Interpreting Surface Structures Using Remote Sensing Technology with Band Combination Technique in Tulehu Geothermal Prospect Area, Maluku

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ABSTRACT

Indonesia is a country with the largest geothermal potential in the world.The potential of this gothermal sources is scattered from Sumatera, Java, Sulawesi, Bali, Maluku and Nusa Tenggara. Tulehu is one of geothermal prospect area in Maluku with appearance several surface manifestations such as hot springs, warm springs and steaming ground. Remote sensing technology can be used to identify lineaments that interpreted as surface structures before doing direct survey especially geophysical survey in the field. This research uses free Landsat 8 OLI imagery, downloaded from www.earthexplorer.usgs.gov and processed by band combination technique with manual observation. The result of this research shows that the main direction of the lineaments developed in Tulehu geothermal prospect area is Northwest-Southeast and Southwest-Northeast. The result also finds that the lineaments are correlated to the appearance of several surface manifestations. The recommendation of the geophysical survey should be focused on Southeast area.

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1. INTRODUCTION

Indonesia is a country with the largest geothermal potential in the world. The potential of this gothermal sources is scattered from Sumatera, Java, Sulawesi, Bali, Maluku and Nusa Tenggara. Geothermal energy can be used directly and indirectly. Indirect use means that geothermal energy used to generate electricity power as new and renewable energy.

Exploration is an important step in geothermal utilization to produce electricity. Exploration activity consist of geological, geophysical and geochemical survey. Remote sensing is one of technology that can be used to identify lineaments as surface structure before doing direct survey especially geophysical survey in the field. The application of remote sensing can make exploration survey be focused on interesting area and decreasing cost of survey.

Tulehu is one of geothermal prospect area in Maluku with appearance several surface manifestations such as hot springs, warm springs and steaming ground. Tulehu is located about 18 kms from Ambon city. Based on PT PLN Geothermal (2009) data, there are 16 surface manifestations in Tulehu geothermal area. The apperance of this manifestations is normally correlated to structures and lithology that developed in the Tulehu field. Identify of surface structure is needed to do because can give some information related to geothermal system type and delineation of up/ out flow zone from a geothermal field.

Figure 1. Location of Tulehu, Maluku (Google Map, 2017)

Table 1. Surface Manifestations in Tulehu Geothermal Prospect Area (PLN Geothermal, 2009)

Name	Type	Degree (°C)
HTG	Hot Spring	49
SLM-1 , SLM-2	Hot Spring	61 - 70
Suli	Warm Spring	35,4
KBJ-1 , KBJ-2	Hot Spring	59 - 70
HTS–1, HTS–2, HTS-3	Hot Spring	56 - 60
SL–1	Hot Spring	90
SL-2	Warm Spring	38 - 48
TLH-4	Warm Spring	40
TLH–1, TLH–2, TLH-3	Hot Spring	70
TBK	Hot Spring	49

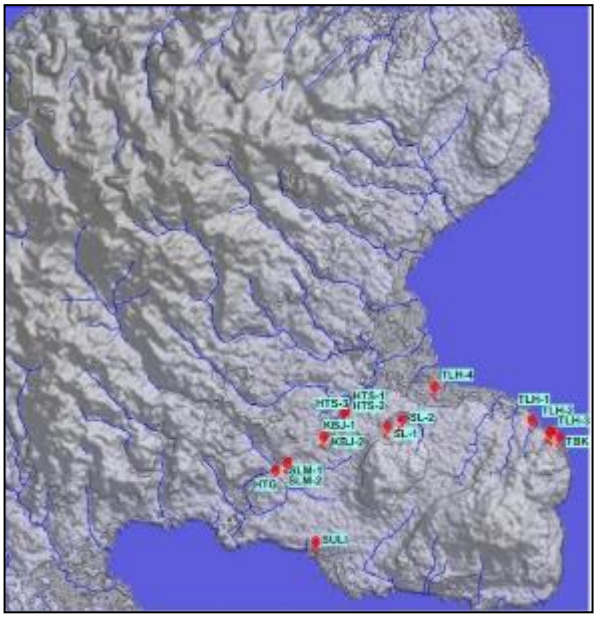

Figure 2. Location of Surface Manifestations in Tulehu Geothermal Area

2. THE COMPREHENSIVE THEORETICAL BASIS

The concept of observation and feature lineament extraction in remote sensing that are correlated to surface structure have been conducted by Abullah, A., et al [1], Siagian, H [2], and Martasari, R. D [3]. Application of lineament extraction technique in geothermal exploration correlating with surface structure and methode of density lineament observation to delineate outflow zone have been conducted by Iswahyudi., et al [4]. The Application of feature lineament extraction used PCI Geomatica of LINE module software from landsat remote sensing have been conducted by Abdullah, A., et al [1], and Novranza, K [5].

There are some techniques that can be used to enhance spectral and spatial resolution. The research about enhancing imagery quality has been conducted by Yuhendra, H., & Sumantyo, J. [6] with Principal Componenet Analysis Transform showing a good result in enhancing imagery quality.

3. RESEARCH METHOD

This research uses free Landsat 8 imagery, downloaded from www.earthexplorer.usgs.gov. Remote sensing data consists of digital data. The data (band 5, 6 and 7) is processed by some softwares such as Global Mapper, ER Mapper, and Surfer. Interpretation of remote sensing data for mapping surface structures is conducted by manual observation.

Figure 3. Landsat 8 imagery of Tulehu Geothermal Area

4. RESULTS AND ANALYSIS

The landsat imagery must be calibrated between radiation and atmospheric by Pan-Sharpening and Principal Component Analysis (PCA) before futher process. These calibrations aims to enhance the quality of imagery from error reflection such as directions of sunlight, weather condition and atmospheric condition. After Pan-Sharpening and PCA process, the spatial resolution at low-band can enhance from 30 m to 15 m.

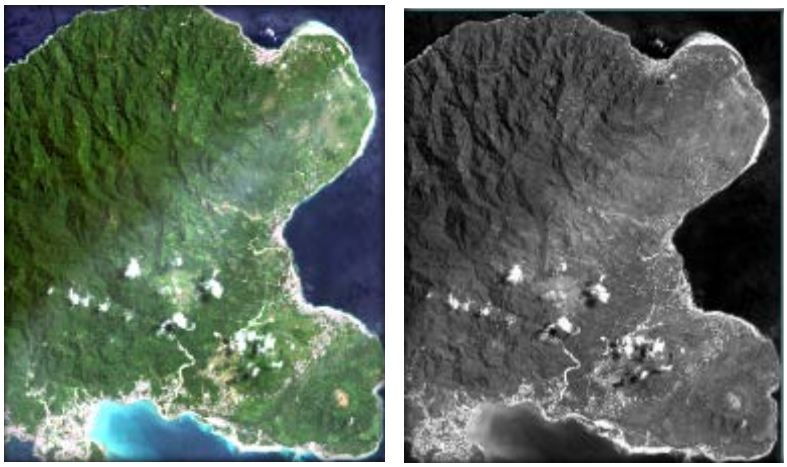

Figure 4. Landsat 8 imagery after Atmospheric Correction Using Pan-Sharpening and Principal Component Analysis (PCA)

The methode of band combination technique can identify some non natural targets such as plantation, residential area, field and man made features. These band combination technique can help to filter out lineaments that are not related to natural structures. Analysis of surface structure in Tulehu geothermal prospect area is conducted at band combination 5, 6 and 7.

Table 2. Target Identification of Band Combination Technique

RGB Band Combination	Target Identification
7 6 4	Urban
5 4 3	Color Infrared (Vegetation)
6 5 2	Agriculture
5 6 7	Geological Structure

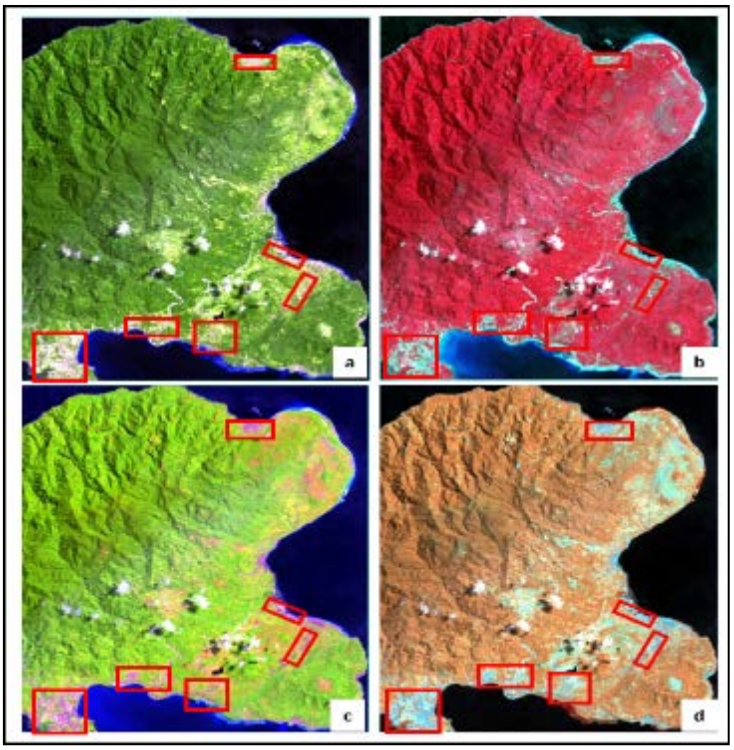

Figure 5. Band Combination on Imagery (a) RGB 764, (b) RGB 543, (c) RGB 652, (d) RGB 567

In identification of surface structures with manual observation, authors have to consider some points such as texture, pattern of lineament, topography, pattern of shadow, and color of dark/ bright imagery. Information related to topography can be conducted by compare between Landsat 8 imagery and Aster Digital Elevation Model (Aster DEM) data. The result of this research shows that the main direction of the lineaments developed in Tulehu geothermal prospect area is Northwest-Southeast and Southwest-Northeast. The result also finds that the lineaments are correlated to the appearance of several surface manifestations. The recommendation of the geophysical survey should be focused on Southeast area.

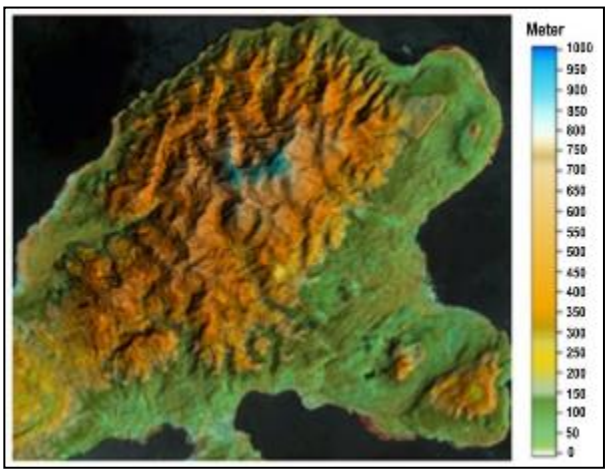

Figure 6. Topography of Tulehu Geothermal Area (Aster DEM)

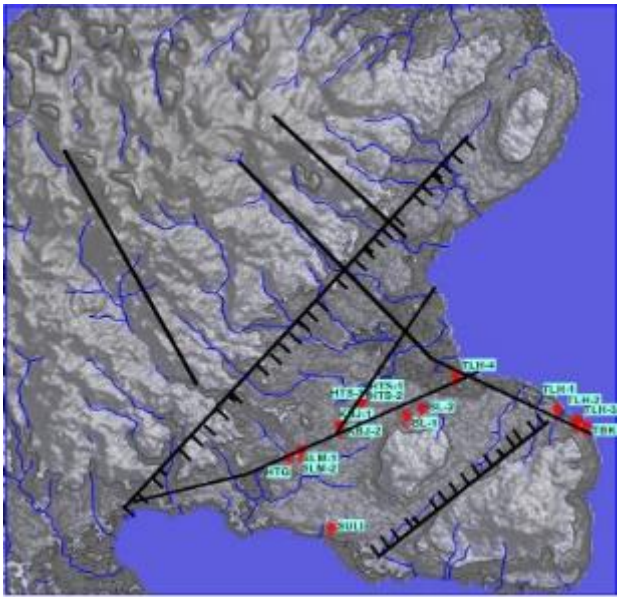

Figure 7. Interpretation of Geological Structures Manually in Tulehu Geothermal Prospect Area

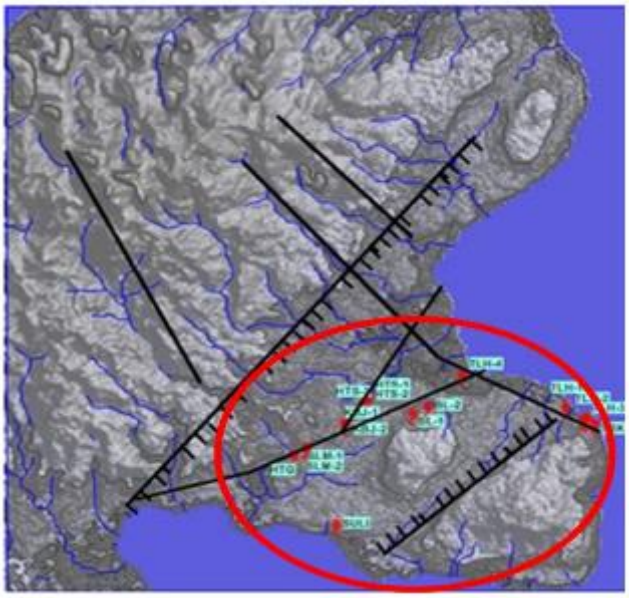

Figure 8. Interesting Area of Geophysical Survey Design

5. CONCLUSION

[1] Remote sensing technology can be used to identify surface structure before doing direct survey in the field.
[2] Based on the remote sensing analysis by using band combination in manual observation, the main direction of lineaments developed in Tulehu geothermal area is Northwest-Southeast and Southwest-Northeast.
[3] The lineaments are correlated to the appearance of surface manifestations.
[4] The recommendation of the geophysical survey should be focused on Southeast area.

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[1] Masters Programs in Physics, Geothermal Exploration Section, Departement of Physics, Faculty of Mathematics and Science, Universitas Indonesia.
[2] PT PLN Geothermal.

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