Laporan PPMI
KK PVG 2026

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10. Draft 2 paper untuk Q1

The Geodiversity of Ranah Minang Silokek Geopark, West Sumatra: Geodynamic Storytelling Through Geosites and Geological Landscapes

Program Utama Unggul - Penelitian, Pengabdian kepada Masyarakat, dan Inovasi (PPMI)

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Background

The Ranah Minang Silokek Geopark (RMSG) in West Sumatra is a National Geopark aspiring for UNESCO Global Geopark (UGGp) status. A critical prerequisite for this recognition is demonstrating the international significance of its geoheritage, which hinges on its geodiversity. The RMSG uniquely records nearly 300 million years of Sumatra's tectonic history, from Paleozoic basement to Cenozoic basin evolution, a narrative rarely emphasized by other Indonesian UGGps. Evaluating this geodiversity is essential to establish its scientific value and support its candidacy for global recognition.

Keyword: Geodiversity, Geoheritage, Sumatra Geodynamics, RMSG.

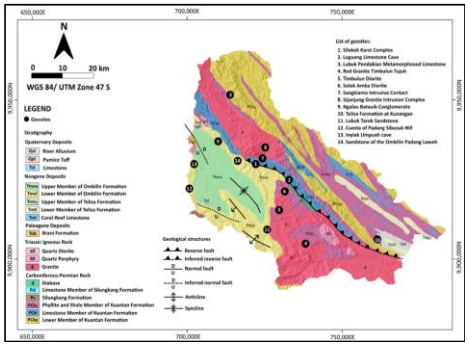
Research Objectives

This study aims to provide a preliminary qualitative inventory of the RMSG's geodiversity to evaluate its international significance. It further seeks to characterize the lithological, stratigraphic, and geomorphological diversity across 14 representative geosites. Furthermore, a benchmarking approach is employed to compare the RMSG's geological themes with existing UGGps. Overall, this study is expected to provide a coherent geodynamic narrative that supports the RMSG's nomination as a UNESCO Global Geopark.

Research Methods

This study applies a qualitative geodiversity assessment combining secondary data review, field investigations at 14 geosites, and cross-validation. The assessment focuses on three principal criteria: representativeness, uniqueness, and integrity/completeness.

Benchmarking against existing UGGps with comparable subduction and volcanic arc themes was conducted to evaluate international significance.



Picture 1. Geological map of the RMSG area, showing the distribution of lithological units and major structural features such as faults and folds.

Discussion and Result

The 14 geosites reveal an exceptional geological record spanning from the Carboniferous to the Quaternary. The Paleozoic Kuantan Formation hosts extensive tropical karst landscapes (Silokek Karst Complex), while Triassic granitoid intrusions (e.g., Sangkiamo Intrusive Contact) record Mesozoic magmatism. Cenozoic basin evolution is captured in the Oligocene syn-rift conglomerates and Miocene sedimentary sequences of the Ombilin Basin. These features collectively narrate Sumatra's evolution from Gondwana origins to Sunda Arc subduction.

The Paleozoic Kuantan Formation is best represented by the Silokek Karst Complex, featuring towering karst cliffs, cave systems, and speleothems developed in Carboniferous–Permian limestones. This karstification began in the Neogene when the limestone was exposed by the Takung Fault. In contrast, the Triassic Sangkiamo Intrusive Contact provides a rare, well-exposed boundary between Triassic granite and the older Kuantan limestone, recording a complex history of magma emplacement and subsequent tectonic deformation. These two geosites together illustrate the transition from Paleozoic carbonate deposition to Mesozoic magmatic intrusion.



Picture 2. Geodiversity of the Silokek Karst Complex; (a) Karst cliffs of the Kuantan Formation along the Kuantan River. (b) Stalactites inside the cave. (c) A cave pillar formed by the joining of a stalactite and stalagmite. (d) Shear fractures in the limestone near Ngalau Basurek Cave.



Picture 3. The geosites that represent the Triassic igneous rock: (c) Solok Amba Diorite with hydrothermal alteration. (d) Sangkiamo Intrusive Contact, showing the intrusive boundary between Triassic granite and Carboniferous–Permian limestone.

The Cenozoic Era is characterized by the formation and filling of sedimentary basins in response to regional extension and subsequent transgression. The Ngalau Batauik Conglomerate records the Oligocene syn-rift deposits of the Ombilin Basin, while the Early–Middle Miocene Telisa and Ombilin Formations preserve transitional marine to fluvial sequences, including fossiliferous shales and coal intercalations. Benchmarking against existing UGGps reveals that the RMSG's long-term tectono-stratigraphic narrative from Paleozoic basement to Cenozoic basin is underrepresented in the Indonesian geopark network, which mostly emphasizes volcanic or karst themes. This positions the RMSG as a complementary candidate with high international significance.

In conclusion, the RMSG's geodiversity is exceptional and merits UGGp nomination; future work should focus on quantitative geosite assessment, petrographic analysis of the granitoids, and geoconservation strategies to ensure sustainable management.



Picture 4. Geosites that represent the Cenozoic deposits in Central Sumatra Basin and Ombilin Basin: (a) Ngalau Batauik as the rift deposit of Ombilin Basin. (b) Telisa Formation outcrop at Kunangan. (d) Cuesta of Padang Sibusuk Hill. (e) Inyiak Umpuah Cave exhibits a sandstone cave.

Outputs and Program Sustainability

This study has produced a preliminary geodiversity inventory that substantiates the RMSG's nomination for UNESCO Global Geopark status. Moving forward, the program will focus on quantitative geosite assessment, detailed petrographic analysis of the granitoids, and geoconservation planning to support sustainable geotourism. These future investigations will ensure that the RMSG's geological heritage is recognized internationally and managed sustainably for research, education, and local community benefit.

References

Microstructural Constraints on Syn- to Post-Magmatic Deformation of North Bangka Granitoids, Indonesian Segment of the Southeast Asian Tin Belt

Program Utama Unggul - Penelitian, Pengabdian kepada Masyarakat, dan Inovasi (PPMI)

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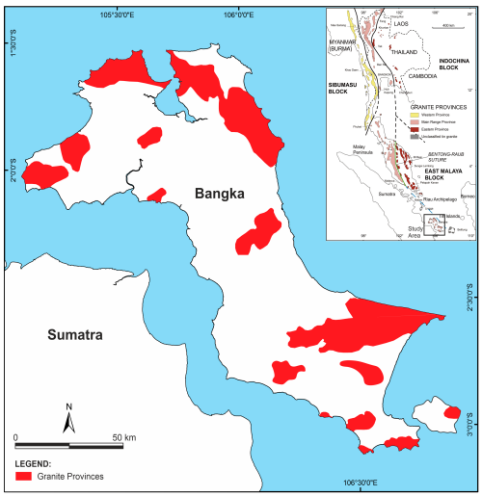
Background

The Southeast Asian Tin Belt (SATB) is one of the world's most significant metallogenic provinces, extending from Myanmar to the Indonesian islands of Bangka and Belitung. North Bangka is dominated by the Late Triassic–Early Jurassic Klabat Granite Complex, emplaced into older metasediments and mafic intrusions during the Sibumasu-Indochina collision. The regional architecture is controlled by NNW–SSE and NNE–SSW fault sets, which exerted a first-order control on the emplacement geometry and post-emplacement deformation of the granitoids. While previous studies have established their geochemical affinity and age, the textural and microstructural record of syn- to post-magmatic deformation remains poorly documented. This gap limits our understanding of how pluton emplacement and cooling are linked to the regional tectono-magmatic evolution of the SATB.

Keyword: Granitoid, Microstructure, Deformation, Southeast Asian Tin Belt, Bangka



Picture 1. Spatial distribution of granite provinces on Bangka Island, Indonesia, with granite-bearing areas shown in red.

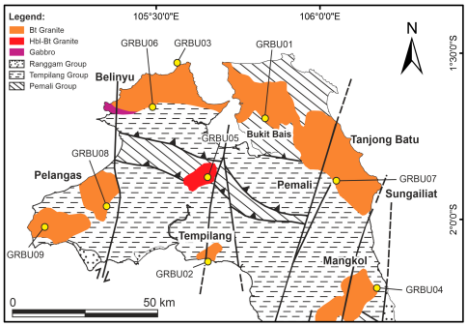
Research Objectives

This study aims to characterize the modal mineralogy and rock classification of North Bangka granitoids through systematic point counting. It further seeks to document the succession of deformation microstructures across the identified lithological types (syenogranite, monzogranite, and quartz syenite).

Furthermore, a microstructural approach is employed to reconstruct the temperature-deformation path and evaluate its implications for the regional tectonic history of the Southeast Asian Tin Belt. Overall, this study is expected to resolve whether the deformation was primarily syn-magmatic or post-magmatic tectonic reactivation.

Research Methods

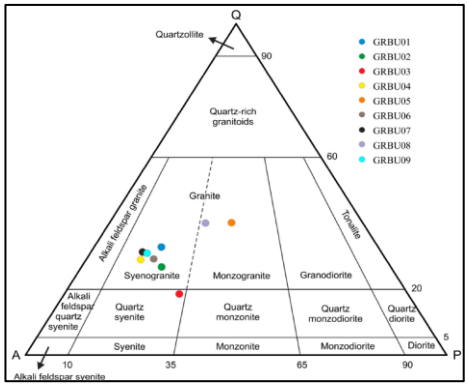
This study integrates petrographic and microstructural analyses of nine representative granitoid samples collected across North Bangka. Modal mineral proportions were quantified through systematic grid-based point counting (3,608 points per section) and classified using the QAP diagram. Microstructural analysis was conducted to identify deformation mechanisms, with relative temperature conditions inferred from established recrystallization regimes: bulging (BLG; <400 °C), subgrain rotation (SGR; 400–500 °C), and grain boundary migration (GBM; >500 °C). This approach enables the reconstruction of a temperature-deformation path from suprasolidus to low-temperature subsolidus conditions.



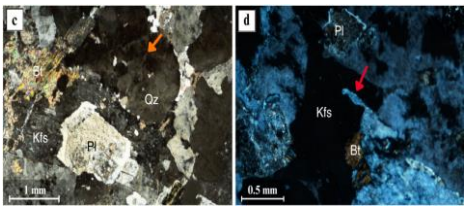
Picture 2. Geological map of the study area and distribution of granitoid samples.

Discussion and Result

The North Bangka granitoids are classified as syenogranite, monzogranite, and quartz syenite. Microstructural analysis reveals a progressive high-temperature deformation history. The early suprasolidus stage (>650 °C) is marked by submagmatic fractures and chessboard quartz. During subsequent high-temperature subsolidus cooling (650–450 °C), deformation continued via grain boundary migration (GBM), subgrain rotation (SGR), and bulging recrystallization (BLG), alongside myrmekite and flame perthite formation.

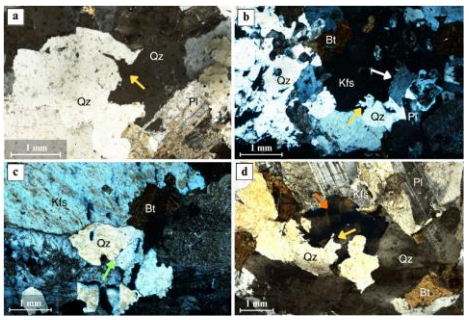


Picture 3. QAP modal classification diagram showing the compositional range of North Bangka granitoids



Picture 4. (c) chessboard pattern extinction in quartz (orange arrow); (d) submagmatic fractures of quartz-filled microfractures in feldspar crystals (red arrow).

The final low-temperature subsolidus stage (<450 °C) is evidenced by undulose extinction, deformation twins, and kink bands in feldspar and mica. This progressive sequence demonstrates that the North Bangka granitoids record a prolonged history of syn- to post-magmatic deformation linked to the regional tectono-magmatic evolution of the Southeast Asian Tin Belt. In conclusion, these microstructural records provide a crucial window into the Sibumasu-Indochina collision history. Future work should integrate geochronological and thermometric analyses to refine the deformation timeline and its implications for tin mineralization.



Picture 5. (a) GBM showing a lobate grain boundary of quartz (yellow arrow); (b) flame perthite (white arrow) and GBM showing a lobate grain boundary of quartz (yellow arrow); (c) BLG in quartz grain (green arrow); (d) GBM showing a lobate grain boundary of quartz (yellow arrow) and chessboard pattern quartz (orange arrow).

Outputs and Program Sustainability

This study has produced a detailed microstructural record linking the emplacement and cooling of North Bangka granitoids to regional tectonics. Moving forward, the program will integrate geochronology and quantitative thermometry to refine the deformation timeline. These investigations will contribute to a broader understanding of the Southeast Asian Tin Belt's metallogenic evolution and support sustainable mineral exploration strategies.

References

Integrating Geological Evolution and Spatial Connectivity In Geotrail Design: A Framework from the Ijen UNESCO Global Geopark, East Java, Indonesia

Program Utama Unggul - Penelitian, Pengabdian kepada Masyarakat, dan Inovasi (PPMI)

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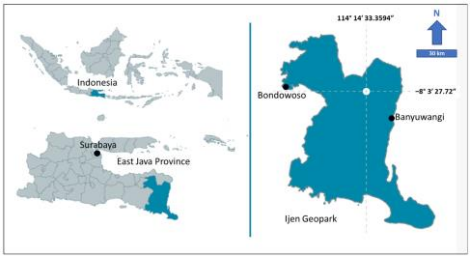
Background

The Ijen UNESCO Global Geopark (UGGp) in East Java, Indonesia, exhibits exceptional geodiversity, recording a transition from Tertiary volcanism to active Quaternary volcanic systems and associated carbonate-karst development. However, existing geotourism remains predominantly site-based, treating geosites as isolated destinations rather than integrated thematic routes. Despite coherent geological relationships among sites, a unifying framework that translates this geological evolution into interconnected geotrail routes is currently lacking. This gap limits spatial integration and the effectiveness of geotrails as interpretative and educational systems.

Keyword: Geotrail, Geodiversity, Spatial Clustering, SWOT Analysis, Ijen UGGp



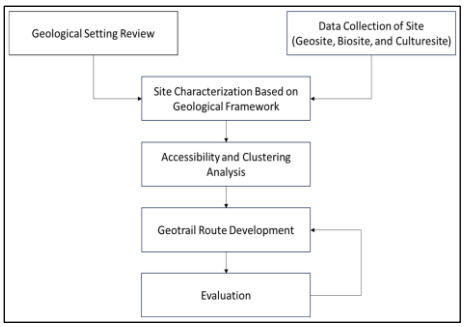
Picture 1. Location of Ijen UGGp in Banyuwangi and Bondowoso Regency within the East Java Province, Indonesia.

Research Objectives

This study aims to identify and structure geotrail routes by integrating geological settings, site diversity, and spatial relationships. It further seeks to develop a systematic framework combining site inventory, spatial clustering, and route evaluation. Furthermore, a SWOT-based approach is employed to assess internal and external factors influencing geotrail development. Overall, this study is expected to bridge the gap between site-based inventories and integrated geotrail systems, using geological evolution as an organizing principle.

Research Methods

This study applies a sequential geotrail identification framework across 37 sites (21 geosites, 6 biosites, 10 cultural sites) within the Ijen UGGp. The methodology integrates a geological setting review, site characterization, accessibility and spatial clustering analysis, and route delineation. Sites are grouped based on geological continuity, spatial distance, thematic coherence, and interpretative value. Finally, a SWOT-based evaluation is employed to assess the feasibility and development potential of the proposed geotrail routes.



Picture 2. Methodological framework for geotrail identification.

Discussion and Result

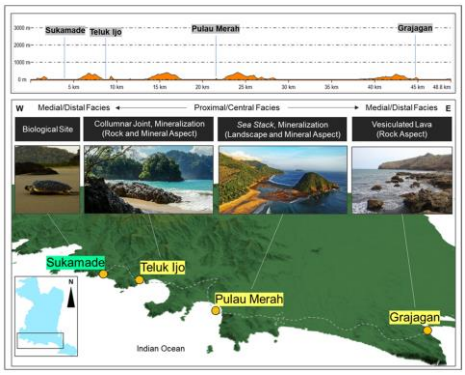
The Ijen UGGp is divided into three distinct geological domains: old volcanism in the southern sector, young volcanism in the northern sector, and carbonate systems in the eastern sector. Spatial clustering identifies three management sectors (Bondowoso, North Banyuwangi, and South Banyuwangi), with young volcanism dominating the site distribution (20 out of 37 sites). This distribution provides a diachronic perspective of landscape evolution, from eroded Tertiary landforms to active Quaternary volcanic features.



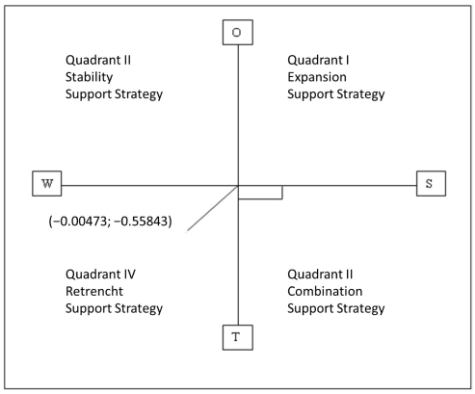
Picture 3. Pie charts showing the geological group distribution of geosite.

Based on these clusters, five geotrail routes were delineated to integrate geological narratives with accessibility. For instance, Route 1 connects coastal geosites from Sukamade to Grajagan, highlighting the transition from medial to proximal volcanic facies alongside coastal ecosystems and maritime culture. Together, the routes trace a coherent north–south geological evolution from older volcanism and carbonates to active Quaternary caldera systems.

However, SWOT analysis indicates a defensive position (internal factor -0.0047; external factor -0.5584), highlighting that accessibility and lack of integrated management rather than geological diversity are the primary constraints. Wide site spacing, uneven interpretative facilities, and external pressures such as volcanic hazards and visitor impacts further challenge seamless route connectivity.



Picture 4. Geotrail Route 1 along the southern coastal sector of the Ijen UGGp (white dashed line), extending from Sukamade (B1) to Grajagan (G8).



Picture 5. Strategic position diagram of geotrail development in the Ijen UGGp based on internal (X-axis) and external (Y-axis) factor values.

In conclusion, this study provides a systematic framework that successfully bridges site-based inventories and integrated geotrail systems.

Outputs and Program Sustainability

This study has produced a structured geotrail framework linking geological evolution, spatial clustering, and SWOT evaluation across five routes in Ijen UGGp. Moving forward, the program will integrate GIS network analysis, visitor flow modeling, and carrying capacity assessments to strengthen route connectivity.

These investigations will contribute to a broader understanding of narrative-based volcanic geotrails and support sustainable geotourism management and pentahelix collaboration.

References

Exploring New Alternative Sources of Rare Earth Elements (REE)

Program Utama Unggul - Penelitian, Pengabdian kepada Masyarakat, dan Inovasi (PPMI)

P. Soemintadiredja, A. Saepuloh, E. Suparka, E. A. Subroto, M. Abdurrachman,
V. Susanto, N. R. Herdianita, N. I. Basuki, I.G.B.E. Sucipta, I. A. Kurniawan, A. S. Subandrio
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Background

The growing demand for Rare Earth Elements (REE) in high-technology applications and the global energy transition highlights the need to identify alternative REE sources and better understand their geological characteristics (IEA, 2024, 2025).

Indonesia's REE potential remains at an early stage of exploration. Therefore, assessments should be expanded to include alternative sources, such as alkaline volcanic rocks, volcanic rocks of geothermal systems, and coal-derived by-products.

Evaluating REE potential requires more than bulk geochemical concentrations (ICP-MS); it also requires an understanding of REE-bearing minerals, mineral associations, and spatial distribution. Integrating geochemical, mineralogical, and microscopic analyses is essential for understanding REE occurrence and assessing its recovery potential from various alternative sources (Montross et al., 2018; Xiong et al., 2024).

Keyword: REE, Volcanic rocks, Coal-derived by-products.

Research Objectives

This study aims to identify and explore alternative sources of Rare Earth Elements (REE), particularly pyroclastic volcanic deposits and alkaline igneous rocks, as potential REE resources that remain underexplored.

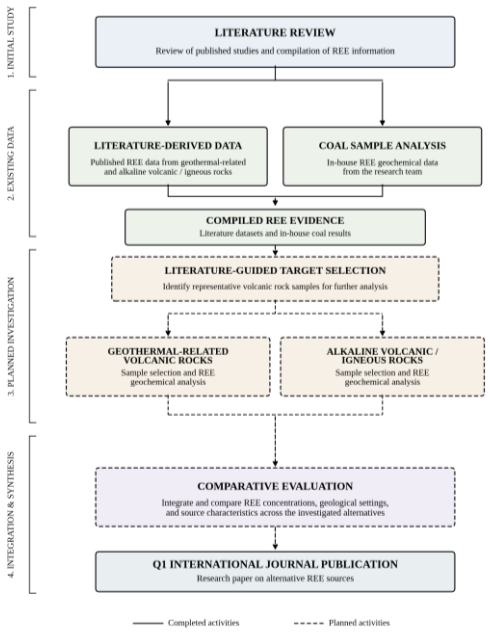
It further seeks to evaluate REE potential through geological and geochemical characterization to understand REE characteristics and distribution across different source types.

Furthermore, a geometallurgical approach is employed to investigate the relationships between mineralogical characteristics, REE occurrence, and extraction potential, providing a basis for identifying optimal REE recovery strategies.

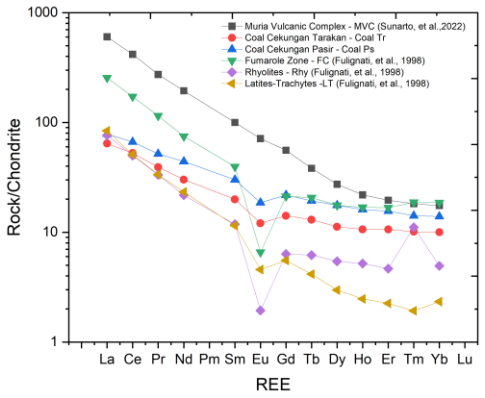
Overall, this study is expected to provide an integrated perspective on alternative REE resource evaluation and contribute to the sustainable development of strategic mineral resources.

Research Methods

This study explores alternative REE sources through literature-based evaluation and geochemical analysis of coal samples, with further investigations planned for geothermal-related volcanic rocks and alkaline igneous rocks.



Picture 1. Research Workflow



Picture 2. Chondrite-normalized REE patterns of coal and volcanic–geothermal rock samples (MVC, FC, Rhy, and LT).

Discussion and Result

Coal samples from the Tarakan Basin (Coal Tr) and Pasir Basin (Coal Ps) exhibit distinct REE distribution characteristics, providing initial insights into REE occurrence in coal from these basins. These characteristics are further evaluated through REE-normalized patterns and the relationships between ΣREE, CaO, and P_2O_5 to investigate potential geochemical factors influencing REE occurrence and enrichment. As geological comparators, volcanic samples from the Muria Volcanic Complex (MVC) exhibit relatively high REE concentrations accompanied by elevated CaO and P_2O_5 contents, which Sutarto et al. (2022) associated with apatite as an REE-bearing mineral. Meanwhile, samples from the Fumarole Zone (FC) and Rhyolite (Rhy) display different REE characteristics, reflecting variations in REE occurrence across volcanic and geothermal environments.

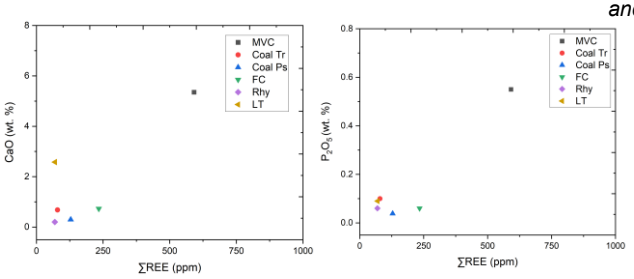
As a further step, ICP-MS and XRF analyses of volcanic rock samples from the Gunung Endut geothermal system are currently underway. These analyses aim to evaluate REE concentrations and whole-rock geochemical compositions for comparison with alternative REE sources identified through the literature review. The findings are expected to provide new insights into alternative REE sources that warrant further investigation in subsequent research stages.

Outputs and Program Sustainability

The program has produced a scientific publication, contributing to the development of research on the potential of Rare Earth Elements (REE) resources. This publication provides a foundation for further investigations into alternative REE sources and their geological and geochemical characteristics.

The program will be further developed to focus on evaluating REE concentrations and distribution in alternative sources, particularly volcanic rocks, including pyroclastic deposits and alkaline igneous rocks. Future investigations will integrate geological, geochemical, mineralogical, and geometallurgical approaches to identify resource potential, characterize REE-bearing minerals, and evaluate potential extraction pathways.

References



Picture 3. Relationships of ΣREE with CaO and P_2O_5 in coal and volcanic–geothermal rock samples.

Exploring the New Potential of Rare Earth Elements: Identification of Deposit Sources and Geometallurgy

PPMI Pandita Utama Unggul Tahun 2026

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The mature Sunda Arc typically produces evolved calc-alkaline magmas, but Guntur Volcano anomalously erupts low-viscosity, high-alumina tholeiitic basalts. Trace element signatures indicate an E-MORB mantle source with minimal crustal contamination and modification during ascent. While depleted Ni, Cr and MgO reflect early olivine and pyroxene crystallization, the primary mantle signature remains intact. This is controlled by the magmatic buoyancy and local SE-trending fault system that only accumulates magma into a shallow (~5 km) pre-eruptive staging zone delineated by VT earthquake swarms.

Methods

1. Remote sensing analyses and field observations.
2. Microscopic petrographic analysis (mineral assemblages and microtextures).
3. Whole-rock geochemical analysis (X-Ray Fluorescence and Induced Coupled Plasma – Mass Spectrometry/Optical Emission Spectroscopy).

Geological Background

Guntur Volcano is the youngest active volcanic centre in the Gandapura-Guntur Volcanic Complex (Purbawinata, 1990), exhibiting a distinct NW-SE volcanic migration driven by local structural lineaments. Unlike neighbouring mature, andesitic volcanic systems, Guntur is effusive-dominant, forming extensive basaltic lava stacks on its SE flank ~3km from the crater (e,g, the 1840 lava flow; Figs. 1 and 2). The SE-trending fault system acts as a primary magmatic conduit. It facilitates the rapid ascent of low-viscosity basaltic magmas, allowing the magma to bypass the typical crustal evolutionary pathways of the Sunda Arc.

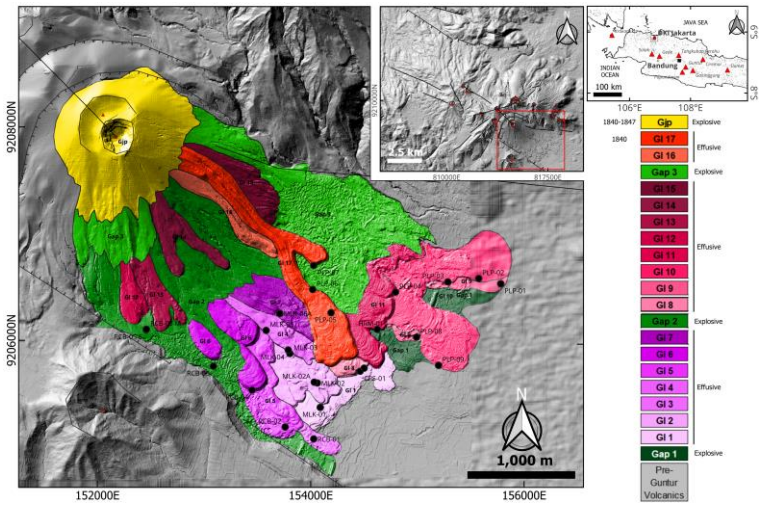

Figure 1. Geological map and simplified volcanostratigraphy of the Guntur Volcano (modified from Surmayadi et al., 1998).

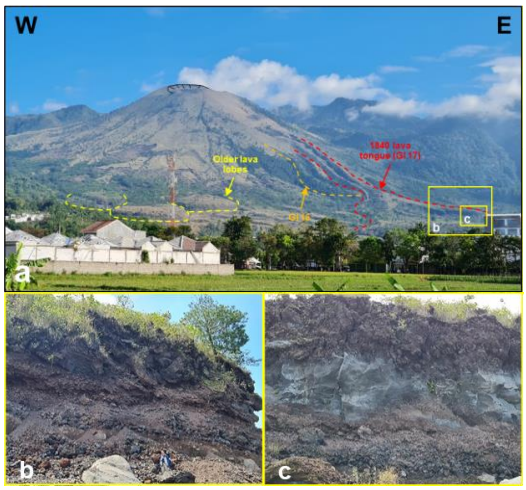

Figure 2. Morphology of the southeastern flank of the Guntur Volcano.

The occurrence of VT swarms at ~5 km depth (Sadikin et al., 2007; Basuki et al., 2019) correlates with the pressure threshold for volatile exsolution depth. Sudden magmatic heating triggers an isochemical to textural shift, by loosing volatiles, triggering undercooling and incorporation of resorbed olivines in the andesites.

Guntur's local SE-trending fault system acts as a high-permeability sub-vertical crustal conduit, creating a mechanical shortcut allowing mantle-derived melts to bypass major reservoirs and LREE assimilation, concentrating Al in the residual melt. This tectonic and structural setting effectively rejuvenates the volcanic center, delivering low viscosity tholeiitic basalts that are geochemically distinct from the regional calc-alkaline baseline.

References and additional info

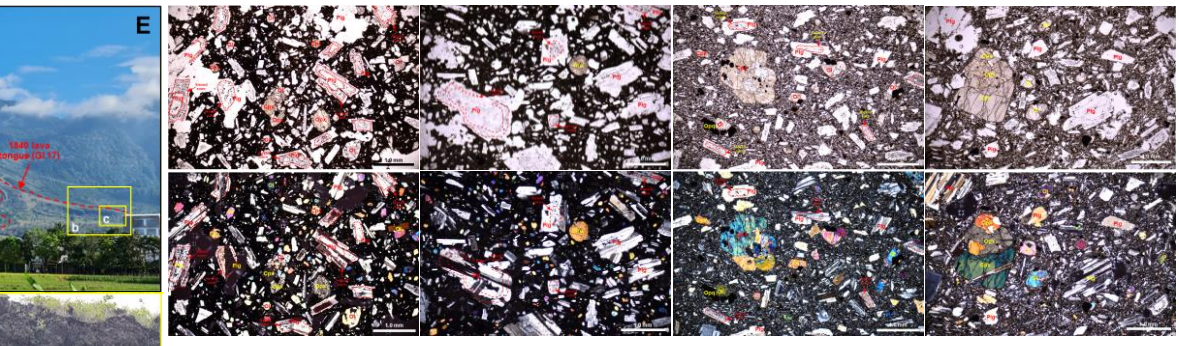

Figure 3. Photomicrographs of mineral assemblages and microtextures observed in Guntur lava.

Plagioclase-olivine-pyroxene phyric lavas transition from basalts with euhedral olivine to pre-explosive andesites with resorbed olivine, despite maintaining identical bulk-rock chemistry. While the high Al_2O_3 (18-20 wt.%) is similar to calc-alkaline high-alumina basalts (HABs; Figs. 5a and c), FeO*/MgO enrichment and trace elements confirm a true tholeiitic trend (Figs. 4 and 5b), driven by lower oxygen fugacity (fO_2) that suppresses early Fe-Ti oxide crystallization. Flat REE patterns, $(La/Sm)_N \approx 1.27\text{-}1.33$, $(Dy/Yb)_N \approx 1$, and low Sr/Y, indicate a homogeneous spinel-facies mantle source (<70 km depth), lacking the crustal or sediment overprinting typical of West Java magmas (Fig. 4a). Sharp Ni (6-22 ppm), Cr (6-45 ppm), and Mg depletion (Fig. 5) reflects deep, early olivine and pyroxene fractionation, followed by rapid, polybaric ascent (Almeev et al., 2013; Marxer et al., 2022) through a thermally efficient structural conduit.

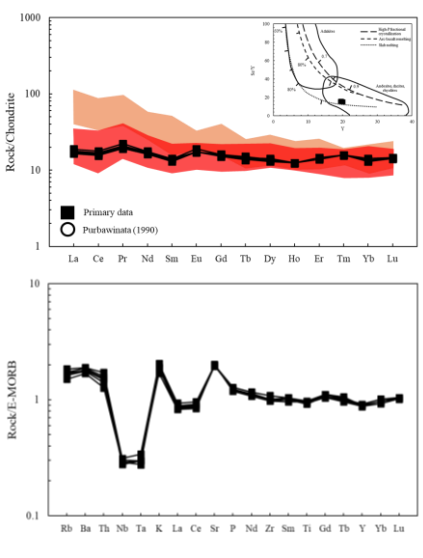

Figure 4. Spider diagram of (a) chondrite-norm REE and (b) E-MORB-norm trace elements.

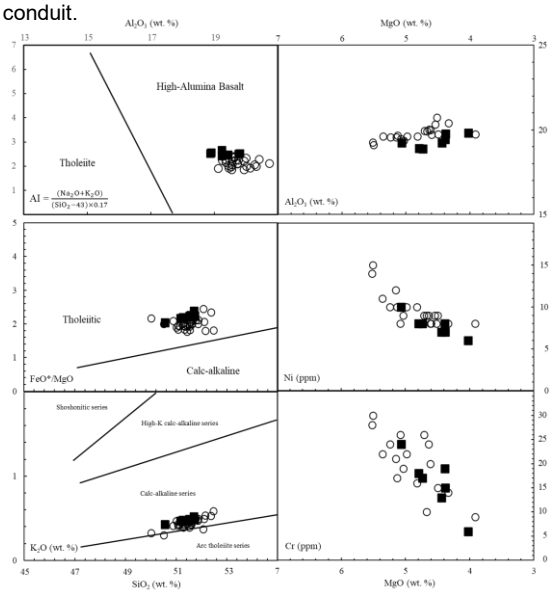

Figure 5. Major and trace element bivariate plots.

Integrasi Data Geologi dan Teknologi untuk Kemandirian Energi dan Air di Iklim Tropis Indonesia
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KK Petrologi, Vulkanologi dan Geokimia
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Baseline Geokimia REE dan pH Sedimen Lahan Bekas Tambang Timah di Pulau Bangka (Indonesia)

Asep Saepuloh* , Ainun Mardiyah, Very Susanto,
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Abstrak

Pemetaan spektral penting untuk memetakan lahan bekas tambang secara luas, cepat, dan efisien. Namun, interpretasi respons spektral memerlukan data dasar (*baseline*) dan validasi lapangan (*ground truth*) berupa data geokimia, sedangkan data logam tanah jarang (LTJ) di lahan bekas tambang timah Bangka–Belitung masih terbatas. Penelitian ini menyajikan data dasar tersebut: 20 sampel sedimen yang dianalisis dengan ICP-MS setelah digesti HF–$HClO_4$–HNO_3 dan dipasangkan dengan pH. Total LTJ (ΣREE) berkisar 16–246 mg/kg (rata-rata 105 mg/kg) dan didominasi LTJ ringan (HREE/LREE 0,06–0,19). pH tidak berkorelasi dengan ΣREE, sehingga kontrol utamanya kemungkinan mineralogi sumber; anomali Ce positif hanya muncul pada sampel ber-pH mendekati netral, dua di antaranya kaya Fe. Hasil ini menjadi *ground truth* awal bagi pemetaan spektral dan basis verifikasi lanjutan.

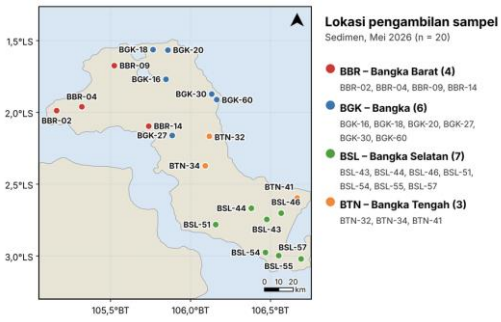
Kata kunci: logam tanah jarang; lahan bekas tambang; pH; ICP-MS; Bangka–Belitung

Pendahuluan

Transisi energi global bergantung pada logam kritis, termasuk logam tanah jarang (LTJ/REE) yang, antara lain, digunakan sebagai bahan magnet pada turbin angin dan kendaraan listrik, sehingga Indonesia memerlukan data sumber daya sendiri untuk kemandirian energi. Data geokimia LTJ di lahan bekas tambang timah Bangka-Belitung masih terbatas, padahal dibutuhkan untuk perencanaan pemanfaatan lahan dan pemetaan spektral (*remote sensing*), dengan ICP-MS sebagai *ground truth* (validasi kimiawi) bagi interpretasi respons spektral.

Penelitian ini bertujuan menyajikan konsentrasi LTJ dan pH sedimen di empat kelompok lokasi sebagai data dasar (*baseline*) serta mengevaluasi hubungan pH dengan konsentrasi dan perilaku LTJ.

Lokasi dan Pengambilan Sampel





Gambar 1. Lokasi dan pengambilan sampel (Mei 2026).

Metode Penelitian

1. Pengambilan sampel
20 sampel sedimen (dari ±100 sampel), Mei 2026; deskripsi litologi

2. Pengukuran pH
pH meter pada sedimen permukaan

3. Digesti
0,5 g sampel dalam 50 mL HF–$HClO_4$–HNO_3

4. Analisis ICP-MS
Hasil dalam mg/kg. Kontrol mutu: duplikat (RPD REE 0,2–5%) dan material acuan bersertifikat.

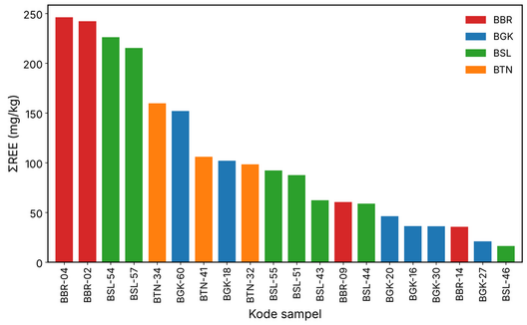
5. Pengolahan data
Normalisasi PAAS · rasio HREE/LREE · korelasi dengan pH

Kelompok lokasi: Bangka Barat (BBR), Bangka (BGK), Bangka Selatan (BSL), dan Bangka Tengah (BTN). BGK-60 adalah batuan granodiorit tanpa data pH, sehingga korelasi pH memakai 19 sampel.

Hasil dan Pembahasan

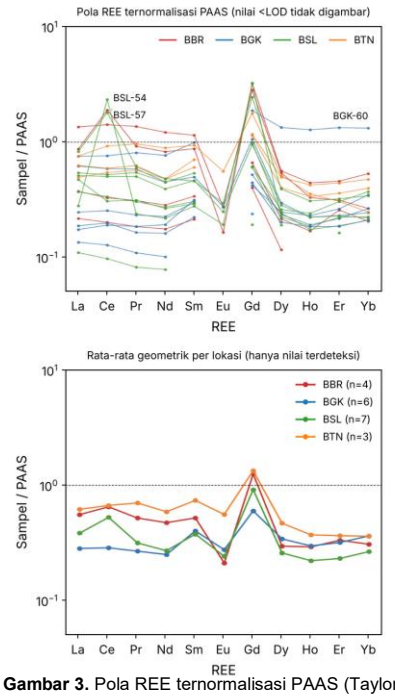
Lokasi (kode)	n	Rata-rata ΣREE (mg/kg)
Bangka Barat (BBR)	4	146
Bangka Tengah (BTN)	3	121
Bangka Selatan (BSL)	7	108
Bangka (BGK)	6	66

Konsentrasi ΣREE berkisar antara 16 hingga 246 mg/kg, dengan rata-rata 105 mg/kg dan median 90 mg/kg, setara atau di bawah nilai kerak atas (Gambar 2). Konsentrasi tertinggi ditemukan pada sampel BBR-04 sebesar 246 mg/kg, BBR-02 sebesar 242 mg/kg, BSL-54 sebesar 226 mg/kg, dan BSL-57 sebesar 215 mg/kg. Rata-rata ΣREE per lokasi secara berurutan adalah Bangka Barat 146 mg/kg, Bangka Tengah 121 mg/kg, Bangka Selatan 108 mg/kg, dan Bangka 66 mg/kg, seperti tercantum pada Tabel 1.



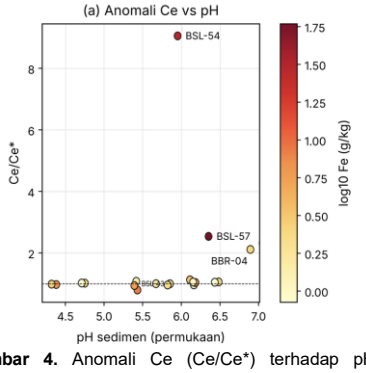
Gambar 2. Total konsentrasi REE (ΣREE, mg/kg) pada 20 sampel.

Pola ternormalisasi PAAS didominasi oleh LTJ ringan, dengan rasio HREE/LREE berkisar antara 0,06 hingga 0,19 (Gambar 3). Sebagian besar sampel berada di bawah PAAS sekitar 0,1 hingga 1 kali. Keempat kelompok lokasi memiliki bentuk pola yang sama, hanya berbeda pada tingkat konsentrasinya



Gambar 3. Pola REE ternormalisasi PAAS (Taylor & McLennan, 1985).

pH sedimen berkisar antara 4,3 hingga 6,9, dengan Bangka Tengah paling asam dan Bangka Barat paling tinggi. pH tidak berkorelasi dengan ΣREE (ρ ≈ 0,08) maupun rasio HREE/LREE (ρ ≈ 0,06), sehingga variasi LTJ kemungkinan dikendalikan oleh mineralogi sumber, bukan oleh pH. Anomali Ce positif hanya ditemukan pada sampel BSL-54, BSL-57, dan BBR-04 yang memiliki pH 5,95 hingga 6,89, dua di antaranya kaya Fe, dan tidak ditemukan pada sampel dengan pH di bawah 5 (Gambar 4). Pola ini sesuai dengan penahanan Ce(IV) pada oksida Fe, namun masih bersifat hipotesis karena hanya didukung oleh tiga sampel sehingga memerlukan lebih banyak sampel untuk dikonfirmasi.



Gambar 4. Anomali Ce (Ce/Ce*) terhadap pH sedimen permukaan; warna = log10 Fe (g/kg).

Kesimpulan

Sebagian besar sampel memiliki konsentrasi LTJ di bawah nilai kerak atas, dengan pengayaan pada beberapa sampel, dan pH tidak menjelaskan variasi LTJ; mineralogi sumber menjadi fokus. Anomali Ce pada sampel kaya Fe ber-pH netral masih hipotesis.

Luaran

- Anthropogenic Gadolinium in the Yodo River System and Tap Water in Japan: Occurrence, Speciation, and Environmental Fate. **(Tahap revisi)**
- Rare Earth Element Uptake and Translocation in Plants Growing on Former Tin-Mining Sediments, Bangka–Belitung Indonesia. **(Penulisan awal)**

Ucapan Terima Kasih

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