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

Jan Westerweel 1, Pierrick Roperch 1, Alexis Licht 2, Guillaume Dupont-Nivet 1,3, Zaw Win 4, Fernando Poblete 1,5, Nathan Cogné 1, Gilles Ruffet 1, Huasheng Huang 6, Hnin Hnin Swe 7, Myat Kai Thi 7, Carina Hoorn 6, Day Wa Aung 7

1 Geosciences Rennes, University of Rennes 1, Rennes, France
2 Dept. Earth and Space Sciences, University of Washington, Seattle, United States
3 Department of Earth Sciences, Potsdam University, Potsdam, Germany
4 Department of Geology, University of Shwebo, Shwebo, Myanmar
5 Departamento de Geología, Universidad de Chile, Santiago, Chile
6 University of Amsterdam, Amsterdam, The Netherlands
7 Department of Geology, University of Yangon, Yangon, Myanmar
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

- 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
- 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
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
Results: middle Oligocene

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

- Near-equatorial latitudes ($2.9\pm2.9^\circ$N)
- Effect inclination shallowing minimal: $2.9^\circ N \Rightarrow 4.7^\circ N$
- Minor rotations
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)
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? (Metcalf, 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
References