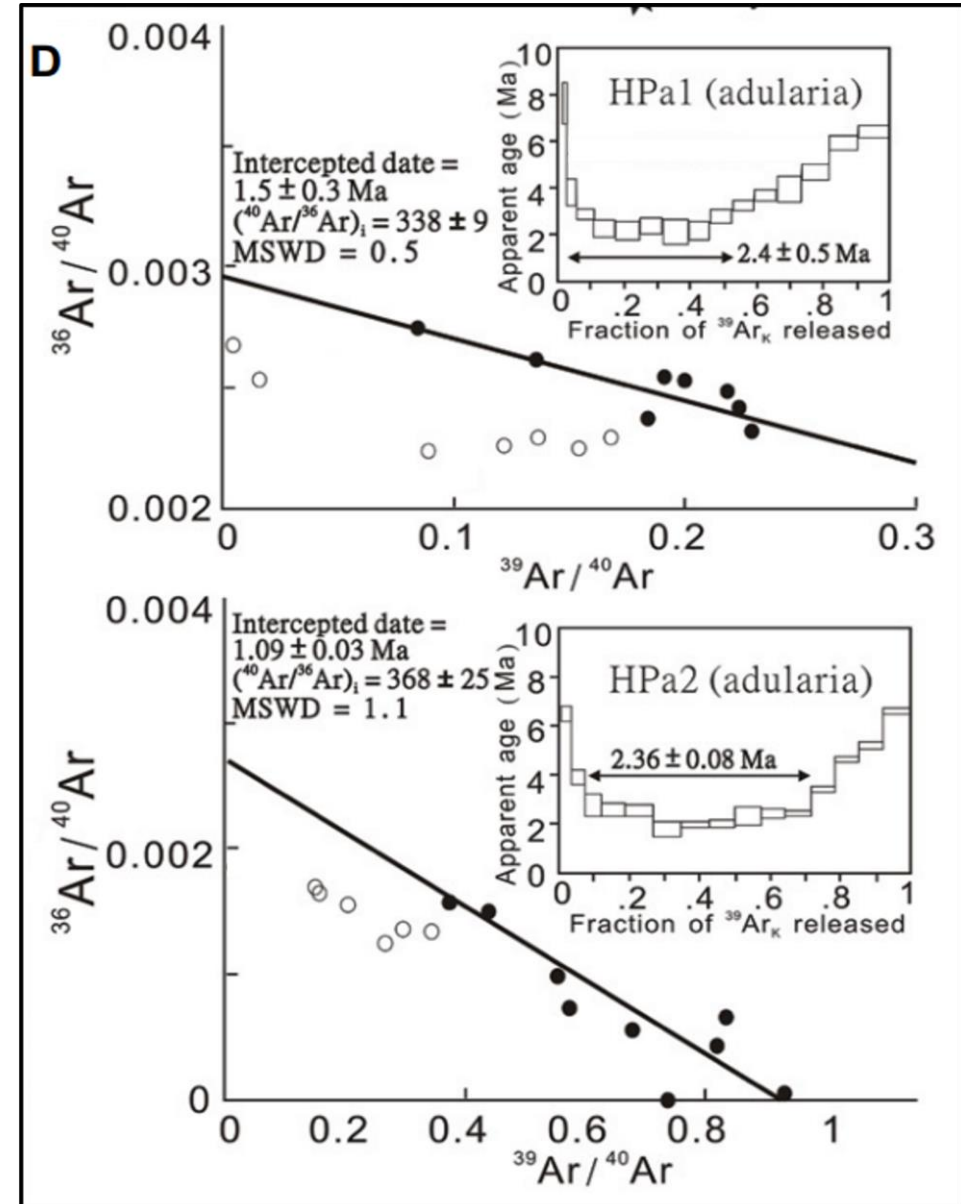
- **Adularia** grain sizes between 140–250 μm .
- After clean up samples, remove visible contamination.

- Samples wrap in aluminum packets.
- Pack with LP-6 Biotite standard for irradiation.

- The LP-6 Biotite standard and samples are measured with step-heating technique.
- Incrementally heated from 500 to 1500 $^{\circ}\text{C}$ using a double-vacuum resistance furnace.

Results

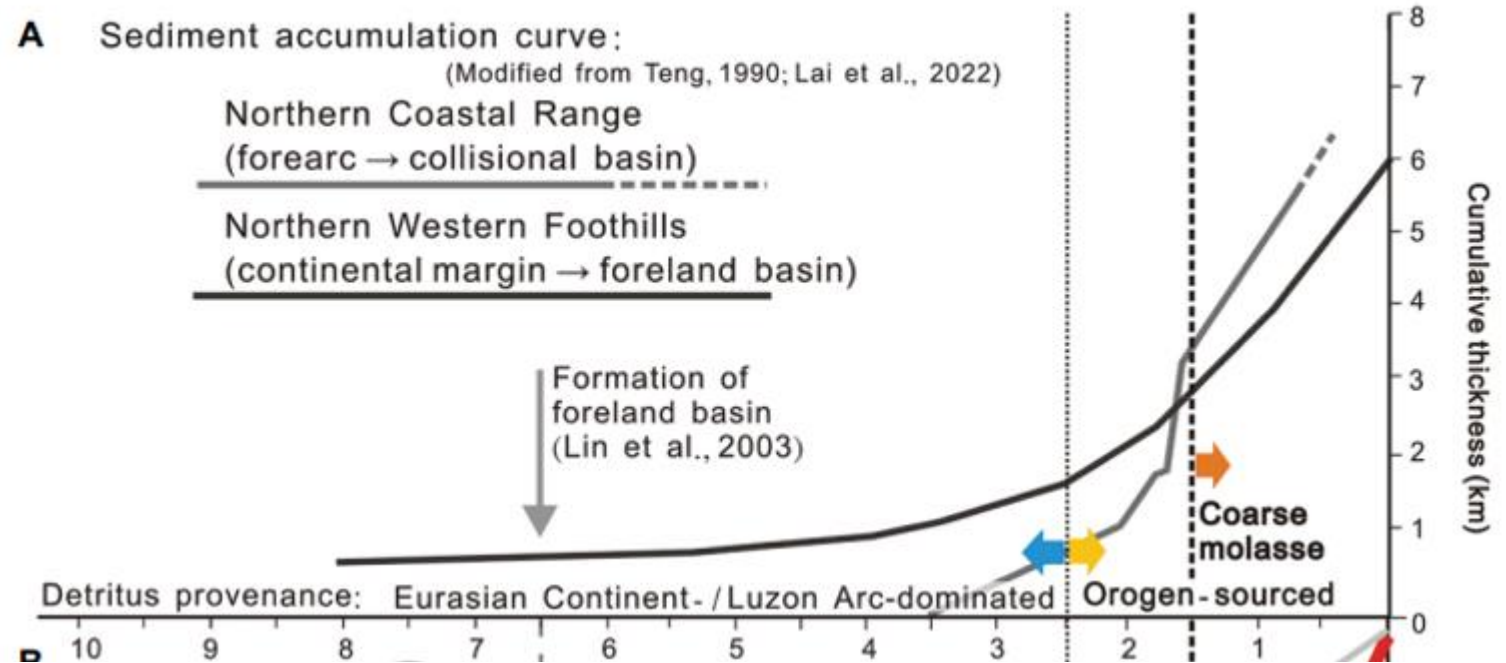
- Age: 1.09~ 1.5 Ma
- Plateau age: 2.4 Ma
- $^{40}\text{Ar}/^{36}\text{Ar}$ Modern atmosphere= 295.5 (Teng, 1990)
- MSWD (Mean square weighted deviates) :
The smaller value is, the better linearity is.
The value smaller than 2.5 is acceptable.



Inverse isochron

Results

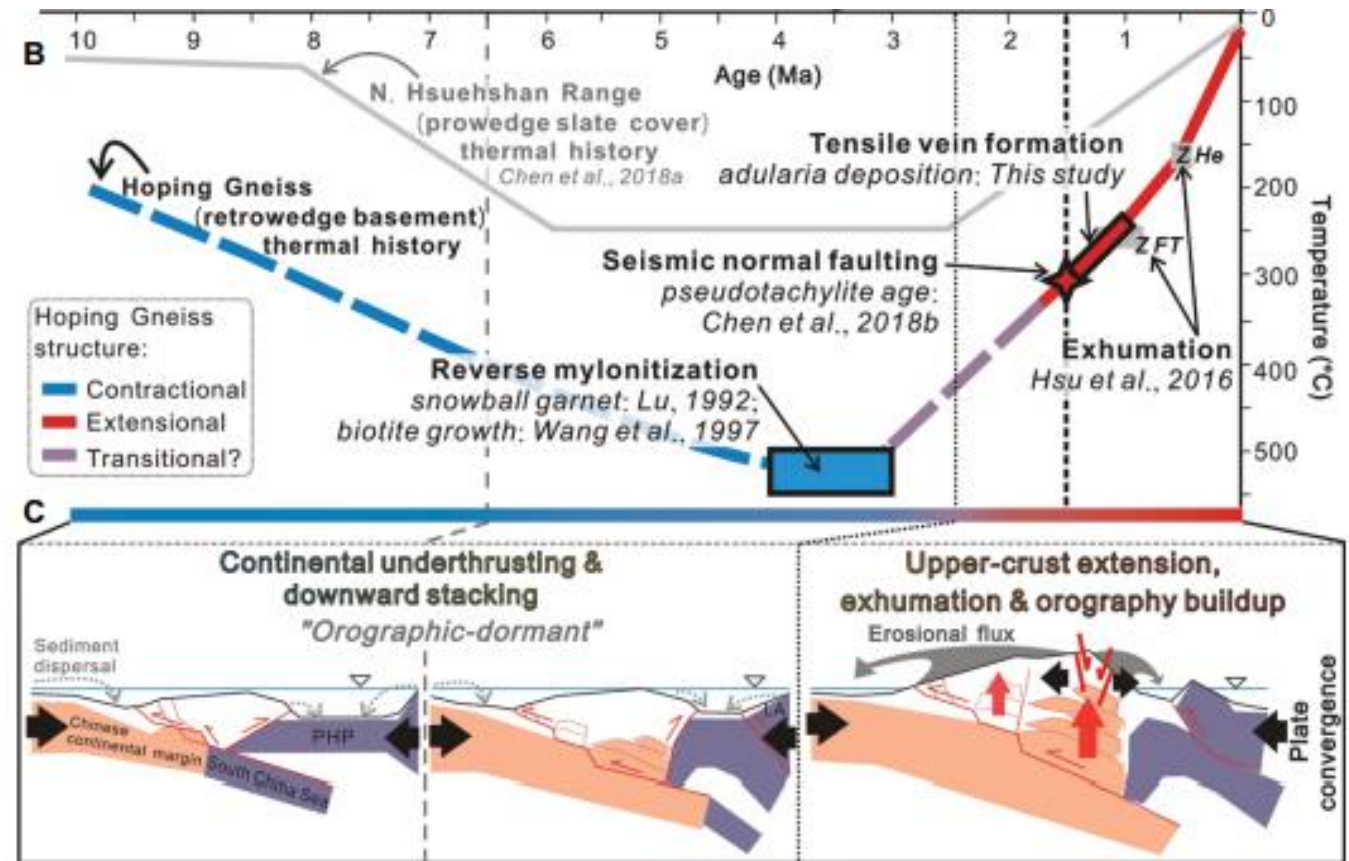
- Rifting stopped at ~ 6.5 Ma due to the orogeny caused by the overthrusting of the Luzon volcanic arc. (Lin et al., 2003)
- The sediment accumulation curves are established on the basis of the stratigraphic information. (Teng, 1990)



Temporal relationship with foreland
sedimentation and relief buildup
(modified by Teng, 1990)

Results

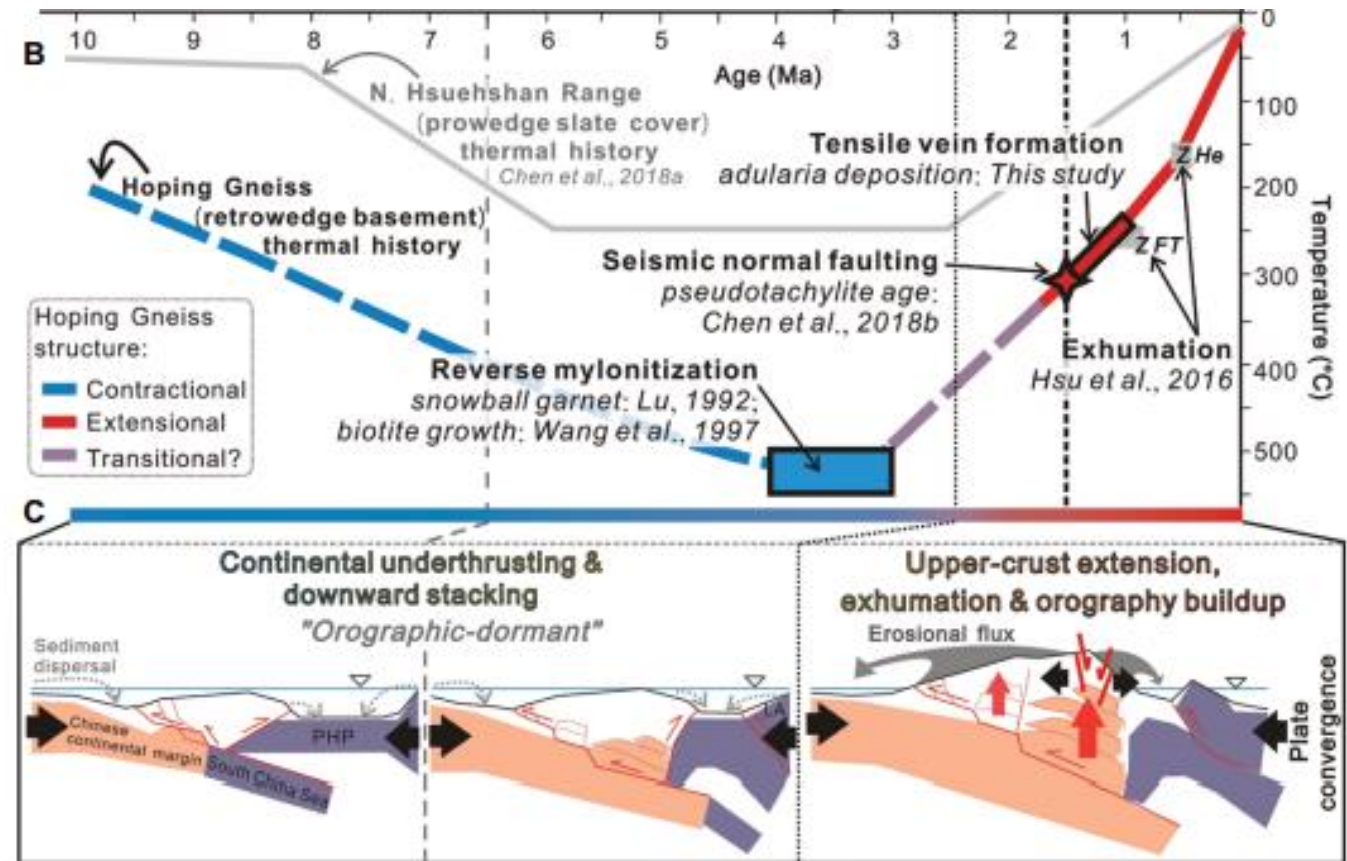
- Based on previously published fission track and (U-Th)/He dates of completely reset detrital zircon and apatite grains. (Hsu et al., 2016)
- An increase in **exhumation** rates from ca. 2–1.5 Ma to ca. 0.5 Ma (2–4 mm/yr). (Hsu et al., 2016)
- $^{40}\text{Ar}/^{39}\text{Ar}$ laser microprobe dating defined the exact time ($\sim 1.6\text{Ma}$) of the pseudotachylite age. (Chen et al., 2018b)



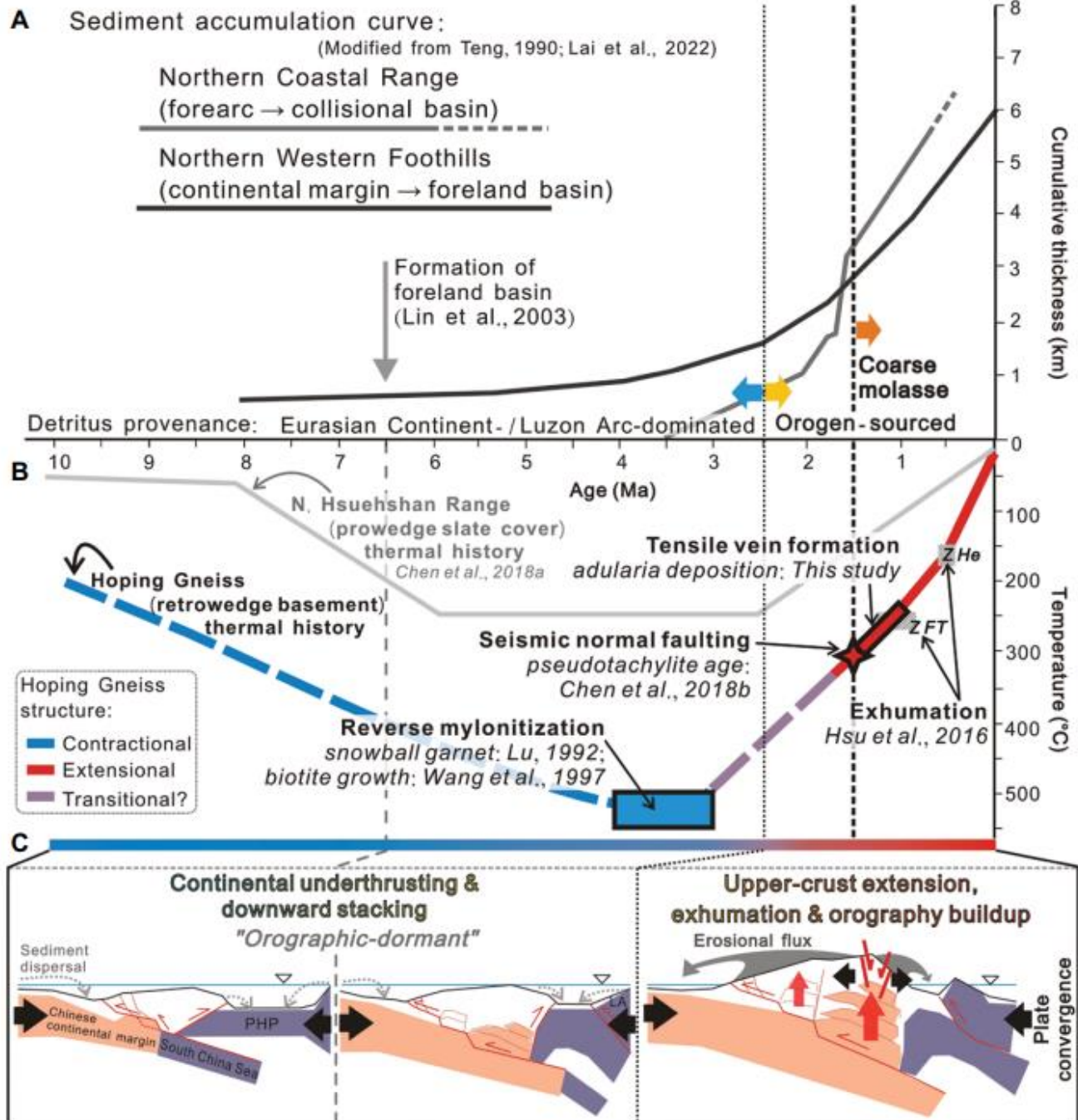
Temporal relationship with foreland sedimentation and relief buildup

Results

- $^{40}\text{Ar}/^{39}\text{Ar}$ dating study for a mylonite zone in a gneiss body in the Tananao Schist near the Hoping area. (Wang et al., 1997)
- The biotite dates represent the Taiwan Mountain Belt might have experienced an extensive internal deformation during 4.1-3.0 Ma. (Wang et al., 1997)



Temporal relationship with foreland sedimentation and relief buildup



- A. Sediment accumulation and molasses arrival in the foreland and forearc basins (modified from Teng, 1990 and Lai et al., 2022).
- B. Thermal-deformation evolution of the Hoping structural complex.
Z FT—zircon fission-track ages.
Z He—zircon (U-Th)/ He ages.
- C. Schematic profiles correspond to the proposed evolutionary stages of orogenic architecture.
PHP—Philippines Sea Plate.
LA—Luzon Arc.

Conclusion

- The results of Ar-Ar dating show that the time of crystallization is about the same as the exhumation and the orography buildup.
- The extensional deformation has been partitioned into secondary normal faults distributed across the hinterland.
- The capability to initiate and speed up both orographic buildup and exhumation indicates that upper-crust extension and the resultant tectonic denudation play an important role in the construction of mountain belts.

Thanks for your listening