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RESEARCH ARTICLE

Geological Mapping and Reconstruction of the Geological Evolution in the Karanganyar Area, Purwanegara District, Banjarnegara, Central Java

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Abstract

The Karanganyar area, Purwanegara District, Banjarnegara Regency, Central Java, forms part of the South Serayu Range, characterized by a complex geological setting resulting from the interaction of carbonate sedimentation, volcanic activity, tectonic uplift, and denudation. This study aims to reconstruct the geological evolution of the research area through geological mapping integrated with geomorphological, lithostratigraphic, petrographic, and structural geology analyses.

The results indicate that the area is dominated by the Karanganyar Denudational Hill Unit with lithostratigraphy comprising a Crystalline Limestone Unit, a Monomict Breccia Unit, and a Polymict Breccia Unit. Geological structures are not significantly developed at the mapping scale. The geological evolution reconstruction reveals that the area developed through four main stages: carbonate sedimentation in a shallow marine environment, followed by volcanic activity, regional uplift, and ongoing weathering and denudation that shaped the current landscape. This study presents a local geological evolution model that enhances the understanding of the geological development of the Karanganyar area as part of the South Serayu Range.

Keywords: geological mapping; geological evolution; lithostratigraphy; South Serayu Range

1. Introduction

1.1 Background

The Karanganyar area, Purwanegara District, Banjarnegara Regency, Central Java, forms part of the South Serayu Range, composed of carbonate and volcanic rocks with a landscape dominated by denudational hills. This lithological and geomorphological diversity reflects the interplay of sedimentation, volcanism, uplift, and denudation processes that formed the geological conditions of the study area.

Geological studies in the South Serayu Range have been extensively conducted at a regional scale; however, detailed geological information regarding the Karanganyar area remains limited. The relationship among geomorphology, lithostratigraphy, structural geology, and geological evolution has not been comprehensively analyzed through detailed-scale geological mapping. Therefore, this research is required to obtain more comprehensive geological data to serve as a foundation for interpreting the geological development of the study area

This study aims to identify the geomorphological, lithostratigraphic, petrographic, and structural characteristics through geological mapping, as well as to reconstruct the geological evolution of the Karanganyar area. The results of this study are expected to provide a local geological evolution model that enhances the understanding of the geological development of the South Serayu Range and serves as a reference for geological research in the surrounding region.

2. Regional Geology

2.1 Location of study area

The study area is located in Karanganyar Village and its surroundings, Purwanegara District, Banjarnegara Regency, Central Java Province, covering an area of approximately 16 km² (4 km × 4 km). Geographically, the study area is situated within the WGS 1984 UTM Zone 49S coordinates with a reference point at 7.460184°S and 109.567295°E. The research location can be reached by land from the Faculty of Engineering, Universitas Jenderal Soedirman, with a distance of approximately 31.7 km. The location map of the study area is shown in Figure 1.

Fig. 1. Location map of the study area.

2.2 Regional Physiography

Physiographically, the study area falls within the South Serayu Mountains Zone based on the classification by Van Bemmelen (1949). This zone is characterized by landforms ranging from denudational to volcanic hills, which developed as a result of the interplay between tectonic activity, volcanism, and exogenic processes. Geomorphologically, the region is dominated by undulating to hilly relief, with drainage patterns that have developed in response to the lithological and morphological conditions of the area.

3. Methodology

This research used a descriptive field survey approach to gather direct geological data across the 16 km2 (4 km x 4 km). study area at a 1:25,000 mapping scale. Primary data were collected by observing rock outcrops, measuring structural features, and documenting surface morphology into field notebooks through sketches, lithological descriptions, and outcrop coordinates. Secondary support data included a 1:25,000 topographic map, the 1:100,000 regional geological map of the Banjarnegara-Pekalongan Sheet (Condon et al., 1996), and DEM SRTM imagery.

Geomorphological Analysis: Performed using morphographic, morphometric, and morphogenetic approaches following Van Zuidam (1985). Slope gradient percentages were calculated from contour density on topographic maps. Geomorphological unit names follow the genetic classification of Brahmantyo and Bandono (2006), while stream network patterns were categorized using Howard's classification (1967).

Stratigraphic Analysis: Constructed based on the Law of Superposition (Steno, 1669) using an informal lithostratigraphic naming system in line with the Indonesian Stratigraphic Code (Komisi Sandi Stratigrafi Indonesia, 1996).

Petrographic Analysis: Carried out on six thin sections under a polarizing microscope using plane-polarized light (PPL) and cross-polarized light (XPL). Sedimentary rocks were classified using Pettijohn (1975), igneous rocks using Streckeisen (1976), and carbonate rocks using Embry and Klovan (1971).

Structural Geology Analysis: Conducted by interpreting ridge and valley lineaments on DEM SRTM imagery combined with field observations of joints and faults. All collected data were integrated to produce geomorphological maps, geological maps, stratigraphic columns, and a reconstructed geological history.

4. Result and Disucussion

4.1 Geomorphology

Physiographically, the study area falls within the Domes and Hills in the Central Depression Zone (Van Bemmelen, 1949), characterized by undulating to steep hilly landforms featuring topographic domes as the primary morphological elements. The drainage pattern within the study area is classified as subparallel according to the Howard (1967) classification, indicating the control of uniform regional slope and regional structures on the flow direction.

Based on morphographic, morphometric, and morphogenetic analyses, the study area is divided into a single geomorphological unit: the Karanganyar Denudational Hill Unit (D3), which covers the entirety (100%) of the research area. This unit is characterized by an average slope gradient of 43.78% with an elevation difference of 120–200 m, strongly dissected hilly relief, and V-shaped valleys indicating that fluvial erosion remains active despite the drainage system having reached a mature to old stage. Passive morphostructures consisting of denudational features, combined with high morphodynamic erosion, indicate that the landscape evolution of this area is primarily controlled by exogenic processes—weathering, erosion, and mass wasting—rather than active tectonic activity.

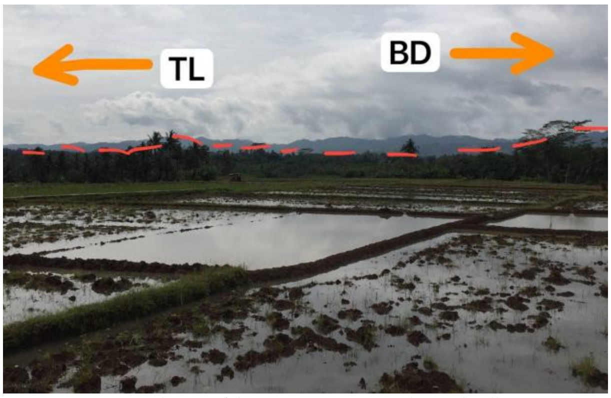

Fig. 2. Landscape of the Karanganyar Denudational Hill Unit.

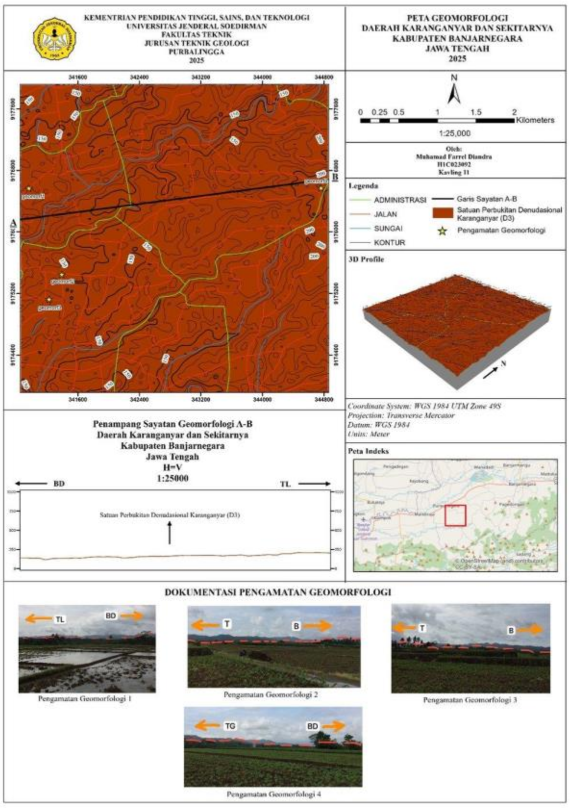

Fig. 3. Geomorphological map of the study area..

4.2 Litostratigraphy

Based on the Law of Superposition (Steno, 1669) and informal lithostratigraphic guidelines (Indonesian Stratigraphic Code Commission, 1996), the study area is composed of three rock units listed from oldest to youngest: the Crystalline Limestone Unit, the Monomict Breccia Unit, and the Polymict Breccia Unit, with unconformable contacts between the units.

The Crystalline Limestone Unit is the oldest unit, occupying approximately 3% of the study area with a thickness of ±147 m, and forms part of the Brecciated Rocks Formation / KTm (Condon et al., 1996). Its lithology comprises light-grey crystalline limestone that is calcareous, compact, and cross-cut by calcite veins. Petrographic analysis reveals a composition of calcite/sparite (75%) and micrite (25%), which is classified as Crystalline limestone according to Embry and Klovan (1971). This unit is interpreted to have been deposited in a shallow-marine environment during the Cretaceous Period.

Monomict Breccia Unit: Unconformably overlies the Crystalline Limestone Unit and formed during the Late Miocene to Early Pliocene as regional uplift halted carbonate deposition and initiated volcanic activity. It consists of volcanic breccia with uniform (monomict) fragments, a tuffaceous matrix, and silica cement with a massive structure, reflecting a terrestrial environment directly influenced by volcanic events.

Polymict Breccia Unit: The youngest unit, unconformably overlying the Monomict Breccia Unit, deposited during the Pleistocene Epoch. The variety of fragment types—including basaltic volcanic rocks based on petrographic plotting (Streckeisen, 1976)—indicates multiple source materials consistent with volcanic debris flows and fluvial reworking around volcanic structures (McPhie et al., 1993). The depositional setting is interpreted as a high-energy terrestrial environment influenced by advanced volcanism and gravity processes.

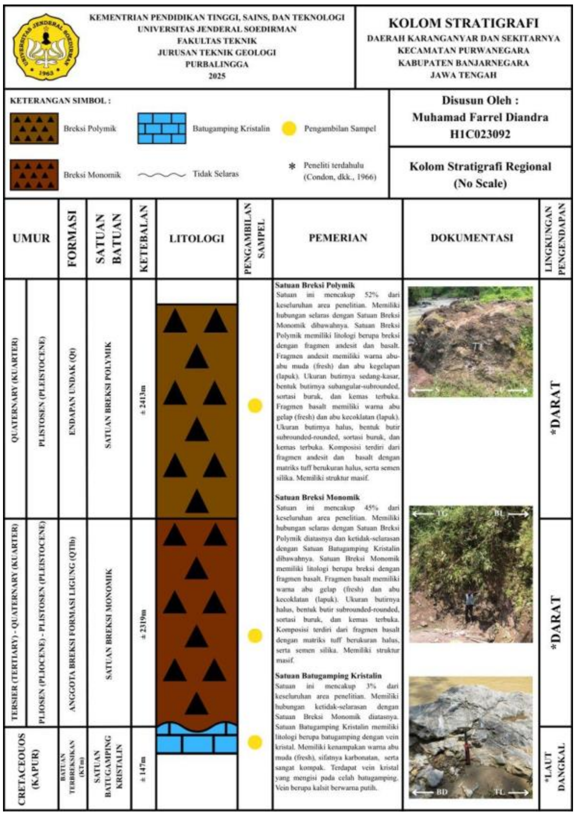

Fig. 4. Stratigraphic Column of the Karanganyar Area and Surrounding Areas.

Fig. 5. Outcrop and hand specimen of the Crystalline Limestone Unit..

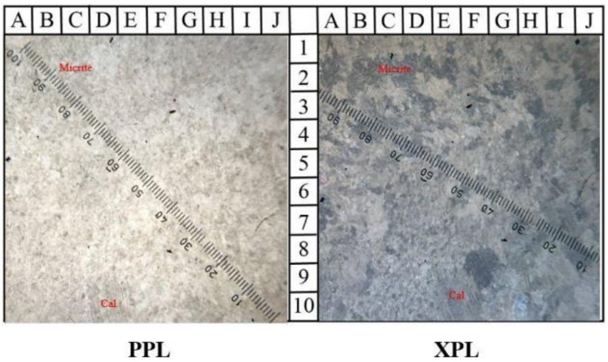

Fig. 6. Thin section of the Crystalline Limestone Unit (Crystalline; Embry and Klovan classification, 1971).

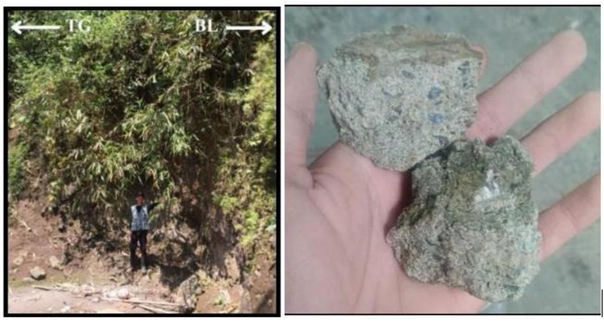

Fig. 7. Outcrop of the Monomict Breccia Unit.

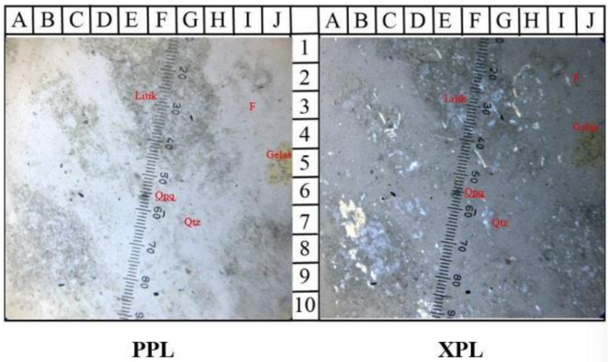

Fig. 8. Thin section of the Monomict Breccia Unit.

Fig. 9. Outcrop of the Polymict Breccia Unit.

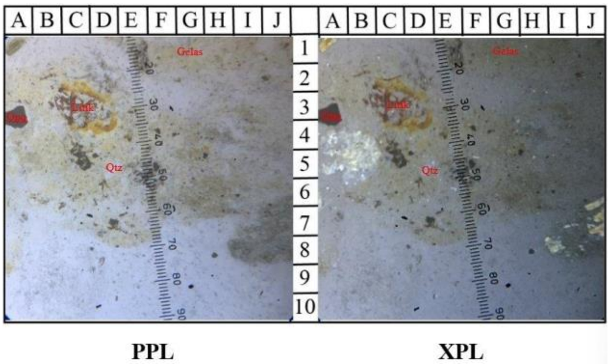

Fig. 10. Thin section of a fragment from the Polymict Breccia Unit (basalt; Streckeisen classification, 1976).

4.3 Structural Geology

Lineament analysis based on SRTM DEM imagery reveals hill and valley lineament patterns with a dominant northwest–southeast orientation, concentrated in quadrants 2 and 4 (N105°E and N285°E). Nevertheless, no joints or faults were identified at the mapped scale, indicating that brittle tectonic deformation is not significantly developed within the study area. This condition suggests that the geological evolution of the Karanganyar area is primarily controlled by volcanism and denudational processes rather than local tectonic activity, although the absence of direct field evidence is also influenced by the limited availability of representative outcrops and intense weathering.

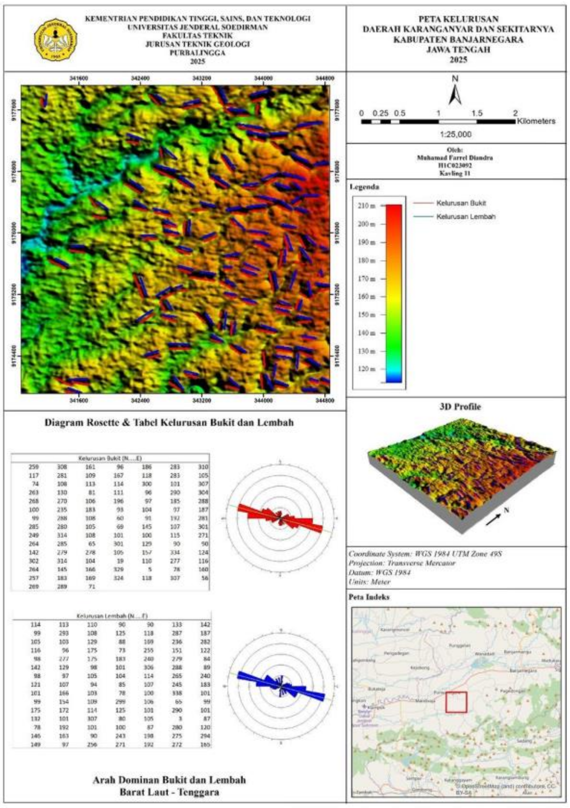

Fig. 11. Lineament map of the study area based on SRTM DEM imagery.

4.4 Reconstruction of Geological History

Integrating geomorphological, lithostratigraphic, petrographic, and structural data allows the geological history of the Karanganyar area to be reconstructed into four main stages, there are Cretaceous stage: Carbonate sedimentation occurred in a shallow marine environment, forming the Crystalline Limestone Unit. Late Miocene – Early Pliocene: Regional uplift ended carbonate deposition and triggered early volcanic activity, resulting in the unconformable deposition of the Monomict Breccia Unit over the limestone. Pleistocene: Volcanic activity intensified, depositing the Polymict Breccia Unit over the monomict breccia, representing a more mature volcanic phase with diverse material sources. Quaternary – Present: Exogenic processes (weathering, erosion, and denudation) became dominant, forming the deeply dissected denudational hilly landscape observed today.

4.5 Geological Resource Potencial

Positive Potential: Indicated by altered rock exposures containing fine-grained to small aggregates of pyrite, showing hydrothermal activity in the past. This indicates indicative metallic mineralization potential that requires further geochemical and mineralogical investigation to assess economic viability. Negative Potential (Geohazards): High susceptibility to shallow landslides on steep hillslopes, where slide material consists mainly of loose, weathered soil. The presence of alteration zones further reduces rock strength, increasing slope instability—especially during saturated conditions—which must be accounted for in land-use planning and disaster mitigation.

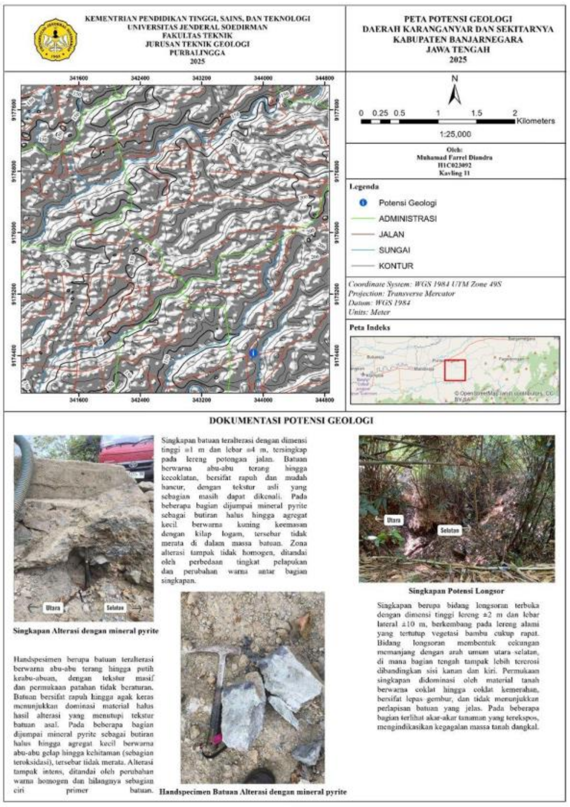

Fig. 12. Geological potential map of the study area.

5. Conclusion

1. The study area consists of a single geomorphological unit, the Karanganyar Denudational Hill Unit, featuring an average slope gradient of 43.78%, elevation differences of 120-200m, a subparallel stream pattern, and high erosional morphodynamics.
2. The informal lithostratigraphy comprises three units (oldest to youngest): the Crystalline Limestone Unit, Monomict Breccia Unit, and Polymict Breccia Unit, separated by unconformities.
3. The structural geology is relatively simple; no joints or faults were identified at the mapping scale, although SRTM lineament analysis shows a dominant NW–SE orientation.
4. The local geological evolution occurred through four main stages: Cretaceous shallow-marine carbonate sedimentation, Late Miocene–Early Pliocene uplift and early volcanism, Pleistocene intensive

volcanism, and Quaternary-to-present denudational processes.

5. The area holds positive potential in indicative metallic mineralization within pyrite-bearing alteration zones, and negative potential in shallow landslide hazards on steep slopes.

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