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Preliminary Study of Sumatera Fault Using 2-D Resistivity Imaging Method

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ABSTRACT

As 2-D resistivity method is applicable to determine near surface structures such as faults, cavities, voids and sinkholes, this method was applied in determining of Sumatran fault at Tangse, Indonesia. The study location covered from latitude N 05°0’40.8” to N 05°1’6.83” and longitude from E 95°54’47.3” to E 95°54’49.66”. The Pole-dipole array was used with 10 m minimum electrode spacing. The result shows the bedrock was detected at depth 30-120 m with resistivity value of >150 Ω.m and the fault identified at distance 570-620 m. It is suspected that the fault is >150 m deep.

KEYWORDS: Fault, Sumatran fault, 2-D resistivity, Pole-dipole, Tangse

INTRODUCTION

Faults are very common geologic structures. They are the fractures along which movement takes place parallel to the fracture surface. Not all faults penetrate to the surface, but those that do, might show a fault scarp, a bluff or cliff formed by vertical movement. When movement takes place on a fault plane, the rocks on opposite sides may be scratched, polished, crushed and shattered into angular blocks, known as fault breccia. Fault planes are also inclined planes and characterized by strike and dip. Two basic faults are defined by; *dip-slip fault*, if the blocks on opposite sides of the fault plane moved parallel to the direction of dip, and *strike-slip faults*, if the block moved along the direction of strike (Monroe and Wicander, 2009).

The Sumatran Fault (SF) is a 1900 km long, dextral fault that runs along the Sumatera Island (Indonesia). As it runs along, it also known as the Great Sumatran Fault. SF is the most active fault in Indonesia as it located in a highly seismic area of the world. The overall geometry for the SF is right lateral strike-slip fault. The fault zone accommodates most of the strike-slip motion associated with the oblique convergence between the Indo-Australian and Eurasian plates. In addition, the subduction zone is associated with Sunda Arc off the west coast of the Sumatera Island. The fault ends at the north part of Sumatera Island, just below the city of Banda Aceh which was devastated in the 2004, Indian Ocean earthquake. After the strikes, pressure on the Great SF has increased tremendously, especially at the north part of Sumatera Island (Weller et al., 2012). As the SF runs the length of the Barisan Mountains, a range of uplifted basement blocks, granitic intrusions, and Tertiary sediments, topped by Tertiary-Recent volcanic. The studies of Mesozoic outcrops in the central of Sumatera Island suggest that SF has a displacement of approximately 150 km (Nurhasan et al., 2011).

GENERAL GEOLOGY

Figure 1 shows the general topography of Tangse, which occupied by flat alluvium, flat topped hills within rugged Barisan Range that runs along the entire western edge of the Sumatera Island. Following the crest of the Bintang Range is a continuous system of axial valleys, including the Kr. Tangse valley, which marks the outcrop of the main fault line of the Sumatera fault system. This is essentially a right lateral fracture system, although gravity faulting is also important (Katili and Hehuwat, 1967; Page et al., 1979). The morphology of the Tangse area is subdued because the rocks are strongly fractured and altered. A long axis of intrusive complex is alined between two obliquely converging fault zones belong to the Sumateran fault syatem. A major feature of the Tangse part of the fault system is the large mass of serpentinized ultramafic rocks.

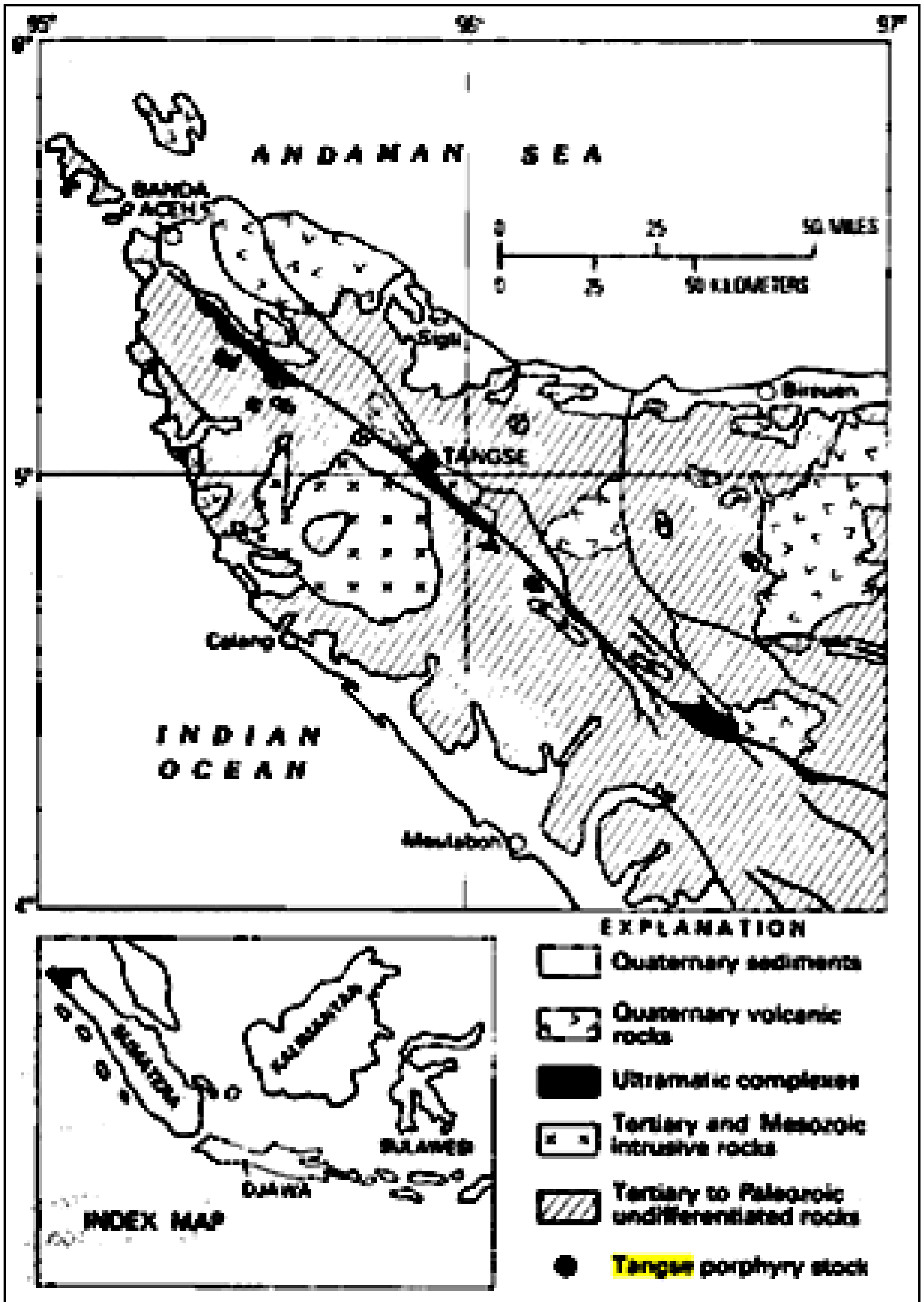

FIGURE 1.—Location and regional geologic map (modified from Young and Johari, 1978).

Figure 1: Location and regional geology of Tangse (Modified from Young and Johari, 1978).

STUDY AREA

The survey was carried out at Tangse district, located in Southern part of Banda Aceh which is precisely at the line of Sumatera Fault system (Figure 2). Generally, the study area is covered by paddy field and residential area. One (1) 2-D resistivity survey line of 800 m long was conducted from latitude N 05°0’40.8” to N 05°1’6.83” and longitude E 95°54’47.3” to E 95°54’49.66”.

Figure 2: 2-D resistivity survey lines at Tangse, Sumatera, Indonesia (Google earth 2013).

THEORY OF GEOPHYSICAL METHODS

For a resistivity survey, electrical current is applied to a pair of current electrodes and the potential difference 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 and the whole system is connected to resistivity meter (Figure 3).

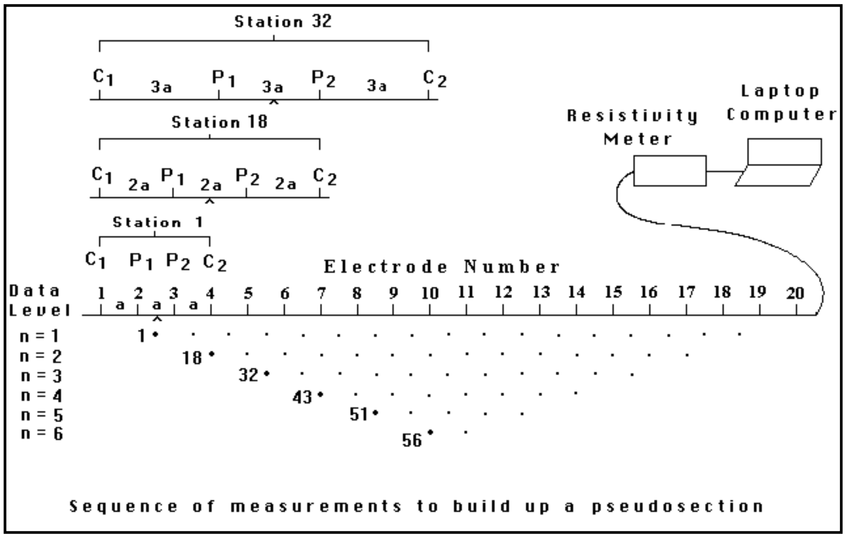

Figure 3: The arrangement of electrodes for a 2-D electrical survey and the sequence of measurements used to build up a pseudo section (Loke, 1997).

According to Loke and Barker (1996b), the apparent resistivity is the bulk average of all soils and rock influencing the applied current. Actual field surveys are invariably conducted over an inhomogeneous medium where the subsurface resistivity has a 3-D distribution. The resistivity measurements are still made by injecting current into the ground through the two current electrodes (C1 and C2), and measuring the resulting voltage difference at two potential electrodes (P1 and P2). From the current (I) and potential ($\Delta\phi$) values, an apparent resistivity (ρ_a) value is calculated using Equation (1).

$$\rho_a = k\frac{\Delta\Phi}{I} \tag{1}$$

where, $$k = \frac{2\pi}{\frac{1}{r_{C1P1}} - \frac{1}{r_{C2P1}} - \frac{1}{r_{C1P2}} + \frac{1}{r_{C2P2}}}$$

The k is a geometric factor that depends on the arrangement of the four electrodes. Resistivity measuring instruments normally give a resistance value, $R = \Delta\phi/I$, so in practice the apparent resistivity value is calculated by Equation (2).

$$\rho_a = kR \tag{2}$$

Figure 4 shows the common arrays used in 2-D resistivity surveys together with their geometric factors.

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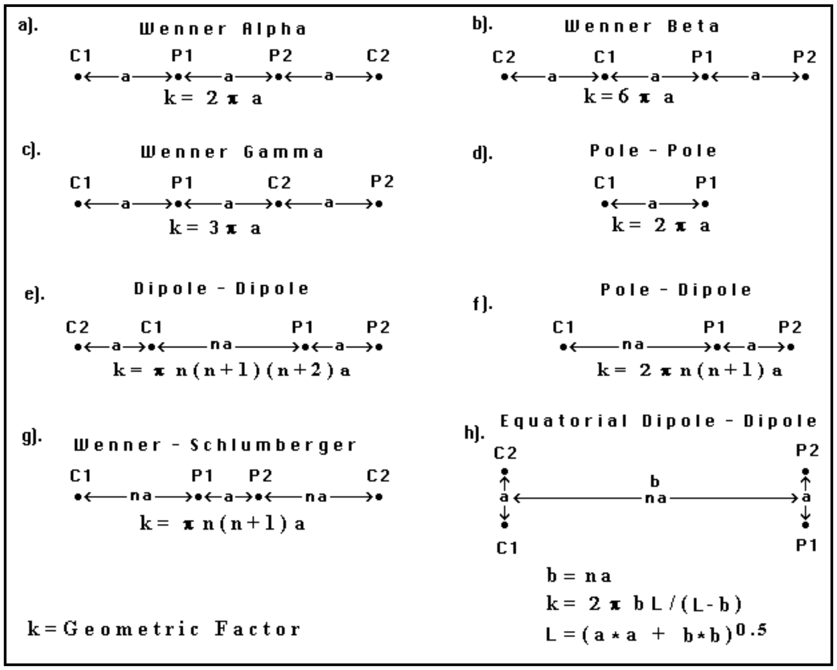

Figure 4: Common arrays used in 2-D resistivity surveys and their geometric factors (Loke and Barker, 1996a).

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: Resistivity (Ω.m) for water-bearing rocks (Keller and Frischknecht, 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 conducted using Terrameter ABEM SAS4000 system with 10 m minimum electrode spacing using stainless steel electrodes and Pole-dipole array. The data acquisition used roll along techniques which make a total length of the survey line is 800 m. The data processed involve standard processing, standard processing with mathematical data extrapolation and modeled using RES2Dinv software. The data were then outputted into Surfer software for gridding, contouring and final presentation.

RESULTS AND DISCUSSION

Figure 5 shows a pseudosection of the final model of 2-D resistivity survey line at Tangse. Generally the overburden of the survey area consist of alluvium with resistivity value of <150 Ω.m and boulders. The bedrock was observed at depth 30-120 m with resistivity value of >150 Ω.m. The fault can be seen at distance 570-620 m where the rock head of the bedrock cannot be detected.

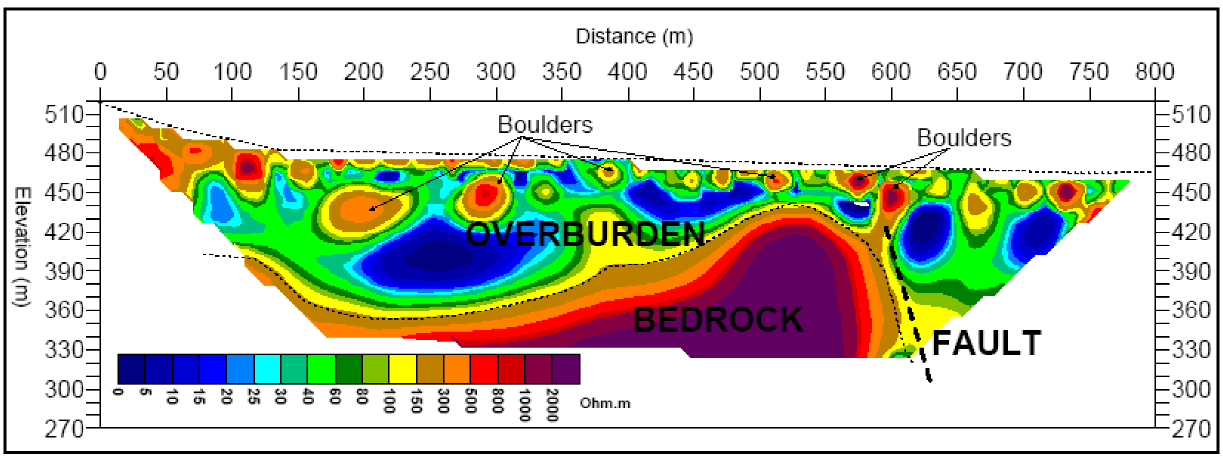

Figure 5: Final pseudo-section model of 2-D resistivity survey line at Tangse.

CONCLUSION

Generally the bedrock was detected at depth 30-120 m with resistivity value of >150 Ω.m and the fault was identified at distance 570-620 m. It is suspected that the fault is >150 m deep. Detail ground geophysical study such as 2-D resistivity, seismic, gravity is recommended for environmental and safety purposes.

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