Activity and motion characteristics on the southern segment of the Red River fault zone, Yunnan province, China

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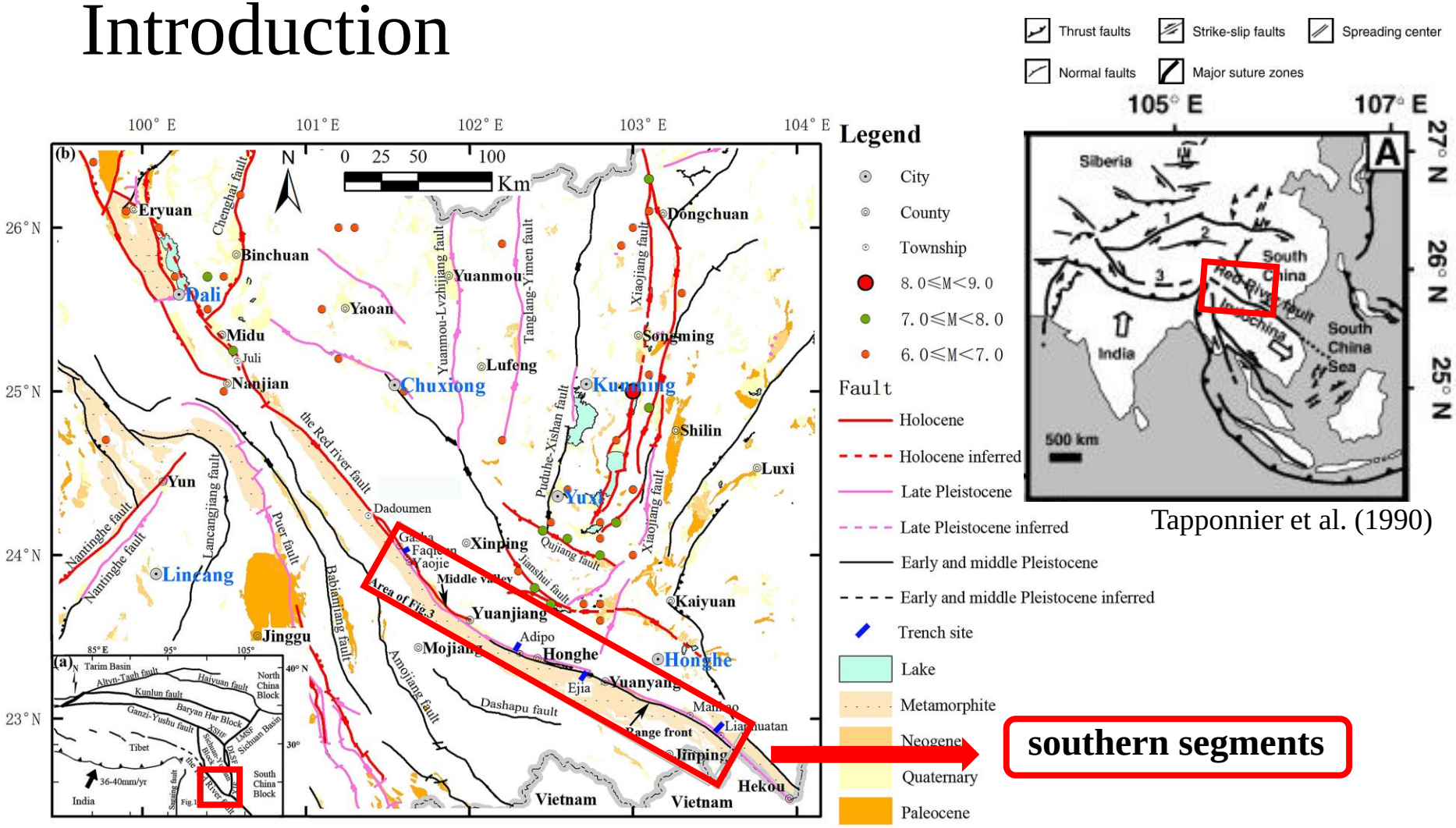
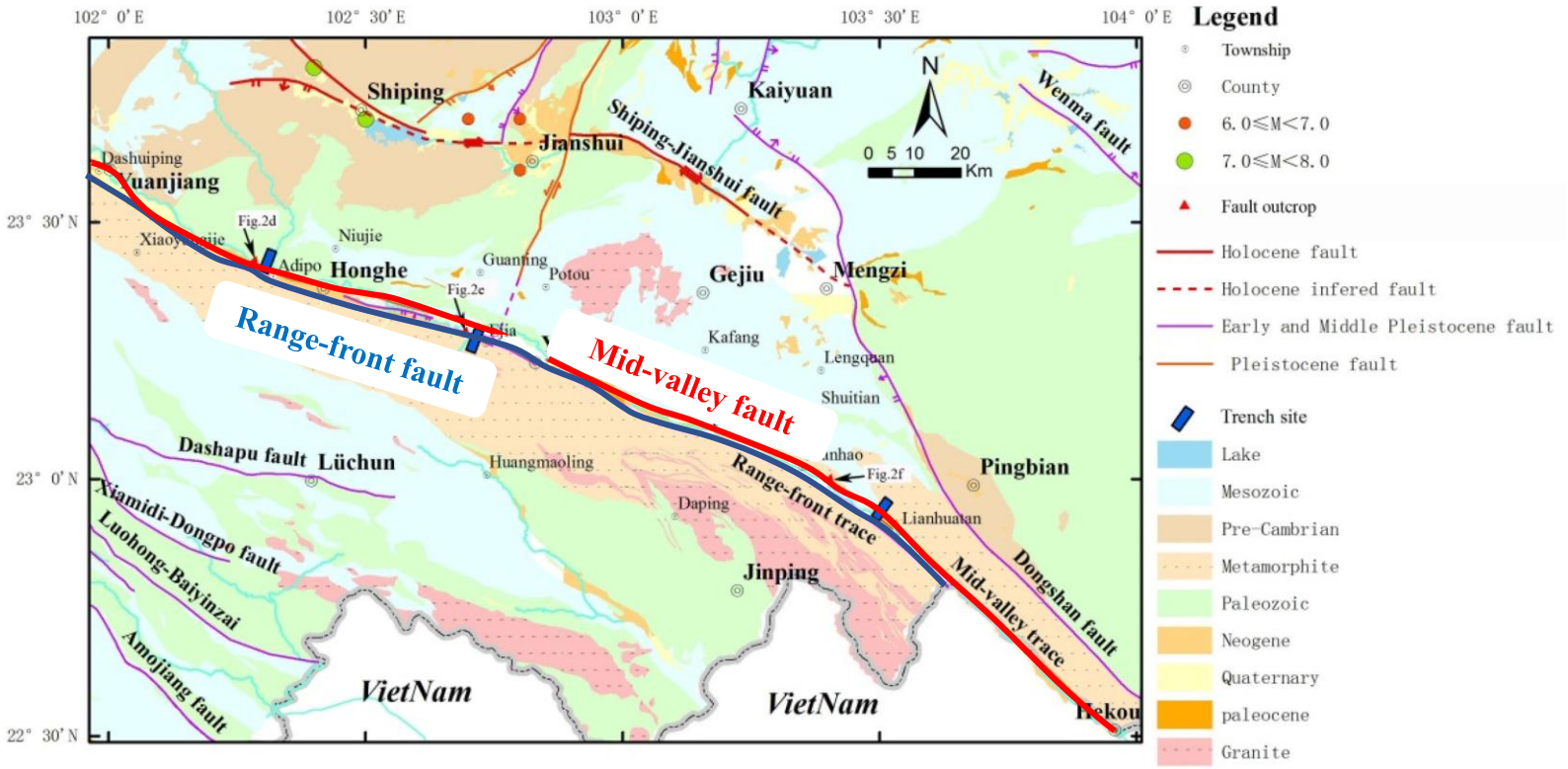
Introduction



southern segments

- The Red River Fault Zone (**RRFZ**) is a major **plate boundary fault** in Asia, extending over 1,000 km from the Tibetan Plateau to the Hanoi Basin, Vietnam.
- In China, **RRFZ** is **divided into northern, central, and southern segments**.
- The southern segment includes **the Middle Valley Fault** and **Range Front Fault**.

Late Quaternary activity of RRFZ



- The activity of the southern segment of the RRFZ is **controversial** .
- **No M≥7 earthquakes have been recorded since 886 AD** in the southern segment of the RRFZ, but earthquakes with a magnitude of 7 or higher occurred in 1652 and 1925 in the northern segment.

Long-term stable or **Long recurrence cycle** ?

Objective

➢Previous Studies

- **Low slip rate (<2 mm/yr)**
- **Rare large earthquake records** Guo et al. (2001)
- **Lack of geological evidence for Holocene activity**

■**Analyze the fault movement characteristic**

■**Search for evidence of Holocene** (within the past 10,000 years) **activity**

Methodology

- **UAV aerial photography**
- **Field geological investigation**

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- **Map active fault traces**
- Construct **High-resolution topographic map**

- **^{14}C dating**

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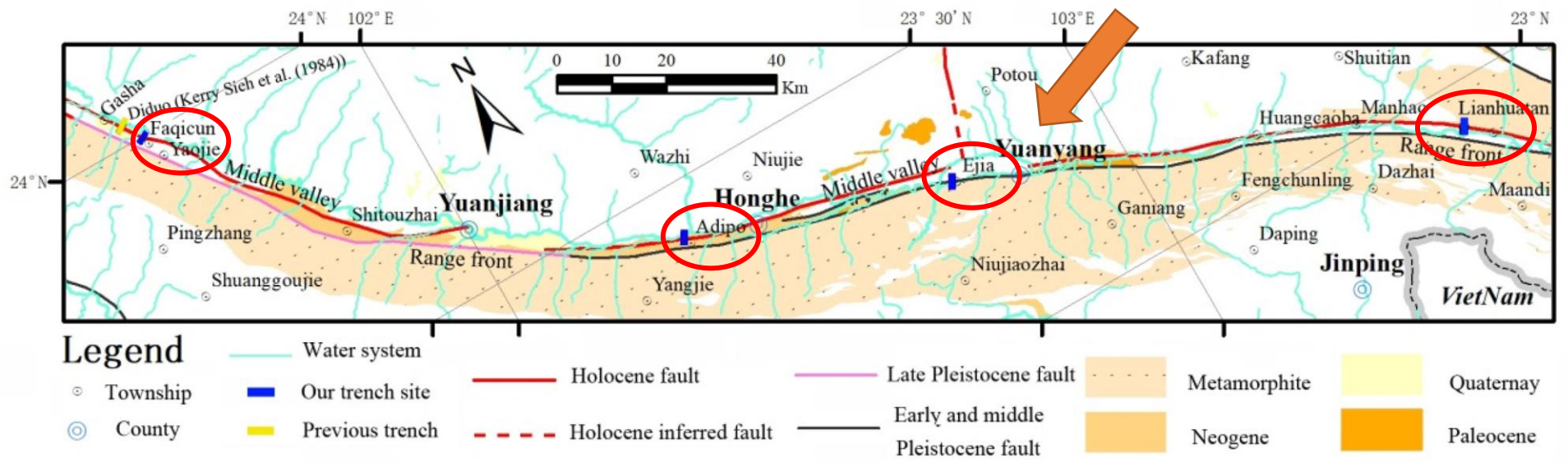
- Determine the age of active faults

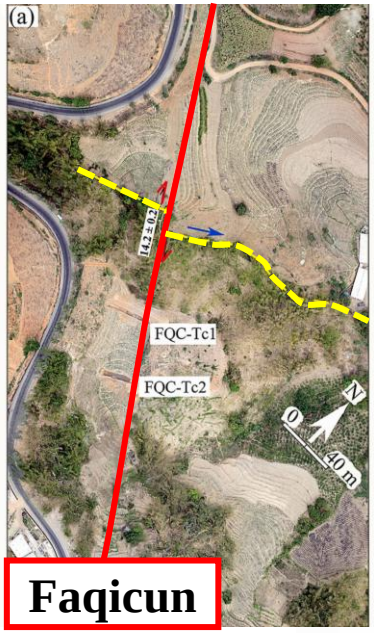
On the Range Front Fault



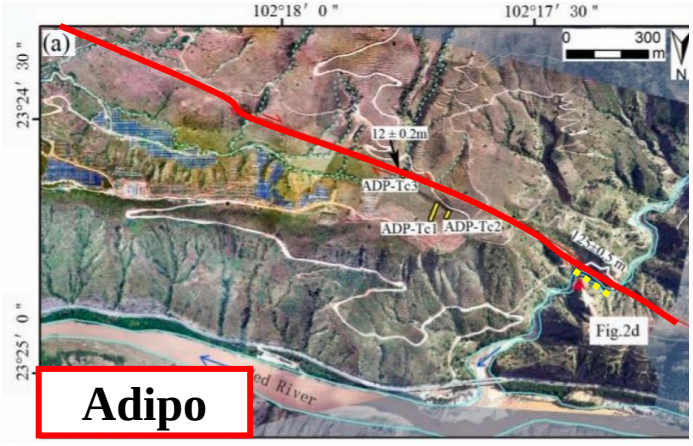
Results and Discussion

➢ Field geological investigation & UAV

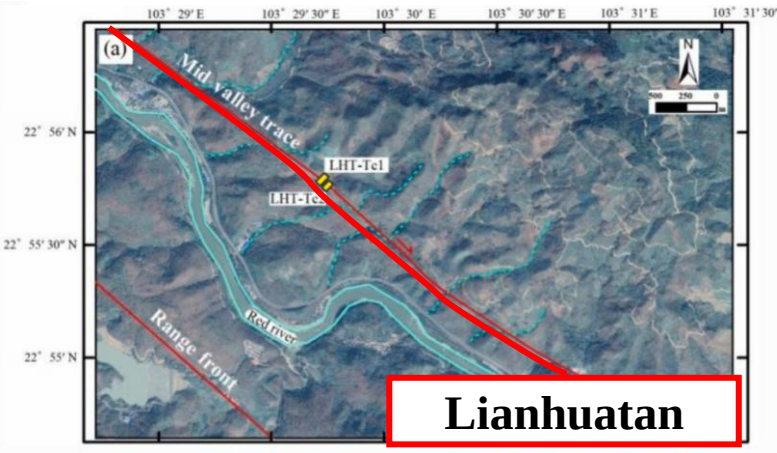
- Mainly normal faulting with a component of **dextral strike-slip**.
  - **Faqicun**: Gully **dextral offset of 14.2 ± 0.2 m**.
  - **Adipo**: River **dextral displacement of 125 ± 0.5 m**
- Supported by field outcrop observations and GPS data.



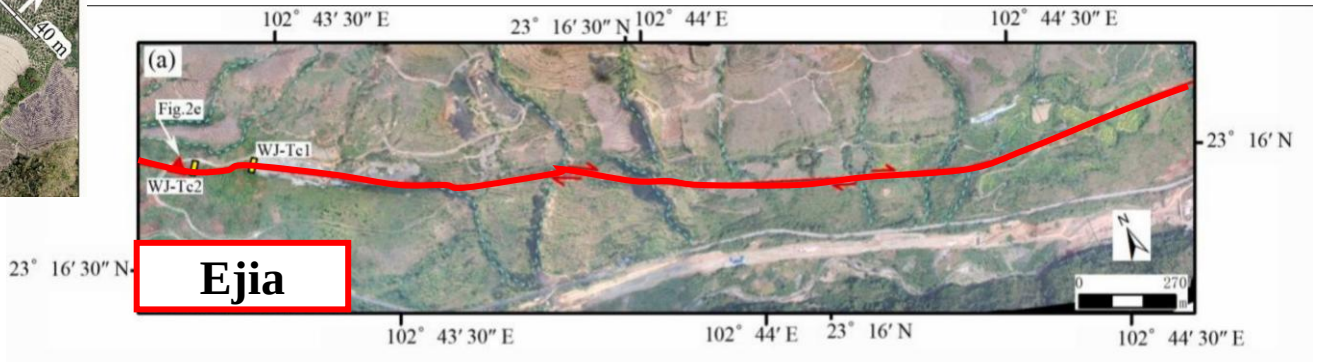
Faqicun



Adipo



Lianhuatan



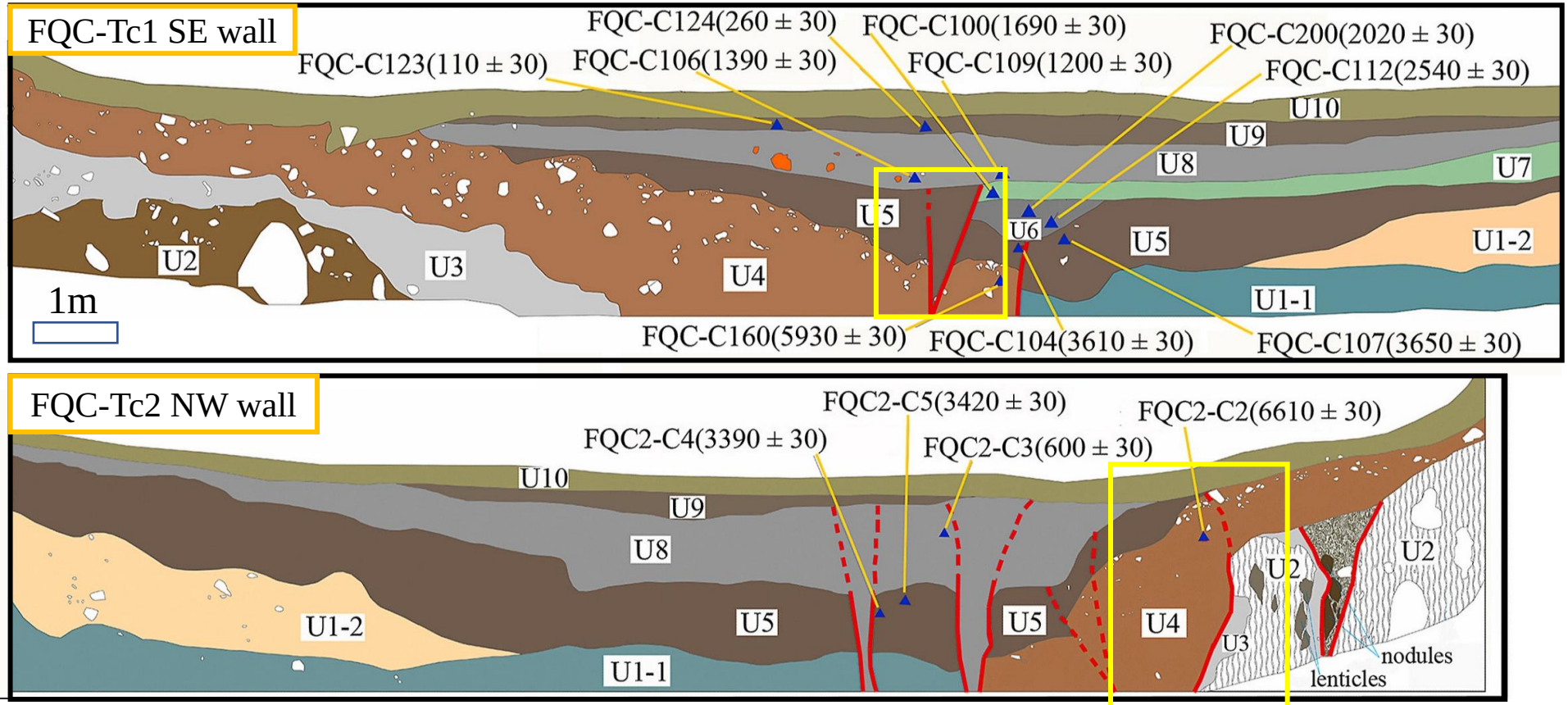
Ejia

Results and Disscussion

➢Geological evidence at **Faqicun**

- **Holocene fault activity** identified.
- **^{14}C dating results:** Fault movements occurred around **3613 - 2616BP and 1622 – 1293BP**.

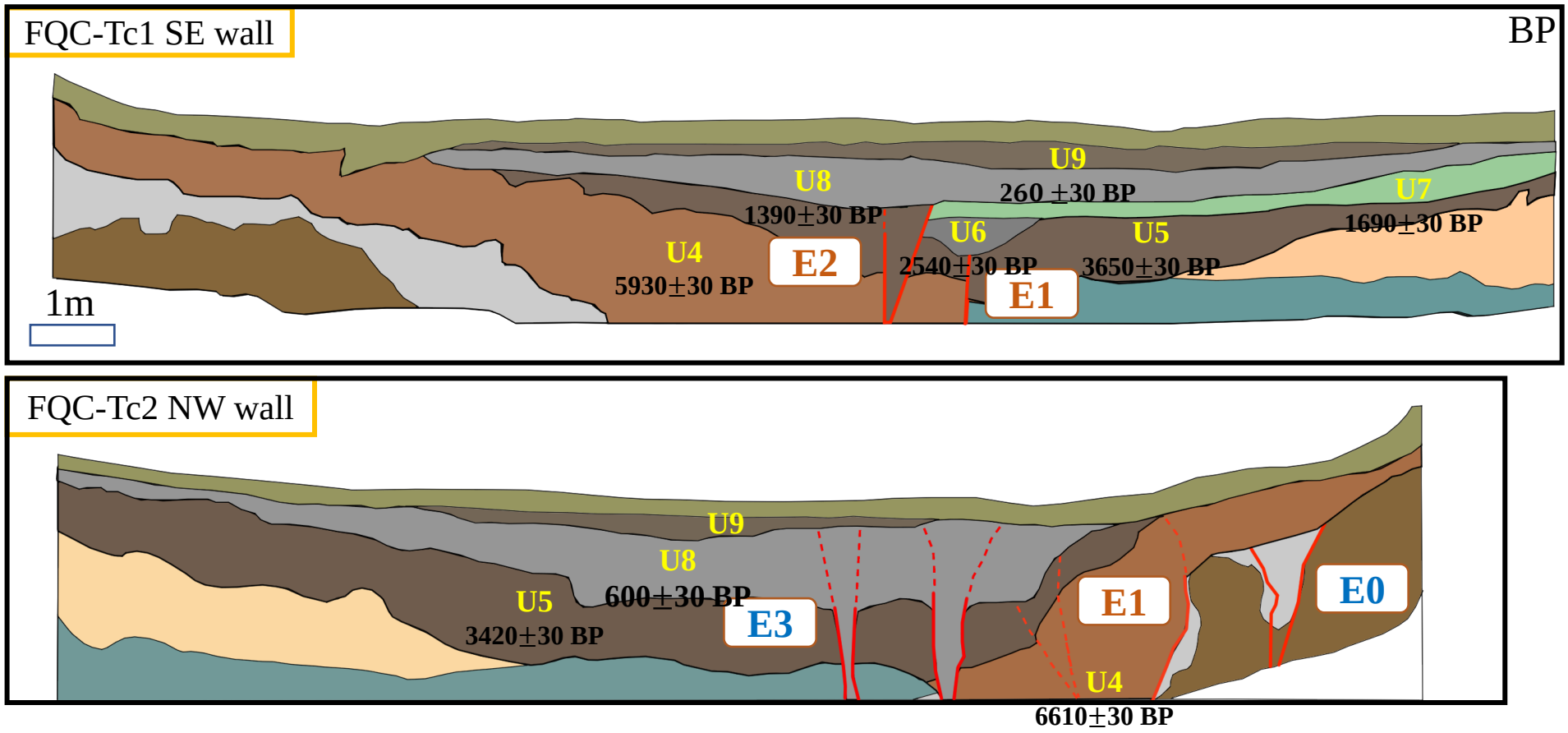
BP



Results and Discussion

➢Geological evidence at **Faqicun**

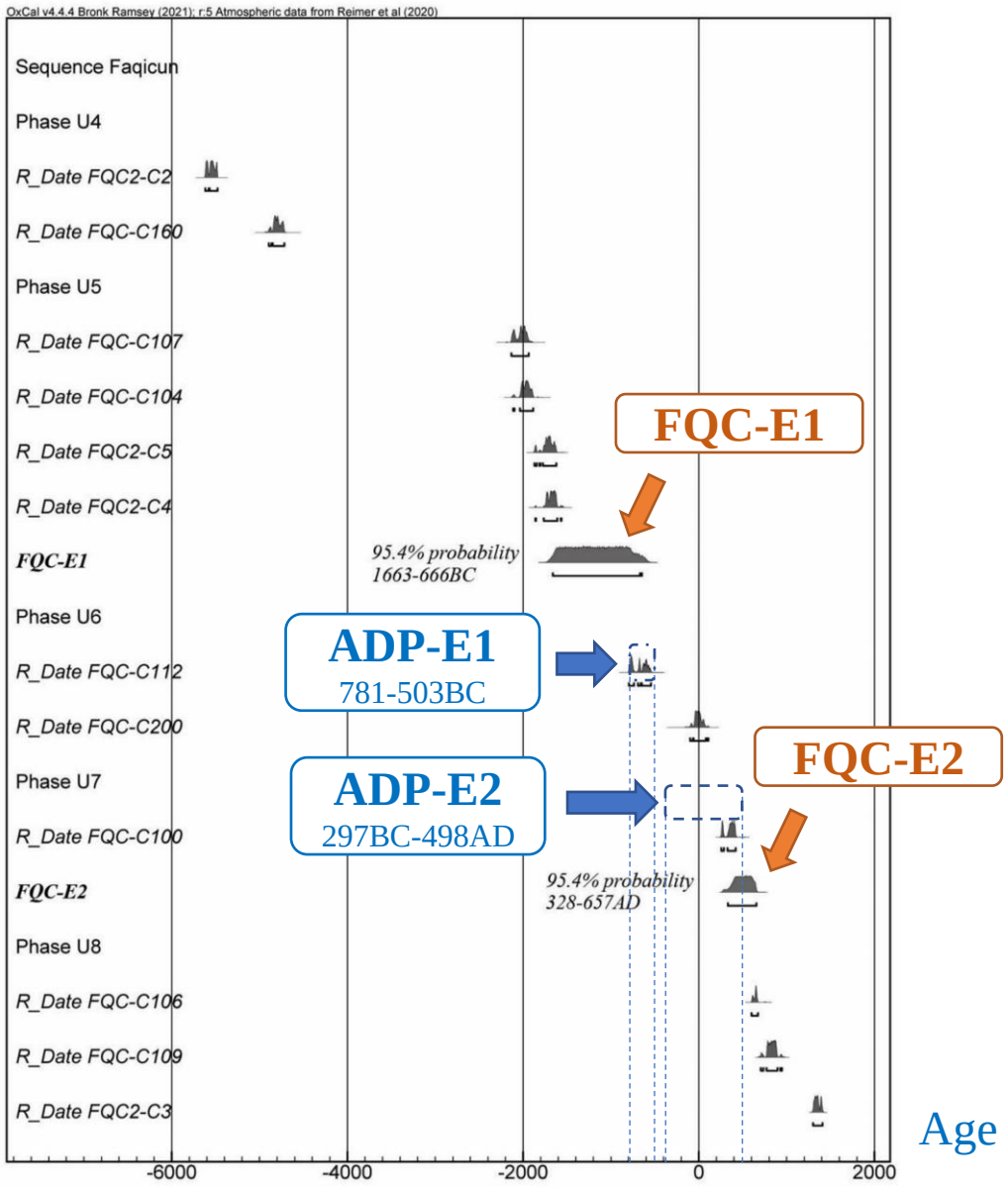
FQC-E0→U4→U5→**FQC-E1**→U6→U7→**FQC-E2**→U8→**FQC-E3**



Results and Discussion

- Paleoearthquake records of the **Middle Valley Fault**

Sample of Radiocarbon dating



Results and Discussion

➢Previous research:

- **Diduo trench site** (Shi et al., 2018) suggested a **recurrence interval** of approximately **6000 ± 1000 years** for large earthquakes.

- **No clear Holocene geological evidence** was found at that time.

➢This study:

- Field investigations and geological evidence from **Faqicun**, **Adipo**, and **Lianhuatan** sites indicate that the **Middle Valley Fault** has experienced **continuous tectonic activity** during the **Holocene**.

- Geological evidence from **Ejia Village** on the **Range Front Fault** indicates at least one paleoearthquake between **476-315 BP**, suggesting **continued Holocene activity contrary** to previous studies.

Conclusions

- **Field geological and geomorphological surveys** indicate that both the **Middle Valley Fault** and **Range Front Fault** remain **active**.
  - Paleoearthquake records of the **Middle Valley Fault**
    - **Faqicun: 3613-2616 BP and 1622-1293 BP**
    - **Adipo: 2731-2453 BP and 2247-1452 BP**
  - Paleoearthquake records of the **Range Front Fault**
    - **Ejia: 476-315 BP**

- The southern segment of the RRFZ exhibits **normal and dextral strike-slip movements**.

- Results differ from previous studies; **seismic risk** of the southern RRFZ **should be reevaluated**.

Future works

- **Research relevance for future Shimen Fault studies:**
  - **Methods applied in this study:**
    - High-resolution remote sensing and field geological surveys
    - Trench excavations for direct observation of fault activities
    - Radiocarbon (^{14}C) dating for determining faulting events

Thanks for your attention.

RRFZ的活動階段

- 最初34-17Ma以前**左旋走滑移動**為主，始中南半島沿著RRFZ向東南擠出800~km(被認為是南海裂開的主要原因)
- 17-5Ma前：較慢冷卻與隆升
- 5-現在：正斷層及右旋走滑為主(可能因為青藏高原下的地殼物質開始向東南緣區流動)

前人研究

1. **Tapponnier 等 (1982)**：

   提出紅河斷裂帶最早期的左旋走滑運動與印度-歐亞板塊碰撞有關，該運動促成了中南半島的擠出與南海開裂。

2. **Allen 等 (1984)**：

   藉由錯動水系觀察，認為紅河斷裂帶在全新世內仍具右旋走滑運動，並推估斷層活動的地震重現週期。

3. **Leloup 等 (1995, 2001)**：

   指出紅河斷裂帶自晚第三紀以來經歷三階段構造演化：最初左旋快速運動→緩慢隆升→轉為右旋運動並伴隨快速隆升。

4. **Guo 等 (2001)**：

   認為紅河斷裂帶南段活動性減弱，未來不易發生大地震；估算最大右旋位移約7.4公里，滑移速率約2.5 mm/年。

5. **Schoenbohm 等 (2006a, b)**：

   提出紅河斷裂帶南段（特別是中谷斷層帶）主要為純右旋走滑運動；而前緣斷層帶則以正斷層活動為主，並與區域內下地殼流動及緬甸隱沒帶後撤作用有關。

6. **Shi 等 (2018)**：

   透過 Diduo 探槽研究推估紅河斷裂帶南段在過去約三萬年內的大地震重現週期約6000 ± 1000年，但缺乏明顯全新世活動證據。

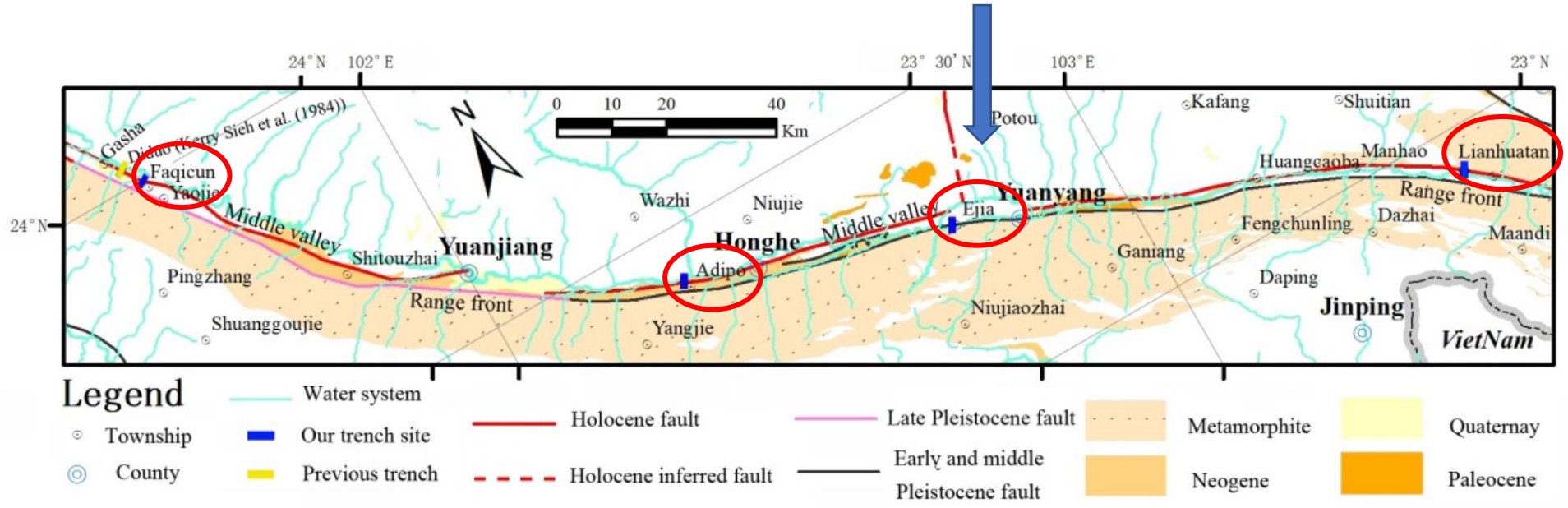
C14訂年

- 當我們用炭14（^{14}C）進行定年時，主要是**測定斷層錯動地層中的有機物（如木炭）的年代**。地層被斷層錯動後會覆蓋新的沉積物，因此可以透過上下地層的年代，推斷地震發生的時間範圍，而非精確的地震發生時間。
- When using radiocarbon (^{14}C) dating to estimate paleoearthquake timing, we primarily **date organic materials** within the faulted and covering layers. This approach provides the age range during which earthquakes occurred rather than exact dates.

Trenching Method

- Nine trenches of the southern segment:
  - **Faqicun**
  - **Adipo**
  - **Ejia**
  - **Lianhuatan**

On the Range Front Fault



➢ Geomorphological and geological evidence at **Adipo**

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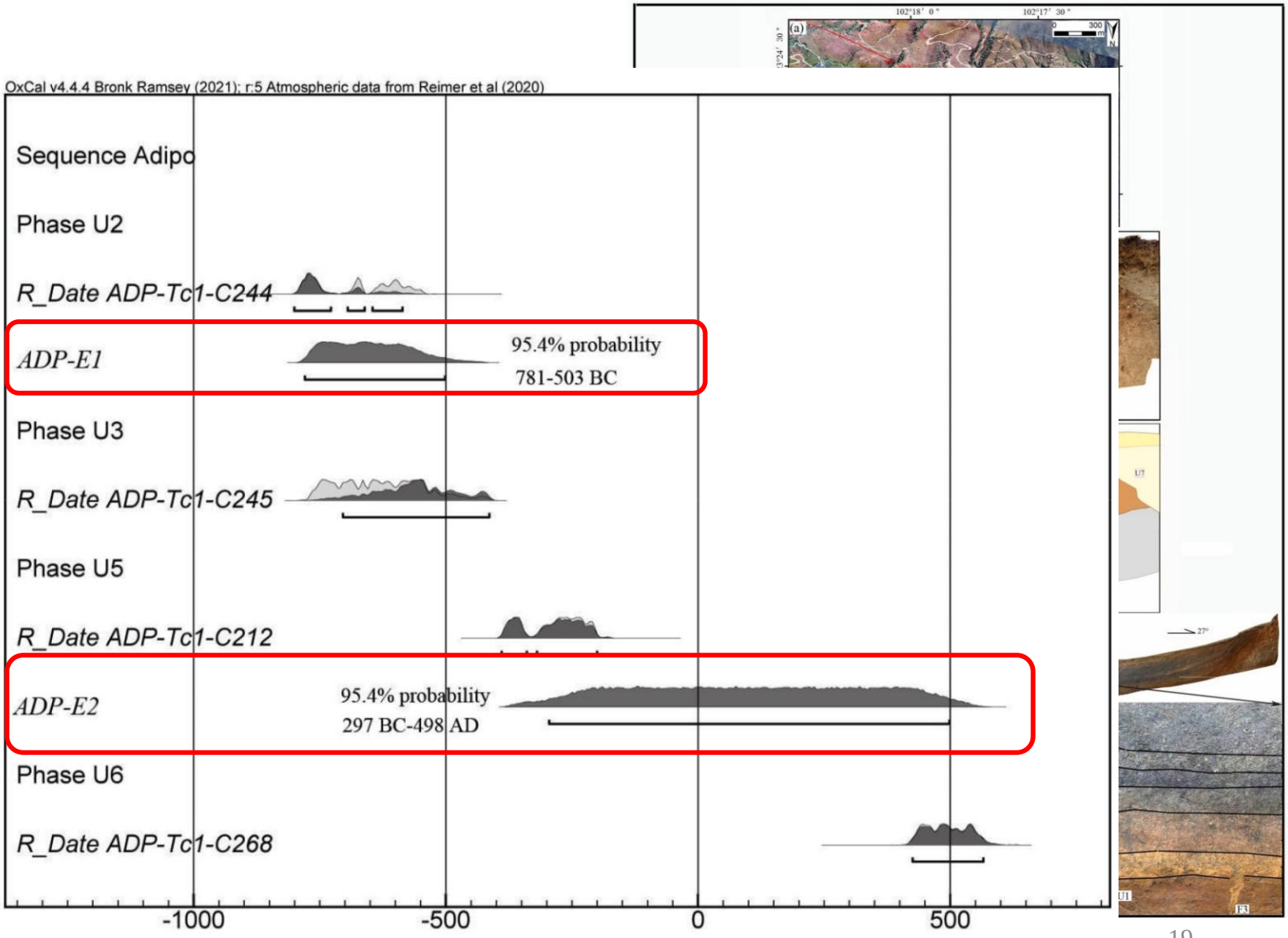

➢ Geomorphological and geological evidence at **Ejia**

- On the Range Front Fault
- At least one paleoearthquake
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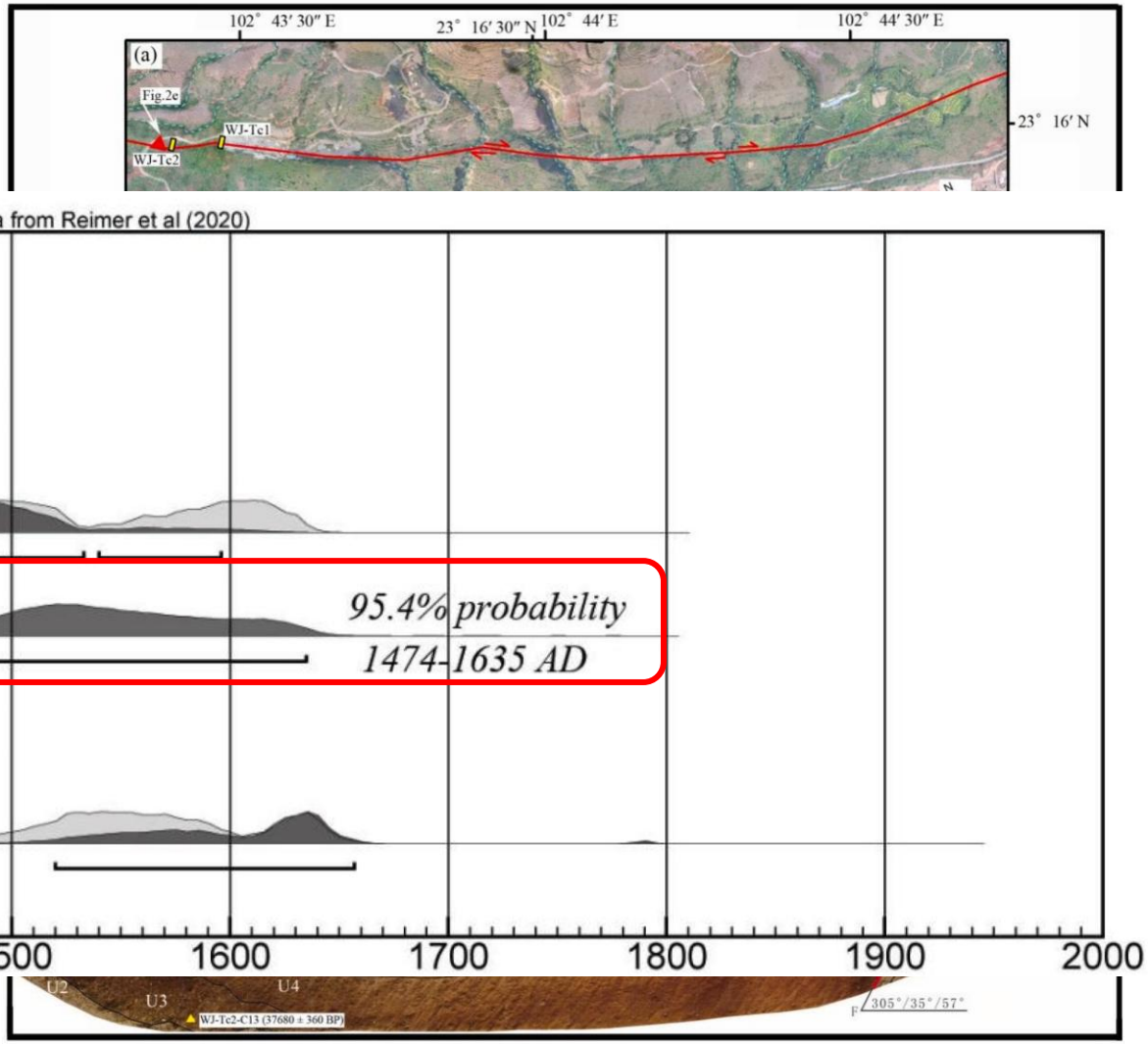
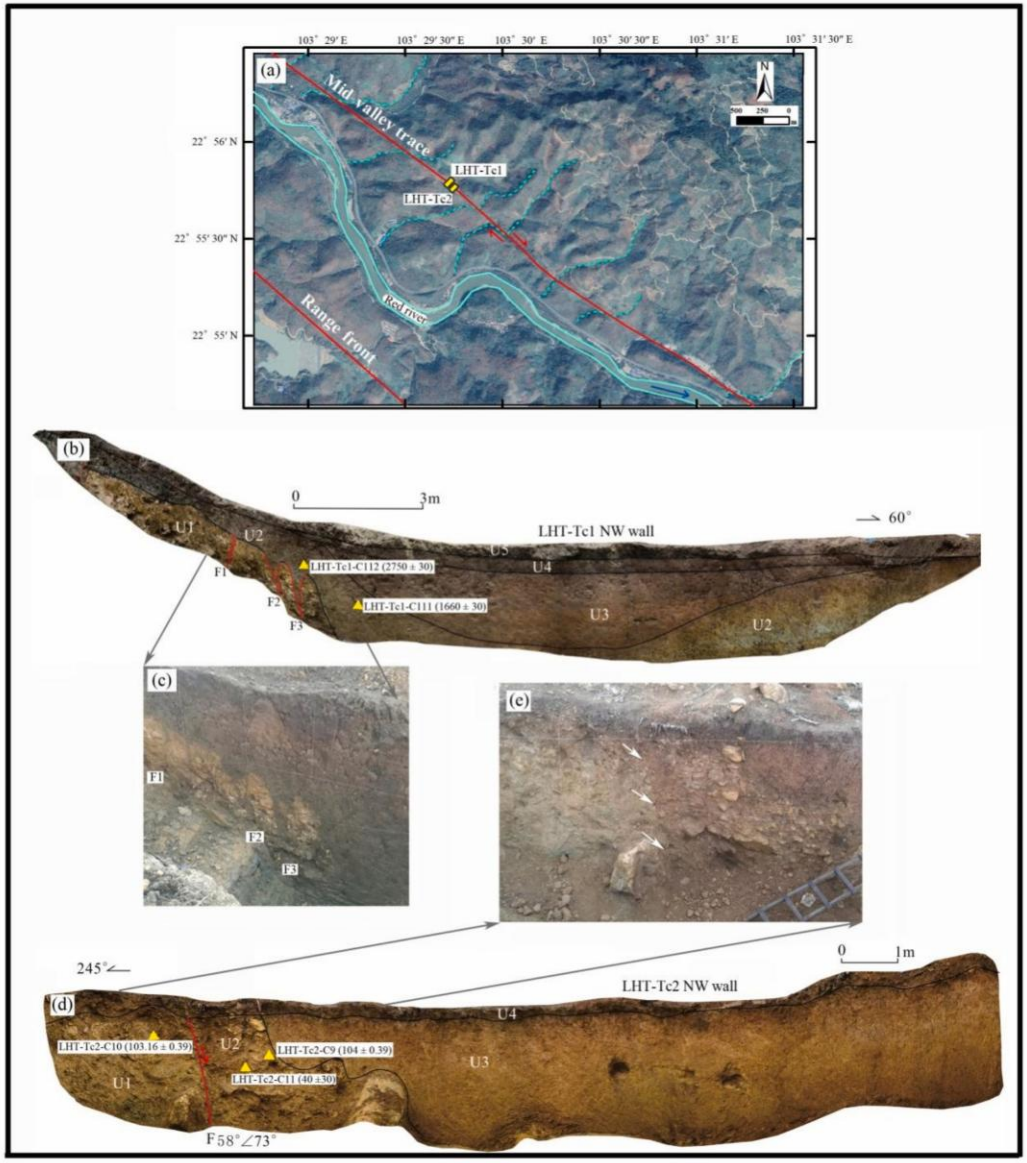
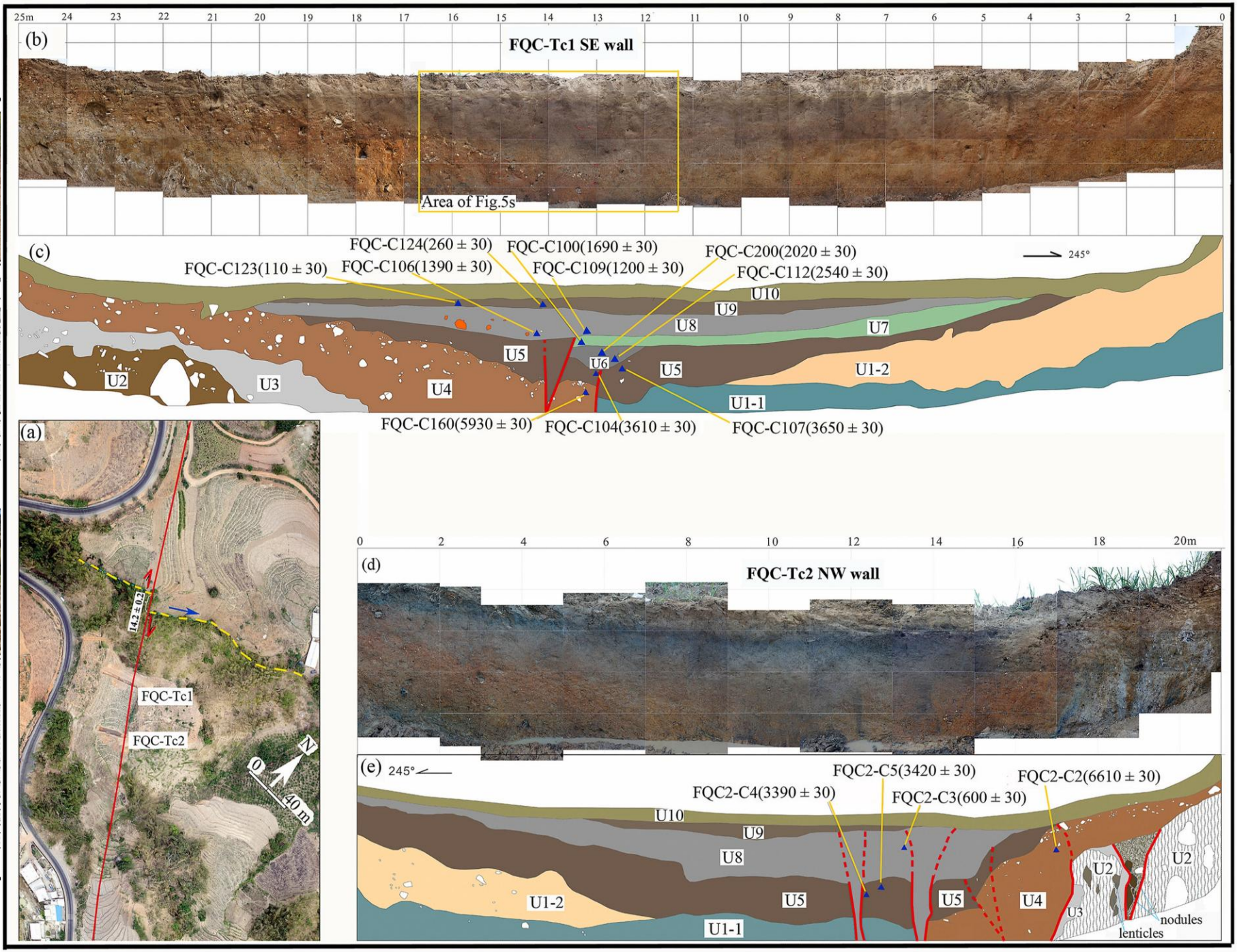


➢ Geomorphological and geological evidence at **Lianhuatan**

- LHT-Tc1:
  Radiocarbon dating indicates faulting occurred approximately **1600–2700 years ago**.

- LHT-Tc2:
  Due to multiple fault disturbances and limited dating constraints, precise paleoearthquake timing remains uncertain.




(b)
FQC-Tc1 SE wall
Area of Fig.5s
(c)
FQC-C124(260 ± 30)
FQC-C100(1690 ± 30)
FQC-C200(2020 ± 30)
FQC-C123(110 ± 30)
FQC-C106(1390 ± 30)
FQC-C109(1200 ± 30)
FQC-C112(2540 ± 30)
245°
U10
U9
U8
U7
U5
U6
U5
U1-2
U2
U3
U4
U1-1
FQC-C160(5930 ± 30)
FQC-C104(3610 ± 30)
FQC-C107(3650 ± 30)
(a)
142 ± 12
FQC-Tc1
FQC-Tc2
N
0
40 m
(d)
FQC-Tc2 NW wall
(e)
245°
FQC2-C5(3420 ± 30)
FQC2-C2(6610 ± 30)
FQC2-C4(3390 ± 30)
FQC2-C3(600 ± 30)
U10
U9
U8
U2
U2
U1-2
U5
U5
U4
U3
U1-1
nodules
lenticles