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Reconstruction of Geological History Based on Stratigraphic Analysis in the Gombong Region, North Serayu Basin

Rekonstruksi Sejarah Geologi Berdasarkan Analisis Stratigrafidi Daerah Gombong, Cekungan Serayu Utara

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Abstract *-* In the North Serayu Basin, there are deepsea sedimentary material and volcanic material are deposited in the terrestrial environment. The varied depositional environments require a detailed geological understanding. Because research has yet to be carried out regarding the reconstruction of the geological history in the Gombong area, this research was carried out to study and understand the chronology of deposition and the condition of its geological structure. Research methods include field observation, stratigraphic analysis, and surface geological structure analysis. From old to young, the stratigraphy of the research area is the Shale Interbedded Unit with Rambatan Sandstone, the Halang Tuff Unit, the Dacite Intrusion Unit, and the Slamet Basalt Lava Unit. The reconstruction of the geological history of the research area began in the Middle Miocene - Late Miocene with the deposition of the Shale Interbedded Unit with Rambatan Sandstone in the lower Bathyal-Abysal bathymetric environment (500-2000 m) and the Halang Tuff Unit was deposited in the Late Miocene-Pliocene-finger conformity. Then, during the Late Miocene, the deposition of the Dacite Intrusion Unit occurred, which had an unconformable relationship (nonconformity) with interbedded shale units with Rambatan Sandstone below. Then, in the Late Miocene - Pliocene, due to the compressional regime phase of the Java Island subduction, a geological structure was formed with the principal stress (σ1) trending relatively northwest- southeast, which resulted in the Sarawak right-slip fault, the Mendelem thrust fault and the Gunungtiga normal fault. Furthermore, during the Pleistocene, volcanic activity continued, producing the Slamet Basalt Lava Unit, which had an incongruent relationship (nonconformity) with the Dacite Intrusion Unit below it.

Keywords: *Geological History, Stratigraphy, North Serayu Basin.*

Abstrak *- Di Cekungan Serayu Utara, terdapat material sedimen laut dalam dan material vulkanik yang diendapkan pada lingkungan darat. Lingkungan pengendapan yang bervariasi tersebut memerlukan pemahaman geologi yang rinci. Karena belum dilakukan penelitian mengenai rekonstruksi sejarah geologi di daerah Gombong, maka penelitian ini dilakukan untuk mengkaji dan memahami kronologi pengendapan dan kondisi struktur geologinya. Metode penelitian meliputi pengamatan lapangan, analisis stratigrafi, dan analisis struktur geologi permukaan. Stratigrafi daerah penelitian dari tua hingga muda adalah Satuan Perlapisan Serpih dengan Batupasir Rambatan, Satuan Tuf Halang, Satuan Intrusi Dasit, dan Satuan Lava Basal Slamet. Rekonstruksi sejarah geologi daerah penelitian diawali pada Kala Miosen Tengah - Miosen Akhir dengan pengendapan Satuan Perlapisan Serpih dengan Batupasir Rambatan pada lingkungan batimetri Batial-Abisal Bawah (500-2000 m) dan Satuan Tuf Halang secara selaras menjari di Kala Miosen Akhir - Pliosen. Kemudian pada Kala Miosen Akhir terjadi pengendapan Satuan Intrusi Dasit yang mempunyai hubungan tidak selaras (nonconformity) dengan satuan perlapisan serpih dengan Batupasir Rambatan di bawahnya. Kemudian pada Kala Miosen Akhir-Pliosen akibat fase rezim kompresional dari subduksi Pulau Jawa, terbentuklah struktur geologi dengan tegasan utama (σ1) yang berarah relatif barat laut-tenggara sehingga mengakibatkan terbentuknya sesar geser kanan Sarawak, sesar naik Mendelem dan sesar turun Gunungtiga. Selanjutnya pada Kala Pleistosen terjadi lagi aktivitas vulkanik yang menghasilkan Satuan Lava Basal Slamet yang mempunyai hubungan tidak selaras (nonconformity) dengan Satuan Intrusi Dasit yang ada di bawahnya.*

KataKunci: *Sejarah Geologi, Stratigrafi, Cekungan Serayu Utara*

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INTRODUCTION

The research area is in the North Serayu Basin, a sedimentary basin containing volcanic material deposits, shallow marine sedimentary deposits, and deep marine sedimentary deposits. Based on field mapping data, the lithology of Gombong area and surroundings are consists from volcanic rock product, there are Lava Basalt Formation, Dacite Intrusion Formation, Tuff Halang Formation, and Shale Interbedded Unit with Rambatan Sandstone Formation (Adam et al., 2024; Figure 1). Located in the Quaternary Volcanic Zone, this zone is occupied by Mt. Slamet (± 3,432 m). The relationship between stratigraphic analysis and geological history explains the process of stratigraphic formation in the research area, which includes the genesis of lithology and the depositional environment (Hutomo & Firmansyah, 2020). Understanding the stratigraphic conditions of the research area will provide an overview and mechanism of geological formation that can be applied as a basis for further research. Geological historical reconstruction explains the depositional history of formations from the Tertiary to the Quaternary in the research area obtained from the results of stratigraphic analysis in the form of correlation between lithologies, fossil content to determine relative age, as well as petrographic analysis to determine the composition of the rocks (Adam & Rochmana, 2022).

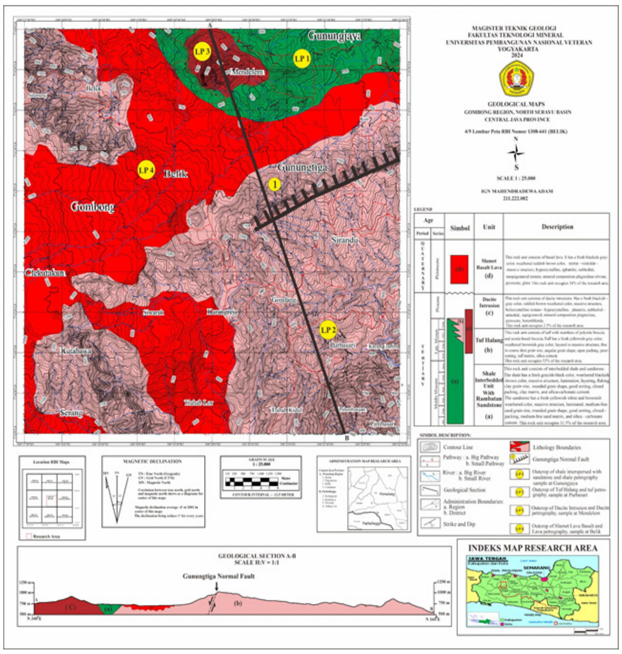


Figure 1. Geological Map of Gombong Region (Adam *et al*, 2024).

Regional Stratigraphy

The regional stratigraphy of the research area is included in the stratigraphy section of the Purwokerto-Tegal area, which has been compiled by Djuri et al. (1996). The research location is on the Indonesian topography map, sheet belik (1308-641). The following is the regional geological stratigraphic order according to Djuri et al. (1996) starting from the oldest, namely the Pamali Formation (Tmp), Rambatan Formation (Tmr), Tertiary Intrusion (Tmi(m)), Waturono Formation (Tmw), Penosogan Formation (Tmpp), Limestone Member of the Halang Formation (Tmphl), Breccia Member of the Halang Formation (Tmphh), Halang Formation (Tmph), Kumbang Formation (Tmpk), Breccia Member of the Tapak Formation (Tph), Limestone Member of the Tapak Formation (Tptl), Tapak Formation (Tpb), Kalibiuk Formation (Tpb), Kaliglagah Formation (Tpk), Clay Member of the Ligung Formation (Qtlc), Ligung Formation (Qtlb), Mengger Formation (Qpm), Gintung Formation (Qpg), Linggopodo Formation (Qpl), Terrace Deposits (Qps), Undiifferentiated Volcanic of Slamet (Qvs), Lava of Slamet Volcanic (Qvls), Laharic Deposits of Slamet Volcanic (Qls), and Alluvium (Qa; Figure 2).

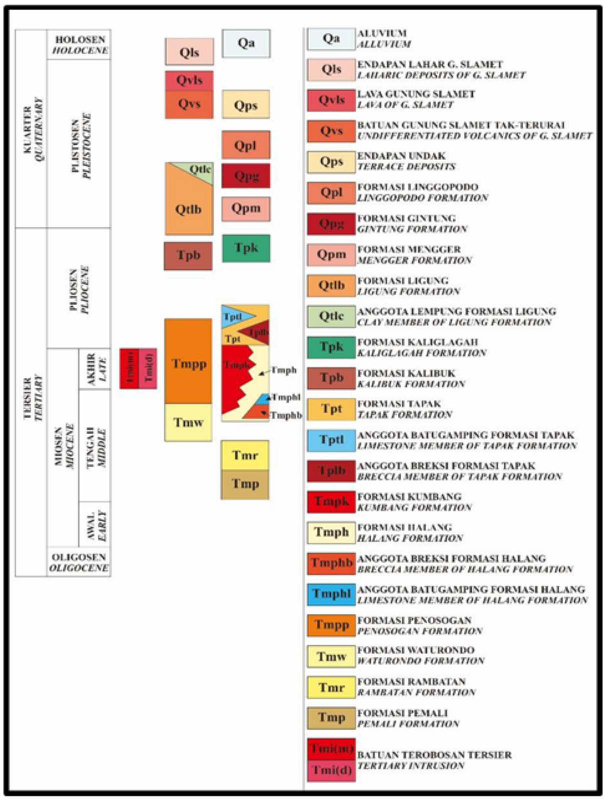


Figure 2. Regional stratigraphy of the Purwokerto-Tegal area (Djuri *et al*, 1996).

METHOD

The methods used include field observations, stratigraphic analysis and geological structure measurements. The analysis starts from petrographic observations and micropaleontologi observations. Petrographic analysis aims to determine the characteristics and mineral composition of thin section. Fossil determination seeks to determine the age of a formation and its depositional environment in determining planktonic and benthonic foraminifera fossils. Then, a geological structure analysis was carried out. After these data are analyzed, a reconstruction of the research area's geological history is formed.

RESULT AND DISCUSSION

Stratigraphy of the Research Area

The stratigraphy of the study area in sequence from old to young consists of five rock units, namely the Shale Interbedded Unit with Rambatan Sandstone (Middle to Late Miocene), the Tuff Halang Unit (Late Miocene to Pliocene), the Dacite Intrusion Unit (Late Miocene) and the Slamet Basalt Lava Unit (Pleistocene; Figure 3).

Shale Interbedded Unit with Rambatan Sandstone (Middle-Late Miocene)

Located at Mendelem and Gunungjaya area (LP1), Consisting of grayish-black shale lithology, with blackish brown weathered color, massive structure, laminated, layered, clay grain size, rounded, well sorted, closed packaging, clay matrix, and silica-carbonate cement (Figure 4). This unit's age and depositional environment are determined based on the fossil content of Foraminifera, which is small amounts contained in sandstone. Based on the results of the analysis, planktonic Foraminifera fossils were obtained such as: *Orbulina bilobata, Globorotalia praemenardii, Sphaeroidinella subdehiscens, Orbulina universal, Orbulina saturalis, Globigoinades immaturus, Globigerinoides extremus, Globiginades immature, Globigerinoides primodius, Globigerinoides obliqus* (Figure 5). Based on the fossils above, it can be concluded that the age of the Rambatan Shale and Sandstone Intercalation Unit is Middle-Late Miocene (N09-N18; Table 1).

Determination of the depositional environment is based on the analysis of benthonic fossils in the Interbedded Shale Unit with Rambatan Sandstone-Bentonic Foraminifera fossils such as: *Rhizamina algaeformis, Bahycipon sars, Reophax ampullaca*. From the results of this analysis, it can be determined that the Rangkat Sandstone Intercalated Shale Unit was deposited in the upper Bathyal to Abysal edge environment 800-3000 meters (Table 2).

The stratigraphic relationship of the Rambatan Sandstone Interbedded Shale unit with the underlying lithology is still being determined because this unit is the oldest rock at the research location (Figure 6).

LEGEND

Age		Simbol	Unit	Description
Period	Series			
QUATERNARY	Pleistocene	(d)	Slamet Basalt Lava (d)	This rock unit consists of basalt lava. It has a fresh blackish gray-color, weathered reddish brown color, scoria - vesicular - massive structure, hypocrystalline, aphanitic, subhedral, inequigranural texture, mineral composition plagioclase olivine, pyroxene, glass. This rock unit occupies 34% of the research area.
TERTIARY	Pliocene	(c)	Dacite Intrusion (c)	This rock unit consists of dacite intrusions. Has a fresh blackish - gray color, reddish brown weathered color, massive structure, holocrystalline texture - hypocrystalline, phaneric, subhedral - anhedral, equigranural, mineral composition plagioclase, pyroxene, horemblenda. This rock unit occupies 2.5% of the research area.
	Late Miosen	(b)	Tuf Halang (b)	This rock unit consists of tuff with members of polymic breccia and scoria basalt breccia. Tuff has a fresh yellowish gray color, weathered brownish gray color, layered to massive structure, fine to coarse dust grain size, angular grain shape, open packing, poor-sorting, tuff matrix, silica cement. This rock unit occupies 52% of the research area.
	Middle Miocene	(a)	Shale Interbedded Unit With Rambatan Sandstone (a)	This rock unit consists of interbedded shale and sandstone. The shale has a fresh grayish-black color, weathered blackish -brown color, massive structure, lamination, layering, flaking, clay grain size, rounded grain shape, good sorting, closed packing, clay matrix, and silica-carbonate cement. The sandstone has a fresh yellowish white and brownish weathered color, massive structure, laminated, medium-fine sand grain size, rounded grain shape, good sorting, closed - packing, medium-fine sand matrix, and silica - carbonate cement. This rock unit occupies 11.5% of the research area.

Figure 3. stratigraphy of the research area (Adam *et al,* 2024).

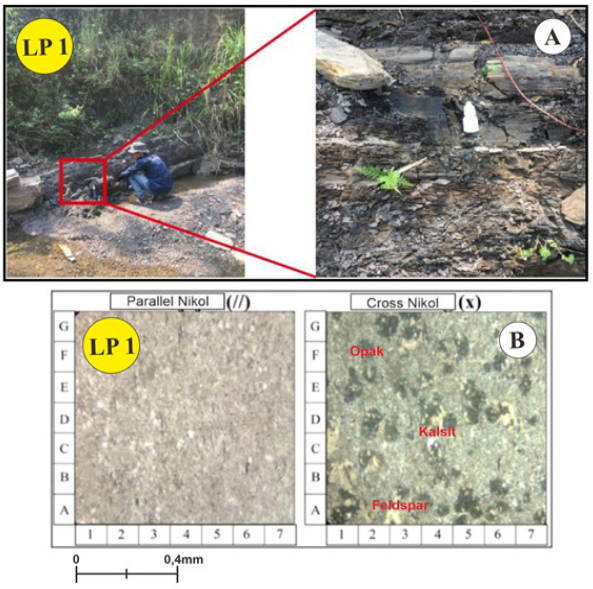


Figure 4. A) Outcrop of shale interspersed with sandstone at Mendelem and Gunungjaya area (LP1), B) Shale petrography.

Figure 5. Foraminifera fossils.

Table 1. Determination of the age of the lower, middle, and upper part of the interbedded shale sandstone unit using planktonic fossils based on Blow (1969)

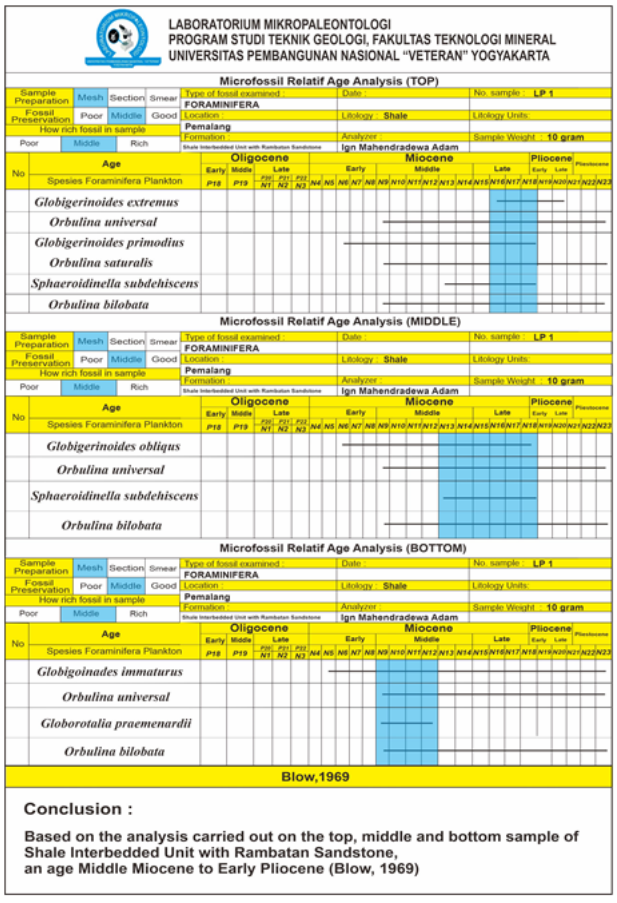
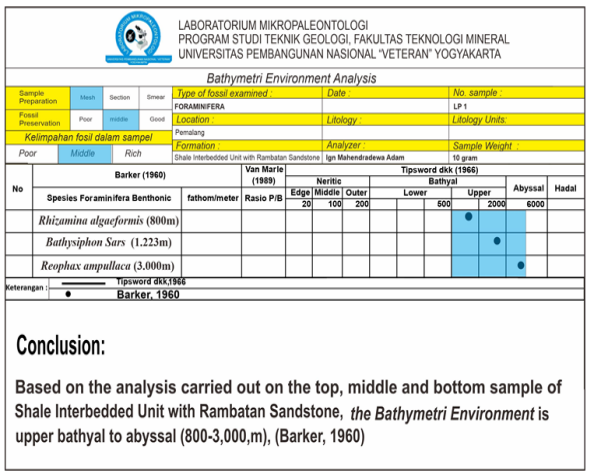


Table 2. Determination of the depositional environment of the Shale Interbedded Unit with the Rambatan Sandstone Unit using benthonic fossils based on Barker (1960)



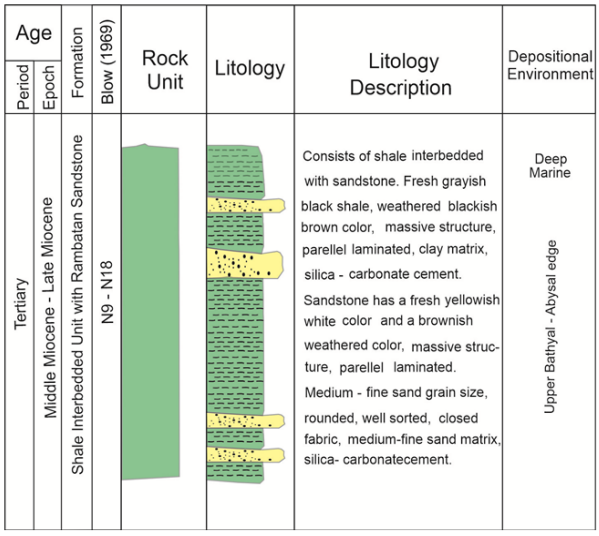


Figure 6. Column lithology of Creation Sandstone Interbedded Shale unit without scale.

Halang Tuff Unit (Late Miocene-Pliocene)

Located at Purbasari, Beluk, Kuta, Gunungtiga, Sirandu, Gondang, Tlahab kidul, Kutabawa. Lithology tuff with polymyctic breccia and scoria basalt breccia. Tuff has a fresh yellowish gray color, weathered brownish gray color, layered sedimentary structure, and massive fine-coarse dust grain size, angular, open packed, poorly sorted, silica cement (Figure 7). Petrographic observations, the name of the rock is lithic tuff (Schmid, 1981), a massive structure with a composition of 10% plagioclase, 10% pyroxene, 5% opaque minerals, 20% volcanic glass, 55% rock fragments (lithic). Determining the age of the Halang Tuf Unit was determined by comparing it with the Halang Formation (Tmph) in the regional stratigraphy of the second edition of the Purwokerto-Tegal Sheet Map by Djuri *et al.*,1996

because the Halang tuff does not contain fossils that can be used to determine the age. Based on the similarity of physical characteristics, the Halang tuff unit is comparable to the Halang Formation (Tmph), which is Upper Miocene to Pliocene in age. The stratigraphic relationship of the Halang Tuff Unit is a rock unit deposited after the shale units found in the study area with an Upper Miocene- Pliocene age. It conformity with the units below it (Figure 8).

Dacite Intrusion Unit (Late Miocene)

Located at Mendelem area. Characteristics of the Dacite Intrusion are fresh blackish gray, weathered reddish brown, massive structure, holocrystalline-hypocrystalline texture, phaneritic, subhedral-anhedral, equigranular, mineral composition of plagioclase, pyroxene, hornblende **(Figure 9)**. The rock's name is Dacite (Travis, Russel B., 1955), and the mineral composition is plagioclase An 26 andesine (60%), pyroxene (15%), 10% hornblende, 5% quartz, and 10% opaque. The age of this Dacite Intrusion Unit was determined by comparing it with the Tertiary breakthrough rock formation

(Tmi(d)) on the second edition of the Purwokerto-Tegal Regional Map Sheet (Djuri *et al*. 1996) because this dacite intrusion does not contain fossils that can be used to determine the age. Based on the similarity of physical characteristics, this diorite intrusion unit is comparable to the Tertiary breakthrough rock formation (Tmi(d), which is of Late Miocene age. The stratigraphic relationship of the Dacite Intrusion Unit with the underlying lithology, namely the Creeping Sandstone Shale Intercalation Unit, is unconformity (*nonconformity*; Figure 10).

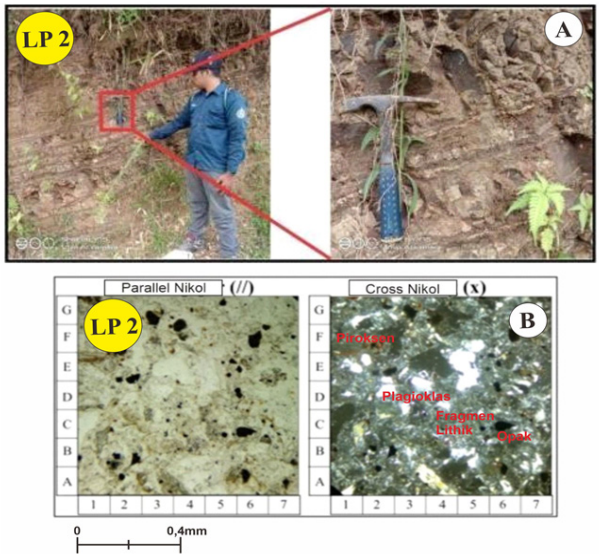


Figure 7. A). Outcrop of Halang Tuff Unit located at Purbasari (LP 2). B). Tuff Halang petrography.

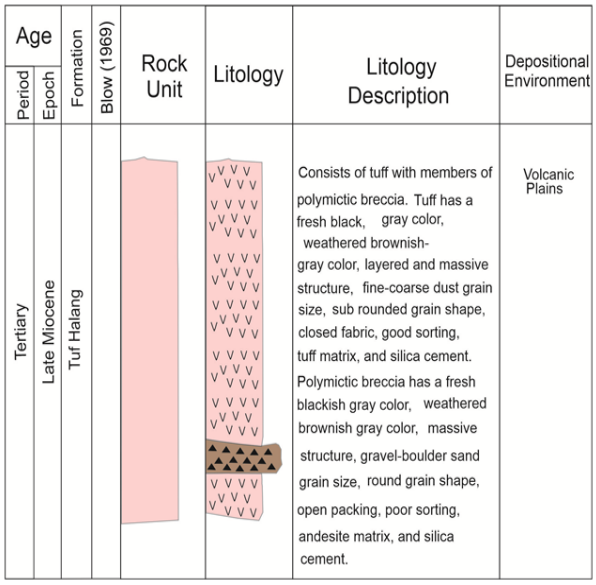


Figure 8. Halang Tuff Unit lithology column without scale.

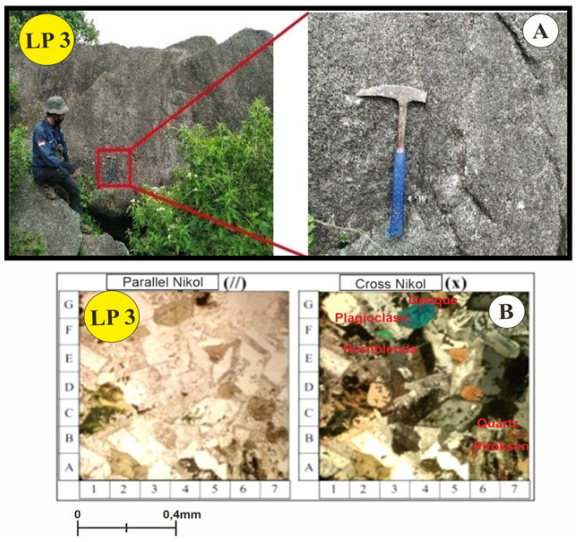


Figure 9. A). Outcrop of the Dacite Intrusion Unit at Mendelem (LP 3). B). Dasit Intrusion petrography.

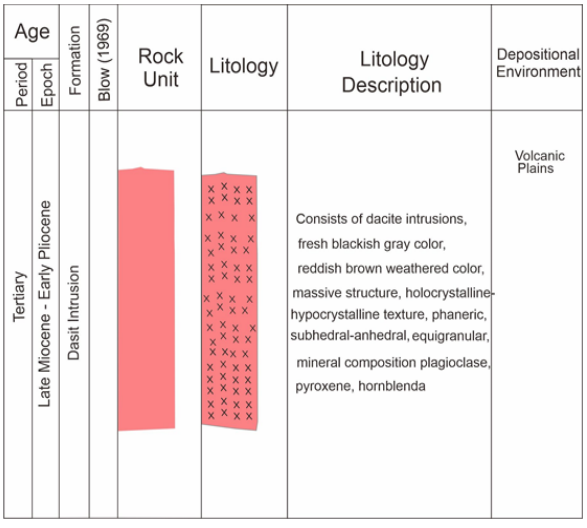


Figure 10. Dacite Intrusion Unit lithology column without scale.

Slamet Basalt Lava Unit (Pleistocene)

Located at Siremeng, Gombong, Belik, Clekatakan, Sirawak, Tlahab lor, Serang. The lithology is basalt lava; fresh color is blackish gray, weathered reddish brown, scoria- vesicular-massive structure, hypocrystalline texture, aphanitic, subhedral, and *inequigranular* (Figure11). Petrographic observation, name Basalt Porphyry (Travis, 1955), dark gray color, massive-scoria structure, degree of hypocrystalline crystallization, aphanitic porphyry granularity, euhedra-subhedral mineral form, inequigranular relationship, mineral composition in the form of Bytownite plagioclase (An 80) (50%), pyroxene (ortho-pyroxene) (20%), olivine (20%), glass 5% and opaque (5%). The age of the Slamet Basalt Lava unit cannot be determined with certainty because it does not contain fossils, so this age determination is based on comparisons with regional stratigraphy in the second edition of the Purwokerto-Tegal Sheet (Djuri *et al*., 1996) Gunungai Slamet Lava (Qvls; Djuri *et al*., 1996). This unit was deposited or formed in a terrestrial environment. Stratigraphic relationship between the Slamet Basalt Lava Unit and The underlying rock unit, namely the Dacite Intrusion Unit, is nonconformity (Figure 12).

Comparability of Research Area Stratigraphy with Regional Stratigraphy

The following table shows the stratigraphic relationship of the research area as a whole between the rock units and the rock members of each unit contained in the research location to the regional stratigraphy on the Geological Map Sheet of Purwokerto-Tegal (Figure 13).

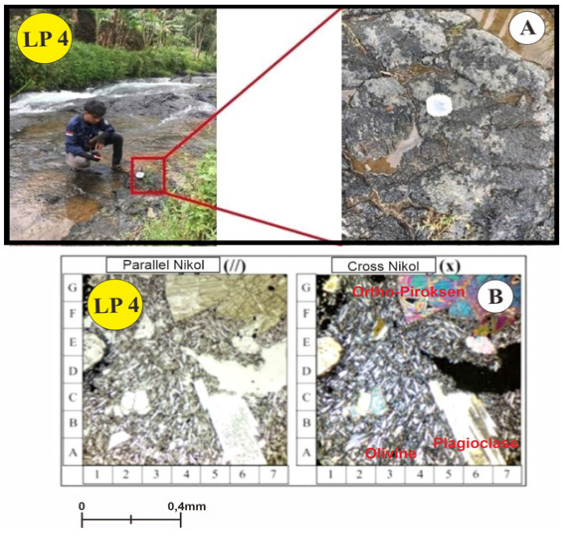


Figure 11. A). Outcrop of Slamet Basalt Lava Unit at Belik area (LP 4). B). Basalt Lava Petrography

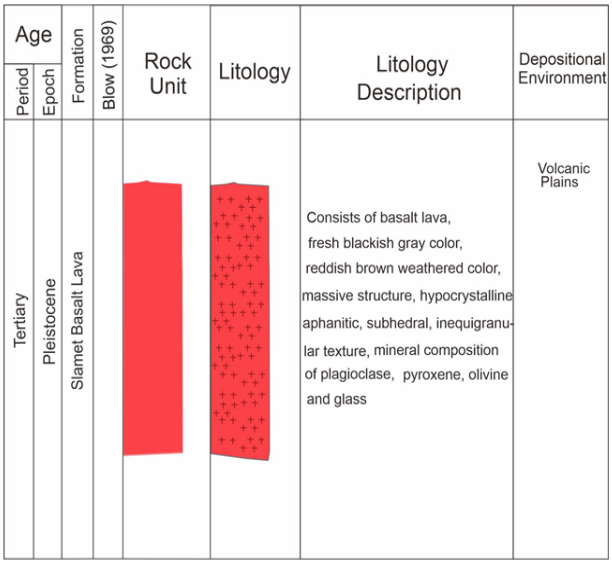


Figure 12. Lithology column of the Slamet Basalt Lava Unit without scales

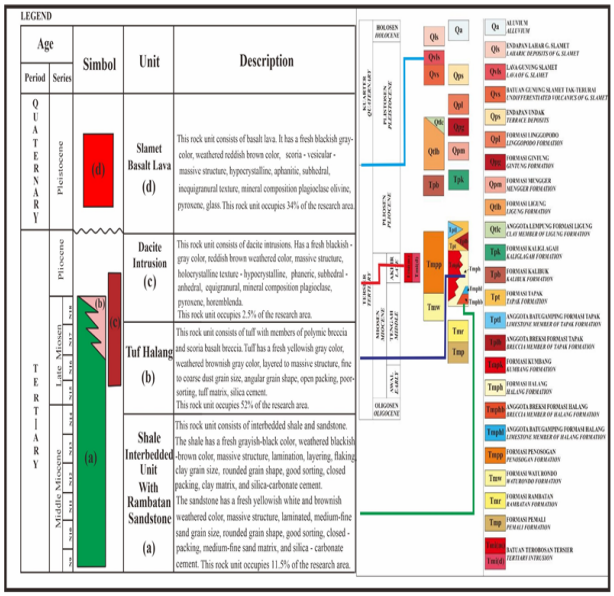


Figure 13. Comparability of Research Area Stratigraphy with Regional Stratigraphy.

Geological Structure of the Research Area

Secondary structures at the research location is normal faults. The fault structure is obtained through field observations and interpretation through images and topographic maps by paying attention to the straightness of the topographic shape and combining the data obtained from field observations. Based on the results of field research and interpretation of DEM satellite imagery (*Digital Elevation Model*) then, there are faults, namely:

Gunungtiga Normal Fault: This fault is located in the eastern part of the research area and extends from the northeast and passes through Gunungtiga Village to Kutabawa Village. Flow patterns characterize this

fault and lineaments and offset topography that appear on the DEM image and in the field (Figure 14). Based on field observations, normal faults were found with data indications in *stepping* and fault mirrors, along with analysis of structural data obtained in the field.

Based on the results of analysis using dips software, the general direction of the N 230 fault plane was obtained/74^{O}, Netslip 72°/ N 314° E, rake 74° is entered into the classification fault diagram (Rickard, 1972)**.**

Geological Structure Mechanism

The structure formation mechanism in the research area is related to the formation of geological structures on the island of Java, especially the formation of the geological structure of the North Serayu zone and Quaternary Volcanism. The geological structures that emerge and develop in the research area are shear faults (*oblique fault*) trending relatively northwest-southeast and downturn faults (a *normal fault*), which have a relative direction of North East-South West; it can be interpreted that the research area is a zone where a strain tectonic regime occurs which produces a horizontal fault system with transtension style with a curved path that will form *releasing bend* thus forming a depression zone*(pull apart basin*; Figure 15).

Figure 14. Outcrop of the Gunungtiga normal fault (1), taken in the field.

Table 3. Structural data on the Gunungtiga normal fault

Strike/dip slickenside (N… ^{O}E/… ^{O})	Rake (… ^{O})	Striation(… ^{O}, N… ^{O}E)
230^{0}/74^{O}	74	72^{O}, N 314^{O} /E

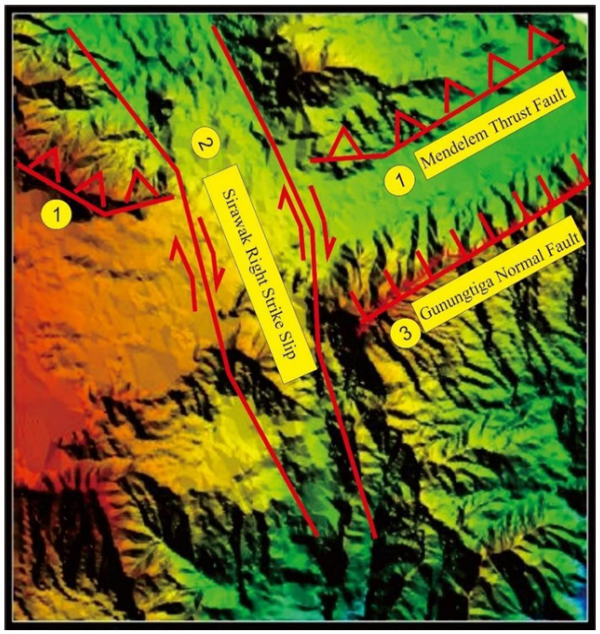


Figure 15. Structure geology in research area.

From the analysis of the geological structure, it can be concluded that the geological structure of the research area was formed in the compressional tectonic deformation phase with the principal stress (σ1) trending relatively northwest-southeast, resulting in a Gunungtiga normal fault in the form of *releasing bend*. The age of formation of the geological structure is estimated to have occurred in the Late Miocene-Pliocene, which is proven by the faulting of the interbedded shale units of the Rangkat sandstone, Dacite Intrusion, and Halang Tuff as well as the Pleistocene which caused older rocks to be faulted and from the flow direction pattern of the Slamet Basalt Lava.

Geological History of the Research Area

The geological history of the research area starts from the Middle Miocene - Late Miocene, where in the Middle Miocene (N9-N18), the interbedded shale unit with creeping sandstone was deposited in the Lower Bathyal-Abysal bathymetric environment of 500-2000 meters, and the Halang Tuff was also deposited in the Late Miocene. Then, during the Late Miocene, volcanism activity occurred in North Serayu, which caused the emergence of the Dacite Intrusion

Unit, resulting in the Creeping Sandstone Shale Intercalation Unit, which was initially dominated by mudstone because it was intruded by the Dacite Intrusion Unit, resulting in most of the mudstone flaking and locally becoming metasediments or hornfels around the zone-rock contact. Then, due to the subduction compression regime on Java Island, strike-slip faults that trended relatively northwest-southeast were formed, along with thrust faults that trended north-south with regional uplift. During the Pleistocene, the research area had changed to a terrestrial environment, and volcanic activity then deposited basalt lava units.

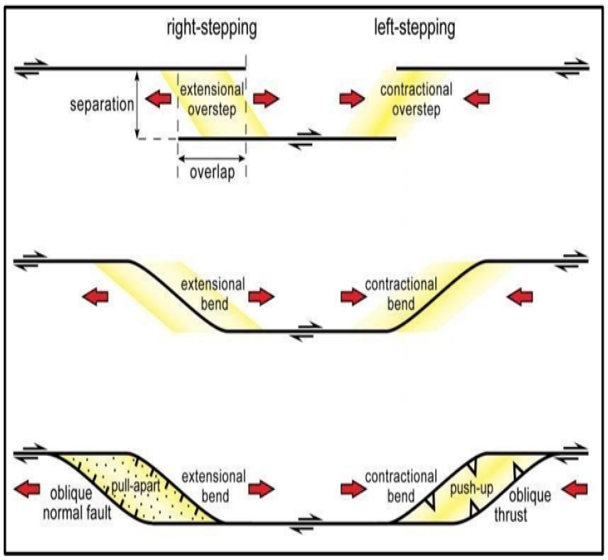


Figure 16. Segmentation on strike-slip faults (Burg, 2013).

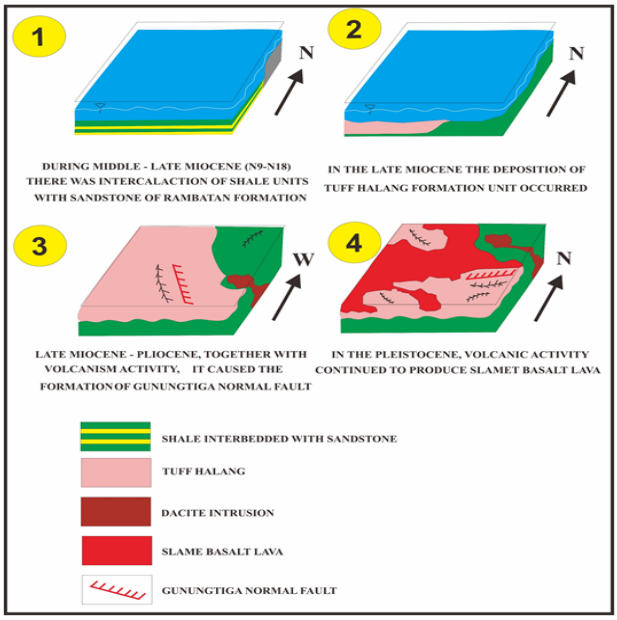


Figure 17. Reconstruction of the geological history of the research area.

CONCLUSION

Based on field data and laboratory analysis and interpretation results, a geological conclusion can be drawn that describes the historical sequence in the framework of space and time. The stratigraphy that makes up the research area from the oldest to the youngest consists of five rock units, namely the Interbedded Shale Unit with Rambatan Sandstone (Middle to Late Miocene), Halang Tuff Unit (Late Miocene to Pliocene), Dacite Intrusion Unit (Late Miocene) and Slamet Basalt Lava Unit (Plistocene).

The reconstruction of the geological history of the research area began in the Middle Miocene - Late Miocene with the deposition of the Shale Interbedded Unit with Rambatan Sandstone in the lower Bathyal - Abysal bathymetric environment (500-2000 m) and the Halang Tuff Unit was deposited in the Late Miocene - Pliocene (finger in sync). Then, during the Late Miocene, the deposition of the Dacite Intrusion Unit occurred, which had a nonconformity relationship with the Interbedded Shale Unit and the Intrusive Sandstone below it. Then, in the Late Miocene - Pliocene, due to the compressional regime phase of the Java Island subduction, a geological structure was formed with the principal stress (σ1) trending relatively northwest-southeast, which resulted in the Gunungtiga normal fault. Furthermore, during the Pleistocene, volcanic activity continued, producing the Slamet Basalt Lava Unit, which had a nonconformity relationship with the Dacite Intrusion Unit below it.

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