Geomorphological Study of the Talumopatu Geothermal Area Gorontalo Regency Gorontalo Province

Rivaldi Helamsyah Putra Hamim[1], *Yayu Indriati* Arifin[1*], and *Intan Noviantari* Manyoe[1]

[1]Universitas Negeri Gorontalo, Jl. Prof. Dr. Ing. B. J. Habibie, Moutong, Tilongkabila, Bone Bolango Regency, Province of Gorontalo, Indonesia 96119

Abstract. Geomorphological research is urgently needed to be carried out in areas with geothermal potential such as in Talumopatu. Geomorphological analysis was chosen to complete the data in the early stages of the geothermal exploration of the study area. The purpose of this study was to determine the geomorphological characteristics of the study area. This study uses image interpretation methods and field excursions to observe the morphology of the study area. The stages of data processing use software applications based on Geographic Information Systems (GIS). The Geomorphological analysis consists of analysis of morphography, morphometry and morphogenesis. The analysis results are then compiled to produce a geomorphological map that refers to the van Zuidam classification. In accordance with the results of the analysis, it can be concluded that the geomorphological condition of the study area is divided into three parts, namely the Alluvial Plain Unit, Peneplains Unit, and Residual Hills Unit.

1 Introduction

Complex geological processes in the collision of various large plates [1-3] give Indonesia great geothermal potential. They are evidenced by 331 potential geothermal points, including 70 Geothermal Working Areas (WKP). Apart from that, the rest is a geothermal area with the potential for further development, spreading it all over the country. Gorontalo has five potential geothermal areas, including the Suwawa Geothermal Working Area, Dulangeya Geothermal Potential, Diloniyohu Geothermal Potential, Pentadio Geothermal Potential, and Pohuwato Geothermal Potential [4]. In addition, there are geothermal sites in Bone Bolango Regency, including Libungo, Lombongo, Pangi, Hungayono, and East Tulabolo [5-9], as well as several undeveloped geothermal fields in the area.

Geothermal development requires several stages of exploration, especially geological exploration, especially in the field of geomorphology [10]. This exploration is urgently needed as a potential for future renewable energy reserves and other possibilities. Previous research on the Talumopatu Geothermal Area only focused on Geochemistry and Geophysics [11]. The discussion of geomorphology was limited to the regional physiographic division of Gorontalo Province, which did not go into detail according to geomorphological aspects. Geomorphological analysis was chosen to complete the data in the early stages of the geothermal exploration of the study area.

Based on the problems and potential in the research area, the authors are interested in studying the geothermal potential in the study area. This research aims to find out the geomorphological description of the Talumopatu geothermal area and its surroundings, Gorontalo Regency, Gorontalo Province.

2 Material and Methods

The Talumopatu Geothermal Area is astronomically located at 00˚ 38' 00" - 00˚ 42' 00" N and 122˚ 35' 00" - 122˚ 40' 00" E. Administratively, the research area is in Mootilango District, Gorontalo Regency. This area is ± 61.2 km west of the Capital of Gorontalo Province, Gorontalo City. This area has five geothermal manifestation points spread across the Talumopatu area, Mootilango District, and the Bongongoayu area, Boliyohuto District.

2.1 Preliminary Stages and Retrieval of Field Data

The Preliminary Stage is the beginning of the research framework which consists of research preparation in the form of satellite and field data collection. Retrieval of satellite imagery using the National Digital Elevation Model data and Indonesian Topographical Map of 1:50,000 scale Molombulahe sheets. In addition, preliminary maps (such as topographical maps, slope maps, excursion trajectory maps, and tentative geomorphological maps) are made to be used during observations at the study area.

Data collection activities are geomorphological, lithological and documentation observations.

*Corresponding author : yayu_arifin@ung.ac.id

Geomorphological observations were carried out in the form of observing the landscape and morphology of the study area (including as rivers, hills and topography), as well as direct observations in the field.

2.2 Data Processing and Analysis Stage

The stages of data processing use software applications based on Geographic Information Systems. Primary data (in the form of field data) and secondary data (in the form of satellite data) were processed and analyzed according to the parameters. Geomorphological analysis consists of analysis of morphography, morphometry and morphogenesis.

Morphographic analysis serves to determine the condition of the landscape of the study area, consisting of topographical analysis and river flow patterns. Topographical analysis was carried out to determine the absolute height of the study area, this analysis refers to the Van Zuidam classification. In addition, an analysis of river flow patterns was carried out based on the Twidale classification [12].

Morphometric analysis was carried out in order to determine the shape of the slopes of an area with reference to the van Zuidam and van Zuidam-Cancelado classifications [13]. In addition, there is a lineament analysis carried out by delineating differences in hue contrast and relief in the image, so that it can determine the main direction of the lineament of the study area. Morphogenic analysis is an analysis that functions to determine geomorphological processes, both endogenous and exogenous processes that occur at the study area. The analysis results are then compiled to produce a geomorphological map that refers to the van Zuidam classification [14].

3 Result and Discussion

3.1 Morphography

3.1.1 Topography

The study area is located at an elevation of 7 – 150 meters above sea level with morphological forms in the form of plains and hills (Fig.1). Based on the classification of the relationship between absolute height and morphography, the study area consists of three parts of topography, namely Lowlands (7 – 50 masl), inland lowlands (50 – 100 masl), and Low Hills (100 -150 masl).

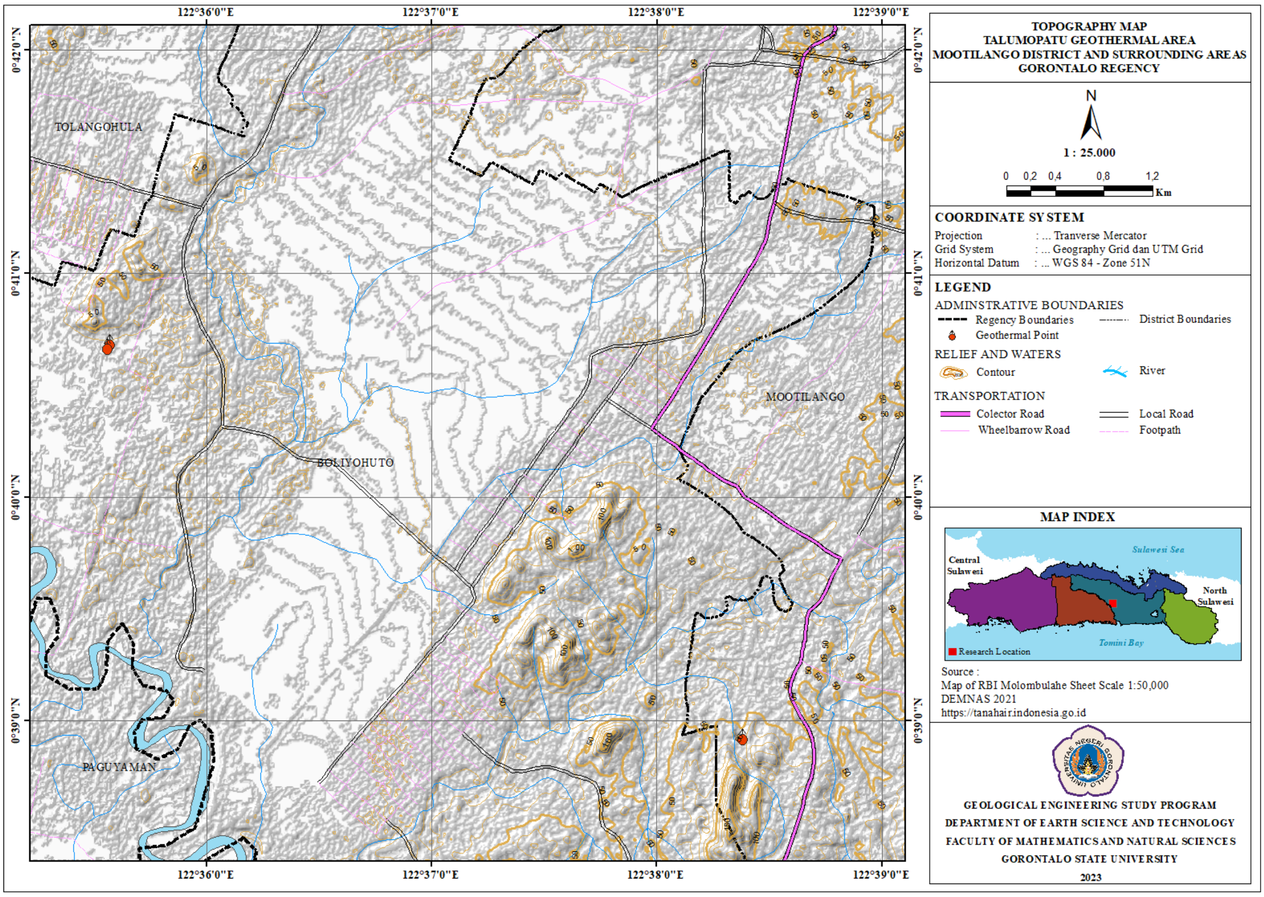

Fig. 1. Topography Map.

3.1.2 River Flow Pattern

The flow pattern of the river in the study area is determined based on the classification of Twidale. The results of the analysis on the topographic map, as well as the results of field observations, show that the rivers in the study area have a sub-parallel to parallel (Fig. 2). This flow pattern is characterized by streams controlled by uniform lithology and slopes, elongated hilly areas, and little structural control.

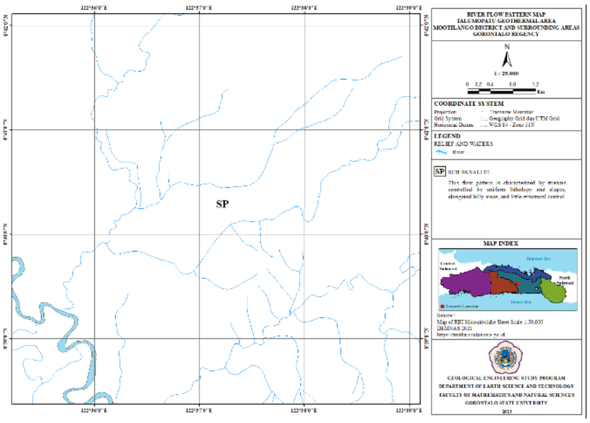

Fig. 2. River Flow Pattern Map.

3.2 Morphometry

3.2.1 Slope

According to the slope classification, the study area varies from flat or almost flat (0 – 2%) with distribution throughout the area and is dominant in the northeast and extends to the southwest of the study location. Slope relief with a gently sloping to sloping (3 – 13%) is scattered in several places. Slopes with a moderately steep to steep (14 – 55%) are distributed in the northwest, southeast and south of the study site. In addition, the slopes with very steep slopes (56 –140 %) are located at several points in the southeast direction of the study area (Fig. 3).

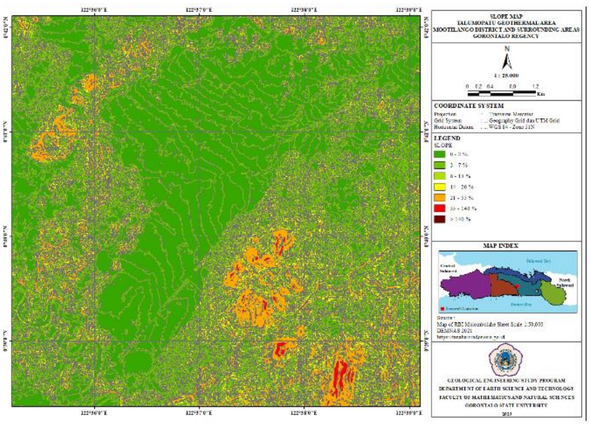

Fig. 3. Slope Map.

3.2.2 Lineament

The lineament pattern of the study area indicated by the red line (Fig. 4). The lineament pattern has a relatively northeast-southwest (NE-SW) main direction. The direction of the lineament has the same direction as the direction of the subsurface structure obtained based on the geomagnetic method through the research of Manyoe et al [11].

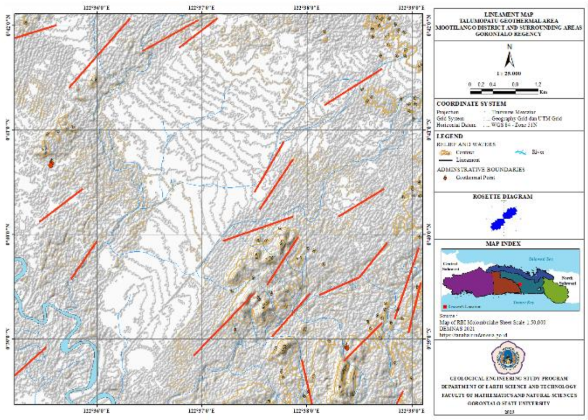

Fig. 4. Lineament Map

3.3 Morphometry

3.3.1 Endogenous Factor

The endogenous factor that works at the study area is intrusion. Its availability at the study area is located in various places in the southeast, center and northwest. The characteristic feature is the lithology in the form of granite, which belongs to the Middle to Late Miocene member of the Boliyohuto Diorite. Apart from that, there is a geological structure in the form of shear fracture in the area.

3.3.2 Exogenous factor

River flow patterns are one of the exogenous factors in the study area. This is evidenced by the dendritic flow pattern which depends on the resistance of a rock, as well as the level of erosion that occurs when viewed through the U - U' valley shape at the study area.

The denudational landscape dominates the study area which is composed of denuded lithology in the form of granite of the Boliyohuto Diorite member of the Middle to Late Miocene age, sandstone which is a member of the pleistocene-holocene lake deposits, and alluvial of Holocene age. The U-shape of the valley in the granite and sandstone areas indicates the occurrence of horizontal and vertical erosion which is equivalent. In addition, the shape of the U' valley in the alluvial area characterizes the dominant horizontal erosion.

3.4 Geomorphological Unit

The geomorphology of the study area consists of Alluvial Plain Units, Peneplain Unit, and Residual Hills (Fig.5). The determination of geomorphological units is based on the van Zuidam classification which divides unit characteristics based on the general relief and slope formation, as well as genetic morphological descriptions formed from endogenous and exogenous processes.

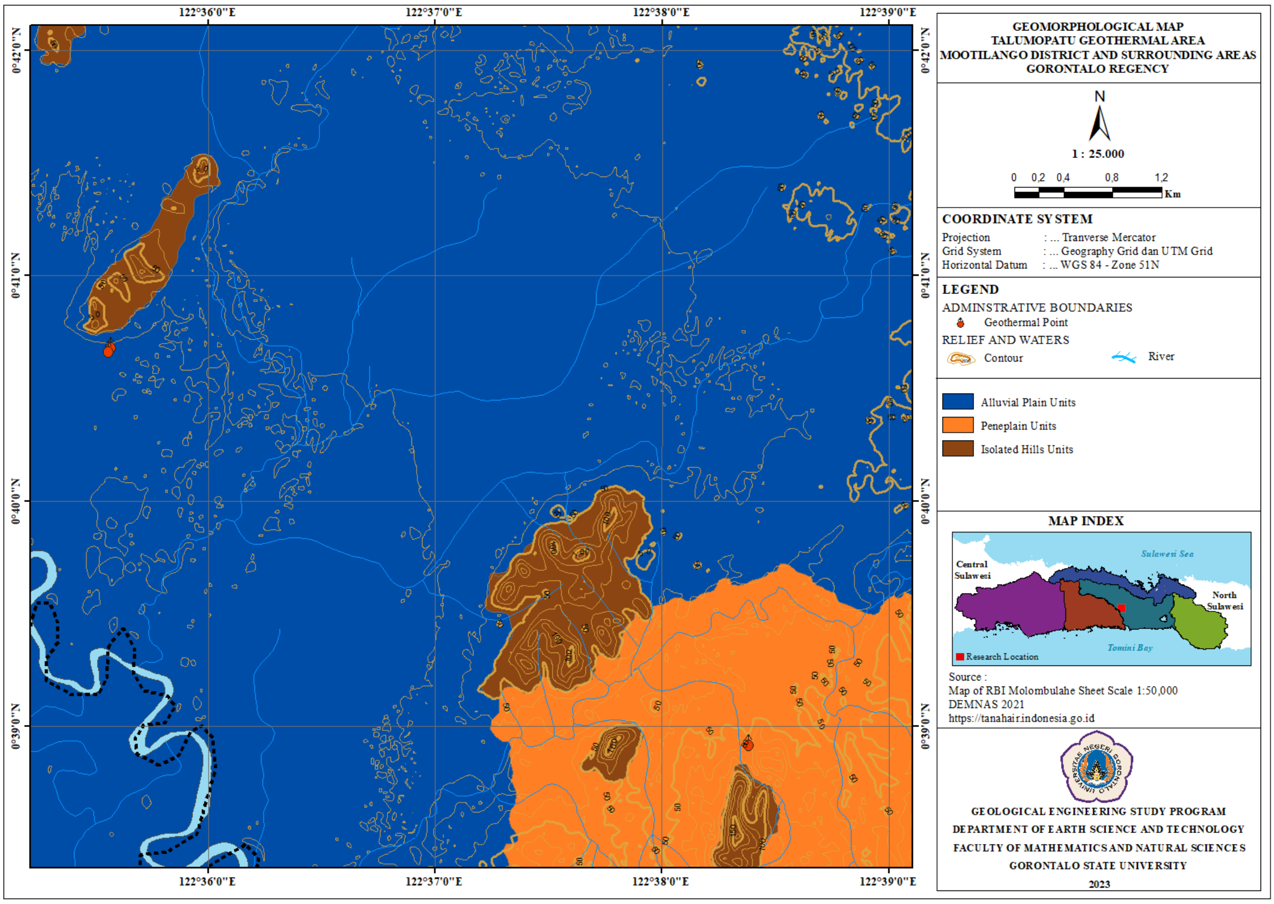

Fig. 5 Geomorphological Map.

3.4.1 Alluvial Plain Units

This unit has a relatively sparse contour pattern (Fig. 5), with an elevation of ± 7 – 25 meters above sea level (Fig. 6). The distribution of the units extends from the northeast to the southwest, the relief units are in the form of plains, and slopes are flat – moderately steep. The composition of the rocks making up this unit is alluvial, with loose material ranging in size from sand to gravel that has not been consolidated. Generally, the rivers in this unit are in the old river stadium stage with a dendritic-shaped flow pattern. The processes that occur in this unit are dominated by lateral erosion and weathering. This unit contains a major river, the Paguyaman River.

Fig. 6. Alluvial Plain Unit.

The composition of the rock making up this unit is alluvial, with loose material ranging in size from sand to gravel that has yet to be consolidated. Compared with the Regional Geology of the Tilamuta area and its surroundings, it has a Holocene age and is included in lake sediment formations.

3.4.2 Peneplain Units

The Peneplain Unit is characterized by a contour pattern that is rather tight and stretches towards the north (Fig. 5), and the distribution of this unit is in the southeast direction of the study area with an elevation of ± 25 – 50 masl. This unit slope is gentle sloping – steep, where the unit relief is plain to hilly. The river in this unit is at the stage of an old adult river stadium with a dendritic flow pattern. The process that occurs is lateral erosion balanced with vertical erosion and weathering that continues to occur.

This unit has a rock composition of sandstone and claystone (Fig. 7). Sandstone has a yellowish-brown color, degree of roundness sub angular - subrounded, carbonate cement, poorly sorted, and grain size of 2 - 1/16 mm. Compared with the regional geology of the Tilamuta area and its surroundings, this unit has a Pleistocene – Holocene age and is included in lake sediment formations.

Fig. 7. The Peneplain Unit.

3.4.3 The Residual Hills Unit

This area has a distribution of units in several places (Fig.5). The unit contour pattern looks relatively dense, with a unit elevation of ± 25 – 150 meters above sea level. The slope of this unit's slopes is sloping to very steep, with unit reliefs in the form of hills (Fig. 8). The river in this area is included in the mature river stadium stage, with a dendritic pattern of river flow. The processes that occur are moderate to extreme weathering and erosion, as well as lithology, which is controlled by structures. In this unit there are geothermal manifestation points at the study area.

Fig. 8. The Residual Hills Unit.

The unit's constituent rocks are in the form of Granite, the characteristic features of this rock are white-gray fresh color, weathered brownish-yellow color, massive structure, holocrystalline, phaneritic, equigranular, euhedral – subhedral, observed mineral composition of quartz, orthoclase, hornblende, and plagioclase, as well as some altered minerals. When matched based on the regional geology of the Tilamuta area and its surroundings, determining the age of the rocks can be compared with the Middle to Late Miocene Diorite formation of Boliyohuto.

3.5 Discussion

The study area is based on endogenous and exogenous processes that affect natural forms. The process begins with the formation of granite rocks in the Middle to Late Miocene [15], the formation of which is a plutonic rock that forms at depth. Then a tectonic process occurred so that the rocks were exposed. Along with the continuous process of weathering and erosion, it causes natural forms to change into denudational landscapes. This coincided with sandstone formation during the Pleistocene and alluvials during the Holocene.

Lineament is a determinant of the existence of a geological structure that becomes a permeable zone, a geothermal transport route to the surface [16]. This is evidenced by the lineament that is right or close to the point of geothermal manifestation.

4 Conclusion

In accordance with the results of the analysis of morphology, morphometry, and morphogenesis, it can be concluded that the geomorphological condition of the study area is divided into three parts, namely the Alluvial Plain Unit, Peneplains Unit, and Residual Hills Unit.

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