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# APPLICATION INTEGRATION METHODS ON LANDSAT ETM + TO DETERMINE EARTHQUAKE POTENTIALS IN PALU GRABEN

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## ABSTRACT

*This study aims to assess the ability of the integration method at Landsat ETM + imagery in recognizing object fault, main fault and secondary fault in Palu Graben. Mapping of fault and calculate earthquake potential, based of fault that is found in Graben of Palu. The image used in this study is Landsat ETM +. Techniques used to process Landsat ETM + is a method of integration. Landsat ETM+ imagery processed with ENVI software 4.4, while the mapping of faults and determining of length using ArcGIS 9.2.The potential of earthquakes is calculated from the length of faults found in the Graben of Palu. Results obtained showed that the patterns of lineament as a picture of fault in the Palu Graben can be extracted from Landsat ETM +. Lineament of fault is seen clearly on Landsat ETM + image processed with integration method and band combination, 45PC1_8. Faults are arranged in the form of map. There are 66 faults found at research sites. Magnitude earthquake 5,5 SR can be produced from the fault with a length greater than or equal to 9 km. If each faults contributes the same to earthquake occurrence, the potential incidence of earthquake with magnitude greater than or equal to 5.5 SR in the Graben of Palu is 33.8%, while the magnitude is smaller than 5.5 SR is 66.2%. The largest magnitude that can occur in Palu Graben, 7.1 SR. These results indicate that the potential earthquake destructive (≥ 5.5 SR) of approximately 33.8%.*

**Keywords**: integration, Landsat ETM +, earthquake, Palu Graben

## INTRODUCTION

Today the role of remote sensing has been progressing very rapidly, indicated by the wide scope of its utilization in various fields such as agriculture, forestry, archeology, geography, geology, regional planning, health and natural disasters. This was driven by the ability of satellite imagery to describe objects and phenomena in the Earth's surface that is relatively complete, covering large areas, similar to the original form. Satellite imagery can be made quickly even for difficult areas explored on terrestrial, can be used for mapping the region when a catastrophic event, and provide a consistent picture so that changes in the short and long term can be observed [*Schowengerdt,* 2007]. The explanation above shows that satellite imagery is an effective tool for monitoring earthquake disaster in a region. Development in technology of remote sensing and its application allows the use of this technology to obtain data before and after the earthquake occurrence.

Several researchers have used remote sensing technology to maping areas vulnerable earthquake disasters, among others, [*Bitelli at al.,* 2004] declare that remote sensing imagery, intermediate resolution Landsat TM with 30 m resolution and high resolution Ikonos imagery, can be used for describe the rapid and comprehensive earthquake disaster area. Identification of a shift in location can also be detected using satellite imagery, aerial photography, GPS, GIS, and field observation. [*Zoran et al.,* 2005] have used multi-sensor image data such as Landsat (MSS, TM, ETM) resolution of 80 m, 30 m, panchromatic 15, MODIS reolusi 250-1000 m, the resolution of ASTER 15 m , 30 m for investigate the hazard earthquakes in Vrancea, Romania. Multi-sensor imagery combined for the analysis of patterns of lineament and mapping neotektonik. Image processing technique done by RGB and IHS method. Obtained some lineament as a fault, lithology and seismic hazard in the Vrancea region. All the researchers mentioned above declare that remote sensing technology was interesting applied for study disaster because it covers large areas, some variables of disaster as fault, lithologi, can be recognized by well and analysis can be done quickly. Especially for Palu Graben , study of earthquakes by using satellite imagery is still very limited. [*Sudradjat,* 1981] using Landsat MSS technology for study geology Palu Graben. Landsat imagery has developing, well spatial resolution, temporal and spectral, so interesting for be applied for earthquake disaster study in Palu Graben.

Earthquake data show that region of Palu Graben often hit by earthquake disaster and has caused substantial losses [*Soehaemi dan Firdaus,* 1995]. All occurance of earthquake damage lies in the fault system of Palu-Koro. As a source of earthquakes that can cause disaster, the identification of the fault in this location is inportant to do. The way that can be done for identify the various fault by aplication of satellite imagery or through direct observation in the field. Faults that passes through dense forest and long very difficult for be observed in the field. Recognition through satellite imagery into a solution that can be relied upon in determining fault like in Palu Graben. Problem faced is the limited spatial data, moderate to large-scale related to the earthquake disaster in the Palu Graben.

Merging multiresolution image data that is low resolution and high resolution can be used to obtain detailed maps on a scale of high reolusi [*Liang,* 2004]. High resolution image can be obtained from the same sensor or from other sensors, but the register should be the same image geometry. Optimizing the use of Landsat ETM + with of integration method PCA, IHS and adaptive filter is important do to clarify the position of fault on the Graben. These results are used to calculate the magnitude of earthquake that can occur in this location. In addition, this method can add spatial data about condition on Palu Graben area so of disaster mitigation planning, earthquakes can be done well. This research is anticipated early in the framework of earthquake disaster preparedness in the future.

The purpose of the research is to assess the ability of the method of integration in clarifying the object fault on multispectral image, well the primary fault as well as secondary fault in the Palu Graben. Mapping of faults and calculating the potential earthquake based on fault that found on the Palu Graben.

## THE METHODS

Location of research is Palu Graben area in position $119^0 45'55''$-$12^0 005'30''$E and $0^0 47'48''$ – $1^0 18'27''$S. The image that was used Landsat ETM, recorded May 26, 2003, 141-61 path row.

Merging band Landsat ETM + using method of integration (combined methods of PCA, IHS and adaptive filter). The algorithm of this method are shown in Fig. 1. The first stage, the selected band of 4 and 5 in the red and green channels because these channels contribute greatly to any combination that do, so the two of this band are separated. The second stage, the merger made on band 1, 2, 3, 6 and 7 with PCA technique. The highest value on the PC, input as blue color in RGB transformation. The third stage is the transformation of RGB to IHS space, then changing the intensity with the panchromatic band (8). The next stage is returned to the RGB space and then do filtering to reduce noise in images as well as clarify the object of study.

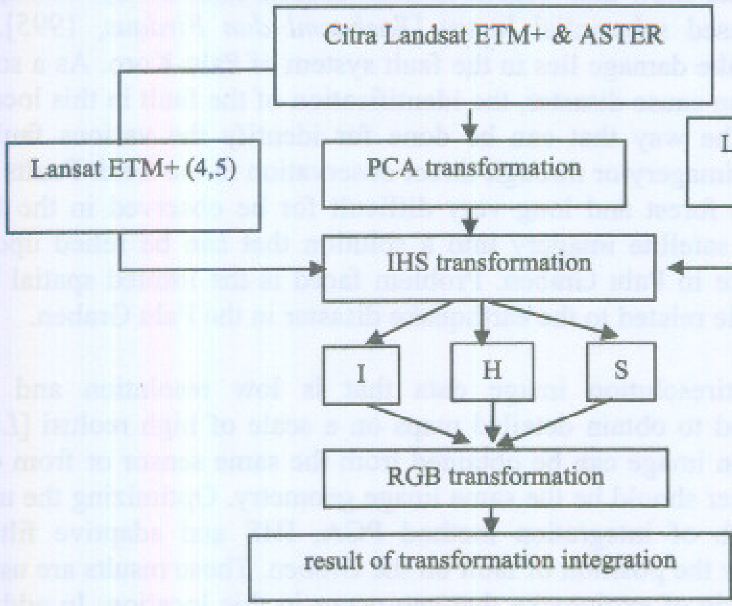


Figure 1. Stages of Image Processing in Integration Method

Processing of Landsat ETM +, carried out using ENVI 4.4 software. The results of processed Landsat ETM + interpreted visually. Interpretation of Image done to obtain faults as the source of earthquakes in the Palu Graben. Further, delineation done of the object fault that found. Field observation done to match the results of interpretation with field conditions. Interpretation of faults was also matched with the geological map Sheet Palu, Poso and some from previous research. The result of fault interpretation that has been matched with field arranged in the form of a map of fault. The length of the fault is determined based on the interpretation of Landsat ETM+ using ArcGIS software. Based on the length and type of faults is determined, width of fault, stress droop and the maximum magnitude of earthquake. The width of fault is calculated using equation 1 and 2 [*Borman and Baumbach in Thant,* 2008]. Large of magnitudes are calculated according to equation 3 and 4 [*Mohammadioun and Serva,* 2001] and [*Elnashai and Sarno,* 2008].

$L = 2W$ ............................................................................................1

$\Delta\sigma N = 10.6 \times W^{0.5}$ dan $\Delta\sigma SS = 8.9 \times W^{08}$ ..........................................2

$Ms = 2\log L + 1.33\log\Delta\sigma + 1.66$ ......................................................3

$Mw = 1{,}005Ms + 0.087$ ..........................................................................4

Note:
L = fault length, W = fault width
ΔσN and ΔσSS = stress drop of normal fault and strike slip fault
Ms = surface magnitude, Mw = magnitude moment

## RESULTS AND DISCUSSION

Landsat ETM + consists of 6 (six) visible band, ie 1,2,3,4,5 and 7 band, while band 6 is the thermal channels and channel 8 is a panchromatic which has a resolution of 15 meters. Transformation of the PCA done on band 1,2,3, and 7 become 4 axis the main components, namely PCA 1,2,3 and 4. Based on this transformation obtained eigenvalues axis the component of 1 that contains information 16229.67 98.06%. Information content of each axis that transformed is shown in Fig. 2. PC1 is the main axis which has the highest information content, combined it with band 4 and 5. A combination obtained is 45PC1 colored of pseudo. These results show that the options of combination fewer, namely one combination. It is proved that the transformation of the PCA is an efficient technique in the selection of a combination of band. Information content of each axis are is transformed shown in Table 1.

Table 1 Percentage of Each PC Information Content of Landsat ETM +

| No | PC | *Eigenvalues* | % |
|---|---|---|---|
| 1 | 1 | 16229,67 | 98,06 |
| 2 | 2 | 279,34 | 1,69 |
| 3 | 3 | 24,03 | 0,15 |
| 7 | 4 | 17,39 | 0,11 |
| | | 16550,43 | 100 |

Source: Results of calculations with PCA Method

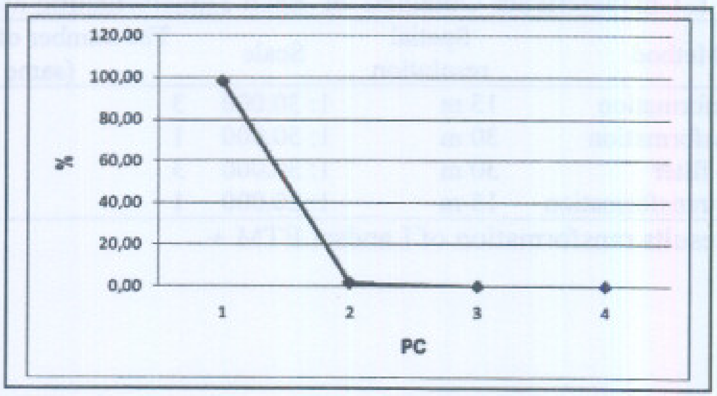


Figure 2. Graph of percentage content of information on every PC.

The next stage is the merging of band has a resolution of 15 m with a band of resolution 30 m. HIS methods used to combine of the different channels resolution. The Merger of band 8 on the various band that have been previously combined with the transformation of the PCA to produce a combination of 45PC1_8. These results further clarify the object fault, lithology, and land cover compared with combinations that do not use the panchromatic band and adaptive filter (Fig.3). Overall characteristics of the integration method are shown in Table 1.

Table 1 shows that the integration method gives the advantage of spatial resolution imagery to be higher (15 m), a larger scale (1: 20,000) and color combinations to be more modest (1 combination). The image processed with the method of integration is interesting to interpreted in order to obtain a clearer object of fault at the sites.

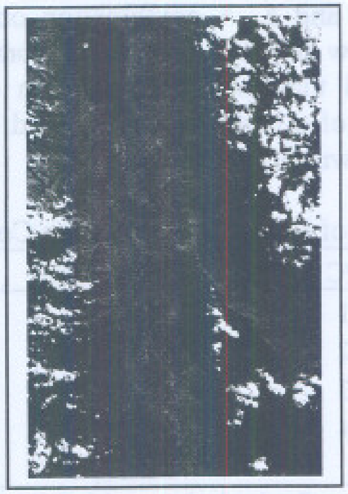

Figure 3. Image Processed by Method Integration

Table 1. Characteristics Obtained of Each Transformation Method

| No | Method | Spatial resolution | Scale | The number of combinations (same color) |
|---|---|---|---|---|
| 1 | HIS transformation | 15 m | 1: 30.000 | 3 |
| 2 | PCA transformation | 30 m | 1: 50.000 | 1 |
| 3 | Adaptive filter | 30 m | 1: 30.000 | 3 |
| 4 | integrasi transformation | 15 m | 1: 20.000 | 1 |

Source: The results ransformation of Landsat ETM +

**Faults and Earthquake Potential in Palu Graben**

Lineament pattern recognition done on the Landsat ETM +. The best combination is used to recognize Lineament on Landsat ETM + is the combined band 45PC1_8. Palu-Koro Fault easily observed on Landsat ETM +. Color straightness, be the striking color difference between the base and the edge of the graben, lineament of the river, gawir lineament, lineament row of triangle-Facets, regular river bending everything to be clearly observed on the Landsat ETM + band combination of 45PC1_8. Lineaments that formed on the Palu Graben are Lineaments disjointed and located in a zone with a width of approximately 1-12 km. Some streams in the Palu Graben, showed a sharp winding pattern such as stairs, which indicates the Lineament that can be associated as a fault. River flow patterns reflect a very strong influence of fault on the Palu Graben. Streams flow into the Palu Graben shows topographic low with soft rock as a manifestation of the fault.

The west side and east of Palu Graben have founded some alluvial fan deposits. Alluvial fan deposition is one of the characteristics of fault in this region. Some of the alluvial fan deposits have a fairly smooth texture and a few others already processed as paddy fields so it looks like body of water the dark colored . Other evidence that can be observed the triangular facets, a reflection of the fault surface. Contrast to [*Sudradjat,* 1981] which states that the aspect of a triangle can not be observed on the Landsat MSS, Landsat ETM + imagery band combinations 45PC1_8, fault characteristics is clearly seen.

The main Palu-Koro Fault located to the west of Palu Graben extends from north to south. Some photos show the existence of morphological field sudden and very steep rise as shown in Fig. 4. In the northern Palu Graben, especially in the area Silae apparent the of a sudden decline indicates vertical movement which is characteristic of the normal fault. This vertical movement can be found in the western region of Palu Graben, and east of the south.

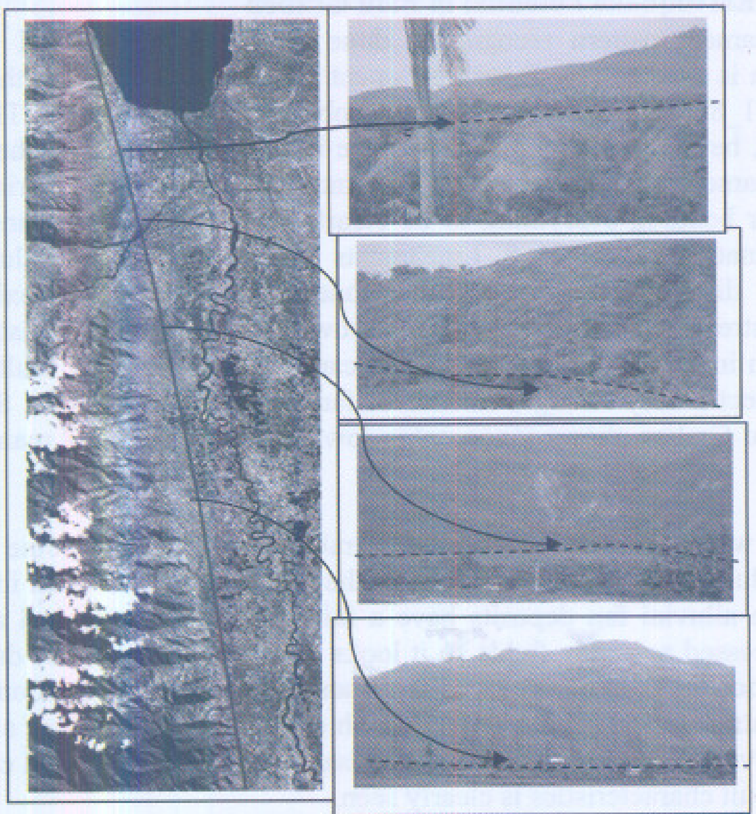

Figure 4. Main Palu Koro Fault and Some Evidence Field

The east side of Palu Graben shows faults pattern an almost straight on the south, and discontinuous in the north. On this side found some local steps which indicate a faults. Another characteristic found in this section is the existence of some alluvial fan. Lineament pattern on the east side Palu Graben, although disjointed by the river, but still showed a pattern consistent as shown on the west side of graben. Some lineament direction of the Palu River flow. This shows that the pattern of lineament found in Palu Graben generally south east - north northwest. This description indicate that the main direction of Palu-Koro Fault is south east - north northwest accordance with the direction of flow of Palu River. Faults found in the Palu Graben with directions like these can be classified as primary Palu-Koro faults.

Were observed also for faults around Palu Graben, either of related directly or indirectly with Palu-Koro Fault, but still affects the region of Palu Graben. In the eastern part of this Graben, enough much found faults that could affect the Palu Graben. One of the fault which has caused destructive earthquake on February 24, 2005 is the Bora Fault. Obvious evidence of this fault is the hot springs appear in the village of Bora Sigibiromaru District. At Fault Bora has been carried out measurements using geoelectric method. The results showed that the fault Bora normal type (Fig.5). This finding is in accordance with what is described by [*Sudradjat,* 1981] that there is some fault in the area around Palu Graben like, Bora Fault, Salua, Saluki, and Rakuta Fault. This study finds that the Gumbasa fault truncated two. Gumbasa Fault very clearly visible on Landsat ETM +.

Palu-Koro fault is a fault system, consisting of short faults that intersect. This movement faults together so as if a single fault. The main Palu-Koro Fault is a relatively long lineament compared with other lineament and direction of the Palu Graben. Faults which are located on the west side and east of Palu Graben direction can be classified as a main fault. Lineaments are relatively short and not the direction of the Palu Graben classified as secondary faults. Palu-Koro Fault system become the main cause of earthquakes in the Palu Graben. Overall fault of found in Palu Graben on the map as in Fig. 6.

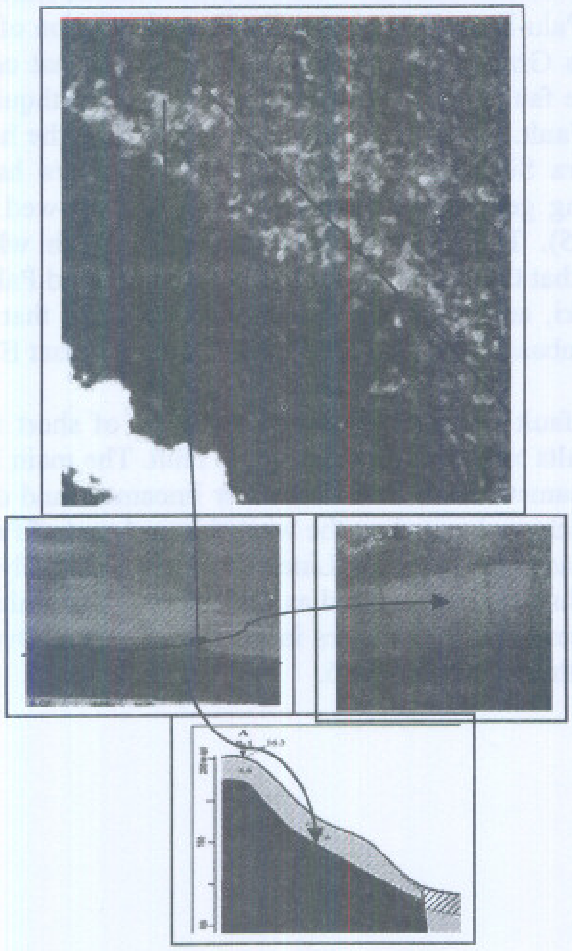

Figure 5. Bora Fault, a, Location Place Hot Springs Photographed from the North direction at coordinates $1^{0}$03'07"S, $119^{0}$57'15''E, b. Hot Springs Bora, c. Results Measurement of geoelectric methods, Looks The Fault in the village of Bora.

The number of faults found in Palu Graben 66 lineament, with details the 15 lineament of the normal faults, and 51 strike slip faults. Longest fault in Palu Graben is 36.86 km and shortest 3.13 km. Fault is the source of earthquakes, so to know the potential earthquake would happen so characteristic of fault need to be researched properly. The longer of fault, the greater the magnitude of the earthquake that may occur. Large magnitude earthquakes is also determined by the type of fault. There are two types of fault found in the Palu Graben, namely strike slip faults and normal fault.

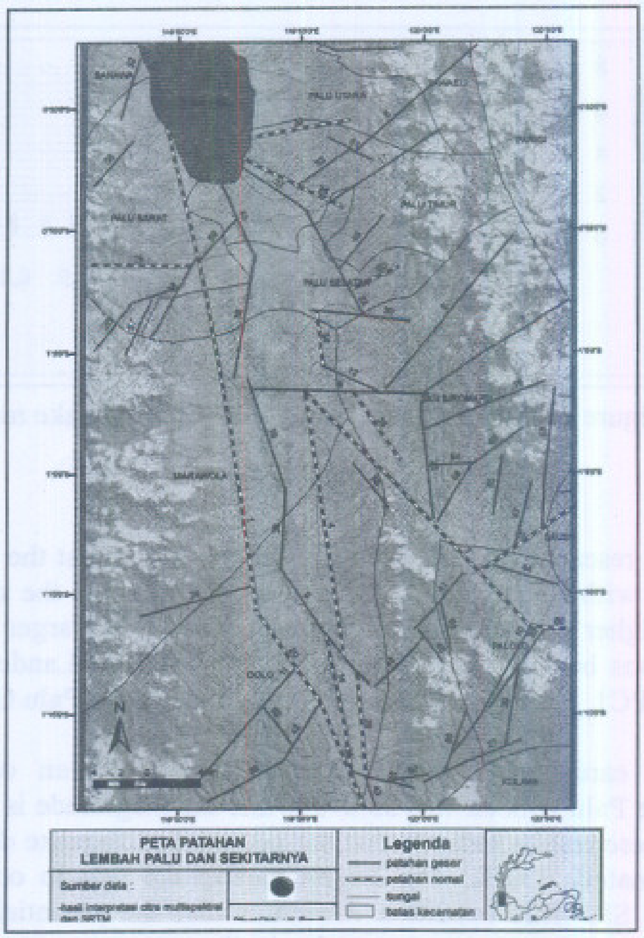


Figure 6. Fault in Palu Graben Results Interpretation of Landsat ETM +

Potential earthquake based on length of fault, the overall has been calculated using equation 1-4. The calculation result is shown in Fig. 7. The result shows that the largest earthquake magnitude that can occur in the Palu Graben was 7.1 on the Richter Scale (SR), calculated from the longest fault found in this Graben. Magnitude earthquake 5.5 SR can be produced from the fault with a length greater than or equal to 9 km. There are 21 fault that have a length greater than or equal to 9 km. If each fault contributes the same to earthquake occurrence, the potential incidence of earthquakes with magnitudes greater than or equal to 5.5 SR on the Palu Graben is 33.8%. For smaller magnitude than 5.5 SR is 66.2%. These results indicate that the potential earthquake destructive (≥ 5.5 SR) of approximately 33.8%. This condition illustrates that the potential for destructive earthquakes are relatively large, especially in the western part which passed by the longest fault in the Palu Graben. Attention to the potential for destructive earthquakes in this location, so preparedness is necessary, in order to reduce losses due to earthquake disaster

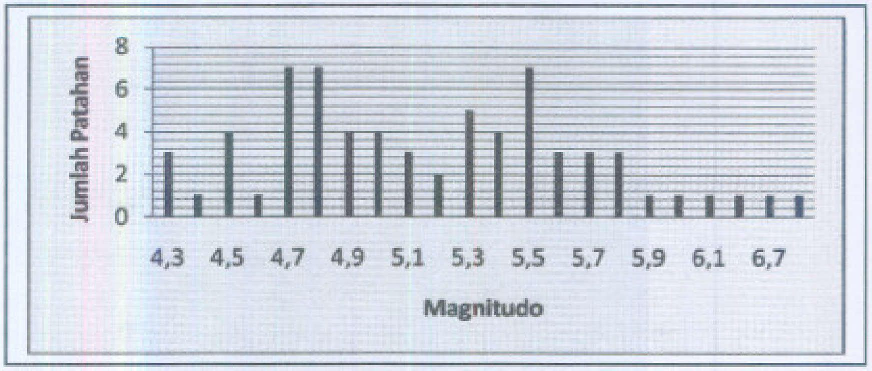


Figure 7. Total Fault and the Great of Earthquake magnitude

## CONCLUSION

Based on research that has been conducted, found that the Landsat ETM + image processed with the method of integration can improve the spatial resolution imagery to be higher (15 m), magnification of scale to be larger (1: 20.000) and color combinations became more simple. Interpretation of Landsat ETM + band combinations 45PC1_8 produce 66 lineament as fault in the Palu Graben.

Potential earthquakes with magnitudes greater than or equal to 5.5 magnitude on the Palu Graben was 33.8%, while the magnitude is smaller than 5.5 SR is 66.2%. These results indicate that the potential earthquake destructive (≥ 5.5 SR) of approximately 33.8%. The largest earthquake that to occur in the Palu Graben was 7.1 SR. This condition illustrates that the potential for destructive earthquakes are relatively large, especially in the western part which passed by main fault Palu Koro.

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