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Seulimeum Fault Verification Using 2-D Resistivity Imaging

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ABSTRACT

2-D resistivity method is a common geophysical method which used to determine near surface structures such as faults, cavities, voids and sinkholes. The survey aimed to verify the Seulimeum fault which located at Northern Sumatra, Indonesia. This Seulimeum fault is one of the segments of Sumatran fault which split at the Aceh Province. Three survey lines of resistivity method were carried out covering Krueng Raya district using Pole-dipole array with 20 m minimum electrode spacing. The data processed using Res2Dinv and result presented using Surfer shows two major areas of overburden and bedrock. Fault was found with depth >600 m.

KEYWORDS: Fault, Seulimeum, pole-dipole, 2-D resistivity, Krueng Raya.

INTRODUCTION

Sumatra fault, the large strike-slip fault running the entire Sumatra Island (Indonesia) is an active fault. This fault zone accommodates most of the strike-slip motion associated with the oblique convergence between the Indo-Australian and Eurasian plates. With the length of 1900 km, Sumatra fault was divided into 20 segments starting from the southernmost which has small slip rate and increasing to the north end of Sumatra Island. Historical earthquake along Sumatran fault have been documented well since 1980 and showing that there is correlation between segmentation of the fault and location of the earthquake in the past ruptures (Natawidjaja et al., 2006). A giant earthquake that strokes the Sumatran fault following by large tsunami on 2004 and triggered aftershock events not only the subduction interplate but also in some segments on the Sumatran fault (Nurhasan, 2011).

In the Aceh province, the fault system was split into two subparallel fault lines, the Anu Batee fault and the Lam Teuba-Baro Fault (Bennett et al., 1981) also named as Aceh-Fault and Seulimeum Fault. The Seulimeum Fault cuts the Lam Teuba volcanic and strongly disrupts the Tertiary sediments to the south-east, where it has an element of downthrows to the northeast. Geomorphic features show that the Seulimeum fault has been actives recently. As it cuts through Plio-Pleistone sediments and volcanic products of the active Seulawah Agam volcano; hot spring occur at its southern end. The fault transects and displaces the axial traces of east-west trending folds affecting Pliocene deposits with the southwest side of the fault having moved northwestwards (Bennett et al., 1981).

GENERAL GEOLOGY

The Krueng Aceh valley is bounded to the south-west by the Aceh fault and to the northeast by the Seulimeum fault. The volcanic of Pleistocene to Holocene age cover most of the North coast foothills on the side of the Seulimeum fault. Within the upper Krueng Aceh valley, the tertiary rocks are covered by up to 500 m thick with Plio-Pleistocene semi-consolidated calcareous and tuffaceous sandstones. From upstream of the town of Jantho to downstream of the town of Indrapuri, the Pleistocene coarse-grained partly volcanic sands and gravels form a prominent terrace surface on either side of the Krueng Aceh. These older terrace deposits may attain a thickness of up to 75 m. The alluvium near the coast of the city of Banda Aceh extends to a depth of more than 200 m below ground level becoming thinner upstream (Bennett et al., 1981).

The lithology of the Aceh province consists of sedimentary and metamorphic rocks from Late Paleozoic to Quaternary age, including young volcanic. The Paleozoic and Mesozoic rocks to the southwest of the Anu Batee fault comprise metasiltstone, slates and recrystallized marble. To the northeast of the fault line, Tertiary and Quaternary sediments occur. The Tertiary basins consist of consolidated to semi-consolidated calcareous or tuffaceoussandstone, silt and mudstones, local intercalations of limestone and were deposited in a marine environment (Bennett et al., 1981).

STUDY AREA

The study was carried out in the area of Krueng Raya which located at the Banda Aceh province (Figure 1). 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.

Figure 1: Resistivity survey lines at Krueng Raya.

THEORY OF GEOPHYSICAL METHODS

During a resistivity survey, electrical current is applied to a pair of current electrodes and the potential difference (voltage) is measured between one or more pairs of potential electrodes. For a 2-D resistivity survey, the current and potential electrodes are generally arranged in a linear array

(Figure 2). Common array types include Wenner, Schlumberger, Pole-pole, Dipole-dipole, Pole-dipole array.

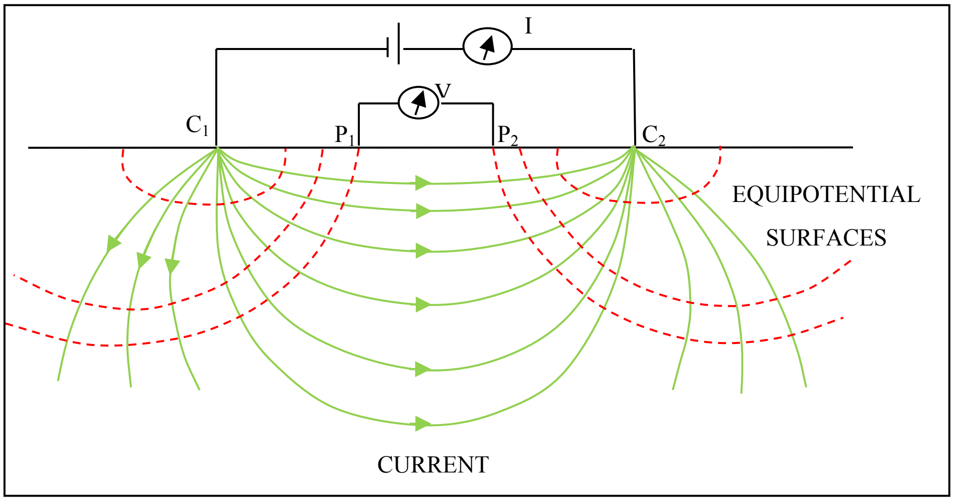

Figure 2: Four-point electrode configuration in a two-layer model of resistivity, ρ_1 and ρ_2. I, current; U, voltage; C, current electrode; P, potential electrode (Modified from Said, 2007).

The apparent resistivity is the bulk average of all soils and rock influencing the applied current. It is calculated by dividing the measured potential difference by the input current and multiplying by a geometric factor specific to the array being used, as well as electrode spacing. The ground resistivity is related to various geological parameters such as mineral and fluid content, porosity and degree of water saturation in the rock. Variations in electrical resistivity may indicate changes in composition, layer or contaminant levels (Loke, 1994). Age of the rock is also important for the resistivity values. Table 1 shows the variation of resistivity value of rocks with the ages.

Table 1: Resistivities (Ω-m) for water-bearing rocks (Keller, 1966)

Geologic age	Marine sand, shale, graywacke	Terrestrial sands, claystone, arkose	Volcanic rocks (basalt, rhyolite, tuffs)	Granite, gabbro etc.	Limestone, dolomite, anhydrite, salt
Quaternary, Tertiary	1-10	15-50	10-200	500-2 000	50-5 000
Mesozoic	5-20	25-100	20-500	500-2 000	100-10 000
Carboniferous	10-40	50-300	50-1 000	1 000-5 000	200-100 000
Pre-Carboniferous Paleozoic	40-200	100-500	100-2 000	1 000-5 000	10 000-100 000
Precambrian	100-2 000	300-5 000	200-5 000	5 000-20 000	10 000-100 000

METHODOLOGY

The 2-D resistivity survey was conducted using ABEM SAS4000 Terrameter, smart cables with 10 m takeout spacing and stainless steel electrodes. The survey used Pole-dipole array with spacing 20m apart which make up total spread length of 800 m. 2-D resistivity data was modeled using Res2Dinv software. The data processed involving "Standard processing" and "Standard processing with mathematical data extrapolation". The data were then outputted into Surfer software for gridding, contouring and final presentation.

RESULTS AND DISCUSSION

Figure 3-5 show the resistivity result of KR1, KR2 and KR respectively. Generally, the study areas are divided into two main layer, 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. Figure 6 shows the fault system detected by 2-D resistivity method.

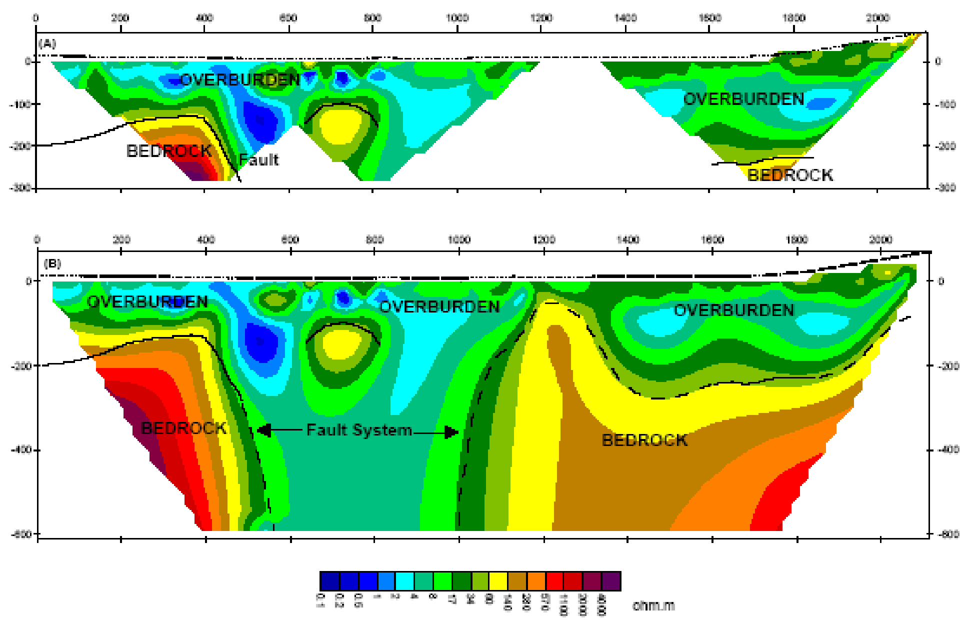

Figure 3: Resistivity pseudosection of KR1; a) Standard processing, b) Standard processing with mathematical data extrapolation.

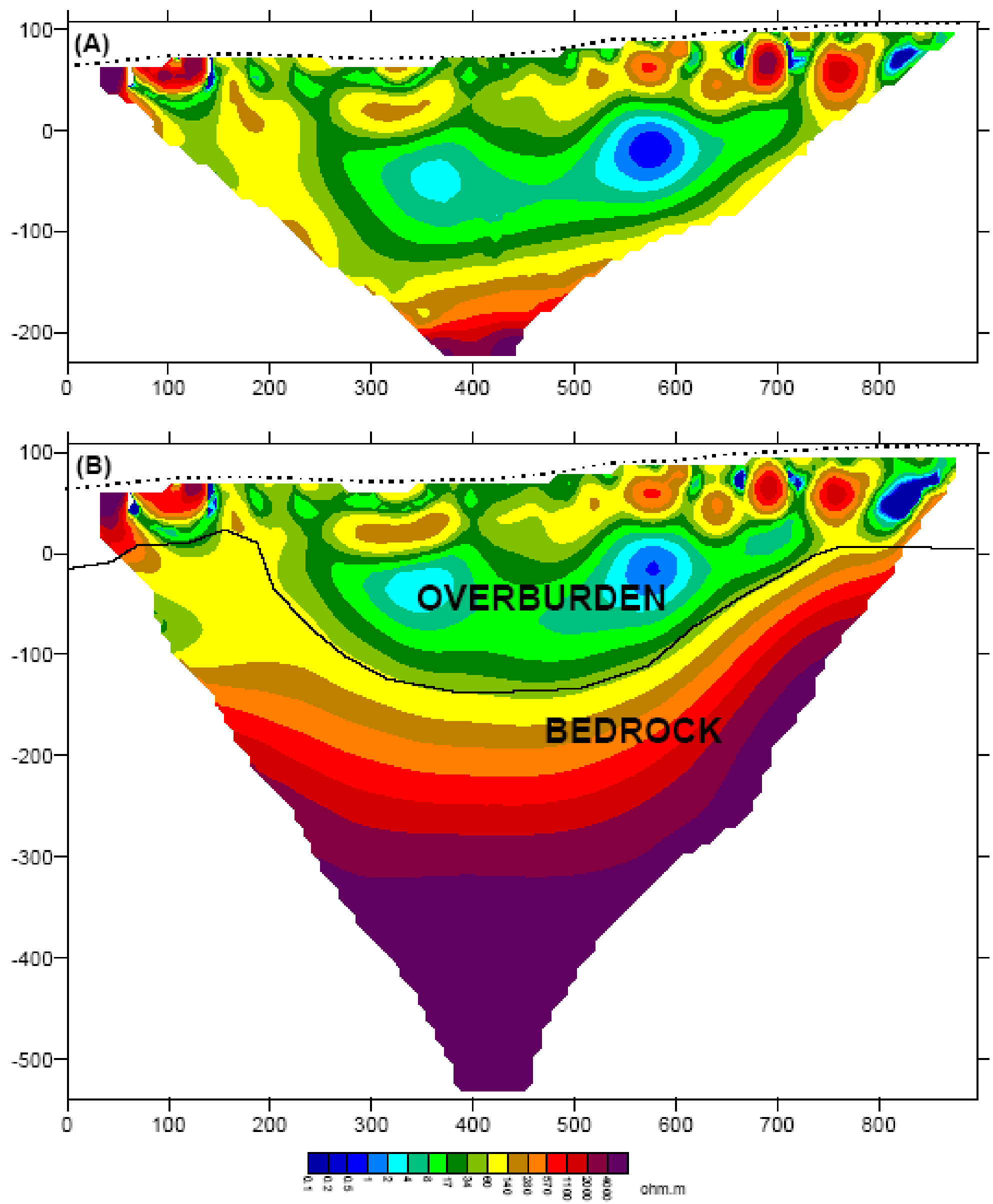

Figure 4: Resistivity pseudosection of KR2. a) Standard processing; b) Standard processing with mathematical data extrapolation.

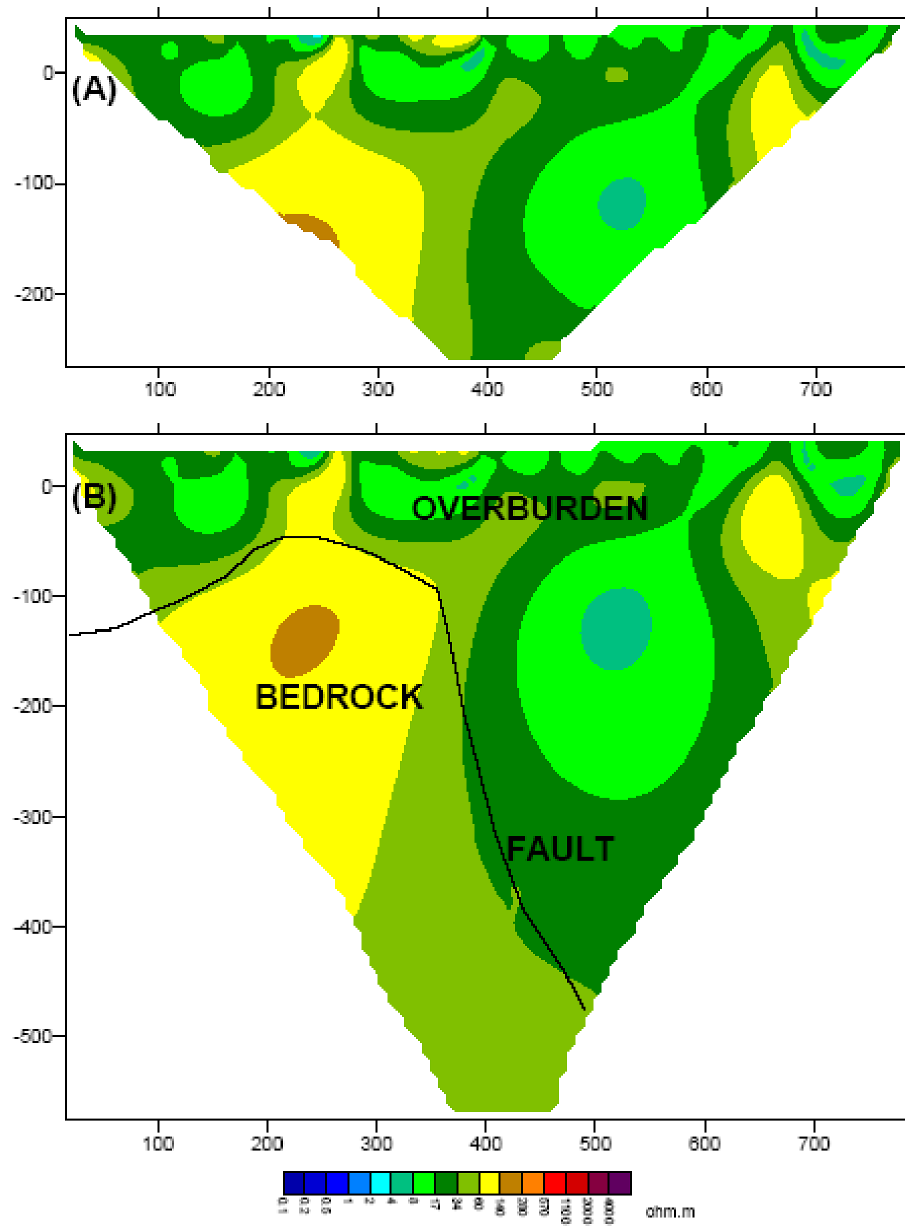

Figure 5: Resistivity pseudosection of KR3. a) Standard processing; b) Standard processing with mathematical data extrapolation.

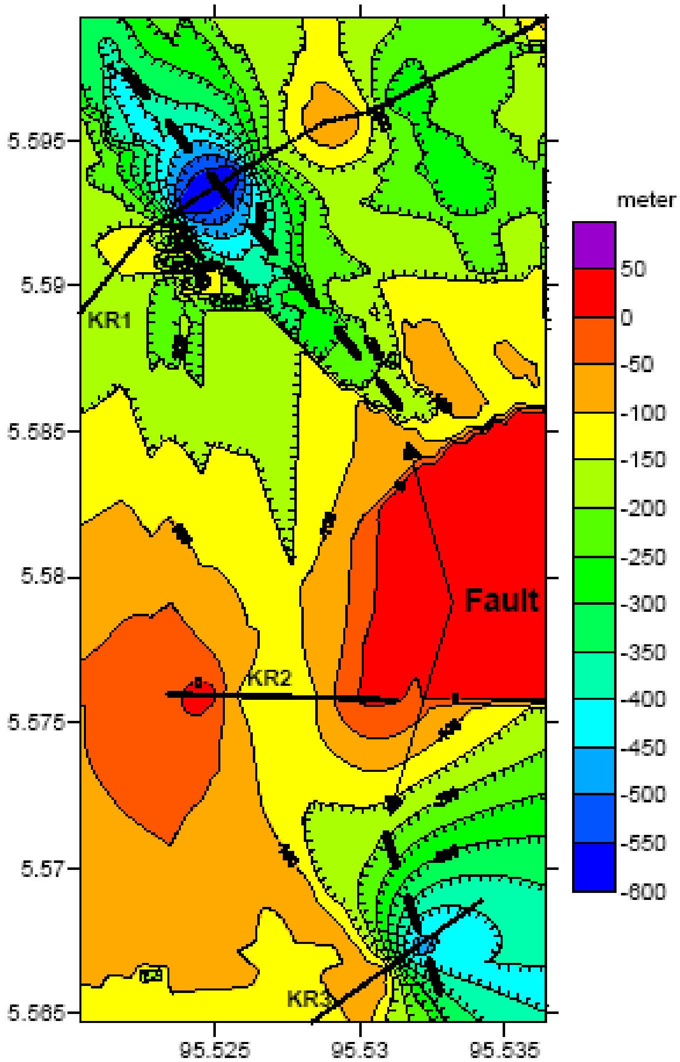

Figure 6: Subsurface topography and fault system of Krueng Raya.

CONCLUSION

Overall, the study area are divided into two main layer, overburden and bedrock with depth >150 m. The contrast between low and high resistivity value indicates fault with the depth >600 m.

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