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# EXPLORING AND INTERPRETATING ALTERATION AREA USING LANDSAT 8 OLI/TIRS IMAGERY AROUND SEMINUNG MOUNTAIN, LAMPUNG BARAT - PESISIR BARAT REGENCIES, LAMPUNG PROVINCE

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***ABSTRACT***
*West Lampung and Pesisir Barat regencies are controlled by complex tectonics and geological structures due to Eurasian and Indo-Australian subduction. The tectonic complexity of this area allows active magma intrusion, hydrothermal fluid activity and geothermal systems with indications of rock alteration. This research aims to map alteration potential through remote sensing and laboratory analysis. The methods used in this research are remote sensing methods through Landsat 8 OLI/TIRS data processing, lineament analysis and petrographic analysis of rock samples found in the research area. Landsat 8 OLI/TIRS satellite images consist of several specific wavelengths that are processed in GIS software to produce maps of alteration areas. The composite bands used were band 432, band 567 and bands 4/2, 6/7 and 5. Lineament analysis was carried out through data extraction with PCI Geomatica software to produce lineament maps and lineament density maps. Petrographic analysis was carried out on four rock samples scattered at the research site, namely andesite and basalt rocks. The results showed that the composite bands 4/2, 6/7 and 5 based on remote sensing, the research area has an alteration zone around the magmatic arc. Lineament analysis shows that the dominant strike direction is southeast-northwest with the main force orientation direction being northeast-southwest. Petrographic analysis shows that metallic minerals, smectite, sericite, and chlorite as alteration minerals appear in the research area. The alteration zone is located close to the bukit barisan magmatic arc with high to medium lineament density in the lithology of the altered andesite-basalt rocks.* *(satu spasi)*
***Keywords****: Landsat 8, composite band, lineament, petrography, alteration minerals*

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## SARI

Kabupaten Lampung Barat dan Pesisir Barat dikontrol oleh tektonik dan struktur geologi yang kompleks akibat penunjaman Eurasia dan Indo-Australia. Kompleksitas tektonik daerah ini memungkinkan terjadinya intrusi magma aktif, aktivitas fluida hidrotermal dan sistem panas bumi dengan indikasi adanya alterasi batuan. Penelitian ini bertujuan untuk memetakan potensi alterasi melalui penginderaan jauh dan analisis laboratorium. Metode yang digunakan dalam penelitian ini adalah metode penginderaan jauh melalui pengolahan data *Landsat 8 OLI/TIRS*, analisis *lineament* dan analisis petrografi terhadap sampel batuan yang terdapat di daerah penelitian. Citra satelit *Landsat 8 OLI/TIRS* terdiri dari beberapa panjang gelombang tertentu yang diolah dalam perangkat lunak SIG untuk menghasilkan peta daerah alterasi. Komposit *band* yang digunakan *band* 432, *band* 567 dan *band* 4/2, 6/7 dan 5. Analisis *lineament* dilakukan melalui ekstraksi data dengan perangkat lunak PCI Geomatica untuk menghasilkan peta *lineament* dan peta densitas *lineament*. Analisis petrografi dilakukan pada empat sampel batuan yang tersebar di lokasi penelitian, yaitu batuan andesit dan basal. Hasil penelitian menunjukkan bahwa komposit *band* 4/2, 6/7 dan 5 berdasarkan penginderaan jauh, daerah penelitian memiliki zona alterasi di sekitar busur magmatik. Analisis *lineament* menunjukkan bahwa arah jurus dominan berarah tenggara-barat laut dengan arah orientasi gaya utama berarah timur laut-barat daya. Analisis petrografi menunjukkan bahwa mineral logam, smektit, serisit, dan klorit sebagai mineral alterasi yang muncul di daerah penelitian. Zona alterasi berada dekat dengan jalur busur magmatik bukit barisan dengan kerapatan *lineament* tinggi hingga sedang pada litologi batuan andesit-basal yang teralterasi.

**Kata kunci:** Landsat 8, komposit band, lineament, petrografi, mineral alterasi

## INTRODUCTION

The research area is located in three regencies: Ogan Komering Ulu Selatan, Lampung Barat and Pesisir Barat (figure 1). It is located in the volcanic arc series of Bukit Barisan which is an area with volcanic landforms. It is characterized by the presence of Ranau Caldera and Seminung Mountain which is one of the results of Mount Ranau volcanic activity that occurred in the Plio-Pleistocene, along with the formation of Ranau lake. This area was formed due to subduction between the Indo-Australian plate and Eurasian plate and the influence of tectonic activity of the Sumatra fault.

Based on previous research according to (Surbakti, et al., 2022), the area around Lake Ranau shows the presence of geothermal manifestations in the form of Lake Ranau hot springs originating from Mount Seminung which is located in the south-southeast direction of the research area. Lake Ranau area has 4 points of geothermal manifestation due to the presence of geological structures in the form of hotsprings (Ibrahim et al. 2022). The research area aims to interpret and explore the distribution of alteration minerals as one of the geothermal manifestations around Mount Seminung.

These alteration rocks play an important role in exploration activities, both geothermal exploration and mineral ore exploration. Alteration rocks are an important clue in geothermal exploration, especially those around geothermal manifestations, indicating that the area has an active geothermal system (Browne, 1970 in Putra et al., 2017). Meanwhile, alteration rocks in ore mineral exploration are an indication that ore deposition has occurred around the alteration rocks. This is also coupled with the fact that there are conventional gold miners around the research area.

Several studies have been conducted in this area such as Munasri et al. (2015), Handini et al. (2017), and Aterta and Hastuti (2019). However, research on

alteration mapping in terms of remote sensing has not been found. So this paper aims to observe the distribution of alteration in the research area through remote sensing, which is the first step in exploration activities. In addition, this research also discusses the alteration zone that occurs in the research area through petrographic analysis.

## LITERATURE REVIEW

### Geological Setting

The island of Sumatra is geologically located on the southwestern margin of the Sunda shelf (Sundaland). This area was formed in pre-Tertiary times where the basement is exposed in the mountain ranges and tin islands (Barber *et al,* 2005). In addition to the mountainous area, in the back-arc section there are basins with potential for oil and gas and coal, one of which is the South Sumatra basin. The South Sumatra basin is a back arc basin formed by the convergence of the Indian-Australian and Eurasian plates. This event produced an east-west oriented extensional strike in pre-tertiary times (de Coster, 1974; Daly *et al.*, 1987 in Amijaya, 2006).

In the research area, Lake Ranau is included in the circular scarf which is a landscape in the form of a crater left over from volcanic activity with a depression formation that occurs due to the movement of the Sumatra fault system, which forms a tectonic depression (Tjia, 1977). The lake is a caldera resulting from the eruption of Mount Ranau which is one of the lakes with considerable geothermal potential. The geological structure in this area is dominated by northwest-southeast trending alignments (Barber et al, 2005).

Research area is composed of several formations, namely Ranau Formation, Bal Formation, Lakitan Formation, Hulu Simpang Formation, Quarternary Volcanic Formation and Sekincau Volcanic Formation (figure 2). The Ranau Formation is Pleistocene in age and consists of rhyolite tuff, carbonate claystone tuff and claystone tuff. The Late Miocene Bal Formation is a volcanic breccia with sandstone and dacite inserts. The Hulu Simpang Formation is Early Miocene in age and is composed of lava, volcanic breccia and altered tuff, composed of andesite to basalt with sulfide content and quartz veins. Quarternary Volcanic (Qv) composed of andesitic to basaltic lava and volcanic breccia. Sekincau Volcanics (Qhv) composed of volcanic breccia, tuff and andesitic-basaltic lava.


Figure 1. Research location area

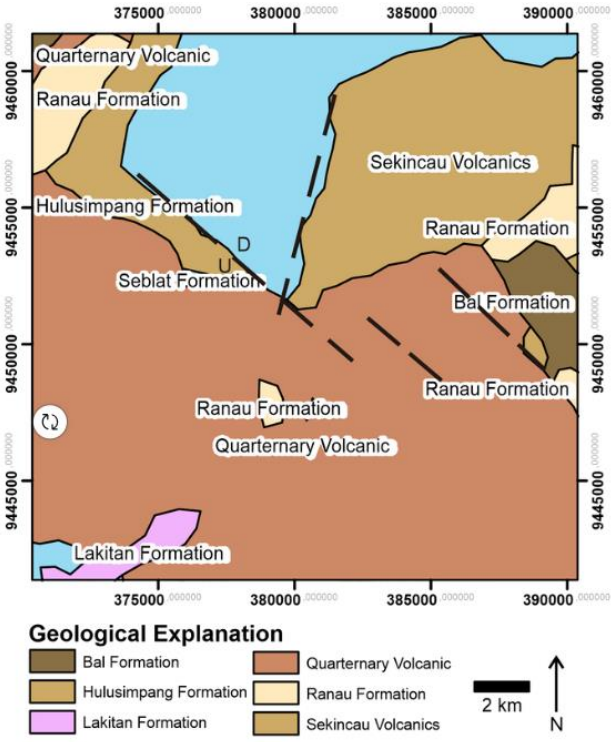


Figure 2. Geological setting in research area

## METHODOLOGY

In determining the distribution of the alteration area, a literature research was first carried out from various sources regarding the geology of the research area. Then a follow-up review was carried out through remote sensing, geological map of the research area and petrographic analysis (Figure 3).

Remote sensing was carried out using Landsat 8 OLI/TIRS satellite imagery data and Digital Elevation Model (DEM) data. Landsat data acquired from the Geological Survey Earth Resources Observation and Science Center (USGS, 2024) and Digital Elevation Model data acquired from Portal Informasi Indonesia which were processed using ArcGIS 10.3 and PCI Geomatica software. Landsat images can be processed to display the appearance of certain objects through image color manipulation (Ibrahim et al, 2020).

The data using ArcGIS 10.3 software, a combination of RGB channels including composite band 432 is performed to determine the original image. The composite band 567 to show the landform and rock texture more clearly. The composite bands 4/2, 6/7, 5 to observe the distribution of alteration, before performing the composite bands, the band ratio was first performed on band 4 and band 2, as well as band 6 and band 7.

The hillshade was made in the research area to see the lineament pattern from the Digital Elevation Model data. Then the lineament pattern is created automatically via PCI Geomatica. The ArcGIS 10.3 software is processed to create lineament density to determine which area has the most lineament patterns.

Reference geological data obtained through regional geological maps and sampling for petrographic analysis. The regional geological maps used in the research area are included in the Kota Agung sheet (Amin et al., 1993) and the Baturaja sheet (Gafoer et al., 1993) with a scale of 1:250.000. Four samples of rocks in different observation location was analysed using petrographic analysis method on the research area to identify the lithology of the rocks and the alteration conditions that

developed in these rocks based on the classification of Corbett & Leach (1998) for knowing about alteration zone in this research area.

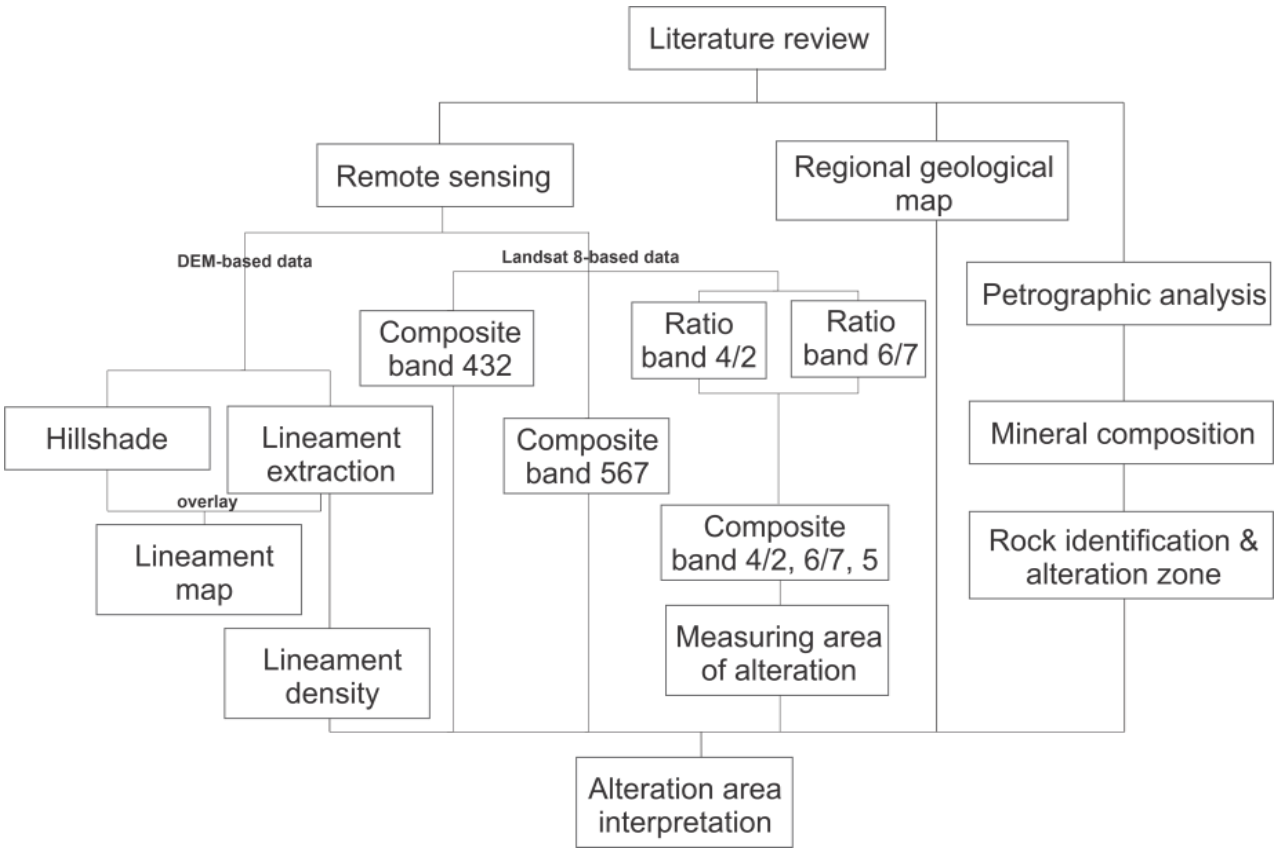


Figure 3. Research flow chart

## RESULTS

Composite band 432 shows the original condition and color of the research area. In this composite band, it can be seen that the research area is dominated by vegetation and there are appearances of Mount Seminung and Lake Ranau in the northern part (Figure 4a). Landforms in the research area are volcanic landforms which are indicated as part of the Bukit Barisan Mountains.

Composite band 567 is made to show clearer geological conditions compared to composite 432, the composite band 567 shows clearer color differences (Putra et al, 2017). The south is an elevated area with a steeper slope, which seems to have a rougher texture. Meanwhile, areas with finer rock textures are found in the northeast around Mount Seminung. It is interpreted that the coarse image texture indicates crystalline rocks such as igneous or metamorphic rocks. The fine image texture shows sedimentary rocks and sedimentary rocks. In addition, it can also be observed that high-density vegetation is dark brown, while low-density vegetation is marked with light brown, settlements are blue and water is black (Figure 4b).

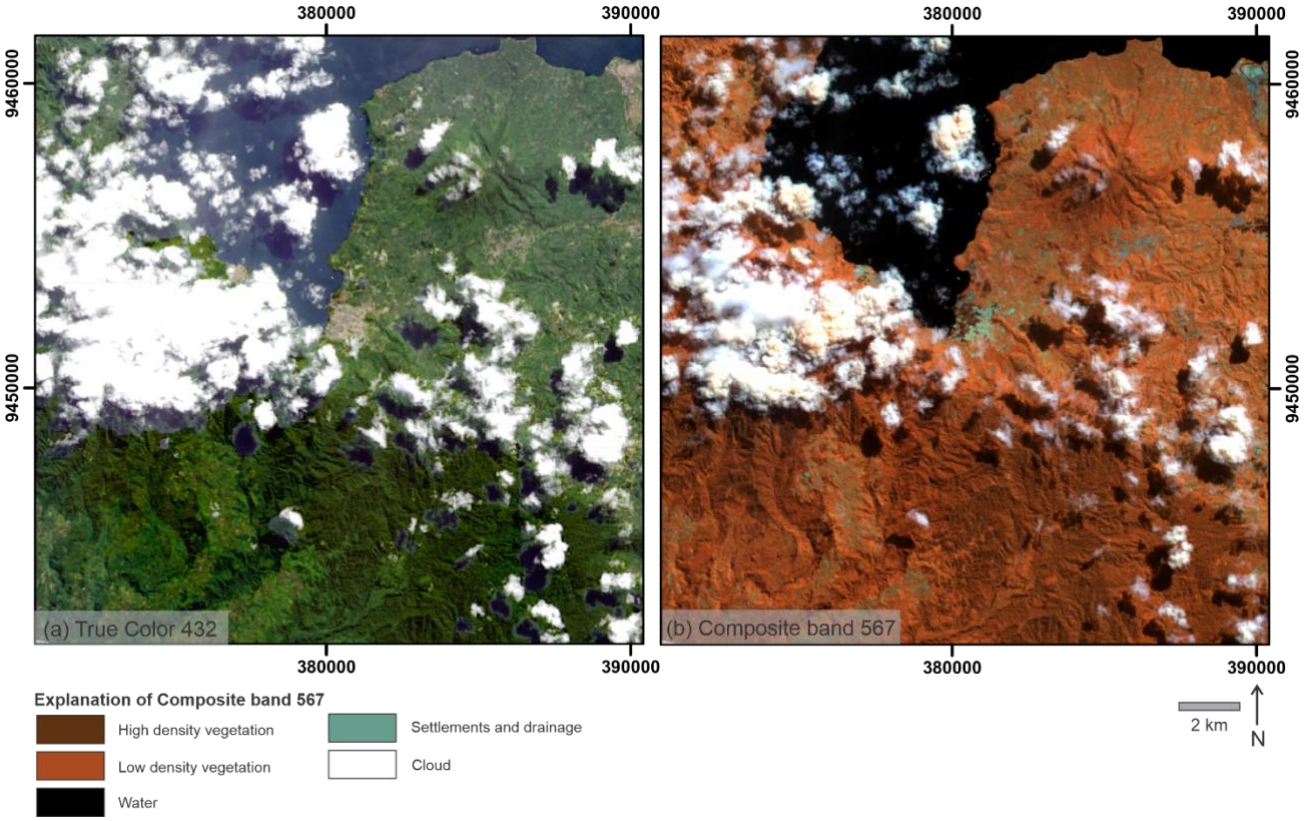


Figure 4. Composite band of Mount Seminung area from Landsat 8 data shows: (a) True color from composite band 4, 3 and 2; (b) Composite band 5, 6 and 7

Lineament analysis in the research area is carried out by identifying Digital Elevation Model data (Figure 5). This map displays that the dominant zones of fracture density in the research area. The map is modeled with green color as low density area to red with high density.

This analysis also identifies the general orientation of the geological structure of the research area. Determination of orientation direction is concluded by displaying the results of lineament analysis with rose diagrams (Figure 6). The rose diagram will show the direction of the force forming the orientation of the lineament. The conclusion obtained from results of the rose diagram of dominant orientation of alignment of the research area has a southeast-northwest direction, with the main direction of the forces acting is northeast-southwest.

The implementation of the map is combined with the presence of alteration in the research area. It appears on the map that areas with high density of fractures and faults are associated with the occurrence of alteration with main direction is southeast-northwest direction.

Based on petrographic analysis, there are four sample of thin section which are classified as andesit and basalt (IUGS) (Figure 7). The extrusive igneous rock classified as andesite (IUGS) with secondary minerals in the form of opaque and sericite and a base mass of glass (Figure 8 (A-B)). Basalt (Figure 8 (C-D)) shows secondary minerals in the form of opaque, sericite, chlorite and smectite and the base mass is crystallin.

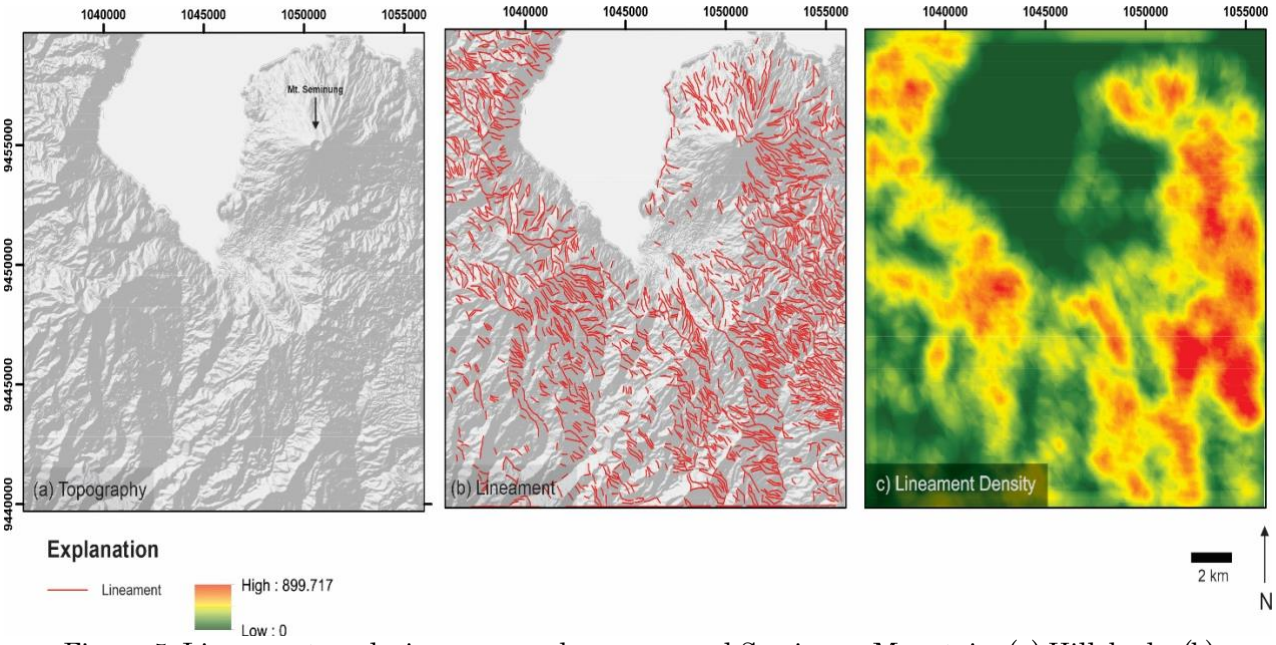


Figure 5. Lineament analysis on research area around Seminung Mountain: (a) Hillshade; (b) Lineament map; (c) Lineament density

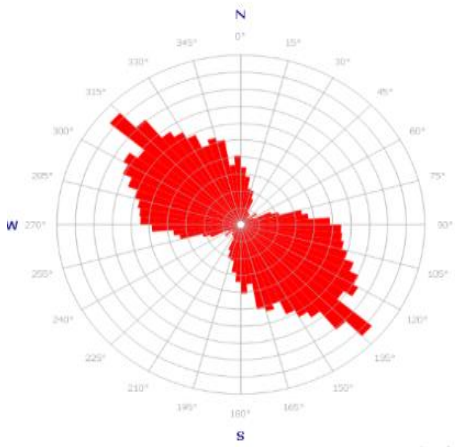


Figure 6. Rose diagram shows the dominant orientation of lineament which is southeast-northwest direction

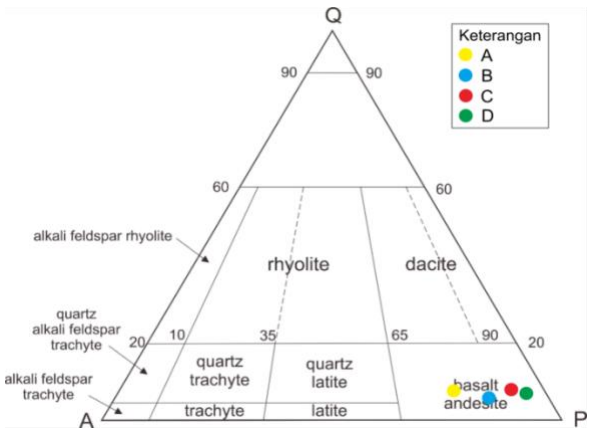


Figure 7. Four sample thin sections are classified as andesit and basalt by IUGS

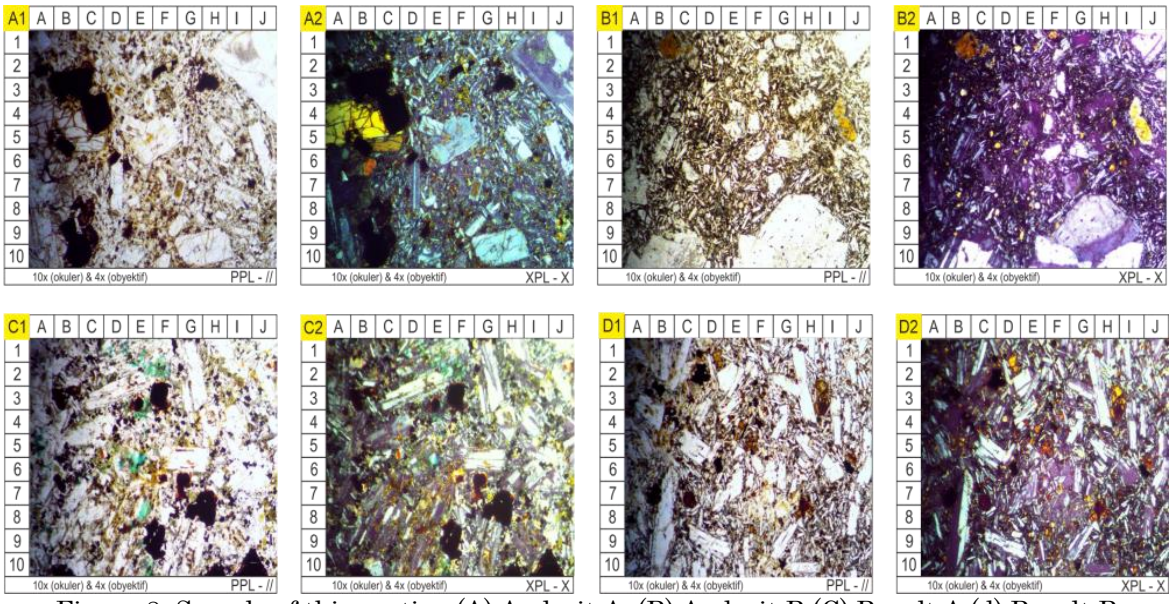


Figure 8. Sample of thin section (A) Andesit A, (B) Andesit B (C) Basalt A (d) Basalt B

## DISCUSSION

The research area is located around the magmatic arc of Bukit Barisan and Mount Seminung. Based on previous research, it is known that the research area is an area that has geothermal potential (Surbakti et al., 2022). Based on Landsat 8 imagery on the composite band 567, it indicates that the south area of research location has a coarse rock texture. This is indicated by the presence of the Andesite-Basalt Volcanic Rock (Qv) Unit with igneous lithology such as basalt and andesite. The northeast direction is dominated by fine textured rocks, which are interpreted as pyroclastic deposits as indicated by the presence of the Breccia Volcanic Tuff Unit.

The composite bands 4/2, 6/7, and 5 shows that there is an alteration area which is dominated in the south direction and belongs to Pesisir Utara and Karyapenggawa Districts. This hydrothermal alteration area is strengthened by the lineament pattern. Based on lineament and lineament density, alteration area appears on the map with high density of fractures and faults. It can be correlated that lineament pattern can be used as an initial estimation of the identification of the presence of alteration in the research area due to the possibility of the formation of fractures as place for hydrothermal fluid to occur. The higher the lineament density, the more fractures are formed and the more massive the alteration that occurs.

## CONCLUSION

The research area is an area with active geothermal system characterized by the manifestation of hot springs and altered rocks. Based on the Landsat 8 OLI/TIRS satellite image in composite band 432, it shows the original appearance in the field, which is dominated by vegetation, the appearance of Mount Seminung and Lake Ranau and Bukit Barisan. This indicates that the research area is in a volcanic landform.

Composite band 567 shows a clearer rock texture and geological landform when compared to composite band 432. Based on channel 567 shows the presence of coarse rock texture in the southern direction which is interpreted as andesite-basalt lava in the Quaternary Volcanic Unit. The northeast direction is dominated by rocks with a finer texture which is interpreted as rock from pyroclastic deposits in the form of tuff of the Sekincau Volcanic Unit.

Composite band 4/2, 6/7 and 5 shows that

the map alteration area with large alteration area located around the Bukit Barisan magmatic arc on coarse textured rocks. Based on the alignment analysis the dominant orientation of the alignment of the research area has a southeast-northwest direction, with the main direction of the forces acting in a northeast-southwest direction. This lineament is still associated with the Sumatra Fault system. This lineament analysis can be used as an initial estimation of the identification of the presence of geothermal in the research area. It is due to the possibility of the formation of fractures as a play zone in the geothermal system.

Petrographic analysis of four rock samples showed that the alteration minerals that appear in the research area are metallic minerals, smectite, sericite and chlorite. It can be concluded that the alteration area is close to the Bukit Barisan magmatic arc in an area with high to moderately high lineament density in the lithology of andesite-basalt altered rocks.

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