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GEOSITE HERITAGE AND FORMATION EVOLUTION OF MAGA WATERFALL, LONG PASIA, SOUTH OF SIPITANG, SABAH

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ABSTRACT

Maga Waterfall is situated in the inland of Long Pasia which is at the south of Sipitang, Sabah. The location of Air Terjun Maga is still less known by the public however, if it is promoted it has the potential to attract local and foreign tourists. An identification survey on the geosite development potential has been done in this area to establish a geological heritage in Sabah. Maga Waterfall has three tiers and streamflow on the rock surface of Meligan Formation. The rock outcrop shows clear primary structures of shallow marine depositional environment of shoreface deposit and secondary structures such as fault and joints which shaped the formation of Maga Waterfall. Apart from that, interesting morphologies made by river erosion are also present. The unique culture of local people and recreational activities could attract more visitors to this geosite. Conservation efforts need to be taken to ensure the sustainability of geotourism development of geological heritage resources in this area.

1. INTRODUCTION

Maga Waterfall is one of the waterfalls in Sabah. It is located far inland of Long Pasia which is at Sia River, 8 km from Long Pasia settlement areas (42°6'.23'' N and 115°39'39.1'' E). Long Pasia is located at the southwest of Sabah which is towards south from Sipitang town (Figure 1). In this area, there are two small settlements known as Long Pasia and Long Miau where the majority of the populations are Lundayeh and Murut ethnic. The main economic activity in this area is agriculture and tourism. The uniqueness and the beauty of Maga Waterfall has made it as a potential waterfall to be developed as Sabah's geotourism product. Undisturbed geological resources and landscape along with its natural flora and fauna at Maga Waterfall area have become a major attraction for local and foreign tourists whom seek peace and tropical forest atmosphere there.

2. GEOLOGICAL BACKGROUND OF LONG PASIA

The geology of Long Pasia mostly was formed by Neogene sedimentary rocks. It consists of three rock units namely Temburong Formation, Meligan Formation and Alluvium (Figure 2). Temburong Formation was introduced [1]. This rock unit is part of Rajang Group and aged from Oligocene to Late Miocene [2]. However, Temburong Formation at Beaufort to Tenom was Oligocene to Early Miocene, while in Sapulut it was aged from Paleocene to Eocene [3]. The depositional environment is deep marine environment which is different with Crocker Formation where it is younger and the rock facies is shalier. In the study area, Temburong Formation was found in the eastern part where it had experienced several folds and thrusts.

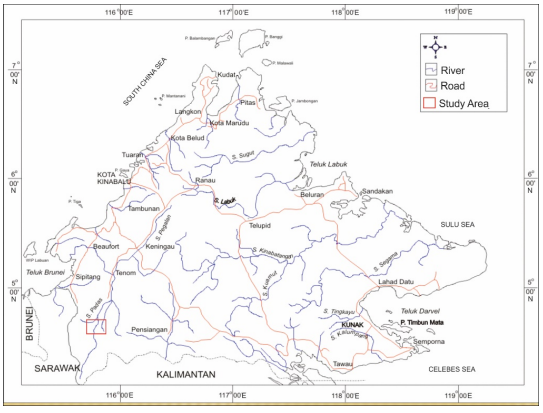


Figure 1: The location of the study area which is Long Pasia, situated at the southern part of Sipitang Town, Sabah.

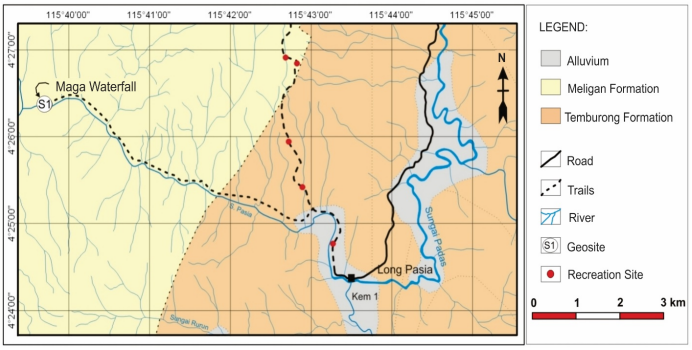


Figure 2: Geological map of Long Pasia consists of three rock units namely Temburong Formation, Meligan Formation and

Meligan Formation was first introduced which consists of well-cemented thick sandstones bedding with white to grayish color, several cross beddings and grain sizes range from medium coarse to coarse [4]. This formation also consists of chalky conglomerate lenses with chert fragments [3]. Whereas, mudstones and shale were thin and most of them have been eroded and weathered due to its fragile properties. Meligan Formation is delta to shallow marine depositional environment based on previous researchers with aged from Early Miocene to Middle Miocene [4,5,2]. Meligan Formation overlie Temburong Formation unconformably, while described Meligan Formation in Sipitang was in late Middle Miocene which deposited at coastal environment [6]. In the study area, the rock bedding has 77°W strike reading and dipped 10° to 15° to the west.

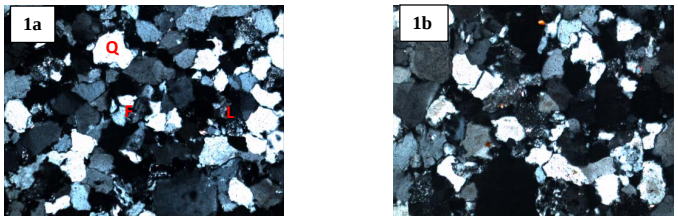
3. HERITAGE VALUE OF MAGA WATERFALL

The heritage value of geological resources or landscapes is divided into four namely: scientific value, aesthetic value, recreational value and cultural value as suggested by some researcher [7]. This heritage value is crucial in identification and classification of geological heritage resources.

3.1 Scientific Value

Maga Waterfall is based of Meligan Formation which consists of thick, white grayish sandstones bedding. The lithology of Meligan Formation is 30 cm to 4 meters thick bedding of coarse grains sandstones, medium

sized sandstones bedding and mudstones (Figure 3). Vertical sequences showed that thick, coarse sandstones are more dominant and interbedded with thin mudstones (2 cm to 15 cm). The mineralogy of sandstones from Meligan Formation is quartz, feldspar (plagioclase based on albite twinning), rock fragments and little amount of matrix (Photomicro 1a). The dominant presence of angular to sub-angular quartz (Photomicro 1b) suggested that the sandstone is chemically matured. Sandstone of Meligan Formation is classified as sublitarenite [8]. Some of attractive sedimentary structures are interbedding of coarse to medium sized sandstones with thin mudstones, parallel lamination, cross beddings 'swalley' and 'hummocky' and ripples. Thick sandstone bedding normally consists of 'swalley' cross bedding structure (Photo 1 and 2). Meanwhile, medium to thick sandstone bedding has 'hummocky' structure (Photo 3), parallel lamination and ripples (Photo 4). Horizontal observation showed the amalgamated sandstone bedding. These sedimentological characteristics suggested shallow marine depositional environment which is coastal deposits dominated by 'swalley' cross beddings.



Photomicro 1: The photomicrographs showed the (a) existence of quartz (Q), feldspar (F) and lithic (L), and (b) the dominance appearance of angular to sub-angular quartz in sandstone sample of the study area

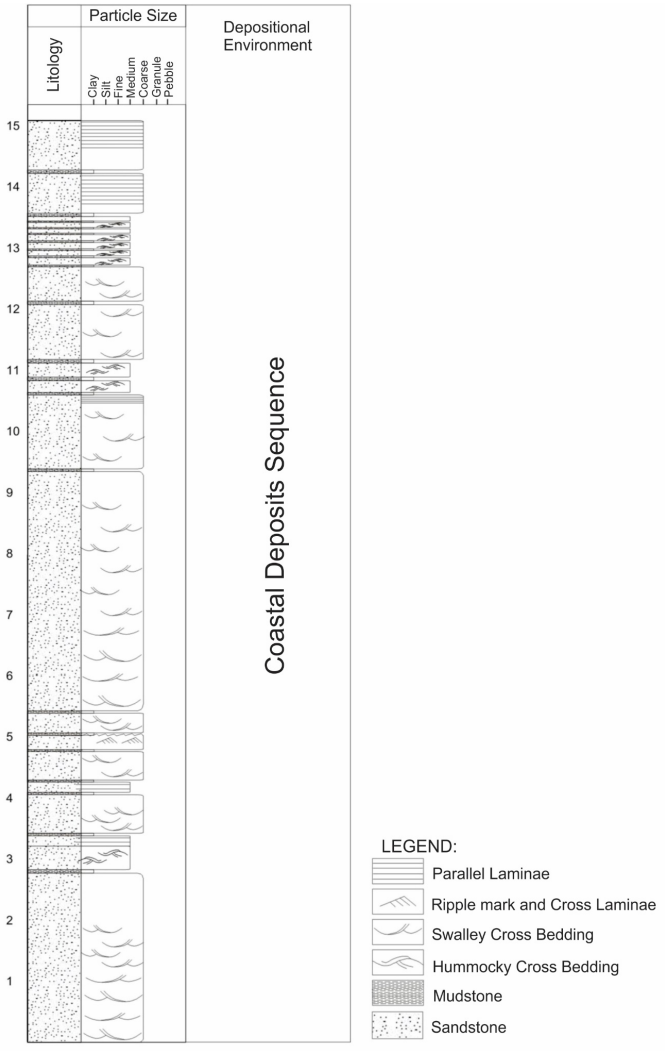


Figure 3: Litholog at the Maga Waterfall Tier

Photo 1: Cross bedding structure 'swalley' on thick sandstone at the river bank outcrop

Photo 2: Cross bedding structure 'swalley' on thick sandstone at waterfall tier AT2 outcrop

Photo 3: Cross bedding structure 'hummocky' (pen as scale)

Photo 4: Ripple structure on the surface of sandstone at Waterfall AT2 outcrop

3.2 Aesthetic Value

Maga Waterfall is very attractive as there are three tiers of waterfalls which look like a cascading waterfall (Figure 4). The morphology that can be seen on this geosite is resulted from river erosion such as waterfall tiers (Photo 5), pothole (Photo 6), tafoni (Photo 7a) and rapids (Photo 7b). The beauty of its landscape and the uniqueness of flora and fauna around this waterfall have also contributes to its aesthetic value.

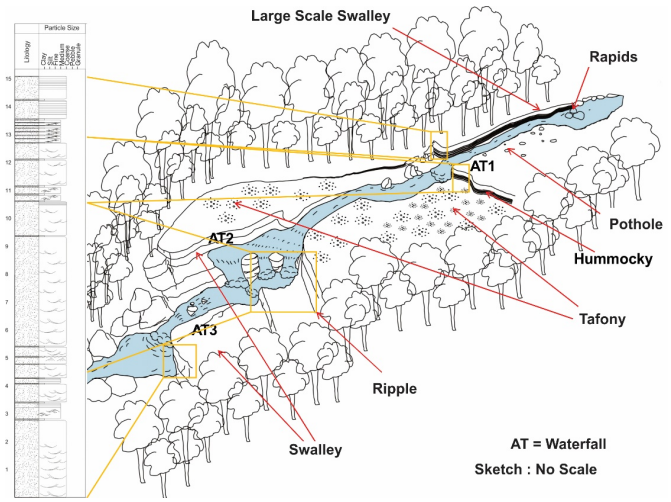


Figure 4: The sketch of Maga Waterfall which consists of three tiers of waterfall and the ocation of primary structure and river-erosion morphologies.

Photo 5: Panorama of Maga Waterfall (AT2) showed river flows on the surface of rock from Meligan Formation

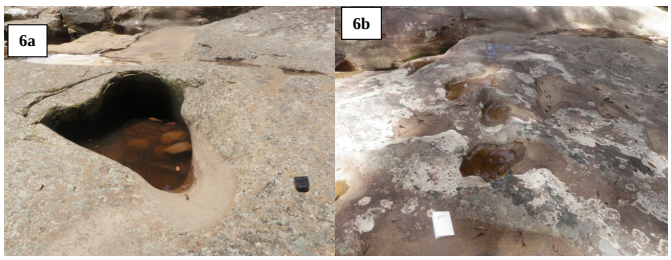


Photo 6: Photo above showed (a) nearly 1-meter diameter of pothole and (b) smaller size potholes

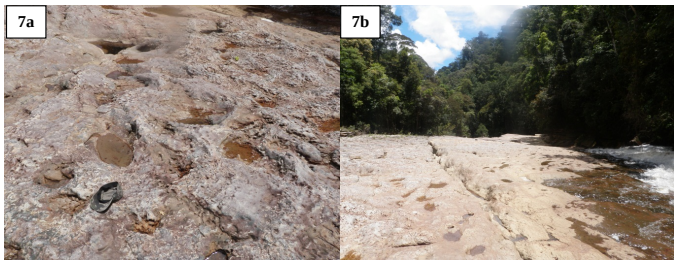


Photo 7: (a) Physical weathering resulted to tafoni morphology and (b) rapid flows on the rock surface of Meligan Formation

3.2.1 Maga Waterfall Formation Mechanisme

3.2.1.1 Waterfall 1 (AT1)

The first waterfall tier has 2 meters height and it is located at the very top (Photo 8). There is wide area before AT1 tier which is based on thick sandstone bedding with 10° dip. On the river banks, parallel lamination of thick sandstone and 'hummocky' cross bedding on thin sandstone is exposed. There is also morphology from the river-erosion process such as potholes with nearly 1-meter diameter. The waterfall flows through the plane of almost 90° gradient of slope. Thick, coarse sandstone bedding with 'swalley' and 'hummocky' cross bedding structure can be seen at the outcrop at AT1.

3.2.1.2 Waterfall 2 (AT2)

The second waterfall is 4 meters high and located 50 meters from first waterfall, AT1. There is flat area between AT1 and AT2 which is based on thick bedding of coarse sandstone (Photo 9). This area consists of small size of potholes and most of the surface is covered with tafoni structure (Photo 10a and 10b). Primary structures that can be observed on the river banks and waterfall tiers are parallel lamination, cross bedding 'swalley' and ripples.

3.2.1.3 Waterfall 3 (AT3)

The third waterfall (Photo 11a) has 8 meters height and located at the lowest part. There is a flat area which separates waterfall AT2 and AT3 (Photo 11b). The longest distance between At2 and AT3 is 15 meters which is based by thick, coarse sandstone bedding. Primary structures such as 'swalley' cross bedding can be observed at the waterfall tier and the river banks.

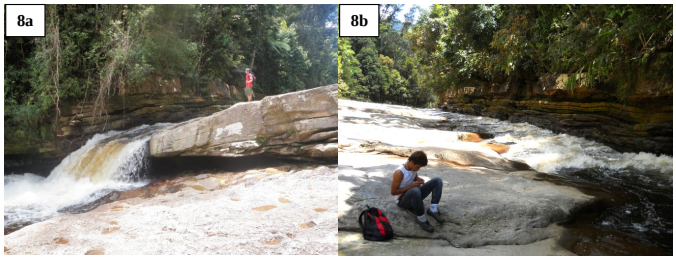


Photo 8: (a) Waterfall AT1 with 2 meters height and (b) river banks at the upper part of waterfall AT1

Photo 9: (a) Side view of waterfall AT2 that showed several tiers of water flows and (b) front view of waterfall AT2

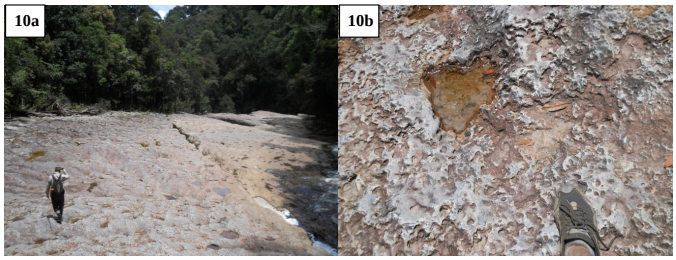


Photo 10: (a) Flat area between Waterfall AT1 and AT2 and (b) tafony structure and small size potholes on rock surface

Photo 11: (a) The view of Waterfall AT3 and (b) is the area in between Waterfall AT2 and AT3

Beside the primary structures, secondary structures formed by tectonic activity can also be observed such as the dip of the bedding, thrusts, joints and faults. The strike of bedding is 77° and dip of Meligan Formation's bedding is very gentle about 10°. The formation of this waterfall can be related to the influence of structural geology and the difference of rock's strength. The influence of structural geology involved with the formation of joints and thrusts on rock beddings. These trends of joints and thrusts form fractures and cracks which contributed to weak plane and became the passage for water flows. The waterfall tier is the effect that has been left by eroded planes of joints or faults.

Meligan Formation consists of sedimentary rocks which is the interbedded of coarse sandstone bedding with thin mudstones [9]. Tectonic activity which occurred during Late Miocene resulted to the dipping and the formation of joints and faults. These faults and joints cut deeper in sedimentary rocks. The water flows usually through the weak planes which formed by joints and faults on sedimentary rocks. By horizontal observation, this rock is covered with thick bedding of sandstone which is highly resistance to weathering and erosion process. However, the presence of joints and faults allowed the water to infiltrate into the fractures and weaken the structure of the rocks itself.

Different type of lithology and its resistance to erosion are also able to control the formation of the waterfall. In this case, the thick, coarse sandstone bedding possesses higher resistance compared to mudstones. For example, at the outcrop of waterfall tier AT1 and AT2, the upper part of the waterfall consists of sandstone bedding which is thick and resistant to the erosion, however at the foot of waterfall is consists of thin bedding of sandstone mudstone that is less resistance to erosion and weathering. In addition, the water flowing down freely at the high-speed due to gravity effect could accelerate the erosion on rocks at the foot of waterfall. This resulted to deep holes formation on the wall of the waterfall's foot. This caused the hanging rocks to collapse eventually to form new waterfall tiers (Figure 5). This process will continue on the other rocks until it is finally formed ladder-like or tier waterfall. The waterfall formation is influenced by the geological factors such as rock lithology, geological structures and river erosion.

3.3 Recreational Value

Among the activities that can be done at Maga Waterfall is picnic, leisure activities, camping, jungle trekking and walking down the river. In addition, several homestays are also provided by residents of Long Pasia, which also include tourism activities such as sightseeing around the village as well as agricultural areas and seasonal rice cultivation and harvesting. Tourists also have the opportunity to learn the handicrafts and watch the cultural show of Lundayeh ethnic. Maga Waterfall is rich with geological resources, flora and fauna, and provide the wide research opportunity to the researchers as well.

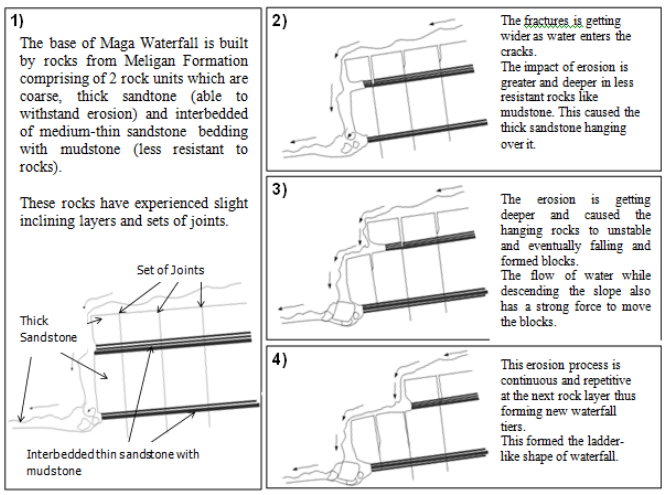


Figure 5: The formation of Maga Watefall

3.4 Cultural Value

Lundayeh ethnic in this area strongly believed that a brave warrior, name Upai Semaring, has once lived in the area around of Maga Waterfall. He was described as having a huge body and a very strong man. Remain of foot print of Upai Semaring is believed to be buried on the surface of this waterfall (Photo 13). Scientifically wise, this dent was resulted from the weathering activity and the river erosion which causes its shape as a foot print.

Photo 13: The dent on the rock surface is believed belongs to the foot print of Upai Semaring [10].

4. CONSERVATION SUGGESTIONS

Maga Waterfall is a protected site in terms of geological sources, landscapes, flora and fauna. If this site is to upgrade as a geotourism attraction area, several things must be considered to ensure its sustainability and the beauty of its geological heritage resources. The information need to be conveyed to all visitors on the importance of geological heritage resources found in this area. This is to create awareness for conserve and preserve the resources either in the form of signboards or printed reading materials. Besides, relevant local authorities should play a role to monitor and to provide basic infrastructures to the visitors such as bin and toilet facilities to prevent contamination, especially on the river water of Maga Waterfall.

5. SECURITY FACTORS

So far, the Maga Waterfall does not have any basic facilities built permanently. Security factors to be taken into account is the possibility of flash flood due to heavy rain at the upstream of the river resulted to drastic increment of discharge volume. Visitor must be precautious of their safety and keep an eye of any changes of the water level. The warning sign should be placed in potentially dangerous areas as a precaution and reminder to visitors.

6. CONCLUSION

The beauty and uniqueness of geological sources and landscapes of preserved Maga Waterfall is a factor of geosite characterization and to upgrade it as a geotourism attraction in Sabah. Maga Waterfall has its own uniqueness comprises of thick sandstone and mudstones of Meligan Formation which age is Late Miocene. There are interesting primary structures that can be observed in this area. The formation of Maga Waterfall is largely influenced by geological factor and river erosion. Apart from that, other attractions around Maga Waterfall are the opportunity to carry out recreational activities as well as to learn the culture of Lundayeh ethnic. This site has a potential as a geosite purposes but several maintenance and conservation measures need to be taken to ensure the sustainability of geological heritage resources of Maga Waterfall remains.

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