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Diversification of Igneous Rocks and Geoheritage Values in Pergau, Jeli Kelantan

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Abstract. This study aims to map rocks variation and geological features and identifying the geodiversity values for geotourism potential in Pergau area. Generally Pergau area is dominated by granitoid body from Noring Granite and Kenerong Leucogranite. Based on the field observation, there are five (5) variation of granites; 1) the coarse grained dominant with quartz and feldspar, 2) fine grained, 3) pink megacryst biotite granite, 4) coarse grained dominant with hornblend, and 5) foliated granite. The assesment of geoheritage values show that Pergau is basically a little too low values to be as geotourism site and the level of significance is only local to state. However, the scientific and education values are higher, which resemble that Pergau area is very important for the research and educational site.

1. Introduction

Diversification is processes that can be differentiate the composition of the igneous rocks. The igneous rocks produced by the several types of magma differentiation such as crystal fractionation, thermo-gravitational diffusion, liquid immiscibility, magma mixing and mixed process. Regional specialization in tourism has shown contrasting impacts on regional economies. On the one hand, it is linked to fast economic growth and higher value added in the region, particularly in coastal or mountainous regions [1]. Tourism is seen as an alternative to decline in traditional industries such as agriculture in general, particularly in lagging or peripheral regions, where territorial policies promote diversification strategies [2]. This is even more the case where localities depend on tourism for their diversification and revival [3].

Geologically, the study area is part of the Stong Migmatite Complex which is divided into three lithodemic units, namely the Noring Granite, Kenerong Leucogranite and Berangkat Tonalite. The locality of the observations and rock samplings consist of the outcrop at Suda Intake, Renyok Intake 1 to 3, Long Intake 1 and 2 and Terang Pumping House. All the outcrops represent different types of granite rock. The rock samplings mostly have done along the waterfall area and along the roadside to the intake area. This study aims to map rocks variation and geological features and identifying the geodiversity values for geotourism potential in Pergau area.

2. Literature Review

Jeli district is located in the foot of Main Range, Peninsular Malaysia. The range consists mostly of granitic rocks with several enclaves of sedimentary/metasedimentary rocks. The Main Range granite is located roughly in the western part of Kelantan stretching along western of the state boundary of Perak



and Pahang. Based on the general geology of Kelantan [4], Jeli district is generally composed of three rock types: (1) Triassic sedimentary rocks (Gunong Rabong Formation), which consists of shale, siltstone, sandstone, and limestone; (2) Permian sedimentary rocks (Gua Musang Formation) which consists of phyllite, slate, sandstone and limestone; and (3) Granitic rocks (acid intrusive). The general geology of Kelantan and Jeli district can be seen in Figure 1. Geomorphologically, Kelantan can be divided into four types of landscape, they are: (1) Mountainous areas; (2) Hilly areas; (3) Plain areas; and (4) Coastal areas [5]. Mountainous landscape forms in the western and northern part of the district. This landscape is composed of the Stong Migmatite Complex, the Main Range granite and schist. Plain landscape forms in the central and eastern part of the district. Tectonic activities in Peninsular Malaysia during the Paleozoic and Mesozoic era affect the land mass principally on the formation of faulting and folding. Localised structures are observed include folding, jointing and faulting in the sedimentary rocks and jointing and faulting in the granitic rocks [4]. The dominant local structures pattern in Kelantan along N-S to NW-SE directions. However, the dominant local structures in Jeli district is along NW-SE NE-SW directions [6]. Pergau Dam or formally known as Sultan Ismail Petra Power Station is a hydroelectric power station located in Jeli, Kelantan. Pergau Power Station has the second largest hydroelectric generation installed capacity in Malaysia. The dam began operation on 2003 and was officially opened in 2003.

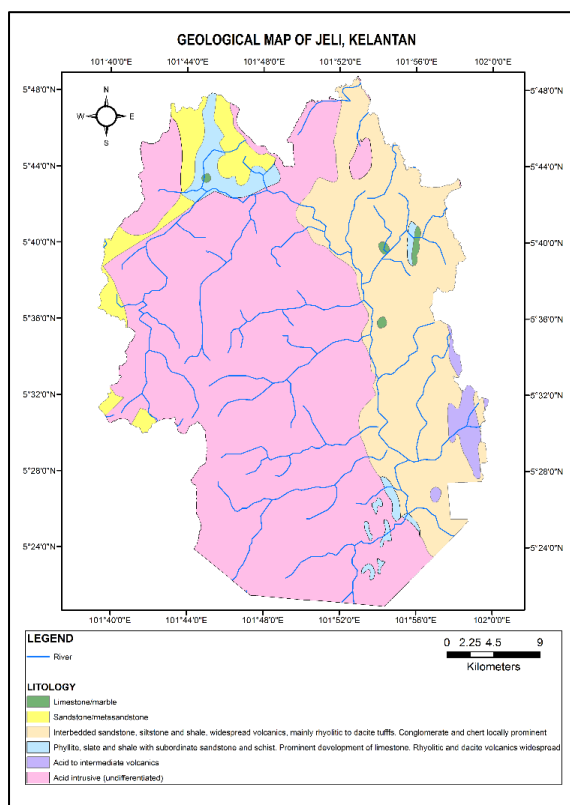


Figure 1. General geology of Jeli district (Source: Department of Minerals and Geoscience Malaysia, 2003)

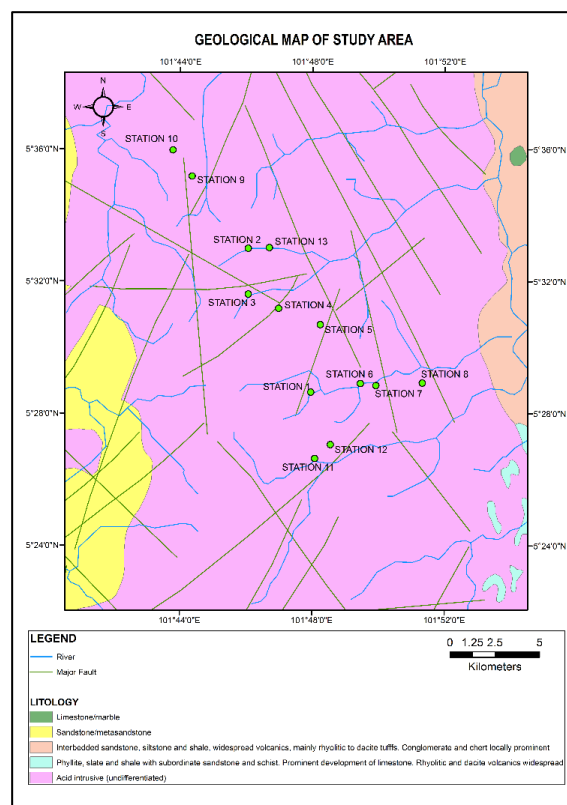


Figure 2. Sampling location for geological mapping during Pergau Scientific Expedition.

3. Materials and Methodology

Materials of the research are including map, photographs, geological hammer, GPS, notebook, plastic samples and literatures related to diversification and the study area. Method used for this study is focusing in the site surveying through the traversing and drone mapping. The rock samplings were collected during the traverse for every 13 stations location. The location for each

measuring/observation station were shown in Figure 2. The traversing for every location includes identification, mapping and description of those geodiversity and their relations to tourism development of the study area. The identification is based on the occurrences of important geological and geomorphological features of the sites. The geological mapping is based on the fieldworks to determine the locations of all those features and their recent geological conditions. All the information from the previous literatures and the field were collected for the descriptions of every geodiversity.

The geoheritage values were assessed based on the added values of scientific, educational, aesthetic, recreational, economic, cultural, historical and functional values [7]. The numerical assessment values is rank between 0-5 where 0 is none, 1-very bad, 2- bad, 3-fair, 4- good and 5-very good [6]. These values show the ranking of how good of the study area to be the potential geotourism place, with the total values of 0-7 represent much too low, 8-14 represent a little too low, 15-21 represent about right, 22-28 represent a little too high and 29-35 represent much too high. However, this value is less precise depend on the assessor's knowledge and might be influenced by subjectivity.

4. Results and Discussions

This study focused on few TNBR intakes at Pergau. Due to some constrain, the results will only show the field observations during the scientific expedition. We covered the Suda, Renyok (1,2,3), Long (1,2) and Terang Pump intakes with 14 total station points. All 14 stations exhibited same lithology, with different mineral composition within. Pergau is located in northern part of Stong Complex. The Stong Complex is divided into three lithodemic units; Noring Granite, Berangkat Tonalite, and Kenerong Leucogranite [8]. From the field observations, five (5) types of granites had been identified; 1) the coarse-grained dominant with quartz and feldspar, 2) fine grained, 3) pink megacryst biotite granite, 4) coarse grained dominant with hornblend, and 5) foliated granite.

4.1 Coarse grained granite dominated with quartz and feldspar

This granite variation dominated the whole Pergau and can be found in most of the stations (Figure 3). It is dominant with quartz and feldspar, with few biotite on it. This mineral composition exhibits the light grey colour for the granite.

4.2 Fine grained granite

This fine-grained granite had been distributed along with the coarse grained granite (dominant with quartz and feldspars) (Figure 4). In few intakes, such as Terang Pump Intake, Renyok Intake 1 and Renyok Intake 2, these two granite variation had been found together and some of them in a contact boundary. The colour of this granite is greyish, with less quartz and feldspar. Some of the fine grained granite became a xenolith in the coarse grained granite and some been intruded by the coarse grained granite.

4.3 Pink megacryst biotite granite

The colour of this granite is pink where it is actually resembled the dominant mineral within, Plagioclase (Figure 5). This coarse grained granite is different from the previous one, because of the mineral contents and the bigger size of the minerals (megacryst). We only found this variation at Renyok Intake 1 and Terang Pump Intake.

4.4 Coarse grained granite dominated with hornblende

At Renyok Intake 2 and 3, we found few coarse grained granite which dominated with hornblend (Figure 3). The colour of the coarse grained granite is white and dark grey colour for the hornblend. Based on field observation, this granite variation probably a diorite, another type of igneous rock, which resemble the similar field observation properties.

4.5 Foliated granite

The most unique granite in Pergau is foliated granite (Figure 6). We found this variation at one station far from all intakes. It has been said that this granite is resulted from metamorphism of Stong Complex.

Based on Singh et al. [8], Pergau is a part of Noring Granite. The Noring Granite had been differentiate from other granitoid rocks at Stong Complex by the dominant pink colour of pink megacryst biotite granite. In certain location, the Kenerong Leucogranite which is intensely foliated can be found. From our observation, all the coarse grained granite is a part of Noring Granite, which had been divided into two facies which is Terang Facies and Belimbing Facies [8]. This facies division is based on the presence of biotite mafic and biotite hornblend minerals. On the other hand, the fine grained and foliated granite is a part of Kenerong Leucogranite, which is made up of fine to medium vein sequence and highly foliated.



Figure 3. The coarse grained granite dominated with hornblend (left) and the coarse grained granite dominated with quartz and feldspar.



Figure 4. Fine grained granite with some hornblende inclusion.



Figure 5. The megacryst plagioclase in pink megacryst biotite granite.



Figure 6. The foliated granite found far from intakes.

In terms on geodiversity, Pergau area is significance in few geoheritage values; scientific, educational, aesthetic, economical and recreational (Table 1). The diversification of granites in Pergau, make it important for scientific and educational. The variation of minerals contents in different granite make it interesting to be study, and explore. In geology, different mineral, and different grained size will resemble different types of magma, with different cooling period. The appearance of waterfall that

formed by these granites is also significant in terms of aesthetic value. All of the waterfall and streams with different rock types is very appealing for economical and recreational values. Table 1 shows the quantitative assessment of the all the geoheritage values at Pergau [7]. Scientific/ educational value is 5 that described where this study area is very good for geotourism potential place. Meanwhile the aesthetic and recreational value is 3 which interpreted as fair for geotourism potential place. Another assessment is economic value that interpreted as 2 which means this study area is in bad rank as geotourism place. The geoheritage assessment values range from 0-5 which represent the very good value (5) to the very bad value (1) and (0) represent no value at all. The total value for all values that been assessed is 13 which represent a little too low in terms of ranking to be a potential geotourism site. The level of significance is local as the natural history feature is only important for the local community [9].

Table 1. The quantitative assessment of Pergau (adapted from Kubalikova, 2013 & Dony Adriansyah et al., 2017)

No	Content	Numerical Assessment
1.	Scientific/ Educational value	5
2.	Aesthetic value	3
3.	Recreational value	3
4.	Economical value	2
5.	Cultural value	0
6.	Historical value	0
7.	Functional value	0
8.	Total	13

5. Conclusion

In this study we managed to focus on the diversification of igneous rocks in Pergau which lead us into few variation of granites. There are 5 variations of granite in this area which are 1) coarse grained granite dominated with quartz and feldspar, 2) fine grained granite, 3) pink megacryst biotite granite, 4) coarse grained granite dominated with hornblend and 5) foliated granite. All of these granites are very important to be preserved, as it is a part of geodiversity that need to be maintained in order to make our earth balance. Pergau area is very unique in term of biotic and abiotic. The abiotic part, which covered the rocks, minerals and all non-living things is very much important together with biotic. These abiotic parts construct the whole geodiversity of Pergau area. The geodiversity is the variation of geological features and been assessed to develop the geoheritage value for geotourism purposes in certain area. In terms of geotourism, the geoheritage values that been assessed show that Pergau is a little too low values to be a geotourism site for public, and the level of significance is only local to state, as Pergau area is only relevant to the local community.

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