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Drainage Pattern Analysis and Its Relationship to Geology in the Darmaraja, Jatigede, and Tomo, Sumedang, West Java

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Abstract*—Drainage pattern analysis is one of the initial geomorphological approaches used in geological mapping. Darmaraja, Jatigede, and Tomo, in Sumedang, West Java have diverse geomorphological and geological characteristics that are important in geological studies, such as variations in slopes, rock types, and geological structures. This study aims to determine the relationship between drainage patterns, slope gradients, and the geology of the study area to support the improvement of the quality of geological mapping. Based on the results, drainage patterns, slope gradient, and geology of the Darmaraja, Jatigede, and Tomo show an interrelated relationship in controlling the formation of landscapes in these areas. Drainage patterns controlled by various geological factors such as slopes, rock types, and geological structures, for example, trellis and rectangular patterns in folded and faulted sedimentary rocks whereas parallel pattern in areas with moderately steep to very steep slopes. Therefore, this integrated approach provides a reliable basis for enhancing geological interpretation and mapping accuracy in the study area.*

***Keywords*—** *Darmaraja, Drainage Pattern, Geology, Jatigede, Tomo.*

I. Introduction

Drainage patterns are an important visual representation of geomorphology in identifying the geological conditions of a region [1]. The shape, direction, and pattern of stream networks are strongly influenced by various geological factors such as lithology, geological structure, slope gradient, and the geological history or geomorphological processes occurring in the area [2]. This suggests that drainage patterns can be used as an indirect approach to analyzing and interpreting geology and its associated processes.

The Darmaraja, Jatigede, and Tomo, Sumedang Regency, West Java, possess a variety of interesting geomorphological and geological characteristics that are important to study as a foundation for understanding the geological conditions [3–6]. This is reflected in the diversity of rock types and geological structures found in the area. Sumedang Regency, West Java, is regionally located within the Bogor Zones [7], which exhibit geological variations in rock and geological structures.

Several previous studies in the Sumedang area have not specifically examined drainage patterns, thus, there is still limited data on this study. Existing drainage patterns show developments over time that can then be further identified. Identification and analysis of drainage patterns play a crucial role in assisting geological mapping activities, particularly in the initial stages of geomorphological interpretation or analysis [8,9]. Drainage pattern analysis helps identify faults, fracture zones, rock layering directions, and estimated rock unit boundaries that are not easily observed directly in the field. Through the use of topographic data and remote sensing imagery, drainage pattern analysis can be conducted in greater detail and effectively. Therefore, the study of the relationship between drainage patterns, slopes, and geology in the Darmaraja, Jatigede, and Tomo areas is expected to improve the quality of geological mapping, both in these areas and in other areas.

II. Methodology

Administratively, the research area is included in the Darmaraja, Jatigede, and Tomo sub-districts, Sumedang Regency, West Java (Fig. 1). The research was conducted through studio analysis involving several spatial data and software for data processing and analysis. The spatial data used include geological maps, Demnas, and stream network data derived from topographic map extraction. Demnas or National DEM was built from several data sources including IFSAR data (5m resolution), TERRASAR-X (5m resolution) and ALOS PALSAR (11.25m resolution), by adding Mass-plotted stereo data with spatial resolution is 0.27-arcsecond, using the EGM2008 vertical datum [10]. The data processing and analysis process used ArcGIS 10.8 software and Geographic Information Systems (GIS). Geographic information systems can help integrate management, processing and analysis processes that are tied into the same coordinate system [11–15]. Based on the existing spatial data, this study will produce several maps for analysis, such as drainage pattern, slope, and geological maps. Furthermore, these maps are used to examine the relationship between the characteristics of drainage patterns with the topographic conditions (slopes) and geology (rock types and geological structures) of the research area.

Drainage patterns can be identified based on modifications to the drainage pattern classification [8]. These drainage patterns are interpreted and analyzed by considering modifications to the drainage pattern classification. The slope

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of the study area is classified based on modifications to the slope classification [16]. The geology of the study area is determined based on modifications and interpretations of regional geological maps [17].

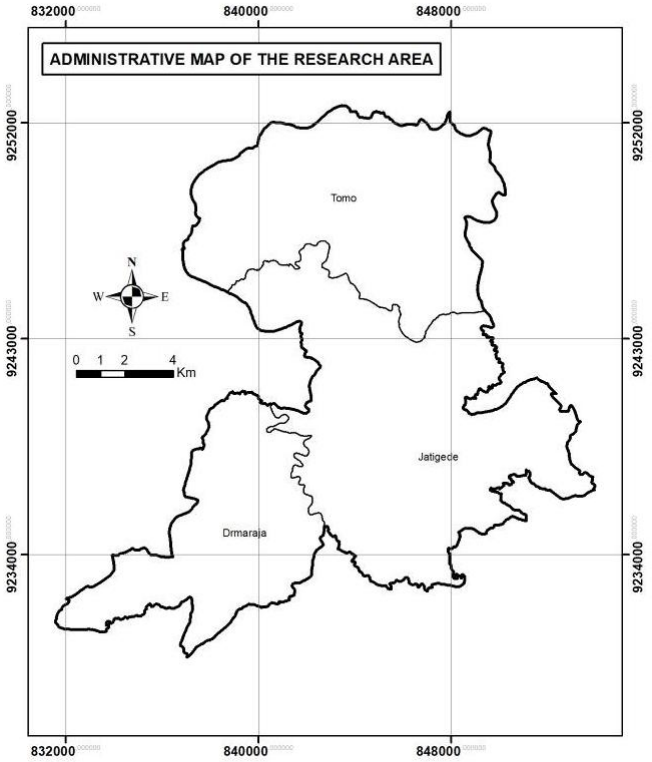

Fig. 1. Administrative Map of The Research area.

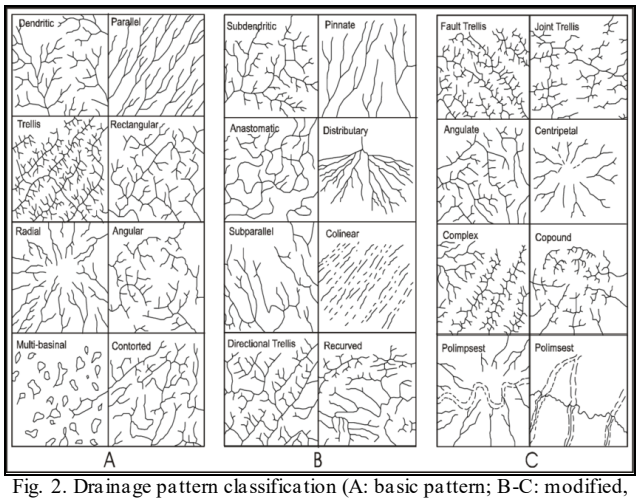

Fig. 2. Drainage pattern classification (A: basic pattern; B-C: modified, complex, compound, palimpsest) [8]

III. Results and Discussions

A. Drainage Pattern of the Research Area

The drainage patterns in the study area are highly diverse, consisting of at least eight drainage patterns, namely parallel, subparallel, dendritic, subdendritic, anastomotic, radial, trellis, and rectangular. All these drainage patterns exhibit distinct characteristics, including slope gradient, rock type, and geological structure.

Parallel and subparallel drainage patterns are distributed throughout the south-southwestern and eastern of the study area. These parallel and subparallel drainage patterns are distinguished by the perfection of their direction, shape, and stream flow. These drainage patterns generally indicate the presence of elongated hillsides or hillsides in the area, with slopes that can vary from gentle to very steep. The area is predominantly composed of volcanic, igneous, and sedimentary rocks with relatively old and high degree of hardness. The influence of geological structures is not dominant, although in some places geological structures can also be found.

Dendritic and subdendritic drainage patterns are found in the central and northern parts of the study area. The main difference between the two is that the subdendritic pattern shows minor geological structural influences, while the dendritic pattern does not. Areas with both drainage patterns exhibit relatively similar topographic characteristics, ranging from flat to slightly steep. The rock types in these areas are relatively homogeneous and moderately hard.

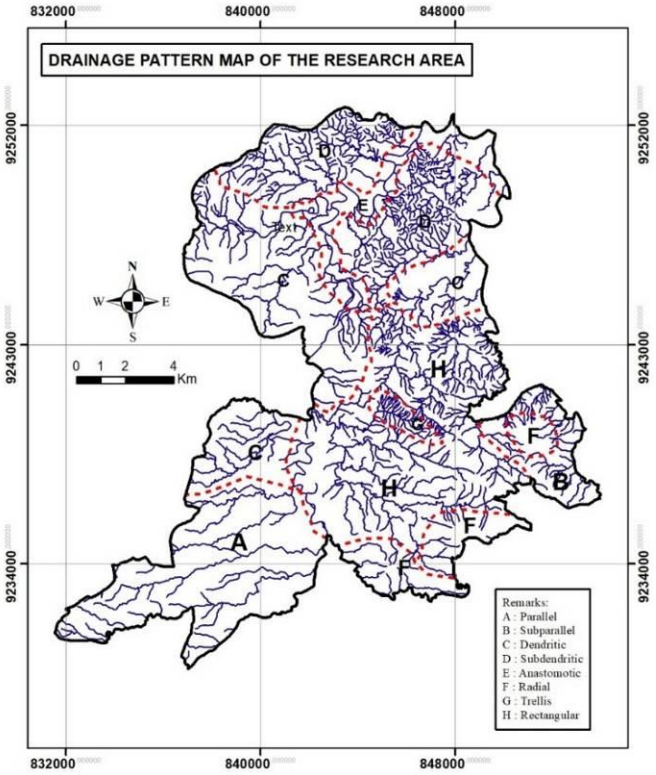

Fig. 3. Drainage Pattern Map of The Research Area.

An anastomotic drainage pattern was identified in the northern part of the study area. This drainage pattern is characterized by a tendency for the river width to widen in several locations with numerous stream bends. Areas with this drainage pattern exhibit flat to gently sloping topography. The rock types in this area consist of loose rock or sedimentary material (alluvium) such as clay, sand, gravel, boulders, and other materials, with no geological structure observed.

Radial drainage patterns are found in several parts of the study area, characterized by flow patterns that radiate from one point in all directions. This drainage pattern is

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characterized by the topography of volcanic cones with moderate to very steep slopes. Some areas with radial drainage patterns may be influenced by geological structures, while others are not.

The trellis drainage pattern can be identified by the parallel main streams intersected at, or nearly at, right angles by their tributaries, that is locally distributed in the central part of the study area. This drainage pattern is characterized by moderately steep to steep slopes. The rocks in this area consist of folded sedimentary rocks or rocks influenced by geological structures. Furthermore, folded structures are also commonly found in areas with this drainage pattern.

A rectangular drainage pattern is found in the central to southeastern parts of the study area. This drainage pattern is characterized by sharply meandering or angular stream flows with relatively steep to steep slopes. The rock composition of the rectangular drainage pattern area is faulted sedimentary rocks. Joints and faults can be found in this area.

B. Slope of the Research Area

Based on the slope gradient map of the study area (Fig. 4), the study area can be divided into five slope gradient classes: flat, gentle, moderately steep, steep, and very steep. Flat areas are shown only in a few small areas, such as in the northern and southern parts of the study area. Gentle slope to moderately steep slopes dominate the northern and southern parts of the study area. Areas with steep to very steep slopes are identified in the central to eastern and southwestern parts of the study area. The distribution of slope gradients in the study area shows a relationship with stream flow patterns and geology (rocks and geological structures) in the study area.

C. Geology of the Research Area

The geology of the research area is composed of various rock formations namely Cinambo, Halang, Subang, Kaliwangu, and Citalang Formation, also intrusive rocks, volcanic rocks, and alluvium. Based on the geological map of the research area (Fig. 5), Darmaraja area in the south is composed of a dominance of Quaternary volcanic rocks, shale from the Oligocene-Miocene of Cinambo Formation, sedimentary rocks from the Miocene Halang Formation, and Pliocene Kaliwangu Formation. Jatigede area in the central part is composed of sedimentary rocks from the Oligocene-Miocene Cinambo Formation (shale and sandstone), the Miocene Halang Formation, the Pliocene Citalang Formation, also Quaternary volcanic and intrusive rocks in some areas. In addition, there are clearly identified fold and fault structures in this area. Tomo area in the north is composed of sedimentary rocks from the Miocene Subang Formation (claystone), the Pliocene Kaliwangu Formation, and Quaternary volcanic rocks.

D. The Relationship Between Drainage Patterns, Slope Gradient, and Geology of the Research Area.

Drainage patterns, slope gradient, and geology of the Darmaraja, Jatigede, and Tomo show an interrelated relationship in controlling the formation of landscapes in these areas. Drainage patterns develop due to the developing lithology and geological structures, namely trellis and rectangular patterns in folded and faulted sedimentary rocks.

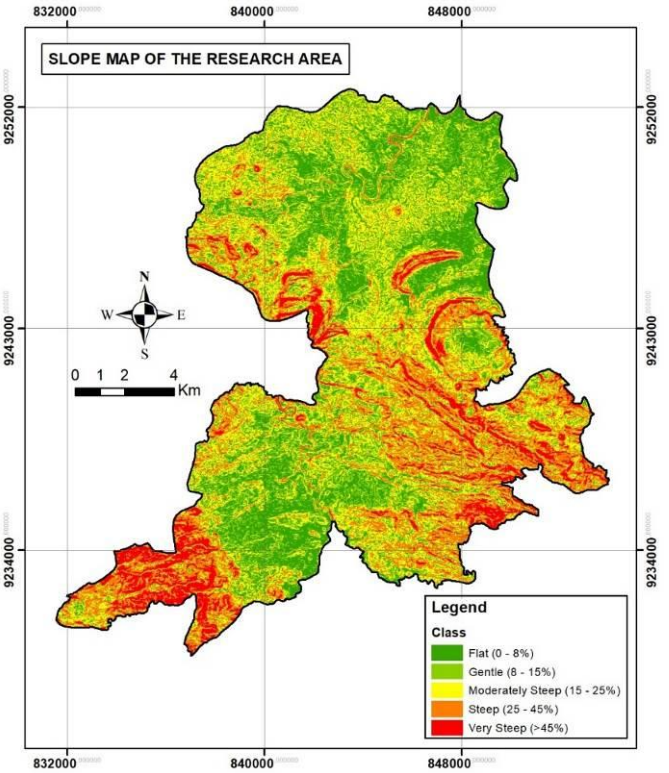

Fig. 4. Slope Map of The Research Area.

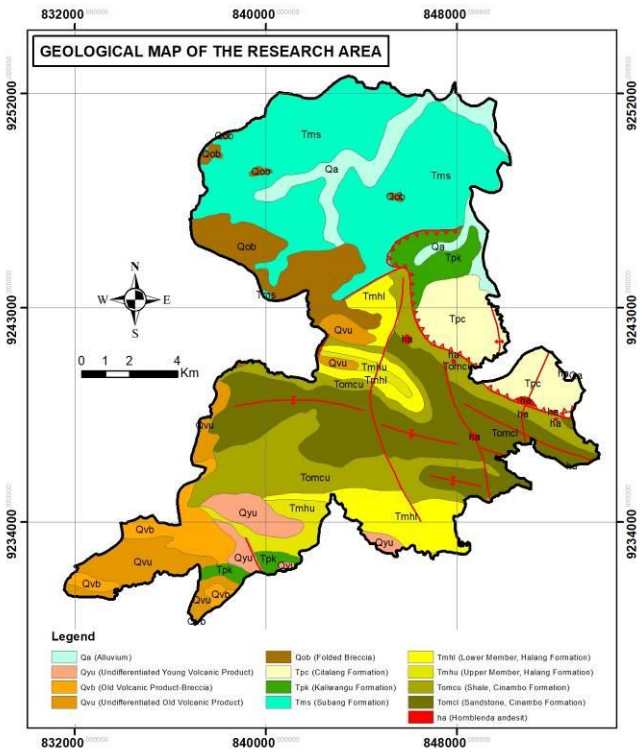

Fig. 5. Geological Map of The Research Area.

Slope gradients are also correlated with the level of rock

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hardness so that they show distinctive drainage patterns, namely parallel pattern in areas with moderately steep to very steep slopes. Furthermore, other drainage patterns show their own characteristics. Various geological and geomorphological processes that occur will produce particular drainage patterns as the main characteristics of the area.

IV. Conclusion

The results of the study indicate that drainage patterns in the study area are controlled by several factors, namely slope gradient, lithology, and geological structure. Variations in drainage patterns such as parallel, dendritic, trellis, rectangular, etc can reflect differences in rock hardness, geological structure intensity, and geomorphological processes that develop in the study area. Several drainage patterns in the study area such as dendritic, parallel, and trellis show their own unique characteristics. The integration of drainage pattern analysis, slope classification, and regional geology based on GIS and spatial data has proven effective in revealing geomorphological-geological relationships that are not always directly identified in the field. Therefore, this approach can be used as an initial reference to improve the quality of interpretation and accuracy of geological mapping in the Darmaraja-Jatigede-Tomo area and other areas with similar geological conditions.

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