

GEOLOGY OF THE KADU AND SURROUNDING AREA, JATIGEDE AND JATINUNGGAL DISTRICTS, SUMEDANG REGENCY, WEST JAVA PROVINCE

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ABSTRACT

Administratively, the research area is located in Kadu and its surrounding areas, Jatigede and Jatinunggal Districts, Sumedang Regency, West Java Province. This study aims to determine the geological conditions and geological history of the research area. The research method consists of three stages: literature study, field observation for data collection, and studio observation combined with laboratory analysis. Based on geomorphological aspects, the research area is divided into three geomorphological units, namely moderately steep denudational low hills, steep structural elongated hills, and very steep structural sedimentary hills. Field observations indicate that the lithostratigraphic units are grouped into four units arranged from oldest to youngest: claystone unit (Sbl), sandstone unit (Sbp), tuff unit (St), and volcanic breccia unit (Sbv). The claystone and sandstone units were deposited simultaneously during the Middle Miocene in a deep marine environment. Subsequently, during a slightly younger period, the tuff unit (St) was deposited conformably with the sandstone unit. Geological structures developed in the study area include anticline and syncline folds formed in the Late Miocene due to compressional tectonic activity, with the principal stress direction trending northeast-southwest. Other structures such as joints and indications of strike-slip faults are also observed. The volcanic breccia unit (Sbv) was deposited from ancient volcanic eruptions in a disconformable relationship with the claystone unit (Sbl) during the Late Pliocene. Geological resources in the study area include andesite quarrying as well as tourism potential at Mount Jagat and the Pine Forest. The main geological hazard in the area is landslides.

Keywords : Anticline, Denudational, Sumedang, Syncline, Volcanic breccia

INTRODUCTION

Geology is the science that studies the Earth, including its constituent materials, physical and chemical processes occurring at the surface and subsurface, as well as the geological history of the planet and its life forms (Thompson & Turk, 1997). Geological processes operate slowly but continuously, producing significant changes over geological time, as proposed by Hutton (1785). Geological studies play an essential role in understanding natural phenomena such as volcanism and tectonic activity, managing natural resources, mitigating geological hazards, and supporting safe infrastructure development. Geological mapping is a fundamental method used to identify and document surface geological features, including lithology, geomorphology, stratigraphy, geological structures, and

geological history, which are subsequently presented in geological maps.

The study area is located in Kadu, Cisampih, Cimanintin, and surrounding areas, Jatigede and Jatinunggal Districts, Sumedang Regency, West Java Province, it lies between 108°9'10.296" E to 108°11'55.295" E and 6°55'5.995" S to 6°52'20.996" S, covering approximately 5 × 5 km². Regionally, the area is composed of Miocene to Pliocene sedimentary and volcanic figure rocks based on the Geological Map of the Majalengka Sheet at scale 1:50,000 (Isnaniawardhani et al., 2020). The geological context includes marine to terrestrial depositional environments and deformation related to regional tectonic activity. However, the regional-scale map provides limited detail and does not sufficiently describe local variations in lithostratigraphy, structural geology, geomorphological characteristics, and

geological evolution. Therefore, a more detailed geological mapping is required to improve the understanding of local geological conditions, resource potential, and geological hazards.

This study aims to conduct detailed geological mapping to obtain comprehensive understanding of the geological aspects in the study area, including rock types and distribution, stratigraphic succession and relationships, structural geology conditions, geological history reconstruction, potential geological resources, and geological hazard assessment.

REGIONAL PHYSIOGRAPHY

Based on morphology, lithology, and geological structure, West Java is divided into five physiographic zones: the Jakarta Coastal Plain Zone, the Bogor Zone, the Bandung Zone, the Bayah Mountain Zone, the Southern Mountain Zone, and the Quaternary Volcanic Zone (Figure 1; Martodjojo, 2003).

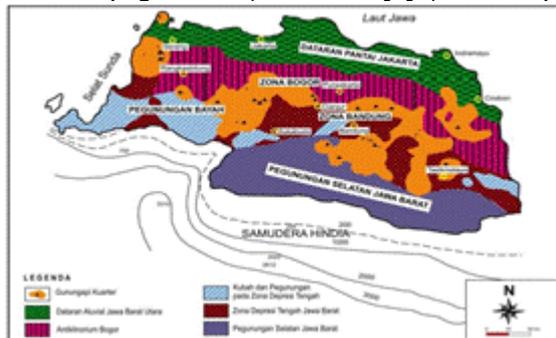


Figure 1. Physiographic Map of West Java according to Van Bemmelen (1949) as cited in Martodjojo (2003)

According to this division, the study area is located in the eastern part of the Bogor Zone. This area consists of folded hills formed from deep marine Tertiary sedimentary rocks that constitute an anticlinorium, with faulting in several places estimated to have occurred during the Pliocene-Pleistocene, contemporaneous with the formation of the Lembang Fault and the uplift of the Southern Mountains (Wardhana et al., 2016).

REGIONAL STRATIGRAPHIC SETTING

A regional stratigraphic study was conducted to obtain a comprehensive understanding of the rock formations closely related to the geological conditions of the mapped area. Referring to previous geological mapping, the study area is included within the Bogor Sheet coverage. The mapping area is based on the Geological Map of the Majalengka Sheet 1309-11 (Isnaniawardhani et al., 2020). This map provides information on lithological types, relationships between rock formations, their formation mechanisms, and the chronological

sequence of formation from the oldest to the youngest units.

Based on the Regional Geological Map of the Majalengka Sheet, the study area is composed of five rock formations, as follows:

1. Shale Member of Cinambo Formation (Nmsch)

The Shale Member of Cinambo Formation is dominated by shale, interbedded with sandstone and limestone. Additionally, tuffaceous sandstone and calcareous sandstone are present. This formation is Middle Miocene in age (15.97 Ma - 13.82 Ma) and was deposited in a lower fan environment within a deep-sea fan system at depths of 500-2000 meters (upper bathyal bathymetry) (Sunarta et al., 2023). This rock formation is regionally the oldest formation in the Majalengka Regional Geological Map Sheet.

2. Sandstone Member of Cinambo Formation (Nmcs)

The Sandstone Member of Cinambo Formation is composed of sandstone, graywacke, calcareous sandstone, tuff, claystone, and siltstone. This formation is Middle Miocene in age (13.82 Ma - 11.608 Ma) but slightly younger than Nmsch, deposited in a lower fan environment within a deep-sea fan system at depths of 200-2000 meters (outer neritic to upper bathyal bathymetry) (Sunarta et al., 2023).

3. Breccia Member of Halang Formation (Nmhbz)

The Breccia Member of Halang Formation is composed of breccia and sandstone. This formation is Late Miocene in age (11.608 Ma - 7.246 Ma), deposited in an upper fan environment within a deep-sea fan system (Sunarta et al., 2023).

4. Breccia Member of Citalang Formation (Npcbx)

The Breccia Member of Citalang Formation is composed of breccia and sandstone. This formation is Late Pliocene in age (<3.600 Ma - 2.588 Ma), deposited in a fluvial depositional environment as a braided river system (Al-Hakim & Rizal, 2021).

5. Sandstone Member of Citalang Formation (Npcs)

The Sandstone Member of Citalang Formation is composed of sandstone and tuffaceous sandstone. This formation is Late Pliocene in age (<3.600 Ma - 2.588 Ma), deposited in a fluvial depositional environment as a braided river system (Al-Hakim & Rizal, 2021)

RESEARCH METHOD

Geological mapping was conducted using the traversing method, defined as systematic

geological data collection along predetermined routes (Lisle et al., 2011). Both open and closed traverses were applied to ensure comprehensive spatial coverage of the study area. Outcrops encountered along riverbanks, riverbeds, slopes, and road cuts were established as observation stations. Field methods included lithological description, measurement of structural orientations, documentation of geomorphological attributes, and sampling of rocks for laboratory analysis. Laboratory work involved petrographic analysis and micropaleontological identification to determine lithological characteristics, relative ages, and depositional environments. (Bermana. I, 2006)

The primary materials consisted of rock outcrops encountered along designated traverses. Rock samples were collected from representative outcrops for laboratory analyses, including petrographic and micropaleontological studies based on lithological variation, stratigraphic position, and structural significance. Petrographic analysis was performed through thin section preparation and microscopic examination to determine mineralogical composition, textural characteristics, and rock classification. Micropaleontological analysis involved fossil extraction, identification, and systematic classification to establish biostratigraphic age constraints and interpret paleoenvironmental conditions of the rock units. Additional observational data included geomorphological elements (morphography, morphometry, morphogenetics, and drainage patterns), sedimentary structures, geological structures (faults, joints, and folds).

Field and laboratory data were integrated and analyzed to delineate geomorphological units, lithostratigraphic units, stratigraphic relationships, and structural patterns. Sedimentological interpretations were used to infer depositional processes and environments. The results were compiled into geomorphological and geological maps and used to reconstruct the geological history and assess geological resource potential and hazards.

RESULT

Geomorphology

Geomorphology analysis starts with the morphography analysis with the landform aspects using the modified Van Zuidam classification by Bermana (2006). The research area consists of High hills, Hills Low hills, and Lowland (Figure 2). Moreover, the morphometry analysis shows that the research area consists of flat to very steep areas (Figure 3).

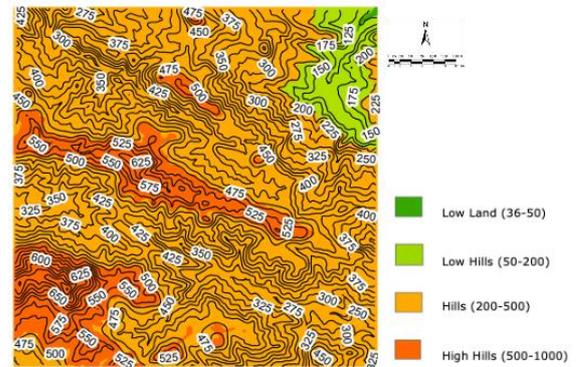


Figure 2. Morphography map

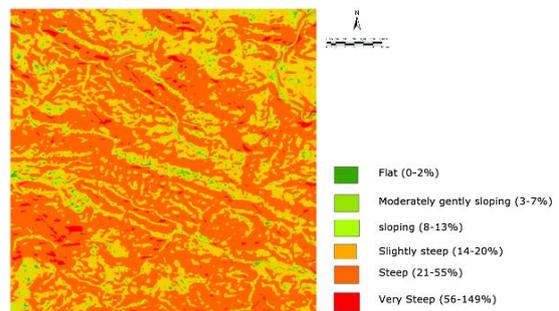
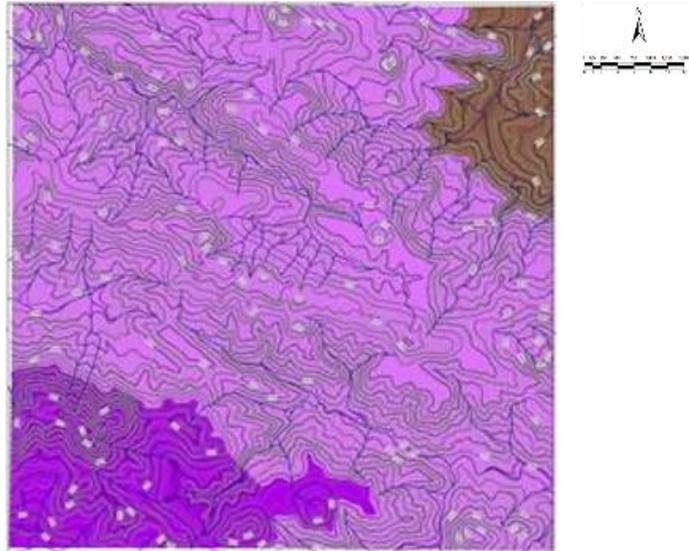


Figure 3. Morphometry map

Drainage Pattern is classified based on Howard (1967), and thus, the research area can be divided into three distinct drainage patterns, which is: dendritic, trellis, and rectangular (Figure 4).

Based on morphographic, morphometric, and morphogenetic analysis, geomorphological unit analysis was conducted and presented in a geomorphological map (Figure 4)



Geomorphological Unit	Symbol	Geomorphological Elements								
		Morphography			Morphometry			Morphogenetic		
		Drainage Pattern	Landform	Valley Shape	Slope Class	Elevation	Slope	Endogenous	Exogenous	Lithology
Moderately Steep Denudational Low Hills Unit	Brown	Dendritic	Low Hills	U-V	Gentle Steep	7-15%	4°-8°	Denudational	Weathering & Erosion	Sandstone, claystone, breccia, tuf
Steep Structural Elongated Hills Unit	Pink	Trellis, rectangular	Hills	V	Steep	15-30%	8°-16°	Structural	Weathering & Erosion	Sandstone, claystone, tuf
Very Steep Structural Sedimentary Hills Unit	Dark Purple	Rectangular	High Heels	V	Very Steep	30-70%	16°-35°	Structural	Weathering & Erosion	Claystone

Figure 4. Geomorphological Map of the Study Area

According to these four aspects, the geomorphological aspects of the area is divided into 3 classes:

1. Moderately Steep Denudational Low Hills Unit

Presented in Figure 5A, this geomorphological unit occupies approximately 10% of the total study area and is located in the northeastern part of the area. Morphographically, it is characterized by low hilly landforms with elevations ranging from about 100 to 200 m above sea level, U-V-shaped valleys, and the presence of the Cilutung River, which exhibits a dendritic drainage pattern. Morphometric analysis shows slope gradients of approximately 4°-8° (7%-15%), classifying this unit as moderately steep slopes (Van Zuidam, 1985). The unit is composed of sandstone, claystone, breccia, and tuff lithologies and has been influenced by endogenous processes, including volcanic activity, as well as exogenous processes such as weathering and erosion.

2. Steep Structural Elongated Hills Unit

This geomorphological unit occupies nearly 70% of the total study area and is distributed

throughout almost the entire study area (Figure 5B). Based on morphographic aspects, this geomorphological unit exhibits hill landforms with elevations of approximately 200-600 meters above sea level. Valleys in this unit have V-shaped forms and rectangular drainage patterns. Based on morphometric analysis, this geomorphological unit has slope gradients of approximately 8° to 16° or about 15% to 30%, classified as steep slopes (Van Zuidam, 1985). This geomorphological unit is composed of interbedded sandstone-claystone, claystone, sandstone, and tuff lithologies that have undergone endogenic processes in the form of tectonic activity including folding and exogenic processes including weathering and erosion.

3. Very Steep Structural Sedimentary Hills Unit

This geomorphological unit occupies nearly 20% of the total study area and is located in the southwestern and central parts of the study area (Figure 5C). Based on morphographic aspects, this geomorphological unit exhibits high hill landforms with elevations of approximately 400-750 meters above sea level. Valleys in

this unit have V-shaped forms and trellis drainage patterns, whose formation is controlled by fold geological structures. Based on morphometric analysis, this geomorphological unit has slope gradients of approximately 16° to 35° or about 30% to 70%, classified as very steep slopes (Van Zuidam, 1985). This geomorphological unit is composed of interbedded claystone-sandstone lithologies that have undergone endogenic processes in the form of tectonic activity and exogenic processes including weathering and erosion.

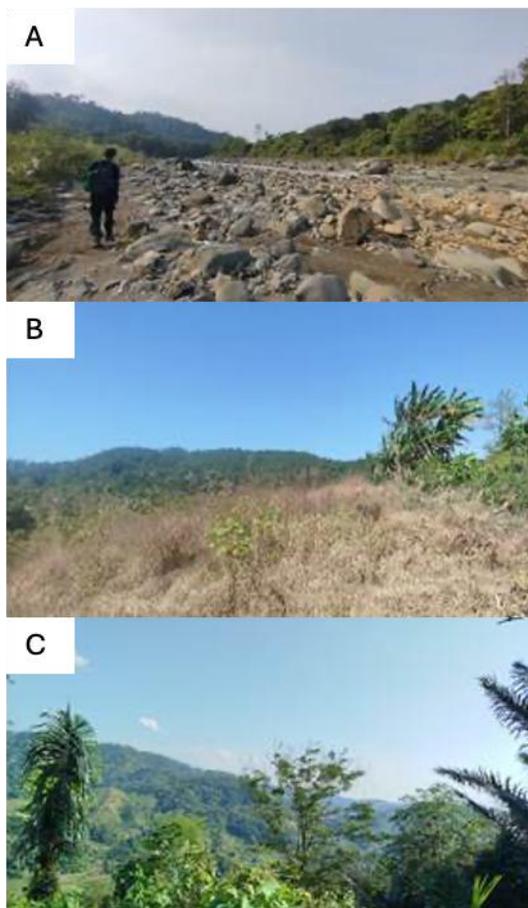


Figure 5. The geomorphological trend observed in study area: A. Moderately steep denudational low hills unit; B. Steep structural elongated hills unit; C. Very steep structural sedimentary hills unit.

Stratigraphy of the Study Area

The stratigraphy of the study area was classified into informal lithostratigraphic units based on field lithology distribution, following the Indonesian Stratigraphic Code (1996) criteria of rock type, combination, uniformity, and dominant properties. Rock unit boundaries were determined using stratigraphic position, topographic characteristics, bedding attitude, and

stratigraphic principles including the law of superposition and cross-cutting relationships. Relative age and depositional environments were established through regional correlation and planktonic and benthic foraminifera analyses. The rock units in the study area are grouped into four groups as follows:

1. Claystone Unit (Sbl)

This unit is the most dominantly distributed unit, occupying nearly 70% of the total study area. It is located in almost all geomorphological units. Based on field observations, this unit consists of claystone, interbedded claystone with sandstone, claystone, sandstone, and volcanic breccia. However, overall it is dominated by claystone with shale, massive, and slump structures. Megascopically, this claystone has a fresh color of blackish-gray to light gray, and a weathered color of grayish-black to grayish-brown. One of the outcrop features is shown in Figure 5A-B. The grain size is clay with soft to hard compaction.

Microscopically, thin sections show a yellowish-brown color (//). It has a subrounded grain roundness degree. Open fabric (matrix supported), and well sorted. The rock composition consists of 7% fragments including carbonate, 87% matrix consisting of clay minerals (59%) and carbonate (28%), and 6% other fragments and minerals in the form of opaque minerals (1%) and skeletal fragments (5%). Based on Pettijohn, F.J. (1975), this thin section is classified as claystone.

Age determination and bathymetric zone analysis were conducted by analyzing foraminifera fossils in one of the samples from this unit, and from the analysis results it can be concluded that the Claystone Unit (Sbl) has a relative age of Middle Miocene (N9-N15) with an Upper Bathyal to Abyssal depositional environment (200 m-4000 m) (Blow, 1969). Based on its stratigraphic position, the Claystone Unit has a conformable relationship with the Sandstone Unit (Sbp), and has an unconformable relationship with the Volcanic Breccia Unit (Sbv). The type of unconformity between the Claystone Unit and the Volcanic Breccia Unit is a disconformity.

2. Sandstone Unit (Sbp)

This unit occupies nearly 20% of the total study area. It is located in the Steep Structural Elongated Hills geomorphological unit. Based on field observations, this unit consists of sandstone and tuff. Megascopically, the sandstone in this unit has a fresh color of light gray to blackish-gray, a weathered color of grayish-brown to blackish-brown, grain size of fine sand (1/8-1/4 mm) to fine sand (1/8-1/4

mm), rounded roundness, closed fabric, no sedimentary structures, well sorted, non-calcareous, and moderately hard to hard. One of the outcrop features is shown in Figure 5C-D.

Microscopically, the rock thin section shows a yellowish-brown color (//), has a subangular grain roundness degree, closed fabric (grain supported), and well sorted. The rock composition in this thin section consists of 57% fragments in the form of quartz (54%); feldspar (1%); and rock fragments (2%), 5% matrix in the form of clay minerals, and 38% other fragments and minerals in the form of carbonate minerals (35%) and opaque minerals (3%). Based on this analysis, it can be concluded that the rock is Quartz Arenite (Pettijohn, 1975).

Based on age determination and bathymetric zone analysis from microfossil analysis, it can be concluded that the Sandstone Unit (Sbp) has a relative age of Middle Miocene (N9-N15) with a Middle Bathyal to Abyssal depositional environment (700 m-5000 m).

3. Tuff Unit (St)

This unit is the smallest unit of the total study area, occupying only about 2% of the total study area. It is located in the Steep Structural Elongated Hills geomorphological unit. Based on field observations, this unit consists only of tuff. Megascopically, this rock has a fresh color of brownish-white and a weathered color of blackish-brown. One of the outcrop features is shown in Figure 5E-F. This rock has a coarse ash grain size, subangular grain shape, moderate sorting, open fabric, and hard consistency. This rock has a composition of minerals, vitric, and lithic components.

Microscopically, the rock thin section shows a yellowish-white color (//), grain relationship (fabric) is open (matrix supported), with poor grain size uniformity/sorting. The matrix is composed partly of volcanic glass (15%), secondary quartz (2%), and clay minerals (5%). It consists of 1% glass/vitric fragments, 2% rock/lithic fragments, and 65% crystal/mineral fragments in the form of secondary quartz (43%) and chlorite (22%), with additional opaque minerals present. This rock has undergone alteration as indicated by the presence of chlorite and secondary quartz minerals; based on Lagat (2009), this rock is in the propylitic alteration zone. Based on Schmidt's (1981) classification, this rock is an Altered Crystal Tuff.

Age determination and depositional environment of this rock unit were determined using regional correlation, namely with the Sandstone Member of Cinambo Formation. From this, it can be concluded that this rock

unit is Middle Miocene in age (13.82 Ma - 11.608 Ma) and its depositional environment is a lower fan environment in a deep-sea fan system at depths of 200-2000 meters (outer neritic to upper bathyal bathymetry).

4. Volcanic Breccia Unit (Sbv)

The Volcanic Breccia Unit occupies the northeastern part of the study area, representing approximately 8% of the total study area within the Moderately Steep Denudational Low Hills geomorphological unit. Megascopically, this rock exhibits a blackish-gray fresh color, blackish-brown weathered color, angular grain shape, open fabric, poor sorting, and moderately hard consistency. The matrix consists of tuff with ash-sized grains dominated by coarse components. Fragments comprise andesite igneous rock with medium crystallinity (1-5 mm), aphanitic granularity, holocrystalline crystallization, equigranular crystal uniformity, predominantly subhedral crystal form (hypidiomorphic granular), and massive structure. One of the outcrop features is shown in Figure 5G-H.

Microscopic analysis of the matrix reveals 17% volcanic glass, 8% quartz microlites, and 13% clay minerals, with 3% vitric fragments, 35% lithic fragments, and 17% crystal/mineral fragments including chlorite (10%), pyroxene (3%), plagioclase (2%), and carbonate (2%). Based on Schmidt's (1981) classification, this is Altered Lithic Tuff. Fragment samples show porphyritic and trachytic textures with hypocrySTALLINE crystallinity, containing 52% phenocrysts (pyroxene 23%, chlorite alteration 29%), 44% groundmass (plagioclase microlites 32%, clay minerals 5%, glass 7%), and 4% opaque minerals. The highly altered nature and porphyritic-trachytic texture indicate this is Altered Andesite.

No benthic or planktonic foraminifera were found in this unit due to its volcanic origin, which is incompatible with foraminiferal habitat. Age and depositional environment determination was based on regional correlation with the Breccia Member of Halang Formation, indicating a Late Pliocene age (<3.600-2.588 Ma) and terrestrial fluvial depositional environment in a braided river system. This unit has a disconformable relationship with the Claystone Unit (Sbl), representing a depositional hiatus without clear evidence of erosion or structural changes between the rock layers.

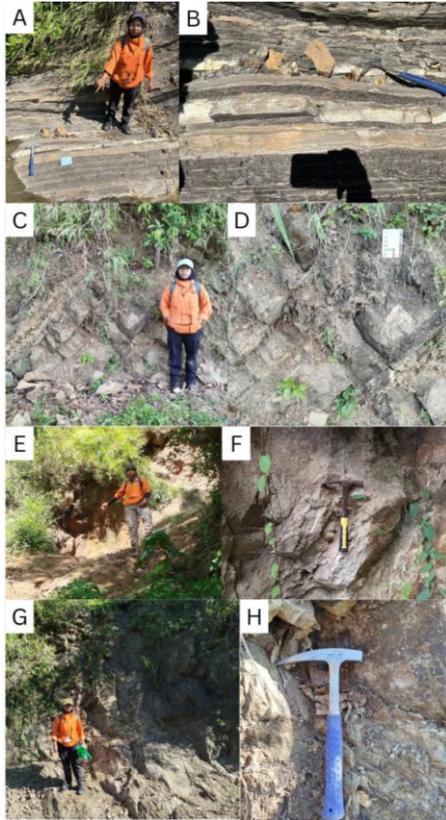


Figure 6. The Field photographs in study area: A-B Claystone Unit (Sbl) outcrops; C-D Sandstone (Sbp) outcrops; E-F Tuff Unit (St) outcrops; G-H Breccia Unit (Sbv)

Geological Structure of the Study Area

Structural geology analysis was conducted through a combination of field data and studio analysis in the mapping area. Interpretation of geological structures in the study area was based on various aspects including strike-dip anomalies, rock unit ages, and lithostratigraphic positions. As supporting data, the presence of structures in the study area was also confirmed through lineament pattern analysis on ridges visible in the DEMNAS (National Digital Elevation Model) map, drainage network patterns, and topographic lineament patterns. This ridge lineament analysis provides estimated information regarding the presence of weakness zones (geological structures) and their associated stress orientations.

Lineament

Lineament pattern interpretation of ridges and valleys was conducted using Digital Elevation Model (DEM) data to identify potential weakness zones related to geological structure formation, particularly faults. Lineament analysis indicates dominant stress

orientations and fracture planes. Based on lineament pattern analysis using Rockworks software, the relative lineament orientation reflects tectonic processes with a northeast-southwest stress direction.

Folds

Folds represent curved structures formed through two main mechanisms, namely bending and buckling. Fold analysis was processed using the Dips software to obtain three classification parameters based on Fluey (1964), including plunge, interlimb angle, and dip of the axial plane. These parameters were derived from opposing strike-dip data on synclinal folds or from strike-dip data with opposite directions on anticlinal folds. As the area is characterized by elongated anticlinal-synclinal hilly landforms, the presence of numerous fold structures of varying types and scales can be anticipated. Based on field observations, a total of 10 folds were identified and classified into four different fold names, namely:

1. Upright Horizontal Fold (Fluey, 1964)
2. Steeply Incline Horizontal Fold (Fluey, 1964)
3. Steeply Incline Gentle Plunging Fold (Fluey, 1964)
4. Upright Gentle Plunging Fold (Fluey, 1964)

Folds

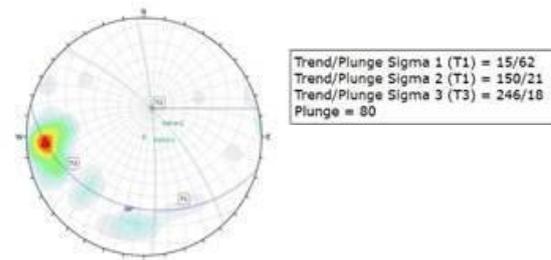


Figure 7. Stereographic projection of joint data

Based on the stereonet analysis of the joint data (Figure 7), it can be concluded that there are indications of extensional tectonic forces (normal fault regime) in the data acquisition area.

DISCUSSION

The geological history of the study area, reconstructed through integrated analysis of stratigraphic relationships, geochronological data, paleoenvironmental interpretations, and structural geology, reveals a complex evolution spanning from the Middle Miocene to the Late Pliocene. This evolutionary history reflects the dynamic interaction between sedimentation processes, volcanic activity,

and tectonic deformation in the region. This output can be represented on the geological map (Figure 8).

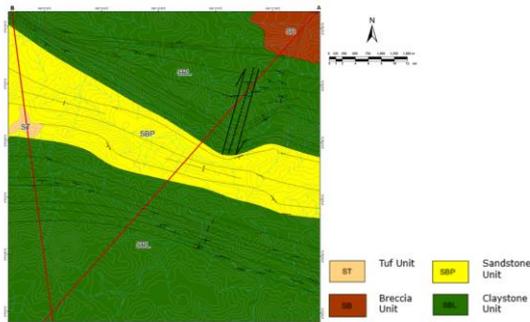


Figure 8. Geological Map

During the Middle Miocene (N9-N15), the study area was characterized by deep marine conditions where the Sandstone Unit (Sbp) and Claystone Unit (Sbl) were deposited contemporaneously and conformably through turbidite mechanisms in middle bathyal to abyssal environments, specifically within the lower fan setting of a deep-sea fan system (Sunarta Et al. 2023). The textural variations and grain size differences between these two units reflect changes in depositional energy related to either basin deepening or reduction in coarse sediment supply. This turbidite deposition represents a period of active sediment delivery from continental sources into a subsiding marine basin.

Subsequently, during the slightly younger Middle Miocene interval (N12-N15), the Tuff Unit (St) was deposited conformably over the Sandstone Unit. The deposition of this volcanic material occurred nearly contemporaneously with the turbidite sedimentation of the underlying units, indicating active volcanism in the region during this period. Volcanic ash from explosive eruptions settled through the water column and accumulated as tuff layers, demonstrating the influence of volcanic processes on the sedimentary record.

A significant tectonic event occurred during the Late Miocene, characterized by compressional convergent tectonism between two lithospheric plates moving toward each other with a relative stress orientation trending northeast-southwest. This compressional regime caused intensive deformation of the Sandstone Unit (Sbp), Claystone Unit (Sbl), and Tuff Unit (St), resulting in the formation of northwest-southeast trending fold structures. The structural analysis indicates the presence of both synclines and anticlines with consistent axial orientations, demonstrating a unified deformational episode. Additionally, evidence of dextral strike-slip faulting suggests that the

compressional system generated lateral displacement components during deformation, possibly related to rotational movement of crustal blocks or partitioning of strain during fold development.

The geological evolution concluded with a dramatic environmental change during the Late Pliocene (<3.600-2.588 Ma), when the Volcanic Breccia Unit (Sbv) was deposited unconformably (disconformity) over the Claystone Unit (Sbl). This unconformity represents a significant hiatus and environmental transition from marine to terrestrial conditions. The volcanic breccia, composed of fragmental volcanic material from ancient volcanic eruptions, was deposited in a terrestrial fluvial environment, likely representing a braided river system transporting volcanic debris from nearby volcanic centers. This shift to subaerial deposition indicates regional uplift and emergence of the study area above sea level, transforming the former marine basin into a terrestrial volcanic-fluvial setting.

The reconstructed geological history provides crucial insights into the broader tectonic and sedimentary evolution in the study area. The turbidite deposition observed in the Middle Miocene units demonstrates the operation of gravity-driven sediment transport mechanisms characteristic of deep-sea fan systems, where sediment-laden density currents flow down submarine slopes, depositing coarse-grained material in proximal fan settings and fine-grained sediments in distal environments. The grain size distribution patterns and sedimentary structures preserved in the Sandstone Unit (Sbp) and Claystone Unit (Sbl) reflect fluctuations in flow velocity and sediment concentration during turbidity current events, controlled by factors including source area uplift rates, sediment supply volumes, and basin subsidence patterns.

The contemporaneous volcanic activity, evidenced by the Tuff Unit (St), indicates the presence of an active volcanic arc system proximal to the basin, with explosive eruptions generating ash plumes that dispersed volcanic material across the marine basin. The Late Miocene compressional deformation represents a critical phase of mountain building directly linked to the convergence and collision of the Indo-Australian Plate with the Eurasian Plate, a tectonic process that continues to shape the geological architecture of the Indonesian archipelago (Van Bemmelen, 1949). The observed northwest-southeast axial trend of these fold structures directly reflects the perpendicular orientation to the northeast-southwest directed compressional stress field, consistent with the

regional stress regime during the Late Miocene collision between the two major plates.

The Late Pliocene unconformity and shift to terrestrial deposition signifies a fundamental change in tectonic regime from active subsidence to regional uplift, driven by continued plate convergence and crustal thickening processes that elevated the former marine basin above sea level. This transition from deep marine to terrestrial environments was accompanied by progressive shallowing of depositional settings, likely influenced by a combination of tectonic uplift associated with the ongoing plate collision and eustatic sea-level fluctuations during the Pliocene (Satyana & Armandita, 2004). The uplift mechanism enabled the development of fluvial drainage systems capable of transporting coarse volcanic debris from newly emerged volcanic edifices, depositing the Volcanic Breccia Unit (Sbv) through high-energy braided river processes characterized by rapid lateral channel migration and continuous sediment aggradation.

The study area contains natural resources classified as Class C minerals according to the Indonesian Mining Law No. 4 of 2009 concerning Mineral and Coal Mining. Class C minerals consist of non-metallic materials including sand, river stones, and igneous rocks utilized for construction materials, road infrastructure, and bridge development. Field observations identified several sites where igneous rocks are extracted through traditional small-scale mining operations conducted by local communities. These extracted materials serve as essential construction resources for infrastructure development and various industrial applications in the region. The presence of these geological resources provides economic opportunities for local communities while requiring appropriate management to ensure sustainable extraction practices.

Beyond mineral resources, the study area possesses potential for geotourism development, particularly at Mount Jagat and the Pine Forest areas. These locations offer opportunities for educational tourism focused on geological and environmental features, which could contribute to local economic development while promoting geological conservation and public awareness of earth science.

Morphometric analysis reveals that the study area is predominantly characterized by moderately steep to very steep slopes, as demonstrated in the slope gradient classification map. This topographic configuration, combined with the lithological

characteristics and structural geological features, creates significant susceptibility to mass movement processes, particularly landslides and soil displacement. The presence of claystone units with inherently low shear strength, coupled with steep slope angles and potential structural weaknesses such as joints and fractures, increases the landslide hazard potential in the region.

Given these geological hazard considerations, infrastructure development planning and implementation within the study area must incorporate comprehensive geotechnical assessments. Site-specific investigations should evaluate slope stability, rock mass characteristics, groundwater conditions, and potential failure mechanisms to ensure that constructed facilities meet appropriate strength and safety standards. Proper engineering geological evaluation is essential to mitigate risks associated with ground instability and to protect both human safety and economic investments in the region. Recommendations include detailed geotechnical site investigations prior to construction, implementation of slope stabilization measures where necessary, and establishment of early warning systems for landslide-prone areas to enhance community resilience to geological hazards.

CONCLUSION

This geological mapping study has successfully achieved its objectives of characterizing the detailed geological conditions of the study area. The research identified three geomorphological units: gentle denudational low hills, steep structural elongated hills, and very steep structural sedimentary hills, which reflect the combined influence of lithological characteristics and tectonic processes in shaping the present-day landscape.

The stratigraphic framework comprises four informal lithostratigraphic units deposited from Middle Miocene to Late Pliocene. The succession begins with the Claystone Unit (Sbl) and Sandstone Unit (Sbp), both of Middle Miocene age (N9-N15), deposited in deep marine environments (upper bathyal to abyssal zones) through turbidite processes. These are conformably overlain by the Tuff Unit (St) of Middle Miocene age (13.82-11.608 Ma), deposited in a lower fan setting of a deep-sea fan system. The succession is unconformably capped by the Volcanic Breccia Unit (Sbv) of Late Pliocene age (<3.600-2.588 Ma), representing terrestrial fluvial deposits from ancient volcanic eruptions in a braided river system.

Structural geological analysis reveals a compressional tectonic regime dominated by

northwest-southeast trending synclines and anticlines, accompanied by joints and fault indications. These structures record northeast-southwest oriented compressional stresses during the Late Miocene, which produced dextral strike-slip faulting and folding patterns that significantly controlled the geological architecture of the region.

The geological evolution reconstructed from this study demonstrates a transition from deep marine turbidite sedimentation in the Middle Miocene to terrestrial volcanic deposition in the Late Pliocene, punctuated by significant tectonic deformation. This study contributes to a more comprehensive understanding of the Miocene-Pliocene geological evolution in the Sumedang area, providing detailed lithostratigraphic, structural, and paleoenvironmental interpretations that refine existing regional-scale geological frameworks. The detailed geological maps and stratigraphic data generated from this research provide essential baseline information for future geological investigations, natural resource exploration, and geological hazard assessment in the region. Further research integrating geochemical analysis and radiometric dating would enhance the understanding of the volcanic history and tectonic evolution of this area.

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