

Sunda Shelf Sea Level

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Title	Carbon Storage, Climate, Biosphere Change, and Continental Weathering on Plio-Pleistocene Low Latitude Shelves: Evidence from the Sunda Shelf		
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### Proponent Information

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### Abstract

During Late Pleistocene glacial to interglacial cycles, the low-latitude tropics were affected by repeated emergence and submergence of some of the world's largest continental shelves. Initial studies suggest that enhanced silicate chemical weathering of exposed sediments and intensified cycling of organic carbon, associated with the growth of rainforests during times of exposure of the 'Maritime Continent', had a significant effect on global atmospheric CO<sub>2</sub> variability through glacial cycles. Unlike their high-latitude equivalents, tropical shelves played a key role in regulating global climate since the onset of polar glaciation in the Pliocene, but this process is presently poorly understood because previous scientific drilling was largely focused on the continental slope and deep-water basins.

We will test the impact of the Maritime Continent on global climate in the recent geological past, spanning multiple glacial to interglacial sea-level cycles. The Sunda Shelf in SE Asia is the world's largest tropical shelf, and thus potentially had the greatest impact on global glacial climate since the Pliocene. Moreover, the Sunda Shelf may have been a site of extensive methane-emission from coastal wetlands that formed during times of rising and high sea-levels, but were subsequently eroded during sea-level regressions, further amplifying glacial-interglacial climatic contrasts. Repeated exposure of the shelf during glacial periods drove drainage reorganization of the large rivers that converge in the area. Such reorganization and splitting both restricted and expanded drainage basins, enhancing speciation rates and thereby resulted in the modern diversity hotspot in this area. The region was also a critical gateway for human migration. However, without constraints on drainage evolution and the fauna or flora in the past these concepts remain untested.

Coring a transect across the shelf from nearshore to the shelf break in the eastern shelf, south of the Mekong Delta, will permit a silicate weathering and organic carbon budget to be reconstructed when coupled with regional seismic datasets. The proposed study region also spans the boundary between the Mekong in the east and the Chao Phraya (Johore) River in the west. Continuous marine deposition along its eastern edge aids biostratigraphic dating of more terrestrial strata preserved further west. The sedimentary sequences recovered will be used to evaluate and quantify the contribution that glacial sea-level lowstand exposure of this extensive tropical shelf made as a globally significant CO<sub>2</sub> and methane sink/source, and assess whether this tropical region acted as a second set of "Lungs of the Earth".

## Scientific Objectives

A Minimum Plan with four sites drilled to the Mid Pleistocene reflector on regional seismic profiles will

- 1) Construct a carbon budget for the northern Sunda Shelf and determine its potential impact on global warming and cooling cycles since the Mid Pleistocene.
- 2) Constrain the duration of shelf exposure and measure the intensity of silicate chemical alteration and carbon storage that occurred each time the continental shelf was exposed during glacial sea-level lowstands since the Mid Pleistocene (~800 ka).
- 3) Measure the quantity and characterize the nature of buried organic carbon on the Sunda Shelf and use regional seismic datasets to infer volumetric carbon storage and recycling budgets.
- 4) Use combined organic, isotopic and inorganic geochemistry together with palynology to determine the distribution and type of terrestrial biomass that developed on the exposed continental shelf during glacial periods of low sea level.
- 5) Reconstruct paleo-rainfall intensities and distribution patterns using biomarker hydrogen isotope ratios across climate cycles.
- 6) Reconstruct the development of river systems across the exposed shelf using provenance proxies; in particular determine the dynamic boundary between the Johore and Mekong rivers.
- 7) Constrain the magnitude and timing of sea-level variation since 800 ka across the Sunda Shelf in Southeast Asia.

An Intermediate Plan calls for the same objectives but drilled to the Base Pleistocene (~2.6 Ma). A Maximum Plan involves six sites drilled to the Base Pleistocene (~2.6 Ma), providing improved spatial resolution.

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.

Cycles of global cooling and warming are largely driven by variations in the orbit of the Earth, which controls the amount of warmth that the planet receives. However, these cycles can be accentuated as a result of feedbacks. We explore the idea that tropical continental shelves play an important role in the waxing and waning of ice sheets. Because the climate is warm and wet in the tropics, even during ice ages, the minerals in the sediments that are exposed when the sea level drops are prone to decay and this process removes CO<sub>2</sub> from the atmosphere. In addition, falling sea level destroys coastal wetlands which are a major source of methane to the atmosphere. Methane is an even stronger greenhouse gas than CO<sub>2</sub>. Continental shelves exposed during glacial times provide ideal locations for the growth of tropical forests which store carbon and further reduce CO<sub>2</sub> in the atmosphere. While those in Africa and the Amazon remain much of the forest in SE Asia was drowned as sea level rose after the last ice age. SE Asia has one of the largest continental shelves on Earth and is currently the largest source of methane to the atmosphere. Rising and falling of sea levels, together with the development of large river systems when the sea level is low, is thought to contribute to biological speciation and the development of the biodiversity hotspot in Southeast Asia. We propose to drill a series of holes across the Sunda Shelf, between Borneo and Vietnam, in order to quantify the amount of chemical weathering and organic carbon burial that occurs during each sea level cycle. By drilling a transect of holes from shallow water towards the shelf edge we will be able to establish the magnitude and time of major sea level cycles and in turn quantify the impact they had on the paleogeography, river systems and chemical weathering over the past 2.5 years when sea level variation has been most extreme.

## Review Response

Submission Type Resubmission from previously submitted proposal

This proposal has been modified following a focused workshop on the topic held in October 2023 run under the Magellan Plus programme. A new set of proponents were assembled and the reviews from the last submission were examined in detail by the workshop team. The proposal was refocused to concentrate more on the carbon cycle, including weathering and the organic carbon cycle. Much greater information is now provided concerning organic geochemistry, biosphere and provenance methods. The drilling sites were reviewed and in some cases moved using newly released, shallow penetrating seismic data provided by local Vietnamese co-proponents. The drilling targets were changed to focus only on the Pleistocene rather than older sequences. This also provides greater focus in looking at the impact of high amplitude glacial cycles before and after the MPT. A new three part plan for drilling is now included, with the minimum focused on the time after the MPT, while the intermediate and maximum plans look at the entire Pleistocene, with greater spatial resolution in the maximum plan.

## Proposed Sites (Total proposed sites: 6; pri: 6; alt: 0; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SUNDA-01B (Primary)	7.61080655 104.2233601	36	241	0	241	Sample shelf sediments of Mid Pleistocene (minimum plan) or Pleistocene (Mid and Max plans) age in order to determine the age of sedimentation, the degree of alteration, organic carbon content, provenance and paleo-water depth. This site is the most landward in our transect and provides the opportunity to sample sediments from the paleo-Johore River.
SUNDA-09B (Primary)	8.2545929 107.2233271	52	197	0	197	Sample shelf sediments down to Mid Pleistocene (162 mbsf; Minimum plan) or base Pleistocene (197 mbsf; Mid and Max plans) age in order to determine the age of sedimentation, the degree of alteration measured by geochemistry and clay mineralogy, organic carbon content, palynology, organic biomarkers, provenance and paleo-water depth. This site is located in the middle of our transect and provides the opportunity to sample sediments within the smaller catchments west of the Mekong and/or the Mekong itself. The sequence is more condensed here, with more unconformities and potentially the chance to sample the most weathered materials.
SUNDA-07B (Primary)	8.79849522 108.8439825	122	796	0	796	Sample shelf sediments down to Mid Pleistocene (282 mbsf; Minimum plan) or base Pleistocene (796 mbsf; Mid and Max plans) age in order to determine the age of sedimentation, the degree of alteration measured by geochemistry and clay mineralogy, organic carbon content, palynology, organic biomarkers, provenance and paleo-water depth. This site is one of the most seaward in our transect but also close to the Mekong River mouth. Nonetheless, the facies are likely more marine and complete compared to further west. The site provides the opportunity to sample sediments within the Mekong drainage.
SUNDA-11B (Primary)	9.99612779 108.4767574	67	176	0	176	Sample shelf sediments down to Mid Pleistocene (152 mbsf; Minimum plan) or base Pleistocene (176 mbsf; Mid and Max plans) age in order to determine the age of sedimentation, the degree of alteration measured by geochemistry and clay mineralogy, organic carbon content, palynology, organic biomarkers, provenance and paleo-water depth. This site is on the outer shelf in our transect but also close to the Mekong River mouth. Nonetheless, the facies are likely more marine and complete compared to further west.
SUNDA-12B (Primary)	8.68867037 103.6775668	41	160	0	160	Sample inner shelf sediments of Pleistocene (Max plan only, 160 mbsf) age in order to determine the age of sedimentation, the degree of alteration measured by geochemistry and clay mineralogy, organic carbon content, palynology, organic biomarkers, provenance and paleo-water depth. This site extends our transect landwards, even further inshore than Sunda-01B and provides the opportunity to sample sediments from the paleo-Johore River and possibly smaller rivers from Cambodia.
SUNDA-08B (Primary)	7.55685348 106.7665617	48	152	0	152	Sample mid shelf sediments of Pleistocene age (152 mbsf, Max plan only) in order to determine the age of sedimentation, the degree of alteration measured by geochemistry and clay mineralogy, organic carbon content, palynology, organic biomarkers, provenance and paleo-water depth. This site is located in the middle of our transect and provides the opportunity to sample sediments within the smaller catchments west of the Mekong and/or the Mekong itself. The sequence is more condensed here, with more unconformities and potentially the chance to sample the most weathered materials. Improves the spatial resolution across the mid shelf beyond Sunda-09B.