

# **Geological indicators of sea-level changes at northern Sabah, Malaysia: Tools for instilling public awareness on global climate changes**

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**Abstract:** Study at Northern Sabah shows evidence of geological indicators of sea-level changes preserved on the coastal areas. The geological features are found on cliffs, islands and ancient shore platforms. They are found at Batu Kuala Tajau, Batu Panjang North, Tanjung Simpang Mengayau, Pulau Kalampunian and Tindakon. The ancient sea-level is several meters above the present sea-level. However, a proper and detailed study needs to be carried out in order to determine the meaningful historical sea-level changes to take into account the tectonic uplift and eustatic sea-level changes in the area. Several of the sites are easily accessible, therefore they could be used as field educational sites to educate and create awareness among the public on global climate changes due to global warming currently affecting the Earth. The catastrophic impact of global climate changes is the rise of global sea-level. Educational aspect such as how the rise in sea-level thousands of years ago has flooded the coastal areas could be imparted upon visitors to the sites. The other geological and geomorphological features in the study area include faults, joints, graded beds, sandstone concretions containing mudstone nuclei, sea notches, sea caves, Liesegang bands, potholes, honeycombs, tafoni and various erosional and weathering features. These features have scientific, aesthetic, recreational and cultural values and as such they comprise the geoheritage resources of the area and should be protected. The geoheritage sites have high geotourism potential for research, educational and recreational activities and could be developed for geotourism purpose with steps to ensure sustainability and protection of the sites. The promotion of educational geotourism at the sites, especially on ancient sea-level changes, could instill public awareness on global climate changes due to global warming and thus would encourage the public to protect the environment. The use of geological features to instill public awareness on global climate changes is an innovative approach to create awareness among the public on the importance to care for the environment.

**Keywords:** Global climate changes, geological indicators of sea-level changes, Northern Sabah

## **INTRODUCTION**

Since the Last Glacial Maximum (LGM) about 21,000 to 19,000 years BP, the Earth has seen global sea-level rise by approximately 120 m to reach its current level. In the Peninsular Malaysia, the sea-level rose during the Holocene Marine Transgression to about 5 m above the present level some 5,000 years BP before falling and stabilizing to its present level (Tjia, 1996). This last sea transgression and regression and the associated erosion and depositional processes have resulted in the coastal geomorphology that is seen today. Sea-level changes throughout the Earth's history provide considerable insight into the past tectonic and climatic history of the Earth. The catastrophic impact of global climate changes is the rise of global sea-level. Among others, the potential environmental and socio-economic effects include flood risk and submergence, salinisation of surface and ground waters, tidal inundation, shoreline erosion, loss of agricultural and fisheries production and damage to coastal infrastructure (MOSTE, 2000; Nicholls, 2003). The association of climate change with sea-level is important particularly for any projection of future sea-level changes. This requires an understanding of the pattern of past sea-levels, especially its recent past. In this respect, the Holocene sea-level changes record the latest significant sea-level changes that have taken place.

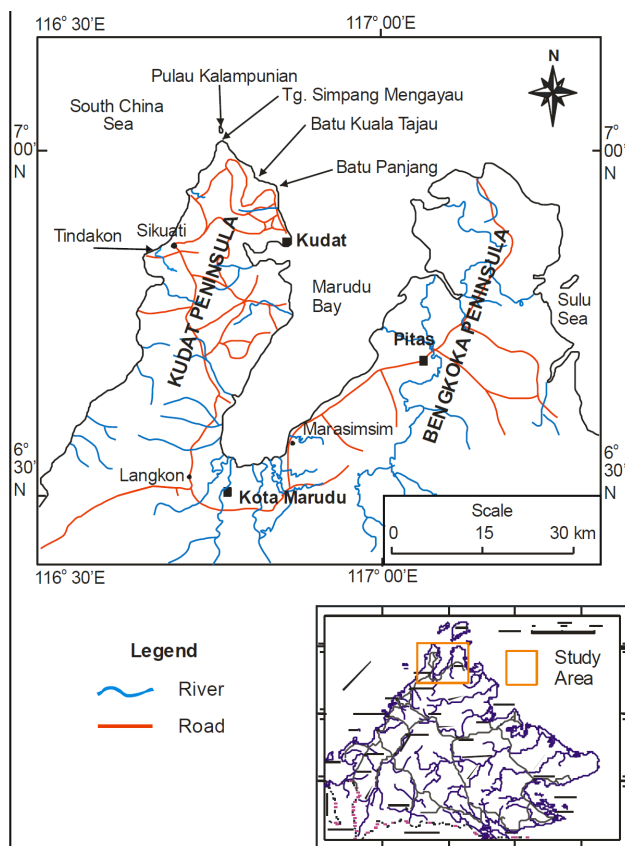
Northern Sabah shows evidence of geological indicators of Holocene sea-level changes preserved on the coastal areas (Muda, 2009). The geological features are found on cliffs, islands and ancient shore platforms. Therefore, a study was carried out in the area to identify the geological indicators of sea-level changes for the purpose of using them as an innovative tool to educate the public on global climate changes.

## **LOCATION OF STUDY AREA**

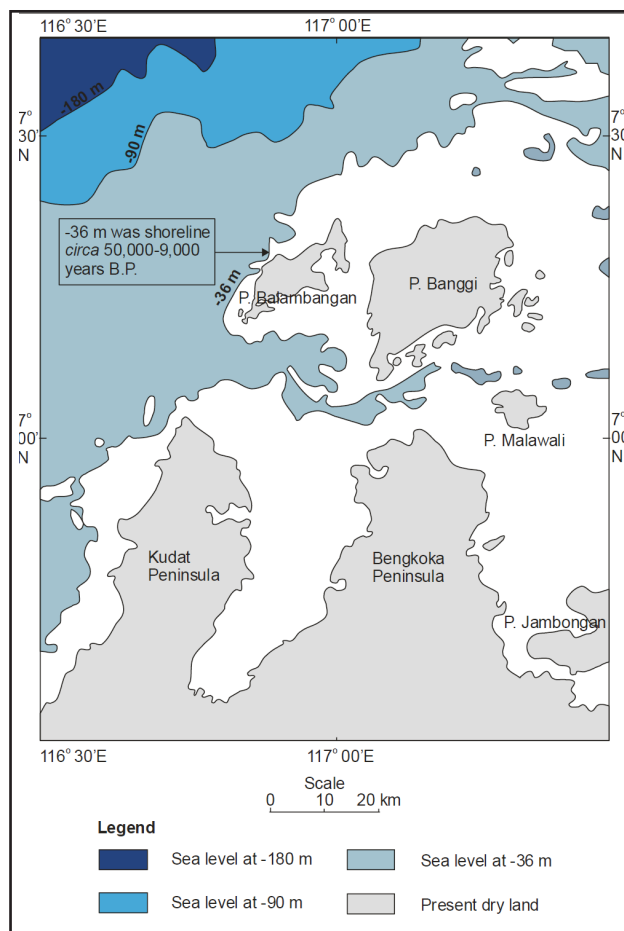
The study area is located in the Kudat Peninsula at Northern Sabah (Figure 1). The Tip of Borneo at Tanjung Simpang Mengayau which is a popular tourist destination is located in the area. Kudat Town which is about 25 km SE of Tanjung Simpang Mengayau is the main town in the area.

## **OBJECTIVES AND METHODOLOGY**

The objectives of the study are to identify the geological indicators of sea-level changes as well as to evaluate the potential of these features for education on global climate changes. The research methodology includes characterization (geological mapping) and evaluation of the morphological features of the coastal areas for educational purpose.



**Figure 1:** Location of study area and site of geological indicators of sea-level changes at Northern Sabah.



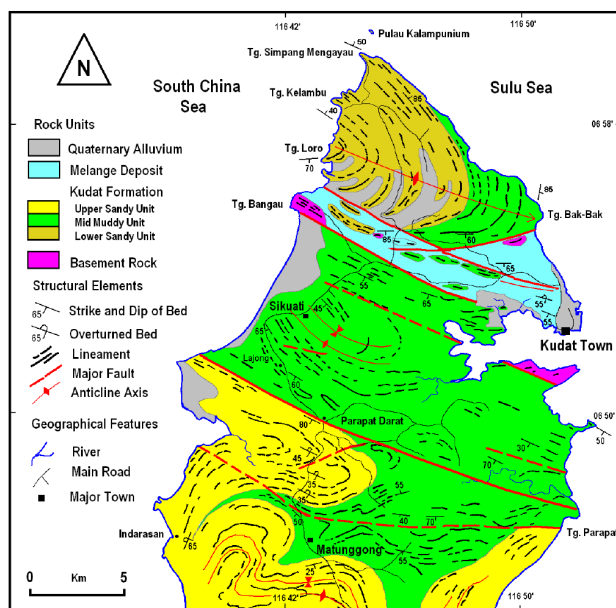
**Figure 2:** The land area of Greater Sabah circa 90,000 and 9,000 years BP included the islands of Banggi, Balambangan, Malawali and Jambongan (modified after Zuraina Majid *et al.*, 1998).

**PALEOGEOGRAPHY**

Between 50,000 to 9,000 years BP, there were several episodes when the sea-level was -36 m below its present level at Northern Sabah (Figure 2). When the sea-level was -36 m, Greater Sabah included the islands of Balambangan, Banggi, Malawali and Jambongan (Zuraina Majid *et al.*, 1998). The geomorphological features presently found in the coastal areas were not developed yet. The sea-level stabilised about 6,000 years ago with some minor fluctuations. The study area might have been uplifted during the Quaternary (Wilson, 1961) and probably tilted towards the east thus affecting the shorelines. Sandy beaches and rocky shores occur mainly on the western coasts of the Kudat and Bengkoka Peninsulas. Mangrove swamps and muddy shores occur mainly on the eastern coasts of both peninsulas. These occurrences indicate that there were upliftment on the western parts and downwrapping on the eastern parts of the Kudat and Bengkoka Peninsulas.

**GENERAL GEOLOGY**

The Kudat Peninsula is mostly underlain by the Kudat Formation of Early Miocene age that was probably deposited in a shallow to deep water environment (Stephens, 1956). This formation is underlain by ophiolitic basement rocks of Cretaceous-Paleocene age. Tongkul (2006) informally divides the Kudat Formation into three lithological units



**Figure 3:** General geology of the Kudat Peninsula (Tongkul, 2006).

namely, Lower Sandy Unit, Middle Muddy Unit and Upper Sandy Unit (Figure 3). The Lower Sandy Unit comprises

mostly sandstone and mudstone with the sandstone predominating. This unit occurs at the northern part of the Kudat Peninsula and coincides with the Tajau Member of Liechti *et al.* (1960). The Middle Muddy Unit comprises sandstone and mudstone with the mudstone appearing more predominating. This unit occurs at the middle part of the Kudat Peninsula and coincides with the Sikuati Member. The Upper Sandy Unit which is also referred as the Gomantong Member comprises sandstone and mudstone of various proportions and occurs at the southern part of the Kudat Peninsula.

### GEOLOGICAL INDICATORS OF SEA-LEVEL CHANGES

The geological features that indicate the sea-level changes at Northern Sabah are found on cliffs, islands and ancient shore platforms. They are found at Batu Kuala Tajau, Batu Panjang North, Tanjung Simpang Mengayau, Pulau Kalampunian and Tindakon in the Kudat Peninsula (see Figure 1).

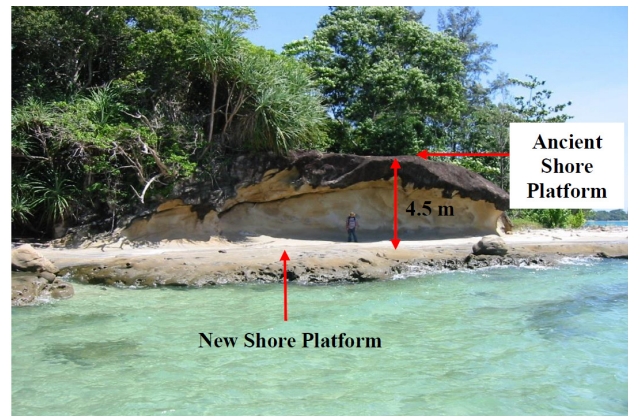
#### Batu Kuala Tajau

Batu Kuala Tajau is an isolated rocky shore located about 900 m west of Kampung Tajau Laut. The area is called Batu Kuala Tajau because of its rocky nature as well as its proximity to the kuala (mouth) of Sungai Tajau. It is located at latitude  $6^{\circ} 58.468' N$  and longitude  $116^{\circ} 48.257' E$ . It can be reached by walking west along the coast from Kampung Tajau Laut. The prominent geomorphological feature in this area is the sea notches formed on sandstone cliffs. The cliffs are fronted by narrow new shore platforms. The height of the cliffs ranges from 4.5 m to about 10 m and indicates ancient shore platforms (Figure 4). However, the meaningful Holocene sea-level could only be determined after taking into account the Holocene tectonic uplift of the area.

Besides the sea notches and shore platforms, the other geological and geomorphological features at the site include graded beds, sandstone concretions containing mudstone nuclei, potholes, honeycombs, tafoni and various erosional and weathering features. These features have scientific, aesthetic and recreational values.

#### Batu Panjang North

The Batu Panjang North area is located at latitude  $6^{\circ} 57.987' N$  and longitude  $116^{\circ} 49.739' E$ . It can be reached by using the Bak Bak Road for 4.8 km from the junction of the Pinangsoo-Bak Bak Road. From here, a dirt road forks right to a former timber factory site located near the coast. From this point, the site can be reached by walking east along the beach for several hundred metres. Locals called the area Batu Panjang (Batu Panjang literally means long rock) due to the existence of an extensive shore platform at the site. Among the prominent geomorphological features of this site are new shore platform and ancient shore platform manifested on a sandstone cliff. The height of the cliff is about 8 m and indicates an ancient shore platform (Figure 5). However, the meaningful Holocene sea-level could



**Figure 4:** A small cliff showing an ancient shore platform which indicates an ancient sea-level. The height of the ancient sea-level is 4.5 m. The tectonic uplift has not been taken into account. (Location: Batu Kuala Tajau, Kudat).



**Figure 5:** An ancient shore platform indicating an ancient sea-level. The height of the ancient sea-level is 8 m. The tectonic uplift has not been taken into account. (Location: Batu Panjang North, Kudat).

only be determined after taking into account the Holocene tectonic uplift of the area.

The other geological and geomorphological features at the site include strike-slip faults, giant sandstone concretions containing mudstone nuclei, sea notches, potholes, honeycombs and various erosional and weathering features display on the cliff and shore platform. These features have high scientific, aesthetic, recreational and cultural values. A sandstone concretion boulder shaped like a jar was observed at the site. Locals named it as Batu Tajau due to its shape that looks like a jar (Figure 6).

#### Tanjung Simpang Mengayau (Tip of Borneo)

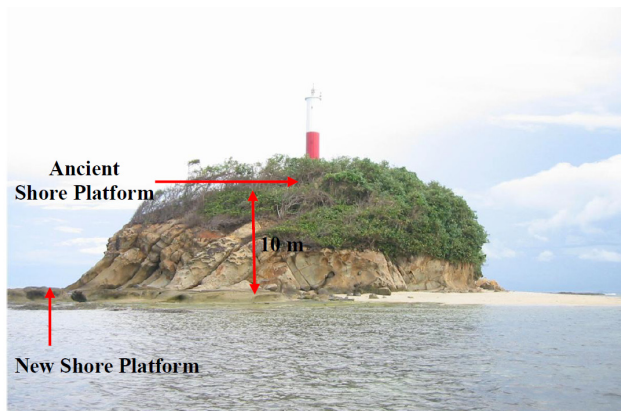
Tanjung Simpang Mengayau which is also known as the Tip of Borneo is a headland located at latitude  $7^{\circ} 02.292' N$  and longitude  $116^{\circ} 44.358' E$  and is about 25 km from the Kudat Town and access to the area is good. The geological and geomorphological diversities at the site include three-dimensional faults, numerous joints, sandstone concretions, new and ancient shore platforms, spectacular cliffs, sea



**Figure 6:** Batu Tajau, a jar-shaped sandstone concretion boulder. (Location: Batu Panjang North, Kudat).



**Figure 7:** An ancient shore platform indicating ancient sea-level. The height of the ancient sea-level is 10 m. The tectonic uplift has not been taken into account. (Location: Tanjung Simpang Mengayau, Kudat).



**Figure 8:** An ancient shore platform indicating an ancient sea-level. The height of the ancient sea-level is 10 m. The tectonic uplift has not been taken into account. (Location: Pulau Kalampunian, Kudat).



**Figure 9:** A cliff showing an ancient shore platform indicating an ancient sea-level. The height of the ancient sea-level is 14 m. The tectonic uplift has not been taken into account. (Location: Tindakon, Kudat).

notches, sea caves, potholes, honeycombs, Liesegang bands, tafoni, pink garnet sand and various erosional and weathering features. These features have high scientific, aesthetic and recreational values. The height of the ancient shore platform at the site is about 10 m (Figure 7) indicating the ancient sea-level. However, the meaningful Holocene sea-level could only be determined after taking into account the Holocene tectonic uplift of the area.

The site is also rich in culture and history. According to locals, the headland became a strategic site to lookout for pirates. To the colonial British, the headland was known as 'The Parting of the Pirate Ways' as this area was once rife with pirates (Hutton, 2003). To the Chinese in Kudat, Tanjung Simpang Mengayau was called as Den Foh Liew, in reference to a lighthouse at Pulau Kalampunian located northeast of the site. Some believed that the fleet of Ferdinand Magellan on its voyage to circumnavigate the globe stopped here for forty-two days to repair their ships.

### Pulau Kalampunian

The Pulau Kalampunian is 1.6 km north of Tanjung Simpang Mengayau. It is located offshore at latitude  $7^{\circ} 3.107' N$  and longitude  $116^{\circ} 44.739' E$ . It is a remnant island, oval in shape and about 100 m long and 37 m wide (Figure 8). Extensive rocky shore is formed around the island which displays geological and geomorphological diversities. One of the prominent geomorphological features is the well-developed extensive horizontal new shore platform formed north, south and west of the island. The height of the island is about 10 m and the top of the island indicates an ancient shore platform. However, the meaningful Holocene sea-level could only be determined after taking into account the Holocene tectonic uplift of the area.

The other geological and geomorphological diversities at the site include faults, sandstone concretions, cliffs, sea stack, sea notches and various erosional and weathering features. These features have high scientific, aesthetic and recreational values.

### Tindakon

The Tindakon cliff is a small sandstone cliff sandwiched between two linear beaches (Figure 9). It is located at latitude  $6^{\circ} 52.230' N$  and longitude  $116^{\circ} 39.520' E$ . It can be reached from Kampung Torongkongon by walking north along the Torongkongon Beach for about 600 m. The cliff is 120 m long and about 20 m wide. The cliff is 14 m high and was once a shore platform when the sea level was higher than at present or before it was uplifted. However, the meaningful Holocene sea-level could only be determined after taking into account the Holocene tectonic uplift of the area.

The other geomorphological features at the site include a sea cave and striking Liesegang bands. During the olden days, the natives were attracted to site because loud sound was produced by the cave during stormy weathers. According to the locals, the sound was produced by some spirits dwelling inside the cave. However, the sound could be explained in geological term. The cave which is 28 m

long is a natural whistle as its mouth is wider than the outlet, the blowhole.

### DISCUSSION AND CONCLUSION

The study at Northern Sabah has identified several evidences of geological indicators of sea-level changes preserved on coastal areas. They are found on ancient shore platforms, cliffs and islands in the area. They occur at Batu Kuala Tajau, Batu Panjang North, Tanjung Simpang Mengayau, Pulau Kalampunian and Tindakon. The ancient sea-levels range in height from 4.5 m to 14 m. However, this height has not taken into account the tectonic uplift and eustatic sea-level changes in the area. A further research is needed in order to determine the meaningful historical sea-level changes to take into account the tectonic uplift and eustatic sea-level changes in the area. The sites are easily accessible, therefore they could be used as field educational sites to educate and create awareness among the public on global climate changes due to global warming currently affecting the Earth. The catastrophic impact of global climate changes is the rise of global sea-level. Educational aspect such as how the rise in sea-level thousands of years ago has flooded the coastal areas could be imparted upon visitors to the sites. This could be done by pointing to height of the ancient shore platform which is higher than the present shore platform indicating a higher sea-level during the ancient times.

The other geological and geomorphological features in the study area include faults, joints, graded beds, sandstone concretions containing mudstone nuclei, sea notches, sea caves, Liesegang bands, potholes, honeycombs, tafoni and various erosional and weathering features. These features have scientific, aesthetic, recreational and cultural values and as such they comprise the geoheritage resources of the area and should be protected. Geoconservation measures include erecting warning signs, creating awareness and granting legal protection such as under the National Heritage Act 2005. In order to raise awareness on the importance of the geoheritage resources, seminars and awareness talks could be conducted for tourist guides, tour operators, relevant government agencies, students, the local communities and the public in general.

The geoheritage sites have high geotourism potential for research, educational and recreational activities and could be developed for geotourism purpose with steps to ensure sustainability and protection of the sites. Basic infrastructure

such as visitor centres, informative panels and directional signages are to be built and the associated informative materials (brochures and maps) to be produced. Geotrails based on climate changes, history and culture, and beautiful landscapes themes are proposed.

In order for the geotourism development to be realised, there should be a smart partnership among stakeholders (local community, tourism industry and local authority) to ensure a successful geotourism development through proper planning and management of the sites. The promotion of educational geotourism at the sites, especially on ancient sea-level changes, could instill public awareness on global climate changes due to global warming and thus would encourage the public to protect the environment. The use of geological features to instill public awareness on global climate changes is an innovative approach to create awareness among the public on the importance to care for the environment.

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