The Identification of Fault Zones in Krueng Raya, Aceh Besar (Indonesia) Using Magnetic Method

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ABSTRACT

Many geophysical methods had been constructed to determine the faults distribution. One of them was the magnetic method. The study explores the use of the magnetic method as an alternative measurement device for fault detection and location in Krueng Raya, Aceh Besar (Indonesia). The magnetic survey was performed using G-856 proton magnetometer and the spacing between stations was 50 m to 100 m randomly. The magnetic data was processed by utilizing Microsoft excels and Surfer8 software which was displayed in a form of contouring and revealed fault zones. The local magnetic value covers -750 to 350 nT. The magnetic results showed the trend pattern of low residual value at north part and high residual value at south part of Krueng Raya which was indicated as fault zones. Geophysical results and geologic mapping indicated that the area is bounded by major faults.

KEYWORDS: Fault, magnetic, Krueng Raya, Aceh

INTRODUCTION

Krueng Raya is located in Aceh Besar district which is one of the areas affected by tsunami disaster and precisely at the line of Sumatra fault system. The Sumatra fault zone (SFZ) is the most active fault in Indonesia as a result of strike-slip component of Indo-Australian oblique convergence. With the length of 1900 km, Sumatra fault was divided into 20 segments starting from the southernmost Sumatra Island having small slip rate and increasing to the north end of Sumatra Island as shown in Figure 1 (Prawirodirdjo et al., 2000). Fault zone is the area in the earth crust located at the boundary of two tectonic plates. The movement of rocks and the plates at fault zone usually induces earthquakes. Minerals are the building blocks of rocks. They are non-living, solid and like all matter, are made of atoms of elements. Minerals form through natural processes within the earth, including volcanic eruptions, precipitation of a solid out of a liquid, and weathering of pre-existing minerals (Tunell et al., 1928). By identifying the minerals present in a given rock, geologists can begin to understand the history of that rock. In this paper, magnetic method was applied to the village of Krueng Raya, Aceh Bear (Indonesia). The magnetic investigation, aimed at locating and imaging fault zones as critical steps in evaluating the earthquake potential of the region.

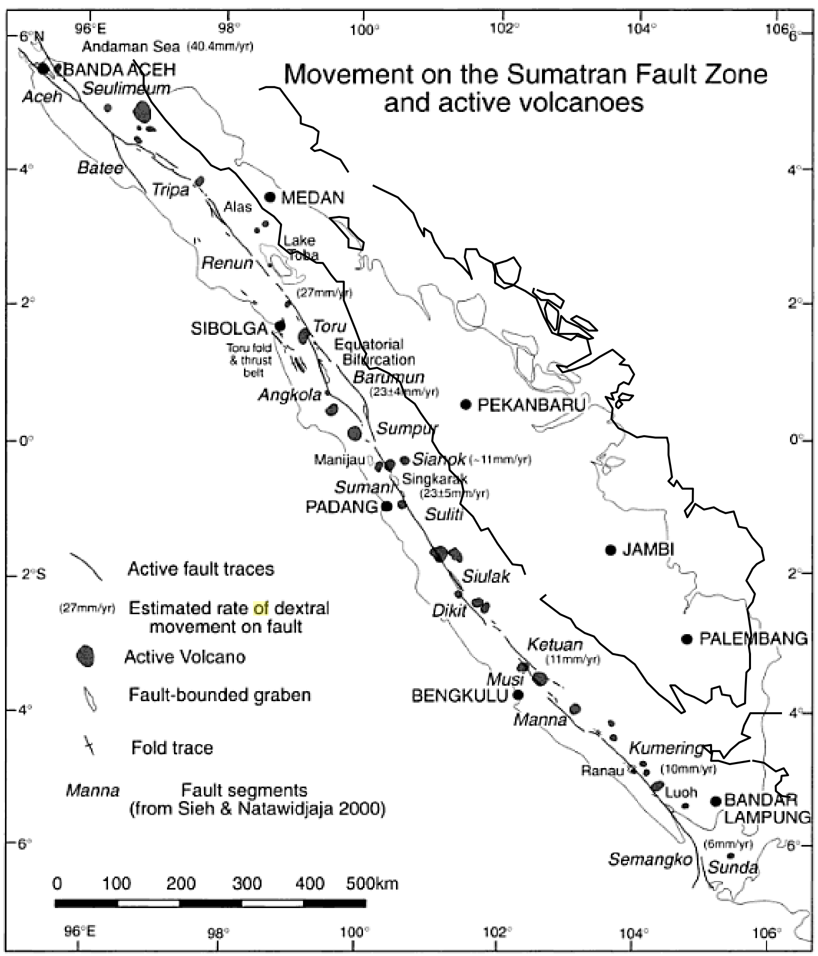

Figure 1: The great Sumatra fault zone (SFZ) is; a) a trench parallel, right-lateral strike-dip fault and b) divided into 20 fault segments.

MECHANISM OF FAULTING

In geology, a fault is a planar fracture or discontinuity in a volume of rock, across which there has been significant displacement along the fractures as a result of earth movement. Large faults within the Earth's crust result from the action of plate tectonic forces, with the largest forming the boundaries between the plates, such as subduction zones or transform faults. Energy release associated with rapid movement on active faults is the cause of most earthquakes. A fault line is the surface trace of a fault, the line of intersection between the fault plane and the Earth's surface. Since faults do not usually consist of a fracture, geologists use the term *fault zone* when referring to the zone of complex deformation associated with the fault plane (McKnoight, 2000). Geologists categorize faults into three main groups based on the sense of slip (Figure 2):

a) Dip-slip fault

Dip-slip faults can occur either as "reverse" or as "normal" faults. A normal fault occurs when the crust is extended. Alternatively such a fault can be called an extensional fault. The hanging wall moves downward, relative to the footwall. A downthrown block between two normal faults dipping towards each other is called a graben. An upthrown block between two normal faults dipping away from each other is called a horst. Low-angle normal faults with regional tectonic significance may be designated detachment faults. A reverse fault is the opposite of a normal fault-the hanging wall moves up relative to the footwall. Reverse faults indicate compressive shortening of the crust. The dip of a reverse fault is relatively steep, greater than 45°.

b) Strike-slip fault

The fault surface is usually near vertical and the footwall moves either left or right or laterally with very little vertical motion. Strike-slip faults with left-lateral motion are also known as *sinistral* faults. Those with right-lateral motion are also known as *dextral* faults. Each is defined by the direction of movement of the ground on the opposite side of the fault from an observer.

c) Oblique fault

A fault which has a component of dip-slip and a component of strike-slip is termed an oblique-slip fault. Nearly all faults will have some component of both dip-slip and strike-slip, so defining a fault as oblique requires both dip and strike components to be measurable and significant. Some oblique faults occur within transtensional and transpressional regimes, others occur where the direction of extension or shortening changes during the deformation but the earlier formed faults remain active.

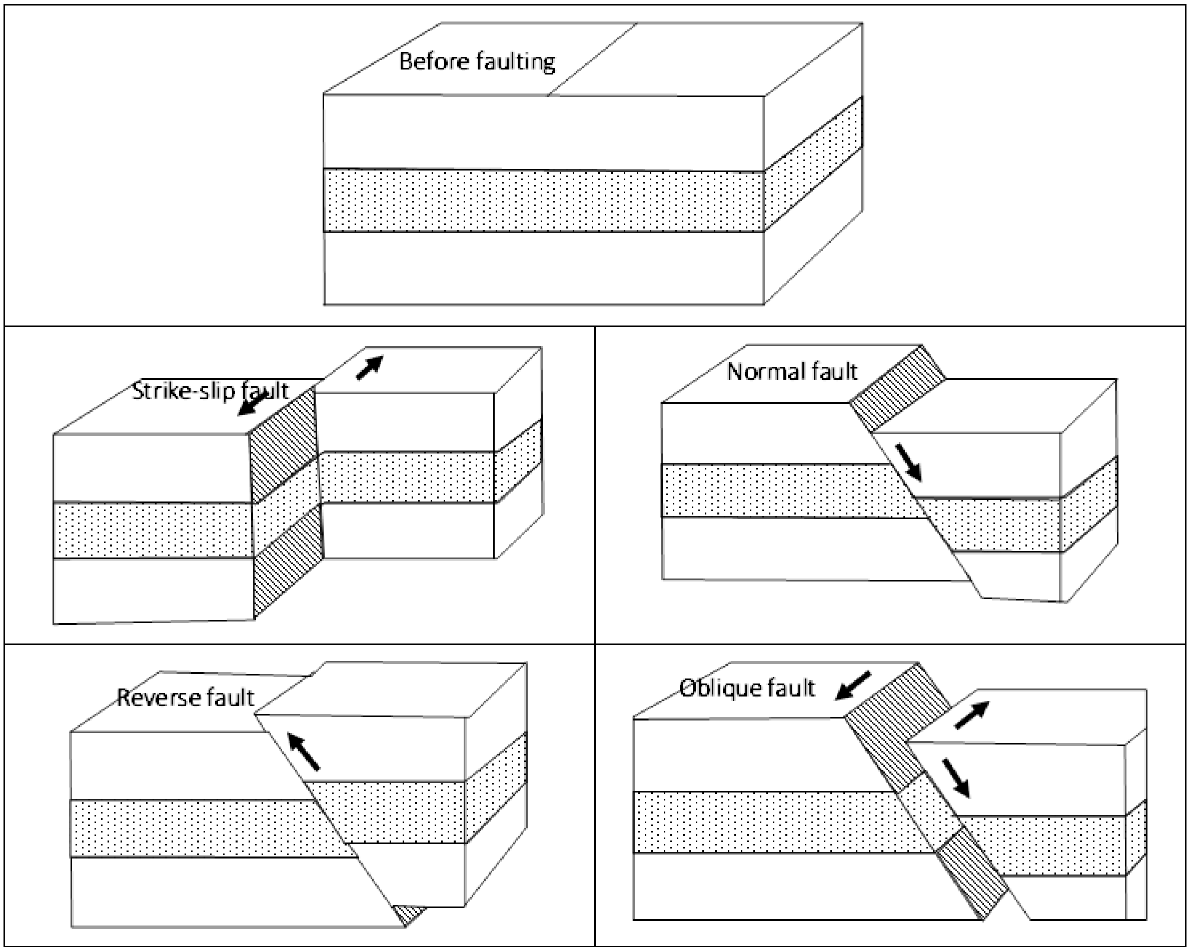

Figure 2: Types of faults

GENERAL GEOLOGY

The regional geology of Aceh Besar Quadrangle has been mapped by Bennet et al., 1981 (Figure 3). Lithology of Krueng Raya is dominated by Lam Teuba volcanic composed of andesitic to dacitic volcanics, pumiceous breccia, tuffs, agglomerate and ash flows which intruded of the Seulimum formation composed of tuffaceous and calcareous sandstones, conglomerates and minor mudstones (Bennett et al., 1981). The prospect area is near the Raya mount and Ie se'uem hotspring. It forms a topographic depression, occupied by alluvial flat and low, flat-topped hills within the Barisan Range, a rugged mountain range that runs along the entire western edge of the island of Sumatra. Following closely the crest of the Barisan Range is a continuous system of axial valleys, including the Kr. Tangse valleys, which marks the outcrop of the main fault line of the Sumatra fault system. This is essentially a right lateral fracture system (Katili and Hehuwat, 1967; Page et al., 1979). The area is controlled by two main faults system, with orientation NW to SE. The topographic morphology of the Krueng Raya is subdued because the rocks are strongly fractured and altered.

Figure 3: Geology map of the study area.

Figure 4: Study area of magnetic survey at Krueng Raya, Aceh Besar (Indonesia).

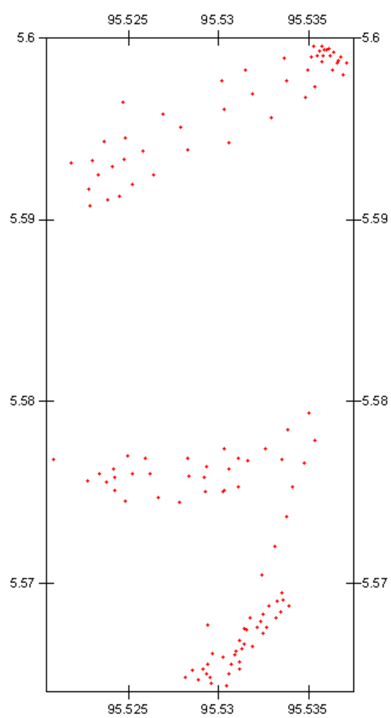

Figure 5: Magnetic stations of Krueng Raya area.

THEORY OF GEOPHYSICAL METHODS

The magnetic method measures the intensity of the natural magnetic field. This includes contribution from the earth's core and crust, as well as any secondary magnetic field induced in magnetic geological bodies, which locally creates positive and negative magnetic field anomalies. Those anomalies are the target of a magnetic survey for geological purposes.

METHODOLOGY

The magnetic survey was carried out with scattered moving station with interval of 50 m to 100 m interval in order to detect the subsurface structure. The used system is designed to measure the total field and/or gradient field, and is essentially proton precession devices. The measured independent grid was later combined to form a single master grid. The master grid provided a full magnetic map for easy display of the anomalies and allows the data to be processed using Surfer8 software. A base station with magnetic homogeneity was selected within the study area to recorded magnetic readings at a time interval of 1 minute to correct the diurnal variation effects of the earth's field from survey measurements. The magnetic survey covered most of the area, except some locations due steel fancies and thick jungle in the area. Base station data was used to correct the moving data, and finally, a total intensity magnetic anomaly map was produced, reflecting the subsurface structure. Magnetic data alone gives a general idea about the subsurface structures affecting the study area. Processing the magnetic data enhances and sharpens the anomalies and trends of the data and helps in the interpretation. In this work, we will apply two techniques in order to estimate the locations of the subsurface faults. First step in magnetic processing was inspecting raw data for spikes, gaps, instrument noise or any irregularities in the data. The next step involved diurnal variation correction and IGRF correction to produce magnetic residual. Once corrections were done, the data were exported into a grid file to the Surfer8 software. After calculating a grid from xyz data in Surfer8, magnetic residual was carried out to compare the difference between a grid value and the new data at any definite location of the site.

RESULTS AND DISCUSSION

Magnetic results show lateral view of the faulting system in the study area (Figure 6). The local magnetic value covers -750 to 350 nT. The total intensity magnetic anomaly map of Krueng Raya, Aceh Besar (Indonesia) shows low magnetic anomalies over northern part and high magnetic anomalies over southern parts of the area, which indicate the presence of fault covering these parts, since the geological surface does not reflect the presence of any faults. Hence, the trend pattern of lower magnetic values than the surrounding could be due to the presence of fault beneath the surface (black dashed lines).

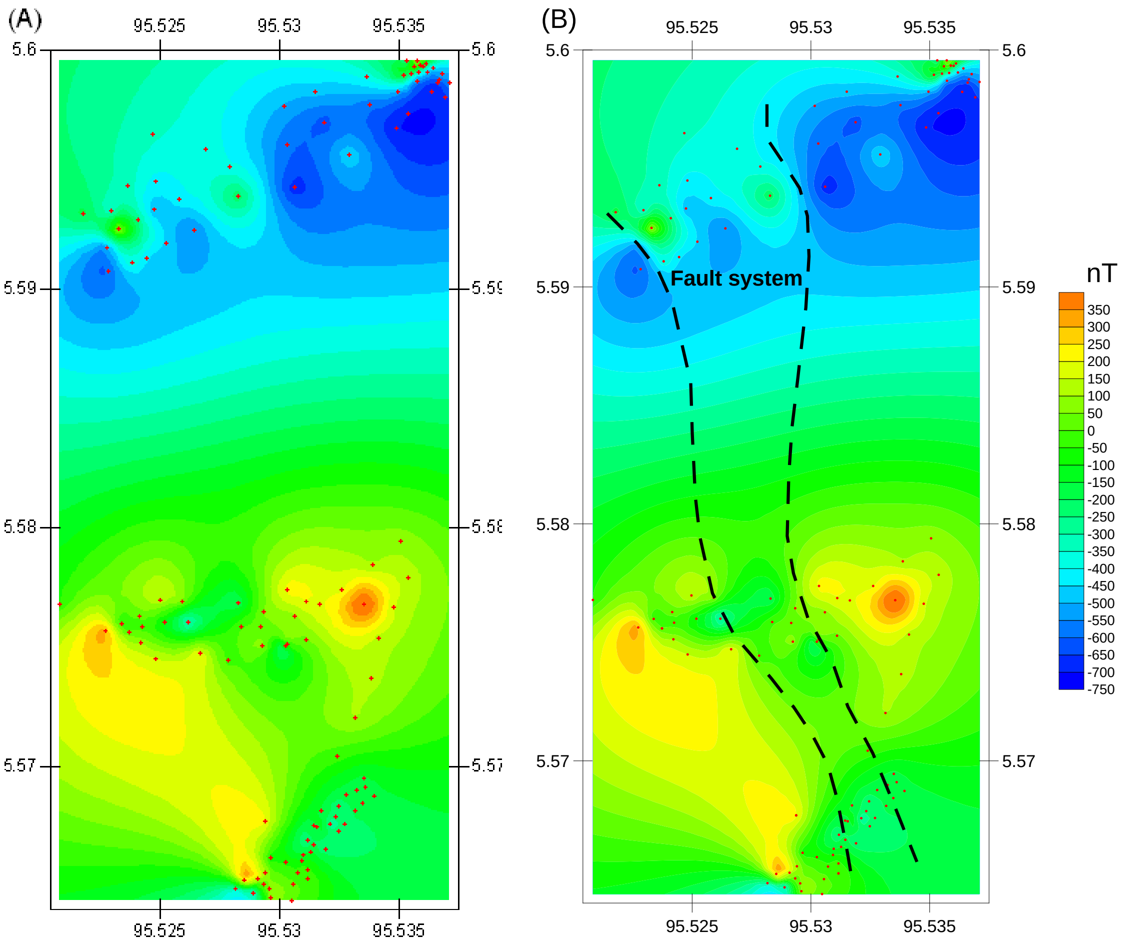

Figure 6: Magnetic anomaly in Krueng Raya; a) local residual b) fault system.

CONCLUSSION

The magnetic results supported with geological map suggested the existence of several small fault plans in the study area. It is clear that the main trend of the two faults in the study area is in the NW-SE direction. However, in some locations, the magnetic results are not matched with geological map, which could be interpreted due to the limitations of the site constrains. Application of magnetic method can be easily determine the fault zones as well as the subsurface characterization in the study area

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