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Hydrogeology of the Balaesang Tanjung Region, Donggala District, Central Sulawesi, Indonesia

A.I Abdullah[1] *, I. Uno[1], F. A. Marhum[1], M. U. Botjing[1], A. Abdullah[2], S. Sandra[2]

1) Geological Engineering Study Program, Tadulako University, Palu City, Indonesia
2) Geophysical Engineering Study Program, Tadulako University, Palu City, Indonesia

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Abstract

Balaesang Tanjung in Donggala Regency is a peninsula surrounded by the sea. This preliminary hydrogeological study aims to estimate the groundwater potential zone in the area. We conducted a qualitative assessment using indicative parameters of morphology, slope gradient, and rock formations. The main feature based on the lowest topography and gentle slope is the location of water accumulation. It is occupied by the Molasse Formation, where limestone and other deposits are characteristic of a porous lithology, which most likely allows infiltration processes to occur in this area. The presence of discontinuities in limestones can serve as secondary porosity for storing fluids. So that the delineation of groundwater recharge follows the distribution of the Molasse Formation and the morphology of the plains. From these results, we recommend that the western Balaesang Tanjung area can act as a low to moderate productive aquifer, where the flow can flow through fissures.

*) e-mail: ahmadimam712@gmail.com

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1. INTRODUCTION

Groundwater is a clean water source used for drinking water and irrigation needs [1]. Groundwater tends not to be disturbed by the environment and conditions on the surface; its quality is only affected by seawater intrusion [2], and infiltration which carries contaminants. In this case, groundwater is good as a source of clean water and will be meaningful for the community in the Balaesang Tanjung region in the Donggala district. This matter is based on the geography of the Balesang Tanjung region. On this peninsula, most of the land is surrounded by the sea. Almost resembling the position of an island in the middle of the ocean. So it is considered to have limited sources of clean water. Based on Balaesang Tanjung's unique geographical conditions, obtaining a potential groundwater location is rare. Moreover, this area has yet to be fully covered by clean water services in all areas by the Government through the Regional Municipal Waterworks. Therefore, we conducted this hydrogeological study as a preliminary study to estimate the groundwater potential zone at Balaesang Tanjung. However, in delineating groundwater locations exists, knowledge of the geological and morphological conditions that can fill and drain groundwater is required. According to Todd and Mays [3], many geological formations can function as aquifers, provided they can store water in rock pores and fractures.

2. METHOD

We use indicative surface parameters with a qualitative assessment to determine potential groundwater zones. Parameters considered playing important role in delineating potential groundwater zones are geomorphology or topography, slope, and rock formations. In the context of geomorphology, water flows from high to low elevation. High-gradation boundaries between plains and hills mostly cover the landscape, so the geomorphological factor is an indicator for assessing groundwater prospects [4]. Likewise, the slope also plays an important role in ensuring the area of infiltration and water drainage, which can be seen from locations with a slope of <13–19%, which are potential locations for groundwater to exist [5]. Next, the existence and movement of groundwater are very dependent on the rock type; it will determine the ability to accommodate and pass groundwater based on the physical characteristics of each lithology [6, 7].

3. RESULTS

The Balaesang Tanjung morphology is mostly hills and mountains at an elevation > 100 m to 650 m (see Figure 1), with a slope of 25% to more than 45%; it is a steep slope (see Figure 2). The highest elevation gradation bounds a lake in the northeastern part.

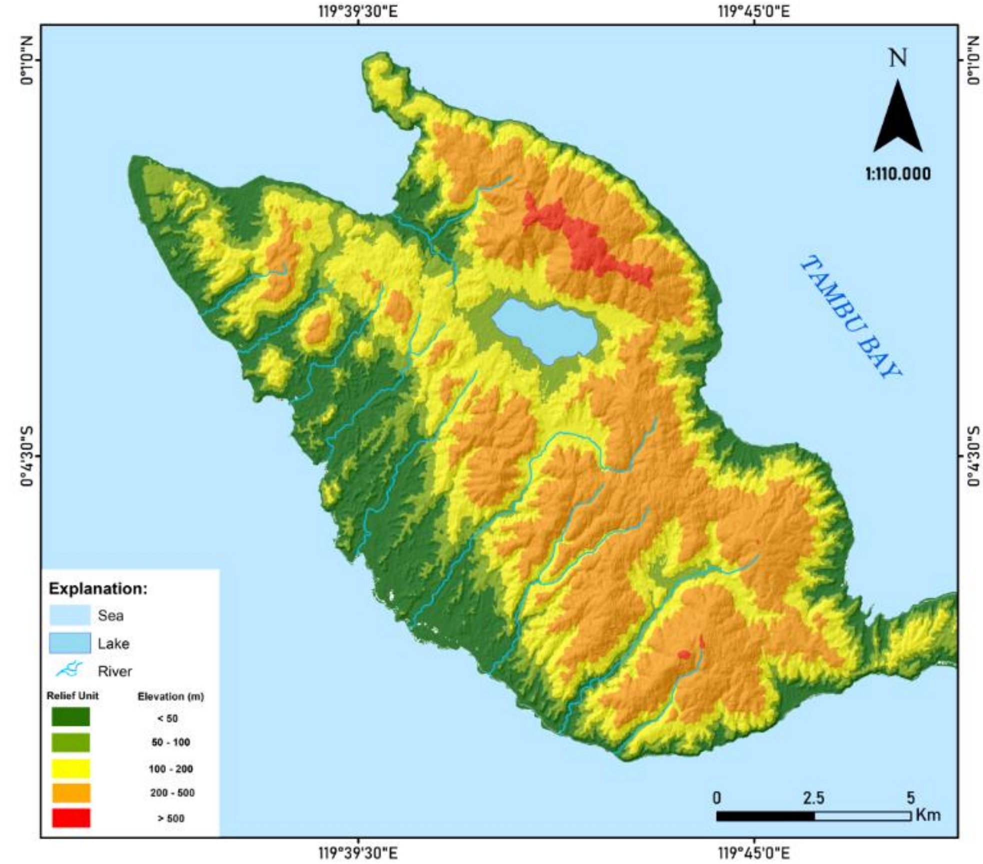

Figure 1. Topographical map of Balaesang Tanjung Region

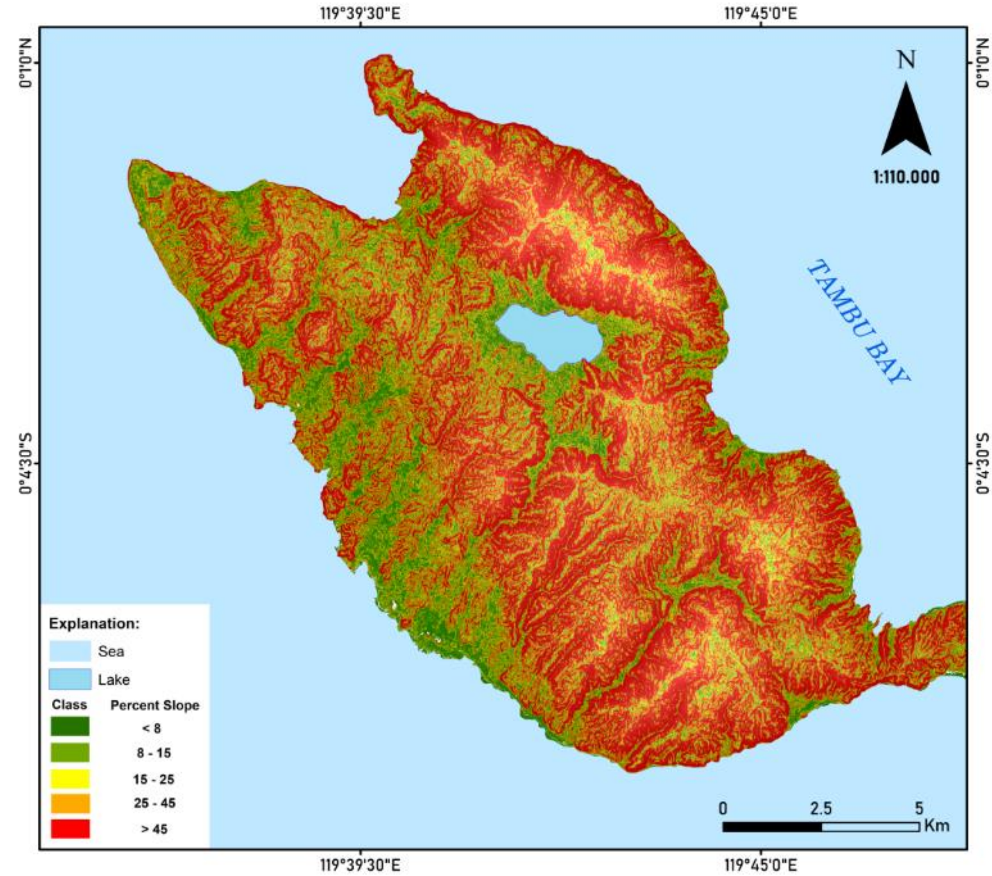

Figure 2. Slope map of the Balaesang Tanjung Region

The probability that the developing geological structure took over in the formation of the peninsula relief and lake at Balaesang Tanjung. According to Sukamto *et al*. [8], the morphology of these hills and mountains is the Tinombo Ahlburg Formation (1913) (Tt), composed of shale, sandstone, conglomerate, volcanic rock, limestone and chert, including phyllite, slate and quartzite near the intrusions (mainly volcanic rock). The age of the fossils found shows the age of the Eocene; this series was widely exposed in the north and east, then there were Breakthrough Rocks (gr), granite and granodiorite. Another unit, Molasa Celebes Sarasin and Sarasin (1901) (QTms), occupies a plain morphology with less than 50 m elevations, with a gentle slope below 15% in the western part. The Molas Unit comprises conglomerates, sandstone, mudstone, coral limestone, and marl; some are weakly hardened (especially limestone). These rocks overlap the Ahlburg Tinombo Formation (1913) (Tt), which is exposed to the west and south. Containing debris from older formations, all of which are only weakly ossified. These rocks continue towards the sea and change into fine-grained clastic rocks. The age of the fossils found indicates the age of the Middle Miocene; it is indicated that the quaternary River deposits also belong to this unit. The groundwater potential in the Molasa Celebes Sarasin and Sarasin (1901) (QTms) sediment area is the greatest because of its high permeability. Older rocks, such as the Tinombo Ahlburg Formation (1913) (Tt) and Breakthrough Rock (gr), have small gradients and are even impermeable (see Figure 3).

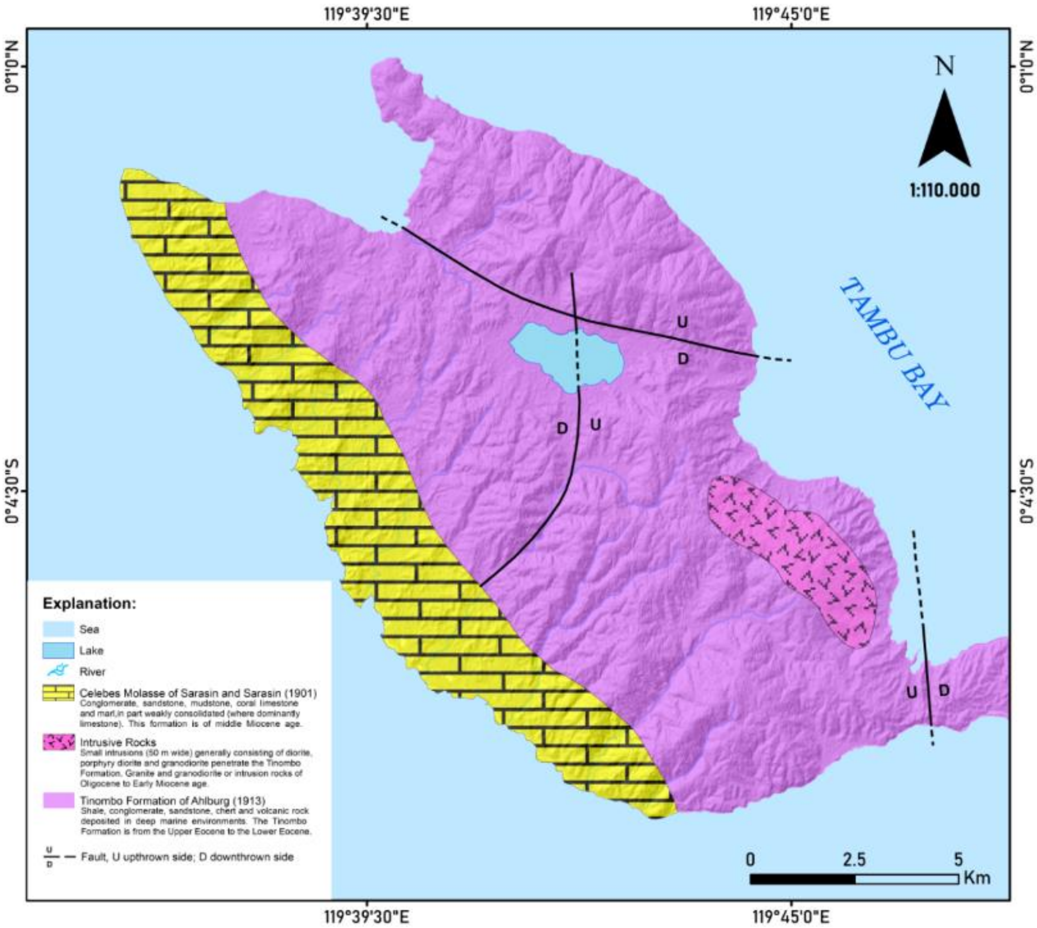

Figure 3. Geological map of the Balaesang Tanjung Region

From a hydrogeological perspective, in solid form, metamorphic rocks, like igneous rocks, are relatively impermeable to water. However, this rock fracture system can act to pass water, although generally, it can only release insignificant amounts of water. According to Prastistho *et al*. [9], fractures in rocks can become aquifers if the fractures are interconnected and there is a water source. Wells that can be developed are likely to have a small discharge. In some cases, the amount of water produced can be less, so pumping can be done many times [10].

The Molas Formation in Balaesang Tanjung area is dominated by limestone and other clastic sedimentary deposits. The limestone topography is controlled by dissolution processes, particularly water seeping through fractures and joints in the limestone, then dissolving it. Gradually, the fractures get bigger and form caves or subsurface water channels [11]. The graduation limestone is generally low to moderate, depending on the number of fractures. The emergence of springs in coastal areas can certainly appear with various debits. According to Freeze and Cherry [12], the permeability of limestone layers is usually no more than 10-7 m/s, with density and porosity variations depending on the consolidation degree and the permeable zone development after deposition.

Based on the morphological characteristics, slope and rock formations, we interpret and delineate the groundwater recharge boundaries in the Balaesang Tanjung Region as groundwater basin boundaries or groundwater potential zones in the lateral direction. The main features are based on topography and slope; the location of the lowest elevation with a gentle slope is the location of water accumulation on the surface. The Molasse Formation occupies this location; limestone and other deposits are characteristic of a porous lithology, most likely allowing infiltration processes to occur in this area. Of course, fractures and discontinuity planes in these rocks can serve as reservoirs of fluids as secondary porosity [11]. So that the delineation of groundwater recharge follows the distribution of the Molasse formation and the morphology of the plains (see Figure 4), with the justifications described in Table 1.

Table 1. Interpretation of groundwater potential zones

Indicator parameters			Interpretation of groundwater potential zones
Geological formations	**Geomorphology, topography**	**Slope**	
Tinombo formation, composed of shale, sandstone,conglomerate, volcanic rock, limestone and chert, including phyllite, slate and quartzite near intrusions (mainly volcanic rock)	These rocks are at an altitude > 100-650 m	25% to over 45%	Not porous, located in the morphology of mountains and hills, steep slopes. Groundwater area is scarce, small productive
Intrusive rock, are the breakthrough rocks, granite and granodiorite	These rocks are at an altitude200-500 m	25 to over 45%	Not porous, located in the morphology of mountains and hills, steep slopes. Groundwater area is scarce, small productive
Molasse formation, composed of conglomerate, sandstone, mudstone, coral limestone, and marl, partially hardened weakly (especially limestone)	These rocks are at an altitude< 50 m	< 8 to over15%	Limestone and other deposits are porous lithologycharacteristic in this area, the most likely for infiltration to occur. Can act as an aquifer with low to moderate productivity. Flow can be through fissures, fractures, and dissolution channels. The emergence of springs can appear in various debits of coastal areas.

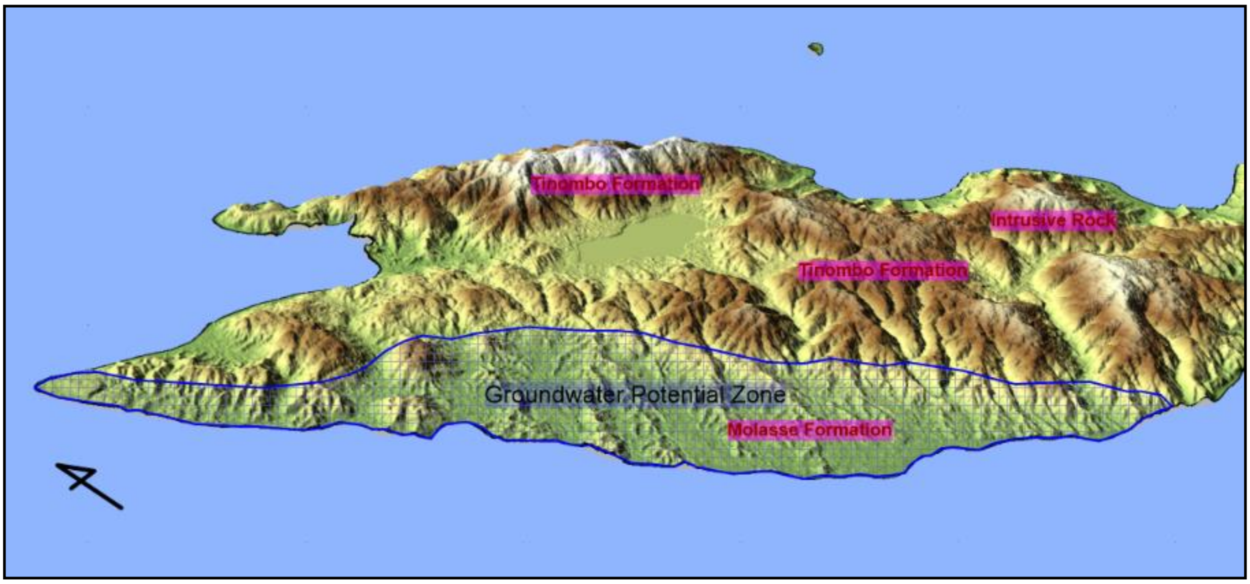

Figure 4. 3-D morphological of Balaesang Tanjung Region, showing that in the western part it is a potential groundwater zone delineated and justified based on topographical parameters, slope, and lithology

4. CONCLUSION

The hydrogeological aspect places morphology and geological formations as important in delineating potential groundwater zones. The existence of discontinuities as secondary porosity also supports rocks as fluid storage. We have defined the Balaesang Tanjung Region as a groundwater basin boundary based on these characteristics. This boundary is considered a zone where all hydrogeological processes can occur, namely in the Molas Formation. This formation is dominated by limestone and other deposits that occupy plains morphology. We realize that the quantitative aspects will need to be better understood; therefore, other study methods must be carried out to support this result, such as giving weight to each criterion in the potential groundwater zones spatial analysis, a more detailed study of geological structures, and subsurface exploration using geophysical methods. Compiling other supporting data will increase the groundwater availability validity, which has been interpreted from this study. However, from this review, we can provide regional recommendations regarding areas that have the potential to utilize groundwater in the Balaesang Tanjung region.

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