International Journal of Engineering Innovation & Research
Volume 3, Issue 4, ISSN: 2277 – 5668

Characterizing Features of Faults using Magnetic Method: Preliminary Results in Seulimeum Fault, Aceh Besar (Indonesia)

M.M. Nordiana, Rosli Saad, Nur Aminuda Kamaruddin, Muhammad Syukri and I.N. Azwin

***Abstract* – The purpose of this study is to characterize the Seulimeum fault system in Krueng Raya, Aceh Besar (Indonesia) using magnetic method. The magnetic survey was performed using G-856 proton magnetometer and the spacing between station was 50-300 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 -700 to 650 nT. The magnetic results showed the trend pattern of low residual value at north part and a lot of spotted high residual value surround Krueng Raya which was indicated as fault zones. Magnetic results and geologic mapping indicated that the area is bounded by major faults.**

***Keywords* – Aceh Besar, Fault, Magnetic, Seulimeum.**

I. INTRODUCTION

Magnetic surveys are useful tool for geophysicicists interested in mapping fault. The results of the survey can aid in better characterizing the subsurface geologic framework of the study area, which has important implications for hotspring or mineral studies.

The horizontal extent of faults can be interpreted from linear anomalies that occur in high-resolution magnetic data. These anomalies are produced by the magnetic contrast between adjacent layers of rock with differing magnetic susceptibility values. It is important to note that magnetic contrast can arise both in faulted and non-faulted rock. In order to locate "true" faults, magnetic anomalies are typically examined in the context of other data (e.g. geologic surface mapping, aeromagnetic data, time-domain electromagnetic data and magnetotelluric data) [1].

Located in Krueng Raya, Aceh Besar (Indonesia), Seulimeum fault is one of the fault segment included in Sumatra fault zone (SFZ). Furthermore, due to the magnetic susceptibilities contrast, this region offers a unique pattern of magnetic surveys in delineating shallow features.

II. SUMATRA FAULT ZONE

Krueng Raya is located in Banda Aceh 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, Sumata 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 Fig. 1 [2].

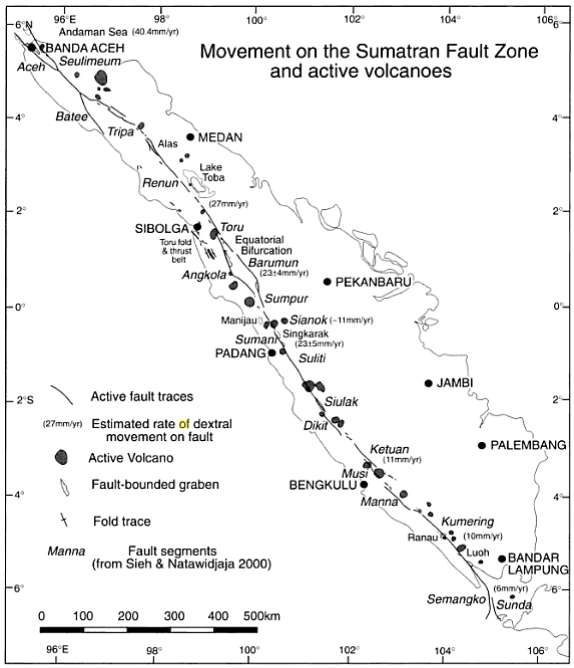

Fig.1. The great Sumatra fault zone (SFZ) is; a trench parallel, right-lateral strike-dip fault and divided into 20 fault segments [2].

III. GENERAL GEOLOGY

The regional geology of Banda Aceh Quadrangle has been mapped by [3] (Fig. 2). The Krueng Raya lithology is dominated by Lam Tuba volcanic, composed of andesitic to dacitic volcanics, pumiceous breccia, tuffs, agglomerate and ash flows which intruded of the Seulimeum formation composed of tuffaceous and calcareous sandstones, conglomerates and minor mudstones [3]. 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 Sumatera Island. 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 Sumatran fault system. This is essentially a right lateral fracture system [4] and [5]. 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.

International Journal of Engineering Innovation & Research
Volume 3, Issue 4, ISSN: 2277 – 5668

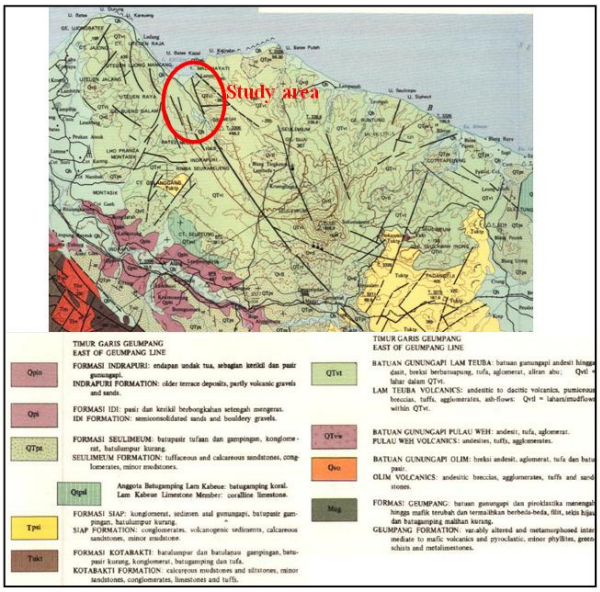

Fig.2. Geology map of the study area.

IV. Previous Work

The Seulimeum fault is one of the segments of Sumatran fault which split at the Aceh Province. [6] aimed to verify the Seulimeum fault which located at Northern Sumatra, Indonesia. Three survey lines of resistivity method were carried out covering Krueng Raya district using Pole-dipole array with 20 m minimum electrode spacing. The study was carried out in the area of Krueng Raya which located at the Banda Aceh province. Three survey lines were conducted, KR1-KR3 across the fault system with the orientation to the east. Total length of KR1, KR2 and KR3 are 2120 m, 900 m, and 800 m respectively. The data processed using Res2Dinv and result presented using Surfer shows two major areas of overburden and bedrock. The layer of overburden consists of alluvium with resistivity value of 10-800 Ωm located at a depth <150 m. Meanwhile the bedrock shows the resistivity value of >140 Ωm. The contrast between low and high resistivity value indicates fault with the depth >600m

V. Study Area

The study was carried out in the area of Krueng Raya, Banda Aceh (Indonesia) with area of 6 km x 8 km (Fig. 3). The magnetic survey was carried out with random moving station. The distance was set at 50-300 m to cover the survey area (Fig. 4).

Fig.3. The magnetic survey at Krueng Raya, Banda Aceh (Indonesia) [6].

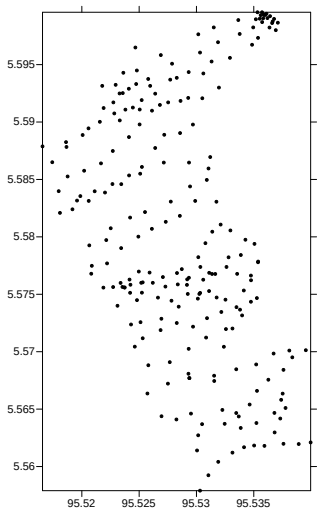

Fig.4. Magnetic stations of Krueng Raya area.

VI. Methodology

The magnetic survey was carried out with scattered moving station with interval of 50 m to 300 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.

VII. Results and Discussions

Ground magnetic data can more easily overemphasize shallow features, the data may suggest the presence of

faults when instead the anomaly is being produced due to variations in magnetic susceptibility. Thus, it is important to evaluate the results of these profiles in conjunction with other data types. Whereas depth estimates cannot be generated from these data, an analysis of these profiles can help determine the horizontal location of possible magnetic contrast.

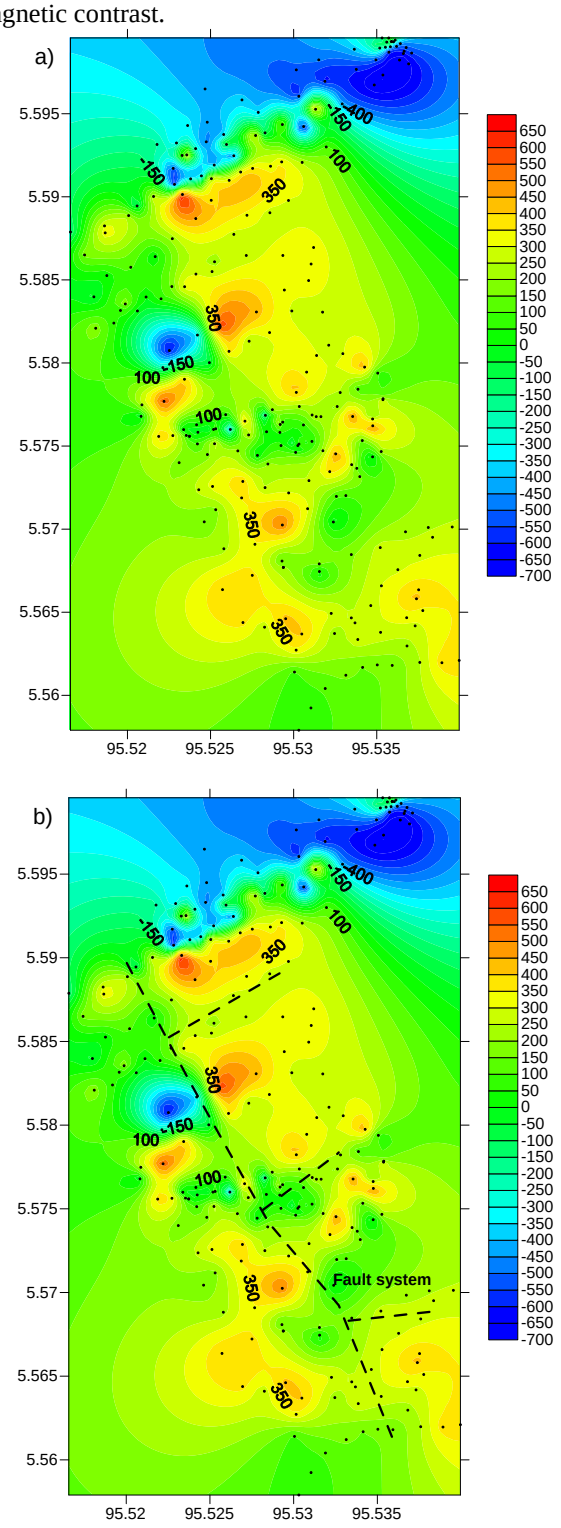

Fig. 5. Magnetic anomaly in Krueng Raya a) local residual and b) fault system.

The data was plotted as a contour map using Surfer8 software and was displayed in nanoteslas (nT). Magnetic results show lateral view of the faulting system in the study area (Fig. 5). The local magnetic value covers -700 to 650 nT. The total intensity magnetic anomaly map of Krueng Raya, Banda Aceh (Indonesia) was characterized by low magnetic anomalies over northern part and high magnetic anomalies spotted surrounding of the area, which indicate the presence of fault covering these parts. Potential faults location are depicted as linear nortwest to southeast trending features due to the the trend pattern of lower magnetic values than the surrounding (black dashed lines). From the magnetic maps, several of the anomalies can be clearly correlated with geological map.

VIII. Conclusion

The magnetic results supported with geological map suggested the existence of several small fault in the study area. It is clear that the main trend of the Seulimeum faults in the study area is in the NW-SE direction. Application of magnetic method can be easily characterized of fault zones in the study area.

Acknowledgment

The authors thank the member of Geophysics group, Universiti Sains Malaysia (USM), Penang, Malaysia, students and staffs of Faculty of Sciences and Faculty of Engineering, Syiah Kuala University (UNSYIAH), Banda Aceh (Indonesia) who helped acquire the geophysical field data.

References

[1] L.E. Howell, Characterizing shallow intrasedimentary faults using magnetic depth estimation methods: Preliminary results of a high resolution aeromagnetic survey at the San Luis Basin, south-central Colorado, 2010.

[2] L. Prawirodirdjo, Y. Bock, J. F. Genrich, S. S. O. Puntodewo, J. Rais, C. Subarya, and S. Sutisna, "*One century of tectonic deformation along the Sumatran fault from triangulation and Global Positioning System surveys*," Journal of Geophysical Research, Vol. 105, No. 28, 2000, pp 343–28, 363.

[3] J. D. Bennett, D. McC Bridge, N. R. Cameron, A. Djunuddin, S. A. Ghazali, D. H. Jeffrey, W. Kartawa, W. Keats, N. M. S. Rock, S. J. Thomson and R. Whandoyo, *Geologic map of the Banda Aceh Quadrangle, Sumatra*, 1981.

[4] J. Katili and F. Hehuwet "*On the occurrence of large transcurrent faults on Sumatra Indonesia: Osaka, Japan*", Osaka City University Journal of Geoscience, Vol. 10, 1967, pp 1-17.

[5] B. G. N. Page, J. D. Bennett, N.R. Cameron, D. Bridge, D. II. McC Jeffery, W. Keats and J. Thaib, "*A review of the main structural and magmatic features of northern Sumatra*," Journal of Geological Society of London, Vol. *1*, 36, 1979, pp 569-579.

[6] K. Nur Aminuda, M. Syukri, S. Rosli, M.M. Nordiana, Marwan. (2014), "*Seulimeum Fault Verification Using 2-D Resistivity Imaging,"* Electronic Journal of Geotechnical Engineering (EJGE), *19*, Bund A.

[7] Google earth, 2013.

AUTHOR'S PRIOFILE

Muztaza M. Nordiana

was born in Johor Bahru, Malaysia, on January 25, 1986. She was graduated BSc (2008) and M.Sc. (2010) in Applied Science (Geophysics) at Universiti Sains Malaysia (USM), Malaysia. She is lecturer at the same university. She is also conducting and teaching undergraduate and postgraduate students in their final year and research projects.

She has experienced working in field that involves engineering and environmental projects including slope, engineering and groundwater in all Peninsular Malaysia including Sarawak, Labuan and Brunei. Her research interest is about Geophysics in mineral exploration, engineering and environmental study.

Dr. Nordiana is a member of European Association of Geoscientists & Engineers (EAGE) and Geological Society of Malaysia. She was obtained fellowship from USM. She was a recipient of the Student Travel Grant Saint Petersburg 2012 sponsor by EAGE Student Affairs. She has published several journals and refereed proceeding papers. She was also received best paper award, best presenter and 3rd prize for national three minutes thesis competition 2014.

Email: mmnordiana@usm.my

S. Rosli

was born in Penang, Malaysia, on 28th February 1960. He is a senior lecturer in Geophysics section, School of Physics, Universiti Sains Malaysia (USM). He obtained his B.Sc from Universiti Sains Malaysia in 1984, M.Sc from USM in 2004 and was awarded a Ph.D. in 2009 from USM. He has served at USM since year 1985.

Prior joining USM, he worked as Tutor in Matriculation Centre USM and School of Physics, USM. His current research activities are Engineering and Environment. He expertise is in Electrical method (2D/3D resistivity/ IP/ SP), Seismic (Refraction and Reflection), Ground Penetrating Radar, Magnetic and Gravity.

Dr. Rosli is a registered member of Institute of Geology Malaysia, Committee member of 2002 One day Geophysics Conference and secretary of 2006 Geophysics conference. He has published several books and more than 80 journals and conference papers.

Email: rosli@usm.my

Kamarudin N. Aminuda

was born in Kelantan, Malaysia, on December 1, 1990. She was graduated BSc (2012) in Applied Science (Geophysics) at Universiti Sains Malaysia (USM), Malaysia.

She has experienced working in field that involves engineering and environmental projects.

Ms. Nur Aminuda is a member of European Association of Geoscientists & Engineers (EAGE) and Geological Society of Malaysia. She has published several journals and refereed proceeding papers.

Email: aminudakamaruddin@gmail.com

M. Syukri

was born Medan, Indonesia, in 1970. He received the B.Sc. degree in Physics from the Sepuluh Nopember Institute of Technology (ITS), Surabaya, Indonesia, and M.Eng. in Applied Geophysics from Bandung Institute of Technology (ITB) Indonesia, and received Ph.D. degree in Geophysics Section, School of Physics, Universiti Sains Malaysia (USM), Malaysia, in 2006. In 1993, he joined the Department of Physics, Faculty of Sciences, Syiah Kuala University (SKU), as a Lecturer.

He is responsible for carrying out teaching and research duties. He lectures Environmental Physics, Thermodynamics, Introductory Geophysics, and Environmental and Engineering Geophysics at the university. He is involved in the administration of degree and postgraduate courses as well as responsible for organizing lectures and supervising final project, seminars and tutorials.

Dr. Syukri current research interests include applied and environmental geophysics. He is a member of the Indonesian Geophysics Association (IGA) and Indonesian Physics Association (IPA).