Analysis of Mineral Composition...

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Research paper

Analysis of Mineral Composition of Alteration Rock in Warm Ground and Steaming Ground in Lahendong North Sulawesi Using Sem-Edx And Ftir

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Abstract

This research is aimed to study the mineral composition of alterations rock in Lahendong geothermal manifestation area, North Sulawesi. This research is using Scanning Electron Microscopic-Energy Dispersive X-Ray Spectrometric (SEM-EDX) and Fourier Transform Infra Red (FTIR) characterization method. The result of the characterization using SEM-EDX shows that the warm ground contained the mineral silica, while the steaming ground contained the kaolinite clay. The rock elements of the warm ground consist of O 71.90% and Si 28.10% with O dominating, this is indicate that the rocks have high porosity, while the rock elements of the steaming ground consist of O 56.86%, Al 1.94%, Si 3.52% and C 7.25% is coating material sample for energy dispersive x-ray spectrometric as penetrate in this rock sample. This result is consistent with the characterization using FTIR.

Keywords: *Rock element composition, alteration rock, SEM-EDX, FTIR*.

1. Introduction

Indonesia's geological condition contributes significantly to the availability of geothermal energy in Indonesia. Geologically Indonesia lies at the meeting of three major tectonic plates, namely: Europe-Asia plate, India-Australia plate and the Pacific plate that play a role in the process of forming volcanoes in Indonesia. Total geothermal potential in Indonesia is 40% of the total in the world. The existence of this geothermal potential can be known by the emergence of geothermal manifestations. Manifestations of geothermal are the visible features on the surface, for example hot springs, warm springs, mud pools, fumaroles, geysers, seepages [1].

Sulawesi has the potential of alternative energy in the form of geothermal, in due to the geological processes of volcanism and tectonics. The island of Sulawesi and its suburbs regionally show complex geological structures, with mineral complexity due to accumulated collisions from various Australian and Pacific macro plate.

Geothermal is a source of thermal energy contained in hot water, water vapor, and rock along with associated minerals and other gases that are genetically inseparable in a geothermal system. Geothermal is a source of heat energy that naturally formed beneath the earth's surface. The source of energy comes from the heating of rocks and water with other elements contained by the earth's heat stored in the earth's crust [1].

The availability of minerals in rocks is very diverse, because the process of formation is also different. But basically, all the minerals and also the rocks that come from the magma, and finally after experiencing other geological processes, then the mineral and rock are formed to be different. In addition to the definition of minerals as rock formers, the mineral is also as a divider or differentiator rocks. So that rocks are divided into three parts based on the composition of the mineral forming. In addition, the factors that also lead to the discrimination of these rocks are the chemical composition, textures and processes that cause the minerals to form. They are also related to rock forming minerals.

Form of geothermal activity in a region, we can see from the appearance of surface manifestations such as: hot springs, mud pools, solfatara, and rock alteration. For the development stage to be a provider of steam geothermal which in business must be to the stage of advanced studies in the form of geology, geochemistry, and geophysics.

The geothermal rock in the North Sulawesi region has various compositions such as olivine, andesite pyroxene, andesite hornblende and gabbro. Rocks change can also be found in North Sulawesi, usually found around fumaroles, hot springs, steaming ground and warm ground. Many rocks that experience changes in shape and color due to geothermal activity that occurs in Lahendong geothermal area.

Composition change is a tangible result of the chemical reaction process between the hydrothermal fluid and the rock it passes and leads to the conversion of primary minerals into alteration minerals. Hydrothermal changes are complex and involve changes in mineralogy, chemistry, and texture. The geothermal rocks have different composition in general, where in the area around Linow Lake have different composition of rock with other location. For that to get information about the composition of rocks in the area then conducted research with the title research studies of mineral rock composition in the manifestation of Lahendong geothermal area, North Sulawesi.

There are several advantages with using FTIR technique for minerals analysis. The sample size required to obtain good spectra is minimal (sub milligram quantities). Moreover, the technique is sensitive to certain common minerals and may provide a quick approach to distinguish polymorphs minerals with the same chemical composition, but with a different crystal structure. Micro-FTIR is also useful as a complementary or alternative technique to other more traditional methods as scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDX). While a mineral specimen may take several hours to be analyzed by XRD, micro FTIR technique can produce a spectrum unique to a mineral in a few minutes. Kaolinite is often cited in the literature as an example of a mineral which when present as a minor impurity may be more difficult to detect by X-ray analysis than by FTIR [2, 3].

This research is aimed to study the mineral composition of alterations rock in warm ground and steaming ground in Lahendong geothermal manifestation area North Sulawesi with using Scanning Electron Microscopic-Energy Dispersive X-Ray Spectrometric (SEM-EDX) and Fourier Transform Infrared (FTIR) characterization technique.

2. Literature Review

Study of volcanic rock and changes in the geothermal surface of gendongsongo with the available results from hot spring and fumaroles were generally strongly alteration and contained kaolinite, halloyite, alit, amorphous silica. The silica minerals contain SiO elements commonly found in quartz (SiO_2), feldspar alkali, albite, feldspar plagiklas, mica muscovite, palygorskite, mica iolite, kaolinite, amphibole, pyroxene, olivine, Non-silica minerals are oxides, sulfides, sulphates, genuine elements, halide, carbonate and phosphate [4].

The studied of SEM (scanning electron microscopic) analysis in researching the process of magnet oxidation to hematite with the result that the relative form larger than the sample would be more easily oxidized by the oval shape of the grain. Oxidation does not create anything new, just producing new results of minerals already contained in magnetite, a very hard form before being oxidized, which is relatively rounded after being oxidized [5]. Quantification of tremolite in friable material coming from Calabrian ophiolitic deposits by infrared spectroscopic explained that three IR bands considered: OH stretching band between 3700 and 3650 cm^{-1}, the stretching bands of the Si-O-Si linkage between 1200 and 900 cm^{-1} and absorbance band at 756 cm^{-1} attributable to tremolite. The quantitative analysis of tremolite using the band due to OH stretchings (3700 – 3650 cm^{-1}) and the band attributed to the Si-O-Si stretchings (1200 – 1900 cm^{-1}) showed high values for all test samples [6]

Study of fourier transform infrared spectroscopic characterization of clay minerals from rocks of Lalibela churches, Ethiopia explained that identification of montmorillonite as a weathering product up to 20 mm from the rock interface beyond the level at which kaolinite, whewellite and gypsum are found, suggests that montmorillonite may penetrate even deeper into the rock substrate causing major rock decay. Result indicate that biological attack by green algae and lichens is currently responsible for severe stone surface, physical and chemical weathering leading to considerable weakening of the churches walls [7]. FTIR spectroscopic studies on coastal sediment samples from Cuddalore District, Tamilnadu, India with result the minerals such as quarts, orthoclase, microcline, albite, kaolinite, montmorlinite, calcite, aragonite, and organic carbon are identified [8]. Analysis of the mineral content of altered rocks in the Toraget area of North Sulawesi using X-Ray Fluorescence (XRF), explains that the results of XRF analysis show that the greatest metal content in alteration rocks in Toraget is iron (Fe) percentage between 74 - 90% and Mn (manganese), Co (cobalt), Cu (copper), Zn (zinc), As (arsen), Zr (zirconium), Nb (niobium), Mo (molybdenum), Sb (stribium), Ta (tantalum), and Pb. [9].

Analysis Fourier transform infrared (FTIR) spectroscopic characterization of natural kaolinite from Assam and Meghalaya northeastern India explained that the main peaks in the infrared spectra reflected Al-OH, Al-O and Si-O functional groups in the high frequency stretching and low frequency bending modes. Few peaks of infrared spectra inferred to the interference peaks for quartz as associated minerals [10]. Study of rock samples taken from coastal Latuhlalat using FTIR method to identify the type of mineral or rock type in the area, so that it can be suspected of post coastal or geological coastal disaster potential such as storm surge in the area of Latuhlalat, Nusaniwe Subdistrict, Ambon. The result of M1 sample analysis with FTIR shows the value of wave number ranging from 3565 cm^{-1} 3595 cm^{-1} formed by O-H function group can identify mineral type that is kaolinite and amphibole. The result of M2 sample analysis with FTIR shows the value of wave number ranging between 1500 cm^{-1}-1570 cm^{-1} formed by functional group C = C can identify mineral type that is quartz. Furthermore, the result of M3 sample analysis with FTIR shows the wave number ranging from 1700 cm^{-1} formed by the functional group C = O [11].

3. Methodology / Materials

The alteration rock in warm ground and alteration rock in steaming ground samples obtained from research location in Lahendong geothermal manifestation area, North Sulawesi.

Figure 1. Warm ground

Figure 2. Steaming ground

The characterization is using Scanning Electron Microscopic-Energy Dispersive X-Ray Spectrometric (SEM-EDX) and Fourier Transform Infrared (FTIR) method.

The micro structure and element composition of alteration rock in warm ground and alteration rock in steaming ground samples obtained with SEM-EDX (SEC, SNE-4500). Sample preparation: the rock samples are attached to the sample holder (stub), place the sample in the chamber coating. Preparation of non-conductive samples using gold sputter coater (Au). After sample in preparation using gold sputter coater, measure height of sample using height gauge, open specimen room on mini SEM, stud height Z according to height of sample at add 10 mm, put sample along with stub above sample stub stand, close the door of the specimen room, press the exchange button to turn on the vacuum pump and wait for the alarm to sound and the switch light switch stops flashing. Next use the live mode software Mini-SEM set the focus of

the tool according to the height of the sample, set the sample position you want to see using the X and Y axis, set the magnification, set the contrast of the picture and save image.
The functional groups of alteration rock in warm ground and alteration rock in steaming ground samples obtained with using FTIR (Perkin Elmer).

4. Results and Findings

The result of SEM and EDX analysis on warm ground rock samples shown in Figure 3, Figure 4 and Table 1.

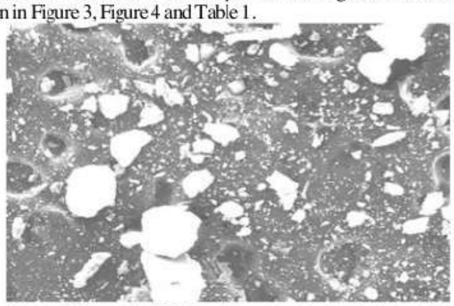

Figure 3. The result of SEM analysis on warm ground rock samples

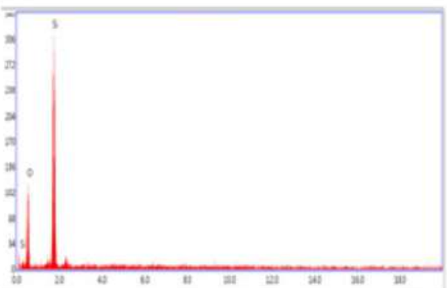

Figure 4. The result of Spectra EDX analysis on warm ground rock samples

Table 1. The Results of EDX analysis on warm ground rock

Element	Atomic %	Error %
O	71.90	7.51
Si	28.10	6.57

The result of SEM and EDX analysis on steaming ground rock samples shown in Figure 5, Figure 6 and Table 2.

Figure 5. The result of SEM analysis on steaming ground rock samples

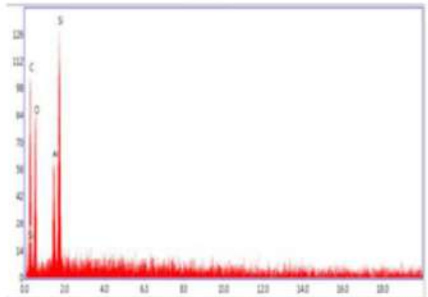

Figure 6. The result of Spectra EDX analysis on steaming ground rock samples

Table 2. The Results of EDX analysis on steaming ground rock

Element	Atomic %	Error %
O	56.86	8.35
C	37.68	7.25
Si	3.52	6.75
Al	1.94	6.80

In the SEM analysis of rocks on warm ground and steaming ground is made 500 times magnification (Figure 3 and 5). From these Figure, can be seen in magnification 500 times irregular or random grain shape, there is a triangle, hexagonal. The elements contained in the rocks are not homogenous.
In the EDX results on warm ground rocks obtained O and Si element (Table 1), with percentage O 71.90% and Si 28.10% with O dominating, this is indicate that the rocks have high porosity. In the steaming ground rocks (Table 2) there are O, Al, Si with percentage content of O 56.86%, Al 1.94%, Si 3.52% and C 7.25% is coating material sample for energy dispersive x-ray spectrometric as penetrate in this rock sample. In the steaming ground rock samples there is a content not possessed in warm ground rocks, where in steaming ground rocks there is an Al element caused by hydrothermal alteration or fluid interaction with rocks. According to EDX results on warm ground have a silica mineral content and on the steaming ground rocks have kaolinite clay mineral content.

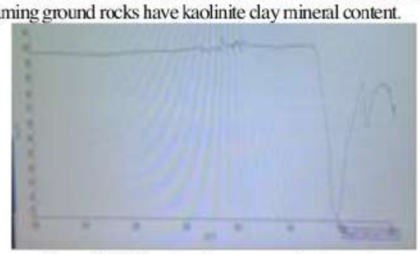

Figure 7. FTIR spectra of warm ground rock samples

The study of type and functional groups of rock minerals shown in FTIR analysis. Figure 7 shown FTIR spectra of warm ground rocks with 1080.2 cm^{-1} and 779 cm^{-1} wave number are quartz mineral (Table 3). This result is consistent with SEM-EDX analysis of warm ground rocks, with the mineral composition is Silica (Si) and Oxygen (O) element.

Table 3. The Results of FTIR spectra on warm ground rock

No.	Observed Wave Numbers (cm^{-1})	Minerals
1	779	quartz
2	1080.2	quartz

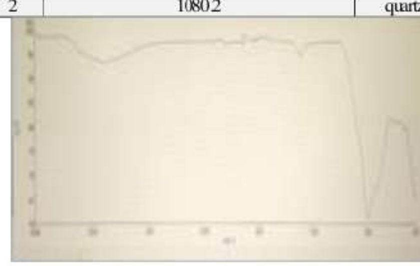

Figure 8. FTIR spectra of steaming ground rock samples

The results of the type and functional groups of steaming ground rocks shown in Figure 8. From this Figure, we can see that wavenumber of 1012 cm^{-1} is kaolinite mineral, at wavenumber of 1614 cm^{-1} is quartz, and at wavenumber of 3398 cm^{-1} is kaolinite minerals (Table 4). This result is consistent with SEM-EDX analysis of steaming ground rock with the mineral composition are Silica (Si), Oxygen (O) and Aluminum (Al) element.

Table 4. The Results of FTIR spectra on steaming ground rock

No.	Observed Wave Numbers (cm^{-1})	Minerals
1	1012	kaolinite
2	1614	quartz
3	3398	kaolinite

5. Conclusion

The result of the characterization using SEM-EDX shows that mineral rocks in Lahendong geothermal area on the warm ground contained the mineral silica, while the steaming ground contained the kaolinite clay. The rock elements of the warm ground consist of O and Si, while the rock elements of the steaming ground consist of O, Si, and Al. This result is consistent with the characterization using FTIR.

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