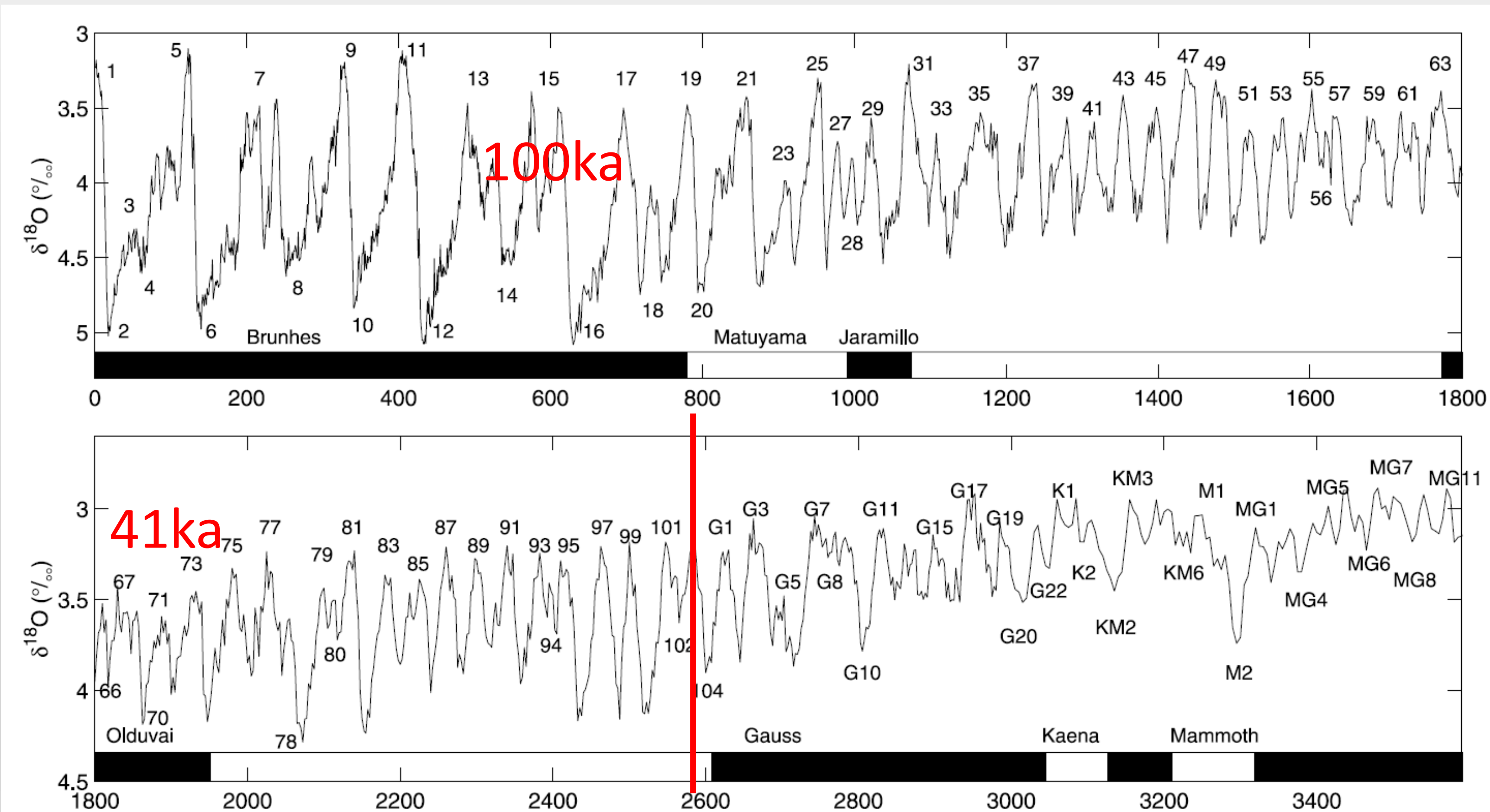
High-frequency Sequence stratigraphy and facies architecture in Cholan Formation (Pleistocene), northwestern Taiwan: the evolution of a foreland basin

Speaker: Xiao-Cheng, Zhu(朱孝承), M.S. students

Advisor: Wen-Shan, Chen(陳文山), Ph.D.

The cycle during Pleistocence

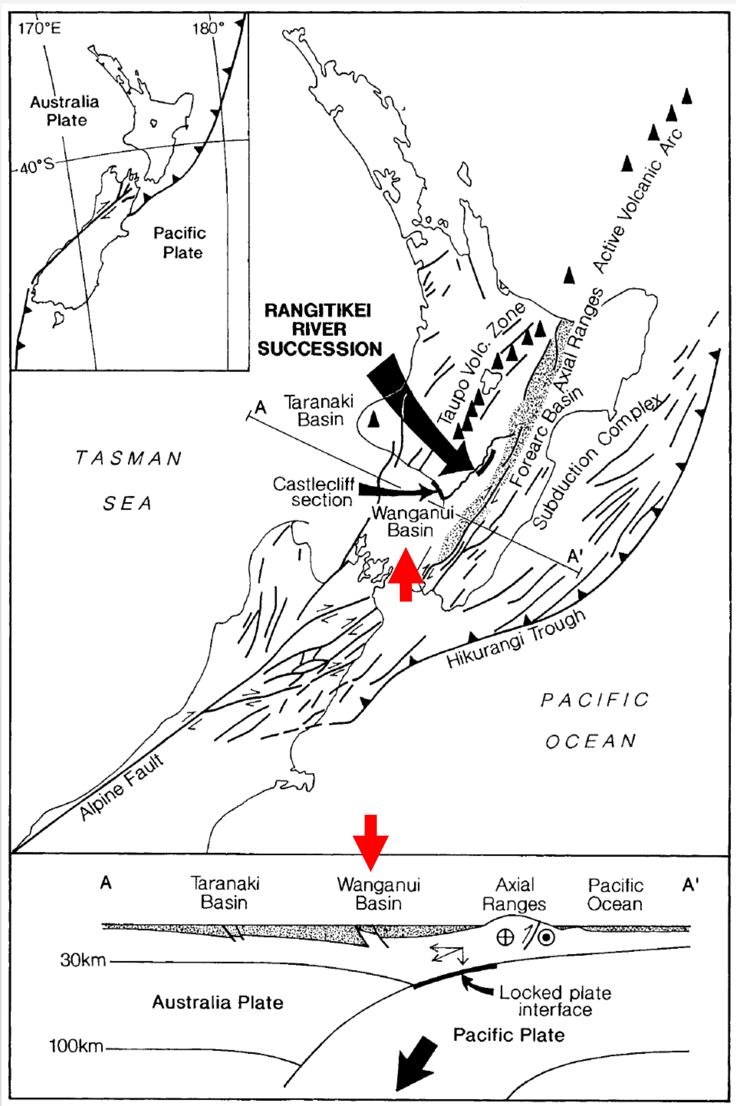
- Chronstratigraphy - 18O stage (LR05) - Milankovitch cycles



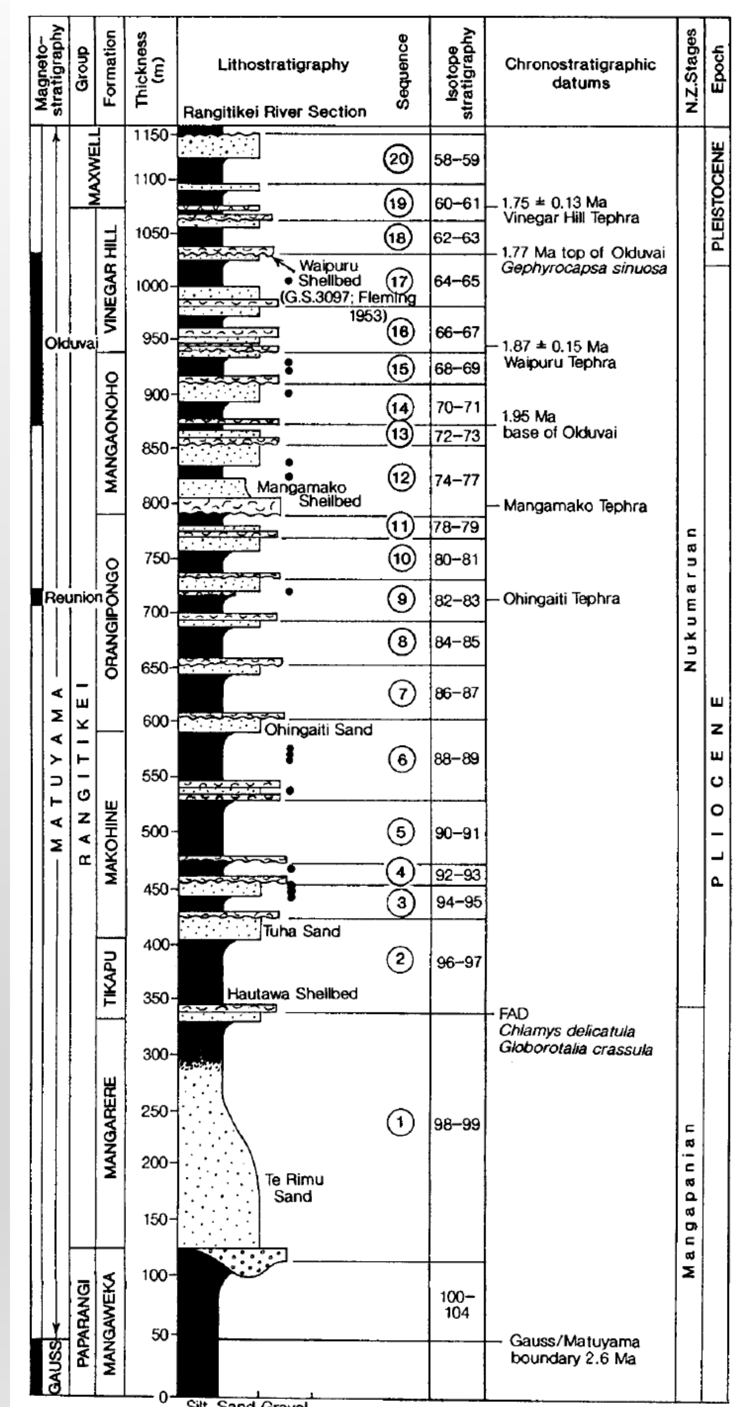
Pleistocene (2.58Ma)

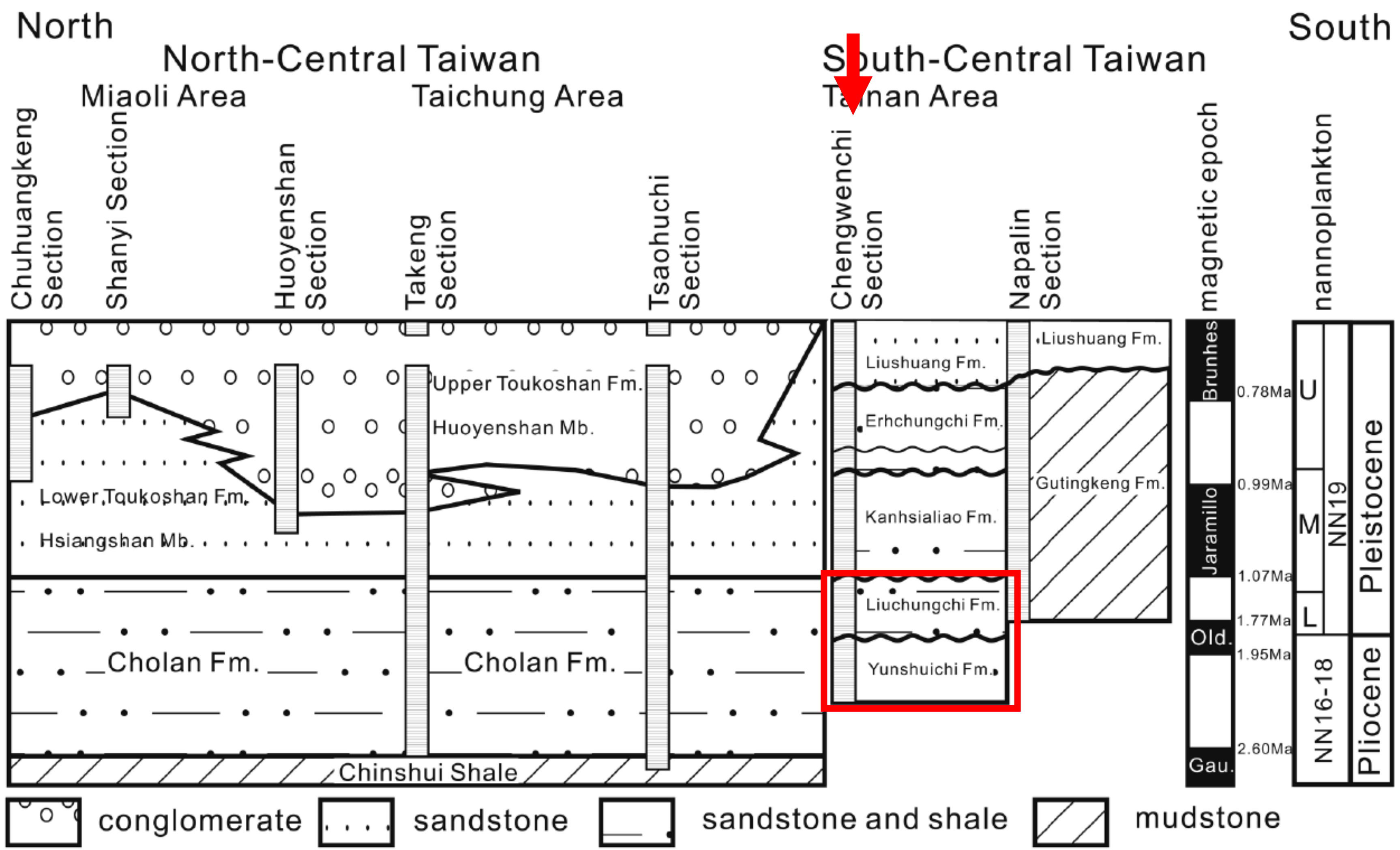
(Lisiecki & Raymo, 2005)

New Zealand



(Naish & Kamp., 1997)

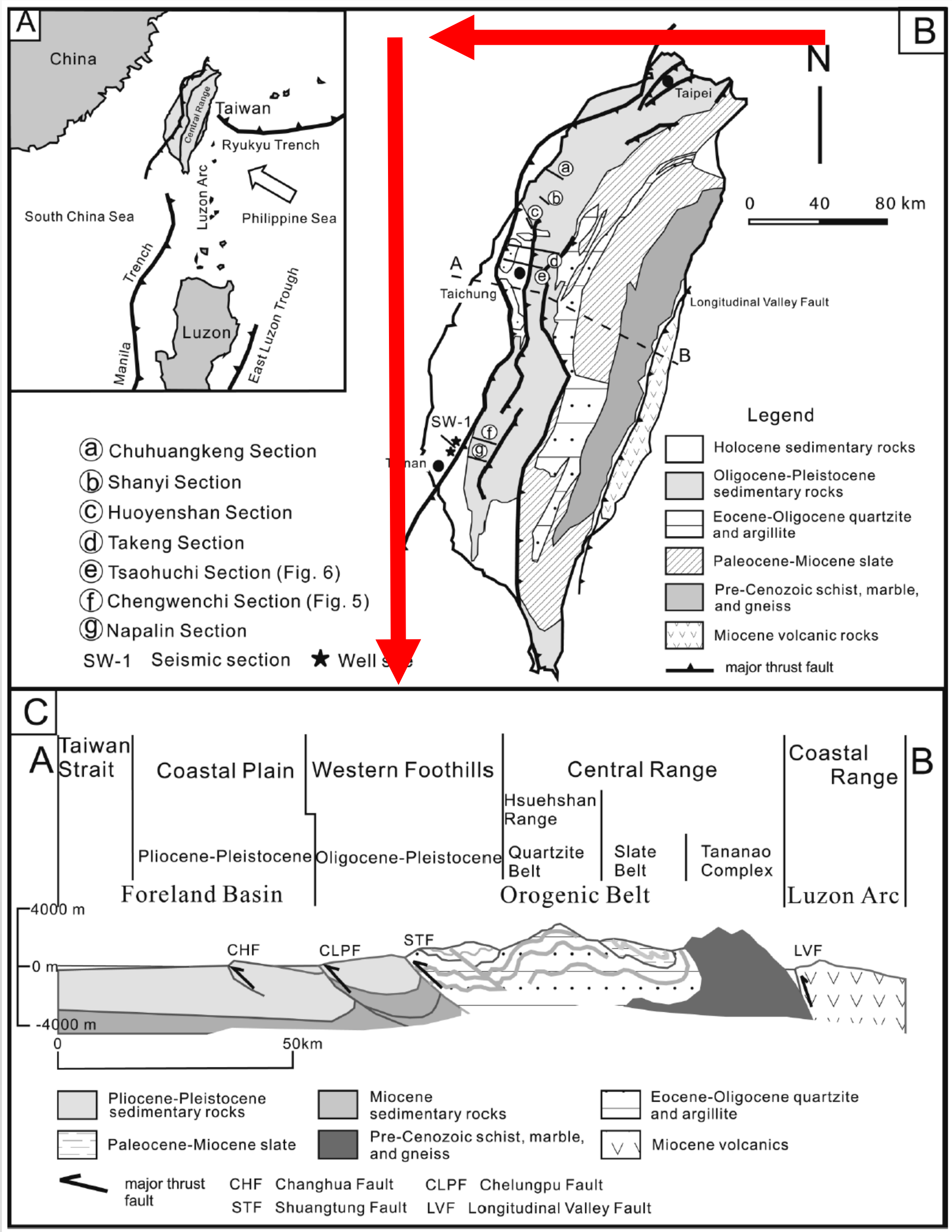




(Chen et al., 2001)

Orogeny range

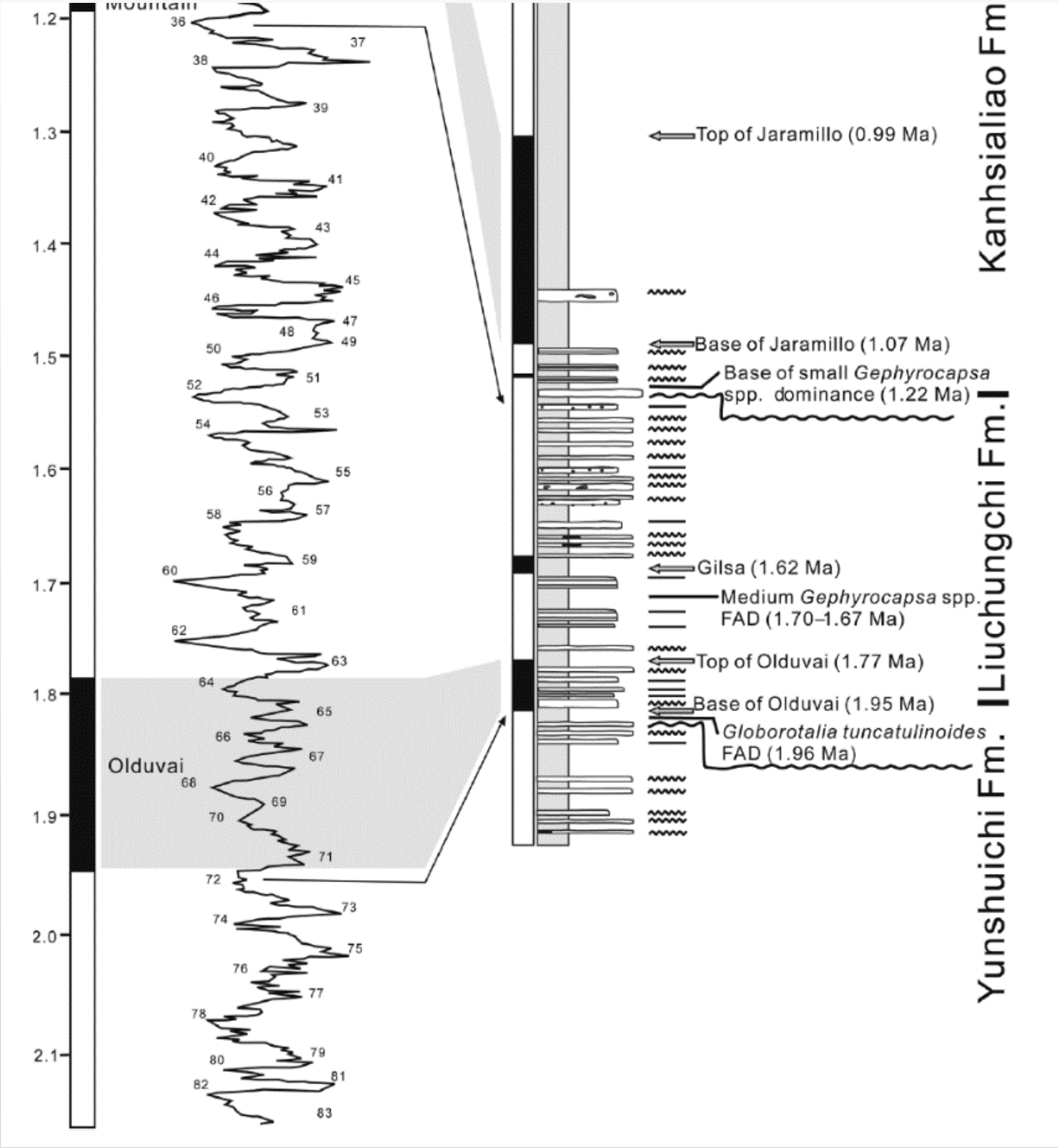
- Hsuhsang range
  (Chen et al., 2019)
  - North: 6-5Ma
  - Central: 5-4Ma
  - South: 4-3Ma
- The Western Foothills
  - North: 2.28±0.69-1Ma (Lock ., 2007, Horng., 2014)



(Chen et al., 2001)

The record of Milankovitch cycle

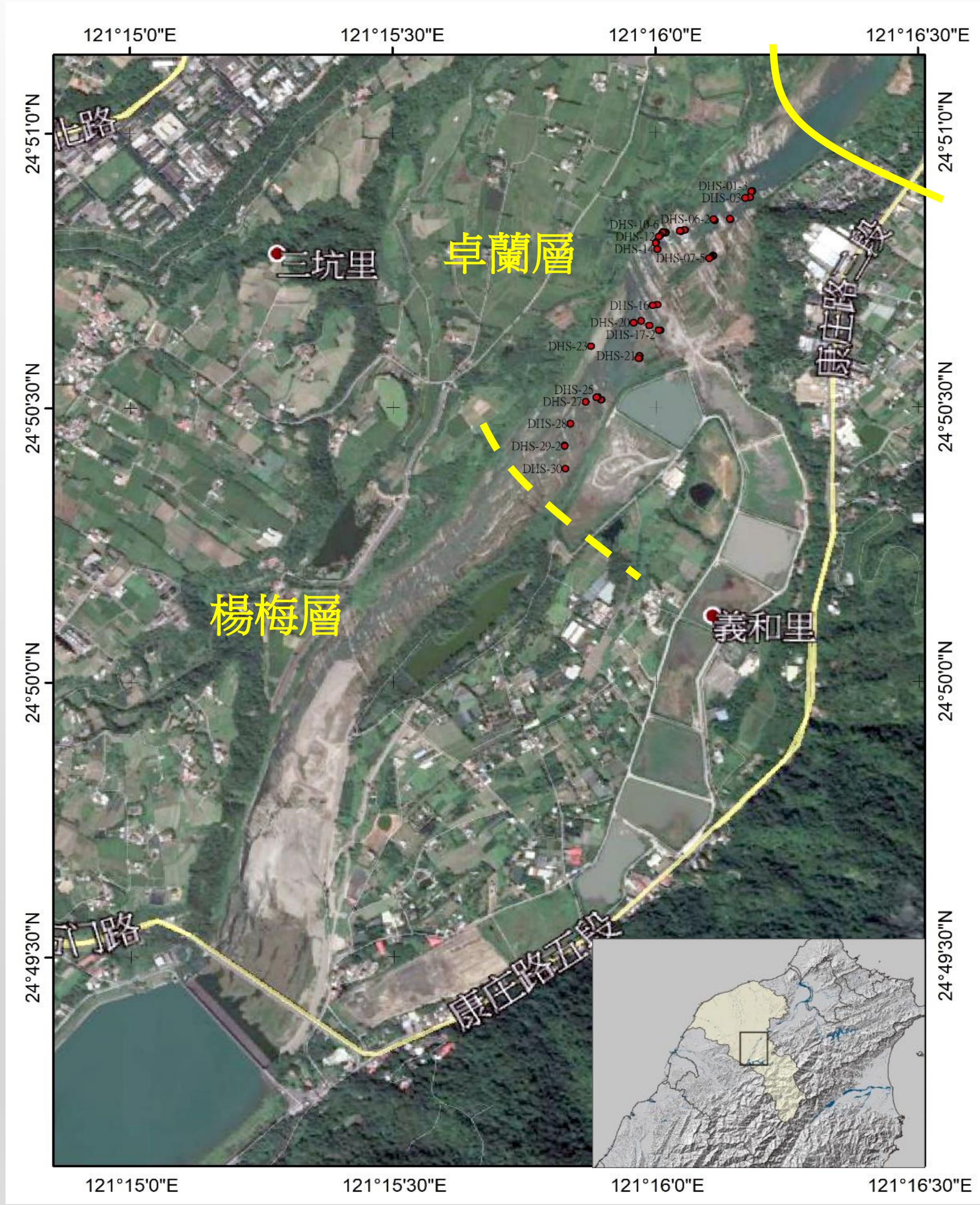
- Yunshuichi Fm. : 1.95Ma (base of Olduvai)
- Liuchungchi Fm. : 1.22Ma (small Gephyrocapsa spp. dominace)
- 19-20 parasequence
- 1 parasequence = 37.5ky≈41ky



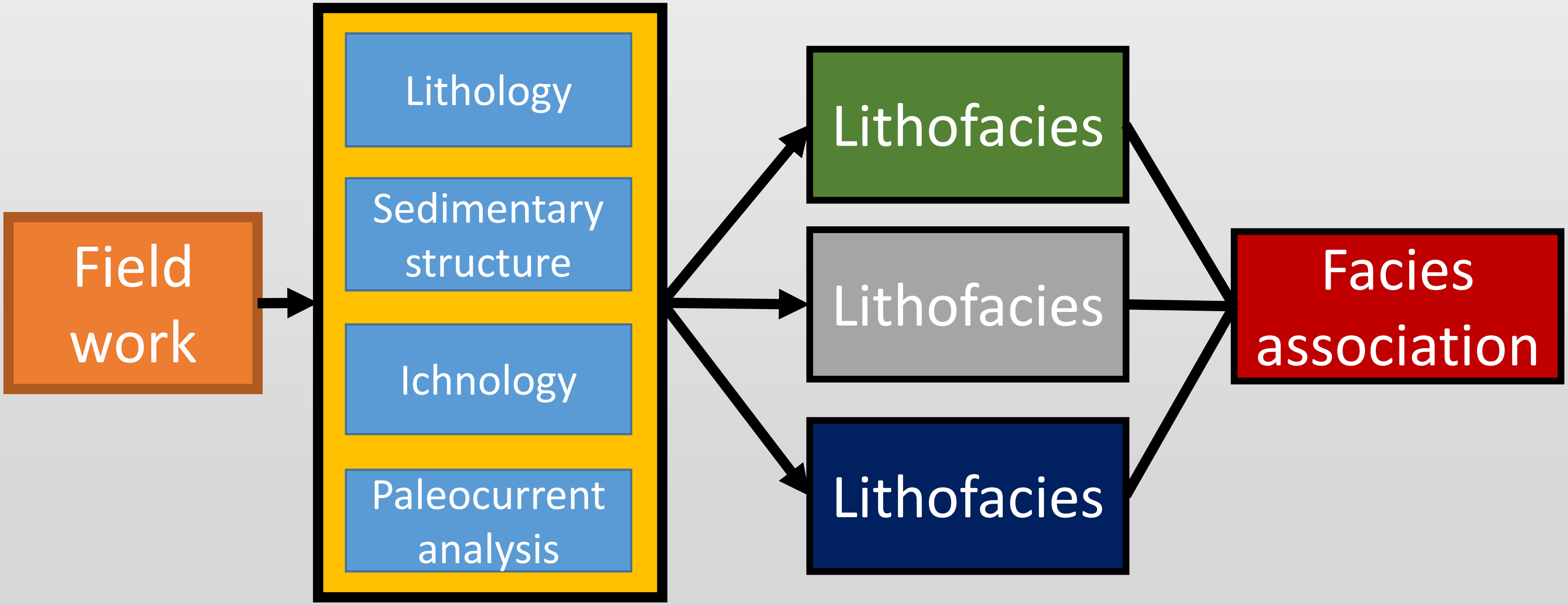
(Chen et al., 2001)

Dahan river section

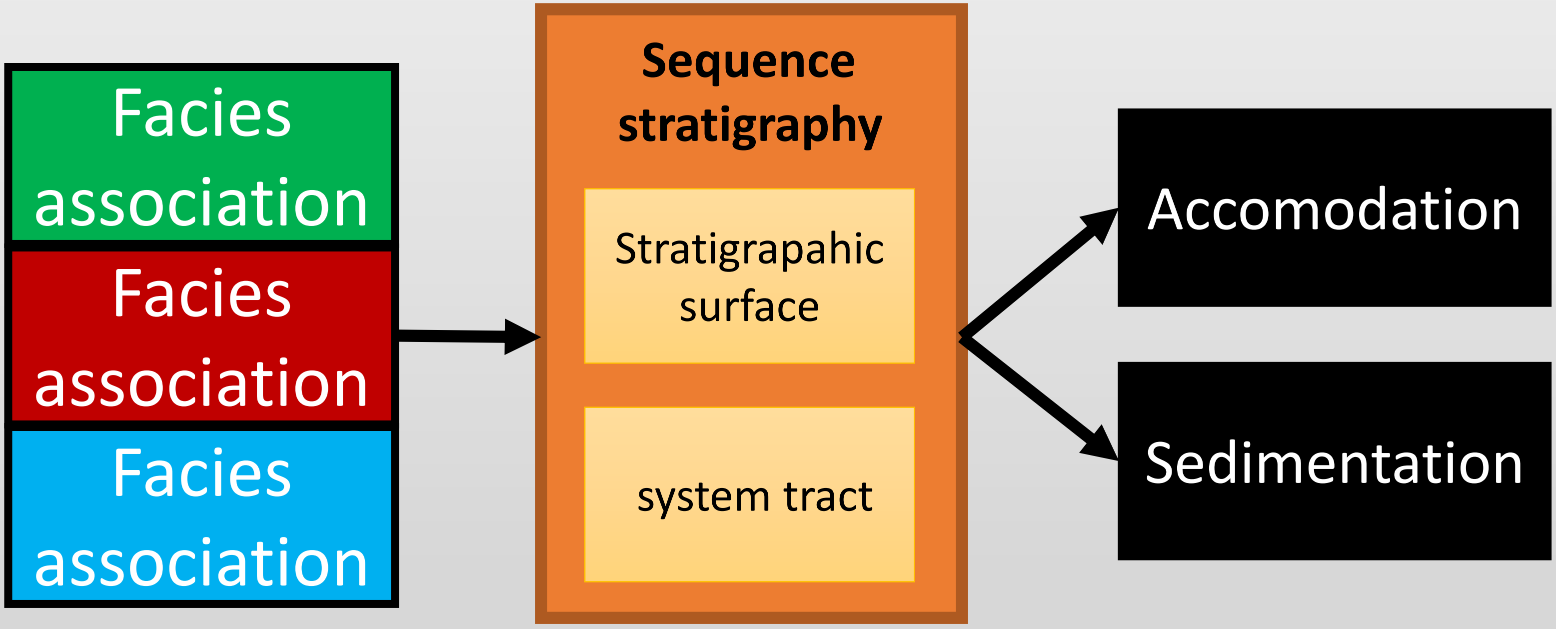
- 3km
  Successive section
- Cholan Fm -> Yangmei Fm
  (Pan et al., 2015)
- Marine to nonmarine
- Upper part -> no age
- Lower part -> NN16-18
  - ***Pseudoemiliania lacunosa* (FAD)**



Method


Field work
Lithology
Sedimentary structure
Ichnology
Paleocurrent analysis
Lithofacies
Lithofacies
Lithofacies
Facies association

Method



Facies association
Facies association
Facies association
Sequence stratigraphy
Stratigrapahic surface
system tract
Accomodation
Sedimentation

Lithosfacies analysis

- 19 classification
  - 6 Mudstone
  - 2 Muddy sand (bioturbation)
  - 6 Fine sandstone
  - 4 Medium sandstone
  - 1 Shell debris layer

Mudstone-6

Pure(prodelta)

Lamination(offshore)

Lenticular(intertidal)

Brackish mud

Greenish(Floodplain)

Greenish+Thal.(lagoon)

Muddy sand-2


Offshore transition
Canon


Offshore transition


floodplain


floodplain

Fine sandstone-6

High bioturbation

Hummocky

Planer cross bedding

Wavy lamination

Flaser

Parallel lamination

Medium sandstone-4

Mud pebble

Carbon debris

Conglomerate

Parallel lamination

Oyster layer

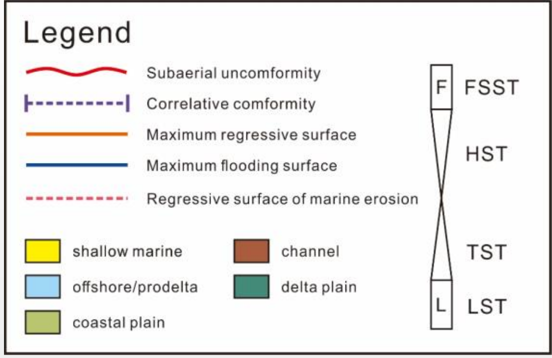
Trunk

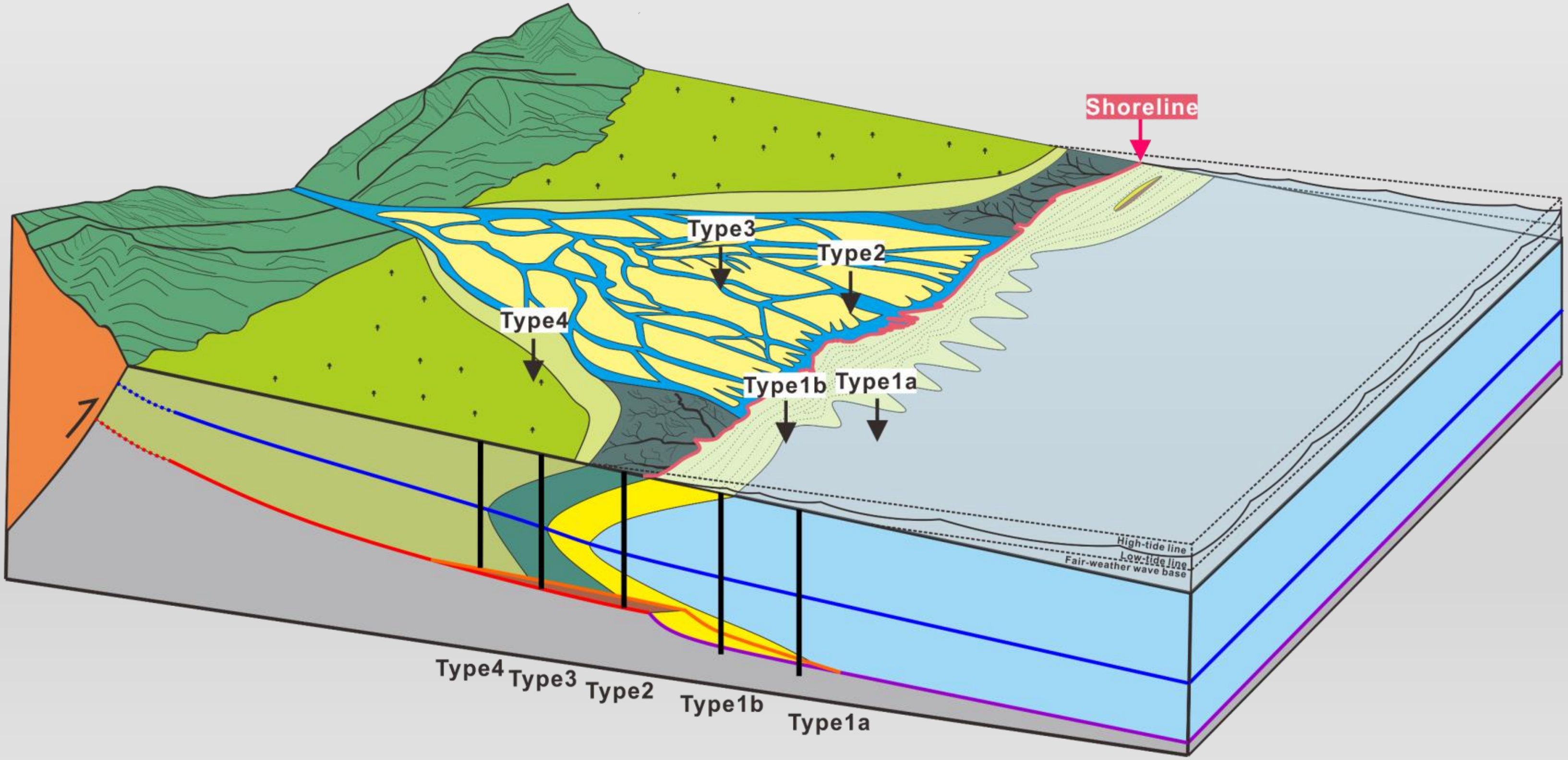
Trunk

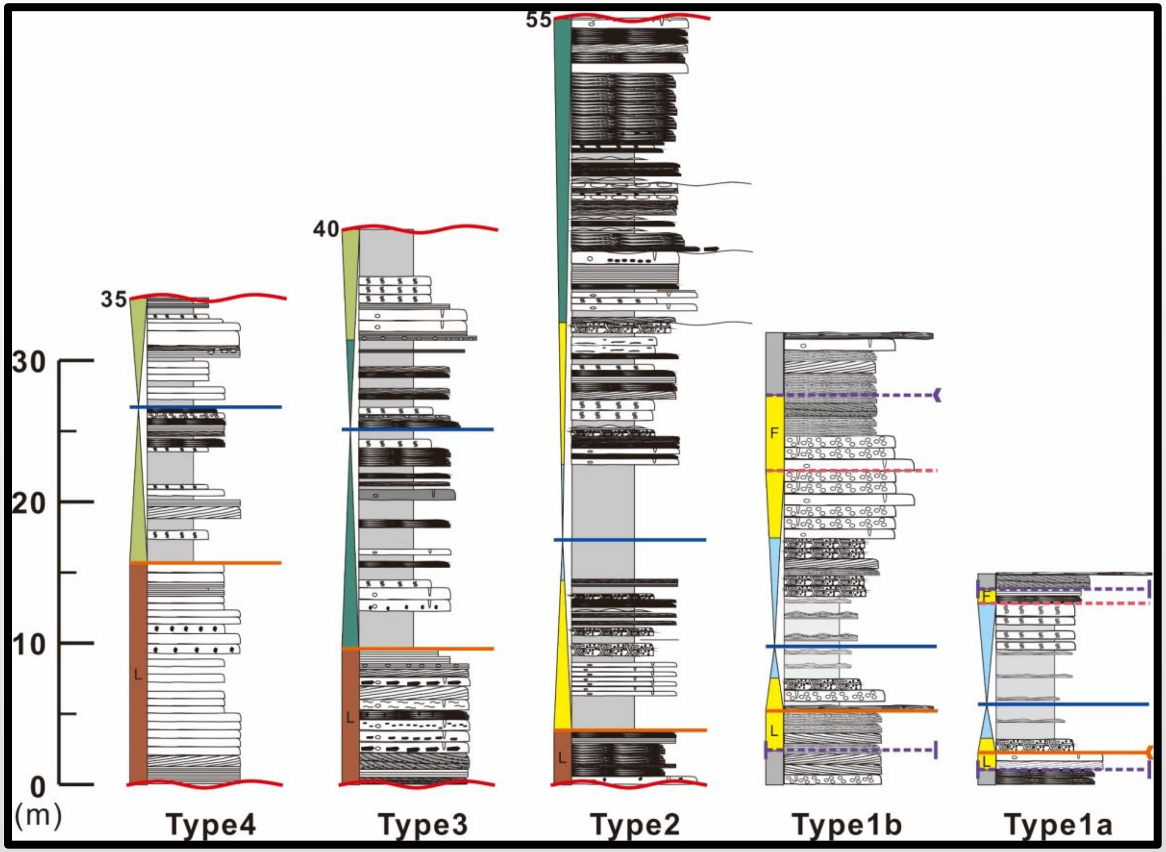
Trunk

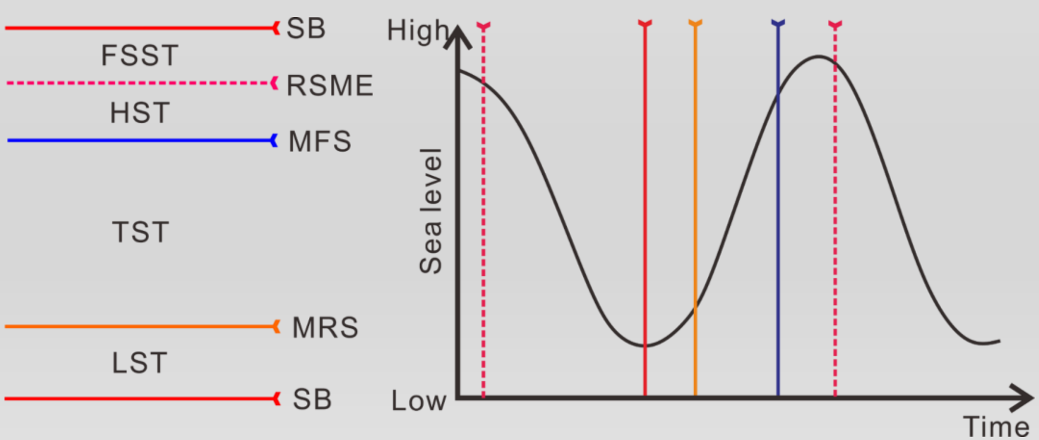
Facies association

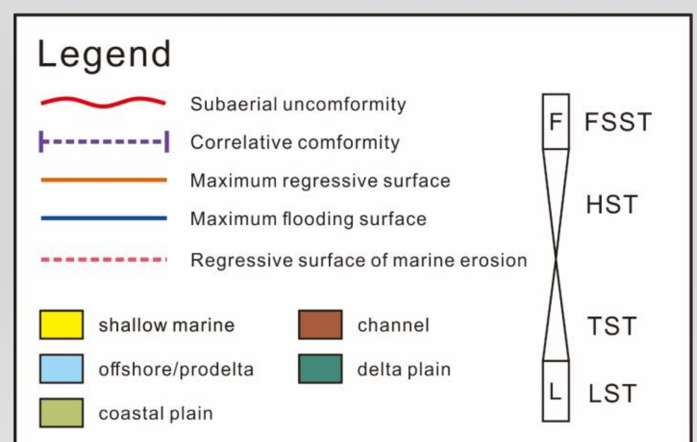
- 4 Types of depositional systems
  - Type1(2.55-1.82Ma): Tidal open coast
  - Type2(1.82-1.61Ma): Tidal-dominated delta (subaqueous)
  - Type3(1.61-1.24Ma): Tidal-dominated delta (subaerial)
  - Type4(1.24-0.53Ma): Coastal plain



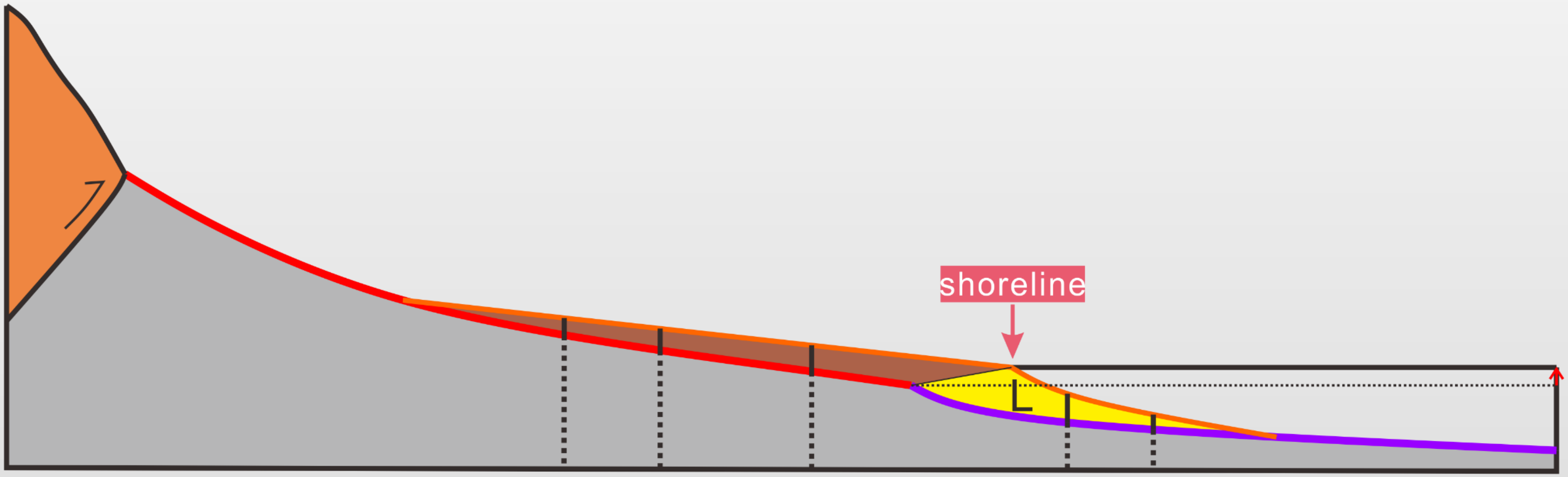


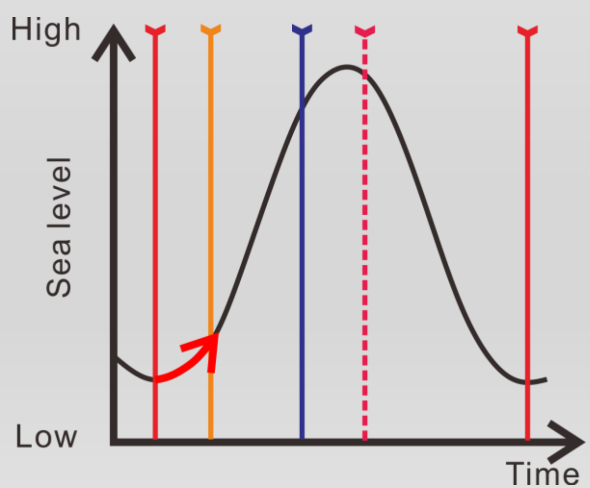

55
40
35
30
20
10
0
(m)
F
L
Type4
Type3
Type2
Type1b
Type1a

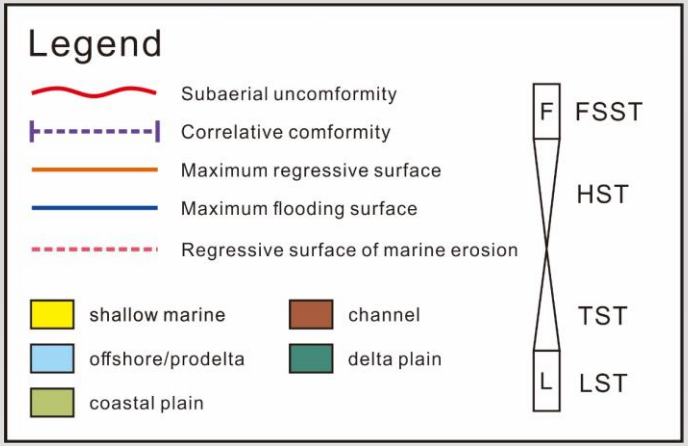

SB
FSST
RSME
HST
MFS
TST
MRS
LST
SB
High
Low
Sea level
Time


Legend
Subaerial uncomformity
Correlative comformity
Maximum regressive surface
Maximum flooding surface
Regressive surface of marine erosion
shallow marine
channel
offshore/prodelta
delta plain
coastal plain
F FSST
HST
TST
L LST

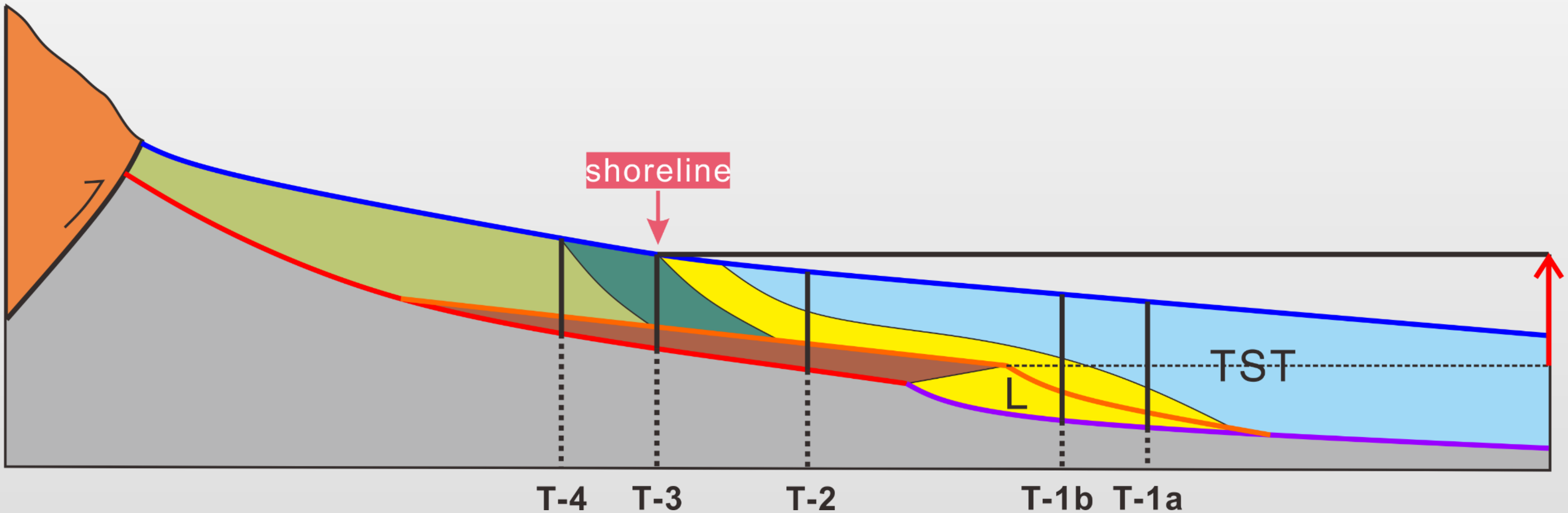
Lowstand system tract(LST)

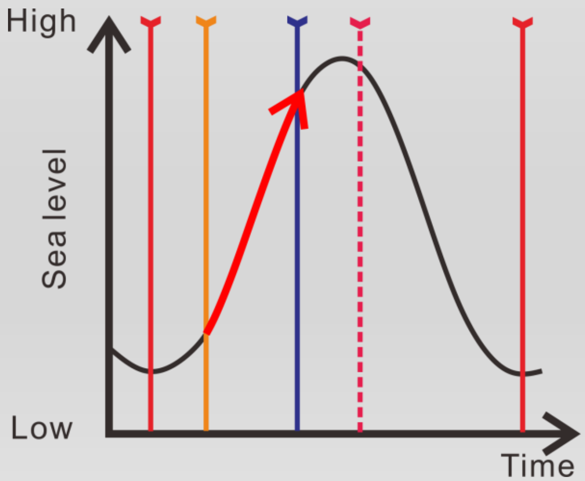


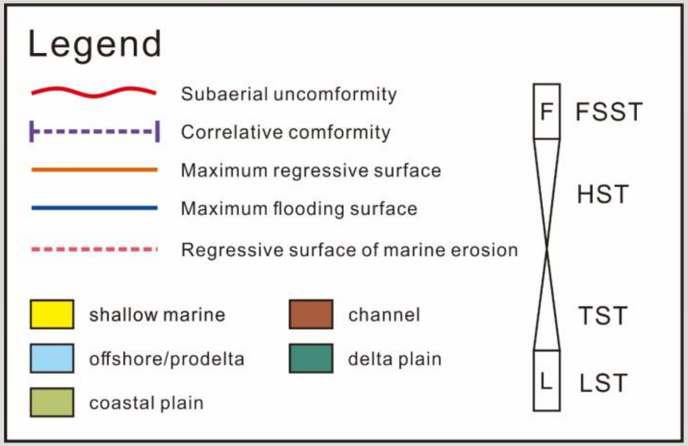




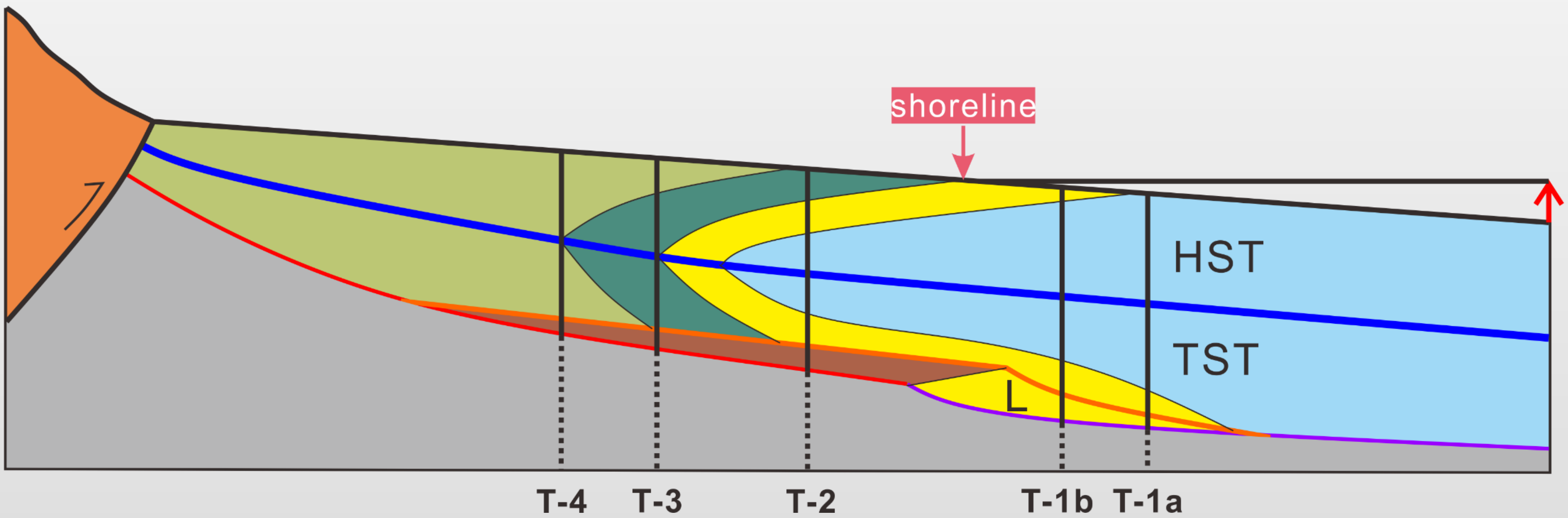
Transgressive system tract(TST)

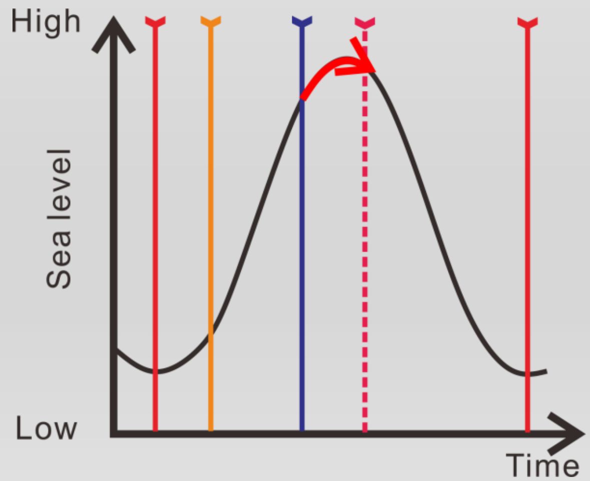


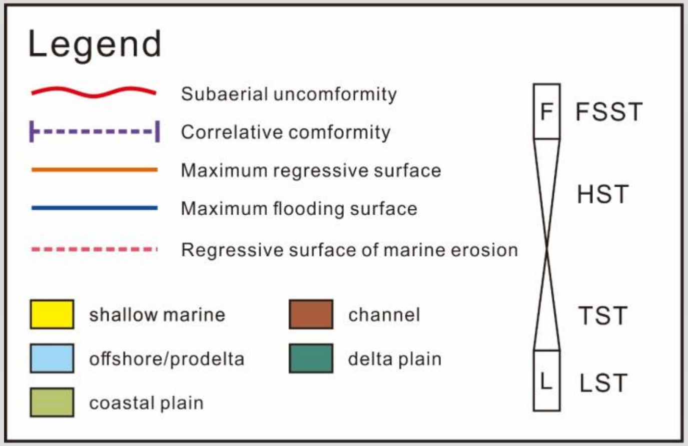




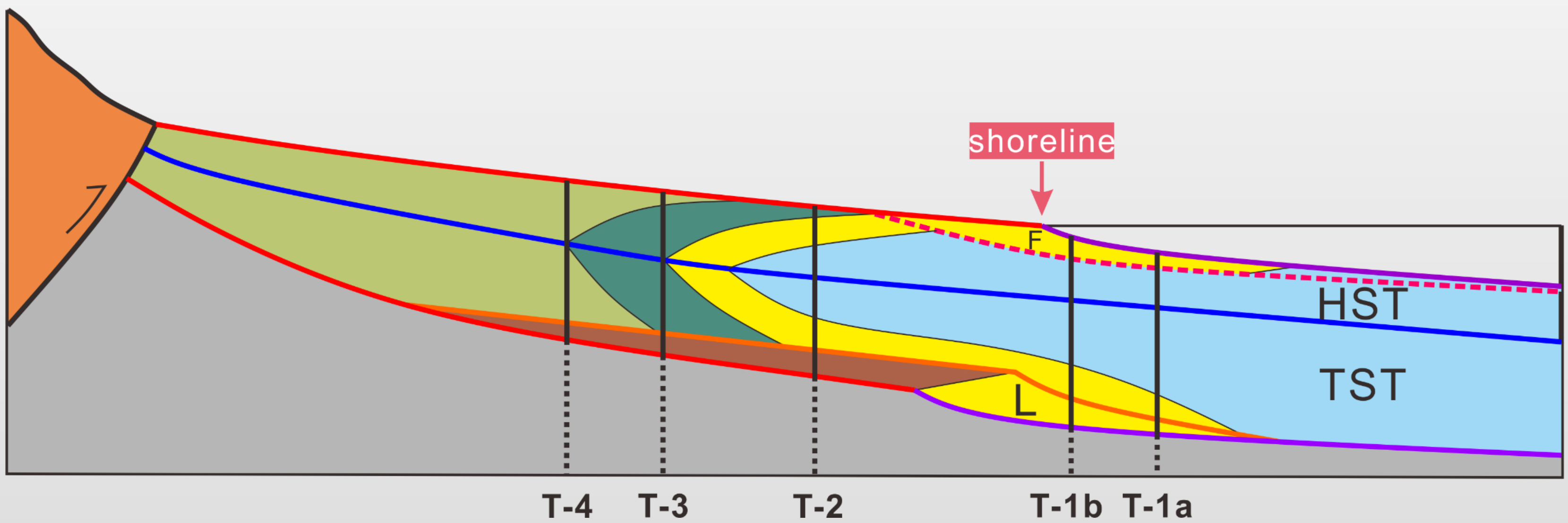
Highstand system tract(HST)

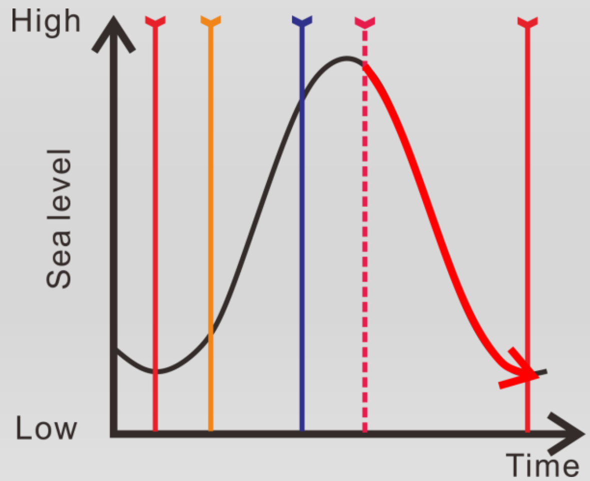


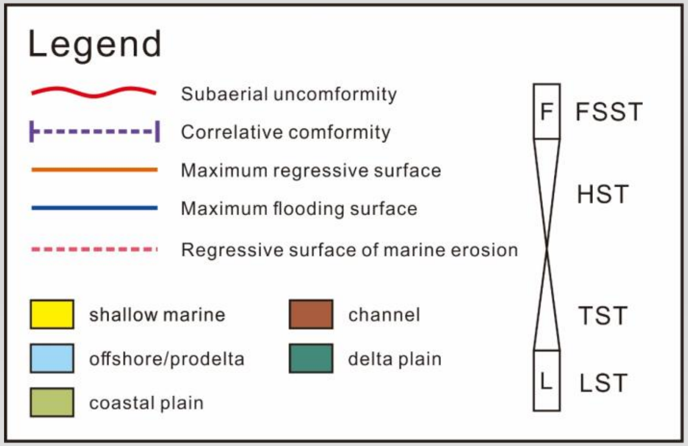




Falling-stage system tract(FSST)

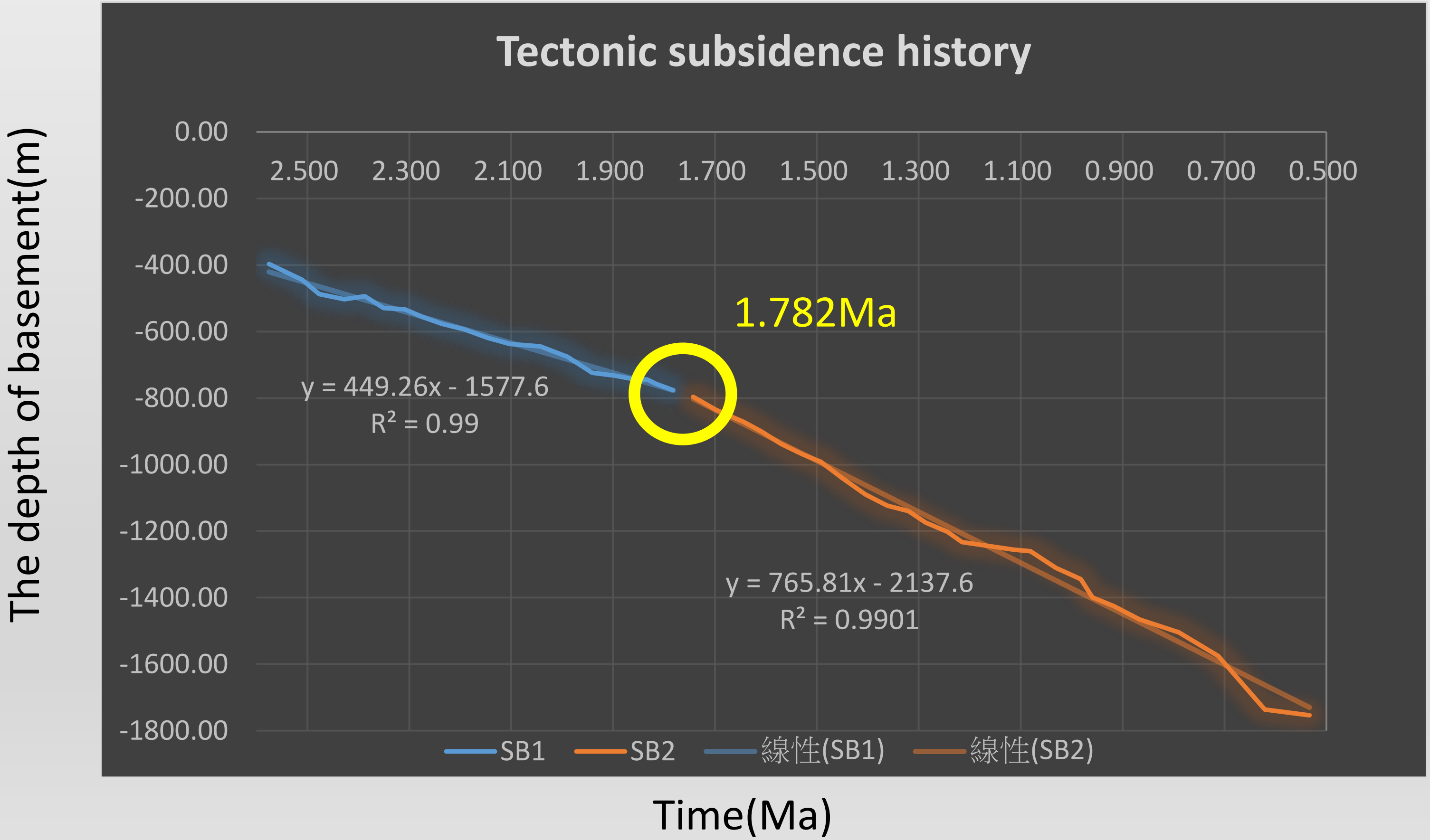






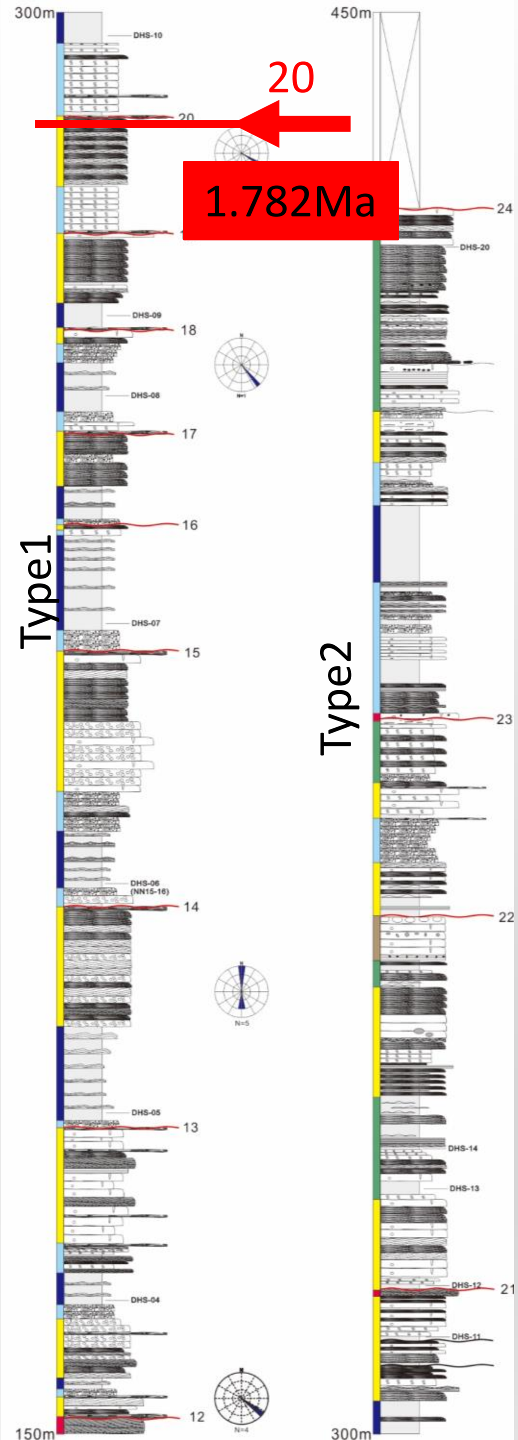
Tectonic subsidence history(long-term)

- 45 sequence boundary = 102 - 14 stage = 2.554 – 0.533Ma
- Paleo sea level = Miller et al.,2011
- Subsidence rate(鄭紹安, 2020, Allen and Allen., 2013)
  - 2.55-1.78Ma = 449.26 m/Ma
  - 1.78-0.53Ma = 765.81 m/Ma



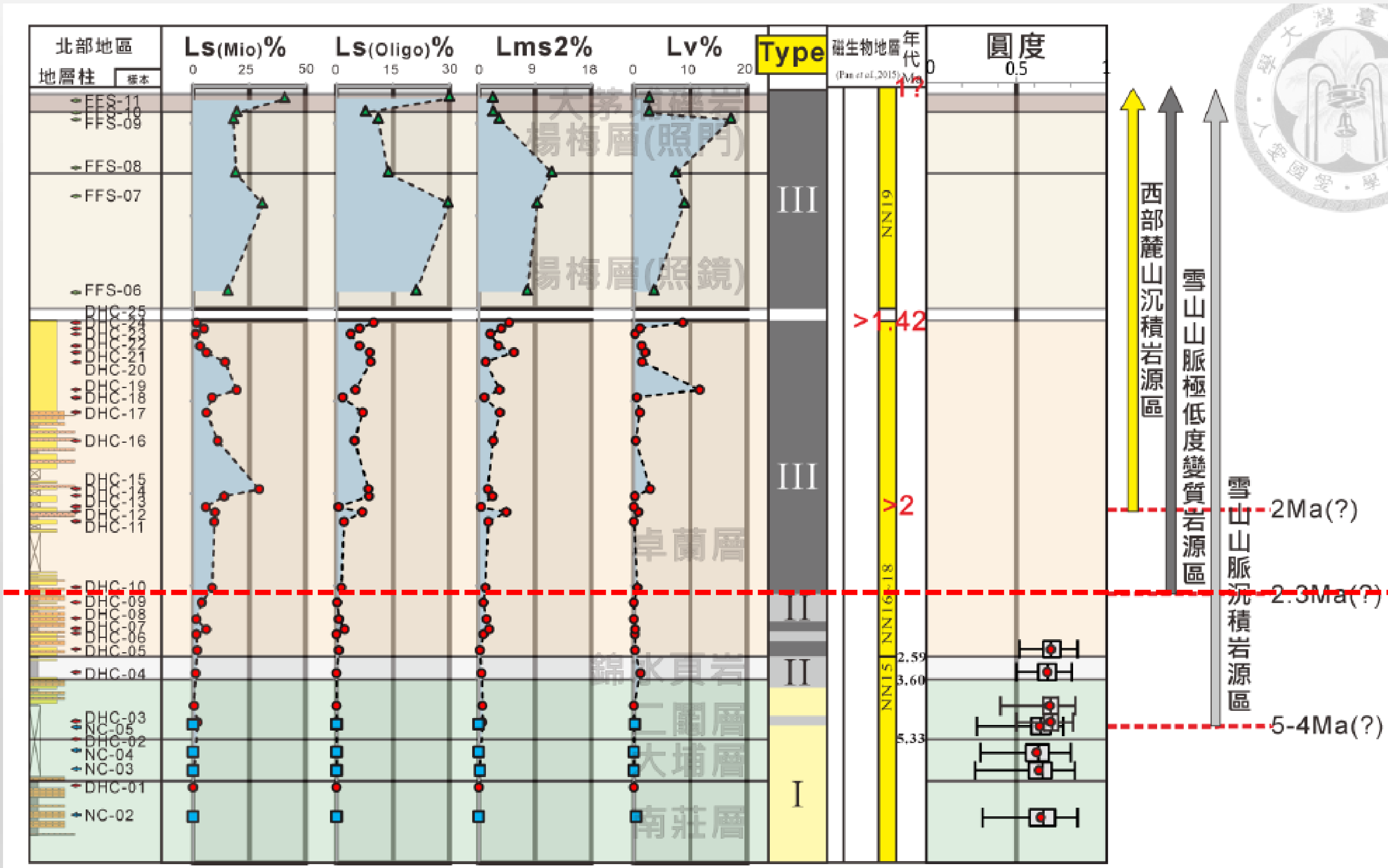
Why is in 1.78Ma?

- No.20 = stage 62 = 1.78Ma
- Sedimentation rate
  - Type1=378 (m/Ma)
  - Type2=750 (m/Ma)
- Subsidence rate
  - 449.25->765.81 (m/Ma)
- Acceleration:
  - Marine to nonmarine



The source of sediment

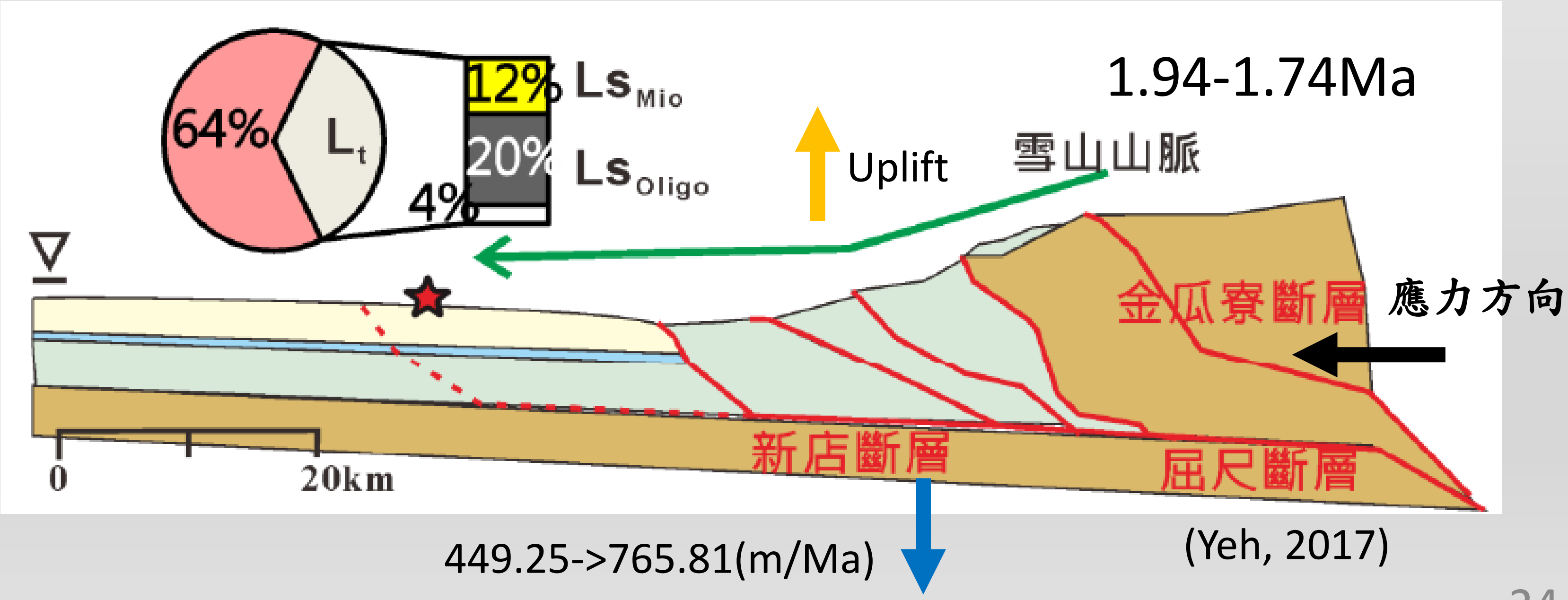
Lms2: Slate fragment
Lv: Igneous fragment



Ls(Mio): Sandstone fragment(Miocene) -> The Western Foothill (Yeh, 2017)
Ls(Oligo): Argillite fragment(Oligocene)-> Hsuhsang range

The uplife of The Western Foothill

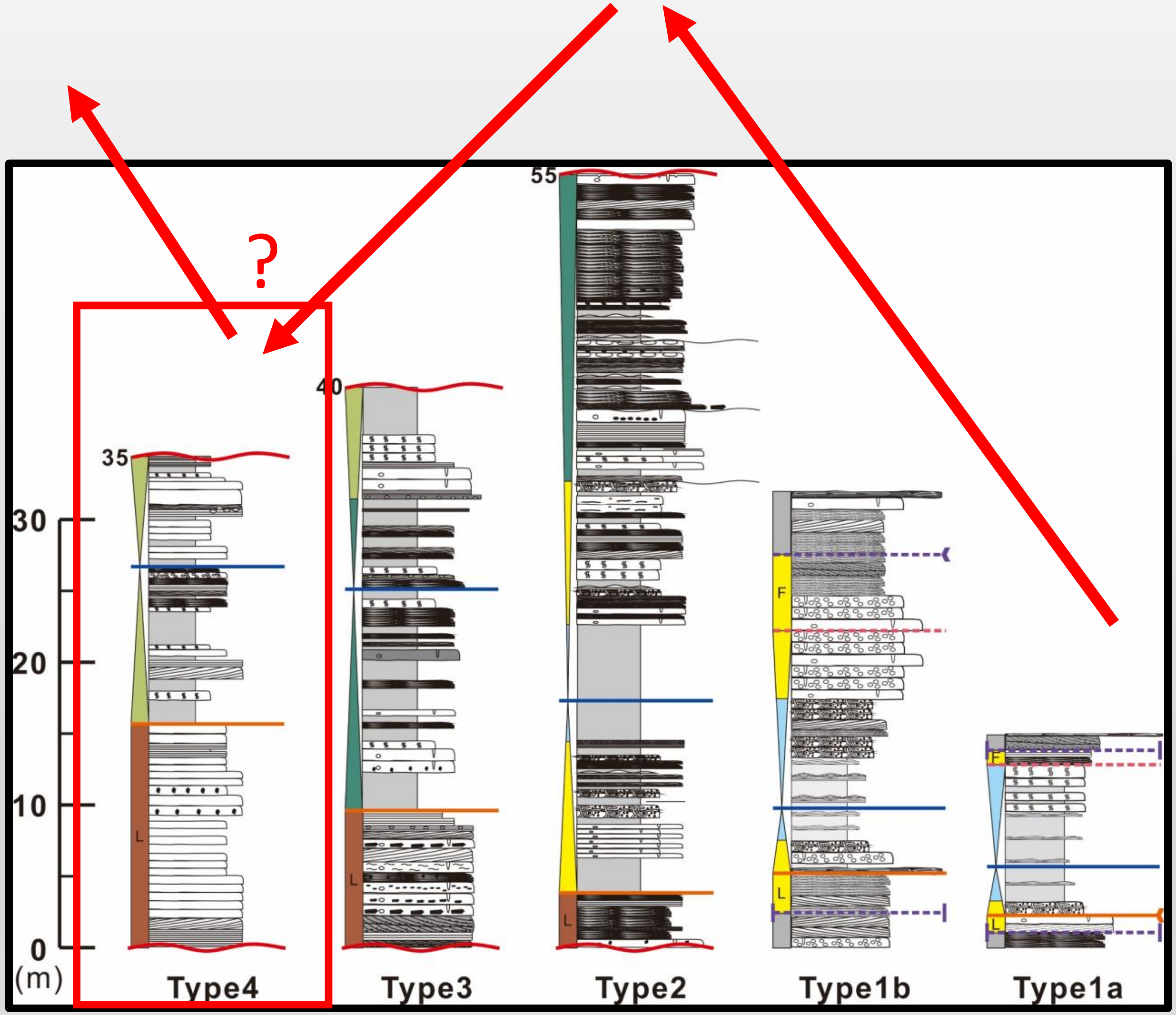
- North: 2.28±0.69-1Ma (Lock et al., 2007, Horng., 2014)
- 1.94-1.74Ma
  - The increase of sediment supply -> increase the loading on the plate -> increase subsidence rate



(Yeh, 2017)

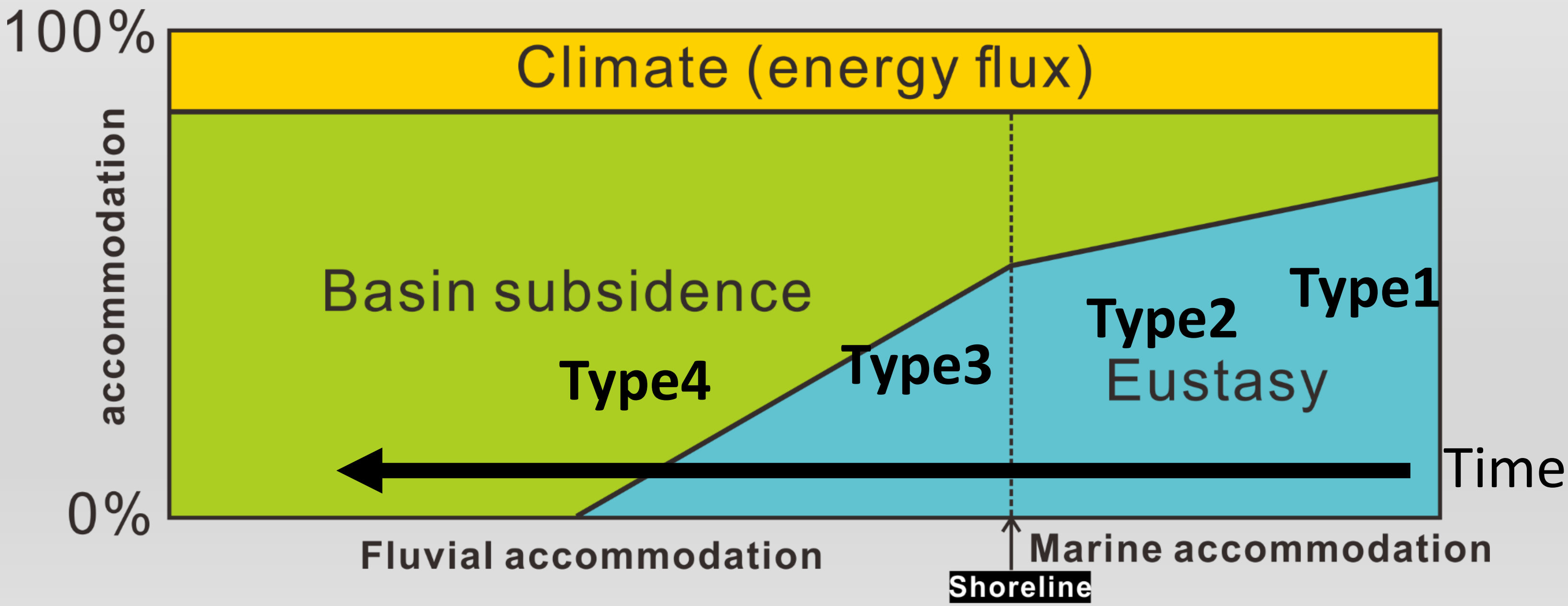
Accommodation v.s. Sedimentation(Short-term)

- Thickness:
  - Type 1: 10-30m
  - Type 2: 20-55m
  - Type 3: 40-50m
  - Type 4: 30-70m
- Total subsidence
  - Tyep 1
    - 449.25(m/Ma)
    - 41ky=18.4m
  - Type 2 –Type4
    - 765.81(m/Ma)
    - 41ky=31.4m
    - 100ky=76.5m



Accomodation – Sedimentation

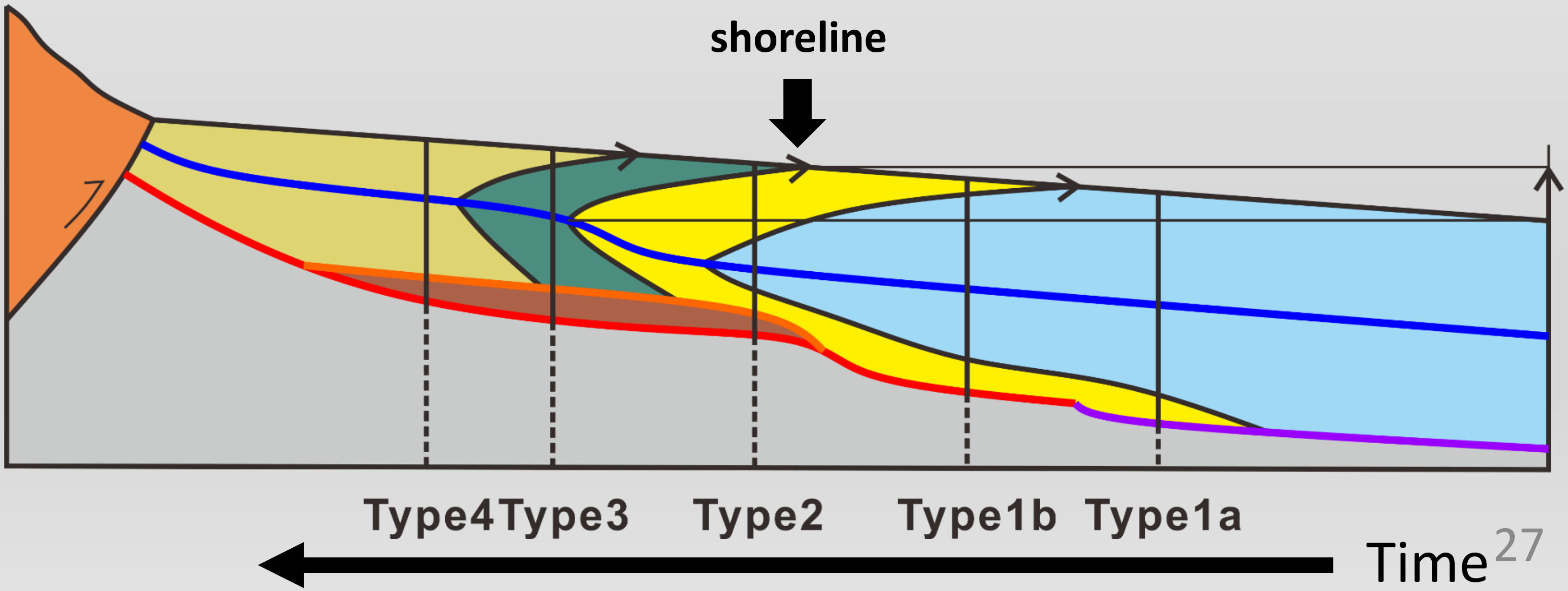
- Type3(1.61-1.24Ma)-Type 4(1.24-0.53Ma):
  - Accommodation: Basin subsidence rate (765.81m/Ma)
  - Floodplain -> High Sedimentation rate > 765.81 (m/Ma)
  - The increase thickness of parasequence(SB-SB)
    - The increase of sedimentation rate
    - The increase of time interval (41ky –> 100ky)



(Catuneanu., 2006)

Mechanism of accommodation and sedimentation

- Marine (Type 1 and Type2)
  - Accommodation <- sea level change
  - Sedimentation <- the distance of shoreline
- Fluvial (Type 3 and 4)
  - Accommodation <- tectonic subsidence
  - Sedimentation <- source (orogeny uplift)
  - Sea level change -> downcutting -> SB-A



Conclusion

- 19 lithofacies
- 4 Types of depositional system and sequence stratigraphy
- The tectonic subsidence rate
  - Type 1 = 449.26 (m/Ma)
  - Type 2-4 = 765.81 (m/Ma)
- The uplife of The western Foothill
  - 1.941-1.743 Ma
    - The increase of sedimentation rate
    - The increase of subsidence rate
    - The acceleration of marine to nonmarine

Reference

- Allen, P. A., & Allen, J. R. (2013). *Basin analysis: Principles and application to petroleum play assessment*: John Wiley & Sons.
- Catuneanu, O. (2006). *Principles of sequence stratigraphy*: Elsevier.
- Catuneanu, O. (2019). Model-independent sequence stratigraphy. *Earth-Science Reviews, 188*, 312-388. doi:10.1016/j.earscirev.2018.09.017
- Catuneanu, O., Abreu, V., Bhattacharya, J. P., Blum, M. D., Dalrymple, R. W., Eriksson, P. G., . . . Winker, C. (2009). Towards the standardization of sequence stratigraphy. *Earth-Science Reviews, 92*(1-2), 1-33. doi:10.1016/j.earscirev.2008.10.003
- Chen, W.-S., Ridgway, K. D., Horng, C.-S., Chen, Y.-G., Shea, K.-S., & Yeh, M.-G. (2001). Stratigraphic architecture, magnetostratigraphy, and incised-valley systems of the Pliocene-Pleistocene collisional marine foreland basin of Taiwan. *GSA bulletin, 113*(10), 1249-1271.
- Dalrymple, R. W., & Choi, K. (2007). Morphologic and facies trends through the fluvial–marine transition in tide-dominated depositional systems: A schematic framework for environmental and sequence-stratigraphic interpretation. *Earth-Science Reviews, 81*(3-4), 135-174. doi:10.1016/j.earscirev.2006.10.002
- Lisiecki, L. E., & Raymo, M. E. (2005). A Pliocene-Pleistocene stack of 57 globally distributed benthic δ18O records. *Paleoceanography, 20*(1), n/a-n/a. doi:10.1029/2004pa001071
- Miller, K., Mountain, G., Wright, J., & Browning, J. (2011). A 180-Million-Year Record of Sea Level and Ice Volume Variations from Continental Margin and Deep-Sea Isotopic Records. *Oceanography, 24*(2), 40-53. doi:10.5670/oceanog.2011.26
- Naish, T., & Kamp, P. J. J. (1997). Sequence stratigraphy of sixth-order (41 k.y.) Pliocene–Pleistocene cyclothems, Wanganui basin, New Zealand: A case for the regressive systems tract. *Geological Society of America Bulletin, 109*(8), 978-999. doi:10.1130/0016-7606(1997)109<0978:Ssosok>2.3.Co;2
- Pan, T.-Y., Lin, A. T.-S., & Chi, W.-R. (2015). Paleoenvironments of the evolving Pliocene to early Pleistocene foreland basin in northwestern Taiwan: An example from the Dahan River section. *Island Arc, 24*(3), 317-341. doi:10.1111/iar.12113
- 葉家志 (2017). *晚中新世以來沉積岩岩象分析探討臺灣中北部山脈剝蝕歷史= Petrographic study of the miocene-pleistocene sandstone in the western foothills, northern taiwan: implication for the unroofing history of taiwan orogenic belt / 葉家志(Jia-Jhih Yeh)撰*: 碩士論文--國立臺灣大學地質科學研究所.


Thank you for attention