Geoheritage resources of the Baliajong River: Potential for geotourism development

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Abstract— Study carried out in the Baliajong River has revealed a hidden trove of rich geological heritage. The river is located about 3 km northeast of Tandek Town in the Kota Marudu District, Northern Sabah. The prominent geological heritage of the area is an ancient oceanic crust of Lower Cretaceous to Paleocene age exposed along the Baliajong River. The ancient oceanic crust comprises predominantly of basalts and associated igneous and sedimentary rocks and forms the basement rock of northern Sabah. These rocks form part of an ophiolite, a slice of the sea floor that was uplifted to the surface during mountain building process. Besides the ancient oceanic crust, the other interesting features of this site are the various geomorphological features such as a periodic subterranean stream that forms a cave, waterfalls, U and V-shaped river valleys and the active geomorphological processes that still shape the area. The Baliajong River is also rich in mining history where manganese was mined in the early 20th century. Remains of railway that was used to transport the manganese ores could still be found. The area is also rich in biodiversity and the riparian forest is still intact. The Baliajong River which is rich in geodiversity, biodiversity and history could be promoted as a geotourism destination. The spin-offs from the geotourism development could benefit the locals and that would encourage them to conserve the geoheritage resources in the area.

Keywords: geoheritage, geodiversity, geoconservation, geotourism, sustainable development

Sumber warisan geologi di Sungai Baliajong: Potensi untuk pembangunan geopelancongan

Abstrak— Kajian yang dijalankan di Sungai Baliajong telah mendedahkan sumber warisan geologi yang tersembunyi. Sungai itu terletak 3 km di timurlaut Pekan Tandek dalam Daerah Kota Marudu, Utara Sabah. Warisan geologi yang ketara di kawasan itu adalah kerak lautan kuno berusia Kapur Bawah hingga Paleosen yang tersingkap di sepanjang Sungai Baliajong. Kerak lautan kuno itu terdiri sebahagian besar dari basalt dan batuan igneus berasosiasi dengan batuan sedimen yang membentuk batuan dasar utara Sabah. Batuan ini merupakan sebahagian daripada ofiolit, iaitu sekeping batuan dasar laut yang terangkat ke permukaan semasa pembentukan pergunungan. Selain dari kerak lautan kuno, fitur lain yang menarik di kawasan itu adalah pelbagai fitur geomorfologi seperti sungai bawah tanah berkala yang membentuk gua, air terjun, lurah sungai yang berbentuk U dan V dan proses-proses aktif geomorfologi yang masih mencorak kawasan itu. Sungai Baliajong juga kaya dengan sejarah perlombongan dimana mangan dilombong pada awal kurun ke-20. Tinggalan landasan keretapi yang digunakan untuk mengangkut bijih mangan juga masih boleh ditemui. Kawasan itu juga kaya dengan kepelbagaian biologi dan hutan tepi sungai masih tidak terganggu. Sungai Baliajong yang kaya dengan kepelbagaian geologi, biologi dan sejarah boleh dimajukan sebagai destinasi geopelancongan. Hasil sampingan daripada pembangunan geopelancongan mampu menguntungkan penduduk tempatan dan keadaan itu akan menggalakkan mereka memulihara sumber warisan geologi di kawasan itu.

INTRODUCTION

The Baliajong River is located about 3 km northeast of Tandek Town in the Kota Marudu District (Figure 1). It can be reached via the Tandek-Togudon Road where the road ends at Kampung Togudon located beside the Baliajong River. Kampung Togudon is mostly populated by the Dusun Kimaragang native. The population is about 300 and most of them earn their livings as farmers. The most prominent geological heritage of the area is the present of widespread ancient oceanic crust exposed along the Baliajong River and is more than 120 million years old based on age of radiolarian fossils from associated chert beds. The occurrence of the ancient oceanic crust contributes to better understanding of the geological history of Sabah and the region. Besides ancient oceanic crust, other interesting features of this site are the various geomorphological features and processes, mining history, biodiversity and culture. The site provides an ideal field site for research and education in geology and related fields. The rich hidden treasures of the site need to be conserved as the hanging 'Sword of Damocles' is looming over them. This could be done by involving the local community to promote the site as geotourism destination and thus ensuring sustainable conservation. Presently, this site is used as an excursion site for geology students from Universiti Malaysia Sabah (UMS).

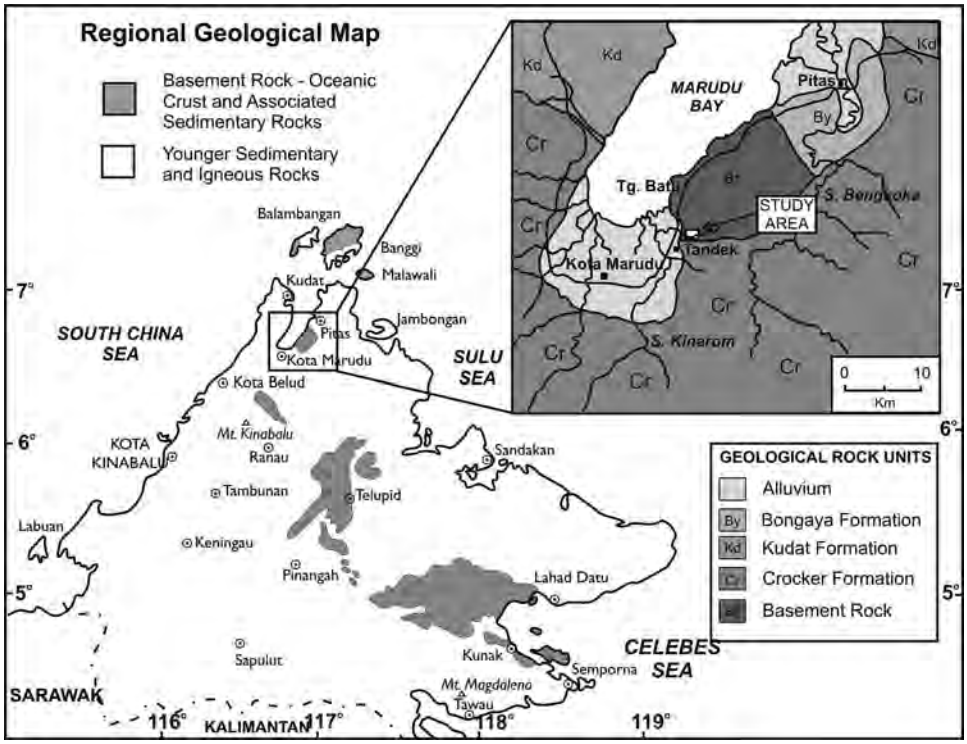

Figure 1: Location map of the Baliajong River showing the regional geology, Kota Marudu, Sabah (modified after Tongkul, 1997).

GEOLOGY

The ancient oceanic crust exposed in the Baliajong River represents a slice of an oceanic crust underlying Sabah and most of Borneo Island (Tongkul, 1997). The exposure continues for a length of about 10 km upstream (Figure 2). The Lower Cretaceous to Paleocene age ancient oceanic crust comprises predominantly of basalts, associated with gabbros, dolerites, cherts and mudstones. The ancient oceanic crust at this area is formerly described as part of the Chert Spilite Formation (Stephens, 1956). These rocks form the basement rock of northern Sabah and form part of an ophiolite, a slice of the sea floor that was uplifted to the surface during mountain building (Tongkul, 1999). The altitude of the immediate surrounding area is up to 500 m above sea level. The ancient oceanic crust is unconformably overlain by younger sediment of the Crocker Formation which is Eocene to Early Miocene in age.

GEOLOGICAL HERITAGE RESOURCES

The ancient oceanic crust of the Baliajong River has been studied and described in great detail by Tongkul (1999). The Baliajong River is a small stream about three metres wide where basalts and associated igneous and sedimentary rocks forming the ancient oceanic crust occur upstream of Kampung Togudon. The current study was carried out for the first 2 km of the river upstream of Kampung Togudon (Figure 3). The geological heritage resources identified are chert, pillow basalt, various geomorphological features and processes and former manganese mines and railway. The geoheritage resources and mining history are described below.

Chert and Pillow Basalt (Ancient Oceanic Crust)

Chert and basaltic pillow lavas that made up the ancient volcanic crust were observed along the river. The frequency of occurrences of the interlayering of cherts and pillow lavas are due to fault thrusting as shown in Figure 4. The bedded cherts are mostly red and greyish in colour with the individual bed ranging in thickness from 5 to 30 cm (Figure 5). The chert contains abundant radiolaria, a microfossil that indicates Early Cretaceous age and a deep sea depositional environment (Basir Jasin and Tongkul, 2000).

The dark greenish basalts mostly occur as pillow lavas and are fine-grained. The individual pillow ranges in size from 30 to 60 cm and sometimes larger. The pillow lava shows radial cooling joints with chilled or glassy rind (Figure 6).

The evolution of the oceanic crust and overlaying younger rocks as suggested by Tongkul (1999) is described below (Figure 7). The oceanic crust in the Baliajong area started to form about 120 million years ago (Early Cretaceous) through the extrusion of late magmatic solution under the sea due to sea floor spreading. Molten lavas rich in iron, nickel, and manganese from deep within the earth rose to the surface through vertical fractures. When hot lavas came into contact with cold seawater, these lavas were rapidly chilled forming pillow-shaped structures with chilled rind. As more lavas were extruded, older lavas were pushed aside and piles of pillow lavas were formed. While the pillow lavas were still being formed, radiolarian chert was deposited on top. According to Basir Jasin (1992), the main source of bedded chert was biogenic silica from radiolarian. Radiolaria is a type of plankton that secretes silica shell (Marshak, 2001). The formation of pillow lavas ceased about 90 million years ago. The ancient oceanic

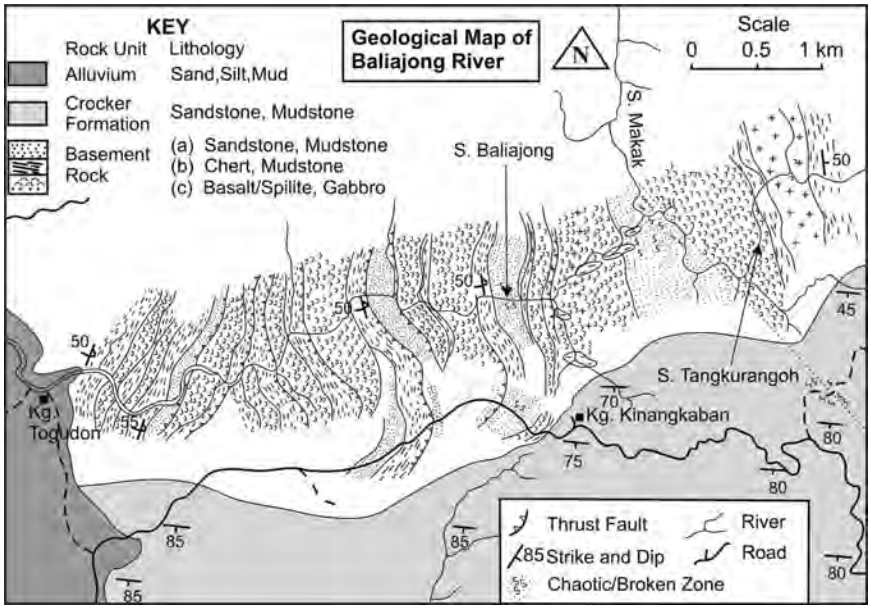

Figure 2: Geological map showing the distribution of ancient oceanic crust (basement rock) and overlying Crocker Formation in the Baliajong River, Kota Marudu, Sabah (modified after Tongkul, 1997).

crust was subjected to tectonic compression about 62 to 22 million years ago followed by the deposition of the Crocker Formation above it. Further deformation of the deformed ancient oceanic crust and Crocker Formation occurred around 22 to 15 million years ago, that eventually uplifted them above sea level. The high rate of weathering and erosion eventually exposed the ancient oceanic crust along the Baliajong River.

Cave and Chert Block

A cave is located a few hundred metres upstream of Kampung Togudon and several metres from the northern bank of the Baliajong River. It is an underground cave carved from the erosion of chert beds by water. The entrance is 3 m wide and the main cave chamber is up to 10 m high and 5 m wide. The cave is about 50 m long, trending NNE-SSW and sloping at 10 degrees. The size of the chamber decreases with length and is less than 1 m at its outlet into the Baliajong River. The formation of the cave is through erosion along chert beds by water that flows from the creek above. The cave is known as 'Luang Mondou' in the local language. 'Luang Mondou' in local language literally means 'dragon hole'. This geological feature, as the local name suggests, astounded the locals and they believe the dark and sinuous cave is a dwelling place for a dragon of some kind.

A remnant of rectangular chert block that looks like a man-made structure to the layman occurs near the Luang Mondou Cave. The chert block is rectangular in shape about 4 m wide, 10 m long and 6 m high. The chert block which looks like a mini tor was a product of prolonged weathering and erosion processes along zone of weakness in the parent rock.

Other Geomorphological Features

Various other geomorphological features occur along the stream such as U and V-shaped valleys, alluvial flood sediment, point and midstream bars, riffles, braided stream, cut banks, pools, potholes, notched cliff, steep cliff, rapids, waterfalls and gorge. Geomorphological processes such as physical, chemical and biological weathering and erosion and depositional processes that are shaping the area are also observed. These geomorphological features and associated processes provide opportunity for research and education in geoscience and related fields.

MINING HISTORY

Former Manganese Mines

Manganese deposit occurs in the vicinity of the Baliajong River Valley and its surrounding mountainous area. J. Carnarvon, a coffee planter in 1902, first discovered manganese ore in the Baliajong River. Exaggerated reports of large and rich deposit led to mining being started by the end of August 1903 (Stephens, 1956).

In 1905, the British Borneo Exploration Company was formed to carry out mining work at seven sites namely, Ka Ka Kuja, Bukit Tugudan, Kaki Tugudan, No. 2 Place, Blanta, Hantu Itam and Lobak Buaya (see Figure 3). Common manganese minerals are psilomelane and pyrolusite. These minerals occur in various forms and take the form of chert enrichment and replacement by manganese.

Mining was carried out mainly by opencast, adit, shaft and tunnel methods. Manganese ores were transported to the railroad along the Baliajong River Valley by rope tramways and ore chutes. A metre gauge railway track was built from a jetty in Tanjong Batu on the shore of the Marudu Bay to the mine sites. The railway track was built along the bank of the river and much of it was completed by the end of 1905. At the peak of mining operation, more than 1,000 workers were employed, mostly as manual labourers breaking up boulders. The labourers were mostly Chinese and Malays and were paid 50 to 70 cents per day (Chambers, 1902).

During the five years of operations, nearly 6 million kilograms of manganese ore were extracted. Raw ores were

stacked as piles near the workings. The mine operator mixed the piles with country rocks and tree trunks and covered these materials with high grade ore. The fraud was not discovered until the first shipment was made. On arrival in England, the ore shipment was found to be low grade and was dumped at the sea (Earhart, 1951). Only 2.8 million kilograms of ores were shipped to the United Kingdom and 2.3 million kilograms were still stacked near abandoned mines.

On the recommendation of R.R. Pilz (Pilz, 1910), a geologist to the British Borneo Exploration Company, mining was stopped due to its low quality and insufficient reserves.

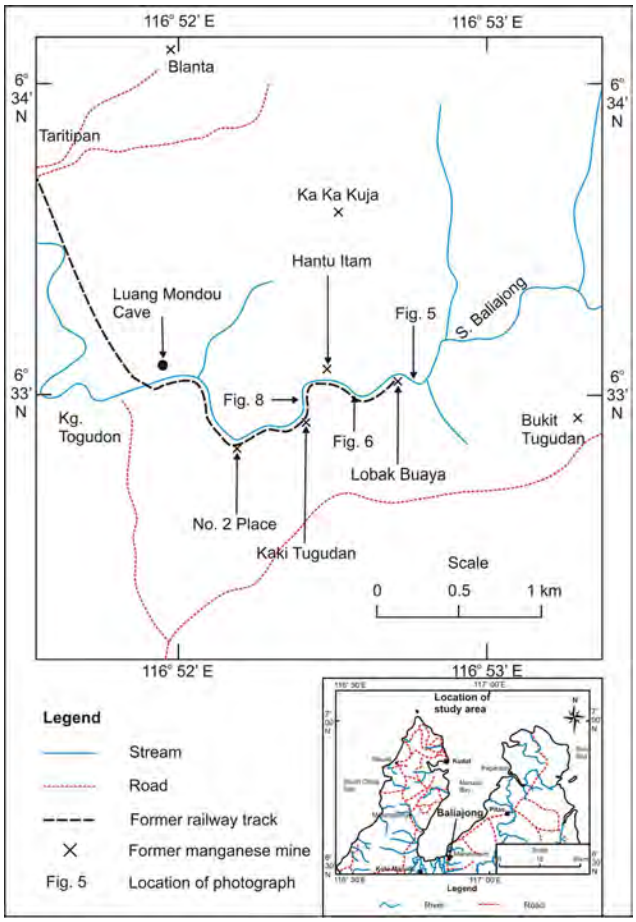

Figure 3: Map showing current study along Baliajong River, Kota Marudu, Sabah.

The mining company suffered great losses. The failure of the manganese mine operation was due to the surficial nature of the manganese ores and the small amount of ore reserves available for mining. Inefficiency of management and fraud by the mining operator caused only a small part to the failure (Stephens, 1954).

Former Railway

The railway that was constructed along the bank of the Baliajong River was doomed to fail from the start. During the present study, rock boulders hundred of kilograms in weight were observed on the river bed. The energy of the river must have been very strong during heavy flooding. It is no surprise that the railway tracks were damaged several times during heavy floods. The total length of the railway track was about 12 km. The railway was built similar to that of the British North Borneo State Railway. During the short lifespan of the railway, two 0−4−2 side tank locomotives were used to transport manganese ores from the workings to the jetty at Tanjong Batu (The Industrial Railway Society, 1967). The locomotives were named as *Biliajong* (Kerr Stuart 767 of 1905, "Waterloo" type) and *Marudu* (built by Dick Kerr in 1905). During the present survey, the remains of railway track cuttings, railway bridge, a side-tipping wagon and spikes were observed (Figure 8 and Figure 9). A section of the present road between Taritipan and Tanjong Batu was believed to be a former railway track. When manganese mines were closed down in 1908, the locomotives were acquired by the British North Borneo State Railway. *Biliajong* was scrapped prior to 1914. *Marudu* continued to serve the North Borneo State Railway and was scrapped in 1954. Though the lifespan of the Baliajong railway was short, it marked an important chapter in the history of Sabah and the nation in general.

SIGNIFICANCE OF GEOLOGICAL HERITAGE RESOURCES

The significance or importance of the geological heritage resources is evaluated based on scientific, aesthetic, recreational and cultural values (Ibrahim Komoo & Mohd Shafeea Leman, 1999). The widespread occurrence of ancient

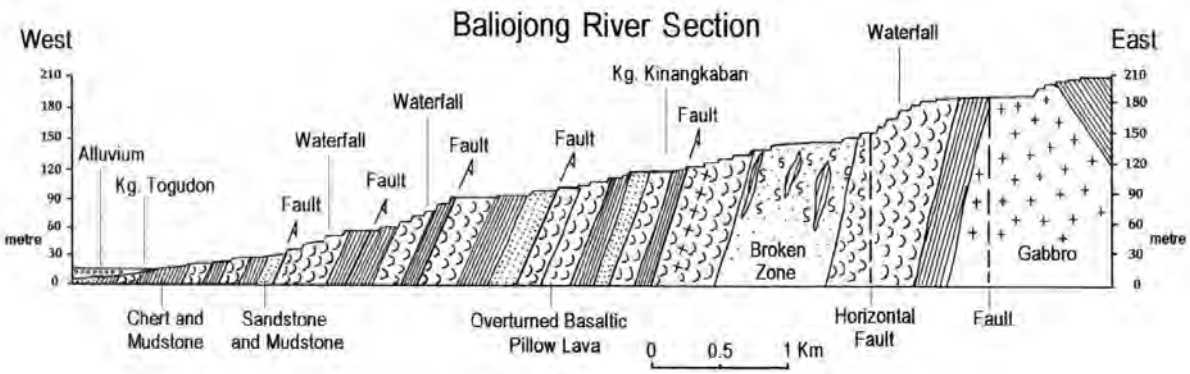

Figure 4: Geological cross-section showing steeply dipping layers of oceanic crusts and associated sedimentary rocks due to thrust faults (Tongkul, 1997).

Figure 5: Reddish chert beds.

Figure 6: A cross section through a single pillow basalt showing radial cooling joints and glassy rind.

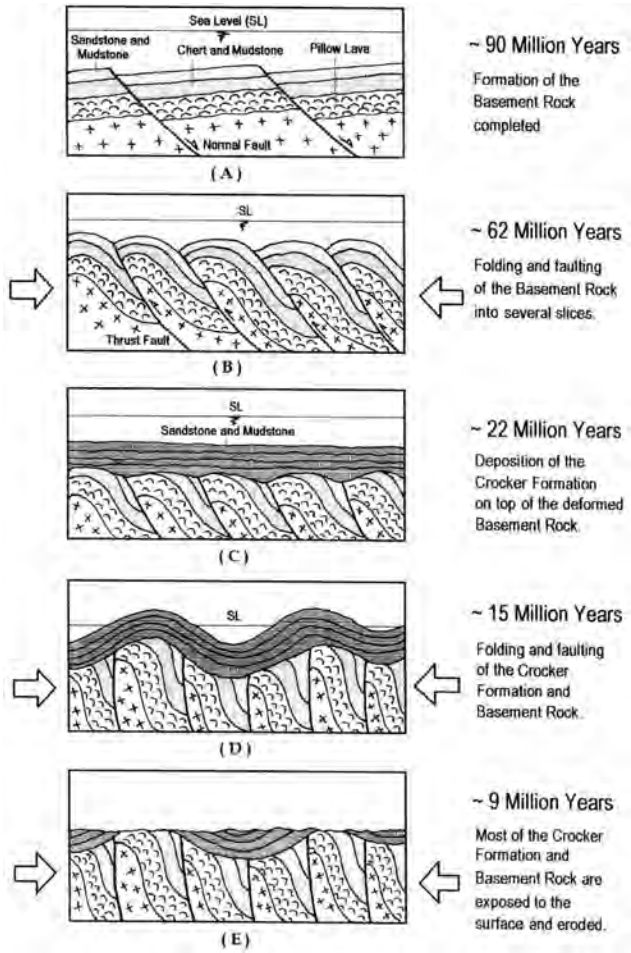

Figure 7: Sequencial model showing the evolution of the ancient oceanic crust and overlaying younger rocks in Tandek, Kota Marudu, Sabah (Tongkul, 1997).

oceanic crust is significant as it records the depositional environmental, tectonic and geological history of the study area and region in general. The various geomorphological features tell the past and present active geomorphological processes that shape the study area besides having aesthetic and recreational values. The occurrence of Luang Mondou Cave that is related to local belief and former mines and railway shows the cultural and historical values of the geoheritage resources. The Baliajong River geoheritage site should be assigned with national status as it has high scientific, aesthetic, recreational and cultural values.

GEOTOURISM POTENTIAL

The geotourism potential of the geoheritage resources focuses on educational and recreational tourism. Educational tourism introduces the intrinsic values of geological resources to increase public knowledge on the history of the physical development of the earth. The geological resources have high educational values as they could be used as tools to understand the geological, tectonic and geomorphological events that shape the study area and the region in general. These resources also have high aesthetic and recreational values and could be used for recreational activities such as cave exploration, sightseeing, river trekking and photographic activity. Visit to former mine and railway track sites and the Luang Mondou Cave could impart the rich mining history and culture of the area to visitors.

GEOTOURISM DEVELOPMENT PLAN PROPOSAL

A committee needs to be formed to undertake the geotourism development and geoconservation in the Baliajong River. The committee includes government and private sectors. The government agencies identified are the local authority, Land Survey Department, Minerals and Geoscience Department, Sabah Museum, Universiti Malaysia Sabah, Ministry of Tourism, Culture and Environment and Village Development Committee. The private sectors include tour operators, tour guides and non-governmental organisations. Basic infrastructure such as visitor centre, geotrail, information panels and directional signage are to be built and associated informative materials (booklets, leaflets and maps) to be produced (Figure 10).

Figure 8: Remains of a side-tipping wagon used to transport manganese ore boulders to the wharf at Tanjung Batu, Marudu Bay

Figure 9: An impression of the steam locomotive 'Marudu' travelling along the bank of the Baliajong River around 1905. Note the present condition of the railway track cutting (2006) at Hantu Itam where the man is standing.

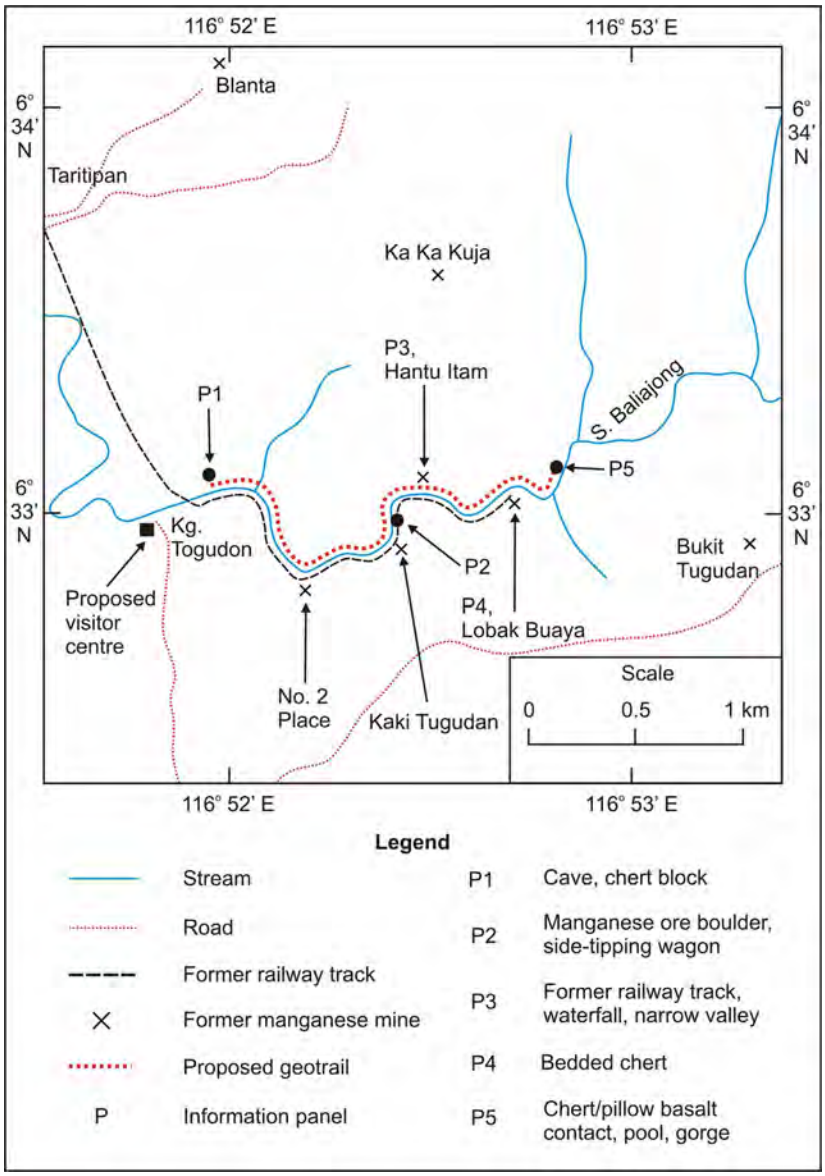

Figure 10: Proposed geotrial at the Baliajong River, Kota Marudu, Sabah.

Geoheritage and geotourism information needs to be disseminated to all relevant stakeholders. Management personnel and tour guides should be trained on various aspects of geotourism.

DISCUSSION AND CONCLUSION

The study unravels rich geological heritage resources in the area. The geological heritage resources are ancient oceanic crust, various geomorphological features and processes and former mines and railway. These geological heritage resources have high heritage values such as the 120 million years ancient oceanic crust that holds the geological record of regional significant. Geomorphological features and associated active processes could provide educational values to visitors as well as opportunities for research and education in geoscience and related fields. The Luang Mondou Cave that is related to local belief and the man-made like chert block show how geological phenomenon has astounded local community. The existence of former mines and railway could provide opportunity for visitors to learn the mining history of the area. It marks an important chapter in the early history of Sabah and the nation in general.

Nature recreations and excursions are suitable such as cave exploration, river and jungle trekking, swimming, photographic activities and visit to former railway tracks and mine sites. The area is also rich in biodiversity and culture. The area has high geotourism potential and it could be enhanced by combining it with other attractions such as the biodiversity and culture of the area.

The geological heritage resources are under threat from uncontrolled development along the river such as opening land for farming and palm oil and rubber planting. Therefore, the area needs to have legal protection under the National Heritage Act 2005. In order for the geotourism development to be sustained, the local community needs to be highly involved. The local community would protect the site if they could gain economic benefits from the tourism development and have a sense of pride of the heritage in the area.

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