Borneo Journal of Resource Science and Technology (2018) 8(2): 109-116

SHORT COMMUNICATION

The Geology of Upper Baleh River, Kapit, Sarawak

EDWARD MUOL[*1] & GABRIEL TONGA NOWEG[2]

[1]Department of Minerals and Geoscience Malaysia, Sarawak**,** Jalan Wan Abdul Rahman Kenyalang Park, 93658 Kuching, Sarawak, Malaysia; [2]Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia
Corresponding author: edwardm@jmg.gov.my
Received: 31 July 2018 Accepted: 6 December 2018 Published: 30 December 2018

ABSTRACT

Geological mapping of the proposed Baleh National Park, Sarawak was conducted during the Heart of Borneo Expedition in Mid November 2015 with Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak. A geological map of the study area is compiled together with maps of the previous studies. The proposed Baleh National Park is made up of plateau and mountain chains. The topography of the study area is closely related to the geology. The plateau is underlain by the volcanic rocks which consists predominantly of tuff and dacitic rocks with scattered agglomerate, while the mountain chains are the ridges which striking east-west direction are underlain by slate interbedded with siltstone, sandstone and mud clast conglomerate of the Layar Member. The Layar Member of the Belaga Formation is suit of deep ocean marine deposits during the Late Cretaceous [100.5–66 million years ago (ma)]. The plateau of the Bukit Tiban was formed as a result of the volcanic eruption during the Late Miocene (11.6–5.3 ma). Several interesting geoheritage sites were observed in the study area.

Keywords: Bukit Tiban, columnar joints, dacite, geoheritage, Layar Member

The recent geological mapping of the Bukit Batu Tiban area is part of the proposed Baleh National Park. The site visit was carried out within a span of 11 days from 19th November until 29th November 2015. A group of 30 scientists from various background on flora and fauna travelled to collect baseline data before the area are to be gazetted as National Park. The distribution of rocks is significant in the study of flora and fauna diversity. The nature of the bedrocks fundamentally influences its overlying soil, and many plants and animal species are typical of certain soils that in turn are associated with certain underlying rocks. The objectives of the study were to map the geological formation which underlain the proposed Upper Baleh National Park as well as to locate the potential geoheritage sites.

The study area is located east of Kapit Town. It is bound by Longitude 114^0 6' E to 114^0 36' E and Latitude 1^0 25' N to 1^0 35.6'N (Figure 1). The overall accessibility to the study area is very poor. The area is connected by the logging track which is only accessible to the major logging pond at Putai. Putai is well served by the express boat once daily.

The geological mapping was carried out along designated route with different lithological characters to confirm the studies by the previous researchers. The access road from Logging base camp to Bukit Tiban and selected rivers were traversed using Global Positioning Station (GPS) to make accurate geological map. Rock samples were collected and geometrical aspect of outcrop were studied stratigraphically and structurally.

Topography – The topography of the area is made up of plateau and the mountain chains. The plateau area which is about 1000 m above sea level are located at the most eastern part of the study area bordering the Kalimantan, Indonesia. While the tableland stands above 1000 m, the area below is about 300 m to 1000 m above sea level formed mountain chains. The topography of the area is closely related to the geology. The tableland is underlain by the volcanic rocks which consists predominantly of tuff and dacitic rocks with scattered agglomerate. The prominent topographical features of these volcanic rock-type are very steep cliffs. The topography of the areas below the tableland is totally different; the mountain chains are the ridges which striking east-west direction are underlain by sedimentary

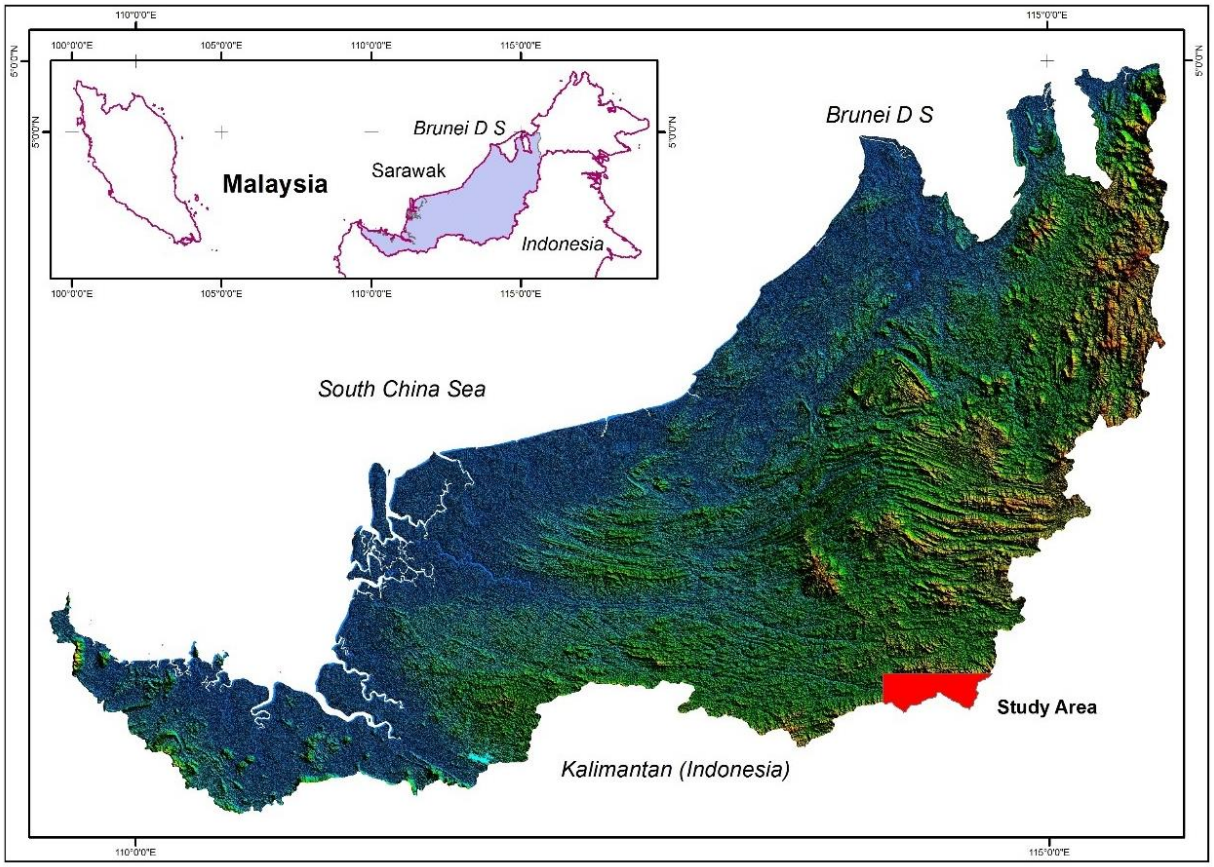


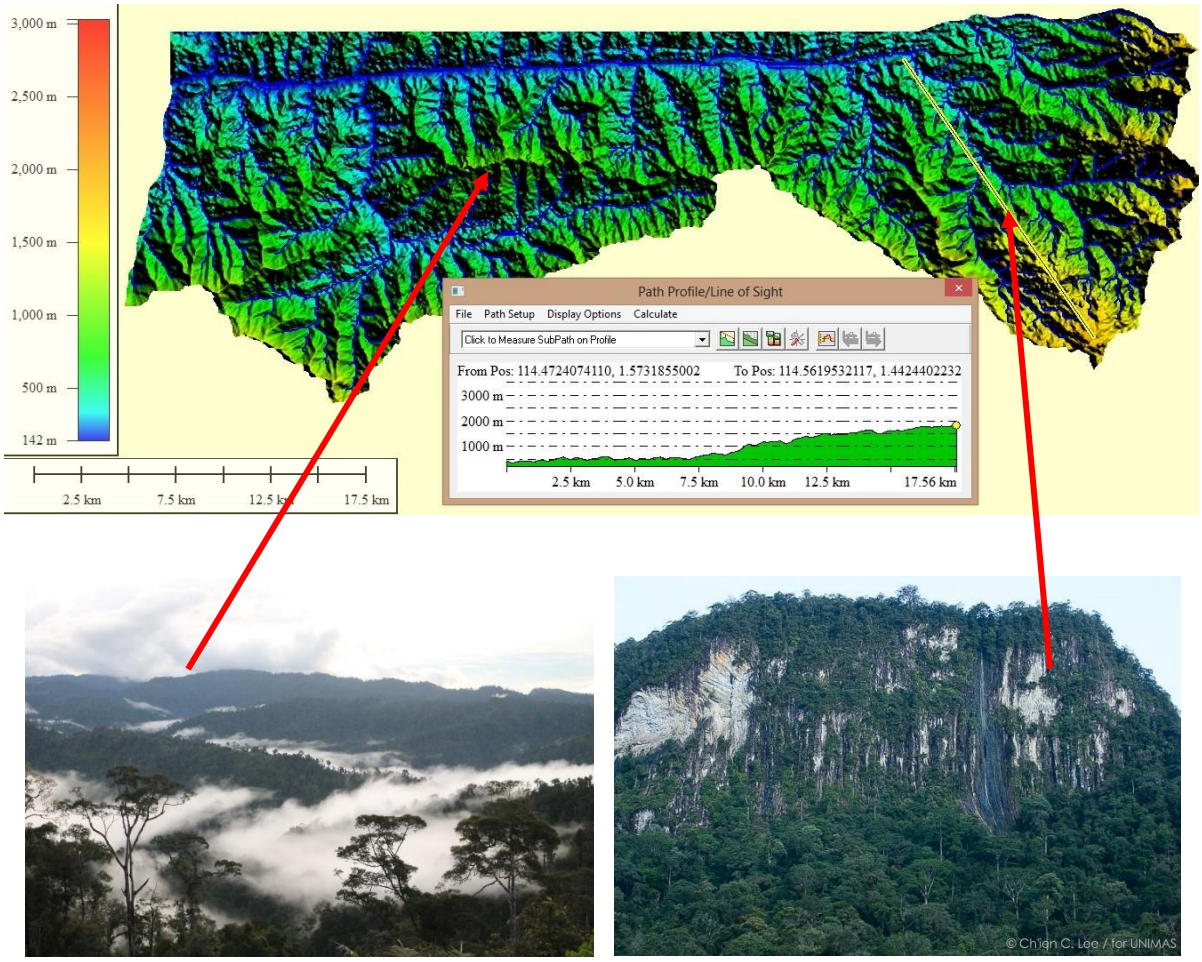
Figure 1. The study area is located at the eastern part of Sarawak bordering with Kalimantan, Indonesia.

rock (Figure 2). These ridges were formed when the sedimentary rock formation were folded.

Drainage – Batang Baleh formed the main drainage system in the study area. The rivers and streams make up generally trellis to dendritic drainage patterns in the study area. The overall drainage pattern of the study area which is underlain mostly by arenaceous rocks of the Layar Member is of a trellis type. The drainage pattern is due to the folded strata of the interbedded sandstone–shale which dominated the eastern part of the study area. It is also controlled by the joint and fault system that are intersecting perpendicularly to the east-west trending beds.

The eastern part of the study area which is underlain by igneous rocks of extrusive type exhibits drainage patterns of dendritic (Figure 3). The drainage pattern is controlled by the geological structure and the resistance of the volcanic rock which also shaped the topographical features.

Geological settings – The geology of Sarawak can be subdivided into three distinct provinces which correspond to three main geographic regions, namely West Sarawak, Central Sarawak and North Sarawak (Figure 4). The geology of West Sarawak is characterised by extensive areas of Triassic sediments, intrusives, metamorphics and volcanics (Banda, 1992). These are overlain in some areas by Late Jurassic to Eocene sediments, which are in places intruded by Late Cretaceous igneous rocks. The Lupar Line separates West Sarawak from Central Sarawak and has been interpreted as a subduction zone (e.g. Hutchison, 2005) or as a major strike-slip fault (e.g. Haile *et al*., 1994). Central Sarawak is dominated by Upper Cretaceous Rajang Group of turbidites, which have a deep water, probably distal character and are intensely folded, faulted and thrusted. These have been interpreted as an accretionary prism (e.g. Hutchison, 2005). North Sarawak is the region north and east of the Rajang-Baram Watershed. This region is underlain by Neogene sediments



(a) **(b)**

Figure 2. On top shows the topographical map of the study area with the view of two different topographical features. (a) Ridges striking east-west direction are underlain by sedimentary rock; (b) Steep cliffs of volcanic rock.

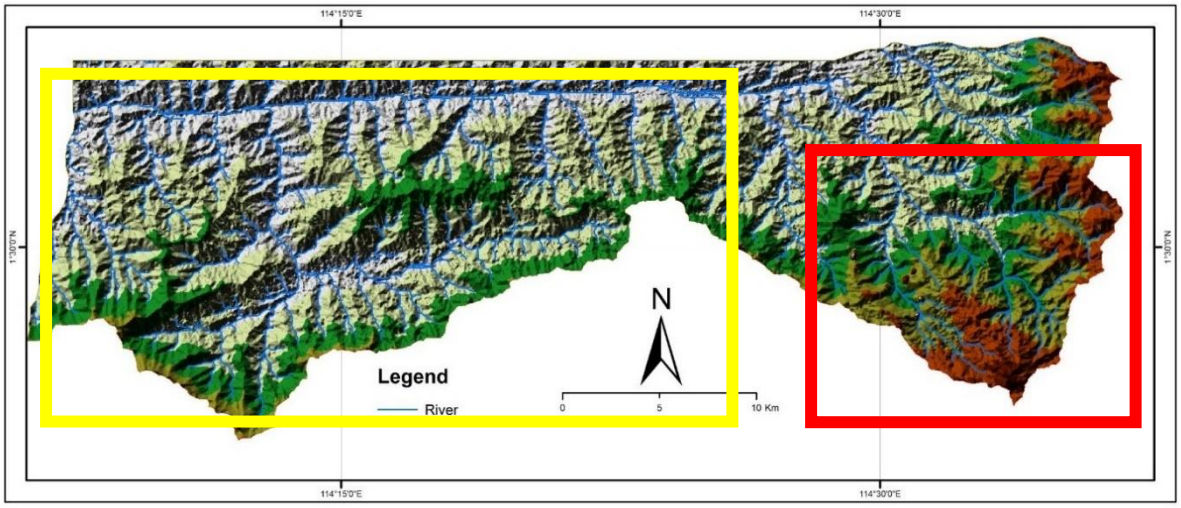


Figure 3. The drainage map which shows the trellis pattern (yellow box) and dendritic pattern (red box).

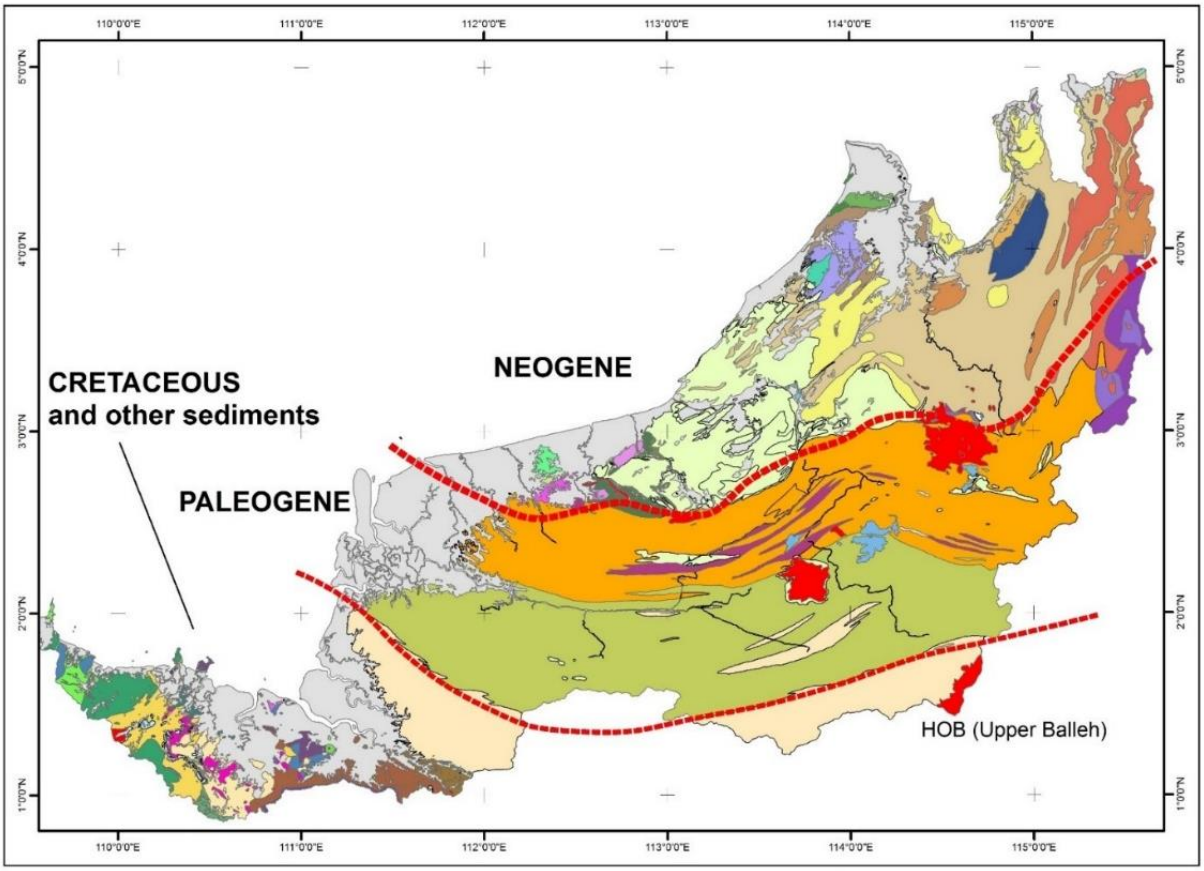


Figure 4. The geological setting of Sarawak are subdivided into three distinct provinces (after Banda, 1992).

of the NW Borneo Basin. Two phases of sedimentation occured during the Neogene Period which resulted in the deposition of thick marine argillaceous sediments overlain by the shallow-water sediments consisting of arenaceous coarse clastics (Banda, 1992).

Regional geology – The study area is located in the area dominated by the Cretaceous and Eocene to Miocene Crocker-Rajang-Embaluh accretionary complex in Central Sarawak. It consists primarily of turbidites which were being shed northeastward off the Schwaner and younger volcanic arcs into a paralic to deep marine trench basin. These sediments were imbricated, deformed, and weakly metamorphosed during the Cretaceous subduction and finally were intruded by late stage and post subduction intrusions of the Sarawak Orogeny. The plateau of Bukit Batu Tiban or generally term as Neuwenhuis Mountains or Mentulang Plateau in Kalimantan occurred during the volcanic activities in Miocene-Pliocene (Banda, 1992).

Site geology – The geological stratigraphy of the Bukit Batu Tiban area is summarized in table 1. The oldest known rock unit is the Layar member of the Belaga Formation (Late Cretaceous) and were deposited in a deep marine. The member consists of mudstone-dominated facies as the lower unit, which coarsens upwards into siltstone-sandstone-conglomerate dominated facies. The base of the Layar Member is in Lubok Antu where it is fault contact with the Lupar Formation (Liechti *et al*., 1960). The overlying stratigraphic and the youngest unit is the Bukit Batu Tiban Volcanics. This unit forms the highest and sometimes lookalike karst topography. It is made up mainly of dacite, tuff, basalt and angglomerate.

Table 1. General stratigraphy of the study area.

Regional Event	Lithostratigraphic Unit	Age (Million years, ma)
Volcanic eruption in Central Sarawak	Batu Tiban Volcanic/ Mentulang Volcanic	Late Miocene (11 ma)
Late Eocene folding		
In Central Sarawak	Layar Member, Belaga Formation	Eocene (56 ma)
Deposition of turbiditic sandstone and shale		

Layar Member (Belaga Formation) – The Layar Member of the Belaga Formation (Late Cretaceous) is part of the Rajang Group which also include the Lupar Formation and other member of the Belaga Formation. In Kalimantan, the Rajang Group extend into Embaluh and Selangkai Formation. The Layar Member which is generally composed of predominantly of slate and phyllite with rhythmically interbedded metagraywacke (Tan *et al*., 1980) are found at the eastern part of the study area. Based on the field mapping by Banda (1992), the Layar Member are divided into four (4) facies, namely; i) Mudstone-dominated facies, ii) Siltstone-dominated facies, iii) Sandstone-dominated facies and, iv) Conglomerate-dominated facies.

During the recent field trip, few rivers and roads were traversed to located and confirm the dominated facies as described by Banda (1992). Among the traversed route are as shown in Figure 5. Mudstone-dominated facies consists of mudstone interbedded with siltstone forms the lower part of the sections. Amongst the sedimentary structures found in this facies are parallel-continous bedding, graded bedding, load structures, small scale cross-bedding and slumping. Siltstone-dominated facies comprises of siltstone interbedded with mudstone (Figure 6). These beds are similiar to the mudstone-dominated facies except that the siltstone beds are the dominant lithology and are generally thicker.

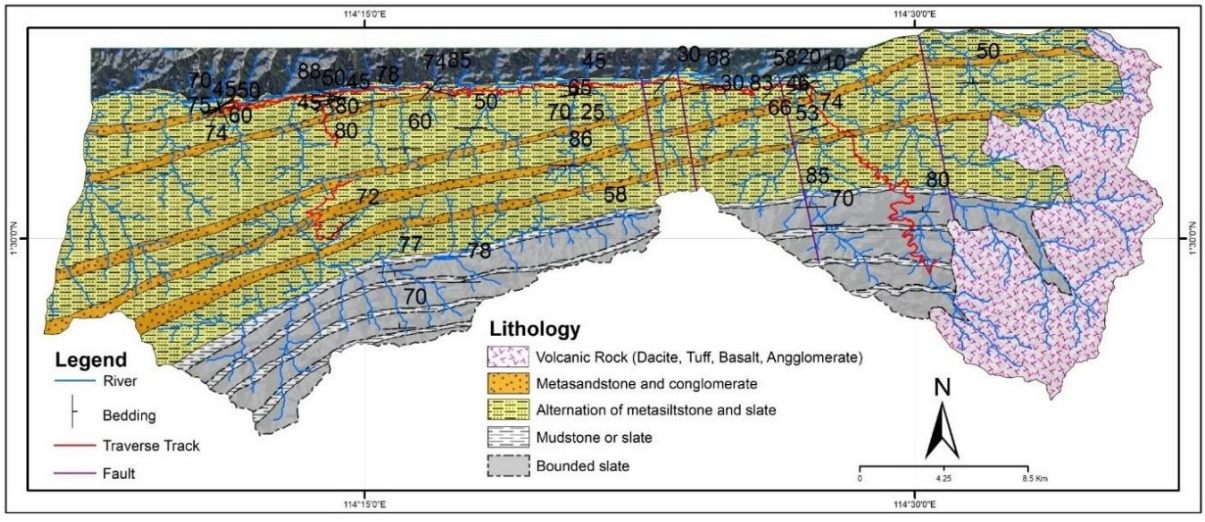


Figure 5. The traversed route of the study area.

Sandstone-dominated facies consists of fine to coarse-grained sandstone interbedded with siltstone and a little mudstone. The massive sandstone is of 30 cm to 3 m thick with sedimentary structures such as graded bedding, flute cast and channelling are commonly found at the base of the sandstone beds (Figure 7).

Conglomerate-dominated facies which forms the top unit of the Layar Member consists of coarse-grained sandstone interbedded with conglomerate. Two types of conglomerate were observed along the Sungai Grugu are para and ortho-conglomerate. Para-conglomerate consists of rafted slabs of mudstone in a coarse-grained matrix and ortho-conglomerate consists of sub-rounded to rounded pebbles of quartz, sandstone and chert embedded in a matrix of coarse-grained sandstone (Figure 8).

The coarsening upwards sequence commonly observed in submarine deltas is the result of mass movement and at the same time, channelling along the delta slope. The conglomerate and sandstone-dominated facies deposits are interpreted as mass-flow products and the mudstone-dominated facies as turbidites deposited in a quiet environment.

Igneous Rock – The igneous rock in the study area comprises of extrusive. This youngest unit of rocks is overlying the Layar Member of the Belaga Formation consists of extrusive igneous such as dacite, tuff and agglomerate. The tuff forms the tableland whereas the dacite forms isolated hill with karst-like features (Figure 9). Dacite is found along the Sungai Menuang Ili as outcrop and big boulder (Figure 10; Banda, 199). Fresh dacite hand specimen is light grey in colour, porphyritic with coarse-grained phenocrysts of feldspar, quartz, biotite in a fine groundmass (Figure 11).

The tuff contains rock fragments embedded in the feldspathic matrix and it is extensive in the study area overlying the dacitic rock forming the plateau. Agglomerate is very minor and associated with tuff with patches. The agglomerate occurs as pyroclastic flow, consisting mainly of rock fragments embedded within welded tuff. The fragments are of several sizes from 1 mm to a few centimetre across. It is commonly observed in the Sg. Menuang Ili as boulder.

Figure 6. Slate with thin beds of metasiltstone.

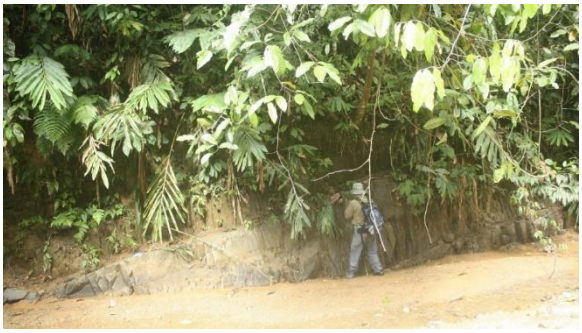


Figure 7. Thick metasandstone beds which dominate the upper layer of Layar Member.

Figure 8. The grab sample of conglomerate with rounded clast of sandstone, slate and quartz.

Figure 9. Karst-like features of dacitic cliff with waterfalls.

Figure 10. Boulders of dacitic rocks found along the Sg. Menuang Ulu.

Figure 11. Hand specimen of fine grained, light grey dacitic rock.

The intrusive rocks are very minor, scattered in a few places in Sg. Menuang and along the access timber track. They occurred as basaltic sill and dykes, intruded into the Layar member. The basalt dykes which occur in the form of columnar jointing body are found along the access logging track (Figure 12a).

Geoheritage – According to Brocx and Semeniuk (2007), geoheritage (geological heritage) is a concept concerned with the preservation of features with importance to earth science, such as landforms, natural and artificial exposures of rocks, and sites where geological features can be examined. Geoheritage is a descriptive term applied to sites or areas of geologic features with significant scientific educational, cultural or aesthetic value (Geological Sociey of America, 2011). Scientifically and educational significant geoheritage sites include those with textbook geological features and landscapes, distinctive rock or mineral types, unique or unusual fossil or other geological characteristic. Cultural significant geoheritage – geological features or landscape played a role in cultural or historical events. Aesthetic significant geoheritage – landscape visually appealing – geological features or processes.

Ulu Baleh possesses rich geodiversity in terms of rocks, geological structures, geomorphological and landscape features. Geoheritage of Ulu Baleh mostly occurred within rocky riverbanks, cliffs, peaks and waterfalls. Some highly significant exposures are potentially to be classified as geoheritage sites, containing one or more geodiversities of high heritage value. Some of the geoheritage sites identified are the basaltic columnar joints (Figure 12a) and waterfall with metasediment outcrops (Figure 12b) which possessed significant value, whereas another geoheritage sites with aesthetic value are dacitic rock cliff

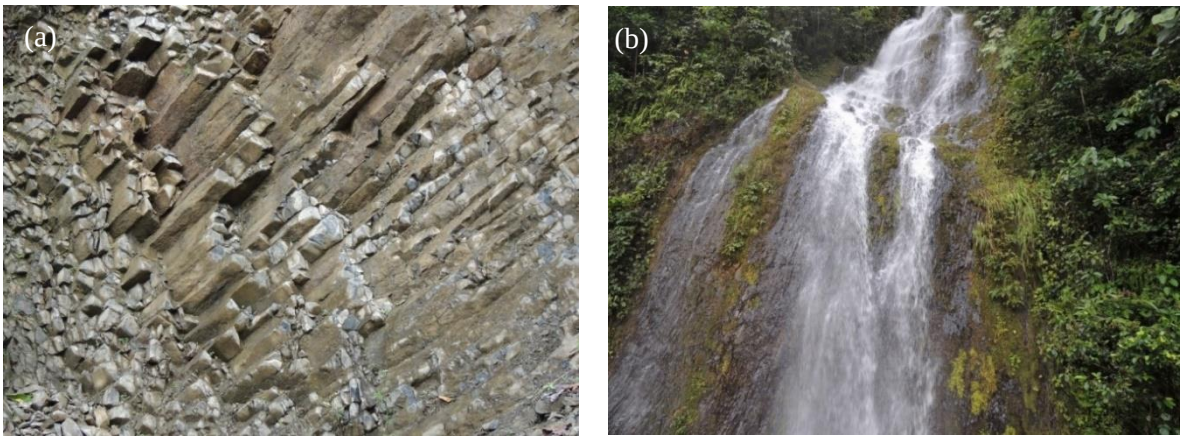


Figure 12. Some outstanding geological features with scientifically and educational value. (a) Basaltic dyke which occurred at columnar joints; (b) Outcrop of metasediment with waterfall.

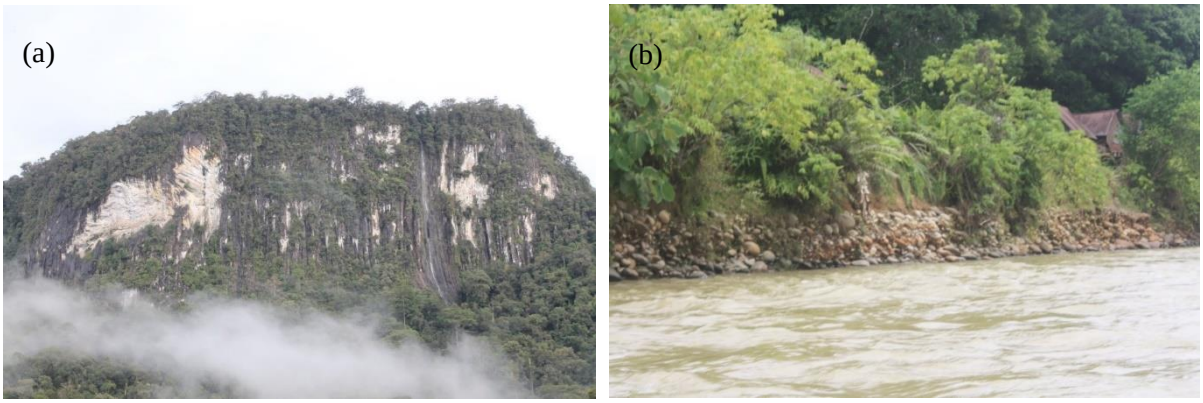


Figure 13. Some outstanding geological features with aesthetic value; (a) Dacitic cliffs with "karst" like features; (b) Colluvium deposits along Baleh river

and colluvium deposits along the Baleh river (Figure 13). The outcrops of basalt and metasediment are significant to education and research as these features are the evidences of the geological process that occurred in the study area millions years ago. Aesthetically significant geoheritage sites of cliffs of dacitic rocks with very high waterfalls and colluvium deposits that are visually appealing because of their geologic features or processes can be tourist destinations and provide local and regional economic benefits.

The upper reaches of the Baleh river are still rich in nature, especially the natural beauty of its topographical features formed by geological processes. The geological formation which age ranges from eocene to late miocene consist of regionally metamorphosed sediments of slate, metasiltstone, metasandstone and mud clast conglomerate. These metasediments are overlain by dacitic, tuff and agglomerate of tertiary volcanic, and intruded by basalt sill. The geomorphological and geological features shape the areas as the potential geoheritage that needs to be preserved such as basaltic columnar joints, karst-like features of dacitic cliff, colluvium along riverbanks and waterfalls at the dacitic cliff.

ACKNOWLEDGEMENTS

The authors thank Sarawak Energy Berhad for funding this project (GL(I01)/SEB/1B/2013 (13)), Sarawak Foresty Department, the Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, WTK Timber Company, the staff of Elite Honour Camp, and the Kenyah community in Long Singut, in particular, Mr. Udau Angie.

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