LINEAMENT DENSITY INFORMATION EXTRACTION USING DEM SRTM DATA TO PREDICT THE MINERAL POTENTIAL ZONES

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Received: 19 February 2016; Revised: 10 March 2016; Approved: 10 June 2016

Abstract. Utilization of remote sensing in geology is based on some identification of main parameters. They were the relief or morphology, flow patterns, and lineament. So it was necessary to study extraction method based on those parameters. This study aimed to obtain lineament density zone in the Geumpang area, Aceh, associated with mineral resource potential. Information of lineament density using remote sensing data was expected to help solve the problems that arised in the activities of early exploration, the difficulty of finding the prospect areas, so that the activities of pre-exploration always required a wide area and required a long time to determine the location of mineral prospect areas, it would have a direct impact on the financial of exploration activities. The used data was Landsat 8 and DEM SRTM of 30 m. The used method was processing of shaded relief on DEM data with the azimuth angle 0^{o}, 45^{o}, 90^{o}, and 135^{o}, then the result of hill shade process was done overlay, so DEM seen from all different azimuth angles. The results of the overlay were processed using the algorithm LINE with parameters such as the radius of the filter in pixels (RADI) 60, the threshold for edge gradient (GTHR) 120, the threshold for the curve length (LTHR) 100, the threshold for line fitting error (FTHR) 3, threshold for angular (ATHR) 30, and the threshold for linking distance (DTHR) 100. Vector lineament data from LINE algorithm process then performed density analysis to obtain lineament density zoning. Results from the study showed that the area has a high density lineament associated with mineral potency, so it was useful for exploration activities to minimize the survey area.

Keywords: *geology, remote sensing, lineament, density, mineral, DEM*

1 INTRODUCTION

Remote sensing technology has grown faster, for spatial, temporal, and spectral resolution, so the applications have become wider. Remote sensing data for geology could be used for identification of mine area, lithology identification, or geomorphological mapping, and identification of other geological parameter. According to Sukamto (1995) on Sidarto (2010) the utilization of remote sensing technology in geology was began since 1960s by Jawatan Geologi by creating photogeology section. At the beginning, the remote sensing data was interpreted using stereoscope, but there were numerous areas that were not supported yet by aerial photo interpretation due to the data unavailability in those areas. The remote sensing utilization on geology was based on some identification of main parameters, such as relief or morphology, drainage patterns, and lineament.

The lineament was the linear feature that could be mapped from the surfaces, and was morphological expression of geologic structure. The straight river valley and parallel segment of the valley was the typical geomorphologic expression of the lineament (O’ Leary, 1976 on Hung et al., 2005). The morphology of lineament on the earth’s surface had been study theme for geologists for years, since the early years of 19th century until now (Hobbs, 1904, 1912 on Hung *et al.*, 2005). Since beginning, the geologists realized that the linear features were the result of weak zones or the structural displacement inside the earth's crust.

The information that was resulted from the lineament extraction was still single lineament spread away on the study areas, so needed to be resulted the lineament density information to understand the lineament accumulation on an area. One of the benefits from the lineament density information was by helping decided the mineralization prospects faster based on parameter of weak zone density, that could be seen as consideration factor of a potential area (Verdiansyah, 2015).

The lineament *density* information was proved effective to be done on various locations, such as mineralization analysis in Afganistan (Hubart *et al.*, 2012), lineament analysis in Maran – Malaysia (Abdullah et al, 2010), tectonic evaluation in north Iraq (Thannoun, 2013), and to identify the land water in India (Prabu and Baskaran, 2013). The lineament density information used remote sensing data was expected to solved problems that existed on earlier exploration activity, which was hard to find prospective area or areas with special anomaly, so those earlier exploration activities always needed a wide area and a long time to decide the anomaly location. It caused direct impact to the financial of exploration activities.

This research aimed to get the lineament density information that was connected to mineral potency on research area. The result of this research was expected to be one of inputs to decide mineral potency in certain area.

2 MATERIALS AND METHODOLOGY

Geumpang area, Aceh, was become a research location because of this area had *Penambangan Emas Tanpa Ijin*–Gold Mining without Permission (PETI) that could be reference related to the existence of gold mineral. The used data was Landsat 8 imagery year 2015 and imagery of DEM (Digital Elevation Model) SRTM (Shuttle Radar Topography Mission) with resolution of 30m.

2.1 Mine Area Identification

The Landsat data was used to identify certain locations of mine area in Geumpang area. The identification was manually based on interpretation keys. To do the identification manually, Landsat 8 imagery needed to be created the color composite to ease identification in mine area. The used color composite on the research was composite of RGB 632, because of the SWIR (Short-wave Infrared) channel was sensitive to the soils, or rocks, whereas the Green channel was sensitive to the vegetation, and Blue channel was sensitive to the water. With RGB composite, the mine area could be divided from vegetated area, and there were differences between wet and dry soil.

2.2 Extraction of Lineament Density Information

On the DEM data, to show the data of more representative images, it was needed to do the process of hillshade used 3D Analyst tools on ArcGIS software. On the first step, it needed to be done the hillshade process on DEM data with 4 value variations of sun azimuth for 0°, 45°, 90°, and 135°; whereas for the input value of sun altitude were all same on 45°. Then, all of the images as result of the hillshade process will be overlaid to get the DEM imagery that was seen from all angles of azimuth (Anwar Abdullah, et al. 2010).

The DEM data as result of overlay then was proceeded using PCI Geomatica software to get the lineament pattern using LINE Algorithm. LINE Algorithm on PCI Geomatica software needed inputs as followed (PCI Geomatica, 2013):

a) **RADI (Filter radius):** This parameter decided the filter radius of the edge detection (on pixel) to decide the level of the smallest detail on a picture. The range of the data for this parameter was 0 and 8192.

b) **GTHR (Gradient threshold):** This parameter decided the threshold for minimum level of gradient for the edge pixel to get binary imagery. The range of the data for this parameter was between 0 and 255.

c) **LTHR (Length threshold):** This parameter decided minimum length of curve (on pixel) that was thought as further lineament (for example, connected to other curves). The range of the data for this parameter was between 0 and 8192.

d) **FTHR (Line fitting error threshold):** This parameter decided maximum mistakes (on pixel) were allowed on the polyline for pixel curve. The low value of FTHR gave a better segment, but also a shorter polyline. The range of the data for this parameter was between 0 and 8192.

e) **ATHR (Angular difference threshold):** This parameter decided maximum angle (on degree) between polyline segments. If not, it was segmented to be two or more vectors. It was also maximum angle between two vectors for them to be connected. The range of the data for this parameter was between 0 and 90.

f) **DTHR (Linking distance threshold):** This parameter decided the minimum distance (on pixel) between the endpoint of two vectors for them to be connected. The range of the data for this parameter was between 0 and 819.

On this research, the value of each parameter that had been used could be seen on Table 2-1. LINE Algorithm on PCI Geomatica was consisted of three phases: *edge detection, thresholding,* and *curve extraction.* At the first phase, the algorithm of *canny edge detection* was applied to produce edge accumulation imagery. At the second phase, the edge accumulation imagery in the threshold to get *binary edge image.* Every pixel that was value for 1 on *binary edge image* was edge element. The threshold value was given by GTHR Parameter. At the third phase, the curve was taken from the elements of binary edge image. This step was consisted of some sub steps. First, thinning algorithm was applied on the binary edge image to create curve of pixel-wide skeleton. Every curve with total pixel less than value of LTHR parameter was thrown away from the next process. The curve of selection result was changed become vector shape. The result was polyline that was approach for the original pixel curve where maximum mistakes (distances between both of them) were decided by FTHR parameter. Last, the algorithm connected pair of polylines that met these criteria: 1. Two segment that was two face-to-face polylines and had same orientation, with the angle between these two segments was less than ATHR value; 2. Two segments that were near each other, with the distance between the endpoint was less than DTHR value (PCI Geomatica, 2013).

After got the lineament vector used *LINE* algorithm, then it was done the density analysis to get the density lineament maps in research area using ArcGIS software.

Table 2-1: Value on each parameter of *LINE* Algorithm

Parameter	Value
RADI (Filter radius)	60
GTHR (Gradient threshold)	120
LTHR (Length threshold)	100
FTHR (Line fitting error threshold)	3
ATHR (Angular difference threshold)	30
DTHR (Linking distance threshold)	100

3 RESULTS AND DISCUSSION

Location of mine area in Geumpang was got by manual interpretation based on interpretation keys on Landsat 8 imagery data year 2015 with composite of RGB 632 (Figure 3-1). The mine area was characterized by the color of brownish white because of the topsoil that had been exfoliated due to mining activities so that was seen on the surface was rock at the bottom. The rough texture on the image indicated mining activities was not done by peeling the layers of soil horizontally but by the way of horizontal mining. Besides, the irregular patterns indicated that the mining activities were done without any plan, and it indicated illegal mining activities. The existence of this mining location would be reference on analysis of relationship between lineament *density* and mineral potency in the research area.

The image result of hillshade process (Figure 3-2b, c, d, e) showed linear features, such as valley lineament or the mountain peak on satellite images looked more prominent than surrounding area. It was caused by combination of dark – bright or shadow effect, where the different input of variable value would produce the difference of shadow form, and influenced the lineament pattern – the existence lineament. All of hillshade result imageries were overlaid so the lineament information that had been produced close to the lineament on the earth's surface, because the images as overlay result was representation of 3 dimension sightings of earth's surface relief information that got the exposure from 4 angles (Figure 3-2f).

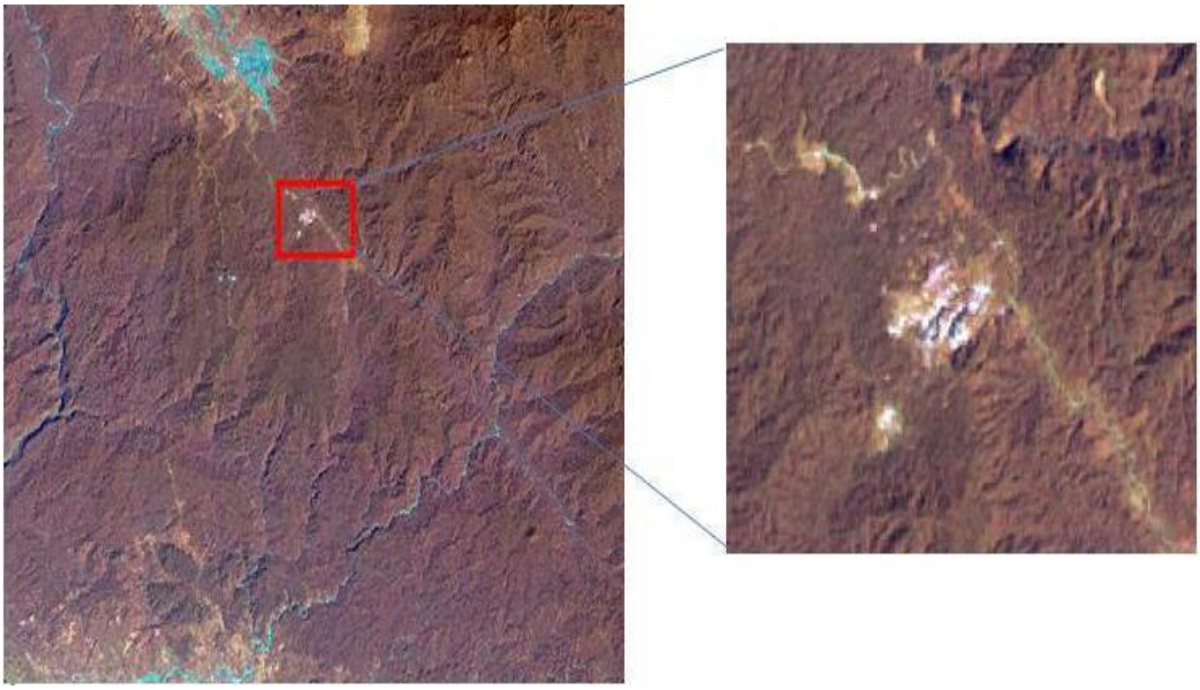

Figure 3-1: Image of Landsat 8 composite of RGB 632 Geumpang area

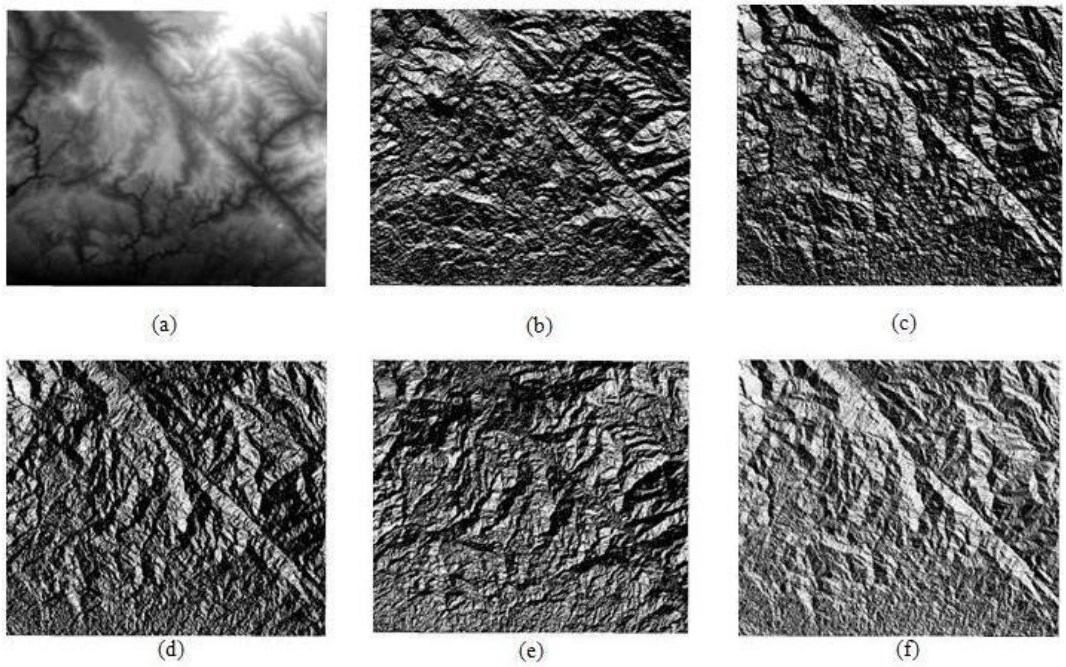

Figure 3-2: DEM SRTM imagery Geumpang area. (a) Before the hillshade processed (b) After done the hillshade 0° (c) After done the hillshade 45° (d) After done the hillshade 90° (e) After done the hillshade 135° (f) After done the overlay

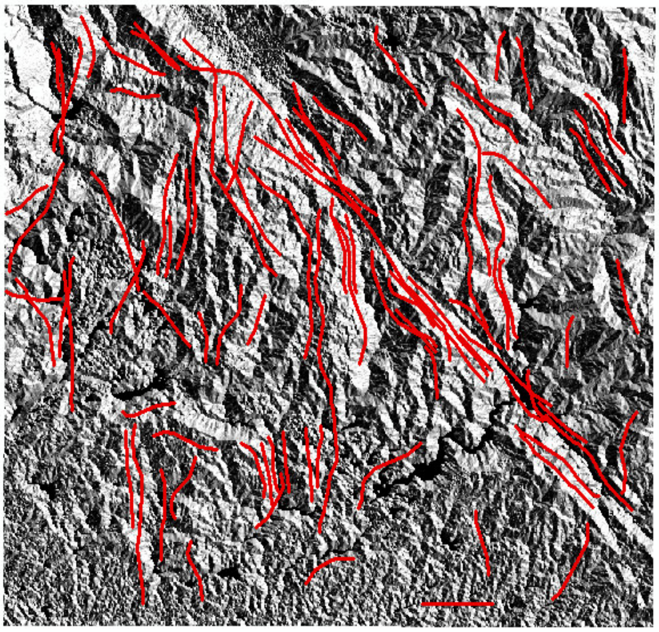

Figure 3-3: The lineament of Geumpang area with the *background* of DEM SRTM imagery with resolution 30 m

The lineament information that was produced on this research (Figure 3-4) showed that mostly lineament had the northwest – southeast direction. It was caused by the lineament in the research area was influenced by one part of Sumatera fault, precisely in a part of Aceh Segment that had northwest – southeast direction (Sieh and Natawidjaja, 2000). It was also strengthened by lineament density information that showed in areas that were traversed by Sumatera fault, Aceh segment had high density value. The Sumatera fault was active fault (Natawidjaja and Triyoso, 2007), so the effect of numerous earthquakes on that area, caused the surrounding area became disaster- prone.

With the density lineament information, it could be analyzed a geological structure zonation that was characterized by those sets of lineaments. The mine area that was got by interpretation of Landsat 8 imagery located on the intersection of two density zones was weak zone that was caused by tectonic process that created geological structures on that area. On the weak zone, hydrothermal process could happen that created precious minerals. Hydrothermal system was identified as hot fluid circulation (50° –> 500°C), laterally and vertically on various temperature and pressure under the earth's surface. This system contained of two main components, they were hot source and fluid phase. Circulation of hydrothermal fluid caused mineral compilation on the rock wall became unstable and tended to adjust new balance by forming the mineral compilation fitted to new condition, and it was known as hydrothermal alteration. Hydrothermal mineral sediment could be formed because of the hydrothermal fluid circulation that leached, transported, and sediment the new minerals as a response of physical or chemical changes (Pirajno, 2012).

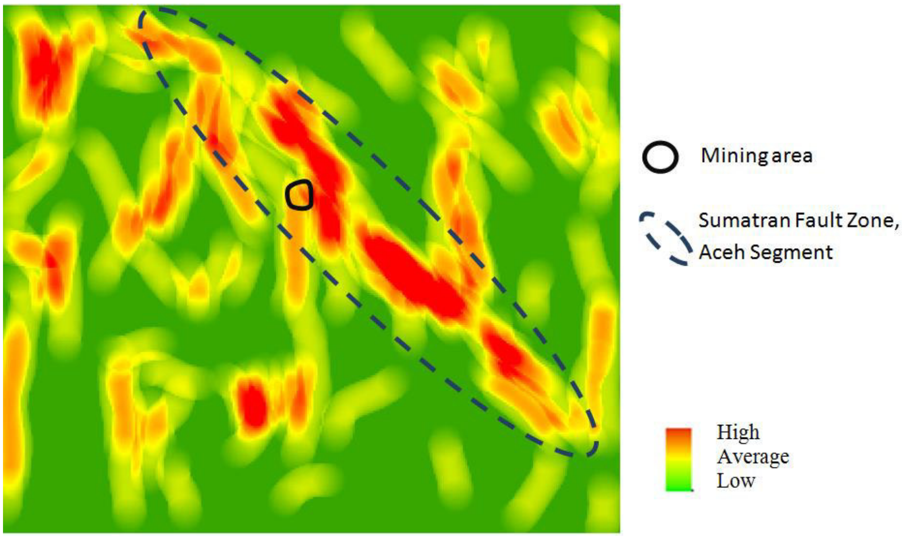

Figure 3-4: The density lineament information, Geumpang area

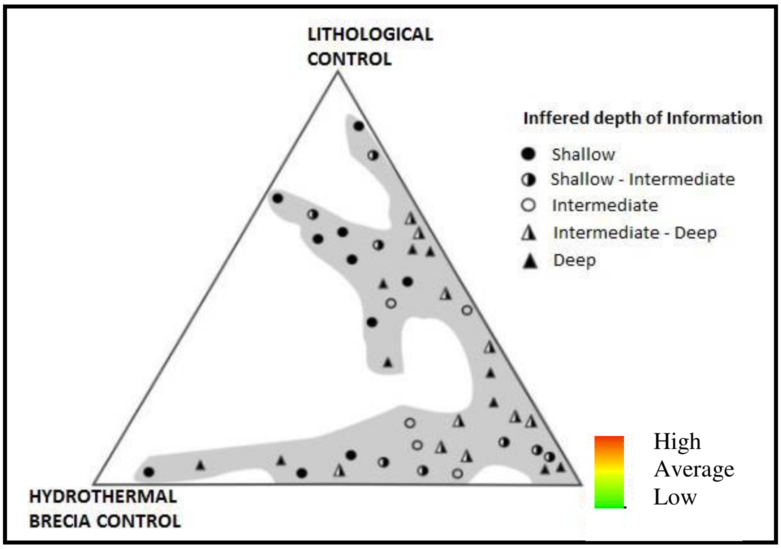

Figure 3-5: Lithostructural concept diagram (Sillitoe, 1999)

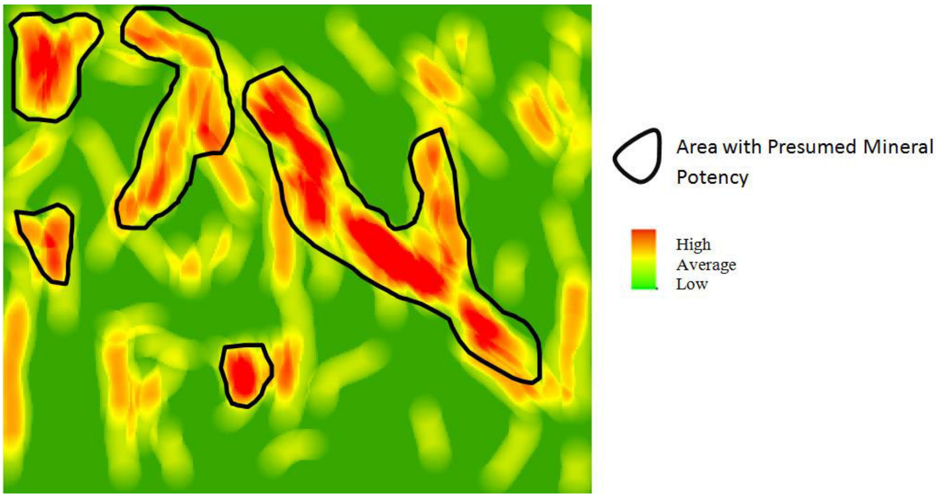

Figure 3-6: Area with presumed mineral potency based on lineament density information

To connect between lineament density information with mineral potency area, it was used the lithostructural concept (Figure 3-5). This concept principally had three basic components, namely lithology control, hydrothermal breccias control, and fault control (Sillitoe, 1999). This concept described generally that mineralization would exist on devastated areas or had very strong structure intensity, so the hydrothermal solution could pass through and sediment precious metal mineral on that area. This litostructural approach could be approximated by lineament density analysis by using general lineament parameter connected to geological structure.

Based on relationship between lineament density information with mineral potency, the research area could be identified into 5 zones that were areas with presumed mineral potency (Figure 3-6). This identification was based on high density value and the existence of intersection between two zones of lineament density. The identification of zone with presumed mineral potency was beneficial for pre-exploration mineral mining activities, so area that would be surveyed could be narrowed on those zones, and could be done faster, and used lower cost.

4 CONCLUSION

The conclusion that could be got on this research was:

a. DEM SRTM data could be used to create lineament density information.
b. In some areas that had high lineament density were weak zones or destructive zones that were caused by tectonic process on those areas.
c. The lineament density information could be used to get presumed mineral potency zone to support exploration activities.

ACKNOWLEDGEMENT

This research supported by Remote Sensing Application Center, LAPAN and the author thank to Dr. Bidawi Hasyim for his guidance on writing this paper.

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