Geological heritage of tip of Borneo at Tanjung Simpang Mengayau, Kudat Peninsula, Sabah

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Abstract— Tanjung Simpang Mengayau, dubbed the "The Tip of Borneo" is one of Sabah's popular tourism sites. The strategic geographical location of this headland is the main attraction for tourist to visit this site. Apart from its beautiful white beach sand, the rocky headland provides an excellent exposure of the lower sandy unit of the Early Miocene Kudat Formation. The sedimentary formation, comprising of a thick sequence of sandstone exhibits primary depositional structures such as lamination, graded bedding and load structures. The thick sandstone beds dipping moderately to the north are cut through by a series of NE-SW trending normal faults and N-S trending joints, clearly visible during low tide. The headland also possesses coastal landforms such as caves, holes and tafoni. These geological features which provide useful insight into the geological history of the region may be utilized for educational purpose, as in geological tourism, to add value to the existing attraction of this site.

Keywords: Kudat Formation, Simpang Mengayau headland, geological tourism

INTRODUCTION

The headland of Tanjung Simpang Mengayau is the latest addition to the many nature tourism sites in Sabah. This headland located at the northern end of Kudat Peninsula (Figure 1) has been aggressively promoted by the Sabah Tourism Promotion Corporation as the "Tip of Borneo". Basic facilities such as parking lots, sheds, a canteen, a souvenir shop and washrooms have been recently built for visitors. A bronze globe marking the location of Tanjung Simpang Mengayau on the globe at latitude 7° North and longitude 116° East has also been built. Most tourists who visit this site would be satisfied just to stand right at the edge of the cliff and watch the blue-green open sea, the South China Sea to the West and the Sulu Sea to the East, without noticing anything else, but some exposed rocks below the cliff. Out of curiosity, some visitors will go down the cliff and look at these strange looking rocks. After some photography session most visitors will leave the site satisfied, while a few maybe wondering what else could they have seen and learned. The geological heritage available in this site is something that eco-tourist definitely missed.

Not until recently, the development of geological heritage resources for ecotourism has been overlooked. While the flora and fauna of a particular site becomes the main attraction, its intrinsic geological resources (e.g. formation of its landscapes; genesis of rocks; development of tectonic structures; rocks with natural, cultural and scientific values) remains largely unknown to the public. Several existing well known sites such as Kinabalu Park, Mulu Caves, Langkawi Islands and Pahang National Park, can offer more value than what is already known. The geological understanding of a particular site can enhance a visitor's appreciation of the natural forces that shaped the earth's physical surface.

In other to highlight the intrinsic values of geological features (scientific, aesthetic and recreational), systematic geological studies of selected sites and characterization of its special features need to be carried out. As an attempt to add value to existing sites and to seek for new areas which has high intrinsic geological values (unique), systematic studies have been initiated throughout the country by the Malaysian Geological Heritage Group since 1998. The study described here is part of this initiative. This study was carried out in 2006 as a follow up of an earlier study carried out in 2000.

GEOLOGY OF KUDAT PENINSULA

Kudat Peninsula is underlain mostly by the Kudat Formation (Stephen, 1956) of Early Miocene age (Figure 2) that was probably deposited in a shelf-slope environment. This sedimentary formation lies on top of ophiolitic basement rock of Cretaceous-Paleocene age. The Kudat Formation is divided into three major lithological unit, a lower, middle and upper units, based on significant changes in the composition of the sediments (Tongkul, 2006). The lower unit is comprised mostly of sandstone and mudstone with the sandy beds predominating. This unit outcrops at the northern tip of the Kudat Peninsula, coinciding with the Tajau Member of Leichti et al. (1960). The middle unit is comprised of sandstone and mudstone with some occurrence of limestone beds and lenses. Here, mudstones appear to predominate and occupy the middle part of the Kudat Peninsula. The sequence has been referred to previously as the Sikuati Member. The upper unit comprising of sandstone and mudstone of various proportions occupies the southern part of the peninsula and referred to previously as the Gomantong Member.

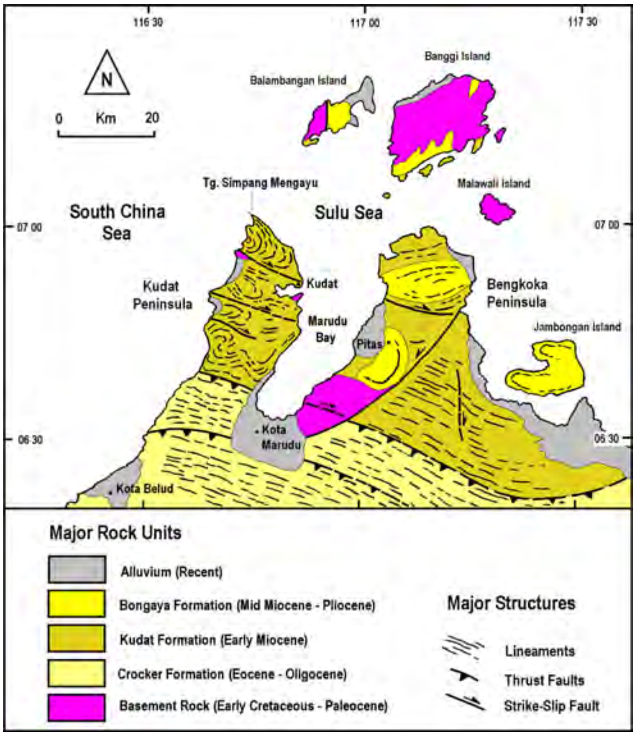

Figure 1: General geological map of Northern Sabah showing the distribution of major rock units and major structures. Tanjung Simpang Mengayau is located at the northern end of the Kudat Peninsula (based on Tongkul, 2006).

A chaotic unit showing linear distribution oriented approximately East-West occurs within the Kudat Formation. This chaotic unit, comprising of various lithologies in a mixed grey and red mud matrix is referred to informally here as the Kudat Mélange. This mélange is interpreted to have formed sometime after the deposition of the Kudat Formation.

The Kudat Peninsula shows elongate strike ridges trending in various directions with the main direction oriented NW-SE (see Figure 2). The diverse orientation of strike ridges is due to the presence of large-scale steeply plunging folds and refolded folds and major NW-SE trending faults affecting the Kudat sediments and ophiolitic basement rocks (Tongkul, 2006). The occurrence of steeply plunging fold and refolded folds indicates that the Kudat Peninsula had experienced polyphase deformation. It is envisaged that early N-S directed deformation produced several E-W trending thrust-fold slices on the Kudat sediments and underlying ophiolitic basement rock. Each slice was between 8-10 kilometers wide and separated by detachment or slip zones. Within each thrust slice, minor folds (F1) and thrust faults occurs causing repetition of the sequence. Later NE-SW directed deformation oriented oblique to the previous one produced horizontal movement along each of the major detachment zones causing second generation folds (F2) to develop within each of the thrust slice. The type of folds varies between individual thrust slices, possibly related to the competency of the sedimentary sequence. The occurrence

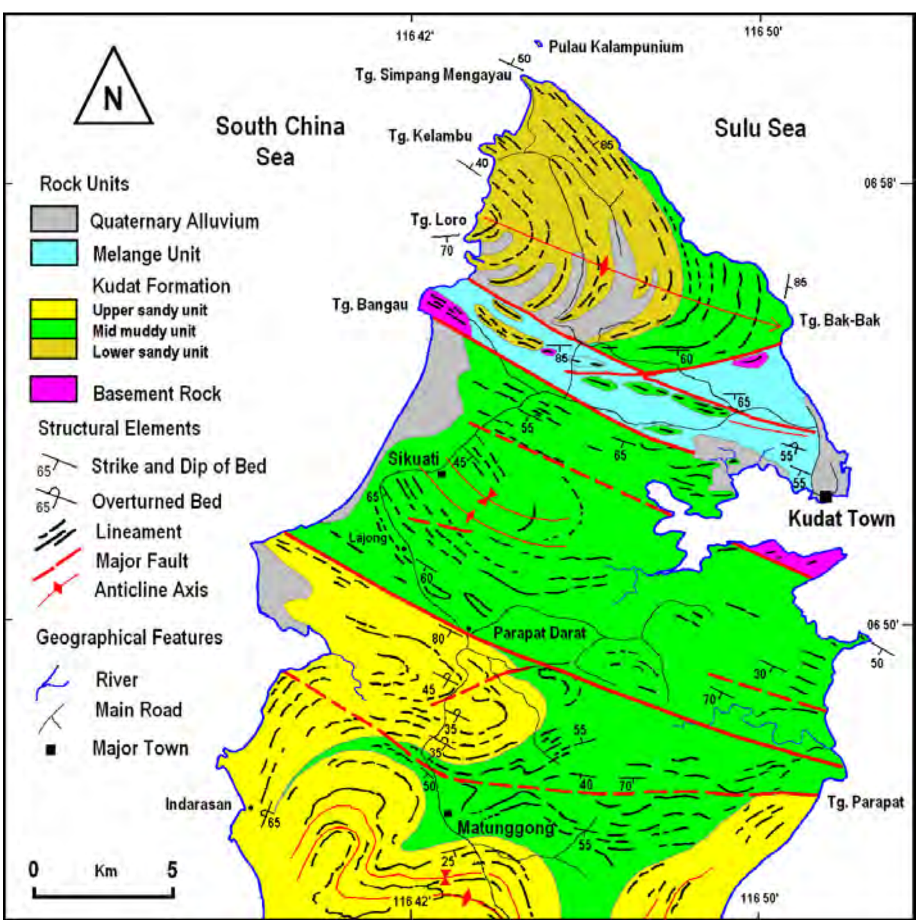

Figure 2: Geological map of Kudat Peninsula showing the distribution of the folded and faulted rock units. The northerly dipping fold limb of the lower sandy unit of the Kudat Formation is well-exposed at Tanjung Simpang Mengayau headland (based on Tongkul, 2006).

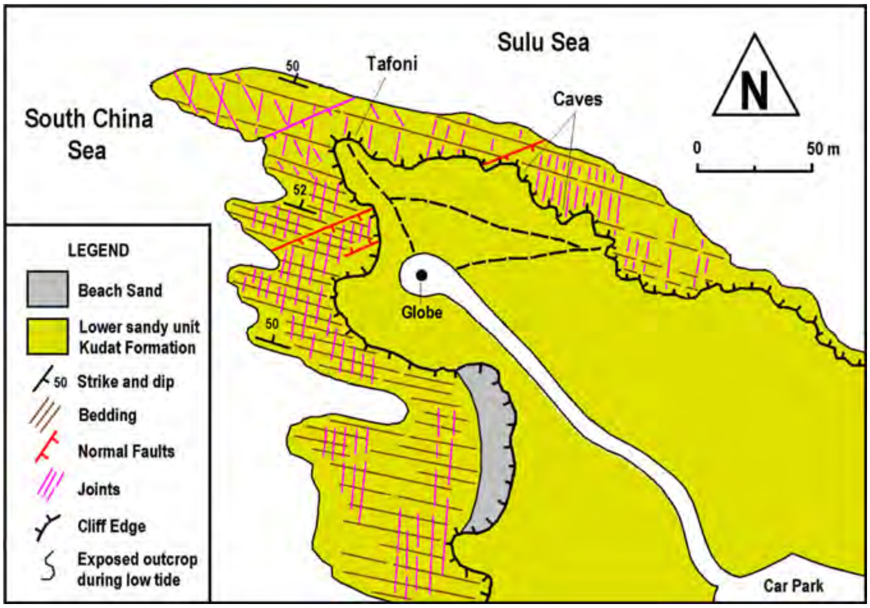

Figure 3: Geological map of Tanjung Simpang Mengayau showing the rock units and geological structures.

of a more competent sandy sequence within the northern thrust slice produced a steeply plunging fold structure. The development of the huge fold was possibly accompanied by intense shearing along a detachment zone, producing the mélange unit here. In the middle and southern thrust slices, where more muddy sequences occur, a contorted Z and W-shaped fold pattern had developed (Tongkul, 2006).

TANJUNG SIMPANG MENGAYAU GEOLOGICAL FEATURES

Lithology

The headland at Simpang Mengayau is made up of the lower sandy unit of the Kudat Formation (Tongkul, 2006). The sandy unit here represents part of the northern limb of the huge steeply plunging fold structure in Kudat (see Figure 2). The unit consists of thick sandstone beds ranging in thickness from 30 to 4000 cm with thin (5-30 cm) mudstone interbeds. The sandstone beds are mostly amalgamated or stacked on top of each other forming enormous thickness reaching to more than 50 meters. In fact the whole of the headland is made up of these sandstones (Figure 3). The sandstone beds show good lateral continuity dipping moderately to the north (Figure 4). The coarse to fine-grained sandstone beds mostly show graded bedding (Figure 5) indicating deposition of the sediments by turbidity currents. Parallel and cross laminations are often seen towards the top of the sandstone beds whereas load structures are at the bottom. Very coarse to granular sandstones are seen in some beds indicating high energy depositional currents, possibly related to channel depositional processes.

Geological Structure

The moderately dipping sandstone sequence oriented around 280° is dissected by a series of vertical conjugate joints trending around 185° and 140°. Normal faults trending around 60° cuts through the sandstone beds showing displacement up to 2 m (see Figure 3). The faults and joints can be clearly seen during low tide (Figures 6, 7, 8 & 9). The normal faults occur as conjugate pairs producing a graben structure (Figures 10, 11 & 12).

Coastal Landforms

Weathering, erosion and deposition has resulted in the formation of cliffs and beaches. Waves crashing on the rocky cliffs have created numerous small sea caves (Figure 13) and holes on the rocky floor (Figure 14). The presence of iron oxide concretions in the thick sandstone beds also creates holes once they are eroded by waves (Figure 15). Weathering on the sandstone surface sprayed by saltwater from the sea has also created honeycomb structures called tafoni (Figure 16). The joints which are more susceptible to weathering are filled by iron oxide deposits (Figure 17) and in some instance provide spaces for roots to grow longer and deeper (Figure 18).

GEOLOGICAL SIGNIFICANCE

The occurrence of the large normal faults trending NE-SW producing graben structures on the Kudat sediments suggests that an extensional NW-SE regime occurred after the deposition and tectonic deformation of the Early Miocene sediments. This extensional regime may be related to the opening of the Sulu Sea during the late Middle Miocene. It is envisaged that similar trending large graben structures may have occurred throughout North Sabah and have created some of the distinctive morphoplogy here such as the NE-SW trending Marudu Bay.

POTENTIAL FOR GEOLOGICAL TOURISM

The easily accessible and well-exposed section of the lower sandy unit of the Kudat Formation here provides an ideal field site for research and education in geosciences and related fields. At the same time, the morphology of the coastline, having several caves, beautiful sandy beach and rocky cliffs makes it a suitable site for recreation activities (e.g. camping, picnics, expeditions). To ensure that the site is protected from uncontrolled development its status as a geological heritage need to be recognized and gazetted as such by the relevant authorities. This site could be gazetted under the National Heritage Act 2005 which provides protection and conservation of unique geological heritage. To give it additional protection the site could also be gazetted under the State Cultural Heritage (Conservation) Enactment 1997. To highlight the intrinsic values of the geological features here it may be a good idea to install posters at strategic locations to provide public-friendly information on the characteristics, origin and significance of the geological features. These posters could be constructed by the Kudat Municipal Council with assistance from Universiti Malaysia Sabah. To increase the knowledge of tourist guides about the site a short field seminar on these geological features may be organized by the Sabah Tourism Promotion Corporation with assistance from Universiti Malaysia Sabah.

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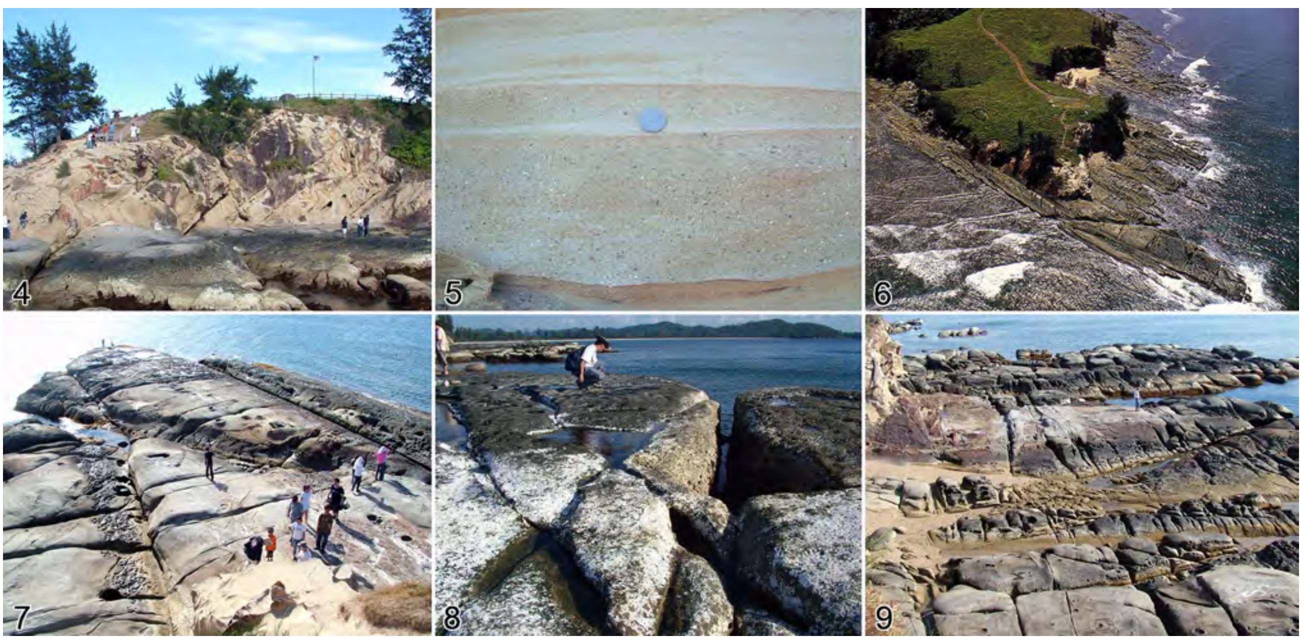

Figure 4: Thick sequence of sandstone beds of the lower sandy unit of the Kudat Formation.
Figure 5: Sandstone of the Kudat Formation showing grain size variation from very coarse-grained at the bottom to fine-grained at the top.
Figure 6: Aerial view of the headland showing highly jointed and faulted sandstone layers jutting out from the cliff. Picture by C.L. Chan.
Figure 7: Highly jointed and faulted thick sandstone beds of the lower sandy unit of the Kudat Formation.
Figure 8: Conjugate set of joints trending 185 ^{0} and 135 ^{0} on the thick sandstone beds.
Figure 9: Numerous N-S trending vertical joints dissecting the sandstone beds.

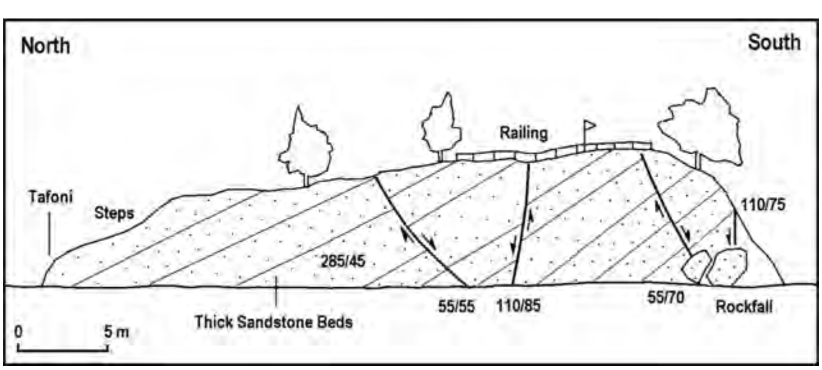

Figure 10: Structural sketch of the cliff face showing the vertical displacement of sandstone beds due to normal faults.

Figure 11: A normal fault trending 55° cutting through the sandstone cliff face and rocky sea floor.
Figure 12: Close-up view of the normal faults causing vertical displacement of about 2 m on the thick sandstone beds.
Figure 13: Caves created by waves eroding the base of the sandstone cliff.
Figure 14: Holes created on the floor of the sandstone beds when spherical-shaped iron oxide concretions were eroded away by waves.
Figure 15: Holes created on the face of the cliff as iron oxide concretions were eroded away by waves.
Figure 16: Honeycomb structure or tafoni created by the formation of a resilient duricrust of cemented rock followed by the development of pits by selective chemical weathering. Salt crystals precipitated from dessicated sea water in the pores of the sandstones wedge out the grains that are not strongly cemented to form pits. Selective weathering enlarges them to create the honeycomb structure.
Figure 17: Vertical joints in sandstone beds filled by iron oxide as a result of weathering.
Figure 18: Vertical joints on sandstone beds provide a space for trees to anchor their roots.

REFERENCES

Liechti, P., Roe, F.W. and Haile, N.S., 1960. The geology of Sarawak, Brunei and Western part of North Borneo. British Borneo Geological Survey Bulletin 3, 360 p.

Stephens, E.A., 1956. The geology and mineral resources of the Kota Belud and Kudat area, North Borneo. Geological Survey Department British Territory Memoir 5. 127 p.

Tongkul, F., 2006. The structural style of Lower Miocene sedimentary rocks, Kudat Peninsula, Sabah. Bulletin of the Geological Society of Malaysia, 49, 119-124.

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