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Research Article

GAMMA RAY EMISSION IN NEOTECTONIC ZONE OF BANDUNG AREA

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ABSTRACT
Bandung is a densely populated city in Indonesia. It is surrounded by several faults that may be moved due to tectonic activity. Meanwhile, stress in the crust change in accordance with crustal deformation due to tectonic activity. Concentrated stresses at some domains in the medium may not only create new micro cracks and act to expand the area and/or volume of pre-existing micro cracks, but also drive pore fluids to flow upward through a crack network when a vent-like path occurs in the network. These cracks can trigger fluid (especially gasses) for coming out from deep underground in response to crustal activity. This kind of condition can increase the activity of natural radioactive elements that comes from the depth of the earth. Therefore, this research aims to present data regarding natural radioactivity, especially gamma ray, from a populated active faults area in the Bandung Highland, Indonesia. This research is conducted based on site – in situ measurements using a filed gamma spectrometer. Measurement position was determined by longitude and latitude in the GPS. The amount of measurement location was 36 points. While, the fault zones were identified by analyzing the lineament from digital elevation model. The results show that there are several indicated faults in research area. Their orientations are commonly east – west and north west - south east. These faults influence the values of gamma dose rate. The measurement of gamma dose rate shows that the nearer with active fault zone, the higher the values of gamma dose rate in research area

Keywords: *Active Faults, Gamma Dose Rate, Tectonic*

INTRODUCTION

Bandung is a densely populated city in Indonesia. It is surrounded by several faults that may potentially be earthquake sources (Afnimar *et al.*, 2015). A morphometric analysis also shows that Bandung Area is surrounded by several active faults. They are Lembang faults in northern part and Ciparay faults in southern part (Emi *et al.*, 2012). This condition can trigger many problems, such as seismic hazard (Madrinovella *et al.*, 2013), volcanic activity, landslide induced by earthquake (Darana, 2014), and radioactive radiation (Kiyak *et al.*, 2014).

Stress in the crust change in accordance with crustal deformation due to tectonic activity. Concentrated stresses at some domains in the medium may not only create new micro cracks and act to expand the area and/or volume of pre-existing micro cracks, but also drive pore fluids to flow upward through a crack network when a vent-like path occurs in the network (Tsukuda, 2008). These cracks can trigger fluid (especially gasses) for coming out from deep underground in response to crustal activity. This kind of condition can increase the activity of natural radioactive elements that comes from the depth of the earth (Tsukuda *et al.*, 2005). Even Ueshima *et al.*, (2012) stated that the distribution of high gamma ray dose rates exists in a straight line of lineament. It means that tectonic activity related with the amount of radioactive emission. Therefore, this research aims to present data regarding natural radioactivity from a populated active faults area in the Bandung Highland, Indonesia. This research is conducted based on site – *in situ* measurements using a filed gamma spectrometer.

Geological Setting

The geological setting of Bandung High¬land region has been investigated by van Bemmelen (1949), Alzwar et al. (1992), Dam (1994), and Silitonga (2003). Based on their research, the region is mostly composed of Quaternary volcanic rocks. In general, the lithology consists of tuff, lapilli tuffs, volcanic breccia, and lava. Most of the volcanic rocks have been deformed. Several active faults trending east-west and north-south, control the geomorphology of the region. Geological map of research area is shown at Figure 1.

Several previous researchers have conducted research on active tectonics in the region. Two of them are Sukiyah (2006, 2009) and Sulaksana (2011). Based on the results of the study, the presence of active tectonics (neo-tectonics) can be determined through the analysis of watershed morphometry, a relatively high erosion rate, and the sinuosity of the mountain front approaching a value of 1. Development of active tectonics hav¬ing taken place until now are reflected by the results of morphometry analysis on the rocks composed of young and old age (Sulaksana, 2011).

Recent paleo-seismological study shows several evidences of near past activities of the fault. This study concluded that within last 2 kyrs, the Lembang fault has been capable in producing earthquake of ~ 6.8 and 6.6 magnitudes at about 2 and 0.5 kyrs BP respectively (Yulianto, 2011 in Afnimar *et al.*, 2015). In the other hand, a morphotectonic analyses research at the southern part of research area shows that there is an active fault. The research was based on the analyses of fractures population and river segments that develop on active fault zone. Measurement is undertaken on the azimuth directions of the number of fractures and river segments. Research methods used are fractures analysis and bifurcation ratio. The azimuth directions of fractures and river segments are analysed with statistic to get accurate verification. Result of research shows that area is controlled by active fault (Sukiyah, 2005). It can be conclude that research area is in the midst of active faults zone.

Gamma Dose Rates

Natural background radiation is the main source of exposure for the people on the Earth. Worldwide average effective dose rate from cosmic rays and terrestrial isotopes is about 2.4 mSv per year (UNSCEAR, 2000), nearly 85% of which comes from natural background radiation. Furthermore, this number is reduced to less than 1 mSv if man-made sources and the internal exposure to Radon daughters are excluded. This value may vary with location on the Earth and the activity concentrations of the radionuclides in soils are directly relevant to the outdoor exposure (Kiyak *et al.,* 2014).

Gamma dose rates were measured in several points that spread around the research area. Gamma dose rate was measured directly at each measurement point, ten times for 15 s each and then averaged. A total of 36 points were measured across the region on a 56.29 km2. In the meantime, a gamma spectrum was recorded at each site as well as gamma dose rate measurements, to calculate the relative contribution of terrestrial radioisotopes to effective dose rate.

MATERIALS AND METHODS

Gamma dose rate was measured using two types of gamma ray measurement equipment. The objects which measured were soil, volcanic rock, and limestone around Bandung. Gamma ray measurements, used a spectral survey meter TN-100 (No.132) made by Techno Inc. Epi and scintillation survey meter PA-1000 (No. SLPA2A28) made by Horiba, Ltd. The detection unit that Spectrum survey meter of TN-100 was used to measure, φ1 "x 1" which is NaI (Tl) scintillator and scintillation survey meter of PA-1000 was used to measure, φ1 "x 1" which is CsI (Tl) scintillator. Have been converted into 1cm dose equivalent rate counting rate, is displayed in μSv/h.

The measuring instrument is proof read in incorporated administrative agency National Institute of Advanced Industrial Science and Technology central part centre radiation measurement section to convert it into absorption dose rate (nGy/h) of the air. The measurement method was measured by placing the instrument on the ground. Measurement position was determined by longitude, latitude in the GPS. The amount of measurement location was 36 points that shown on the map (Figure 1). Measurement was performed on December 23-25, 2012.

RESULTS AND DISCUSSION

Faults in Research Area

There is not any outcrop evidence of geological structure in research area. Nevertheless, based on interpretation of lineaments which are generated from digital elevation method, there are some indicated faults in research area. Their orientation are east – west and north west - south east.

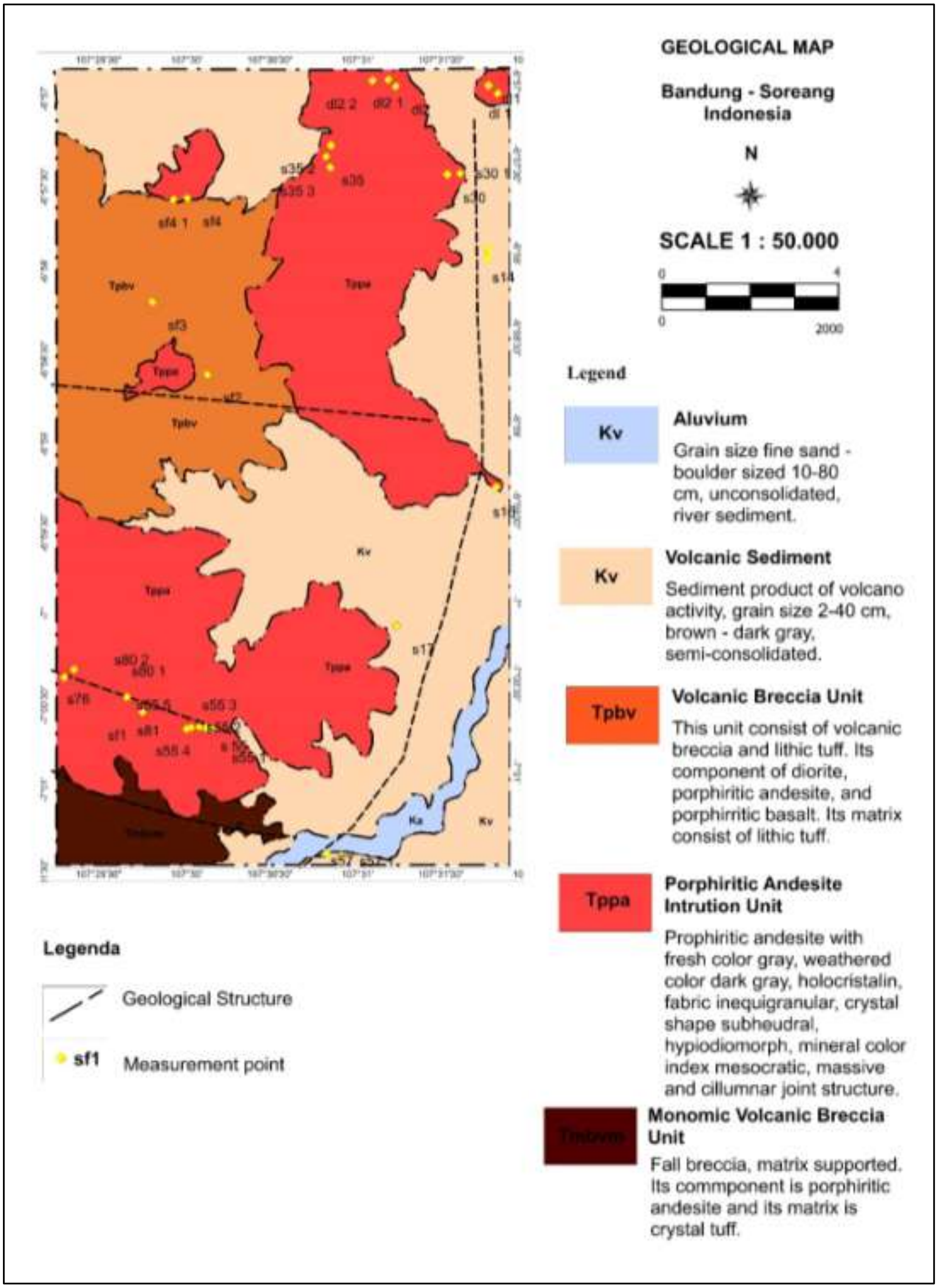

Figure 1: Geological Map of Research Area

Appearance of interpreted faults in research area is shown in figure 2. According to this map, it can be concluded that geomorphology of research area is influenced by geological structure. Geological structure in research area, i.e. faults, may affect the emission of gamma ray in research area.

Terrestrial Gamma Dose Rate in Fault Zone

Gamma dose rates measured in research area are presented in Table 1. Measurements were conducted at a total more than 30 points in the entire study area. Spatial distribution of gamma dose rate in research area and its relationship with faults are shown at Figure 3.

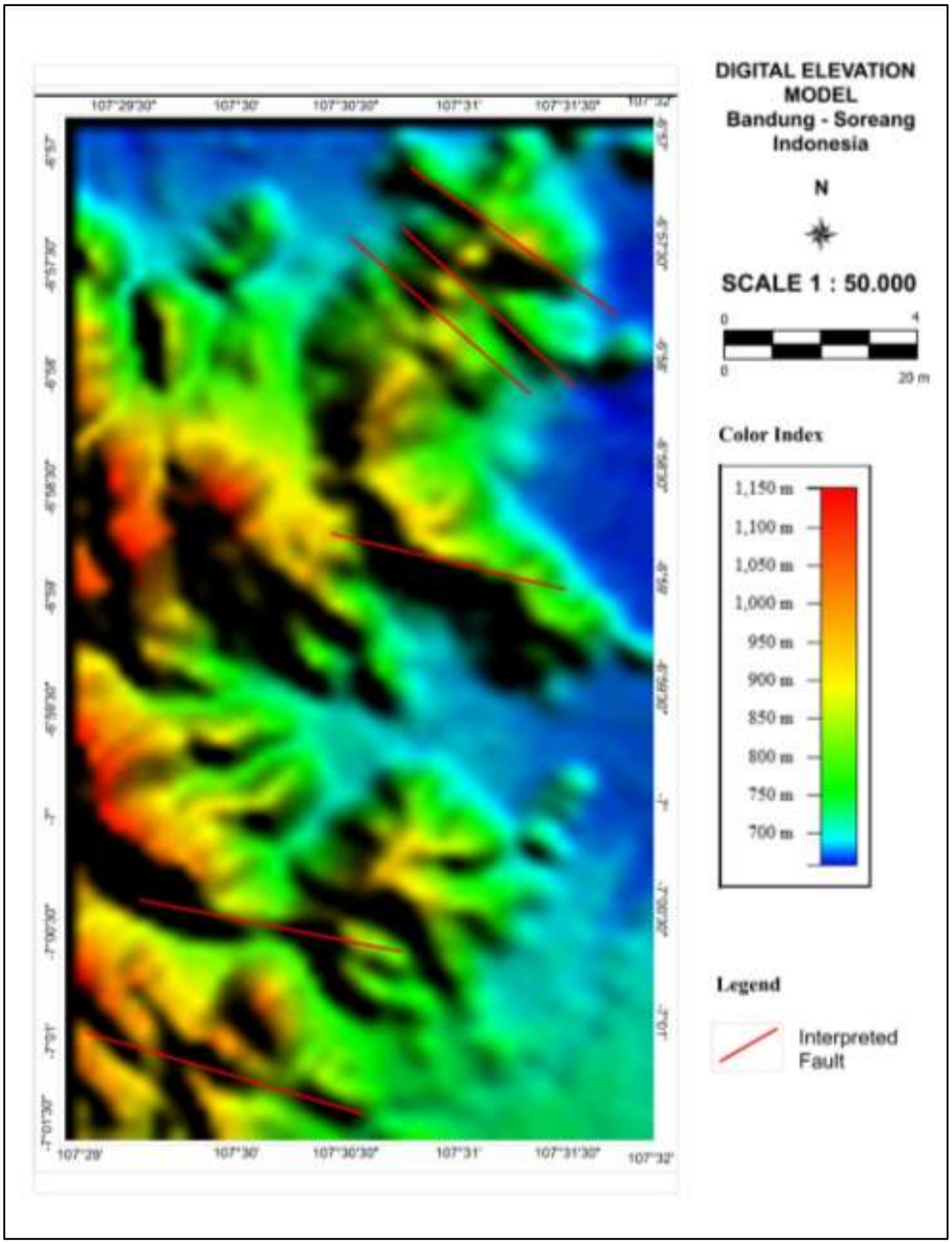

Figure 1: Elevation Model of Research Area

Table 1: Gamma Dose Rate Measured Across the Research Area

No.	Location	Gamma Ray Average µGy/h	Gamma Ray Average nGy/h
1.	s14	0.05	52.00
2.	s14 1	0.04	42.00
3.	s30	0.03	31.00
4.	s30 1	0.05	53.07
5.	dl 1	0.04	42.27
6.	dl1 1	0.05	51.07
7.	dl2	0.03	33.58
8.	dl2 1	0.04	43.67
9.	dl2 2	0.05	47.00
10.	s35	0.07	65.73
11.	s35 2	0.04	38.08
12.	s35 3	0.04	39.87
13.	s16	0.03	32.40
14.	s17	0.04	39.13
15.	s55 3	0.05	54.82
16.	s55 1	0.05	50.67
17.	s55 2	0.04	41.44
18.	s55 4	0.05	48.00
19.	s55 5	0.02	20.33
20.	s 55	0.05	48.89
21.	s57	0.03	29.07
22.	s57 1	0.03	28.21
23.	s76	0.03	25.93
24.	s80 2	0.02	21.47
25.	s80 1	0.08	79.08
26.	s81	0.05	45.44
27.	sf1	0.03	26.00
28.	sf2	0.04	35.00
29.	sf3	0.03	30.26
30.	sf4	0.04	36.50
31.	sf4 1	0.03	34.90
Average			40.87±12.79

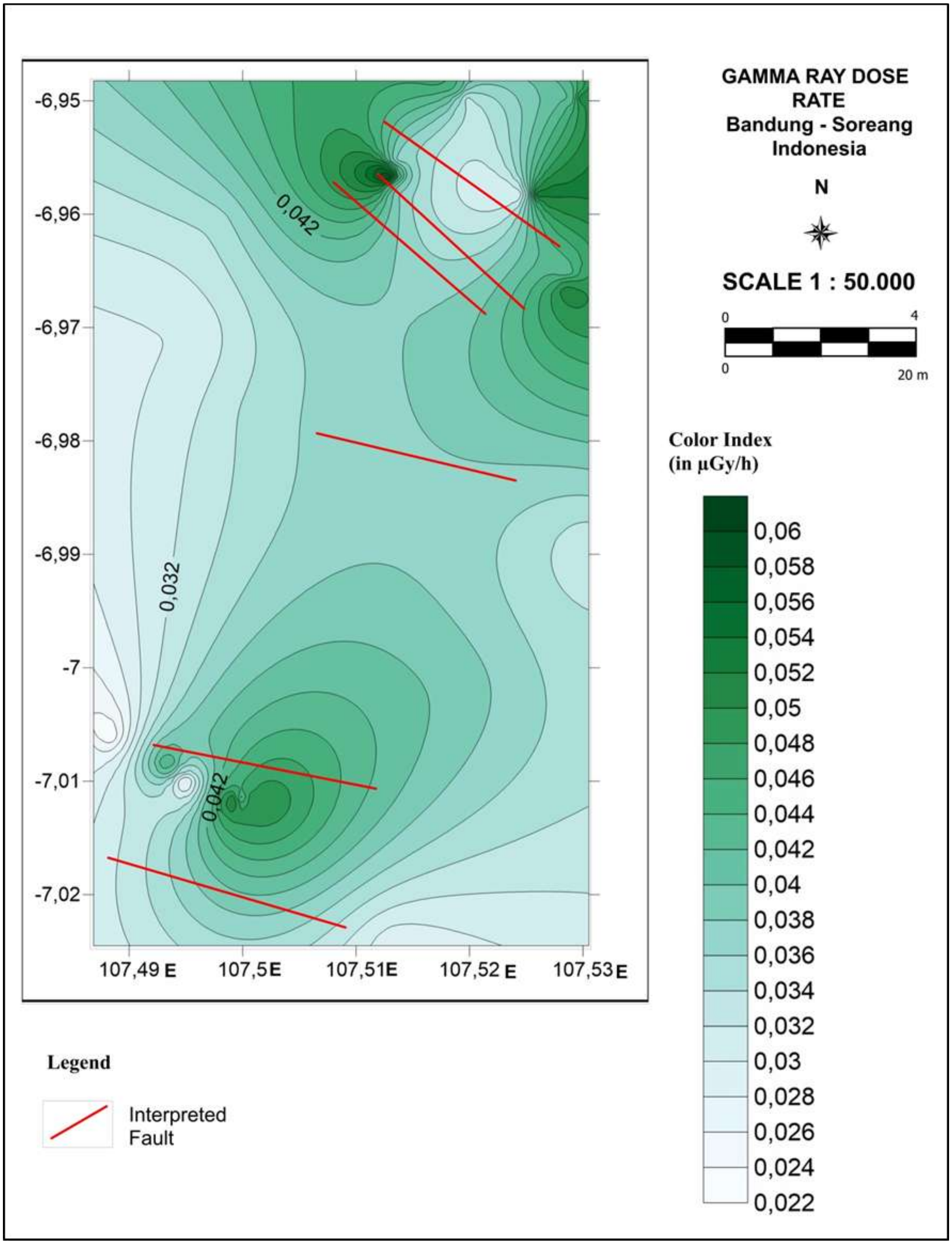

Figure 3: Gamma Ray Dose Rate of Research Area

From table 1, it is known that the gamma ray dose rates of Bandung-Soreang area are between 20, 33 –

79,07692 nGy /h, with average 40,86733 nGy/h and standard deviation only 12,79002 nGy/h. The standard deviation is more than 10%, it could be an anomaly from the rock itself.

The dose rates measured in each measurement point show relatively similar distribution as presented in Table 1. However, a significant difference in terrestrial gamma dose rates (consequently in faults area) was observed between them, as shown in Figure 3. As the gamma dose rates measured in North faults zone were ranging between 0,042-0,06 μGy/h, in South faults zone these values were between 0,042-0,06 μGy/h. From this map can be known that the rates of gamma ray became increase at fault zones. The value of gamma ray dose rate is lower outside of fault zone, for example is in east part of research area, the value of gamma dose rate is between 0.022-0.032 μGy/h. A similar study regarding outdoor gamma survey in faults area using the gamma spectrometer was previously conducted in Western Anatolia Fault Zone, Turkey (Kiyak, 2014). It also shows that the value of gamma ray dose rate became increase inside or near of fault zones.

CONCLUSION

Based on analysis of geological structure and measurement of gamma dose rate in research area, it can be concluded that:

• The geology and geomorphology of research area are influenced by geological structure, i.e. active faults.
• The orientations of active faults in research area are east – west and north west - south east.
• The values of gamma dose rate in research area are influenced by active faults.
• The nearer with active fault zone, the higher the values of gamma dose rate in research area.

It is also better if the next research uses the analysis of morphotectonic to interpret active faults in research area. Statistical analyses for determining the correlation between active faults and the value of gamma dose rate also should be conducted in future research.

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