

## Geoheritage of Pulau Balambangan, Kudat, Sabah

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**Abstract**— The Balambangan Island, offshore Sabah offers outstanding scientific, aesthetic and cultural values that make the island very important in terms of geoheritage conservation. Despite its small size, the island has beautiful landscape and other geological elements that bear high ecotourism potential. The island has a wide spectrum of rock types and paleoenvironments. It has basalt deposited together with deep sea sediments and also shallow marine clastics as well as carbonates. The age of the rocks range from Cretaceous to Pliocene. Since its emergence, the island has been carved by weathering and erosion into beautiful landscapes and morphologies. The clastic sediment at the southern tip of the island has been carved by wave into various shapes some of which resemble certain animals. Weathering and erosion on the Balambangan limestone member, on the other hand have produced unique karst morphology and landscape. The Balambangan Limestone hosts more than 20 caves with beautiful cave formations. The youngest Timohing Formation provides a good example of the recent products of geological processes and can be of high scientific value. In summary, the island has a very good potential for geotourism, edutourism and conservation.

Keywords: geoheritage, conservation geology, Pulau Balambangan

### INTRODUCTION

Conservation geology embodies a rigorous study of intrinsic geological resources and their development (Ibrahim Komoo, 1997). Research in this field is still new and needs more effort in identifying geological resources that have high heritage value. This new initiative is based on the concept of utilizing resources without destruction which is far from the traditional concept of geology that aims to utilize the earth resources destructively (Kadderi Md Desa, 1997).

Balambangan Island located offshore of Kudat Peninsula is a small island about 24 km (length) by 18 km (width). The population on the island is quite sparse and mainly concentrated in two villages, Kg. Batu Sireh and Kg. Selamat. Quite a number of boat people are living a nomadic sea-faring life.

This study has been carried out to evaluate the geological elements that exist on the island in the context of geoheritage for conservation and ecotourism. Field geological observation, photography, and mapping have been carried out during the fieldwork, with the main focus on morphology, landscape and cave assessments in the context of geological heritage values.

The objectives of this study were to evaluate and map all geological elements including rock types diversities, morphologies and landscapes on the island for conservation purposes.

### PHYSICAL SETTING

Balambangan Island lies to the west of Bangi Island. It is 24 km long elongated in the northeasterly direction and has an irregular, deeply embayed southeastern coastline

(Figure 1). Most of the hilly country runs in a southeasterly direction down the centre of the island. The hills rise to a height of about 170 m and have rounded profiles but, towards the south, they are dissected by fairly steep-sided valleys. Further south, a deep land-locked bay, Ayer Simpul, separates these rounded hills from the rugged limestone country that forms the southern tip of the island. There, a prominent cliff, with a vertical height of 50 to 170 m, rises above a coarse boulder scree and extends across the country in a southeasterly direction towards Tanjung Kalutan.

In the centre of the island, the hills are bounded on their northwestern and southeastern flanks by plateau having an

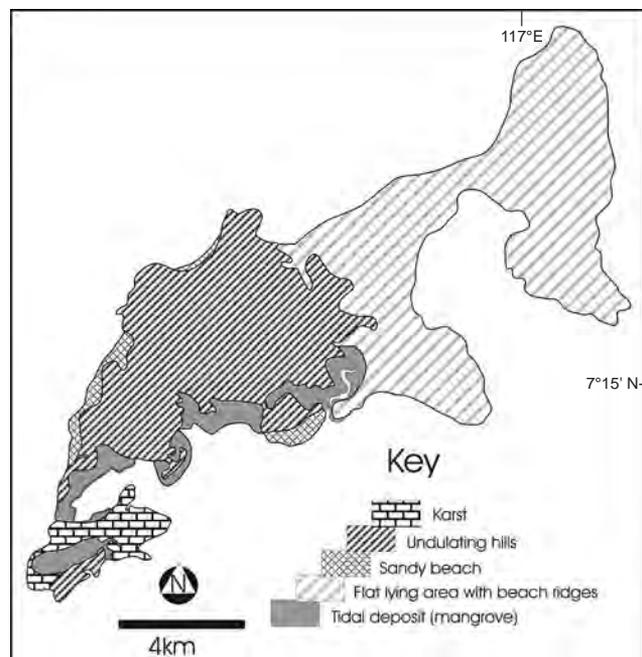


Figure 1: Geomorphologic Map of Balambangan Island.

elevation of about 15 m above sea level. Towards the north, however, the southeastern plateau decreases in height and extends over the whole of the northern part of the island, where it forms a sandy stretch of country little more than 2 m above high water mark. The island is drained by short streams flowing directly from the hills to the sea or, as on the south coast, meandering for some distance through a mangrove swamp. Where they cross the southeastern plateau, the streams are deeply incised and, although irregular in their courses, have no riverside alluvium. The formation of these gullies or miniature canyons is a result of uplift that took place in Pleistocene times (about 2 million years ago) (Wilson, 1961).

**BRIEF GEOLOGY AND GEOLOGICAL HISTORY OF THE BALAMBANGAN ISLAND**

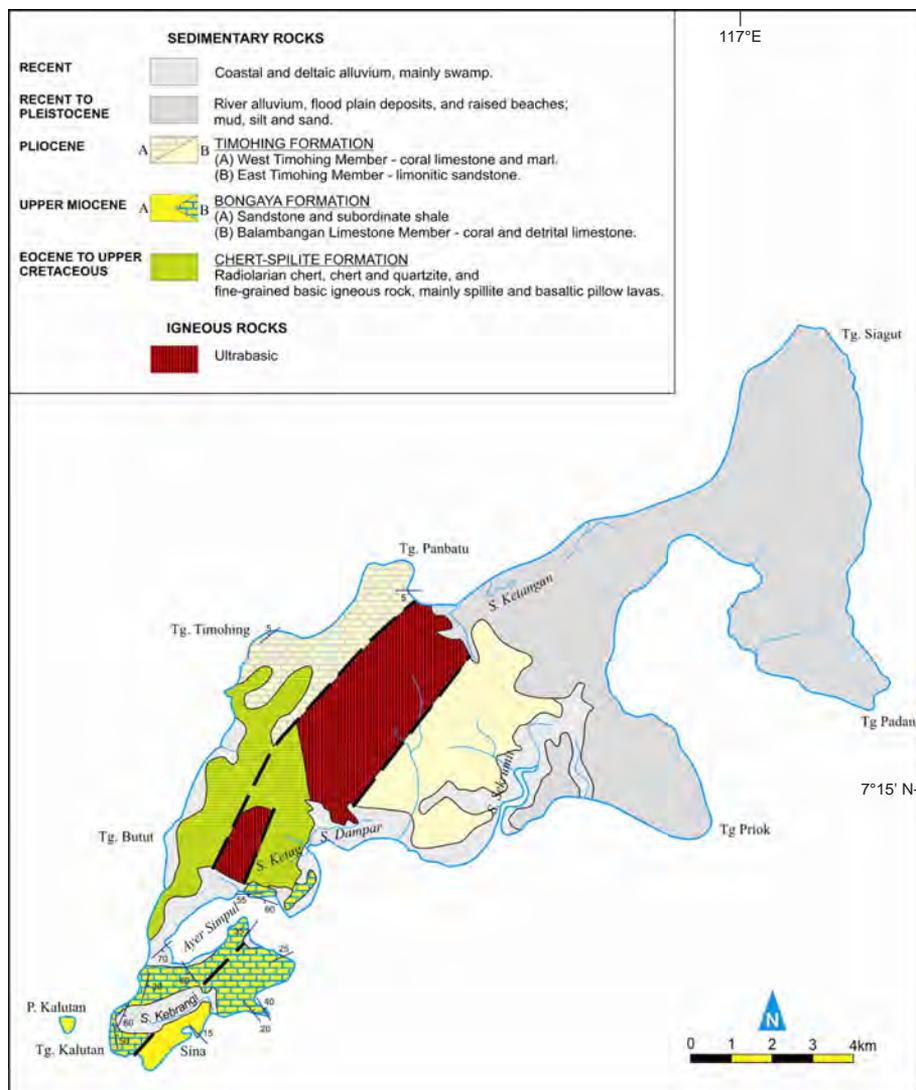
Balambangan Island can be divided into several geological units comprising coastal and river alluvium, three sedimentary formation, and ultrabasic igneous rocks. The sedimentary formations consist of the Chert-Spillite

Formation, Bongaya Formation and Timohing Formation (Figure 2).

The geological history of the Balambangan Island started in Late Cretaceous (about 60 million years ago) with the deposition of sediments of the Chert-Spillite Formation in a deep sea environment. The Chert-Spillite Formation is composed of fine-grained volcanic rock (basaltic and spillite lavas), with intercalations of banded chert. The rock was formed during a period of intense volcanic activity (Wilson, 1961).

Subsequent geological evolutions have brought the sea bed up into shallow water environments. During the Late Miocene time (about 10 million years ago) sands and coral reef were formed in shallow marine environments. This group of sediments is included in the Bongaya Formation. The coral reef is now called the Balambangan Limestone that outcrops in the southern part of the island. It consists of mainly corals in living position and other reef building organisms and coral fragments (Figure 3).

Most of North Borneo was probably land during Pliocene time (5-2 million years ago) except in the Balambangan area



**Figure 2:** Geological Map of Balambangan Island (modified from Wilson, 1961).

during which the deposition of the Timohing Formation was still going on in very shallow marine environments. The sediments consist of sand, coral reef and marl (a mixture of carbonate material and mud). This group of sedimentary rock is now called the Timohing Formation that comprises limestone and sandstone in the western part of the island.

The area was uplifted during the Pleistocene. All rocks were exposed and the softer sediments were eroded and redeposited as coastal deposits, which consist of beach sand and swamp sediments. Owing to continuous accumulation of sediments, a series of strand lines in the form of beach ridges have been left behind on northeastern Balambangan.

## GEOLOGICAL HERITAGE

Balambangan Island though small in size contains a lot of scientific, aesthetic and cultural heritage values that must be protected from being indiscriminately exploited for short term economic gains.

This small island is made up of various rock types including ultrabasic and chert-spillites that were derived from oceanic crust, shallow marine sedimentary rocks (sandstone and limestones) and coastal alluvium that are still being formed until the present day.

### Rock Diversity

The ultrabasic and chert-spillites were actually part of the oceanic crust that were brought up to the surface during the last tectonic event. Though the same rocks can still be found in other parts of Sabah, their presence with other younger formation give a complete geological history of the northern Sabah in general and the Kudat area in particular, from the Cretaceous (60 million years ago).

The Bongaya Formation which is younger than the chert-spillites comprises two members (sandstone and limestone). The formation was deposited in shallow marine environments. The limestone represents a coral reef of about 10 million years old. It is similar to the present day corals of Sipadan Island or other coral islands offshore Semporna.

Scientifically this rock unit is very significant because the occurrence of limestone hills is very rare in Sabah and the Balambangan Limestone provides a complete reef sequence. On top of that it also gives a good 3D view of an ancient coral reef, that can become a model for the study of other ancient reef deposits. More importantly, large and beautiful caves with high aesthetic value occur in this limestone.

Karst landscape and fault scarps are only found in this limestone terrain. On the southwestern tip, the limestone outcrop forms a spectacular strike ridge. The ridge which has the highest population of cycad plants we have ever seen can be regarded as a national heritage.

The sandstone member of the Bongaya Formation has a high aesthetic value in the form of beautiful undulating landscape. At the southern most tip of the island, the sandstone of Bongaya Formation has been carved by wave actions into several animal-shaped features. Here also we can see rock falls, wave abrasion platforms and sea stacks

that collectively form a very scenic view.

The Timohing Formation which comprises coral limestone and limonitic sandstone was named after Tanjung Timohing on Balambangan Island. This rock unit is scientifically very important because it is the type section of the formation and can only be found on this island. The Timohing Limestone on the western part of the island forms a very scenic landscape where undulating topography, sea-cliffs, sea-caves, remnant islands, abrasion platforms and excellent outcrops can be found.

The sandstone member which occurs to the east of Sungai Dampar forms beautiful outcrops and ridges about 10 meters above the present day sea-level. The rock was formed in a shallow marine environment and probably represented coastal or coastal sand-bar deposits.

Alluvial deposits cover almost half of the island and consist of the recent sediments that were deposited by the sea and rivers and these form low lying flat land with a series of beach ridges on higher grounds just a few meters above the present day sea-level. The beach ridges record the sea level fall in the recent past and form scenic present day beaches.

### Caves

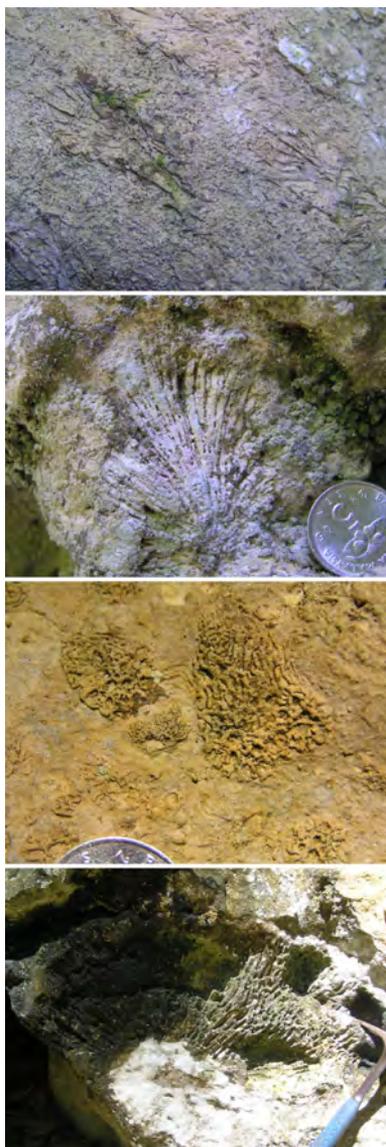
Limestone caves are special features found on the Balambangan Island especially in the Balambangan Limestone in the southern part of the island. According to the local people, there are more than 20 caves in the Balambangan limestone and of these, 4 caves have been studied and mapped in detail. Most of these caves are still unexplored and undocumented. All the caves are very special in the sense that they contain a lot of beautiful and unique cave formations in the form of stalactites, stalagmites, flow stone, straw and many more varieties of speleothems (Figure 4). Apart from that, the caves also have great scientific value. The cave deposits can be used for the study of past climatic conditions. Oxygen isotope values from the stalactites or stalagmites can tell us what has been going on in the recent past especially in the Northern Sabah area. If the caves are destroyed we may not have any chance to study them let alone to pass this valuable heritage to future generation.

Though many more caves occur in Sabah, the caves of Balambangan Island are special because they contain a lot of beautiful cave speleothems of various sizes and some of them are still being formed.

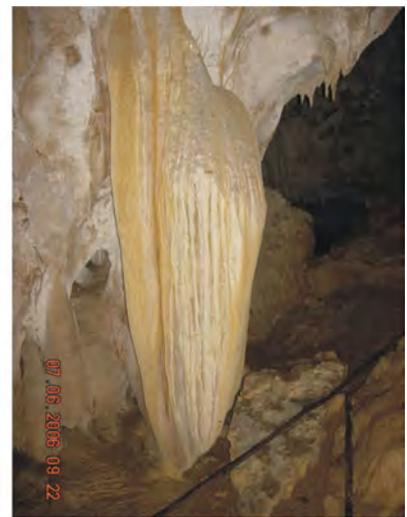
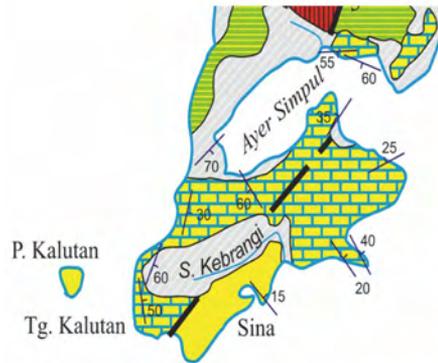
This area occupied by the Balambangan Limestone is the only area in western Borneo where one can find the development of young sea-karst and sea-caves.

## DISCUSSION AND CONCLUDING REMARKS

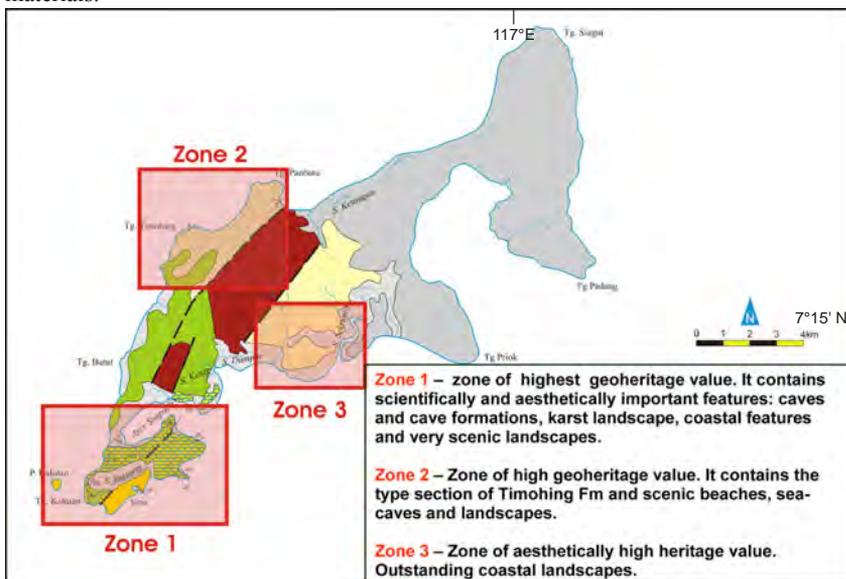
In summary, the whole of the Balambangan Island has high heritage value. Rock types are so diverse and that makes the island very important scientifically. The areas occupied by the Bongaya and Timohing formations in particular are rich in geological elements, morphologies and landscapes that are of the highest heritage value. Most



**Figure 3:** Balambangan Limestone consisting of coral and coral derived materials.



**Figure 4:** Some of the caves features found in Balambangan Island.



**Figure 5:** Suggested zones of high heritage value for conservation.

of the unique features and landscapes such as limestone caves, sea caves, and other erosional features are found on these terrains. Some parts if not the entire these island be conserved and protected from being exploited for any short term destructive economic gain like limestone quarrying. From our assessment we conclude that the island has three areas of significant geoheritage importance with high geoheritage value (Figure 5).

Zone 1 (Zone of highest geoheritage value): this zone covers the whole of the Balambangan Limestone in the southern part of the island. It has the highest geoheritage value. It contains scientifically and aesthetically very important features such as caves, cave formations, karst landscapes, coastal features and very scenic landscapes.

Caves and cave formations are very sensitive to any disturbance. Should any quarrying activities occur nearby the cave formations will be the first to be affected. All the stalagmites and other cave features will drop to the cave floor and the thin cave roof will also collapse.

Zone 2 (Zone of high heritage value): this zone is located in the western part of the island and it covers the Timohing Limestone Member. It contains the type section of the Timohing Formation (a section that represents the typical Timohing Formation) and scenic beaches, sea-caves and landscapes.

Zone 3 (Zone of aesthetically high value): this zone consists of outstanding coastal landscapes and morphologies.

Based on the finding of this study it is suggested that these sensitive and high heritage value areas be totally protected and conserve for future generations and it could also be a popular tourist destination if good governance, conservation and properly guided infrastructural development can be put in place.

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