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Early to Middle Miocene Dissectec Arc of Karangsambung Area: A Case Study of Waturanda and Penosogan Formations Provenance

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Abstract

This study undertakes a comprehensive analysis of the geological conditions within a specific region, with a dual objective. Firstly, it aims to detail the geophysical attributes, structural aspects, and formation processes of the region. Secondly, it strives to establish a connection between the provenance, or origin, of the sedimentary materials in the region and its geological characteristics. The primary subjects of the research are the Waturanda and Penosogan Formations. These formations were selected due to their unique geological properties that offer insights into the geological history of the region. The primary method employed in the study was petrographic analysis. This technique, involving a microscopic examination of rocks, facilitated a detailed investigation into the rock samples from both formations, highlighting their mineralogical constitution and overall textures. The study also involved a thorough examination of the original rock or parent material of the Waturanda and Penosogan Formations. This analysis provided important information about their inherent geological attributes and formation processes. One of the key findings was the identification of the tectonic environment in which these formations were developed. The study revealed that the tectonic setting was a magmatic arc, specifically a dissected arc. This significant insight into the geological conditions has profound implications for understanding the geological evolution and history of the region, thereby enriching our knowledge of Earth's dynamic geological processes.

1. Introduction

There have been numerous investigations on the connection between the genesis and composition of rocks[1]–[3]. These investigations have been quite successful in separating source terranes by the specific composition and tectonic setting[4]. It is recognized that the minerals can depict historical processes based on the QFL diagram[5]. The Sundaland plate's southernmost point is where Java Island is situated[6]. Movement between these plates has been taking place since the Late Cretaceous, and the Sundaland plate is an active edge moving convergently with the Indian Ocean plate[7]. The island of Java is made up of a complex of volcanic arcs, prisms, and subduction zones as a result of these tectonic movements, and it is also home to tertiary and quaternary volcanic formations[8]. The Pemanukan-Cilacap fault and the Kebumen-Muria fault, which make up Java Island, are two significant faults [9].

Katili (1971) [10]asserts that Karangsambung is a part of the Cretaceous subduction zone based on the discovery of ophiolite rocks. [11] declares that this area served as a positive flower structure of a regional left shear fault that ran from northeast to southwest. As a result, rocks from the Pre-Tertiary to the Tertiary are exposed here[11], [12]. One of the formations in the Karangsambung region is the Penosogan Formation. Sandstones, mudstones, Tuffs, Marls, and Calcarenites make up this formation. The carbonate-type sandstone and claystone layers at the bottom give the structure its distinctive appearance. According to [13], this formation was formed in a marine environment with turbidite currents.

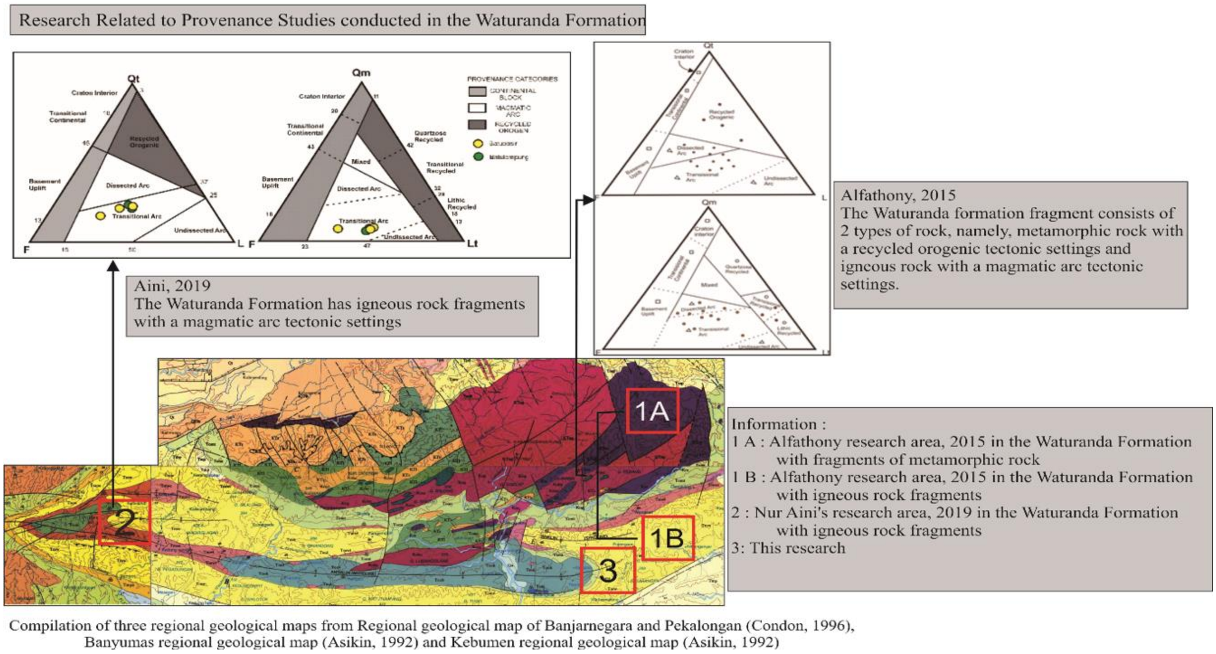

Figure 1. The compiled 3 regional geological maps as the location of the previous studies and this study [15], [16], [18]–[21].

Breccia with Andesite fragments and Sandstone made up the Waturanda Formation[14]. The Breccias are composed of gravel-sized andesitic particles in a matrix of coarse sand. According to [10], [13]this deposit dates from the Early Miocene Period [14]. The study was done by [15]. Metamorphic rock and volcanic rock make up the two sets of fragments that make up the original rock of the Waturanda Formation [15]. The authors have not discovered any studies about the provenance of the Penosogan Formation in the meantime, this paper aims to create a magmatic arc orogenic tectonic order based on petrographic analysis and a recycled orogenic tectonic order.

[15], [16] explored the lithology of the Sandstone and Claystone, which are members of the Waturanda tuff, respectively, in their provenance studies of the Waturanda Formation. According to [15] research in the IA and IB research regions (Figure 1), two different types of pieces were discovered in the Waturanda Formation. Metamorphic rocks with the kinds of slate, phillite, quartzite, and chert were discovered in the IA region as fragments. The tectonic order in the region is therefore determined by the Qt-F-L and Qm-F-Lt diagrams to be Recycled Orogenic. In contrast, it was discovered that the fragments found in the IB region were igneous rocks of the Basalt-Andesite type. It is determined that the tectonic setting in the region is a Magmatic arc (transitional arc-dissected arc) based on the Qt-F-L and Qm-F-Lt diagrams. K Feldspar minerals were found in large quantities in the petrographic incisions of sandstone samples according to research done by [16]. The Qt-F-L and Qm-F-Lt diagrams' plots reveal that the study area is a magmatic arc (transitional arc), according to the findings. The authors are thus interested in employing petrographic studies to investigate the provenance of the Waturanda and Penosogan Formations in the Wadasmalang and nearby regions, to learn more about the origins of the Karangsambung area's Waturanda and Penosogan Formations.

2. Methodology

This study combined a thorough literature review with the analysis of field data, fostering a comprehensive understanding of the geological landscape. Surface geological information was compiled through mapping the study area, and rock samples from distinct formations were collected for detailed analysis. The resulting data, including mineral proportions and rock identification, guided the petrographic examinations. Each rock sample was meticulously prepared, sliced into thin sections, and examined under a polarizing microscope. This process enabled a precise study of the rock's internal structure and mineral composition.

The Gazzi-Dickinson method, a robust technique in petrographic studies, was employed for point counting of quartz, feldspar, and lithic minerals within each section. This detailed examination revealed insights into the mineralogical makeup of the rock samples, contributing significantly to the overall understanding of the region's geological conditions and processes.

3. Results

3.1 Provenance of Waturanda and Penosogan Formation

Provenance analysis is a method used to determine the source of a sedimentary rock[1], [4], [5]. The Sandstone composition is influenced of parameters such as the initial composition of the source rock, climate, tectonic setting, and depositional processes [17]. Tectonic processes affect the characteristics of lithology [14]. The study in this research area is the Waturanda and Penosogan Formation provenances. The aim is to determine the origin of the sedimentary rocks of the two formations and to interpret the tectonic setting in the area. In this research, researchers analyzed petrographically. In petrographic analysis, point counting was performed on 9 thin sections. The minerals counted include the mineral quartz (Q) which is divided into monocrystalline and polycrystalline quartz. Feldspar (F) which is differentiated into K feldspar and plagioclase feldspar, and lithic rock (L). Then the percentages and plots on the Qt-F-L and Qm-L-S diagrams.

3.1.1 Waturanda Formation

In this study, 3 rock samples were taken in the Waturanda Formation with sample codes A1, A2, and A3. The sandstone analyzed is Arenite type. The sandstone composition of this Formation is 36-41% quartz, 36-41% feldspar, and 23-26% rock fragments. The grain size is coarse sand (0.5-1 mm), Subangular grain shape, good sorting, point contact found between items. The matrix of the Waturanda formation consists of clay sizes, cement in the form of iron oxide. In the Waturanda Formation, there are various types of minerals that can be identified petrographically. In detail the minerals are described as follows.

3.1.1.1 Quartz

Quartz in this formation has a percentage of 36-41%. In this formation there is a type of quartz with monocrystalline. This quartz is characterized by the presence of 1 crystal, with the optical characteristics of the appearance under the microscope in the PPL condition, Colourless, Low relief, No pleochroism, Anhedral crystal form. In the XPL condition, i.e., first-order interference color, has no cleavage (Figure 2).

The monocrystalline quartz found is Undulatory and Non-undulatory Monocrystalline Quartz. There is not any polycrystalline quartz was found which is an indication of metamorphic rock in this formation. Strained monocrystalline quartz was found to have a percentage ranging from 3-4%, this indicates that this quartz was formed due to tectonic forces.

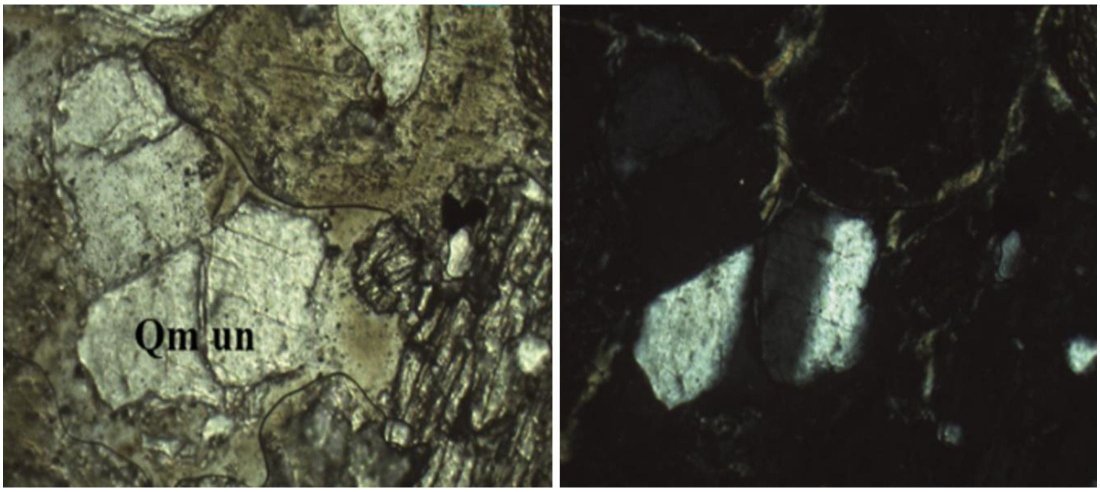

Figure 2. A photomicrograph of Quartz monocrystalline in parallel polarization (PPL) (left), Quartz monocrystalline in cross polarization (XPL) (right).

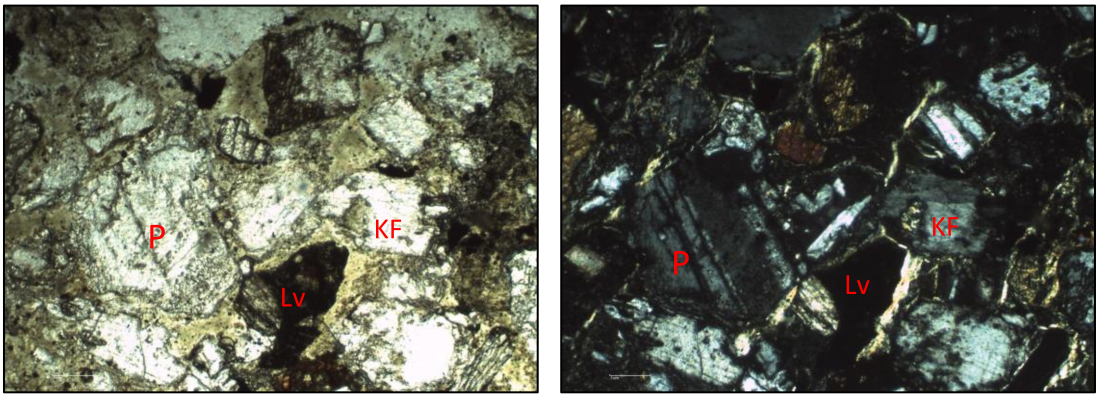

Figure 3. The photomicrograph of Plagioclas Feldspar (PPL) (left), Plagioclas Feldspar (XPL) (right).

3.1.1.2 Feldspar

In this formation there is feldspar with a composition ranging from 36-41%. The feldspar found was of the Plagioclase feldspar type and the K Feldspar was of the Orthoclase type. Appearance of plagioclase feldspar minerals under PPL microscopy conditions, namely, Colourless, No Pleochroism, Moderate relief, Anhedral crystal form. 1st order interference color, and Carlsbad twinning. The presence of feldspar plagioclase minerals, indicates that the source of this rock is of volcanic origin. The K Feldspar mineral, viewed under a microscope under PPL conditions, has the appearance of Colourless, Low relief, No pleochroism. Appearance in XPL conditions, namely, Subhedral crystal form (Figure 3).

3.1.1.3 Rock Fragment

In the thin section of the Waturanda formation, it is dominated by rock fragments. Volcanic rock fragments. 0.3-1.9%. No metamorphic rock fragments were found. There are also unstable minerals which are still included in the rock fragment classification (L). Opaque minerals 13.2-19.2%. This mineral has an appearance in PPL and XPL, black and opaque. As well as pyroxene minerals 5.2-11.4%. This mineral has the appearance of PPL, Colorless, High Relief, Subhedral, Not have any pleochroisme, Have cleavage.

3.1.2 Penosogan Formation

In this study, 6 rock samples were taken in the Penosogan Formation, on Section 2 (B1, B2, and B3) and on Section 3 (C1, C2, and C3) The sandstones analyzed were of the Arenite and Wacke types. The sandstone composition of this Formation is 57-64% quartz, 26-32% feldspar, and 4-11% rock fragments. Subrounded grain shape, Good sorting, Point contact between grains found. In the Penosogan Formation, there are various types of minerals that can be identified petrographically

3.1.2.1 Quartz

Quartz in this formation has a percentage of 26-30%. In this formation there is monocrystalline Quartz. This quartz is characterized by the presence of 1 crystal, with the optical characteristics of the appearance under the microscope in the PPL condition, namely, Colourless, Low relief, No pleochroism, Anhedral crystal form. In the XPL condition, i.e., first-order interference color, has no cleavage. The monocrystalline quartz found is strained and non-strained monocrystalline quartz. Strained monocrystalline quartz is found to have a percentage of 1-6%. polycrystalline quartz was not in this thin section.

3.1.2.2 Feldspar

In this formation there is feldspar with a composition ranging from 60-68%. The feldspar found was of the Plagioclase feldspar type and the K Feldspar was of the Orthoclase type. Appearance of plagioclase feldspar minerals under PPL microscopy conditions, namely, Colourless, No Pleochroism, Moderate relief, Anhedral crystal form. The appearance of the XPL conditions is that there is a 1-way split, 1st order interference color, and Carlsbad twinning. The presence of feldspar plagioclase minerals, indicates that the source of this rock is of volcanic origin. The K Feldspar mineral, viewed under a microscope under PPL conditions,has the appearance of Colourless, Low relief, No pleochroism.

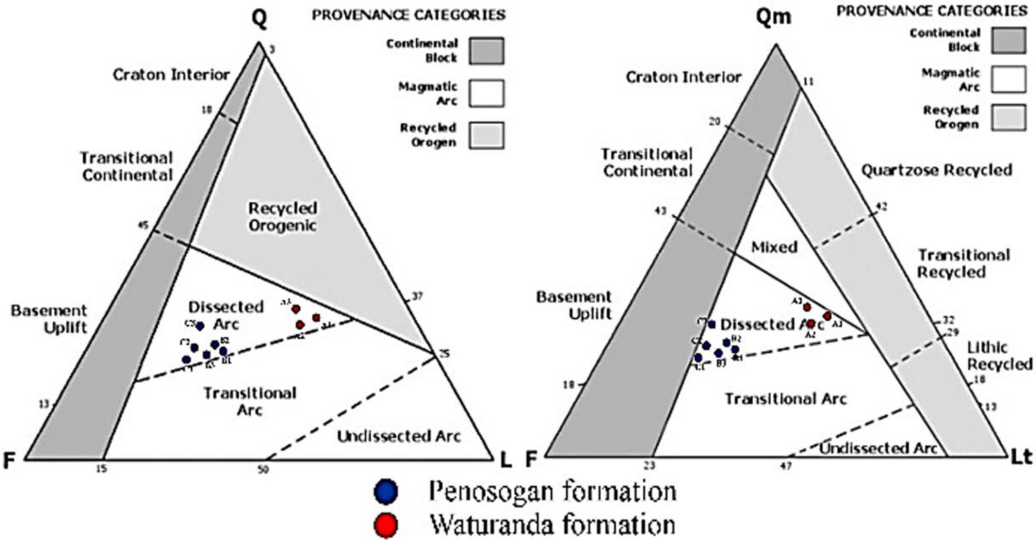

Figure 11. Plot the result on the diagram Qm-F-Lt dan Qt-F-L

3.1.2.3 Rock Fragment

The thin section in the Penosogan formation is dominated by rock fragments, in the form of volcanic rock fragments. 0-0.9%. No metamorphic rock fragments were found. There are also unstable minerals which are still included in the rock fragment classification (L), 3.6-11.4% opaque minerals. This mineral has the appearance of PPL and XPL, which is black and opaque. As well as pyroxene minerals 0-2.8%. This mineral has the appearance of PPL, Colourless, High relief. No pleochroism. The appearance of XPL is that there is a 1-way split, 2nd order interference color.

3.2 Plot on the Dickinson and Suczeck Diagram

To obtain the origin of sedimentary rocks, the composition of the minerals is calculated using point counting and then the percentage is calculated. The percentage results were then plotted on the Qt-F-L, Qm-F-Lt triangle diagram.

4. Dicussion

In the Waturanda Formation, it was found that the Provenance of this formation originates from the Magmatic arc (Dissect arc). This is shown in the plot diagram of [22]. The area is petrographically characterized by the abundance of monocrystalline quartz, feldspar in the form of plagioclase, and lithic volcanic rocks. The Waturanda Formation is the result of active volcanic activity during the Oligocene - early Miocene. In the Penosogan Formation, it was found that the Provenan of this formation is based on the plot on the Dickinson diagram, the Magmatic arc (Dissected arc).

Based on petrographic analysis, it was found that there were Opaque Minerals, Pyroxene Minerals, Volcanic Liths, and also plagioclase indicating that the origin of these rocks came from volcanic areas. The sub angular grain shape indicates that the rock was not transported far from the source rock. The different charracteristic between Waturanda and Penosogan Formation on the thin section are size of the mineral. The mineral of Waturanda formation is bigger than Penosogan Formation. It causes that Waturanda was first formed than Penosogan formation. Penosogan formation was formed it cause erossion of Waturanda formation.

5. Conclusion

In the Waturanda and Penosogan formations, there are rock fragments, opaque minerals, glass minerals, pyroxene minerals and plagioclase of the Carlsbad type. This indicates that the origin of the two formations is Volcanic Rock. After calculating quartz, feldspar, and also lithic minerals, then plotting them on the QtFL and QmFL diagrams, it is found that the tectonic setting of the Waturanda and Penosogan Formations is a Dissected arc (Magmatic arc).

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