

IODP Proposal Cover Sheet

1007 - Full

Sunda Shelf Carbon Cycling

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Title	Evolution of the Pliocene-Pleistocene Tropical Sunda Shelf (SE Asia): Reconstructing Sea Level Change, Drainage System Development, and Carbon Cycling		
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Keywords	Sea level, paleo-river, carbon cycling	Area	South China Sea

Proponent Information

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Abstract

The Earth has cooled gradually since the middle Miocene and accelerated over the past 5 Ma leading to the development of Northern Hemisphere ice sheets, and since then, the cooling has been punctuated by recurring ice ages. Many hypotheses have been proposed to explain this cooling trend, but with no consensus. The emergence of the low-latitude Maritime Continent has been proposed to be a driver for the global climate change during the Pliocene-Pleistocene epochs. The growth of the Maritime Continent should have intensified the chemical weathering of basaltic silicates, increased atmospheric CO₂ consumption, and thus cooled the planet subsequently by forming the ice sheets. With lowering the eustatic sea level, the exposure of low-latitude continental shelf could favor developing large paleo-river systems, which are expected to contribute to the transport of weathering products and the propagation of marine vegetation, further enhancing the carbon sequestration. To test this scientific hypothesis, we propose to drill in tectonically stable sedimentary basins on the tropic Sunda Shelf, the western part of the Maritime Continent, to reconstruct Pliocene-Pleistocene sea-level change, drainage system development, and carbon cycling.

The Sunda Shelf provides particularly well-suited conditions for comprehensive high-resolution studies to reconstruct major geomorphic changes on the Maritime Continent and to assess associated interactions with the global climate. As the largest tropical shelf in the world, the Sunda Shelf was completely exposed during sea-level lowstand periods, allowing the development of large paleo-drainage systems and widespread rainforests and marine vegetations. Here we propose a Mission Specific Platform-based drilling project on the Sunda Shelf in the southern South China Sea to drill ten sites throughout four major sedimentary basins along two largest paleo-river systems to retrieve sedimentary sequences deposited since 5 Ma. Sampling the paleo-river systems to determine their age and sedimentary environment will allow to reconstruct the eustatic sea-level fluctuations and the development of major drainage systems. This will help us understand the erosional response to tectonic activity occurred in drainage hinterlands of SE Asia and the flux of weathering products on the shelf. The Sunda Shelf and adjacent land regions were covered by rainforests and marine vegetations during sea-level lowstand periods, comparable with those in modern Amazon and Congo systems in term of environmental impact and carbon storage. The retrieved sedimentary sequences will be used to evaluate the contribution of the glacial exposure of this major tropical shelf region functioning as an enormous CO₂ sink and carbon sequestration.

Scientific Objectives

The science mission of this drilling campaign is to test the hypothesis that the emergence of the low-latitude Maritime Continent with associated chemical weathering of basaltic silicates and carbon sequestration efficiency of marine vegetation is a driver for the Pliocene-Pleistocene global climate change.

The specific scientific objectives of this project are:

1. To document the history of eustatic sea-level fluctuations over the past 5 Ma in relation to glacial/interglacial cycles and boreal ice sheet extent with a special focus on the Pliocene-Pleistocene transition and the associated rapid variability.
2. To reconstruct the development of major river systems in the Sunda Shelf region, the erosional response to tectonic activity in the hinterland, and the flux of weathering products on the shelf.
3. To evaluate the contribution of the glacial exposure of this major tropical shelf region as a massive sink for carbon and source for atmospheric greenhouse gas emissions, and to assess its role in regulating and shifting global climate.

Non-standard measurements technology needed to achieve the proposed scientific objectives

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Science Communications Plain Language Summary

Using simple terms, describe in 500 words or less your proposed research and its broader impacts in a way that can be understood by a general audience.

The Earth has been cooling over the past 5 million years, leading to the development of Northern Hemisphere ice sheets. Since then, the cooling has been punctuated by recurring ice ages, i.e., alternating between interglacial and glacial stages. Scientists have tried to understand the reason, but with no consensus. Recently, there has been an overwhelming opinion that the emergence of the low-latitude Southeast Asian islands (called "Maritime Continent") has driven this cooling trend. This hypothesis says that the islands should have consumed atmospheric CO₂ through intensifying the chemical weathering and finally cooled the planet.

To test this scientific hypothesis, we propose to drill in the Sunda Shelf, the largest tropical shelf in the world. The Sunda Shelf is located in the western part of the Maritime Continent, and it is very tectonically stable and particularly well-suited for addressing the hypothesis. We have designed a total of ten sites throughout four major sedimentary basins (Pattani Basin, Malay Basin, and West/East Natuna Basin) and along two largest paleo-river systems (North Sunda River and Chao Phraya-Johore River) to retrieve sedimentary sequences deposited since 5 million years ago. A series of analytical methods will be applied to these core samples to study: (1) the eustatic sea-level fluctuations, (2) the paleo-river system development, and (3) the carbon cycling. This project is of significance for understanding long-term (tectonic and climate scales) and short-term (millennial scale) cooling trends with interglacial and glacial alternations over the past 5 million years.

Proposal History

Submission Type **Resubmission from declined proposal**

Declined Proposal Number **907-Pre**

Review Response

The proposal has been strongly rewritten by considering scientific objectives, implementation strategies, and comments from the SEP. Here major changes are highlighted:

1. The science mission through testing a hypothesis that the emergence of the low-latitude Maritime Continent is a driver for the Pliocene-Pleistocene global climate change is clearly presented. Three specific objectives are used to support the science mission.
2. The drilling target area is extended from the outer shelf of the West/East Natuna Basin to the entire Sunda Shelf including the Pattani Basin and the Malay Basin in the inner and middle shelf (Gulf of Thailand). The new drilling area covers all major sedimentary basins and expects to obtain the full/complete records of the Sunda Shelf evolution.
3. Although site seismic data are not fully available, detailed survey cruises have been prepared (delayed due to the influence of Covid-19 pandemic). Considering mostly likely acquisition of seismic data and potential geopolitical conditions, a two-expedition plan is proposed.

Proposed Sites (Total proposed sites: 20; pri: 10; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SS-01A (Primary)	9.2642666 101.3727690	71	425	0	425	Sampling Pliocene-Pleistocene sediments of the inner shelf and Chao Phraya-Johore River's upper reaches, this site aims to study drainage system development and carbon cycling.
SS-02A (Primary)	9.1728983 101.4452223	71	451	0	451	Sampling Pliocene-Pleistocene valley fills of the Chao Phraya-Johore River's upper reaches, this site aims to study drainage system evolution.
SS-03A (Primary)	9.6970459 101.2989645	67	505	0	505	Sampling Pliocene-Pleistocene sediments of the coastal area and Chao Phraya-Johore River's upper reaches, this site aims to study sea level change and drainage system development.
SS-04A (Primary)	7.0570909 103.1446443	52	382	0	382	Sampling Pliocene-Pleistocene sediments of the inner shelf and Chao Phraya-Johore River's tributaries originating from the Malay Peninsula, this site aims to study drainage system development and carbon cycling.
SS-05A (Primary)	6.4824589 103.6738589	58	466	0	466	Sampling Pliocene-Pleistocene sediments of the inner shelf and Chao Phraya-Johore River's middle reaches, this site aims to study sea level change, drainage system development, and carbon cycling.
SS-06A (Primary)	5.2195339 104.8348970	71	448	0	448	Sampling Pliocene-Pleistocene sediments of the middle shelf and Chao Phraya-Johore River's middle reaches, this site aims to study sea level change, drainage system development, and carbon cycling.
SS-07A (Primary)	4.328276 105.8902998	85	270	0	270	Sampling Pliocene-Pleistocene sediments of the middle shelf and Chao Phraya-Johore River's southern tributaries, this site aims to study drainage system development and carbon cycling.
SS-08A (Primary)	6.0420913 108.5820773	103	358	0	358	Sampling Pliocene-Pleistocene sediments of the outer shelf and Chao Phraya-Johore River's lower reaches, this site aims to study sea level change and carbon cycling.
SS-09A (Primary)	2.4624345 107.5640488	82	166	0	166	Sampling Pliocene-Pleistocene sediments of the middle shelf and North Sunda River's middle reaches, this site aims to study drainage system development and carbon cycling.
SS-10A (Primary)	5.3933154 110.3830168	161	491	0	491	Sampling Pliocene-Pleistocene sediments of the outer shelf to the shelf edge and North Sunda River's lower reaches, this site aims to study sea level change and carbon cycling.
SS-11A (Alternate)	9.3853451 101.2767266	71	417	0	417	Sampling Pliocene-Pleistocene sediments of the inner shelf and Chao Phraya-Johore River's upper reaches, this site aims to study drainage system development and carbon cycling. This is an alternate site for SS-01A.
SS-12A (Alternate)	9.2640920 101.491472	69	442	0	442	Sampling Pliocene-Pleistocene valley fills of the Chao Phraya-Johore River's upper reaches, this site aims to study drainage system evolution. This is an alternate site for SS-02A.
SS-13A (Alternate)	8.7911615 101.6467396	69	464	0	464	Sampling Pliocene-Pleistocene sediments of the coastal area and Chao Phraya-Johore River's upper reaches, this site aims to study sea level change and drainage system development.
SS-14A (Alternate)	6.9337576 102.7500000	46	416	0	416	Sampling Pliocene-Pleistocene sediments of the inner shelf and Chao Phraya-Johore River's tributaries originating from the Malay Peninsula, this site aims to study drainage system development and carbon cycling. This is an alternate site for SS-04A.
SS-15A (Alternate)	5.9203582 104.1909414	67	433	0	433	Sampling Pliocene-Pleistocene sediments of the inner shelf and Chao Phraya-Johore River's middle reaches, this site aims to study sea level change, drainage system development, and carbon cycling. This is an alternate site for SS-05A.

Proposed Sites (Continued; total proposed sites: 20; pri: 10; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SS-16A (Alternate)	5.1524383 104.8965083	66	425	0	425	Sampling Pliocene-Pleistocene sediments of the middle shelf and Chao Phraya-Johore River's middle reaches, this site aims to study sea level change, drainage system development, and carbon cycling. This is an alternate site for SS-06A.
SS-17A (Alternate)	4.5033204 106.039961	85	350	0	350	Sampling Pliocene-Pleistocene sediments of the middle shelf and Chao Phraya-Johore River's southern tributaries, this site aims to study drainage system development and carbon cycling. This is an alternate site for SS-07A.
SS-18A (Alternate)	6.483694 108.3875716	105	319	0	319	Sampling Pliocene-Pleistocene sediments of the outer shelf and Chao Phraya-Johore River's lower reaches, this site aims to study sea level change and carbon cycling. This is an alternate site for SS-08A.
SS-19A (Alternate)	3.5803483 108.5726929	99	135	0	135	Sampling Pliocene-Pleistocene sediments of the middle shelf and North Sunda River's middle reaches, this site aims to study drainage system development and carbon cycling.
SS-20A (Alternate)	5.0037278 109.9969343	120	169	0	169	Sampling Pliocene-Pleistocene sediments of the outer shelf to the shelf edge and North Sunda River's lower reaches, this site aims to study sea level change and carbon cycling. This is an alternate site for SS-10A.