LIMESTONE GEOHAZARD BY USING GEOMORPHOLOGICAL STUDY AT KABUPATEN PANGKAJENE AND KEPULAUAN, SOUTH SULAWESI, INDONESIA

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ABSTRACT: The study area is located at Kecamatan Bungoro, Kabupaten Pangkajene and Kepulauan of the South Sulawesi province in Indonesia. The coordinate is S 4° 45' 45" to S 4° 48' 35" and E 119° 37' 01" to E 119° 39' 45". The objectives of the research are to produce updated and comprehensive of geological map, analyse the potential surface karst limestone and other features that may contribute to geohazard by using the geomorphological study and to classify a geohazard zone of karst limestone based on 3D block diagram and profile graph of the study area. The geomorphology of study area were divided into five of geomorphology landscape unit which are steep hill karst landscape unit, rolling-hilly karst landscape unit, karst plain landscape unit, denudation hill landscape unit and lastly is intrusion mountain landscape unit. Based on the morphograhic, morphometry and morphogenetic analysis shows that the age of the study area is younger to older. There were three rock unit at the study area from youngest to oldest which is trachyte intrusion unit, limestone unit and sandstone unit. The geological structures at the study area are fold, joint and fault. The parameter used for analysis the potential surface karst limestone by geomorphological study is morphometry. An analysis of morphometry to discover the slopes angle of karst hill and the results were associated with the features of karst and limestone mining activities produce the division of limestone geohazard zone at karst topography of study area Therefore, the limestone geohazard is occurred by the slopes angle of karst hill, karst features and mining activities.

1. INTRODUCTION

Geohazard is known as a geological phenomenon which is can lead to harmful event that caused by the Earth to the environment and people surrounding. Karst commonly occurs in carbonate rock such as limestone and dolomite. Karst limestone can contribute to the geohazard which are sinkholes, rock fall, cavities and others. Besides that, land-use at the karst topography can leads to the risks to the flora and fauna too. For example, mining activities at the karst terrain can destroy the topography of the karst and it is classify as limestone geohazard too.

Geomorphology is study about the origin and evolution of topographic which is created by the physical or chemical processes on the surface of the Earth. Based on the geomorphology definition, geomorphology is a part of geology that learns about the architecture of the surface of the Earth. According to the Van Zuidam (1985), the main aspect for the geomorphology is morphometric, morphogenesis, morphographic and morphochronology.

1.1 REGIONAL GEOLOGY AND TECTONIC SETTING

South of Sulawesi of west side is dividing by structural from west arm of Sulawesi by Walanae Depression. According to Van Leeuwen (1981) and Sukamto (1981), Walanae Depression is known as strike-slip fault which is sinistral movement. Sukamto and Supriatna S. (1982) stated that the oldest rock at Pankajene and West of Watampone is flysch sediment from Marada Formation and Balangbaru Formation. Hamilton (1979) and Sukamto (1982) found that, oldest rock in South Sulawesi located at Barru and Tonasa II area which are metamorphic rock, ultra-basalt and sediment.

The volcanic activities of under the sea is active during Palaeocene and the proved of the eruption is at east of Bantimala and Birru. Birru is located at regional geology of Ujungpandang, Benteng and Sinjai. During Lower Eocene, west of the area was near the mainland which is characterized by land depositional and coal in the Malawa Formation. At the east, it was shallow marine depositional environment which is characterized by interbedded

carbonate clastic rock from Salo Kalupang Formation. The depositional of Malawa Formation only occur during Lower Eocene while Salo Kalupang Formation occurs until Upper Oligocene (Sukamto and Supriatna S., 1982). At west part, the depositional of carbonate rock is thick and wide from Upper Eocene until Lower Miocene. It seems that the shallow marine depositional environment is wide. The tectonic process at west part is occurring until Lower Miocene. Figure 1 below shows regional geology map of South Sulawesi, Indonesia (Wilson, 1996).

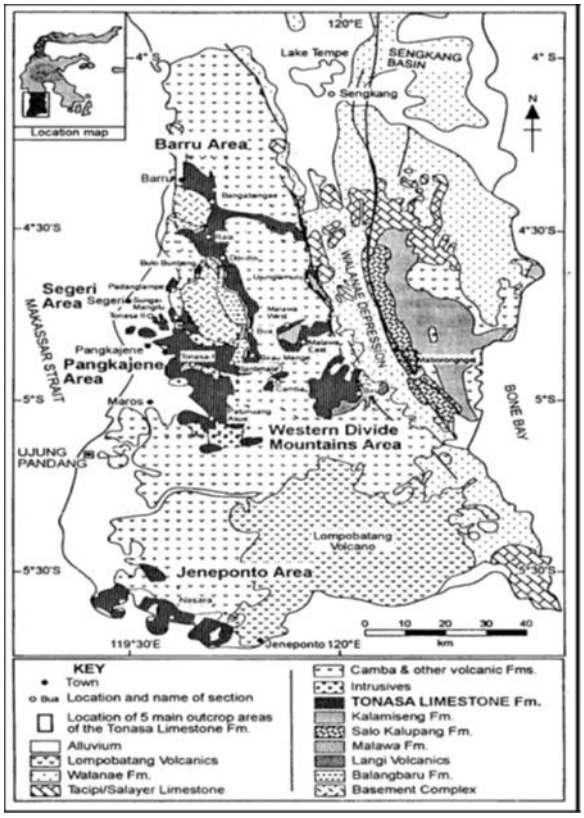


Figure 1. Regional Geology Map of South Sulawesi, Indonesia (Wilson, 1996)

1.2 GEOLOGY OF STUDY AREA

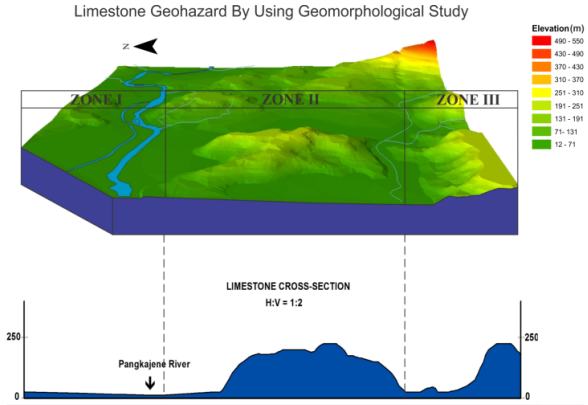
This study is conducted at Kecamatan Bungoro, Kabupaten Pangkajene and Kepulauan of South Sulawesi, Indonesia which is lies within the coordinate S 4° 45’ 45” to S 4° 48’ 35” and E 119° 37’ 01” to E 119° 39’ 45”. It is dominantly covers limestone karst topography (figure 2). The sequence stratigraphy in the research area from old to young is Malawa Formation, Tonasa Formation and Trachyte intrusion. Figure 3 shows the geological map of the research area.

2. METHOD

During field observation, geological and geomorphological study will be conducted for this research. The principal of interpretation of the geomorphology is in terms of contour pattern, drainage pattern and lineament which help to interpret the geology of the area. The parameters is a morphometry which is that used for the interpretation of the geohazard for the karst tower of the study area. From the morphometry, it can be identified the characteristics of the karst and also the land use at the karst tower either the karst tower will leads to the risk for the community that lived surrounding or to the environment. From this method, it will produce updated geological map, and zonation of the limestone geohazard of the study area from the 3D block diagram and profile. Geological map, geomorphological map and 3D block diagram were produce by using ArcGIS software for the entire study.

3. RESULT AND DISCUSSION

Based on the geomorphological study such as morphometry analysis and geomorphological observation, the east side of the study area is divided into three zones. For each zone, the data collected during field site will be described in detail which is the results focus in morphometry analysis and geomorphology field observation (figure 4).



	ZONE I	ZONE II	ZONE III
Morphology	The slope angle in percentage is 0% and flat area. The highest point in zone I is 18 metres from mean sea level. It is known as karst plain landform.	The percentage of slopes angle is started from 0% to 100% which is flat to steeply dissected-mountainous area. Karst plain landform surrounded the hilly karst. The highest point is 227 metres from mean sea level.	The percentage of slope angle is relatively with 30% to 100% from hilly-steeply to steeply dissected-mountainous. The highest point of karst hill in Zone III is 315 metres from mean sea level.
Land-use	Occupied with villages and agriculture such as paddy field.	Dominantly with limestone mining activities. There is paddy field at karst plain which is located at north and east of the hilly karst.	There is village but not relatively dominated as in Zone I and no plantation and mining activities.
Risk	Based on the geomorphological observation, this area will not lead to the limestone geohazard because there is no any activities that leads to the risk	Based on the geomorphological observation, zone II is the main contributor to the limestone geohazard due to the continuously limestone mining activities. This activitites increase severity of geohazard to the natural topography of karst.	Based on the geomorphological observation, this zone can lead to the limestone geohazard due steepness of slopes and also existence of the underground cave of karst hill.
Zone scale	LOW	HIGH	MODERATE

Figure 4. Zone division geomorphology result of east side of Bungoro.

3.1 ZONE I

Zone I is known as karst plain morphology unit. The highest point is 18 meters of mean sea level. In zone I, the percentage of slopes is 0% and based on Van Zuidam (1985) slopes classification it is known as flat area. This zone is dominantly with villages and also agriculture which is paddy field. Pangkajene River **(**figure 5**)** is located at zone I and the water from the river is used for daily life. Based on the morphometry analysis result, zone I is not lead to the limestone geohazard because of the topography is karst plain landforms which is flat and no karst hill. Besides that, there are no man-made activities that can leads to the geohazard limestone.

(a)  (b) 

Figure 5. View of Pangkajene River of east side (a) and west side (b) in Bungoro.

3.2 ZONE II

Zone II is known as hilly karst morphology unit. The highest point is 227 meters of mean sea level. In zone II, the percentage of slopes angle is 0% to 100%. In this zone, it has flat to steeply dissected-mountainous area. The karst hill is surrounded by the karst plain landform. At the east and north side of karst hill in zone II is relatively with paddy field (figure 6). This zone is dominantly limestone mining activities (figure 7). Based on the morphometry analysis result, zone II is main contributor lead to the limestone geohazard. Half of the original karst topography in zone II has been disturbed by mining activities.

Figure 6. North view of karst hill of zone II.

Figure 7. South view of karst hill of Zone II.

3.3 ZONE III

Zone III is a karst hill morphology unit which is the highest point of zone III is 315 meters of mean sea level. The percentage of slope angle is relatively with 30% to 100% from hilly-steeply to steeply dissected-mountainous to the north (figure 8). This zone area has population but then not dominated such as in zone I area. Based on the morphometry analysis result, zone III can lead to the risk of limestone geohazard such as rock fall due to steepness slope to the villagers. Besides that, there is an underground cave at this karst hill (figure 9). Underground cave in zone III can be one of the factors that may contribute to the development of sinkhole in the future.

Figure 8. View of the karst hill of Zone III.

Figure 9. Underground cave at Zone III.

4. CONCLUSION

Geomorphology at the study area is divided into five morphology unit which is Steep Hill Karst Landscape unit, Rolling-hilly Karst Landscape unit, Karst Plain Landscape unit, Denudation Hill Landscape unit and Intrusive Landscape unit. The zonation of the limestone geohazard is divided based on the results of morphometry and also the activities that contribute to the limestone geohazard. Zone II is high for the limestone geohazard. This is because the mining activities dominant in zone II. The increasing limestone mining activities are resulting in damage of the natural karst topography**.**

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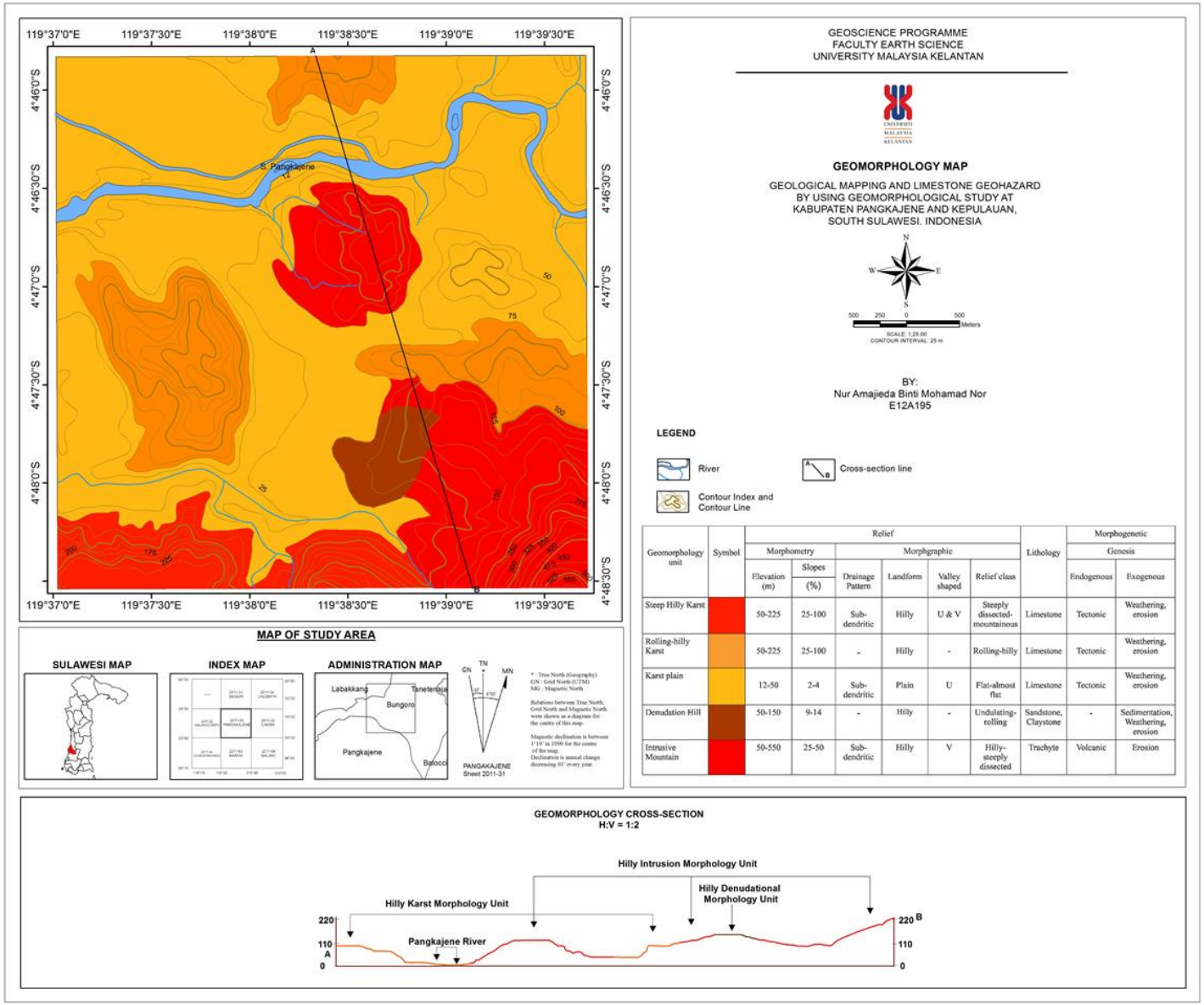

Geomorphology unit	Symbol	Relief						Lithology	Morphogenetic	
		Morphometry		Morphographic					Genesis	
		Elevation (m)	Slopes (%)	Drainage Pattern	Landform	Valley shaped	Relief class		Endogenous	Exogenous
Steep Hilly Karst		50-225	25-100	Sub-dendritic	Hilly	U & V	Steeply dissected-mountainous	Limestone	Tectonic	Weathering, erosion
Rolling-hilly Karst		50-225	25-100	-	Hilly	-	Rolling-hilly	Limestone	Tectonic	Weathering, erosion
Karst plain		12-50	2-4	Sub-dendritic	Plain	U	Flat-almost flat	Limestone	Tectonic	Weathering, erosion
Denudation Hill		50-150	9-14	-	Hilly	-	Undulating-rolling	Sandstone, Claystone	-	Sedimentation, Weathering, erosion
Intrusive Mountain		50-550	25-50	Sub-dendritic	Hilly	V	Hilly-steeply dissected	Trachyte	Volcanic	Erosion

Figure 2. Geomorphological map of Bungoro area.

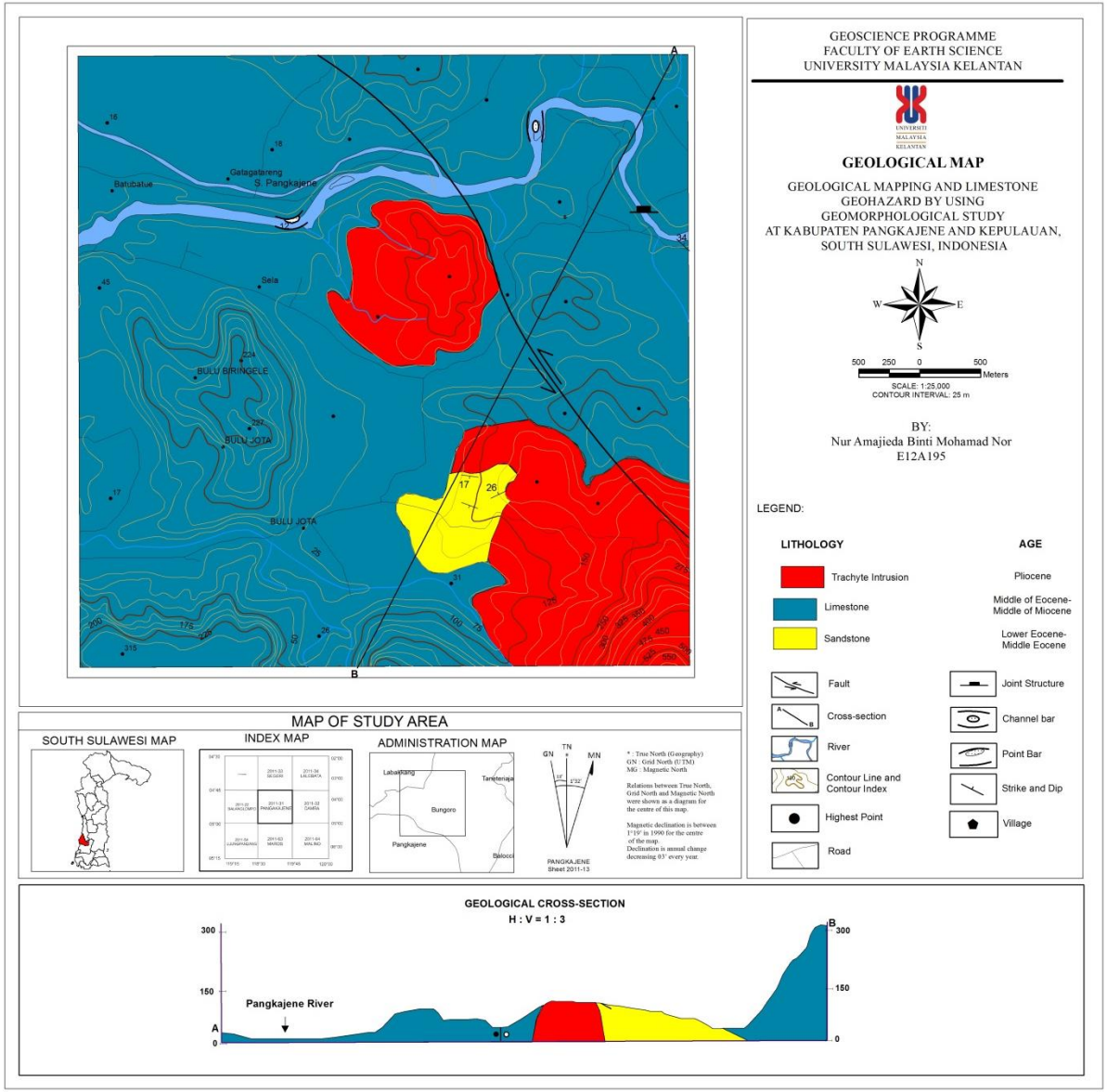

Figure 3. Geological map in Bungoro.