



ENSO may have contributed to sea level changes in the Gulf of Thailand during the late Holocene

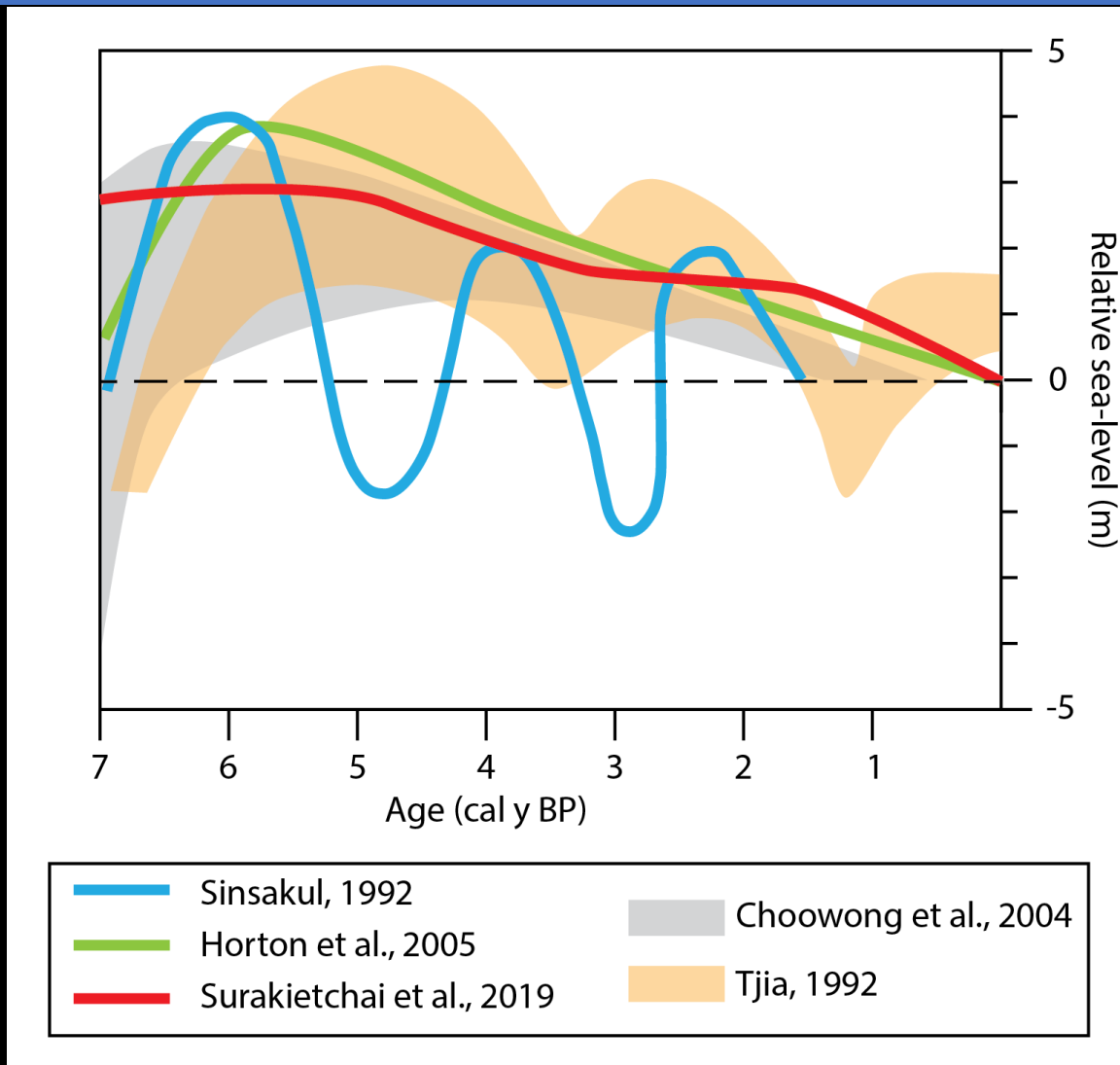
by

Akkaneewut Jirapinyakul, Worakamon Nudnara, Paramita
Punwong, Robin Nohall, Apichaya Englong, Chawisa
Phujareanchaiwon, Kweku Afrifa Yamoah, Montri Choowong

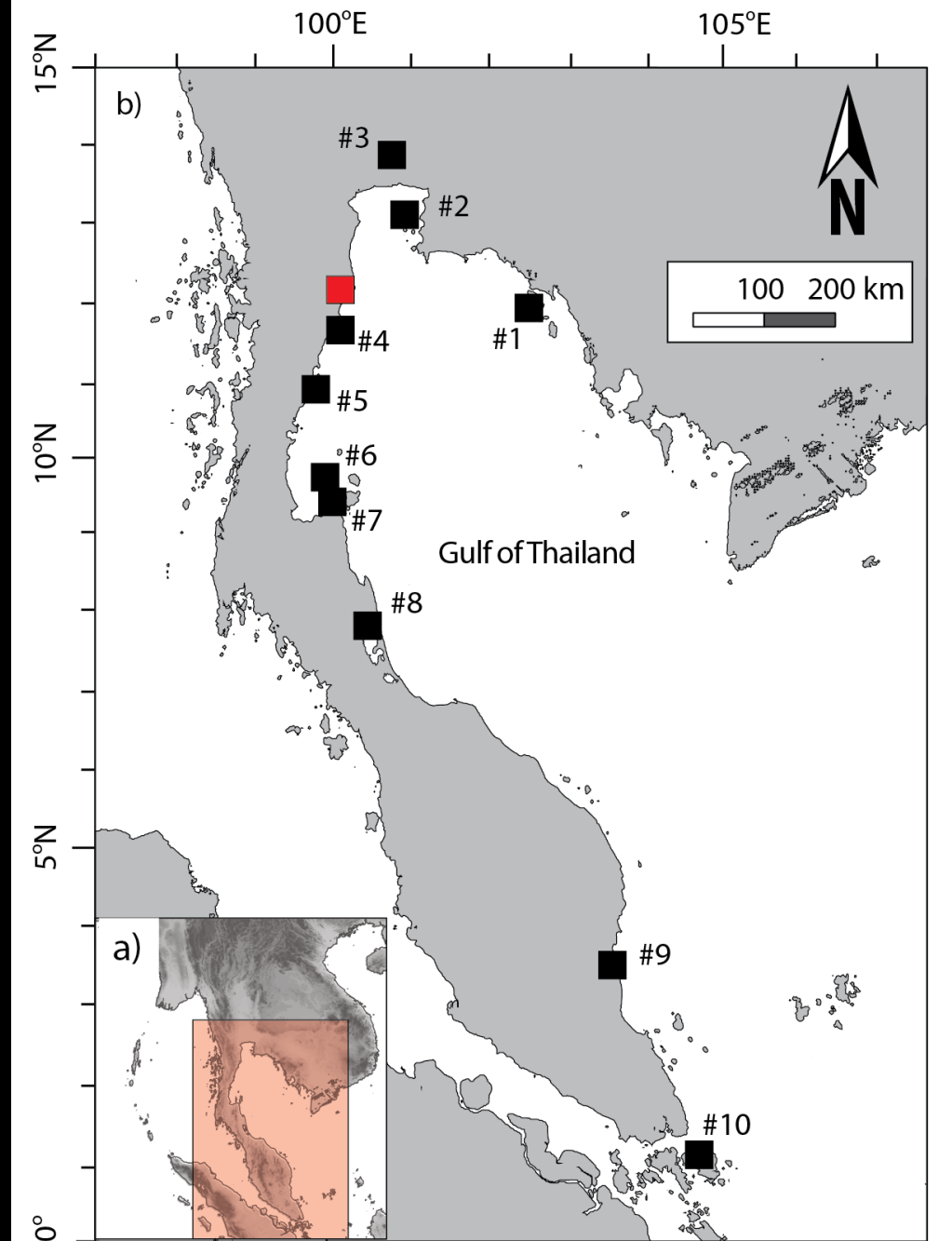
submitted to the Holocene

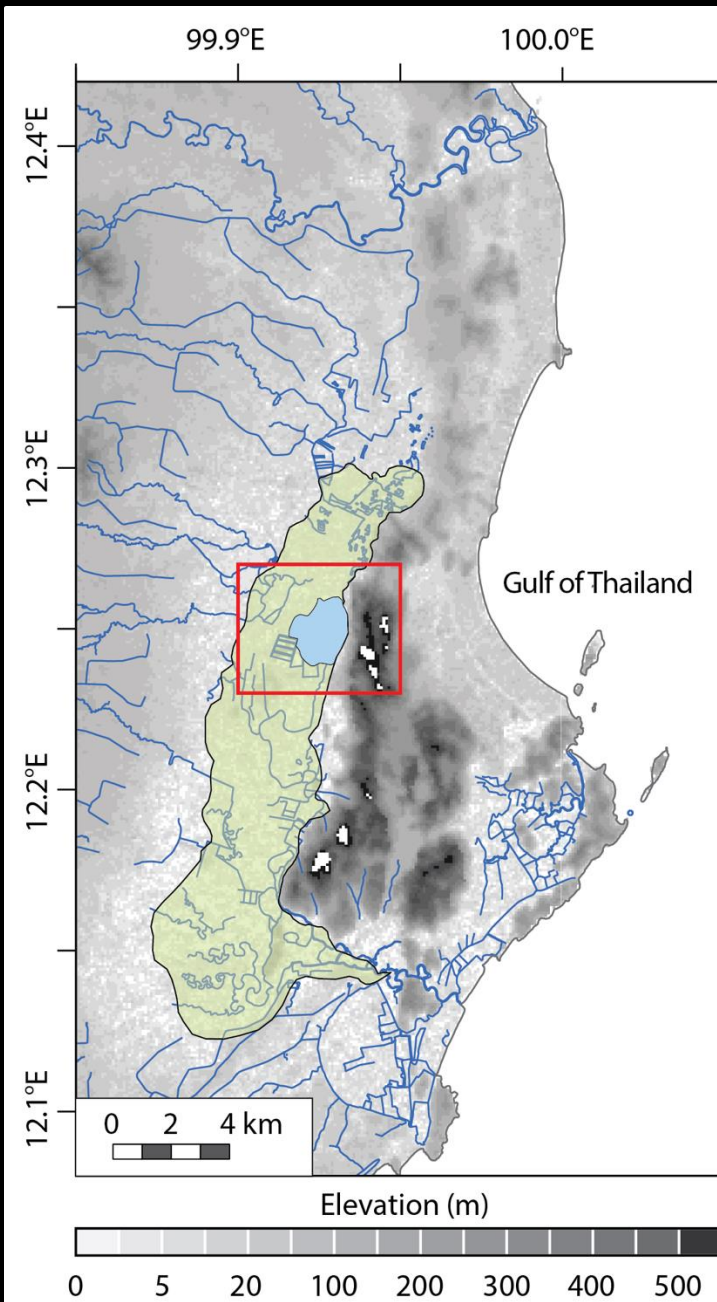


- The Gulf of Thailand is a shallow sea bordering the eastern part of the Southeast Asian Mainland.
- The Gulf of Thailand is considered a far-field site and tectonically stable over the Holocene epoch and will thus not require glacial isostatic and tectonic adjustments.
- These all together makes its is an ideal location to study RSL fluctuations (e.g., Horton et al., 2005; Hanebuth et al., 2011; Chabangborn and Wohlfarth, 2014; Oliver and Terry, 2019 Chabangborn et al., 2020).

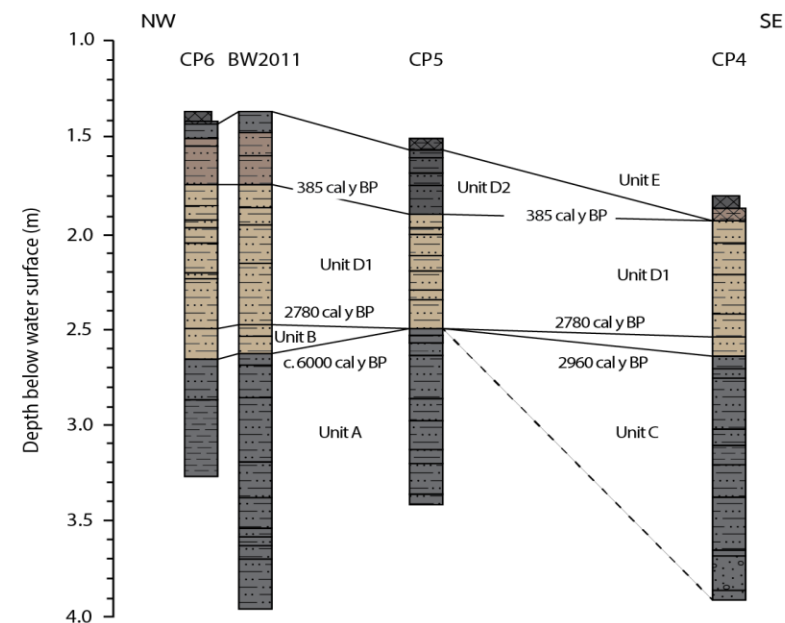
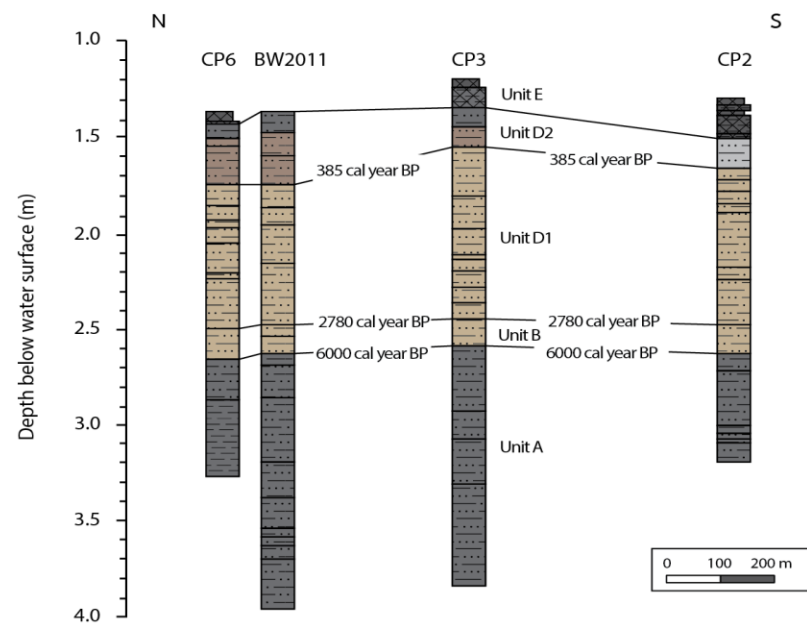
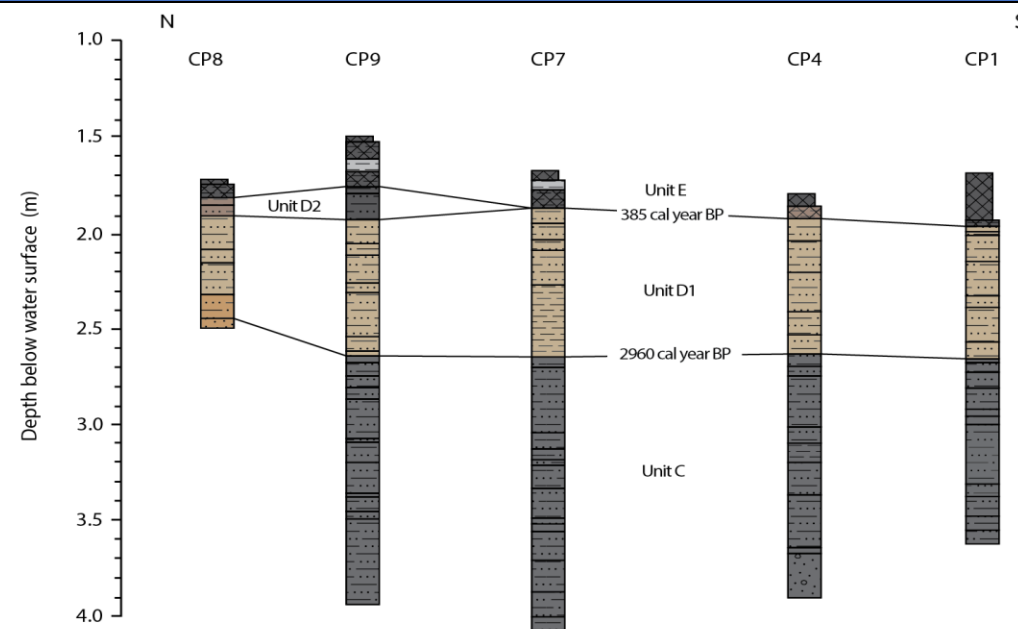
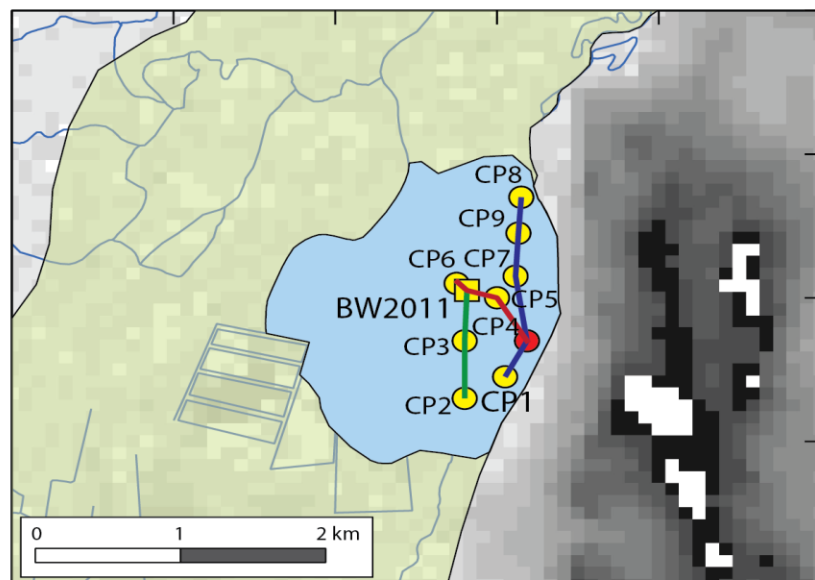


Sea-level curves and envelopes based on records in the Gulf of Thailand (GoT) and Thai-Malay Peninsular redraw from Sinsakul (1992), Tjia (1992), Choowong et al. (2004), Horton et al. (2005), and Surakietchai et al. (2019).

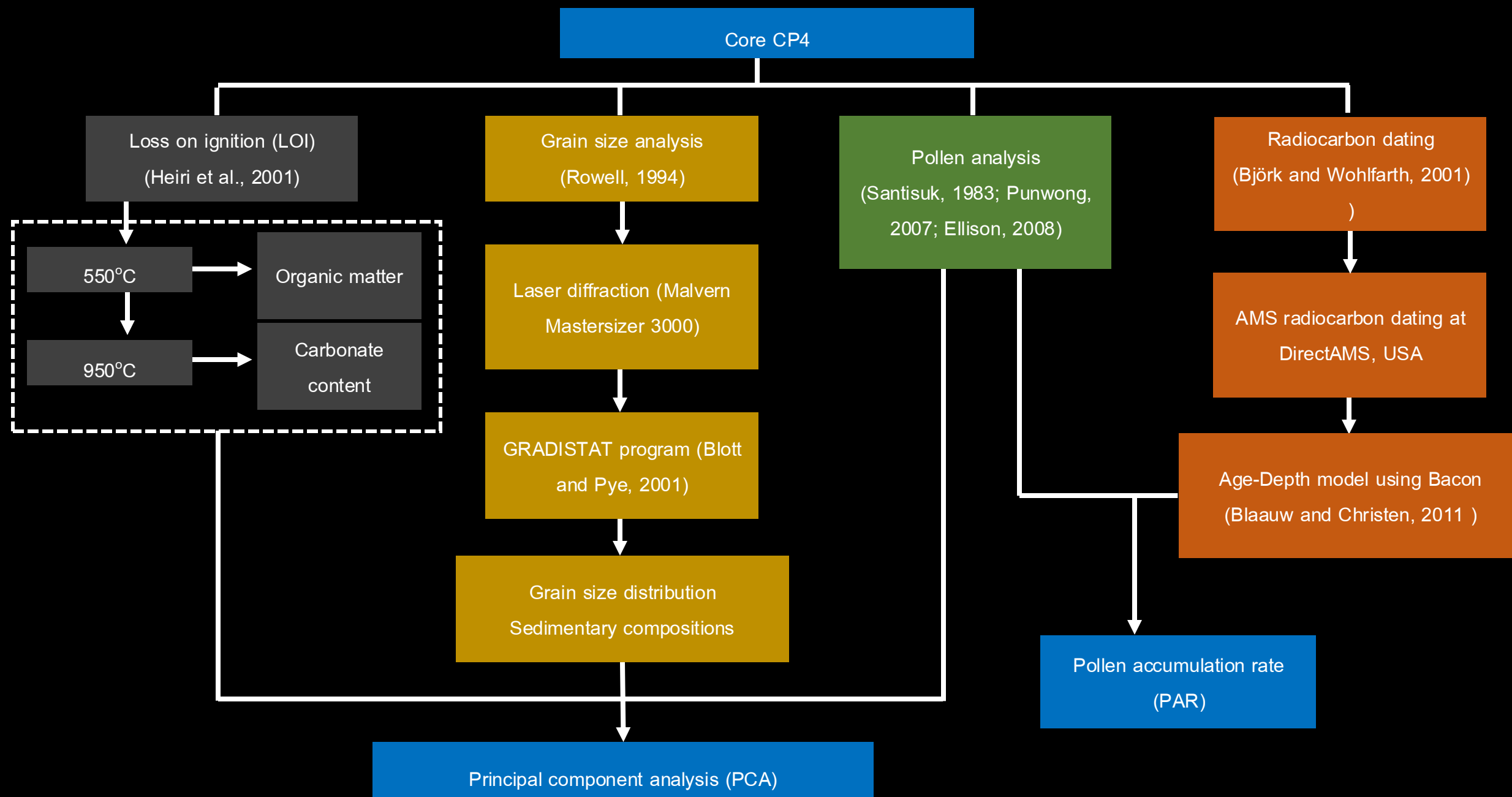


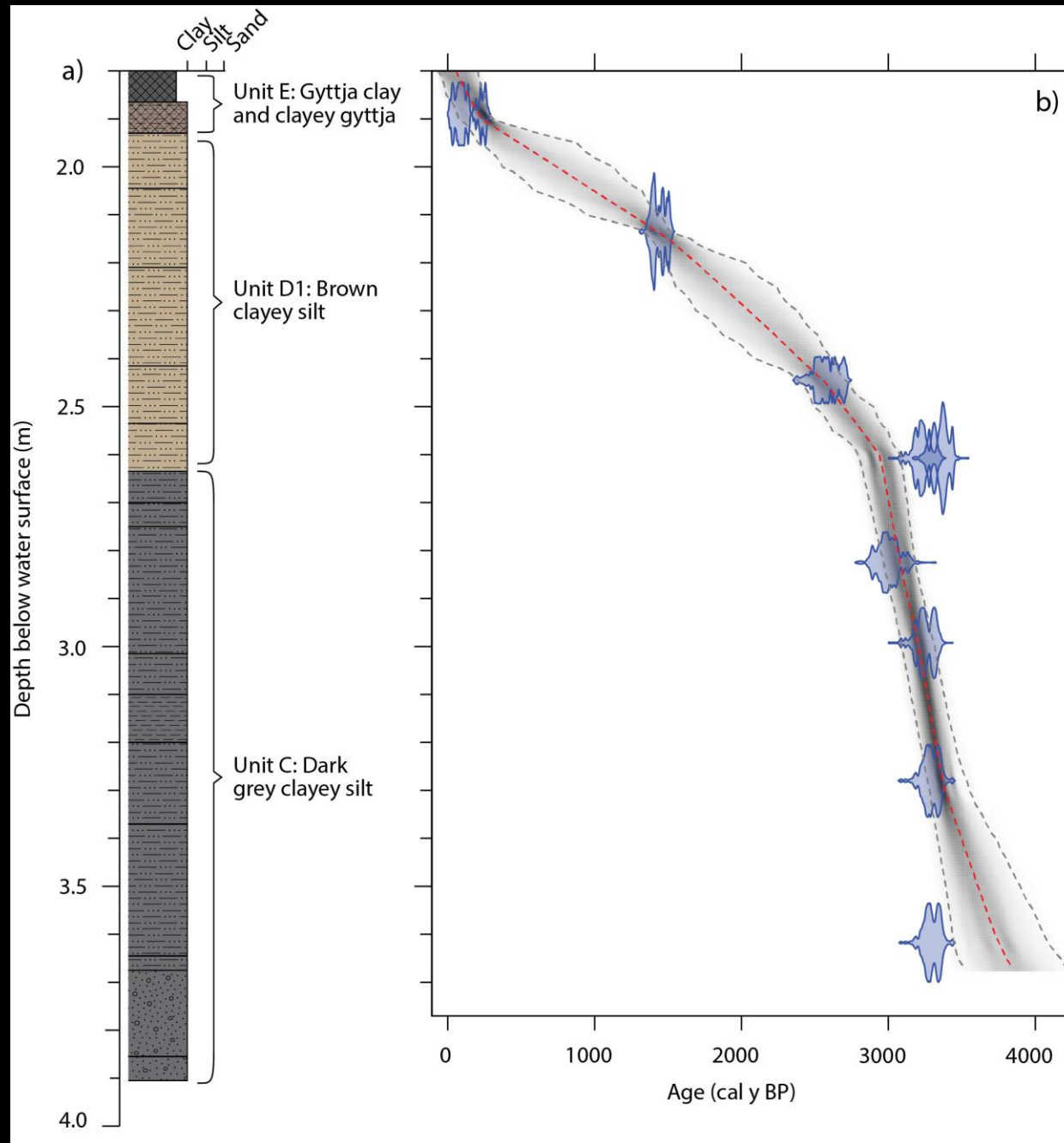


The Sam Roi Yot national park covers an area of approximately 98.8 km² and can be divided into wetland, limestone mountain range, and coastal plain from west to east based on their geomorphology (Koskelainen, 2014; Surakiatchai et al., 2018).

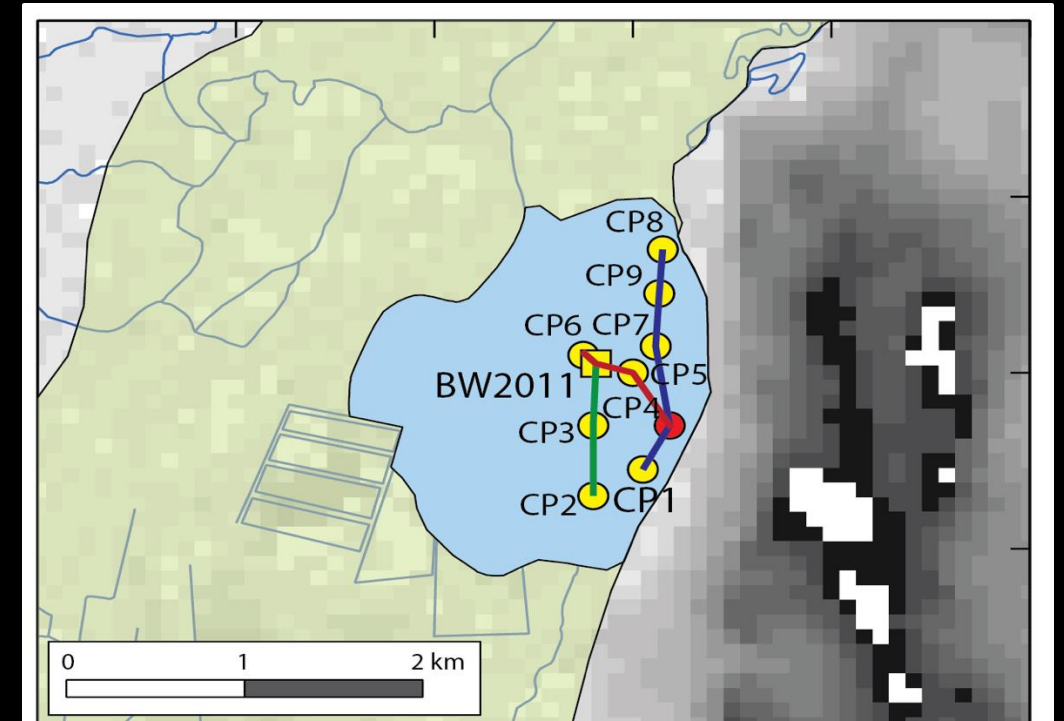


Gyttja
 Gyttja clay
 Clayey silt
 Clayey silt with gravels

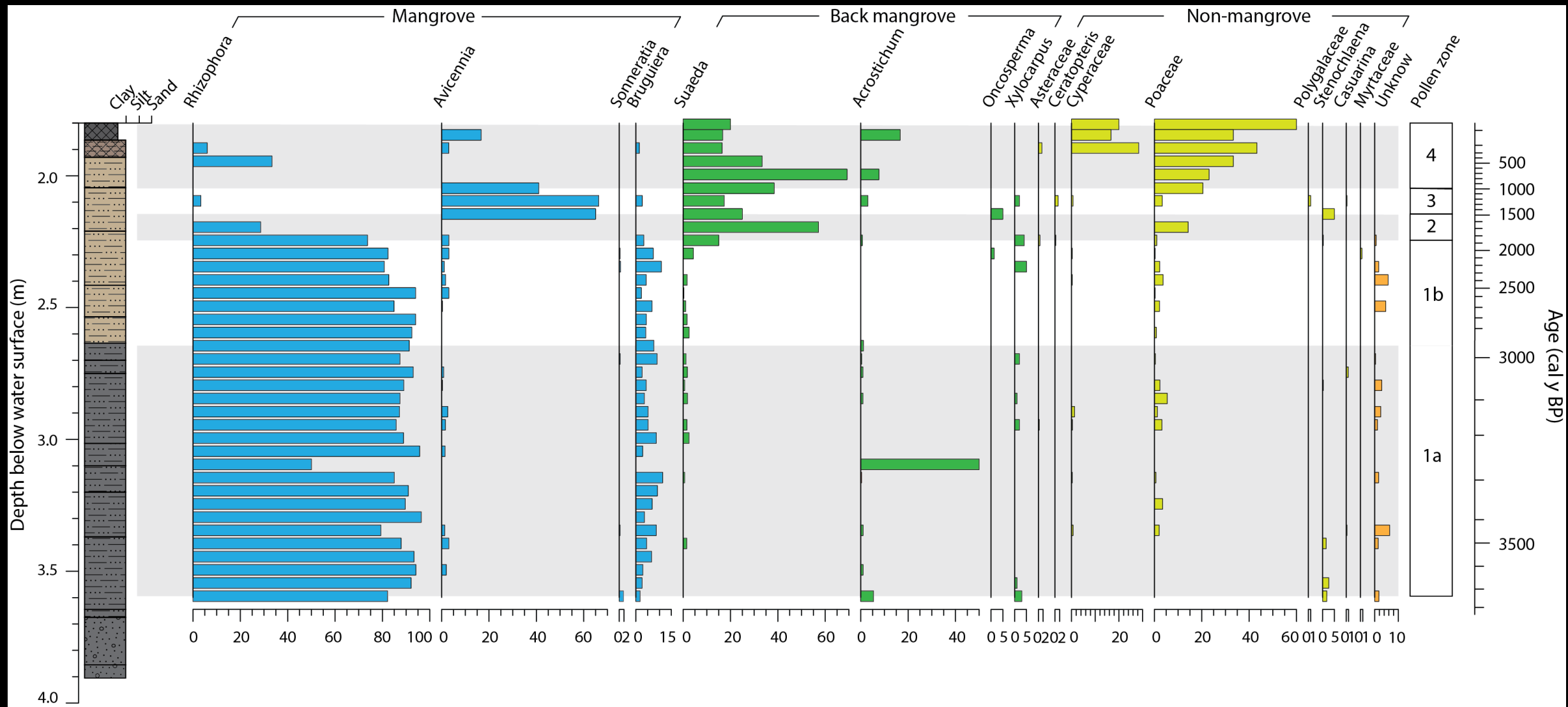




(a) Lithostratigraphy and (b) age-depth model constructed by Bacon (Blaauw and Christen, 2011) for core CP4

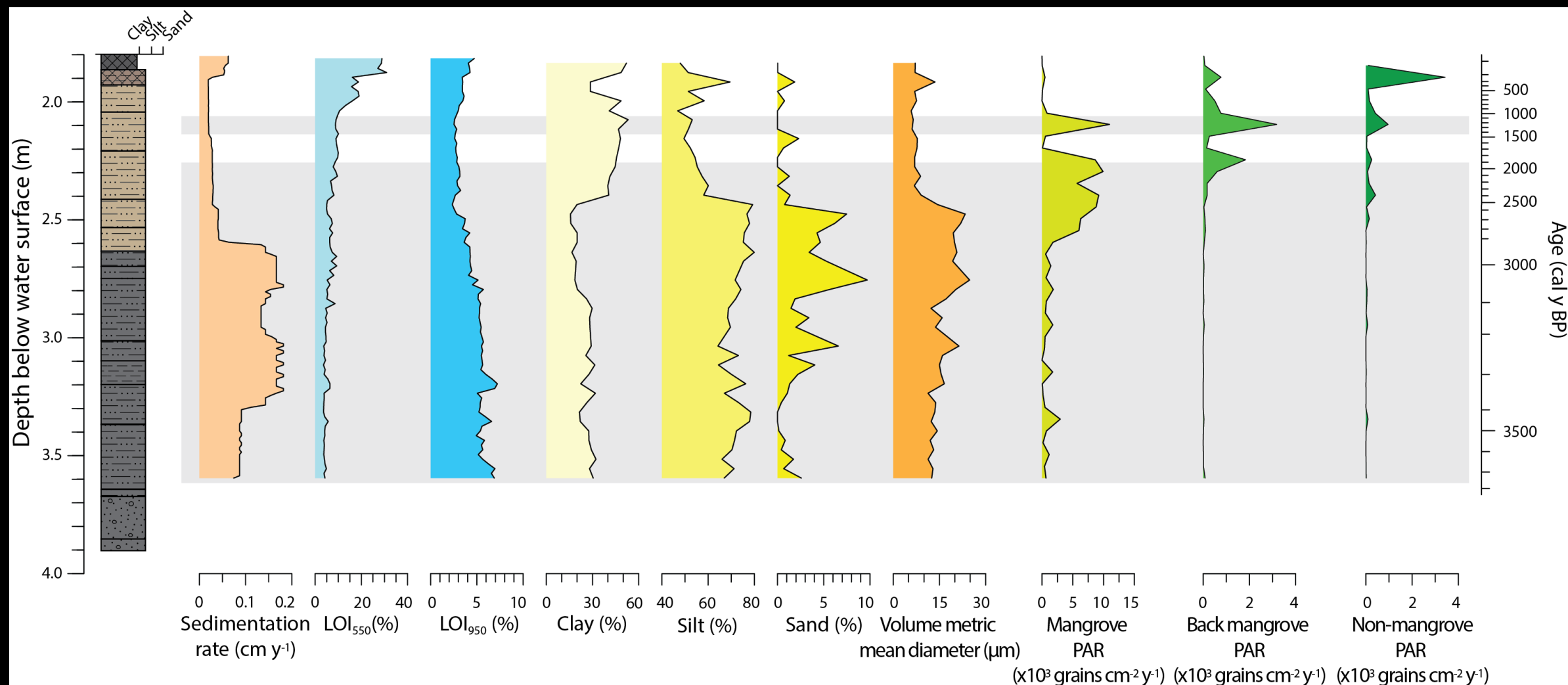


Core CP4 was dated using nine radiocarbon measurements of charcoal, with a range of c. 3750 to 60 cal y BP.

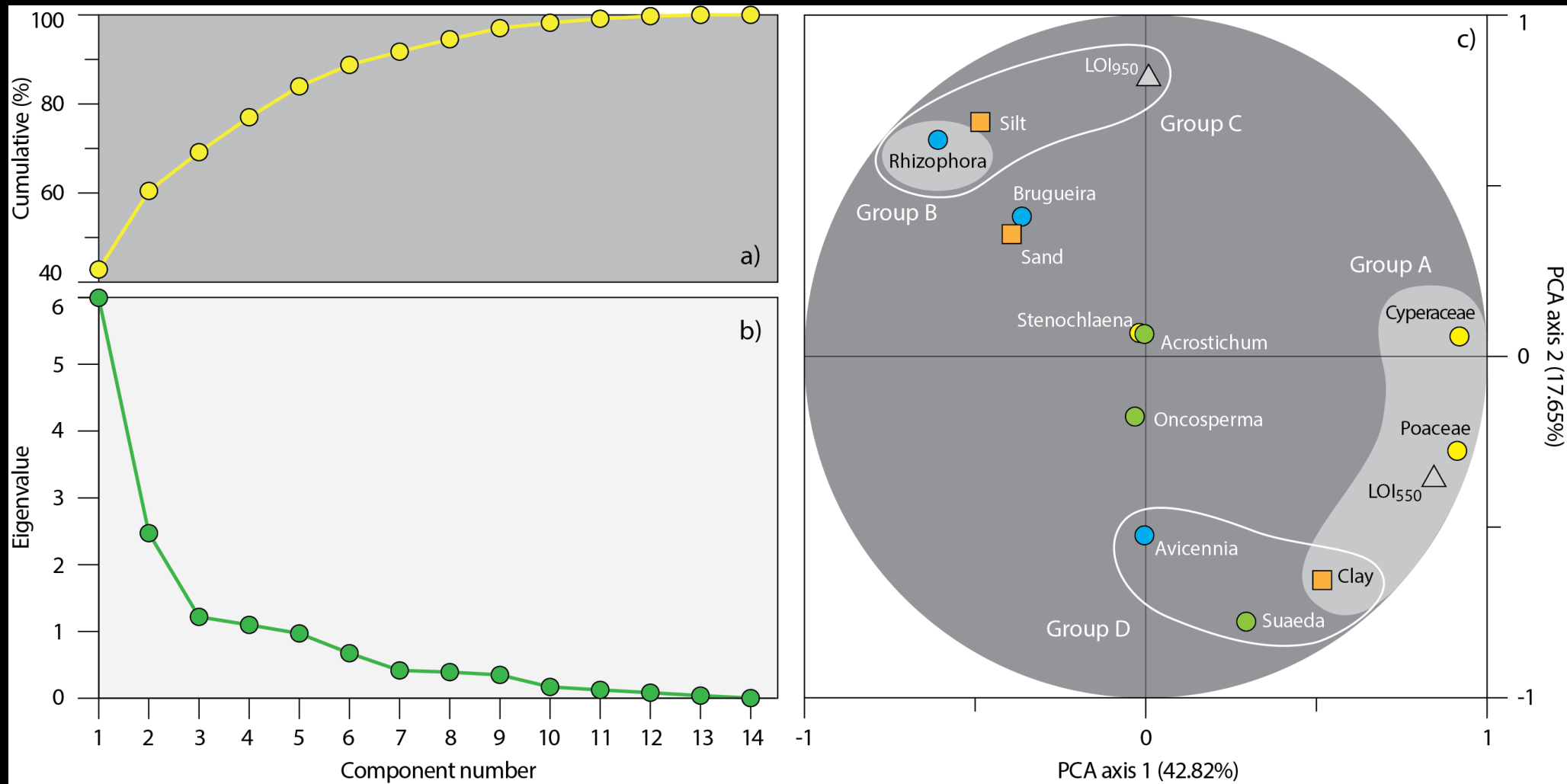


Pollen percentage diagram of sediment sequence CP4, divided into four pollen zones based on the percentages of the major pollen taxa

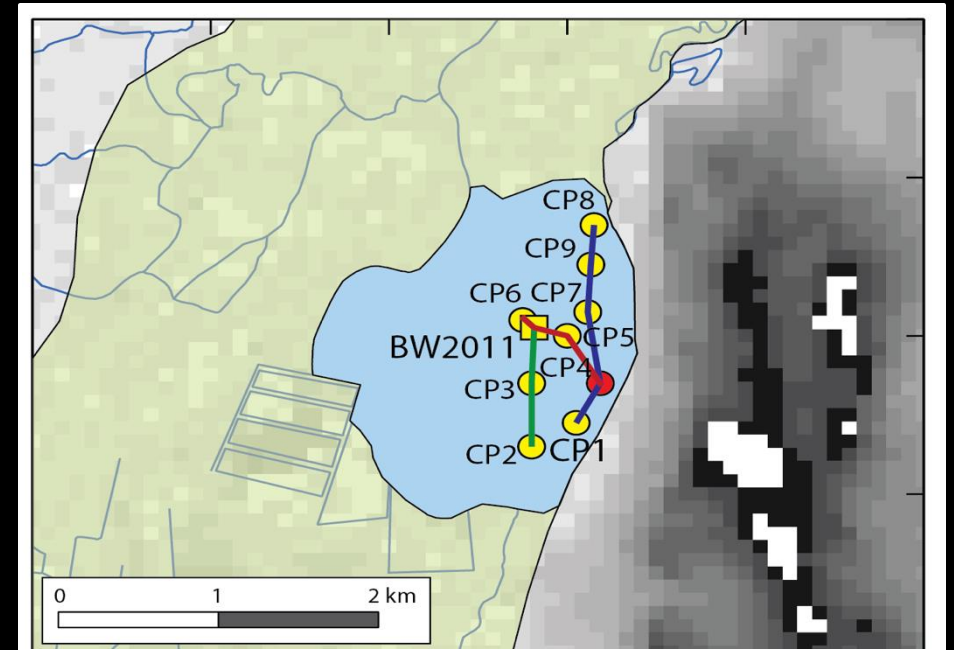
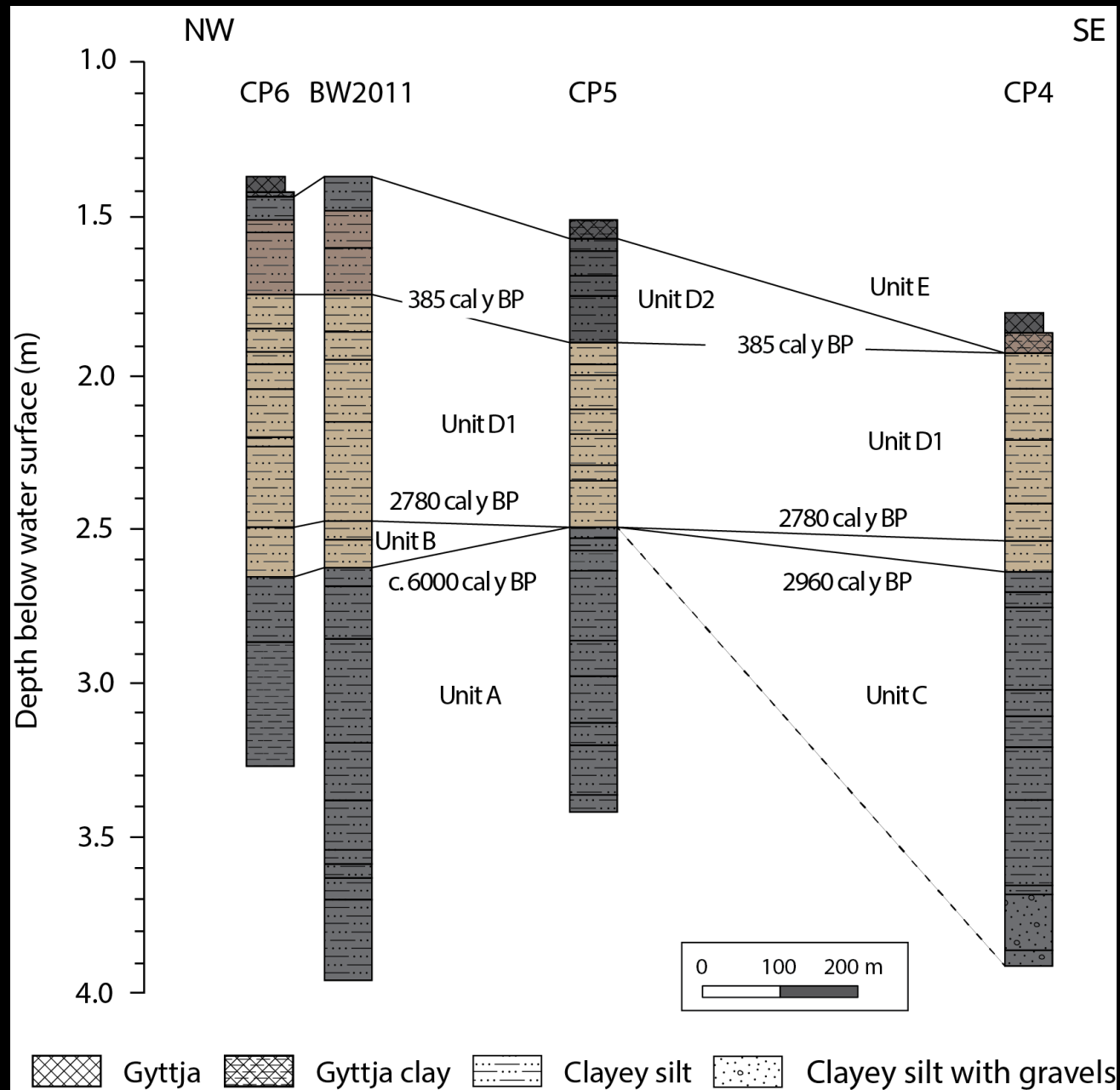




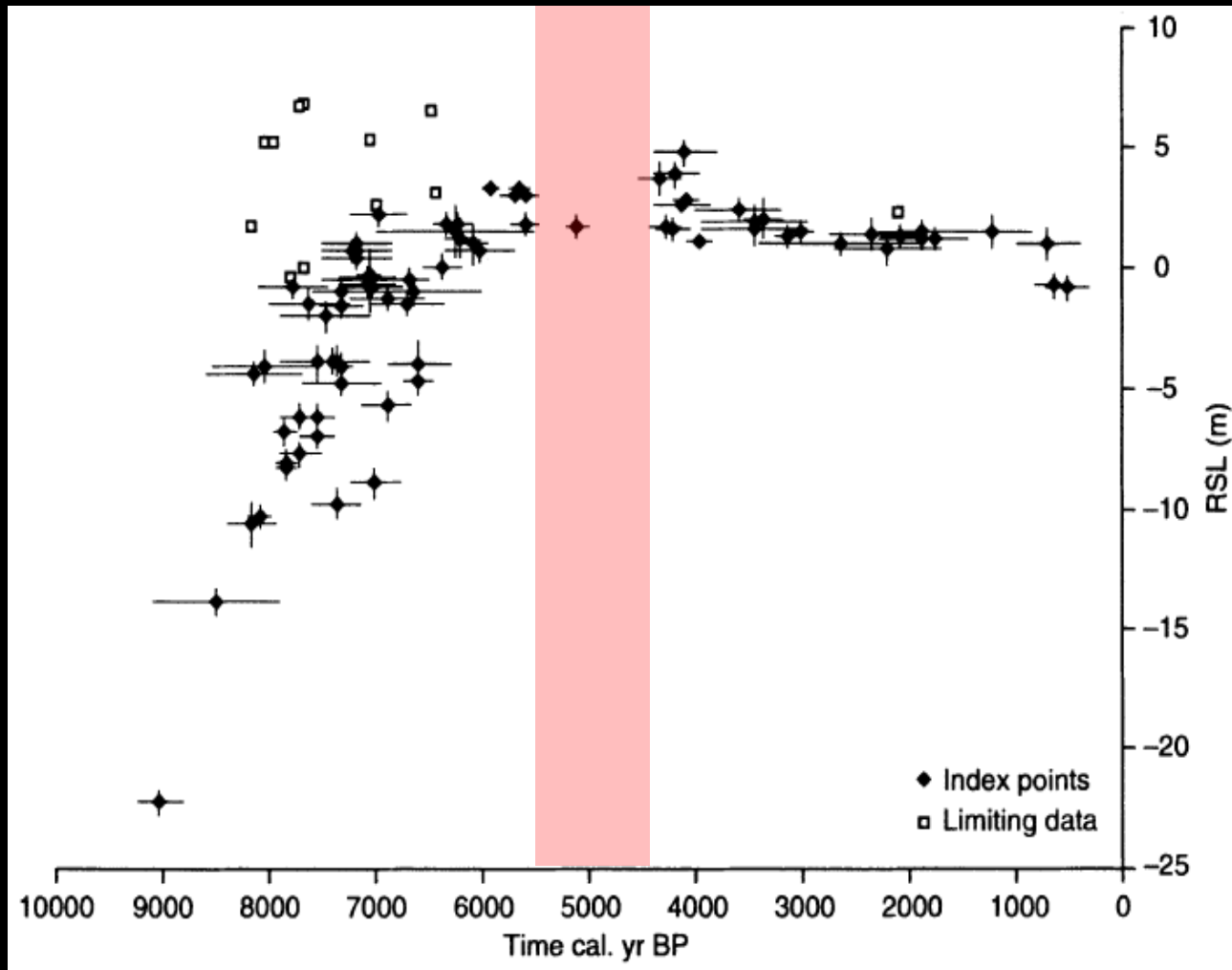
Lithostratigraphy, sedimentation rate, LOI at 550 and 950 $^{\circ}\text{C}$, the percentage of clay, silt, and sand fractions, grain size distribution, and mangroves, back mangroves, and mangrove associates pollen accumulation rate (PAR).



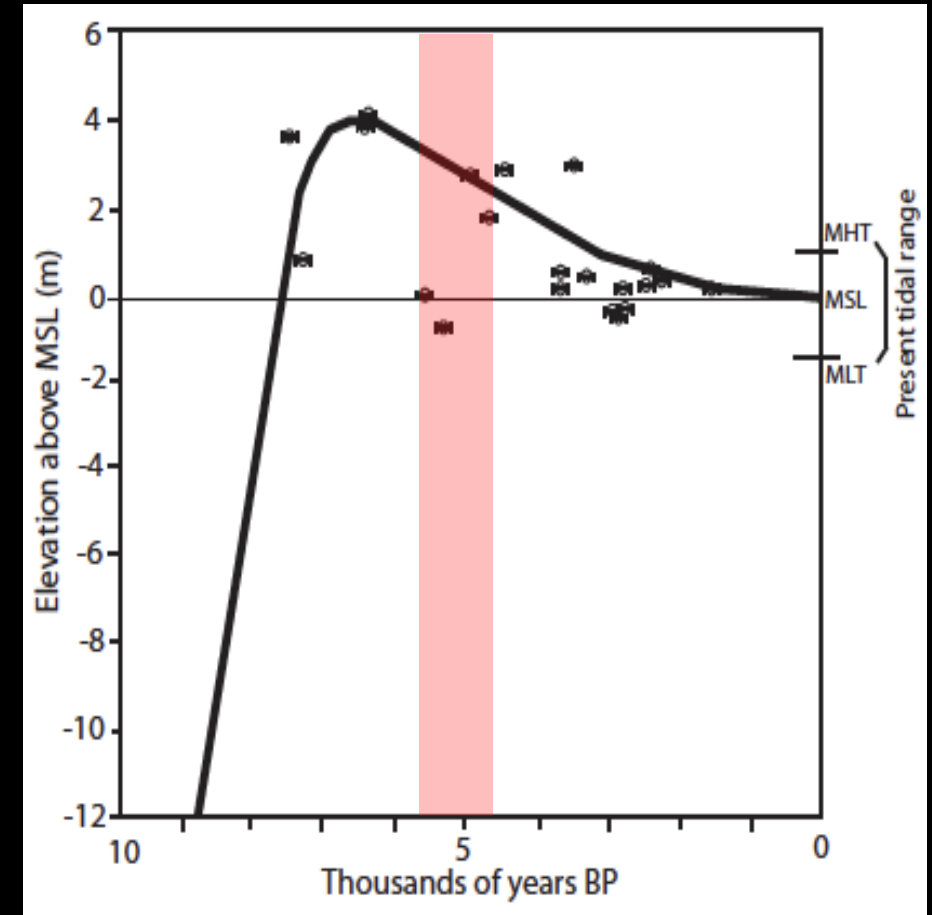
LOI, sediment components, and the percentage of most frequent pollen taxa obtained from core CP4 were included in the principal component analysis (PCA). The PCA showing (a) the cumulative variance of the first two components is 60%, and of the first four components is 77% of the total variance and (b) the eigenvalues of axes 1 and 2 are the most dominant, and therefore (c) axes 1 and 2 were identified to play a role in the SRY wetland. Groups A and B (the light grey areas) and Groups C and D (in the white lines) are the data analyzed on axes 1 and 2, respectively



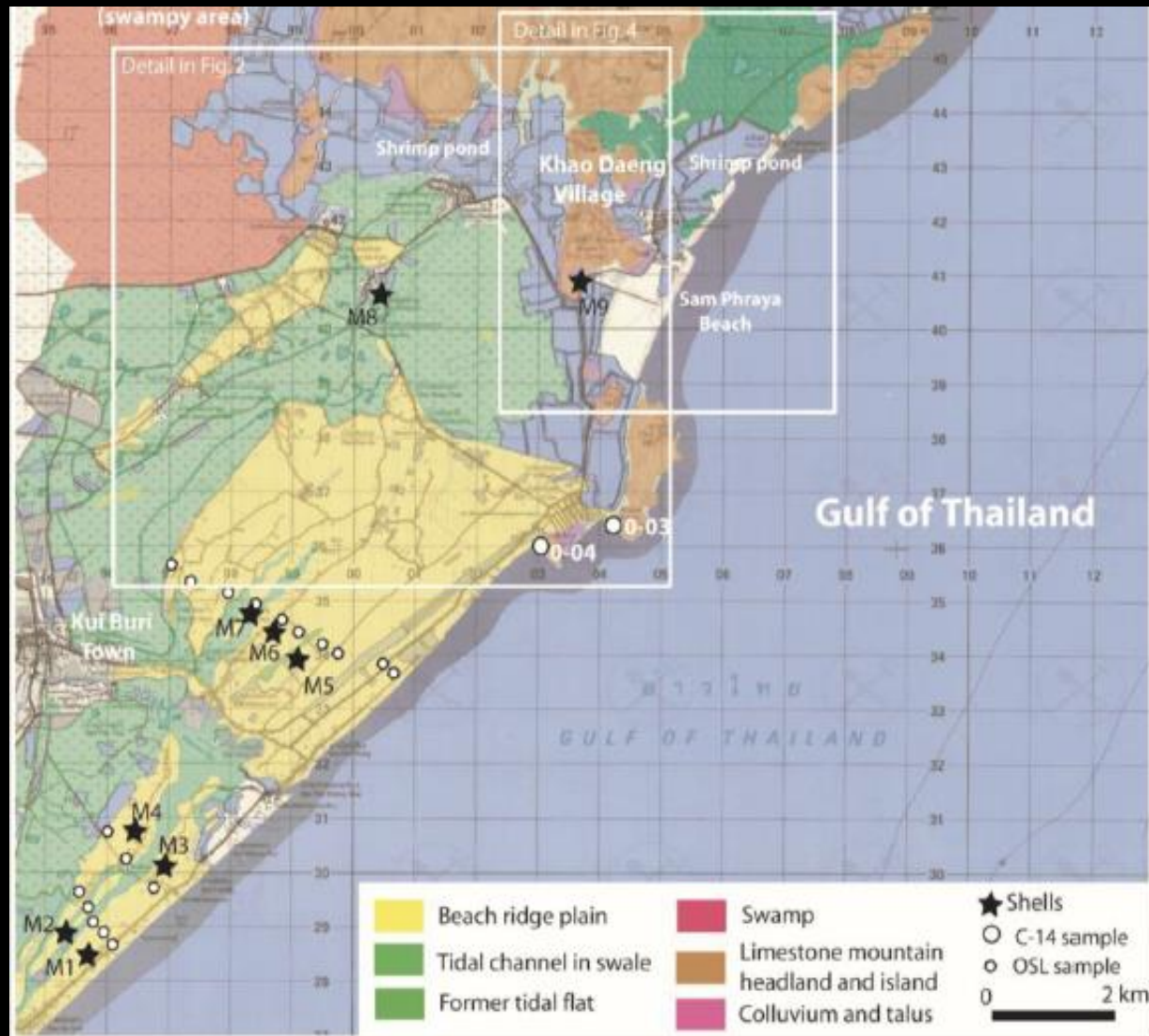
Lithostratigraphic correlations for the NW-SE transects



Malay-Thai Peninsular relative sea level index points (Horton et al., 2005)



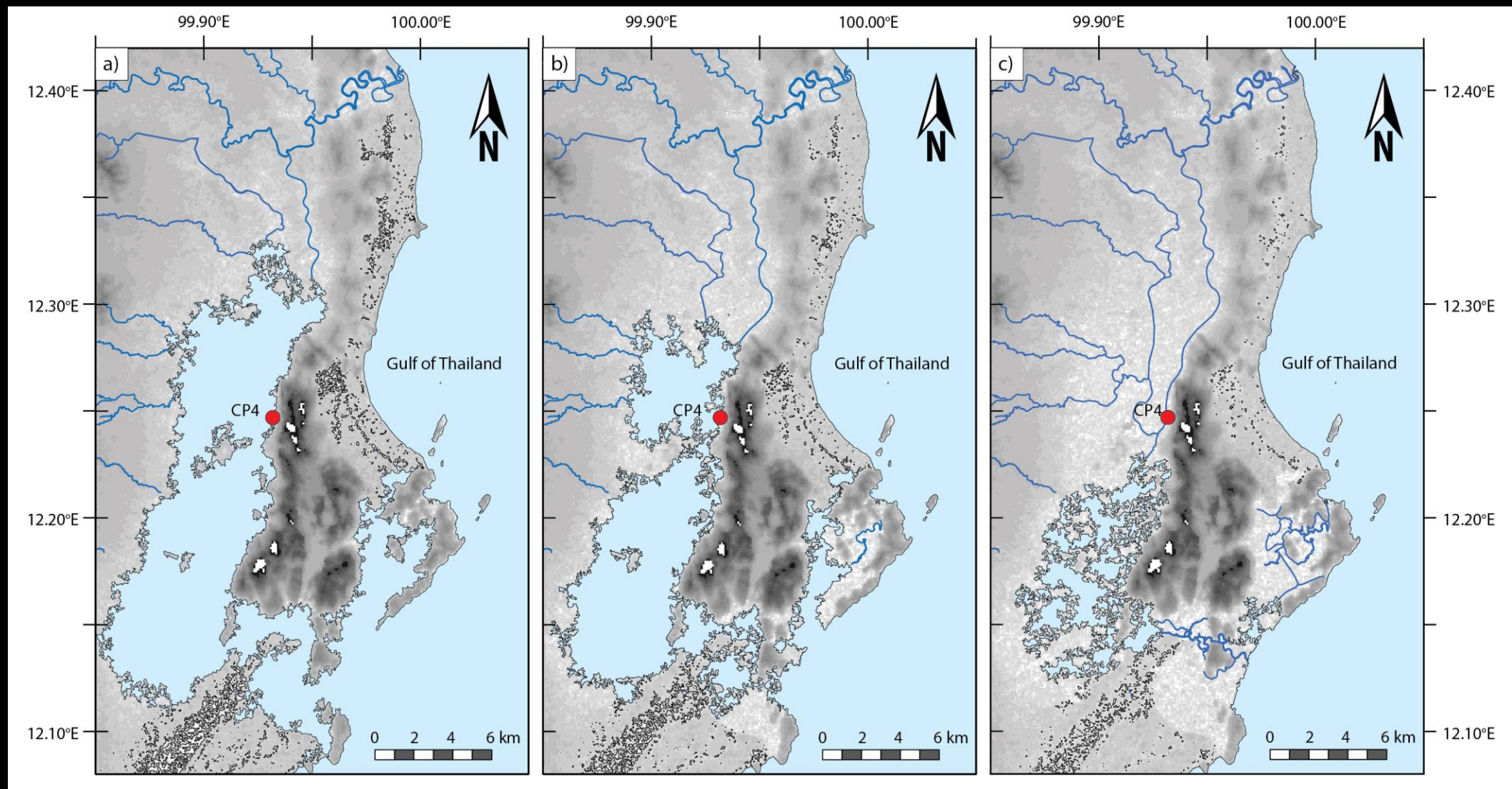
Sequential OSL dating of beach ridge series in Chumporn Provinces and reanalysis of relative sea level curve in the Gulf of Thailand (Nimnate et al., 2015)



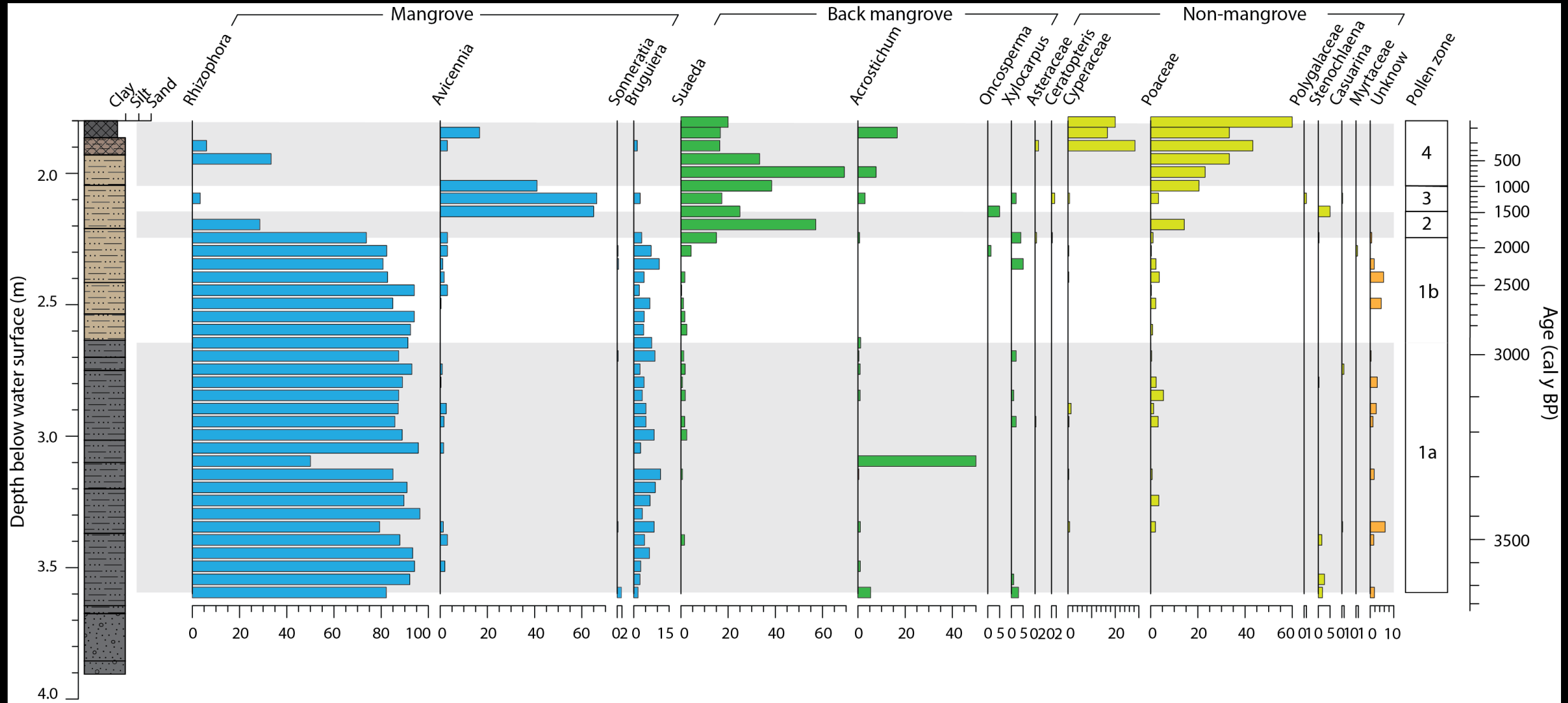
OSL dating results from the beach ridge plain (Surakietchai et al., 2018)

Sample no.	Distance from shoreline (m)	U (ppm)	Th (ppm)	K (%)	Water (%)	De (Gy)	Age (y)	Age (BP)
K4-1	170	1.91±0.10	0.35±0.14	2.40	0.58±0.05	0.55±0.01	950±80	884±80
K4-2	430	2.48±0.12	0.53±0.14	12.36	0.67±0.05	1.58±0.03	2350±220	2284±220
K4-3	1180	2.62±0.12	0.53±0.16	3.20	0.84±0.06	2.08±0.06	2463±250	2397±250
K4-4	1500	2.63±0.04	0.57±0.27	0.34	0.85±0.06	3.37±0.12	3980±200	3914±200
K4-5	1900	2.53±0.10	0.55±0.16	1.43	0.80±0.05	6.54±0.19	8186±700	8120±700
K4-6	2200	2.80±0.01	0.65±0.06	4.00	0.88±0.03	6.41±0.31	7270±450	7204±450
K4-7	2480	2.70±0.03	0.72±0.04	1.69	0.96±0.03	6.18±0.15	6410±260	6344±260
K4-8	3100	4.05±0.03	0.73±0.06	1.98	1.10±0.04	6.94±0.23	6282±340	6216±340
K4-9	3500	5.13±0.05	0.85±0.08	1.77	1.34±0.05	9.08±0.31	6756±390	6690±390
K4-10	3800	4.73±0.07	1.01±0.08	2.02	1.41±0.05	10.34±0.30	7339±390	7273±390

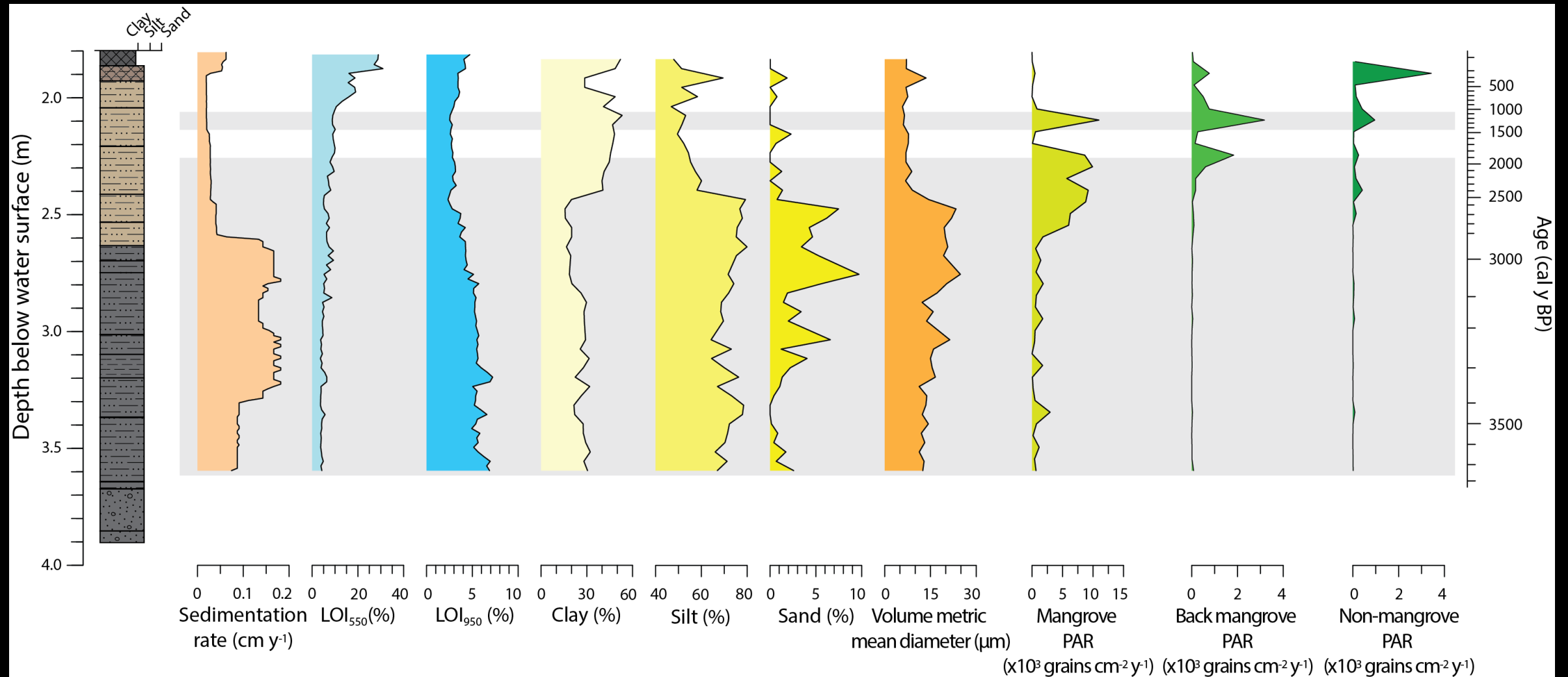
NW-SE beach ridge series in the southeastern part of the Sam Roi Yot national park (Surakietchai et al., 2018)



Coastal evolutions based on the Digital Elevation Model (DEM) at the RSL of a) 3, b) 2, and c) 1 m APSL in Sam Roi Yot area. The location of core CP4 is the red circle.

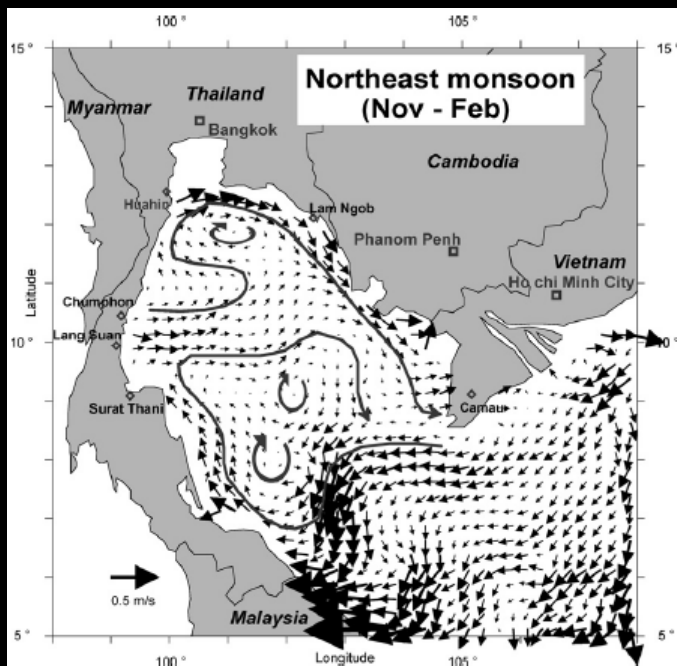
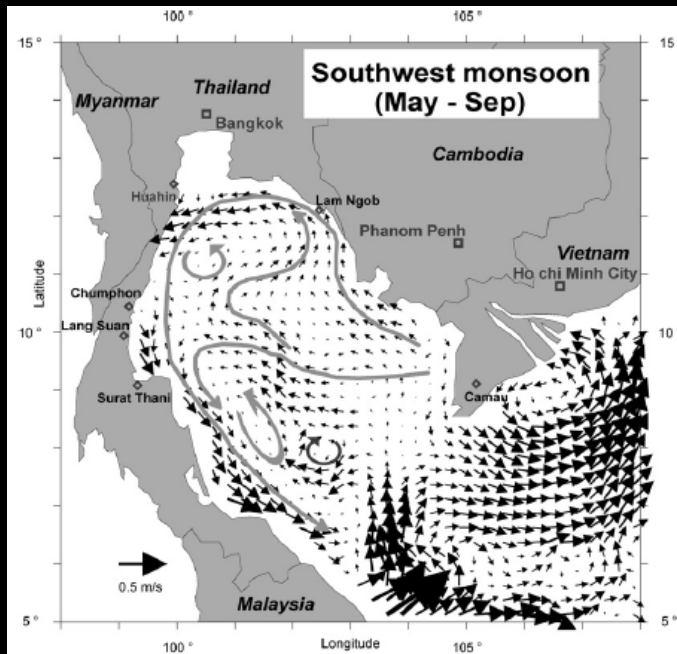


Pollen percentage diagram of sediment sequence CP4, divided into four pollen zones based on the percentages of the major pollen taxa

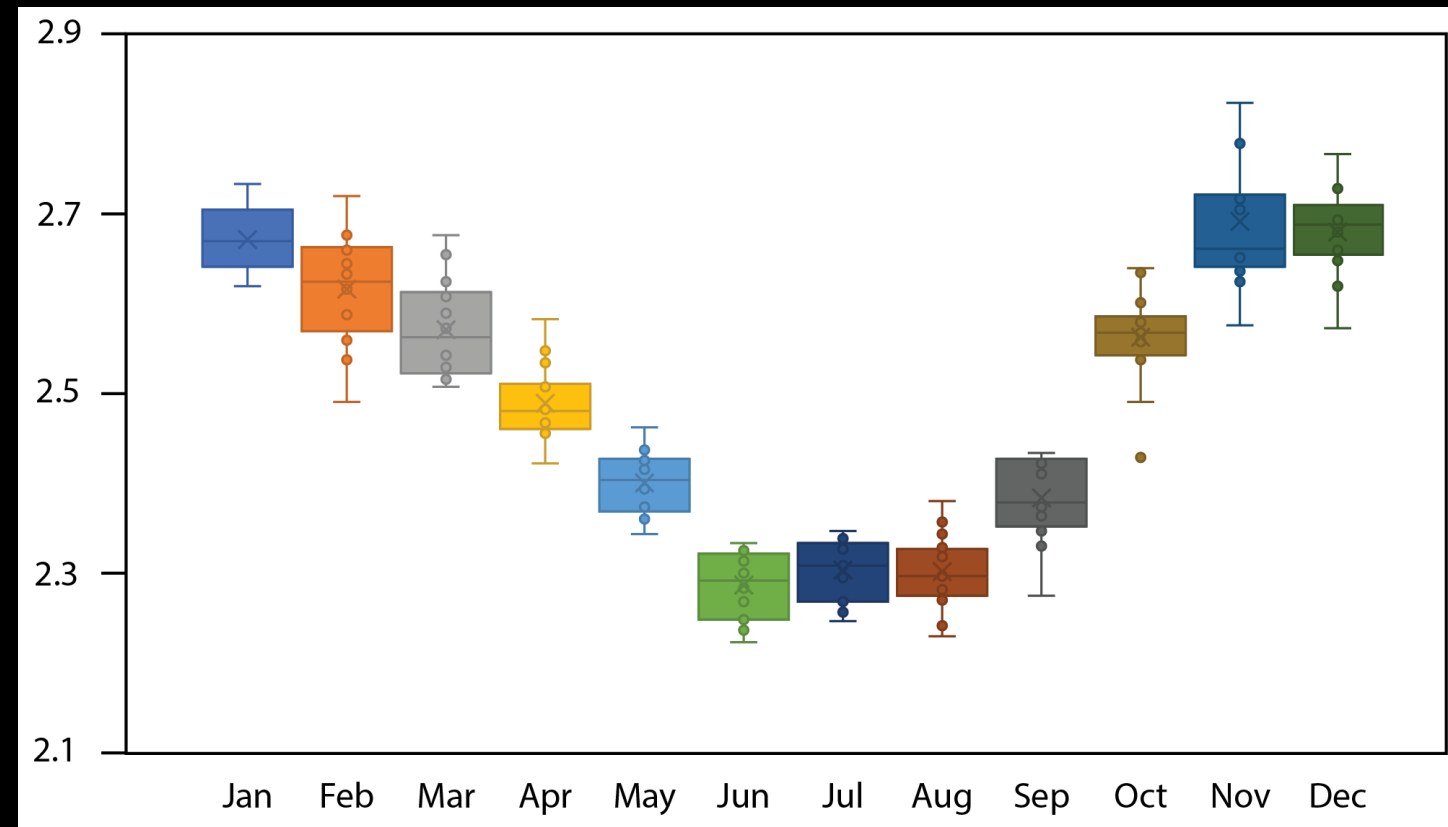


Lithostratigraphy, sedimentation rate, LOI at 550 and 950 °C, the percentage of clay, silt, and sand fractions, grain size distribution, and mangroves, back mangroves, and mangrove associates pollen accumulation rate (PAR).

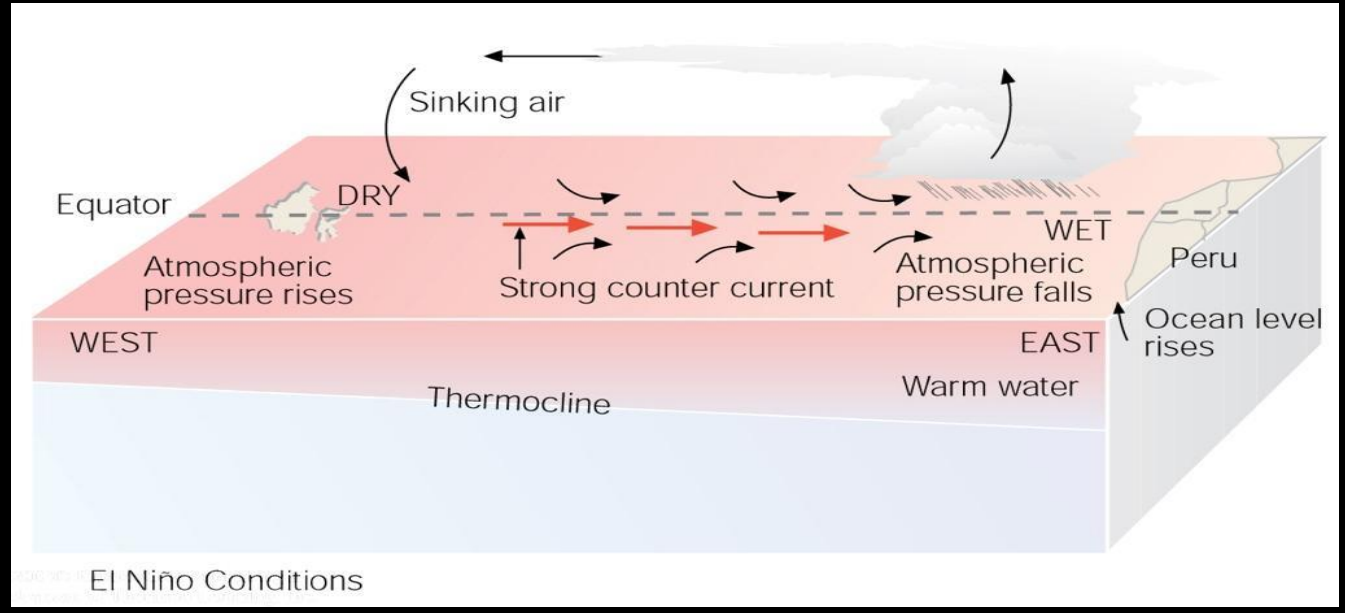
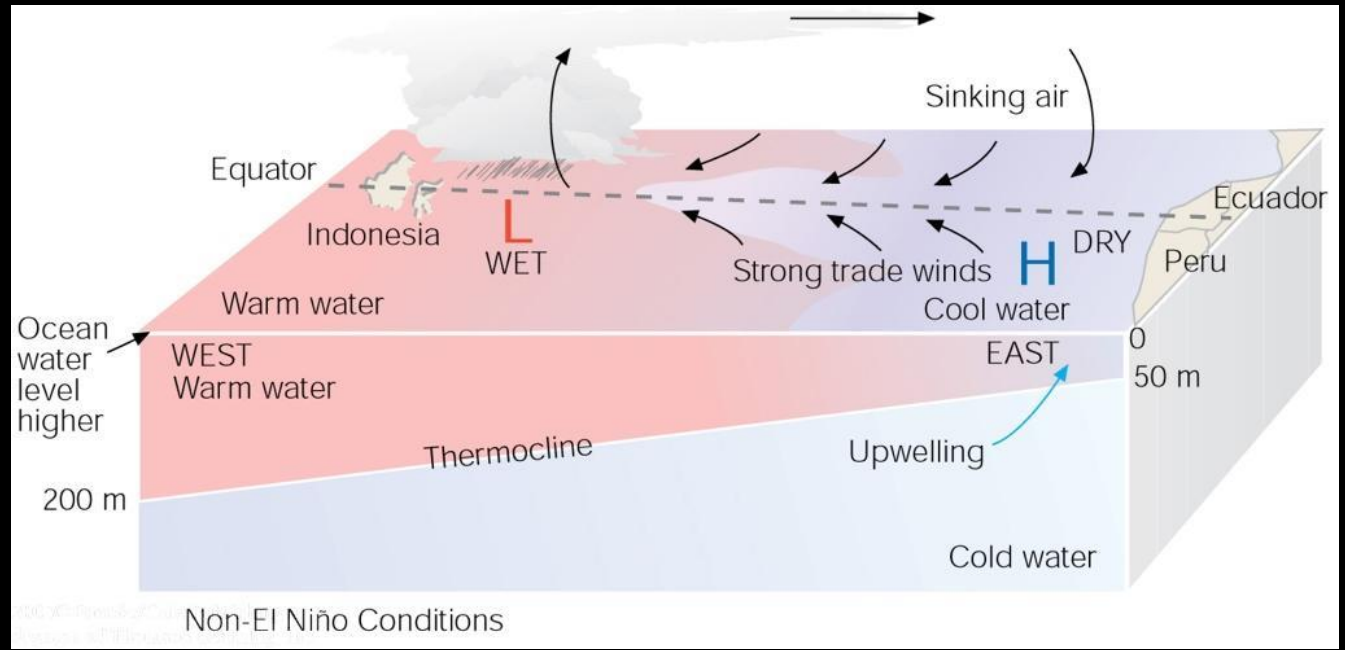
- The mangrove pollen, especially *Rhizophora*, were continuously abundant suggested a continuous inflow of saline water to the wetland at 3750–1850 cal y BP.
 - The low mangrove pollen influx suggested that the mangrove pollen were possibly transported to the site during c. 3750–2950 cal y BP.
 - The gradual increases in the sedimentation rate, sand fraction, and grain size distribution indicated the increased RSL at c. 3750–3200 and 3050–2950 cal y BP, which was intervened by a lowering in the tidal inundation, possibly reflected regression at 3200–3050 cal y BP.
 - The expansion of mangrove swamp forest at the coring site, as indicated by a significant increase in mangrove pollen influx, particularly of *Rhizophora* and *Bruguiera*, from 1000 to 5700 grains/cm²/y at 2950 cal y BP .
 - The enlargements in the sand and silt fractions coincided with the gradual rise in the mangrove PAR, which implied the continued intrusion of saline water accompanied by mangrove forest expansion at c. 2950–2450 cal y BP. The replacement of the silt with the clay component was possibly related to a reduced tidal inundation and RSL changes and environmental shifts caused by the thriving mangrove forests in the wetland at c. 2450–1850 cal y BP.
- The meager pollen grain count seemed to be caused by wetland exposure and oxidation, implying the continued fall in the RSL from 1850 to 1450 cal y BP.
- Although *Avicennia* is a salt-tolerant plant that can grow over a wide range of Watson's inundation classes, its increased pollen dominance in these samples implied an increased tidal inundation reflecting an excursion of transgression at 1450–1050 cal y BP.
- However, by c. 500 cal y BP, the percentage of Cyperaceae and Poaceae pollen gradually increased, suggesting an evolution of the wetland to a freshwater marsh, similar to the present

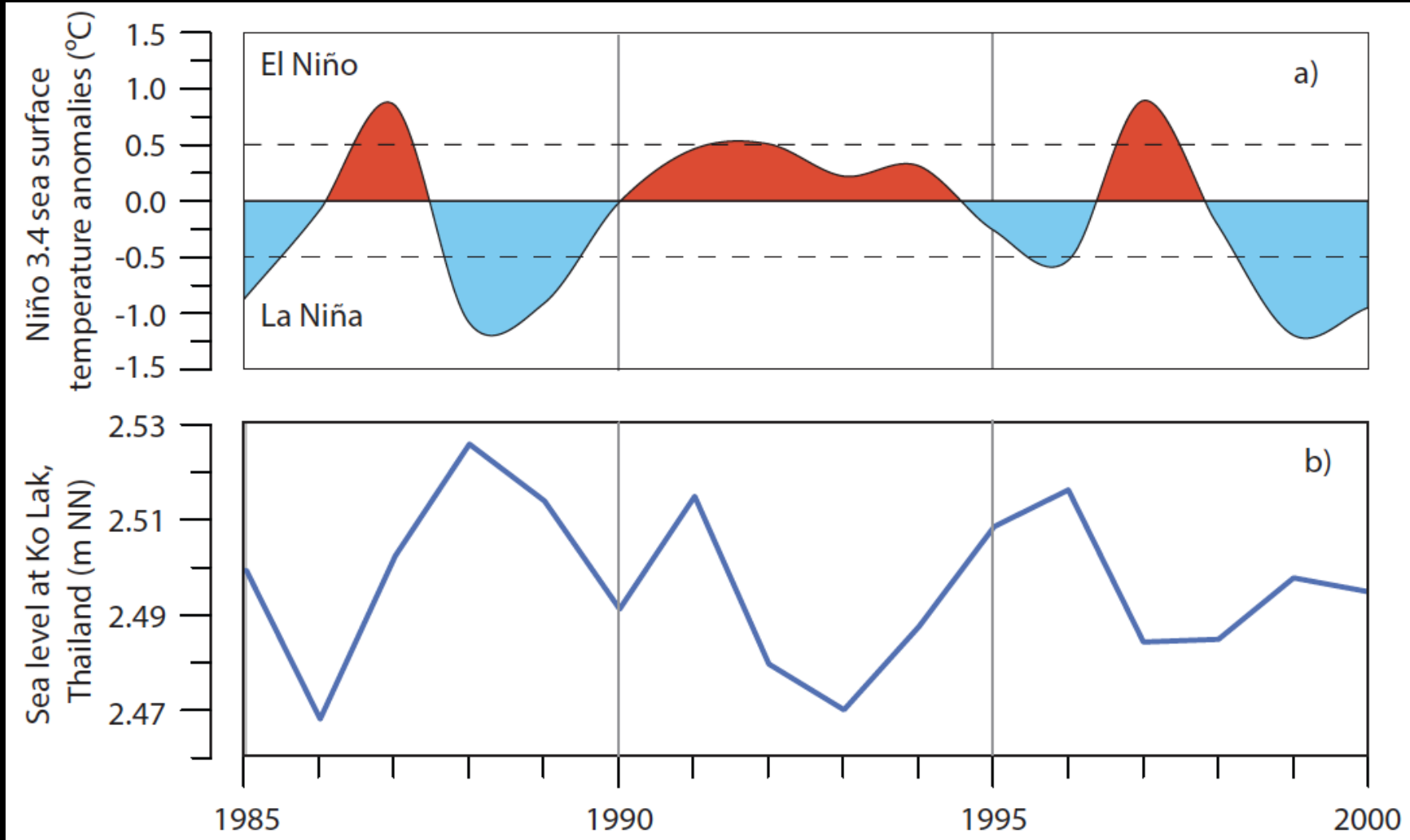


Sea surface current in the Gulf of Thailand during the SW and NE monsoon (Sojisuporn et al., 2010)

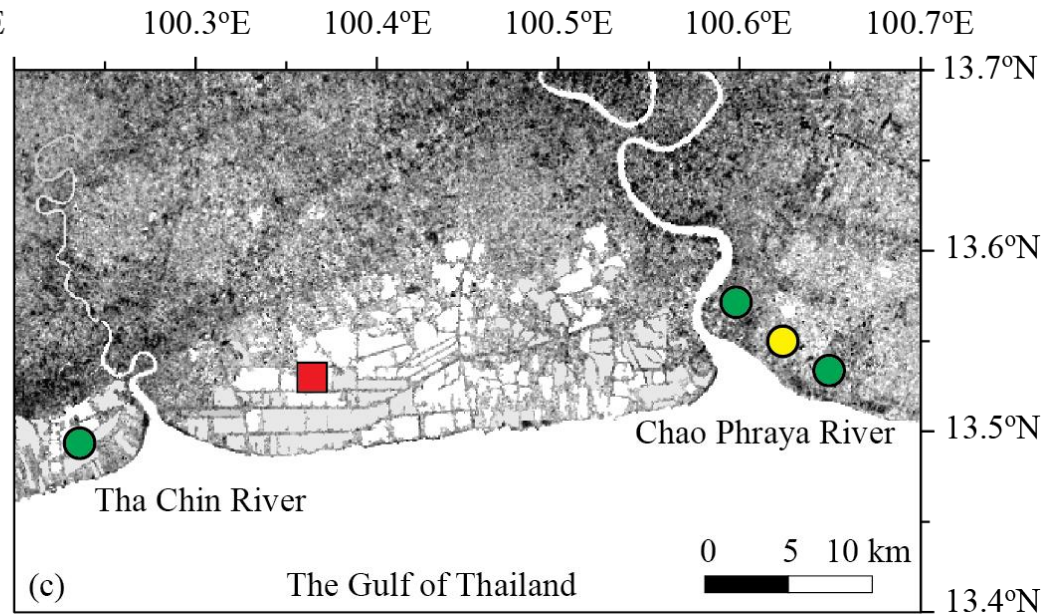
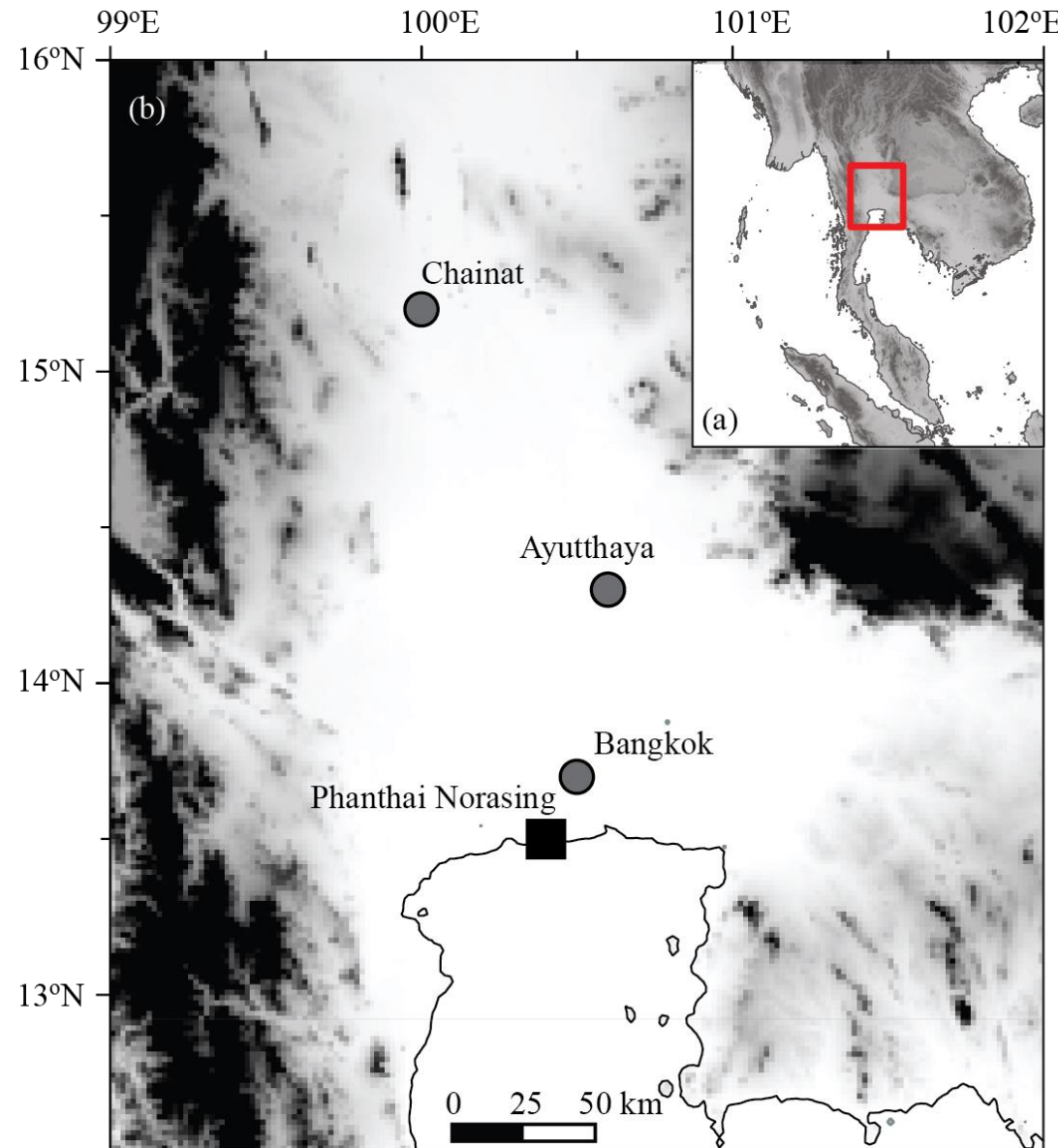


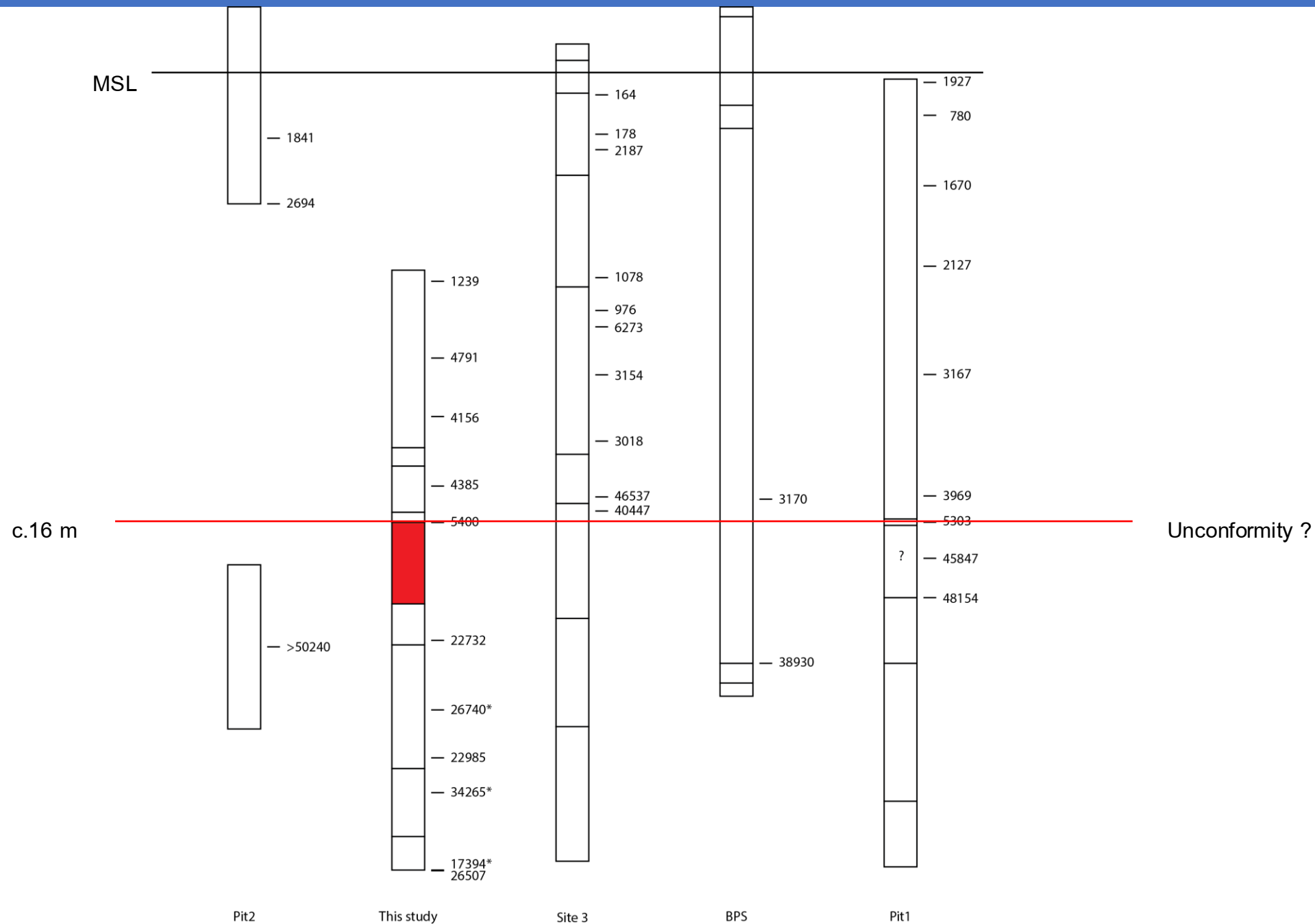
The monthly sea level from coastal tide gauge station Ko Lak, the Gulf of Thailand from 1985-2000 (WOCE Sea Level, WSL (2006)).





Comparison between the sea surface temperature (SST) anomaly at Niño 3.4 region (5°N - 5°S , 120 - 170°W) (National Centers for Environmental Information, 2023) and the monthly sea level from coastal tide gauge station Ko Lak, the Gulf of Thailand (WOCE Sea Level, WSL (2006)).







Thank you for your attention