

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

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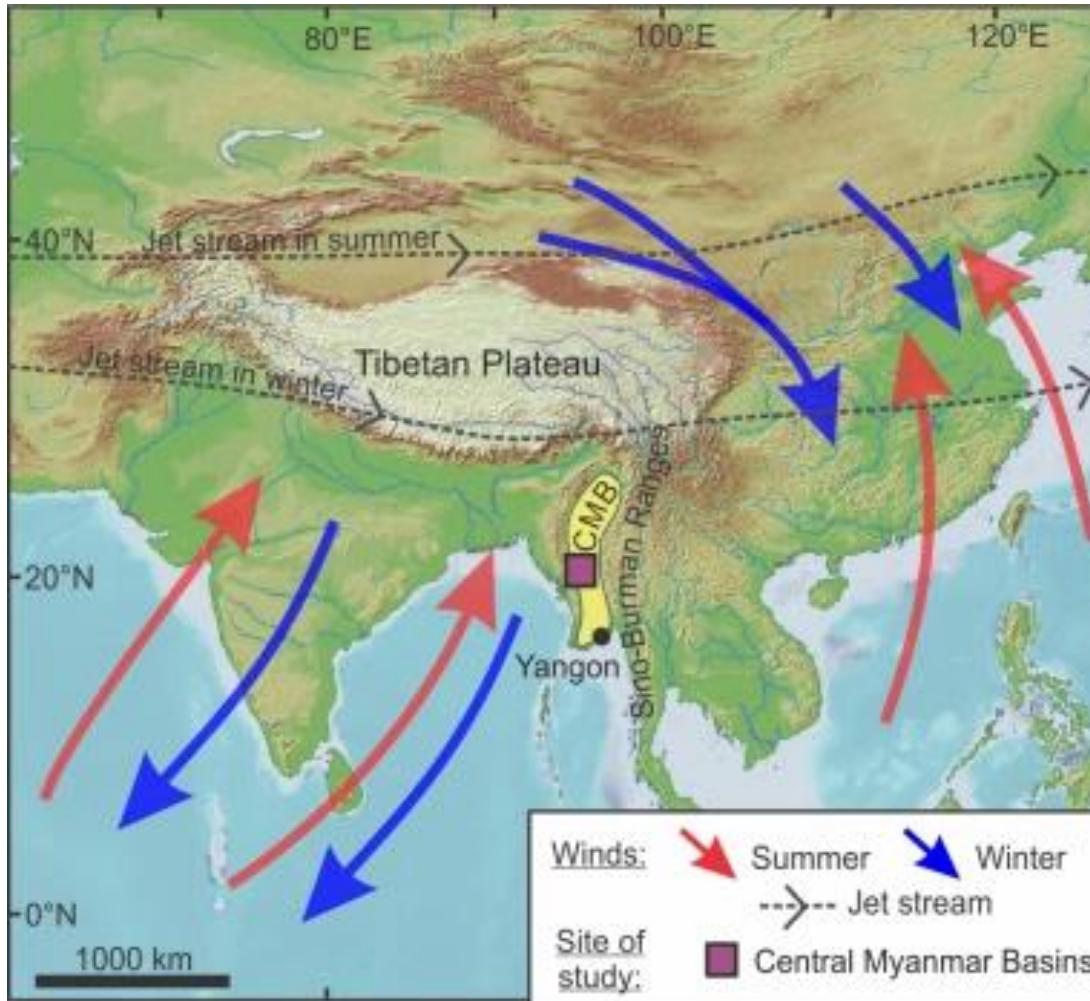
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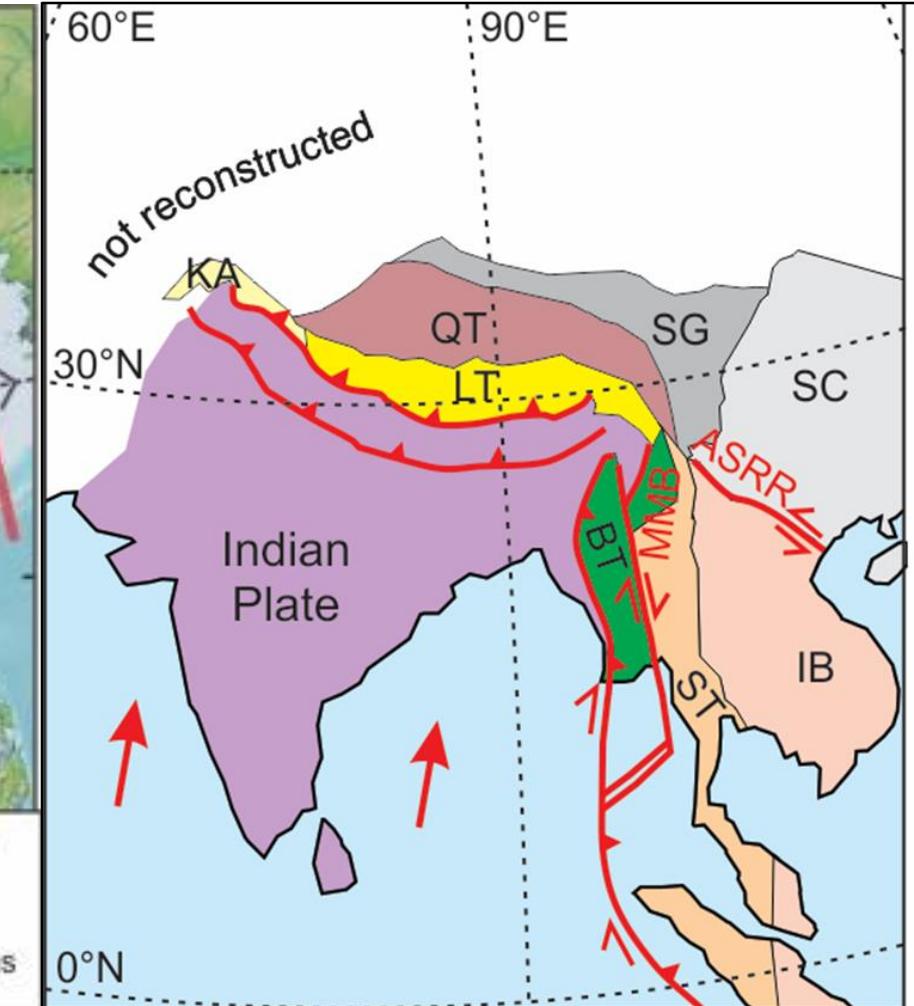
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Paleomagnetism Burma Terrane (BT), Myanmar



Paleolatitude Burmese monsoonal proxies

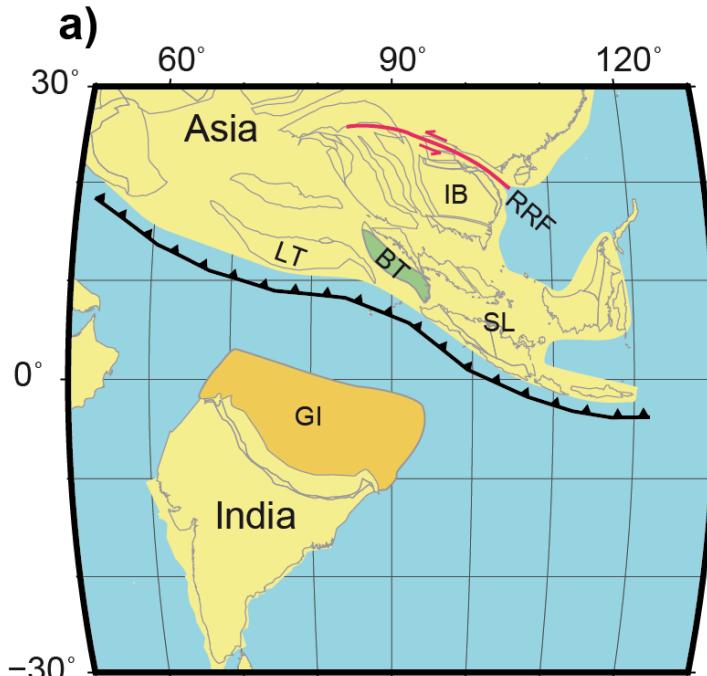
Paleogeography Asia



Asian tectonics

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

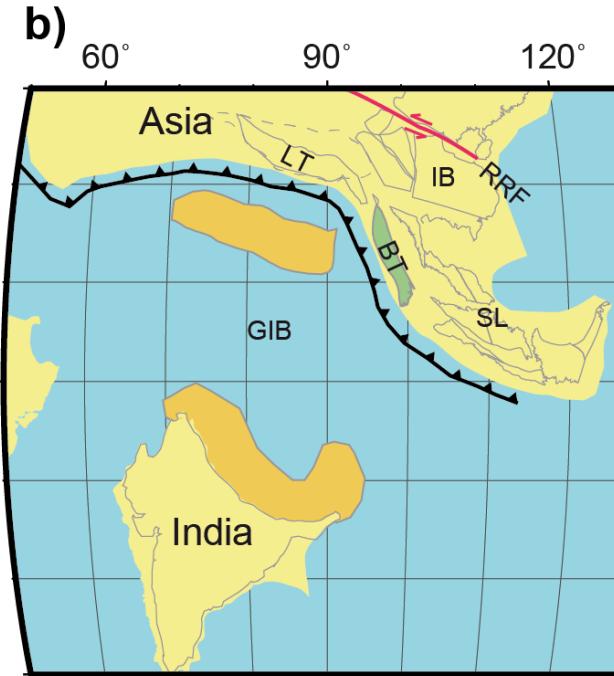
Position Burma Terrane different for 3 scenarios India-Asia collision (60 Ma)



E-W subduction zone /
Significant extrusion Indochina

- Relatively high latitude
- Large clockwise rotation BT

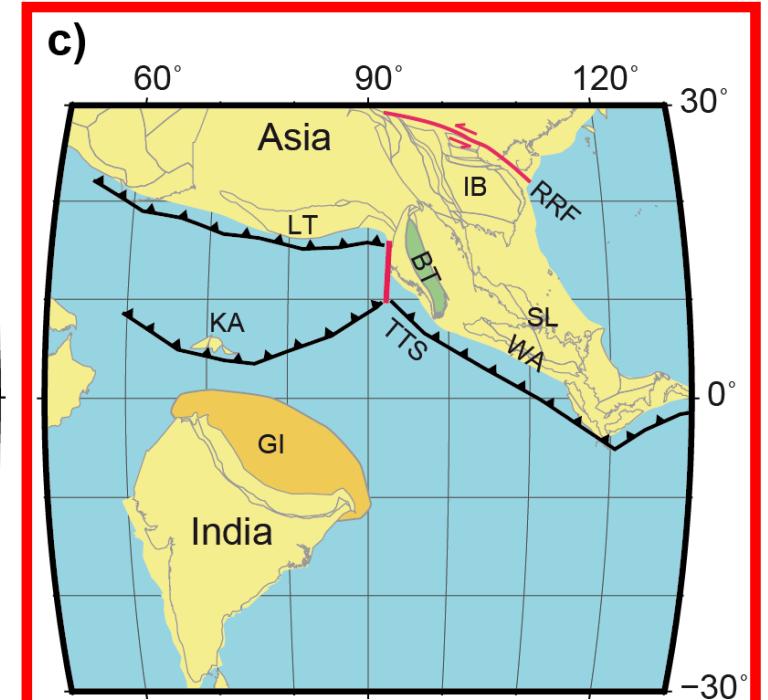
(Cogne et al., 2013; Replumaz et al., 2010, 2013; Royden et al., 2008)



Greater India Basin (GIB)

- Relatively high latitude
- Little rotation BT

(Van Hinsbergen et al., 2012, 2018)

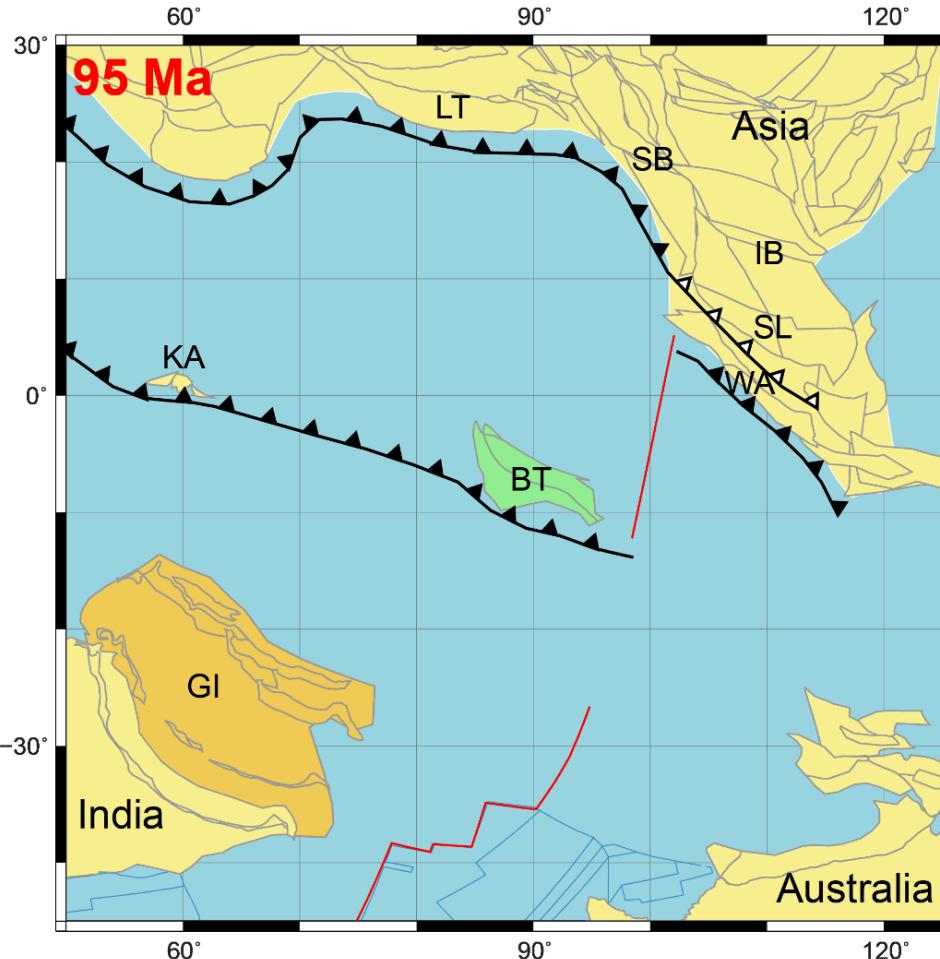


Trans-Tethyan Arc

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

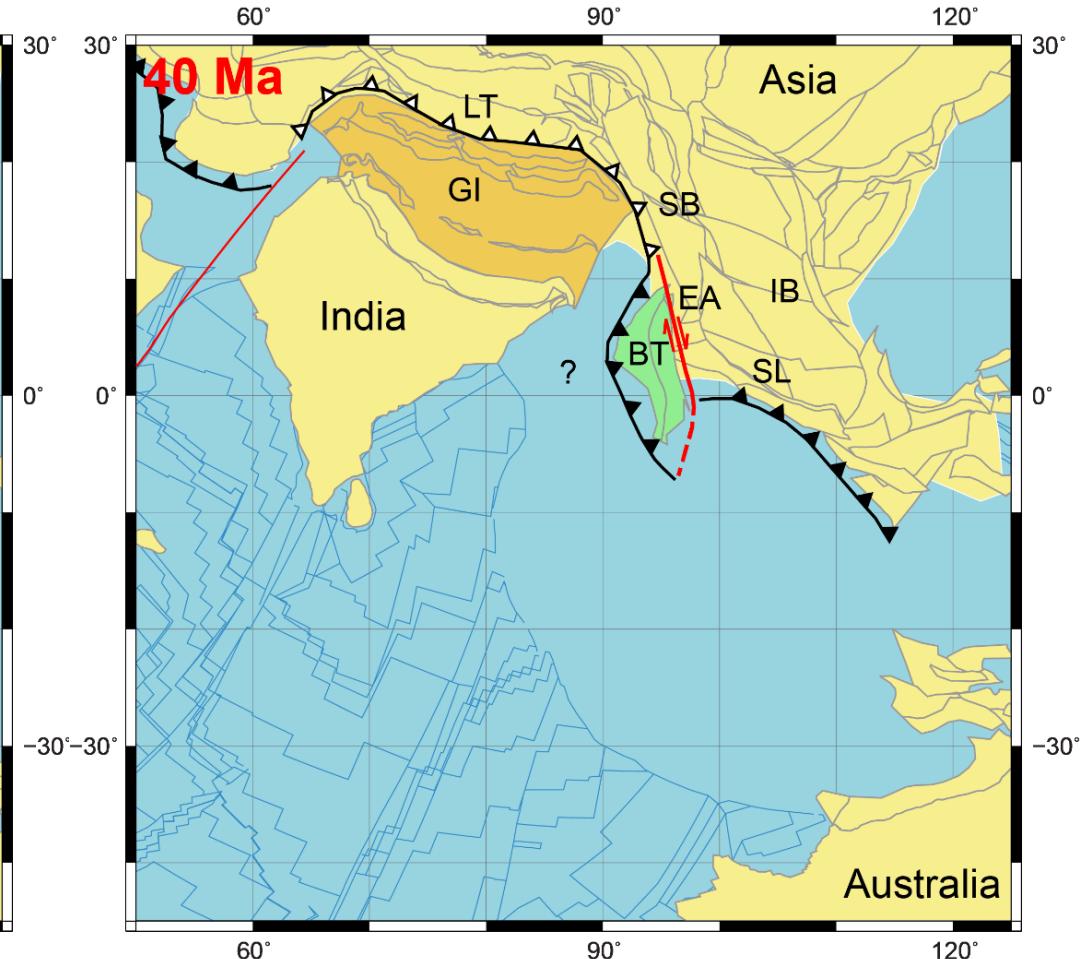
(Hall, 2012; Jagoutz et al., 2015, Zahirovic et al., 2016)

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

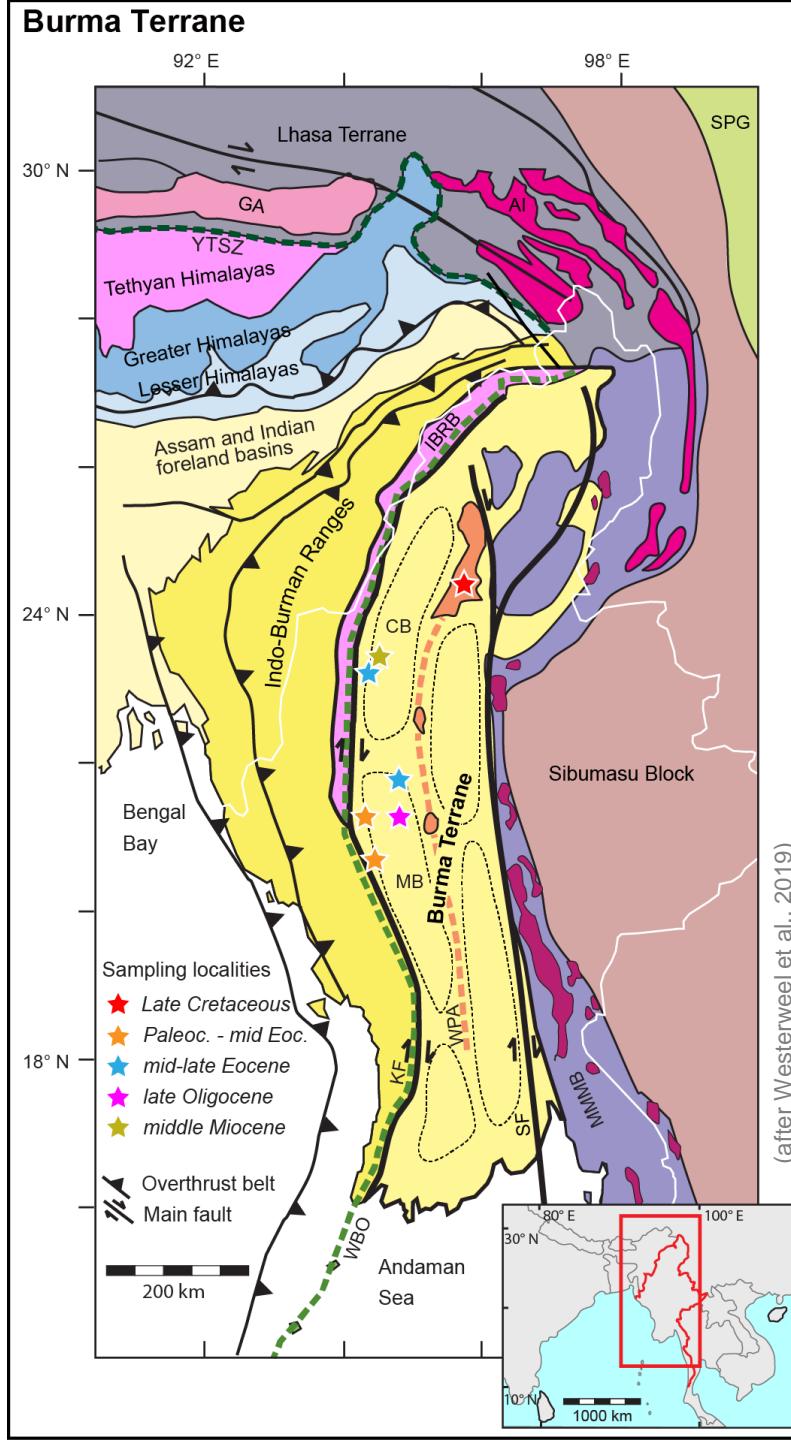
2000 km northward strike-slip motion

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



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)

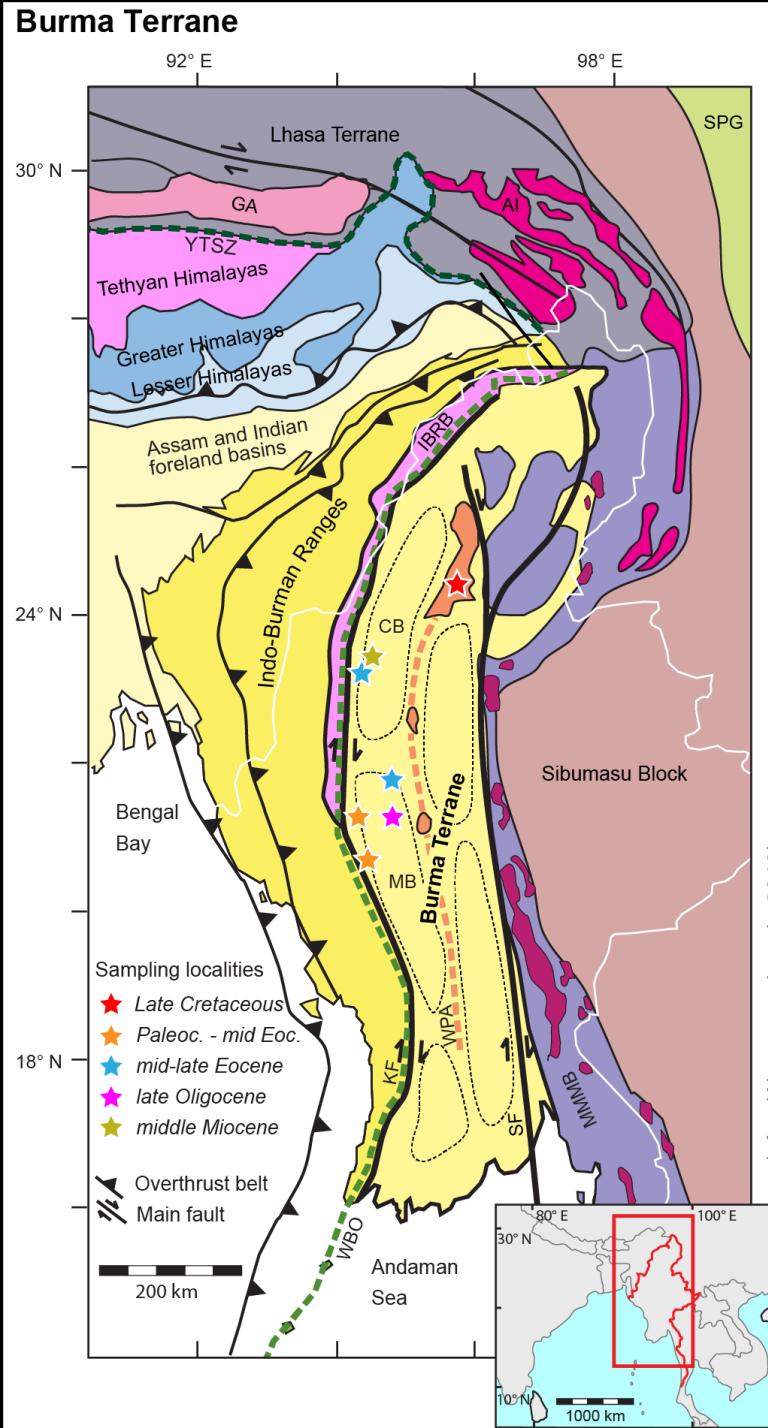
- Pondaung Ranges: *9 sites, 89 samples in paleosols*

Middle Oligocene (Minbu Basin)

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

Middle Miocene (Chindwin Basin)

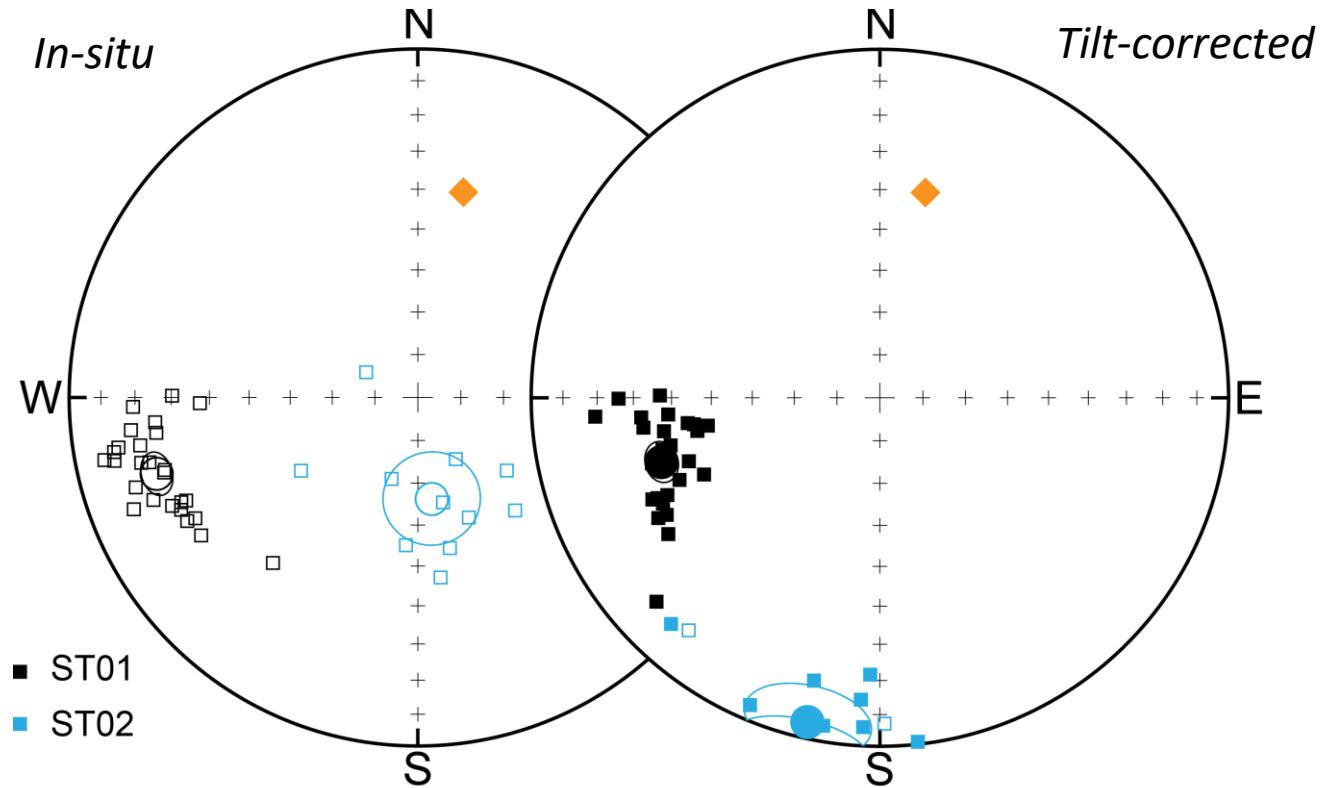
- Kalewa: *27 sites, 219 samples in paleosols*



Results: late Paleocene – middle Eocene Sidoktaya



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

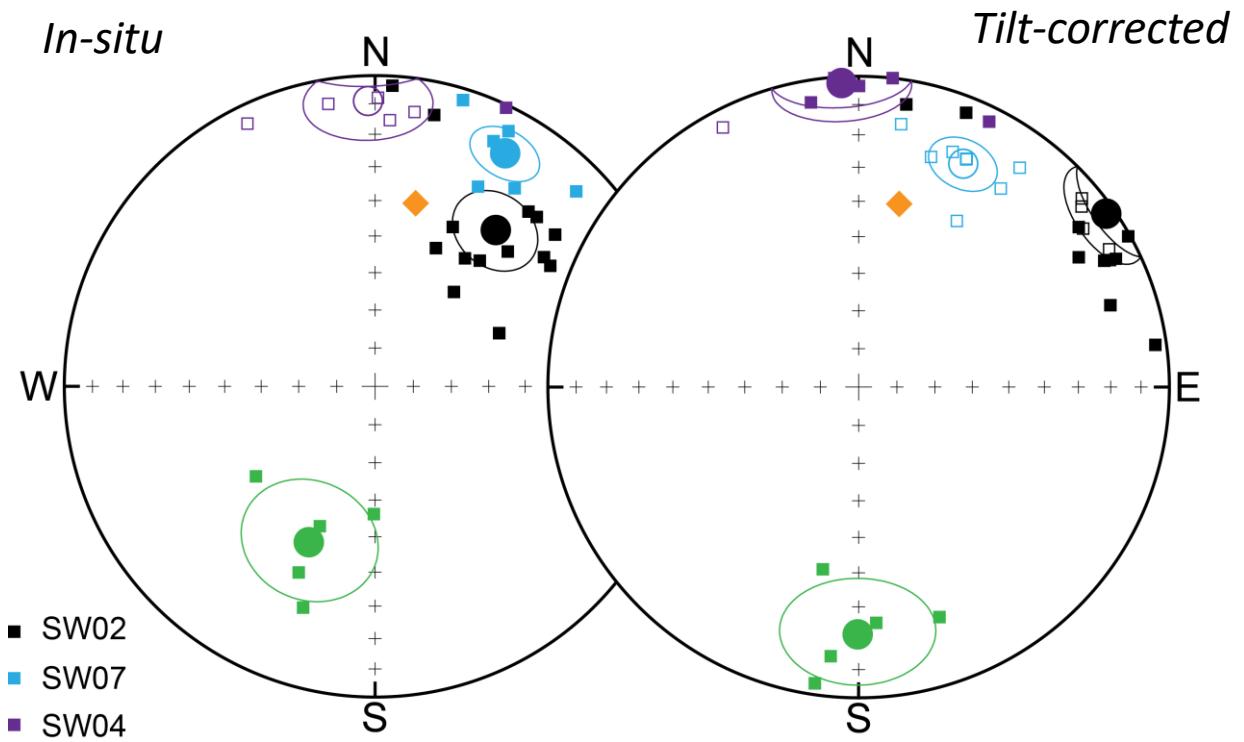


- ChRM different from present-day field and with reverse polarity (*Magnetic field mostly reversed at this time*)
- **Site ST01:** Very stable ChRM. Positive inclination/reverse polarity after tilt correction implies a southern hemisphere paleolatitude
- **Site ST02** less good, more scatter → local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

Results: late Paleocene – middle Eocene Saw



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

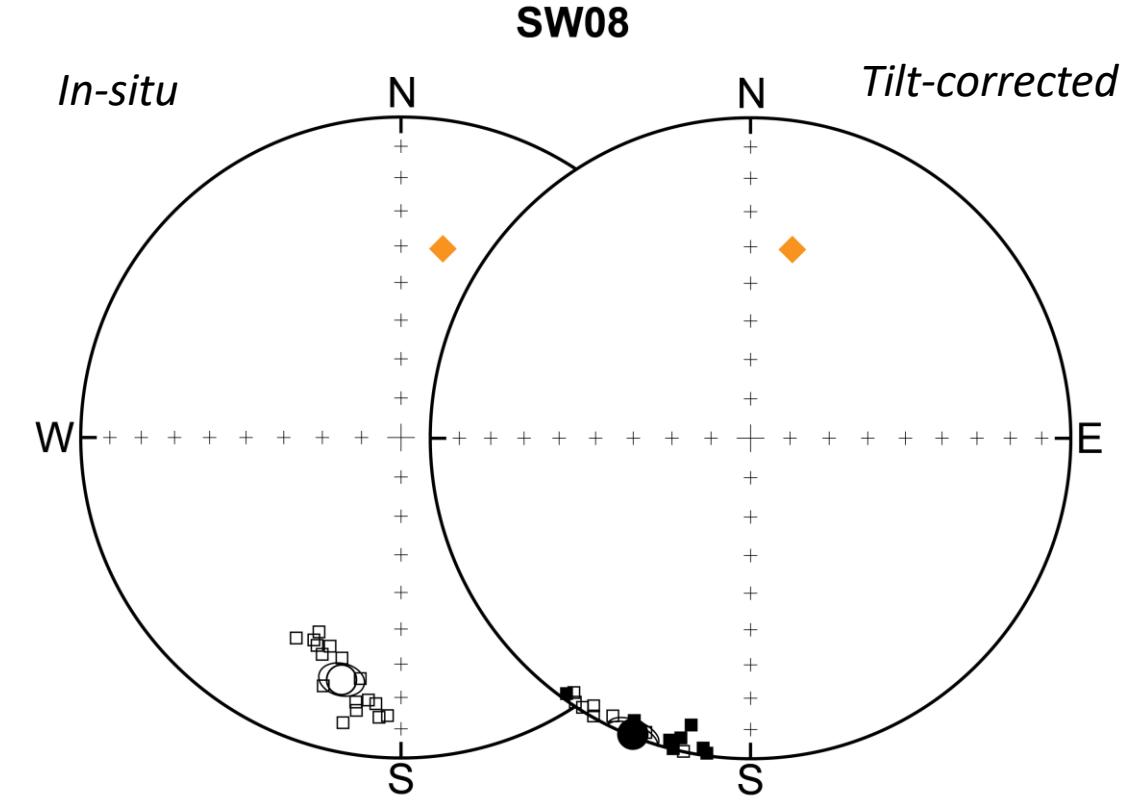


- Declinations sites **SW02** and **SW07** same eastward trend as Sidoktaya (*see previous slide*)
- Declinations sites **SW03** and **SW04** affected by local faulting
- Inclinations in all sites give southern to near-zero latitudes

Results: late Paleocene – middle Eocene Saw

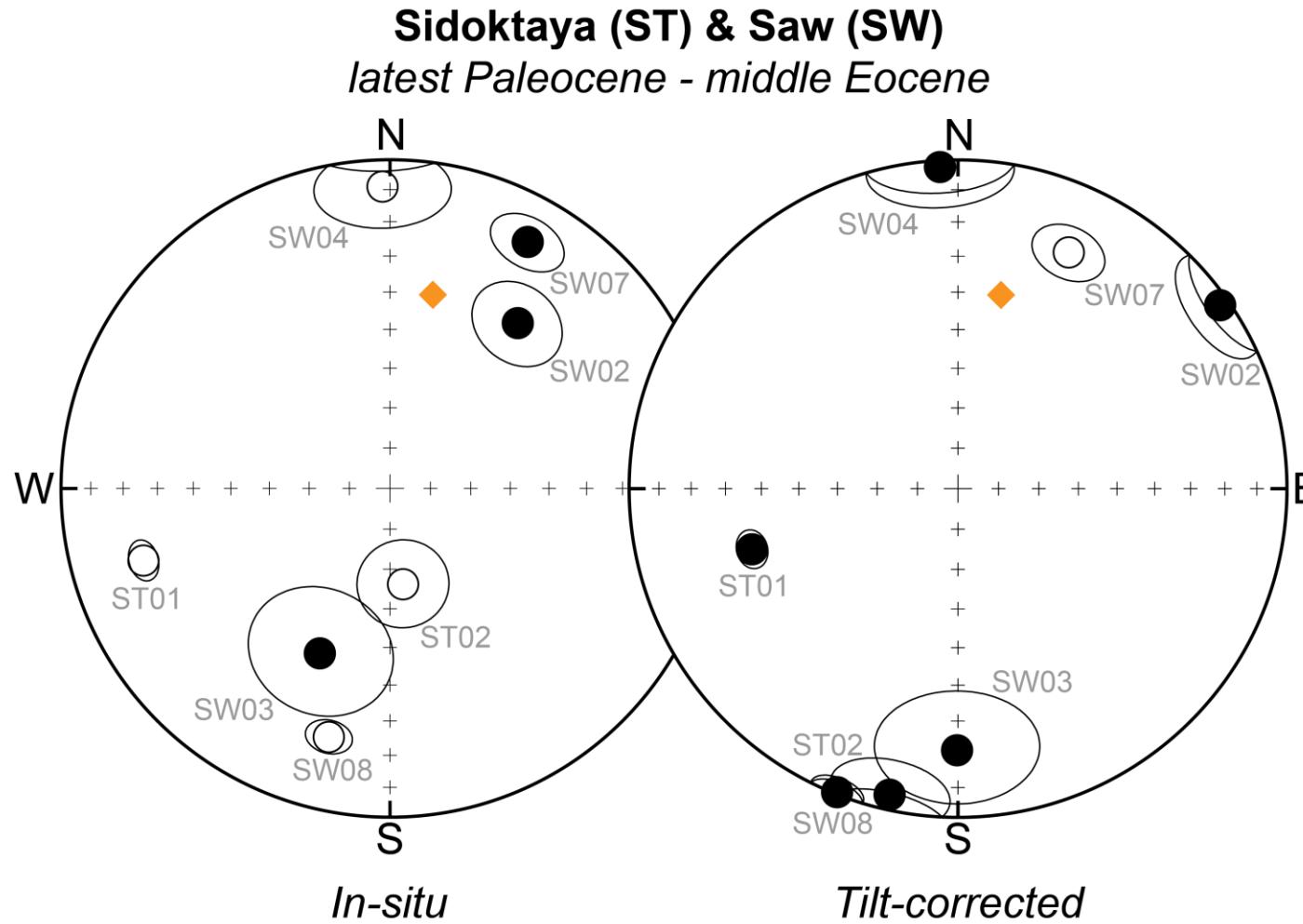


- Tabyin Formation
- Minbu Basin
- 16 samples in fresh blue-grey mudstones



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

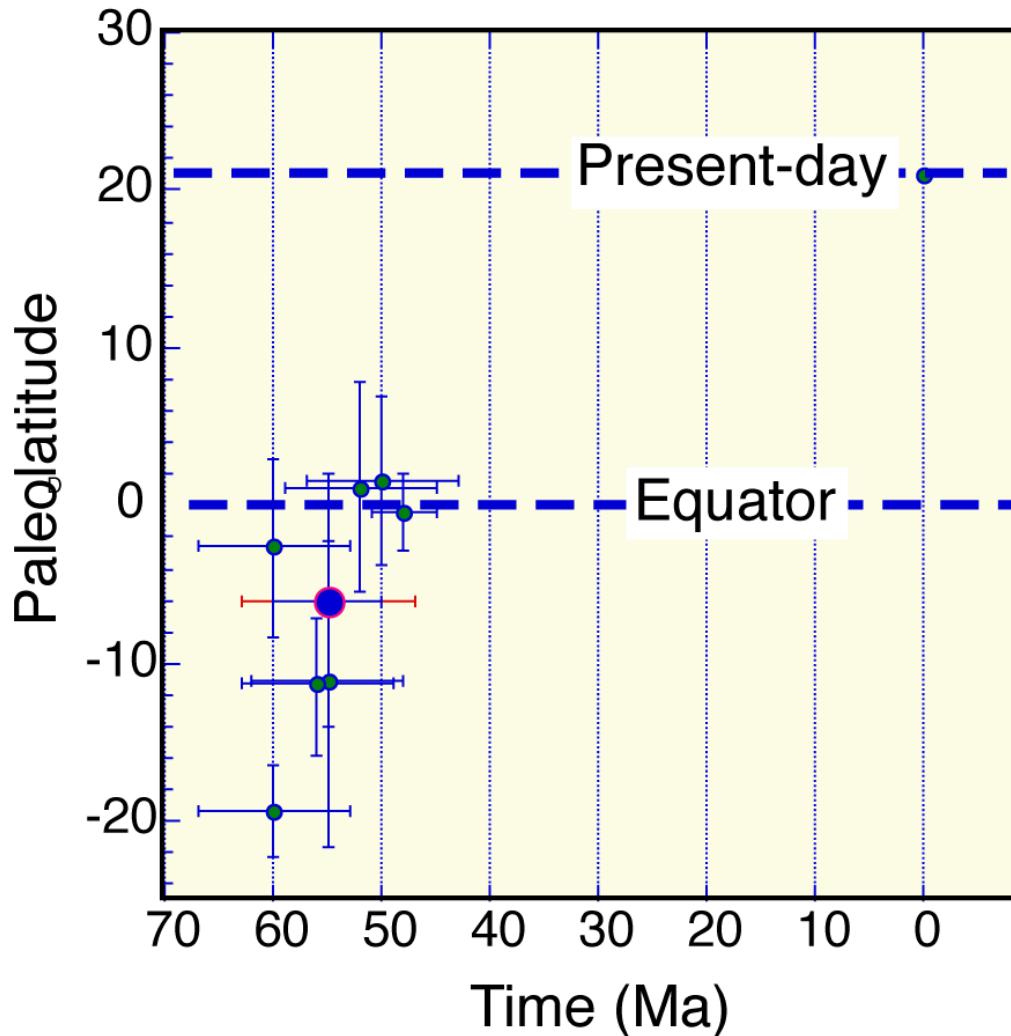
Results: late Paleocene – middle Eocene



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



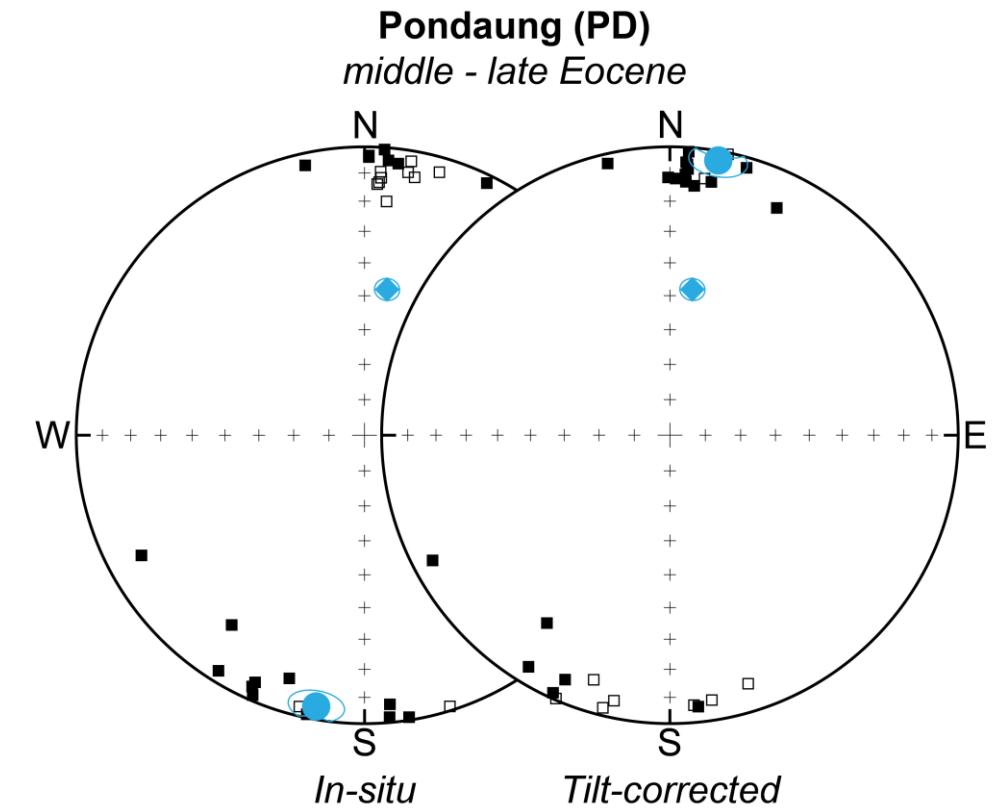
Inclinations:

- Less scatter in inclination, consistently negative to near-zero
 - ➔ Southern hemisphere – near-equatorial latitudes Burma Terrane ($\sim 10^\circ S$)
 - ➔ Similar as position India at that time

Results: late Eocene

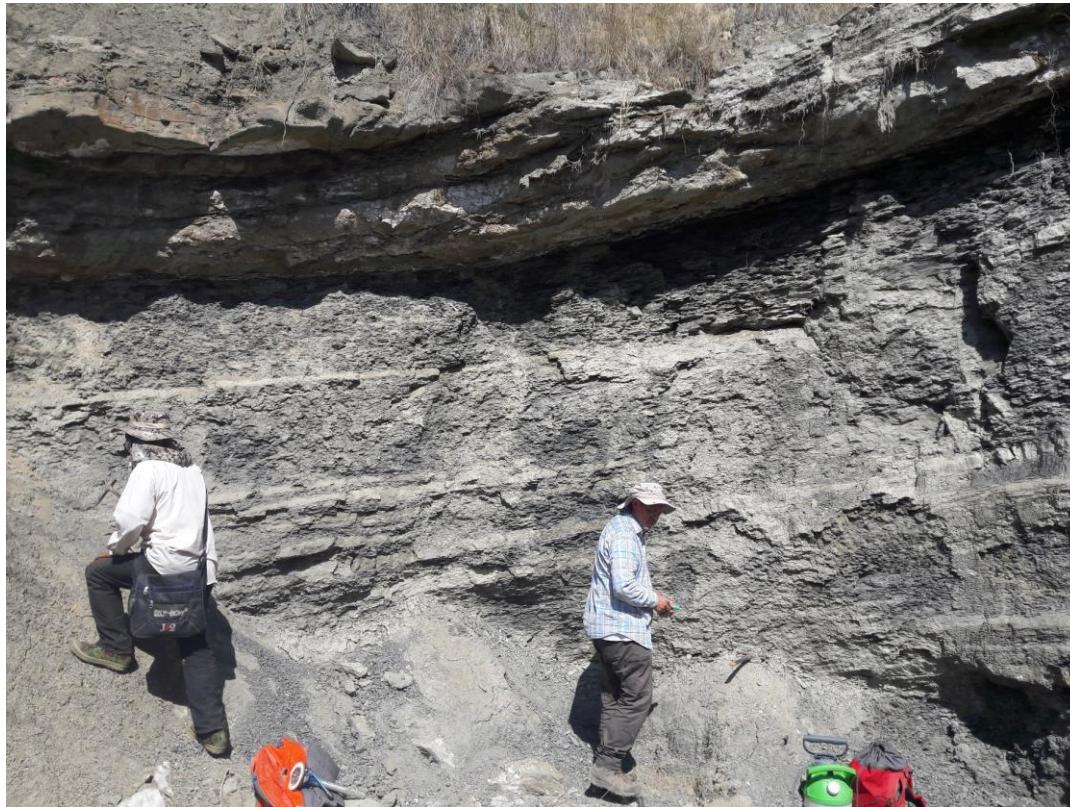


- Pondaung Formation
- Pondaung Ranges
- Strong overprint in present-day field, but 29 reliable samples from paleosols

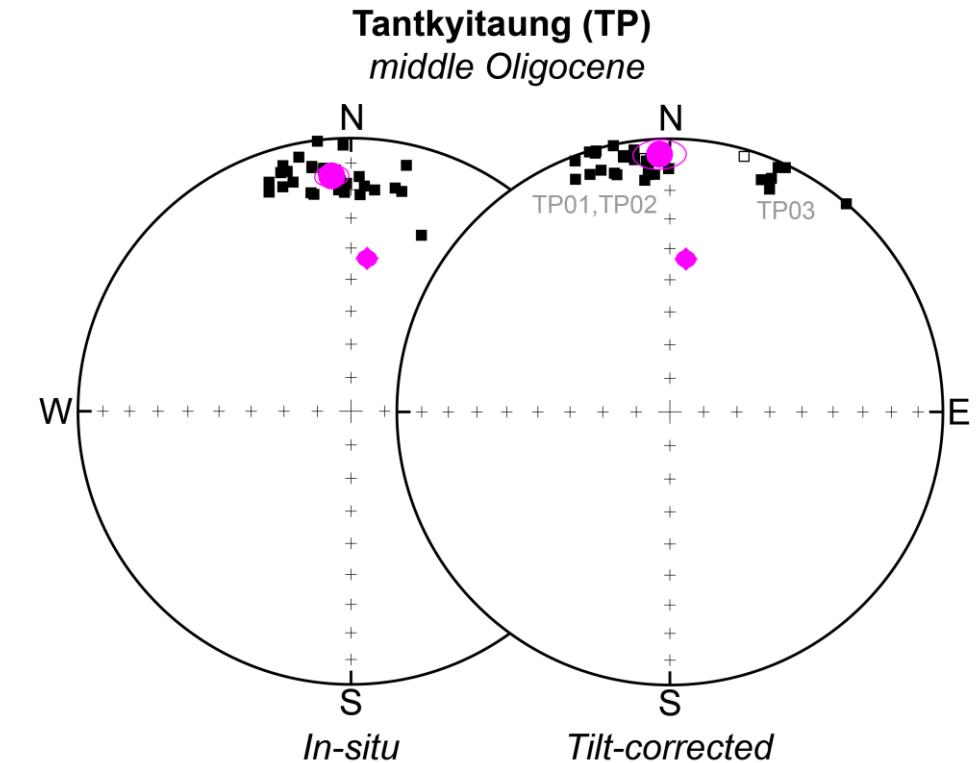


- Near-equatorial latitude ($2.5\pm1.3^{\circ}\text{N}$)
- Negligible clockwise rotation ($3.0\pm4.4^{\circ}$)
- Effect inclination shallowing minimal: $2.5^{\circ}\text{N} \rightarrow 4.2^{\circ}\text{N}$
- Indistinguishable with published late Eocene result

Results: middle Oligocene



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

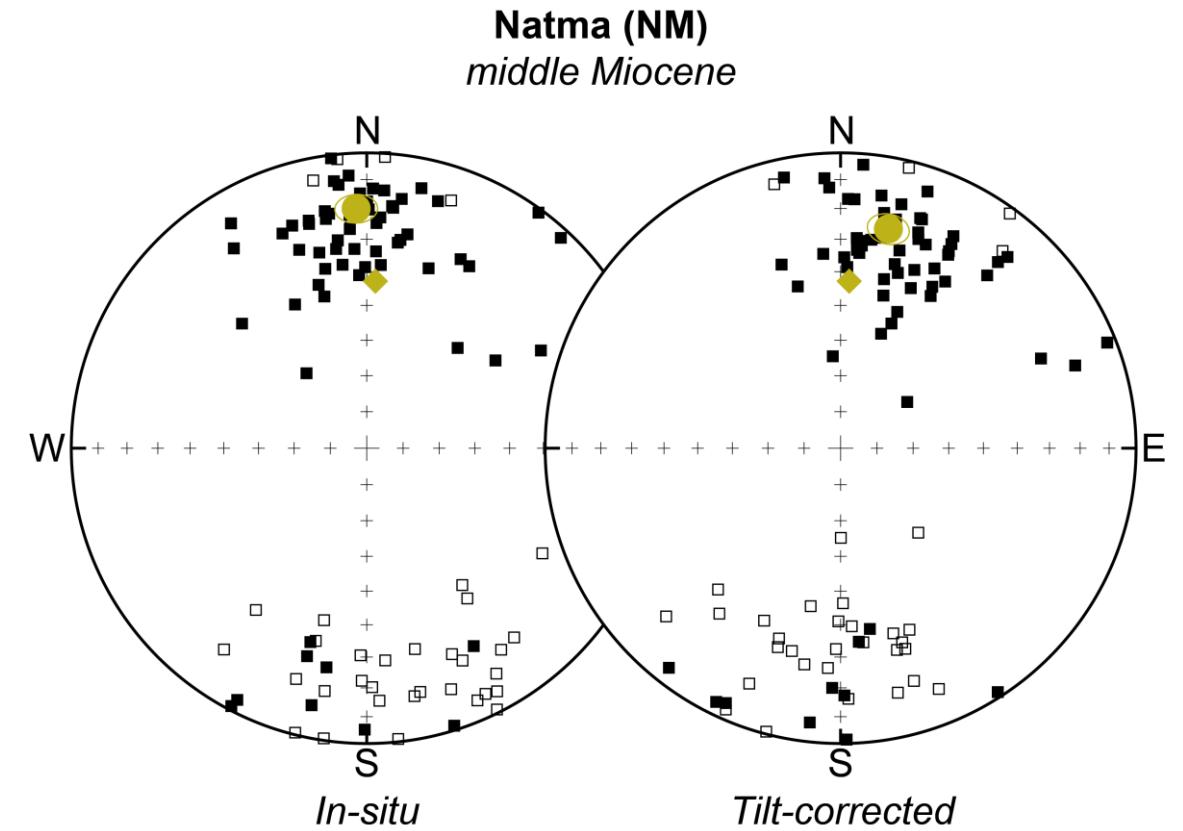


- Near-equatorial latitudes ($2.9\pm2.9^{\circ}\text{N}$)
- Effect inclination shallowing minimal: $2.9^{\circ}\text{N} \rightarrow 4.7^{\circ}\text{N}$
- Minor rotations

Results: middle Miocene

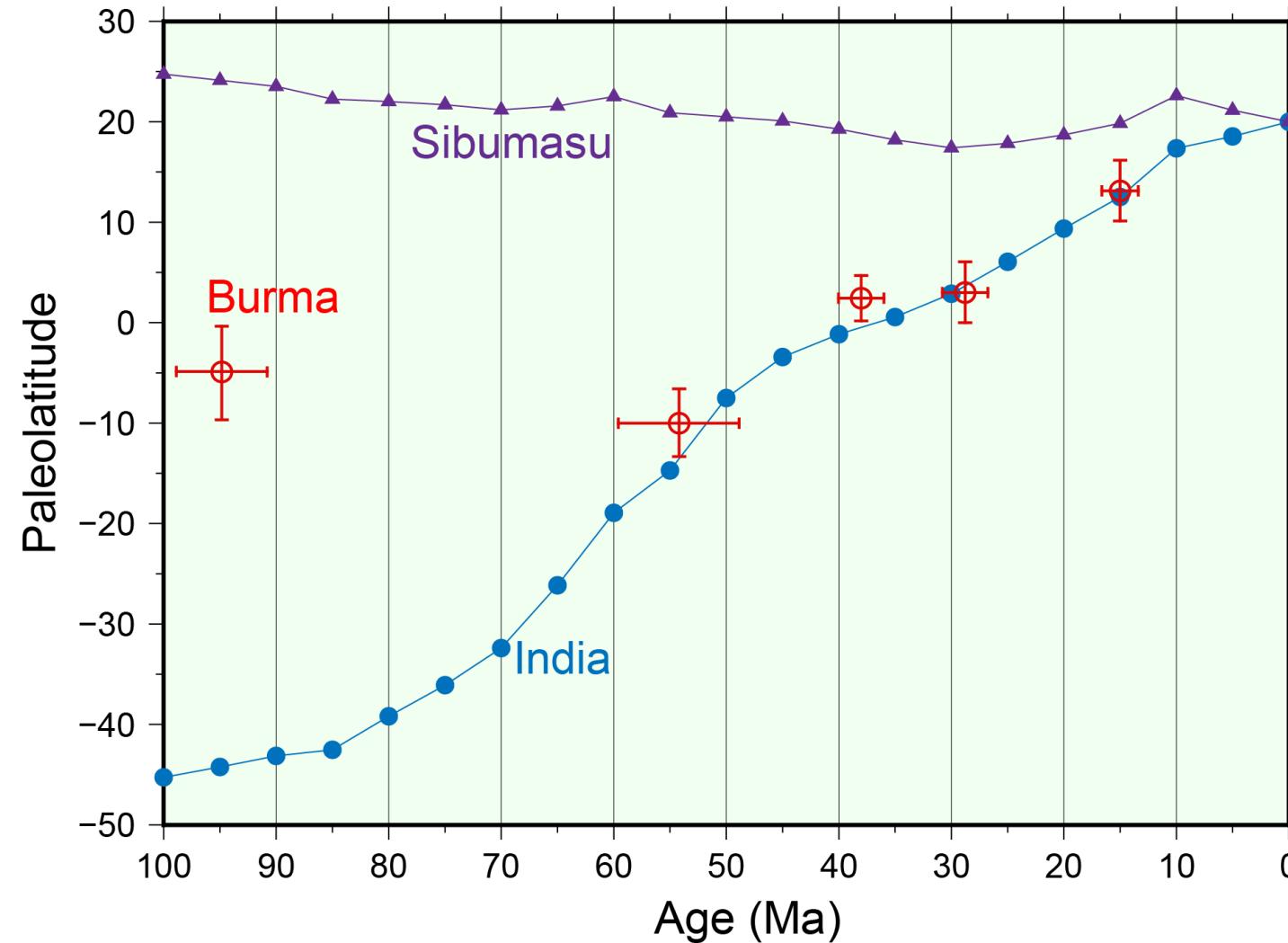


- Natma Formation
- 98 samples from paleosols
- Chindwin Basin



- Negligible clockwise rotation ($9.3\pm4.8^\circ$)
 - Paleolatitude similar as offset estimates from dextral strike-slip Sagaing Fault ($13.1\pm2.9^\circ\text{N}$)
- 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)

Work in progress: 95 Ma GPlates reconstruction

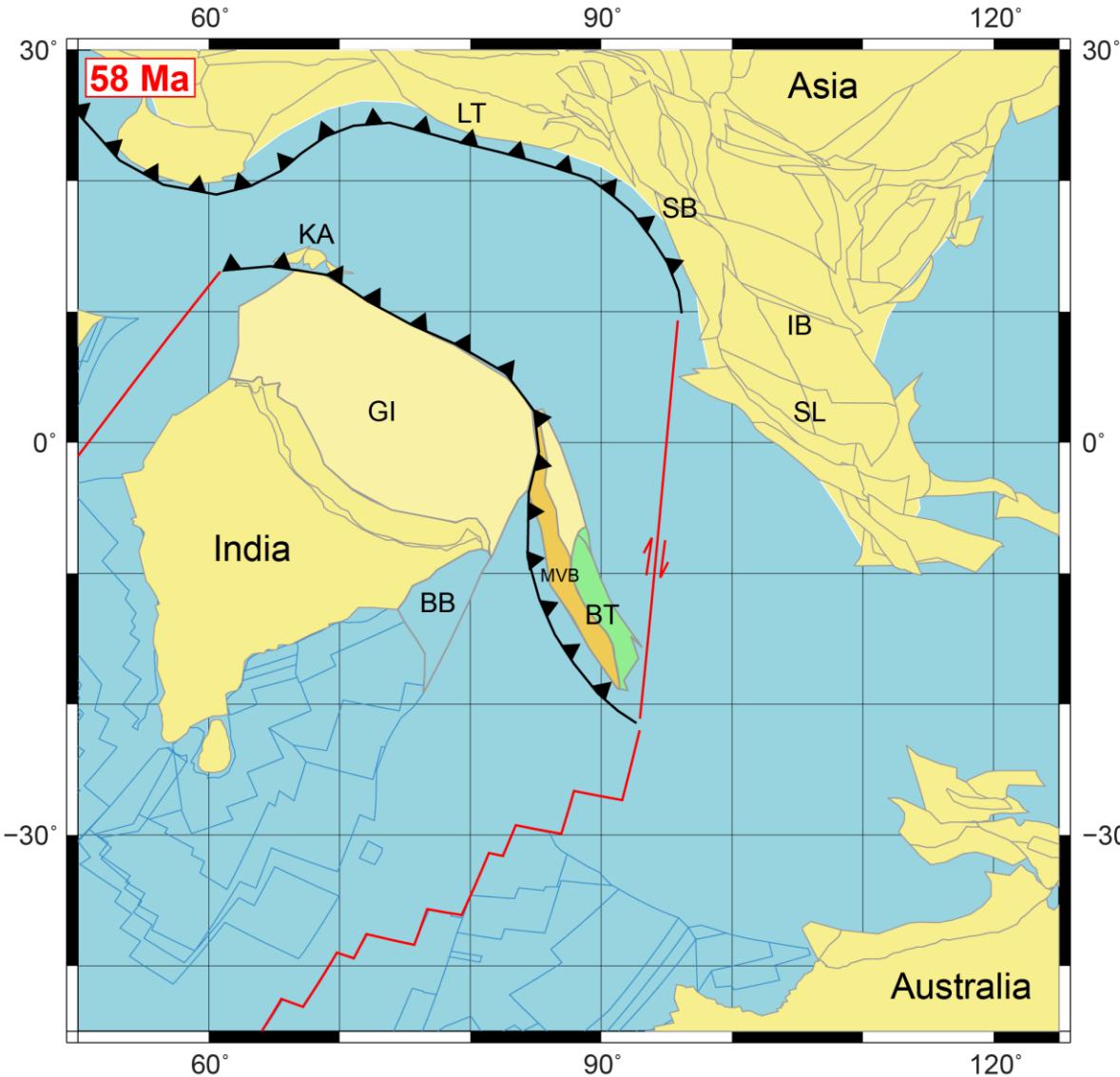


→ Intra-oceanic origin as part of Trans-Tethyan subduction system

Questions:

- Correlation with Kohistan Arc?
(*Jagoutz et al., 2015; Liu et al., 2016; Mitchell et al., 2012; Pettersson, 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*)

Work in progress: 58 Ma GPlates reconstruction

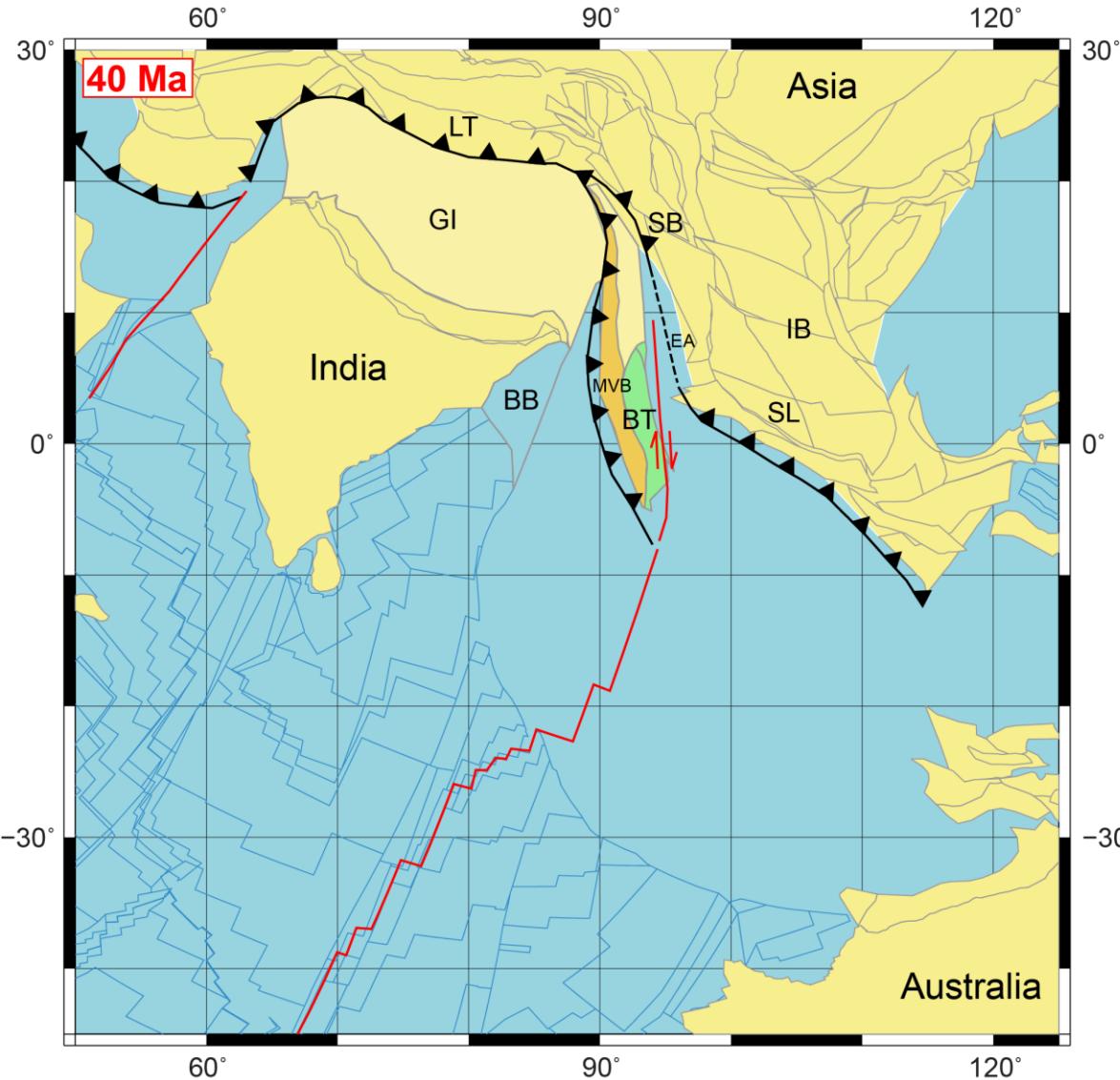


→ Onset coeval motion Burma Terrane and India

Questions:

- Direct collision Burma Terrane and India?

Work in progress: 40 Ma GPlates reconstruction



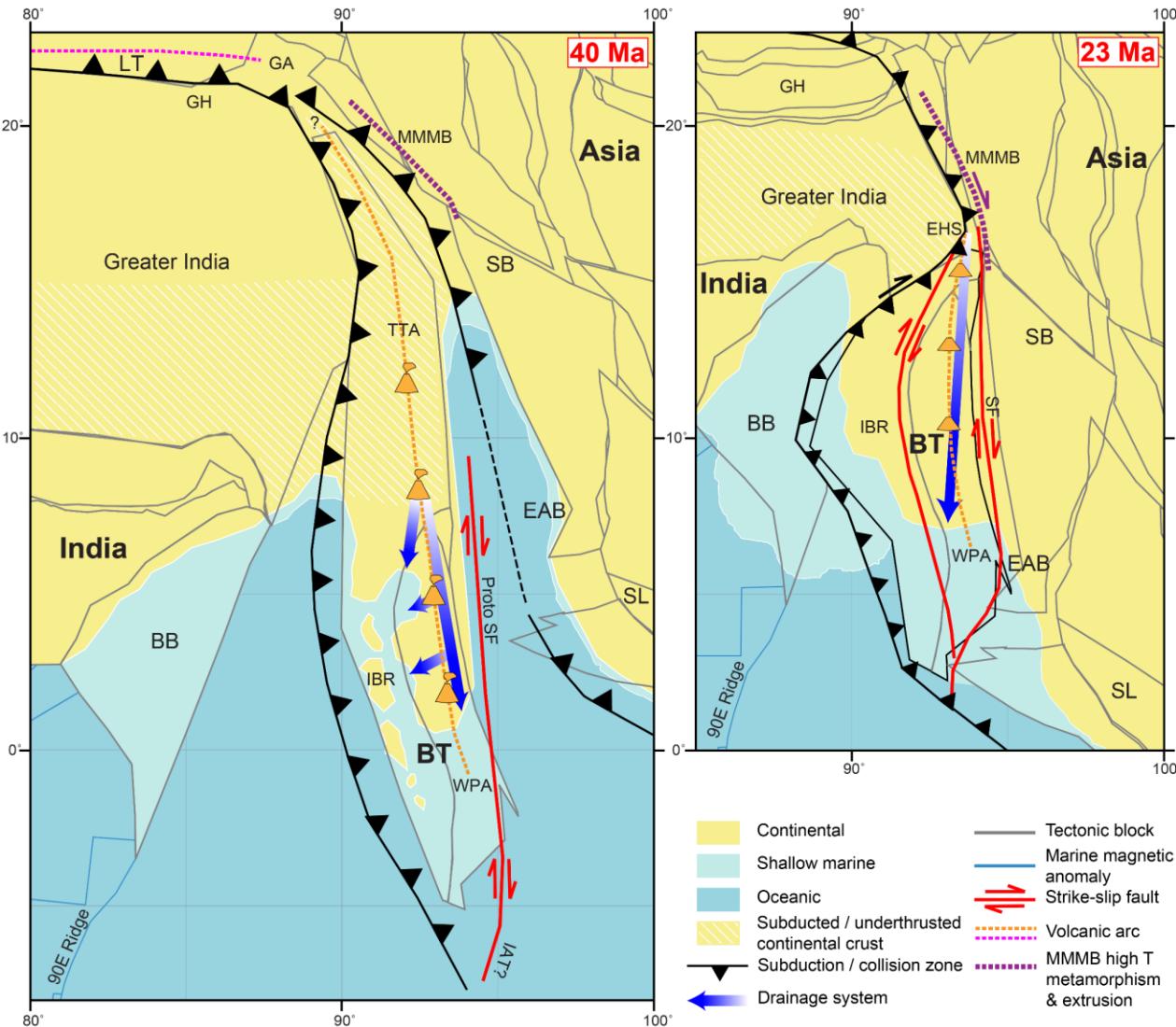
- Significant ~2000 km northward motion with little rotation from late Eocene to present-day
- Little relative motion between India and the Burma Terrane

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?

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.)

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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