GEOTOURISM POTENTIAL AT SILAM COAST CONSERVATION AREA (SCCA), SILAM, SABAH

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ABSTRACT. *A research has been conducted at Silam Coast Conservation Area (SCCA) to evaluate the geotourism potential of the geological heritage resources. The study area is located at Silam, Lahad Datu, in the eastern part of Sabah. The SCCA and surrounding area are made up of igneous and sedimentary rocks of ultramafic, gabbro, amphibolite, basaltic dykes, plagiogranites and basaltic rocks capped by red radiolarian chert. It is also known as the Darvel Bay Ophiolite Complex which represents the ophiolitic sequence of oceanic crust that formed during Jurassic to Cretaceous around 150-80 million years ago. In SCCA area, only pillow basalt, lava basalt, chert and minor occurrence of basalt dyke are present. Mid-Miocene tectonic event has deformed and uplifted the rock unit. SCCA is a coastal area which also covers few small islands namely Tabun Island and Saranga Island to the northeast of the conservation area in Darvel Bay. The geomorphology and geologic features contribute to the aesthetic values of the area that enhance the scientific values. Two potential geosites have been identified which are Tabun-Saranga islands and Pandanus-Ara beaches that hold unique features of remnant cliff, wave-cut cliff, faults, caves, stacks, tafoni, headland, pocket beach, colluvial beach deposit and remnant of raised coral colonies. Development of this geosites could lead to conservation for sustaining the geological heritage resources as well as contributing to the state's economy and tourism industry.*

KEYWORDS: Geotourism, Silam Coast Conservation Area, SCCA, Tabun,Island, Saranga Island.

INTRODUCTION

The SCCA is surrounded by many landscapes, areas and sites treasured consisting of series of pocket beach along the coastal area, beautiful river, lowland topography, Silam moutain and geological resources such pillow basalt, chert, peridotite and serpentinite. Silam Coast Conservation Area (SCCA) is situated on the south east foothills of Silam Range or Silam Mount The terrain is characterized by NE-SW trending ridges with gentle slopes. Several streams has drained the undulating terrain of the site which formed a dendritic and parallel drainage pattern. The main river of the area is Sg. Silam. To the east and southeast of SCCA

lies Darvel Bay. There are several small islands located nearby namely Tabun Island and Saranga Island.

The developments of the main topographic features appear in general to be controlled by lithology and geologic structures. The hilly to undulating region to the Northwest is underlain by crystalline basement and ultramafic rocks. The undulating hill slopes to low lying areas to the southwest is underlain by basalt and chert association or formerly known as the Chert Spilite Formation. The north-northeast elongation of the ridges is coincident with the direction of elongation of the ultramafic rock mass. The dendritic drainage pattern may be controlled by the bedrock fracture pattern. The research site is also covered by recent alluvium mainly on the valleys and coastal area.

There are no significant studies focus on geotourism potential have been done so far in Silam Coast Conservation Area (SCCA). Hence, it is very significantly important to carry out a research on this area. The objectives of this research are to provide the knowledge and information about the geological aspect regarding the petrography of the rock, beach morphology, historical geology and geotourism potential for geological heritage resources at the SCCA.

Geological Background of SCCA

The geological map of the Silam Coast Conservation Area (SCCA) was illustrated in Figure 1. Based on the figure, the rocks in the study area comprised of volcanic-sedimentary rock (Chert-Spilite Formation) and Ultramafic-serpentinite rock of the Darvel Bay ophiolite complex (DBOC). Leong (1974, 1977) had done an extensive work on geology of igneus and sedimentary rock of the Upper Segama Valley and the Darvel Bay. Leong (1974) has reported the occurrence of Crystalline Basement at Upper Segama area consist of amphibolite, hornblende schist and gneiss, granodiorite, tonalite, granite and had been dated in range Cretaceous to Triassic (Kirk, 1962; Leong, 1974, 1998; Hutchison 1997). The Chert Spilite formation of Early Cretaceous age at Upper Segama area comprised complex extrusive igneous rock such as basalt, spilites, volcanic breccia, agglomerates and associated with radiolarian chert, limestone and clastics (Leong 1974, 1977). The Darvel Bay Ophiolite Complex (DBOC) proposed by Shariff *et al.,* (1992) was composed of ultramafic, gabbro, amphibolite, basaltic dykes, plagiogranites, and basaltic rocks capped by red radiolarian chert. This complex was formerly known as Chert-Spilite Formation and other igneus rock association in (Fitch, 1955) and (Leong, 1974). The complex was also categorized as ophiolite sequence which was a terminology for a group of metamorphic, igneous ultramafic and igneous mafic rocks. The complex was surrounded by melange and overlain by Neogene and Quaternary sediments.

Shariff *et al.*, (1992) categorised the sequence of the ophiolite in the Darvel Bay area into three rock units namely ultramafic unit (mantle peridotite through ultramafic cumulate), gabbro and dyke units and volcanic sedimentary unit. No sheeted dyke complex was found in

the study area. The ultramafic unit comprise largely of serpentinized peridotites, dunites and pyroxenites. The gabbro unit consisted of layered and massive gabbros, amphibolites and plagiogranites. Volcanic rock unit was represented by the lava basalt with minor layered basalt, metatuffs and volcanic breccia. Lava basalt was occasionally associated with red bedded radiolarian cherts. The age of chert sediment was thought to be Cretaceous ranging from Barremian to Valanginian (Leong, 1977), however the latest work of radiolarian chert at Kunak Area had resulted an age ranging from Aptian to Turonian (Junaidi & Basir, 2010; Junaidi & Basir, 2012; Junaidi & Basir, 2013). Hence we can conclude that the radiolarian chert at study area ranged from Valanginian to Turonian. The age of igneous rock underlain the radiolarian chert was older than chert perhaps Jurassic. The rock association at study area was considered as an ophiolite sequence which represented an oceanic crust (Shariff *et al.,* 1992; Shariff 1996a, 1996b; Basir, 1991, 2000; Hutchison, 2005).

The geological history of the study area started with the evolution of igneous and metamorphic rock known as the Darvel Bay Ophiolite Complex, also categorized as Ophiolite sequence. As mentioned earlier, the Darvel Bay Ophiolite Complex comprised of ultramafic unit, gabbro and volcanic clastic unit. During the middle Miocene, deep basin appeared to have been formed in a very unstable condition. Extensive uplifting, faulting and folding had brought up the rock to the surface of the ocean. This was due to the tectonic activities. Rock units those formed exotic blocks during the middle Miocene period which were now represented by mélange (Kuamut Formation). This rock unit in melange was characterized by the highly deformed and fractured rocks of older formation. During the Quaternary period, active processes of weathering and erosion caused the breakdown of rocks into sediments which then followed by sedimentation process. This resulted in the alluvial deposits occured in low land such as flood plain, valley and coastal areas. The remnants of raised coral colonies at the beach of all two geosites indicated that the area has undergone sea level changes during the age of Pleistocene-Holocene. Colluvial beach deposit or known as colluvium of ultramafic rock debris or scree deposites (Leong, 1974) formed terrace along the beach area. It contained fragments from the basalt rock cliff where some of it was mixed with coral remnants.

MATERIAL AND METHOD

On 10 May 2015 to 20 May 2015, an extensive fieldwork focus on geotourism potential had been conducted at Silam Coast Conservation Area (SCCA). Field studies had included geological mapping and sampling for petrography analysis, geomorphological features and geotourism potential. Thin section preparation for petrographic analysis was based on Kerr (1977) by using polarize microscope. Method used for geotourism potential which includes identification, mapping and description of those geosites and the identification was based on the occurrences of important geological and geomorphological features of the sites.

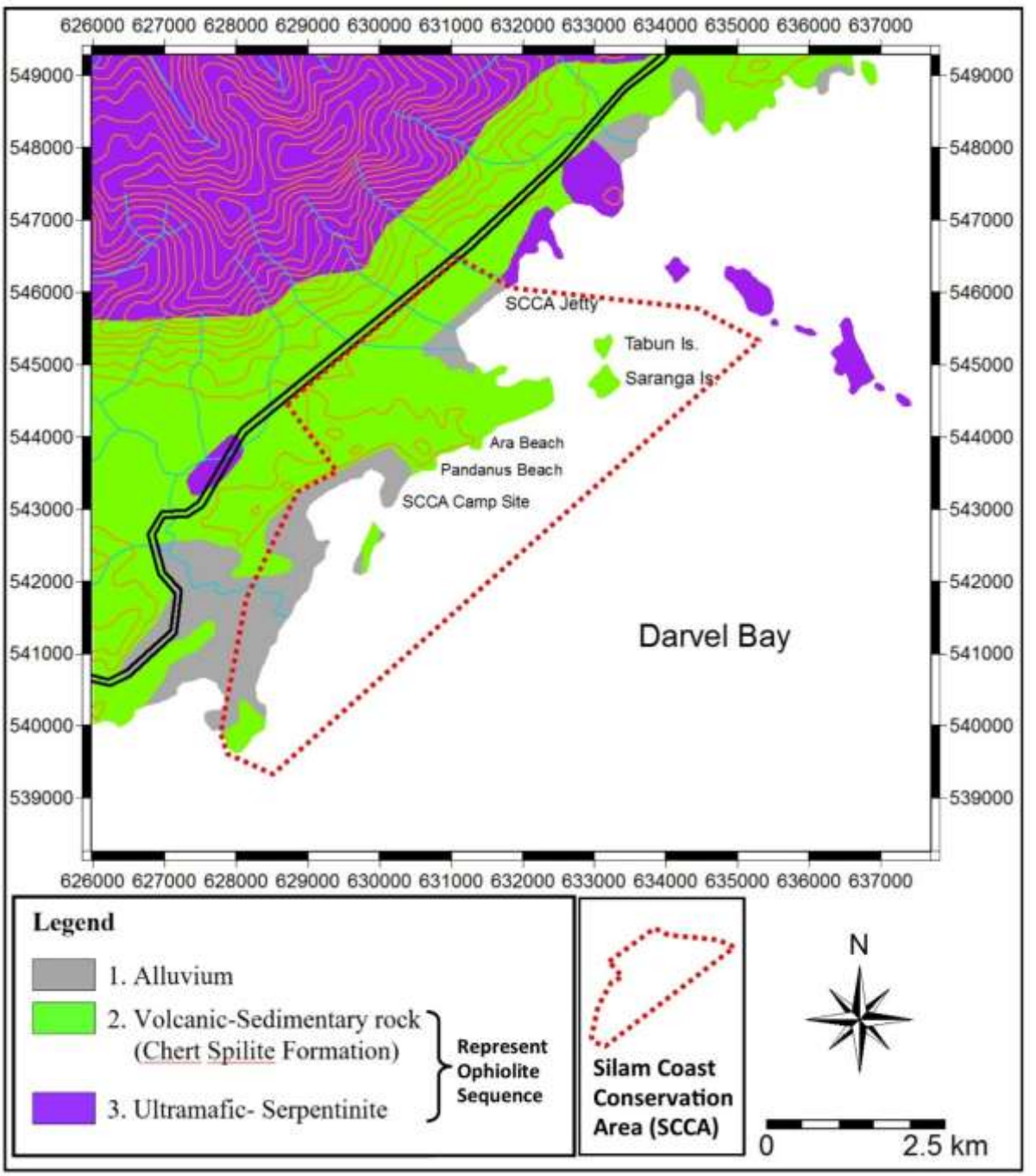

Figure 1: Geological map of study area (Modified from Leong 1974; Shariff *et al.*, 1992)

Petrography

The geology of SCCA is mainly underlain by basaltic rocks. There are two types of basalt have been observed, namely pillow basalt and lava basalt. Basically this two rocks unit have same geochemical composition, but have different texture of mineral arrangement and structure of the rock.

Field observation shows that the pillow basalt has a clear pillow shape and layering while the lava basalt has plain surface with no apparent structure. Both types of basalt outcrops can be found along coastal area and Tabun-Saranga Island. The sizes of pillow basalt range from 40- 60 cm long. The petrography of pillow basalt shows larger phenocrysts of subhedral clinopyroxene in groundmass of finer crystals of plagioclase and pyroxene (Figure 2). Lava basalt of the study area is observed as brownish in colour and sometimes greenish. Some of the rocks have been brecciated, probably due to tectonism. Thin section of lava basalt (Figure 3) shows the grain size of minerals is fine to medium. Commonly it has interstitial textures of plagioclase laths. Minerals of plagioclase and pyroxene are made up mostly both the massive and pillow basalt.

Chert of the study area occurs as block and can be found in several locations away from the beaches. The Chert exists as block and has undergone high deformation. They are reddish-brown in colour and associated with lava basalt. Thin section shows the abundance of radiolarian fossils or known as radiolarite identified as spherical spumellarids along with quartz veins (Figure 4).

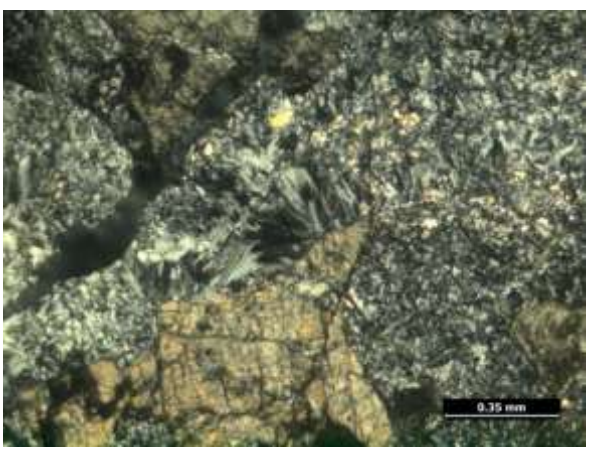

Figure 2: Photomicrograph of pillow basalt showing larger phenocrysts of subhedral clinopyroxene within finer crystals of plagioclase and pyroxene

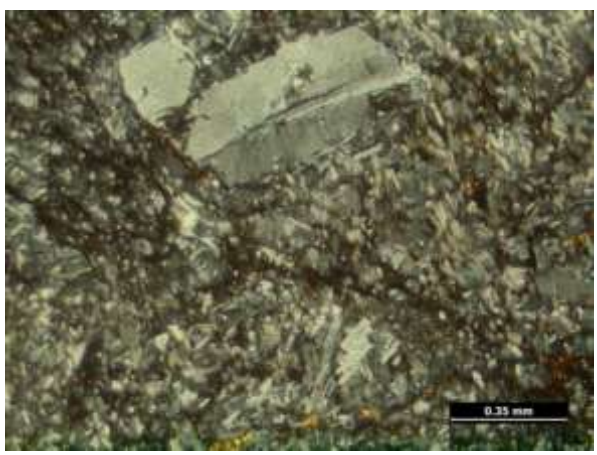

Figure 3: Microphotograph of lava basalt showing carlsbad-albite twinning

Figure 4.a: Chert block found at SCCA Jetty area.

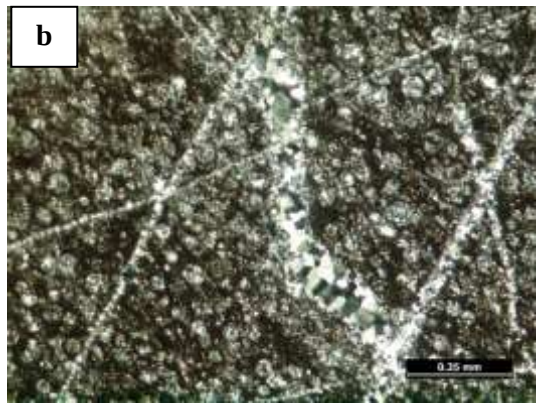

Figure 4.b: Photomicrograph of chert showing spherical spumellarids and quartz veins

Geotourim potential

Geopark is a territory encompassing one or more sites of scientific importance, not only for geological reasons but also by virtue of its archaeological, ecological or cultural value. The age of the Darvel Bay Ophiolite Complex at SCCA area probably ranges from Jurassic to Cretaceous (Hutchison 2005; Leong 1974). This rock unit is a part of ophiolite sequence of oceanic crust. In SSCA area only basalt or pillow basalt and chert are present and do not have a complete section of the ophiolite sequence. Other rock unit of ophiolite sequence such as gabbro, peridotite, dyke, are present at surrounding area e.g. Upper Segama, Danum, Tingkayu, Lahad Datu and Mount Silam. This rock unit are widespread in Sabah region, and has a unique and interesting geological characteristic which can only be found in Sabah and in several parts of Sarawak. This area will provide knowledge and information about the geological aspect of the study area. In this conservation area, two geosites have been identified to be having geotourism potential (Figure 5).

Geosite 1: Saranga Island & Tabun Island

Geosite 1 represents by two small islands namely Saranga Island (southern part) and Tabun Island (northern part) (Figure 5 & 6). The geology of both islands are made up by pillow basalt, lava basalt (Figure 7), and volcanic breccia of volcanic unit of the Darvel Bay Ophiolite Complex. The distinct feature of pillow basalt is observed along the cliff of coastal area at the Saranga Island and Tabun Island (Figure 8 & 9). Geologic features that can be observed including, colluvial deposit that form flat terrace below the basalt cliff (Figure 10) and remnant of raised coral colonies located in the western part of Saranga Island (Figure 11). Coastal geomorphology feature such as pocket beach, rocky beach, sandy beach and cliff as a result from coastal erosion processes (Figure 12) can be observed in this geosite.

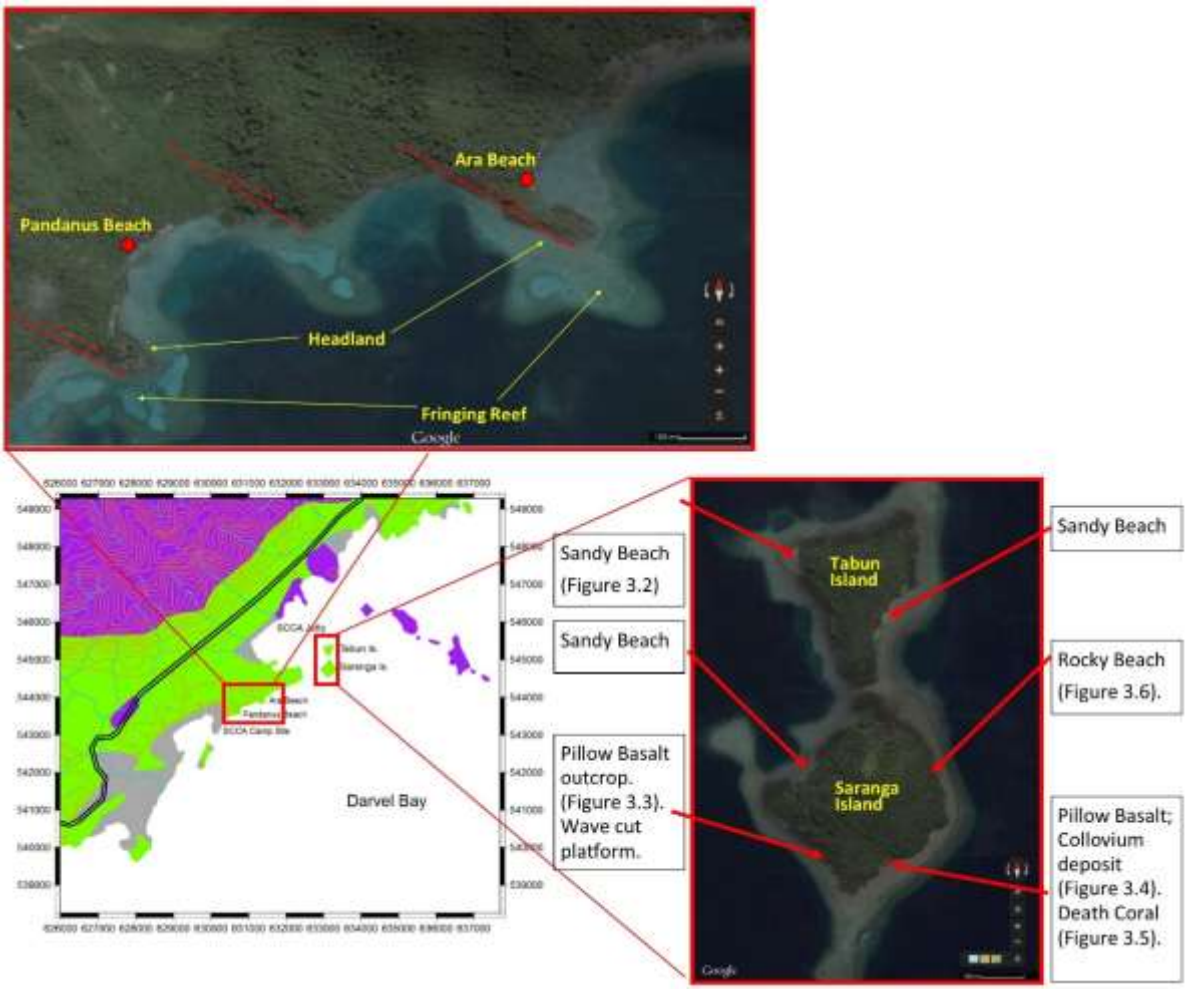

Figure 5: Geosites 1 and 2 identified as having geotourism potential at the study area.

Figure 6: During low tide both islands are accessible by foot

Figure 7: Cliff made up of lava basalt and pillow basalt at Saranga Island

Figure 8: Wave cut platform morphology of pillow basalt outcrop at Saranga Island.

Figure 9: Different colour of pillow basalt indicates different degree of weathering process.

Figure 10: Colluvial terrace exposed below basalt cliff forming a flat platform at Saranga Island.

Figure 11: Remnant of Recent coral skeletal in colluvial deposit

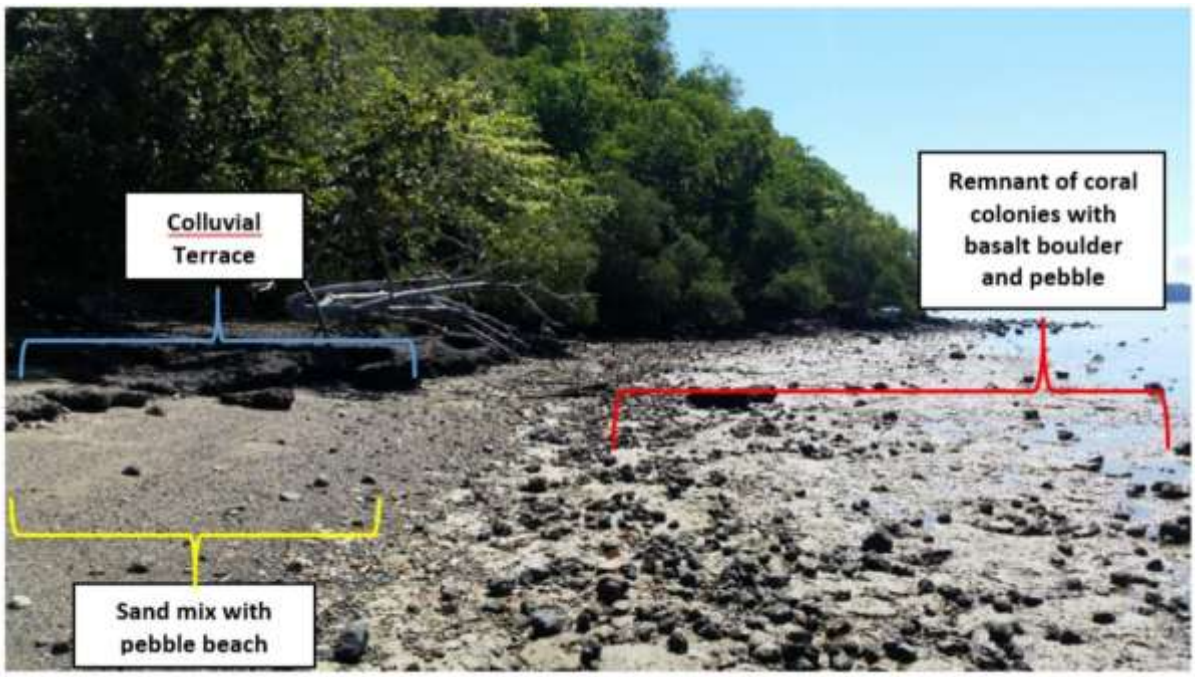

Figure 12: Colluvial terrace and remnant of raised coral with basalt boulders and pebbles

Geosite 2: Pandanus & Ara Beach

The Pandanus & Ara Beach is located approximately 1 km - 2 km from the Tumunong Hallu basecamp (Figure 5). Figure 13 shows the pocket beach and headland morphology of Pandanus Beach. The geology of the area is made up of lava basalt and some of the rock is highly deformed by tectonic event creating faulting and fracture (Figure 14). Basalt outcrop can be observed at headland of Pandanus-Ara beach. Erosional and depositional processes created beautiful geomorphologic features along the coastline. The beach is covered by dark coloured sand and rocky beach (Figure 15 & 16). Sand sample taken from the beach contains rock fragments of spillite, basalt and schist and quartz mineral with some coral and foraminifera (Figure 17-20). Other features such as colluvial deposit (Figure 21), raised coral remnant (Figure 22), wave cut platform (Figure 23) and pitholes (Figure 24) are also preserved along the coastline.

Figure 13: Satellite image of Pandanus-Ara Beach showing pocket beach morphology.

Figure 14: Fault zone at tip of the beach with small stacks of rocks caused by coastal erosional process (Fault: 143/80).

Figure 15: Dark coloured sand and rocky beach.

Figure 16: Dark coloured sand exposed at Ara Beach.

Figure 17: Sand sample showing mixture of rock and mineral fragments.

Figure 18: Coral skeletal.

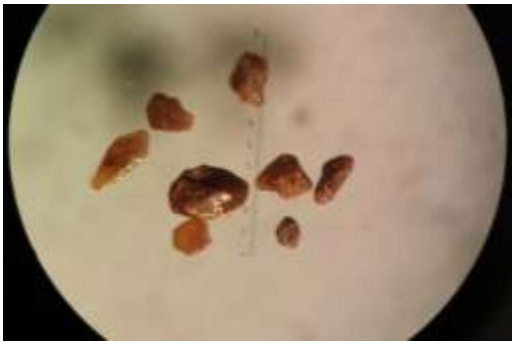

Figure 19: Chert fragments.

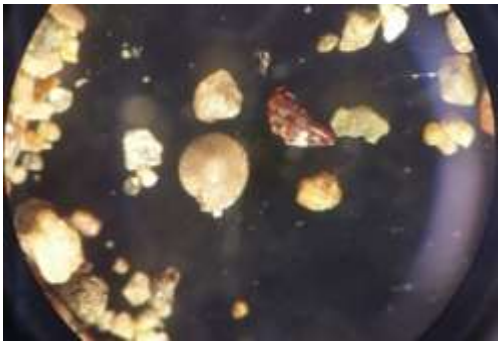

Figure 20: Foraminifera.

Figure 21: Colluvial deposit exposed at the beach.

Figure 22: Remnant of raised coral.

Figure 23: Wave cut platform as a product of repeated wave erosion.

Figure 24: Pitholes in rocks at Pandanus Beach due to weathering and wave erosion.

Both geosites 1 and 2 have the potential to be developed as a geoutourism attraction. The aesthetic and recreational values enhance the scientific value of the geological heritage resources in this area. Apart from the geological resources, the geosites hold its own flora and fauna both living in land and sea. Some recreational activities such as sight-seeing, picnic, camping, hiking and diving in the ocean can be done here. This geosites are important

to conserve as it is worth more than just preserving the beautiful geological and geomorphological features as it records the geological historic events that occurred in the past. Thus, it is suitable for future research and education. Table 1 shows the value of the geological heritage resources in the study area, while Figure 25-27 display the scenic view around the geosites.

Table 1: Valuation of geological heritage resources of the study area.

Geological Resources	Characteristics	Value
Rock units: lava basalt, pillow basalt and chert	Formed part of Darvel Bay Ophiolite Complex representing ophiolitic sequence of oceanic crust which had developed during Jurassic to Cretaceous. Outcrops observed in Tabun-Saranga Island and Pandanus-Ara Beach.	Scientific
Coral remnant	The remnant of raised coral colonies at the beach indicates that the area had undergone sea level changes during the age of Pleistocene-Holocene.	Scientific
Colluvial deposit	Colluvial deposit formed terrace along the beach containing basalt fragments derived from basalt cliff along with some coral skeletal.	Scientific
Wave cut platform	Gently sloping angle of basalt bedrock product of wave erosional process.	Scientific and Aesthetic
Pandanus and Ara Beach	Variety of geomorphologic features of pocket beach, headland, rock stacks, rocky beach with dark coloured sand, colluvial terrace, remnant of raised coral, abrasion platform and pitholes due to weathering, erosional and depositional processes.	Scientific, Aesthetic and Recreational
Tabun and Saranga Island	Islands that made up of basalt and chert representing ophiolitic sequence with other coastal geomorphologic features of cliff, pocket beach, rocky beach, sandy beach, colluvial terrace and remnant of raised coral.	Scientific, Aesthetic and Recreational

Figure 25: Panoramic view during sunrise from SCCA camp

Figure 26: Geosite 1: Tabun and Saranga Island

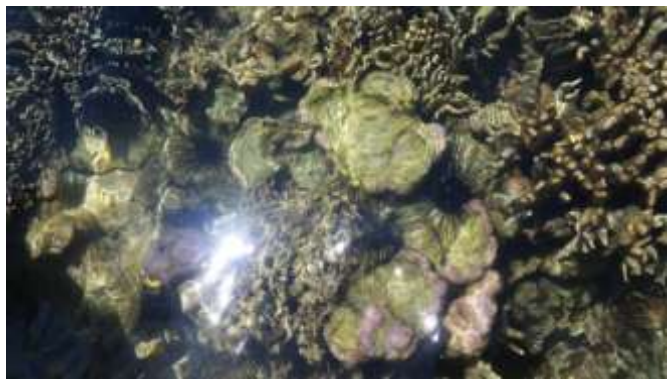

Figure 27: Coral reefs and sea urchin are visible under clear seawater

Evolution or structural control on beach morphology

The location of study area is situated at island and along coastline makes it prone to weathering, erosional, and depositional processes producing variety of beautiful geomorphologic features. Figure 28 display the simplified diagram on the formation of pocket beach of Pandanus in SCCA area. The beach is underlain by basalt that formed during Pre-Cretaceous. During the Middle Miocene, tectonic event acted towards the area resulting in the uplifting and development of series of lateral fault trending NW-SE (143/80) in the bedrock. These fault lines were the weak zones in the bedrock which were highly prone to weathering and wave erosion. These processes repeated over time, and finally producing the pocket beach and headland morphologies in the SCCA area. Continual destructive wave acting towards the headland makes it vulnerable to erosion, as the wave's energy gets concentrated here and gradually will develop other coastal features such as rock stacks and pitholes. Development of wave cut platform (Figure 29) is also related to the geological structure of the study area. The rock cliff at the coastline is made of basalt that is deformed, creating joints and faults. Intense physical and chemical weathering acting towards these joint makes it vulnerable and easily eroded by wave erosion. Repeated weathering and wave erosion processes will finally produce wave cut platform with gently sloping angle of hard bedrock that are exposed during low tide. Colluvial deposit that form terrace along the beach is a product of basalt cliff weathering and depositional processes.

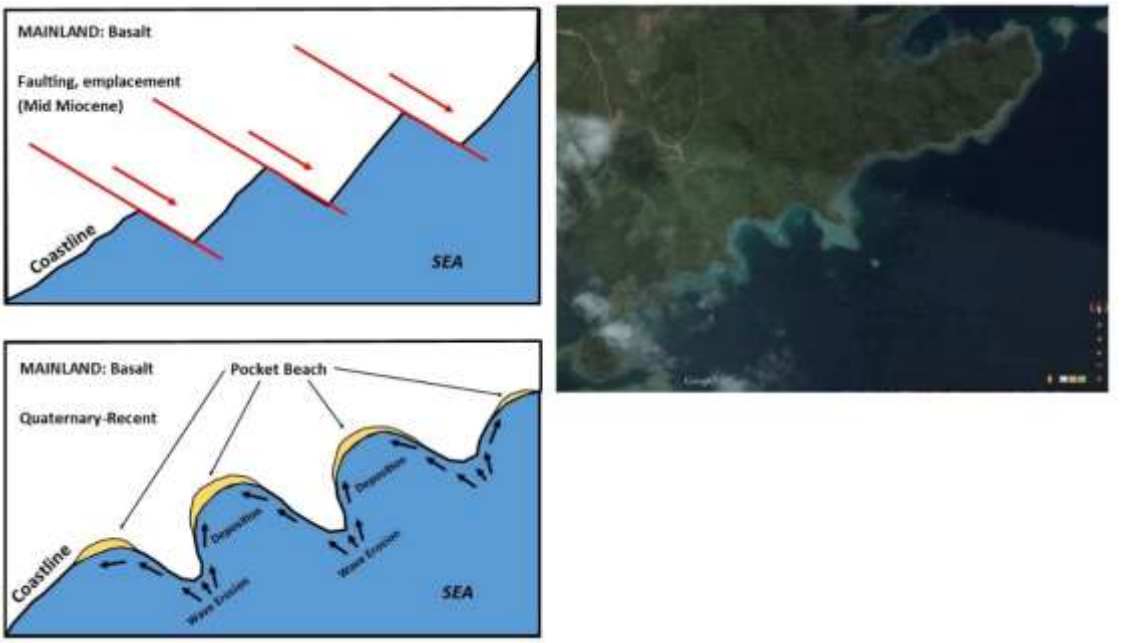

Figure 28: The formation of pocket beach**.**

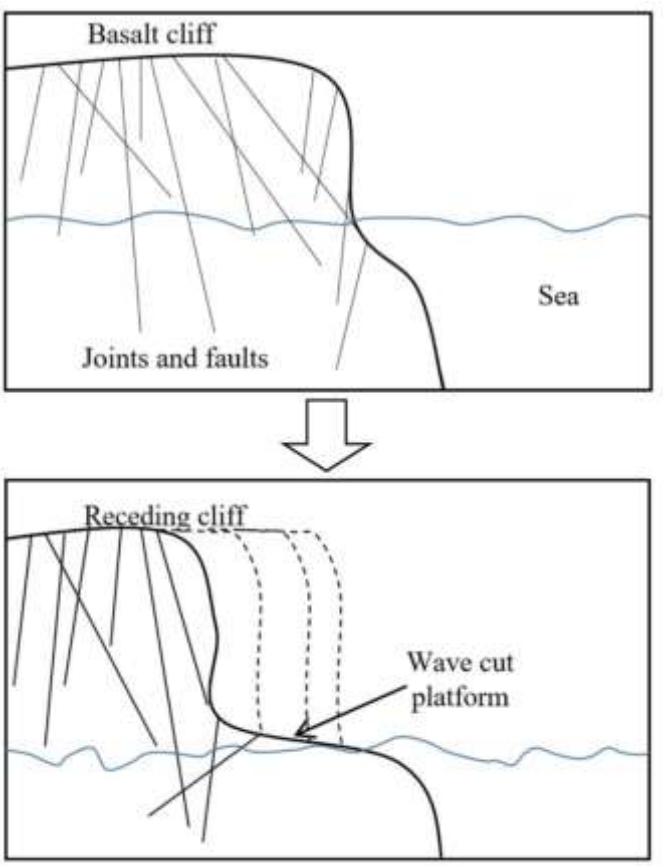

Figure 29: Formation of wave cut platform is controlled by joints and faults.

CONCLUSION

Two geosites have been identified namely Tabun-Saranga Island & Pandanus-Ara Beach. The geology of SCCA areas are mainly consist of Basalt (Pillow Basalt, Lava basalt) of the Darvel Bay Ophiolite Complex. This rock unit was a part of Ophiolite Sequence in the Oceanic Crust which was developed during Jurassic-Cretaceous age. The Quaternary Deposits also have been found as Alluvium, Colluvial deposit and coral remnant at the beach. The coastal area of SCCA area has geological, aesthetic, and recreational values and has potential to be developed for geotourism. It is recommended that the beaches at the Silam Coast Consevation Area to be conserved in order to protect the beautiful landscapes. Geotourism activity could be promoted on some of the beaches at the Tabun-Saranga Island and Pandanus-Ara Beach. The study of geological aspect of beaches for geotourism development is an innovative way for value added to their existing aesthetic attraction in order to enhance and sustain the state's tourism industry.

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