Thermal maturity of a fold–thrust belt based on vitrinite reflectance analysis in the Western Foothills complex, western Taiwan

Arito Sakaguchi, Akiko Yanagihara, Kohtaro Ujiie, Hidemi Tanaka, Masanori Kameyama

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Presenter: Tzu-Chen Tai
Advisor: Prof. Maryline LE BEON
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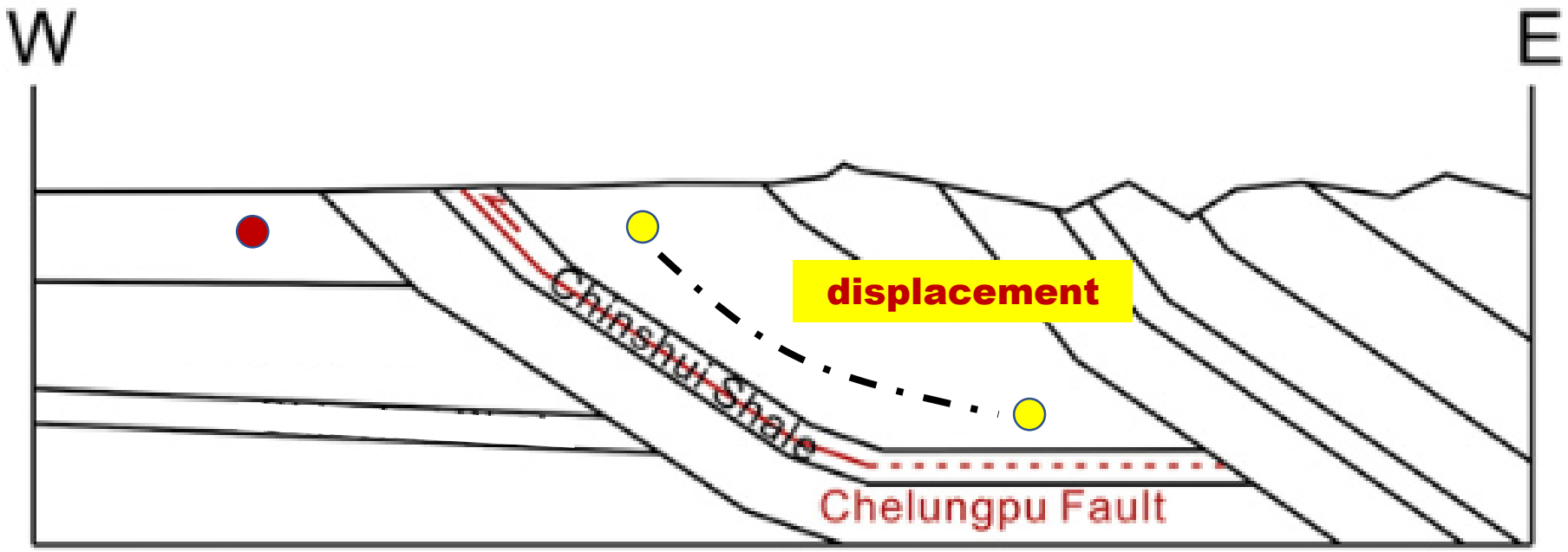
Introduction

- Thermal maturity, often assessed through vitrinite reflectance, is crucial for understanding the thermal history of sedimentary basins and the evolution of fault systems.
- Vitrinite reflectance (%Ro) is a quantitative measurement of the amount of light reflected by vitrinite particles under a microscope.
- It increases predictably with thermal exposure and provides a reliable indicator of maximum temperature experienced by sedimentary rocks.

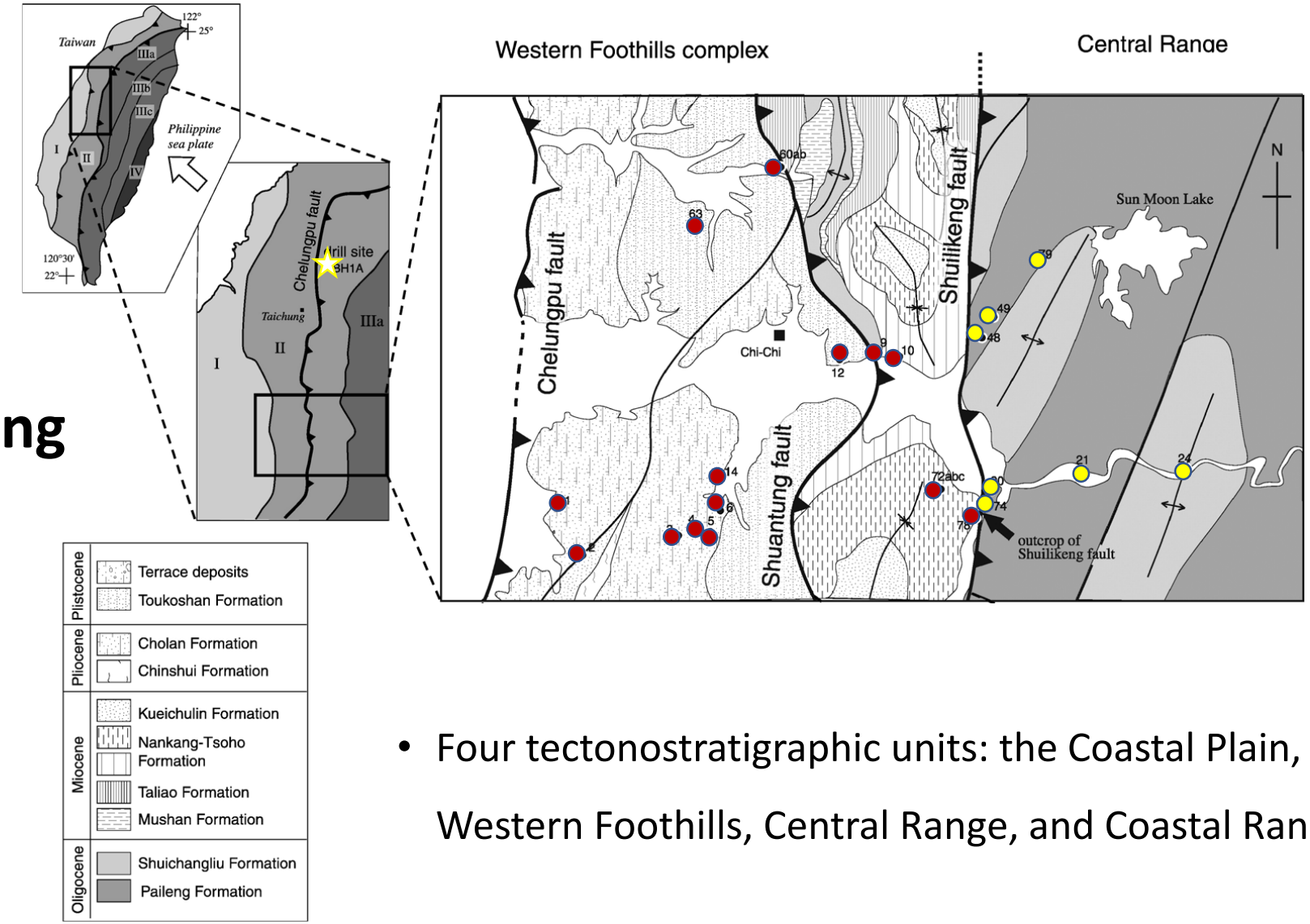
**** The higher the %Ro, the greater the thermal maturity. ****


W
E
displacement
Chinshui Shale
Chelungpu Fault

Objectives

- ✓ To quantify the burial depths of rocks in the Western Foothills complex and Hsuehshan belt, assess fault displacements with a focus on the Shuilikeng fault, and evaluate thermal maturity using vitrinite reflectance to interpret the region's geological and tectonic history.
- ✓ To estimate the peak temperatures experienced by the fault rocks during frictional heating.

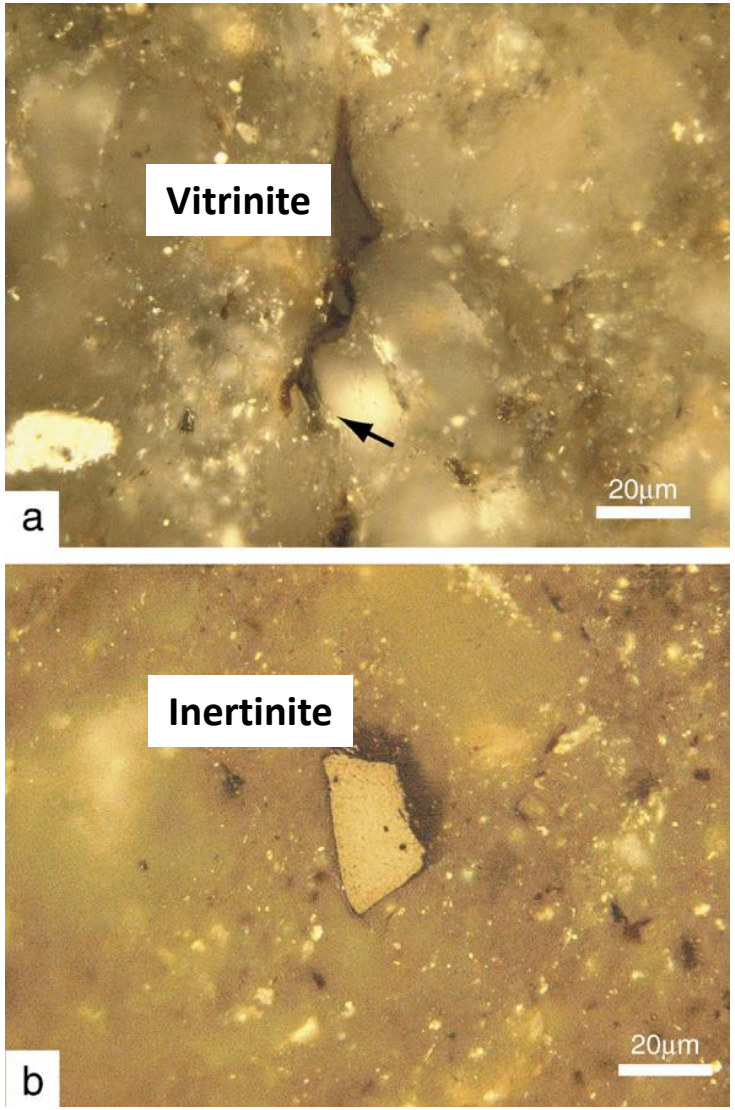
Geological setting



- Four tectonostratigraphic units: the Coastal Plain, Western Foothills, Central Range, and Coastal Ranges.

Method

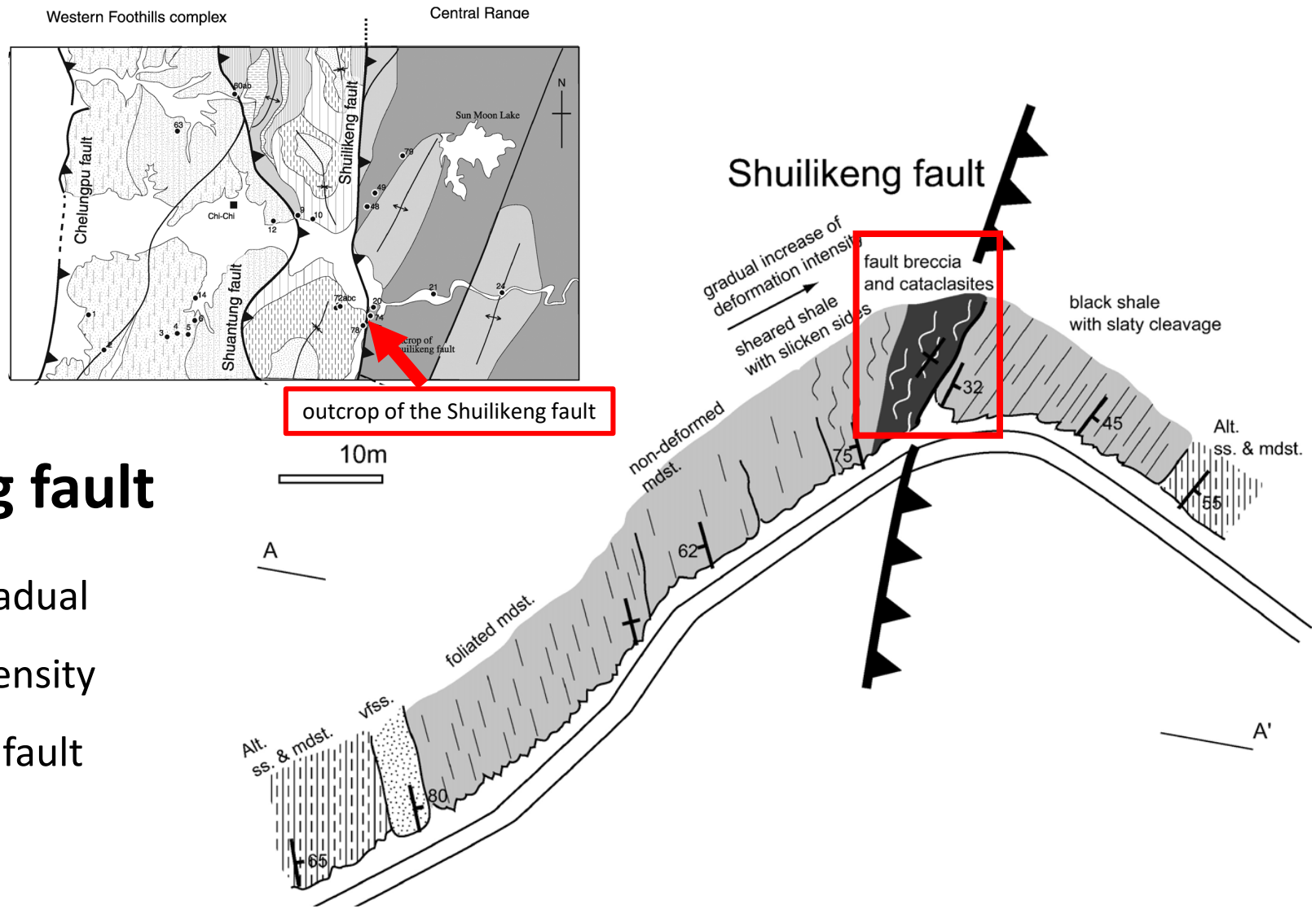
- Microscope observation
  - It involved distinguishing between reworked detrital inertinite and diagenetic vitrinite.
- Measurement of Vitrinite Reflectance
  - Random mean reflectance of vitrinite is obtained from 23 to 175 vitrinite particles for each samples.
- Calculation of Maximum Temperature, Burial depth and Cumulative displacement



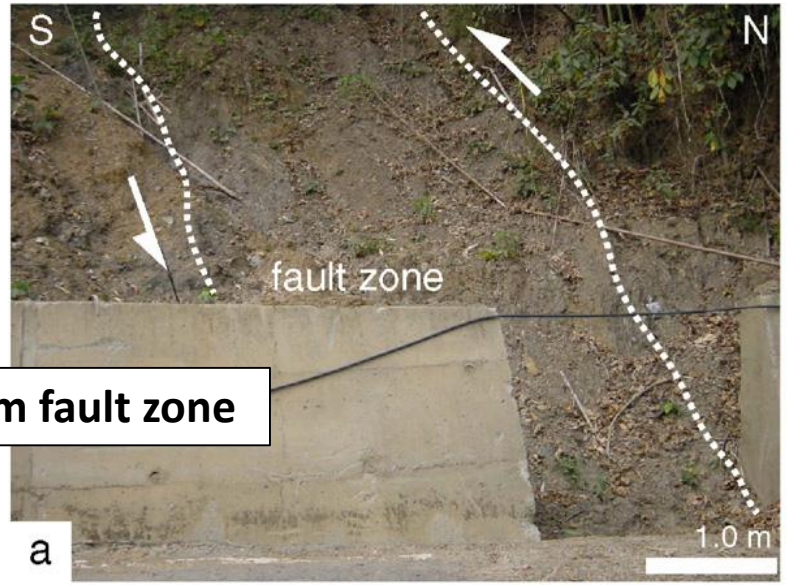
The gelatinization during heating is characteristic feature in vitrinite.

Result 1 - Shuilikeng fault

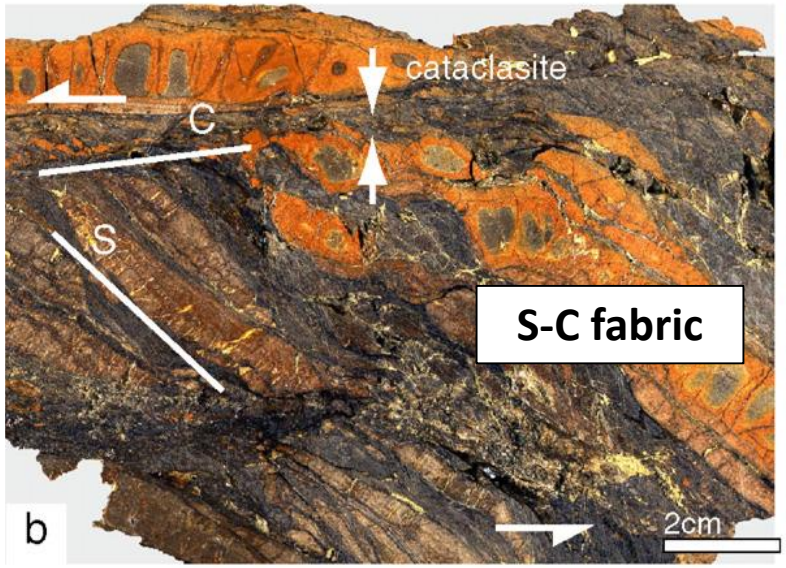
- This figure highlights the gradual increase in deformation intensity as rocks move closer to the fault zone.



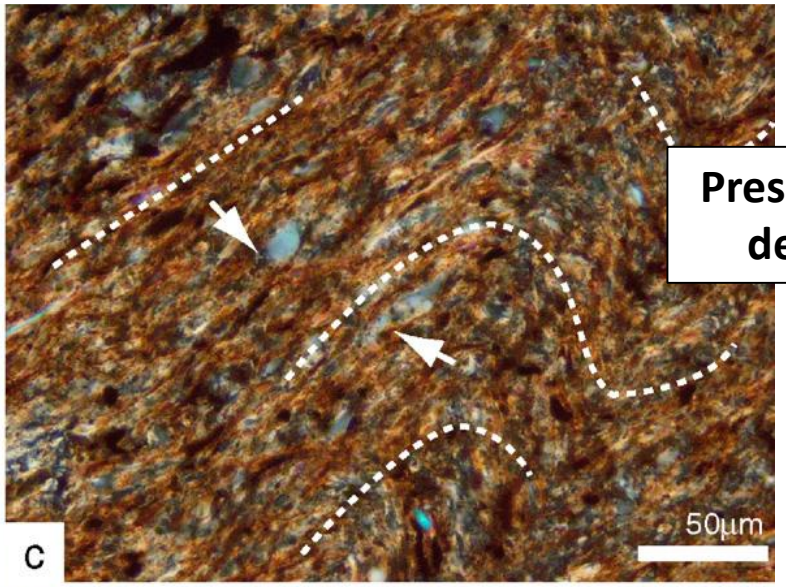
Result 1 - Shuilikeng fault



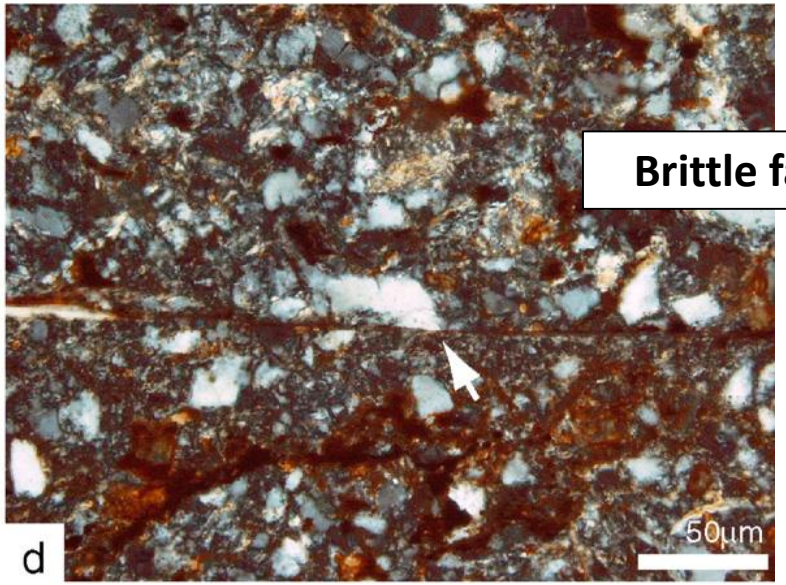
5 – 6m fault zone



S-C fabric

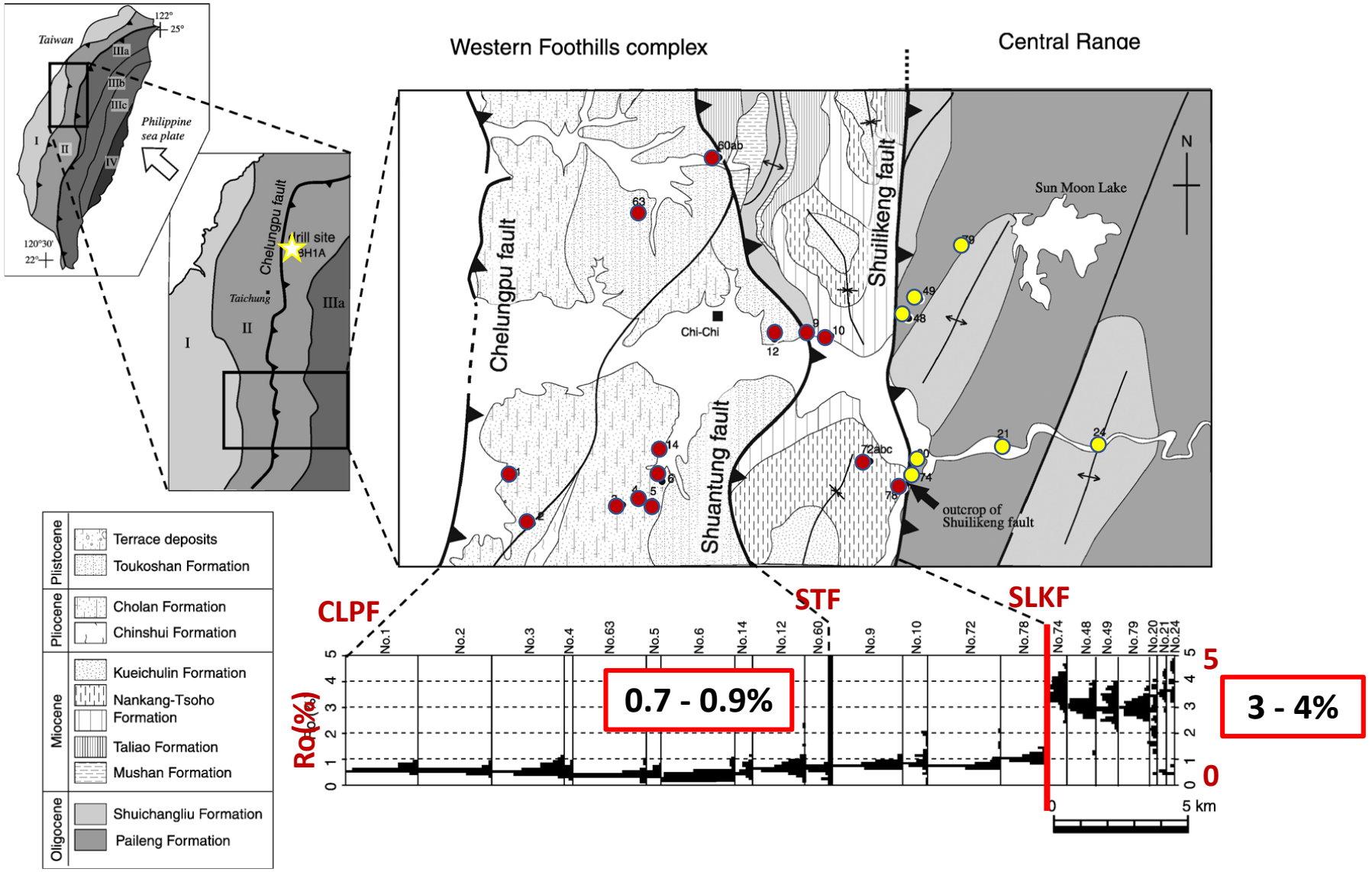


Pressure solution deformation



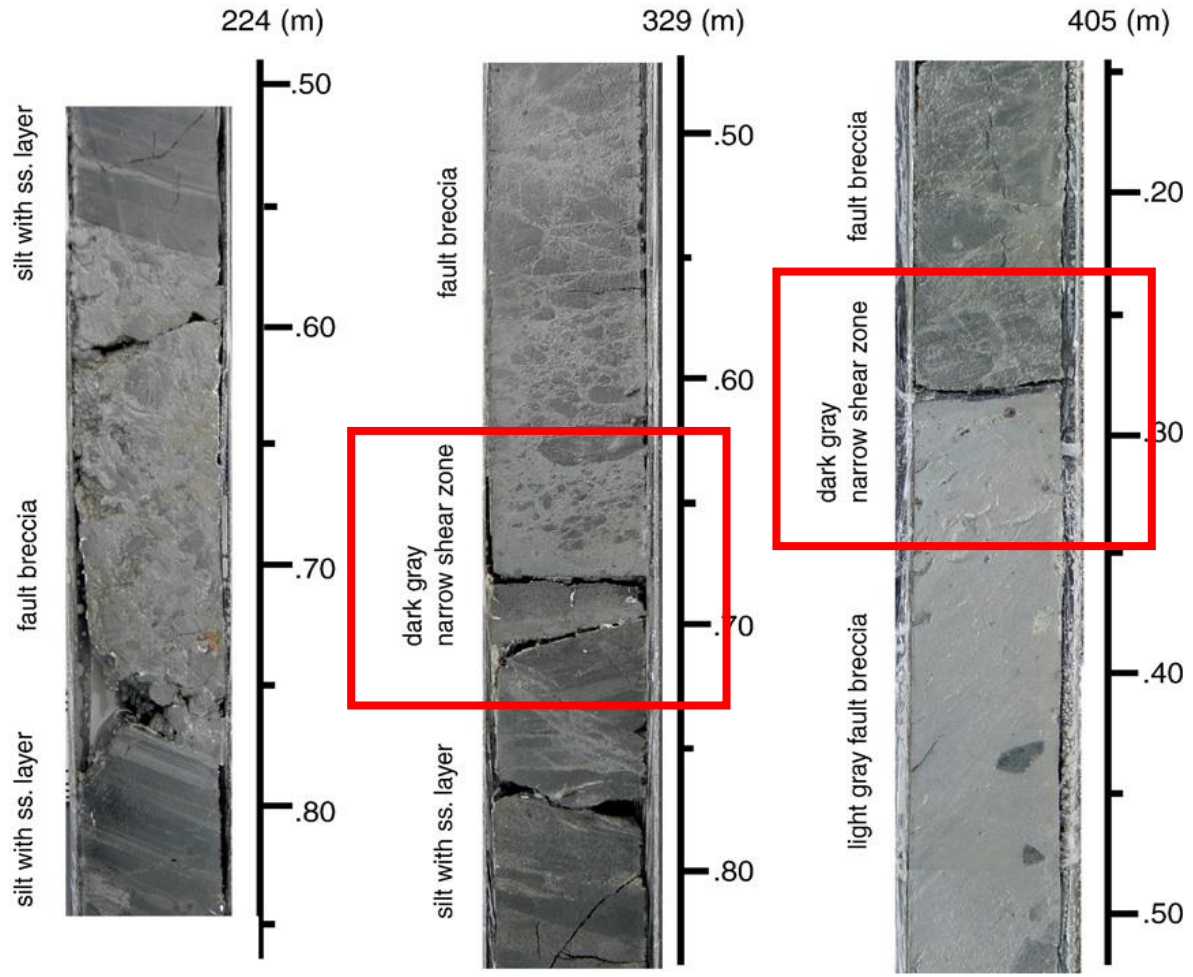
Brittle failure

Result 1 - Shuilikeng fault



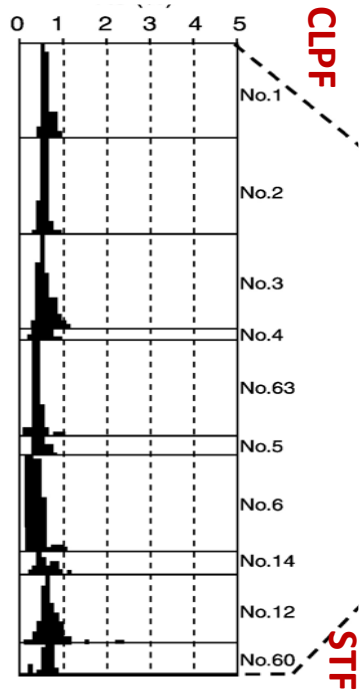
An increase in vitrinite reflectance from west to east across the region.

Result 2 - Chelungpu fault



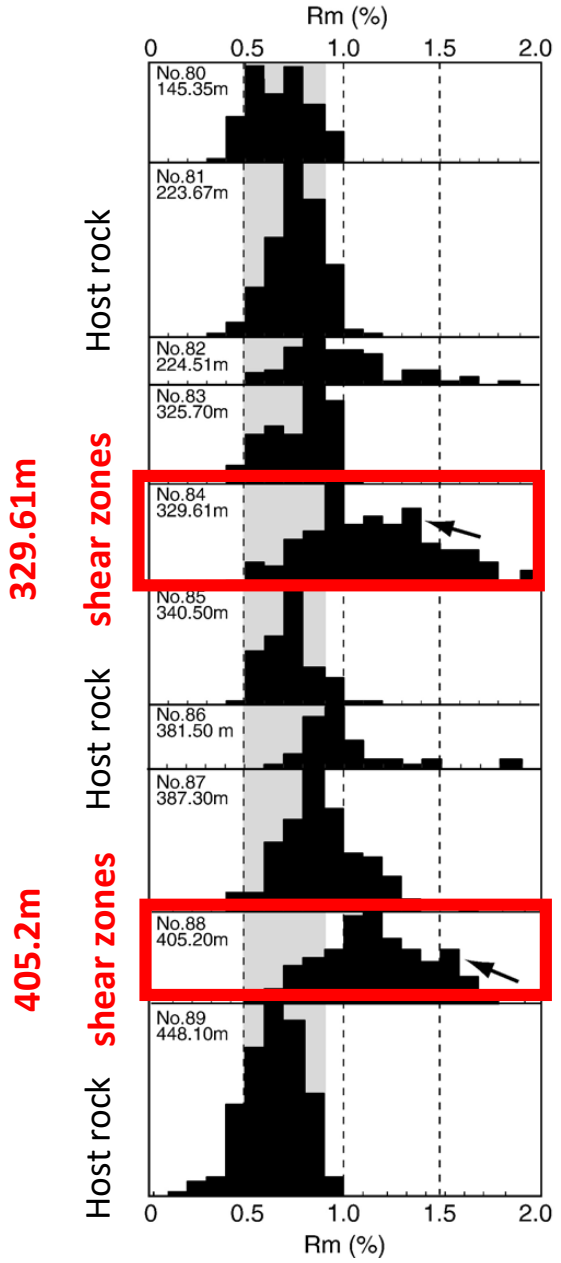
- A borehole, inclined 50° westward, intersected the fault and revealed three major fracture zones at depths of 225 m, 330 m, and 405 m.

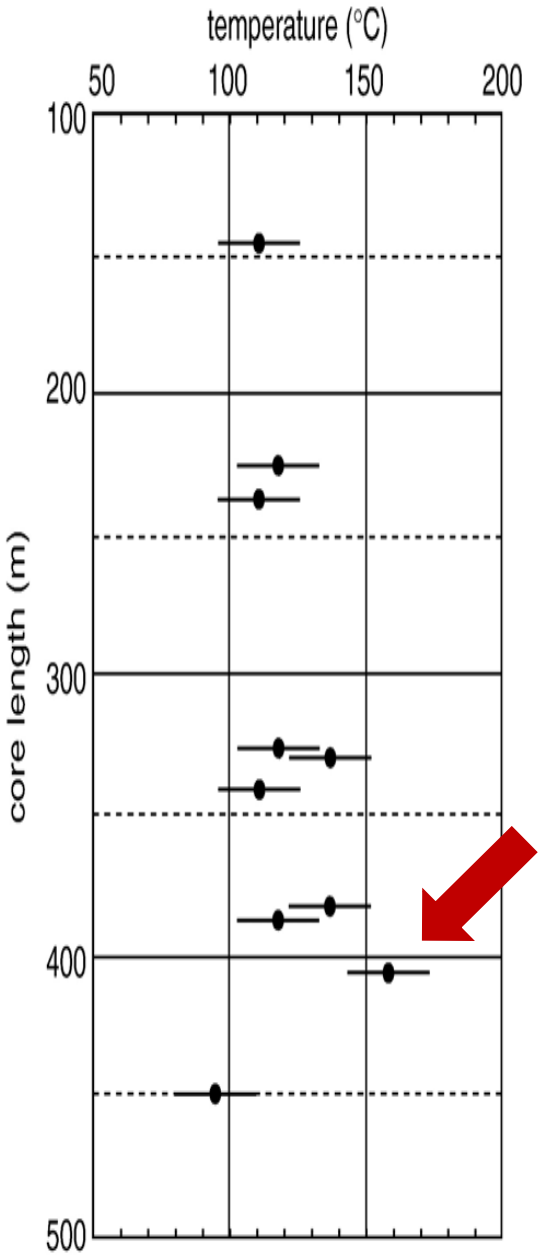
- The vitrinite reflectance values in most samples range between 0.7% - 0.9%, which aligns with surface outcrop data near the Chelungpu fault.



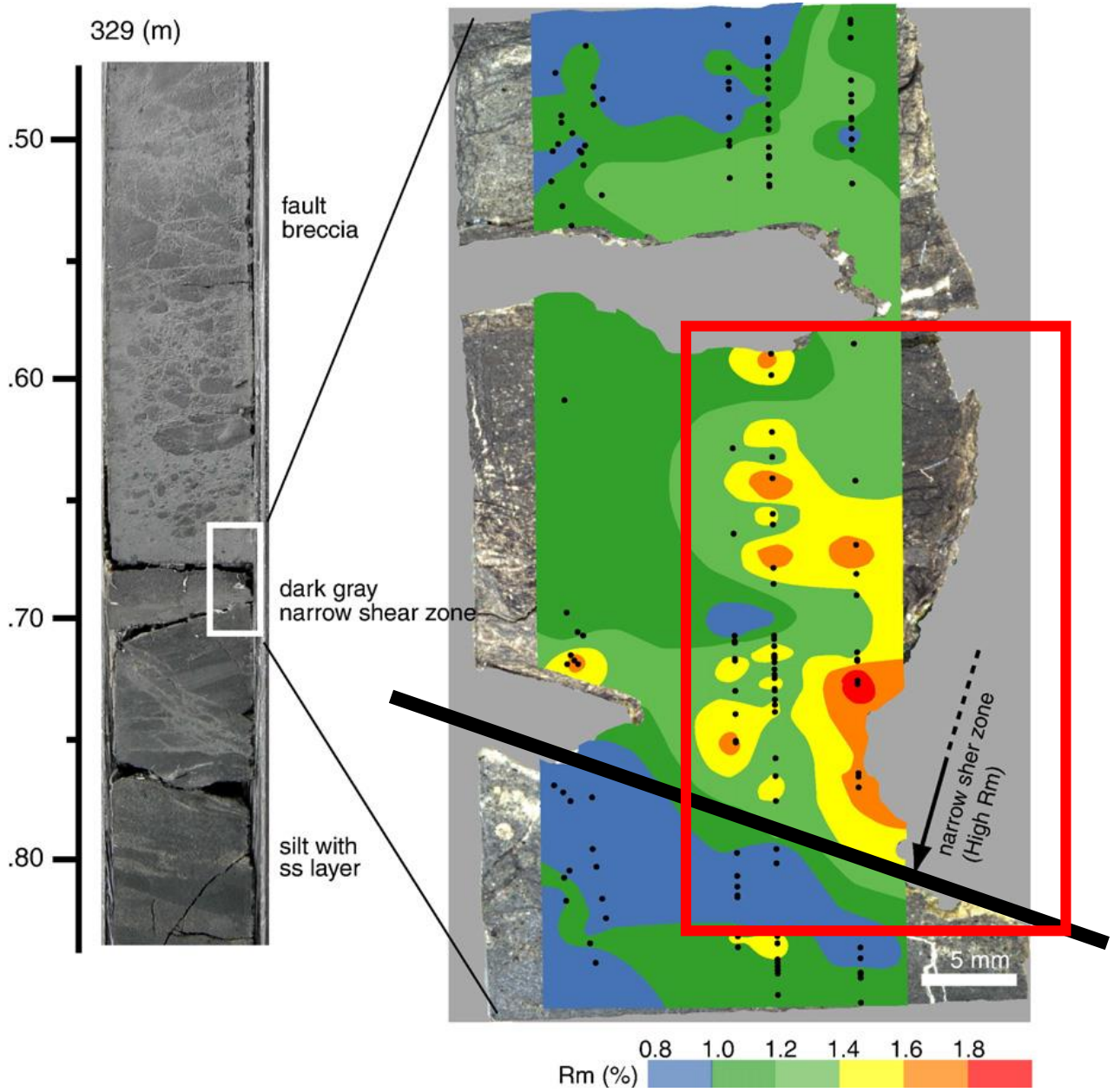
Average : 0.7% - 0.9%

Gray bottom: average





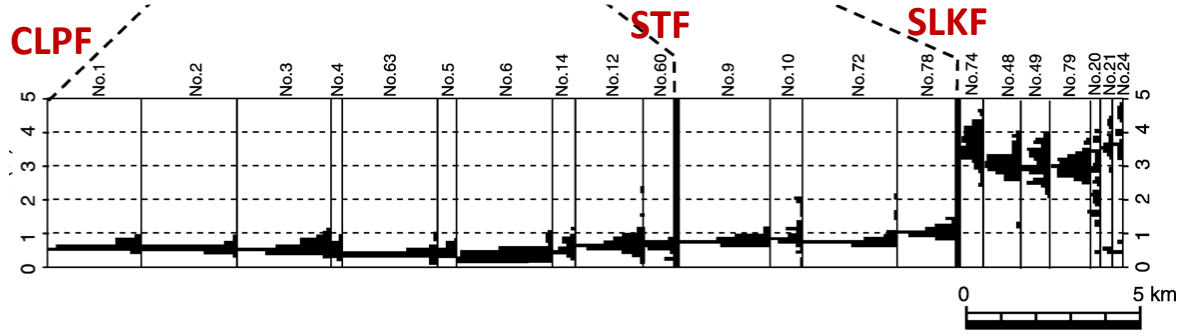
Result 2 - Chelungpu fault



The average Rm=1.4%, and locally it is as high as 1.8%.

Red square shows high stress concentrations.

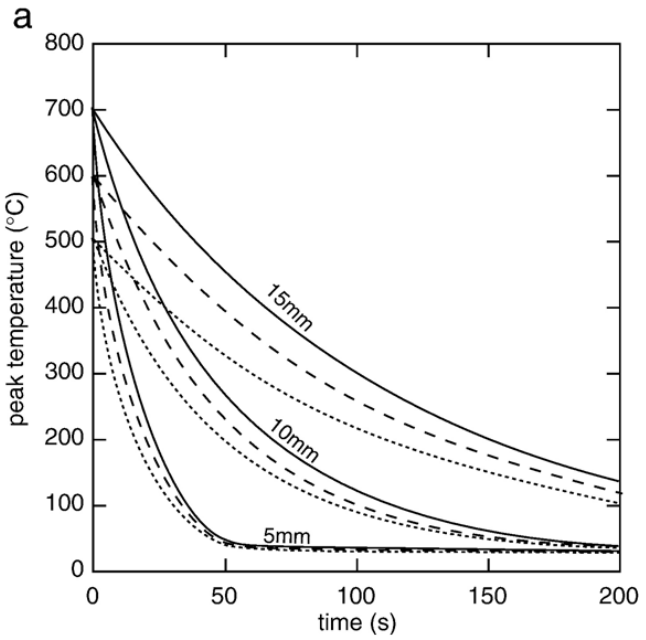
Discussions

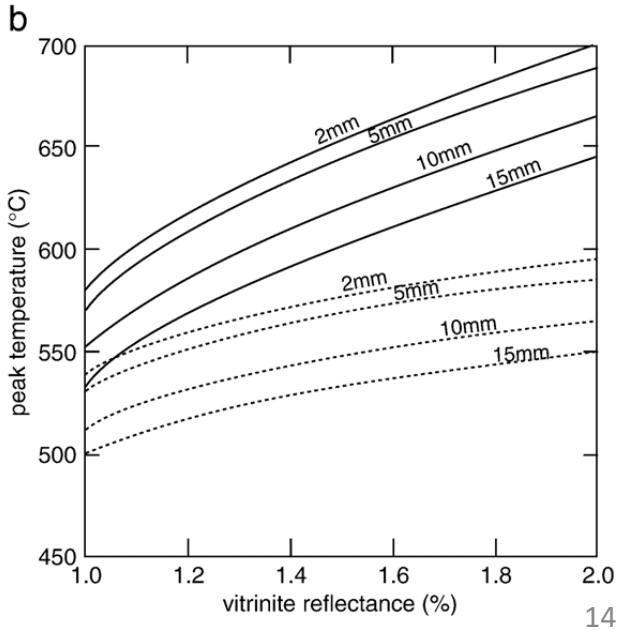


- This study estimates the burial depths in the Western Foothills complex based on vitrinite reflectance values, which range from 0.4% to 3.6%, corresponding to temperatures between 53 °C and 284 °C.
- The estimated burial depths in the Western Foothills complex range from 1.8 to 4.1 km, while the hanging wall of Shuilikeng fault shows greater depths of 9.2 to 9.8 km.
- The Shuilikeng fault exhibits the largest cumulative displacement in the area.
  - Shuilikeng Fault: between 4.8 km and 6.2 km.
  - Chelungpu Fault: less than 2.3 km to 3.0 km.
  - Shuangtung Fault: less than 2.3 km to 3.0 km.

Ro% → Peak T → Depth → Displacement

- The thickness of the heat source is measured from high vitrinite reflectance zone.
- Estimated temperature of the vitrinite reflectance of 1.8%, with a thickness of 5 mm is 670 ± 30 °C and 580 ± 30 °C

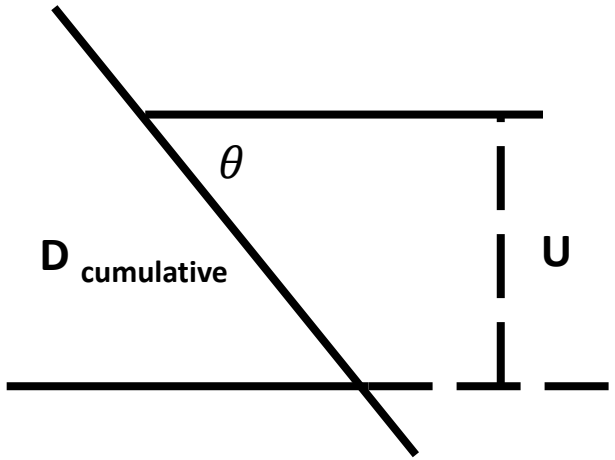




Conclusion

- This study estimated burial depths ranging from 1.8 to 4.1 km in the Western Foothills complex and between 9.2 and 9.8 km in the Hsuehshan belt, with an error margin of ±1.1 km.
- The findings indicated that the Shuilikeng fault exhibits a greater cumulative displacement compared to other faults, such as the Chelungpu and Shuangtung faults, which have smaller displacements and similar thermal characteristics.
- This study highlighted the significant thermal effects associated with faulting, including localized increases in temperature due to frictional heating during seismic events, which were reflected in the higher vitrinite reflectance values.

Thanks for your listening!



$$T\ peak = \frac{\ln(Ro) + 1.68}{0.0124}$$

Ro: vitrinite reflectance

$$U = \frac{T\ peak - T\ current}{\mathrm{d}T/\mathrm{d}z}$$

U: uplift

$\frac{dT}{dz}$: *thermal gradient*

$$D = \frac{U}{\sin\theta}$$

D: displacement

θ: *dip angle*

(Patrick Makuluni, 2021)