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STUDI PETROGRAFI SATUAN BATUAN FORMASI JAMPANG, DAERAH CIBENDA, KECAMATAN CIEMAS, KABUPATEN SUKABUMI, INDONESIA

PETROGRAPHIC STUDY OF THE ROCK UNITS OF THE JAMPANG FORMATION, CIBENDA AREA, CIEMAS DISTRICT, SUKABUMI REGENCY, INDONESIA

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Abstrak— Daerah Cibenda, yang berada di Kecamatan Ciemas, Kabupaten Sukabumi, merupakan bagian dari Geopark Ciletuh dan memiliki keragaman geologi yang signifikan sehingga memerlukan kajian mendalam. Penelitian ini bertujuan untuk mengidentifikasi karakteristik petrografi dari satuan batuan utama serta merekonstruksi evolusi geologi berdasarkan data mikroskopis. Metode yang digunakan adalah analisis sayatan tipis pada sampel batuan yang dikumpulkan dari lapangan dan diamati menggunakan mikroskop polarisasi. Tiga satuan batuan utama yang dikaji adalah Satuan Batupasir, Satuan Breksi, dan Satuan Andesit. Hasil analisis menunjukkan bahwa satuan batupasir terdiri dari batuan berbutir halus hingga sedang yang didominasi oleh fragmen batuan dan feldspar. Satuan breksi tersusun atas komponen polimik, yaitu tuf kristal dan batupasir dalam matriks batupasir. Sementara itu, satuan andesit menunjukkan tekstur porfiritik dengan fenokris plagioklas dan piroksen. Temuan ini mengindikasikan bahwa proses pengendapan dan intrusi magmatik terjadi secara berurutan, membentuk urutan geologi yang mencerminkan evolusi dari lingkungan laut menjadi aktivitas tektonik dan magmatik di daerah Cibenda.

Kata kunci: Cibenda, Evolusi Geologi, Formasi Jampang, Petrografi, Sayatan tipis

Abstract— *The Cibenda area, located in Ciemas District, Sukabumi Regency, is part of the Ciletuh Geopark and possesses significant geological diversity that necessitates detailed study. This research aims to identify the petrographic characteristics of the main rock units and reconstruct the geological evolution based on microscopic data. The method employed is thin section analysis of rock samples collected from the field and observed under a polarizing microscope. The study focuses on three primary rock units: the Sandstone Unit, Breccia Unit, and Andesite Unit. The analysis reveals that the sandstone unit consists of fine-to-medium-grained rocks dominated by lithic fragments and feldspar. The breccia unit is composed of polymictic components, specifically crystal tuff and sandstone, within a sandstone matrix. In contrast, the andesite unit exhibits a porphyritic texture with phenocrysts of plagioclase and pyroxene. These findings suggest a sequential occurrence of sedimentary and magmatic processes, forming a geological sequence that reflects the evolution from a marine depositional environment to subsequent tectonic and magmatic activity in the Cibenda area.*

Keywords: *Cibenda, Geological Evolution, Jampang Formation, Petrography, Thin Section*

I. INTRODUCTION

The Cibenda area, located in Ciemas District, Sukabumi Regency, is a part of the **Ciletuh Geopark**, a region with national and international recognition for its rich geological, biological, and cultural diversity. The presence of varied rock units, complex geological structures, and a significant geological history shaped by plate collision millions of years ago makes this area crucial for detailed study [1], [2]. A key approach to understanding this area's geological framework is through petrographic analysis, which can reveal the mineralogical and textural characteristics of rocks—essential records of a region's geological history [3]. The study area is shown in Figure 1.

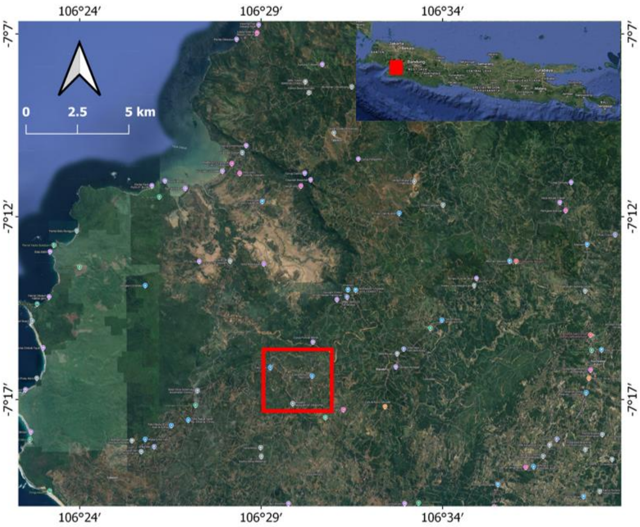

Figure- 1. The Study Area

Previous research in the Ciletuh area has primarily focused on broad geological investigations, such as identifying rock formations, assessing geotourism potential, and conservation efforts. These studies have significantly contributed to our understanding of stratigraphic units like the Jampang Formation, Bayah Formation, and Ciletuh Formation. Specific topics covered include the characteristics of igneous rocks [3], sedimentary rocks [4], rock dating through metamorphic rocks [5], geological structural interpretation [6], depositional environment [7], and rock geochemistry [8]. Beyond mineral and rock studies, other research has explored geotourism assessments [9] and engineering geology [10].

However, these studies have not comprehensively examined the surrounding areas, including the Cibenda region. Consequently, there is a lack of research specifically addressing the geological conditions of this area, particularly through a petrographic approach. Petrographic analysis is vital for uncovering geological processes such as depositional mechanisms, source material identification, and the history of tectonic and magmatic activities within a rock unit. Without this, our understanding of the geological dynamics in Cibenda, a crucial point in the Southern Mountain geological system, remains incomplete. This highlights the necessity for research that integrates field data with microscopic analytical results to form a robust interpretive basis.

II. LITERATURE REVIEW

Physiographically, the study area belongs to the Southern Mountain Zone (see Figure 2). This zone stretches from Pelabuhan Ratu Bay to Nusakambangan Island, running in a west-east direction. It is approximately 50 km wide, though it narrows to just a few kilometers in the east. The Southern Mountains underwent folding and uplift during the Miocene, with a gentle dip towards the Indian Ocean. The zone is further divided into three subzones: Jampang, Pangalengan, and Karangnunggal [11]. The Jampang highlands are a prominent feature along the northern boundary, characterized by steep slopes and escarpments, while the terrain gradually descends to the south. The boundary between the Southern Mountain Zone of West Java and the Bogor Zone is clearly visible in several locations, such as the Cimandiri Valley. Here, the boundary is marked by a sharp morphological contrast between the rolling hills of the Cimandiri Valley and the adjacent highlands of the Southern Mountains, with an elevation difference of about 200 meters. Continuous uplift has led to the formation of deep, narrow valleys. It's important to note that not all areas of the Southern Mountains in West Java were submerged during the Late Miocene transgression (when the Bentang Formation was deposited) [11].

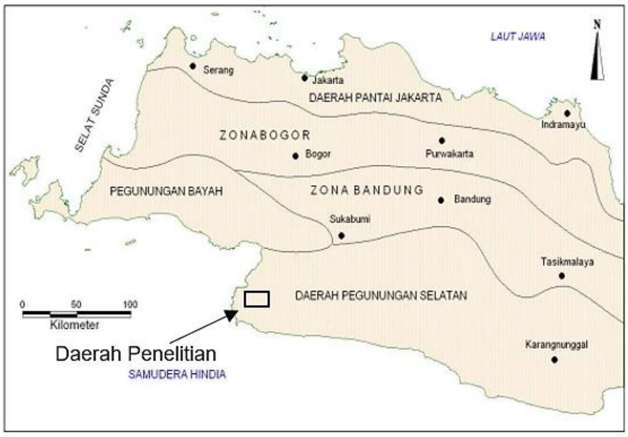

Figure- 2. Physiography of the study area **[11]**

Based on regional geology, the study area is composed of several formations, from oldest to youngest: the Jampang Formation Cikarang Member (Tmjc), Jampang Formation Ciseureuh Member (Tmja), Cilegok Porphyry (Tmcs), and Citanglar Coastal Sediments (Qpcb) [12]. Their descriptions are as follows (see Figure 3):

A. Jampang Formation Cikarang Member (Tmjc)

The Jampang Formation Cikarang Member consists of a variety of rocks, including tuff, lapilli tuff interbedded with tuffaceous shale, pumice sandstone, limestone, calcareous sandstone, tuffaceous claystone, globigerina marl, andesitic lava intercalations, breccia (sometimes with conglomeratic textures), tuff breccia, tuffaceous limestone, and brecciated limestone. These rocks are well-lithified and display colors of gray, green, brown, and black. The igneous rocks are predominantly altered andesite, amphibole, and dacite, with propylitic alteration being common. The volcanic rocks are mainly composed of pyroxene andesite and andesite. This member is dated to the Lower Miocene and was deposited in a shallow marine (neritic) environment. In the southern part of the area, from Ciletuh to the coast, the formation is dominated by sandstone containing pebbles and cobbles, with interspersed breccia layers up to 3–5 meters thick. This well-bedded, sand-rich unit is known as the Cikarang Member. The breccia unit in the northern part is challenging to map using the law of lateral continuity due to rapid facies changes between breccia and sandstone deposits.

B. Jampang Formation Ciseureuh Member (Tmja)

This member consists of andesite and basalt lava flows and is dated to the Lower Miocene.

C. Cilegok Porphyry (Tmcs)

This unit comprises andesite and basalt porphyry intrusions that concordantly intrude the Cikarang Member of the Jampang Formation.

D. Citanglar Coastal Sediments (Qpcb)

These sediments are composed of sandstone, sandy clay, clay, and gravel, with lenses of titanomagnetite.

III. METHODS

Fieldwork involved direct observation of rock outcrops, macroscopic description, and measurement of geological structures, including the strike and dip of bedding planes. Outcrop coordinates were recorded using a Global Positioning System (GPS) device. Outcrops were typically observed along riverbanks, cliffs, and roadside exposures, as well as in open areas such as gardens or vacant land. In addition to photographic documentation, representative rock samples were collected for analysis. Samples were selected based on freshness, lithological representativeness, and stratigraphic position. Subsequently, these samples were prepared as thin sections for petrographic analysis.

Petrographic analysis focused on the physical and chemical properties of the rock samples to determine their classification. Physical properties observed include color, texture, sorting, grain size, grain shape, and grain-to-grain contacts. Chemical properties were inferred from the mineralogical composition. The analysis culminated in the naming of each rock sample according to established classification schemes. Igneous rocks were classified according to [13], sedimentary rocks according to [14], and pyroclastic or volcanic rocks according to [15].

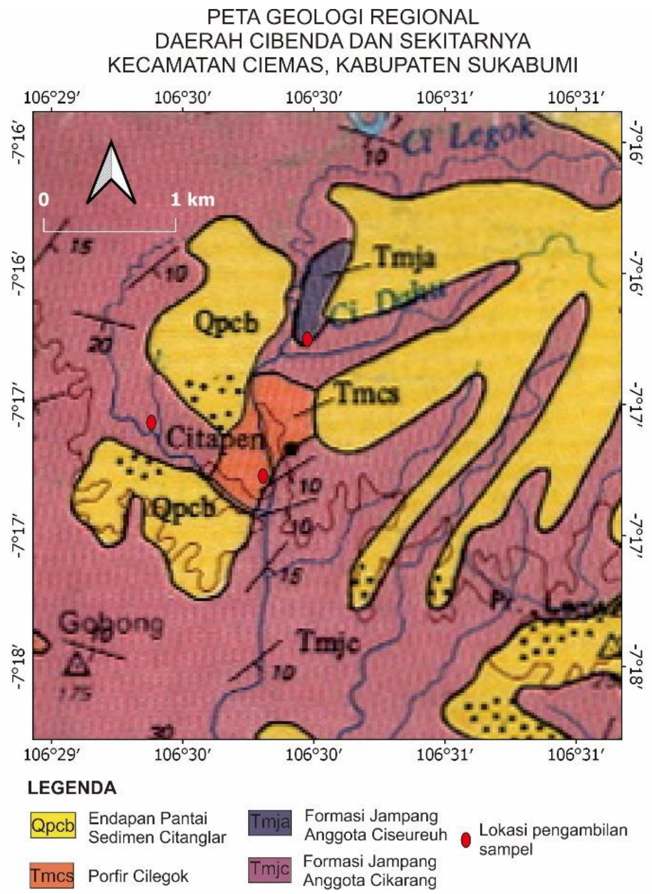

Figure- 3. Regional geological map of the study area [12]

IV. RESULTS AND DISCUSSION

A. *Results*

The stratigraphy and nomenclature of the rock units in the study area were established using an informal lithostratigraphic framework. Each rock unit was named according to field-observed characteristics, including lithology, rock-type combinations, degree of lithological uniformity, and stratigraphic relationships. Unit boundaries were defined by lithological contacts and inferred from topographic features and bedding orientations. Stratigraphic positions were determined using fundamental principles, such as the Law of Superposition, which states that in an undisturbed sequence, older strata underlie younger ones. Based on these field observations, the study area was subdivided into three distinct rock units. From oldest to youngest, these are:

1. Sandstone Unit (Tmbp)
2. Breccia Unit (Tmbx)
3. Andesite Unit (Tma)

1) Sandstone Unit (Tmbp)

This unit is predominantly composed of sandstone intercalated with claystone and represents the dominant lithology in the mapped area. It is distributed within a structural plateau geomorphological unit. Cross-section reconstruction and strike-pattern analysis indicate that this is the oldest unit, underlying the Breccia Unit. The strike of the Sandstone Unit trends predominantly southwest–northeast, with a gentle dip ranging from 4º to 17º. (Figure 4).

Figure- 4. Outcrop of the sandstone unit

Microscopic examination shows the sample to be yellowish-brown under plane-polarized light and gray under cross-polarized light. The matrix comprises approximately 25% clay minerals. The components include 10% rock fragments, 40% quartz, 15% plagioclase, 20% pyroxene, and 20% opaque minerals. According to Pettijohn's (1975) classification, the sandstone is identified as feldspathic wacke (Figure 5).

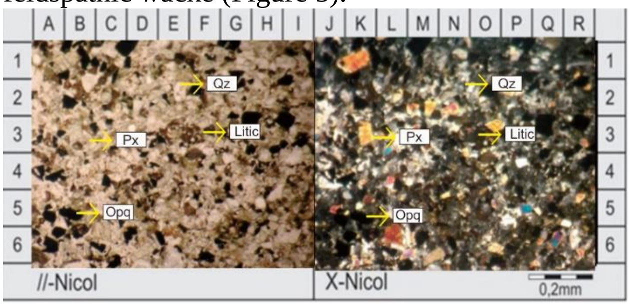

Figure- 5. Microphotograph of sandstone unit

2) Breccia Unit (Tmbx)

The Breccia Unit occupies a structural hill geomorphological unit distributed in the southern part of the study area. This unit consists of breccia lithology. Based on cross-section reconstruction and lithological contact differences observed in the field, the Breccia Unit concordantly wedges into the Sandstone Unit.

Megascopic field descriptions indicate that the breccia is gray, with weathered surfaces showing yellowish-brown hues. The clast sizes range from pebbles to cobbles, with sub-angular to sub-rounded shapes, poor sorting, and a hard texture. The components are polymictic in nature. The breccia contains white to gray tuff clasts with weathered yellowish-brown surfaces, lapilli-sized grains, sub-angular shapes, good sorting, closed texture, hardness, and a glass composition. It also includes gray sandstone clasts with weathered dark-gray surfaces, medium- to fine-grained sand size, sub-rounded shapes, good sorting, closed texture, and hardness. The matrix consists of gray sandstone with weathered yellowish-brown coloration, fine sand grain size, sub-angular shape, poor sorting, open texture, and hardness (Figure 6).

Figure- 6. Outcrop of the breccia unit

Based on microscopic descriptions, the breccia matrix appears yellowish-brown under plane-polarized light and black under cross-polarized light. The matrix is composed of 39% clay minerals and 16% glass. The components include 8% plagioclase, 5% pyroxene, 15% rock fragments, 10% quartz, and 7% opaque minerals. According to Pettijohn's classification (1975), the breccia matrix is classified as lithic wacke. (Figure 7).

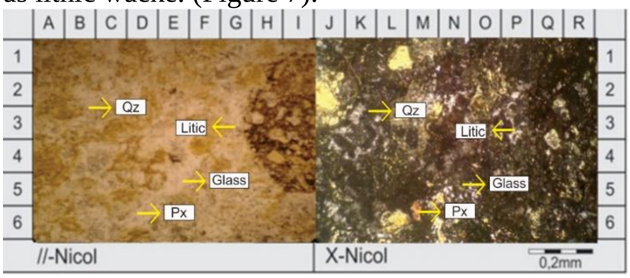

Figure- 7. Microphotograph of the breccia matrix

Component A of the Breccia Unit shows microscopic features of brown under plane-polarized light and grayish-black under cross-polarized light. The matrix consists of approximately 10% microcrystalline plagioclase and 60% volcanic glass. The components include 15% plagioclase, 10% pyroxene, and 5% rock fragments. Based on the classification [15], Component A of the Breccia Unit is classified as crystal tuff (Figure 8).

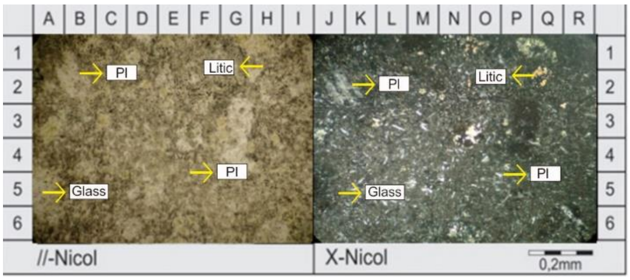

Figure- 8. Microphotograph of crystal tuff

Component B of the Breccia Unit exhibits microscopic characteristics of dark brown under plane-polarized light and grayish-black under cross-polarized light. The matrix is composed of approximately 12% microcrystalline plagioclase and 8% opaque minerals. The components consist of 40% plagioclase, 10% pyroxene, 20% rock fragments, and 10% quartz. Based on the classification [14], Component B of the Breccia Unit is classified as feldspathic wacke sandstone (Figure 9).

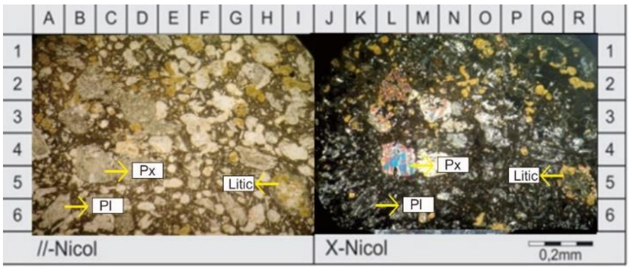

Figure- 9. Microphotograph of felspatic wacke

3) Andesite Unit (Tma)

The lithology of this unit is andesitic igneous rock. Based on megascopic field descriptions, the andesite is characterized by a dark gray color with weathered surfaces displaying yellowish-brown hues. It exhibits a porphyritic texture with hypocrystalline crystallinity, inequigranular fabric, and subhedral crystal shapes. The color index is melanocratic, and the mineral composition consists of plagioclase and pyroxene (Figure 10).

Figure- 10. Outcrop of the andesite unit

Based on microscopic descriptions, the andesite appears brown under plane-polarized light and grayish-black under cross-polarized light. The groundmass consists of 45% microcrystalline plagioclase and 10% opaque minerals. Phenocrysts comprise 23% plagioclase, 12% pyroxene, and 5% quartz. Based on the classification [13], this rock is identified as andesite. The type of plagioclase, determined using the Michel–Levy diagram, is andesine with an extinction angle of 25° (Figure 11).

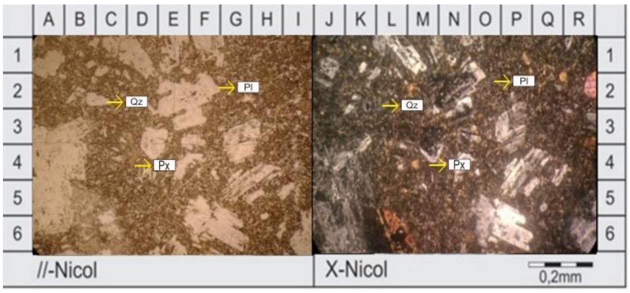

Figure- 11. Microphotograph of andesite

B. Discussion

Petrographic analysis of the Sandstone Unit indicates that the rock belongs to the lithic wacke and feldspathic wacke groups, with major components comprising rock fragments, feldspar, quartz, and a clay-rich matrix. The grain texture is generally angular to sub-rounded, with poor sorting and an open framework, reflecting deposition under moderate- to low-energy conditions. These characteristics suggest transport agents such as gravity flows and suspension operating within a marine environment, particularly in the medial to distal parts of a submarine fan [16]. This also indicates that the sediment source of the sandstone originated from a tectonically active terrestrial area, delivering clastic material to the marine basin.

Petrographic data reveal that the breccia contains polymictic components, consisting of crystal tuff and sandstone fragments bound within a sandstone matrix, and is lithologically classified as lithic wacke and crystal tuff. The angular fragment shapes, relatively large grain sizes, and very poor sorting indicate deposition by high-energy mass-flow mechanisms, such as debris flows, within a marine setting. This also suggests the involvement of both subaerial and subaqueous volcanic activity in supplying the materials that formed this unit, marking a transition from a passive sedimentation phase to a more active geodynamic phase.

The geological evolution of the study area is further indicated by the presence of andesitic intrusive bodies, petrographically characterized by a porphyritic texture with plagioclase and pyroxene phenocrysts embedded in a microlitic groundmass. This texture reflects a relatively slow magma crystallization process at shallow depth. The andesite intrusion concordantly penetrates the sandstone and breccia units, marking the onset of the post-sedimentary tectono-volcanic phase. This intrusion is thought to be related to arc magmatism activity associated with subduction processes south of Java Island, active since the Early Miocene. The presence of the intrusion not only indicates changes in temperature and pressure in the host rocks but also serves as a marker for the initiation of uplift and structural deformation in the Southern Mountains region, as evidenced by the occurrence of joints and morphological lineation patterns [11].

Regionally, the petrographic characteristics of the three rock units in the study area show significant similarities to the Cikarang Member of the Jampang Formation in terms of mineral composition, texture, and depositional environment. The Jampang Formation comprises tuffaceous sandstone, breccia, and andesitic lava bodies or intrusions of Early Miocene age, deposited in shallow- to deep-marine environments. This similarity suggests that the rock units in the Cibenda area are likely part of the same depositional system or have a close lateral correlation with the Jampang Formation. Therefore, the petrographic analysis not only strengthens the local geological interpretation but also provides a basis for linking stratigraphic and tectonic relationships regionally within the Southern Mountain Zone of West Java. This age interpretation aligns with previous studies using nannofossil biostratigraphy, which dated the Cikarang Member of the Jampang Formation to the Late Oligocene–Early Miocene [17].

Thus, the geological evolution of the Cibenda area can be reconstructed as a sequential series of processes, beginning with the marine sedimentation of fine clastic materials (Sandstone Unit), followed by the deposition of volcanic materials in the form of breccia (Breccia Unit), and culminating in post-sedimentary andesitic intrusions. Each stage is distinctly recorded in the petrographic characteristics of the respective units, reinforcing their stratigraphic equivalence with the Jampang Formation at the regional scale. The petrographic approach in this study not only yields microscopic insights into the rocks but also provides a comprehensive interpretative framework for reconstructing the geological history of the Cibenda region within the broader context of southern West Java.

Chronostratigraphically, the geological history of the study area begins in the Early Miocene, during which the deposition of the Sandstone and Breccia Units occurred simultaneously. The Sandstone Unit was deposited through low-energy currents or suspension mechanisms within a submarine fan environment, while the Breccia Unit formed from gravity-driven debris flows with distinct sources and flow directions. Both units exhibit a conformable and interfingering stratigraphic relationship. Following the deposition of these two units, an andesitic intrusion occurred, cutting concordantly through the sedimentary layers. Based on the principle of cross-cutting relationships, this intrusion is interpreted as the youngest unit in the study area.

V. CONCLUSION AND SUGGESTION

A. Conclusion

This research successfully identified the petrographic characteristics of the three main rock units in the Cibenda area—namely, the Sandstone, Breccia, and Andesite Units—which reflect a sequence of geological processes, from marine sedimentation and volcanic gravity flows to shallow magmatic intrusion. The close relationship between the rock characteristics at Cibenda and the Cikarang Member of the Jampang Formation confirms that this area is an integral part of a broader regional geological system. This finding not only enriches local geological data but also strengthens cross-regional stratigraphic correlations that are crucial for applied geological mapping and the conservation of the Ciletuh Geopark area. Through a focused petrographic approach, this study demonstrates that microscopic rock analysis is capable of reconstructing detailed geological history while providing an important scientific basis for the future development of advanced studies such as geochemistry, geochronology, and tectonic modeling.

Thus, the results of this research not only address the problems and achieve the objectives set but also make an important scientific contribution to the enrichment of local geological data. Furthermore, these results strengthen the understanding of stratigraphy and geological dynamics in the Southern Mountains of West Java and support the development of the scientific value of the Ciletuh Geopark area through petrographic approaches and geological evolution analysis.

B. Suggestion

To strengthen the interpretation of the petrographic analysis results, further methods such as geochemical analysis (e.g. X-Ray Fluorescence/XRF or Inductively Coupled Plasma Mass Spectrometry/ICP-MS) are recommended to quantitatively determine the chemical composition of the rocks.

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