INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Integrated Geomorphological, Stratigraphic and Structural Controls on Landscape Evolution of the North Serayu Zone, Central Java, Indonesia

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DOI: https://doi.org/10.51244/IJRSI.2026.1306000521

Received: 08 July 2026; Accepted: 13 July 2026; Published: 21 July 2026

ABSTRACT

Geological mapping is essential for understanding the relationships among geomorphology, stratigraphy, lithology, and structural geology, which collectively control landscape evolution. This study aims to characterize the geomorphology, stratigraphy, structural geology, and geological evolution of the Rembang area and its surroundings in the North Serayu Zone, Central Java, Indonesia. The research employed an integrated qualitative and quantitative geological mapping approach combining field investigations, geomorphological analysis, stratigraphic interpretation, structural measurements, petrographic observations, Geographic Information System (GIS), and Digital Elevation Model (DEM-SRTM) analysis over a 16 km² study area. The results identified two principal geomorphological units, namely denudational hills (55%) and denudational plains (45%), characterized by dendritic to sub-dendritic drainage patterns controlled by lithological resistance and tectonic structures. Stratigraphically, the area consists of three major lithological units: Andesite Intrusion, Andesite Breccia, and Quaternary Alluvial Deposits, representing successive magmatic, volcanic, and surface depositional processes. Structural analysis revealed a dominant northwest-southeast tectonic trend expressed by joints and a dextral normal fault that significantly controls ridge alignment, valley orientation, and drainage development. Petrographic observations indicate porphyritic to aphanitic andesite composed predominantly of plagioclase, quartz, and biotite, confirming shallow intrusive magmatism. The reconstructed geological evolution suggests that the area experienced Pliocene magmatism, followed by Pleistocene volcanism, subsequent tectonic deformation, and ongoing Holocene denudation and fluvial sedimentation. These findings demonstrate that the present landscape represents the combined effects of lithological resistance, tectonic deformation, and prolonged denudational processes, providing valuable insights for regional geological interpretation, geohazard assessment, land-use planning, and geotourism development.

Keywords: geological mapping; geomorphology; stratigraphy; structural geology; landscape evolution; North Serayu Zone; Central Java; DEM-SRTM; tectonic geomorphology.

INTRODUCTION

Geological mapping is a fundamental scientific approach for identifying the relationships among lithology, geomorphology, stratigraphy, and geological structures within a region. In contemporary geological studies, landscapes are recognized not merely as products of exogenic processes but also as expressions of lithological characteristics, tectonic activity, and the long-term evolution of geological structures operating over geological timescales (Liu et al., 2023). Therefore, integrating geomorphological, stratigraphic, and structural geological analyses is essential for developing a comprehensive interpretation of the geological evolution of a region. The Rembang area and its surroundings in Purbalingga Regency, Central Java Province, Indonesia, constitute an important geological setting because they are located within the tectonically active Sunda Arc system. Tectonic reconstructions of the Indonesian region indicate that the geological evolution of Java has been strongly influenced by plate interactions and Cenozoic deformation processes, which governed the development of sedimentary basins, volcanic arcs, and regional structural frameworks (Hall, 2012; Zahirovic et al., 2014). The present study covers an area of approximately 16 km², encompassing Bantarbarang, Klapa, Karangsari, and

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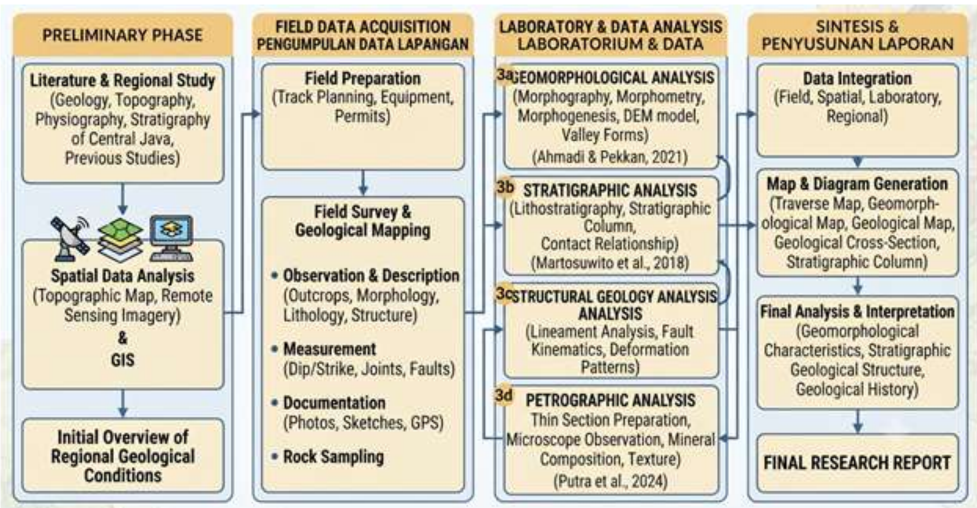
Punggelan Villages, and focuses on the characterization of geomorphological units, stratigraphic succession, geological structures, and the reconstruction of the area's geological history.

From a regional perspective, the study area forms part of the North Serayu Basin, a tectono-sedimentary province characterized by a complex history of sedimentation and tectonic evolution. Previous investigations of the Merawu Formation have demonstrated that the basin comprises layered sedimentary successions recording variations in depositional environments and stratigraphic relationships controlled by tectonic processes (Hafizh Izzatush Shalih et al., 2026; Martosuwito et al., 2018). Likewise, studies of the Halang Formation in the North Serayu Basin have identified turbidite-dominated successions consisting primarily of sandstone and mudstone deposited in deep-marine environments, providing critical insights into the regional basin evolution (Barizi et al., 2024).

Previous geomorphological and structural investigations in the North Serayu region further indicate that tectonic activity has exerted a fundamental control on landscape development, including the formation of hills, valleys, geomorphic lineaments, and morphotectonic blocks. Sunan et al. (2023) demonstrated that tectonic deformation is closely associated with landform evolution, particularly in terrains where morphology is controlled by normal faulting and differential block uplift (Sunan et al., 2023). Despite these regional studies, an integrated geological investigation combining geomorphology, stratigraphy, structural geology, and petrography has not yet been conducted for the Rembang area. Accordingly, this study aims to characterize the local geological framework, clarify the relationships among lithostratigraphic units and tectonic structures, and reconstruct the geological processes responsible for the evolution of the present-day landscape. Such an integrated approach provides a more comprehensive understanding of the geological evolution of the North Serayu Zone while contributing to regional geological mapping, geohazard assessment, land-use planning, and geotourism development.

Materials and Methods

This study employed an integrated surface geological mapping approach combining geomorphological, stratigraphic, structural geological, and petrographic analyses. Systematic field surveys and descriptive geological observations were conducted to collect data on rock outcrops, landforms, lithology, bedding orientation, geological structures, and lithological relationships. These datasets were integrated with laboratory investigations and spatial analyses to establish a comprehensive geological interpretation. The study was carried out over approximately 16 km² in Bantarbarang, Klapa, Karangsari, and Punggelan Villages, Purbalingga Regency, Central Java, Indonesia. This methodology was designed to characterize the geomorphological and geological framework and reconstruct the geological evolution of the study area through the integration of geomorphological, stratigraphic, structural, and petrographic evidence.



Gambar 1. Research Methodology

Preliminary Stage

The preliminary stage involved a comprehensive review of regional geological information, including geological and topographic maps, physiographic and stratigraphic data of Central Java, remote sensing imagery, and previous geological studies. These datasets were integrated and analyzed using Geographic Information Systems (GIS) and spatial analysis techniques to establish an initial understanding of the geological setting, geomorphological patterns, and potential structural controls within the study area. The integration of base maps, satellite imagery, and GIS provided a reliable framework for planning field investigations, designing geological traverses, and conducting the preliminary identification of geomorphological and lithological units (Evans et al., 2020; Huggett, 2017; Jensen, 2016; Liu et al., 2023).

Field Data Collection

Field data collection began with survey preparation, including traverse planning, equipment preparation, and permit acquisition, followed by systematic geological investigations at representative locations covering the range of geomorphological and lithological variations. Field observations included detailed descriptions of rock outcrops, lithology, weathering characteristics, geological contacts, and rock structures, together with measurements of bedding orientation, joint sets, and fault indicators. All observations were comprehensively documented through field notes, geological sketches, photographs, GPS coordinates, and representative rock sampling for laboratory analyses. These procedures followed established geological mapping protocols that emphasize systematic field observations and accurate documentation as the foundation for reliable geological interpretation (Barnes & Lisle, 2018; Compton, 1985; Shalih et al., 2026).

Laboratory and Data Analysis

The analytical phase integrated four complementary components: geomorphological, stratigraphic, structural geological, and petrographic analyses. Geomorphological analysis combined morphographic, morphometric, and morphogenetic assessments with DEM interpretation and drainage pattern analysis to evaluate the influence of lithology and geological structures on landscape development (Ahmadi & Pekkan, 2021). Stratigraphic analysis established the lithostratigraphic succession based on lithological characteristics, stratigraphic position, and contact relationships (Martosuwito et al., 2018). Structural interpretation integrated field measurements with remotely sensed lineament analysis to determine deformation patterns, whereas petrographic analysis employed polarized light microscopy of thin sections to identify mineral assemblages, textures, and rock-forming processes with greater accuracy (Putra et al., 2024; Tucker, 2011).

Data Integration and Geological Interpretation

The final stage involved integrating field observations, spatial interpretations, and laboratory results to develop a comprehensive regional geological model of the study area. This synthesis produced geological traverse maps, geomorphological maps, drainage pattern maps, lineament maps, geological maps, geological cross-sections, and stratigraphic columns. These outputs were subsequently used to interpret geomorphological characteristics, stratigraphic relationships, structural geological patterns, and the geological evolution of the Rembang area and its surroundings. By combining field observations, laboratory analyses, remote sensing, and regional geological information within a unified framework, the integrated approach improved the consistency and reliability of the geological interpretation (Fossen, 2016; Twidale & Vidal Romani, 2021).

RESULTS AND DISCUSSION

Geomorphological Characteristics of the Study Area

Geomorphological analysis indicates that the Rembang area and its surroundings comprise two principal geomorphological units: the Denudational Plain Unit and the Denudational Hill Unit. These units were delineated through the integration of morphographic, morphometric, and morphogenetic analyses based on the geomorphological classification proposed by Van Zuidam (1985), using topographic maps, SRTM-derived elevation data, and field observations. The Denudational Plain Unit occupies approximately **45%** of the study

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area, whereas the Denudational Hill Unit covers approximately **55%**, making it the dominant landform. The spatial distribution of these units demonstrates that landscape evolution has been governed by the interaction of lithological resistance, prolonged denudational processes, and regional structural controls. These findings are consistent with contemporary geomorphological concepts, which interpret landforms as the product of dynamic interactions among lithology, exogenic processes, and tectonic forcing (Barizi et al., 2024; Liu et al., 2023).

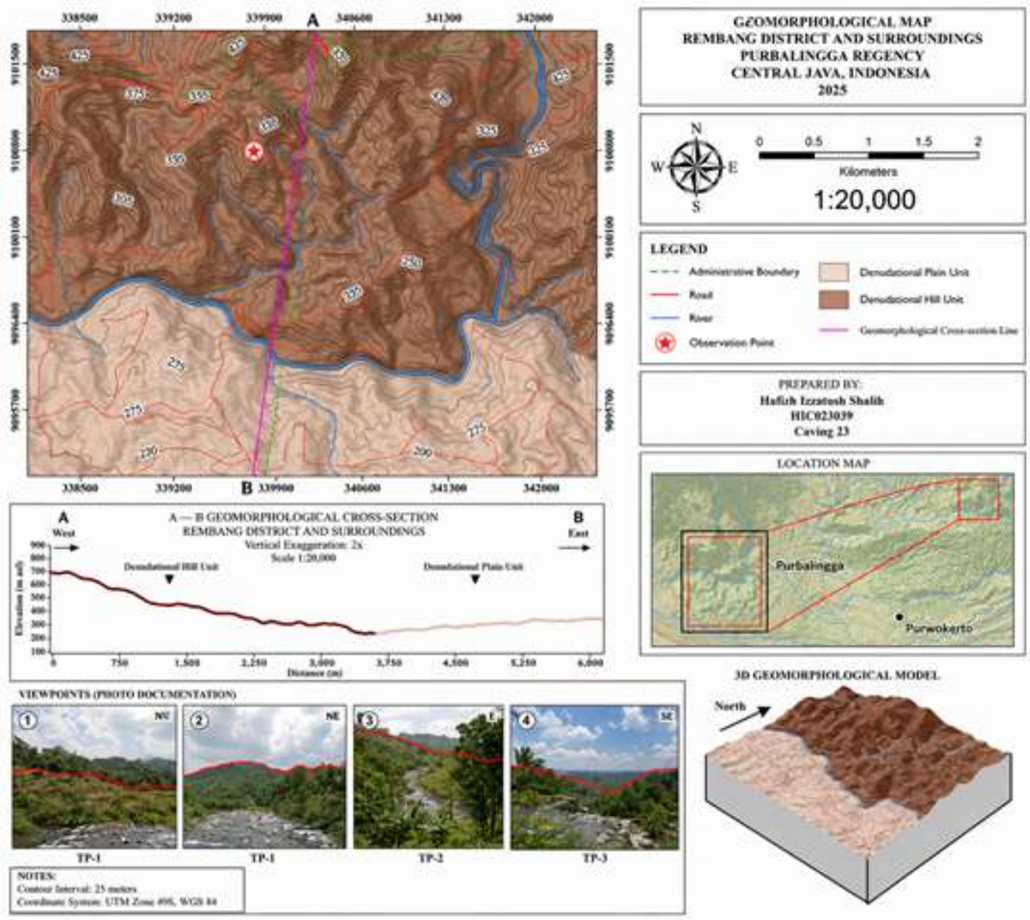

Figure 2. Geomorphological Map of the Rembang District and Surrounding Areas, Purbalingga Regency, Central Java, Indonesia.

The Denudational Plain Unit is characterized by gently to moderately undulating topography, slope gradients ranging from 8% to 12%, relative relief between 220 and 560 m, concave hillslopes, and broad U-shaped valleys. This unit is predominantly developed on relatively unconsolidated alluvial deposits that are highly susceptible to weathering, lateral erosion, and denudational processes. In contrast, the Denudational Hill Unit exhibits strongly dissected topography with steeper slopes of 24% to 40% and relative relief of 200 to 320 ***m***. The unit is distinguished by convex hillslopes, parallel ridges, and narrow U-shaped valleys developed on resistant andesite and volcanic breccia. These contrasting geomorphological characteristics indicate that variations in relief are primarily controlled by differences in lithological resistance to long-term denudational processes.

The drainage network within the study area exhibits predominantly dendritic to sub-dendritic patterns, with streams classified as consequent drainage systems. Dendritic drainage commonly develops over relatively homogeneous lithologies, whereas sub-dendritic patterns indicate the increasing influence of local geological structures, variations in rock resistance, and slope gradients on drainage evolution. The occurrence of parallel ridges, geomorphic lineaments, and spatial variations in drainage configuration suggests that landscape development has been controlled not only by fluvial erosion and denudation but also by tectonic deformation influencing valley orientation and ridge alignment. These observations are consistent with remote sensing studies demonstrating that geomorphological lineaments and drainage patterns provide reliable indicators for identifying faults, fracture systems, and morphotectonic evolution in structurally controlled terrains (Ahmadi & Pekkan, 2021; Liu et al., 2023).

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Stratigraphy and Lithological Characteristics

Geological mapping indicates that the study area is composed of three principal lithostratigraphic units: the Andesite Intrusion Unit**, the** Andesite Breccia Unit, and the Alluvial Deposit Unit. This succession records the geological evolution of the area from early intrusive magmatism through subsequent volcanic fragmentation to the accumulation of the youngest unconsolidated surface deposits. Stratigraphically, the Andesite Intrusion Unit represents the oldest rock unit, followed unconformably by the Andesite Breccia Unit, whereas the Alluvial Deposit Unit constitutes the youngest sedimentary sequence formed during recent surface processes.

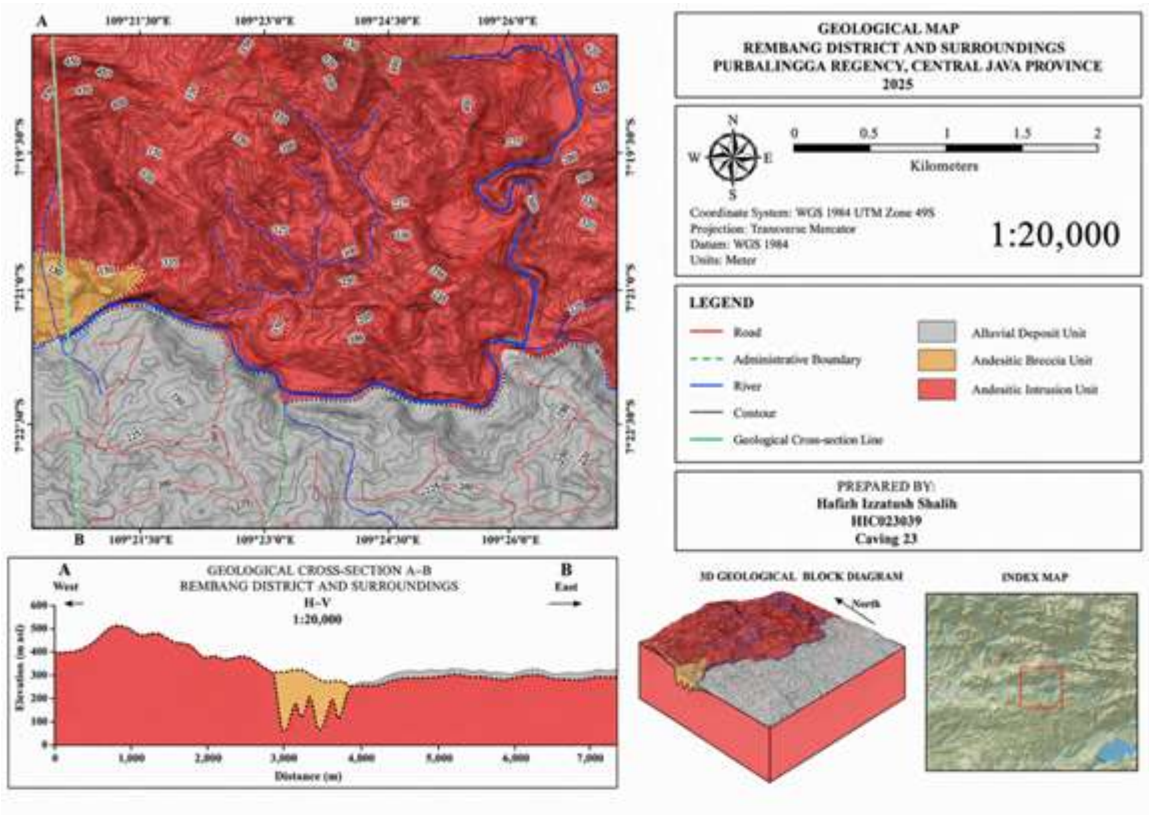

Figure 3. Geological Map of the Rembang District and Surrounding Areas, Purbalingga Regency, Central Java, Indonesia.

The Andesite Intrusion Unit is the dominant lithological unit, covering approximately 45% of the study area with an estimated thickness of about 200 m. It is assigned to the Ligung Formation and consists predominantly of andesitic intrusive rocks. Petrographic examination reveals porphyritic to aphanitic textures composed mainly of plagioclase, quartz, and biotite. These mineralogical and textural characteristics indicate magma crystallization at shallow crustal levels, suggesting emplacement during an early phase of subaerial magmatic activity that established the local geological basement and significantly influenced subsequent geological development.

The Andesite Breccia Unit occupies approximately 15% of the study area with an estimated thickness of about 50 m and is primarily exposed in Bantarbarang Village. The unit is characterized by light brown fresh surfaces, dark brown to black weathered surfaces, a massive structure, and mineral assemblages dominated by plagioclase, quartz, and biotite. These characteristics indicate that the unit represents fragmental volcanic deposits derived from explosive eruptions or the reworking of andesitic volcanic materials. The occurrence of volcanic breccia records an important stage of volcanic activity that succeeded the emplacement of the intrusive andesite body.

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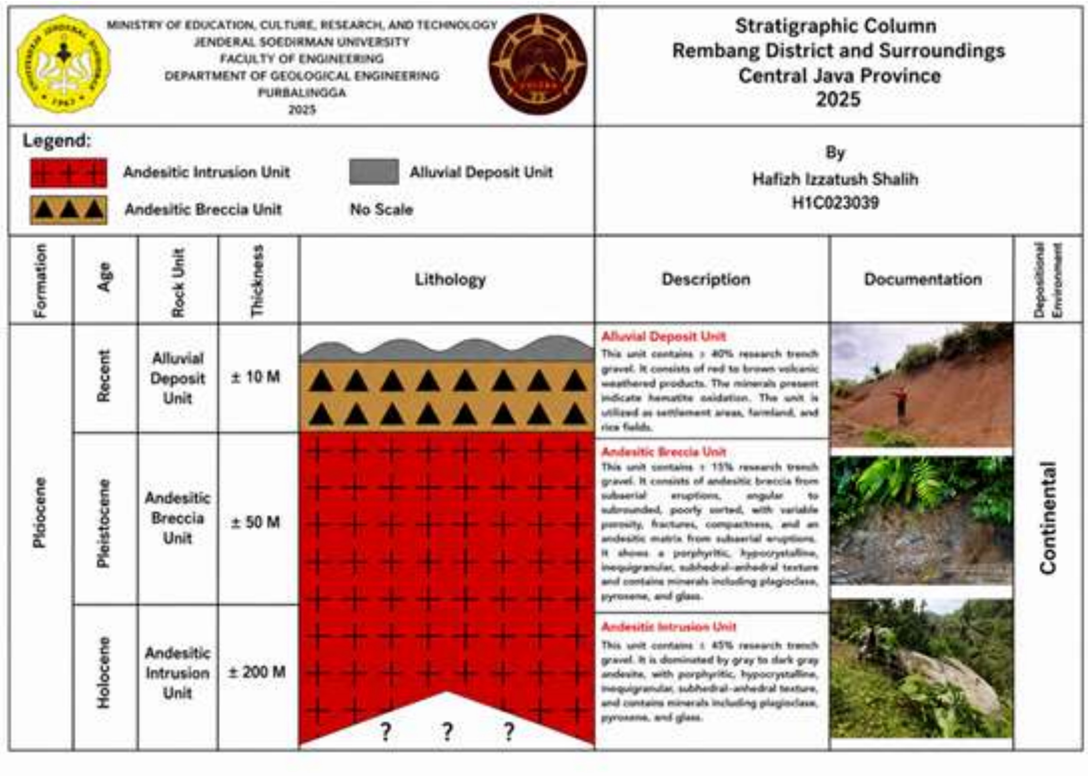

Figure 4. Stratigraphic Column Rembang District and Surrounding Areas, Purbalingga Regency, Central Java, Indonesia

From a regional perspective, the occurrence of andesitic intrusive rocks and volcanic breccias is closely related to the volcanic evolution of Central Java, particularly within the **North** Serayu Basin and the Java Volcanic Arc**.** Previous studies have demonstrated that the Serayu Basin records a complex tectono-stratigraphic history in which sedimentation evolved under strong tectonic influence and changing depositional environments (Martosuwito et al., 2018). Likewise, investigations of the Halang Formation have documented complex lithological associations consisting of sandstone, calcareous sandstone, mudstone, marl, tuff, and volcanic breccia, reflecting the interaction between sedimentary and volcanic processes during basin evolution (Barizi et al., 2024).

The Alluvial Deposit Unit represents the youngest geological unit and was formed through the weathering, erosion, transportation, and deposition of materials derived from older rock units. These deposits occur predominantly along floodplains and river channels and consist of unconsolidated sediments originating from the erosion of andesite, volcanic breccia, and other volcanic rocks. Their distribution indicates that exogenic processes remain active throughout the study area, with ongoing slope weathering, fluvial sediment transport, and sediment accumulation in topographically lower areas. Consequently, the alluvial deposits provide evidence for the continuing geomorphological evolution of the landscape under present-day surface processes.

Satuan Intrusi Andesit memiliki penyebaran dominan, yaitu sekitar 45% luas daerah penelitian, dengan ketebalan diperkirakan mencapai ±200 m. Satuan ini termasuk ke dalam Formasi Ligung dan memperlihatkan karakter batuan beku berkomposisi andesitik. Secara petrografis, batuan ini menunjukkan tekstur porfiritik hingga afanitik dengan komposisi mineral utama berupa plagioklas, kuarsa, dan biotit. Karakter tersebut menunjukkan proses pembekuan magma pada kedalaman dangkal hingga dekat permukaan, sehingga satuan ini dapat ditafsirkan sebagai produk aktivitas magmatisme darat pada fase awal pembentukan daerah penelitian.

Structural Geology and Tectonic Control

Structural geological analysis indicates that the study area is dominated by joints and faults as the principal deformation structures. Lineament analysis derived from DEM-SRTM data reveals a predominant northwest-southeast (NW-SE) orientation of ridges and valleys. This orientation is consistent with joint measurements

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obtained from the andesite intrusion, which indicate a principal stress direction of N316°E, corresponding to a northwest-southeast tectonic trend. The joint system comprises two dominant shear fracture sets: Shear Fracture 1 (N112°E/47°SW) and Shear Fracture 2 (N351°E/44°NE). These structural characteristics demonstrate that brittle deformation played a significant role in controlling the fracture network and structural fabric of the study area.

The integration of joint measurements, geomorphological lineament analysis, and field observations indicates that the dominant fault is interpreted as a dextral normal-slip fault (right normal-slip fault). This structure is characterized by a combination of normal displacement and right-lateral strike-slip movement, reflecting a complex tectonic deformation regime. The fault exerts a strong influence on valley alignment, ridge orientation, and the development of structural weaknesses that subsequently facilitate weathering and erosional processes. Consequently, the present geomorphological configuration reflects the interaction between tectonic deformation and prolonged denudational processes operating throughout the geological evolution of the area.

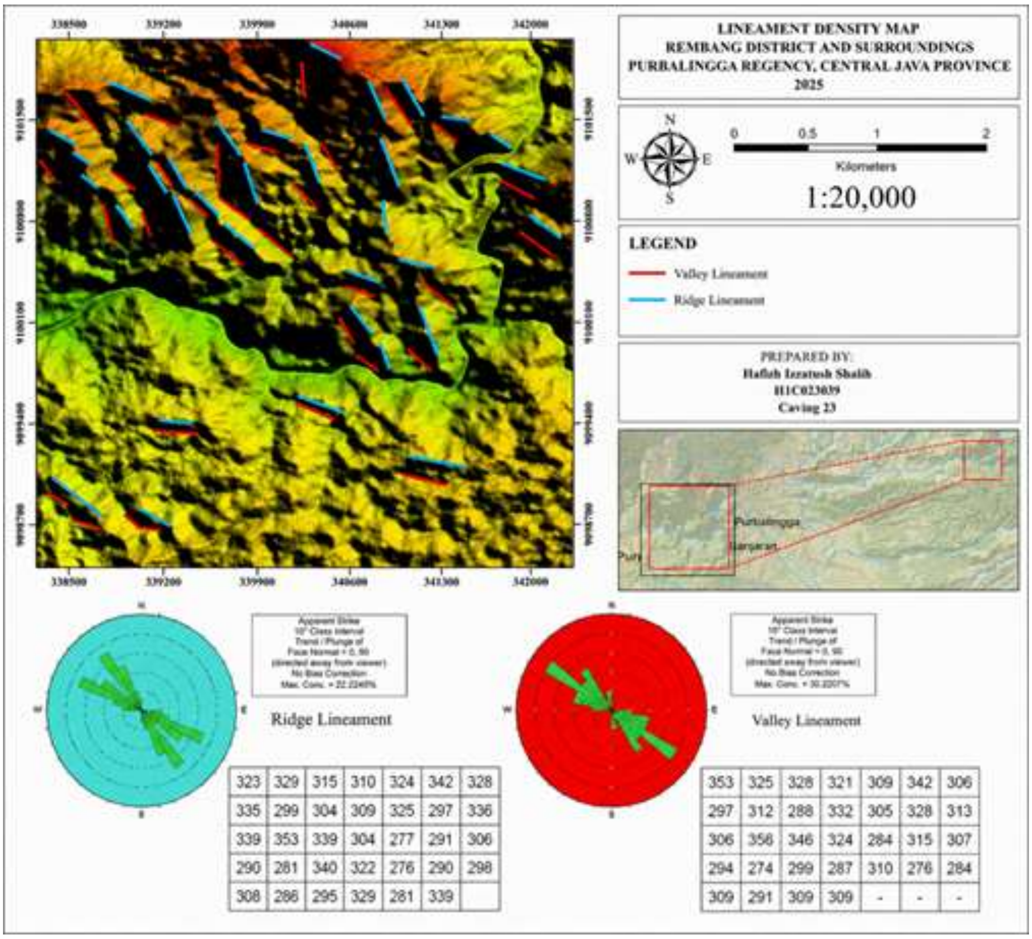

Figure 5. Lineament Density Map Rembang Distict

This interpretation is consistent with the principles of geological lineament analysis, whereby linear geomorphic features expressed by ridges, valleys, and drainage networks commonly represent the surface manifestation of fractures, faults, or broader deformation zones. Previous studies have demonstrated that DEM**,** SRTM, and remote sensing imagery provide effective datasets for extracting geological lineaments, although field verification remains essential for confirming their geological significance (Ahmadi & Pekkan, 2021). At the regional scale, tectonic deformation in Java is closely associated with the Cenozoic tectonic evolution of western Indonesia, driven by the interaction between the Australian Plate, oceanic lithosphere subduction, and tectonic blocks surrounding Sundaland, which collectively controlled the development of regional structural patterns, volcanic arcs, and sedimentary basins (Hall, 2012; Zahirovic et al., 2014).

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Synthesis of the Geological Evolution of the Study Area

The reconstructed geological history indicates that the evolution of the Rembang area and its surroundings began during the Pliocene with subaerial magmatic activity that emplaced the Andesite Intrusion Unit. This unit forms the dominant local basement and is characterized by porphyritic to aphanitic textures, reflecting crystallization at shallow crustal levels. Following the emplacement of the intrusion, the area experienced a period of non-deposition and erosion that produced an unconformable contact between the Andesite Intrusion Unit and the overlying younger lithological units. This unconformity marks a significant interruption in the geological record and represents a transition between successive stages of regional geological evolution.

During the Pleistocene, volcanic activity resumed, resulting in the deposition of the Andesite Breccia Unit above the older intrusive rocks under unconformable conditions. This unit represents fragmental volcanic deposits generated by subaerial eruptions and the subsequent reworking of volcanic materials. Petrographic analysis indicates that the breccia consists predominantly of andesite clasts within a tuffaceous matrix accompanied by pyroclastic components, including crystal tuff and lapilli tuff. The unconformable relationship between the intrusive and volcanic units reflects a transition from intrusive magmatism to younger explosive volcanism, documenting a major change in the geological processes that shaped the study area.

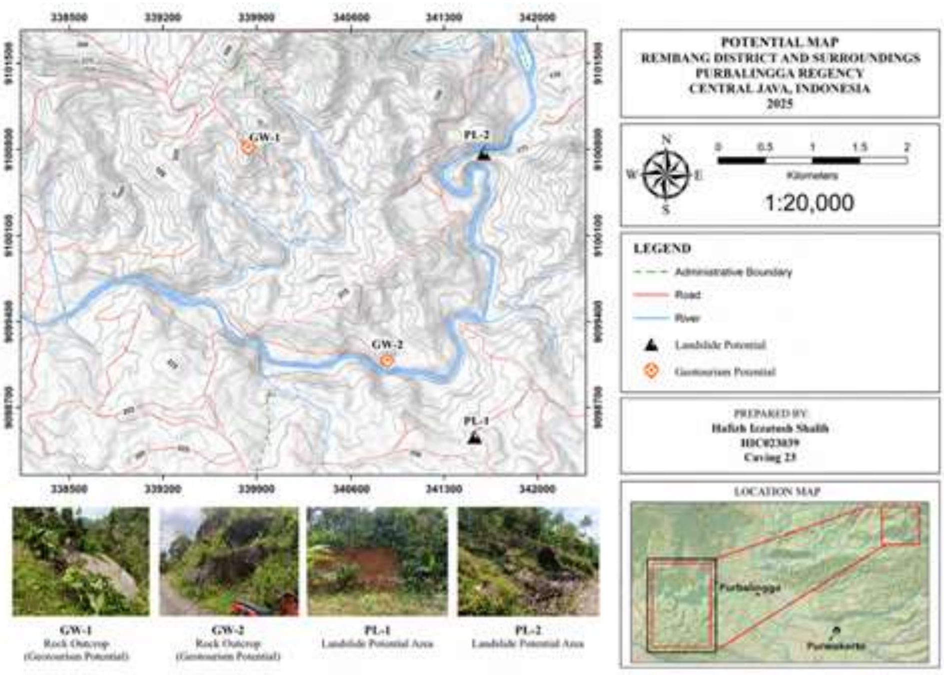

Figure 6. Potential Map Rembang District

Following the emplacement of the principal lithological units, the study area underwent tectonic deformation that produced extensive jointing and faulting. The dominant northwest-southeast (NW-SE) principal stress regime generated brittle deformation, culminating in the development of a dextral normal-slip fault. This fault system subsequently controlled the alignment of ridges, valleys, and other linear geomorphic features while creating zones of structural weakness that enhanced weathering and erosion. Consequently, tectonic deformation became a fundamental control on the geomorphological evolution of the study area, influencing both landscape morphology and the spatial distribution of erosional processes.

The youngest stage of geological evolution extends from the Holocene to the present, during which exogenic processes have become the dominant geomorphic agents. Intensive weathering of mafic-bearing igneous rocks has produced reddish-brown residual soils through oxidation, while erosion progressively disintegrates the exposed bedrock. Weathered materials are subsequently transported by surface runoff and fluvial systems before being deposited as the Alluvial Deposit Unit across floodplains and river valleys. The development of these unconsolidated deposits demonstrates that landscape evolution remains active, with continuous interactions among weathering, sediment transport, and fluvial deposition shaping the present-day geomorphology of the study area.

Geological Implications and Potential of the Study Area

The geological mapping results indicate that the study area possesses both significant opportunities and geological constraints. One of the primary positive implications is its potential for educational geotourism, supported by well-exposed and easily accessible outcrops of andesite and dacite. These outcrops provide valuable natural laboratories for field-based geological education, enabling the interpretation of igneous rocks, volcanic products, geological structures, and the relationships between lithology and landscape evolution. Consequently, the geological diversity of the area offers substantial scientific, educational, and geoconservation value while supporting sustainable geotourism development based on geological heritage.

Conversely, the study area exhibits considerable susceptibility to mass movements and landslides, particularly within the denudational hill unit characterized by steep slopes and intensely weathered volcanic rocks. Slope gradient, lithology, fractures, fault systems, and weathering intensity represent the principal geological factors controlling slope stability. According to Ehsan et al. (2025), geological parameters including topography, lithology, faults, and joint systems significantly influence landslide susceptibility, whereas external triggering factors, particularly intense rainfall, accelerate slope failure (Ehsan et al., 2025). These findings highlight the necessity of incorporating geological and geomorphological information into hazard assessment, land-use planning, and disaster risk mitigation strategies within the study area.

The results further demonstrate that the geological evolution of the Rembang area reflects a close interaction among magmatism, volcanism, tectonic deformation, and long-term denudational processes. The present geomorphology, characterized by denudational hills and plains, developed through the combined effects of differential resistance between andesite and volcanic breccia, northwest-southeast structural control, and ongoing exogenic processes. Therefore, the integrated analysis of geomorphology, stratigraphy, structural geology, and petrography provides a robust scientific framework for reconstructing local geological evolution while supporting sustainable land-use planning, geohazard mitigation, and the development of geology-based geotourism initiatives.

CONCLUSIONS

The integrated geological investigation demonstrates that the Rembang area and its surroundings have evolved through the interaction of magmatic, volcanic, tectonic, and denudational processes. Two dominant geomorphological units, the Denudational Plain Unit **and** Denudational Hill Unit, reflect variations in lithological resistance and structural control. The stratigraphic succession, comprising the Andesite Intrusion Unit**,** Andesite Breccia Unit, and Alluvial Deposit Unit, records successive stages of Pliocene magmatism, Pleistocene volcanism, and Holocene sedimentation. Structural analysis identifies joints and a northwest-southeast-oriented dextral normal-slip fault as the principal tectonic features governing landscape development. These findings provide a comprehensive geological framework for understanding regional landscape evolution while supporting geological mapping, geohazard assessment, sustainable land-use planning, and geotourism development.

REFERENCES

1. Ahmadi, H., & Pekkan, E. (2021). Fault-based geological lineaments extraction using remote sensing and GIS—A review. Geosciences, 11(5), 183. https://doi.org/10.3390/geosciences11050183
2. Barizi, A. R. F., Prasetyadi, C., Janukusuma, M. A. S., & Setiawan, M. N. (2024). Sedimentary facies and depositional environments of the Halang Formation in the North Serayu Basin: Insights from outcrop study in Bantarbolang, Pemalang, Central Java. Berita Sedimentologi, 50(1), 1–9. https://doi.org/10.51835/bsed.2024.50.1.447
3. Barnes, J. W., & Lisle, R. J. (2018). Basic Geological Mapping (5th ed.). Wiley-Blackwell.
4. Compton, R. R. (1985). Geology in the Field. John Wiley & Sons.

5. Ehsan, M., Anees, M. T., Bakar, A. F. B. A., & Ahmed, A. (2025). A review of geological and triggering factors influencing landslide susceptibility: Artificial intelligence-based trends in mapping and prediction. International Journal of Environmental Science and Technology, 22, 17347–17382. https://doi.org/10.1007/s13762-025-06741-6
6. Evans, I. S., Gutierrez, F., & Pope, G. A. (2020). Geomorphometry and landform analysis: Progress and future directions. Earth Surface Processes and Landforms, 45(6), 1329–1343. https://doi.org/10.1002/esp.4801
7. Fossen, H. (2016). Structural Geology (2nd ed.). Cambridge University Press.
8. Hafizh Izzatush Shalih, Bimadexa Primaebara, Millata Najwa, & Agus Rochmat. (2026). Integrasi Metode Penginderaan Jauh Dalam Pemetaan Alterasi Hidrotermal Daerah Cihonje Banyumas Menggunakan Citra Landsat 8 OLI/TIRS [Dataset]. Zenodo. https://doi.org/10.5281/zenodo.20485289
9. Hall, R. (2012). Late Jurassic–Cenozoic reconstructions of the Indonesian region and the Indian Ocean. Tectonophysics, 570–571, 1–41. https://doi.org/10.1016/j.tecto.2012.04.021
10. Huggett, R. J. (2017). Fundamentals of Geomorphology (4th ed.). Routledge.
11. Jensen, J. R. (2016). Introductory Digital Image Processing: A Remote Sensing Perspective (4th ed.). Pearson.
12. Liu, Y., Lu, G., Meng, Z., Guo, D., Hu, D., Zhu, L., & He, H. (2023). GIS approach for expressing structural landforms: Forms, elements, and relationships. Applied Sciences, 13(23), 12872. https://doi.org/10.3390/app132312872
13. Martosuwito, S., Bachri, S., & Kamal, Z. A. (2018). Stratigraphical and sedimentological review of the Merawu Formation, Serayu Basin, Central Jawa, Indonesia. Indonesian Journal on Geoscience, 5(2), 117–128. https://doi.org/10.17014/ijog.5.2.117-128
14. Putra, A. G., Ma'ruf, A. K., Sakti, H. P. M. A., & Pratama, A. S. N. R. (2024). Quantitative analysis of thin section using frequency measurement (point counting), a case study on limestone of the Rajamandala Formation, Cikamuning, West Java, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology.
15. Shalih, H. I., Primaebara, B., Najwa, M., & Rochmat, A. (2026). INTEGRASI METODE PENGINDERAAN JAUH DALAM PEMETAAN ALTERASI HIDROTERMAL DAERAH CIHONJE BANYUMAS MENGGUNAKAN CITRA LANDSAT 8 OLI/TIRS. 8(2), 145–163. https://doi.org/10.5281/zenodo.20485288.
16. Sunan, H. L., Nurlatifah, M., Laksono, F. A. T., & Widagdo, A. (2023). Analysis of tectonic influence on morphological formation: Case study of Gapura Pemalang Area. Journal of Earth and Marine Technology, 3(2), 104–123.
17. Tucker, M. E. (2011). Sedimentary Rocks in the Field: A Practical Guide (4th ed.). Wiley-Blackwell.
18. Twidale, C. R., & Vidal Romani, J. R. (2021). Landforms and Geology (2nd ed.). CRC Press.
19. Zahirovic, S., Seton, M., & Müller, R. D. (2014). The Cretaceous and Cenozoic tectonic evolution of Southeast Asia. Solid Earth, 5(1), 227–273. https://doi.org/10.5194/se-5-227-2014