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India-Asia collision paleogeography constrained by Burma Terrane (Myanmar) Late Cretaceous to Miocene paleomagnetic data

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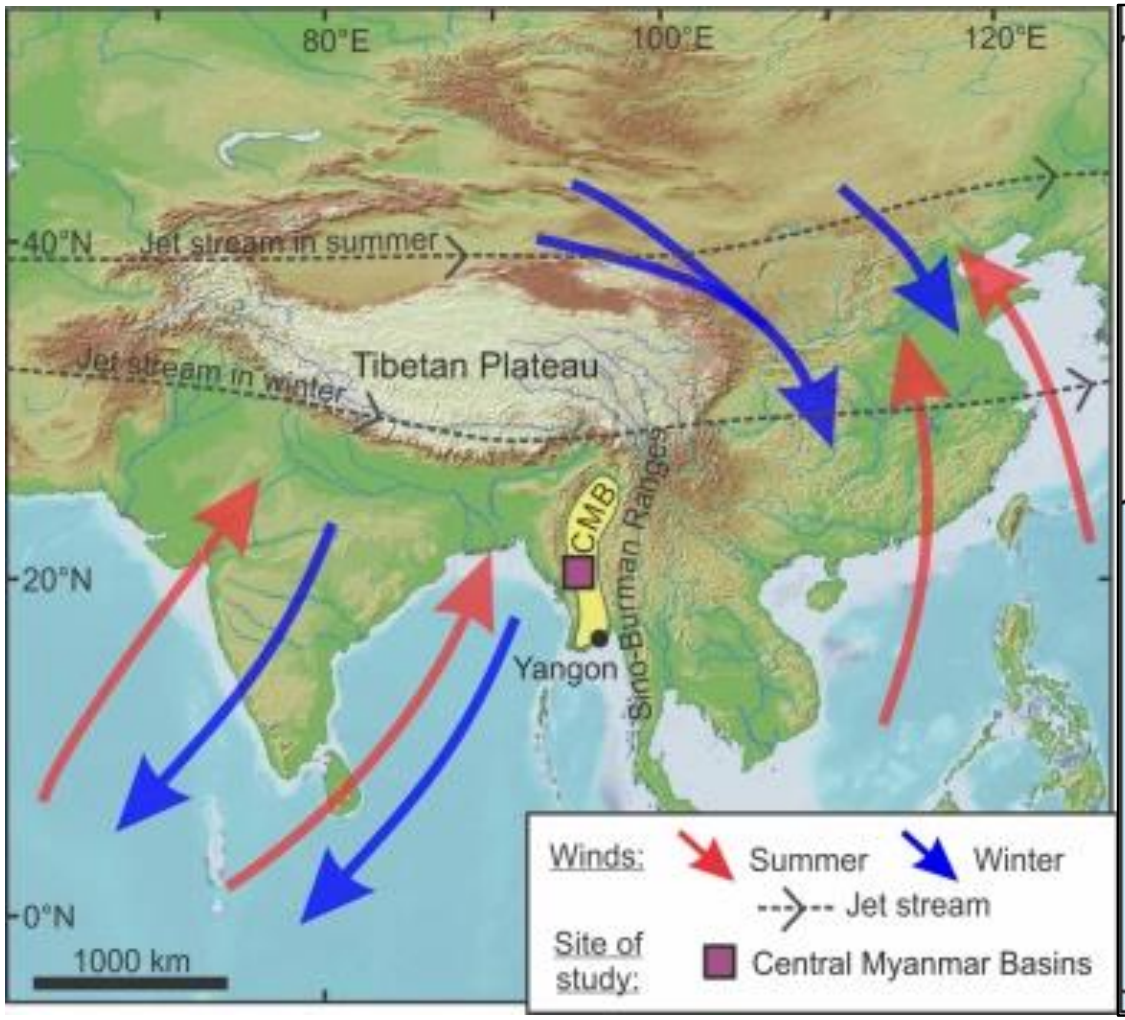
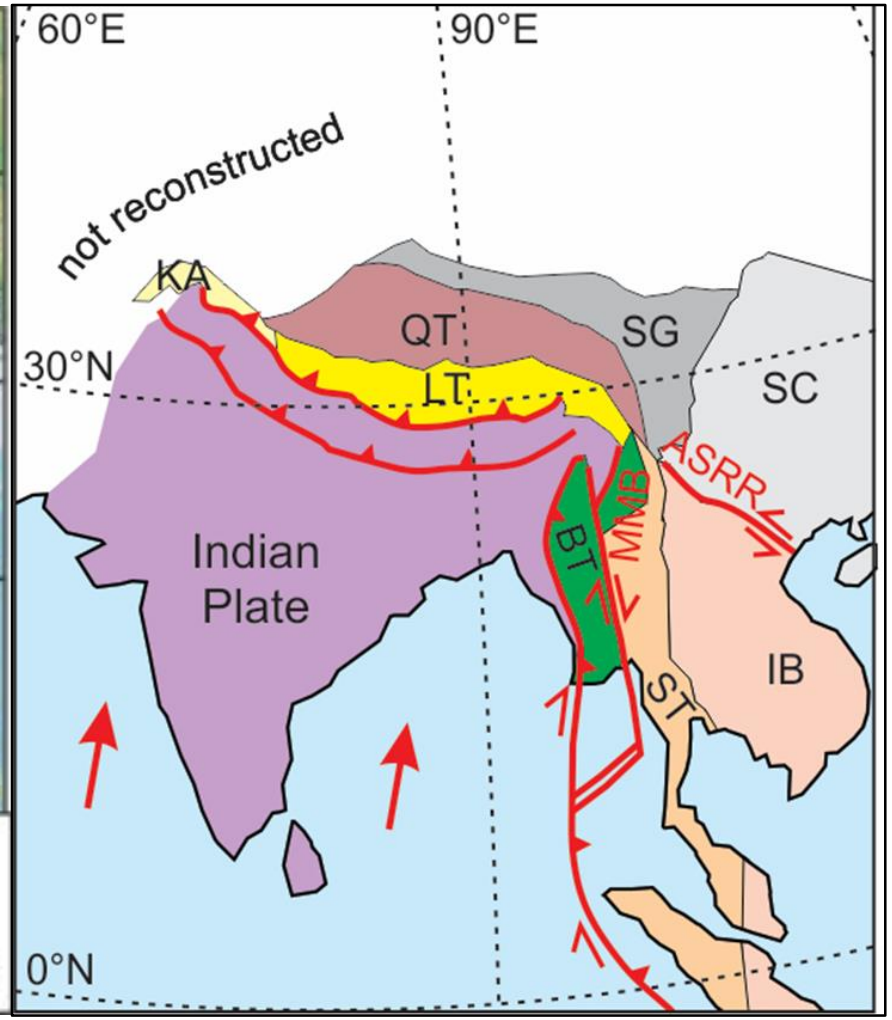
Paleomagnetism Burma Terrane (BT), Myanmar





(modified after Pubellier, 2008; van Hinsbergen et al., 2011a; Hall, 2012; Royden et al., 2008)

Paleolatitude Burmese monsoonal proxies

Asian tectonics

Paleogeography Asia

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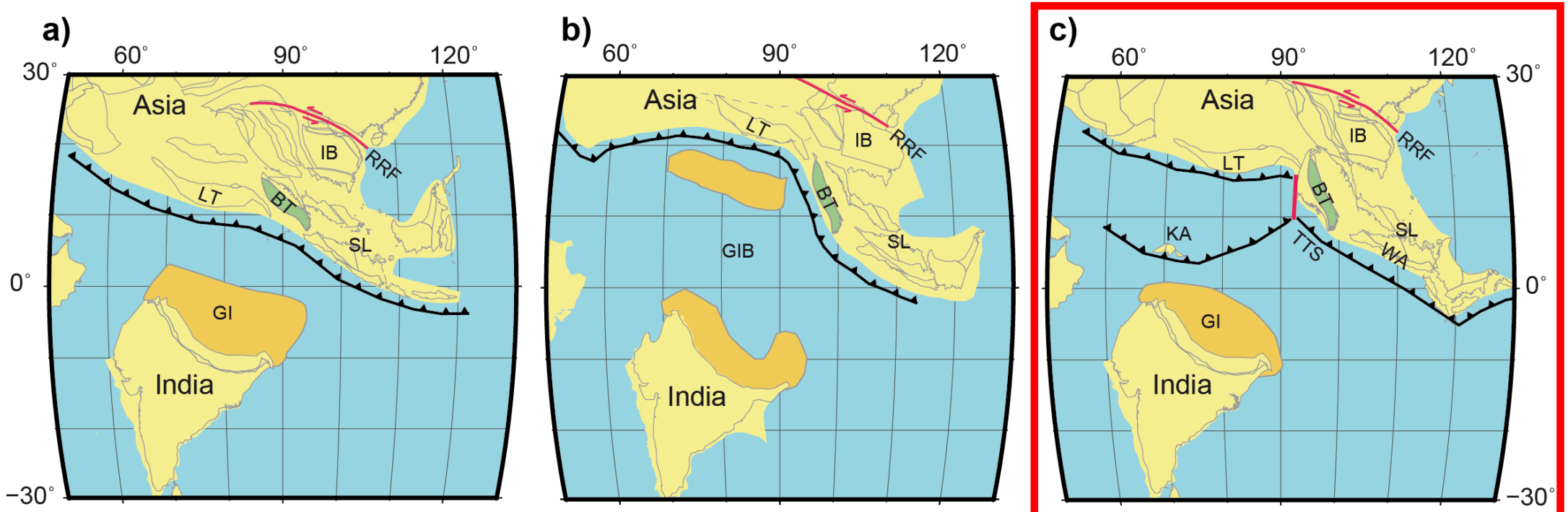
Position Burma Terrane different for 3 scenarios India-Asia collision (60 Ma)



E-W subduction zone /

Significant extrusion Indochina

- Relatively high latitude
- Large clockwise rotation BT

(Cogne et al., 2013; Replumaz et al., 2010, 2013; Royden et al., 2008)

Greater India Basin (GIB)

- Relatively high latitude
- Little rotation BT

(Van Hinsbergen et al., 2012, 2018)

Trans-Tethyan Arc

- BT as part of Trans-Tethyan / Incertus Arc
- Paleolatitude less constrained, arc was potentially farther south

(Hall, 2012; Jagoutz et al., 2015, Zahirovic et al., 2016)

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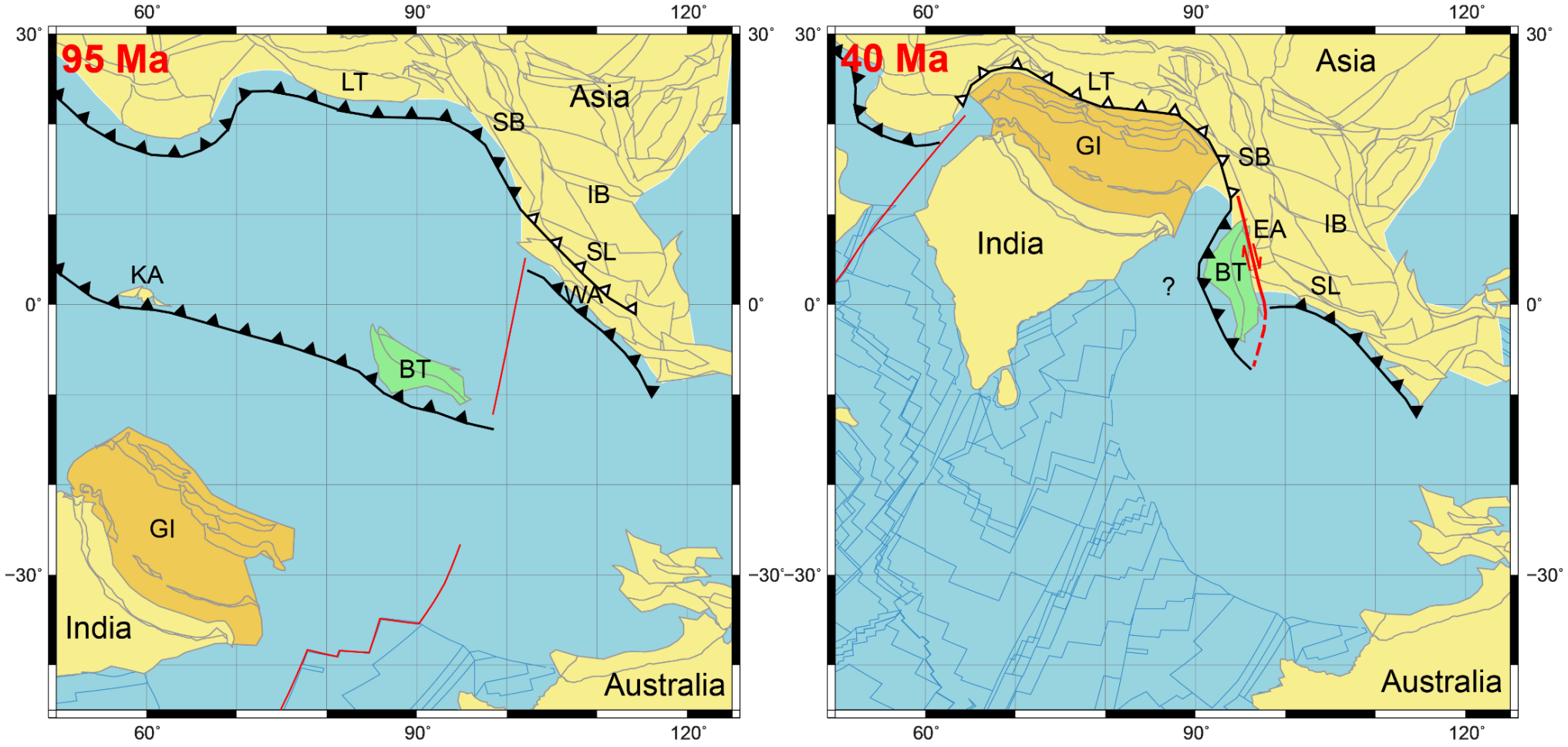
Westerweel et al. (2019) - Paleomagnetic results 95 and 40 Ma:
Near-equatorial latitudes for Burma Terrane



Trans-Tethyan island arc

Andean-type volcanism

~60°C clockwise rotation

2000 km northward strike-slip motion

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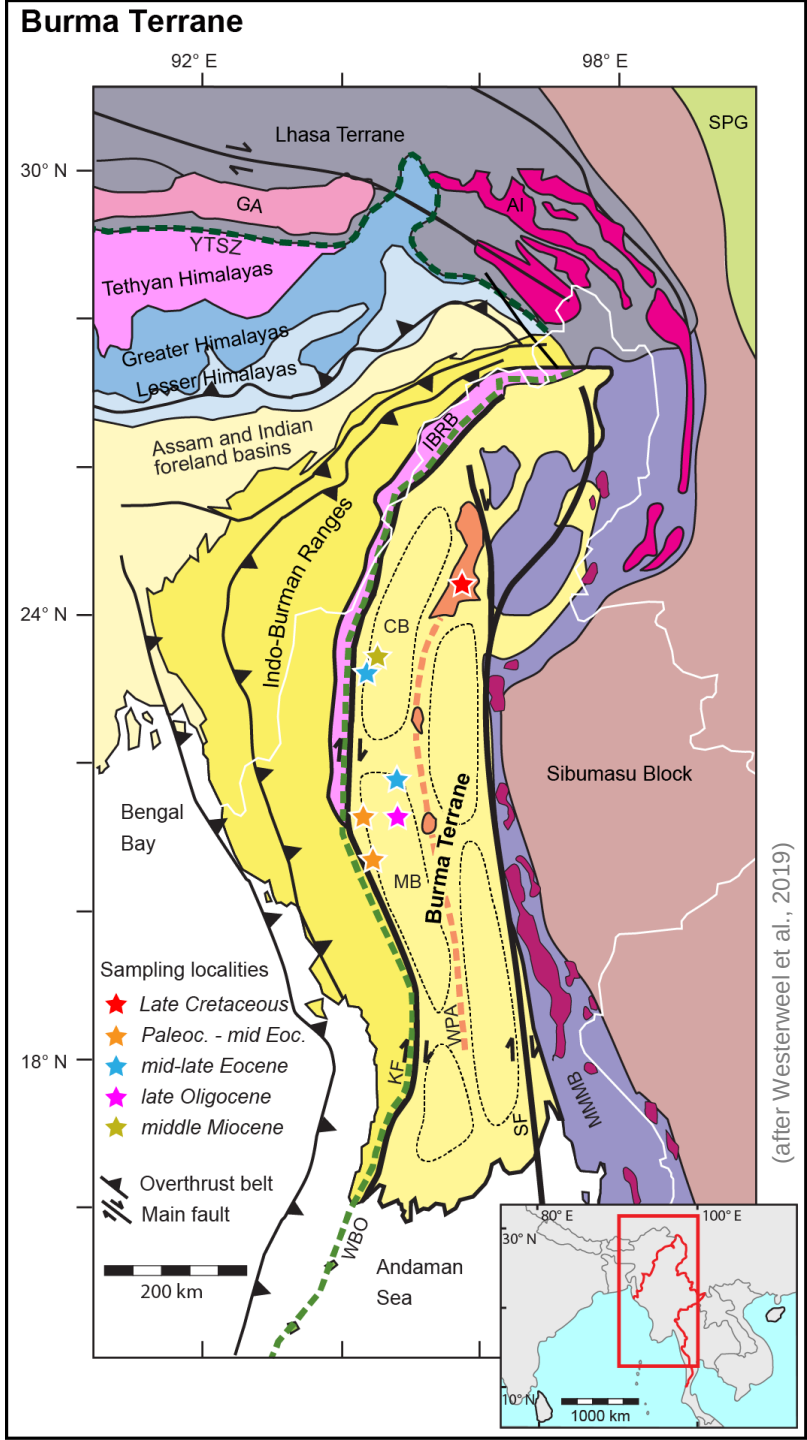
Questions

- Pre-Cretaceous origin of the Burma Terrane
- When was the Burma Terrane incorporated onto the Indian Plate?
- What was the mechanism of clockwise rotation?
- When and where did Burma / eastern India collide with Sibumasu?

➔Paleomagnetic sampling **late Paleocene – middle Eocene**, **late Eocene**, **middle Oligocene**, **middle Miocene** sediments in Myanmar (Burmese forearc basins)

➔GPlates model of the India-Asia collision including deforming plates



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Sampling Burmese forearc basins

Late Paleocene – middle Eocene (Minbu Basin)

- Sidoktaya: *1 site in fresh grey mudstones, 2 sites in tuffs (71 samples)*
- Saw: *7 sites in fresh grey mudstones and siltstones (63 samples)*
- Ngape & Datkon: *7 sites in tuffs and volcaniclastic sandstones (75 samples)*

➔Only fresh mudstones provided reliable stable magnetizations, tuffs Ngape & Datkon highly scattered

Late Eocene (Minbu Basin)

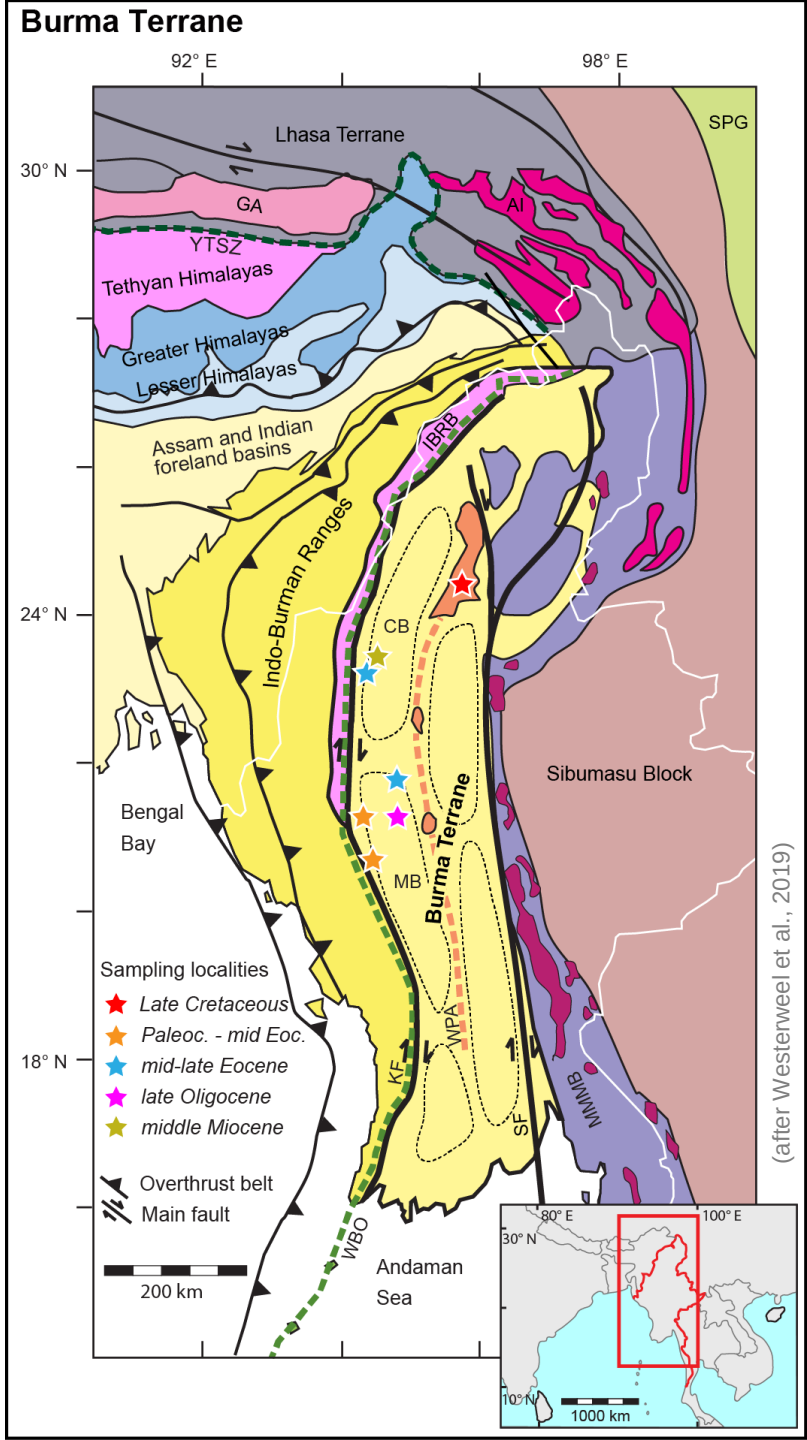
- Pondaung Ranges: *9 sites, 89 samples in paleosols*

Middle Oligocene (Minbu Basin)

- Tantkyitaung Pagoda (Bagan): *3 sites, 31 samples in fresh siltstones*

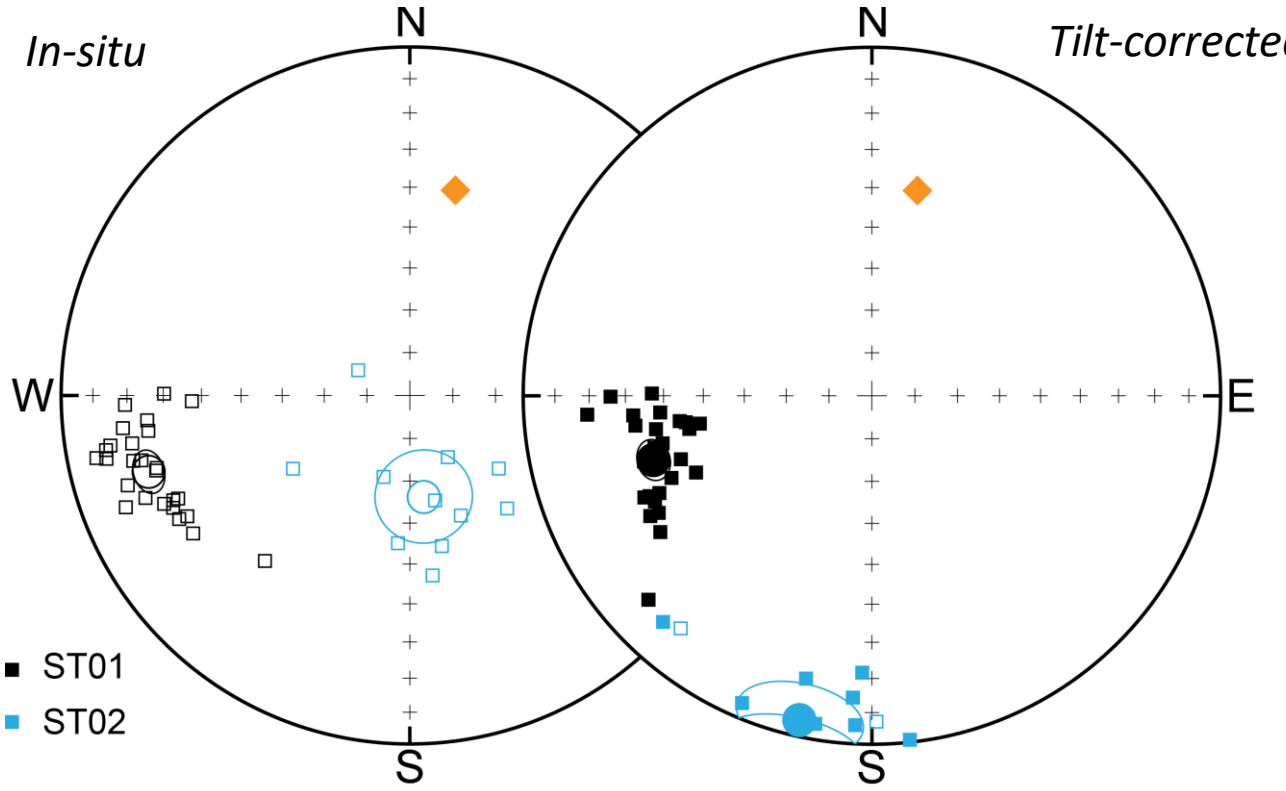
Middle Miocene (Chindwin Basin)

- Kalewa: *27 sites, 219 samples in paleosols*



Results: late Paleocene – middle Eocene
Sidoktaya

- Paunggyi and Laungshe Fms.
- Minbu Basin
- 37 samples in fresh blue-grey mudstones & tuffs



- ChRM different from present-day field and with reverse polarity *(Magnetic field mostly reversed at this time)*
- **Site ST01:** Very stable ChRM. Positive inclination/reverse polarity after tilt correction implies a southern hemisphere paleolatitude
- **Site ST02** less good, more scatter ➔ local deformation

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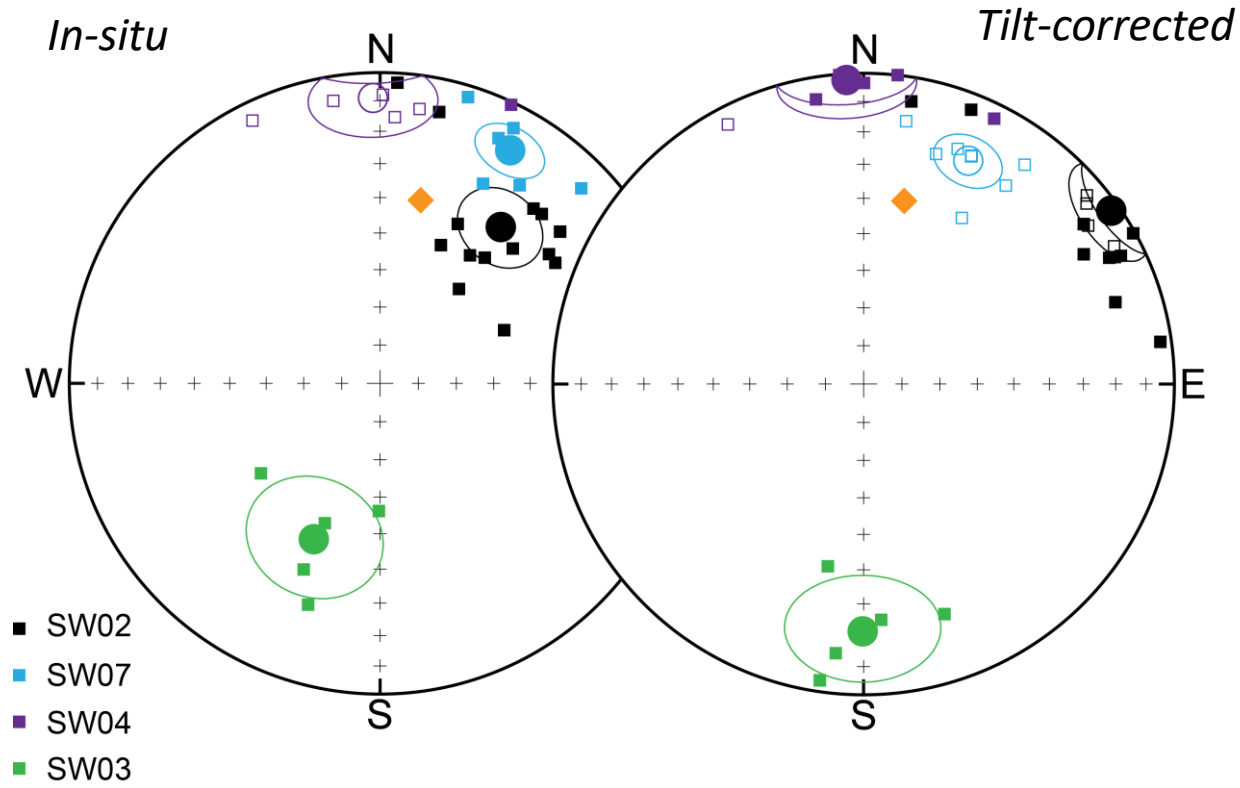
Results: late Paleocene – middle Eocene

Saw

- Laungshe and Tilin Fms.
- Minbu Basin
- 34 samples from fresh blue-grey mudstones



- Declinations sites **SW02** and **SW07** same eastward trend as Sidoktaya *(see previous slide)*
- Declinations sites **SW03** and **SW04** affected by local faulting
- Inclinations in all sites give southern to near-zero latitudes

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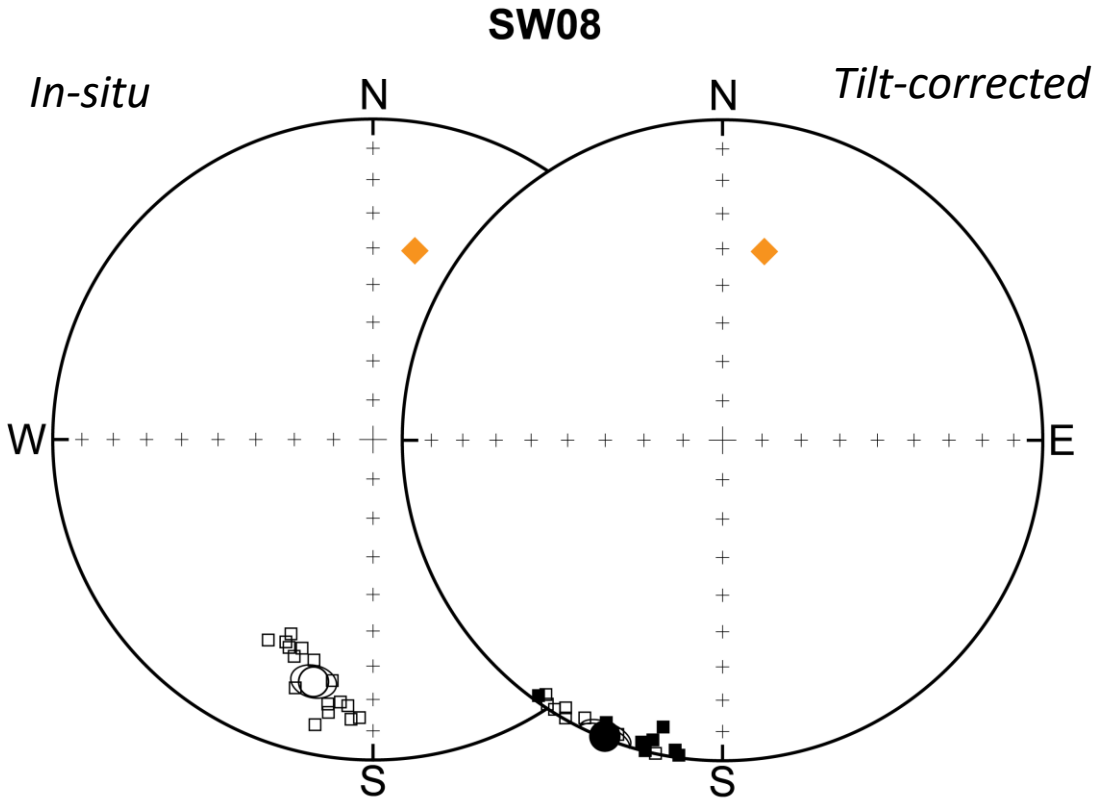
Results: late Paleocene – middle Eocene

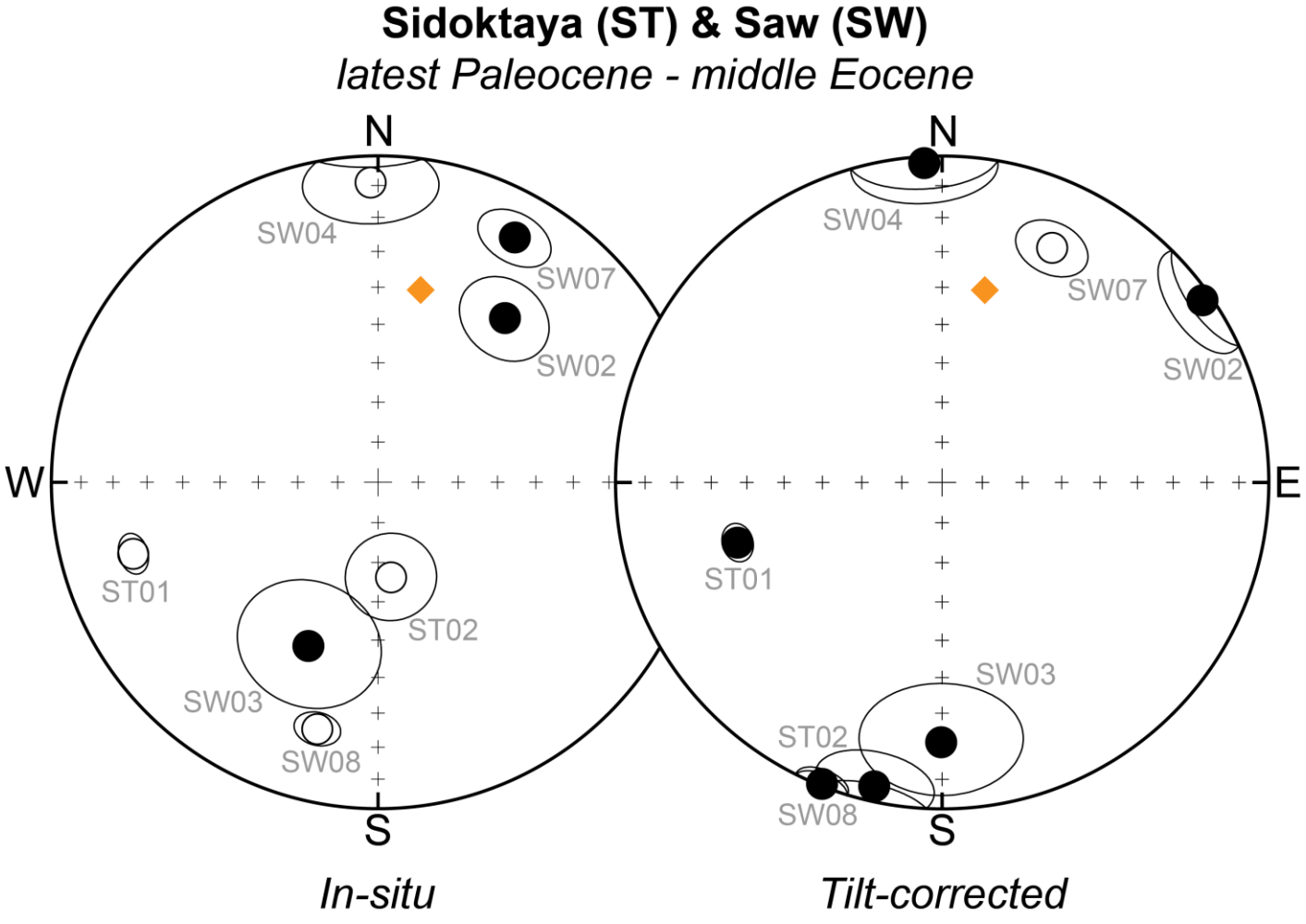
Saw



- Tabyin Formation
- Minbu Basin
- 16 samples in fresh blue-grey mudstones

- **Youngest site SW08**
- Excellent grouping results, reverse polarity
- Both declination and inclination intermediate between older results and late Eocene results *(see Slide 12)*

Results: late Paleocene – middle Eocene

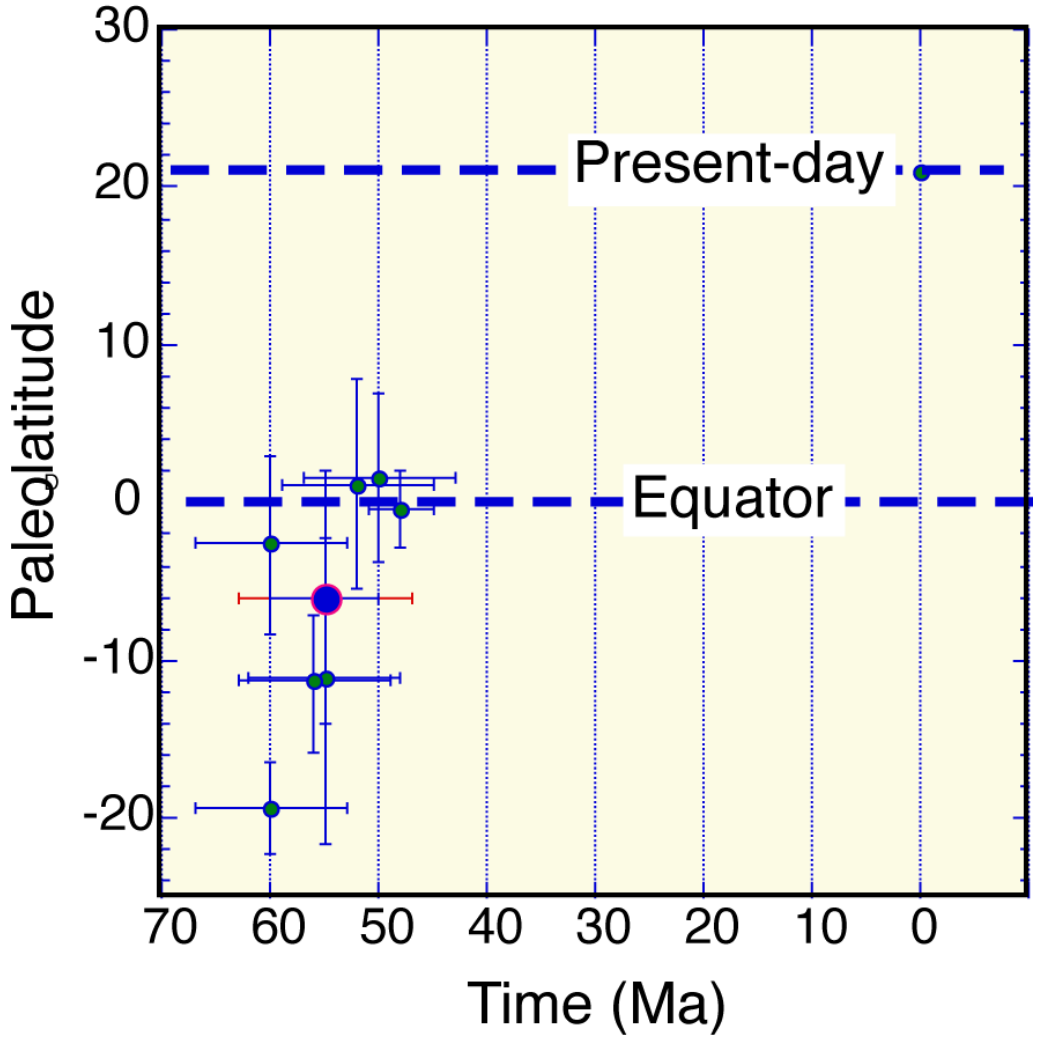


Declinations:

- Sites of both normal and reverse polarity
- Scatter in declination due to local rotations, but trend towards the north-east

➔ **A possible global clockwise rotation of the Burma Terrane, but local vertical-axis rotations due to local tectonic complexities *cannot be rejected***

Results: late Paleocene – middle Eocene



Inclinations:

- Less scatter in inclination, consistently negative to near-zero

➔ **Southern hemisphere – near-equatorial latitudes Burma Terrane *(~10°S)***
➔ **Similar as position India at that time**

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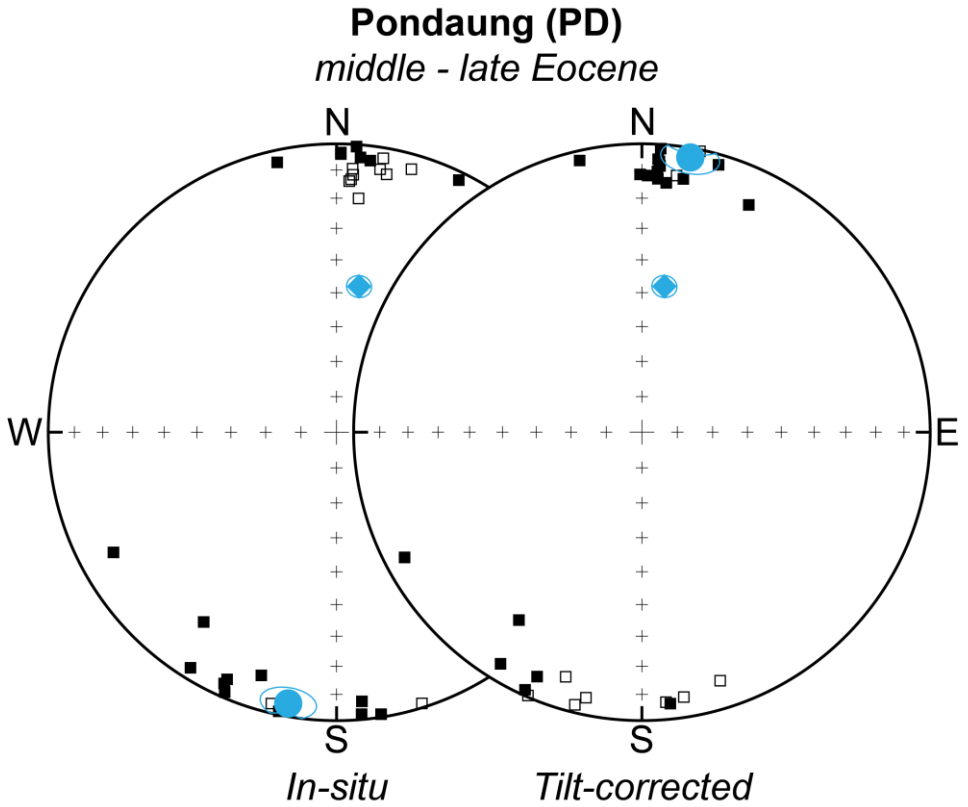
Results: late Eocene

- Pondaung Formation
- Pondaung Ranges
- Strong overprint in present-day field, but 29 reliable samples from paleosols



- Near-equatorial latitude *(2.5±1.3°N)*
- Negligible clockwise rotation *(3.0±4.4°)*
- Effect inclination shallowing minimal: *2.5°N* ➔ *4.2°N*
- Indistinguishable with published late Eocene result

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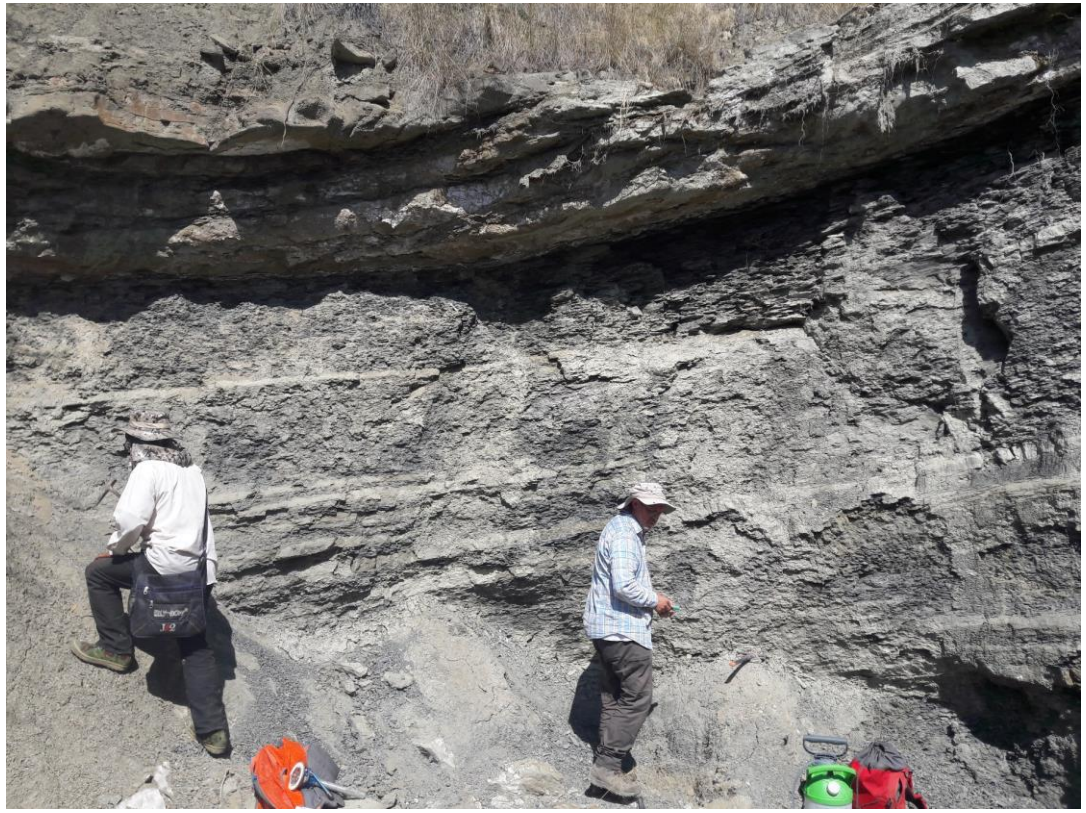
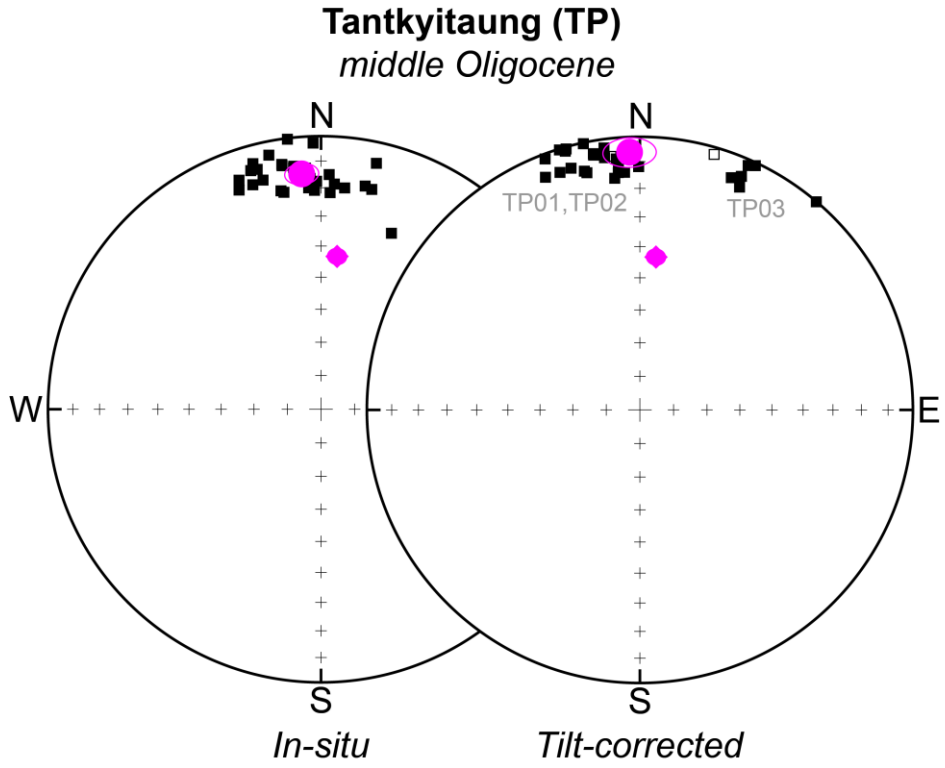
Results: middle Oligocene





- Padaung Formation
- Minbu Basin
- 29 samples from fresh siltstones

- Near-equatorial latitudes *(2.9±2.9°N)*
- Effect inclination shallowing minimal: *2.9°N* ➔ *4.7°N*
- Minor rotations

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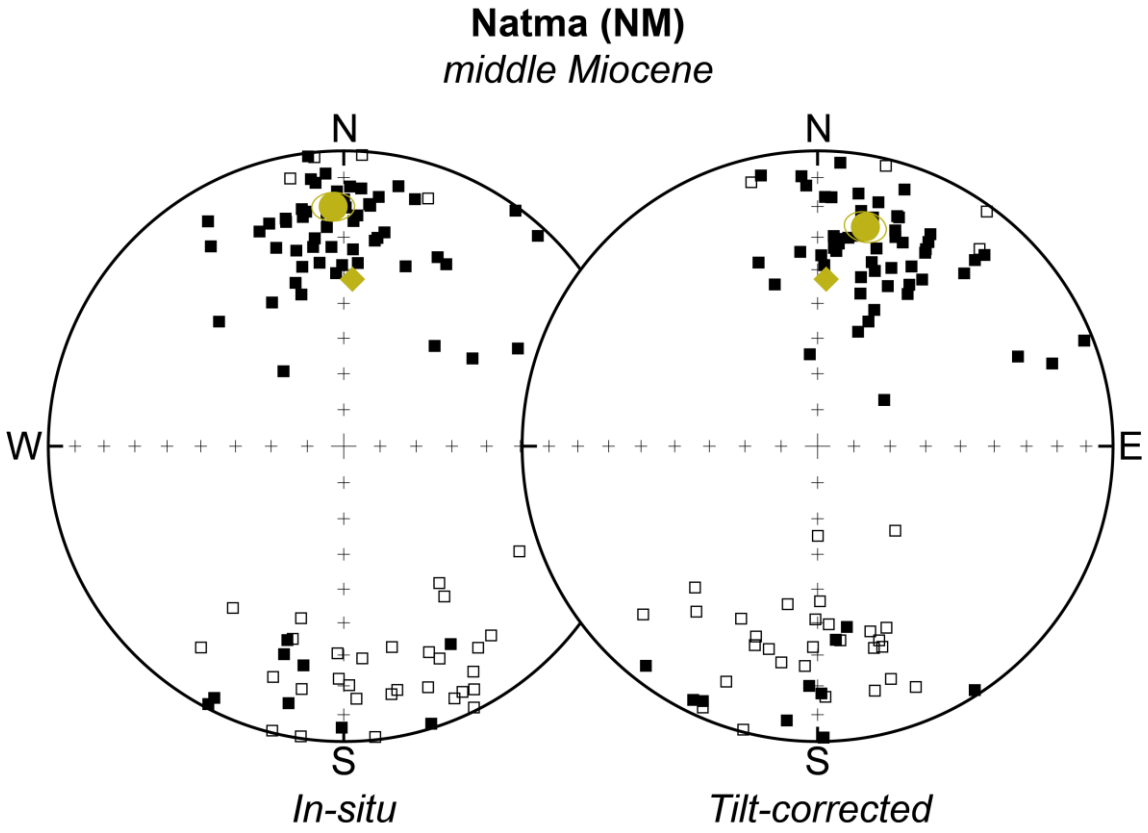
Results: middle Miocene

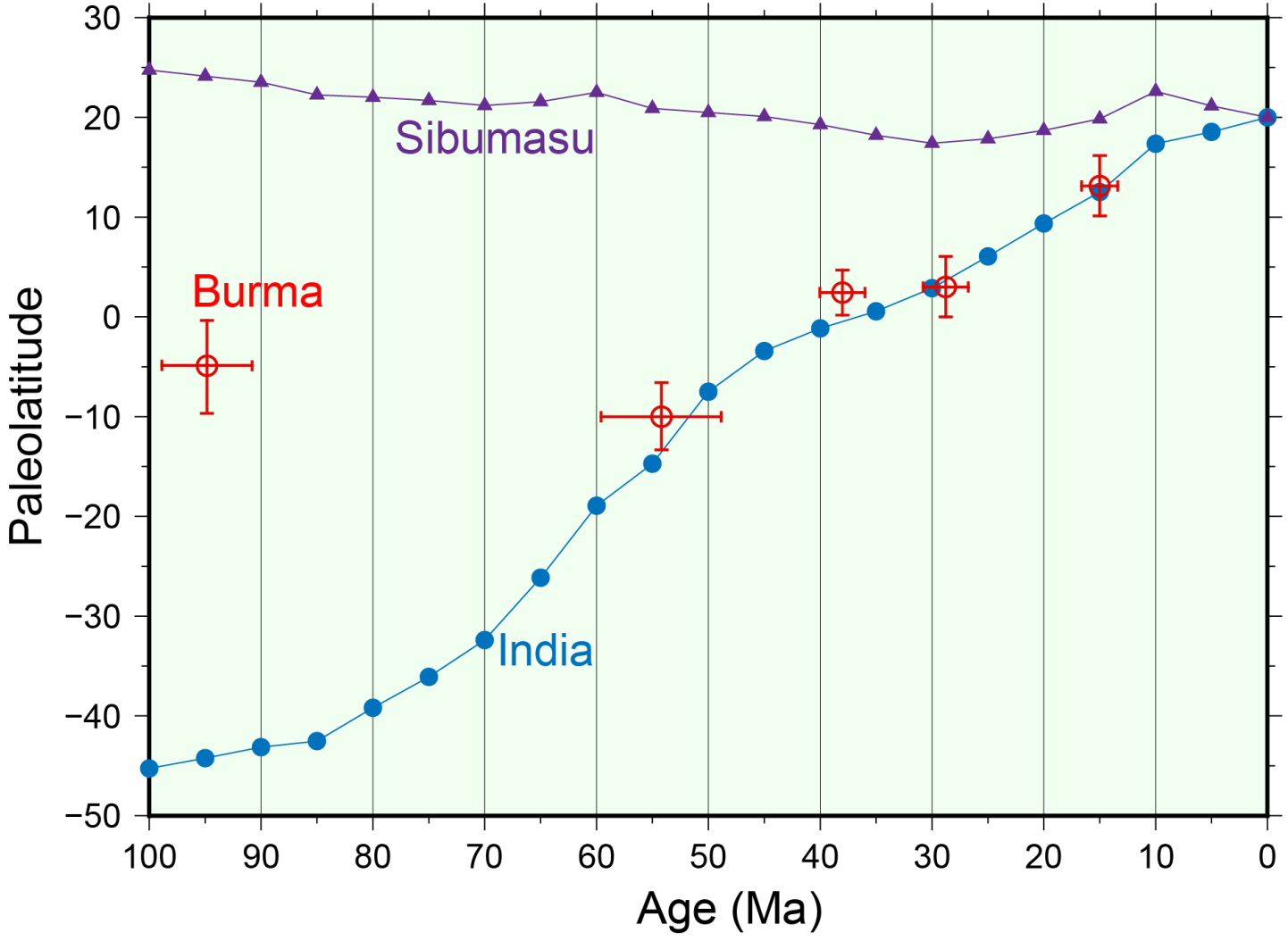
- Natma Formation
- 98 samples from paleosols
- Chindwin Basin



- Negligible clockwise rotation *(9.3±4.8°)*
- Paleolatitude similar as offset estimates from dextral strike-slip Sagaing Fault *(13.1±2.9°N)*

➔ *Therefore effect inclination shallowing minimal*

Results: Latitudinal motion Burma Terrane



- Near-equatorial - southern latitudes for the Burma Terrane
- Coeval motion with India since late Paleocene – early Eocene
- Cenozoic collision with Asian margin (Sibumasu)

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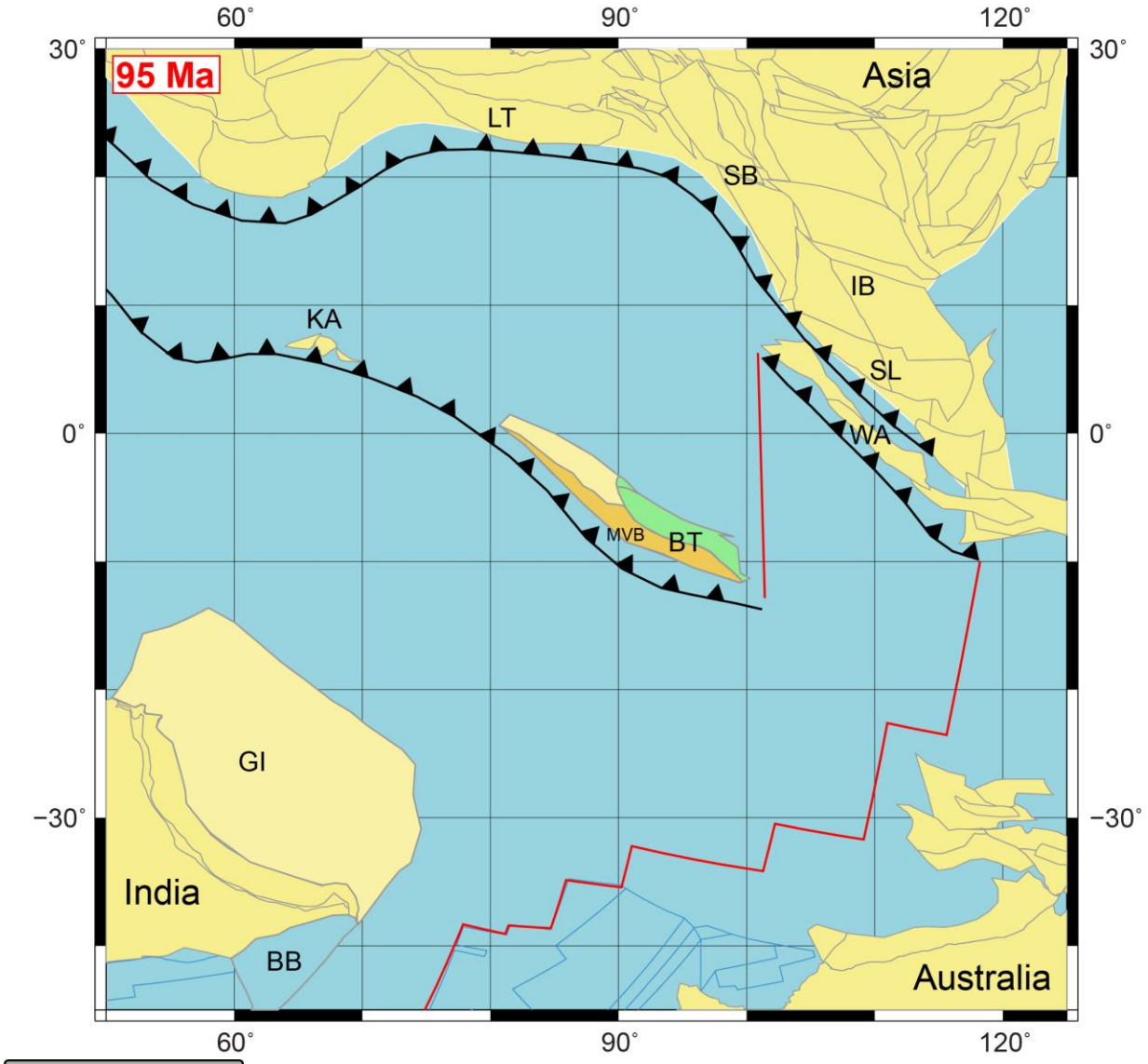
Work in progress: 95 Ma GPlates reconstruction



➔ Intra-oceanic origin as part of Trans-Tethyan subduction system

Questions:

- Correlation with Kohistan Arc?
  (Jagoutz et al., 2015; Liu et al., 2016; Mitchell et al., 2012; Petterson, 2019)
- Known Burmese crustal fragments of Gondwanan, Sibumasu and Cathaysian origin incorporated into this subduction system?
  (Metcalfe, 2013; Sevastjanova et al., 2016; Yao et al., 2017)

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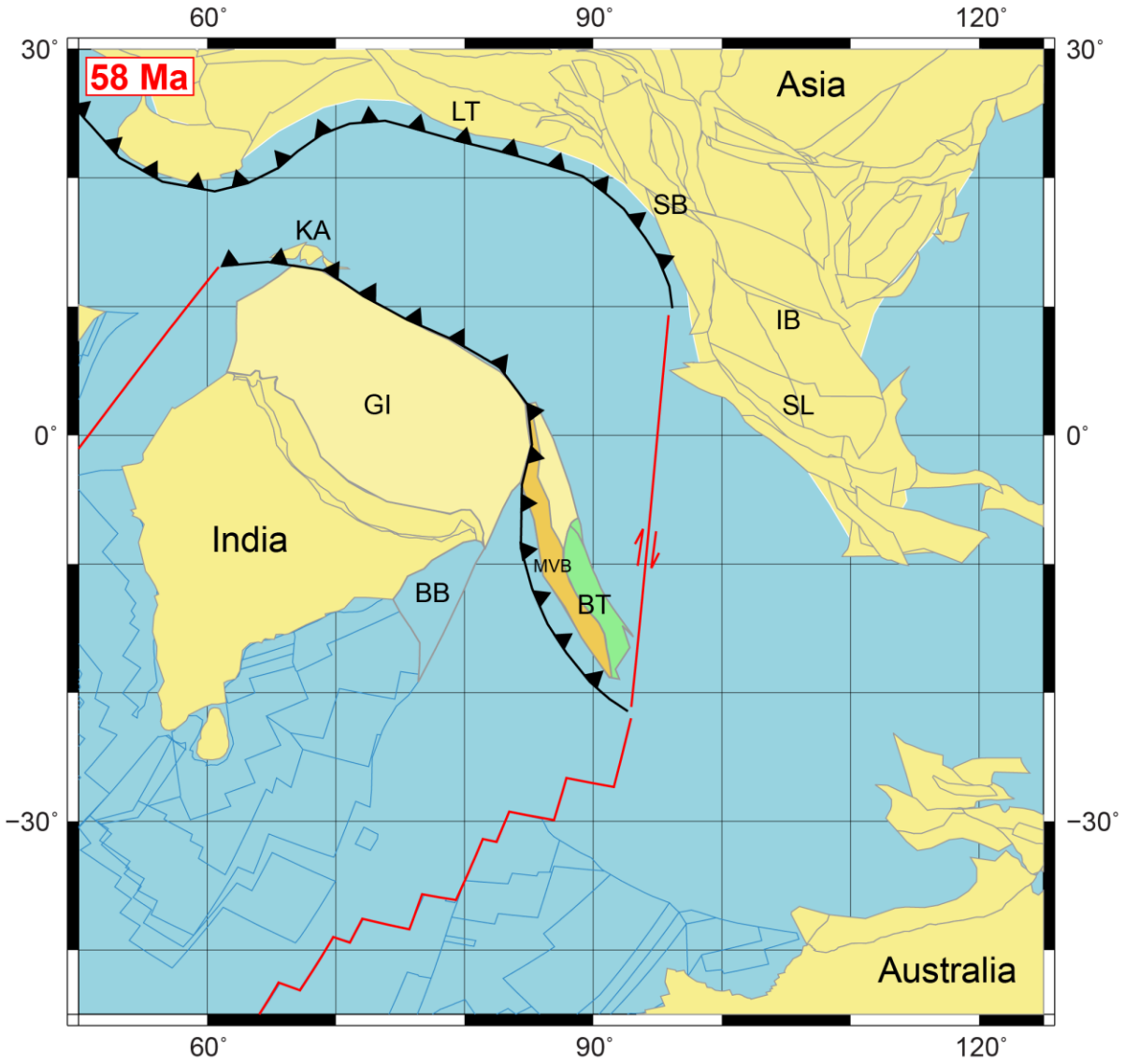
Work in progress: 58 Ma GPlates reconstruction



➔Onset coeval motion Burma Terrane and India

Questions:

- Direct collision Burma Terrane and India?

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Work in progress: 40 Ma GPlates reconstruction

➔ Significant ~2000 km northward motion with little rotation from late Eocene to present-day

➔ Little relative motion between India and the Burma Terrane

Questions:

- How long was the Burma Terrane isolated from Sibumasu?
  ➔ *More western position would allow observed E-W extension in Eastern Andaman Sea (EA)*
- India-Australia Transform?
  (Morley et al., 2020)

Next slide: Record of Burma Terrane – Sibumasu collision in sedimentary facies Burmese forearc?

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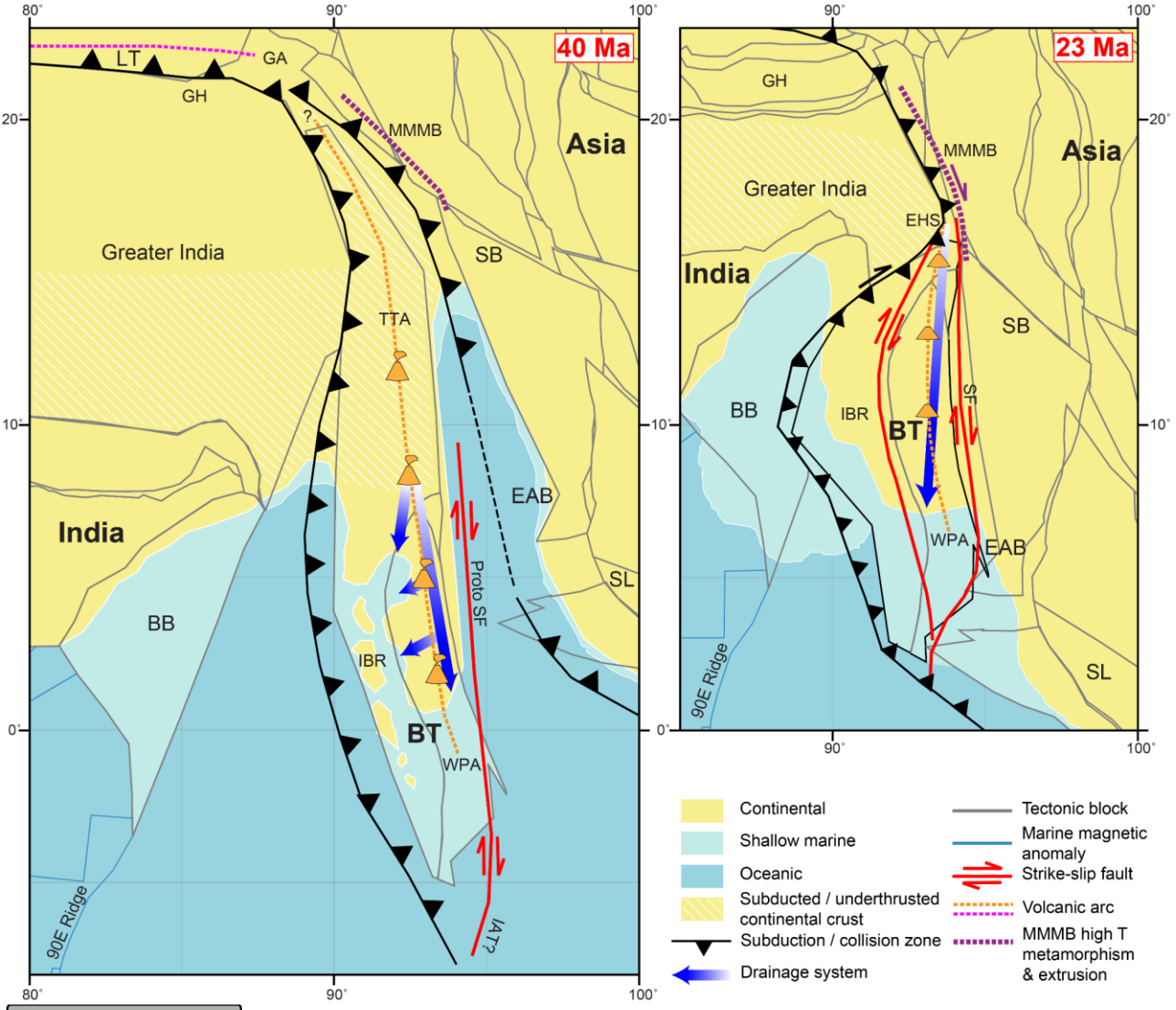
Record of Burma – Sibumasu collision



Sedimentary facies Chindwin Basin (northern Burmese forearc):

1. Late Eocene overfilling and incipient uplift phase
2. Major uplift and exhumation during late Oligocene – early Miocene

➔Record of **1)** joint India/Trans-Tethyan Arc - Asia collision and **2)** Burma – Sibumasu collision + Set-up modern Himalayan drainage system

(Westerweel et al., subm.)

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Conclusions

Key implications of our paleomagnetic results on the Burma Terrane:

- **Late Cretaceous:** southern hemisphere position distant from the Asian margin
- **Late Paleocene – middle Eocene:** incorporation onto Indian Plate and major clockwise rotation
- **Middle Eocene – present:** Northward motion coeval with India from near-equatorial position
- **Late Oligocene – early Miocene:** Collision with Sibumasu

➔Fits best with Trans-Tethyan Arc setting

➔Necessary to re-evaluate many aspects of the geology of Myanmar

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