

## RESEARCH ARTICLE

# The Exotic Beauty of Karst Morphology of Langgun Island and Geotourism Potential of Langkawi Island, Malaysia

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## Abstract

The research area is located in the eastern part of Langgun Island, Langkawi, Malaysia. Several small islands in the area are included in the research scope, including Anak Tikus Island, Anak Berangan Island, Batang Tunggang Cape, and Langgun Cape. Research on karst geomorphology is still very poor in the research area, especially regarding the classification and the history of the formation. The main motivation for this research is to reveal the beauty and uniqueness of the karst morphology of the research area, which is one of the most valuable geological heritages. Chemical weathering caused by surface water and underground water causes the limestone exposed on this island to form an island karst landscape. The karst morphology in Langgun Island is classified into exokarst and endokarst geomorphology. The morphology of exokarst is divided into two, namely negative exokarst and positive exokarst. The negative exokarst geomorphology found in the study area is dolina and uvala. Meanwhile, the morphology of positive exokarst consists of weathering island karst, which is karst resulting from wave erosion (tombolo, sea stumps, abrasion platforms, sea notches), and residual hills (karst tower and karst cone). The endokarst morphology found is the stalactite feature. This research will be able to increase understanding of karst development so that it forms a unique, beautiful morphology and increases the value of tourism potential, especially in the research area to influence tourist to visit.

**Keywords:** Langgun Island, exokarst, endokarst, morphology, geotourism

## 1. Introduction

Karst landscapes have subsurface water channels, caverns, plateaus, rocky terrain, deep valleys, and carbonate towers (Gillieson, 2005; Ford & William, 2007; Sahara & Setiawan 2022; Catur et. al, 2018; Fitriadi 2017; Yuskar 2017; Ansori et. al, 2021, Yusuf 2023; Suryadi et. al, 2019; Harbowo et. al, 2017), but understanding of karst geomorphology concepts is a challenge because much of formation the karst system particularly in Langgun Island not well documented.

The Langgun Island is one of a group of small islands in Langkawi, which has significant landforms, landscapes, and specific karst features, that are valuable for society places including scientific, educational, cultural, ecosystem, tourism, recreational, and other values. The island has geo-heritage value, which must conserved for study, and the magnificence landscape will remain as an inheritance for future generations. Nevertheless, information regarding these geological features and their formation is still lacking. Therefore, this research motivation is to reveal the beauty of karst morphology in this area and its formation history, so that it can be simply understood by other researchers and the general public. Furthermore, this research will attract interest in learning about nature, increasing tourists, and providing educational value to preserve the beauty of geological heritage.

Previous researchers only focused on discussing the geomorphology of mesoscale bio-erosion along the coast of Langkawi Karst (Ali & Taborosi, 2015; Hodgkin, 1970) and fossil occurrence (Lee, 2001; Saparin & Ismail, 2002; Niko

et.al, 2018), while never discussing in detail the morphology of karst and its formation. Here we provide a useful manual to help field workers with the recognition and interpretation of karst features and their formation. This information is very useful for geo-morphologists and geologists with an intuitive field guide that might help them determine common karst morphology. This will be the first systematic report on karst morphology in Langgun Island, as far as we are aware, which will be able to increase understanding of karst development so that it forms a unique, beautiful morphology and increases the value of tourism potential, especially in the research area to influence tourist to visit.

## 2. Geological Setting

The Langkawi Islands are geologically peculiar because they have the most complete Paleozoic rock outcrops in peninsular Malaysia. There is a sequence of Lower Paleozoic rocks (Machinchang Formation and Setul Formation) and Upper Paleozoic rocks (Singa Formation and Chuping Formation), and granite outcrop in the middle of island that uplifts the four Formations that were previously below the surface, then exposed to the surface as seen at present (Jones 1981; Lee 2009; Mohd Shafeea et al. 2007).

The Setul Formation is exposed in Langkawi Islands and Perlis State. The distribution of this formation is more concentrated in the eastern part of Langkawi. It is exposed as karst hills scattered widely in the lower part of the Kilim River, in addition to forming a large part of Langgun Island and several other small islands. Most of these limestones

are thin-bedded and dark gray, and contain layers rich in fossils. This Formation has been divided into 4 members based on significant lithological differences in the coastal outcrops of Teluk Mempelam on Langgun Island (Jones, 1981; Ali et al 2003). The members are Lower Limestone Member, Lower Greywacke Member, Upper Limestone Member and Upper Greywacke Member.

### 3. Method

We provide field equipment and stationery to support data collection in the field, including camera, GPS, compass, geological hammers, measuring tape, rulers, pencils, pens, plastic samples, helmets, and safety shoes. In order to conduct of research around the island which is quite far away to offshore, we rented a boat for three days. With the use of a water-resistant digital camera, hand phone, and a hand magnifier, geomorphological observations were taken. A field notepad that could withstand water was used to record observations. Field observation locations were captured using a Garmin GPS device.

### 4. Result and Discussion

In the research result, we discuss in detail two topics. Including karst morphology and geo-tourism potential.

#### 4.1 Karst Morphology

Some karst morphologies found around Langgun Island and Kilim Basin can be divided into exokarst and endokarst. The morphology of negative relief exokarst found is doline and uvala. Both are formed due to the process of erosion and dissolution. The exokarst morphology is positive relief found around the study area which is island karst, conical or tower karst, and residual hills.

The formation of dolines on Langgun Island is most likely caused by dissolution, collapse, and substances. In addition, it is covered with a layer of permeable sediment, so that it can be filled with water and become a lake can be seen through the satellite image on Figure 1. The lake on Langgun Island is a special attraction for biology and geology field. Biological studies will focus on diversity of biota in the lake, while geological studies focus on the geomorphology of lake formation and existing geological structures. In addition, the lake is one of the reasons for domestic or international tourists to visit the island. But due to the limitations encountered during the fieldwork, the author was unable to record the lake's field photos and see the lake's morphology directly.



Fig 1. Satellite image of Langgun Island area shows Lake and Uvala

The uvala formed on Langgun Island is an association between several dolines that form one unit. The author found that there were approximately 20 dolines and 4 km uvala that form in the study area, which is detected from satellite image (Figure 2). The uvala morphology indicates that Langgun Island is mature stage. This is because the formation process takes a long time around hundreds until millions of years.

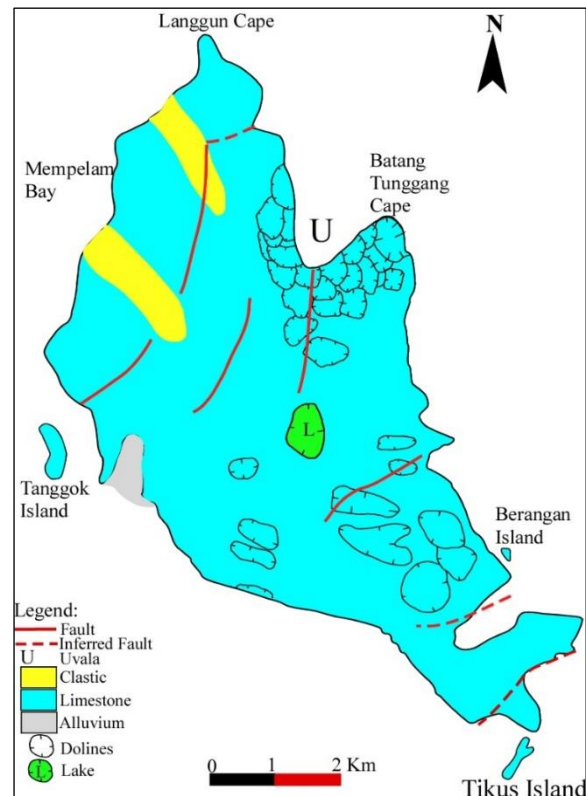


Fig 2. The map shows several negative exokarst morphologies such as dolina, tasik and uvala at Langgun Island

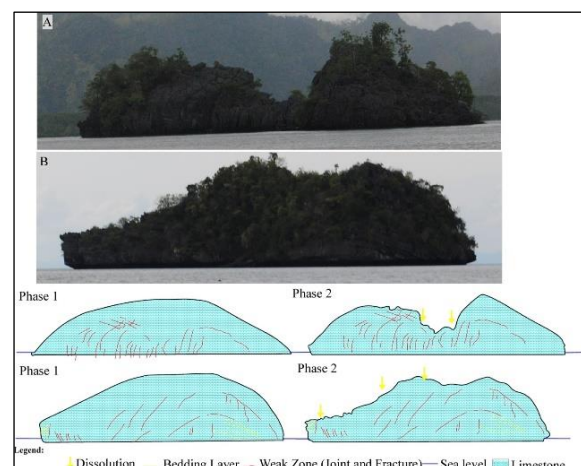


Fig 3. Illustration formation of residual island karst morphology of A) Anak Tikus Island B) Tangkok Island. The features morphologies caused by the phases of dissolution and erosion of rainwater and sea water.

Langgun Island is one of the karst morphology islands in the Kilim Basin. Due to the process of water erosion and dissolution, as well as the many fractures and joints, the author divides the karst morphology of this island into residual island karst, including the residual island karst morphology of Anak Tikus Island (Figure 3A) and Tangkok Island (Figure 3B). The formation of this residual island morphology to be almost the same as the formation of cone



karst, where the process of continuous dissolution and erosion makes separate and isolated parts.

In addition, the active process of sea erosion also produces morphological features of wave erosion such as sea notch, sea stack, tombolo, rock fall, and abrasion stage. Sea notches are formed due to the erosion of sea waves that come from front or side of the island. This continuous erosion causes the formation of a vertical indentation structure. The tidal process affects the formation of the sea notch. Illustration of formation of the sea notch shows in Figure 4.

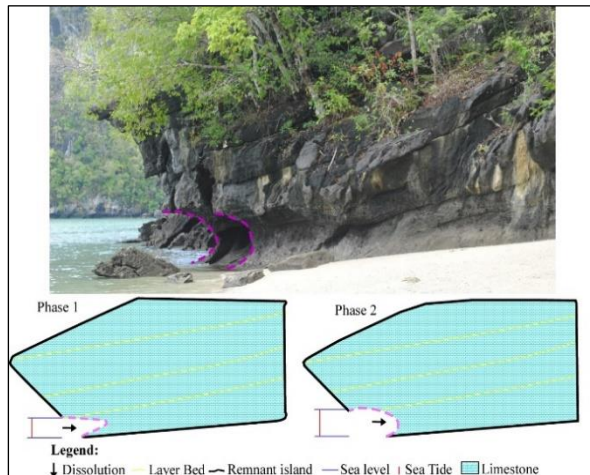


Fig 4. The image shows sea notches and the formation process

The sea stack is a structure that exists vertically in the sea or near the coast. Its formation is caused by wave erosion at the end of the beach or cape, then formed a sea notch. When erosion occurs continuously, it will cause the formation of a sea arch, then become a separate and isolated sea stack at the Mempelam Bay. The illustration of the formation of a sea stack shows in Figure 5.

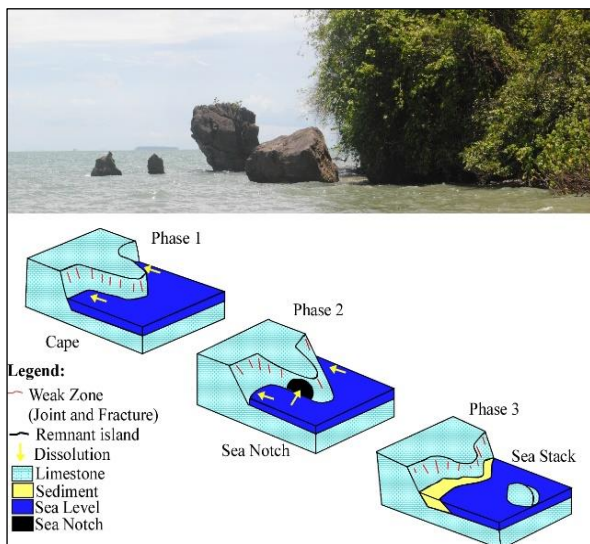


Fig 5. The image shows the morphology of vertical wave erosion called sea stacks and the process of their formation at the Mempelam Bay

One of these sea stack was found in the study area which is close to Mempelam Bay. The Mempelam Bay is potential for tourist attraction particularly camping site. In addition to enjoying the beauty of its beautiful sandy beach (Figure 6). This area is found to be a bird habitat such as eagles, also geological potential such as hot spring, which is convenient for tourist destination.



Fig 6. Photo shows beautiful sandy beach at the Mempelam Bay. This location has a tourist camp and an eagle habitat.

The morphology of another wave erosion found such as tombolo at Langgun Island is shown in Figure 7. It is a Recent-aged sand sediment deposit that was carried by sea currents and trapped due to the presence of two islands that act as sand traps. When the incoming current becomes the sand transport agent, there is a continuous repetition and it will deposit sand with a large volume. When the water recedes, these sand sediments are more clearly visible. Illustration of tombolo in Setul Formation is sketched on Figure 8.

Abrasion stage is morphology formed due to seawater erosion, it was found at the Mempelam Bay. The rocks here are cherts with a reddish color containing iron oxide Figure 8.

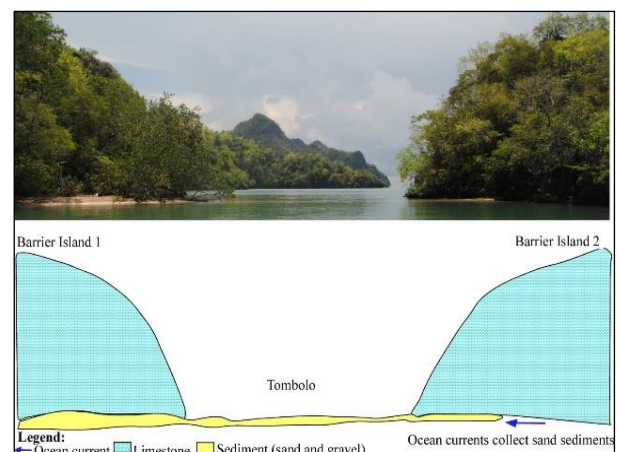


Fig 7. Tombolo morphology and illustration of its formation in the research area



Fig 8. Photo shows the abrasion stage at Teluk Mempelam Bay



Another positive relief exokarst morphology found in the study area is the residual hills or towers. The author divides it into round hill and conical hills. Round hills are separate hills with cliffs and rounded peaks shows in Figure 9. This morphology was formed and influenced by three main sets of faults or faults which are oriented northwest southeast, north-south, and east-west which are around the Kilim Basin. This structure results in higher dissolution rates along fault and fault bands and at intersections between the two. The process of continuous dissolution will deepen and widen the crack or fault and eventually form a conical hill. An illustration of conical hill formation shows in Figure 10.

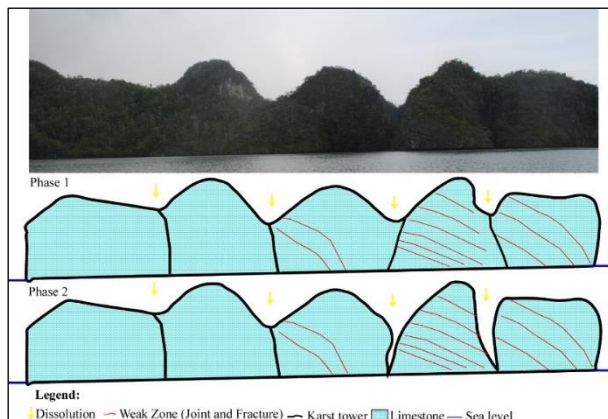


Fig 9. Round hill morphology and its formation process

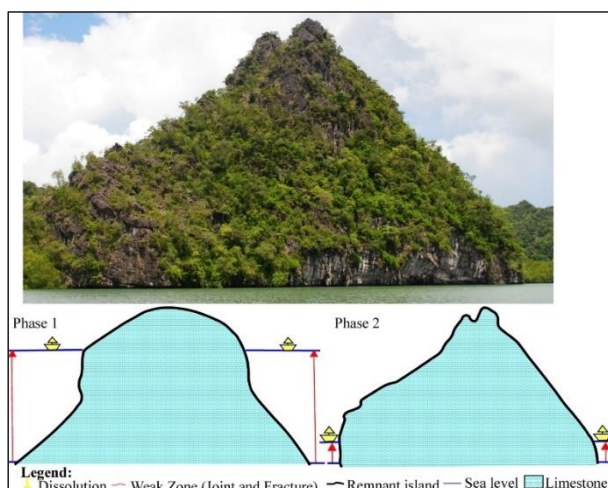


Fig 10. Conical hill morphology and its formation process

Rugosa (Figure 11A), gastropod (Figure 11B) and bivalves (Figure 11C) found at Langgun Island, which indicate deposition during Cambrian period.

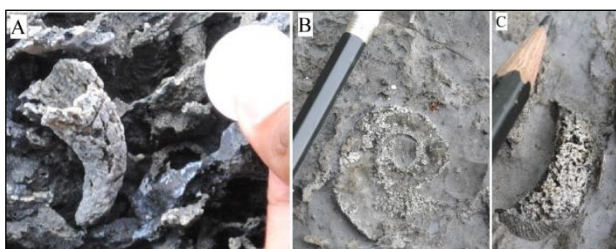


Fig 11. Photo shows rugosa, gastropod and bivalves at Langgun Island

#### 4.2 Geo-tourism Potential

Research area has potential for geotourism specifically in geological distinction consisting unique landscape, which

shows magnificent exokarst and endokarst. Landform characteristic shows karst morphology with steep cliff and abrasion platform. The rock unit and rock type is dominated by limestone, which has abundant of mineral including calcite, dolomite and silica mineral, also skeletal fossil.

Based on result, Langgun Island fulfil six characteristic from eight of them including landscape, landform, rock unit, rock type, mineral and fossil. Due to research limitations, we have not examined soil and crystal characterization. Figure 12 shows geotourism potential triangle in geological distinction at Langgun Island.

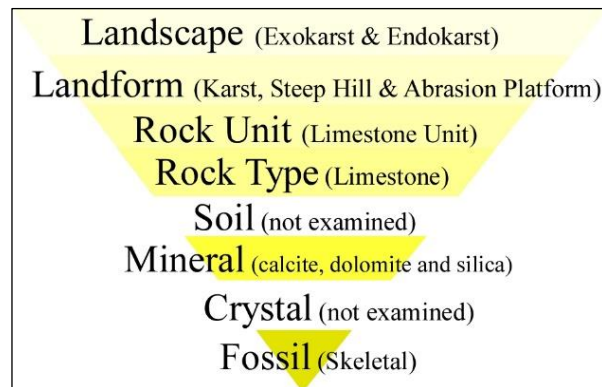


Fig 12. The triangle of geo-tourism potential based on geological distinction at Langgun Island

#### 5. Conclusion

Langgun Island exhibits both exokarst and endokarst morphologies, contributing to its potential value for geo-tourism in the study area. Exokarst morphologies at Langgun Island include dolines and uvala. Exokarst morphologies also include island karst, conical karst, and residual hills. These karst features, such as dolines, uvala, island karst, conical karst, and residual hills, enhance the geological variation and attractiveness of the research area for geo-tourism.

The research area at Langgun Island has specific characteristics in terms of landscape, landform, rock, mineral, and fossil, which contribute to its geo-tourism potential. The landform characteristic includes steep cliffs and abrasion platforms. The dominant rock unit is limestone, which contains minerals such as calcite, dolomite, and silica, as well as skeletal fossils. The research area fulfills six out of eight characteristics for geo-tourism, including landscape, landform, rock unit, rock.

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