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CHARACTERISTICS OF SEMILIR FORMATION IN RELATIONSHIP WITH THE PERIOD OF VOLCANIC ACTIVITY

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ABSTRACT: The Semilir Formation in the Baturagung area is a tipelocation of the Semilir Formation that is physiographically located on the part of the Southern Mountains Zone. Its spread extends from the western part of Imogiri, DIY, in the middle of Mt. Baturagung, to the eastern end of Mt. Gajahmungkur height. The Semilir Formation in the research area is aligned under Nglanggeran Formation and above Kebo-Butak Formation. The arrangement of rocks Semilir Formation in the basin of the Southern Mountains of Java is still seen from the standpoint of stratigraphy-sedimentology. The rock formation mainly consists of alternating breccia, sandstone, and claystone. Where the rock unit consists of tuff, tufflapilli, and pumice breccia, with generally rich in volcanic glass and quartz. These characteristics are related to volcano activities. This phenomenon is interesting to be studied further in order to reveal the volcano activities at that time that plays a role in the Semilir Formation. This study was studied from the perspective of stratigraphy-sedimentology and volcanology by measuring a detailed measurement of stratigraphy in order to obtain a sequence of lithologic variations of its constituent rocks. Detailed stratigraphic measurements that are characteristic of the Semilir Formation in connection with the periodization of volcanic eruptions in the South Mountain Basin indicate that there were 84 units of volcanic eruptions in 14 periods lie on the older volcanic rock succession. The location of this research is Semilir, Baturagung, Nglipar, Gunung Kidul, approximately south of Klaten, Central Java.
Keywords: Volcanic rock, characteristic of semilir formation, periodization of volcanic eruption

1. INTRODUCTION

The name of Semilir Beds was introduced by Bothe [1], the Geological Map of Jiwo Hills and Southern Mountains, presented at the 4th Pacific Science Congress in Bandung. Then, Sumarso and Ismoyowati [2] treat it as a Semilir Formation, Samudro and Sutisna [3] also followed the naming, in the 1: 50,000 Geological Map of Klaten, which was later followed in the Geological Map of Surakarta and Giritontro scale 1: 100.000 [4].

The Semilir Formation stratigraphy formed in the Southern Java Basin has been widely studied and in fact, almost the entire region has been systematically mapped. But a thorough understanding of the South Java Mountain zone is still limited. Many aspects of earth that still need to be studied, whether geomorphology, stratigraphy, sedimentation, geological structure, tectonic or tectonic development, and especially volcanic activities.

Some researchers have conducted research in fields that are also related to periods of volcanic activities with approaches in accordance with their respective expertise and research objectives. Some of these researchers include Werner et al. [5] with a volcanology approach; Belizal & Lavigne [6] with a geomorphological approach; Bagalwa & Karume [7] with a remote sensing approach; Armijos et al. [8], Loughlin et al. [9], Yamaoka et al. [10] with a risk management approach; and Yan [11] with a gravity approach.

The lower part of this Formation is the Kebo-Butak Formation. In its development, this Semilir Formation becomes famous because it was considered to have increased volcanic activities as a result of the eruption activities that form the caldera while the Kebo-Butak Formation considered being the beginning of an increase in volcanic activities in Central Java.

The Semilir Formation was chosen for the study, although previous researchers have done a lot of research in the southern mountains region, particularly in the Semilir Formation because the Semilir Formation has variations of lithology from volcanic eruptions. However, if the condition of the rock is dominated by volcanic eruption rocks, which at the time of previous researchers still have not touched how the arrangement of rocks to form Semilir Formation, then how the characteristics of these rocks are only composed by sedimentation due to previous rock weathering or other rocks.

The research is located in the Cermo Tegalrejo River area, the path of Baturagung-Mt. Semilir, Gunung Kidul Regency, DIY, Indonesia. The study was conducted on an area located in Easting 461.143 - 463.124 and Northing 9. 133. 595 - 9. 136. 769, on the path of Baturagung-Mt. Semilir.

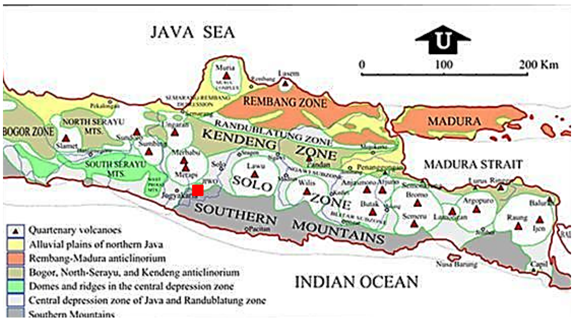


Fig. 1. Location of research area (shown by the red box)

2. METHODOLOGY

The method used in this research is a detailed measurement of stratigraphic cross section from field geology survey, rock sampling, and laboratory analysis. The data acquisition technique in geological mapping section is carried out with detailed stratigraphic cross section measurement in open location, both have certain rules and requirements regarding data density, track direction, and mapping scale. Rock sampling is taken every 20-50 cm. Measurable and bonded stratigraphic measurement was carried out by making continuous lithologic records along the mapping path using a scale of observations that measured stratigraphic cross section scale 1:50 to scale 1: 10. It had better accuracy and accuracy in data and data processing. The core of this work is a combination of three main work, namely navigation, track measurement, observation and recording of geological conditions in detail and rock sampling.

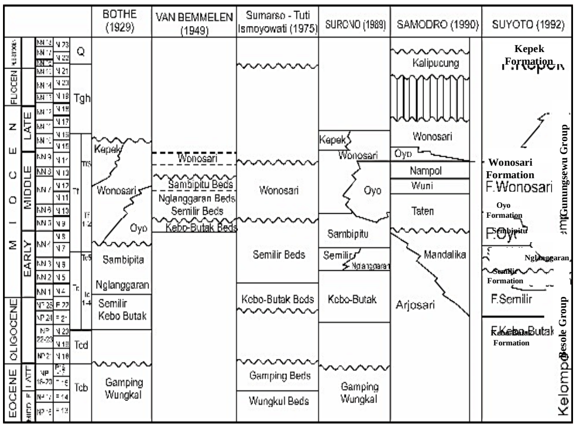
3. RESULT & DISSCUSION

3.1 Result

The Semilir formation was exposed throughout the Southern Mountains, the southern coast of central Java, the lower part of the Semilir Formation is Kebo-Butak Formation and the upper part being covered by the Nglanggeran Formation. Semilir formation spread on the slopes of north Baturagung which is quite steep so the lower part contact with the Kebo-Butak Formation reaches the south hills and comes into contact with the Nglanggeran Formation above.

The Semilir Formation is dominated by volcanic rocks in the form of crystal tuff, tuf lapilli, and pumice breccia. The lower part of this formation is composed of sandstone of lithic-feldspathic wackes. The lower calcareous at the lower part contains foraminifera and nannofossils, indicating the marine environment and early Miocene age (NN3). The upper part consists of andesite breccia and sandstone. In some places above there are some thin lignite lenses and wooden fossils. At the upper part, shows the extensive spread of grain-flow sediments. This section is interpreted as terrestrial deposition. Based on the age determination with radiometric dating in pumicebreccia showing age 17.0 + 0 million years and 16.0 + 1.0 million years or the end of the early Miocene. The brightening enviroment of the Semilir Formation indicates a superficial upwardness, from which the shallow sea was turned to ashore. The fascities of the andesite breccia and the sandstone are deposited in a relatively short time. This indicates that voluntary activities increasing rapidly at the upper part formation deposition. Surono et al. [4] implied that the massive eruptions which form the Bleary Formation are thought to be centered in the Baturetno Basin.

Table 1. Compilation of Southern Mountains stratigraphic data [1], [2], [4], [12].



3.1.1 Data analysis

In this study, detailed lithological data from the sequences of bedding layers of deposits in the vertical direction will be separated into units of volcanic rock and rock units of rock previous results.

This is done to support the understanding characteristics of the constituent rock formations and the periodization of volcanic eruptions in the study area.

Semilir Formation rocks are dominated by rocks derived from volcanic activities. The composition of rock forming Semilir Formation consists of mixing between clastic sediments, volcanoclastic and pyroclastic. The environment of the formation is deep sea until shallow. This indicates that in the basin is filled by direct products of volcanic activities and clastic materials from the land.

The upper part of Semilir Formation is dominatedby volcanic rocks showing the intensive volcanic activities. This is proven by the charcoal deposit at the upper part the formation. Detail stratigraphic measurement starting from the Kebo-

Butak Formation up to Semilir Formation. The measurement at the upper part of Kebo-Butak Formationis shown in Fig. 2. Alternating breccia and sandstone in limestone can be found in this section. The rocks contain green glauconite minerals.

To the south, the rock age is also younger and more dominated by volcanic rock origin with an average strike of $60^0 – 70^0$ with a dip of $17^0 – 20^0$.

The source of the volcano eruption is likely from northern research area, which is indicated by a dip that directed to the south. Probably most of the volcanic eruption sources are still below sea level and a small part (probably in the north) has already emerged above sea level. This last point is evidenced by the discovery of charcoal pieces at the upper part of this formation. This charcoal is thought to be part of a burning plant during a volcanic eruption on land and carried away by gravity flowing toward the sea (Fig. 2.).

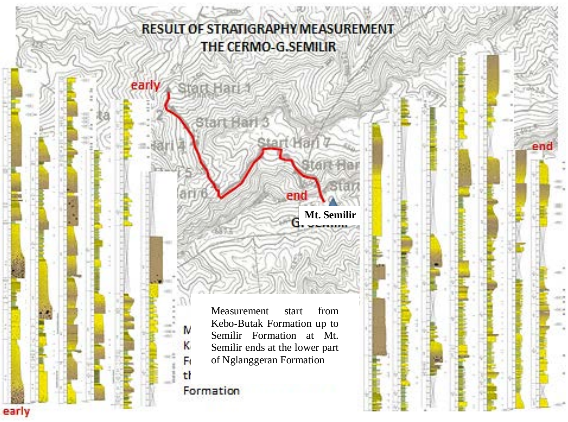


Fig. 2. Represents measurable detailed stratigraphic measurement on the Semilir Formation section

The Kebo-Butak Formation is directly below the Semilir Formation which is the rocks unit dominated by volcanic activities rocks, spread west-east on the northern slopes of the Baturagung Mountains. The Kebo Formation is a turn between sandstone, claystone, tuff, and shale, while the Butak Formation consists of polymic breccia with sandstone, claystone, and limestone/shale. Deposited on a shallow deep-sea basin filled with volcanic rocks. Compared to Kebo-Butak Formation is much more active as in Surono [12] (Fig. 3).

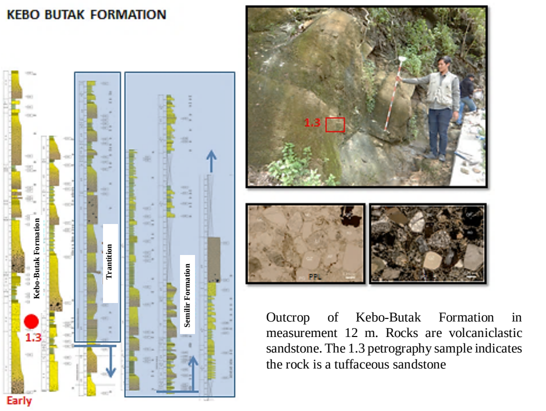


Fig. 3. The stratigraphic measurement at the upper part of Kebo-Butak Formation

The transitions unit above Kebo–Butak consists of breccia with sandstone upward, with the fragments sometimes consists of lapilli and tuff stones (Fig. 4.). Above the transition unit, the sequence of tuff layering lapilli, breccia, pumice, sandstone, and volcanic activities. At the upper part of this unit contains charcoal showing the products of volcanic activities covering the plants. This rock unit is the boundary of the Semilir Formation with the Nglanggeran Formation thats is above it, this unit contains the andesitic breccia, epiclastic, and pyroclastic breccia as the lower part of the Nglanggeran Formation.

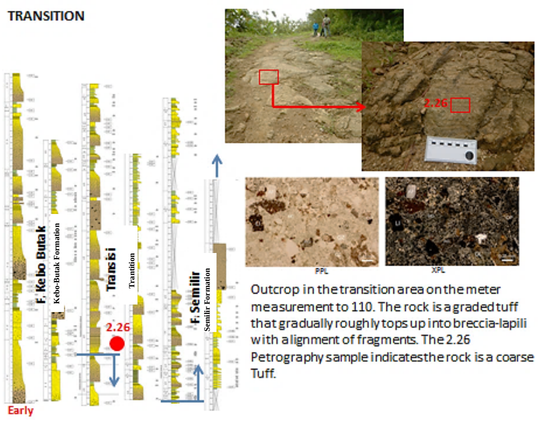


Fig. 4. The stratigraphic measurement at the transition of Semilir Formation

Above the transition, the unit is seen volcanic activities which is the first period (Period I). The first eruption periode recorded in Semilir Formation was marked by the apperience of tuff coating material . The first volcanic activities produce seven unit of the eruption. Unit 1-2 of than show the weak activities and unit 3-7 the stronger activities resulted in the volcanic product (Fig. 5).

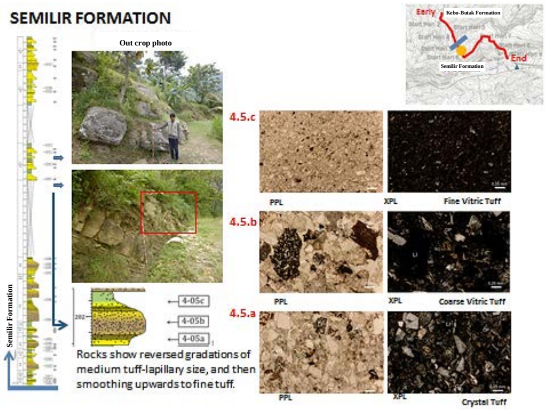


Fig. 5. The stratigraphic measurement at the lower part of Semilir Formation

The middle part of Semilir Formation (Fig. 6) showing each large lower unit of upward. The repetition of a large unit of eruption occurs and showing pumice breccia becomes fine tuff.

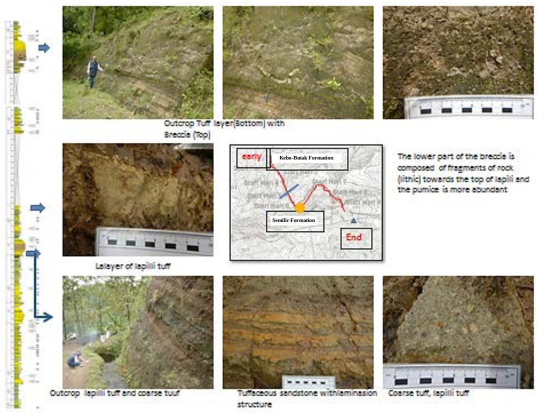


Fig. 6. The Stratigraphic Measurement at the middle part of Semilir Formation

Fig. 7. The stratigraphic measurement at the upper part of Semilir Formation.

The upper part of Semilir Formation (Fig. 7) indicated the rock unit layering in the form of a pumice breccia repetition increasingly upwards into fine tuff. In the upper unit, there is a charcoal in pumice breccia showing volcanic activities burning wood and plant.

3.2 Discussion

The result of the analysis shows that the rock of Semilir Formation Unit shows the period of volcanic eruption alternating with the turbidite period located on the slope at the edge of the basin. The turbidite rocks are characterized by breccia, sandstone and limestone, gradation structure, massive and bedding, while eruption periods with lithologic features are tuff deposits, lapillituff, breccia with a volcanic glass supported mass still intact. However, in the two periods between the preceding eruption period and the subsequent eruption period, the rock units are characterized by the discovery of a rock layer containing no tuff. The angled crystalline shapes on the crystal tuf and the still intact glass structure on the glass tuff give a significance mean to the origin of the material, i.e. the material of the rock unit is derived from the volcanic origin material. Stratigraphy of the study area showed the existence of volcano rock intrusion units with the rock of previous rock clastica. This means that in rock clastica layer formation, the volcano activities rest. But there are other possibilities, i.e. the fire volcano remains active with the resulting material pointing to the other side, or not direct to the hollow of the Southern Mountains so that the process of volcanic clastic material sedimentation from its volcano continues.

From the above mentioned detailed stratigraphic measurement, the succession of rocks shows the development of the volcano eruption. At first, the base of the volcanic rocks was Kebo-Butak Formation consisting of the breccia with glouconitic minerals indicating the marine environment of deposition. Underline the basement, volcanic rocks were deposited consisting of alteration between tuff, lapilli, breccia and volcanic sands. Pumice fragments sometime are also found and indicating the peak of the eruption or the proximal stage.

The volcanic succession indicated that 13 period of the eruption had accured, most probably in the upper Miocene as indicated by the fosil in the alternating limestone. The development of the activities strated with mild eruption producing tuff layer with 18,5 meters (Period I) in thickness. It was followed by the same eruption and producing major ash deposits. No pumice was found in Period II. The reperiod activities as indicated by the presence of paleosoil which than followed by the normal activities of the eruption with bigger size producing the abundance of breccia. The repetition of activities can be recorded from the presence of alternating tuff layers. As many as 5 periods of such eruption were occurred (Period I-V).

Finaly the proximal eruption occured producing pumice, perhaps during this periods, the caldera was formed (Period VI).

The Caldera was forming might be continued with more pumice products with the total thickness of this period are 100.5 meters. Following the proximal stage, a normal mild eruption took place as indicated by the presence of tuff layers. Perhaps volcanic mudflow deposits were also sedimented as shown from the upgraded layer of volcanic materials.

The second proximal stage which was larger, later on, took place (Period XIII) indicated by the formation of a thick pumice layer, with a total thickness of 114.5 meters.

The entire activities were terminated with the small activities which finally ended. The whole rocks then were covered by another activity of a volcanic eruption from other volcanic center producing Nglanggeran Formation.

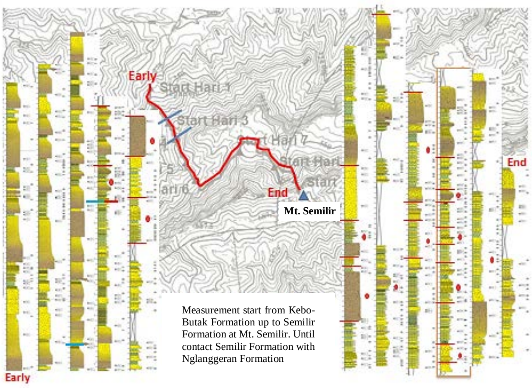


Fig. 8. Periodization of volcano eruption

From Fig. 8. Detailed stratigraphic measurement has 79 unit eruptions in the 13 periods of volcanic activities, in each period there are units of the eruption. And the rock thickness of the previous rock results during the pause or volcanic eruption is not recorded in the basin of the Southern Mountains as in Table 2.

Table 2. The result of calculation of thickness and eruption periodization in Semilir Formation

No	Volcanics eruption period	Number of eruption units	Volcanic rock thickness (m)	Other rock thickness (m)
			Transition	87,5
	I	7	9	10,4
	II	2	5,3	4,6
	III	1	7,7	31
	IV	2	10	8,8
	V	2	7,15	109,7
	VI	22	100,5	39,1
	VII	1	7,3	25,1
	VIII	3	21,2	8
	IX	2	4	14,2
	X	4	6,7	9,5
	XI	3	4	6,8
	XII	1	2,3	6,8
	XIII	29	114,5	
	XIV	5	32	
	14 Periods	84 Units		
		Amount of thickness	331,65 m	274 m + 87,50 m
		The thickness of Semilir Formation		= 693,15 m

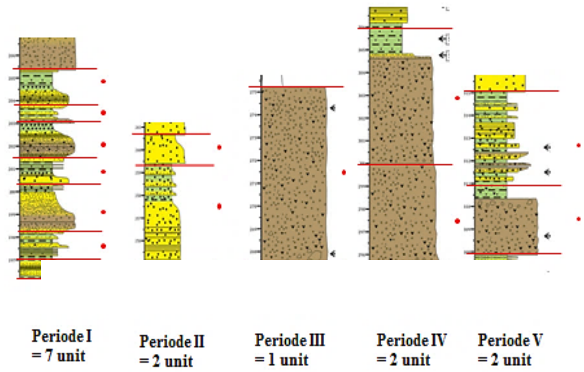


Fig. 9. The stratigraphic succession units were producted during eruption period I, II, III, IV, and V of Semilir volcanic activities, • = Unit Eruption

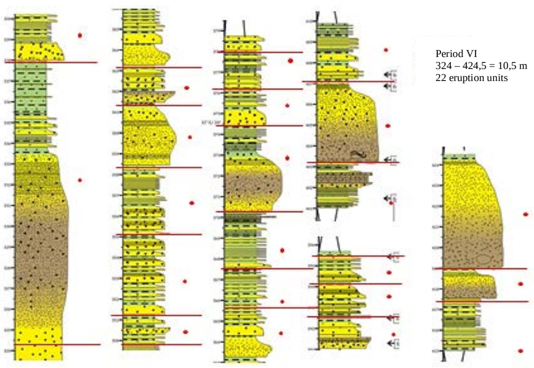


Fig. 10. The stratigraphic succession units were producted during eruption period VI of Semilir volcanic activities

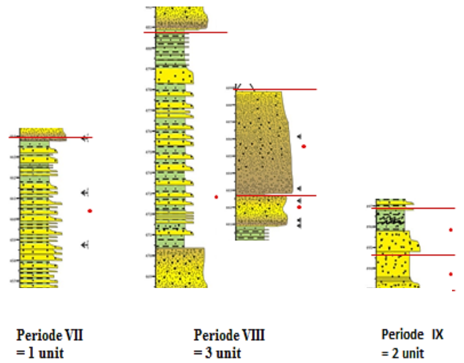


Fig. 11. The stratigraphic succession units were producted during eruption period VII, VIII and IX of Semilir volcanic activities

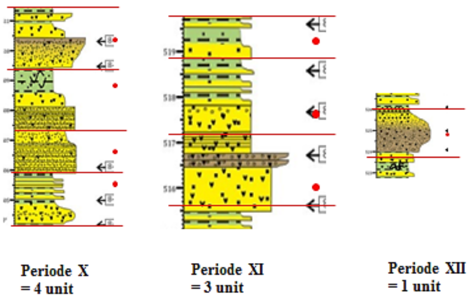


Fig. 12. The stratigraphic succession units were producted during eruption period X, XI and XII of Semilir volcanic activities

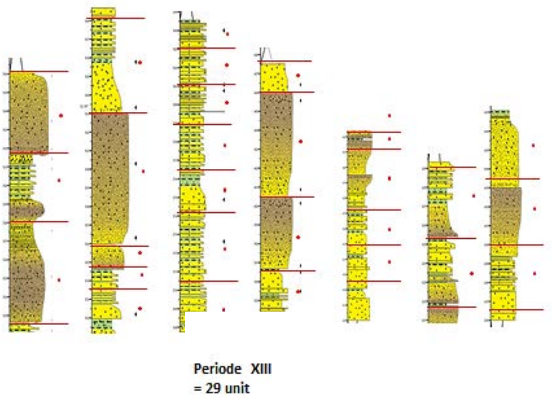


Fig. 13. The stratigraphic succession units were producted during eruption period XII of Semilir volcanic activities

From the detailed stratigraphy section, it can result that 14 period volcanic activities are recorded. The sequence of the period is as follow in Table 3.

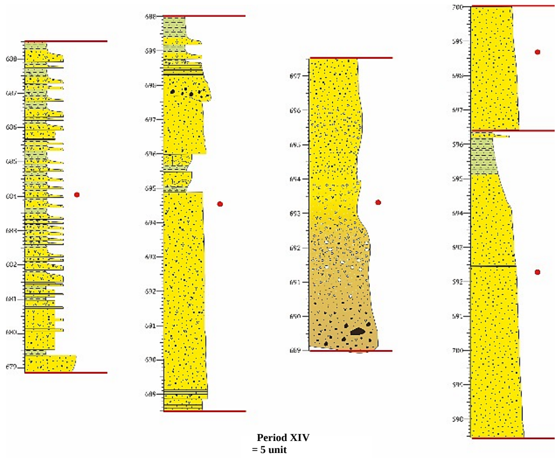


Fig. 14. The stratigraphic succession units were producted during eruption period XIV of Semilir volcanic activities

Table 3. The period of volcanic activities in Semilir Formation

Period/ Phase	Erupt-ion Unit	Thick-ness (m)	Description
I	7	18.5	The first eruption period recorded in Semilir Formation was marked by the appearence of tuff coating material. The first volcanic activities produce seven unit of the eruption. Unit 1-2 are the weak activities and unit 3-7 are the stronger activities resulted in the volcanic product.
II	2	5.65	This period produces 2 unit of tuff with very fine grain size. No pumice was found.
III	1	7.7	In this period, there is 1 unit of large eruption producing breccia, claystone fragments 3-20 cm, dominant pumice and lapilli of 0.3-3 cm thick. The lower part of this sequence is an old erosion surface.
IV	2	9.4	In this period, there is 2 unit of large eruption indicated by breccia and abundance of lithic rocks. At the lower part, there is paleosoil.
V	2	7.2	In this period, there is 2 unit of large eruption marked by the existence of abundant breccia.
VI	22	100.5	In this period, there is a repetition of 4 times the big eruption and to the upper part getting smaller. The large units in unit 1-5, 6-11, 12-20, 21 and 22 indicate each unit large to upward. The repetition of a large unit of eruption occurs showing pumice breccia becomes fine tuff.
VII	1	7.30	In this period, a big eruption occurs marked by existence pumice abundance in breccia.

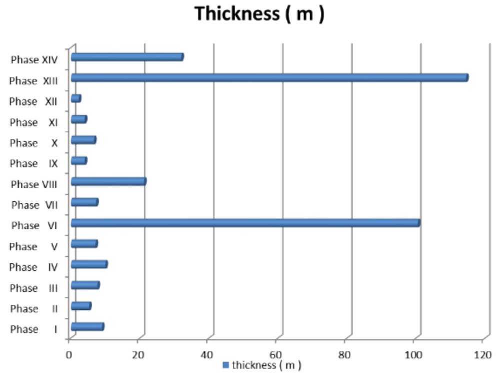
VIII	3	21.20	In this period, 3 eruptions occurred, reversed gradation breccia and irregular bedding at the base layer.
IX	2	4	In this period, 2 unit of eruption gradual in the form of coarse tuff repetition between fine tuff.
X	4	6.7	In this period, 4 unit of the eruption, gradual lapilli tuff-coarse tuff.
XI	3	4	In this period, there is 3 unit of the eruption, gradual lapilli tuff-fine tuff.
XII	1	2.3	In this period, 1 unit of eruption occurs, reverse gradded, abundance pumice.
XIII	29	114.5	In this period, there are 29 units of the eruption, occurred 9 sub eruption period. The strongest eruption occurred in unit 1 -3, 4-5, 6-8, unit 9-17 and becoming medium eruption in unit 18 and unit 19, recurred at the very explosive eruption marked very thick laps of brass with reverse gradation, unit 20-27 becoming medium eruption and big eruption as shown in unit 20-21 are very strong.
XIV	5	32	There is 5 unit eruption in the last period. Mostly an alternation of tuff-lapilli along with breccia with normal grading.

Volcanologists have their own standards for measuring explosive strength. The measure is the VEI Volcano Explosivity Index. VEI is the scale agreed by volcanologists to measure the magnitude of a volcanic eruption. The determination is based on the volume of tephra (solid material) and the height of the cloud column. The larger the volume of solid material released, the higher the VEI.

The Volcanic Explosivity Index (VEI) is a relative measure of the explosiveness of volcanic eruptions. It was devised as Newhall and Self research [13].

The volume of products, eruption cloud height, and qualitative observations (using terms ranging from "gentle" to "mega-colossal") are used to determine the explosivity value. The scale is open-ended with the largest volcanoes in history given magnitude 8. A value of 0 is given for non-explosive eruptions, defined as less than 10,000 m^3 (350,000 cu ft) of tephra ejected; and 8 representing a mega-colossal explosive eruption that can eject 1.0×1012 m^3 (240 cubic miles) of tephra and have a cloud column height of over 20 km (12 mi). The scale is logarithmic, with each interval on the scale representing a tenfold increase in observed eject criteria, with the exception of between VEI 0, VEI 1 and VEI 2.

Table 4. Relationship eruption period with the resulting thickness



In table 4. shows the development of layer thickness, this is related to the Volcano Explosivity Index (VEI) which the VEI value is proportional to the increasing strength of the eruption (volume).

From the table, the 6th and 13th periods show the thickest is in the 13th period of the eruption. This happens repeatedly, the eruption power in the formation of rock units in the Semilir Formation.

4. CONCLUSIONS

Based on the study, the following conculsions can be drawn that:

1. Ancient volcanic activities Mt. Semilir took place in 14 period indicated by 84 unit of the stratigraphically volcanic products.
2. Rock layers of Semilir Formation have a strike 60^0-70^0 with a dip of 15^0-20^0. It has 661.15 meters thickness where the 87.5 meters is a transitional sediment, then a repetition of rocks from the eruption directly measured 299.65 meters while the rock which not derived from the volcanic eruption measured 274 meters.
3. After that at the measurement to 87.5 meters came a unit of rock in the form of tuffaceous sandstone, towards the upper part of the tuff thickness measured 9 meters. This shows the activities of the first volcano that started the formation of Semilir Formation. In this period there are 7 units of the eruption.
4. The largest eruption unit in the period XIII is 29 units of the eruption, while in the period VI there are 22 units of the eruption.
5. In period VI, the volcanic activities increased rapidly produce with 100.5 meters thickness. This is repeated volcanic activities which increase again in period XIII reaches 114.5 meters thickness.

5. ACKNOWLEDGEMENTS

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