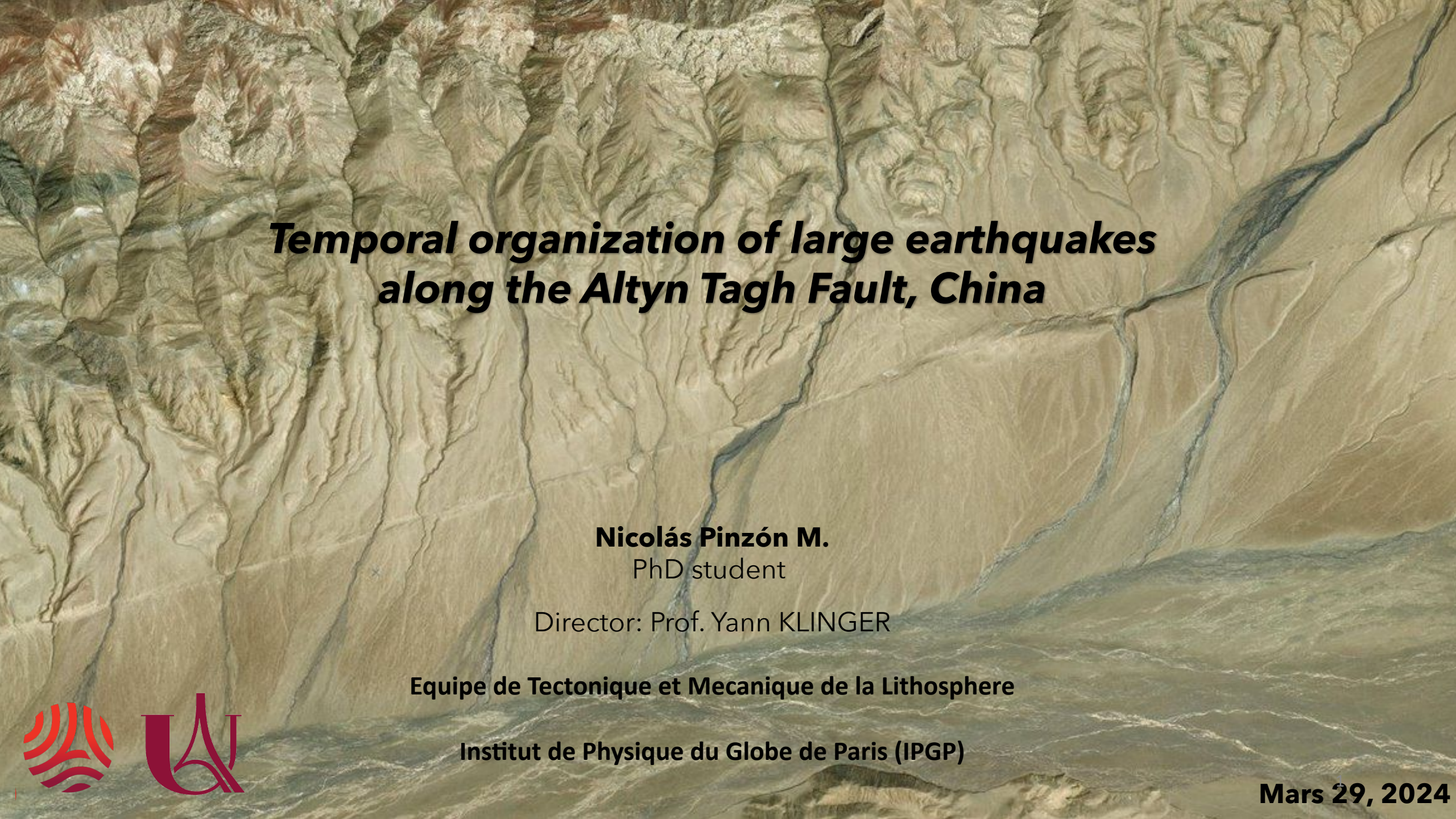


Temporal organization of large earthquakes along the Altyn Tagh Fault, China

Nicolás Pinzón M.
PhD student

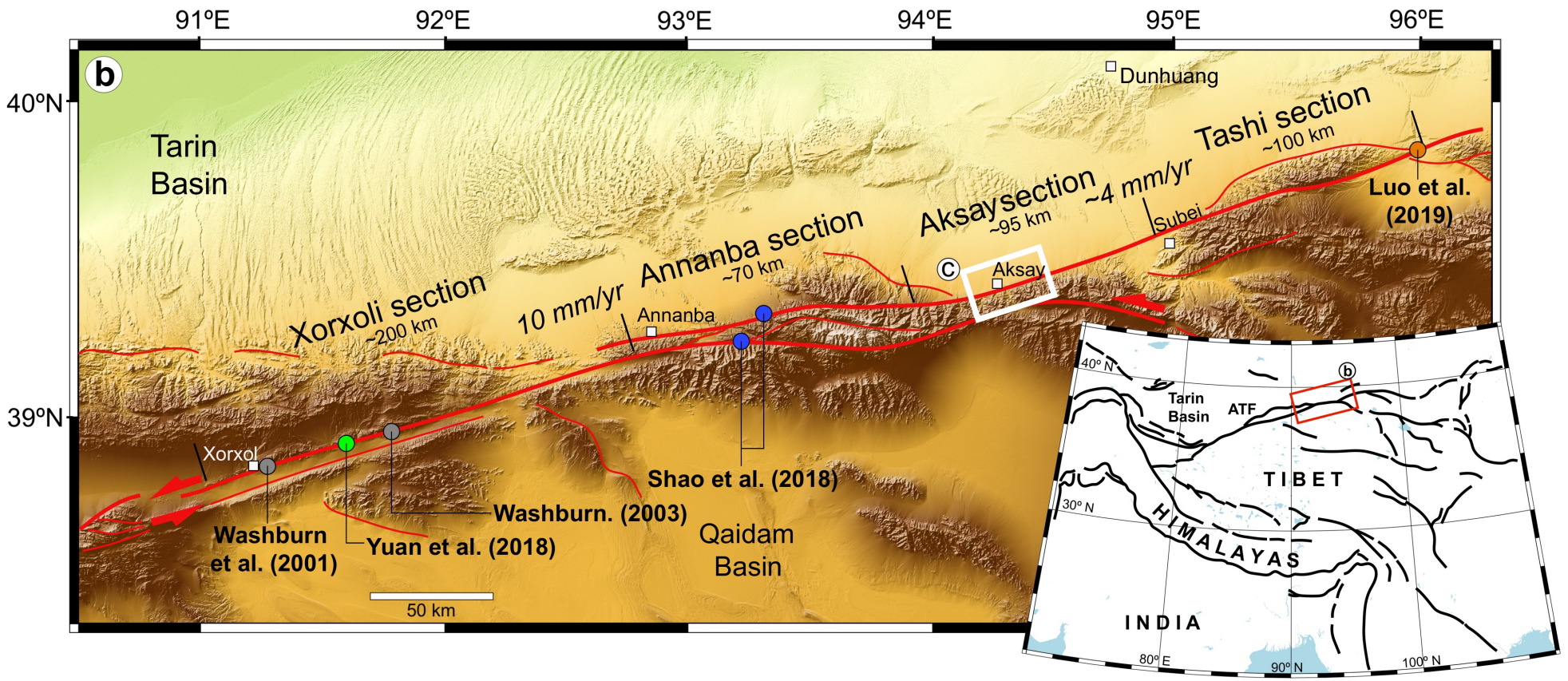
Director: Prof. Yann KLINGER

Equipe de Tectonique et Mecanique de la Lithosphere

Institut de Physique du Globe de Paris (IPGP)

Mars 29, 2024

How do earthquakes accommodate deformation along strike-slip faults?

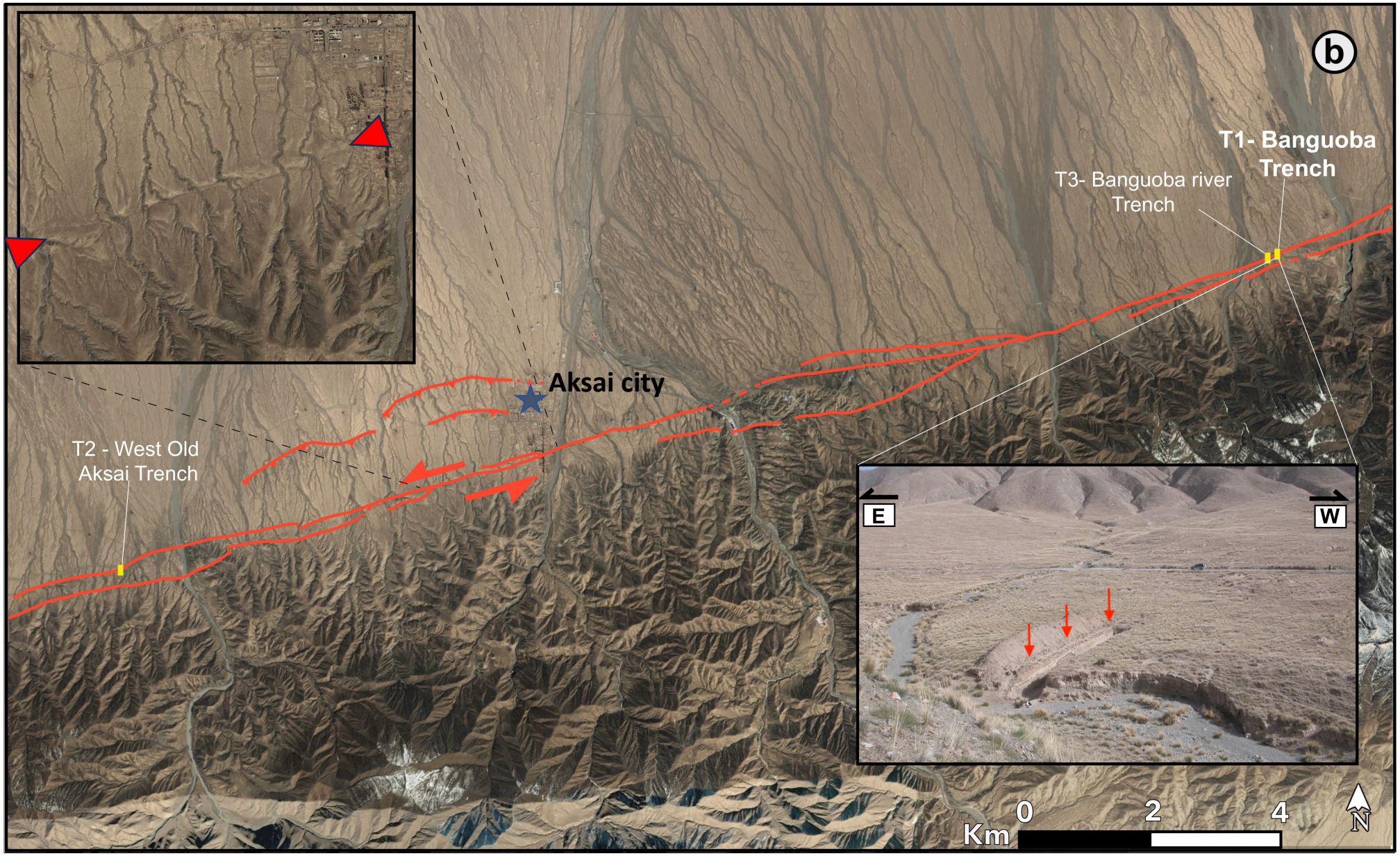


No instrumental earthquakes.
No historical records about major events.
Paleoseismic history still poorly known. Then, there is no clear pattern of rupture repetition.

Paleoseismicity along the eastern Altyn Tagh Fault (ATF)

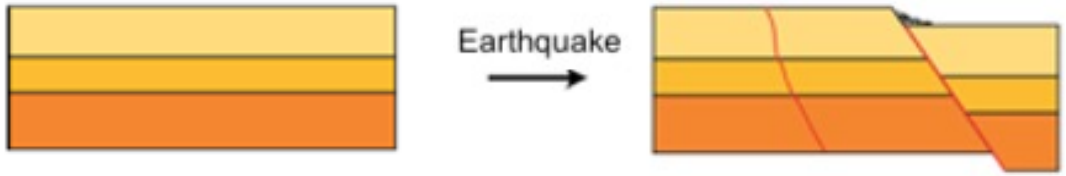
b
Aksai city
Km 0 2 4
N

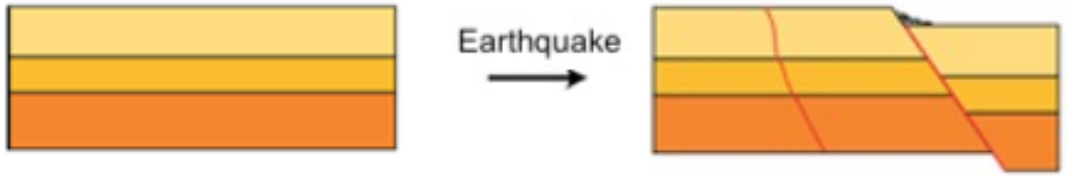
b
Aksai city
Km 0 2 4
N


b
T1- Banguoba Trench
T3- Banguoba river Trench
Aksai city
T2 - West Old Aksai Trench
E
W
Km 0 2 4
N

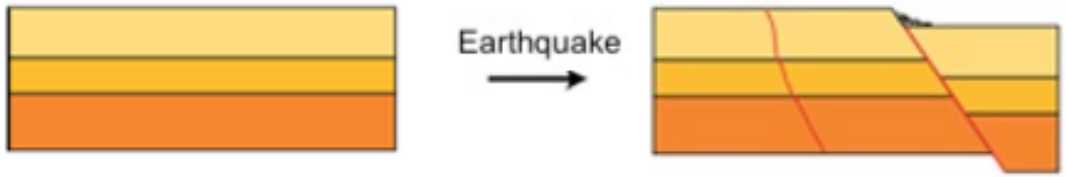
Fault topography far from being obvious and ubiquitous loess layer

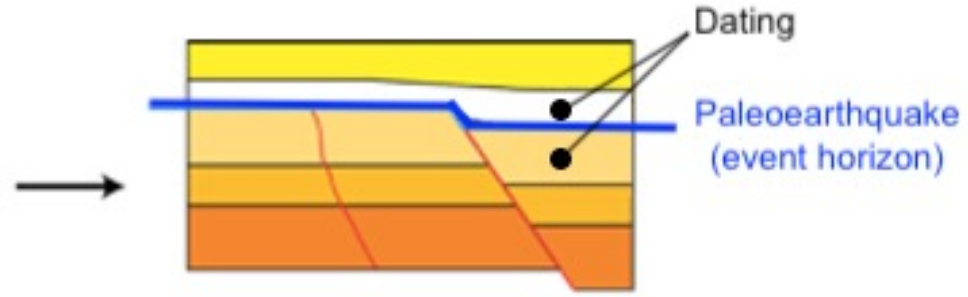
Fault topography far from being obvious and ubiquitous loess layer


Earthquake

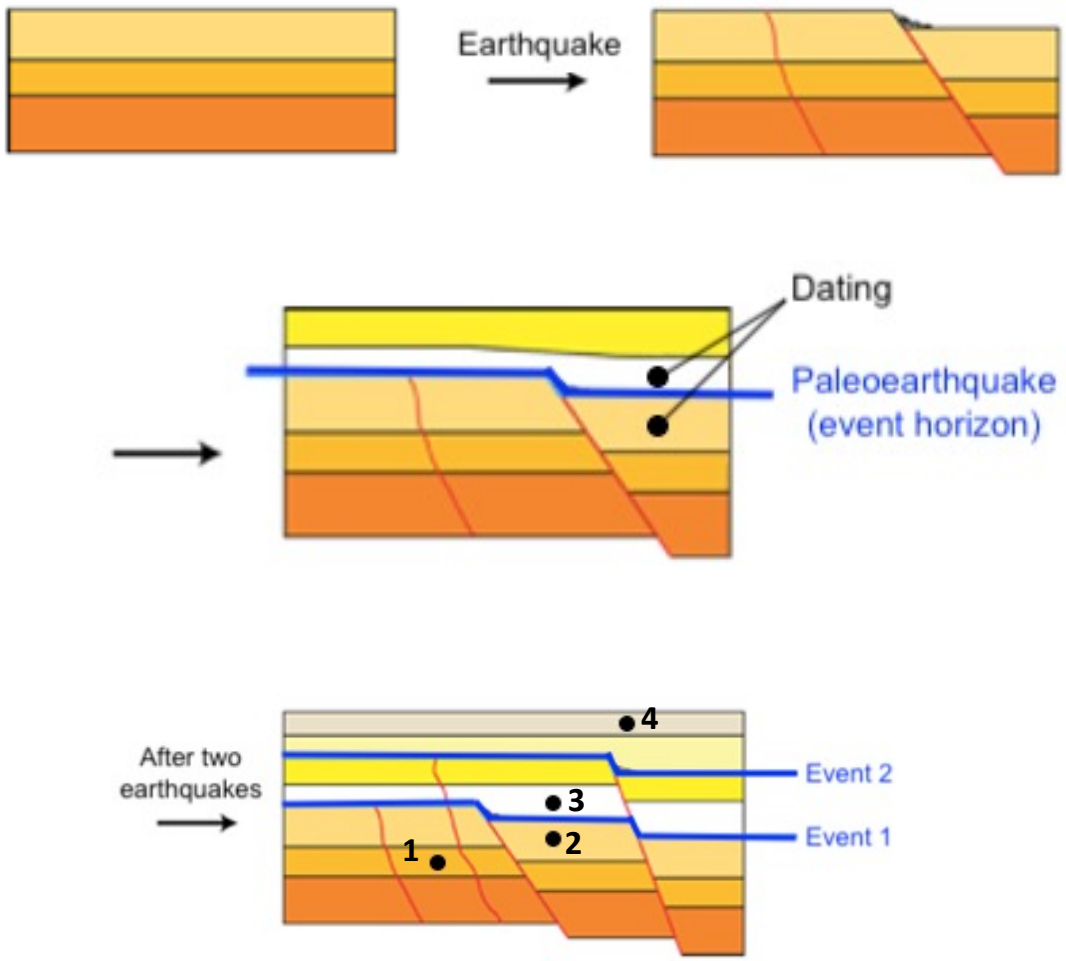


Ridgecrest, California, area in 2019. Credit: USGS/Ben Brooks

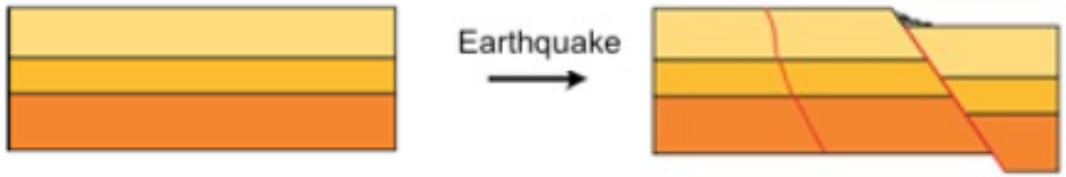


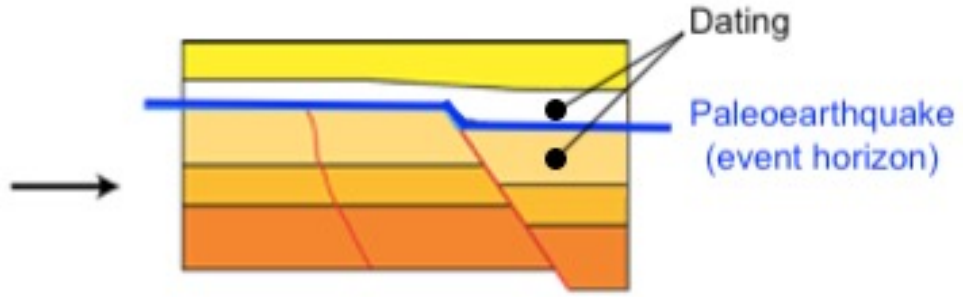


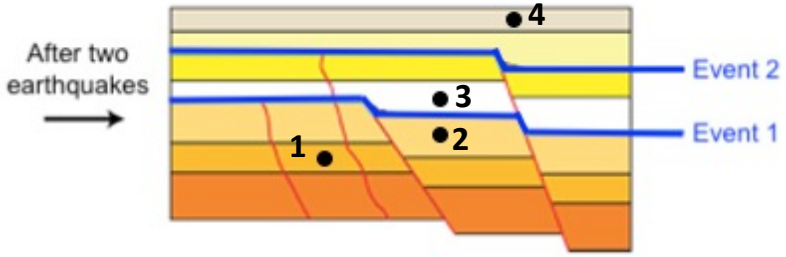
Ridgecrest, California, area in 2019. Credit: USGS/Ben Brooks

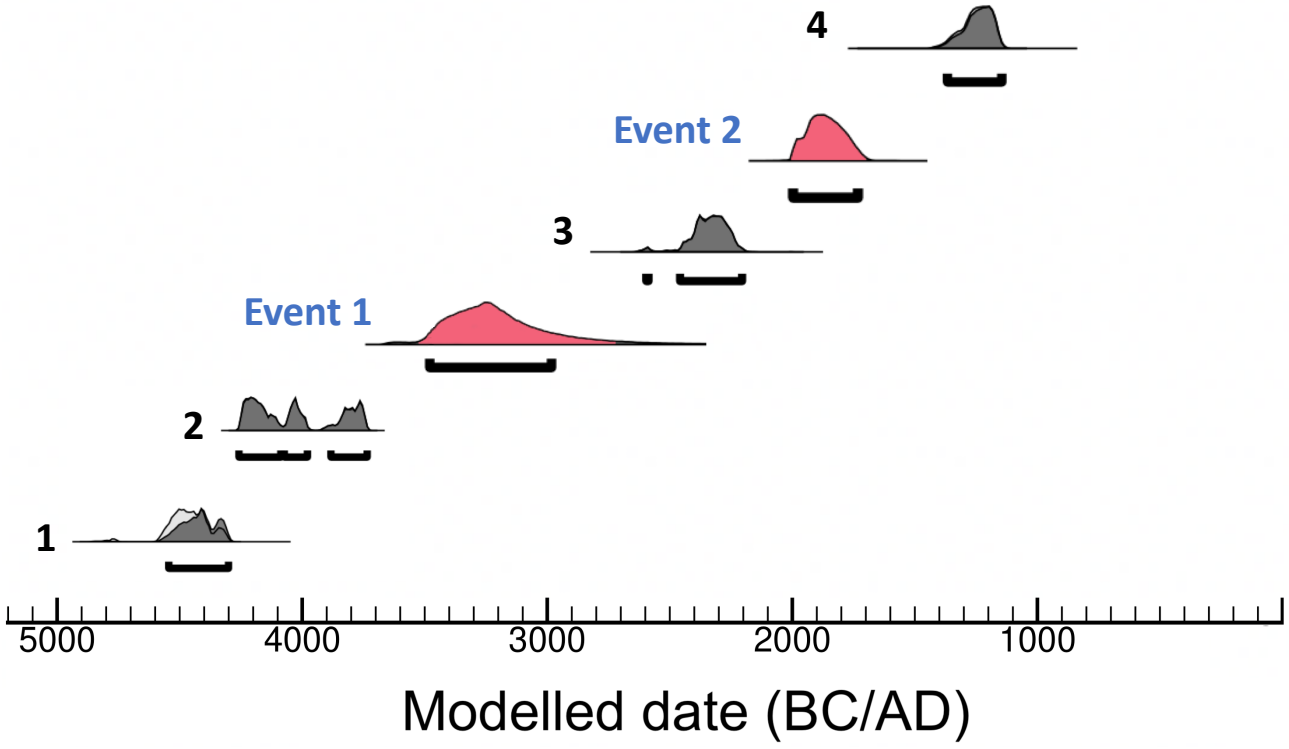


Ridgecrest, California, area in 2019. Credit: USGS/Ben Brooks

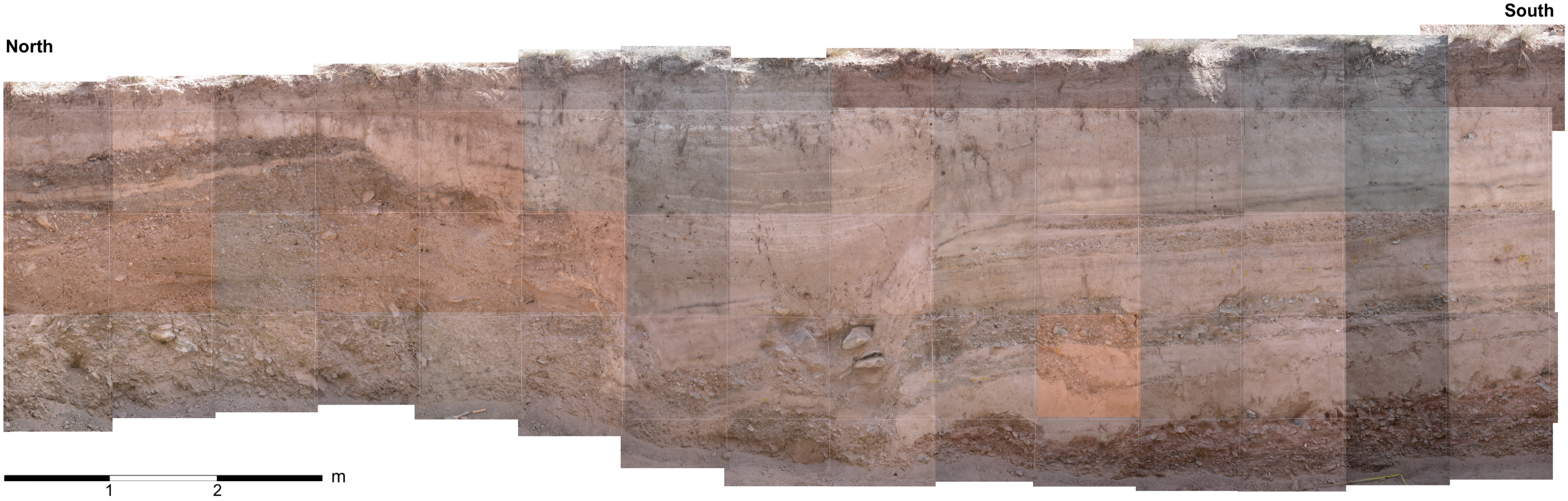

Earthquake

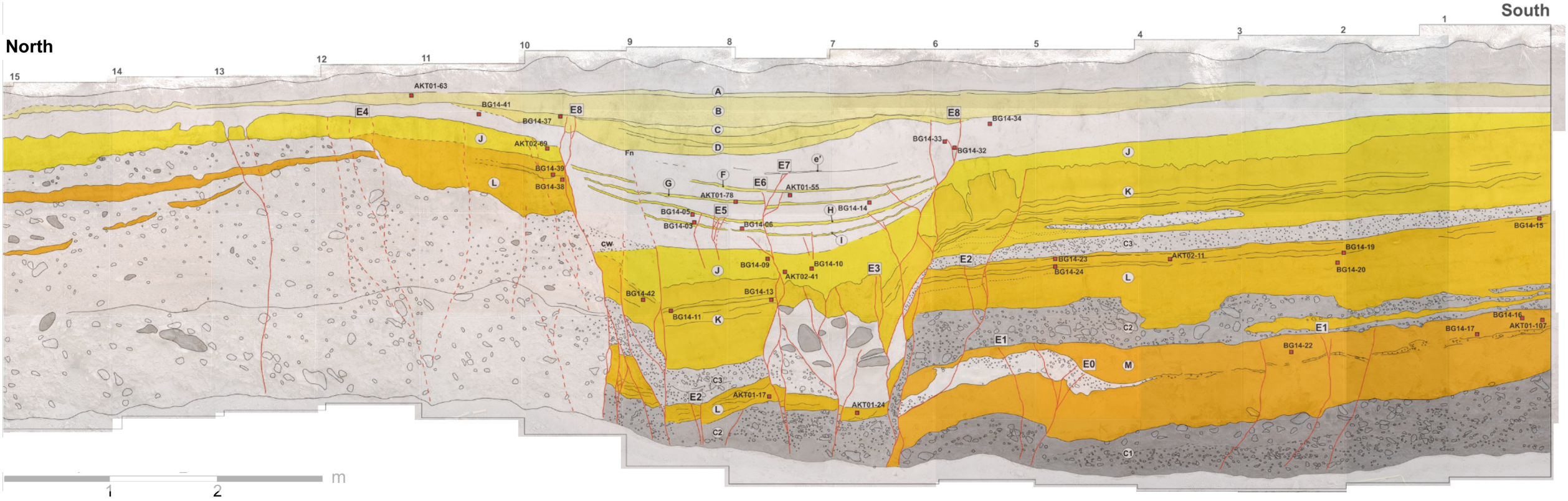

Dating
Paleoearthquake
(event horizon)


After two
earthquakes
4
Event 2
3
Event 1
1
2

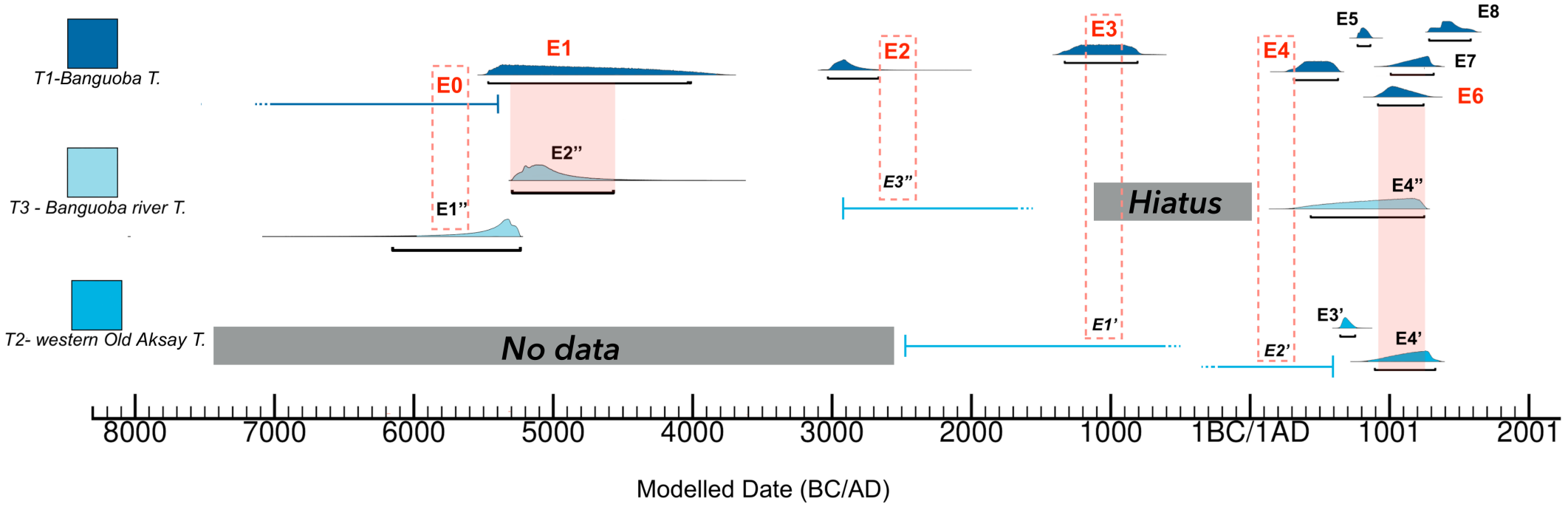

4
Event 2
3
Event 1
2
1
5000
4000
3000
2000
1000
Modelled date (BC/AD)

T1 – Bangoba Trench (master trench)



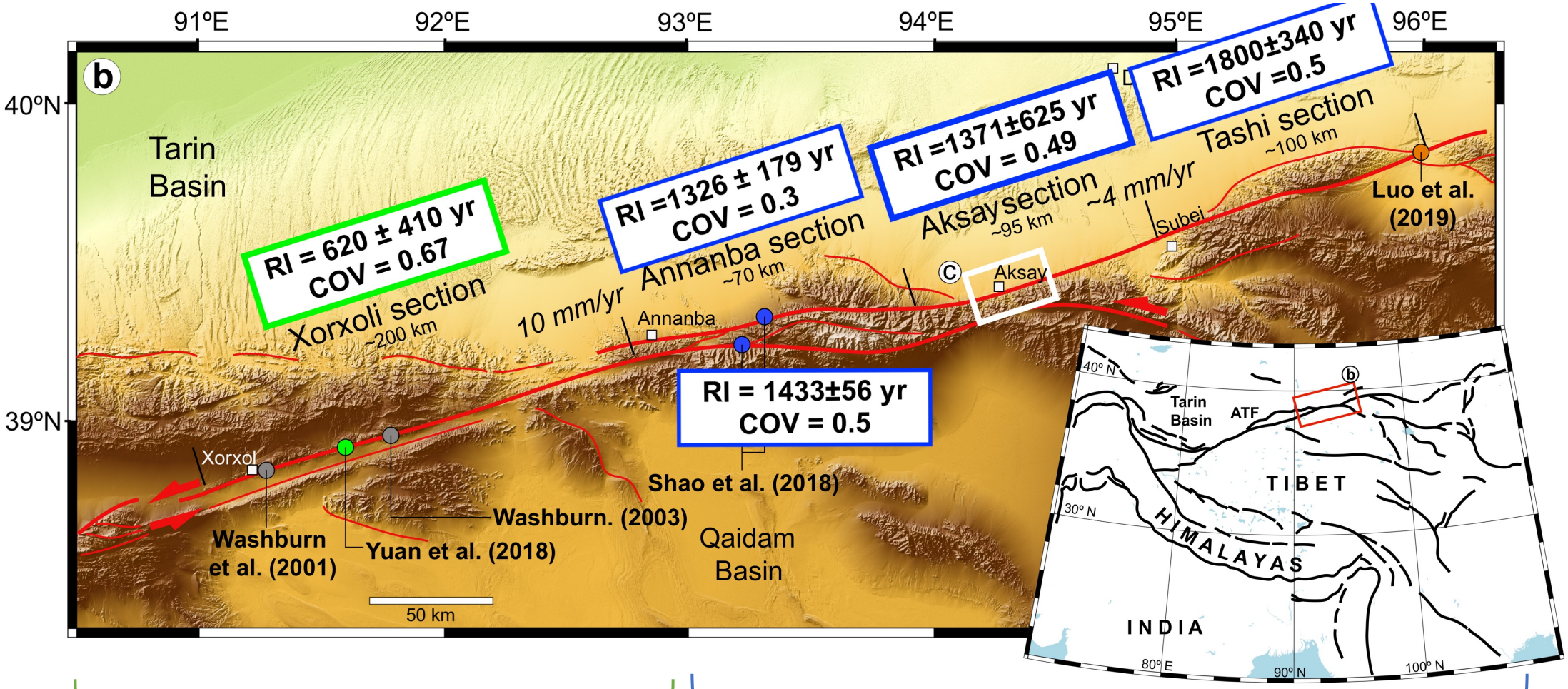

North
South
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
AKT01-63
BG14-41
BG14-37
BG14-39
BG14-38
AKT02-69
BG14-05
BG14-03
AKT01-78
AKT01-55
BG14-06
BG14-14
BG14-09
BG14-10
AKT02-41
BG14-13
BG14-42
BG14-11
AKT01-17
AKT01-24
BG14-33
BG14-32
BG14-34
BG14-23
BG14-24
AKT02-11
BG14-19
BG14-20
BG14-15
BG14-16
AKT01-107
BG14-17
BG14-22
E0
E1
E2
E3
E4
E5
E6
E7
E8
A
B
C
D
e'
F
G
H
I
J
K
L
M
C1
C2
C3
Fn
CW
m
1
2

Spatial location of the trench T1
N
T2
Aksai
T3
T1



- The average recurrence interval for the northern ATF is ~1371 ± 600 yr.
- the recurrence behavior of each fault segment of the ATF is rather periodic than random (COV ~0.46)

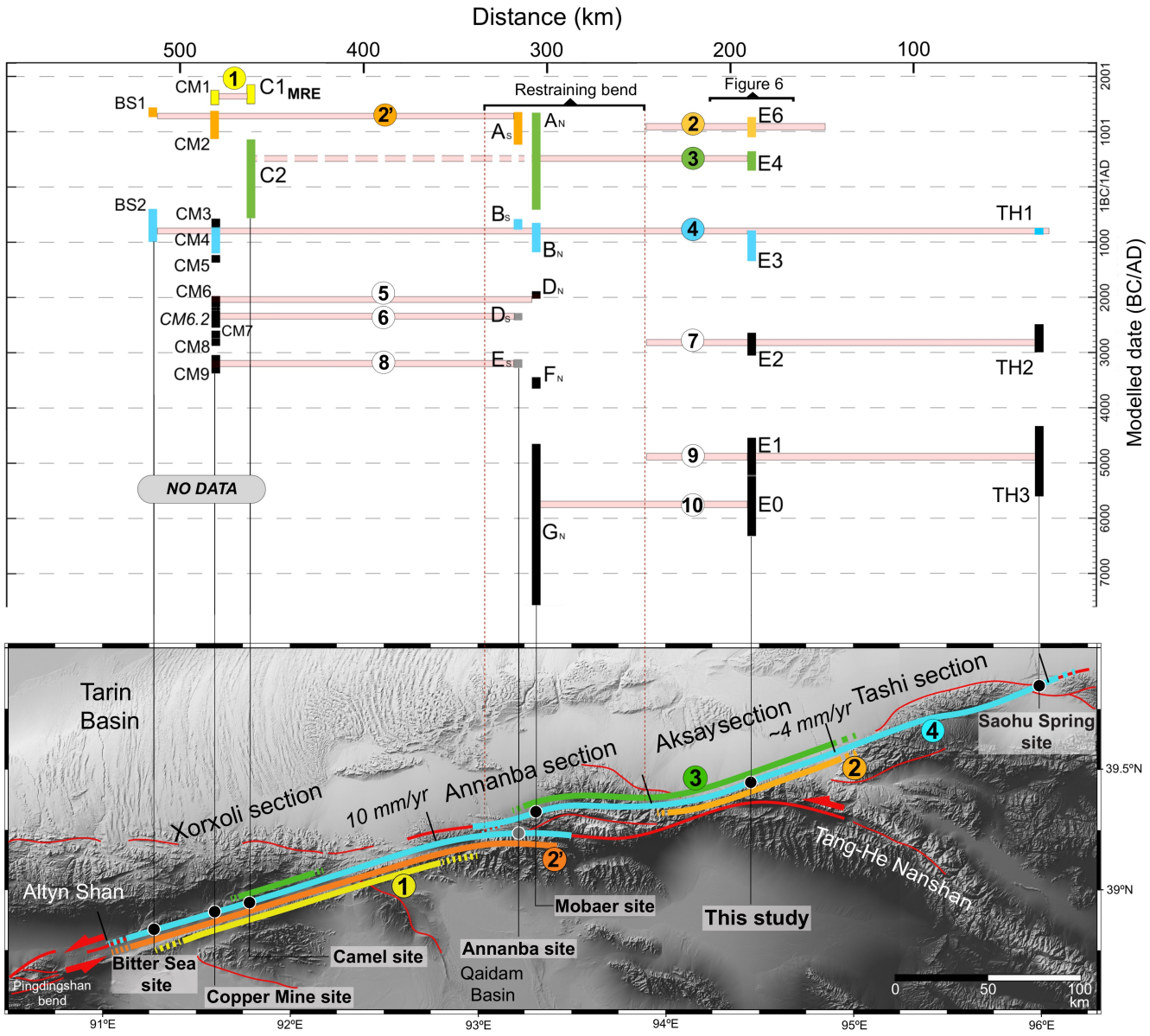
Summary of the Paleoseismic data



Lower return intervals
Higher COV - starting to deviate from a periodic behavior

Higher return intervals
Lower COV – strongly periodic behavior

Rupture Pool at a Regional Scale



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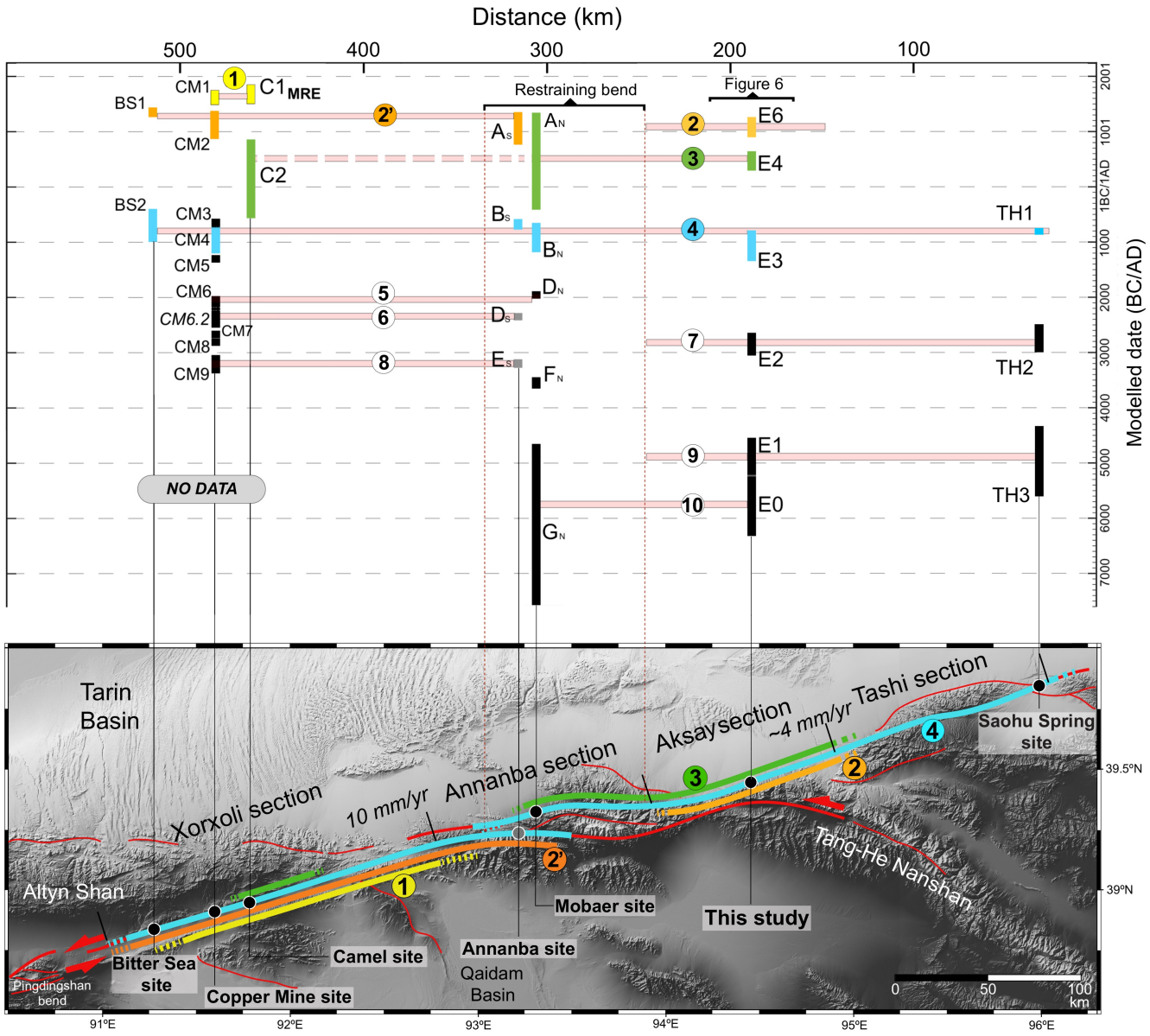
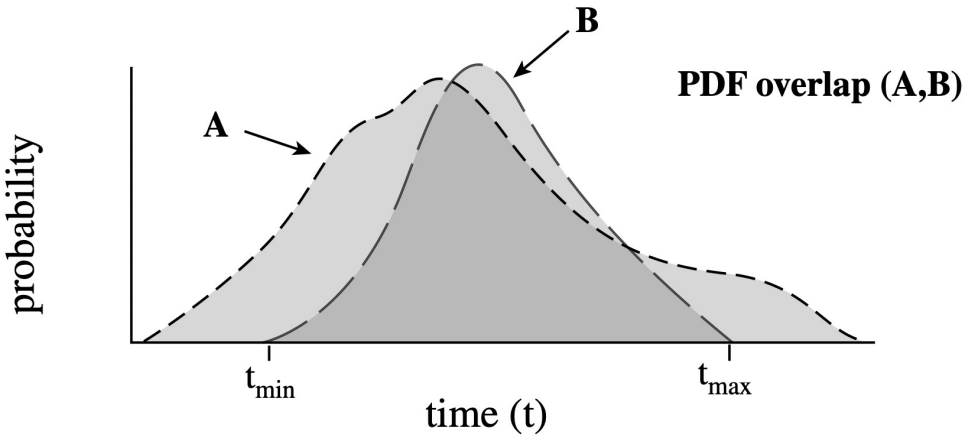


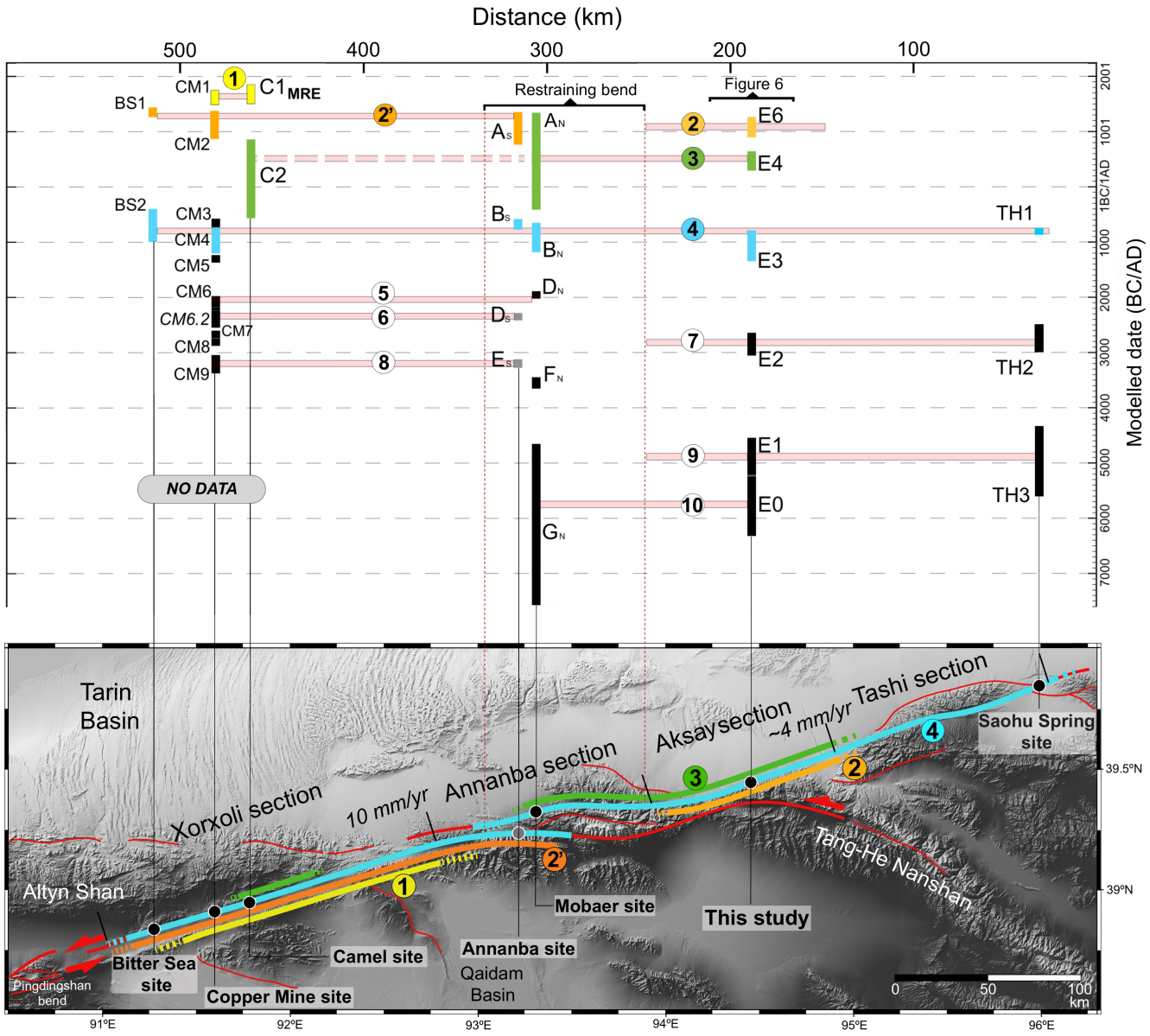
Compare and **Correlate** earthquake PDFs



$$\text{overlap area}(i,j) = \sum \min[pyr_i(\tau), pyr_j(\tau)], \quad (1)$$

Minimum overlap criteria $(x^2) = 0.09$

Rupture Pool at a Regional Scale



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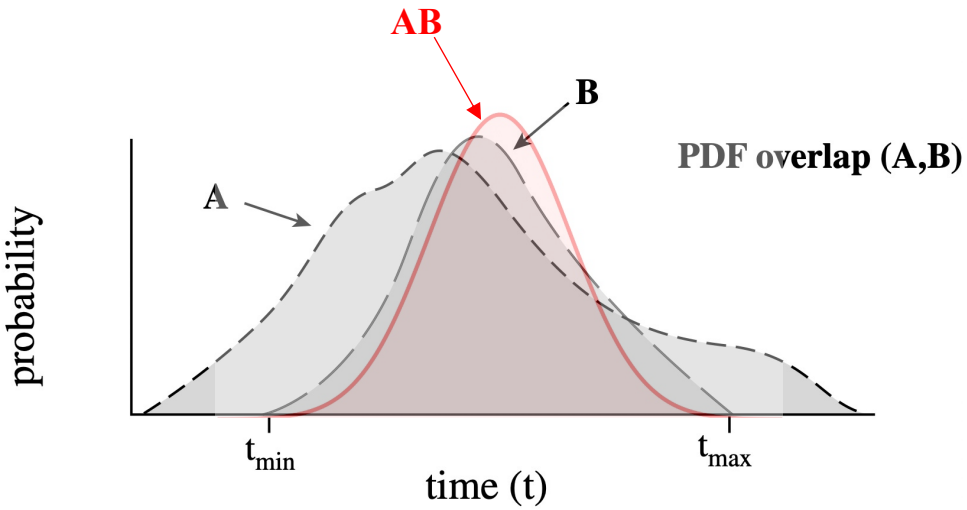

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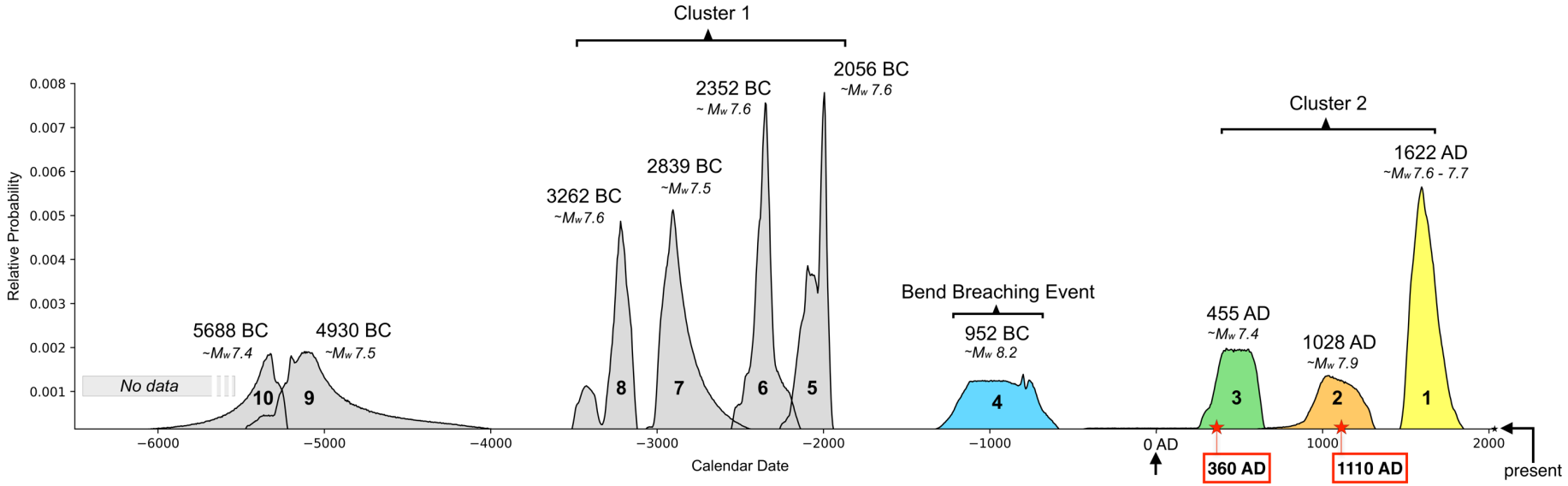
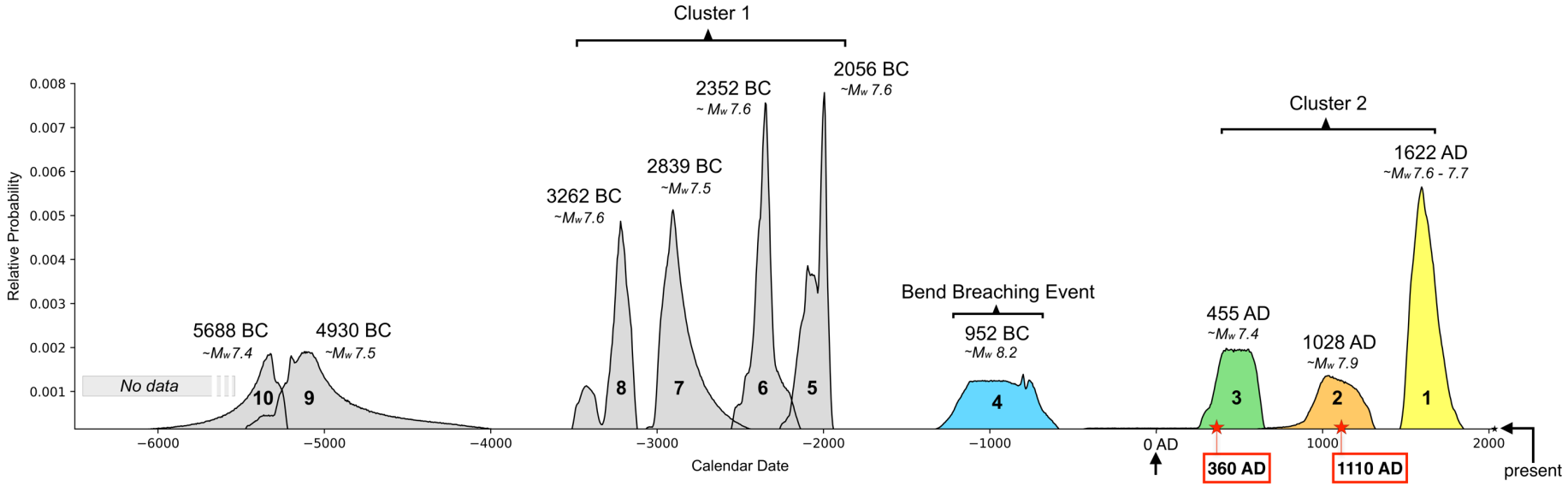


Although at a local scale, the fault shows independent quasi-periodic rupture behaviors, **at a regional scale these large events exhibit a temporal cluster organization.**

These clusters present interevent times of **475 ± 108 yr** and are proceeded by long-lull periods of **1393 ± 230.**



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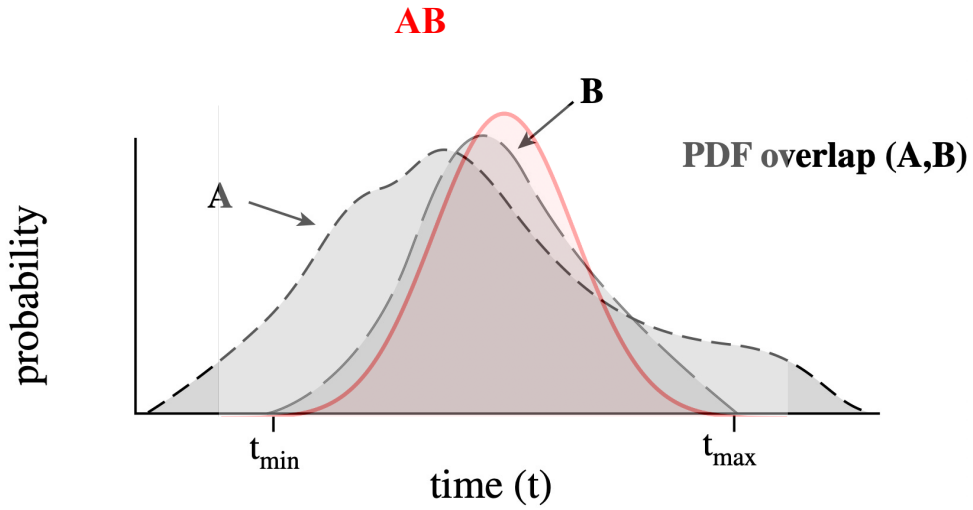
These clusters present interevent times of **475 ± 108 yr** and are proceeded by long-lull periods of **1393 ± 230.**

Eastern ATF - either at the early stage of a seismic quiescence period or at the late stage of a cluster period.

4 m slip-deficit (10 mm/yr) compatible with a minimum magnitude of ***Mw 7.3.***

Correlate earthquake PDFs

How to combine paleoseismic data?



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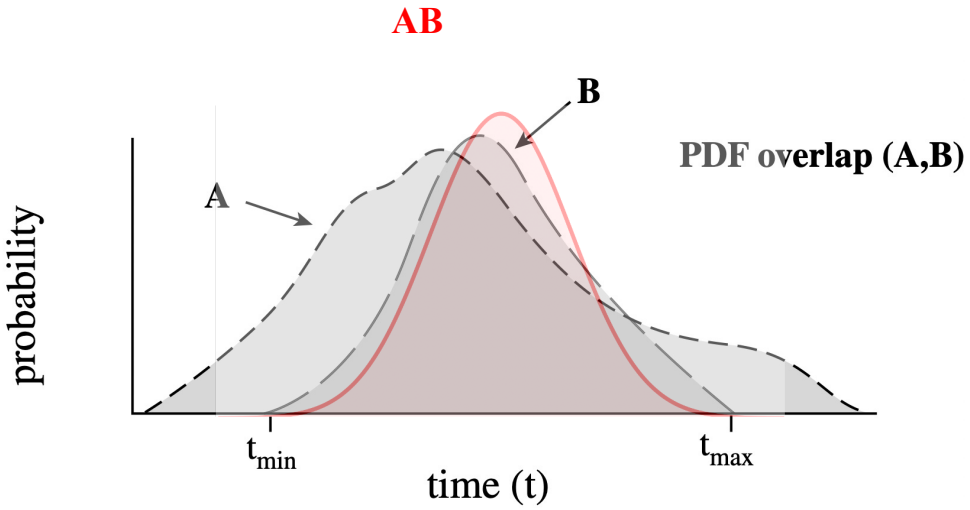
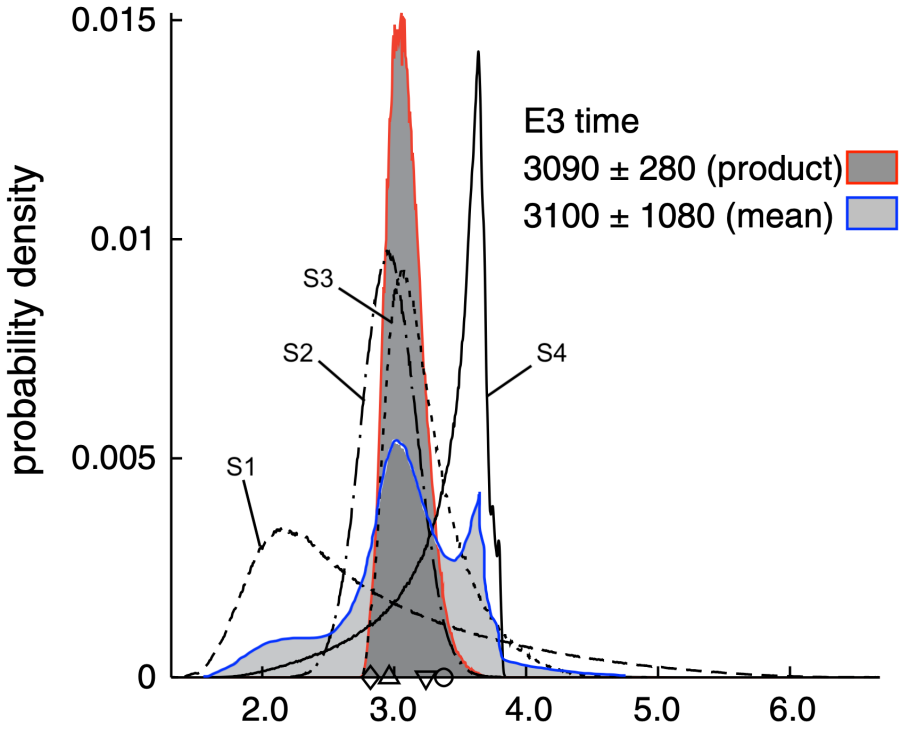
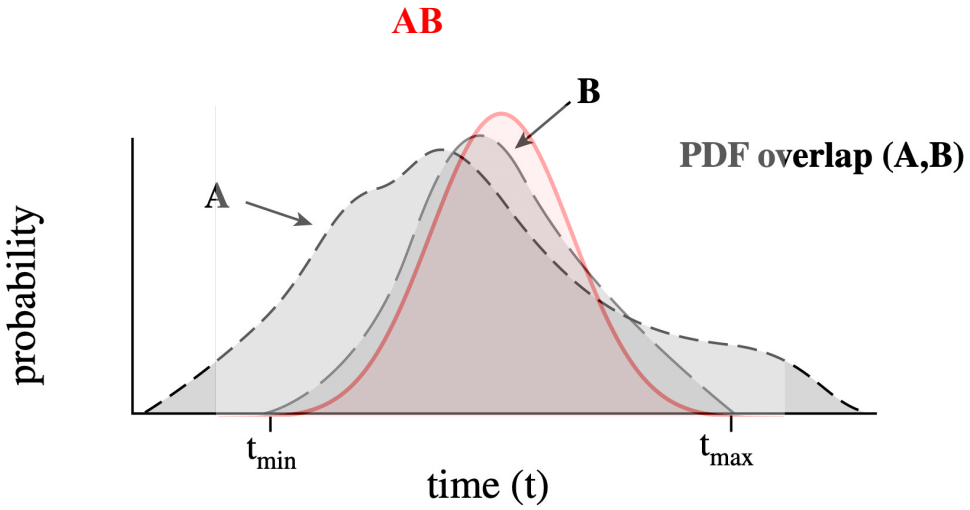


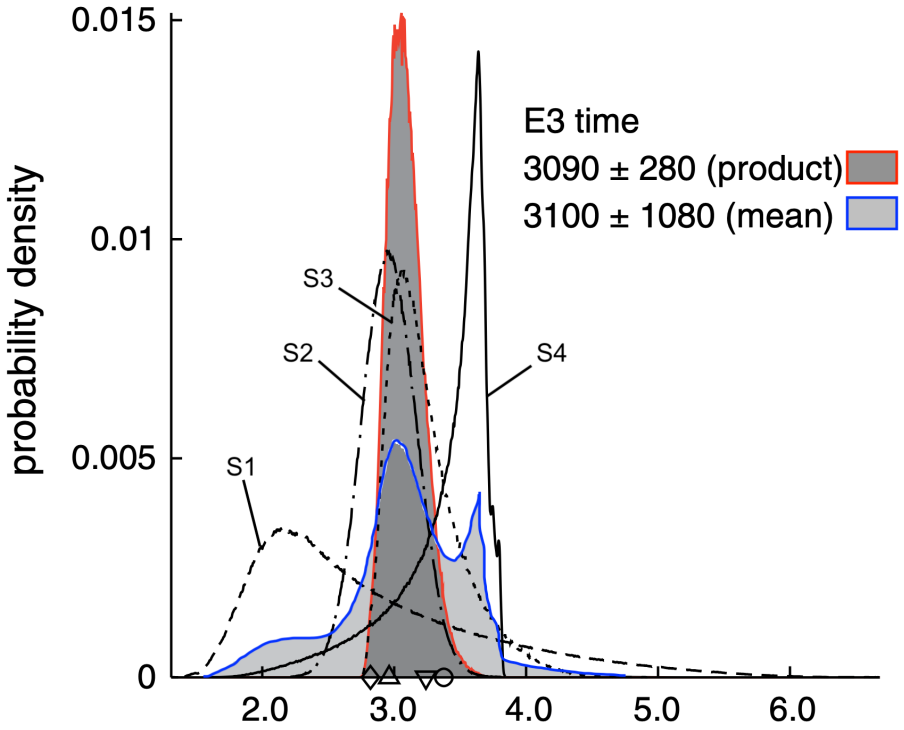


Mean-rupture Method
(Biasi et al., 2009)

Product-rupture Method
(DuRoss al., 2011)

How to combine paleoseismic data?





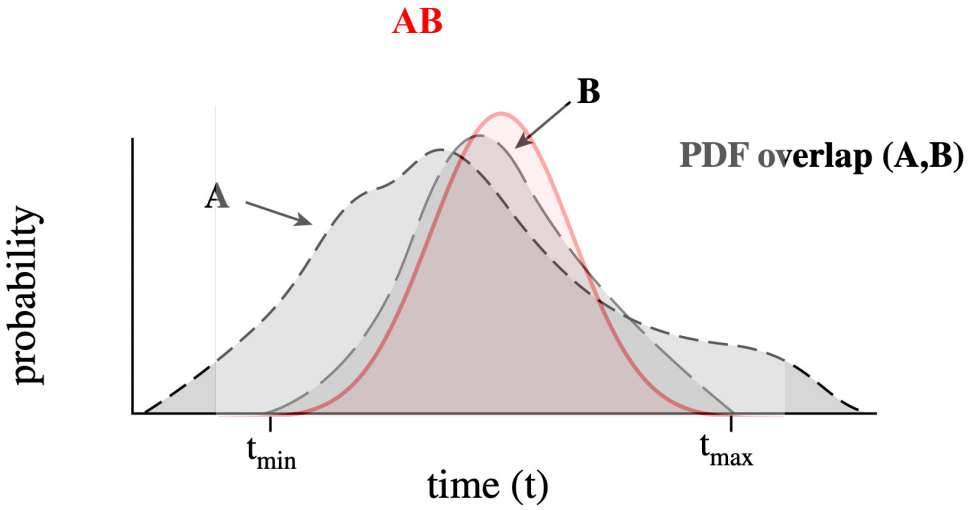
Mean-rupture Method
(Biasi et al., 2009)

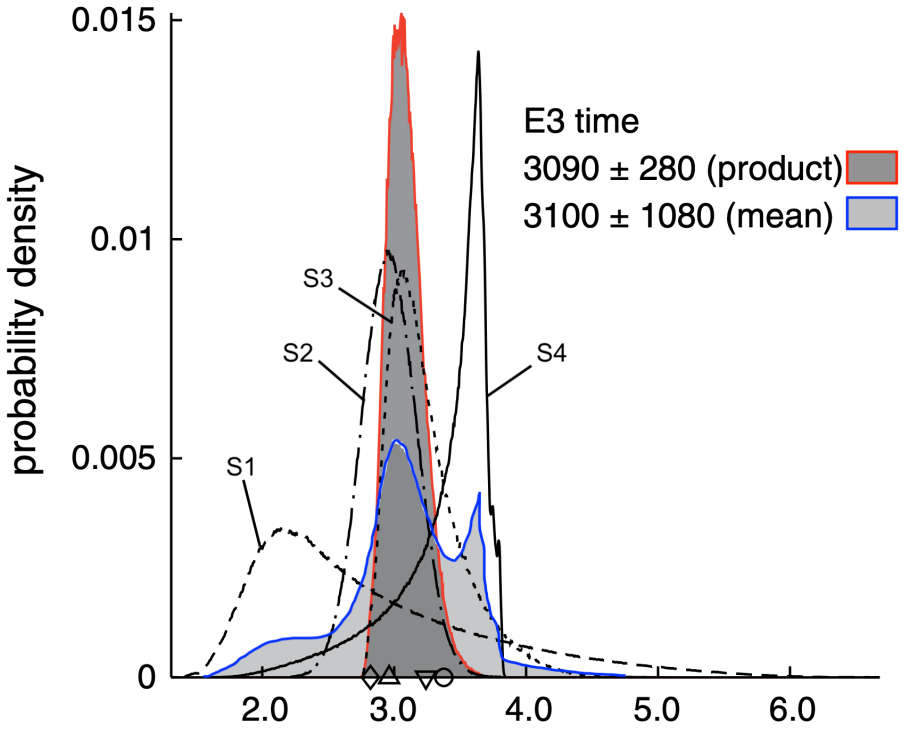
- Large uncertainties
- Theoretically correct

Product-rupture Method
(DuRoss al., 2011)

- Smaller uncertainties
- Abrupt reduction of the probabilities to cero.
- Lack of theoretical foundations from a mathematical perspective.

How to combine paleoseismic data?





Mean-rupture Method
(Biasi et al., 2009)

- Large uncertainties
- Theoretically correct

🤷

Ok...

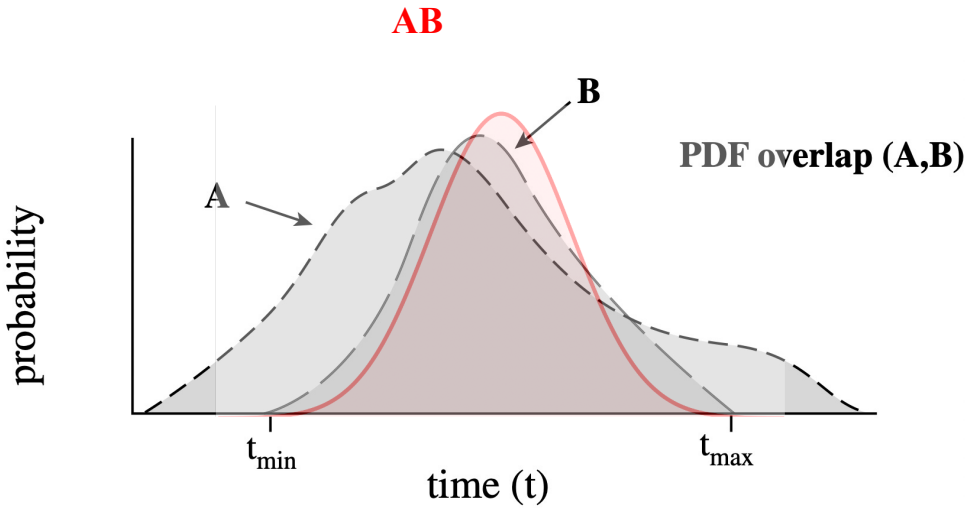
Product-rupture Method
(DuRoss al., 2011)

- Smaller uncertainties **but at what cost?**
- Abrupt reduction of the probabilities to cero.
- Lack of theoretical foundations from a mathematical perspective.

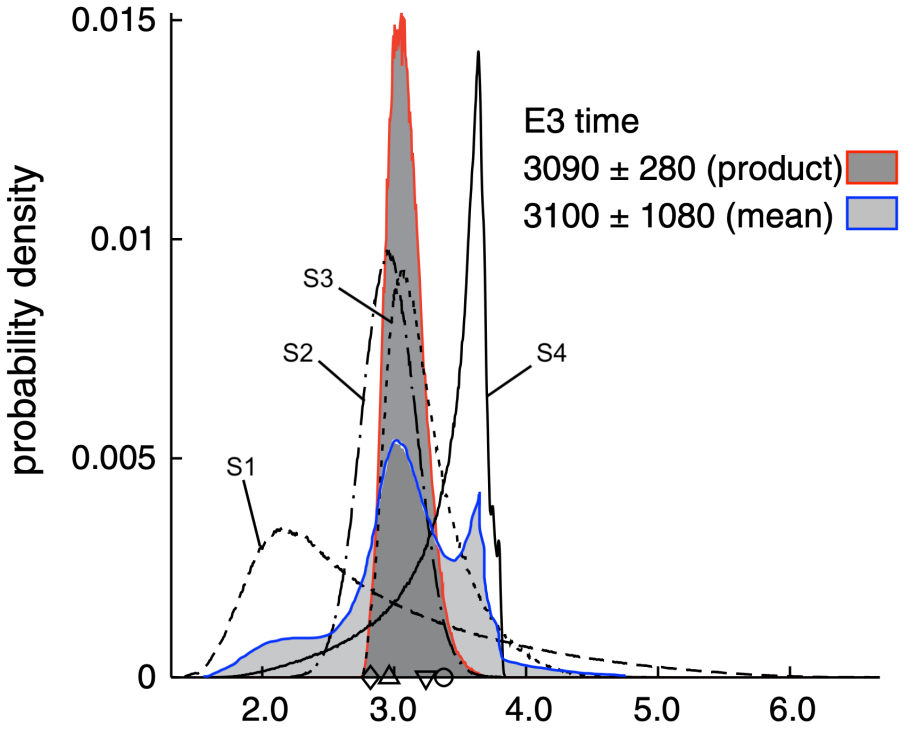
😕

Hmm...

How to combine paleoseismic data?



Looking for a method that yields better-constrained ages and is consistent with the earthquake rupture assumptions and the probability theory.



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Hmm...

Thanks for your attention