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| Research Article |

# Modern Ripples and Oxide Limestone at Pasir Padi Beach, Pangkalpinang, Bangka Belitung Province, Indonesia: A Case for Geotourism Development

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**Abstract:** Bangka Island, located in the eastern coast of Sumatra, is part of Indonesia's unique and diverse geological heritage. Despite its potential, many of its coastal geosites remain poorly exposed and managed in terms of geoheritage value and geotourism development. This study focuses on Pasir Padi Beach, Pangkalpinang, aiming to evaluate its potential as a geotourism site using a integrated approach consisted of field surveys, geosite inventory assessment, and petrographic analysis of oxide limestone from the Tanjung Genting Formation. Observations captured well-preserved modern ripple structures and dynamic shoreline processes that reflect active coastal sedimentation processes, offering valuable knowledge for both education and research. The site accessibility, combined with its past and modern geological features, showing it as a potential natural field laboratory for coastal sedimentology and geomorphology. Furthermore, the development of geotourism in this area bring a positive impact for supporting local economies through community engagement and sustainable tourism practices. The results support the inclusion of Pasir Padi Beach in Bangka Island geoheritage planning and recommend further efforts toward site conservation, interpretation, and integration into local tourism strategies towards becoming geoeducational field laboratory.

**Keywords:** Geotourism, Pasir Padi Beach, Pangkalpinang, Tanjung Genting Formation

## INTRODUCTION

Geotourism is a branch of tourism that places geological, geomorphological, and landscape features at the center of its appeal, while emphasizing the principles of sustainability, education, and environmental stewardship (Newsome & Dowling, 2025; Brilha, 2018; Kubalikova, 2013; Hose, 2012). Within the broader framework of geoheritage management, geotourism plays an imperative role as a medium for empowering earth science education and local economic, as well as for fostering conservation awareness (Adriandra et al., 2025; Ansori, 2018; Hadian & Suganda, 2023). Moreover, geotourism offers a means of reconciling the need to conserve geological and natural resources with the pursuit of sustainable, tourism-based economic development (Reynard et al., 2016).

As global awareness of the importance of geoheritage protection continues to grow, many regions around the world are increasingly developing their geotourism potential to support sustainable development goals (SDGs), particularly in the areas of education, environmental conservation, and local economic growth (Newsome & Dowling, 2025). As an archipelagic nation with high geological diversity, Indonesia holds significant opportunities to advance geotourism as part of its national strategy for sustainable tourism development.

The Bangka Belitung Islands Province is one such region endowed with abundant geological resources and distinctive coastal geomorphological characteristics. Located in the eastern part of Sumatra, the archipelago consists of numerous large and small islands formed through tectonic processes and the weathering of ancient granitic rocks (the Pemali and Klabat Formations) (Hall, 2014; Metcalfe, 2013; Hutchison, 1994). In addition to its mineral resources—particularly tin—the region offers geological attractions such as white-sand beaches, massive granite formations, and dynamic tropical coastal systems.

Pasir Padi Beach, located in Pangkalpinang City, is one of the principal coastal areas on Bangka Island (Figure 1). The beach features a distinctive landscape characterized by fine white sand, an extensive and gently sloping shoreline, and a coastal ecosystem that remains relatively undisturbed (Figure 1).

Geologically, this area forms part of a coastal system shaped by fluvial and marine sedimentation, offering significant potential for coastal geological interpretation to both the general public and visitors (Figure 1).

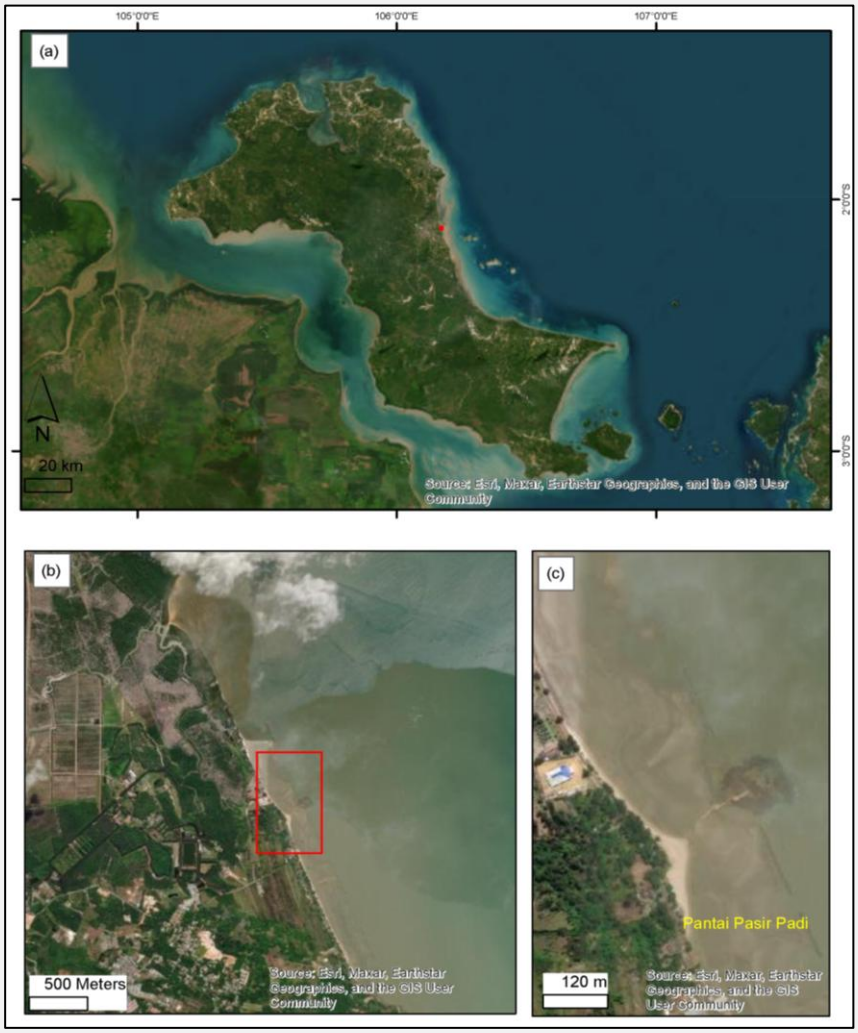


Figure 1. (a) Satellite view of Bangka Island, Indonesia. (b) Zoom in view of Pangkalpinang City. (c) Aerial view of Pasir Padi Beach with shoreline morphology.

Although Pasir Padi Beach has long been recognized as a local tourist destination, its geological values and geotourism potential have yet to be fully identified or utilized. Unlike other geosites in the Bangka Belitung region that have been incorporated into geopark networks or designated conservation areas (Zukhri, 2021), Pasir Padi Beach has not yet received adequate attention in the context of geoheritage. In fact, the area possesses notable advantages in terms of accessibility, visual appeal, and opportunities for integrating tourism, education, and conservation.

Furthermore, geotourism development at Pasir Padi Beach could serve as a strategic starting point for introducing geotourism approaches in the Pangkalpinang area, which has traditionally been dominated by mass tourism centered on recreational beach activities. With an appropriate developmental framework, the site could be cultivated as an open-air Earth science laboratory for education in structural geology, tectonics, sedimentology, coastal geology, and community-based sustainable geotourism models.

This study aims to identify and evaluate the geotourism potential of Pasir Padi Beach using geoheritage criteria and a sustainability-based approach. The research focuses on compiling an inventory of geoheritage elements within the area, analyzing their scientific, educational, aesthetic, and economic values, and assessing both the site readiness and the local community capacity for developing geotourism.

In addition, the study seeks to provide recommendations for sustainable geotourism development and enhance its potential to be the first earth science field laboratory in the region. Guided by these objectives, the research further explores broader implications by addressing key questions concerning the geological and geomorphological features at Pasir Padi Beach that possess geoheritage value, the feasibility of developing the area as a geotourism destination, and the challenges and opportunities associated with its geotourism development.

## MATERIAL & METHODS

### Data Colection

In this study, we combined a literature review with direct field observations of the rock outcrops present at Pasir Padi Beach, including observations of morphology and modern sedimentary processes, as well as sample collection for microscopic analysis of rock characteristics. The literature review was used to obtain a comprehensive explanation of the geological conditions and history of Pasir Padi Beach as an object of sustainable geotourism potential grounded in Earth science. Petrographic analysis was conducted on one oxide limestone sample that was sectioned in three different orientations from the same specimen. One petrographic thin section was cut perpendicular to the bedding, while the other two thin sections were cut parallel to the bedding.

### Evaluation Framework

In assessing the geosite inventory criteria of Pasir Padi Beach, we relied on field observation data as the main source for the preparation of the quantitative assessment. These observations include observations of the lithology characteristics, geological structures, geomorphological processes that are still ongoing, and the surrounding environmental conditions that can influence the integrity of the geosite. The data were then processed systematically so that they are able to describe the actual condition of the geosite in a more measurable way. With this approach, the assessment results are not only descriptive, but also reflect objective values based on the indicators that have been determined so that they can be scientifically accounted for.

The assessment framework that was used refers to the geosite assessment criteria developed by Brilha (2016) and Kubalikova (2013), which at present has become one of the most widely cited methods in geoconservation studies (Adrianda et al., 2025). This method has been used globally in various tectonic setting, and geomorphological landscapes. The framework is designed to assess a geosite from various aspects, starting from its scientific value and educational potential to its vulnerability to disturbance and its management needs. Kubalikova's approach offers a clear and standardized assessment structure, thus allowing comparison between geosites in different regions (Table 1). In addition, this method provides detailed indicator boundaries, making it easier for researchers to understand the components that are most influential in determining the strategic value of a geosite.

Table 1. Criteria, indicators, and parameters used for the quantitative assessment of the potential value of geosites from Kubalikova (2013).

| Assessment Dimension | Criterion | Score | Description |
|---|---|---|---|
| Scientific and Intrinsic Value | Integrity | 0 | Totally destroyed site |
| | | 0.5 | Disturbed site with visible abiotic features |
| | | 1.0 | Site without destruction |
| | Rarity (number of similar sites) | 0 | More than five similar sites |
| | | 0.5 | Two to five similar sites |
| | | 1.0 | Only site within the area of interest |
| | Diversity (number of features/processes) | 0 | One visible feature or process |
| | | 0.5 | Two to four visible features or processes |
| | | 1.0 | More than five visible features or processes |
| | Scientific knowledge | 0 | Unknown site |
| | | 0.5 | Scientific papers at national level |
| | | 1.0 | High scientific knowledge; monographic or detailed studies |
| Educational Value | Representativeness and visibility/clarity | 0 | Low representativeness and poor clarity |
| | | 0.5 | Medium representativeness, mainly for specialists |

| Assessment Dimension | Criterion | Score | Description |
|---|---|---|---|
| | | 1.0 | High representativeness and clarity for the general public |
| | Exemplarity and pedagogical use | 0 | Very low exemplarity and pedagogical potential |
| | | 0.5 | Existing exemplarity with limited pedagogical use |
| | | 1.0 | High exemplarity and strong potential for geodidactics and geotourism |
| | Existing educational products | 0 | No educational products |
| | | 0.5 | Leaflets, maps, or web pages |
| | | 1.0 | On-site information panels or interpretive facilities |
| | Actual educational use (excursions, guided tours) | 0 | No educational use |
| | | 0.5 | Site included in specialized excursions (e.g., students) |
| | | 1.0 | Regular guided tours for the public |
| Economic (Tourism) Value | Accessibility | 0 | More than 1000 m from parking area |
| | | 0.5 | Less than 1000 m from parking area |
| | | 1.0 | Less than 1000 m from public transport stop |
| | Presence of tourist infrastructure | 0 | Tourist facilities more than 10 km away |
| | | 0.5 | Tourist facilities within 5–10 km |
| | | 1.0 | Tourist facilities within 5 km |
| | Local products | 0 | No local products related to the site |
| | | 0.5 | Some local products related to the site |
| | | 1.0 | Site is emblematic for local products |
| Conservation Value | Actual threats and risks | 0 | High natural and anthropogenic risks |
| | | 0.5 | Existing risks that may disturb the site |
| | | 1.0 | Low risk; almost no threats |
| | Potential threats and risks | 0 | High natural and anthropogenic risks |
| | | 0.5 | Existing potential risks |
| | | 1.0 | Low potential risk |
| | Current conservation status | 0 | Ongoing destruction |
| | | 0.5 | Previously damaged, currently under management |
| | | 1.0 | No visible destruction |
| | Legislative protection | 0 | No legal protection |
| | | 0.5 | Protection proposed |
| | | 1.0 | Legal protection (e.g., natural monument, reserve) |
| Added Value | Cultural value (historical, archaeological, religious) | 0 | No cultural features |
| | | 0.5 | Cultural features weakly related to abiotic elements |
| | | 1.0 | Cultural features strongly related to abiotic elements |
| | Ecological value | 0 | Not ecologically important |
| | | 0.5 | Moderate ecological influence |
| | | 1.0 | Strong influence of geomorphology on ecological features |
| | Aesthetic value (colors, structure, viewpoints) | 0 | One color / one pattern / no viewpoints |
| | | 0.25 | 2–3 colors / 2–3 patterns / 1–2 viewpoints |
| | | 0.5 | >3 colors / >3 patterns / ≥3 viewpoints |

The application of the Kubalikova (2013) method is not only limited to one region but has also been widely used in various geological contexts around the world. One example of its application is on

Devonian–Carboniferous–aged geosites in Morocco, as reported by Naimi & Cherif (2021), which shows that this method is able to adapt to different geological characteristics. In Indonesia, the same method has been used in the assessment of geosites in the Karangsambung–Karangbolong National Geopark area (Ansori et al., 2022), thus providing an applied example that is close to the context of this study. The success of its application in various locations strengthens the belief that the Kubalikova (2013) approach is relevant to be used for evaluating the Pasir Padi Beach geosite, as well as serving as a basis for building management recommendations that are more effective and sustainable.

To further clarify the application of the Kubalikova (2013) method, the geosite assessment was conducted using a semiquantitative scoring system based on clearly defined criteria and indicators. Following Kubalikova (2013), Pasir Padi Beach geosite was evaluated across three main dimensions: scientific and intrinsic value, educational value, added value, and economic value, each composed of multiple criteria. For each criterion, qualitative field observations such as representativeness of geological features, degree of preservation, accessibility, safety, visibility of geological elements, and didactic potential were systematically interpreted and then translated into numerical scores using the standardized ordinal scale proposed by Kubalikova (2013). Scores were assigned based on predefined classes (Table 1), ensuring consistency and minimizing subjectivity.

The resulting aggregated scores were normalized to a 0–100 scale to allow comparison between dimensions and with other geosites evaluated in other studies. This come from each criterion that was then multiplied by its respective weighting factor, as defined by Kubalikova (2013), to reflect its relative importance within each assessment dimension. The weighted scores for individual criteria were summed to obtain the final value for each dimension (scientific, educational, additional, conservation, and economic). This structured procedure ensures that qualitative geological and socio-economic characteristics are assessed in a transparent, reproducible, and comparable manner, while still allowing expert judgment to be applied within a standardized framework.

## GEOLOGICAL & GEOMORPHOLOGICAL CHARACTERISTICS

Pasir Padi Beach has quite distinctive coastal geological characteristics, especially viewed from its sand composition, which is dominated by fine to medium quartz grains (Figure 1) (Akhrianti et al., 2024). The yellowish-white color of the sand indicates a high quartz purity, with little content of heavy minerals such as ilmenite and zircon—minerals commonly found in the Bangka region, which is rich in secondary tin deposits (Barber et al., 2005; Akhrianti et al., 2024). Its pattern shows a deposition process that occurs continuously, influenced by sea current dynamics and tidal activity. This process forms relatively stable coastal sediment layers, although they still show seasonal variations depending on wave intensity and rainfall. The presence of organic material and fragments of marine organism shells also contributes to enriching the characteristics of coastal deposits in this area.

Morphologically, the Pasir Padi shoreline tends to be gentle with a semicircular shape, reflecting relatively low wave energy dynamics (Akhrianti et al., 2024). In several locations, especially on the western part of the beach, there are small sand mounds or beach ridges formed by the accumulation of sediment during repeated tidal periods (Figure 1). Although they do not develop into large dune systems, these features still reflect active coastal morphological formation processes.

Changes in the shoreline occur gradually but consistently. Some zones show signs of abrasion, especially near residential areas and tourist facilities that do not have natural coastal protection (Akhrianti et al., 2024). This erosion is caused by a combination of human activities and increased wave energy during certain seasons. Conversely, there are also beach segments experiencing accretion or material addition, creating new zones with potential to be utilized as green open spaces or geotourism interpretation paths.

Geologically, the Pasir Padi Beach area is part of Quaternary sedimentary formations formed by fluvial and marine activities over thousands of years (Figure 2) (Barber et al., 2005). Bangka Island itself is composed of old granite rocks from the Klabat Granite Formation, which have undergone intensive weathering, producing sediment material that is then transported to the coast through river flow and wave activity (Barber et al., 2005; Hall, 2014; and Metcalfe, 2013). In the Early Triassic, the Tanjung Genting Formation was deposited in a shallow marine environment, consisting of metapsandstone, sandstone, sandy shale, and claystone with oxide limestone (Figure 2) (Barber et al., 2005; Hall, 2014; and Metcalfe, 2013).

The dominant geological processes in this area include physical and chemical weathering of granite, sediment transport by surface currents, and deposition in the tidal zone. In addition, regional tectonic processes also influence the slope patterns and elevation of the shoreline, although on a

relatively small scale. The interaction between these endogenous and exogenous processes is what forms the coastal geological character observed today.

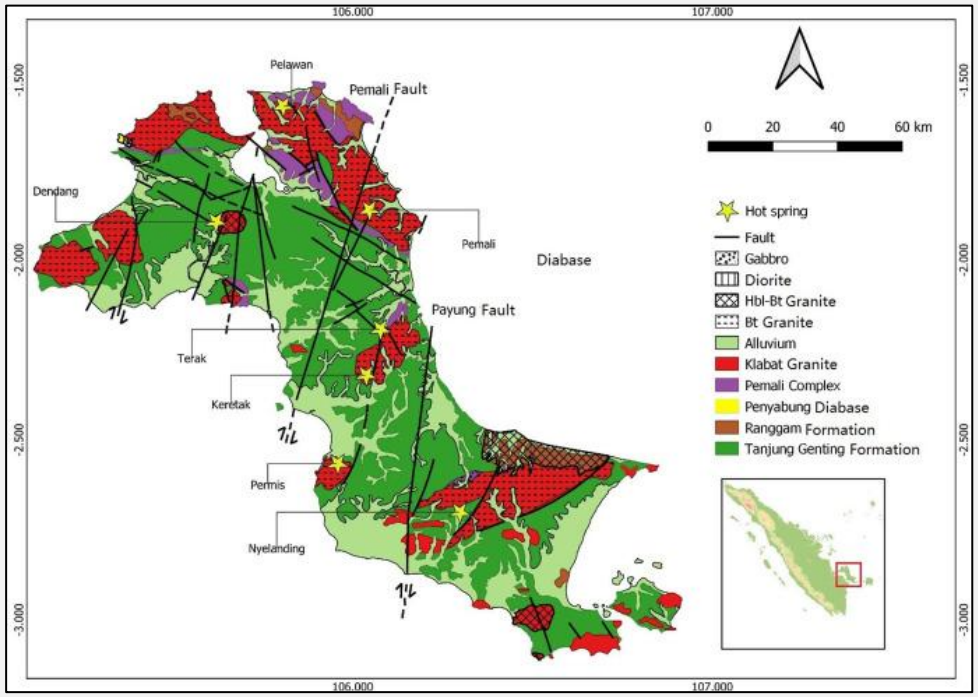


Figure 2. Geological map of Bangka Island (after Mangga & Djamal, 1994; Margono et al., 1995; Ng et al., 2017; Siregar et al., 2024).

## RESULTS & DISCUSSION

### Modern Sedimentary Process of Ripples

In addition to having rock outcrops, which are one of the important elements in geological studies, Pasir Padi Beach also contains other geological wealth in the form of coastal landscapes and the dynamic processes that shape them (Figure 3). The coastal landscape in this area reflects the long-term interaction between oceanographic factors, tidal dynamics, and sediment supply from the land, resulting in distinctive beach morphology. The diversity of these geomorphological features provides a strong basis for understanding how natural processes work continuously in shaping the Earth's surface over a relatively short timescale. This condition makes the coastal area of Pasir Padi Beach one of the locations that is interesting to study from the perspective of modern coastal geology.

In addition to its geomorphological value, Pasir Padi Beach also has great potential as a natural laboratory for studying various branches of Earth sciences, especially sedimentology and sediment transport dynamics. The activity of waves, currents, and wind in this coastal area creates patterns of sediment material distribution that can be observed directly in the field, making it an ideal location for research and observation-based learning. Variations in grain size, deposition patterns, and changes in beach surface morphology over time provide a real illustration of how physical processes work to regulate the movement and deposition of sediments. Thus, this area is not only scientifically rich but also has high educational value for students, researchers, and visitors who want to study coastal dynamics directly.

One of the sedimentary structures most easily found at Pasir Padi Beach is ripples, which commonly form in the intertidal to foreshore zone during low water conditions (Figures 1 and 3). The presence of these ripples indicates that the depositional environment at this beach is dominated by medium to low energy, allowing the formation of regular and easily observed ripple patterns. This structure is an important indicator that records the interaction between waves, tidal currents, and the influence of wind, which in this area generally comes from the northeast. The shape and orientation of the ripples not only provide information about flow direction and the strength of the acting energy, but also help in understanding the dynamics of modern sedimentation actively occurring at Pasir Padi Beach (Figure 3).


Figure 3. Pasir Padi shoreline view from land. (a) shoreline view during low tide outcropping the oxidize rock. (b) modern ripples with ongoing subaerial process. (c) modern ripples during the low tide showing tide current direction.

### Tanjung Genting Formation Outcrop

At Pasir Padi Beach, there is a peninsula consisting of outcrops of oxide limestone from the Tanjung Genting Formation. The limestone of the Tanjung Genting Formation at Pasir Padi Beach is generally grayish white to reddish-brown due to oxidation processes (Figures 3 and 4). This reddish color indicates a high content of iron oxide ($Fe_2O_3$), resulting from the weathering of ferromagnesian minerals. The texture of the limestone is generally fine crystalline to microcrystalline (sparite and micrite), with a massive and compact structure.

These rocks are exposed in relatively hard and compact conditions, showing small fractures and surface weathering that cause an intense reddish color (Figures 4 and 5). In several locations, small cavities are observed, which possibly result from dissolution or bioturbation activity. The internal structure is generally non-bedded (massive), but in some parts shows thin lamination that may indicate a calm depositional environment. The main composition is calcite ($CaCO_3$), with traces of clay minerals, fine quartz, and iron oxides. Surface oxidation processes show the alteration of iron-bearing minerals into hematite and goethite, which give the reddish color.

This limestone is interpreted to have formed in a calm shallow marine environment, such as a lagoon or carbonate platform (Nichols, 2009; Barber et al., 2005). These characteristics are reinforced by the presence of micritic structures and a few microscopic fossils such as foraminifera and fragments of marine organisms (Figures 3-5). The limestone undergoes oxidation on the surface due to interaction with tropical humid water and air, causing chemical weathering and the appearance of a reddish color. This process commonly occurs in carbonate rocks exposed in coastal areas with tropical climates, such as at Pasir Padi Beach.


Figure 4. (a,b) Outcrop view of Tanjung Genting Formation from distance, (c) zoom in of the claystone with oxide limestone outcrop.

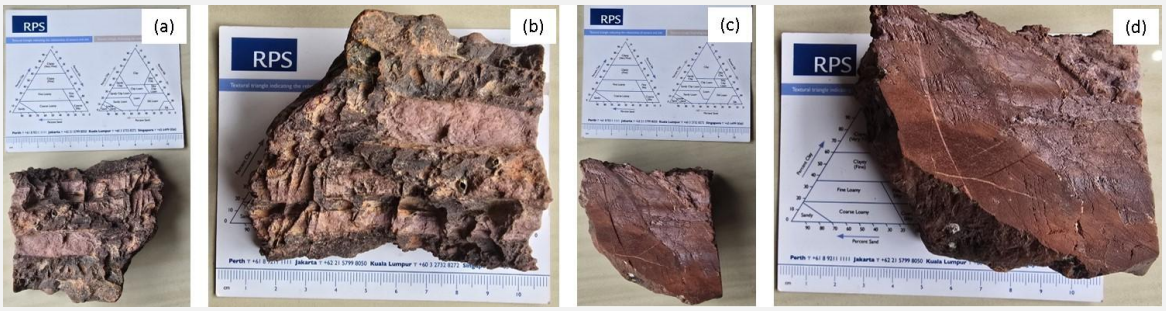


Figure 5. Hand samples of claystone with oxide limestone. (a,b) view showing the layering. (c,d) view showing the slabed side of the rock.

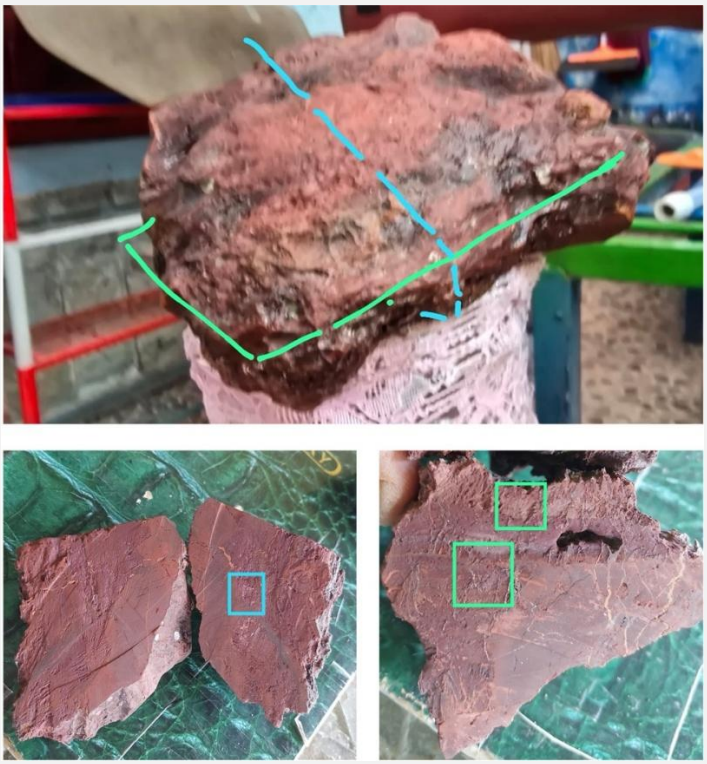

Figure 6. Rock sample for petrographic analysis. Blue line cut the rock perpendicular to the rock layer. Green line cut the rock parallel to the rock layer.

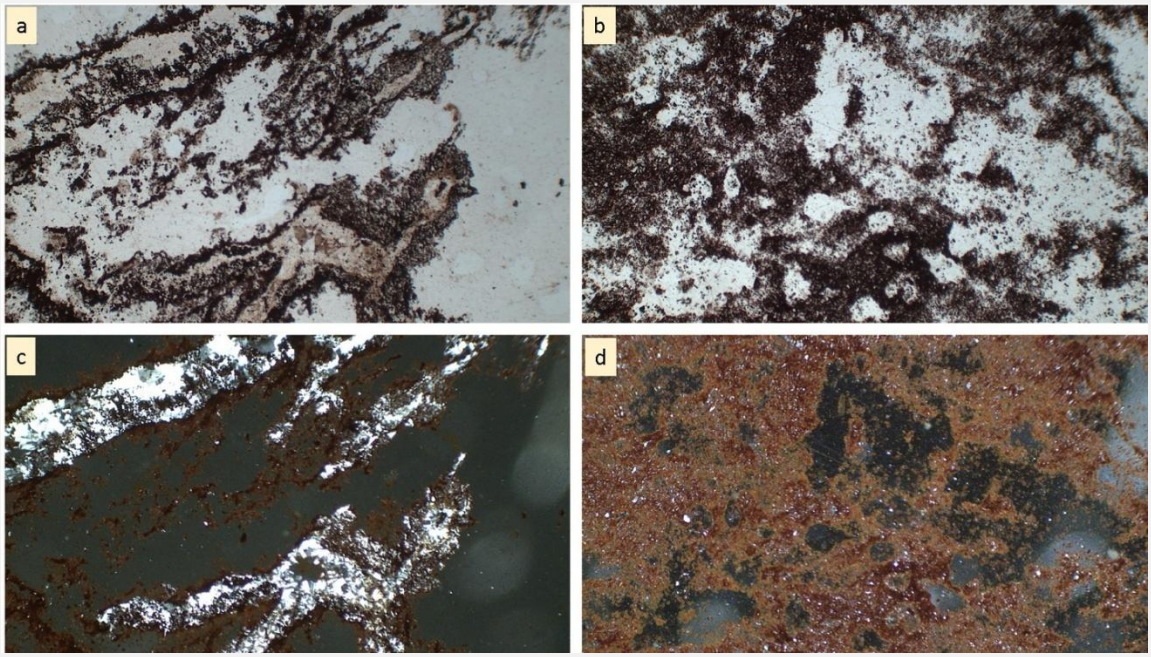


Figure 7. Petrographic view of the claystone with oxide limestone showing calcite veins in white coloured linear features and oxidation in red colour.. (a,b) Paralel nicol view. (c,d) cross nikol view.

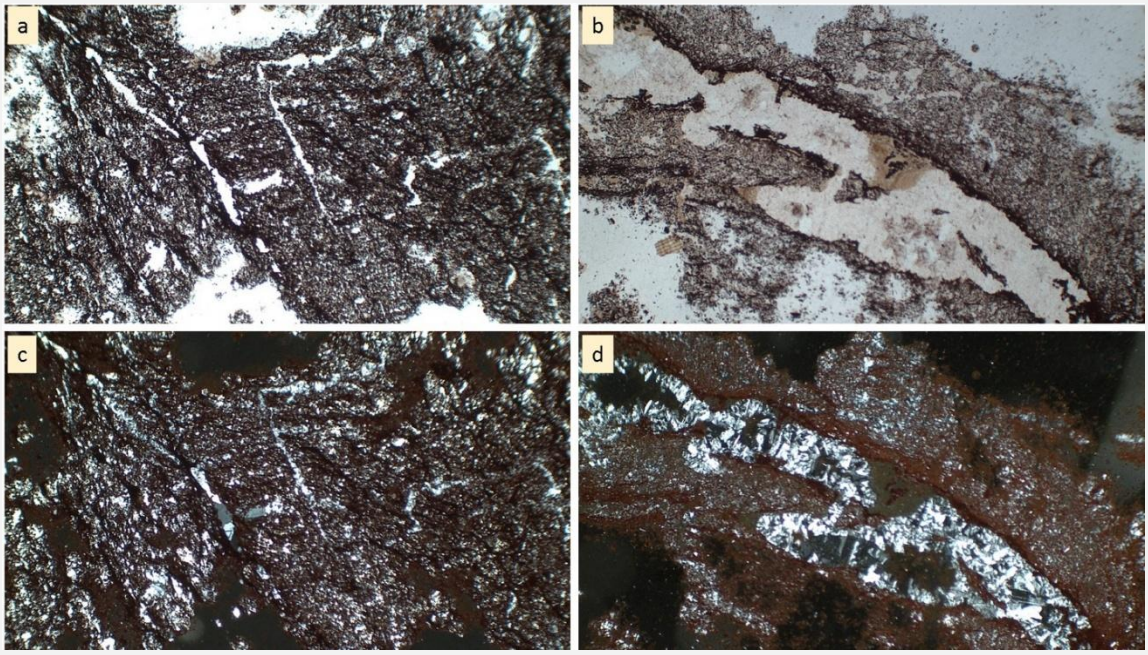


Figure 8. Petrographic view of the claystone with oxide limestone showing fractures filled with calcite mineral surrounded by oxidation. (a,b) Paralel nicol view. (c,d) cross nikol view.

Petrographic analysis from the field sample plays an imperative role in strengthening the scientific and educational value of the Pasir Padi Beach geosite by bridging microscale lithological characteristics to bigger scale observable geomorphology of coastal processes. Based on thin-section observations (Figures 6-9), the limestone is classified as micritic wackestone (Dunham, 1962) with a minor bioclastic component. The presence of iron oxides as pores and fractures filling indicates secondary oxidative alteration, which most likely related to meteoric waters transporting iron in an oxidized state ($Fe^{3+}$). This diagenetic overprint suggests a process of subaerial exposure and late stage diagenesis, that provides microscale evidence for typical tropical weathering and coastal evolution in the study area. These petrographic characteristics not only support the scientific significance of the Pasir Padi Beach Geosite, but also enhance its geoeducational potential by enabling complex processes such as oxidation, diagenesis, and exposure history to be interpreted by using an integration of both microscopic observations and readily observable macroscopic coastal features (Figures 10 and 11). Consequently, petrography analysis can contribute directly to the site geological interpretation as a dynamic coastal geoheritage asset rather than merely a descriptive lithological element.

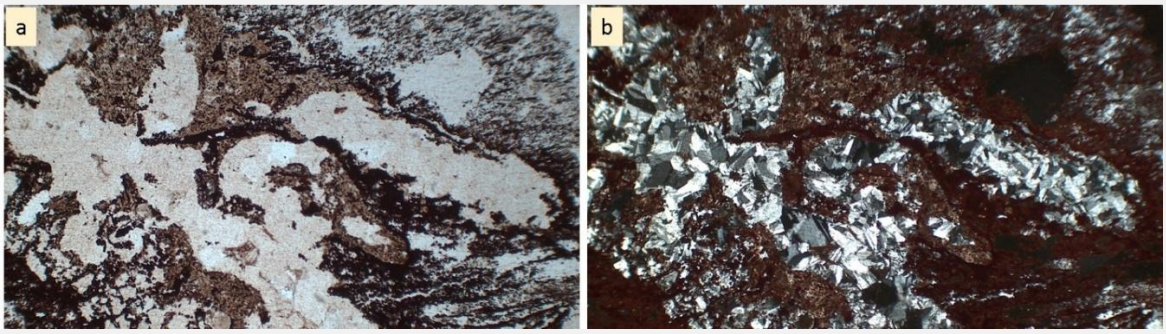


Figure 9. Petrographic view of the claystone with oxide limestone showing calcite mineralization accumulated in the porous areas during later diagenetic processes. (a,b) Paralel nicol view. (c,d) cross nikol view.

**Assessment metrics: scientific value, geoeducation, aesthetics, accessibility, conservation requirement**

The evaluation of Pasir Padi Beach as a potential geoheritage site was conducted using a set of standardized assessment metrics, including scientific significance, educational value, aesthetic quality, accessibility, economic potential, and conservation requirements (Table 2 & Figure 10). The results reflect the multifaceted value of this coastal site within the broader context of geotourism and sustainable heritage management.

Tabel 2. Assesments of Potential Geotourism Spots in Pasir Padi area.

| Parameter | | Pasir Padi Beach |
|---|---|---|
| Scientific and Intrisic Values | Integrity | 0,5 |
| | Rarity (number of similar sites) | 1 |
| | Diversity | 0,5 |
| | Scientific Knowledge | 1 |
| % | | 75% |
| Educational Values | Representativeness and Visibility/ Clarity of the Features / Processes | 1 |
| | Exemplarity, Pedagogical use | 1 |
| | Existing Educational Products | 0 |
| | Actual Use of a Site for Educational Purpose | 0.5 |
| % | | 62.5% |
| Economical Values | Accessibility | 1 |
| | Presence of Tourist infrastructure | 1 |
| | Local Products | 1 |
| % | | 100% |
| Conservational Values | Actual threat and Risk | 0,5 |
| | Potential Threat and Risks | 0,5 |
| | Current Status of a Site | 0,5 |
| | Legislative Protection | 0,5 |
| % | | 50% |
| Added Values | Presence of Cultural Value | 1 |
| | Ecological Value | 1 |
| | Aesthetical Value | 1 |
| % | | 100% |
| Mean | | 77.5% |

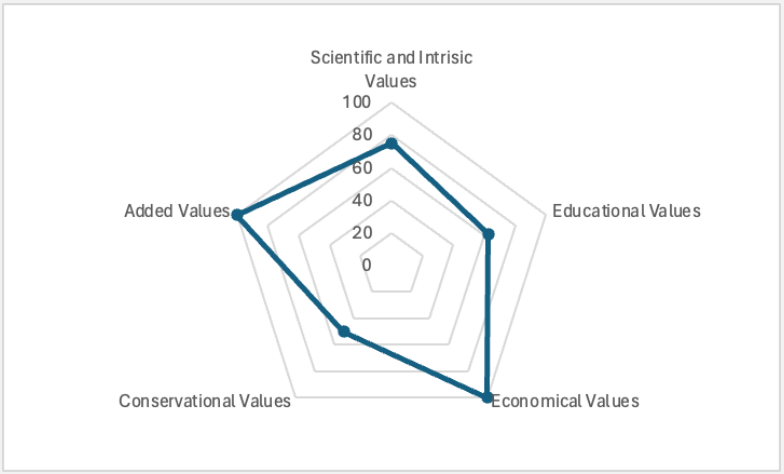


Figure 10. Digram of the geotourism potential tendencity values of Pasir Padi Beach geosite.

Scientific and intrinsic value received a high score of 75%, highlighting the site importance as a modern sedimentary environment. The presence of well-preserved ripple marks, active shoreline processes, and exposures of oxide limestone from the Tanjung Genting Formation provides an excellent

field setting for interpreting recent and ancient depositional systems. Tanjung Genting Formation is known as one of the oldest sediment deposits in western Indonesia. This formation was deposited during Mesozoic time. Pasir Padi Beach, in where the formation is exposed offers a unique and rare opportunity to explore this Pre-Tertiary deposits directly in the field. Tanjung Genting Formation is also known as oxided sediment that can also be seen in the petrographic analysis (Figures 7-9). These features make the site particularly valuable for sedimentological studies, as well as for comparative analysis with other shallow marine depositional settings in Southeast Asia (Figure 11).

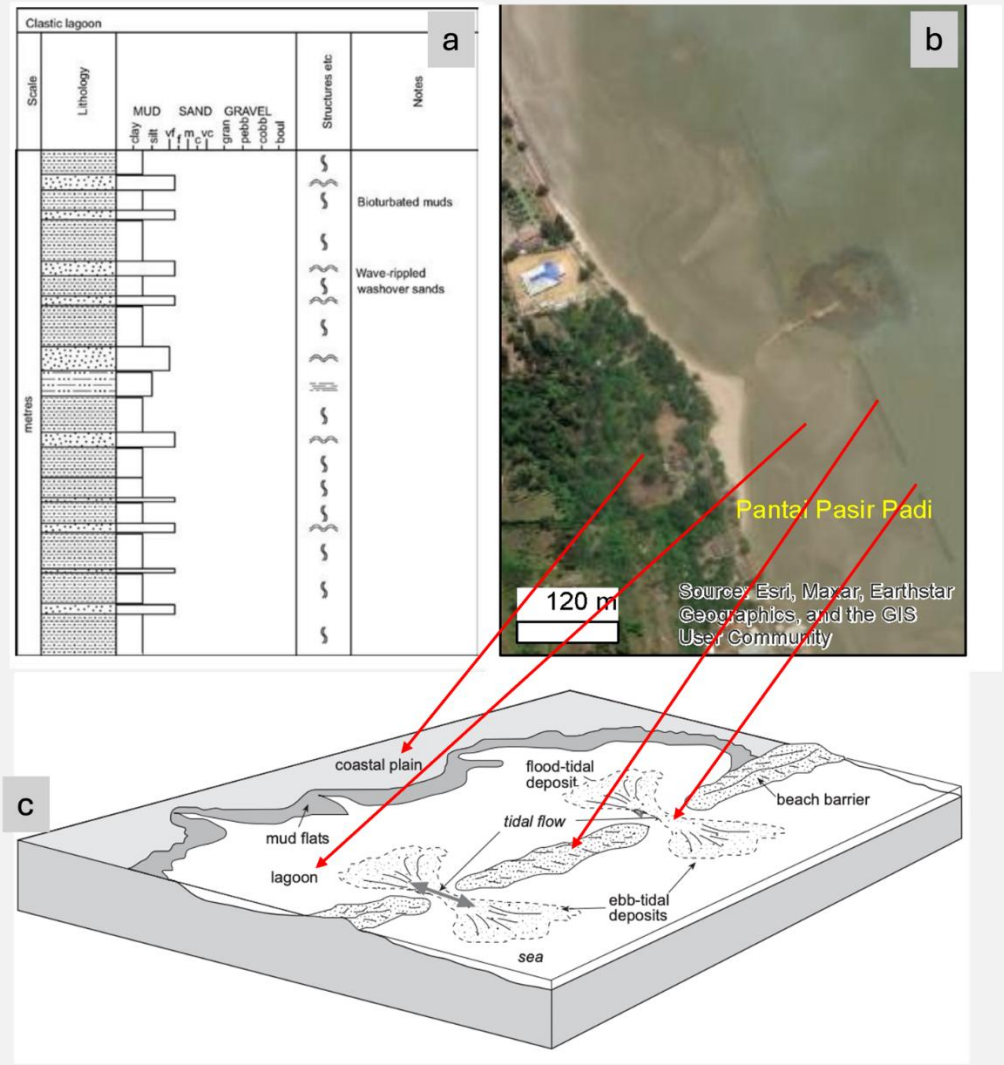


Figure 11. Sedimentological model of Pasi Padi Beach geosite. (a) sedimentological log of lagoon deposit. (b) Pasir Padi Beach geomorphic unit. (c) Schematic sedimentological models After Nichols (2009).

The educational value, while slightly lower at 62.5%, still indicates meaningful potential, particularly for targeted programs in geoeducation. The beach offers accessible and observable examples of primary sedimentary structures that can be used for outdoor learning by schools and universities. However, the current lack of interpretive infrastructure, such as signage, guided tours, or structured curricula, likely contributed to the moderate score. This highlights the need for investment in educational programming and collaboration with local academic institutions.

From an economic perspective, the site scored the highest, at 100, underlining its strong potential for community based geotourism. This high value comes from an established food, water park facilities, and management to organize the Pasir Padi Beach area and its surrounding. These established facilities increase the accessibility from the city, well-built tourism infrastructures such as hotel, and seafood

restaurant, and also local food product such as coconut and fish cake. Pasir Padi Beach is already a known recreational destination, and the integration of geotourism activities could enhance local livelihoods, diversify income sources, and stimulate small-scale tourism enterprises. This potential economic uplift, when paired with conservation-based tourism, positions the site as a strategic opportunity for sustainable development.

Similarly, added values which include cultural, recreational, and community relevance were rated at 100. The beach serves as a popular gathering space and is embedded in the cultural life of the local population. Its role as a communal area supports its candidacy not only as a natural heritage site but also as a socially embedded landscape that can bridge science and society. The aesthetic and visual appeal of Pasir Padi Beach, though not individually scored here, is evident in the Pasir Padi Beach wide, gently sloping shoreline, ripple sedimentological structures, and open sea views elements that contribute to a strong sensory experience for both casual visitors and scientific observers. These qualities align well with global standards for aesthetic value in geoheritage assessments.

In terms of accessibility, Pasir Padi Beach benefits from its proximity to the city center of Pangkalpinang and its ease of access via road infrastructure. This logistical advantage supports its feasibility as a site for frequent educational visits, public outreach, and tourism. However, the site growing popularity also necessitates consideration of its conservation requirements. Without proper management, the natural features particularly ripple structures that are sensitive to physical disturbance could be degraded by unregulated foot traffic or coastal development. A formal conservation plan, including zoning, visitor management, and interpretive infrastructure, will be essential to balance use and preservation. Overall, the mean value score of 80.1 indicates a high potential for Pasir Padi Beach to be developed as a geoheritage site. Its scientific and economic significance, combined with its cultural and educational promise, presents a compelling case for its inclusion in regional geotourism and geoheritage strategies. Strategic investment in geoeducation tools, conservation planning, and community engagement will be key to unlocking the full value of this coastal geosite.

## Discussion

Compared to several other geological sites in the Bangka Belitung Islands Province, such as Parai Tenggiri Beach or Tanjung Kelayang in Belitung, which have been designated as part of the Belitong National Geopark, Pasir Padi Beach displays a different but equally interesting character. The two locations in Belitung are known for their iconic giant granite exposures, which are the local geological hallmark. In contrast, Pasir Padi Beach does not offer spectacular granite landscapes, but its main strength lies in the uniqueness of its coastal sedimentary system and the modern processes that can be directly observed. This difference indicates that geological diversity in the archipelago is not only determined by prominent igneous rocks but also by continuously ongoing coastal dynamics (Zukhri et al., 2021; Akhrianti et al., 2024).

In addition to its geological uniqueness, Pasir Padi Beach has another advantage in the form of accessibility, as it is located near the center of Pangkalpinang City. This accessibility makes it easier for general visitors, students, and researchers to conduct field observations without requiring long travel or complex terrain conditions (Akhrianti et al., 2024). Beyond its easy access, the site offers an important opportunity to integrate macroscopic coastal features with microscopic petrographic characteristics, such as micritic wackestone textures, bioclastic components, and oxidation features related to subaerial exposure and tropical weathering. This integration strengthens the educational value of the site by enabling visitors to connect visible coastal landforms with underlying sedimentary and diagenetic processes. The potential integration between geological education aspects and mass tourism activities also becomes an added value, as this area can offer a more inclusive learning experience for the broader public. Thus, Pasir Padi can serve as an entry point for the public to learn about coastal geology without relying on more difficult-to-access locations.

On the other hand, the presence of active geomorphological elements such as erosion zones, shoreline changes, and small dune formation makes Pasir Padi Beach very relevant for education about dynamic geology. These features allow visitors to directly observe how natural processes occur and how coastal morphology can change over a relatively short period. With a well designed interpretative approach for example, through information boards, educational trails, or participatory monitoring programs this area has great potential to be developed as a supporting geosite within a broader geopark framework in the future. This potential strengthens the position of Pasir Padi as a location that is not only attractive for tourism but also contributes to public geological literacy (Newsome & Dowling, 2025; Zukhri et al., 2021).

## CONCLUSIONS & RECOMMENDATIONS

The assessment of Pasir Padi Beach reveals its strong potential as a geoheritage site with multifaceted value. Scientifically, the site presents an accessible and dynamic coastal environment featuring well-preserved ripple structures and exposures of oxide limestone, valuable for sedimentological and geomorphological studies. While current educational use remains limited, there is clear opportunity for development through structured geoeducation programs and interpretive infrastructure.

Economically, Pasir Padi Beach holds exceptional potential as a geotourism destination, offering significant community-based benefits and opportunities for sustainable local development. The site's cultural and recreational significance further enhances its intrinsic and added values, supporting its broader relevance beyond geology alone.

However, the increasing human activity in the area underscores the urgency of implementing conservation measures to protect its natural features. Establishing site-specific management plans, educational outreach, and stakeholder involvement will be essential to ensure the sustainable use of this geosite.

In conclusion, Pasir Padi Beach meets key criteria for geoheritage designation and merits inclusion in regional geotourism and conservation planning. Its development as an educational and economic resource should be pursued with balanced attention to preservation, accessibility, and community engagement.

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