

## Identification and Analysis of Geoheritage Potential in Paser Regency as Supporter of the Geotourism Development in East Kalimantan

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**Abstrak** – Kabupaten Paser merupakan bagian dari Provinsi Kalimantan Timur, Indonesia, yang berada di selatan provinsi tersebut. Secara geologi, Kabupaten ini termasuk bagian dari Pegunungan Meratus yang merupakan hasil kolisi Sundaland dengan Mikrokontinen Paternoster. Oleh karena itu, Kabupaten Paser memiliki kondisi geologi, baik geomorfologi, litologi, maupun struktur geologi, serta kondisi alam yang beragam dan unik yang berpotensi sebagai *geoheritage*. Penelitian ini bertujuan untuk mengidentifikasi dan menganalisis beberapa lokasi yang ada di Kabupaten Paser yang berpotensi sebagai lokasi *geoheritage* sehingga dapat mendukung dalam pengembangan geowisata di Kalimantan Timur. Metode deskriptif dilakukan dalam pengambilan data lapangan. Analisis geomorfologi dan petrologi dilakukan untuk mengetahui karakteristik geologi yang nantinya akan menjadi ciri khas unik lokasi-lokasi yang berpotensi sebagai *geoheritage*. Analisis kuantitatif dengan metode Kubalikova dilakukan untuk memberikan penilaian terhadap lokasi yang berpotensi sebagai *geoheritage* yang meliputi aspek nilai intrinsik dan keilmuan, nilai pendidikan, nilai ekonomi, nilai konservasi, dan nilai tambahan. Terdapat 9 lokasi yang berpotensi sebagai *geoheritage* yaitu Air Panas Danum Layong, Air Terjun Doyam Seriam, Embung Muru, Air Terjun Gunung Rambutan, Goa Loyang, Goa Tengkorak, Goa Losan, Gunung Boga, dan Air Terjun Lempesu. Lokasi tersebut memiliki kondisi geologi dan wisata yang cukup baik untuk dikembangkan menjadi lokasi *geoheritage*. Analisis kuantitatif menggunakan pembobotan Kubalikova (2013) juga menunjukkan lokasi tersebut sesuai untuk dikembangkan menjadi *geoheritage* dengan penilaian diatas 50%. Perlu dilakukan peningkatan baik dalam infrastruktur dan pengelolaan yang dilakukan secara berkesinambungan sehingga dapat menarik wisatawan dan mendukung geowisata di Kalimantan Timur.

**Kata Kunci:** *Geoheritage*, Geowisata, Kabupaten Paser.

**Abstract** – Paser Regency is part of East Kalimantan Province, Indonesia, which is in the south of the province. Geologically, this district is part of the Meratus Mountains which is the result of the Sundaland-Paternoster Microcontinent collision. Therefore, Paser Regency has geological conditions, both geomorphology, lithology and geological structures, as well as diverse and unique natural conditions that have the potential to become *geoheritage*. This research aims to identify and analyze several locations in Paser Regency that have the potential to become *geoheritage* locations so that they can support the development of geotourism in East Kalimantan. Descriptive methods were used in collecting field data. Geomorphological and petrological analysis is carried out to determine geological characteristics which will later become unique characteristics of locations that have the potential to become *geoheritage*. Quantitative analysis using the Kubalikova method was carried out to provide an assessment of locations that have potential as *geoheritage* which includes aspects of intrinsic and scientific value, educational value, economic value, conservation value, and additional value. There are 9 locations that have potential as *geoheritage*, namely Danum Layong Hot Water, Doyam Seriam Waterfall, Embung Muru, Mount Rambutan Waterfall, Loyang Cave, Tengkorak Cave, Losan Cave, Mount Boga, and Lempesu Waterfall. This location has geological and tourism conditions that are good enough to be developed into *geoheritage*. Quantitative analysis using Kubalikova's (2013) assessment also indicates that these locations are suitable for development as *geoheritage*, with assessments exceeding 50%. Improvements in infrastructure and management need to be made on an ongoing basis so that they can attract tourists and support geotourism in East Kalimantan.

**Keywords:** *Geoheritage*, Geotourism, Paser Regency.

## **INTRODUCTION**

Paser Regency is part of East Kalimantan Province, Indonesia, which is in the south of the province. Geologically, this district is part of the Meratus Mountains which is the result of the Sundaland-Paternoster Microcontinent collision. Therefore, Paser Regency has geological conditions, both geomorphology, lithology and geological structures, as well as diverse and unique natural conditions that have the potential to become geoheritage. The geotourism study will introduce areas that have the potential to become geotourism areas. By analyzing geotourism potential, it is hoped that people, both local and overseas, will know and want to visit the area. Apart from that, it is also hoped that this study can provide recommendations for developing and managing geotourism in Paser Regency. This research aims to identify and analyze several locations in Paser Regency that have the potential to become geoheritage locations so that they can support the development of geotourism in East Kalimantan.

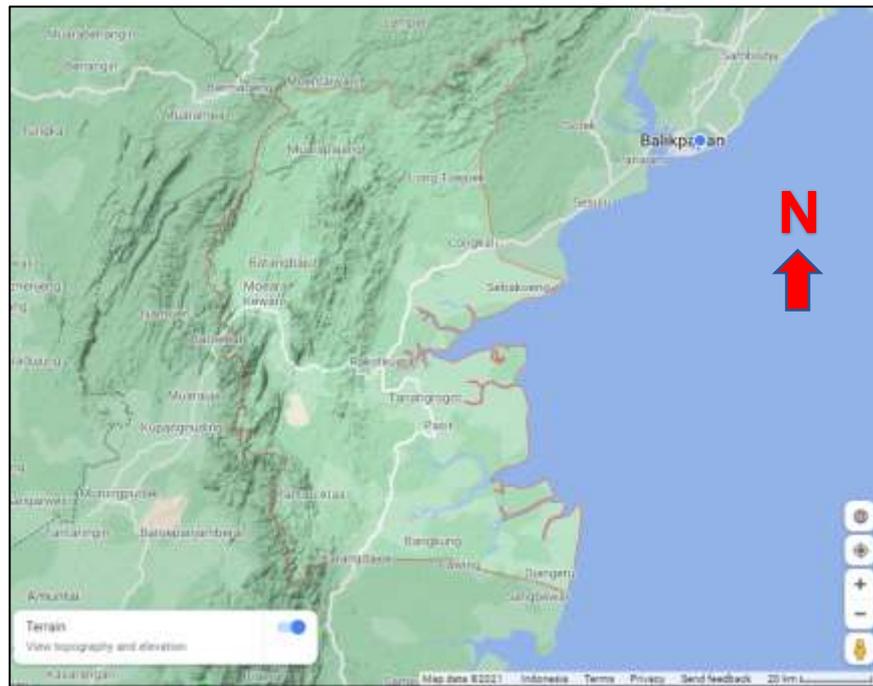
The research location is in Paser Regency, East Kalimantan Province, as seen in Figure 1. This research focuses on the geological and geotourism characteristics of locations that have the potential to become geoheritage in the research area. The assessment of these locations is based on the Kubalikova method which includes aspects of intrinsic and scientific value, educational value, economic value, conservation value, and additional value. The assessment carried out will be the basis for recommendations for development.

Geotourism is a term that comes from two words, namely geology and tourism. According to Kusumahbrata (1999) in Hidayat (2002), geotourism is a sustainable natural tourism activity with the main focus on the geological appearance of the earth's surface in order to encourage understanding of the environment and culture, appreciation, conservation, and local wisdom. Geotourism offers a natural tourism concept that highlights the beauty, uniqueness, rarity, and wonder of natural phenomena related to geological phenomena described in popular or simple language. In developing geological tourist attractions, it can adapt the quality criteria for tourist attractions proposed by Damanik and Weber (2006), namely (1) there must be uniqueness which is defined as a combination of rarity and distinctive attraction inherent in a tourist attraction, (2) originality or genuineness, that mean is not adopting models or values that are different from the original values, (3) Authenticity which is associated with the degree of antiquity or exoticism of culture as a tourist attraction, and (4) Variety or diversity of products and services offered.

Geotourism attractions should have criteria (Sammeng, 2001) in the form of information aspects, diversity aspects, beauty and uniqueness, cross-country adventure, and the availability of natural ecosystems. Geotourism can be used as a medium for the dissemination of natural science, environmental education and nature conservation, as well as the realization of sustainable tourism development based on local wisdom. The principles that must be considered in developing geotourism are (Hermawan, 2017):

1. Geologically based, is a formation resulting from geological processes. Physical aspects used as tourist attractions can include soil conditions, mineral content, rock types, and so on.
2. Sustainable, meaning that the development and management of geotourism does not damage or reduce its sustainability.
3. Geologically informative, meaning that geotourism is equipped with information about natural and geological processes so that people will be aware and not try to damage the beauty of the environment.
4. Locally useful, meaning it is able to provide benefits to the surrounding community.
5. Visitor satisfaction, meaning that geotourism must be able to generate satisfaction from good tourism management, supported by excellent service, able to present beautiful, unique and original attractions, and able to provide guarantees for the security and safety of visitors.

Regionally, the research area has quite complex geological conditions. The research area is composed of tectonite rocks and intrusive rocks of Mesozoic age, and also Tertiary sedimentary rocks (Hidayat and Umar, 1994). This condition is because the research area is part of the Meratus Mountains which is the result of the Sundaland-Paternoster Microcontinent collision. Regionally, tectonic activities in this area are presumed took place since Jurassic. As consequences the Jurassic rocks are emplaced, folded, and faulted, which is accompanied by magmatic activities. After that, it followed by the deposition of clastic sediment and volcanic in Early Cretaceous. Since Early Paleogene till Early Eocene, uplift, erosion and levelling off took place. As result, terrestrial sediments are deposited. It forms the base of Tertiary basin in southeast Kalimantan, in some places carbonate deposits formed.



**Figure 1.** Research area location (red line boundary).

## METHOD

The primary data collection is conducted through a descriptive method, involving field observations that encompass descriptions, recordings, and measurements to understand the geological and tourism conditions at the research location. Some of the activities carried out during field observations include:

- Plotting the positions of geotourism locations and field data using GPS.
- Observing the location, including its condition, rock outcrops, and their characteristics, measuring the orientation and dip of rock layers, and measuring the thickness of layers.
- Observing indications of changes in lithology and geological structures. Measurements are also taken of these features.
- Collecting rock samples that represent rock units.
- Taking photographs of the location and interesting landforms.
- Completing field forms and assessing geotourism aspects such as the condition of public facilities and accessibility that support the location.
- Conducting interviews with local residents around the geotourism location if necessary.

Secondary data is obtained from sources such as satellite imagery, SRTM DEM, and digital maps, including geological maps and RBI maps.

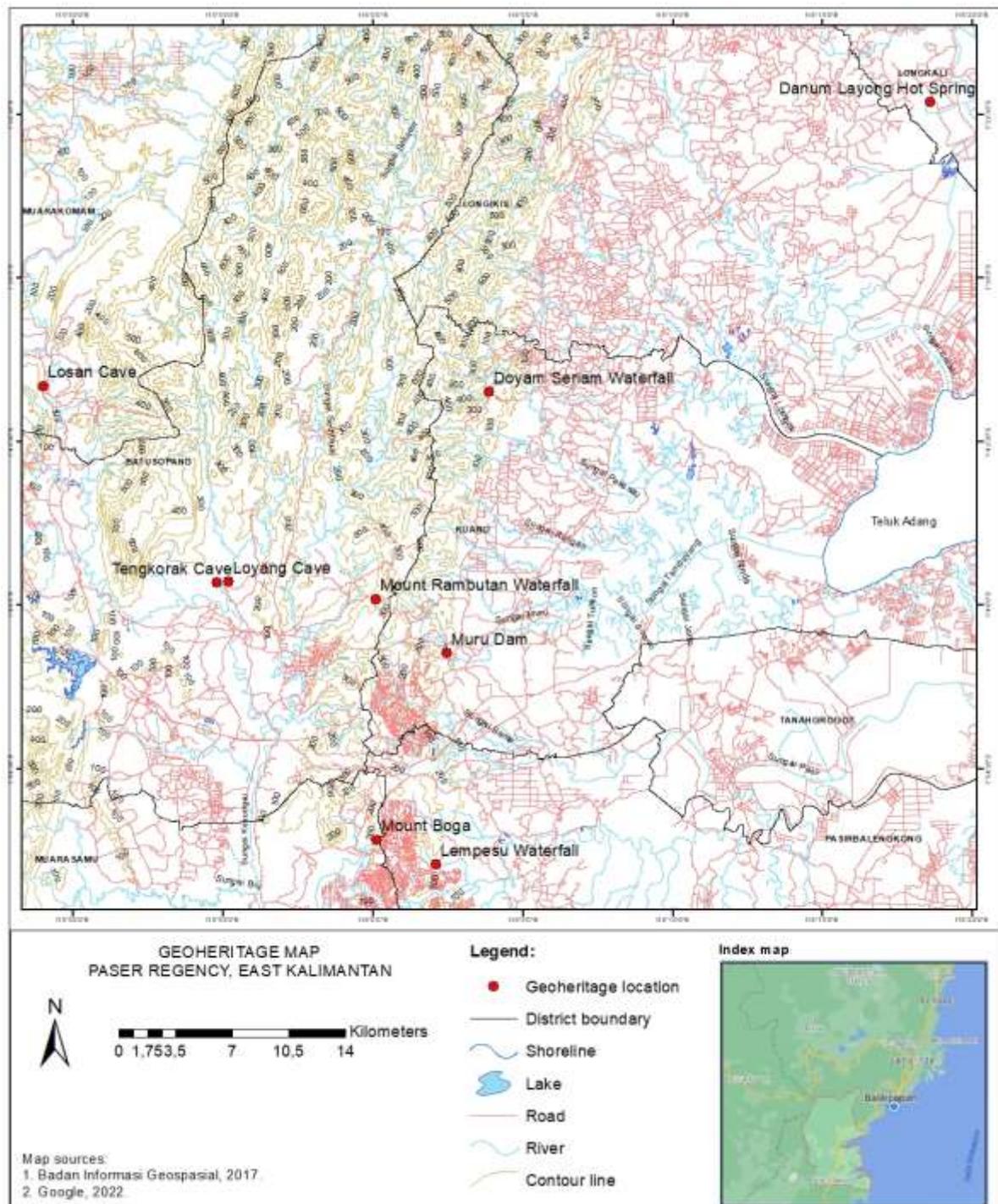
The analysis is conducted based on both primary and secondary data obtained with the aim of identifying locations that are suitable for prioritizing geotourism development. The analysis results in a geotourism map that provides information on geotourism locations. Petrological analysis is also performed to determine the detailed types and compositions of rocks at the geotourism locations, as well as to provide information about lithological characteristics for edu-geotourism purposes at those locations.

Quantitative analysis method has been employed at potential geoheritage locations that have been visited, and an assessment using the Kubalikova (2013) parameters has been conducted. This assessment is aimed at identifying geoheritage sites that are suitable for prioritizing in geotourism development in the research area. The final assessment is performed by calculating the average final score. Subsequently, the final score is examined to determine whether the geoheritage site is suitable for designation as a geotourism area. If the result is less than 50%, it indicates that the geoheritage location is less suitable and requires improvement in areas with lower scores. If the average final assessment score is above 50%, the geoheritage location is considered suitable. The evaluation using the Kubalikova (2013) parameters provides priority candidates for geoheritage sites that are suitable for geotourism. After obtaining the priority

candidates for geoheritage, the next step involves creating a map of geoheritage locations and their accessibility. The assessment carried out will be the basis for recommendations for development.

## RESULT AND DISCUSSION

Based on the field survey conducted in Paser Regency, nine locations with geotourism potential have been identified. The geotourism locations found include caves, waterfalls, hills, dams, and hot springs. These locations exhibit their unique characteristics, such as lithological variations originating from ancient rock formations, geothermal manifestations, or distinctive morphological features with natural scenery. The positions of these geotourism locations, as seen in Figure 2, consist of Danum Layong Hot Springs, Doyam Seriam Waterfall, Muru Dam, Mount Rambutan Waterfall, Loyang Cave, Tengkorak Cave, Losan Cave, Mount Boga, and Lempesu Waterfall.



**Figure 2.** Geoheritage map of Paser Regency.

Danum Layong Hot Springs (Figure 3) is located at coordinates 1.534505°S and 116.309592°E in Long Kali Village, Long Kali District. Access to this location is available by road, taking approximately 2 hours from Tanah Grogot or about 1.5 hours from Penajam. Danum Layong Hot Springs are situated at an elevation of 16 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Early Miocene Bebulu Formation (Tmbl). The lithology found at this location consists of massive limestone with intense jointing. The limestone represents part of a coral reef body, with the presence of coral fragments and mollusk shells. Danum Layong Hot Springs are believed to be a non-volcanic geothermal manifestation. The location features slightly turbid warm water with a distinct sulfuric aroma. There are pools that contain the hot spring water, allowing tourists to enjoy water activities. In addition to its scenic photographic opportunities, visitors can observe the presence of organisms on the limestone.



**Figure 3.** Danum Layong Hot Spring.

Doyam Seriam Waterfall (Figure 4) is situated at coordinates 1.697469°S and 116.064644°E, located in Modang Village, Kuaro District. Access to this location is available by road, taking approximately 2 hours from Tanah Grogot or about 1 hour from Kuaro. Doyam Seriam Waterfall is situated at an elevation of 169 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Jurassic Ultramafic Complex (Ju). The lithology found at this location consists of serpentinite and hazburgite with intense jointing. Quartz veins are also observed within the rocks. Doyam Seriam Waterfall exhibits a cascading morphology with relatively low cascades, ranging from 1 to 5 meters in height. The water flow is quite vigorous with clear water. The natural environment around the waterfall is well-preserved. At certain points along the waterfall, calm pools are formed, allowing tourists to enjoy water activities in addition to the waterfall itself. The waterfall is situated in a hilly area, making it a potential camping site for adventurous tourists who enjoy the outdoors.



**Figure 4.** Doyam Seriam Waterfall.

Muru Dam (Figure 5) is situated at coordinates 1.843901°S and 116.041301°E, located in Kuaro Village, Kuaro District. Access to this location is available by road, taking approximately 45 minutes from Tanah Grogot or about 15 minutes

from Kuaro. Muru Dam is situated at an elevation of 61 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Jurassic Ultramafic Complex (Ju). The lithology found at this location consists of serpentinite and hazburgite. These lithologies exhibit a highly intense jointing. Muru Dam is a man-made reservoir created by damming the Muru River, primarily for irrigation purposes in the surrounding area. This location is suitable for learning about dam morphology and geotechnical aspects related to earth sciences. Additionally, there are outcrops of rock formations along the dam's edge, which can serve as educational materials. The beautiful scenery and pristine atmosphere make this place a good spot for photography for tourists.



**Figure 5.** Morphology of Muru Dam.

Mount Rambutan Waterfall (Figure 6) is located at coordinates 1.813404°S and 116.001517°E, situated in Sungai Terik Village, Batu Sopang District. Access to this location is available by road, taking approximately 1 hour from Tanah Grogot or about 30 minutes from Batu Kajang. Mount Rambutan Waterfall is situated at an elevation of 231 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Jurassic Ultramafic Complex (Ju). The lithology found at this location consists of serpentinite and hazburgite, both exhibiting intense jointing. Mount Rambutan Waterfall is a cascade of water falling from a height of approximately 15 meters. The water flow is quite vigorous with clear water. The natural environment around the waterfall is well-preserved. There is a pool at the base of the waterfall, allowing tourists to enjoy water activities. This geotourism location is situated alongside the main road, making it a resting spot for travelers on long journeys.



**Figure 6.** Mount Rambutan Waterfall.

Loyang Cave (Figure 7) is located at coordinates 1.802785°S and 115.920747°E, situated in Kasungai Village, Batu Sopang District. Access to this location is available by road, taking approximately 15 minutes from Batu Kajang or about 2 hours from Tanah Grogot. Loyang Cave is a natural cave formation in a karst hill at an elevation of 80 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Oligocene to Early Miocene Berai Formation (Tomb). The lithology found at this location consists of thick massive

limestone. The limestone is part of a reef body, containing fragments of corals and mollusk shells. Loyang Cave is a natural cave formed through the process of karstification. Various formations, including stalactites and stalagmites, can be found within the cave. The cave has a sizable entrance. The natural environment around Loyang Cave is well-preserved. In addition to its suitability for photography, visitors can observe the presence of organisms in the limestone. The morphology of this geotourism location forms a hill, making it potentially suitable for climbing activities for adventurous tourists.



**Figure 7.** Loyang Cave entrance.

Tengkorak Cave (Figure 8) is located at coordinates 1.804252°S and 115.913034°E, situated in Kasungai Village, Batu Sopang District. Access to this location is available by road, taking approximately 15 minutes from Batu Kajang or about 2 hours from Tanah Grogot. Tengkorak Cave is a natural cave formation in a karst hill at an elevation of 68 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Late Eocene Tanjung Formation (Tet). The lithology found at this location consists of layered limestone with a thickness of approximately 10 meters. The rocks also exhibit intense jointing and contain larger foraminifera like *Lepidocyclina*. Tengkorak Cave is a natural cave formed through the process of karstification. It earned its name due to the presence of several human skulls and bones found in the cave. These skulls were placed in the cave by the local community in the past as a final resting place, just like in the Toraja region. The cave has an entrance that is not very large but can be navigated by adults. The natural environment around the cave is well-preserved. In addition to being a great spot for photography, visitors can observe the presence of organisms in the limestone. The location also features a river area, providing water-based recreational activities for tourists, with clear water and a relatively gentle current.



**Figure 8.** Tengkorak Cave entrance.

Losan Cave (Figure 9) is located at coordinates 1.693974°S and 115.816700°E, situated in Batu Butok Village, Muara Komam District. Access to this location is available by road, taking approximately 45 minutes from Batu Kajang or about 2 to 3 hours from Tanah Grogot. Losan Cave is a natural cave formation in a karst hill at an elevation of 95 meters above

sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Oligocene to Early Miocene Berai Formation (Tomb). The lithology found at this location consists of thick massive limestone. The limestone is part of a reef body, containing fragments of corals and mollusk shells. Losan Cave is a natural cave formed through the process of karstification. The cave features various formations, including stalactites and stalagmites. The cave has an entrance that is not very large but can be navigated by adults. The natural environment around the cave is well-preserved. In addition to its suitability for photography, visitors can observe the presence of organisms in the limestone.



**Figure 9.** Losan Cave ornaments.

Mount Boga, also known as Mount Embun (Figure 10), is located at coordinates 1.948006°S and 116.002280°E, situated in Luan Village, Muara Samu District. Access to this location is available by road, taking approximately 1 hour from Tanah Grogot. Mount Boga is a hilly landform at an elevation of 215 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is within the Jurassic Ultramafic Complex (Ju). The lithology found at this location consists of serpentinite and hazburgite. These lithologies exhibit highly intense jointing, and some quartz veins are also present. Mount Boga represents an elevation with a beautiful surrounding morphological landscape. In the morning, the lower surrounding areas are often covered in mist, giving the impression that this location is above the clouds. This location is a great spot for photography for tourists, offering picturesque landscapes and rock outcrops. Furthermore, it also serves as a camping site for adventurous travelers who enjoy outdoor experiences.



**Figure 10.** Morphology of Mount Boga.

Lempesu Waterfall (Figure 11) is situated at coordinates 1.961137°S and 116.035228°E, located in Lempesu Village, Pasir Belengkong District. This location is accessible by road, approximately 30 minutes to 1 hour from Tanah Grogot. It can also be reached from Mount Boga in about 15 minutes. Lempesu Waterfall is situated at an elevation of 21 meters above sea level. According to the Geological Map of the Balikpapan Sheet by Hidayat and Umar (1994), this location is

at the contact between the Jurassic Ultramafic Complex (Ju) and the Cretaceous Haruyan Formation (Kvh). The lithology found at this location includes basaltic lava presumed to be from the Haruyan Formation and serpentinite presumed to be from the Ultramafic Complex. These lithologies are intersected by a horizontal fault, which also acts as the contact between the formations. Additionally, intense jointing has intersected these lithologies, creating an appearance of layering. Furthermore, limestone lithology, originating from the Kuaro Formation (Tek), can be found unconformably overlying the basaltic lava and serpentinite. In certain areas, limestone formations form caves. Lempesu Waterfall exhibits a cascading morphology with relatively low cascades, ranging from 1 to 4 meters in height. The water flow is quite vigorous with clear water. The natural environment around the waterfall is well-preserved. At some points along the waterfall, calm pools are formed, allowing tourists to enjoy water activities in addition to the waterfall itself.



**Figure 11.** Lempesu Waterfall morphology.

Nine locations with the potential to be designated as geoheritage sites in Paser Regency have been subjected to quantitative analysis using the Kubalikova parameter (2013). Based on the assessments conducted (Table 1), these nine locations have achieved percentage values exceeding 50%, indicating their strong potential as geoheritage sites. Furthermore, these locations can be prioritized as supporting sites for geotourism areas in East Kalimantan.

**Tabel 1.** Kubalikova assessment of Paser District geoheritages.

No	Geoheritage Location	Assessment Aspect (Kubalikova, 2013)																				Total	Persentase (%)
		Intrinsic and Scientific Value				Educational Value				Economic Value			Conservation Value				Additional Value						
		A	B	C	D	A	B	C	D	A	B	C	A	B	C	D	A	B	C	D	E		
1	Danum Layong Hot Spring	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	13,5	72,97
2	Doyam Seriam Waterfall	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	12	64,86
3	Muru Dam	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	13	70,27
4	Mount Rambutan Waterfall	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	13	70,27
5	Loyang Cave	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	13	70,27
6	Tengkorak Cave	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	14	75,68
7	Losan Cave	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	13,5	72,97
8	Mount Boga	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	13,5	72,97
9	Lempesu Waterfall	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	12	64,86

## CONCLUSION

The Paser Regency has 9 locations that hold significant potential as geoheritage based on geological characteristics and Kubalikova assessment, namely Danum Layong Hot Springs, Doyam Seriam Waterfall, Muru Dam, Mount Rambutan Waterfall, Loyang Cave, Tengkorak Cave, Losan Cave, Mount Boga, and Lempesu Waterfall. Enhancing these geoheritage is necessary, encompassing both infrastructure development and sustainable management, to ensure that tourists can enjoy their visits comfortably.

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