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The Present-day Landscape of Bukit Keluang Formation: Geoheritage Potential for Conservation and Geotourism

(Keadaan Semasa Landskap Formasi Bukit Keluang: Potensi Geowarisan untuk Pemuliharaan dan Geopelancongan)

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ABSTRACT

The Late Permian sedimentary rock of Bukit Keluang Formation is well exposed on three isolated hills namely the Bukit Keluang, Bukit Bubus and Bukit Dendong. The consecutive hills exhibit a unique landscape of linear ridge surrounded by the alluvial plains and are well known for their beautiful sandy beaches and outstanding landscapes. Geological landscape in the area falls into three heritage value set (scientific, aesthetic and recreational value) that in need of immediate conservation. Scientific evidence shows that the study area exhibits a unique lithologically and structurally controlled landscape characterised by first order topography of folded and thrusted sequence (anticlinal hill), linear cuesta ridge and denudation hill. Differential erosion of the conglomerate-sand-shale sequences led to the development of linear ridge with different elevation profiles. The geometric and geographic position of the hills conforms with the regional structural trend in the area with the N-S trending fault system is inferred as the major fault that displaced the Bukit Keluang Formation. Internal complexities in the individual structures in the form of cross-faults, oblique-faults and lineaments trending NW-SE, NE-SW to N-S directions have formed cave morphological feature and divide the hills into separate blocks. The geological landscape also contributes to an aesthetic value such as the beautiful hilly landscape and sandy beach, while recreational values including hiking, mountain biking and water activities. Geological heritage and geotourism could have a positive future in Bukit Keluang, Bukit Bubus and Bukit Dendong. The in-situ *and* ex-situ *geological conservation is urgently needed in order to support the efforts to implement geoscience knowledge to the public.*

Keywords: Bukit Keluang Formation; geological conservation; geological landscape; geotourism

ABSTRAK

Batu sedimen Formasi Bukit Keluang berusia Perm akhir tersingkap dengan baik di tiga bukit terpencil iaitu Bukit Keluang, Bukit Bubus dan Bukit Dendong. Bukit-bukit tersebut mempamerkan landskap unik permatang linear yang dikelilingi oleh dataran aluvial dan terkenal dengan pantai berpasir yang indah dan landskap yang luar biasa. Landskap geologi di kawasan ini dibahagikan ke dalam tiga set nilai warisan (nilai saintifik, estetik dan rekreasi) yang memerlukan pemuliharaan segera. Bukti saintifik menunjukkan bahawa kawasan kajian memperlihatkan landskap dikawal unik oleh litologi dan struktur yang dicirikan oleh topografi yang terbentuk oleh jujukan yang terlipat dan tersesar (bukit antiklin), permatang kuesta linear dan bukit gondol. Hakisan yang berbeza pada jujukan konglomerat-pasir-syal menyebabkan pembentukan permatang linear dengan profil ketinggian yang berbeza. Kedudukan geometri dan geografi bukit sesuai dengan tren struktur serantau di kawasan kajian dengan sistem sesar berarah N-S disimpulkan sebagai sesar utama yang menganjak Formasi Bukit Keluang. Kerencaman struktur individu dalam bentuk sesar silang, sesar serong dan lineamen berarah NW-SE, NE-SW dan N-S telah membentuk morfologi gua dan membahagikan bukit-bukit tersebut kepada blok berasingan. Landskap geologi ini juga menyumbang kepada nilai estetik seperti landskap perbukitan yang indah dan pantai berpasir, manakala nilai rekreasi termasuklah aktiviti mendaki, berbasikal rentas bukit dan aktiviti air seperti berkelah. Warisan geologi dan geopelancongan di Bukit Keluang, Bukit Bubus dan Bukit Dendong mempunyai masa depan yang cerah. Pemuliharaan geologi secara in-situ *dan* ex-situ *sangatlah diperlukan bagi menyokong usaha mengetengahkan ilmu geologi kepada masyarakat.*

Kata kunci: Formasi Bukit Keluang; geopelancongan; landskap geologi; pemuliharaan geologi

INTRODUCTION

The United Nation 2030 Agenda for Sustainable Development defines 17 Sustainable Development Goals (SDG) to be applied in all countries. Many of these goals will demand proper management of nature, including both geodiversity and biodiversity ProGEO (2017). Geoconservation practice under the UNESCO Global Geoparks may help to accomplish at least six sustainable development issues.

Geological conservation or geoconservation effort in Malaysia begin as early as in the 1990s. The Langkawi

UNESCO Global Geopark is the first geopark in Malaysia and the first in Southeast Asia (Mohd Shafeea et al. 2007). The increasing awareness of geoconservation needs has boosted efforts to develop more geoparks in the country. In order to achieve the goal of promoting geoconservation, basic geological heritage studies need to be carried out vigorously and systematically by the geoscientist community.

As contribution on progressing geological heritage study, we present the current research findings on the structural geology of Bukit Keluang Formation in the northern part of Terengganu, Peninsular Malaysia. The aim is to substantiate the role of lithology and structure in the development of the present-day landscape and geological heritage potential for geoconservation and geotourism development. Geological landscape in geological context is a landscape which includes the nature and origin of the rock material, endogenic and exogenic processes and special geological and geomorphological features that yield the final landform (Ibrahim & Mazlan Othman 2001). A geological landscape has been closely related to man since the existence of humankind. The terms such as hill, river, gully, barrow and mountain in the name of places are a manifestation of landscape in most geographic destination or addresses clearly indicated human appreciation to geological landscape (Tanot Unjah et al. 2013).

Geological landscape naturally provides us with their clean air, unique landscapes and wildlife, scenic beauty, rich cultural heritage, and recreational opportunities hence become attractive places for many tourists. In other words, the geological landscape plays a vital role in ensuring the interaction between human beings and nature. Landscape formation, according to Ibrahim (2000), is one of the geological diversities and can be categorised as geological heritage resources.

THE STUDY AREA

Bukit Keluang, Bukit Bubus and Bukit Dendong are located about 6 km to the south of Kuala Besut, along the coastline of northern Terengganu (Figure 1). The topographic relief of the hills ranging from 30 to 100 m above sea level occupies an area about 2.5 sq. km. Geologically, the rock formations are mostly sedimentary, belonging to the Late Permian age of Bukit Keluang Formation (Kamal Roslan & Ibrahim 1994). These hills are famous for their beautiful sandy beaches and outstanding landscapes. The area is located near Terengganu - Kelantan border, thus attracts many tourists from both states to carry out recreational activities.

Bukit Keluang, Bukit Bubus and Bukit Dendong have been listed as one of the geosites in Terengganu (Askury & Kamal Roslan 2001). The geosites is very rich with the geological heritage values, primarily the scientific value as well as aesthetic, recreational and economic value (Che Aziz & Kamal Roslan 2001). As the areas received many visitors throughout the year, it is an excellent opportunity to promote the importance of geoheritage conservation among the public. Apart from being visited by tourists, the area is also a good research laboratory for earth science's students.

GEOLOGICAL SETTING

The Bukit Keluang Formation comprises interbedded of reddish continental clastic sedimentary rocks such as conglomerates, sandstones, siltstones, mudstone and shales (Kamal Roslan & Ibrahim 1994; Kamal Roslan et al. 2000; Zakaria Hussain et al. 2008). The formation is overlain unconformably on top of strongly deformed Permo-Carboniferous of probable Cretaceous age metasediments (Kamal Roslan & Ibrahim 1994; Ibrahim & Kamal Roslan 1994; Kamal Roslan et al. 2000).

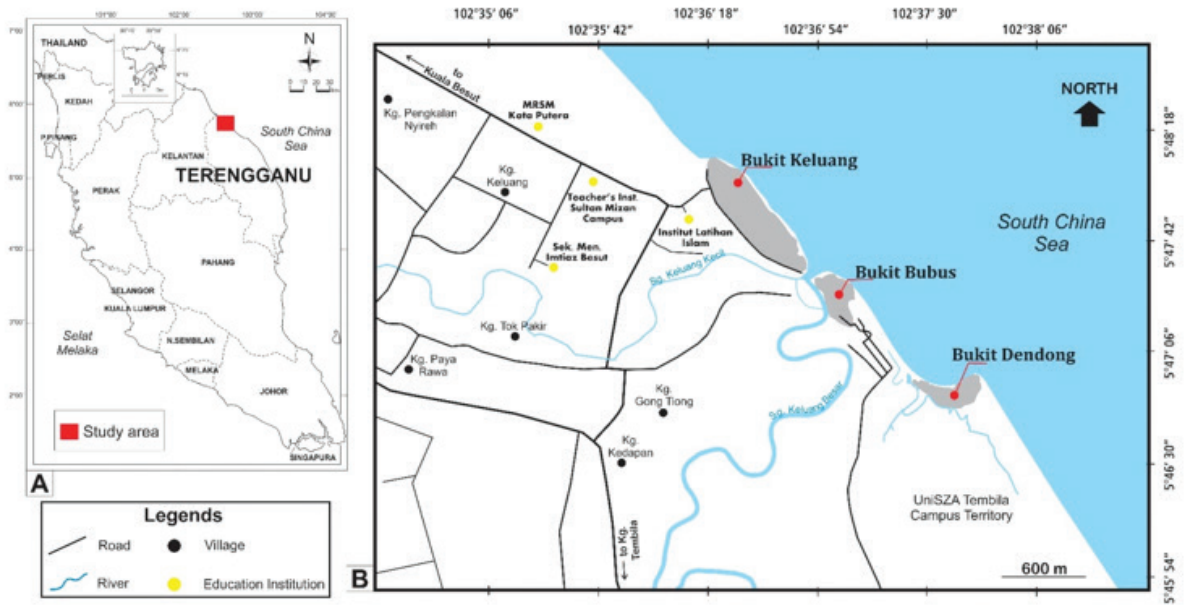

FIGURE 1. A) Map of Peninsular Malaysia with study area and B) The location of Bukit Keluang, Bukit Bubus and Bukit Dendong

The formation has thinning and fining upwards sequences with a total of six facies namely, massive conglomerate, dominant conglomerate interbedded with sandstone, dominant sandstone comprises conglomerate lenses, thickly bedded sandstone, sandstone interbedded with siltstone and siltstone interbedded with mudstone. A detailed facies analysis suggests that the formation have been deposited in braided stream which later changes to meandering stream (Kamal Roslan & Ibrahim 1994, 1993; Kamal Roslan et al. 2000), whilst the reddish colour of the rocks is caused by the presence of high iron oxide (Kamal Roslan & Che Aziz Ali 1996).

Generally, Bukit Keluang exposure encompasses massive conglomerate which gradually changes to interbedded of conglomerate and sandstone in the younger sections (Kamal Roslan & Ibrahim 1994) with varying dips of 30°-40° orientated to the southwest (Ibrahim & Kamal Roslan 1994; Kamal Roslan et al. 2000). Contradict to the Bukit Bubus and Bukit Dendong, the sequences are predominant by alternation of sandstone, siltstone and mudstone (Kamal Roslan & Ibrahim 1994) yield very steeply dipping towards the south (Ibrahim & Kamal Roslan 1994; Kamal Roslan et al. 2000).

In early studies, the age of formation was difficult to assign because no palaeontological evidence found during that time. Hence, the age interpretation was assumed based on their lithologies and depositional environment. Koopmans (1968) classified Bukit Keluang, Bukit Bubus and Bukit Dendong as a basal member of Tembeling Formation and correlates Bukit Keluang conglomerate with late Triassic-Jurassic red to purple polymict conglomerate called Murau Conglomerate crops out at Mersing area, Johor. Later in 1985, Geological Survey Department of Malaysia mapped the Bukit Keluang area as Carboniferous age. However, according to Kamal Roslan and Ibrahim (1994, 1993), there is an angular unconformity between the underlying Carboniferous bed and Bukit Keluang Formation, besides their difference in lithologies and structures. Thus, they proposed a new stratigraphic unit named as Bukit Keluang Formation and presumed this unit as Jurassic-Cretaceous age because continental deposits of Peninsular Malaysia are known to be Jurassic-Cretaceous age.

However, Khoo et al. (1988) discovered Late Permian plant fossils at Redang Island, which later assigned as continental deposits by Kamal Roslan et al. (1997). Thus, this proved that the continental deposits of Peninsular Malaysia are not only from Jurassic-Cretaceous age but also from Late Permian. This statement was later confirmed by Mohd Shafeea et al. (1999) based on the discovery of plant fossils in Bukit Keluang Formation exposed at Bukit Dendong and Bukit Bubus. The fossils are *Lobatannularia* sp., *Pecopteris* sp., *Calamites* sp., *Tingia* sp., *Cordaites* sp. and *Taeniopteris* sp. which are corresponding to the Late Permian age. Some of these fossils are highly correlatable with Redang Island's plant fossils (Mohd Shafeea et al. 1999).

Structurally, few tectonic evidence particularly reverse and normal faults commonly observed at these hills (Ibrahim & Kamal Roslan 1994; Kamal Roslan & Ibrahim 1993), yet, the most complex structures crop out at the south part of Bukit Keluang (Ibrahim & Kamal Roslan 1994). For instance, asymmetrical west-plunging folds formed by reverse faults (N105°E/32°) can be found at Bukit Keluang and Bukit Dendong (Ibrahim & Kamal Roslan 1994; Kamal Roslan & Ibrahim 1993).

Methods

The study includes the interpretation of the general geology of the study area in Terengganu as shown in Figure 1. During the outcrop survey, the study was emphasised in the description of general geological characteristics such as lithology, texture, succession characteristic and identification of structural features that requires details observation. Additionally, observation on tourist attraction, recreational activities, and how it affects local people social-economic have also been taken into account. A drone has been used to record and capture images on a large scale plan view and side view of the consecutive hills. The data was used in interpreting the geomorphological characteristic of the hills and capture the beautiful scenery. Integration of the primary data (consists of field observations and survey, strike-dip reading, field photographs and sketch mapping) and drone image interpretation was later performed to substantiate the role of lithology and structure in the development of the present day landscape and current geological heritage potential for geotourism development.

Research Findings and Discussion

LANDSCAPE VALUE SET

Tourist or public always sees geological landscape based on their physical appearances such as geometrical shape, vegetation cover and the beauty (aesthetic properties). Very few of them understand the geological process that formed the landscape. However, in geology's perspective, landscape generally related to heritage value set which can be divided into four major types: its importance in providing a record of the earth's evolution (scientific value); uniqueness and natural beauty (aesthetic value); its potential recreation elements (recreational value); its historical and cultural nexus (cultural value) (Ibrahim & Tjia 2002).

Geological landscape can fall into one or several of these heritage value types. Nevertheless, within the scope of this paper, the measurement will focus on scientific value, aesthetic value and recreational value.

SCIENTIFIC VALUE

The Late Permian sedimentary rock of Bukit Keluang Formation is well exposed on three isolated hills with a unique landscape of linear ridge surrounded by the alluvial plains. The area has been providing as an excellent

training location among geology students for decades due to its various scientific values ranging from structural, lithologically, geomorphology and fossil records. One of the interests is the presence of an unconformity that can be used to determine the basal part of the formation and to constrain the geologic events of the area. The Bukit Keluang Formation is overlain unconformably on top of Permo-Carboniferous meta-sediments that have been strongly deformed into a series of close to tight folds (Figure 2(a), 2(b) & 2(c)). Another scientific value that will be briefly discussed in this paper is the structural and lithological controls on landscape formation.

Present day morphological expression of the Bukit Keluang form the highest linear ridge trending NW-SE with about 1.5 km long and more than 100 m elevations (Figure 3(a)). The hill is mainly composed of general NW-SE trending massive conglomerate interbedded with sandstone beds belonging to the basal part of Bukit Keluang Formation. The conglomerate composed of massive, well rounded and poorly sorted gravels with little matrix support hence is more resistant to erosion. Meanwhile, the Bukit Bubus located south of Bukit Keluang has lowered topographic surface with less than 70 m elevations. The hill is mainly composed of interbedded conglomerate and sandstone beds in the northern part of the hill (lower part) transitioned into interbedded sandstone and shale bed in the southern part.

The Bukit Bubus having the same NW-SE trend with the Bukit Keluang and lithological reconstruction of the lower part of the hill found to be part of Bukit Keluang unit. Hence, the hill is interpreted as a denudation hill which is the remnant of the linear ridge of Bukit Keluang. This form has lowered topographic surface than the original surface (Figure 3(b)). In the southern part of the area, the Bukit Dendong mainly composed of interbedded sandstone and shale beds belonging to the upper part of Bukit Keluang

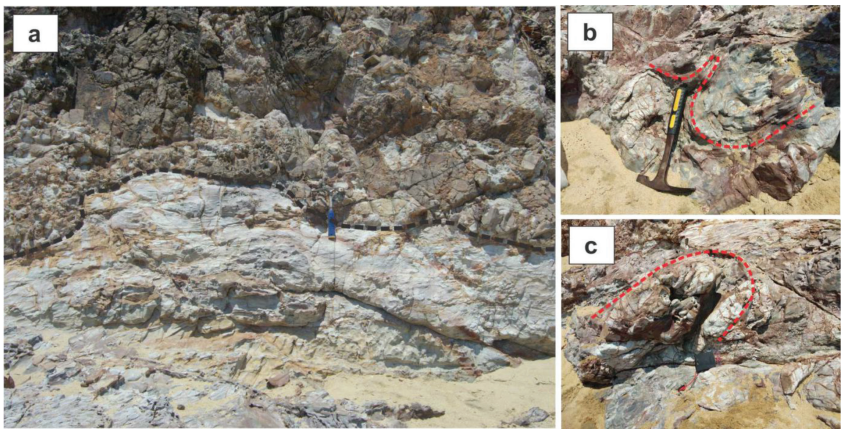

FIGURE 2. a) An angular unconformably between the underlying Permo Carboniferous meta-sediments and the overlying Bukit Keluang Formation, (b & c) The meta-sediments have been strongly deformed into a series of close to tight folds

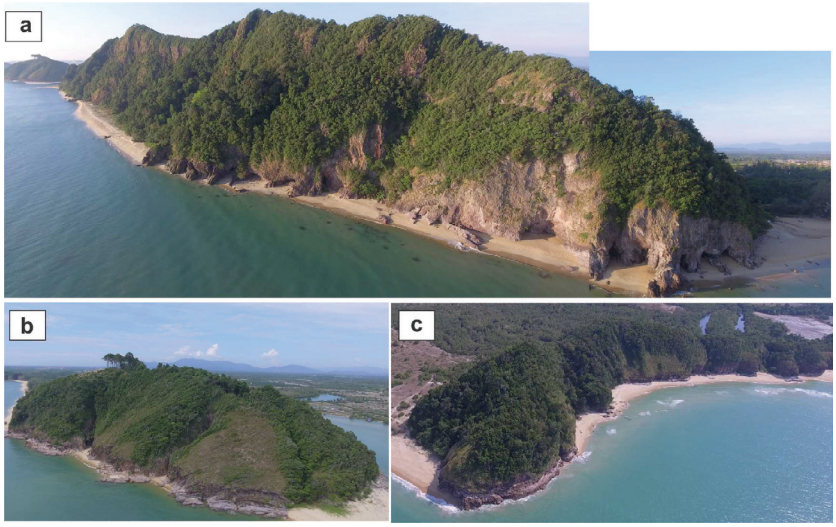

FIGURE 3. The Late Permian sedimentary rock of Bukit Keluang Formation is well exposed on three isolated hills; (a) Bukit Keluang, (b) Bukit Bubus and (c) Bukit Dendong). The hills exhibit a unique landscape of linear ridge surrounded by the alluvial plains

Formation has developed into linear cuesta ridge. The ridge is in trend with general E-W strike and having an asymmetric topographic profile with a steeper erosional limb and a gentler limb representing dip of the original bedding planes (Figure 3(c)).

There is a difference in the trend of the hill ranges with Bukit Keluang and Bukit Bubus having an NW-SE trend, while the southern hills, the Bukit Dendong having approximately E-W trend (Figure 1). Their geometric and geographic position conforms with the regional structural trend in the area. In general, the fault systems in the study area have three main trends: A NE-SW fault system, which is approximately perpendicular to the Bukit Keluang linear ridge; a NW-SE to E-W fault system; and a N-S fault system, which is the most prominent fault system in the studied areas.

On the eastern coast of Bukit Dendong, the formation has been deformed into a series of close to tight and slightly overturned folds. These folds are accommodated by a series of WNW-ESE trending axial plane parallel thrust faults vergence to the NNE (Figure 4(a)). This structure formed first order topography of anticlinal hills as a direct consequence of folding of the sedimentary strata (Figure 4(b)). This early structure is cut and bound to the east and west by nearly NW-SE trending lateral fault with a reverse sense of movement, as shown by its asymmetric drag fold structures (Figure 4(c)).

Beyond this point, the morphological expression of the occurrence of the fold is not clear, especially in the northern part of Bukit Keluang. This is due to the difference in the lithological characteristic of the hills with massive conglomerate are more competent to folding. Nevertheless, in the southern part of the Bukit Bubus, an E-W to NE-SW fracture cleavages can be attributed to this first phase of folding. These fracture cleavages have been sheared along

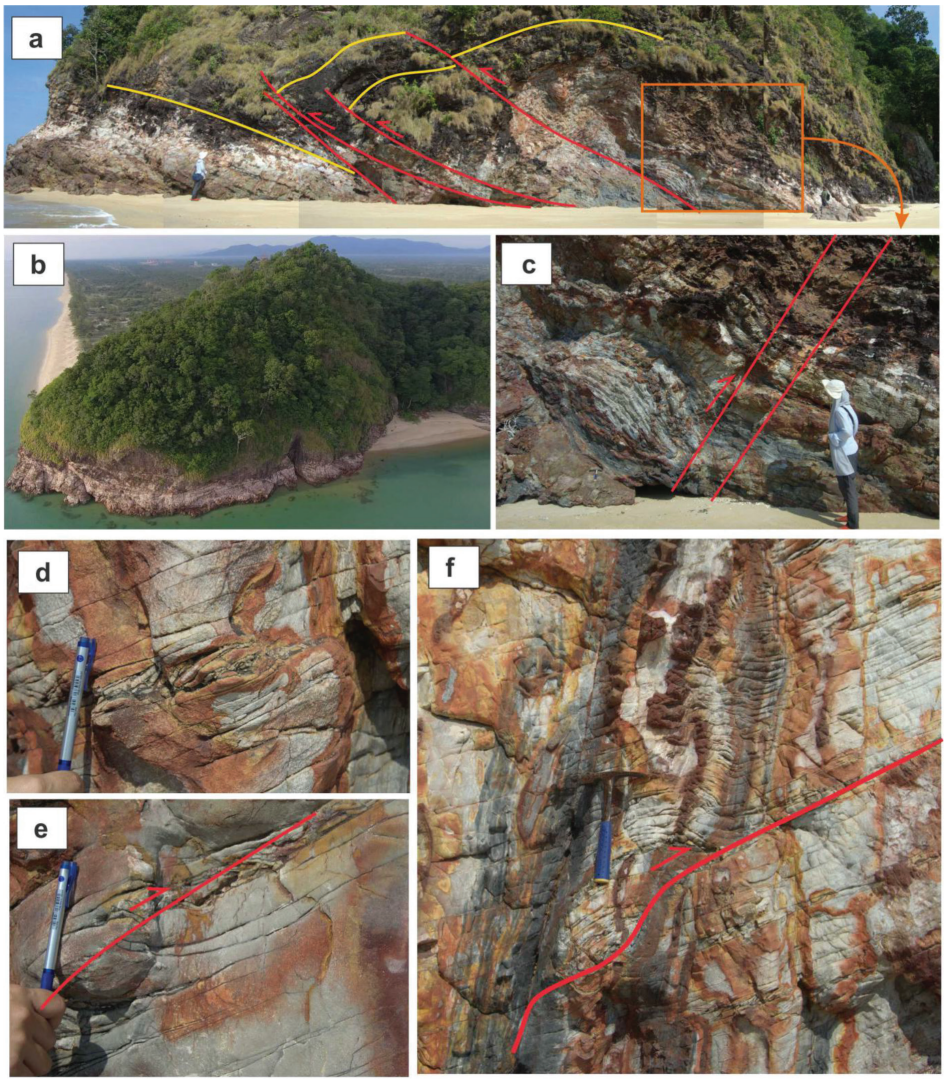

FIGURE 4. The Bukit Keluang Formation has been deformed into (a) A series of close to tight and slightly overturned folds accommodated by a series of axial plane parallel thrust faults, (b) The anticline formed first order topography of anticlinal hills as a direct consequence of folding of the sedimentary strata, (c) The anticline is cut by nearly NW-SE trending lateral fault with reverse sense of movement, (d) A E-W to NE-SW fracture cleavages that can be attributed to this first phase of folding has been sheared along its plane leaving a sigmoidal geometry, and (e & f) Folded by a series of NE-SW trending thrust fault

its plane, leaving a sigmoidal geometry and folded by a series of NE-SW trending thrust fault superimposed on the earlier structures (Figure 4(d), 4(e) & 4(f)).

A NW-SE and NE-SW trending fault systems with normal sense of movement have also been recorded in the study area with some of these faults have been cut by younger N-S trending lateral fault (Figure 5(a)). The NW-SE fault system shows oblique-slip nature of lateral fault with a normal component (Figure 5(b)). The N-S trending fault system shows a clear morphological expression of a dextral fault with the right block was right-thrown relative to the left block as interpreted clearly from the map view (Figure 5(c)).

A N-S trending active floodplain have developed between the consecutive hills and occupy the lowermost topographic position (Figure 6(a)). They are subjected to frequent flood inundation and fluvial depositional processes. A probable fault N-S trending fault may exist along this zone, which is also evident from the facts that there is a distinct elevation difference across this zone. This fault system is inferred as the major fault that displaced the Bukit Keluang Formation into three isolated hills, namely Bukit Keluang, Bukit Bubus and Bukit Dendong. Furthermore, internal complexities in some individual structures in the form of cross-faults, oblique-faults and lineaments trending NW-SE, NE-SW to N-S directions running across the margin have either formed cave morphological feature or divide the hills into separate blocks (Figure 6).

GEOLOGICAL HERITAGE POTENTIAL AND THE NEEDS FOR CONSERVATION

The geological heritage of this area, as mentioned by Che Aziz and Kamal Roslan (2001) and Kamal Roslan et al. (2000) are summarised in Table 1. The latest findings also included in the same table. The table shows that the consecutive hills representing the Bukit Keluang Formation have many geoheritage values and therefore, are important to conserve. The geological landscape is less exposed to immediate destruction than other resources (fossiliferous outcrop). However, efforts to conserve these resources still should be conducted on the basis of raising awareness about the importance of environmental protection and understanding the geology. Here are some recommendations of conservation plans that are perceived and necessary to be practised in all three geosites.

IN-SITU CONSERVATION (GEOSITE CONSERVATION)

One of the processes in geosite management by Prosser et al. (2006) is the production of interpretative materials. Up until now, there is no interpretative board provided by the local authority at the site. The simplest geological information should be provided so that the knowledge of the geological landscape is easily understood by various generations and backgrounds. The interpretation board should be placed at the proper location, which is easy to access and safe for visitors.

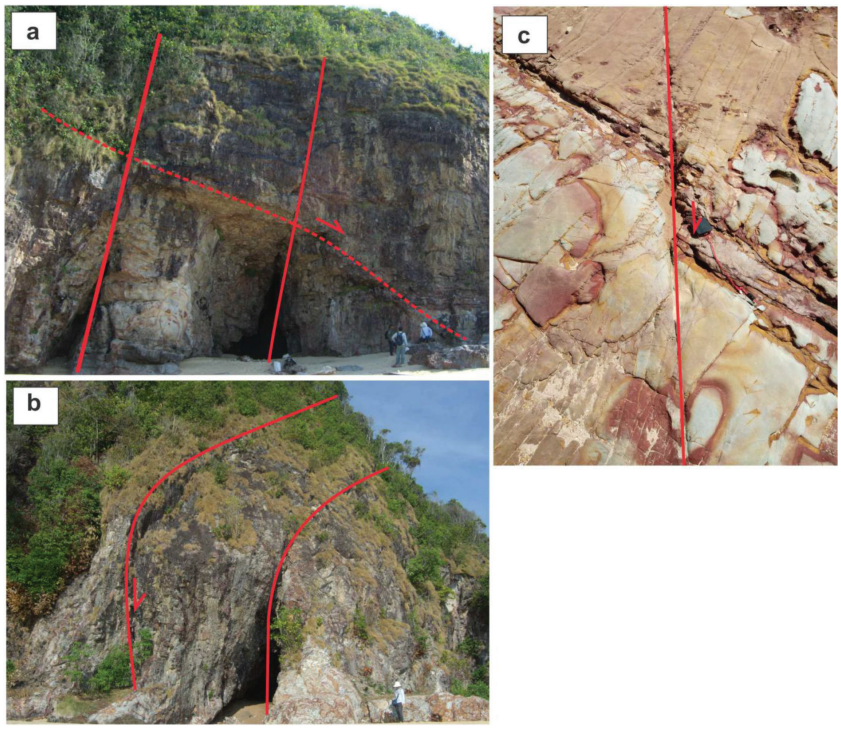

FIGURE 5. (a) A NE-SW trending fault systems with normal sense of movement have been cut by younger N-S trending lateral fault, (b) A NW-SE lateral fault system shows oblique-slip nature of lateral fault with a normal component, (c) A N-S trending fault system shows a clear expression of a dextral fault with the right block was right-thrown relative to the left block

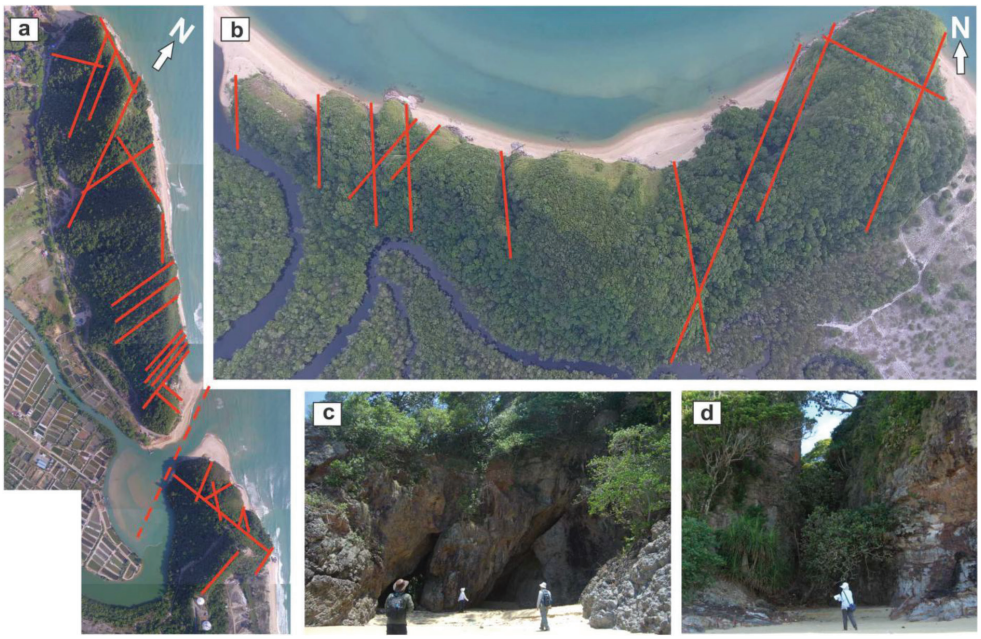

FIGURE 6. Field observation and lineaments mapping show that; (a) A probable fault N-S trending fault may have existed along the N-S trending active floodplain between the Bukit Keluang and Bukit Bubus, (a & b) Internal complexities of some individual structures in the form of cross-faults, oblique-faults and lineaments trending NW-SE, NE-SW to N-S directions running across the margin, and (c & d) These structures have either formed cave morphological feature or divide these hills into separate blocks

TABLE 1. The Geological heritage of Bukit Keluang, Bukit Bubus and Bukit Dendong

Geosite	Scientific value (geology)	Aesthetic value	Recreational value	Cultural and economic value
1. Bukit Keluang	- Lithology - Sandy beach - Landscape formation (hill, caves, tunnel, sea arch) - Plant fossils - Structure (sedimentary and tectonic) - Ancient sea level - Unconformity	- Beautiful hilly landscape and sandy beach	- Picnic - Water activities (fishing, camping, swimming, kayaking) - Beach activities (volleyball, football) - Hiking - Jogging - Mountain biking	- Old jetty for fishers located between Bukit Keluang and Bukit Bubus) - Food stalls - Outdoor clothing stall - Toys stall
2. Bukit Bubus	- Lithology - Sandy beach - Landscape formation-hill, - Plant fossils - Structure (sedimentary and tectonic)	- Beautiful hilly landscape and sandy beach	- Picnic - Fishing - Extreme sport-Paragliding	- Old jetty for fishers located between Bukit Keluang and Bukit Bubus)
3. Bukit Dendong	- Lithology - Sandy beach - Landscape formation-hill - Plant fossils - Structure (sedimentary and tectonic)	- Beautiful hilly landscape and sandy beach	- Picnic - Fishing - Swimming	-

In the case of Bukit Keluang, since the area is famous for hiking activity, the right target for understanding earth science is the hikers. Information board with a full description of geological features, understandable content and straightforward scientific messages can be set up in the selected areas as illustrated in Figure 7(a) & 7(b). At Bukit Bubus, the good place to set up an information board is at the starting base of paragliding activity (Figure 7(c)).

As outlined in Table 1, there is also fossiliferous outcrop, which is very abundant in plant fossils. The late Permian plant fossils are very rare and stratigraphically significant in dating the rocks. Because of fossils are vulnerable to destruction by natural processes and human activities, they

FIGURE 7. Suggested location to set up an information board, (a) Pitstop at the peak of Bukit Keluang provided by the local authority, (b) Old jetty between Bukit Keluang and Bukit Bubus and (c) Paragliding starting base at the peak of Bukit Bubus

need urgent conservation in both forms *in-situ* and *ex-situ*. Some crucial sites need to be controlled and monitored so as not to be disturbed or harmed by the public. It is also a need to put an information board at the fossil site.

EX-SITU CONSERVATION

Specimen removed from sites for investigation and because of their scientific value need to be conserved *ex-situ* in collections (Kollmann 2002). Some important geological materials such as the variety of rocks and fossils should be placed in an exclusive space for exhibitions as well as for research and educational purposes. It is, therefore, a necessity to establish a mini-museum or galleries that can accommodate the material.

In the museum or gallery, the geological information material and posters can be placed along with interesting diagrams to brief the history and evolution of the Bukit Keluang Formation. Most geological information is quite complex to be understood by non-geologists. Hence, it is necessary to provide informative posters with a clear picture taken from the field to show how does the geological deformation processes took place to make up the current landscape.

GEOSCIENCE EDUCATION ACTIVITIES FOR GEOTOURISM

The word geotourism defined by Newsome and Dowling (2010) is a form of tourism that specifically focuses on geology and landscape. It promotes tourism to geosites

and the conservation of geodiversity and an understanding of earth sciences through appreciation and learning. This is achieved through independent visits to geological features, use of geo-trails and viewpoints, guided tours, geo-activities and patronage of geosite visitor centres. Geotourism relates tourism and geology in such a way that the public can experience the earth's geological wonders with environmental and cultural understanding, appreciation, and conservation through formal and informal education (Sofia et al. 2013). Both definitions emphasised the importance of educating and learning of geological knowledge and the success of geotourism much depends on the aesthetic, cultural, recreational and scientific value perceived by the tourist.

Marilah et al. (1999) have outlined three key actions in developing a geotourism plan, namely: Geosite development specifically for geotourism; infrastructure development for geotourism; and design of the geotourism activities. The geosite development for geotourism in Bukit Keluang, Bukit Bubus and Bukit Dendong have yet to be developed. This development effort is also a part of an *in-situ* conservation effort as highlighted earlier and is the urgent need to be hastened.

In order to ensure that these efforts are successful, the geology community, in particular, must play their respective roles in earnest. Geological research in each geosites needs to be strengthened and this activity must be carried out permanently and continuously. Strong geological backgrounds in geosites will enhance the scientific value of the geological heritage that will then be shared with the public.

Kamal Roslan et al. (2000) has proposed some essential geological information to be publicised for geotourism purposes. The information is: Type of rock and its formation process; natural tectonic activity; plant fossil and its interpretation; cave and process of its formation; ancient coastline and its development; and ancient sea level. Their suggestion can be used as the main component in highlighting the strength of the geological scientific value at the three hills. The geosite maps on each hill should be provided as a reference before any geotourism activities can be carried out. Geosite with scientific value such as fossil sites, mega-scale fold structure, the unconformity location, and cave sites have to be positioned on the map accurately. Geosites map that was developed can be a guide in drafting the geotrail as the third action in developing a geotourism plan.

The infrastructure development for geotourism in this area is still poor. According to Marilah et al. (1999), among the appropriate geotourism infrastructure is the concept of exhibitions such as museums, galleries, and rock gardens. In other words, it is also an *ex-situ* conservation approach. All geology-related materials like brochures, leaflets and geotourism map should be provided here for tourist. The museum is proposed to be developed in the Bukit Keluang area as the area has become a well-known spot for hiking and recreation activity. In designing geotourism activities, the concept of geotrail is seen to be very useful.

A geotrail delivers geotourism experiences through a journey linked by an area's geology and landscape as the basis for providing visitor engagement, learning and enjoyment. Geotrails should relate directly to the tourism experience of a journey linking destinations. Geotrails are best constructed around routes currently used by tourists; in essence, geotrails should form logical journeys linking accommodation destinations (Geological Society of Australia Inc. 2017). In the case of Bukit Keluang formation, a good geotrail can be developed through the existing tourism activity.

Tourists may have the opportunity to cross the river mouth between Bukit Keluang to Bukit Bubus by speedboat to see the fascinating geological features and rock formations in this hills. Meanwhile, at Bukit Dendong, tourists can experience walking on the moderately coarse to fine grain sandbar and sandridge which formed by the wave energy. Recent sedimentological processes, structure and tectonic evidence in separating Bukit Dendong into small hills can be observed here. The geotourism activities can be carried out in the way of guided by geologically knowledgeable tourist guide or individual who have been given training in interpretation and communicating geological information or independently/self-guided by referring to the geological leaflets and geotourism maps.

Conclusion

Geological landscape of Bukit Keluang formation falls into three heritage value set (scientific, aesthetic and recreational value). Scientific value can be assessed in terms of its contribution to scientific knowledge that, in turn, contributes to the landscape evolution and records of earth's history. The landscape development in the study area shows distinct imprints of lithological and structural control and can be deduced as follows: Landscape development characterized by first order topography of folded and thrusted sequence (anticlinal hill), linear cuesta ridge and denudation hill; differential erosion of the conglomerate-sand-shale sequences led to the development of linear ridge with different elevation profiles; incompetent sand-shale sequences are prone to folding and thrusting compared to competent conglomerate sequences; The geometric and geographic position of the hills conforms with the regional structural trend in the area (NE-SW, NW-SE to E-W and N-S fault systems) and the N-S trending fault system is inferred as the major fault that displaced the Bukit Keluang Formation into isolated hills; and internal complexities in the individual structures in the form of cross-faults, oblique-faults and lineaments trending NW-SE, NE-SW to N-S directions running across the margin have formed cave morphological feature and divide the hills into separate blocks.

The geological landscape also contributes to an aesthetic value such as the beautiful hilly landscape and sandy beach, while recreational values including hiking, mountain biking and water activities like picnic. The geological heritage and geotourism could have a positive

future in Bukit Keluang, Bukit Bubus and Bukit Dendong. There is still much geological research at the fundamental level need to be done. As geologist and researcher, our primary goal should be to share the geological information preserved at this geosites with the general public and decision-makers rather than confining this information to those with specific academic interests. Increasing awareness of the importance of geological heritage values at the particular geosites will support proper planning and management decisions as well as promote laws for the protection of the area.

Finally, the ultimate and the most innovative approach towards the best management of geological heritage conservation is the geopark concept. Also, the birth of future 'Besut National Geopark' will undoubtedly arouse the great interest of people to know more about geology and hence help to popularise geosciences. Through this approach, it is likely to contribute to the growth of the geotourism sector in Besut area and on the other hand, contribute to the diversification and, thus, the extension of the tourism activities in Terengganu.

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