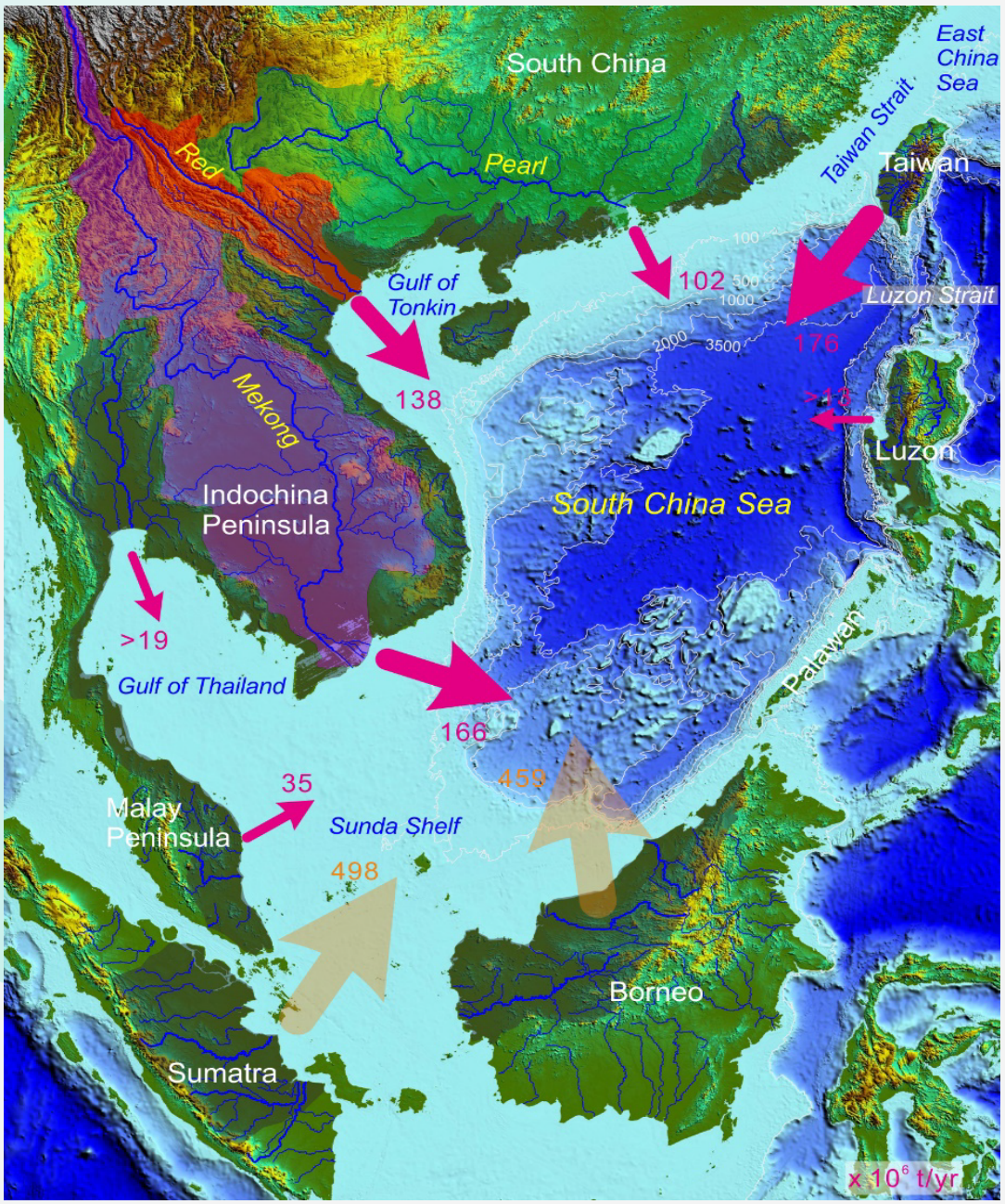
16TH

INTERNATIONAL WORKSHOP ON THE FLUVIAL SEDIMENT SUPPLY TO THE SOUTH CHINA SEA

6-7 November 2023, Shanghai

PROGRAM & ABSTRACTS



Venue

Room B200, Ocean Building, Tongji University (1239 Siping Road, Shanghai)

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BACKGROUND

The South China Sea offers an excellent natural laboratory for studying source-to-sink transport process of fluvial sediments among the global marginal seas. Numerous rivers, including the world's large rivers (e.g., the Pearl River, the Red River, and the Mekong River) as well as small mountainous rivers (e.g., rivers in Taiwan), supply as much as 700 Mt/yr of observed suspended sediments to the South China Sea. Upon entering the sea, the fluvial sediments are further transported by various coastal, surface, and deep/bottom oceanic currents, which are related to the East Asian monsoon winds, intrusion of the subsurface Kuroshio Current, and deep water from the Western Pacific through the Luzon Strait. The sediments have recorded detailed climatic and environmental changes occurring in land source regions both naturally and anthropogenically. Fluvial sediments in adjacent waters of the South China Sea (e.g., other marginal seas of the western Pacific Ocean and marginal seas of northern Indian Ocean) have undergone similar source-to-sink processes, which together with the South China Sea sediments present broader regional and global environmental and climatic changes.

To understand the fluvial sediment supply to the South China Sea, the UNESCO Intergovernmental Oceanographic Commission's Sub-Commission for the Western Pacific (WESTPAC) initiated the project on South China Sea Fluvial Sediments and Environmental Changes (FluSed) (2008–2025). The project provides a regional platform for scientists interested to advance their scientific knowledge and to stimulate new ideas. A workshop was held in Shanghai in 2008 for the initial meeting of collaborators. Since then, annual workshops have been hosted at different countries around the South China Sea. The annual workshops aim to integrate various research approaches, stimulate scientific interactions, provide updates, and discuss collaborative opportunities. This year, after a three-year continuing influence of Covid-19 pandemic on international traveling, the 16th FluSed workshop will return to Shanghai and to be held on 6-7 November 2023.

ORGANIZERS

IOC Sub-Commission for the Western Pacific (WESTPAC)
State Key Laboratory of Marine Geology, Tongji University, China

VENUE

Meeting Room B200, Ocean Building, Tongji University (1239 Siping Road, Shanghai). See the maps for details of location and transportation. Online participation through the Zoom meeting system is available (notice separately).

Note: the venue is located in the campus of Tongji University. To enter the campus, a personal identity document (passport or Chinese ID Card) is needed to show up at the main gate.

HOTEL

Rooms at Kingswell Hotel Tongji (50 Siping Road, Shanghai) are reserved for all participants. See the maps for details of transportation from airports and to the workshop venue.

MEALS

ALL meals during the workshop will be arranged by the workshop organizers. Lunch is arranged in the workshop venue; dinner is the restaurant or hotel (will be noticed); breakfast is at hotel.

ORGANIZERS CONTACTS

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MAPS

The workshop venue (Meeting Room B200, Ocean Building, Tongji University) is located approximately 50 km away from the Pudong International Airport and 30 km away from the Hongqiao International Airport. The hotel is Kingswell Hotel Tongji, which is 800 m away from the venue, and takes 10 minutes on foot.

WORKSHOP PROGRAM

November 6 (Monday)

Opening Session, Chair: Zhifei Liu			
08:30-08:50	Welcome speech		
08:50-09:10	Zhifei Liu	Tongji University	Sixteen years of cooperative research on South China Sea fluvial sediments (FluSed): Review and prospects
Weathering/erosion Session, Chair: Edlic Sathiamurthy			
09:10-09:30	Fernando Siringan	University of the Philippines Diliman	Coastal erosion along the northwest coast of Luzon: Trends and causes
09:30-09:50	Pham Nhu Sang	Tongji University	Effects of grain size, sedimentary recycling, and lithology on the chemical weathering index: A case study of river sediments in the lower Mekong River basin
09:50-10:10	Maria Gracia C. Padrique	University of the Philippines Diliman	Investigating the use of image segmentation and random forest classifier for textural analysis of the conglomerate unit of lagdo formation, Southwest Panay, Philippines
10:10-10:30			Coffee Break
Source-to-sink Session, Chair: Fernando Siringan			
10:30-10:50	Hoang Van Long	Vietnam Petroleum Institute	Holocene sedimentation of the Mekong River Prodelta
10:50-11:10	Mingyang Yu	Tongji University	Low sediment transport efficiency from Tibetan Plateau to Indian Ocean through the Yarlung Zangbo-Brahmaputra-Ganges system
11:10-11:30	H.M. Zakir Hossain	Jashore University of Science and Technology	Distribution of major, trace, and rare earth elements in a transect of cores in the Bay of Bengal offshore Bangladesh
11:30-11:50	Tiffany Ashley F. Uy	University of the Philippines Diliman	Determining geologic controls of submarine groundwater discharge (SGD) through low-cost acoustic mapping
11:50-12:10	Penjai Sompongchaiyakul	Chulalongkorn University	Abundance and composition of microplastics in Mekong River's sediment
12:10-13:30			Lunch

Geochemistry Session, Chair: Xianfeng Wang			
13:30-13:50	Thomas M. Blattmann	ETH Zürich	Decadal scale change in the cycling of organic carbon on Luzon island of the Philippines
13:50-14:10	Hongzhe Song	Tongji University	The control of clay mineral nanostructures on sequestration of fluvial sedimentary organic carbon
14:10-14:30	Mengli Chen	National University of Singapore	Boundary exchange completes the marine lead (Pb) cycle jigsaw
14:30-14:50	Kim Soben	Royal University of Agriculture	Assessment of peatland biodiversity in mangrove forest of the coastal zone in Cambodia
14:50-15:10	Thav Sopheak	Royal University of Agriculture	Mangrove in South China Sea: Distribution and biomass in Cambodia
15:10-15:30			Coffee Break
Paleoclimate/climate Session, Chair: Penjai Sompongchaiyakul			
15:30-15:50	Xianfeng Wang	Nanyang Technological University	Variability of the Maritime Continent Intertropical Convergence Zone during the past 30,000 years
15:50-16:10	Anne Karla M. Navarro	University of the Philippines Diliman	Holocene monsoonal variation in northeastern Luzon deduced from foraminiferal and sedimentological records from Luzon Strait
16:10-16:30	Nugroho Dwi Hananto	National Research and Innovation Agency (BRIN)	Reconstruction past changes and evolution of Indonesian throughflow
16:30-16:50	Thanakorn Jiwarungrueangkul	Prince of Songkla University Phuket Campus	Paleo-productivity on the continental slope off the Mekong River in the southern South China Sea since the Last Glacial Maximum
16:50-17:10	Jariya Kayee	Nanyang Technological University	Metal concentrations of atmospheric aerosol and wet deposition flux in west Singapore during the northeast monsoon in 2023
18:00-20:00			Dinner

November 7 (Tuesday)

Drainage/basin Session, Chair: Hoang Van Long			
08:30-08:50	Edlic Sathiamurthy	Universiti Malaysia Terengganu	Palaeo Pahang River during the Holocene – some morphologic features identified
08:50-09:10	Gonzalo Carrasco	Nanyang Technological University	Zinc bioavailability in the Malacca Straits, Singapore, southern South China Sea and coastal Borneo: A measure of environmental impact and natural resilience
09:10-09:30	Xun Yu	Tongji University	Transition of basalts from tholeiitic to alkaline from southern Vietnam records the deceleration of asthenospheric upwelling after termination of seafloor spreading
09:30-09:50	Xixi Zhao	Southern University of Science and Technology	Tectonic rotation and latitudinal displacement of SW Yunnan and Indochina Blocks: Constraints from new and published paleomagnetic data
10:10-10:30	Tapan Chakraborty	Indian Statistical Institute	Changing sedimentary architecture of channel sandstone bodies: Cryptic signals of basin evolution from the Neogene Siwalik deposits of Eastern Himalaya
10:30-10:50	Suchana Taral	Pondicherry University	Recognition and significance of facies characteristics and architecture in a sandy wave-tide influenced delta: an example from Siwalik foreland basin, Tista valley, eastern India
10:50-11:10			Coffee Break
Discussion Session, Chair: Zhifei Liu			
11:10-12:00			Discussion on collaboration
12:00-13:00			Lunch
Field excursion, Guide: Xun Yu			
13:00-18:00			Visit to State Key Laboratory of Marine Geology (Lingang campus)
18:00-20:00			Dinner

Note: 20 min presentation = 15 min talk + 5 min discussion

Sixteen years of cooperative research on South China Sea fluvial sediments (FluSed): Review and prospects

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The South China Sea provides a unique natural laboratory for studying source-to-sink transport processes of sediments in the world's marginal seas. Large world-class rivers, small mountainous rivers, and various tropical rivers gather together billions of tons of fluvial sediments annually, accumulating in the South China Sea to record high-sedimentation-rate of climate change and human activity. Thus, the South China Sea has become an ideal place for conducting research on addressing current global change.

To understand the fluvial sediment supply to the South China Sea, the UNESCO Intergovernmental Oceanographic Commission's Sub-Commission for the Western Pacific (IOC/WESTPAC) initiated the project on *South China Sea Fluvial Sediments and Environmental Changes (FluSed)* (2008–2025). The project has successfully provided an international platform for scientists interested to advance their scientific knowledge and to stimulate new ideas and collaborations. This presentation will introduce the fruitful activities of this project over the past 16 years, including academic exchanges, project cooperation, and youth talent cultivation, and suggest potential cooperations plans in the next phase.

Coastal erosion along the northwest coast of Luzon: Trends and causes

Fernando P. Siringan[1*], Ma. Yvainne Sta Maria[1], Jamela Jirah Clemente[1], Angelo Maon[1], Ellen Mae Carmelo[1], Rodel Ducao[1], Louis Philippe Facun[1], Ara Rivina Malaya[2], Floribeth Cuison[2]

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Coastal erosion is a prevalent problem along an almost 600 km long coastline of northwest Luzon. In this study, satellite images and maps complemented by field surveys are used to establish trends of shoreline change. The causes of erosion and their relative contributions are identified using ancillary oceanographic and meteorological data, and anecdotal accounts. The largest and fastest shifts in shoreline position, which can be within a kilometer of either erosion or accretion, are in delta shorelines. A shift in river mouth position, mostly natural, is the main driver of these changes. However, co-seismic subsidence caused by an 8.1 magnitude earthquake in 1990 combined with eustatic rise of sea level and natural compaction, is likely a major contributor to continuing extensive erosion in the delta plain shorelines in the southern part of the study area. Shorelines fringed by extant or relict coral reefs, although dominated by erosion, have mostly only undergone several meters of shoreline shift. This low magnitude of erosion is attributed to the attenuation of waves by extant or relict reef platforms. Storms led to large changes as well, mostly erosion, but the shorelines tend to recover after a while. However, more frequent passage of storms tends to result to more widespread erosion. Seawalls and groins, meant to mitigate erosion, and solid-based piers contribute to erosion. Other contributors to erosion include beach mining and quarrying, degradation of coral reefs, and removal of beach vegetation. Coastal erosion is expected to worsen with the acceleration of eustatic sea level rise and increase in frequency and intensity of typhoons.

Effects of grain size, sedimentary recycling, and lithology on the chemical weathering index: A case study of river sediments in the lower Mekong River basin

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Although the Chemical Index of Alteration (CIA) has been applied widely to estimate the intensity of chemical weathering in river basins, but grain size, sedimentary recycling, and lithology can significantly impact the chemical weathering proxy. In this study, major and trace element geochemistry of clay, silt, and sand-fraction sediments in the lower Mekong River basin (Cambodia and Vietnam) have been utilized to investigate the effects of grain size, sedimentary recycling, and lithology on the chemical weathering index. Al_2O_3/SiO_2 versus CIA, WIP versus CIA, and Sc/Th versus CIA have been extensively used to estimate the influence of grain size, sedimentary recycling, and lithology on the chemical weathering proxy, respectively. The diagrams of Al_2O_3/SiO_2 versus CIA in most silt and sand-fraction sediments display strong positive correlations (average 0.666 and 0.778), while clay-fraction sediments present very weak correlations between Al_2O_3/SiO_2 and CIA (average 0.011). Very weak correlations between WIP and CIA are found in most silt and sand-fraction sediments (average 0.042 and 0.037), whereas clay-fraction sediments show very strong negative correlations in the diagrams of WIP versus CIA (average 0.953). However, all clay, silt, and sand-fraction sediments display weak or very weak correlations (average 0.288, 0.168, and 0.027, respectively) in the diagrams of Sc/Th versus CIA. These indicate that silt and sand-fraction sediments in the lower Mekong River basin are strongly influenced by grain size and sedimentary recycling, but not clay-fraction sediments, and most clay, silt, and sand-fraction sediments are principally independent of the lithology in the source regions. In the region, clay-fraction sediments are, therefore, first-cycle rather than polycyclic sediments, and their element geochemistry can be used as relevant proxies of chemical weathering intensity.

Keywords: grain size; sedimentary recycling; lithology; chemical weathering; Mekong River

Investigating the use of image segmentation and random forest classifier for textural analysis of the conglomerate unit of lagdo formation, Southwest Panay, Philippines

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Gravel morphology and textures could provide information on the depositional setting, transporting medium, and provenance of sedimentary conglomerates. The conglomerate unit of the Lagdo Formation, Anini-y, Panay occurs as a boulder-field of clast-supported polymictic conglomerates overlying a massive reefal limestone. This conglomerate unit consists of granule to cobble-sized clasts enclosed in coarse-grained sand-sized, well-indurated, and hard matrix. The hard and well-indurated characteristics of the conglomerate made it challenging to conduct 3D morphological and grain-size measurements of the clasts using calipers or sieving methods. Thus, this study's main objective is to investigate the use of image segmentation of 2D images to create grain boundary maps where textural parameters such as mean size, grain shape, sorting, elongation ratio, and clast-to-matrix ratio could be obtained. Specifically, this study explored the use of Trainable Weka Segmentation, a plugin in Fiji, in training and classifying clast and matrix on the 2D images of the Lagdo conglomerates. Probability maps, which show regions of the clasts and matrix, were generated. Watershed segmentation was then applied on these maps to generate blobs that represent the clasts which were then applied to a pixel-based grain size analysis in Fiji. To validate the segmentation process done in Trainable Weka, we conducted handcrafted measurements of the clasts' dimensions via the Fiji app through visual identification of the a- and b-axis of the clasts. Grain size, standard deviation, shape, and elongation ratio were compared for both methods. Over-segmentation was observed in the machine-learning-based segmentation in Weka due to secondary fragmentation and occlusion of large clasts. However, elongation ratios and the indicated environment of deposition were found to be the same for 4 out of 5 conglomerates using both methods. In addition, clast-to-matrix ratios plot in the same regions in the conglomerate classification ternary diagram. The similarities in the results from the two methods indicate the potential use of image segmentation and machine learning as tools for future sedimentological analysis of 2D images despite the limitations and challenges of obtaining dimensions from well-indurated rudaceous conglomerate units.

Keywords: machine learning; image segmentation; grain size analysis; image analysis; conglomerate

Holocene sedimentation of the Mekong River Prodelta

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The Mekong River delta is considered one of the largest mega deltas in the world. Evolution of the delta system has been controlled by a number of elements such as tectonic uplift of the source region, break-up and subsidence of the continental margin, paleoclimate change and the sea-level fluctuation, etc. The Holocene sea-level rise demonstrated a rapid period of sea-level rise since the Last Maximum Glaciation. This event led to a rapid transgression overall. However, part of the Mekong Delta has been extended due to sediment supply being dominant over accommodation space creation. In this study, we use high resolution seismic data acquired from the North, central and the West of the Mekong River prodelta to define the interactions between the sediment supply and the accommodation space extension at different parts of the the prodelta (Figure 1). Seismic interpretation in the northern margin of the prodelta shows thin sedimentary package overlies directly on the pre-Cenozoic basement rocks, which were broken by a series of normal faults. The present seabed is relatively steeper than other parts of the delta and hence sediments have been commonly bypassed towards the deep water by turbidity current (Figure 2). Right at the center of the prodelta, a wedge-shaped seismic package demonstrates a significant amount of the Late Holocene sediments were trap in the nearshore zone while the deeper water part shows a thinner sequence due to the sediment starvation (Figure 3). It is noted that the northwestern part of the seismic profile in figure 3 is characterized by seismic reflection-free fashion. This characteristic is likely caused by the shallow gas accumulated in the sandy sediment, which is commonly observed in the nearshore sediments along the coast of Vietnam. Unlike the northern and central areas of the prodelta, the western part of the area is distinguished by thinner, horizontally bedding sediment. it might be attributed to the fact that less sediments have been released to the West (Figure 4). It is clear to identify that many paleochannels have been stacked vertically, which can be observed on seismic profile. The channels have been resulted from vertical incision and horizontal migration of the paleochannels in Holocene.

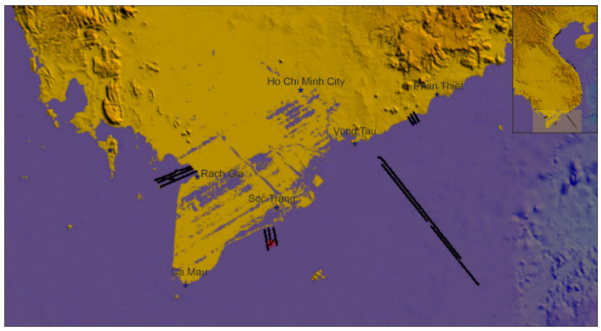

Figure 1. Location of the study area and high-resolution seismic lines

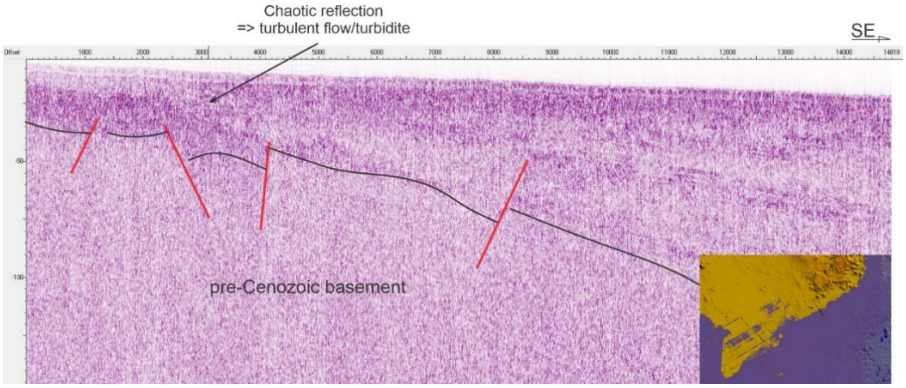

Figure 2. Geological structure and sediment configuration of norther Mekong River Prodelta

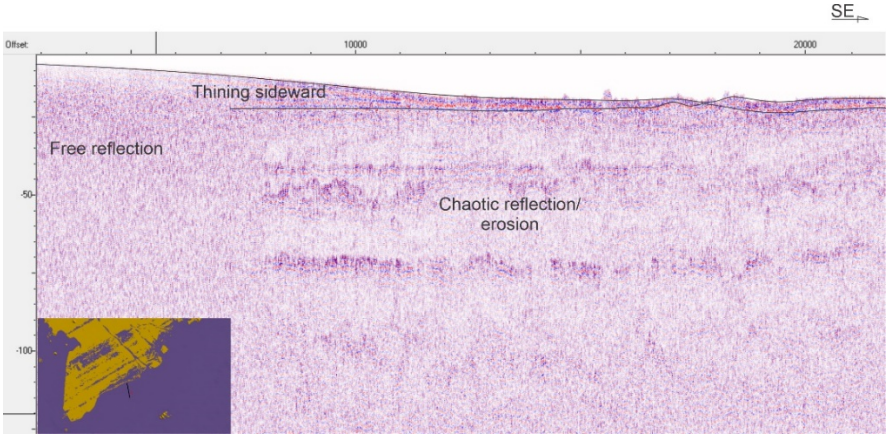

Figure 3. Different seismic facies show different characteristics of the sediments in the center part of the Mekong River Prodelta

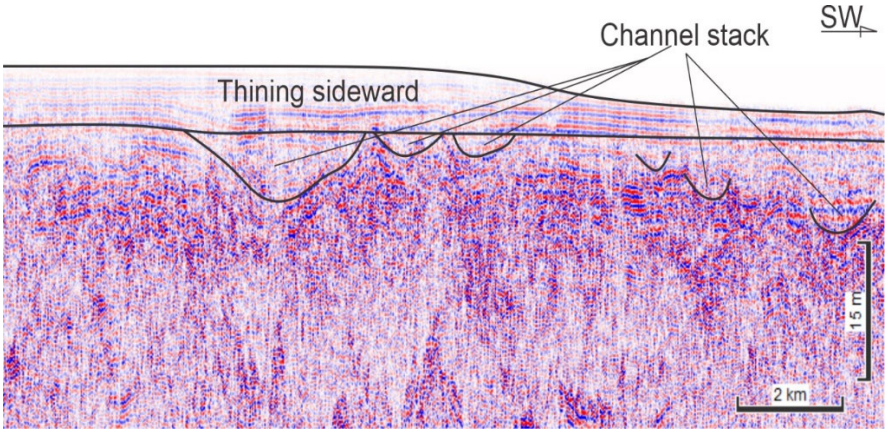

Figure 4. Configuration of sediments in the West of the Mekong River Prodelta

Low sediment transport efficiency from Tibetan Plateau to Indian Ocean through the Yarlung Zangbo-Brahmaputra-Ganges system

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The Tibetan Plateau-Himalayan system and its originated large rivers contribute huge amounts of terrestrial sediments to global oceans. However, the efficiency of sediment transport has rarely been studied. In this study, we selected the Yarlung Zangbo-Brahmaputra-Ganges river system, considered to have the most efficient sediment transport, and used major-element and Nd-Sr isotopic geochemistry of sands to trace transport processes. We find that higher Na_2O/SiO_2 and K_2O/SiO_2 ratios and more radiogenic εNd (–10 to –8) and non-radiogenic $^{87}Sr/^{86}Sr$ (0.7096–0.7215) in the upper and eastern-middle Yarlung Zangbo mainly reflect greater contributions from the Tibetan Plateau (Lhasa Block), while lower Na_2O/SiO_2 and K_2O/SiO_2 ratios and more non-radiogenic εNd (–13 to –9) and radiogenic $^{87}Sr/^{86}Sr$ (0.7174–0.7210) in the western-middle Yarlung Zangbo indicate more contributions from the Tethyan Himalaya. In contrast, more non-radiogenic εNd (–17 to –10) and radiogenic $^{87}Sr/^{86}Sr$ (0.7164–0.7516) in the lower Yarlung Zangbo-Brahmaputra-Ganges indicate dominant contributions from the Higher/Lesser Himalayas. We estimate that the Tibetan Plateau accounts for ~61% of the Yarlung Zangbo sands before exiting the plateau, and contributes only ~21% to the Indian Ocean, with a predominance of ~69% from the Higher/Lesser Himalayas. The decreasing contributions of the Tibetan Plateau downstream indicate retention of sediments en route, resulting from two-level tectonic trapping of the Eastern Syntaxis and the Himalayan foreland basin. The prominent contributions of the Higher/Lesser Himalayas indicate strong erosion of the Himalayan front, favored by heavy monsoon rainfall. Our study implies that the influence of Tibetan Plateau-derived sediments on the ocean cannot be immediate.

Distribution of major, trace, and rare earth elements in a transect of cores in the Bay of Bengal offshore Bangladesh

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Three sediment multicore samples (n = 15) were collected from the Bay of Bengal offshore Bangladesh in order to evaluate their elemental variations, provenance, and source-area weathering signatures. Major, trace, and rare earth elements (REEs) show high enriched in TiO_2, Fe_2O_3T, Ni, Cr, V, Rb, Th, Zr, Sc, La, and Y and depleted in CaO, Na_2O, Sr, Ba, and Pb relative to the average upper continental crust (UCC) composition. SiO_2 and Al_2O_3 contents ranging from 54 to 71 wt.% and 12 to 18 wt.%, respectively with high Al_2O_3 in clay-rich sediments. Chondrite-normalized REE patterns for the Bay of Bengal sediments show a high enrichment in light REE (LREE) relative to the heavy REE (HREE; La_N/Yb_N, 7.26-8.46) coupled with clear negative Eu anomalies (Eu/Eu*, 0.60-0.71), suggesting a felsic source provenance. The sediments are compositionally low mature to immature in nature and classified as greywacke and litharenite. Provenance discrimination diagrams suggest that the studied sediments were derived largely from felsic sources with compositions close to the average dacites, rhyolites, I- and S-type granites. Trace element ratios of Th/Sc, La/Sc, Zr/Sc, Cr/Th, and Th/Co indicate a felsic provenance overall. Comparison with potential source rocks of the Himalaya-Tibetan Plateau supports the Bay of Bengal sediments originating from felsic quartzose recycled detritus of the Himalayas. The ICV (Index of Compositional Variability), CIA (Chemical Index of Alteration), and PIA (Plagioclase Index of Alteration) proxies, and Rb/Sr and K_2O/Rb ratio values of the marine sediments indicate low to moderate degree of chemical weathering in their source area. This weathering pattern in the sediment samples could be influenced by the intensity of Himalayan monsoon climates.

Keywords: geochemistry; provenance; chemical weathering; sediments; Bay of Bengal; Bangladesh

Determining geologic controls of submarine groundwater discharge (SGD) through low-cost acoustic mapping

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Submarine groundwater discharge (SGD) is the direct discharge of water across the seafloor. This phenomenon allows the transport of land-derived materials and nutrients to the ocean, with fluxes comparable to river discharge, sometimes even exceeding them. SGD, which may bring freshwater from terrestrial sources or recirculated seawater, affects the ecosystems and biogeochemistry in the area. SGDs are usually found in coastal and shallow areas, but they remain challenging to detect and thus, difficult to map. Mapping is essential in estimating the potential magnitude of the influence of SGD and identifying the factors that control the distribution and nature of SGDs. Different methods have been employed to identify the occurrence and map SGDs, from chemical tracers and isotopes to geophysical tools such as electrical resistivity. Following a serendipitous discovery of bubbly SGD through acoustic imaging using GPS echosounders, this work utilizes low-cost GPS-fish finders which use multifrequency down imaging and side scan imaging to image the substrate and the occurrence of SGD along the eastern-southeastern coast of the Calumpan Peninsula, Mabini, in Batangas. In Mabini, river systems are mostly ephemeral. As such, SGD is a fundamental process of the hydrologic cycle, and brings nutrients to the sea. The occurrence of bubbly SGDs is caused by the hydrothermal nature of the study site, where fluids, including gases, emanate from the seafloor. The gaseous discharge allows for the density and acoustic contrast between the seawater and SGD. A total length of 65-km line survey data was acquired from the 6.5-km long study site. Sparse bubbly SGDs, where bubbles are few and widely spaced, are sporadically distributed throughout the study area. Curtain bubbly SGDs, where bubbles are more closely spaced, resembling a curtain, are usually found where lineaments converge when projected offshore. They can also be widespread where limestone outcrops are found on land. Spring bubbly SGDs, where high amounts of discharge emanate from a point in the seafloor, can be found in areas where lineaments converge offshore. They can also be found emanating from bedding planes. Parabolic water column anomalies emanating from the seafloor but with no trains of reflectors rising to the surface, suspected to be non-gaseous or water-rich SGD, are typically co-located in the zones with the other types of bubbly SGDs. The distribution and nature of SGD in the study area can be attributed to the geology of the area, such as the permeability of lithologies that serve as the coastal aquifers, as well as the presence of structural features such as faults, lineaments, and bedding planes where discharge may seep out.

Keywords: submarine groundwater discharge (SGD); bubbly SGD; acoustics; fish finders; Mabini; geologic controls

Abundance and composition of microplastics in Mekong river's sediment

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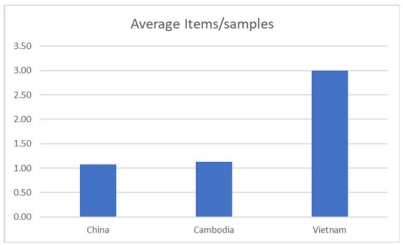
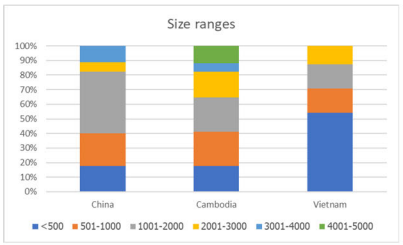
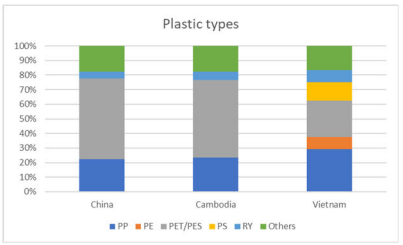
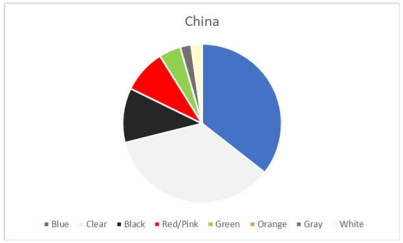
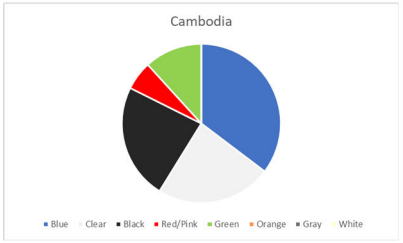
Microplastic (MPs) contamination in the environment is a global problem, as evidenced by the increasing amount of research worldwide. To our knowledge, this study is the first to investigate the MPs distribution in Mekong River. Sediment samples were collected from the riverbank along Mekong River from China to Vietnam in Year 2020-2021. In this abstract only presents the results from China, Cambodia and Vietnam sections. The results in Thailand and Laos sections are not yet completed. There are 42, 15 and 8 sediment samples from China, Cambodia and Vietnam sections, respectively. From all sediment samples, only fiber and fragment shapes of MPs were detected. From overall of 88, 26 and 44 suspected items in China, Cambodia and Vietnam sediments, only 45, 17 and 24 items, respectively, were identified as MPs, the rest are non-MPs (including cotton/cotton-flax and unidentified). Fiber shape MPs are mainly found in the upstream section (75-80%), while slightly more fragment than fiber in Vietnam sediment. Blue and clear are the two most frequently observed colors. Red/pink and orange colors are observed more In Vietnam sediment than those in the upstream. Interestingly, average items per sample and smaller sizes of MPs are increased downstream. Composition of MPs, identified by FTIR, comprises of polypropylene (PP), polyethylene (PE), polyethylene terephthalate/polyester (PET/PES), polystyrene (PS), rayon (RA) and others (including poly(ethylene co-acrylic acid), polyacrylic and melamine-urea-formaldehyde resin). No PE and PS types of MPs are found in China and Cambodia sections. In China and Cambodia sediments, the most dominant polymers are PET/PS followed by PP. While in Vietnam section, more variety of MPs types are investigated with the two main polymers namely PP and PET/PS. Types of polymers found in Mekong sediments from China and Cambodia are PET/PES >> PP >> others > RY, whereas in Vietnam are PP > PET/PS > others > PS > PE = RY. The increasing of items and types of MPs in sediment downstream implies that there are more terrestrial MPs entering into the river but some of them end up in sediment. According to our recent study in Tapi-Phumduang River system in southern Thailand (Chinfak et al., 2021), we found one-third reduction in net MPs entering the sea due to tidal exchange. Since the flow of Mekong River is much higher than the Tapi River, some of the remaining MPs in Mekong River's water column might be a significant source of MPs discharged to the South China Sea.


Average Items/samples
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
China
Cambodia
Vietnam


Size ranges
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
China
Cambodia
Vietnam
<500
501-1000
1001-2000
2001-3000
3001-4000
4001-5000


Plastic types
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
China
Cambodia
Vietnam
PP
PE
PET/PES
PS
RY
Others


China
Blue
Clear
Black
Red/Pink
Green
Orange
Gray
White


Cambodia
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Clear
Black
Red/Pink
Green
Orange
Gray
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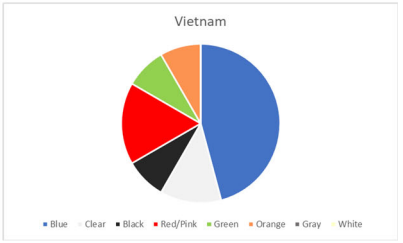
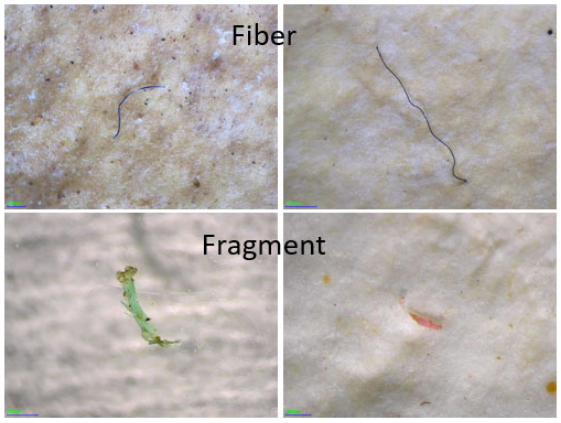
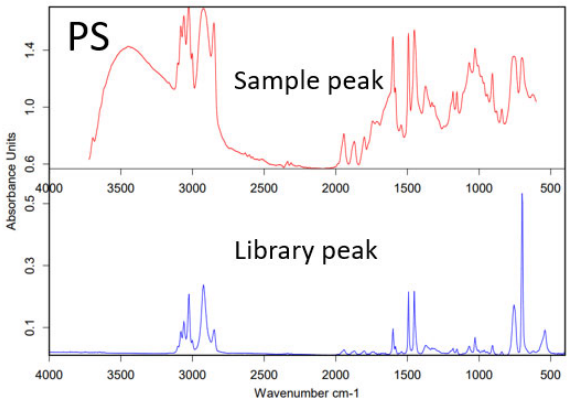
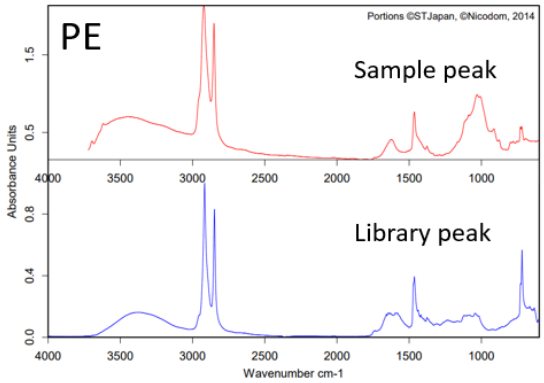
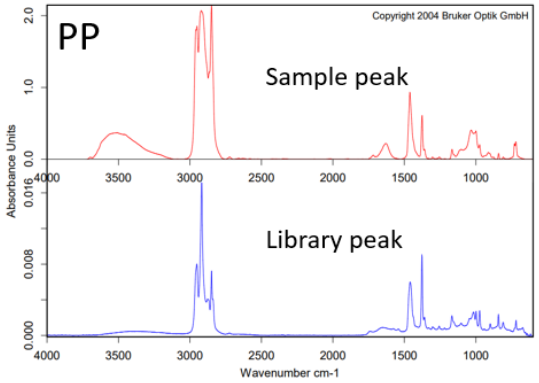
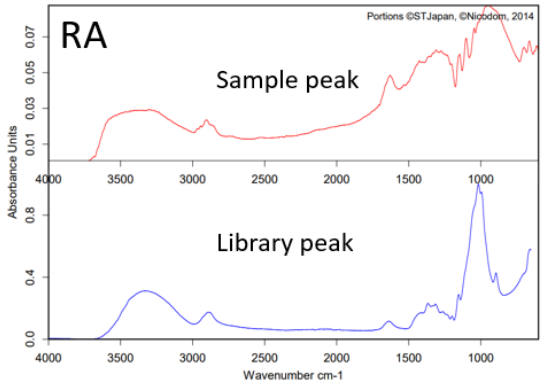

Vietnam
Blue
Clear
Black
Red/Pink
Green
Orange
Gray
White

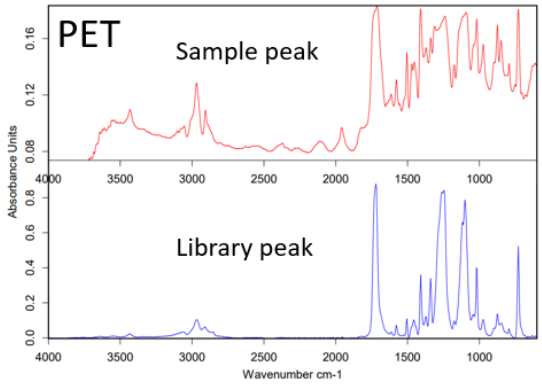

Fiber
Fragment


PS
Sample peak
Library peak
Absorbance Units
Wavenumber cm-1


PE
Portions ©STJapan, ©Nicodom, 2014
Sample peak
Library peak
Absorbance Units
Wavenumber cm-1


PP
Copyright 2004 Bruker Optik GmbH
Sample peak
Library peak
Absorbance Units
Wavenumber cm-1


RA
Portions ©STJapan, ©Nicodom, 2014
Sample peak
Library peak
Absorbance Units
Wavenumber cm-1


PET
Sample peak
Library peak
Absorbance Units
Wavenumber cm-1

Decadal scale change in the cycling of organic carbon on Luzon island of the Philippines

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Southeast Asia is the region with the highest land-ocean fluxes of sediment in the world. Previously, we have characterized the organic matter composition of riverine sediments from the island of Luzon from the Philippines (Lin et al., 2021). In this study, we returned to the same sampling sites to investigate the changes taking place in the cycling of carbon from this dynamic sedimentary system. Between the time of first sampling in 2007 and the time of second sampling in 2016, we observe marked changes in the radiocarbon age of sedimentary organic carbon appearing to reflect increased erosion of older earthen material into rivers. As the type of organic matter based on stable carbon isotope signatures appears to remain similar on average, these older ages may reveal increased mobilization of deeper soil material. This strong change we observe within the timespan of a decade indicates rapid environmental changes likely related to regional anthropogenic activity and or global climate change. The loss of these deeper soil layers implies that organic carbon that has built up on land over centuries is being transferred to the ocean where it faces an uncertain fate. We emphasize the importance of time series observations for understanding the dynamic changes taking place in our Earth system today and we will present the progress of our interpretations.

Reference:

Lin, B., Liu, Z., Eglinton, T. I., Blattmann, T. M., Kandasamy, S., Haghipour, N., and Siringan, F. P., 2021, Organic Matter Compositions and Loadings in River Sediments From Humid Tropical Volcanic Luzon Island of the Philippines: Journal of Geophysical Research: Biogeosciences, v. 126, no. 7.

The control of clay mineral nanostructures on sequestration of fluvial sedimentary organic carbon

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The association between clay minerals and organic carbon is pivotal for understanding transport, burial, and preservation processes of sedimentary organic carbon. However, fine-scale microscopic studies are still limited in assessing the effect of diverse clay mineral structures and properties on organic carbon sequestration. In this study, we employed X-ray photoelectron spectroscopy, Fourier transform infrared spectroscopy, and transmission electron microscopy coupled with energy dispersive spectroscopy and electron energy loss spectroscopy analyses to investigate the nanoscale interaction between clay minerals and organic carbon of two typical fluvial sediment samples with contrasting clay mineral compositions and organic carbon origins. Sample from Taiwan shows abundant illite and chlorite with petrogenic organic carbon, while sample from Luzon has significant smectite with pedogenic organic carbon. The results show that primary organic carbon constituents of both samples consist mainly of saturated hydrocarbons, although the Luzon sample exhibits a higher proportion of oxidized organic carbon. We observed that the nanostructure of the clay minerals controls the distribution of organic carbon. In the Luzon sample, the organic carbon is tightly associated with smectite, occupying expandable interlayer spaces. In the Taiwan sample, however, the organic carbon is primarily confined on the surface and edge of illite. These findings offer valuable insights into the selective association of organic carbon with clay minerals and underscore the role of clay mineral nanolayer structures in governing the occurrence and preservation of organic carbon in sediments. A comprehensive understanding of these interactions is crucial for accurate assessments of carbon cycling and sequestration in the natural environment.

Keywords: clay minerals; organic carbon; nanostructure; fluvial sediments; Taiwan; Luzon

Boundary exchange completes the marine lead (Pb) cycle jigsaw

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[8]*Faculty of Fisheries Technology and Aquatic Resources, Maejo University, Chiang Mai, Thailand*

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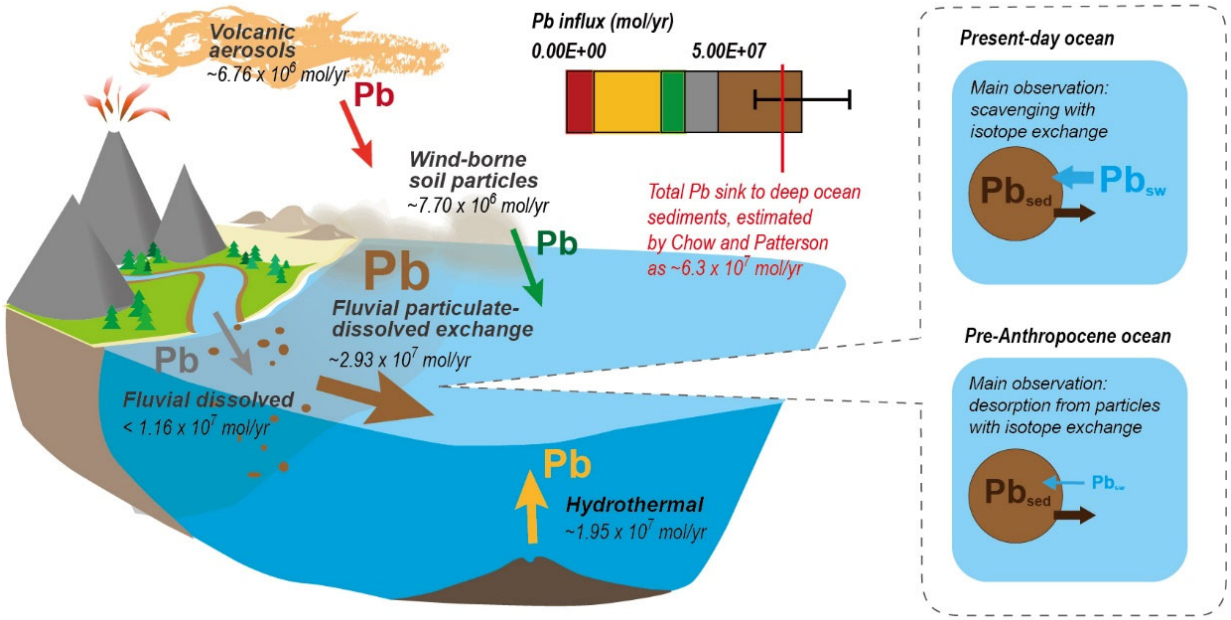
Land-to-ocean transfer of geogenic materials influences the composition of seawater and is an important process affecting biogeochemical element cycling involving interactions between the atmosphere, hydrosphere, geosphere, and biosphere. Within the ocean, the cycling of lead (Pb) has a long-standing paradox: global-scale studies on the deep-sea sediments indicate a significant fluvial/boundary Pb input (source), whereas most of the new work identifies coastal areas as sinks of Pb. Thus, the ocean Pb balance is incompletely specified both prior to and after the commencement of the Anthropocene. This uncertainty limits our ability of using Pb isotopes for source apportionment and muddles our interpretation of climate-weathering feedback in Earth's history.

Herein, we analyze a new dataset of seawater Pb concentrations isotopes from equatorial Southeast Asia, which is a region with a relatively small land mass yet contributes approximately one-third of the world's fluvial sediment inputs to the ocean. We show that the exchange of Pb between the dissolved and particulate phases is a vital process controlling the transport of Pb from lands to adjacent seas. In combination with model simulations, we further illustrate that dissolved-particulate exchange accounts for a significant fraction of Pb input into

the ocean prior to the Anthropocene. Thus, we find that the paradox to date was largely related to an incomplete assessment of land-to-ocean particulate transfer of Pb and subsequent transformation to the dissolved form. With Pb as an example, our study adds a crucial piece of evidence to the importance of boundary exchange in marine element cycling.



Assessment of peatland biodiversity in mangrove forest of the coastal zone in Cambodia

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Peatlands, one of the wetland categories that accumulate organic matter under anaerobic conditions, play an important role in supporting life and serve as natural carbon storage for mitigating global climate change. Peatland areas in Cambodia were not identified broadly until recently; however, it was such a tremendous pleasant shock that the first area of peatland was found in the country located within a mangrove ecosystem. The mangrove peat was first explored in 2012 and later confirmed in 2014 in Koh Kong province. The study found that 4,976 hectares of mangrove peat were confirmed in Peam Krasop Wildlife Sanctuary. In 2015, a similar study conducted in the same Province, but different location - at Botum Sakor National Park resulted in an additional 4,768 hectares of mangrove peat being confirmed (Lo, et al., 2016). Approximately, 22 species were recorded during the field study, it is noted that *Melalueca leucodendron* was also found, sometimes seen together with *Brugueira sexangular*. The study aimed to identify the current socio-economic situation of the local livelihoods in the natural environment and assess biodiversity in the peatland areas. Based on the available peatland distribution in mangrove forests. Two provinces: Kep and Kampot provinces were selected to conduct this survey in coastal areas: Both provinces were selected due to having plenty of natural resources, biodiversity, fisheries, mangrove forests, and salt farms. Ninety-two samples of respondents were selected for the study from the two provinces. The interview and focus group discussion are used to conduct socio-economics, while the assessment of biodiversity included plants, mammals, birds, herpetofauna, and fish applied different research methods, including transect line, scanning and observation method, national forestry inventory, rapid assessment method, and interviews. This is also identified habitats and related to physical factors (topography, climate, soil properties, etc.). The results found that a total of plant species was 60 species, with 4 dominant tree species, 7 species of mammals, 55 species of birds, 4 species of amphibians, 34 species of reptiles, 34 species of marine fish, and 28 species of freshwater fish.

Mangrove in South China Sea: Distribution and Biomass in Cambodia

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Mangroves provide vital ecosystem services including forest products, environmental education opportunities, and reduction of carbon emissions. The coast of Cambodia with the total distance of 435 km, covered by mangrove forest area of 33,978 hectares. Mangrove was found distributed in four-coastal provinces of Cambodia namely: Koh Kong (75%), Preahsihanouk (16%), Kompot (6%), and Kep (3%). There are 74 species of plants in the mangrove systems of Cambodia, from 53 genera and 35 families. Most of the mangrove forests along the coastal areas of Cambodia are dominated by two main species, namely Rhizophora apiculata and Rhizophora mucronate. Abundant mangrove forest areas are located in the large estuary of Peam Krasob/Koh Sraloa in the Koh Kong Province. In order to manage the mangrove forests in Cambodia, their total biomass needs to be determined. An allometric equation was developed in Cambodia to estimate the Above Ground Biomass (AGB) and Below Ground Biomass (BGB) for mangrove forest. As the result, the estimated average AGB is 150 tons/hectare and BGB is 29 tons/hectares.

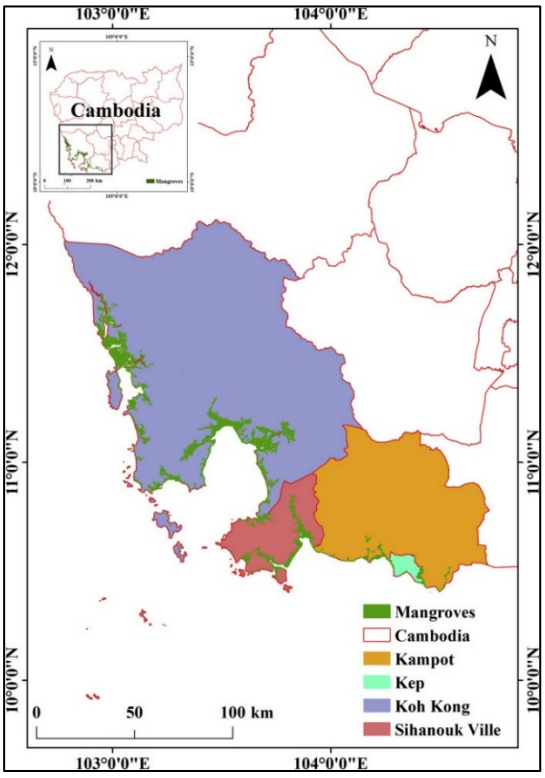

Figure 1. Map of Mangrove Distribution in Cambodia

Variability of the Maritime Continent Intertropical Convergence Zone during the past 30,000 years

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The intertropical convergence zone (ITCZ) plays a key role in regulating tropical hydroclimate and global water cycle through changes in its convection strength, latitudinal position and width. The long-term variability of the ITCZ, along with the corresponding driving mechanisms, however, remains obscure, mainly because it is difficult to separate different ITCZ variables in paleoclimate proxy records. Here we report a new speleothem oxygen isotope ($\delta^{18}O$) record from southwestern Sulawesi, Indonesia, and compile it with other speleothem records from the Maritime Continent. Using the spatial gradient of speleothem δ18O along a transect across the ITCZ, we constrain ITCZ variabilities over the Maritime Continent during the past 30,000 years. We find that ITCZ convection strength overall intensified from the last glacial period to the Holocene, following changes in climate boundary conditions. The mean position of the regional ITCZ has moved latitudinally no more than 3° in the past 30,000 years, consistent with the deduction from the atmospheric energy framework. However, different from modern observations and model simulations for future warming, the ITCZ appeared narrower during both the late Holocene and most part of the last glacial period, and its expansion occurred during Heinrich stadials and the early-to-mid Holocene. We also find that during the last glacial and deglacial period, prominent millennial-scale ITCZ changes were closely tied to the variability of the Atlantic meridional overturning circulation (AMOC), whereas during the Holocene, they were predominantly modulated by the long-term variability of the Walker circulation.

Holocene monsoonal variation in northeastern Luzon deduced from foraminiferal and sedimentological records from Luzon Strait

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The seasonally reversing winds of the East Asian Monsoon (EAM) result in wet and dry seasons on an annual basis. In the Philippines, these seasons are known as the SW Monsoon or "*habagat*" and the NE Monsoon or "*amihan*". This monsoonal variation influences the climate of the country and the currents on the bodies of water surrounding it. Because of the importance of the variability of the EAM in understanding climate and ocean currents, it has been the focus of several studies. Considering that the climate in the Philippines is generally described in terms of the amount of rainfall received, it is important to understand how the precipitation may vary over time. Furthermore, extreme climate conditions can significantly impact the different aspects of human lives or result in disasters such as floods, landslides or drought. Hence, it is important to understand the variability of precipitation in a region for a better grasp of the possible ecological, societal and economic impacts.

This study will be looking at how the monsoonal precipitation in the northeastern Luzon Region has varied during the Holocene in response to climate forcing mechanisms based on the sedimentary record of core MD06-3044 and MD06-3043. In particular, the study aims to investigate the monsoonal precipitation variability in the Cagayan Region during the Holocene through ^{14}C dating of planktonic foraminifera in core sediments, determination of temporal variation of sea surface temperature based on changes in planktonic foraminifera abundance, and determination of the variation of sedimentary flux in the area through major elemental ratios and magnetic proxies. The monsoonal variation will primarily be based on the trends of the results of these analyses. The precipitation variability will also be compared with the results of different studies in the East Asian Monsoon Region to see how the response in the northeastern Luzon Region varies with other areas affected by the East Asian Monsoon.

Reconstruction Past Changes and Evolution of Indonesian Throughflow

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Changes in ocean and atmospheric circulation patterns in the Western Tropical Pacific are associated with global society and economic impacts via shifts in rainfall, temperature extremes, and ecosystem failures. This proposal aims to explore past climate variability in the Indonesian seas for increasing predictability and reduce impacts of future climate change in this highly populated area. The Indonesian Throughflow (ITF) is a key element of global circulation pattern transporting surface waters and heat from the Pacific to the Indian Ocean. Future predictions from transient climate models indicate a slowdown of the ITF in response to the freshening and warming in the subpolar North Atlantic–Arctic Ocean and the resultant weakened Atlantic Meridional Overturning Circulation (AMOC). The research will explore the underlying physical processes that link changes in the AMOC and the ITF. Current observations and future modeling of the ITF variability are hindered by lack of knowledge of the underlying physical processes of these teleconnections. We will explore the past 25,000 years of climate change, focusing on specific periods of global climate states significantly different to modern conditions offering possibilities to test the relationship between shifts in global climate, changes in ocean circulation patterns, and shifts in the ITF.

Keywords: Indonesian Throughflow; past climate; Atlantic Meridional Overturning Circulation

Paleo-productivity on the continental slope off the Mekong River in the southern South China Sea since the Last Glacial Maximum

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Ocean primary productivity is one of key processes in controlling the atmospheric carbon dioxide and oceanic ecosystem function. To understand the paleo-productivity behavior in the southern South China Sea, temporal variation in paleo-productivity of Core SO18383–3 recovered from the continental slope off the Mekong River were integrated. The elemental ratios of Bio/Al, bBa/Al, Zn/Al, and Sr/Al were used to reconstruct paleo-productivity evolution, showing that the paleo-productivity was low around the Last Glacial Maximum (LGM) and early deglaciation (29.9–14.8 cal ka BP) then increased during the main deglaciation period (14.8–8.0 cal ka BP), before gradually declining during the Holocene (8.0–1.1 cal ka BP). This variation in paleo-productivity intensity was significantly controlled by the change in phosphorus input driven by the East Asian summer monsoon. This study greatly increased our understanding of the principal forcing factors on paleo-productivity in the southern South China Sea since the Last Glacial Maximum.

Keywords: biogenic element; East Asian monsoon; paleo-productivity; geochemistry

Metal concentrations of atmospheric aerosol and wet deposition flux in west Singapore during the northeast monsoon in 2023

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Southeast Asia has become a hotspot of anthropogenic particulate matter (PM) emissions due to increased coal combustion, high-temperature industrial operations, vehicular traffic, and agricultural biomass burning. Metals bound PM can affect to environment, even at extremely low concentrations. Atmospheric aerosols are removed via wet and/or dry deposition processes. Atmospheric deposition is considered to be a major source of toxic metals to ecosystem.

We collected coarse mode particles ($PM_{10\text{-}2.5}$) and rainwater in west Singapore in Northeast monsoon during 2023. To investigates the metal concentrations in the atmosphere and how much these metal flux to the ecosystem. Twelve metals (Al, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Ni, Pb, V and Zn) in atmospheric aerosols and rainwater were investigated. All samples were determined using inductively coupled plasma-mass spectrometry (ICP-MS) after acid digestion and preconcentration.

The results show that metals bound aerosols indicate significantly high concentrations of Al, Mg and Fe (average >100 ng/m^3), moderate concentrations of Ca, Zn and Pb (average 10 – 32 ng/m^3), and low concentrations of V, Cr, Mn, Ni, Cu and Cd (average <10 ng/m^3). The same trend was observed in rainwater samples, where Al, Mg, Fe, Ca and Zn were presented in high concentrations (average 6 – 17 µg/L), while V, Cr, Mn, Ni, Cu, Cd and Pb were presented in low concentrations (average <5 µg/L). Furthermore, the study assessed the wet deposition flux of metals in west Singapore during northeast monsoon season, which ranged from 1 – 582 µg m^{-2}. This process was found to be influenced by both the amount of rainfall and the pH of the precipitation.

Palaeo Pahang River during the Holocene – some morphologic features identified

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This paper presents some interesting morphologic characteristics of palaeo Pahang River during the early Holocene marine transgression of Sunda land to the post Holocene high-stand (HST) marine regression period. The features were identified from analysis of shallow seismic (CHIRP) profiles, 3D seismic time slices and cross-sections of Penyu Basin, and satellite images of present lower Pahang River basin. These identified changes to river morphology (i.e., pattern and cross-section) were related to climate induced sea level change from the Last Glacier Maximum (LGM) around 21-22 ka BP to present day. Palaeo flow rate of Pahang River before the onset of HST was estimated based on reconstructed channel morphology. It was found that the computed bank-full flow of palaeo Pahang River was about 15% lower than the present average peak flow for a river basin size that was essentially the same size at the point of computation. This suggests a drier climate at the onset of HST.

Zinc bioavailability in the Malacca Straits, Singapore, southern South China Sea and coastal Borneo: a measure of environmental impact and natural resilience

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Zinc is a trace metal with clear enzymatic roles for phytoplankton, but it can be toxic in high concentrations. Knowing its concentration and bioavailability facilitates an understanding of the biological response to zinc concentrations present in the marine environment. With the goal of tracking how anthropogenic sources of this metal and the perturbations to the natural chelating ligand sources affect its concentration, chemical speciation and bioavailability in the coastal and estuarine environment, we present here a compilation of our group's work in rivers, estuaries and seawater in the Malacca Straits, the southern South China Sea, Singapore coastal waters, and coastal Borneo's rivers and estuaries. Work by collaborators on the sources and degradation of marine and terrestrial organic matter in this region will help link to the metal's bioavailability regulation by natural organic matter, highlighting the dominance of riverine organic matter bringing water with peat and mangrove different signatures. Further comparison with global ligand patterns will focus on the connection to a global pool of metal regulation through global ocean circulation.

This project is part of an umbrella project that groups small scale work on local and regional mangroves, local scale seasonal monitoring of other metals' sources, collaborations investigating large rivers in South East Asia, and a collaborative effort to study coral records of metal accumulation. As the region represents an area of intense ship traffic, agricultural and aquacultural activities, as well as urbanization and industrialization, understanding the environmental impact of the balance of metal and chelating ligand sources is important to evaluate economic progress that has taken place over the recent decades, and to plan for future development. As such, we analyzed the current scenario of metal concentration and organic ligand from different sources we have studied in the region, and built up a simple model to estimate the capacity of the natural coastal ecosystem to handle pollution coming from anthropogenic activity. We put together ideas tracking the historical evolution of natural organic matter and metal sources, highlighting the importance of these concepts for policy and planning.

Transition from tholeiitic to alkaline basalts from southern Vietnam records the deceleration of asthenospheric upwelling after the termination of seafloor spreading

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Large amounts of intraplate basalts were erupted within and surround the South China Sea basin after the termination of seafloor spreading. In particular, the eruptive units in South Vietnam are the most voluminous in the Indochina Peninsula. Previous studies paid much attention to the petrogenesis of alkaline basalts, and built the connection between alkaline basalts, mantle source heterogeneity, and origins of the heterogeneity. However, intraplate basalts are always characterized by interlayered eruption of both alkaline and tholeiitic basalts. In general, a transition from tholeiitic to alkaline basalts is observed on the timescale. Nonetheless, no suitable interpretation was obtained to explain the petrogenesis of such a transition.

Whole rock geochemical compositions for tholeiitic and alkaline basalts from southern Vietnam are reported in this study to understand the petrogenesis of southern Vietnam basalts and the deep dynamics behind them. In comparison with alkaline basalts, southern Vietnam tholeiitic basalts are characterized by lower MgO, TiO_2, K_2O, higher SiO_2, Al_2O_3, and more depleted in strongly incompatible elements and radiogenic Sr and Nd isotopes. The geochemical features of tholeiitic basalts are similar to those of the SCS MORB samples. In contrast, alkaline basalts show geochemical features similar to reported intraplate basalts derived from carbonated mantle source, such as negative anomalies of Zr, Hf, and Ti, and light Mg isotopic compositions. Source pressure estimations of southern Vietnam basalts show that origin of alkaline basalts is much deeper than tholeiitic basalts. The above results together show that transition from tholeiitic to alkaline basalts record a shift of mantle melting from shallow mantle to deep mantle after seafloor spreading, indicating the significant deceleration of asthenospheric upwelling. Such a mantle dynamic phenomenon is different from the active mantle upwelling as generated by mantle plume.

Tectonic Rotation and Latitudinal Displacement of SW Yunnan and Indochina Blocks: Constraints From new and Published Paleomagnetic Data

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The India–Asia collision and formation of the Tibetan Plateau are arguably the most important geological events of the last 100 Ma in Earth's history. The collision directly reshaped large part of Asia and changed regional climate and biodiversity. Yet the tectonic consequences and geodynamic models are widely different and have been long debated. Several key tectonic questions remain unanswered, such as: (1) Was Myanmar at the collision front before the India-Asia collision or connected with the Lhasa block? (2) Was there a nearly 90 ° arc bend on the eastern side of the Himalayas? (3) Was Indochina Block attached to the South China Block and traveled with it during the convergence? Paleomagnetic data have long been used to hypothesize that the Cenozoic extrusion of the Indochina Block along the left-lateral Aliao Shan-Red River fault, as a result of the India-Asia collision, may have been associated with southward paleolatitude movements and vertical-axis rotations. However, the detailed rotation and latitudinal displacement of blocks of SE Asia remain controversial. In this study, we report results of our paleomagnetic study on the Jurassic-Eocene sedimentary and volcanic rock from the western Yunnan and critically review the available paleomagnetic data from the southeast margin of the Tibetan Plateau, NW part of the South China Block, as well as those from Myanmar and Indochina. Paleomagnetic declinations from our study as well as those from blocks in the SE Tibetan margin and the northern Indochina reveal large coherently clockwise rotations for blocks in the SE Tibetan margin and the northern Indochina. These blocks are bounded by fold-thrust belts and strike-slip faults, which may have accommodated these block rotations during the Cenozoic. On the other hand, there is no paleomagnetically resolvable southward motion of the Indochina Block with respect to Eurasia based on the published paleomagnetic data.

Changing sedimentary architecture of channel sandstone bodies: Cryptic signals of basin evolution from the Neogene Siwalik deposits of Eastern Himalaya

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Unraveling the sedimentary basin evolution is one of the major goals of earth scientists interested in understanding the large-scale crustal processes, regional climate changes and concentration of economically important resources. A variety of proxies from petrography to stratigraphy, geochemistry to geochronology, structural analysis to seismic studies, are dedicated to the study of basin evolution. Both machine data and field studies are important components of the scientific studies of basin evolution, although in some cases complete decoupling of field data and machine-generated data may result in erroneous reconstruction of the basin evolution. In this paper we present our data from field analysis of the Siwalik succession across a strike length of ~700 km spread over four transects along the Eastern Himalayan Foreland Basin (EHFB). We intend to show that careful documentation of changes in architecture of channel bodies are indicative of changing surface processes and such changes in the surface processes are indication of variation of the major controlling factors like tectonics, climate or sea level. A veritable wealth of knowledge revealed from the field-based study of the channel body architecture from these Neogene foreland deposits necessitates a remarkable departure from the current overall understanding about the paleogeography, climate, and tectonics of this basin.

In the western end of our study area, i.e., in the Tista Valley, the sedimentology of the Middle Siwalik succession indicates a marine deltaic environment where fluvial facies is less important component and occurs commonly as delta mouth sub-aqueous channels usually referred to as Terminal Distributary Channels (TDC). Many of the workers were mislead by the apparent concave-upward basal surface of the sandstone bodies of TDC and identified these as depositional signature of continent interior alluvial channels system. Due to lack of careful examinations, these workers missed the presence of combined flow bedforms and a complex paleocurrent pattern of these channel-fill successions, beside the smooth-bottomed nature of these channel-like features, representing the delta mouth subaqueous channels. The brackish water influence is further corroborated by trace fossils, paleo-spores and pollens, reported from this succession. As we move to the east, much of Middle Siwalik rocks of eastern Bhutan and western Arunachal Pradesh are made up of large-scale unidirectional bedforms showing S to SW paleocurrent. A clear gradation from marine delta-mouth deposits to continent interior fluvial deposits is well- exposed in the transition from Lower Siwalik to Middle Siwalik succession of these areas. Such changes in the architecture and facies of the channelized

sandstone bodies clearly indicate a change in the tectono-climatic regime of the foreland basin and is consistent with sea level low stand and establishment of a large-scale continent interior drainage system.

The fluvial Middle Siwalik succession is well-exposed in the Itanagar area. The road cut sections reveal the internal architecture of a large-scale braided river comprising a series of braid bar deposits. Based on the average thickness of cross-beds, a channel depth of 30 to 50+ m is estimated, indicating that these channels were deeper than the present-day Brahmaputra River at Bangladesh (12-50m). This indicate that a major continental drainage was established in the eastern foreland during the deposition of the Middle Siwalik. However, the mean paleocurrent direction of ~170˚, measured from these cross sets, is oriented at high angle to the trend of the mountain belt. Whereas most of the workers assumes that the Middle Siwalik paleochannels as axial drainage system the actual data in Itanagar area contradicts this. We suggest this may indicate more southward orientation of the drainage system prior to the uplift of the Shillong Plateau. Uplift of the Shillong Plateau is dated at around 5 Ma whereas the base of the Middle Siwalik in the Itanagar must have been older than 7.5 Ma.

The Itanagar section exposes the transition of the Middle Siwalik fluvial system into a second marine succession in the overlying part of the Upper Siwaliks deposits. This transition is marked by the abrupt increase in the mudstone-siltstone, development of smooth-bottomed channels, presence of wave-generated structures, evidence of tidal reworking and presence of brackish water tolerant trace fossils. This transition is better exposed further east in the Siji River section. In the Siji River section, the coarse-grained fluvial bars of the Middle Siwalik succession contains several horizons where subtle evidence of tidal reworking is present. Facies and architecture of tide-reworked braid bars, tidal and estuarine channels are distinctly different from the large-scale channel bodies of the Itanagar area. These changes once again denote a renewed marine transgression in the Eastern Himalayan foreland basin and must be reflective of major changes in tectonoclimatic regime and/or sea level in the basin.

The U-Pb age of the detrital zircons from the Siwalik sediments of eastern foreland, our study area, indicate the presence of the Gangdese Batholith derived sediments in the foreland deposits. The detrital age data, coupled with the assumption of fluvial deposition for the entire Siwalik succession of the Eastern Himalaya, forms the basis of several major paleodrainage reconstructions of the Eastern Himalayan Foreland Basin. We present evidence from the study of the architecture of the channel sandstone bodies that the paleogeography of the Eastern foreland basin is much more complex than that presumed and is marked by two marine transgressions. Varying architecture of channel sandstone bodies reveal: a) Much of the channels bodies in the Tista Valley at the western end of the study area represents lower delta plain or delta mouth subaqueous channels; b) the lower Siwalik throughout the Eastern Foreland Basin is marine rather than a meandering fluvial deposit; c) the large continent interior braided fluvial deposits in parts of the basin shows a gross drainage orientation transverse to the foreland basin axis and should not be referred as an axial drainage system; d) a significant part of the Upper Siwalik succession represents a product of second marine transgression in the basin.

Recognition and significance of facies characteristics and architecture in a sandy wave-tide influenced delta: an example from Siwalik foreland basin, Tista valley, eastern India

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Despite advances in facies analysis of deltaic deposits, the effects of basinal processes in ancient rock records are not widely documented, and their facies characteristics remain poorly understood. Riverine processes are easily recognizable in a rock record compared to wave or tide processes therein, that result in the difficulty of detailed facies analysis of the complex deltaic systems. Most of the previous studies are based on the fluvial-marine transition along the axis of a basin from proximal to distal part. However, there may be similar variation from river-dominated facies in case of transverse rivers that feed wave-tide dominated axial marine system. In this paper the interactive dynamics of fluvial and basinal processes preserved in a strike-parallel outcrop belt of deltaic deposits, in the Neogene Foreland sediments of the Darjeeling-Sikkim Himalaya (eastern India) have been investigated. The lateral and vertical co-existence of wave-storm-tide modulated prodelta-delta-front deposits, open marine bay-fill deposits and riverine delta front to delta mouth deposits are well-preserved in this succession. The tidal signatures are subtle and fluvial-tidal features are mostly developed as inter-flood deposits or off-axis interdistributary regions. 10s of meters scale vertical successions of fluvial and wave-tidal facies is interpreted to indicate autogenic processes like fluvial discharge fluctuations (seasonality) or avulsive relocation of the major distributary channels and subordinate variation in wave-tide influence controlled by the extant physiography in a mixed-type deltaic deposit. We document the architectural elements of an evolving mixed-type delta system parallel to paleocoastline developing in response to autogenic processes. The effect of allogenic processes of sea level change (HST-TST-HST) and tectonic activity is recognised in 100s of meter scale vertical succession displaying major changes in the lithology and facies association. The improved identification of process interactions, and their preservation in ancient fluvial to marine transition zones, is fundamental to refining interpretations of ancient deltaic successions. The significant outcome of this study-Recognising the features of weak tide or wave processes overlooking which may result in a wrong interpretation of exclusively fluvial environment for river-dominated sandy deltaic sediments that lack of marine body fossils.

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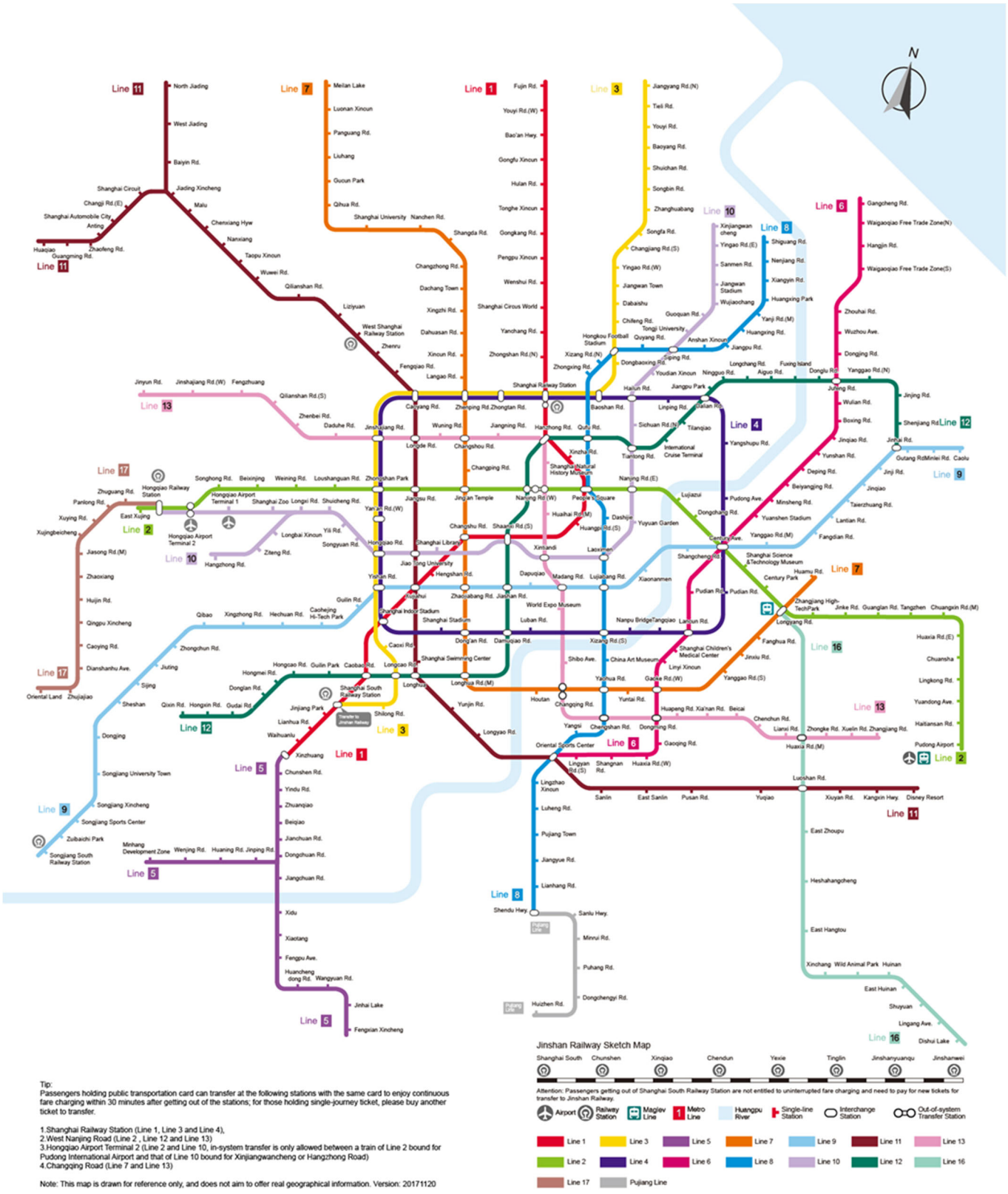

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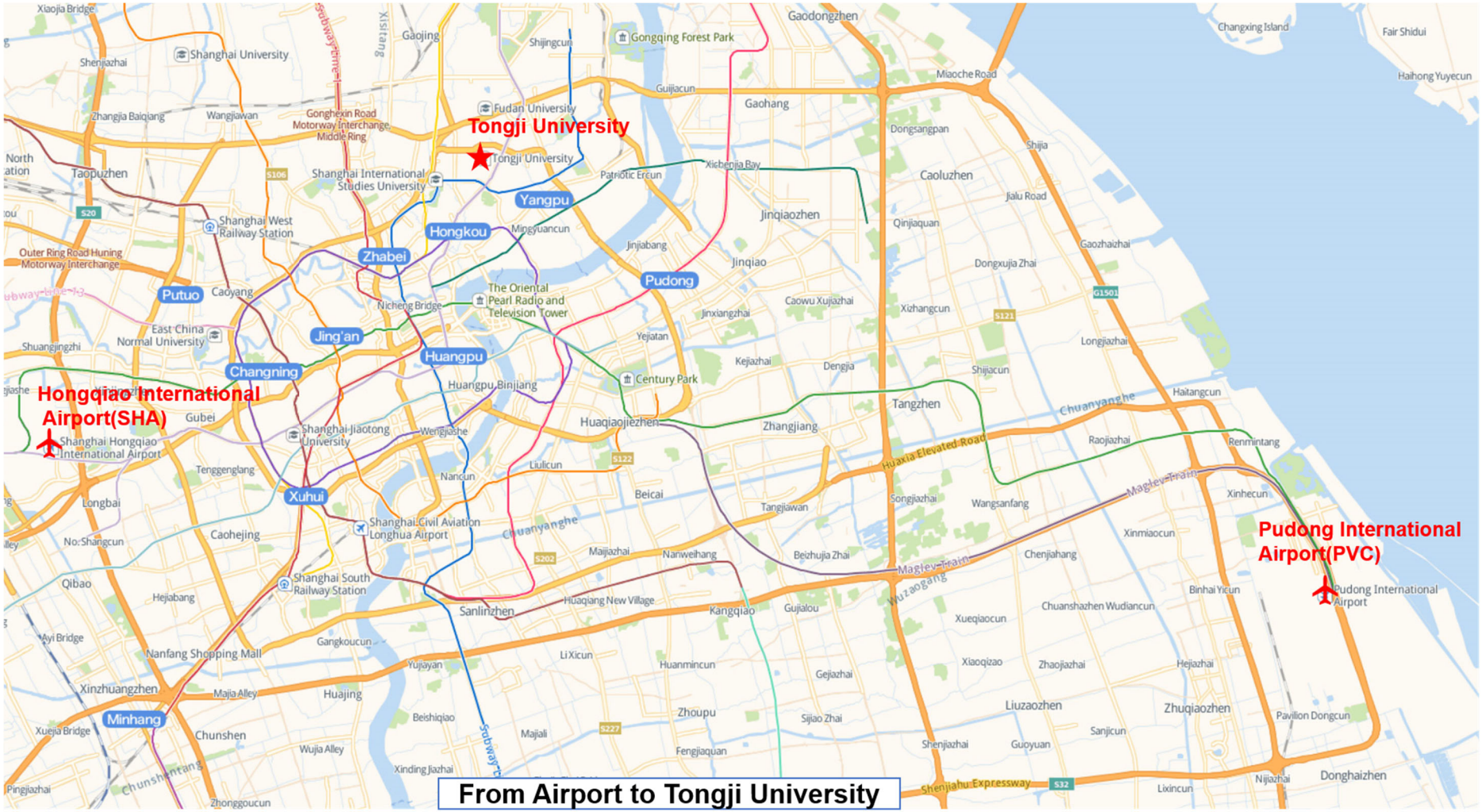
Note: This map is drawn for reference only, and does not aim to offer real geographical information. Version: 20171120

SHANGHAI METRO NETWORK MAP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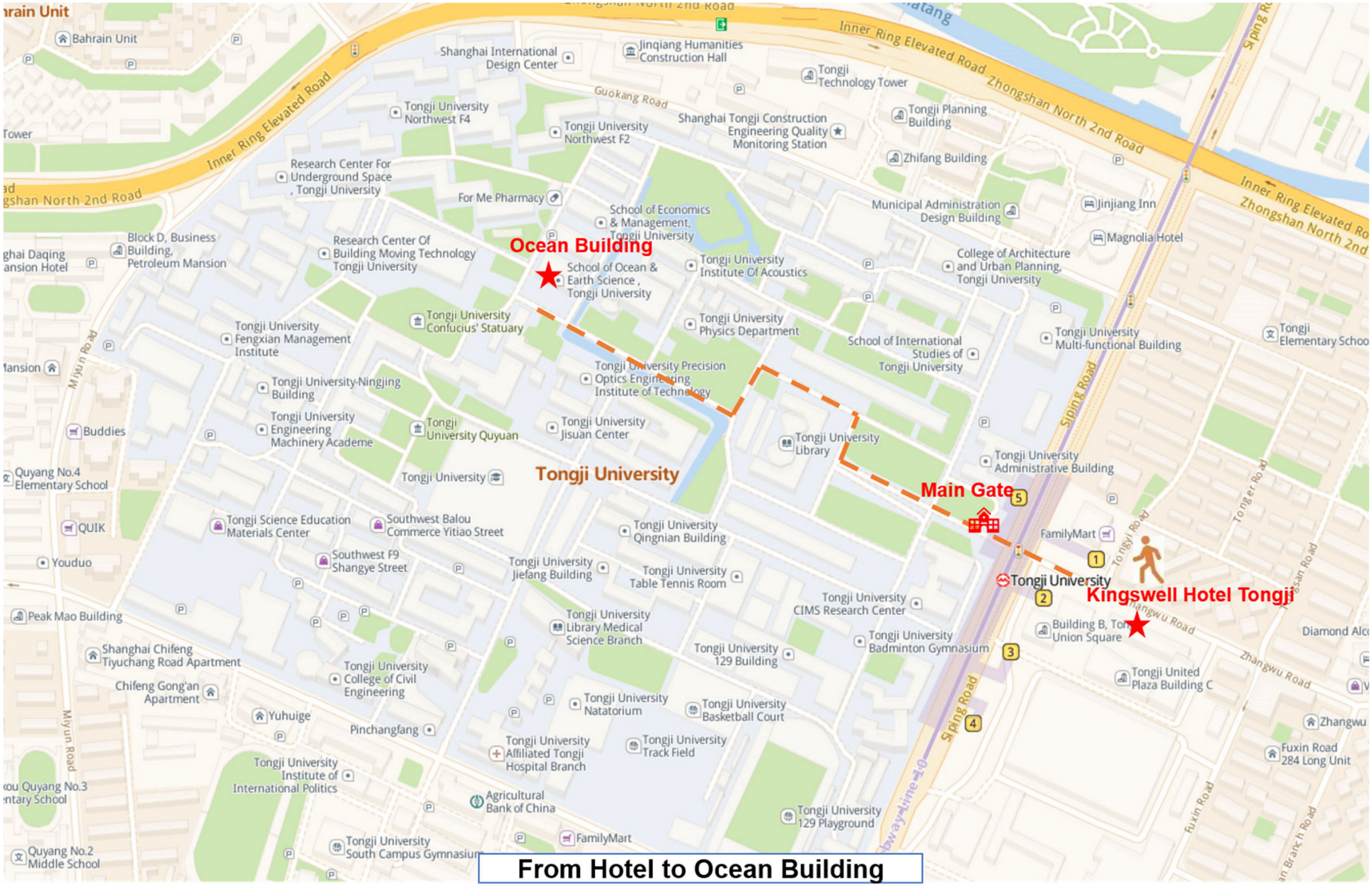
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QUIK
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