

CHAPTER 4

GRAVITY MODELING

4.1 Introduction

In order to transfer gravity anomalies into a meaningful geologic picture of the bedrocks, a modeling program is required. Gravity anomalies over the study area have been modeled by two-dimensional (2-D) interactive forward modeling using GM-SYS (Gravity and Magnetic Modeling System, Version 3.0) program (GM-SYS, 1993). This program assumes that all bodies in the model are prisms extending to infinity in the strike direction, perpendicular to the line of profile. In this method, subsurface geology is described by a set of uniform density, n-sided polygons which represent the cross-section shapes of the two-dimensional structures.

The program requires an initial estimate of model parameters (depth, shape, and density), and the selected parameters are varied in an attempt to reduce the weighted root-mean-square errors between the observed and calculated gravity. The assumed model is then modified until an acceptable agreement between calculated and observed values is reached. However, the 2-D modeling may not be valid for bodies that are not much longer than their widths or thicknesses. To avoid this unreasonable assumption of infinite extent, an end correction that enables modeling bodies of finite strike length (two-and-one half dimensional)

can be applied. A two-and-one half dimensional modeling is limited along strike (y-axis) by $\pm y$ values. It is expected that this technique would give a better approximation and reliability of subsurface geology.

The gravity model across the study area is quantitatively interpreted based on gravity profiles which have been constructed perpendicular to the gravity anomalous zone. The profiles selected for modeling are shown in Figure 4.1. It is important to point out that the source-mass distribution and their geometrical forms are non-unique. Their shapes may be closely approximated by modeling, but need not be real, however, a good match between the calculated and the observed curve is essential. Therefore, the merit of this modeling lies in pointing out the significant lateral density contrasts in shaping the gravity profile rather than in portraying the actual forms and sizes of these bodies.

4.2 Laboratory density determination procedures

Core samples from the study area (Appendix B) were randomly picked for density determination by the procedures as the follows:

1. The core rock samples were dried in a thermostatically controlled oven at a temperature of 105°C for six hours. After cooling for 30 minutes, the oven dried samples were weighted in the air, and the corresponding values were recorded as W_{dair}
2. The oven dried samples were then soaked in water for 2 days.

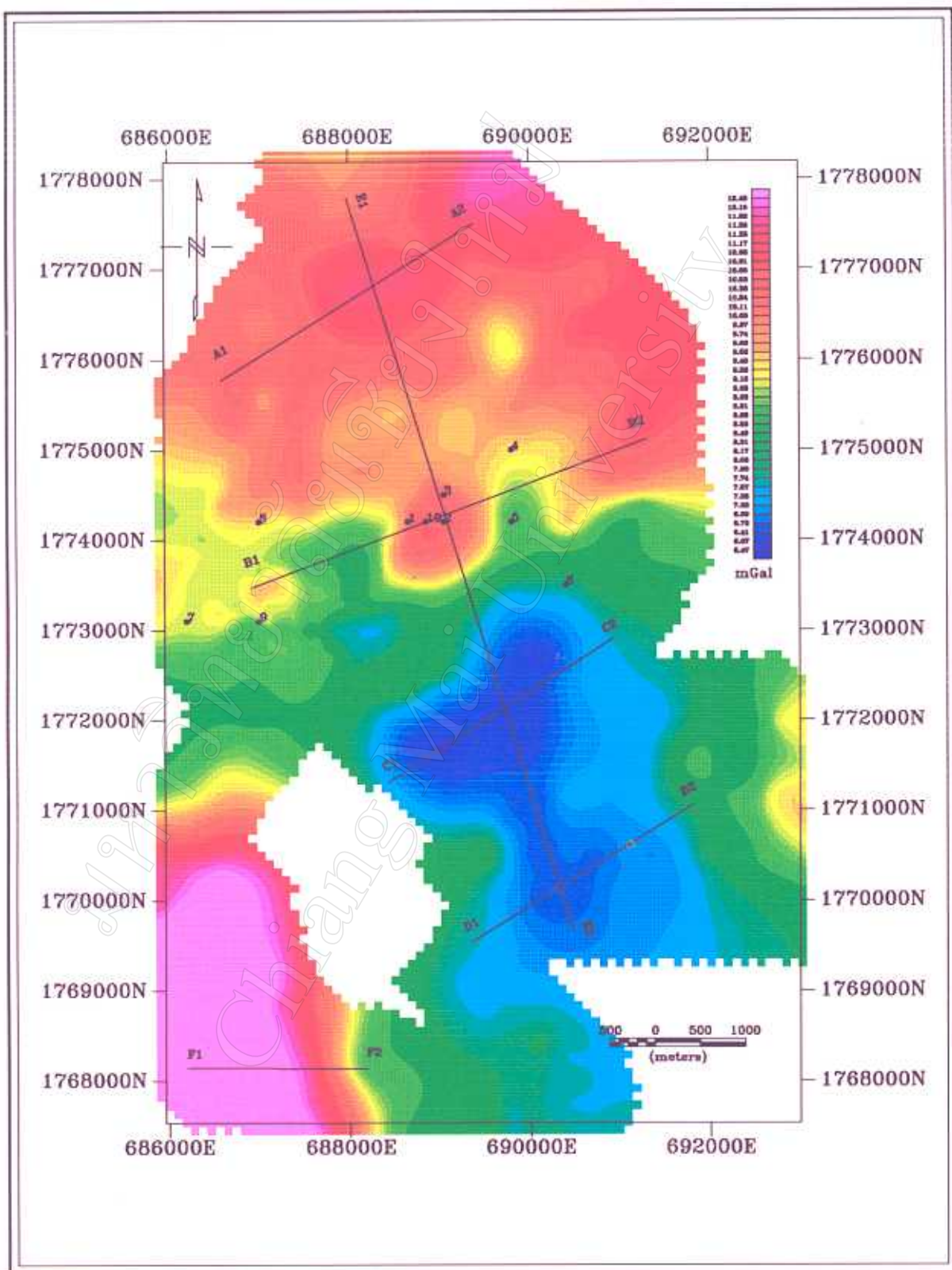


Figure 4.1 Gravity profiles

3. After becoming water saturated, the samples were suspended from a hook on a balance and then immersed in a vessel full of water. The samples were subsequently weighed while immersed and the weight recorded was W_w

4. Saturated samples were thoroughly dried by moist cloth, weighed in air, and the weight recorded became W_{sair}

The density of the water saturated sample, D_{sat} , the density of the oven dried sample, D_{dry} , were calculated from the laboratory data. The formula used to calculate these densities are as the follows:

$$D_{sat} = W_{sair} * D_w / (W_{sair} - W_w)$$

$$D_{dry} = W_{dair} * D_w / (W_{sair} - W_w)$$

where D_w = density of water, 1 g/cc.

Noted on Table 4.1, the high density values of andesite samples are probably caused from the presence of disseminated sulfide minerals (Figure 4.2). They are commonly found in borehole no. CD 1, CD 3, and CD 10.

4.3 Modeling of gravity profiles

To form the basis for interpretative on subsurface geology, computer models of gravity anomalies along six profiles were constructed. Five of them cross cut five anomalous zones in a roughly W-E direction and intersect the SW-NE direction model. The following constraints were used in the modeling:

Table 4.1 Laboratory density measurements of core samples

Samples No.	Rock Type	Weights(in water)				Weights(air) (g)	Densities (g/cc)
		1	2	3	Average		
GPR 2/2	Gypsum	95.32	95.38	95.35	95.35	166.11	2.348
CD 1	Andesite	174.98	174.93	174.95	174.98	266.32	2.918
CD 3	Andesite	196.66	196.59	196.52	196.59	303.42	2.840
CD 4	Andesitic tuff	109.54	109.57	109.55	109.55	174.12	2.697
CD 5	Andesite	137.99	137.95	137.92	137.95	208.30	2.961
CD 6	Limestone	139.49	139.44	139.45	139.46	224.34	2.643
CD 7	Andesitic tuff	169.77	169.83	169.85	169.82	268.36	2.723
CD 9	Andesitic tuff	102.77	102.81	102.73	102.77	163.22	2.700
CD 10	Andesite	105.42	105.41	105.42	105.42	159.09	2.960



Figure 4.2 Dissiminated sulfide minerals in andesite (in circle) from borehole no. CD 10

1. The strike lengths of the model bodies were limited to distances that are correct for the possible lengths of the individual bodies indicated by the associated gravity anomalies; this approximation is used in two-and-a half dimensional gravity modeling.
2. The geometry of density units is constrained by data from Table 4.2
3. Most of the rock types in the study area are andesitic tuff and andesite with varying densities and believed to overlie limestone (2.64 g/cc).

Table 4.2 Model's parameters and geological interpretation

Model	Block	Density (g/cc)	y maximum (km)	y minimum (km)	Density of adjacent block		Geological interpretation
					y maximum (g/cc)	y minimum (g/cc)	
A1A2	1	2.18	10.0	10.0	2.18	2.18	Top layer
	2	2.74	8.0	3.0	2.74	2.74	Andesitic tuff
	3	2.92	5.5	0.2	2.92	2.92	Andesite
	4	2.64	9.0	1.0	2.64	2.64	Limestone sequence
	5	3.00	9.0	9.0	3.00	3.00	Igneous rock
B1B2	1	2.18	10.0	10.0	2.18	2.18	Top layer
	2	2.74	5.0	6.0	2.74	2.74	Andesitic tuff
	3	2.92	3.0	6.0	2.92	2.92	Andesite
	4	2.64	5.0	4.0	2.64	2.64	Limestone sequence
	5	3.00	9.0	9.0	3.00	3.00	Igneous rock
C1C2	1	2.18	10.0	10.0	2.18	2.18	Top layer
	2	2.74	2.5	8.5	2.74	2.74	Andesitic tuff
	3	2.92	0.8	8.0	2.92	2.92	Andesite
	4	2.64	4.0	6.0	2.64	2.64	Limestone sequence
	5	3.00	9.0	9.0	3.00	3.00	Igneous rock
D1D2	1	2.18	10.0	10.0	2.18	2.18	Top layer
	2	2.74	1.0	10.0	2.74	2.74	Andesitic tuff
	3	2.64	2.0	9.0	2.64	2.64	Limestone sequence
	4	3.00	9.0	9.0	3.00	3.00	Igneous rock
E1E2	1	2.18	10.0	10.0	2.18	2.18	Top layer
	2	2.74	3.0	3.0	2.74	2.74	Andesitic tuff (NW)
	3	2.74	1.6	2.5	2.74	2.74	Andesitic tuff (SE)
	4	2.92	1.0	2.0	2.92	2.92	Andesite
	5	2.64	4.0	4.0	2.64	2.64	Limestone sequence
	6	3.00	9.0	9.0	3.00	3.00	Igneous rock
F1F2	1	2.18	10.0	10.0	2.18	2.18	Top layer
	2	2.34	0.5	0.5	2.34	2.34	Gypsum sequence
	3	2.90	0.5	0.5	2.90	2.90	Anhydrite sequence
	4	2.64	5.0	9.0	2.64	2.64	Limestone sequence
	5	3.00	9.0	9.0	3.00	3.00	Igneous rock

4. The average density of andesitic tuff and andesite used in modeling is 2.74 g/cc and 2.92 g/cc respectively.

4.3.1 Gravity model along profile A1A2

The model is 3000 m long and extends across the study area in SW to NE direction. It is located on the northern half of the study area. Gravity high around the center of the profile (Figure 4.3) suggests the presence of a rock body with high density beneath the Quaternary deposits. Considering andesitic tuff at Khao Khan Tha which borders the western limit, it implies the occurrence of that andesitic tuff body in the western side of the model and its extension is limited to the center of the profile.

As mentioned above, most of the rock types in the area are andesitic tuff (2.74 g/cc) and andesite (2.92 g/cc). Therefore, the gravity high is likely caused from an intrusive body such andesite. This is in agreement with both surface geology around the cross-cutting point of andesite and the presence of fault features (NE-SW direction) that was delineated from the enhanced bouguer gravity maps. At depth below 300 m, the rocks appears to be of slightly lower density, and therefore, interpreted as limestone (2.64 g/cc). The rock units in the model near 2,000 m on the ground is required to tie with the model E1E2.

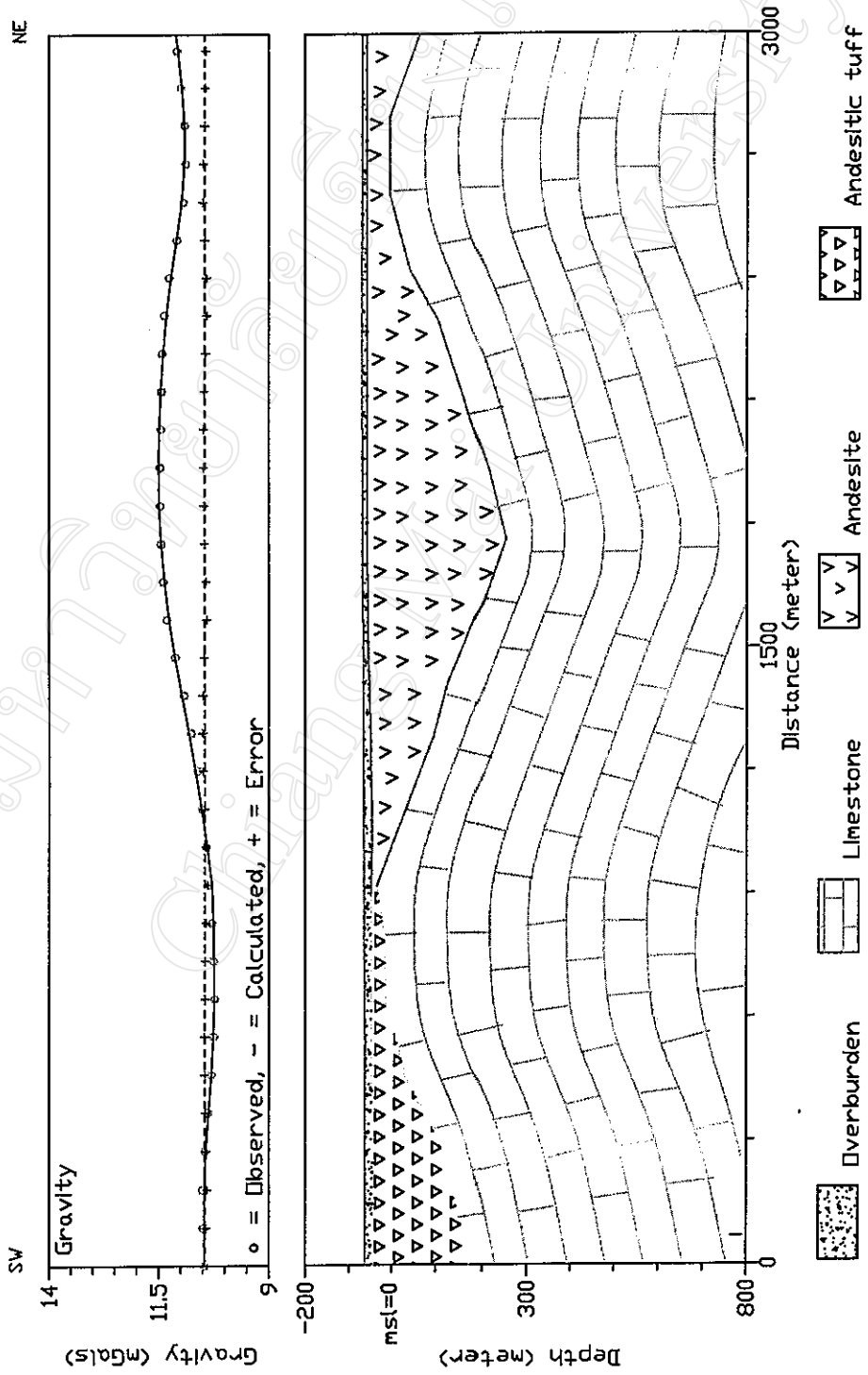


Figure 4.3 Gravity model along profile A1A2

4.3.2 Gravity model along profile B1B2

The model is 4000 m long and also run in SW-NE direction. It is located on the northern of the study area toward the south from model A1A2 with the distance of 2,600 m (Figure 4.4). The gravity high which appears at the center of the profile is also caused from an andesite body (2.92 g/cc). Ambiguity of gravity interpretation across this profile was minimized by using the control from borehole information (CD-1, CD-2, and CD-10). The same andesitic tuff unit from model A1A2 is also found at the western side of the profile. On the center of the profile, limestone extends its thickness to about more than 800 m. The rock units at 2,200 m in the model is required to tie with the model E1E2.

4.3.3 Gravity model along profile C1C2

The model is 2800 m long and traverses from SW to NE. It is located on the lower part of the study area, with the distance of about 2,300 m southward of model B1B2. Anomalous features of the model show gravity high around the center of a broad gravity low (Figure 4.5). It is interpreted that the rocks are similar to that in model A1A2 and in model B1B2. They indicate that andesite occur at the middle of the model and bounded by andesitic tuff on both sides. However, it is different in shape and thickness. It might be the southward continuation

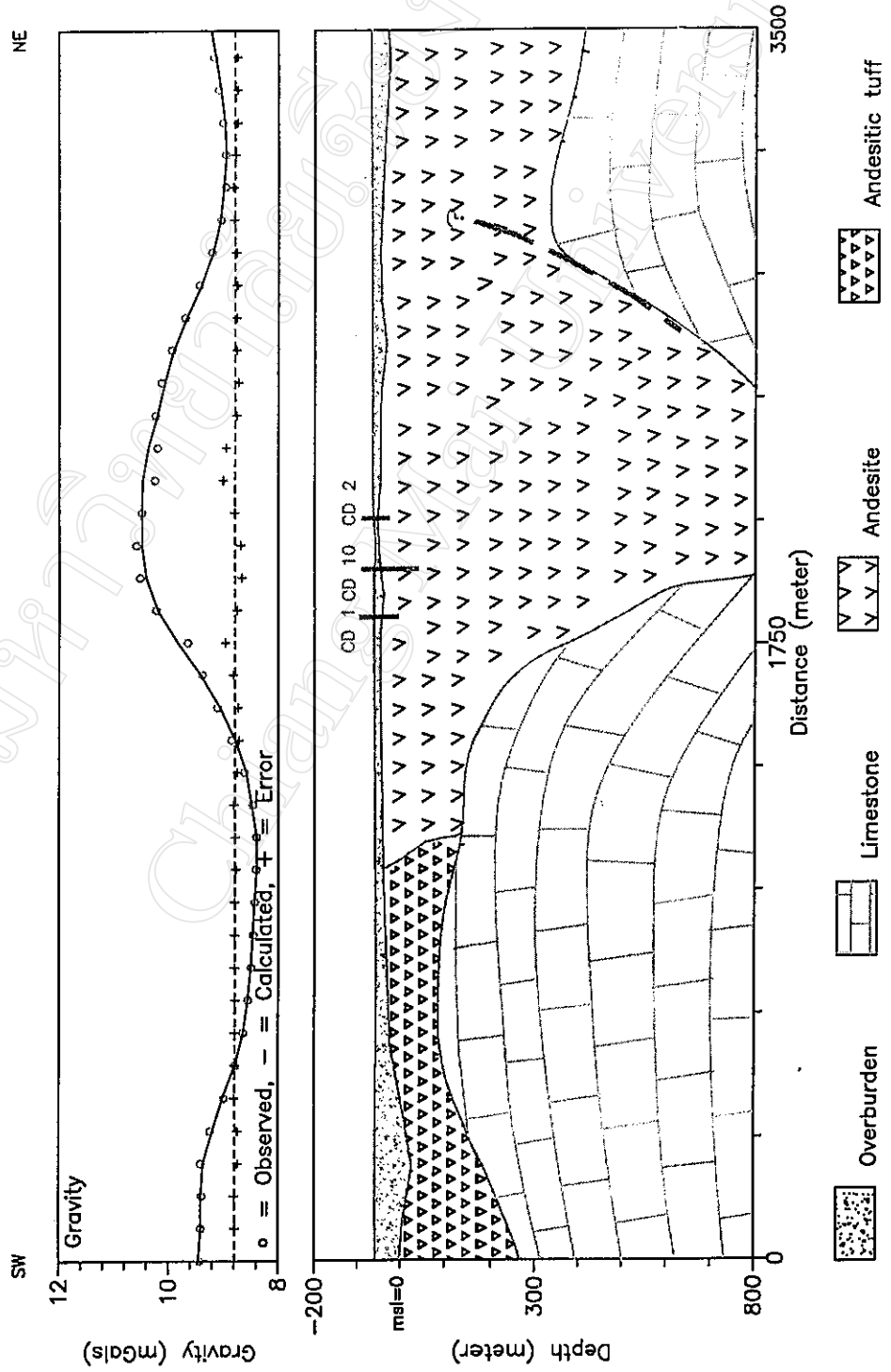


Figure 4.4 Gravity model along profile B1B2

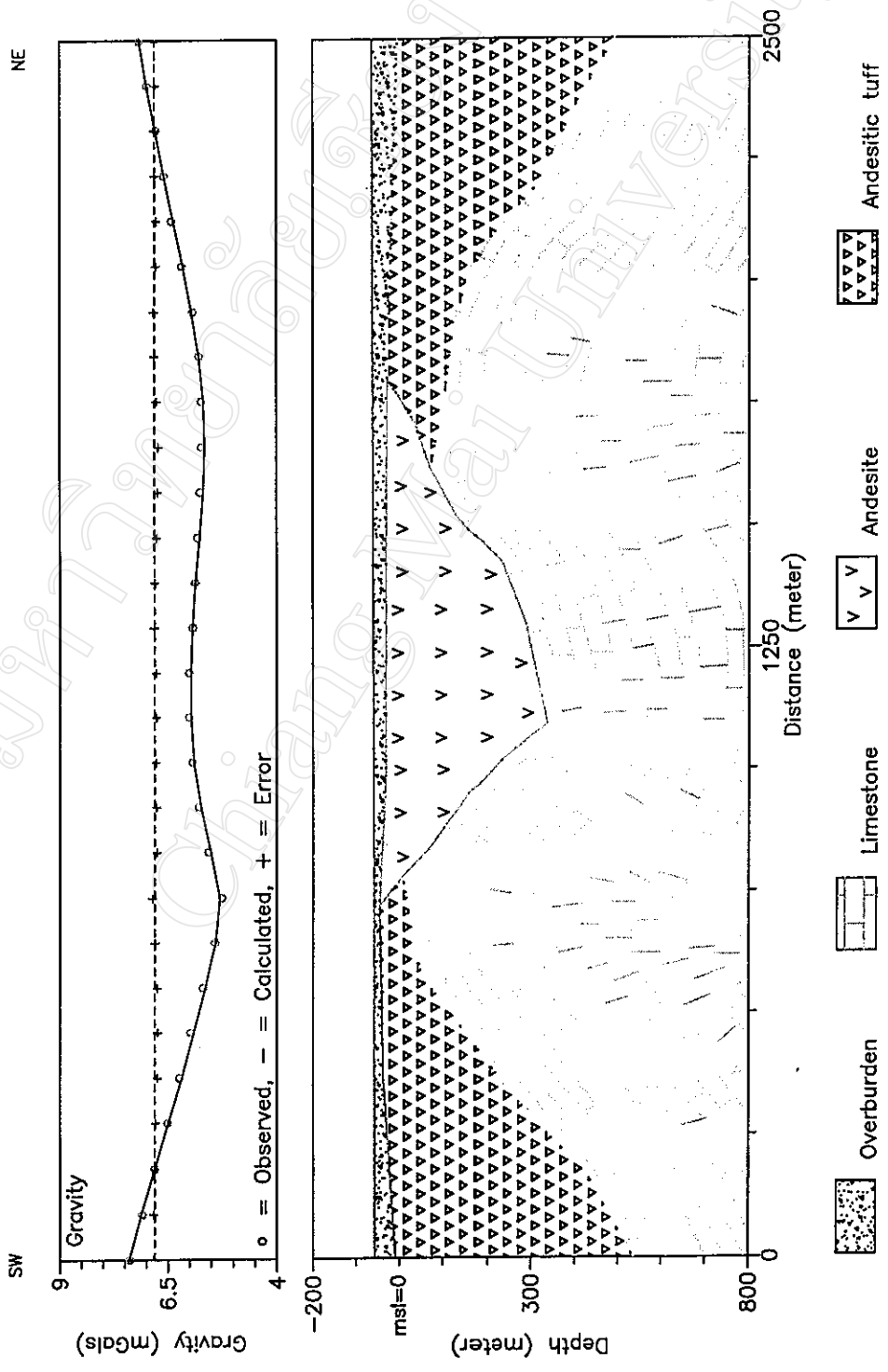


Figure 4.5 Gravity model along profile C1C2

of a shallow andesite from model B1B2. The rock units at 1500 m in the model on the ground will be match, correspond to the model E1E2.

4.3.4 Gravity model along profile D1D2

The model is 2,500 m long and runs in SW-NE direction. It is located on the lowest part of the study area with the distance of about 2,000 m southward of model C1C2. The anomalous features of the model shows only gravity low (Figure 4.6). This model has two distinctive density units, the lower one belongs to limestone which appears to be very thick around the center, and it is also covered by andesitic tuff. Extention of andesite body does not seem to reach to this area. The rock units at 1,200 m in the model on the ground is required to tie with the model E1E2.

4.3.5 Gravity model along profile E1E2

The model is 8,000 m long and extended from NW to SE across the study area. It is the longest profile and is perpendicular to the SW-NE models (Figure 4.7). It shows the presence of andsite at the center of the profile which is flanked by a andesitic tuff unit. They also overlie a limestone body. An andesite body is thicker around the middle and its boundary is limited to the southwest portion of the model. This relationship is coincident with the model B1B2 and the model D1D2 respectively. The pattern of decreasing in gravity towards the NW

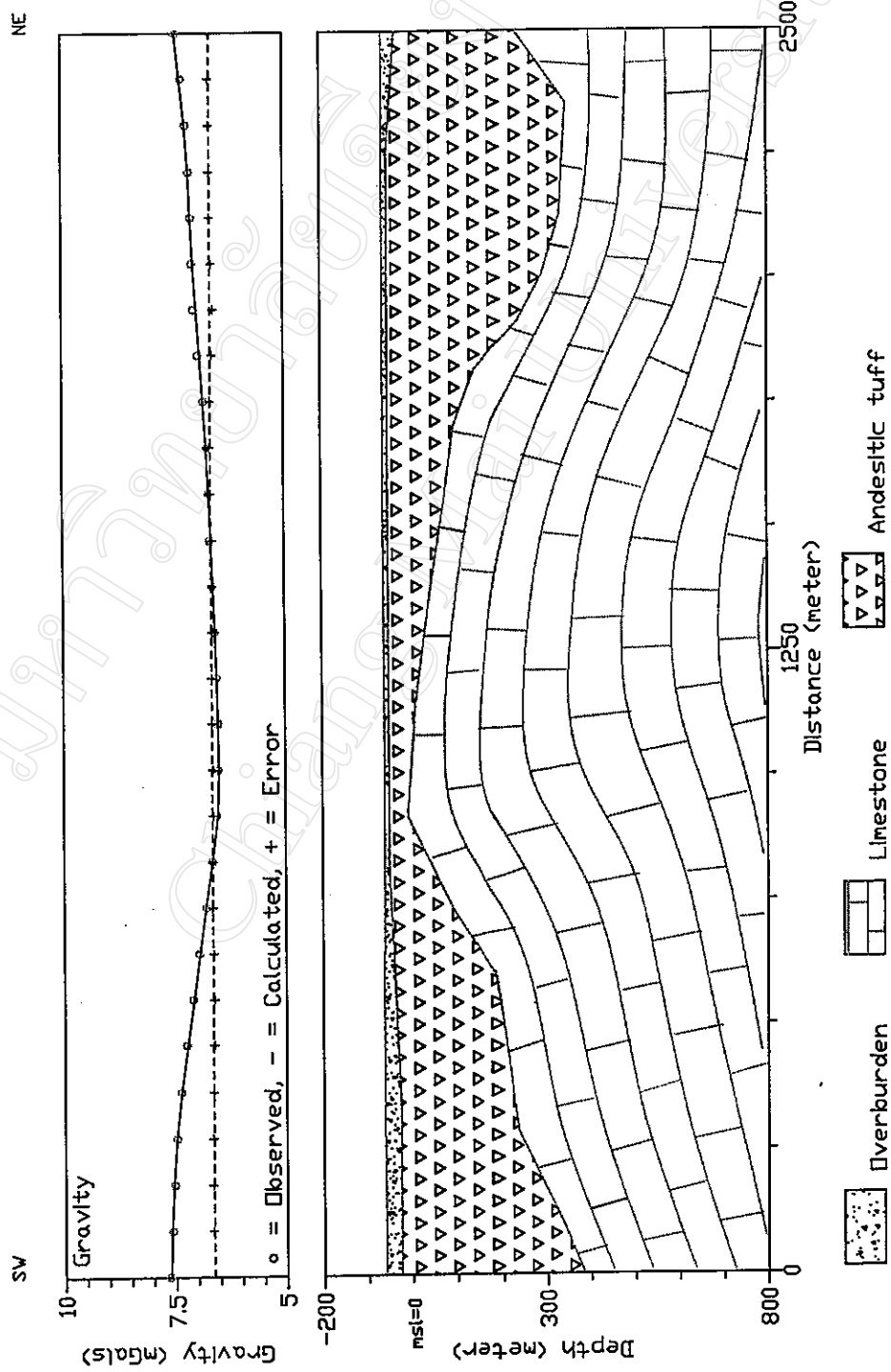


Figure 4.6 Gravity model along profile D1D2

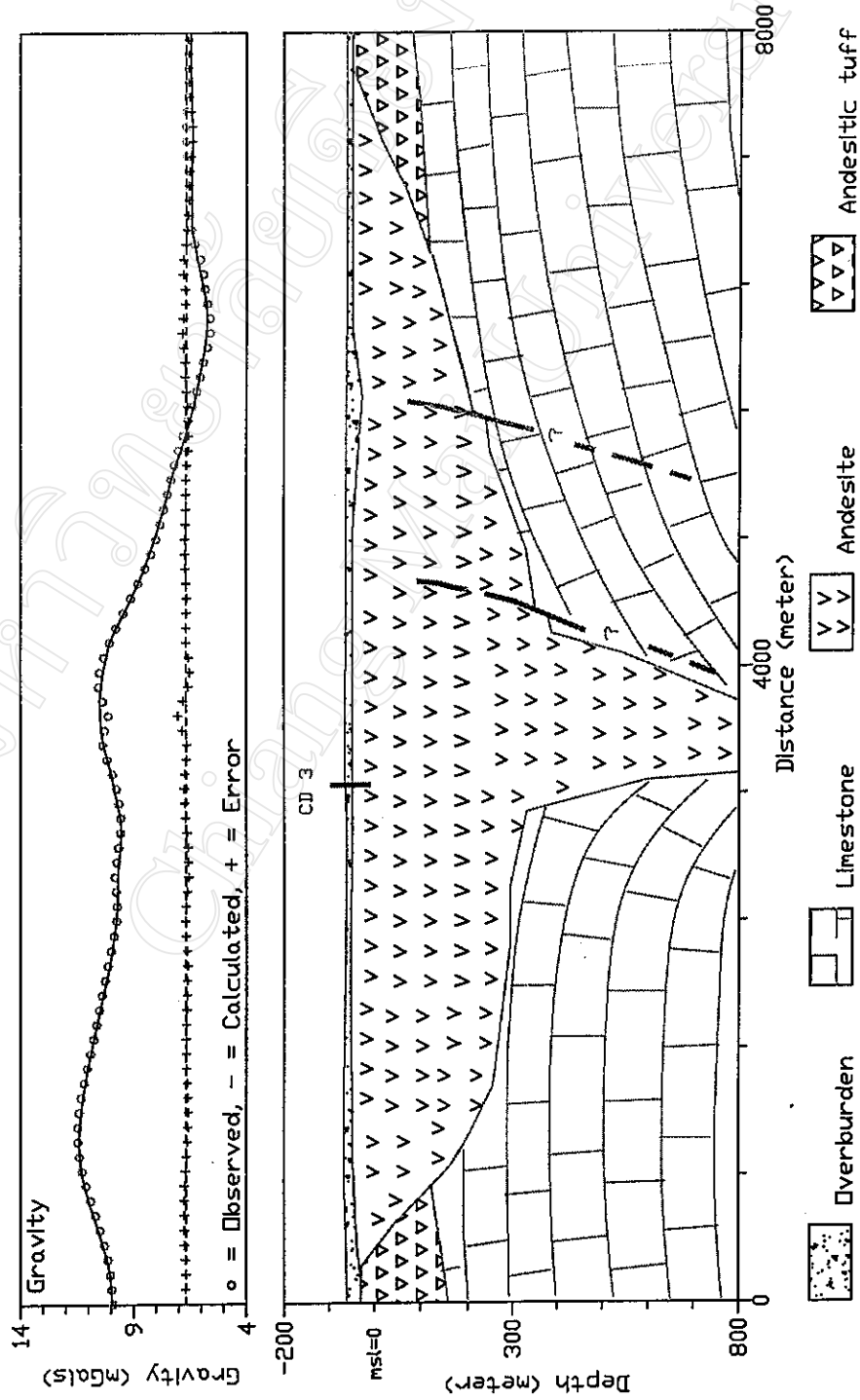


Figure 4.7 Gravity model along profile E1E2

corner of the model implies the occurrence of lesser-density rock type on the SE of the profile. In this case, it is possible that limestone may lie shallower toward in SE portion of the study area than that in NW portion.

4.3.6 Gravity model along profile F1F2

The model is 1,500 m long and traverses the area from W to E. It is located on the lower left portion of the study area. The model lies immediately north of an active gypsum mine. As shown in Figure 4.8, the model shows two major units, gypsum (2.33 g/cc), and anhydrite (2.9 g/cc). These sulphate rocks are underlain by limestone (2.64 g/cc). The decreasing in gravity from W to E of the profile suggests extension of a limestone body farther eastward. The model having these rock units testified not only the different in geologic setting, but also the magnitude of gravity values to others.

It is suggested that the study area is controlled by faults which terminate the extension of the rocks, especially the extension of gypsum body at the left portion of the area. The information from outcrop geology, boreholes, and interpreted models at the study area indicate that the boundary between andesitic tuff and andesite is probably located across the middle of the study area and limited to southward. Although the models give a better fit to the observed and calculated gravity, it must be kept in mind that a perfect fit does not make a necessarily correct solution, and such a solution may be misleading if its limitations are not

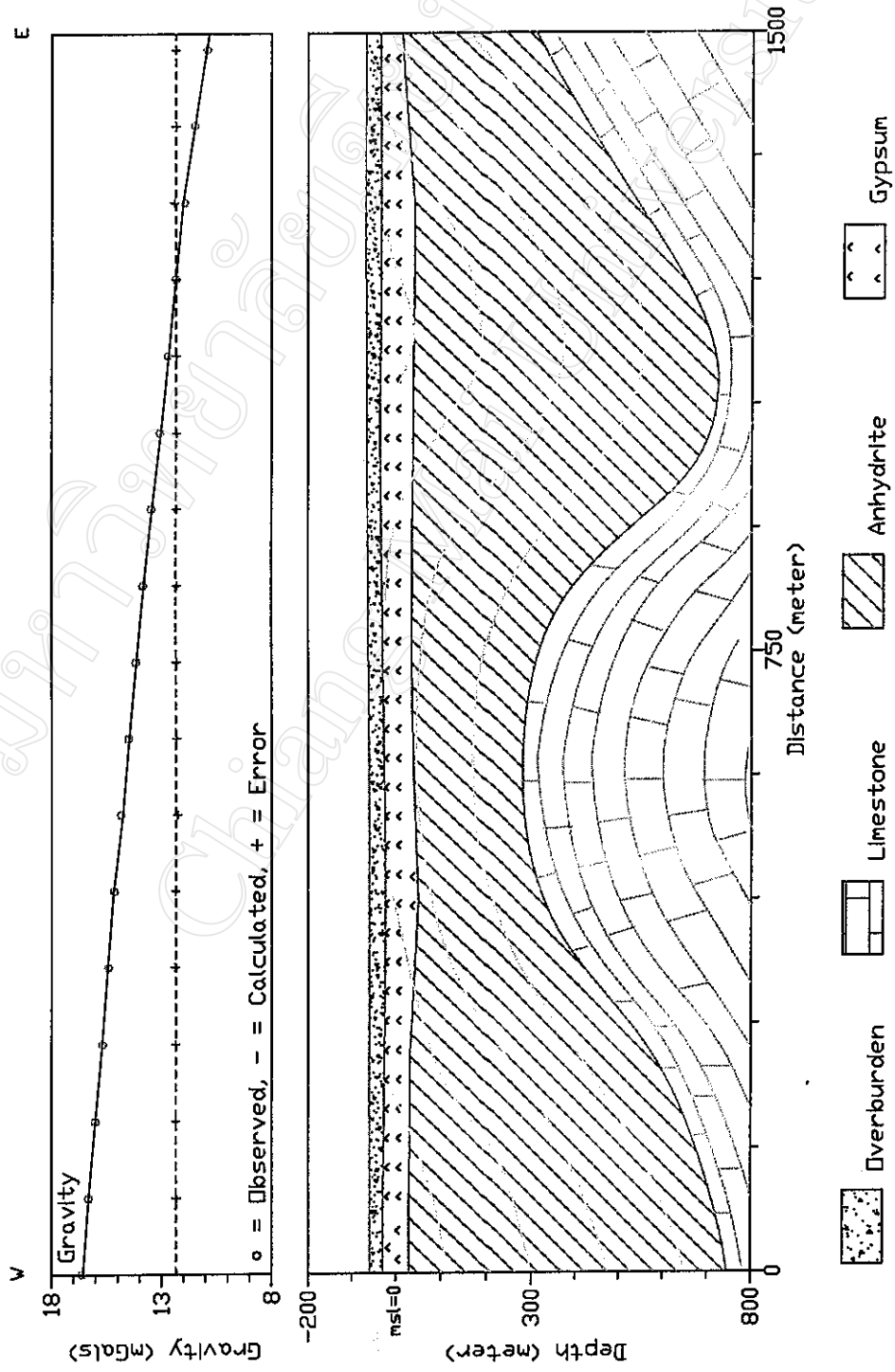


Figure 4.8 Gravity model along profile F1F2

appreciated. The models are by no means unique, both for inherent ambiguity in the gravity field interpretation caused by lack of enough constraint and invalidates of two-dimensionality.

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