A preliminary study on the element abundance in the Hulusimpang Formation, Way Kalianda, Pesawaran, Lampung, Indonesia

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Abstract. Hulusimpang Formation has known as Oligocene-Miocene rocks that consisted of volcanoclastic rock. Its scope was wide, especially in southern Sumatra. This formation is supposed as a prospect host of various hydrothermal mineralization. A preliminary study was carried out to examine the abundance of elements located in Way Kalianda River, Pesawaran, Lampung. This study was conducted by ensuring its stratigraphy and analyzing its composition using an X-Ray fluorescence analyzer. The lithologies generally consist of lapilli tuffs, volcanic breccias, interbedded by claystone and sandstone; in addition, it is also frequently found petrified wood and andesitic-lithic fragments. As a result, the significant abundant elements are Fe (35.5%), Si (27.9%), Al (17.4%), K (6.7%), Cl (5.5%), Ti (1.7%), and Ca (1.5%) and also Mn, Ag, P, Mg, Sr, Zr, and Co. It also presents trace elements such as Rb, Zn, Pb, Te, V, Ba, Cr, Sn, Ni, Ga, Nb, Mo, and Eu. These elements are suggested from distal facies of intermediates-magma series Tertiary volcano.

1. Introduction

Hulusimpang Formation (Fm.) is a Late Oligocene-Early Miocene volcanoclastic rock formation that consists of volcanic breccia, lava, and tuff, andesitic and basalt rock unit. This formation is one of the broadest rock formations in Lampung Province after the Plio-Pleistocene Lampung Fm. Delineation of this formation was reviewed and recorded in the Tanjungkarang Geological Map Sheet [1,2]. This volcanoclastic might be correlated with the NW-SE Bukitbarisan Mountain Range [1,2]. This volcanic arc orogeny was formed by the subduction of the Indian-Australian Ocean plate to the Eurasian Plate since the Eocene [3]. This subduction was still continued at the oblique direction of N23°E, along the island of Sumatera [4].

Hulusimpang Fm. was supposed had economic mineral host, which exploited since 1904 and still prospective [1,5,6]. In this paper, to provide certain scientific information, the element abundance in this location would be provided in more detail, especially on the Way Kalianda river section, Kedondong, Pesawaran, Lampung, Indonesia (Figure 1).
2. Method
A method of Measured Stratigraphy (MS) was conducted on the Way Kalianda River by transect section (from bottom to top). With lithology description and the fossil findings in the stratigraphic section. The representative points were sampled and analyzed further for their element compositions and petrographic characteristics.

Analyzing the element composition used PANalytical Epsilon 3XL Benchtop XRF Spectrometer. Every element was calculated in percentage % (w/ w). Petrographic observation confirms in detail rock characteristics such as rock texture, mineral composition, and alteration features.

3. Results
This section discused 1150 m stratigraphy along Way Kalianda River, NW-SE oriented. The lithologies generally consist of lapilli tuffs, volcanic breccias, interbed of claystone sandstone. The sedimentary features are commonly observed in this section, strike-dip N±278°E/±27°N. Andesite was found in the form of fragments. Several layers found some high mineralized by petrified wood.

The lapilli tuffs have light gray color, mildly weathered, lapilli matrix (around 2mm), well-packaged, well-sorted, paralleled bedding. It consists of rounded andesite fragments and also petrified wood frequently. The volcanic breccias have dark brown, partially altered, coarse-grained with smaller matrix, poor-sorted, open-packaged, paralleled bedding, rounded andesite fragments, lapilli tuff, and notable of petrified wood clast. The interbed of sandstone and claystone consists of yellow-brown color medium-coarse sandstone and light gray claystone had paralleled bedding as seen in Figures 2 and 3.

Representative samples were taken for X-ray Fluorescence. There are some major elements (more than 1%) such as Fe (35.5%), Si (27.9%), Al (17.4%), K (6.7%), Cl (5.5%), Ti (1.7%), and Ca (1.5%). Some minor elements such as Mn, Ag, P, Mg, Sr, Zr, and Co; also present trace elements such as Rb, Zn, Pb, Te, V, Ba, Cr, Sn, Ni, Ga, Nb, Mo, and Eu (Figure 4). It is confirmed that the abundance element is based on the mineral found in the thin section.

The petrographic analyses of the samples are shown in Figure 5. The texture includes grain size <1/256 - 1 mm, medium sorting, and open packing. The mineral composition of this rock consists of quartz (Qz). The plane-polarized light (PPL) shows mostly white color and the cross-polarized light (XPL) shows white-grey until black color, low relief without cleavage, low pleochroism, anhedral crystal form, presented spreaded in the petrography analyses. Its abundance is 3%. Pyroxene-orthoclasts in the PPL observations were bright brown, XPL yellow-gray-brownish-orange color, low relief, 2-way cleavage, weak pleochroism, present spotted in the section, the abundance is 2%.
Figure 2. River section in Way Kalianda, Pesawaran, Lampung (a-d), the fragment of petrified wood (e), and breccia lithology in Way Kalianda.
Figure 3. Stratigraphic profile on Way Kalianda River section, Pesawaran, Lampung.
Figure 4. Average element abundance in Hulusimpang Fm, in Way Kalianda River section.

Figure 5. Representative petrography in thin section, note: Gv: volcanic glass, Py: pyrite, Sp: sphalerite, opx: opaque minerals.

The volcanic glass is brownish white in color (PPL), in XPL grey-blackish color, crystalline relief-pleochroism, invisible cleavage, and present spread in the thin section, the abundance is 70%. The opaque minerals in the PPL and XPL observations. It looks dark and in the thin section looks scattered with abundances of 10%. The pyrite mineral was present spreads on the yellow incision filling of the cavity by 10%. Sphalerite is present as dark gray in the thin section. Its amount is around 5%. The rock is vitric tuff.
4. Discussion

Generally, Hulusimpang Fm. in the Way Kalianda section is a sedimentary deposit of volcanoclastic, consisting of volcanic breccia, tuff-lapilli, tuffaceous sandstone-claystone with andesitic-lithic and fragments of petrified wood. The presence of wood fossils shows that this depositional process has a role in eroding the paleo-vegetated environments. These petrified woods identified as Dipterocarpaceae, show the paleoenvironment depositional condition of the terrestrial-lowland rainforest ecosystem. These petrified wood fragments had been strongly silicified with other permineralization [7]. Therefore, it was suggested that Hulusimpang Fm's origin in this section is from distal volcanic facies with relatively dense lowland rainforest. A detailed examination recommends identifying the genus and analyzing it to further its geochemical characteristic.

Hulusimpang Fm. in this section consists of major elements such as Fe (35.5%), Si (27.9%), Al (17.4%), K (6.7%), Cl (5.5%), Ti (1.7%), and Ca (1.5%). The presence of dominant Fe and Al indicates that this volcanoclastic material has undergone weathering and transported off the original material before deposited. This Fe can be present in pyroxene (othopyroxene [(Mg,Fe)SiO₃] or clinopyroxene [Ca(Mg,Fe)Si₂O₆]), amphibole [NaCa₃(Mg,Fe)₄Al₂Si₃O₁₀(OH,F)₂], and biotite minerals [K(Mg,Fe)₃AlSi₃O₁₀(OH,F)₂]. Fe can be present in the hydrothermal-alteration environment as sulphide minerals (pyrite/Fes₂). Meanwhile, the Al is a relatively immobile element withstands acid dissolving/leached. It also indicates the level of rock weathering. Al can present from some minerals, such as amphibole, biotite, muscovite [KAl₃Si₃O₁₀(OH,F)₂], or alteration mineral chloride [(Mg,Fe,Al)₄(Si,Al)O₁₀(OH)₈] [8]. It was from igneous rock origin. The amount of Al is 17.4% and indicates the peraluminous characteristics of the Hulusimpang Fm. Similar K and Ca occurrences can be found in the Feldspar mineral group, which has cumulatively a relative low amount than that of the Al amount. It is confirmed that the Mg composition was relatively low (0.33%) and not basaltic. These minerals are commonly present in the andesitic-igneous rock; originated from the intermediate-magmatic volcanoes. Pyroxene, amphibole, and feldspar minerals were also observed in the thin section. It is supported by the presence of Ti (1.7%), which indicates the role of magmatism and hydrothermal activity. This hydrothermal condition can also be confirmed by the presence of Cl/chloride (5.5%)--a major element. Chloride is generally associated with hydrothermal solutions, which enrich some metallic elements. This hydrothermal fluid is relatively acidic (low pH), which leaches the metal elements. Based on the result of the major element compositions, it shows that Hulusimpang Fm. in this section was originated from altered volcanoclastic due to the hydrothermal activity.

Examining the minor elements, the presence of Ag (0.89%) is relatively significant, followed by the appearance of Mn (0.89%), Sr (0.23%), Zr (0.20%), and Co (0.14%)--shows that there has been epithermal activity in this section, had low sulfidation condition. The presence of pyrite and Au grains also confirms it. These characteristics are similar to other sections of the observed Hulusimpang Fm, located on the west coast of southern Sumatra, covering Bengkulu, Jambi, and the west coast of Lampung [5,6,9].

Some researchers also identified the occurrences of the epithermal gold mineralization in Hulusimpang Fm of Sako Merah-Manau, Jambi [6]. Hulusimpang Formation. It appears as the host of the epithermal gold trap. Hulusimpang Fm. in western Lampung which is also classified as a volcanoclastic, originating from the calc-K alkaline magma series with dominant plagioclase composition. The SiO₂ composition increases with the presence of MgO and FeO elements. In addition, Al₂O₃, K₂O, MnO, and CaO also occurred. In the Bengkulu Basin, Herawati [10] explained that chlorite, sericite, and pyrite occurred in Hulusimpang Fm. It indicates alterations in high-temperature mineralization (180-300°C) and low sulfide epithermal environments. The Hulusimpang Fm. also indicated that originated from trachyandesite types, extrusive igneous rock with trachyte and andesitic composition. That samples are also characterized by calc-alkaline. Its characteristics are similar to this study (Hulusimpang Fm in Way Kalianda section).

This study confirms that the Hulusimpang Fm. in the Way Kalianda River section was part rocks of intermediate-volcanoclastic rocks. This volcanoclastic area originated from paleo-volcano in western Sumatera. Mangga [1] suggests it occurred at Oligocene-Miocene. This paleo-volcano is due to the
activity of the Indo-Australian subduction pointing to Eurasia. Hall [3] also considers that at Oligocene-Miocene, the mainland of Sumatra did not have the size as the current condition. The mainland began to go widely towards the eastern part (Sumatra back-arc basin). The volcanic arc stretches parallelly to the Bukitbarisan Mountain range along the orogeny of the Quaternary volcanic formation. The presence of frequent Dipterocarpaceae petrified wood in this section indicates that the terrestrial environment had occurred at the Oligocene-Miocene; it had relatively stable conditions (ecosystem) that allowed the successions of lowland rainforest. It is supposed to be distal volcanic facies as the terrestrial environment in the Sumatera back-arc basin.

5. Conclusion

Hulusimpang Fm in the Way Kalianda River section is a tertiary volcanic deposit that had an abundance of elements of significant elements such as Fe (35.5%), Si (27.9%), Al (17.4%), K (6.7%), Cl (5.5%), Ti (1.7%), and Ca (1.5%); minor abundance such as Ag (0.89%), Mn (0.89%), P (0.52%), Sr Mg (0.33%), Zr 0.20%), and Co (0.14%), and also occurred trace elements such as Rb, Zn, Pb, Te, V, Ba, Cr, Sn, Ni, Ga, Nb, Mo, and Eu. There are indications of alteration and sedimentary depositional processes of volcanoclastic, indicating over alteration minerals such as chlorite and pyrite, and (petrified) wood fossils. It was suggested that it was distal volcanic facies which is associated with lowland rain forest paleoenvironment.

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