THE GEOTHERMAL FIELDS IN CENTRAL PART OF THE SUMATRA FAULT ZONE AS DERIVED FROM GEOPHYSICAL DATA

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Abstract

Sumatra island is a part of an island arc produced by oblique subduction process of the Indian-Australian Plate beneath SE Asia Plate. The main result is a large dextral strike-slip fault called the Great Sumatra fault. Magmatic activities related to the subduction process controls the volcanic chain along the major weak zone created by this fault system. High-enthalpy geothermal resources in the central part of the island are closely associated with these phenomena. They are most likely developed beneath the volcanic complexes area and fed by shallow rhyolitic to andesitic magma chamber. Geophysical data from two geothermal fields that are the Muaralaboh and Talang Mt. areas were analyzed. The methods used are gravity. magnetic, resistivity sounding, resistivity mapping, resistivity head-on, and very low frequency electromagnetics. Extensive and intensive surface geothermal features are found in both area. The most important structural features in these two geothermal fields as inferred by geophysical methods are faults associated with grabens. It therefore **is** concluded that most geothermal system in central Sumatra are graben-type systems.

INTRODUCTION

The Great Sumatra Fault Zone or the Great Sumatra Fault System is located on Sumatra island, the western part of Indonesian Archipelago. It trends along the long axis of the island and located in the western part. Some volcanic activity is also present. Consequently, a number of geothermal areas are found in the region (Figure. 1). Two of them are Muaralaboh and Talang Mt. geothermal fields These two fields are easily recognized by the existence of some surface manifestations such as hot spring, solfataric and hmarolic activities, and craters. Their location are also not far from the main road or the district town of Muaralaboh and Solok (Figure 2) Some field investigations, namely geology, geochemistry, and geophysics, have been canied out in these areas.

The objective **of** this paper **is** to discus the result of geophysical data analysis from two areas, Muaralaboh and Talang Mt. The methods used are gravity, magnetic, resistivity sounding, resistivity mapping, resistivity head-on, and very low frequency electromagnetics

MUARALABOH GEOTHERMAL FIELD

Muaralaboh geothermal field is located northwest of Kerinci Mt., approximately 12 km southeast of Muaralaboh town (Figure **2)**

The Bouguer gravity map is calculated using Bouguer density of 2 4 g/cc (Figure **2)** This map shows a northwest-southeast trend cut by a north-south trend In some part there are some positive values surrounded by negative values The residual value (Figure **3)** is calculated by subtracting the regional Bouguer anomaly from the trend surface, giving closed contours in the Idung Mancung area and Pinangawan area It possibly reflects an intrusive body (7) The 2D gravity model based on data shown in Figure **3** is calculated by Talwani poligonal methods, as shown on Figure **4.**

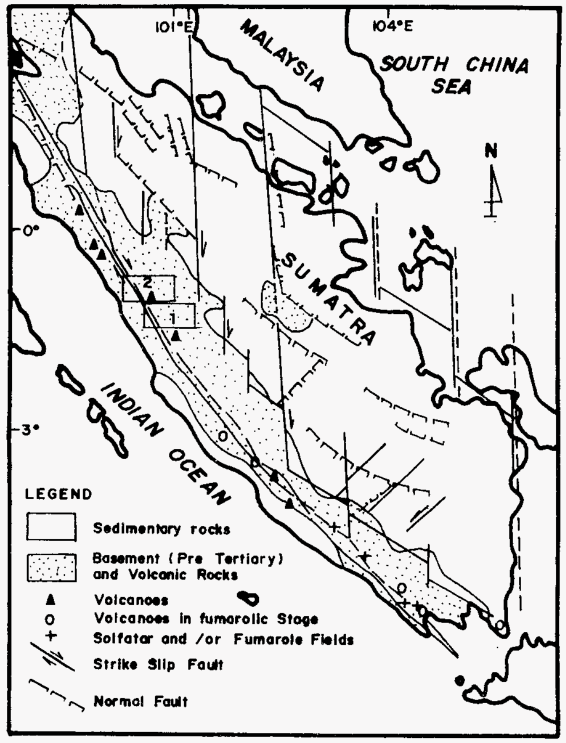

Figure 1. The Great Sumatra Fault Volcanoes and Associated Geothermal Manifestation, and the location of Muarabboh (1) ond Talang MT (2) Geothermal Field

The total magnetic anomaly **map** gives some dipoles trending east-west. The anomalous body inferred by gravity data of Idung Mancung is present as a dipole with a strong positive anomaly compared to surrounding area (Figure **3)**

The resistivity sounding method gives values below 50 Ohm-m around Idung Mancung and also Pinangawan regions. This result gives convincing evidence that there **is** a thermal region in Idung Mancung (Figure **3).** The *cap* rock in the region is shown on the resistivity profile as inferred by the resistivity sounding (Figure **3).** The resistivity head-on gives a more convincing position of the fault. The latter mentioned method is applied only across the surface expression of the Idung Mancung fault and, combined with the VLF method, gives **an** accurate position of the fault (Figure **3** & 5). It shows that the fault has an northwest-southeast strike and dips about 85^0 to the southwest. This fault is very meaningfull in utilization of the system **as its** location within the thermal region. The surface thermal features show an intimate relationship with the fault; the arrangements of the surface thermal features are adjacent to the weak zone (Figure **3).**

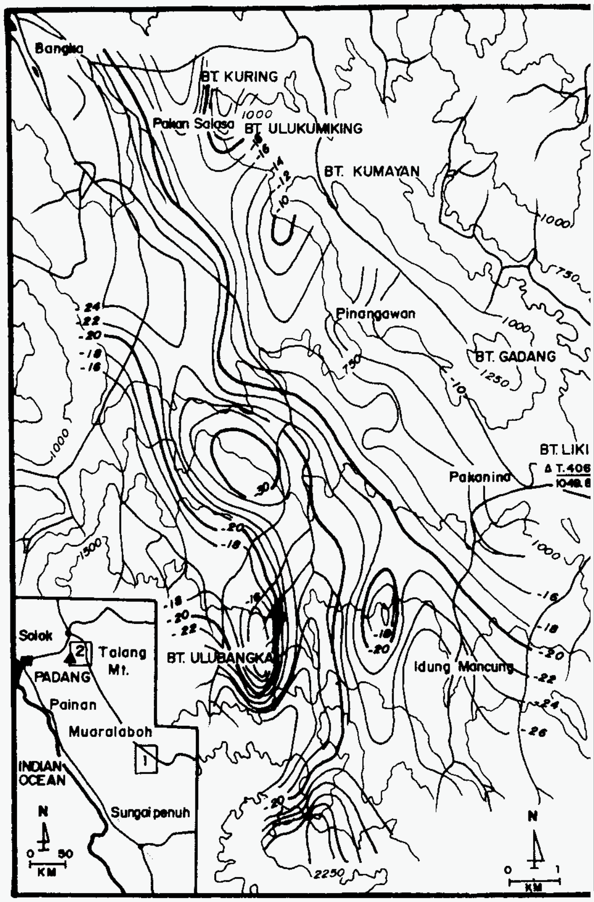

Figure 2. Location Map of Muaralaboh (1) and Tolang Mt (2) Geothermal Fields, and the Bouguer Gravity Anomaly Map of Muaralaboh Geothermal Area

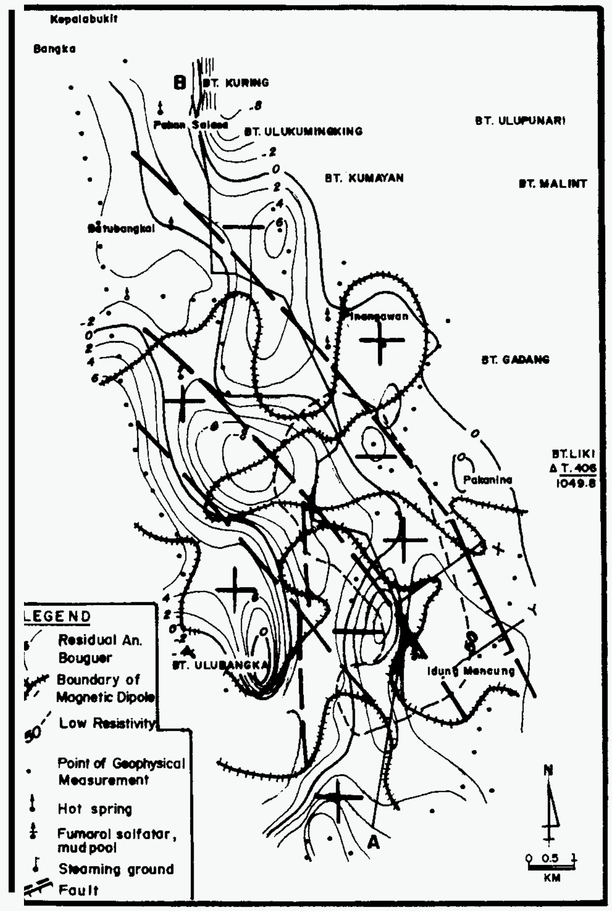

Figure 3. Residual Bouguer Gravity Anomaly, Magnetic and Low Resistivity Data of Muaralaboh Geothermal Area

A summary of all geophysical data is shown on Figures 3 & 4; the section cross southeast-northwest through the Idung Mancung thermal features. Figure 4 shows that the Muaralaboh geothermal field is controlled by graben. The depth to the thermal reservoir is approximately 1000-1500m.

TALANG MT. GEOTHERMAL FIELD

The Talang Mt geothermal field is located northeast of Talang volcano, approximately 15 km south of Solok town (Figure 2) Surface manifestations in this area are hot springs, fumarolic and solfataric fields and altered zone

The residual Bouguer gravity map in the area is constructed using the Bouguer density of 2 4 g/cc (Figure *6)* The close contour with the value of 3 mgal is found in the area of Batubarjanjang, it could be interpreted as an intrusion body The 2D model can be seen in Figure 7 The Bouguer Anomaly map also shows an approximate northwest-southeast grain

The total magnetic map gives some contours and dipoles arranged in a northwest-southeast direction This trend can be seen more clearly in the residual anomaly map A strong positive anomaly *can* be seen on the residual map with the value of 400 gamma (Figure *6)* The low resistivity values (< 50 Ohm-meters) found south of Batubarjanjang, most of them are situated northeast of Talang Mt (Figure *6)*

The resistivity head-on and VLF anomalies measured in the fault area are related directly to the surface thermal manifestations The permeable zone in the region is controlled by faults of the northwest-southeast direction, with more than 80^0 of dip The presence of a geothermal trap in the Talang Mt. geothermal area and the occurence of possible heat source (indicated by a shallow intrusion body) are interpreted as seen in Figure 7. The latter is also stressed by the presence of surface geothermal manifestation such as fumaroles, solfataras, hot spring.

Structurally, the prospective area is located in a graben Therefore the geothermal system in the area also identified as graben type structure as geothennal system the same as in the Muaralaboh area.

THE GREAT SUMATRA FAULT AND GEOTHERMAL FIELD

Sumatra island is a part of island arc produced by subduction of the Indian-Australian Plate beneath the SE Asia Plate (Figure 8). One of the important results is the presence of a large dextral strike-slip fault; located in the western part of the Sumatra island, This fault has a NW-SE trend along the long axis of the island, and is called the Great Sumatra fault *system* This subduction area is characterized by the presence of some active volcanoes, earthquakes and of several geothermal fields.

Tectonically, Sumatra island is also marked by some continous tectonic deformation since the Mesozoic, indicated by intensive fracturing both in the pre-Tertiary and Tertiary sediments as well as the Quaternary volcanic rocks (Katili, 1985) The depth of the subduction zone beneath the volcanic chain on the interest area is approximately 100 km (Rock et al., 1982). The magmatic activity related to the subduction process controls the volcanic chain along the major weak zone created by the Great Sumatra fault system. High enthalpy geothermal resources in the central Sumatra area are closely associated with this volcanism of

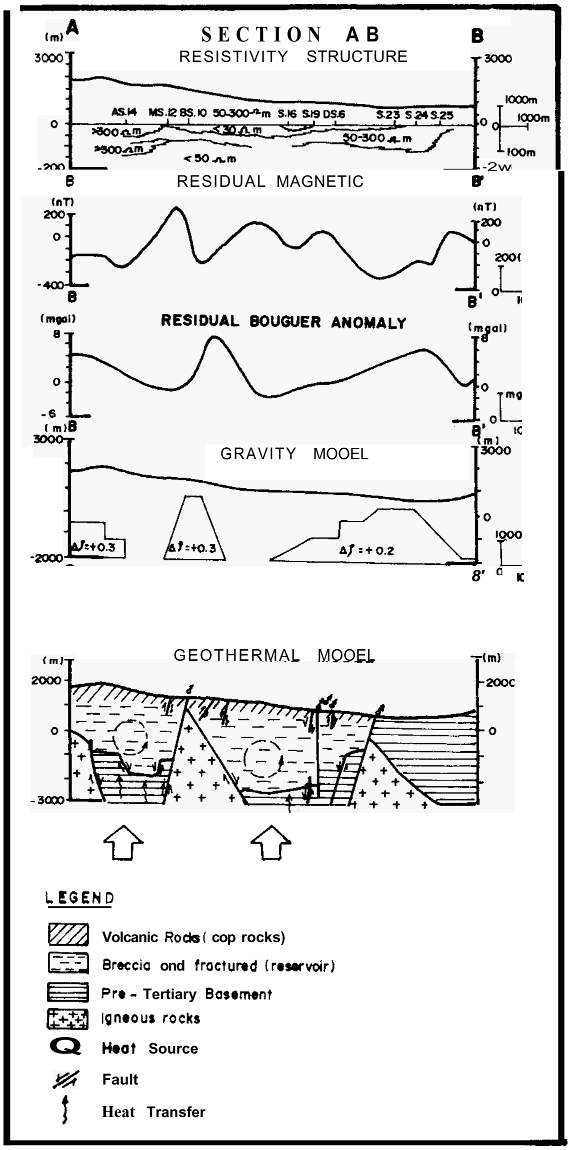

Figure 4. Geothermal model of Muaralaboh Geothermal Field AB (see figure 3)

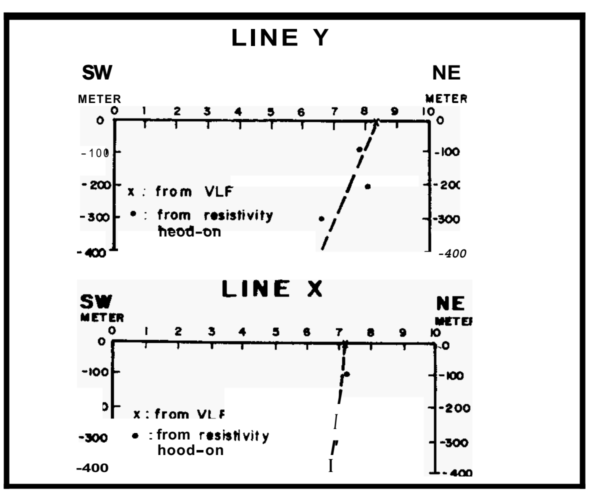

Figure 5. Determinatbn of Idung Mancung Fault from VLF ond Resistivity Head-on Data

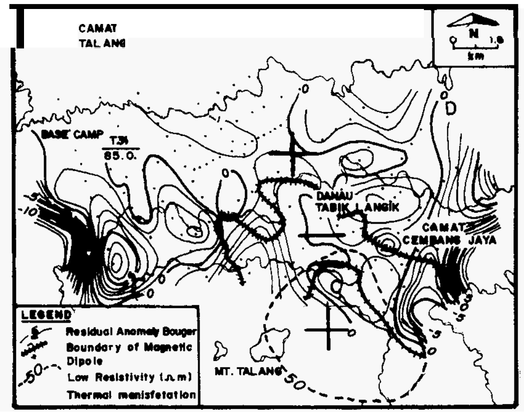

Figure 6. Residual Bouguer Anomaly Map, Total Magnetic Anomaly and Low ResistivityData of Talong Mt Geothermal Field

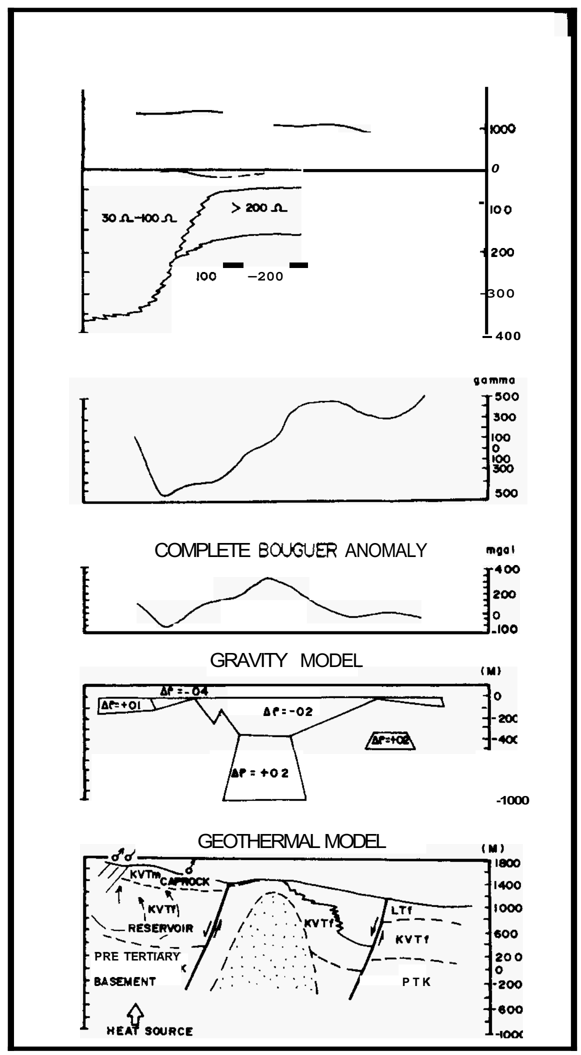

Figure 7. Geothermal model along section CD of Talang Mt Geothermal Field

a rhyolitic to andesitic composition; some of them are **most** likely developed beneath the volcanic complexes and are fed by **shallow** magma chamber (Figure 9).

The studied areas are situated in the eastern part of the middle Great Sumatra fault zone. The fault presence in this area are the second order

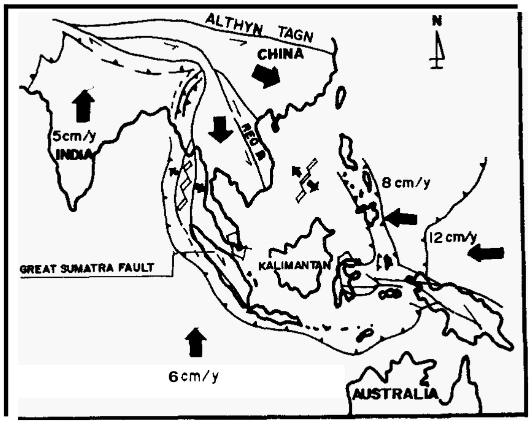

Figure 8. Tectonic setting of Southeast Asia and the Great Sumatra Fault (Tapponier, 1979 and Katili 1989 op. cit. Sudradjat 1989)

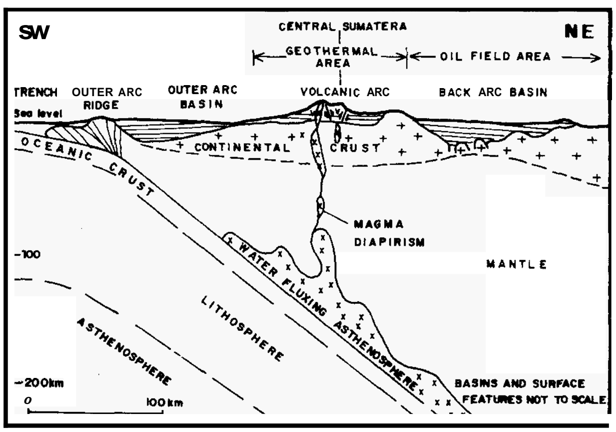

Figure 9. Simplified Tectonic Section A Cross Sumatm (William et al, 1985), showing the Location of Graben Type Model of Geothermal Area

or probably third of the Sumatra fault, therefore they trend northeast-southwest or northwest-southeast, or north-south Most of them are normal faults, indicating a tensional stress The stress should be the second or third order produce by the mentioned oblique subduction

Graben structures are common in the region Both Muaralaboh and Talang Mt geothermal fields show the evidence that the systems are trapped in the graben structure, *so* they are called graben-type geothermal systems

CONCLUSION

From the above discussion, it can be concluded that
1 The geothermal systems in the Central Part of the Great Sumatra Fault Zone are graben-type geothermal systems
2 There is a close relation between Quaternary volcanism and the geothermal systems in Sumatra Island
3 Utilization of geothermal systems in the Central Part of the Great Sumatra Fault Zone should take into account the fault structure as the guide to porosity and permeability guidence of the reservoir
4 There should be a large potential high-enthalpy geothermal system around the Great Sumatra Fault as supported by surface manifestation, structure and history of volcanic activities

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