Tephrostratigraphy Study Using Petrographic Method in Leles Sub-basin, Bogor, West Java

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Tephrostratigraphy is a study used in determining pyroclastics layers, especially those in Ash/Tephro grain-sized, that can be used as a correlational tool to find out the order of sedimentation from one volcanic eruption. Leles Sub-Basinal, Garut, is composed mainly by Quartenary Sediment on the toppest layer and Tertiary Sediment on the bottom (Sunardi, 2014). The settiing of Garut Basin located in a plateau which is surrounded by volcanic plateau and dominated by lake sediment, and geographically located at low latitudes (Sunardi, 2016). Based on the existence of Leles Sub-Basinal which is located on active volcanic complex, followed by its pyroclatics sediments, it is very ideal for this area to be the object of Tephrostratigraphy Study. Moreover, earlier study was never been done before thoroughly at Leles Sub-Basinal area.

Based on mineralogical study, the tephro of Leles Sub-Basinal divided to Crystal Tuf, Lithic Tuf, dan Vitric Tuf (Schmidt, 1981). The commonly found minerals are quartz, plagioclase, pyroxen, feldspar, and opaque. The emersion of other minerals, such as olivin, amphibole, and biotite are not visible in general. Based on the presentastion of that main minerals, it was concluded that the tephro located in Leles Sub-Basinal came from andesitic and basaltic magma types. While from granulometric analysis, tephro from Leles Sub-Basinal was grouped in coarse ash and fine ash with well sorting and fall deposits mechanism of sedimentation. This tephro contains many heavy minerals with bulk density variated around 2850-2900 kg/m^3, which consists of apatite, biotite, and hornblende. Those heavy minerals are commonly found in ash falls lithology (Gale & Hoare, 2011). Stratigraphically, there were twoperiods of eruption happening at Leles Sub-Basinal area, with unidentified volcanic vents due to lack of data. It is also concluded that the supported station in the south has stratigraphical relationship with key station.

Keywords: Tephro, Tephrostratigraphy, Tuf, Leles Sub-Basinal.

Introduction

Tephrastratigraphy is one applied geological science which is used as correlational tool in defining depositional sequence of volcanic eruption, especially for materials with Ash grain-sized.

Tephrastratigraphy could be one of the best method to validate the analogue of petroleum system which has been explored to be more precise.

This study are objecting to characterize each layer of tephra, which leads to infer the volcanic depositional type. It is also held to correlate the stratigraphical relationship between each outcrop, as well as the depositional sequence and the way they were transported into their current location today.

Leles sub—basin is surrounded by both active and passive volcanoes, such as Haruman Mt., Kaledong Mt., Mandalawangi Mt., Guntur Mt., and Papandayan Mt. Thus makes it existed in the area of volcanic province. But, the only possible vents for the tephra layers founded near by the key station are Guntur Mt. and Papandayan Mt.

Based on its physiography position, Leles Sub-basin is located in the Bandung zone (Van Bemmelen, 1949). It consists of pyrclastic deposits and surface deposits including collovium, alluvium, and lacustrine deposits.

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Methodology

The first step that has to be done to collect the data was field study, where the megascopic features of every outcrops consisting tephra layers were recorded and few kilograms of their samples were taken. Those samples were divided into three different purpose, which meant to be used as petrographic sample, granulometric sample, and heavy minerals sample.

Tephra samples that have been collected were analyzed according to their purpose. The petrographic analysis used classification by Schmidt (1981), where tephra samples are classified based on the composition of crytals, vitric, and rock fragments. The granulometric analysis used classification by CAS & Wright (1987), using the results data of grain sieving while the further calculation was still required. On the other hand, the heavy minerals used classification by Gale & Hoare (2011), with the specific gravity of heavy minerals varied around 2850-2900 kg/m^3.

Analysis and Results

The megascopic features on an outcrop could be one of the tools to characterize layers of tephra. These features are including geometry thickness, colour, and grain size. The thickness from all the outcrops are varying around 2m-7m. For the colour, there are three major colour existed on the outcrops, which are greyish brown, redish brown, and soft brown. The sizes of grain appear are fine ash and coarse ash.

The petrographic data provides several characteristic with different percentages of crystals, vitric, and rock fragmen. The type of crystals that are examined in each samples including plagioclase, quarts, a-feldspar, pyroxen, and opaque. Other features that are involving in characterizing the tephra is colour, grain size, fabric, percentage of clay minerals, and vitric composition. Based on this analysis, the data is divided into four main groups presented below.

The assesment of granulometric analysis is obtained from four types of data. Among them are range of phi, mass for each sieving, cummulative mass, and percentage of the mass of fine materials. These are compared with the CAS & Wright's classifications afterwards, both the grainsize and the sorting, with results as shown by table 3.

For determining the grain size of tephra, the dominance of individual mass of each sieving are calculated using the data of sieving number. Grain size scale by Schmidt (1981) is then compared with correlation table between range of phi and grain size of modern pyroclastic deposits by CAS & Wright (1987). Result shows that the tephra samples have two types of grain size, which are fine ash and coarse ash. This result matches the previous data from megascopic grain size appeared on the outcrops in the field. Hereafter, sedimentation sorting from tephra can be determined by calculating deviation standart of granulometric analysis, using the range of phi in each sieving, with the amount of individual mass as its frequency score. Based on that, the number of sorting around 1.0-1.39 are showing in result. After comparing with the table of correlation between phi and grainsize by CAS & Wright, all of tephra sample of the studied area are classified to well sorted pyroclastics deposits.

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Table 1. 3 groups of outcrops differ by megascopic features

Megascopic Features	ST TT, HD 1 H	HD 1 K, HD 2, HD 3 K, HD 5, HD 6, HD 7	HD 3 H, HD 4
Thickness	0,2-1,5 m	0,5-3,5 m	2-3,5 m
Colour	Greyish Brown	Redish Brown	Soft brown
Grain size	Fine ash	Coarse ash	Fine ash

Table 2. 4 groups of outcrops differ by petrographic features

Megascopic Features	ST TT, HD 1 H	HD 1 K, HD 2, HD 3 K, HD 5, HD 6, HD 7	HD 3 H, HD 4
Thickness	0,2-1,5 m	0,5-3,5 m	2-3,5 m
Colour	Greyish Brown	Redish Brown	Soft brown
Grain size	Fine ash	Coarse ash	Fine ash

Table 3. 2 groups of ourcrops differ by granulmetric features

Granulometric Features	ST TT, HD 1 H, HD 3 H, HD 4	ST TK,HD 1 K, HD 2, HD 3 K, HD 5, HD 6, HD 7
Sorting	Well sorted	Well sorted
Depositional Mechanism	Fall deposits	Fall deposits
Type of Tephra	Fine ash	Coarse ash

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There are three types of depositional mechanism of pyroclastics deposits. They are fall, flow, and surge, with different main feature owned by each mechanism. One of the difference is sorting. Fall deposits relatively have well-sorted grain, caused by aeolian fractionation or as know as weathering by wind. Flow deposits generally have poorly sorted grain, because this mechanism are strongly affected by topography, where it will always fill a lower topographical figure when it deposited. Same goes for surge deposits. Therefore, based on their type of sorting, which is well sorted, all of tephra samples are classified as fall deposits.

Similar with petrographic analysis, the results of heavy minerals analysis divided the tephra into four main groups. By the total percentage of these heavy minerals, it is also concluded that the tephra samples are divided into two types, relating the type of magma from the volcanic eruption happened back then. By the application of Bowen's Mineral Series, the percentage of heavy minerals will have inverse proportion with acidity level of a provenance. So that, we can suggest that the higher percentage of heavy minerals containing in a tephra, such as pyroxen, hornblende, and biotite, the less acidity level owned by its provenance. Tephra with total percentage of heavy minerals below 30% is categorized as basalt-type magma, while tephra with total percentage of heavy minerals above 30% is categorized as andesite-type magma. Moreover, tephra in Leles Sub-Basin consists of many kind of heavy minerals with specific gravity varies around 2,850-2,900 kg/m^3, including apatite, biotite, and hornblende, which is classified as ash falls lithology according to Gale & Hoare (2011).

Discussion

According to the results of the afforementioned data, including field data petrographic data, granulometric data and heavy minerals data, stratigraphical relationship between each outcrops is then interpreted. The purpose is to understand depositional condition of tephra in Leles sub- basin. The correlation is built on the similar features appear in each outcrops and poured on stratigraphic log as shown in figure 1.

According to the stratigraphic log, the thinning thickness of coarse tuff from HD 5 to HD 1 (section A to D) indicates that the deposition was originated from south of studied area, where the minerals classified as crystal tuff dominantly and also andesit/ intermediate minerals based on heavy minerals. Section E to H illustrates that the rocks are comprised of basaltic minerals. Coarse tuff (crystal tuff) is located below fine tuff that are tephra classified as vitric tuff. Based on superposition, coarse tuff is older than fine tuff. The difference of acidity conclude that composition of rocks in 2 different groups of section is deposited under the influence of different periods of volcanic vents.

Conclusion and Recommendation

Tephra in Leles sub-basin is categorized as Crystal tuf and Vitric Tuf (Schmidt, 1981) or Ash (Fisher, 1966). Tephra in Leles sub- basin then divided into well sorted fine ash and well sorted coarse ash based on the granulometric data, and are produced by depositional mechanism of fall deposits. This data is also supported by the result of heavy mineral analysis which conclude that all the tephra layer contain many kinds of mienerals that are generally found in ash falls lithology. Moreover, the type of magma during the eruption producing tephra is also interpreted.

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Table 4. 4 groups of outcrops differ by heavy minerals features.

Heavy Minerals Features	ST TT, HD 1 H	HD 1 K, HD 2, HD 5	HD 3 H, HD 4	HD 3 K, HD 6, HD 7
%Pyroxen		5-6	24-25	15-20
%Biotite		7-8	7-8	5-8
%Hornblen-de	2-5	3-5	5	3-4
%Ilmenite	1.25-1.33		1.9-2.01	2.11-2.66
%Magnetite	2.38-2.58		4.16-4.19	4.64-5.35
%Apatit	0	0	0.43-0.46	
Other Minerals	-	-	Pyrite	-

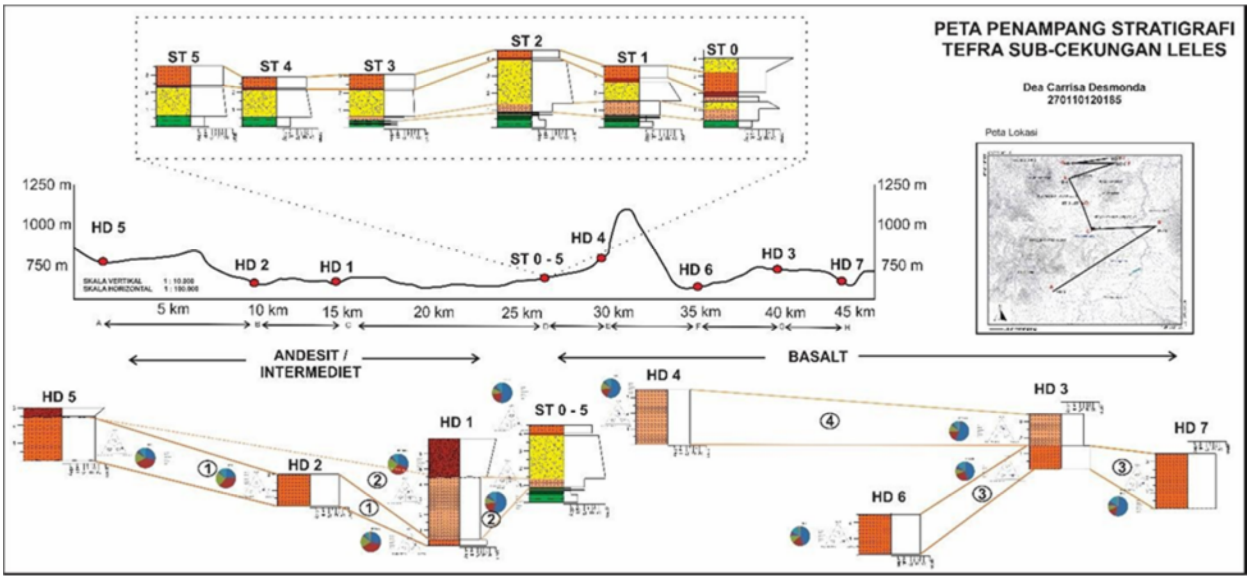

Figure 1. Stratigraphic Log interpreted by the available data in Leles sub-basin

There are two types of magma, andesitic- intermediet for tephra samples located southward the study area, and basaltic magma for the remaining tephra located northward.

Stratigraphically, and supported by petrographic data, tephra in Leles sub-basin comes from two different volcanic eruption with different kinds of magma type. According to superposition law, coarse ash/coarse tuff tephra is older than fine ash/fine tuff andesitic tephra, and basaltic tephra is also the same. It is remain indefinetely about the volcanic vents for each tephra, as there is not adequate data to

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conclude such things. To find out the location of volcanic vents, additional outcrops and sample data are needed. Those should be taken around each active volcanoes as key stations, to be compared with the outcrops scattered in the middle of Leles sub-basin, which take part as the objects of this study. This study could be improved by adding geochemical analysis as secondary data.

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