Morphotectonic Study Based On The Mountain Sinuosity (SMF) Method in Kramat And Surrounding Area, Karangmoncol-Purbalingga District

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Abstract. The study area is in the Karangmoncol District and its surroundings, Purbalingga Regency, Central Java Province, Indonesia. The study was conducted to determine the level of tectonic activity using morphometric analysis in the slopes and valleys. The analysis carried out is Mountain Front Sinuosity (Smf). Geological mapping was carried out to determine the types of rocks in the research area. Smf measurements were carried out on each rock group. Smf measurement is done by selecting a certain elevation contour line facing the valley. Two points on the contour line are connected by a straight line. The value of Smf is calculated by dividing the length of the selected contour line (Lmf) by the length of the straight line of two points on the contour (Ls). The rock of the Halang Formation in the northern part of the study area which is old (Late Miocene) has a high Smf value (3.89 points) which indicates it is not tectonically active. The rock of the Kumbang Formation in the middle of the study area that is old (Late Miocene) has a moderate Smf value (2.67 points) which indicates it has a weak tectonic level. The rocks of the Kumbang Formation are composed of volcanic rocks such as lava, breccia and tuff that are dipped to the south. The young Tapak Formation rock (Pliocene) in the southern part of the study area has a high Smf (3.16 points) which indicates it is not tectonically active.

Keywords: tectonic, morphometric, formation, Miocene, and rock.

1. Introduction

Tectonic geomorphological studies can be used to reveal the process of forming topographical features that can be used as indicators of the pattern, strength and average of tectonic movements [1], [2]. Its application can be used in rock fracture disaster paths [3] or earthquake paths. In other words, the relative tectonic activity of a location can be known by the presence of spatial data [4] and quantitative geomorphology [5].

Morphometry is a quantitative measurement in the form of landforms/morphology [6]. In morphotectonic studies, morphometric analysis is needed that can be used to identify the characteristics of the area's shape and its relation to developing tectonic activity [7].

The Karangmoncol area has a mountainous morphology, the formation of which is controlled by uplifting tectonic processes through folding and fault structures [8]. This tectonic activity in addition to forming morphology is also a potential disaster threat in this area. The problems raised in the morphotectonic study based on quantitative geomorphological methods in the Kramat area, Karangmoncol District, Purbalingga Regency, are how the quantitative geomorphological characteristics related to tectonic activity in the research area and how the level of tectonic activity relates to active fault lines in the research area.

2. Method

The research was carried out in the field and in the laboratory from April to August 2022. The series of research flows that will be carried out begins with the collection of secondary and primary data. Secondary data in the form of regional geological maps, regional stratigraphic columns and geological

history of the study area. The primary data used are field data and quantitative geomorphological data. Field data are mainly in the form of morphological data, rocks and fault/fault structures in the study area. Quantitative geomorphological data produces a map of Mountain front sinuosity (Smf).

Calculation of mountain front sinuosity (Smf) is carried out using the formula of [6] which expresses Smf with the equation Smf = Lmf / Ls, where Lmf is the length of the front mountains along the bottom; Ls: the length of the straight face of the mountains.

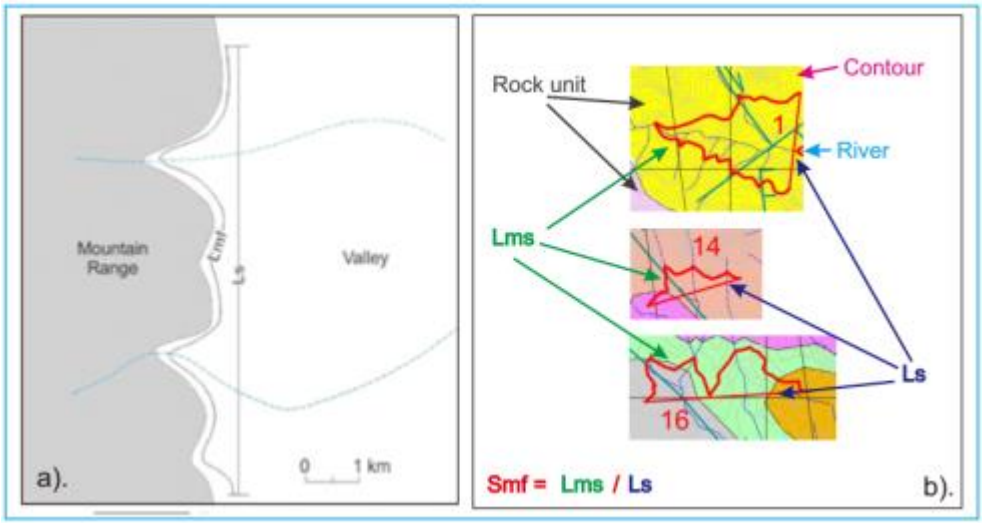

Figure 1. a). Method of calculating mountain face sinusity (Smf) [6] and implementation in study area.

High Smf values are associated with inactive tectonics. High Smf values are associated with hilly landscapes. Meanwhile, low Smf values are associated with strong tectonics which will describe the wide plains in front, narrow valleys and steep hills [6]. Smf scores are divided into 3 classes which are described in Table 1.

Table 1. Classification of the Mountain Frontal Sinusity (Smf) class according to Bull and McFadden (1997).

Class	Smf	Tectonic Activity	Description
1	1,2-1,6	Strong	Associated with the wide plains landscape, narrow valleys and steep hills.
2	1,8-3,4	Weak	Associated with landscapes of steep slopes and floodplains that are narrower than valley plains.
3	3,5-7,0	Not active	Associated with hilly landscapes.

3. Result and Discussion

Geologically, the research area is composed of Halang, Kumbang and Tapak Formation. These rocks are scattered in a west-east direction (strike) and relatively tilted (dip) to the south (Figure 4). The Halang Formation is composed of black-tuff sandstone, the Kumbang Formation is composed of volcanic rocks in the form of lava and breccia, while the Tapak Formation is composed of sandstone-claystone.

Black sandstone-tuff rocks are spread approximately 25% in the northern part of the study area. Outcrops in this unit were found in the northern part of the research area which were exposed in fresh to weathered conditions. Outcrops found in the drainage channels are in fresh condition. The thickness of this unit can be calculated from a cross-section of >500 meters. This rock is interpreted as the oldest unit (late Upper Miocene) and is part of the Halang Formation.

Basaltic lava outcrops (Figure 2) were found in the northern to central part of the study area which were exposed in a fresh state. Outcrops found in the dominant drainage channel were in fresh condition. The unit thickness from the calculation through the cross-section is estimated to be approximately 1400 meters. This rock is interpreted as the Kumbang Formation rock. Based on the dip of this rock, it is directed to the south.

Figure 2. Igneous rock of pillow lava that composes the steeply sloped Homocline Ridge in the Baleraksa area.

Basaltic lava rock occupies approximately 40% of the map of Kramat and its surroundings. This basalt lava unit consists of a very dominant basalt lava. Megascopically, basalt lava, as the main component, is dark gray in color, texture based on its crystal form which includes subhedral-anhedral, the degree of crystallization is hypocrystalline, with aphanitic granularity. The primary structures found in the field are pillow structures and columnar joints. It has a mineral composition of olivine, pyroxene and plagioclase. Megascopically, it is dark gray to black, very compactly, there is a backing effect that causes the color to blacken. This rock is interpreted as part of the Kumbang Formation which has a Late Miocene age.

Breccias occupy approximately 10% in the study area. Outcrops in this unit are found in the middle of the research area which are exposed in a fresh to weathered state. Outcrops were found in a rather fresh condition. The thickness of this unit can be calculated from a cross section of approximately 100 meters thick. This unit is interpreted as a unit with the same age as the basalt lava unit with claystone inserts.

Figure 3. A Northward view of the steeply sloped Homocline Mountains in the Baleraksa area.

This breccia is composed of fragments and matrix. Megascopically, this breccia has silica cement, a glassy matrix such as small fragments, floating fragments in the matrix, monomicly arranged and basalt fragments. Basalt fragments have a light gray color, aphanitic, massive, consisting of the minerals olivine, pyroxene, plagioclase. There are many outcrops of this breccia unit in the middle of the research area. This rock is interpreted as part of the Kumbang Formation which has a Late Miocene age.

Alternating claystone-sandstone occupies approximately 25% in the study area. Outcrops in this unit

were found in the southern part of the research area which were exposed in fresh to weathered conditions. Outcrops found on the riverbed are in fresh condition. The thickness of this unit can be calculated from the cross section of the incision > 625 meters thick. This rock is interpreted as part of the Tapak Formation which has a Pliocene age.

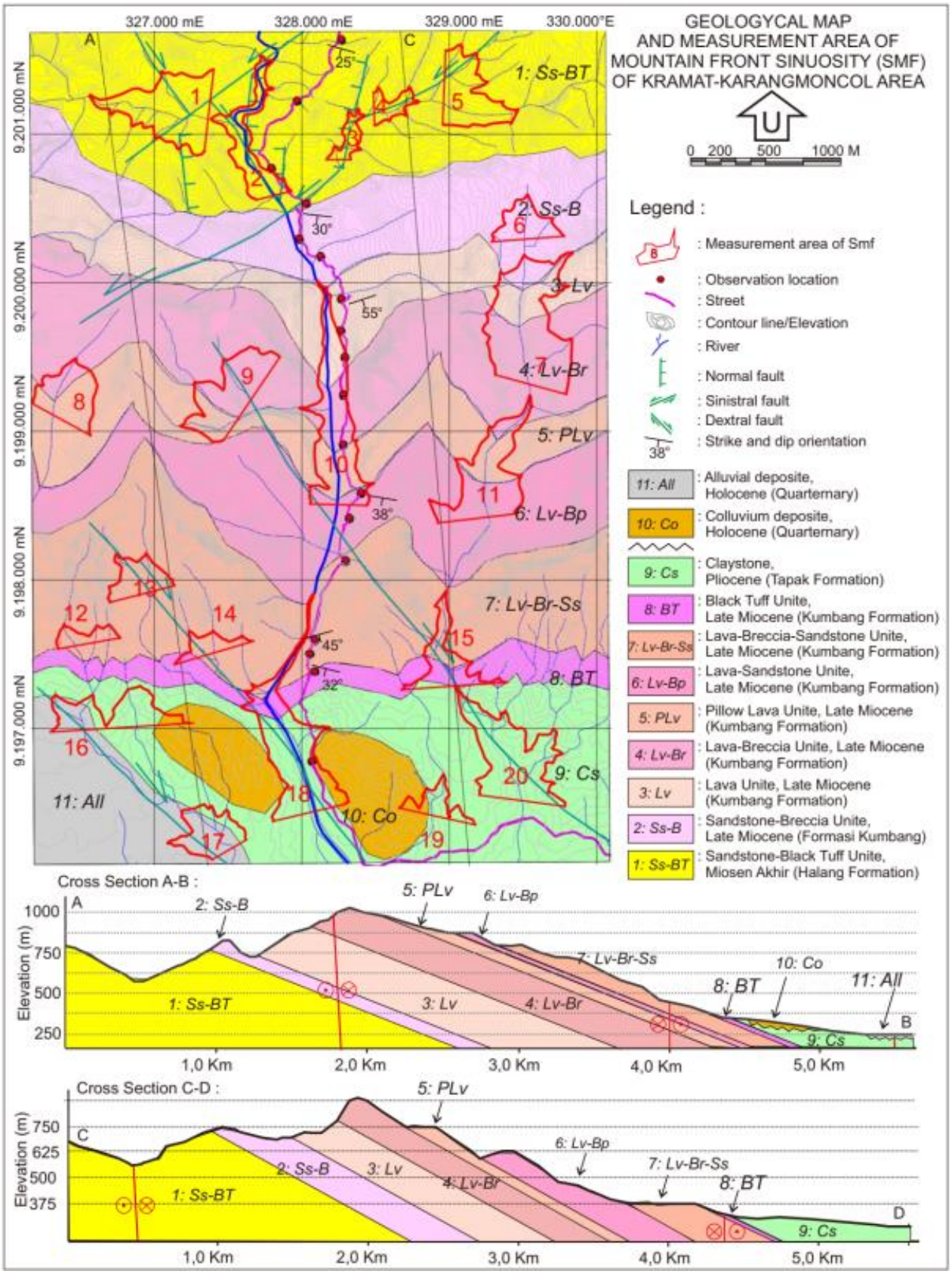

Figure 4. Geological Map of Karangmoncol-Purbalingga area.

Measurements using the mountain sinuosity (Smf) method were carried out by collecting 20 data (Figure 4 and Table 2). Lmf measurement data is carried out on contours with a certain height. The Lmf contour in one measurement area is different from the contour in another measurement area. The line Ls connects two places with the same contour value of elevation. A total of 5 measurements were made at the Halang Formation in the northern part of the map, 10 measurements at the Kumbang Formation in the center and 5 measurements at the Tapak Formation in the southern part.

Table 2. Calculation of Smf

No Area	Lmf (meter)	Ls (meter)	Smf	Average Smf	Class	Formation
1	2148	553,7	3,88	3,89	Not Active	Halang
2	513,9	306,9	1,67			
3	1082	168,8	6,41			
4	953,3	229,7	4,15			
5	1673	503,1	3,33			
6	907,5	486,9	1,86	2,67	Weak	Kumbang
7	2757	507,7	5,43			
8	1118	452,7	2,47			
9	1682	683,2	2,46			
10	1095	722,4	1,52			
11	2613	526,9	4,96			
12	684,5	434,3	1,58			
13	972,5	453,6	2,14			
14	799,2	559,7	1,43			
15	2034	718,9	2,83			
16	1737	971,5	1,79	3,16	Not Active	Tapak
17	1393	264,3	5,27			
18	677,9	434,4	1,56			
19	1206	533,2	2,26			
20	2902	587,8	4,94			

The results of the calculation of the SMF data that have been obtained are 20 data, the average Smf value is 3.89 in the Halang Formation, 2.67 in the Kumbang Formation and 3.16 in the Tapak Formation. According to Bull and McFadden (1997) the results of this measurement are classified as inactive tectonic for the Halang and Tapak Formation in the north and south (Figure 3, Figure 4 and Figure 5). Meanwhile, the middle part which is composed of the Halang Formation has a weak tectonic level. This weak tectonic level is responsible for the uplift of the study area. This uplift was responsible for intensive vertical erosion accompanied by landslides on the slopes facing the main river (Figure 6). This causes the formation of a mountainous morphology with steep slopes and a rough texture in the center of the study area.

Figure 5. A young river stage with V-shaped cliffs, in the steeply sloped homocline mountains to the north of the study area

Figure 6. The potential for landslides in the homokline mountain area with steep slopes in the middle of the study area.

4. Conclussions

The Halang Formation rock in the northern part of the study area as the oldest rock (Late Miocene age or about 15 million years ago) has a high Smf value (3.89 points) which indicates it is not tectonically active. The formation which is composed of sandstone and tuffaceous claystone has a hilly morphology with a rather steep slope.

The rock of the Kumbang Formation in the middle of the study area which is Late Late Miocene (10 million years ago) has a moderate Smf value (2.67 points) which indicates it has a weak tectonic level. This formation forms a mountainous morphology with steep slopes. The rocks of the Kumbang Formation are composed of volcanic rocks such as lava, breccia and tuff that are dipped to the south.

The rock of the Tapak Formation which is the youngest rock (Pliocene/5 million years ago) in the southern part of the study area has a high Smf (3.16 points) which indicates it is tectonically inactive. The rocks of this formation are interspersed with claystone and carbonate sandstone with a slope (rock dip) to the south.

5. **Acknowledgment**

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