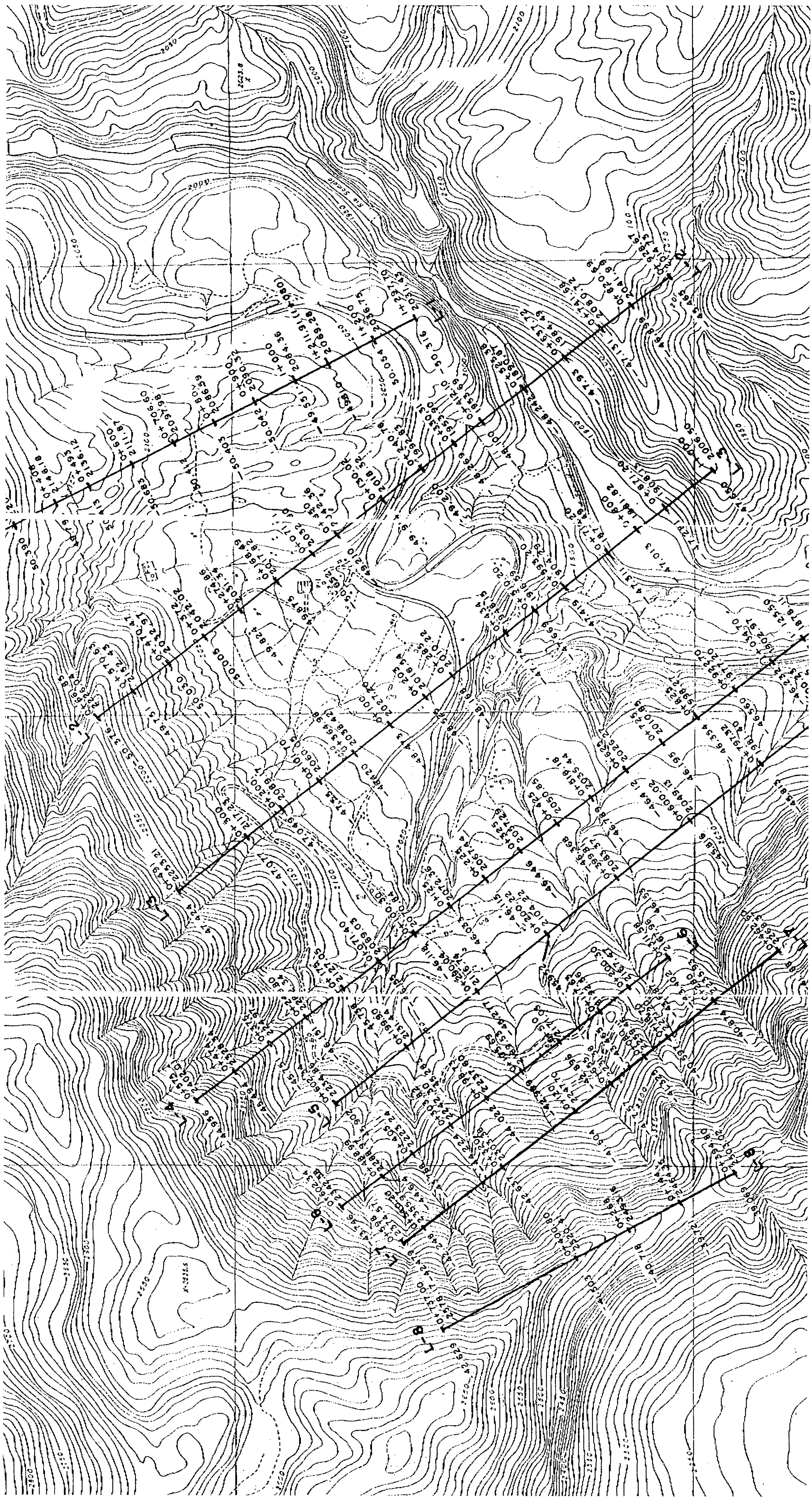

GL01502

PRELIMINARY INTERPRETATION

DETAILED GRAVITY SURVEY, ZUNIL I AREA

Introduction

The UURI study of the 1989 Zunil I detailed gravity data has included several elements including rview of INDE Bouguer Gravity maps and principal facts, measurement of densities, computation of the Bouguer Gravity anomaly for densities of 2.20 and 2.30 g/cc, contouring, qualitative interpretation, and numerical modeling. A brief review of the results to date follows.

Density Studies for Bouguer Gravity Data Reduction

Density determinations were completed for Zunil I drill core available at UURI. Saturated densities for seven volcanic rock core samples from drill holes Z-2, Z-11, and ZCQ-2 averaged 2.25 g/cc. The saturated density for a granodiorite (altered) core sample from ZCQ-4 was found to be 2.58 g/cc. These few density values are in good agreement with density values reported by Cordon (1989) in a more extensive density study of core samples from well Z-11.

Also in support of the density study, Bouguer anomaly profiles were calculated for lines 2, 3, 7, and 8 using eight density values ranging from 1.7 to 2.67 g/cc. These profiles were compared to elevation along the profiles following the density determination method of Nettleton. These profiles suggest that densities of 2.1 and 2.2 g/cc result in Bouguer gravity profiles which have the least correlation with topography, and are therefore most appropriate for the densities used in Bouguer and topographic corrections. The Nettleton method is somewhat limited because of three-dimensional effects near the profiles and by subsurface density variations. Regional Bouguer gravity maps for densities of 2.00, 2.50, and 2.67 g/cc were also correlated with topography. The 2.00 and 2.50 density maps showed much less correlation with topography than the 2.67 density map. We conclude, on the basis of this evidence, density measurements, and experience in other volcanic areas, that densities of 2.20 and 2.30 g/cc are most appropriate for Bouguer and topographic corrections for depths to 1000 m in the Zunil I area. A density of 2.0 to 2.1 may be most appropriate for depths of 0 to 300 m.

Bouguer Map Preparation

UURI contoured Bouguer Gravity maps reduced at densities of 2.00 and 2.67 g/cc which were telefaxed to UURI from CyM/MKE. Contouring the maps at 0.5 milligals (mg) allowed identification of questionable data values and provided one indication of the noise level of the data. Review of principal facts provided by INDE reveals numerous topographic corrections exceding 12 mg, and a maximum topographic correction of 15.8 mg for a density of 2.67

g/cc. This corresponds to a maximum correction of 11.8 mg for a density of 2.0 g/cc and 13.6 g/cc for a density of 2.30 g/cc. The difference in terrain corrections excedes 3.0 mg (at p=2.30 g/cc) for adjacent stations at several locations. An error of 10 to 30 percent is common in estimating terrain corrections for cases of severe topography, suggesting a possible error level of 1.4 to 4.1 mg from inaccuracies in terrain corrections alone. The contoured data suggest an error level somewhat less than this, perhaps indicating a diligent effort in terrain corrections by INDE.

UURI determined Bouguer corrections and topographic corrections for all stations for densities of 2.20 and 2.30 g/cc, plotted Bouguer anomaly maps, and contoured these maps at 0.5 mg.

Qualitative Interpretation

Bouguer anomaly maps for densities of 2.00, 2.20, and 2.30 g/cc were superimposd over topographic maps at a scale of 1:10,000 and evaluated for topographic correlation. All three maps showed less correlation with topography than the 2.67 g/cc Bouguer Anomaly map, with the 2.00 and 2.20 g/cc maps showing the least correlation.

Geologic structures were interpreted from the steep gradient areas of all three maps. These gradients are thought to arise from subsurface density contrasts along linear features, most probably faults. The high frequency content (i.e. steep gradient and short extent normal to the trend) of most gradients suggest many of the density contrasts occur within 500 m of the surface (and hence above the granodiorite) or result from: a) other near surface density variations, or b) inaccuracies in the data collection and/or reduction.

Structures interpreted from the data are compared for the three Bouguer anomaly maps and summarized on Plate I. The agreeement of structures qualitatively interpreted is rather good. A structure which trends northwest near ZCQ-6 is the most consistantly interpreted structure, and is most likely to extend to considerable depth. Several northeast-trending structures are also indicated on multiple maps. The agreement is best for structures interpreted form the 2.20 and 2.30 g/cc maps. A direction of fault movement is suggested for several faults, assuming that the density contrast results from movement on top of the more dense granodiorite. This sense may disagree with fault directions observed at the surface in volcnic rocks.

Quantitative Interpretation

Inspection of regional Bouguer Gravity maps (at p = 2.00, 2.50, and 2.67 g/cc), and the new detailed data indicate the presence of strong regional gradients in the Zunil I area. The most important northwest-trending gradient on the 2.67 g/cc map is due to the incorrect density reduction. All maps indicate a complex regional gradient with a strong northeast component of −15 mg/3 km (−5mg/km) to the northeast. A simple linear gradient of −5mg/km to N 45 E was judged to be the most certain and least biased regional gradient in the Zunil I area, and this regional gradient was then removed from the 2.30 g/cc detailed survey data. This resulted in a Residual Gravity Anomaly map, Plate II.

The residual gravity anomaly map has been interpreted qualitatively to identify probable structures, and these are compared to structures interpreted earlier. The residual map shows a weak 2 mg positive anomaly which trends N 60 E adjacent to a similar low, suggesting a horst-graben geometry. Northwest trending structures including one near ZCQ-6 can also be inferred.

Numerical Modeling

Numerical modeling of the residual gravity map is now in progress. Most portions of the map show three-dimensional anomaly patterns rather than two-dimensional anomalies. This is especially true in the main area of intrest, near wells ZCQ- 3, −5, −6. The UURI three-dimensional gravity modeling program GME was judged to be most appropriate for modeling these data.

Results to date indicate that most of the anomaly patterns, particularly the higher frequency features, can be attributed to density contrasts between the surface and the granodiorite, i.e. above depths of 800 m. This does not mean that structures are not present in the granodiorite, just that the density contrasts in the overlying volcanics and closer to the gravity meter, are dominant in the gravity data. Preliminary gravity model results are presented here to support these observations.

DENSITY MEASUREMENTS OF ZUNIL CORE SAMPLES

Sample #	Dry weight (g)	Suspended weight (g)	Saturated weight (g)	Vol (cu. cm)	Density (g/cu. cm)
Z-11 89m	283.61	167.95	297.30	129.35	2.19
Z-11 476m	211.00	130.30	222.65	92.35	2.28
Z-11 165m	305.30	173.05	312.60	139.55	2.19
Z-2 580m	295.05	175.65	308.00	132.35	2.23
Z-11 590m	148.50	89.21	152.10	62.89	2.36
ZCQ-2 103m	610.06	365.00	616.50	251.50	2.43
Z-2 624m	205.80	119.12	218.60	99.48	2.07
ZCQ-4 1015m (granodior.)	821.00	512.50	830.40	317.90	2.58
				Average:	2.29

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~~April~~ May 26, 1989

Telecommunications
1092 Annex C
CAMPUS

Please telefax the attached pages to Luis Merida at CM Engineering in Guatemala. The telefax number is 011-5022-34-06-27.

Mr. Merida's full name and address is

Ing. Luis Felipe Merida I.
Cordon Y Merida, Ings.
6a.Avendia 6-94, Zona 9
Guatemala C. A.

A phone number for the company is:

011-5022-31-64-94

If you have any problems please give me a call at 524-3437.

The telefax should be charged to account number 9-92300.

Kathryn A. Ruth
UURI/ESL

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May 25, 1989

Ing. Luis Felipe Merida I.
Cordon Y Merida, Ings.
6a.Avendia 6-94, Zona 9
Guatemala C. A.

Dear Luis:

It was a pleasure to have you here in Salt Lake City. My staff enjoyed sharing the results of their work with you. I hope your visit with your daughter was also enjoyable.

During the last several days I have had several discussions with Duncan about his geologic work and Ross about the gravity studies. Duncan plans to arrive in Guatemala City on Saturday, June 3 with his wife Leslie. He will confirm his plans with you on June 2. Could you meet them at the airport (it will probably be the Continental flight)? The mylars have been made and most of the photolinears have been plotted. Duncan has a copy of the photolinear map and will bring it with him. I will send a better copy to you when it is completed.

Ross has completed his review of the existing gravity data and has written a report on his findings. His report is entitled "Zunil Gravity Studies: Review Comments" and was sent to Roy yesterday. A copy is enclosed for your review. Even though Ross's conclusions are based on poorly documented data, I think they are very important with respect to siting new drill holes and to defining areas that require additional geologic examination. We need to confirm these conclusions with the data from the new surveys. In addition, we need to document the corrections that have been made to the old data sets that Ross has worked with. In view of the potential importance of the gravity data to our project, I think it would be very useful to have Ross fly to Guatemala when the new survey is completed so that he can begin modelling the data with Palma.

Please get a copy of Ross's report to Palma as soon as you can. Tell him the main point of this report is that a density of 2.30 gm/cc, as measured in Z-11, is much better than the 2.67 gm/cc value used for the Bouguer correction of the gravity data. In the report, Ross shows how use of the lower value and the removal of regional gradients can lead to an interpretation which seems to be in much better agreement with the known geology and would allow for a more detailed structural interpretation of the area.

In doing his work Ross had to pick the data off of page size maps. No detailed information on station locations, elevations, and the principal facts of the gravity data where available. In his experience, accurate position, elevation and terrain corrections are difficult to achieve in areas were topographic relief is extreme, such as at Zunil. Nevertheless, a high degree of accuracy is needed to develop a correct interpretation of the data.

It is good to learn that topographic corrections are being applied to the results of the new detailed gravity survey and that data reduction can be done by computer at INDE. Ross suggests that the data reduction should be completed for several densities (e.g. 2.25, 2.30, 2.35, 2.40, 2.45, and 2.67 gm/cc) if this can easily be done on the computer. He thinks that 2.30 gm/cc will probably be best for the Bouguer and terrain corrections.

We have 2 1/2 and 3-D numerical modelling programs on our main computer which could be used to help interpret the gravity data that has been generated. In order to interpret the data we will need maps at an appropriate scale (including the previous surveys for regional information) and the principal facts with an indication of what densities were used, what the elevation accuracy was and what the terrain corrections were for both inner and outer zones. In the long run, it would be better to get Ross to Guatemala to study the data with Palma and to agree with him on the approach to numerical modeling and a final interpretation than to try to copy and send all of the data.

Final drafts of our geochemical, alteration, and fluid inclusion reports should be done very soon as promised. Short reports on the resistivity and mercury surveys will also be prepared. Did you get any response from INDE on the preliminary reports we gave you?

Keep me posted on the progress you make with INDE.

Give my regards to everyone, especially Ana Maria, and thank her for the basket of apples. Sue loved them.

Best regards,

Joe Moore

DRAFT DRAFT

ZUNIL GRAVITY STUDIES

REVIEW COMMENTS

Introduction

Both regional and detailed gravity surveys have been completed by INDE in the Zunil area. A regional survey extends from Quetzaltenango on the north to south of Cerro El Galapago, covering approximately 90 sq km. A more detailed survey of approximately 30 sq km covers the Zunil I geothermal project area. The locations of the gravity survey are not indicated on the available maps with the exception of the main 15 sq km area of the detailed survey. The principal facts of the gravity data (latitute, longitude, station location, station elevation, elevation accuracy, terrain corrections, etc.) were not available for review.

A draft report which describes gravity models of the Zunil I area (Cordon, 1989) and other information refer to a Bouguer gravity anomaly map computed for a density of 2.67 gm/cc. Although this is a commonly used density for igneous, metamorphic and sedimentary terrains, it is almost always too high for young volcanic provinces. Use of an incorrect density in gravity data reduction will lead to false anomalies. U. S. Geological Survey studies on Hawaii (Kinoshita et al, 1963) and by Woollard (1951) on Oahu indicated that a density of 2.30 gm/cc was most appropriate even in this province of basaltic lava flows. Williams and Finn (1982) concluded the bulk densities of most Cascade volcanic edifices fell in the range 2.15 to 2.35 gm/cc in their studies of silic volcanoes of the Cascades. Couch et al. (1982) used a Bouguer density of 2.43 for data reduction in their study of the Western and High Cascades of Oregon. A density of 2.45 is often used for the Tertiary volcanics of the Basin and Range province in the Western United States. The 2.30 gm/cc average density reported by Cordon (1989) for 620 m of volcanic rocks in well Z-11 is in good agreement with both the Cascade and Hawaii studies.

A quick correlation between the Zunil gravity maps and the topographic maps, using transparent overlays, shows high spatial correlations between gravity lows or negative gradients, and topographic highs or positive gradients. This is additional confirmation that the 2.67 gm/cc used in the Bouguer gravity reduction is too high.

Basic Gravity Formulation

The successful utilization of gravity data is quite dependent upon good field procedures and the careful application of a number of corrections to the observed gravity values. Gravity data reduction has been described in detail by Dobrin (1960), Telford et al (1976), and numerous others. It is appropriate to review some points here.

The value of the earth's gravity field, g, at any point on the earth's reference spheroid is given by the following formula, adopted by the International Association of Geodesy in 1967:

$$g = g_o(1 + \alpha \sin^2 \phi + \beta \sin^2 2\phi) \quad (1)$$

where g = equatorial gravity = 978.0318 gals at sea level, ϕ = latitude, and the constants α and β are α = +0.0053204 and β = -0.0000058 respectively.

Following the notation of Telford et al (1976) the Bouguer gravity g_B is given by,

$$g_B = \text{observed } g + (\text{tidal} + \text{drift corr.}) + \text{latitude corr.} + \text{free air corr.} + \text{Bouguer corr.} + \text{terrain corr.} \quad (2)$$

The reduction of observed gravity data to Bouguer gravity values, in metric units, is given by

$$g_B = g_{obs} + d_{t+d} + 0.8122 \sin 2\phi \text{ mgal/km} + 0.3085\ h \text{ mgal/m} - 0.04188\ h\sigma \text{ mgal/m} + t.c. \quad (3)$$

The latitude correction is positive as one approaches the equator; h is the elevation of the station above the datum plane in meters; σ is the density of the earth slab between the station and the datum plane (often chosen to be 2.67 gm/cc). The free-air correction is positive for stations above the chosen datum plane, while the Bouguer correction is negative for stations above the datum plane. The terrain correction is always positive.

The Bouguer anomaly is

$$G_B = g_B - g_r \quad (4)$$

where g_r is a local reference station value, or g_r = g from eq.1.

The density used for data reduction occurs in eq. 3 in the Bouguer correction and in the terrain correction. Many computer routines for gravity data reduction calculate the Bouguer gravity for several densities simultaneously. In areas of high topographic relief such as the Zunil area the incorrect choice of the density used in the Bouguer and terrain corrections can give rise to misleading gravity maps. The variation in the Bouguer correction for several different densities and station elevations above or below the datum elevation is illustrated in Table 1, below.

Table 1. Bouguer Correction (mgal)

Station Elev. (m)	σ=2.3	σ=2.45	σ=2.55	σ=2.67
1.0	0.0963	0.1026	0.1068	0.1118
10.0	0.9632	1.0261	1.0679	1.1182
100.0	9.6324	10.2606	10.6794	11.1820
200.0	19.2648	20.5212	21.3588	22.3639
400.0	38.5296	41.0424	42.7176	44.7278
600.0	57.7944	61.5636	64.0764	67.0918
800.0	77.0592	82.0848	85.4352	89.4557
1000.0	96.3240	102.6060	106.7940	111.8196

Surface elevations within the area of the detailed gravity survey vary from less than 2000 m near the Samala River to almost 3200 m on Cerro Candelaria. From Table 1 we note that the difference in the magnitude of the Bouguer corrections for an elevation difference of 1000 m and densities of 2.67 and 2.45 gm/cc is 9.21 mgals. Similarily the difference in Bouguer corrections for an elevation difference of 400 m and densities of 2.67 and 2.30 gm/cc is 6.20 mgals. We believe that a substantial portion of the gravity minima occuring over major topographically high areas are due to an improper density (2.67) in the Bouguer correction.

Terrain Corrections

From the data reviewed it is not clear to what degree terrain corrections may have been applied. Survey procedure in areas of extreme topographic variation such as Zunil should include the estimation of near-station corrections (Hammer zones A-D, or 0-170 m) in the field and the application of outer-zone terrain corrections by hand or by computer. An example field sheet for the determination of near-station terrain corrections is included as Figure 1. The quality of older topographic maps may have made terrain corrections for outer zones difficult or impractical. Terrain corrections for many of the Zunil gravity stations could range from 5 to more than 10 mgal, with a high probable error. Since terrain corrections are always positive, incomplete terrain corrections probably contribute to the large gravity minima which correlate with major topographic highs.

Gravity Modeling by M-K

Cordon (1989) reports on the results of preliminary gravity modeling of the graben area within the detailed survey. Because his modeling attempts to match the Bouguer gravity data, which has been reduced with an incorrect density, the models are dominated by low density bodies northwest of the graben. The computed gravity values do not provide a detailed fit to the observed gravity data over the granodiorite body, even though care has been taken to use drill control on the depth to the granodiorite (from ZCQ wells 1-6) and density data for overlying volcanics from well Z-11.

Cordon (1989) recognized the probable effect of an incorrect density in the reduction to the Bouguer gravity, but proceeded with the modeling study as requested by the Advisory Committee. He concludes, correctly, that the graben itself is not responsible for the large negative gravity anomaly. Nevertheless, attempting to match the observed data, and not removing the regional gradient due to the low density volcanic center, yields misleading results. The presence of a 10 km wide, 6 km thick intrusion with a density of 2.0 to 2.1 gm/cc, as he concludes, is highly unlikely. Documented densities for the lightest igneous rocks include (Telford et al, 1976): rhyolite (2.35-2.70); dacite (2.35-2.8); and obsidian (2.2-2.4). Also, a magma body of the size, depth, and density indicated is unlikely, without ongoing, catastrophic eruptive activity.

Alternative Interpretations

In view of the foregoing critical evaluation, it is appropriate to illustrate what might happen using approximately corrected gravity data and an alternative interpretation method. Without exact station locations, elevations, and other principal facts for the gravity data, one cannot complete an accurate reduction of the gravity data. Using adjustments to the gravity data appropriate to a density of 2.3 for the Bouguer correction from Table 1, and rough esimates of station location and elevation from 1:40,000 scale maps, the gravity data along profile A-A′ have been adjusted as shown in Figure 2. No adjustment for the effect of changing the density in the terrain correction could be made because we had no information on the magnitude of the terrain corrections. Both regional and residual gravity data along M-K profile A-A′ are shown. Where the data overlap, the detailed gravity profile is 8 to 20 mgal higher than the regional gravity indicating reference to a dfferent datum or base station, or additional corrections. Both profiles show an inverse trend to the plot of station elevation taken from the regional scale (1:40,000) topographic map. Profile g_B estimates the change in Bouguer gravity for a density of 2.30 above a datum of 1800 m. The negative anomaly on the northwest is reduced by as much as 17 mgals as compared to the Bouguer gravity for a density of 2.67. Complete terrain corrections might have further reduced this minimum.

Figure 3 illustrates the manual fit of a low frequency curve to the adjusted Bouguer gravity data. This curve simulates a regional gradient probably due to the low density units associated with volcanic centers (Volcan Santa Maria; Cerro Candelaria) below the 1800 m datum plane, and perhaps to incomplete terrain corrections. The residual anomaly results when the regional gradient is removed from the adjusted gravity values. Numerical modeling of this profile, at an expanded vertical scale, would be appropriate only if accurate station locations, elevations, and other data would justify the additional effort. Data processing such as this would result in a more realistic model for the Zunil I area. The approximate position of three faults inferred from the steeper gravity gradients of this residual anomaly profile are shown.

Figure 4 illustrates an alternative (interim) interpretation of fault locations suggested by the detailed gravity data. The positions of three faults interpreted from the residual anomaly of profile A-A′ are indicated along this profile. While there is some agreement with structures previously interpreted by INDE, the position of some faults is different and additional northwest-trending structures are indicated. This qualitative interpretation assumes that the existing data are sufficiently accurate as presented (even with a 2.67 density and existing terrain corrections) to support the steep gradients indicated by the contour map. No new numerical modeling has been undertaken to support this interpretation, but some of the northwest trending structures agree with linear features that have been interpreted from topographic expression and aerial photos.

If the interpretaion of three faults just west of ZCQ-6 is correct, this may indicate a zone of considerable fracturing and permeability important to the siting of future production wells. The detailed gravity survey now in progress will provide detailed data with good elevation and location control suitable for in-depth numerical modeling to test this interim interpretation.

Recommendations

The granodiorite intersected in Zunil drill holes appears to be well expressed in the gravity data, and major structures which might indicate areas of higher permeability can be inferred from the gravity data. Additional gravity data modeling would be warranted if existing survey data have sufficient accuracy (observed gravity, station location, station elevation, terrain corrections) and the data are reduced using a density of 2.30 g/cc for the Bouguer correction. If there is concern about the level of accuracy of existing data, further modeling should await the completion of the new gravity survey. Care should be taken to complete near-station terrain corrections in the field, and to complete outer zone corrections as well. It may be wise to reduce the data using several densities for the Bouguer correction, such as 2.30, 2.40, and 2.45 g/cc.

References

Cordon, U. J., 1989, Gravity models of the Zunil I geothermal field, Quetzaltenango, Guatemala: M-K Engineer, Tech. rep. (draft), 17 p., Feb.

Couch, R. W., Gemperle, M., Connard, G., and Pitts, G. S., 1982, Structural and thermal implications of gravity and aeromagnetic measurements made in the Cascade volcanic area: abs., Geophysics, v. 47, n.4, p. 424.

Dobrin, M., 1960, Introduction to Geophysical Prospecting, 2nd ed., McGraw-Hill, New York.

Kinoshita, W. T., Krivoy, H. L., Mabey, D. R., and MacDonald, R. R., 1963, Gravity survey of the island of Hawaii; USGS Prof. Paper 475-C, p. C114-116.

Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1976, Applied Geophysics, Cambridge Univ. Press, Cambridge, 860 p.

Williams, D., and Finn, C., 1982, Evidence from gravity data on the location and size of subvolcanic intrusions: preliminary results; abs., Geophysics, v. 47, n. 4, p. 425.

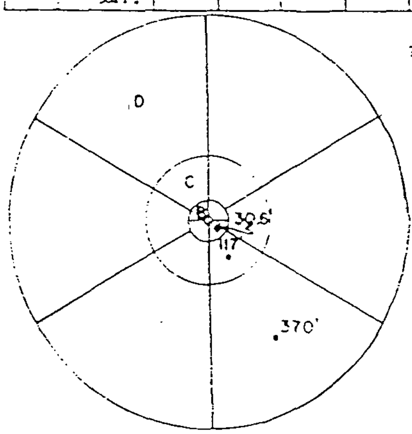
Woollard, G. P., 1951, A gravity reconnaissance of the island of Oahu: Am. Geophysical Union Trans., v. 32, n. 3, p. 358-368.

EXPL TION SERVICES – GEOPHYSICS DIVISIO

INNER TERRAIN CORRECTION ONLY

Zone \ Compartment			1	2	3	4	5	6	Corr. ±0.01 Mg.
6.56' to 54.6'	B	Elev. Diff.							
		Corr.							
54.6' to 175'	C	Elev. Diff.							
		Corr.							
175' to 558'	D	Elev Diff.							
		Corr.							

Total Corr.=________ Mg.



ROCK DENSITY = 2.00
INNER TERRAIN CORRECTION TABLES

ZONE B 4 Compartments 6.56' to 54.6' ±h, ft.	T	ZONE C 6 Compartments 54.6' to 175' ±h, ft.	T	ZONE D 6 Compartments 175' to 558' ±h, ft.	T
0 - 1.1	0	0 - 4.3	0	0 - 7.7	0
1.1-1.9	0.1	4.3- 7.5	0.1	7.7-13.4	0.1
1.9- 2.5	0.2	7.5- 9.7	0.2	13.4-17.3	0.2
2.5- 2.9	0.3	9.7-11.5	0.3	17.3-20.5	0.3
2.9- 3.4	0.4	11.5-13.1	0.4	20.5-23.2	0.4
3.4- 3.7	0.5	13.1-14.5	0.5	23.2-25.7	0.5
3.7- 7	1	14.5-24	1	25.7-43	1
7 - 9	2	24 -32	2	43 -56	2
9 -12	3	32 -39	3	56 -66	3
12 -14	4	39 -45	4	66 -76	4
14 -16	5	45 -51	5	76 -84	5
16 -19	6	51 -57	6	84 -92	6
19 -21	7	57 -63	7	92 -100	7
21 -24	8	63 -68	8	100 -107	8
24 -27	9	68 -74	9	107 -114	9
27 -30	10	74 -80	10	114 -120	10
		80 -86	11	120 -127	11
		86 -91	12	127 -133	12
		91 -97	13	133 -140	13
		97 -104	14	140 -146	14
		104 -110	15	146 -152	15

Prospect ____________ Date ____________

Station # ____________

Surveyor ____________ Computed By ____________

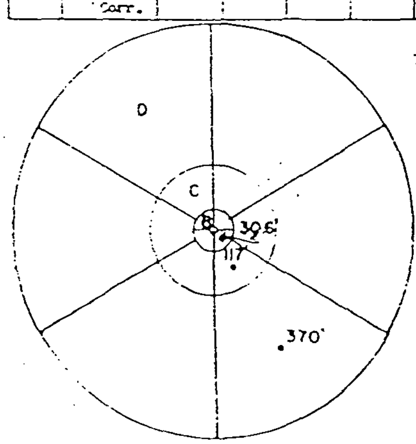
Note: Values are in feet to center of compartment.

EXPL TION SERVICES – GEOPHYSICS DIVISIO

INNER TERRAIN CORRECTION ONLY

Zone \ Compartment			1	2	3	4	5	6	Corr. ±0.01 Mg.
6.56' to 54.6'	B	Elev. Diff.							
		Corr.							
54.6' to 175'	C	Elev. Diff.							
		Corr.							
175' to 558'	D	Elev Diff.							
		Corr.							

Total Corr.=________ Mg.



ROCK DENSITY = 2.00
INNER TERRAIN CORRECTION TABLES

ZONE B 4 Compartments 6.56' to 54.6' ±h, ft.	T	ZONE C 6 Compartments 54.6' to 175' ±h, ft.	T	ZONE D 6 Compartments 175' to 558' ±h, ft.	T
0 - 1.1	0	0 - 4.3	0	0 - 7.7	0
1.1-1.9	0.1	4.3- 7.5	0.1	7.7-13.4	0.1
1.9- 2.5	0.2	7.5- 9.7	0.2	13.4-17.3	0.2
2.5- 2.9	0.3	9.7-11.5	0.3	17.3-20.5	0.3
2.9- 3.4	0.4	11.5-13.1	0.4	20.5-23.2	0.4
3.4- 3.7	0.5	13.1-14.5	0.5	23.2-25.7	0.5
3.7- 7	1	14.5-24	1	25.7-43	1
7 - 9	2	24 -32	2	43 -56	2
9 -12	3	32 -39	3	56 -66	3
12 -14	4	39 -45	4	66 -76	4
14 -16	5	45 -51	5	76 -84	5
16 -19	6	51 -57	6	84 -92	6
19 -21	7	57 -63	7	92 -100	7
21 -24	8	63 -68	8	100 -107	8
24 -27	9	68 -74	9	107 -114	9
27 -30	10	74 -80	10	114 -120	10
		80 -86	11	120 -127	11
		86 -91	12	127 -133	12
		91 -97	13	133 -140	13
		97 -104	14	140 -146	14
		104 -110	15	146 -152	15

Prospect ____________ Date ____________

Station # ____________

Surveyor ____________ Computed By ____________

Note: Values are in feet to center of compartment.

Fig. 1. Field computation chart for near station terrain corrections.

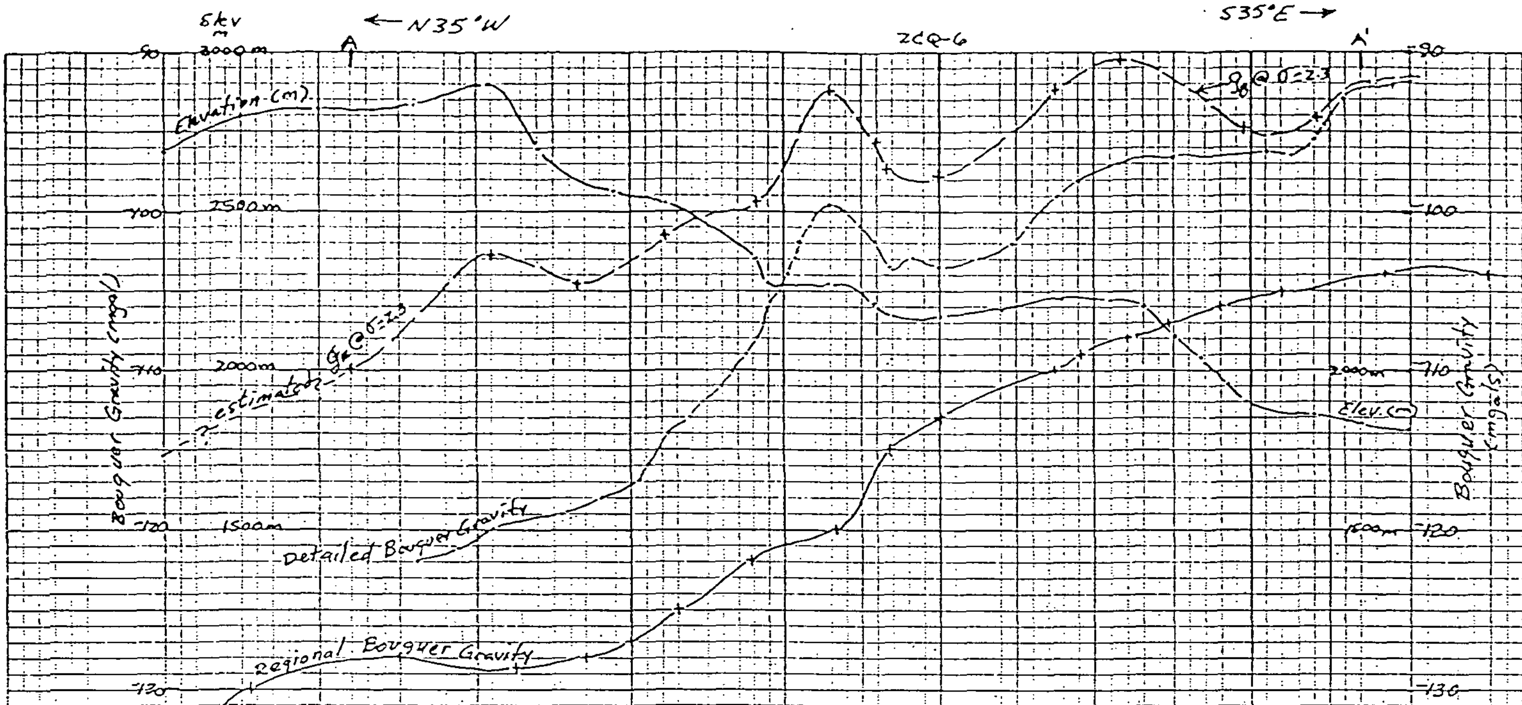


Figure 2. Comparison of regional Bouguer gravity, detailed Bouguer gravity, and surface elevation along profile A-A'. Also shown is the estimatedBouguer gravity for the detailed survey using a density of 2.30 g/cc.

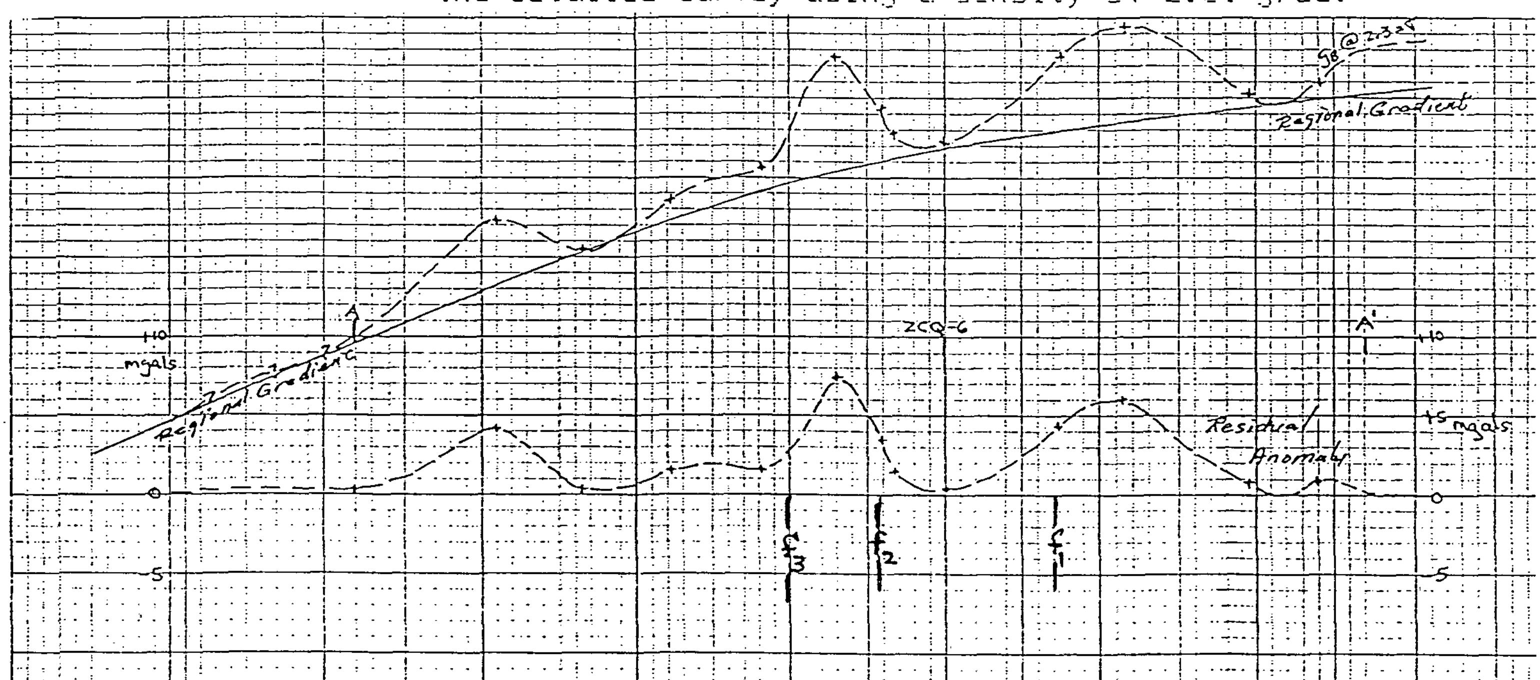


Figure 3. Identification of a regional gradient along profile A-A', and its removal to form a residual anomaly suitable for numerical modeling.

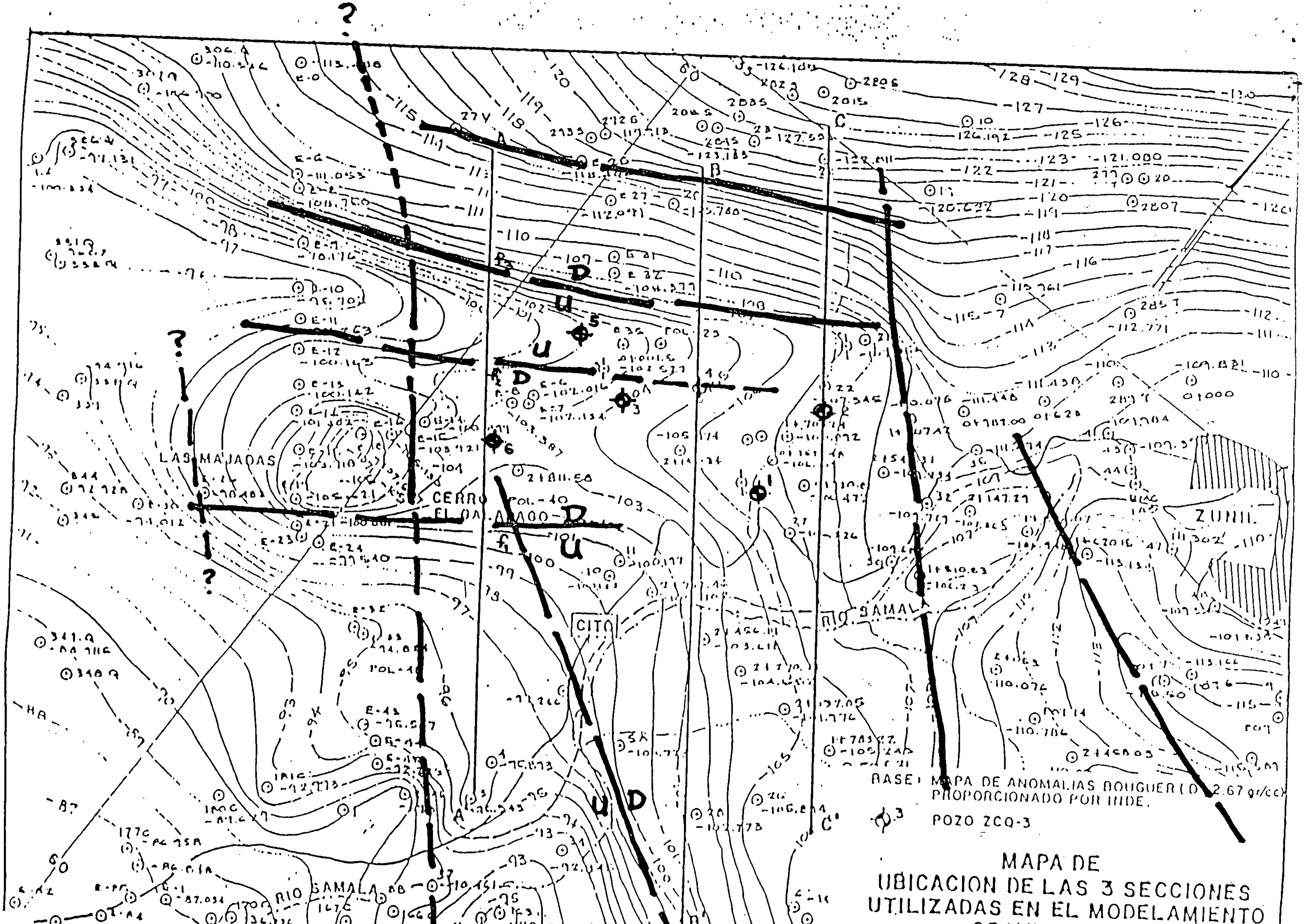


Figure 4. Location of faults in the Zunil 1 area as inferred from the detailed gravity survey. This interpretation has not been supported by numerical modeling.

INSTITUTO NACIONAL DE ELECTRIFICACION

I. N. D. E.

GUATEMALA, C. A.

FORMA 741012

DIRECCION CABLEGRAFICA
INDE GUATEMALA,
TELEX - INDE - 5324-GU

NUMERO 0-650-1421-89
REFERENCIA

Al contestar, sírvase mencionar este número y referencia.

10-871 Técnico/GF / 26+
HD
IR
Panel
en proceso

Guatemala,
22 de noviembre de 1,889.

CORDON Y MERIDA, INGS.
10:40 am
24 NOV 1989
6a. Avenida 6-94 Zona 9
GUATEMALA, C. A.

Señor Ingeniero:
Luis Felipe Mérida
Co-Director
Cordón y Mérida Ings.
Mk-Ferguson Company
Morrison-Knudsen Engineers, Ings.
Presente

stimado Ingeniero Mérida:

Tengo el agrado de dirigirme a usted para dar respuesta a su nota # 353 del 8/11/89 sobre los trabajos recomendados por el Panel que consideran extra. Al respecto tenemos los siguientes comentarios en el mismo orden de la nota mencionada.

GEOFISICA

A. Queremos informarles que las inversiones de los sondeos eléctricos verticales se las podemos proporcionar en cuanto nos comunique cuales de los SEV les interesan de acuerdo al listado que le remitieramos en nota 0-650-965-89; las restantes actividades mencionadas en su nota, corresponden a la interpretación que su empresa tiene que realizar para lograr localizar con más precisión las principales disconcontinuidades (zonas de mayor fracturación probable) y que es parte de los alcances del trabajo del estudio neotectónico.

B. Queremos recordarle que los datos reducidos para Bouguer de las extensiones en dirección oeste-noroeste de las líneas 2, 4 y 8 se los enviamos con nota 0-650-1158-89 de -

/2

INSTITUTO NACIONAL DE ELECTRIFICACION
I. N. D. E.
GUATEMALA, C. A.

DIRECCION CABLEGRAFICA
INDE GUATEMALA
TELEX - INDE - 6324-GU

FORMA 74105 A

NUMERO	
REFERENCIA	

Al contestar, sírvase mencionar este número y referencia

fecha 22/8/88 y aprovechamos para adjuntarle a la presente nota las correcciones topográficas de las prolongaciones de las líneas mencionadas, para las densidades de 2.00, 2.2, 2.25, 2.3, 2.35, 2.4, 2.45, 2.5, 2.55, 2.6, 2.67 y 3.00; con estos datos lo demás es parte de la interpretación para lograr los alcances por ustedes propuestos originalmente.

C. La determinación del gradiente regional que corresponde al efecto de las rocas mas profundas corresponde a la interpretación que tuviera que entregarnos U. Cordón y el mismo que se utilizara para interpretar las secciones para el area del grid, ya que el mismo no puede variar en un area tan pequeña, no vemos porque tiene que determinarse nuevavamente. Con respecto a la anomalía residual no puede tomarse como un trabajo aislado o adicional porque es parte también de la interpretación, pues se trata unicamente de efectuar una resta (Anom. residual = Anom. bouguer - Anom. regional).

D. Con relación a este punto no encontramos la razón para que lo incluyan como trabajo extra, ya que sería falta de responsabilidad de cualquier Geofísico obviarlo para obtener una debida interpretación de los resultados de los perfiles del modelo numérico.

Cabe mencionar que el trabajo de geofísica que queda por ejecutar esta contemplado dentro de los alcances del estudio neotectónico, por lo que no autorizaremos un solo día mas para dicho profesional.

HIDROGEOLOGIA Y MODELACION NUMERICA

A. La hidrogeoquímica y la interpretación isotópica obedece a a la necesidad de comparar y determinar con un grado de certeza confiable las interpretaciones presentadas por su

FAX 208 586 6658
801 524 3453
CyM Cordon y Merida, Ings.
6a. Ave. 6-94 zona 9 - Guatemala, C.A. Telefonos 317972, 318631, 318612

F A X

Fecha: DEC 18, 1989
Proyecto Zunil I
RE: 10-87/GUA/UTAH/648

A : DR. JOSEPH MOORE / Fax No.: (801) 524 3428
HOWARD ROSS
SECTION MANAGER - GEOCHEMISTRY
EARTH SCIENCE LABORATORY

CC: MARTIN ANDERSON

De: LUIS MERIDA Fax No.: (011) 502 2 34 06 27

Asunto: GEOPHYSIC / NEOTECTONIC

Total de paginas enviadas: 24
(incluyendo esta)

DEAR JOE:

I AM SORRY BEING SO LATE WITH THIS MESSAGE. (AS YOU MIGHT IMAGINE, IT IS WHAT YOU POLITELY CALL IT "LACK OF COMMUNICATION"). I WANT TO RESUME IT FOR YOU AS FOLLOWS:

1. RIGHT AFTER I RECEIVED YOUR LETTER CONFIRMING THAT YOU WILL BE DOING WHAT THE PANEL REQUESTED, I SENT A LETTER TO INDE CONFIRMING THE SAME AND MENTIONING THAT IT WAS 16 DAYS OF EXTRA WORK. THEY REPLIED SAYING THAT THEY COULD DO MOST OF THE WORK AND THAT THEY ONLY NEEDED THE INTERPRETATION OF THEIR NUMERICAL WORK. PLEASE LOOK AT THE ADDENDUM I WITHIN THIS MESSAGE.

2. I WAS SURPRISED BY THEIR POSITION AND SO I DECIDED TO DISCUSS IT WITH THEM PERSONALLY, INSTEAD OF SENDING A LETTER, TO AVOID THE MENTIONED LACK OF COMMUNICATION. QUITE SOME TIME HAVE PASSED SINCE I REQUESTED THE APPOINTMENT TO DISCUSS IT. IT WAS PROGRAMMED FOR TODAY, THEN AGAIN ANOTHER POSTPONEMENT UNTIL THURSDAY 21ST.

3. I WANT TO EXPLAIN MY POSITION TO YOU AND I WOULD REALLY LIKE TO HEAR YOUR OPINION, MUCH BETTER IF IT COMES IN WRITING:

A. ACCORDING TO MY UNDERSTANDING YOU FINISHED THE RESISTIVITY WORK AND YOUR CONCLUSIONS WERE PRESENTED BY MIKE AT THE PANEL MEETING AND IS CONTAINED IN OUR REPORT. FOR THE GRAVITY WORK, IT SEEMS THAT THE 3-D MODEL WAS IN PROCESS BUT THE PRELIMINARY RESULTS WERE

CONCURRENT WITH THE PREVIOUS ONES: I.E. YOUR MODEL WAS CONFIRMING THE PREVIOUSLY FOUND STRUCTURES. THEN, WHAT MR. DUPRAT REQUIRED IS ANOTHER WAY TO LOOK AT THE RESISTIVITY AND GRAVIMETRIC DATA IN PARALLEL, TO HAVE A UNIQUE SOLUTION. CLEARLY THIS IS WHAT MAKES IT AN EXTRA WORK. PLEASE CONFIRM IF I AM RIGHT.

B. ALTHOUGH I WOULD NOT LIKE TO RECEIVE A NUMERICAL PROCESS MADE BY THIRD PARTIES THEN DO THE INTERPRETATION TO COMPLETE THE MODELING, THEORETICALLY IT IS POSSIBLE. THIS IS THE PROCEDURE INDE WANTS TO FOLLOW TO COMPLETE DUPPRAT'S REQUIREMENTS.

C. CONCLUSIONS

C.1. PLEASE DO LET ME KNOW IF WHAT I SAY IN A. IS OK.

C.2. PLEASE LET ME KNOW YOUR OPINION ABOUT MR. DUPPRAT'S COMMENTS AND METHODOLOGY PROPOSED. WILL IT BRING A BETTER LIGHT ABOUT THE STRUCTURES IDENTIFICATION AND THE GRANODIORITE CEILING. OR IS MERELY ANOTHER WAY TO INVESTIGATE THE PROBLEM?

C.3. IF C.2. IS AFFIRMATIVE I BELIEVE WE SHOULD NEGOTIATE THE BEST WE CAN TO DO IT, TO HAVE A GOOD FINAL GEOPHYSICAL REPORT.

C.4. IF C.2. IS IRRELEVANT WE SHOULD EMPHASIZE IN OUR REPORT MIKE'S/HOWARD'S FINDINGS AND MAKE FEW COMMENTS ABOUT DUPPRAT'S METHODOLOGY, MAKING CLEAR THAT INDE PERFORMED THE DATA PROCESSING AND THE FIELD WORK. IN THIS CASE WE MIGHT AGREE ON DOING IT FOR LESS THAN THE FAMOUS 16 DAYS. LET ME KNOW HOW MUCH.

C.5. ANY-WAY JOE I BELIEVE WE SHOULD PROCEED AT ONCE TO FINISH WHATEVER IS PENDING OF THE NEOTECTONIC THAT DO NOT CAUSE EXTRA WORK ORDER. WHEN I FINISH DISCUSSING WITH INDE I WILL LET YOU KNOW WHAT PROCEEDS REGARDING DUPPRAT'S REQUIREMENTS. IF BY NOW YOU HAVE A FINAL VERSION OF THE 3D MODELLING BY MIKE/HOWARD I WILL APPRECIATE IF YOU SEND ME THE MATERIAL.

PLEASE DO EXCUSE ME ABOUT THIS MINOR DETAILS. SIXTEEN DAYS OF WORK IS IRRELEVANT COMPARED TO THE DELAY WE ARE HAVING AND THE PROBLEMS OF COMMUNICATIONS ASSOCIATED. ALMOST FOUR MONTHS SINCE THE PANEL MEETING TOOK PLACE AND STILL NO AGREEMENT REGARDING THE GEOPHYSICS.

I TAKE THE OPPORTUNITY TO SAY HELLO THROUGH THIS MESSAGE TO OUR FRIENDS FROM UURI, WISHING YOU ALL PROSPERITY AND SUCCESS IN NEXT YEAR.

CONVEY MY REGARDS TO YOUR FAMILY. ANA MARIA IS BACK FROM THE U.S. AND ASK ME TO SAY HELLO TO YOU.
LLLL

THOUGHTS ABOUT ZUNIL I GRAVITY

The quality of every gravity data set should be carefully reviewed before detailed interpretation such as numerical modeling should be completed.

Our concerns for the Zunil data are increased because: we note differences in the regional and detailed survey values and contour maps; the density used in Bouguer corrections appears to be too large; we know that the terrain is very rugged; it may be difficult to get accurate elevations and station locations; terrain corrections, both near station and outer zones will be quite large. To date we have only reviewed page size map which cover areas of 90 sq km and 30 sq km respectively, and station locations, elevations, etc. are not known with much confidence.

The gravity data appear to map important structures and should contribute to drill hole siting.

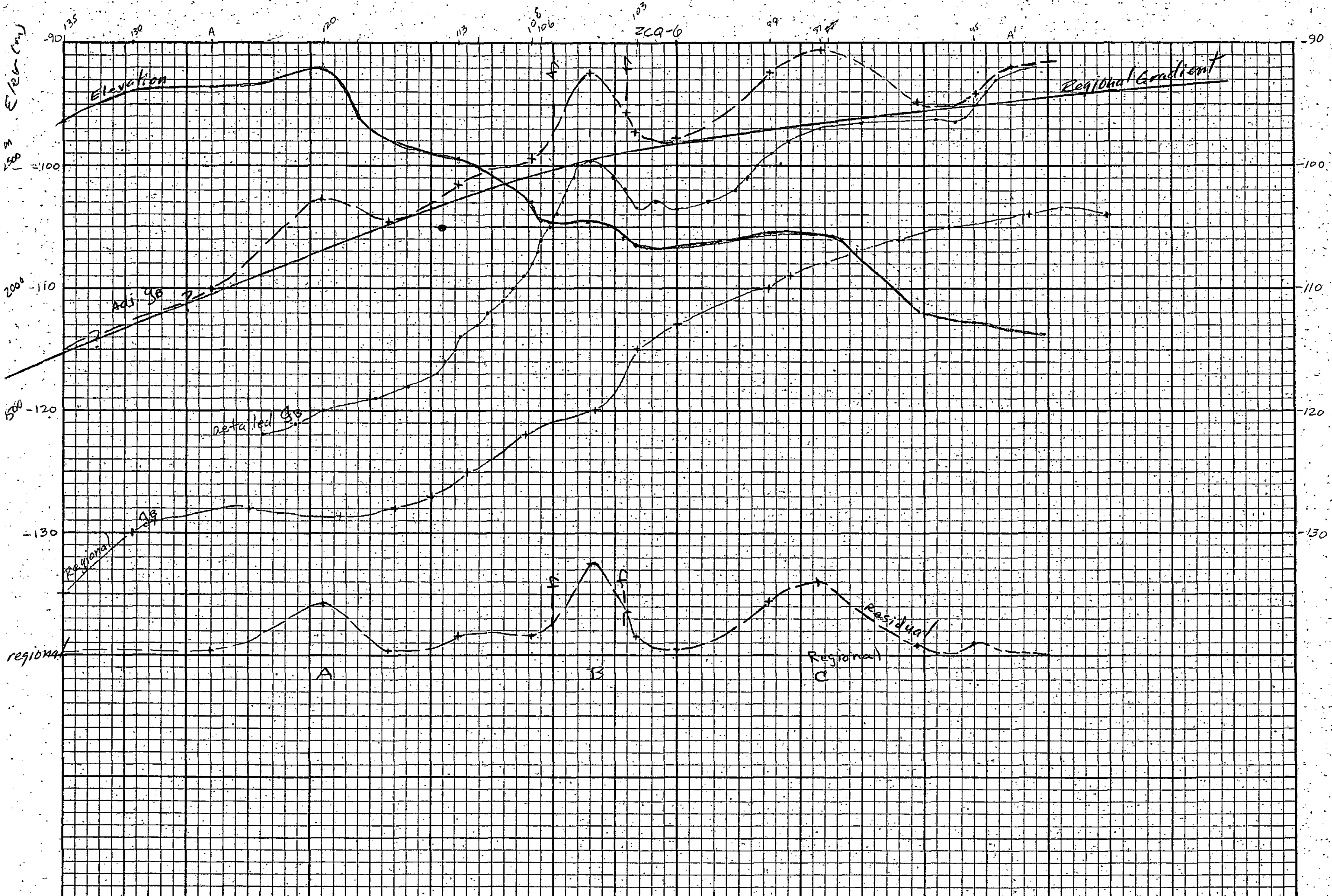
The amplitude of anomalies related to the structures defining the "graben" and probably cutting the granodiorite is relatively small, probably less than 10 mgals in most cases. Therefore the gravity data throughout the detailed survey should be accurate to 1 mgal or better in order to justify quantitative analysis and to influence drill siting decisions.

The existing gravity data could be verified, corrected to a different Bouguer density, and replotted for subsequent interpretation if the data are good enough, if near station terrain corrections have been made, and if outer zone terrain corrections have been completed. We expect accuracte terrain corrections would require a few man weeks of time by engineering or geophysical personnel if present terrain corrections are not accurate.

Are the existing data available in some conventional format for gravity data principal facts? Are the data available on disk suitable for input to computer reduction routines? Is a gravity data reduction program up and running at INDE or M-K?

UURI has programs for gravity data reduction but these have not been used in some time and may require work. Plotting and contouring of revised data would probably be done manually. UURI would have to do a manual regional gradient removal as we do not have programs for this which are up and running, and the data are not in digital form on a uniform grid.

UURI programs for 2 1/2 and 3-D gravity modeling should be ready to go when the data are ready for interpretation.

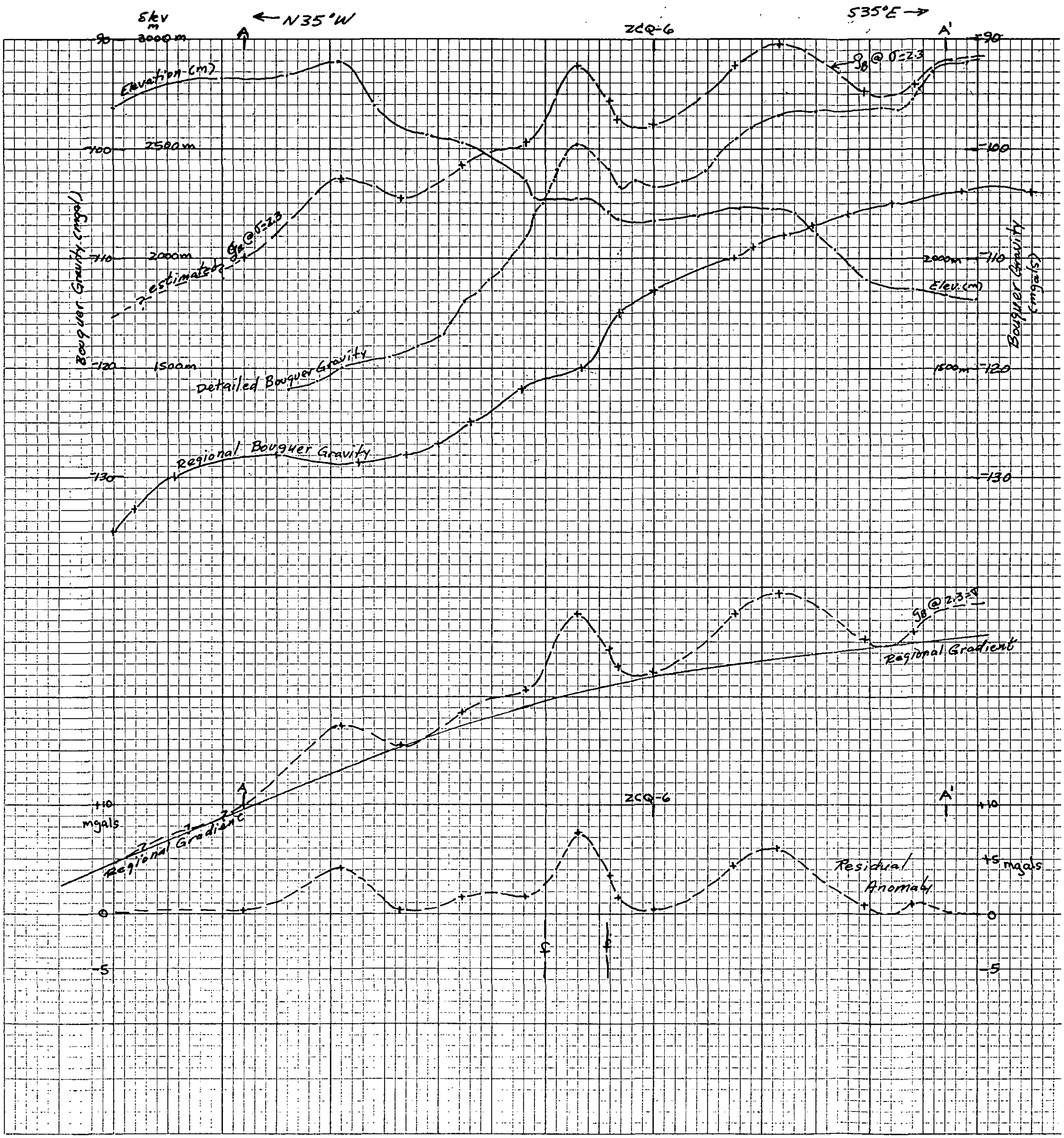

ZCQ-6
A
A'
Elevation
Regional Gradient
Adj gB
Regional gB
Residual
Regional
regional
B
C
-90
-100
-110
-120
-130
2000
1500

5/22/89

Zuni

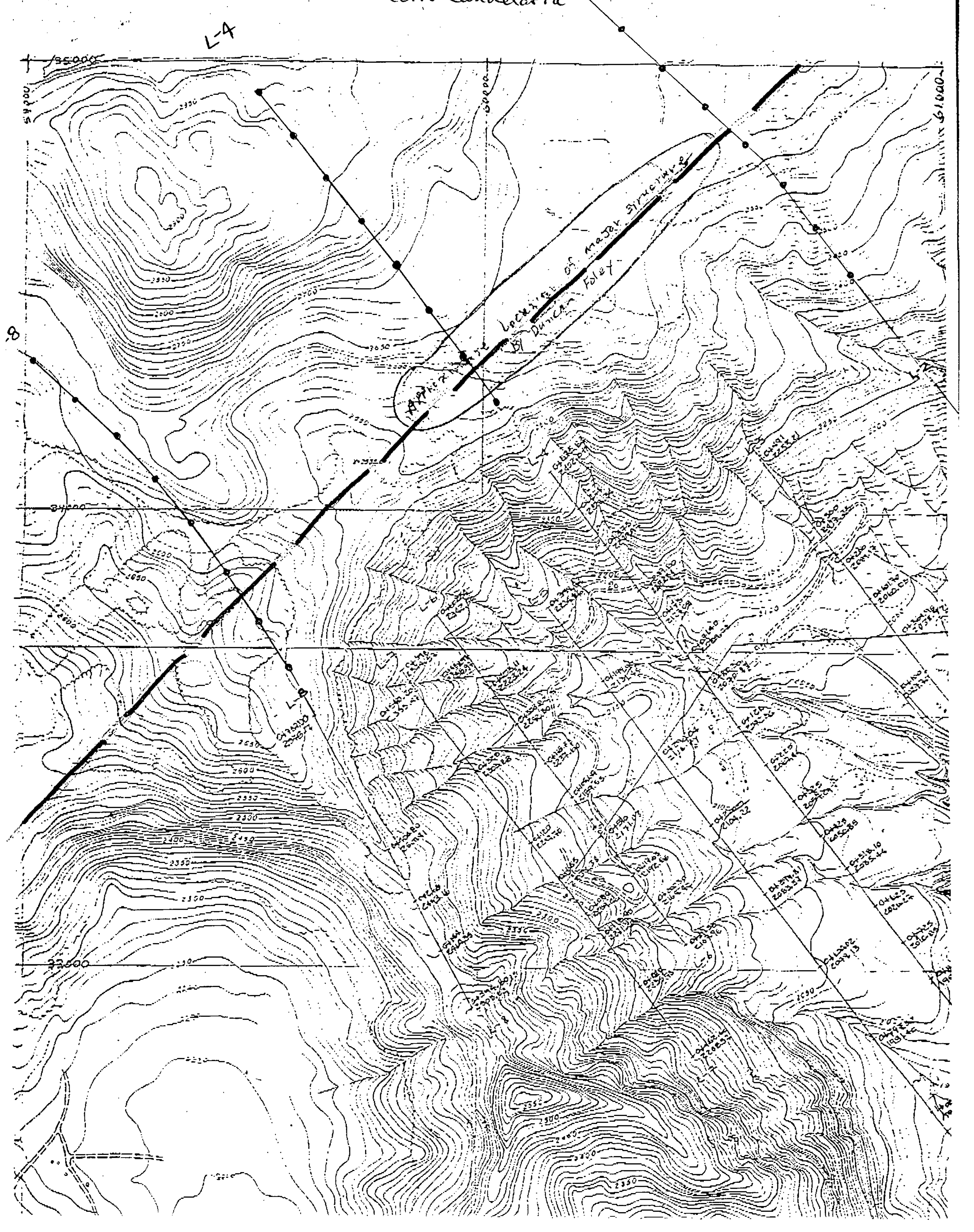
Evaluation of Bouguer Gravity Anomaly along profile A-A'

Gravity Data		Elevation		Δg_B
Regional	Detailed	Surface	datum E_s-1800m	(2.67-2.30)
NW -135		2680	880	13.6
-130		2800	1000	15.5
-128.5 A	-126	2830	1030	16.0
A	-120	2900	1100	17.1
	-118.7	2700	900	14.0
	-113	2530	730	11.3
	-108	2350	550	8.5
	-100	2275	475	7.4
	-10.7	2200	400	6.2
	-103	2175	375	5.8
6	/	2175	375	5.8
	-99	2230	420	6.65
	-97	2220	420	6.51
	-95	1860	60	.93
A'		1830	30	.46

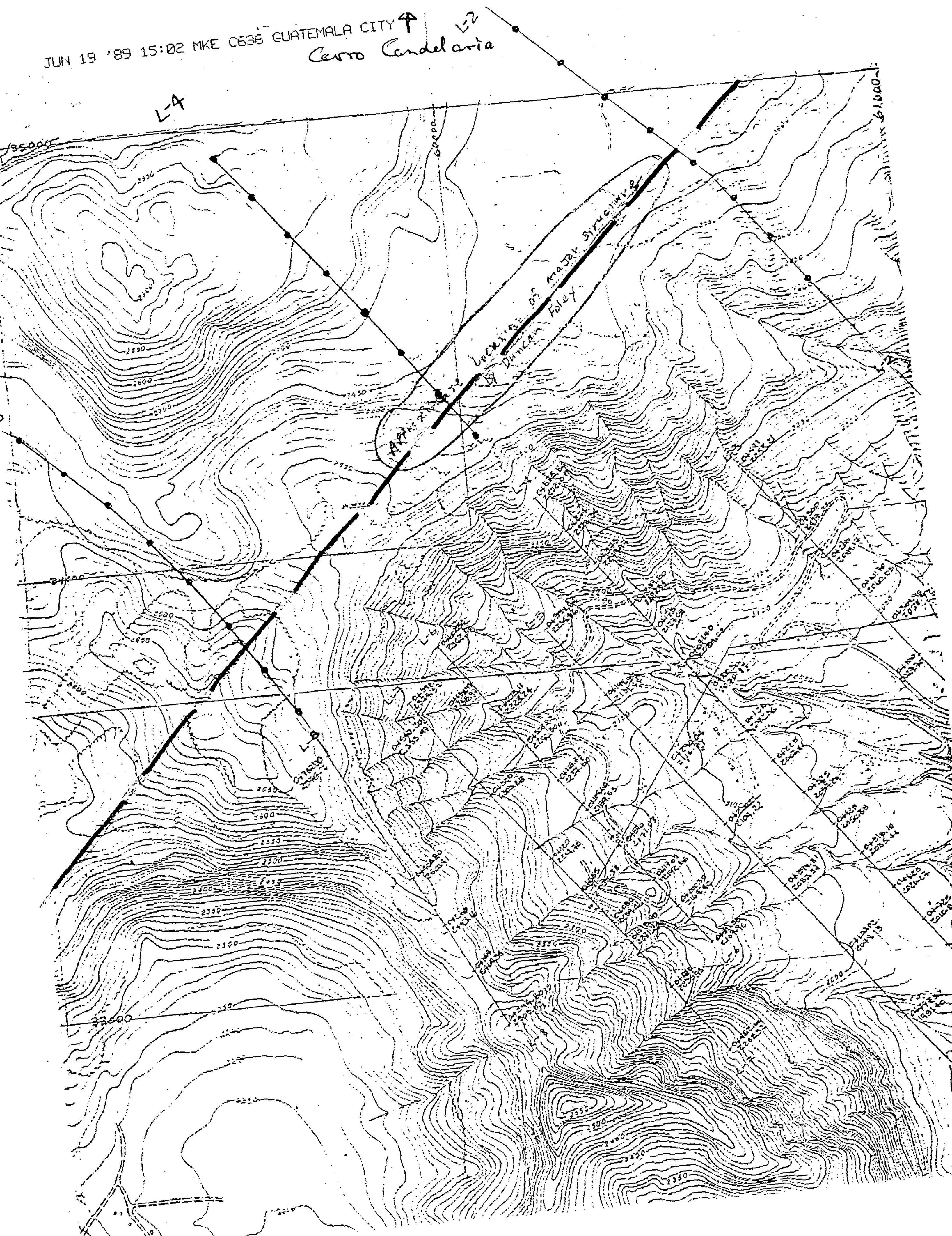


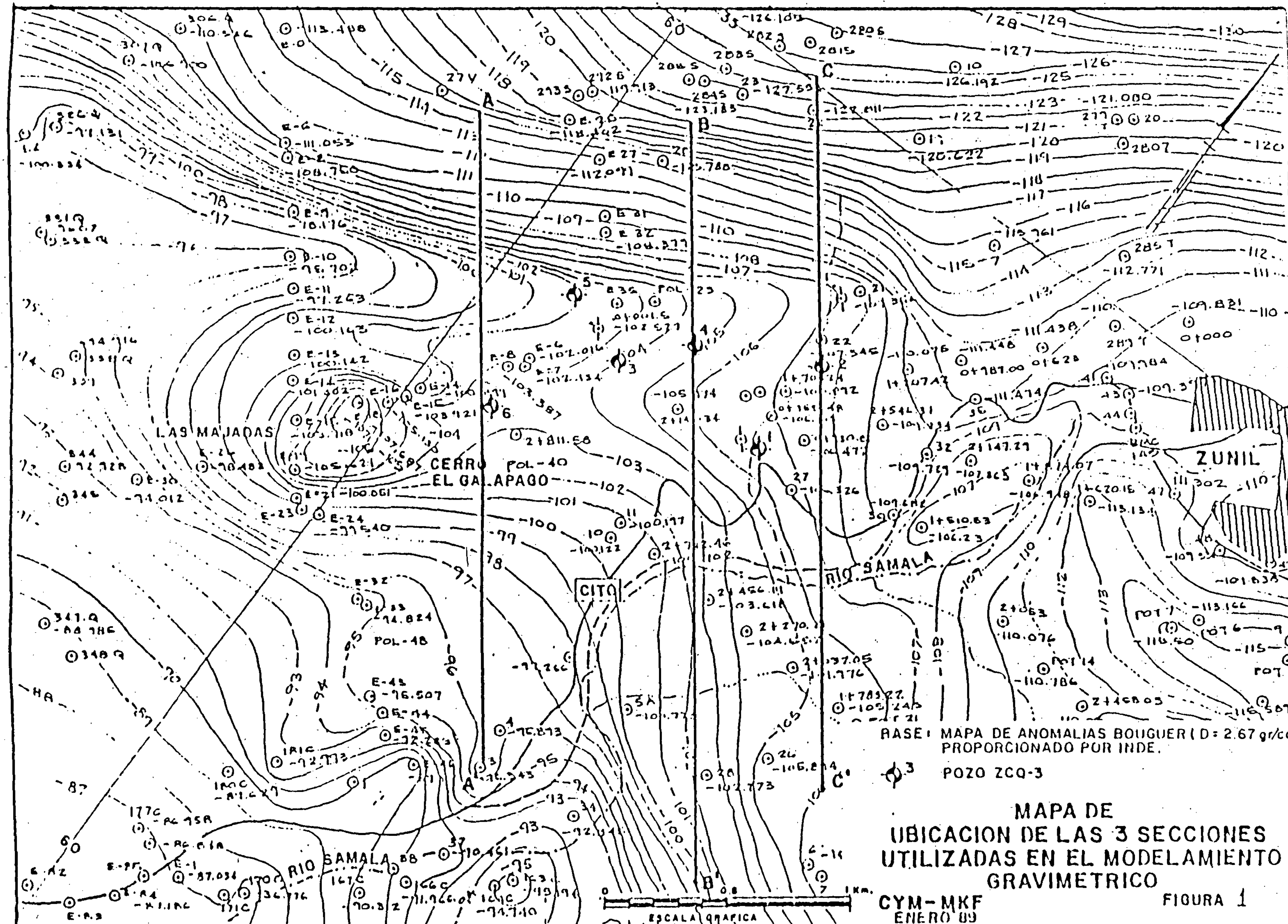
Elev
m
← N35°W
S35°E →
A
A'
ZCQ-6
-90
3000m
-100
2500m
-110
2000m
-120
1500m
-130
Elevation (m)
g_B @ σ=2.3
g_B @ σ=2.3
estimated
Detailed Bouguer Gravity
Regional Bouguer Gravity
Elev. (m)
Bouguer Gravity (mgal)
Bouguer Gravity (mgals)
g_B @ 2.3 = B
Regional Gradient
Regional Gradient
+10
mgals
+5 mgals
Residual Anomaly
0
-5

JUN 19 '89 15:02 MKE C636 GUATEMALA CITY



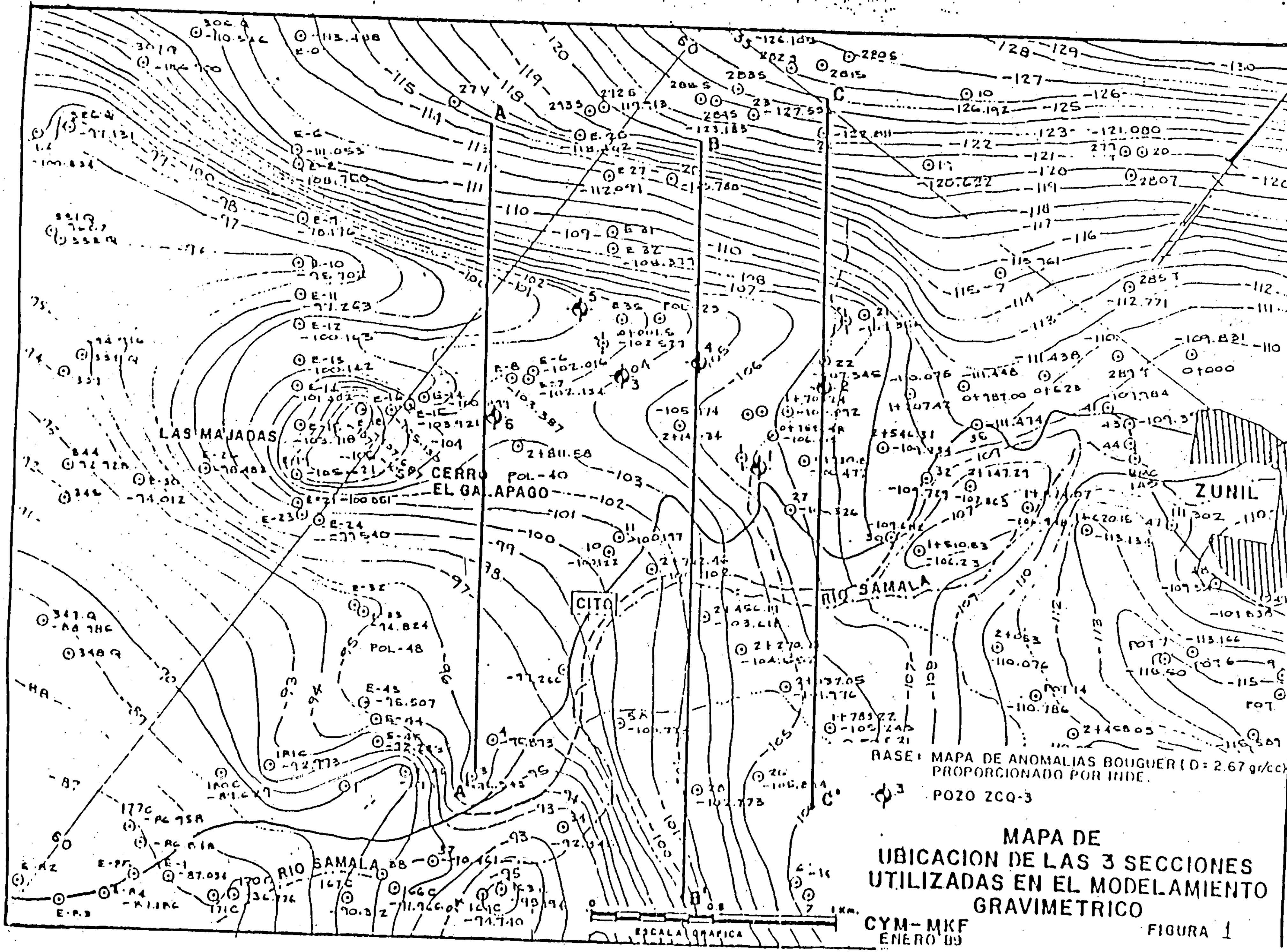
JUN 19 '89 15:02 MKE C636 GUATEMALA CITY





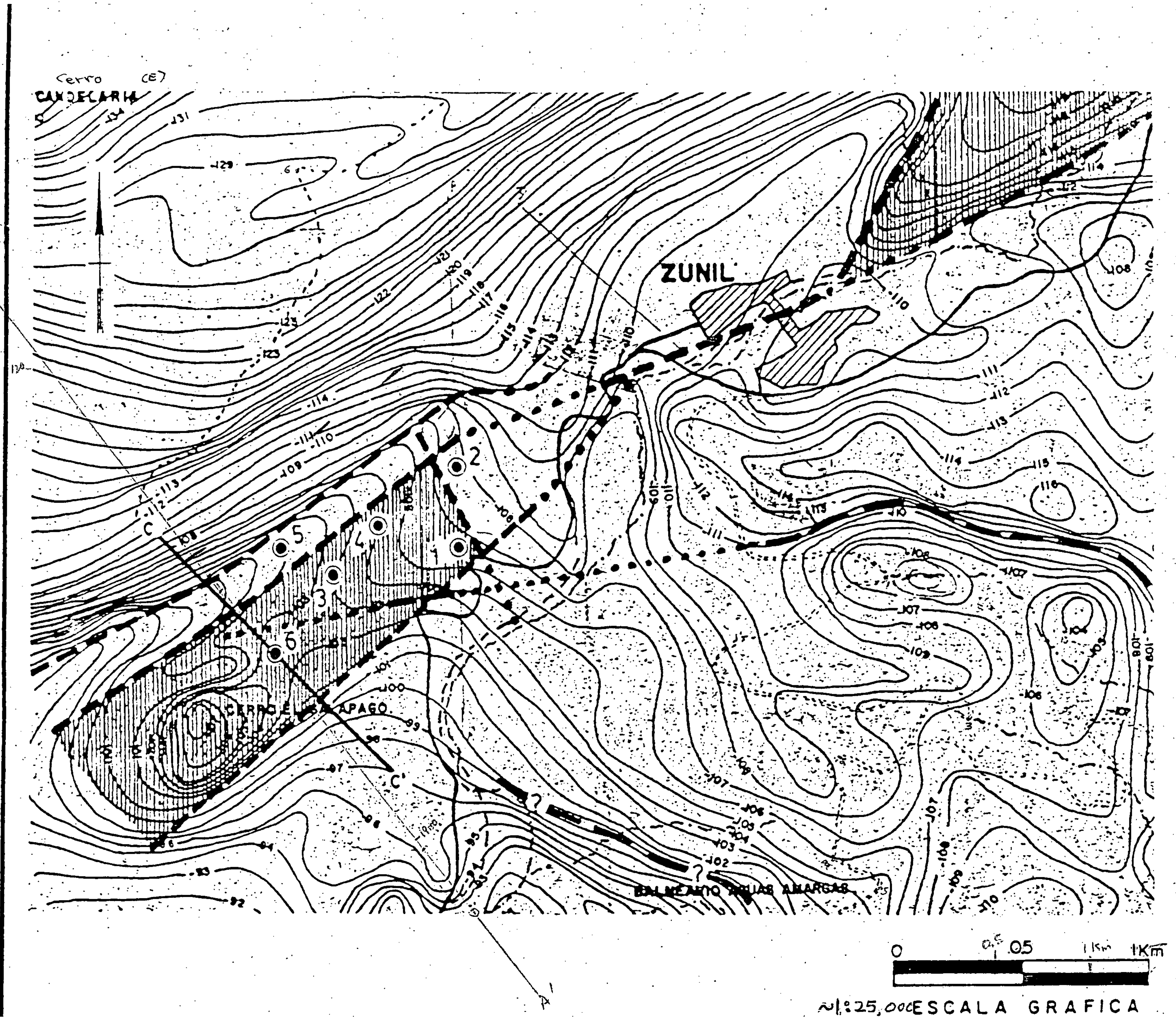
MAPA DE UBICACION DE LAS 3 SECCIONES UTILIZADAS EN EL MODELAMIENTO GRAVIMETRICO

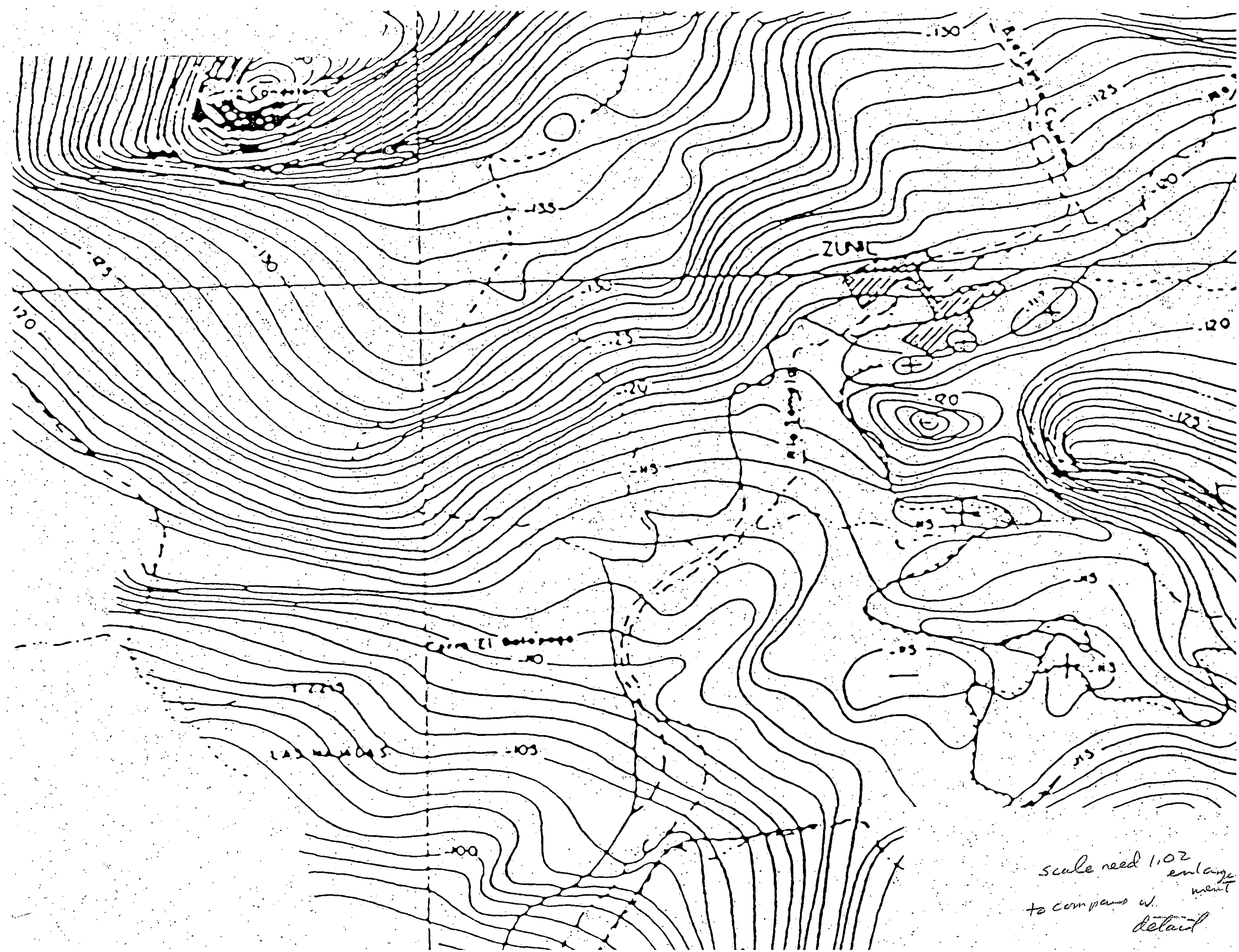
FIGURA 1



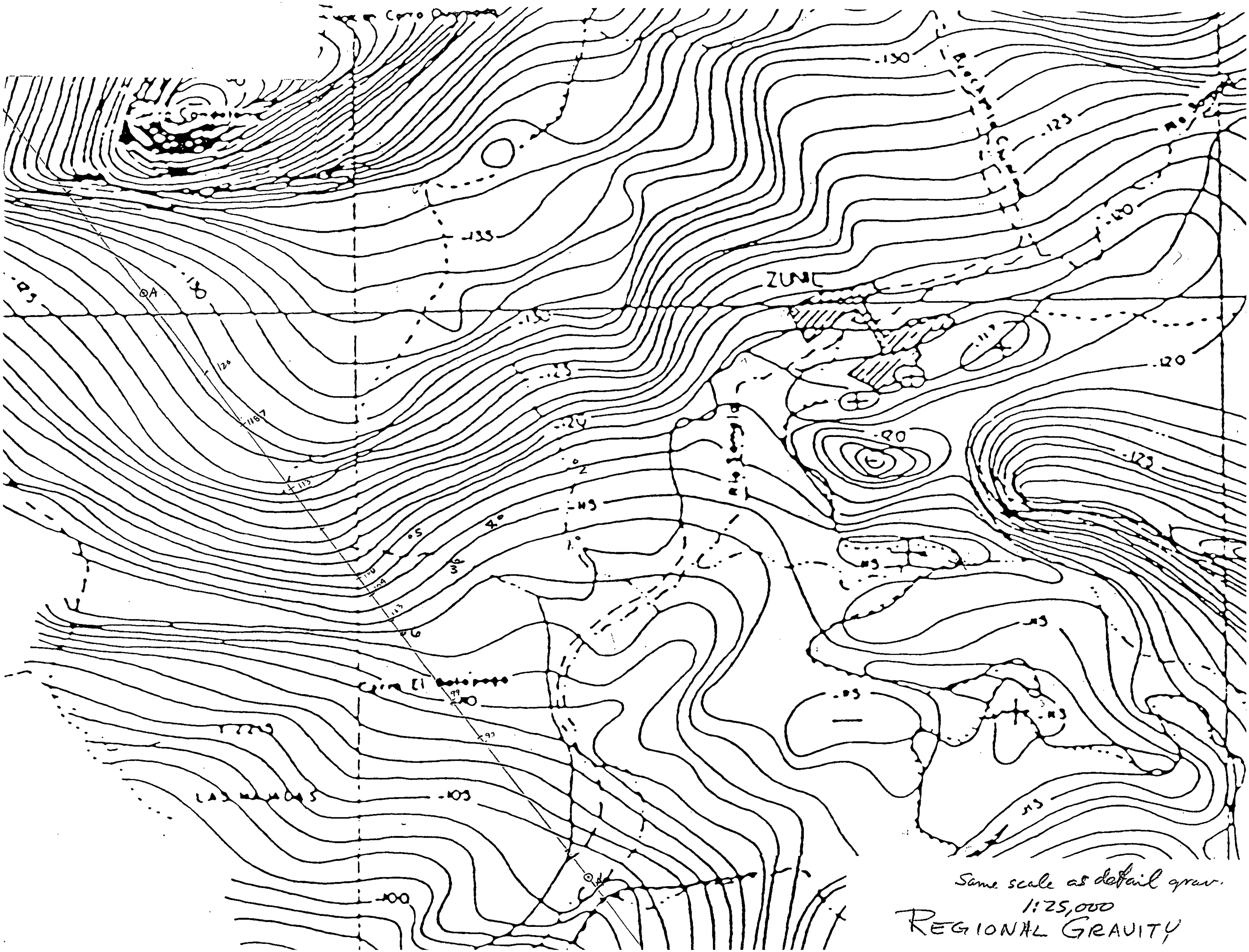
MAPA DE UBICACION DE LAS 3 SECCIONES UTILIZADAS EN EL MODELAMIENTO GRAVIMETRICO

FIGURA 1


Cerro (E)
CANDELARIA
ZUNIL
C
C'
A
A'
1
2
3
4
5
6
0 0.5 05 1Km 1Km
~1:25,000 ESCALA GRAFICA

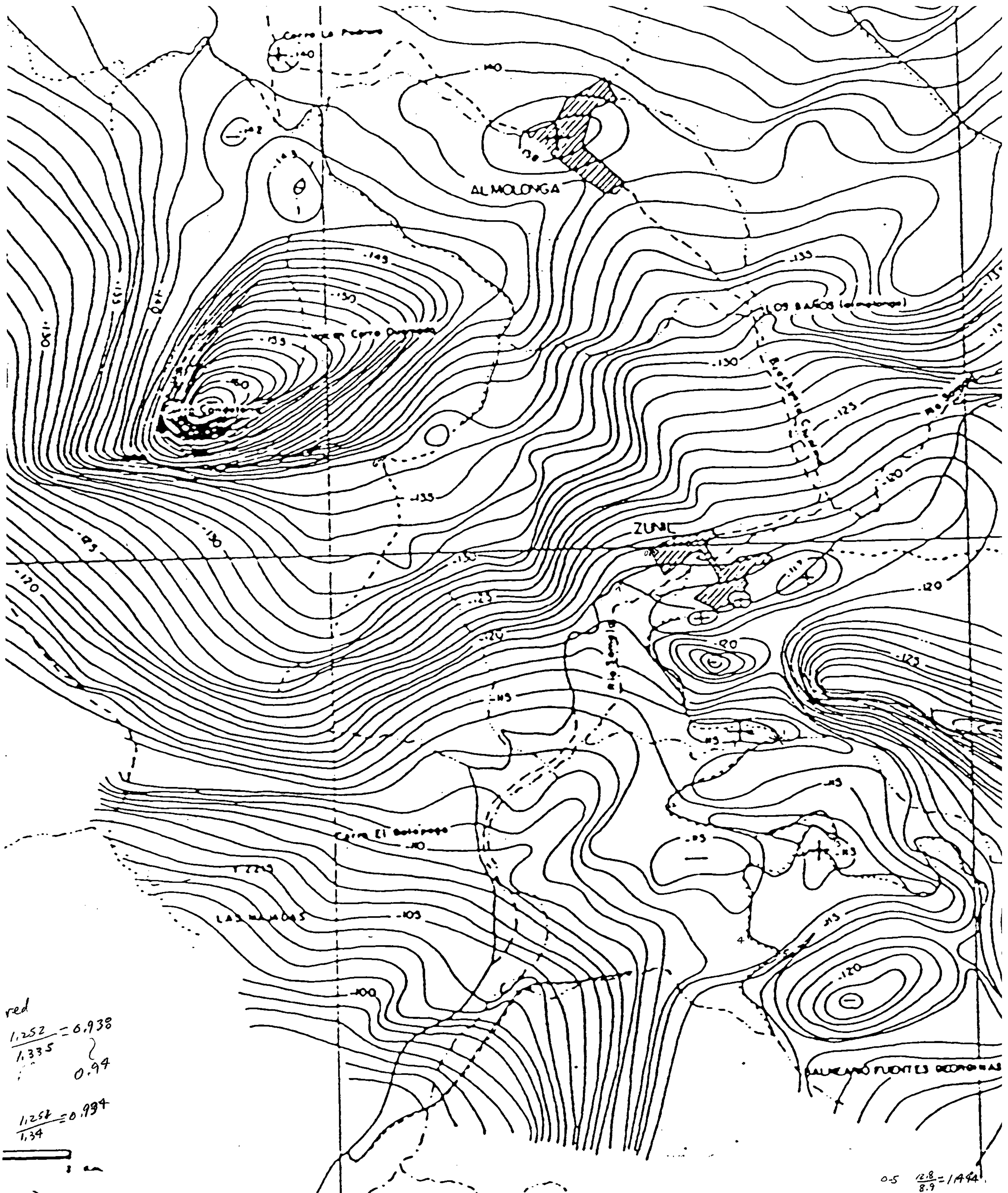


scale need 1.02 enlargement
to compare w. detail



Same scale as detail grav.
1:25,000

REGIONAL GRAVITY



red
$\frac{1,252}{1,335} = 0,938$
0,94

$\frac{1,252}{1,34} = 0,934$

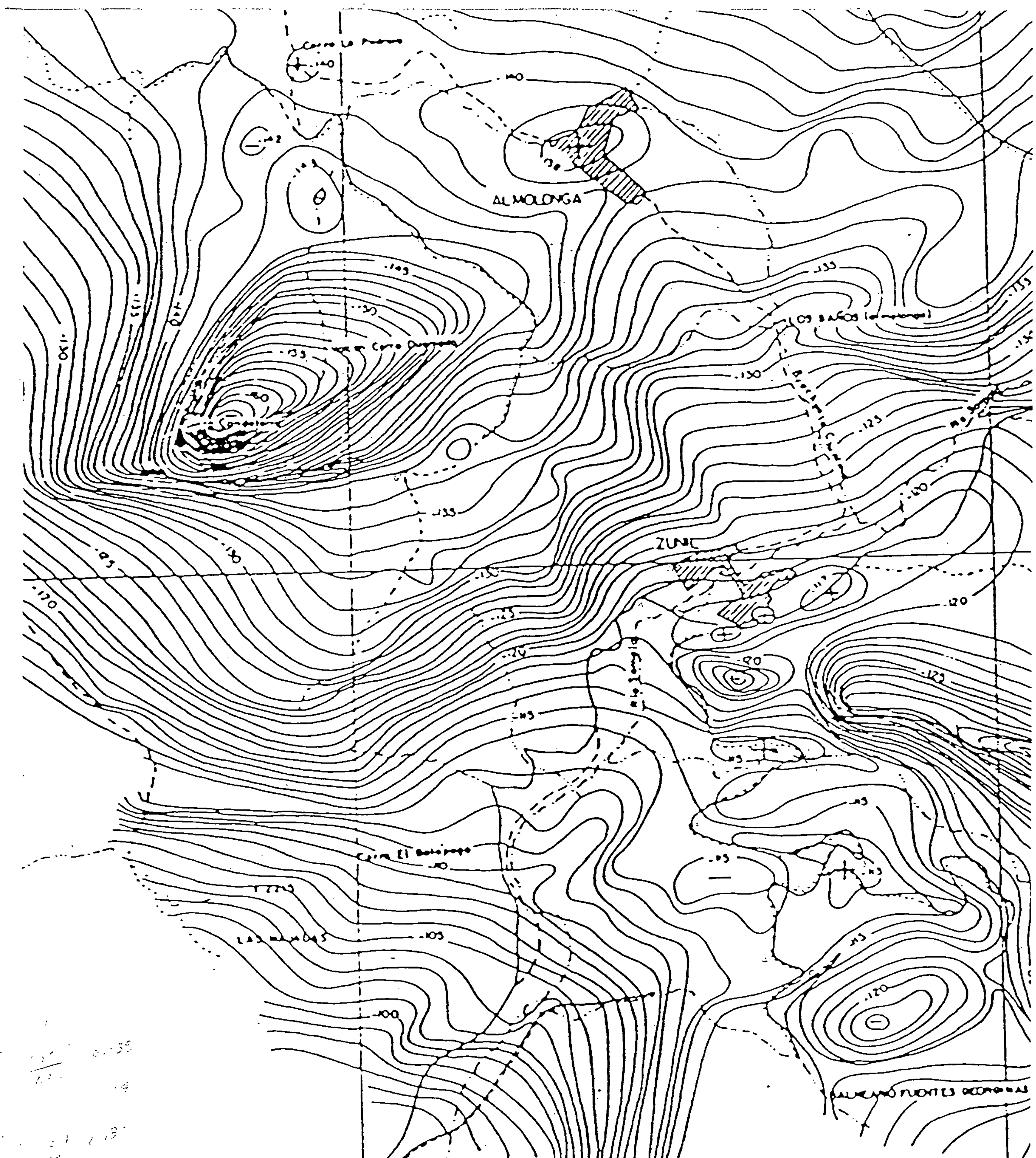
0-5 $\frac{12.8}{8.9} = 1,444$
7-5 $\frac{12.3}{8.4} = 1,46$
5-6 $\frac{19.2}{13.3} = 1,443$

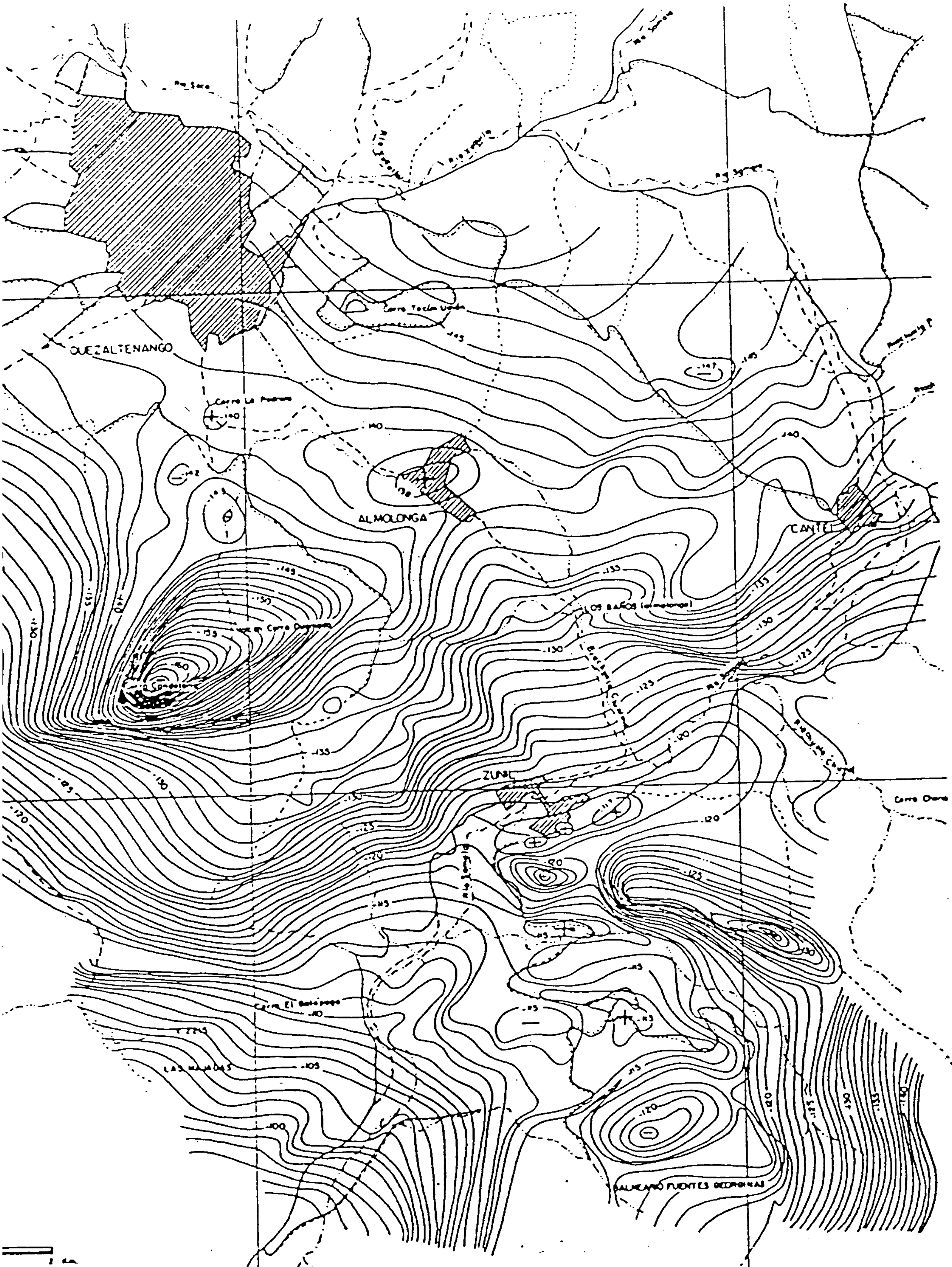
1,42x1,02

1,42x1,42

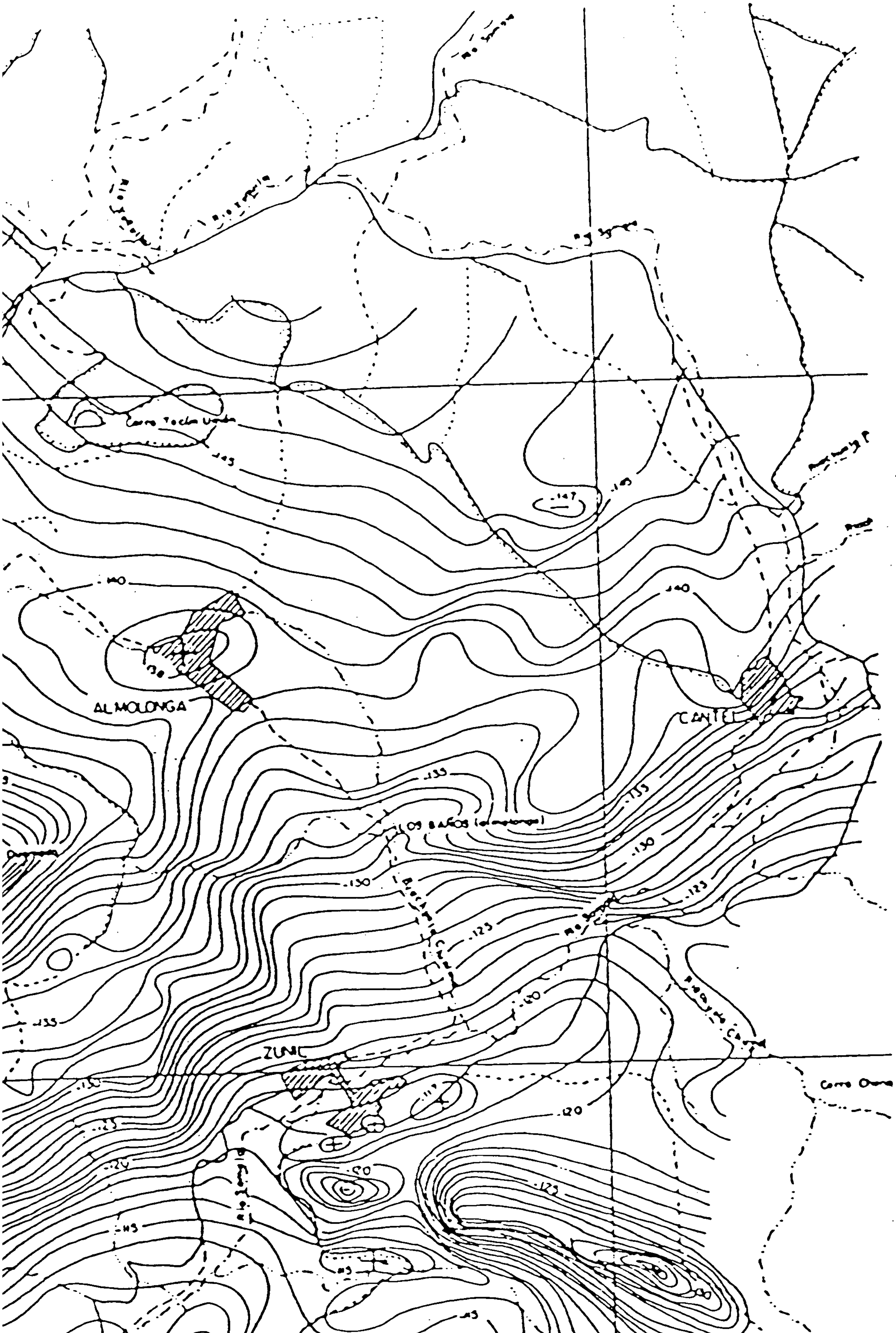
1,42

Regional Gravity @ 1:40 metric w.reg. topo.



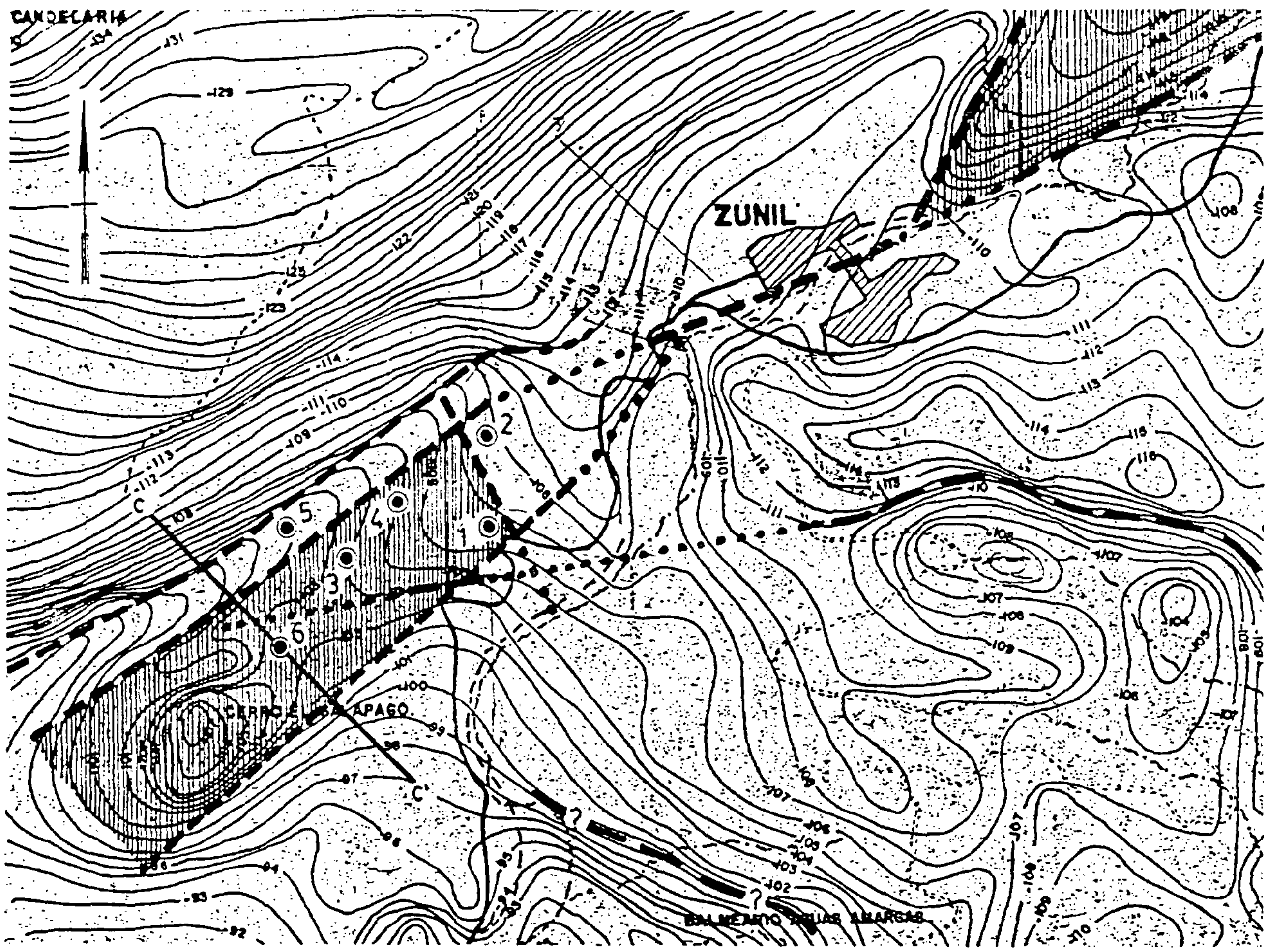


X1.42 Reg Grav



r. 9
1.42 x 1.42

HR
X1,38



0 05 1Km

ESCALA GRAFICA

SIMBOLOGIA

AREA CON DEPLAZAMIENTO HACIA ABAJO DEL BASAMENTO ASI COMO UN GRABEN.

C — C' SECCION

PROBABLE FALLA RELACIONADA A FALLAMIENTO EN EL BASAMENTO. PUNTOS DENOTAN SOSPECHA.

◉3 POZO

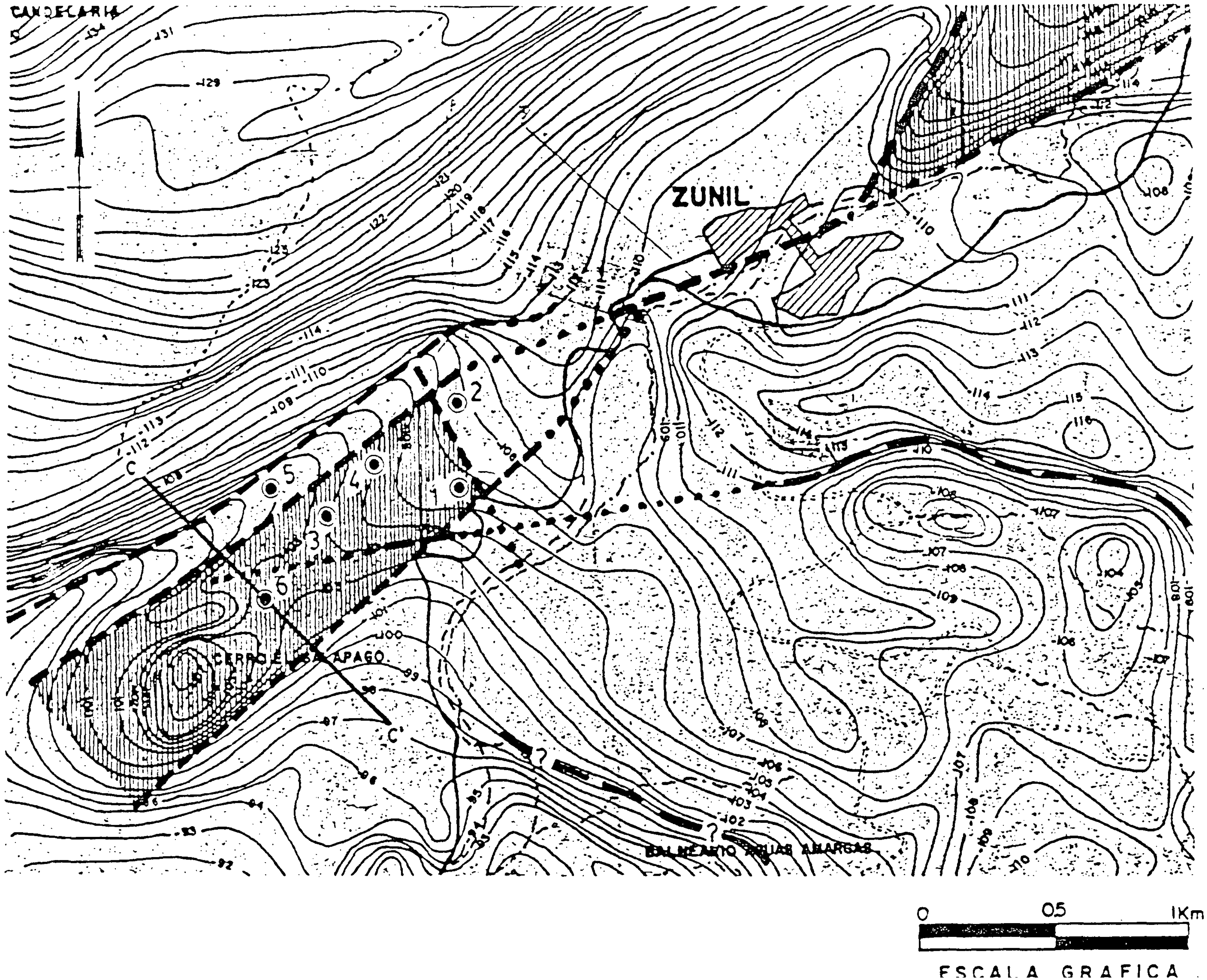
INFORMACION BASE: PLANO INDE POR ING. J. PALMA

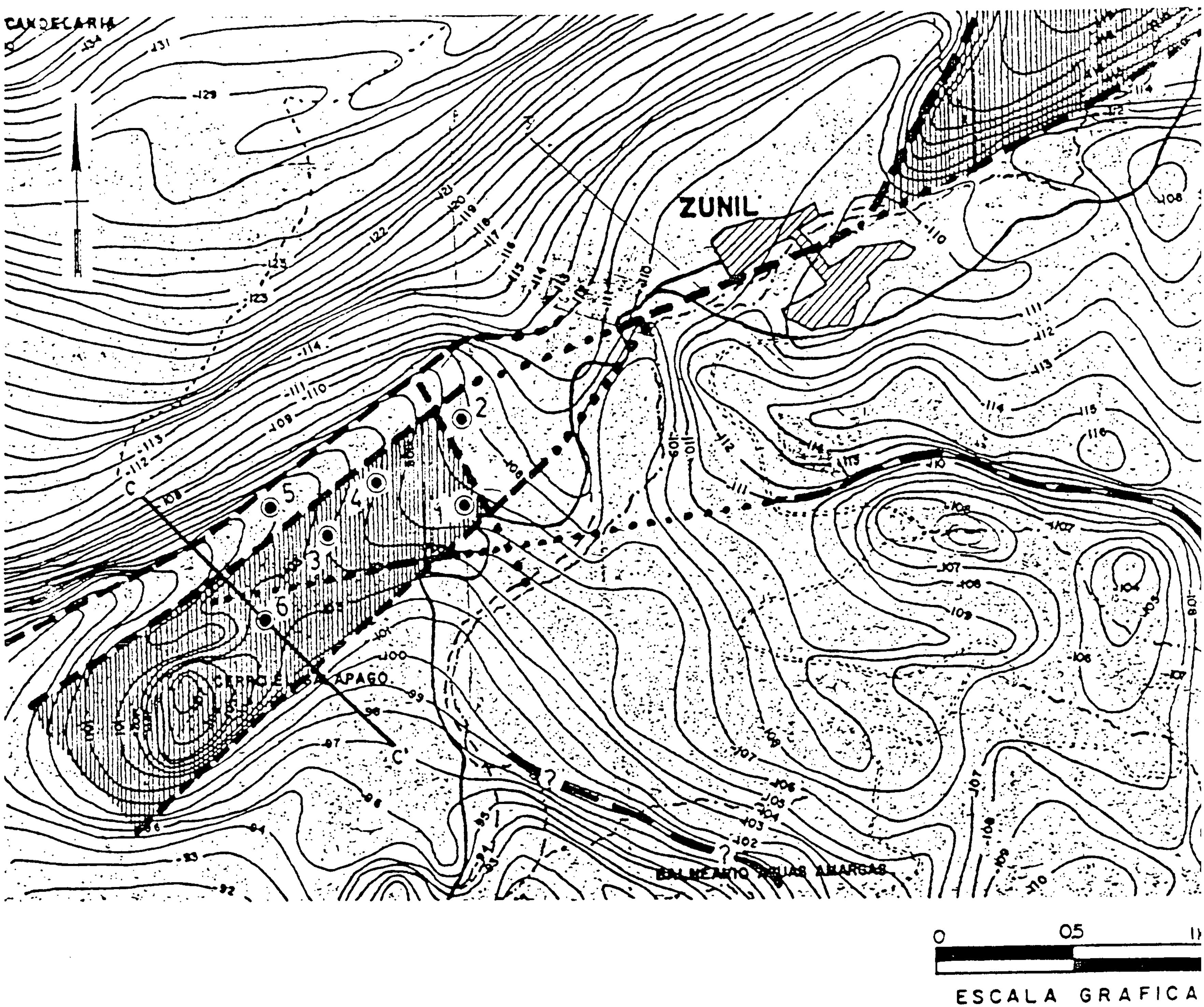
INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

MAPA DE ANOMALIAS BOUGUER

CyM / MKF. FIGURA: 3.3-9


CANDELARIA
ZUNIL
0
05
1Km
ESCALA GRAFICA



CANDELARIA
ZUNIL
CERRO EL SAPAGO
BALNEARIO AGUAS AMARGAS
C
C'
0
05
ESCALA GRAFICA

① Roy Mink - Guatemala

(208) 386-5000 Susan Mitchell

Phone
011-5022-31-64-94
C & M Engr.
Cordon y Merida

Telefax 011-5022-34-06-27

atemala:

9.

access to intnatl lines

country code:

2)

code

2)

then number:

9 - 011 - 502 - 2 - 317972, or 318631, or 318612

Secretary: Christina

7/18/89

Louis Marida - From the desk of

Carolyn Davidson

Eduardo: @ Geothermex
August - Final meeting

Final report on geophys its needed @ end of month. -

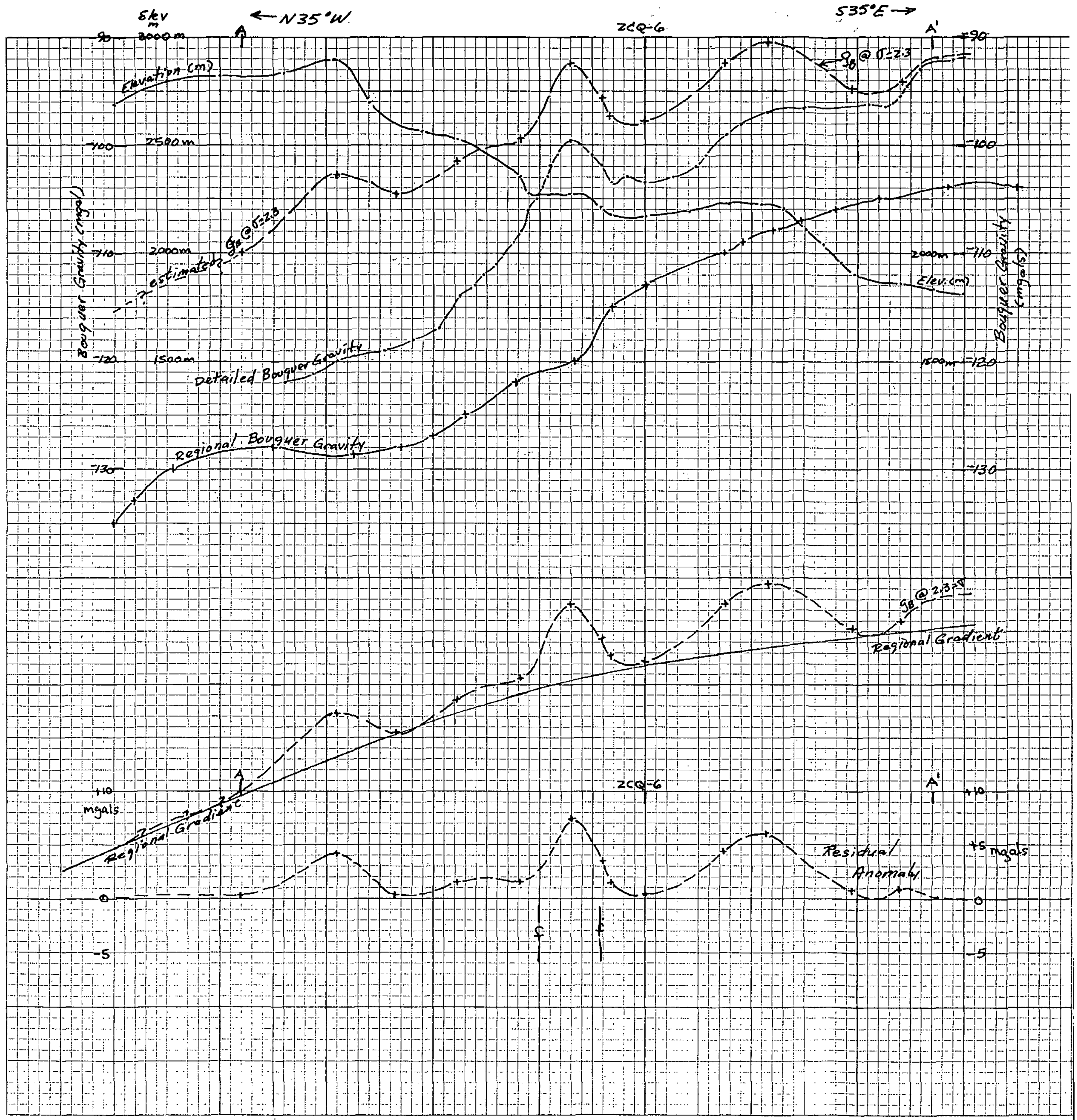
Eduardo will
August

Discuss with Joe & Roy Mink.

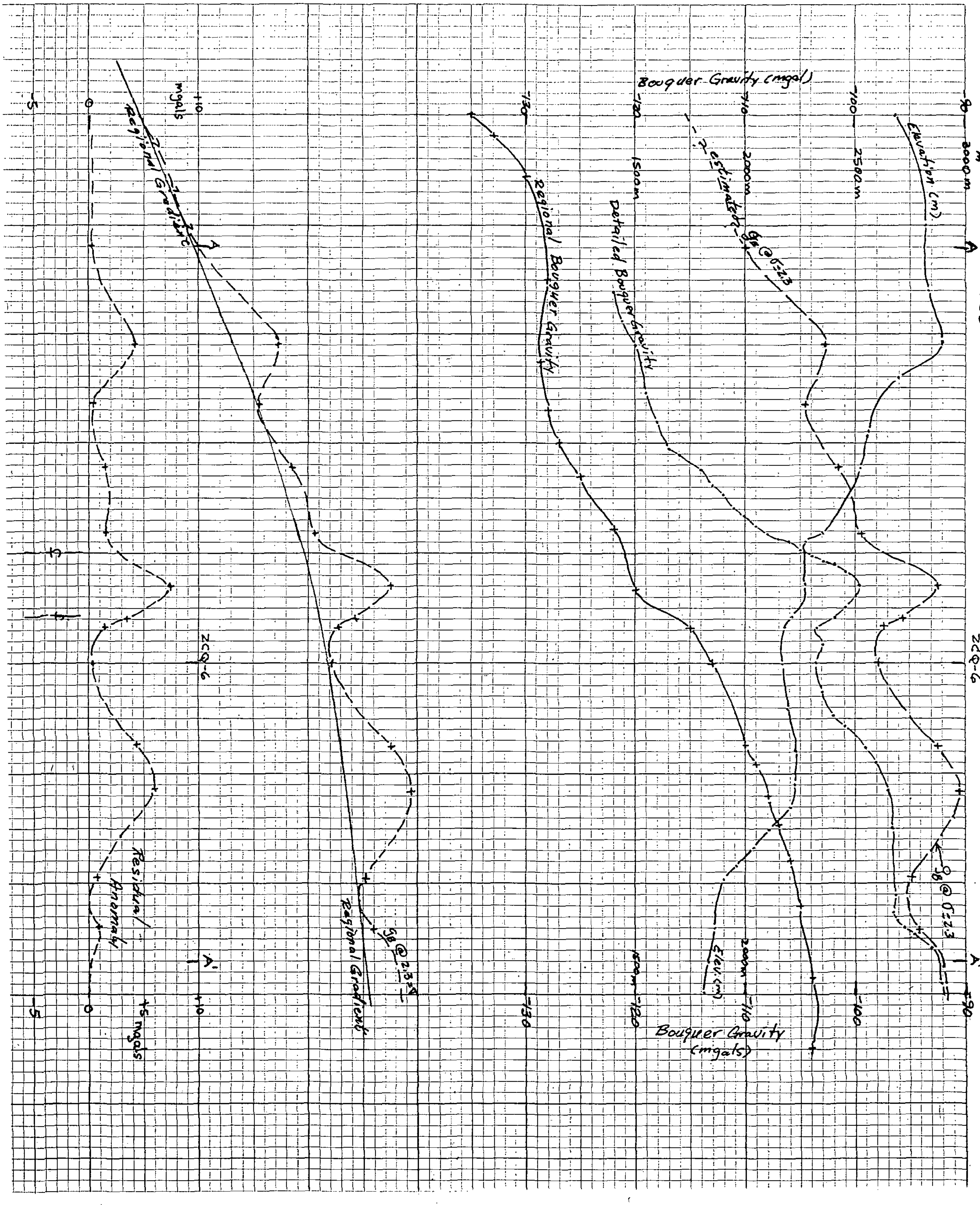
Old detailed survey @ N60°E - graben-horst
+ N40°W - cross cutting near ZCQ #6
New survey
N-40°W

(602) 327-5501
Zonge

DOE drilling:
3 3000' 12" diam hole
near Frisco. -



Elev m
← N35°W
S35°E →
A
A'
ZCQ-6
-90
3000 m
-100
2500 m
-110
2000 m
-120
1500 m
-130
Elevation (m)
Elev. (m)
g_B @ σ=2.3
g_B @ σ=2.3 estimated ?
Detailed Bouguer Gravity
Regional Bouguer Gravity
Bouguer Gravity (mgal)
Bouguer Gravity (mgals)
g_B @ 2.3=σ
Regional Gradient
+10
mgals
+5 mgals
0
-5
Residual Anomaly


Bouguer Gravity (mgal)
Elev
Elevation (m)
3000m
2500m
2000m
1500m
N35°W
S35°E
A
A'
ZCQ-6
Regional Gradient
Regional Bouguer Gravity
Detailed Bouguer Gravity
estimated
Residual Anomaly
mgals
+5 mgals
Elev. (m)
Bouguer Gravity (mgals)
-90
-100
-110
-120
-130
+10
0
-5

AREA
UT
SaltLK
Grav

EXAMPLE OF PRINCIPAL FACTS
FOR GRAVITY DATA

Listing of Principal Facts of Gravity

Stations in Jordan Valley, Utah

by

Laura F. Serpa and Kenneth L. Cook

April 15, 1980

Listing of gravity data in Jordan Valley area, Utah

All of the stations listed on the following pages have been tied to the gravity base station network in Utah (Cook et al., 1967). Because the various surveys were conducted over several years and with different instruments, the accuracy of the various surveys will vary. Any station that did not appear to be accurate enough to be included in the contour map is indicated with an '*' and may represent a bad reading or possible error in input to the computer.

The following is a listing of the station prefixes used in this listing and the source of these gravity values. Where possible the estimated accuracy is also given.

Prefix	Taken by	Accuracy
W	Cook and Berg, 1961	0.5 mgal
H	W. Johnson, 1958	
RR	W. Johnson, 1957-58	
BL	J. Berg & L. Rauser, 1958	
A	Novotny, 1957-58	
MB	Novotny, 1957-58	
P	Parker-wide spaced, 1979	0.05 mgal
PG	Parker-tight grid, 1979	0.05 mgal
MBE	D. Mabey	2.5 mgal
78	1978 gravity class, University of Utah	1.0 mgal
F	R. C. Fox, 1979	0.05 mgal

STAT.	LATITUDE	LONGITUDE	ELEV.	OBSERVED GRAVITY	THEOR. GRAVITY	FREE AIR	SIMPLE BOUGUER	T.C.	COMPLETE BOUGUER
78216	40.43.950	111.45.200	5213.00	979737.20	980245.69	-18.15	-195.75	14.11	-181.64
78217	40.44.550	111.47.470	5350.00	979729.13	980246.58	-14.23	-196.50	8.22	-188.28
78218	40.45.270	111.42.620	5564.00	979714.38	980247.66	-9.93	-199.49	4.39	-195.10
78301	40.34.830	111.50.580	4787.00	979736.50	980232.13	-45.27	-208.36	2.93	-205.43
78302	40.34.350	111.46.730	5350.00	979693.24	980231.42	-34.96	-217.23	19.91	-197.32
78303	40.34.300	111.46.260	5480.00	979679.28	980231.34	-36.61	-223.31	25.30	-198.01
78304	40.34.570	111.40.740	7704.00	979551.06	980231.76	43.94	-218.53	17.72	-200.81
78305	40.34.330	111.41.990	7200.00	979574.34	980231.39	20.18	-225.12	18.30	-206.82
78306	40.34.360	111.43.540	6493.00	979611.04	980231.43	-9.66	-230.87	32.48	-198.39
78307	40.34.280	111.44.510	6054.00	979635.84	980231.32	-26.04	-232.29	36.06	-196.23
78308	40.34.320	111.45.480	5740.00	979657.11	980231.37	-34.36	-229.92	29.59	-200.33
78309	40.34.330	111.45.840	5620.00	979657.24	980231.39	-35.53	-227.00	27.39	-199.61
78310	40.34.390	111.47.340	5270.00	979706.04	980231.48	-29.74	-209.28	11.56	-197.72
78311	40.34.390	111.47.860	5219.00	979711.31	980231.48	-29.26	-207.07	7.80	-199.27
78312	40.34.680	111.48.290	5138.00	979718.06	980231.91	-30.57	-205.62	6.27	-199.35
78313	40.34.570	111.49.030	5011.00	979724.20	980231.76	-36.22	-206.94	4.75	-202.19
78314	40.34.840	111.50.000	4804.00	979736.16	980232.15	-44.12	-207.79	3.44	-204.35
78315	40.34.850	111.51.150	4725.00	979739.80	980232.16	-47.93	-208.91	2.65	-206.26
78316	40.34.850	111.52.280	4520.00	979753.39	980232.16	-53.62	-207.61	2.05	-205.56
78317	40.35.280	111.53.890	4367.00	979765.36	980232.80	-56.68	-205.46	1.53	-203.93
78318	40.34.830	111.53.400	4466.00	979756.53	980232.13	-55.43	-207.58	1.64	-205.94
78319	40.34.830	111.54.280	4368.00	979763.70	980232.13	-57.58	-206.39	1.49	-204.90
78320	40.35.280	111.54.280	4357.00	979766.21	980232.80	-56.77	-205.21	1.47	-203.74
78321	40.35.260	111.55.700	4364.00	979766.01	980232.77	-56.28	-204.96	1.19	-203.77
78322	40.35.260	111.56.850	4444.00	979761.84	980232.77	-52.93	-204.33	.95	-203.38
78324	40.35.270	111.59.140	4626.00	979752.64	980232.79	-45.03	-202.63	.77	-201.86
MBE01	40.31.370	112. 5.600	5519.00	979700.75	980226.98	-7.11	-195.14	2.05	-193.09
MBE02	40.31.560	112. 6.950	7057.00	979668.87	980227.28	105.37	-135.05	16.35	-118.70
MBE03	40.31.050	112. 7.820	7150.00	979600.59	980226.52	46.69	-196.90	7.62	-189.28
MBE04	40.30.070	112. 8.220	7090.00	979608.98	980225.06	50.80	-190.75	5.29	-185.46
MBE05	40.30.610	112. 8.390	7401.00	979587.63	980225.87	57.91	-194.24	8.86	-185.38
MBE06	40.30.830	112.10.090	6990.00	979618.54	980226.19	49.83	-188.31	8.50	-179.81
MBE07	40.31.450	112. 9.700	6465.00	979648.45	980227.12	29.43	-190.83	8.59	-182.24

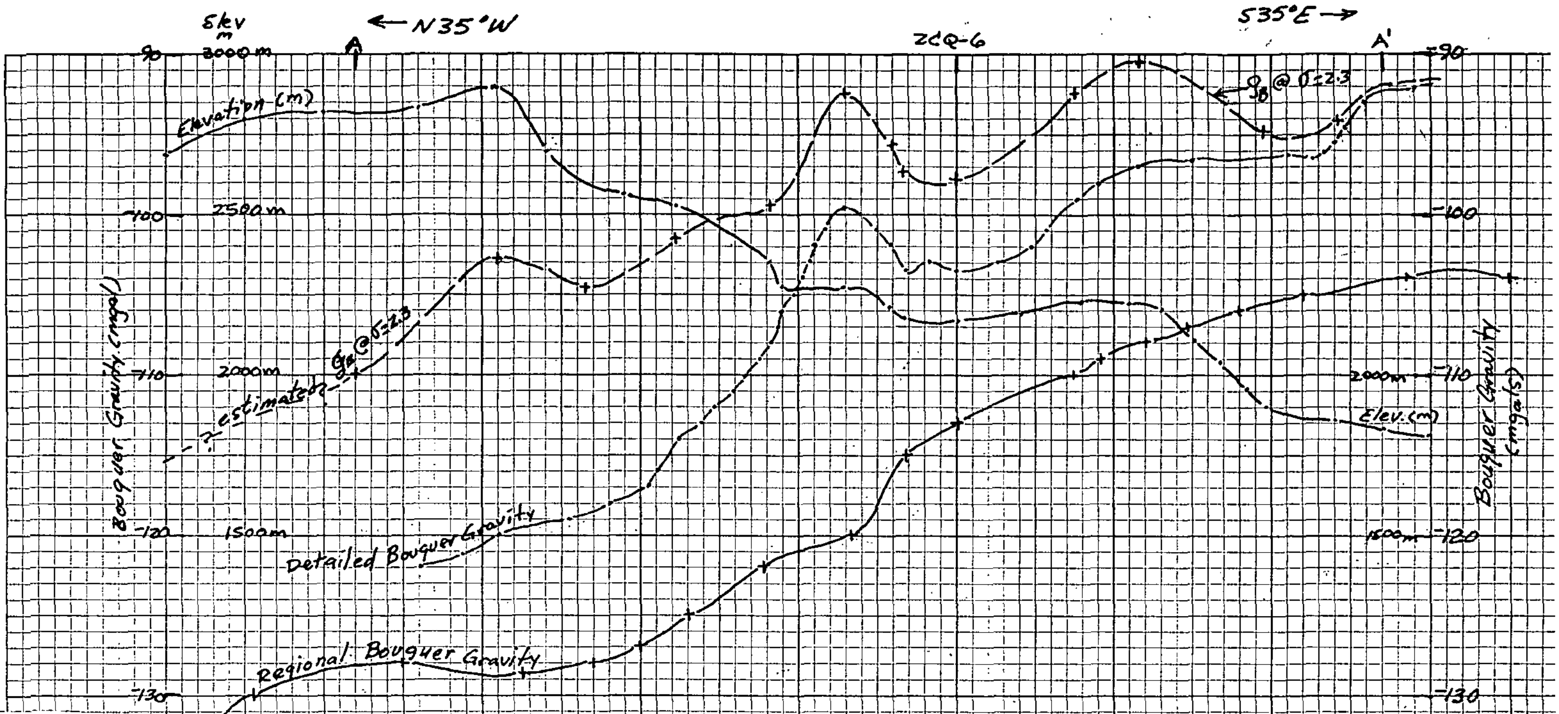


Figure 1. Comparison of regional Bouguer gravity, detailed Bouguer gravity, and surface elevation along profile A-A'. Also shown is the estimatedBouguer gravity for the detailed survey using a density of 2.30 g/cc.

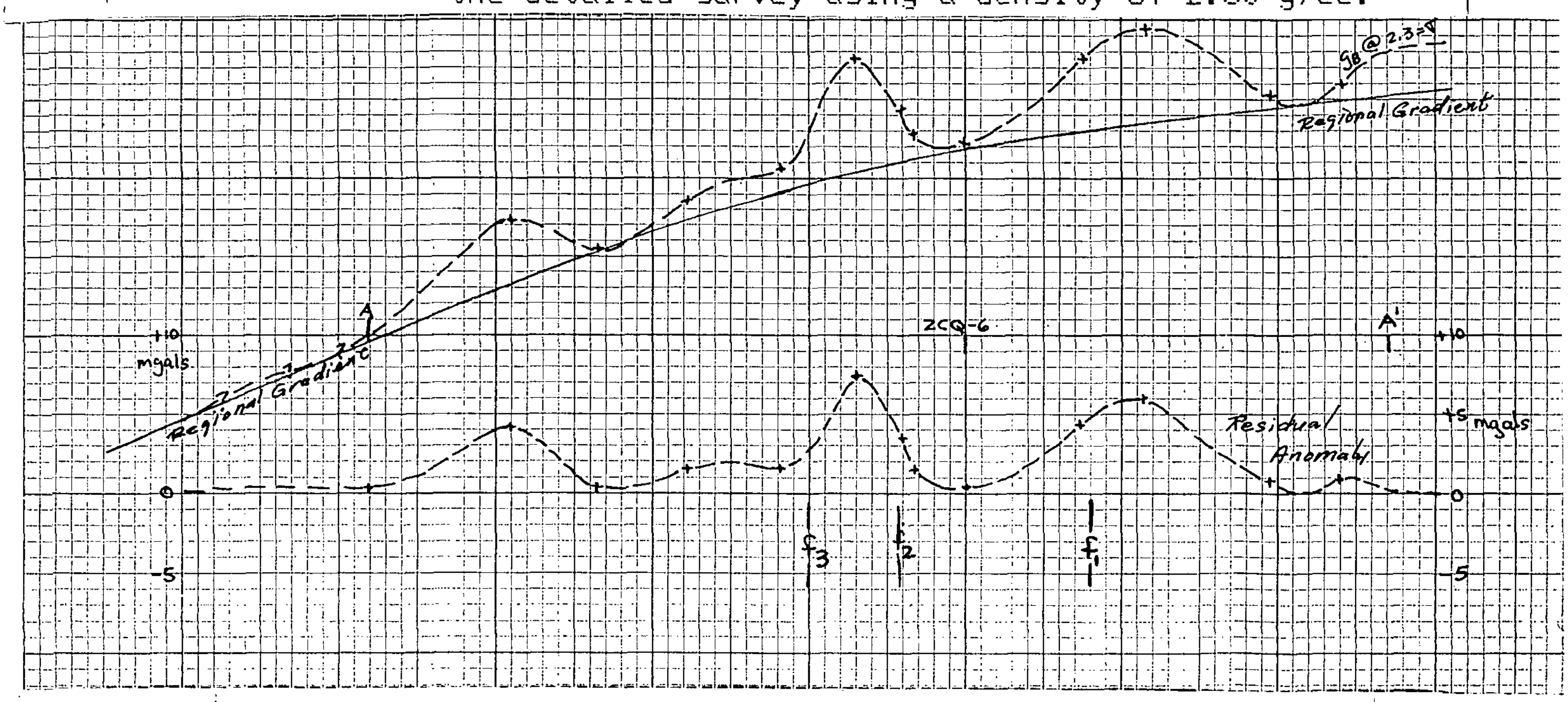


Figure 2. Identification of a regional gradient along profile A-A', and its removal to form a residual anomaly suitable for numerical modeling.

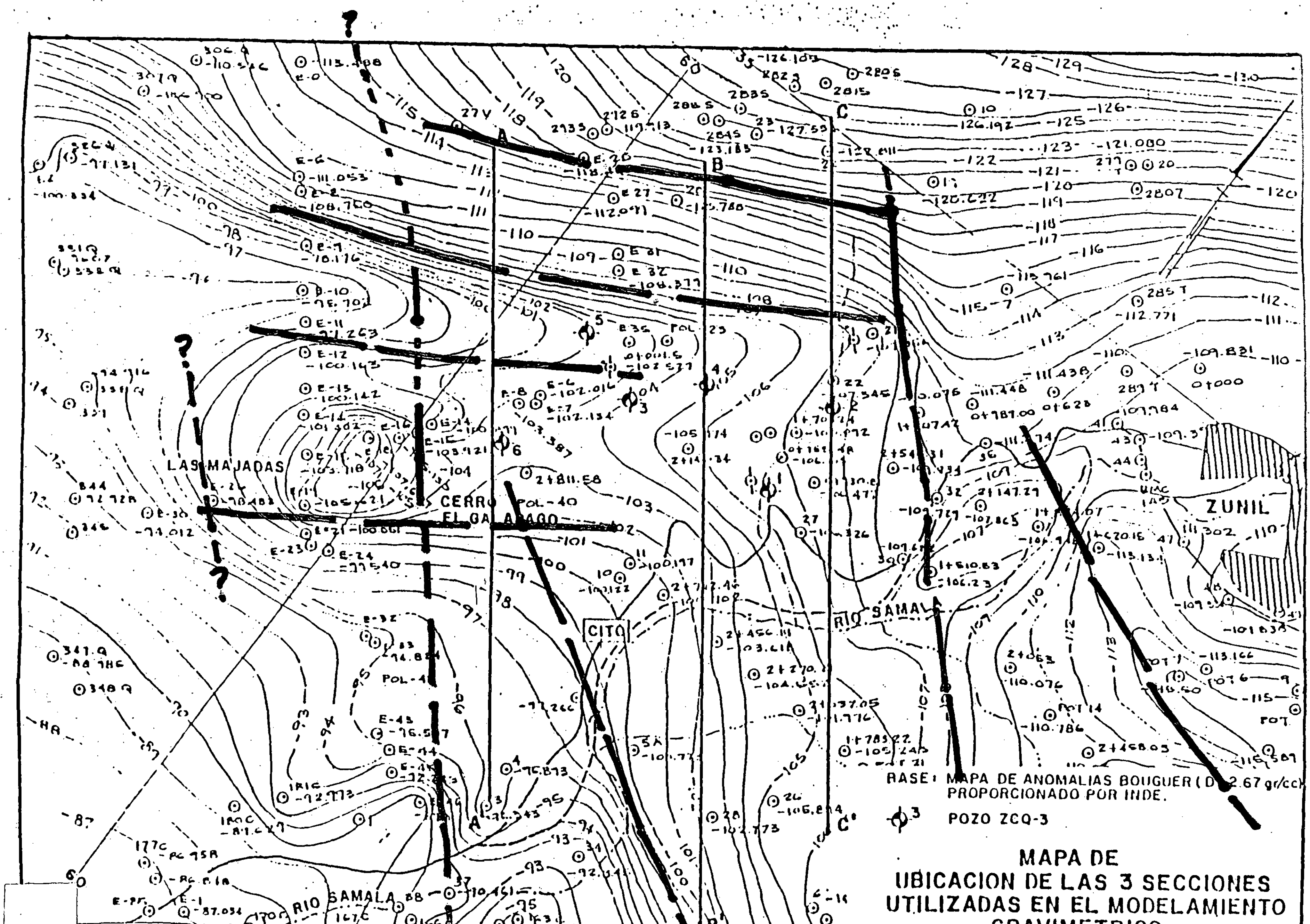
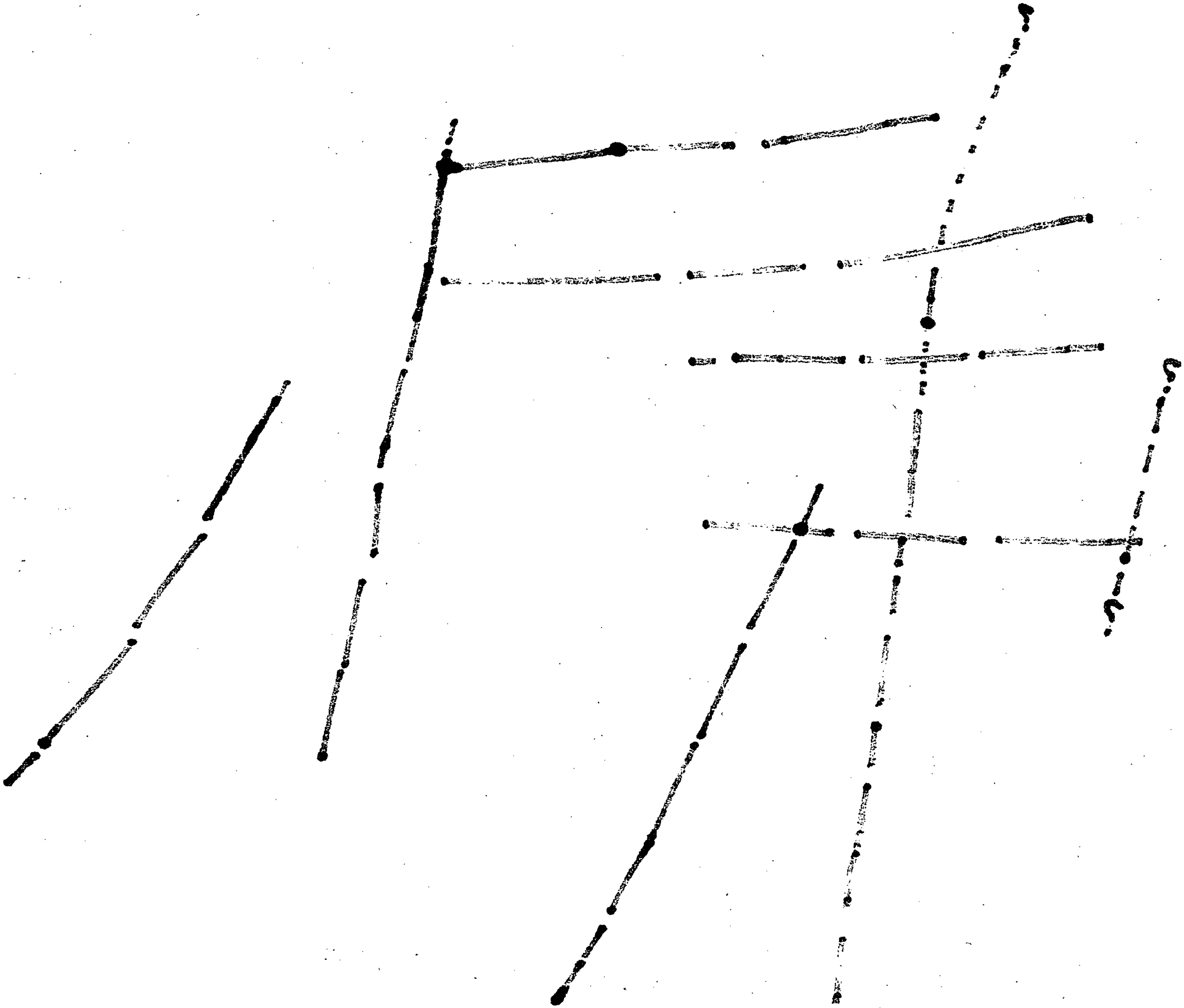
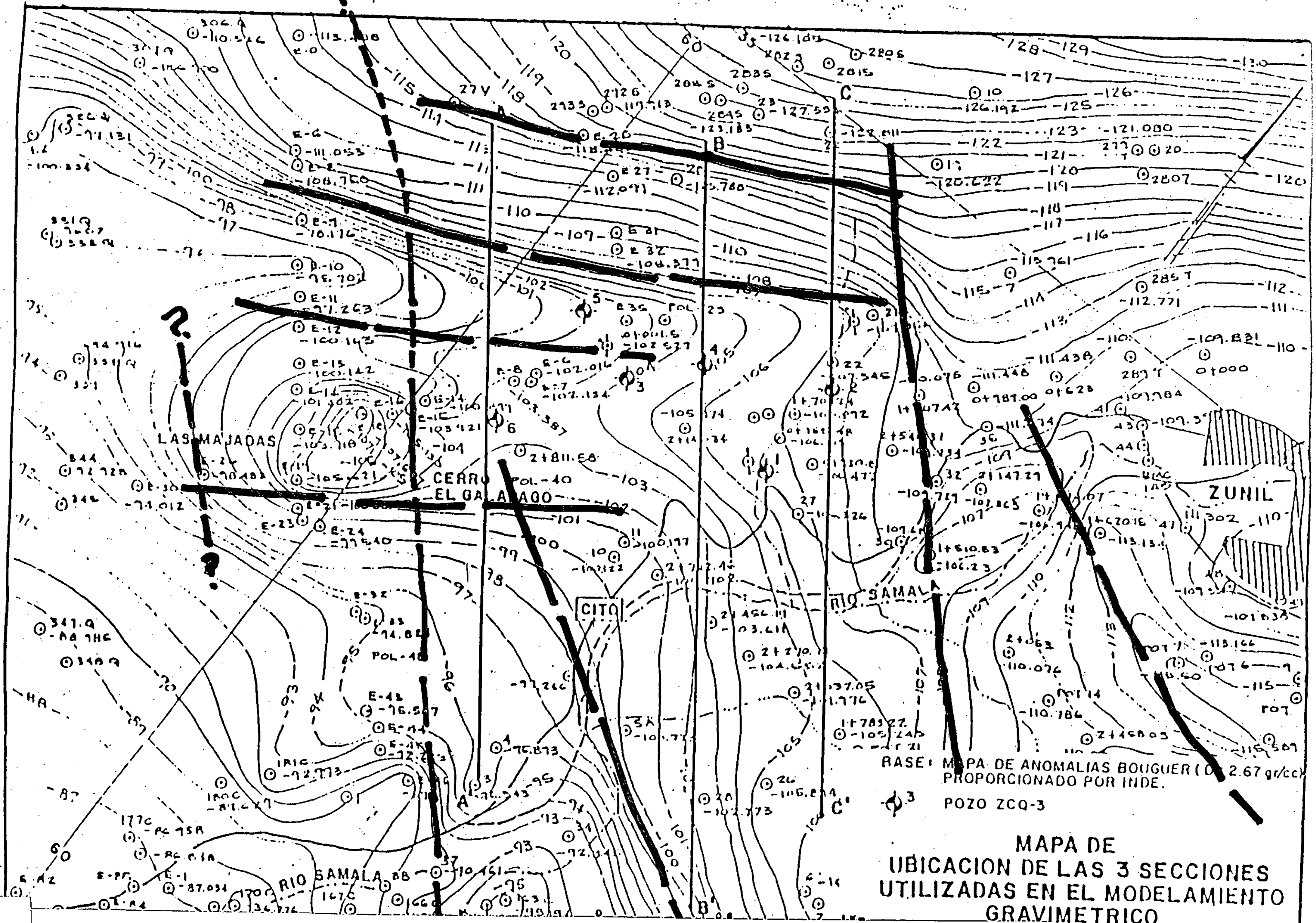


Figure 3. Location of faults in the Zunil 1 area as inferred from the detailed gravity survey. This interpretation has not been supported by numerical modeling.





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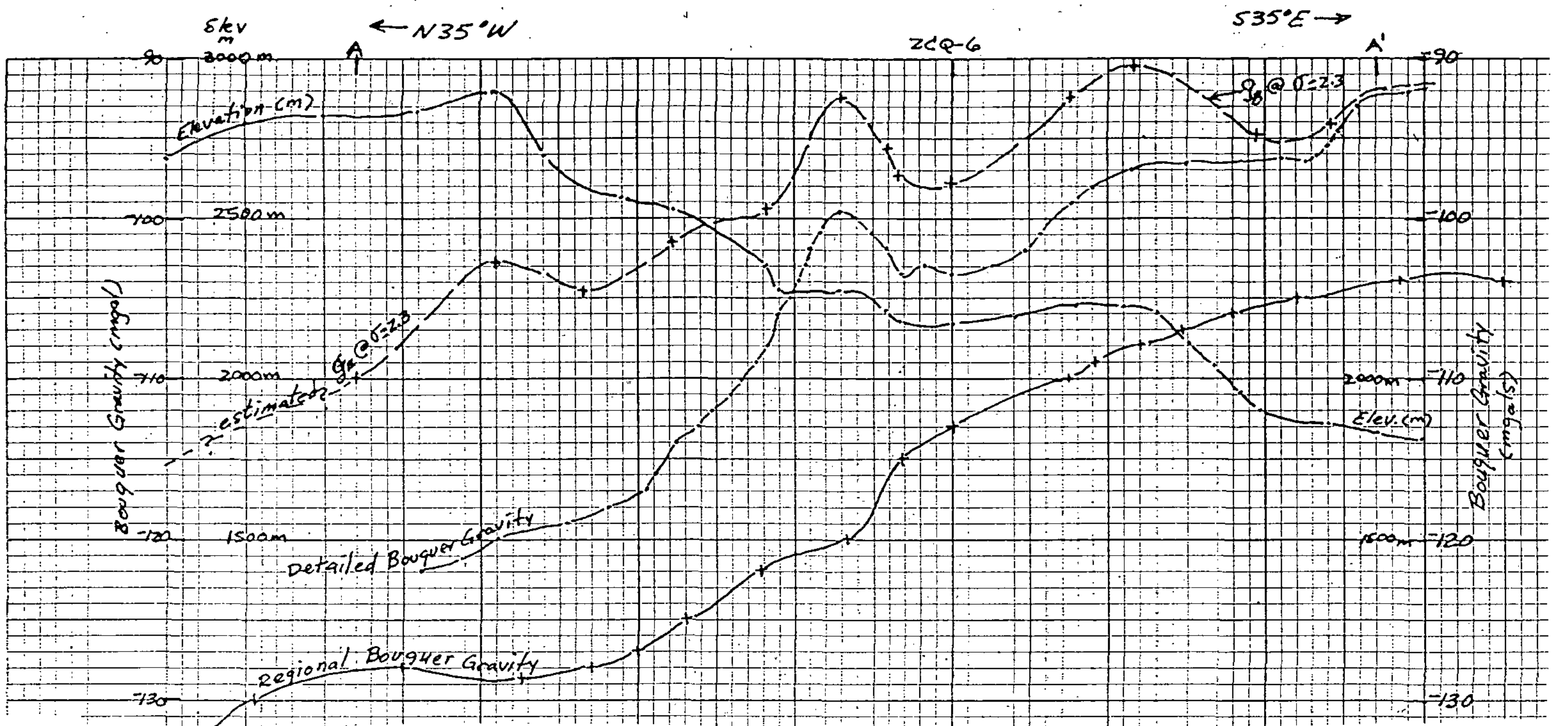

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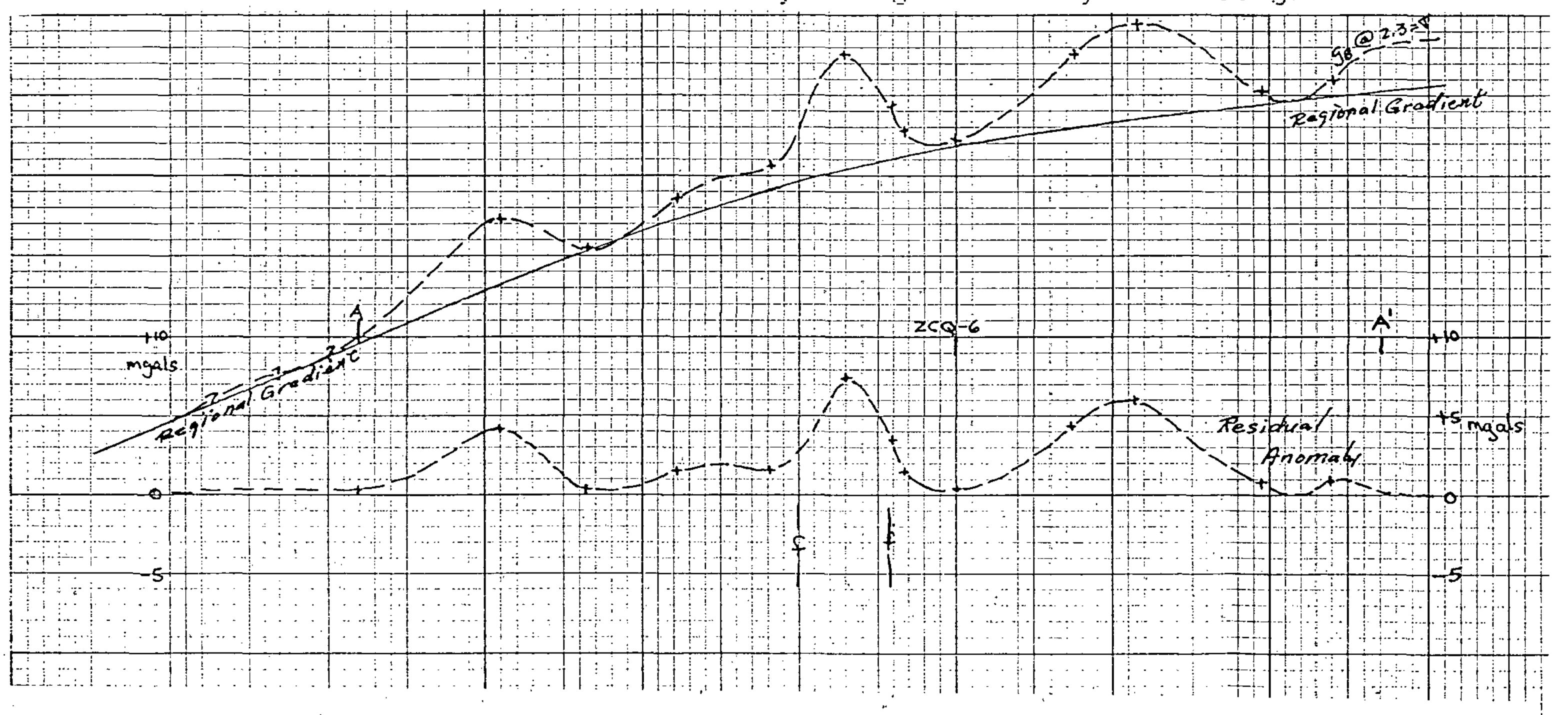


Figure 2. Identification of a regional gradient along profile A-A', and its removal to form a residual anomaly suitable for numerical modeling.

Scale 1:25,000

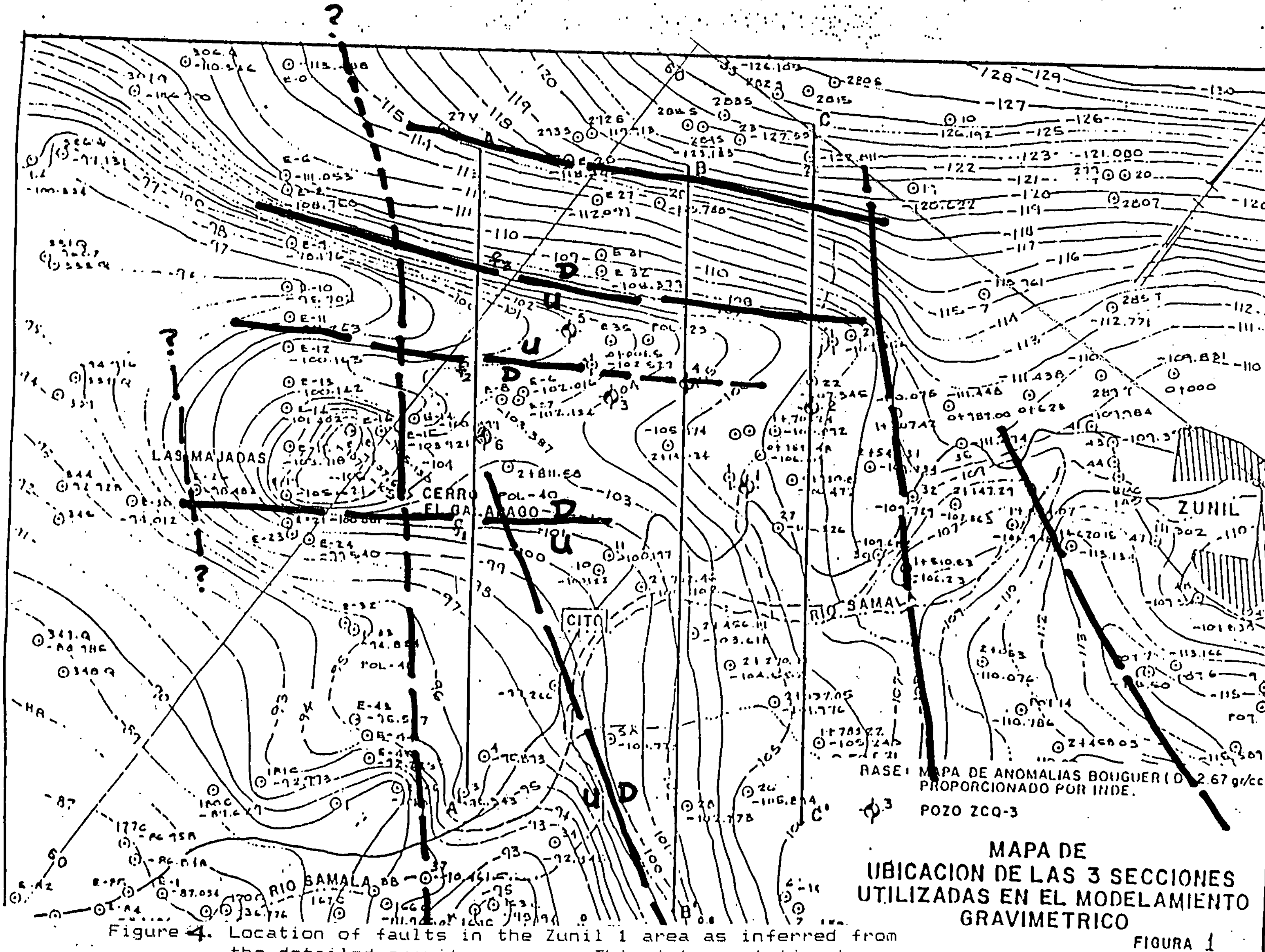


Figure 4. Location of faults in the Zunil 1 area as inferred from the detailed gravity survey. This interpretation has not been supported by numerical modeling.

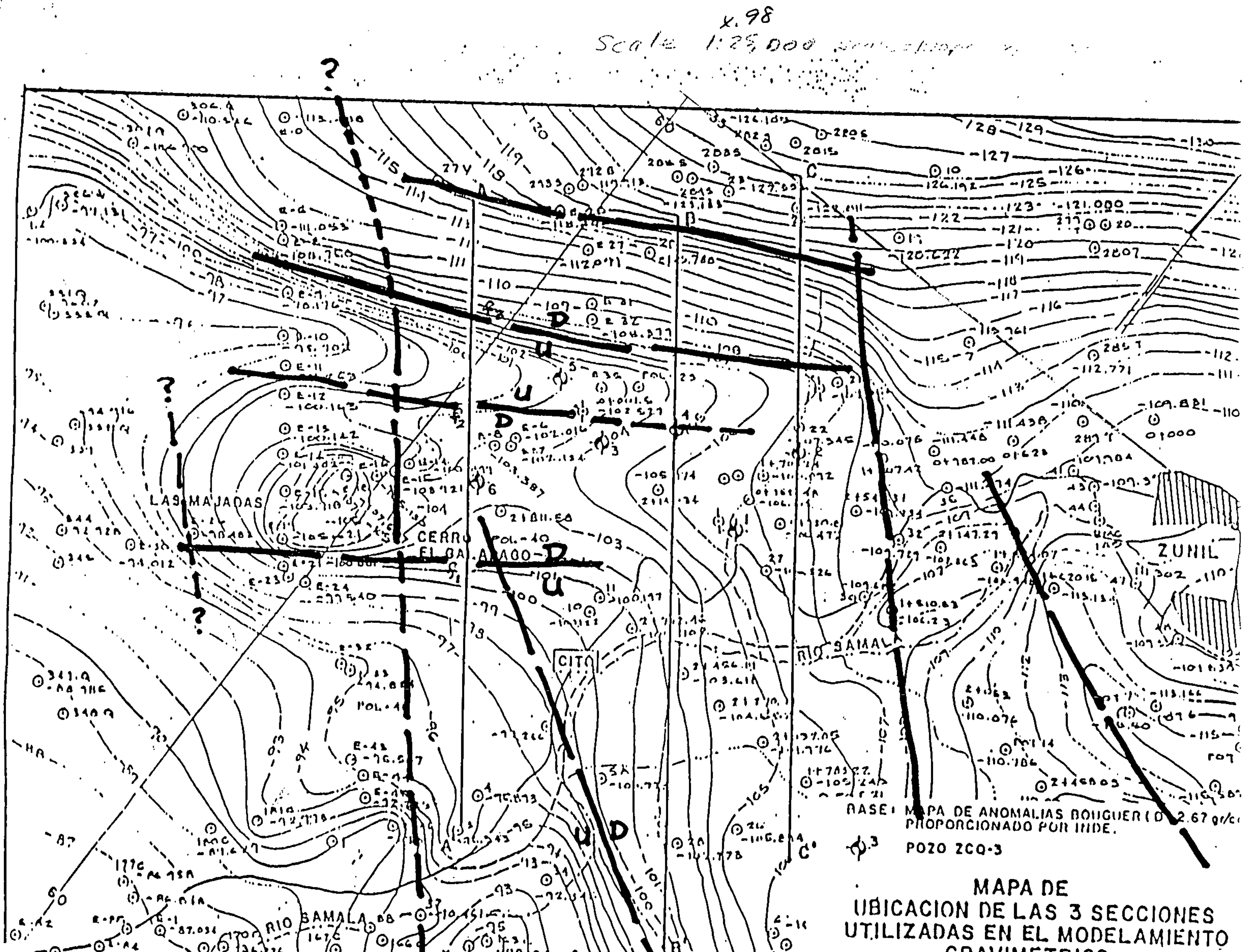
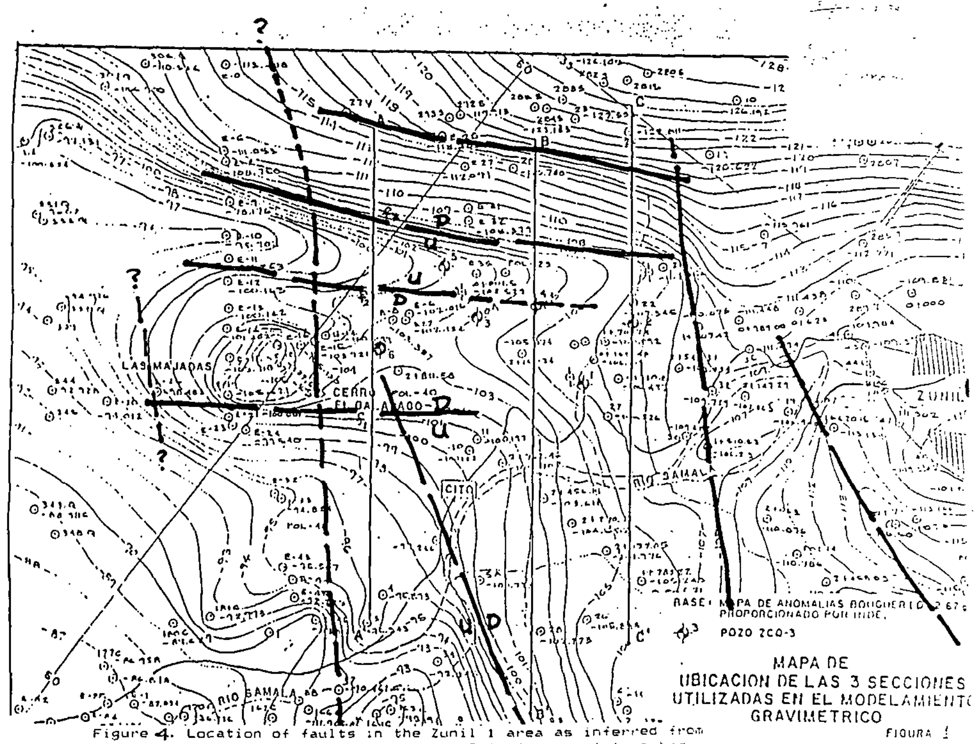


Figure 4. Location of faults in the Zunil 1 area as inferred from the detailed gravity survey. This interpretation has not been supported by numerical modeling.

0.70 x 0.70 = 1:40,000



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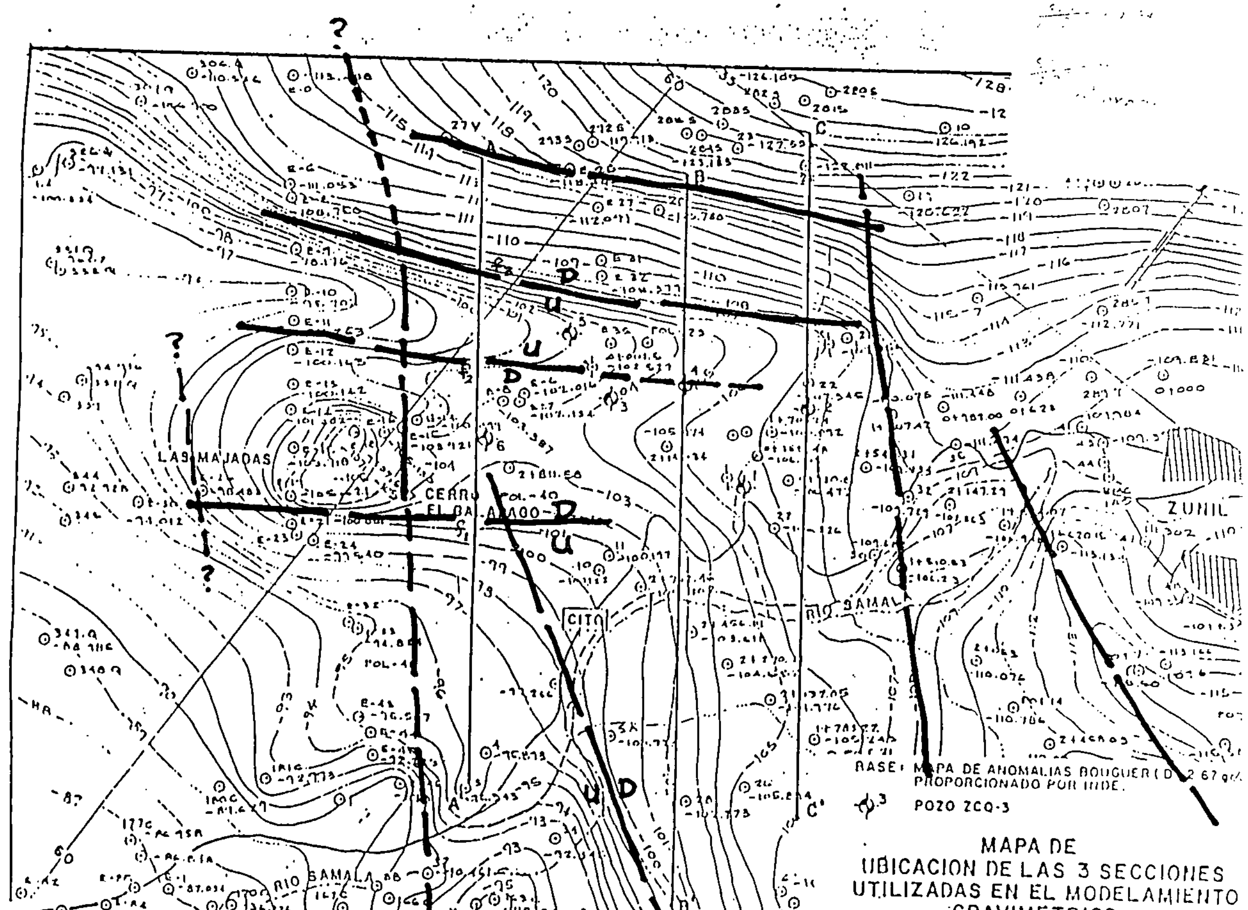
0.70x0.89



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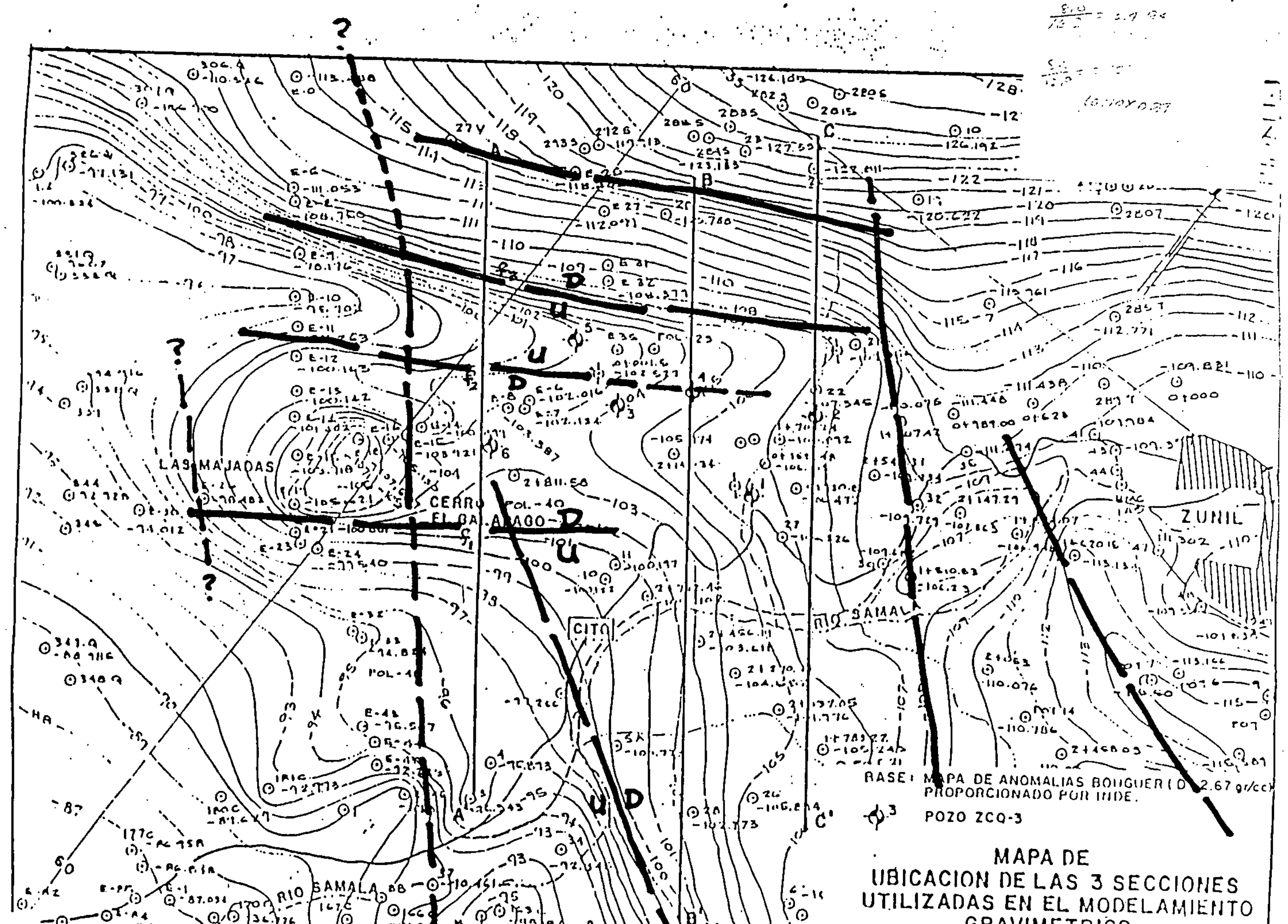
x.70



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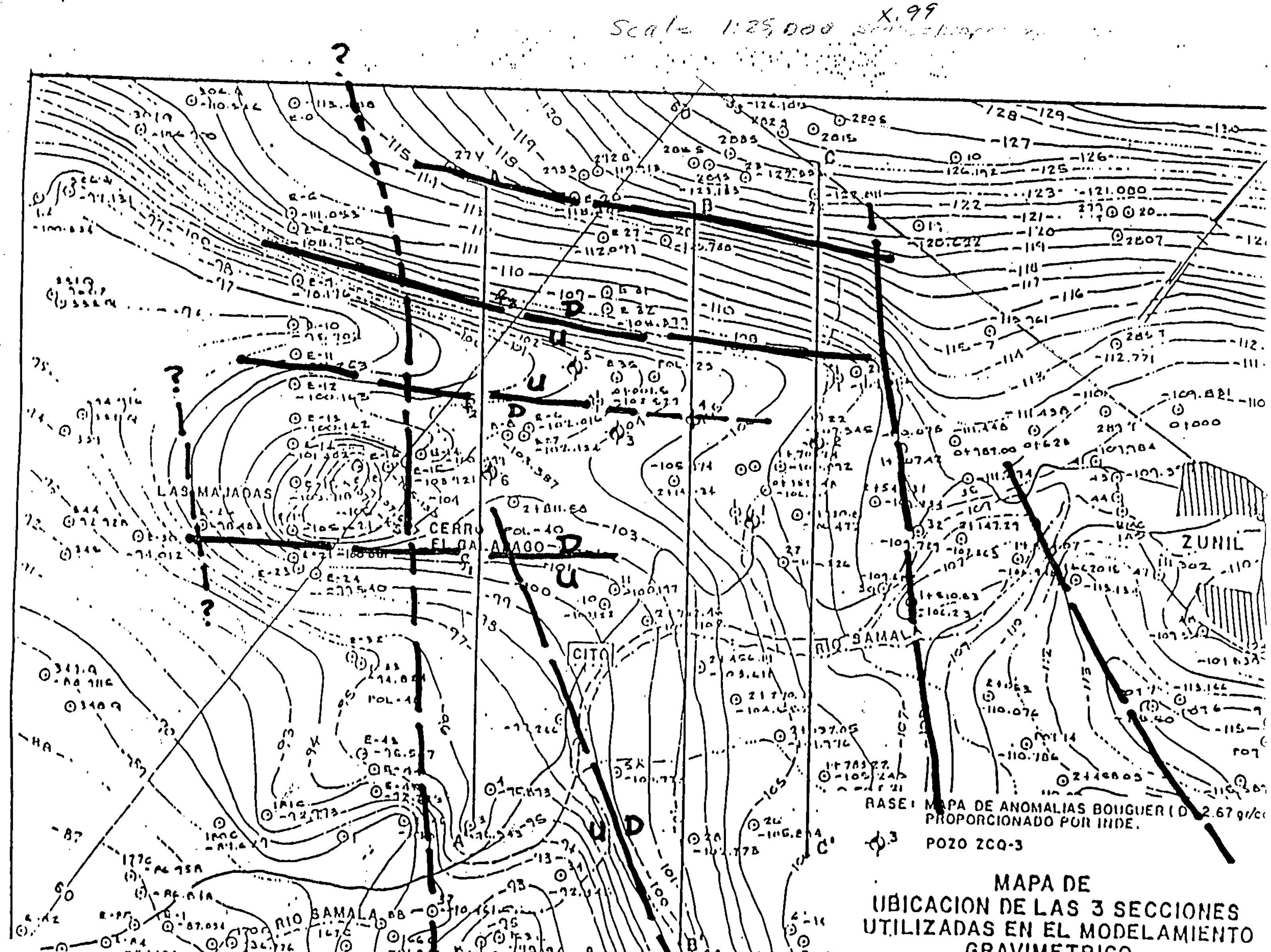

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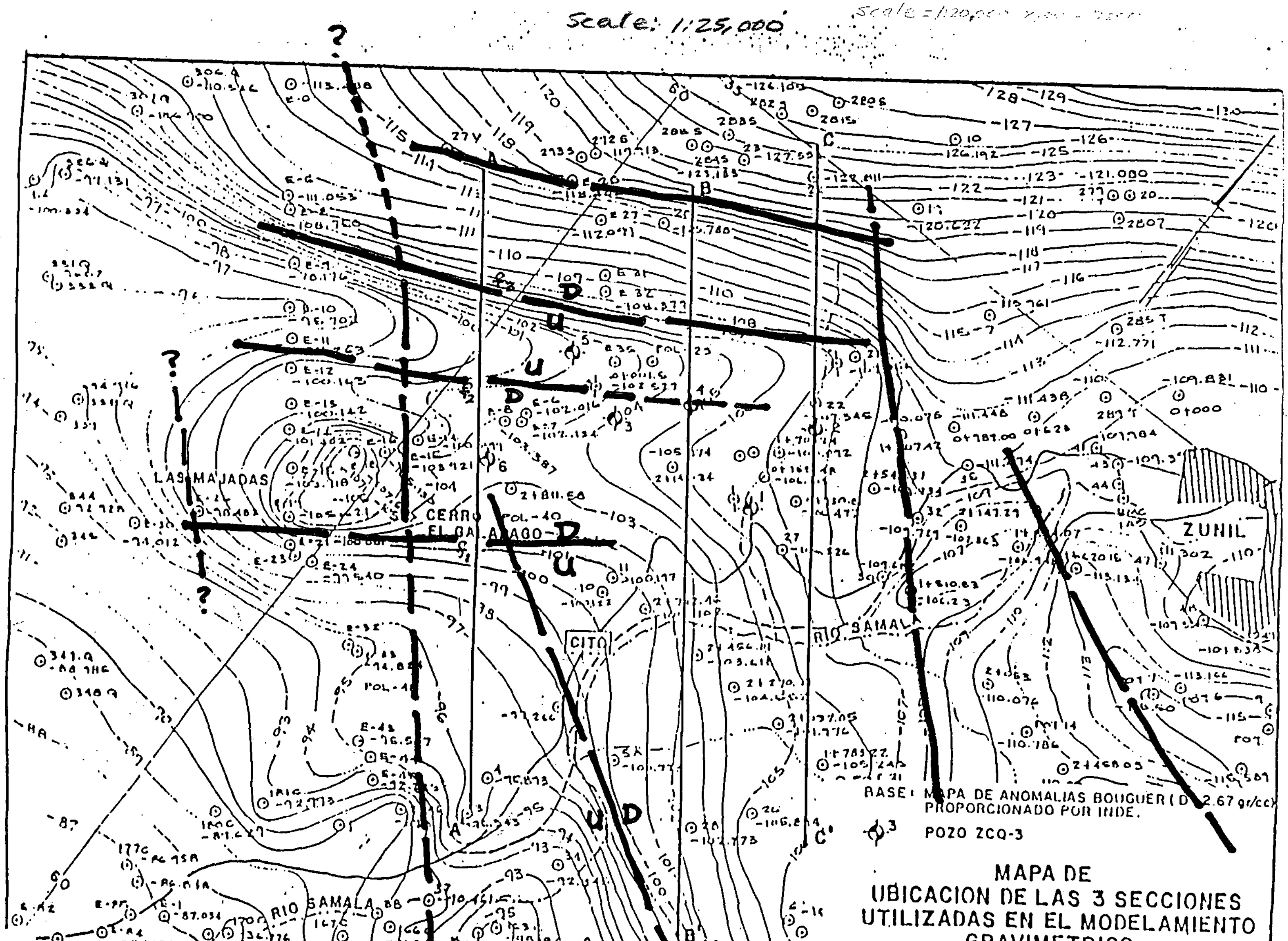


Figure 4. Location of faults in the Zunil 1 area as inferred from the detailed gravity survey. This interpretation has not been supported by numerical modeling.

FAX 801-524-3453+

10-87/GUA/UTAH/CE/438

JUNE 19, 1989

TO : JOE MOORE

FROM : LUIS MERIDA

DEAR JOE:

I RECEIVED YOU FIVE REPORTS AND A COPY OF EACH FOR INDE (IN YOUR REMITTANCE IT IS MENTIONED 12 INSTEAD OF 10. THANKS A LOT. IT SEEMS WE ARE GETTING CLOSER TO THE POINT. EXCELLENT. WITH DUNCAN'S WORK AND ALSO WITH ROYS', IT REMAINS THE PROBLEM OF GEOPHYSICS. INDE HAS NOT FINISH THEIR GRAVITY WORK AND THEY ARE ELUSIVE ABOUT HOWARD'S TRIP TO GUATEMALA. SO WE CAME UP WITH THE IDEA OF INVITING ONE THE YOUNG GEOPHYCIST THAT SPEAK ENGLISH TO GO TO UURI AND WORK WITH HOWARD IF THERE IS NO INCONVENIENT FROM YOU. PLEASE LET ME KNOW TO APPROACH INDE. THEY ALSO SAID THEY WILL FINISH BY NEXT FRIDAY. FOR THE SAME MATTER I AM SENDING YOU A COPY (2 PAGES) WITH THE LINES USED FOR THE GRAVITY SURVEY. BY TODAY PROBABLY DUNCAN REACHED YOU BY PHONE AND EXPLAINED THE IMPORTANCE OF INVESTIGATING A STRUCTURE NE TRENDING HIGH ABOVE THE RIM OF THE FIELD. PLEASE ASK HOWARD WHAT EXTENSIONS OF THE LINES HE NEEDS, IF ANY, FOR THE EVALUATION OF THAT STRUCTURE. YOU MIGHT LIKE TO DISCUSS THAT WITH DUNCAN.

ROY WANTS TO KNOW WHAT IS YOUR ADVICE ON THE FOLLOWING BECAUSE OF CUSTOMS PROBLEMS. RELATED TO HG SOIL SAMPLES WE HAVE ONLY ONE STICKER FOR THE BOX AND NO REMITTANCE FORM AS WE DID HAVE FOR THE PREVIOUS ONE: WOULD IT BE BETTER FOR ROY TO CARRY THE MERCURY SAMPLES OR DHL THEM.

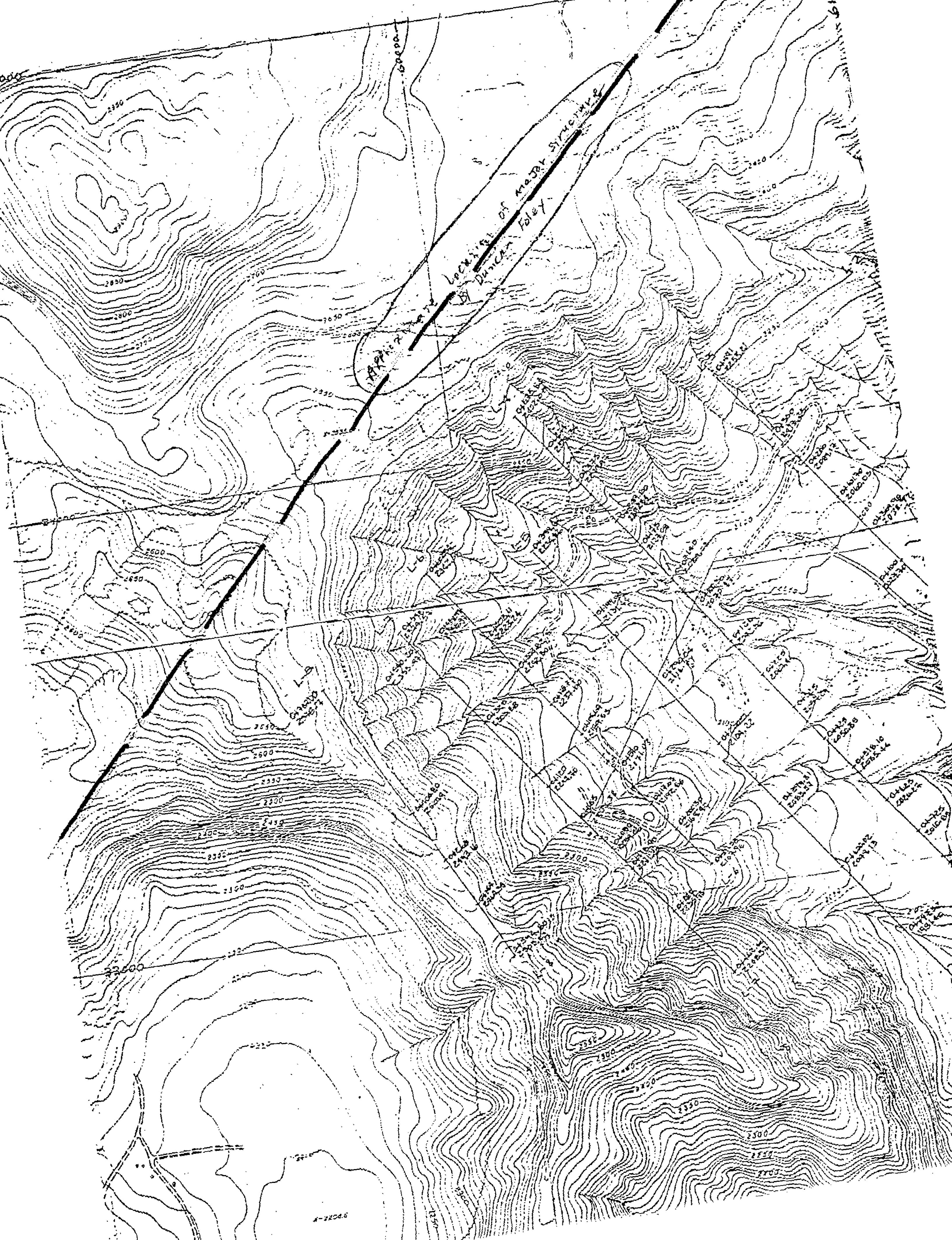
LOOKING FORWARD FOR YOUR ANSWER. THANKS A LOT AGAIN FOR YOUR REMITTAL.
LLLL

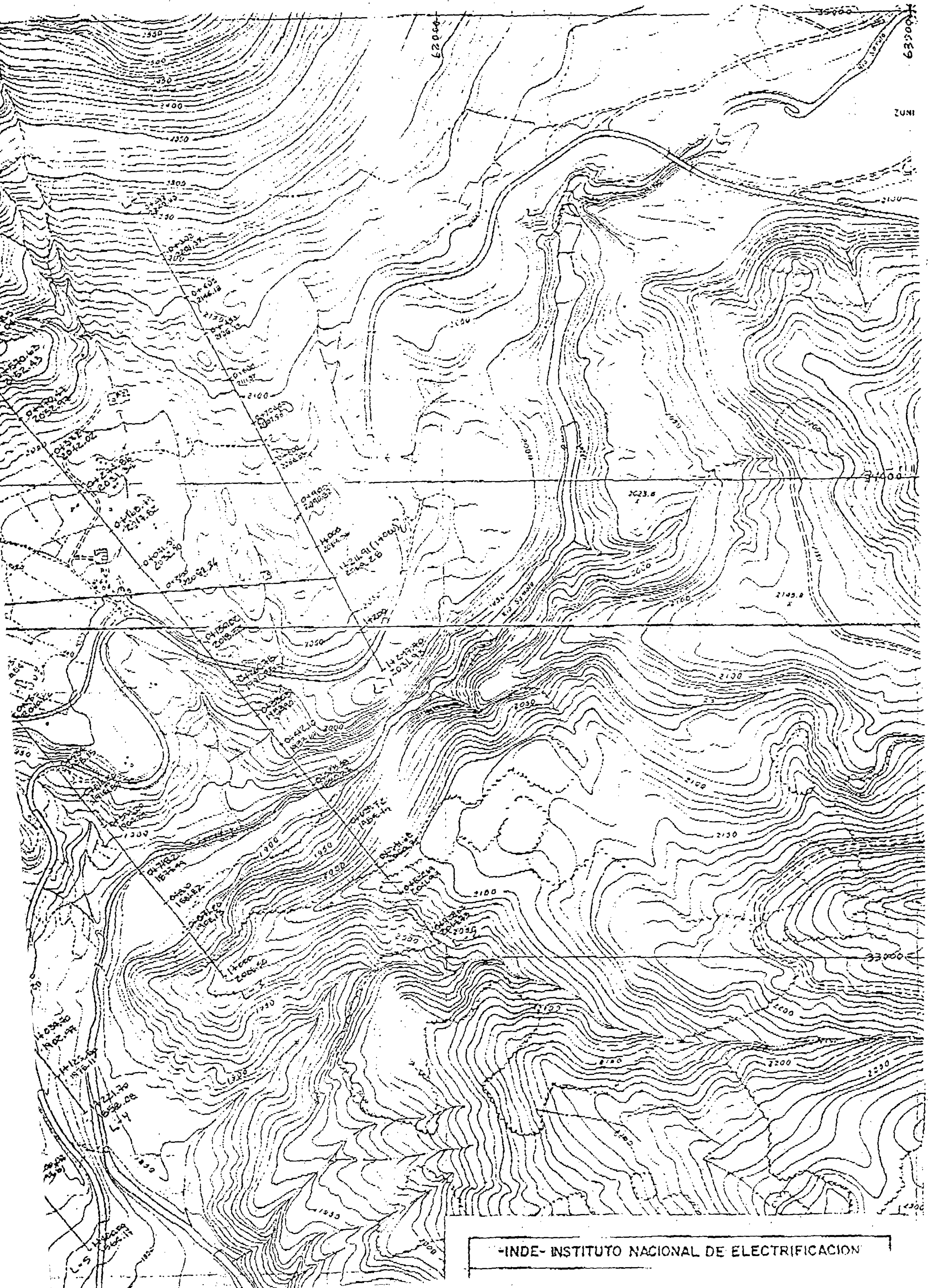
HPR → JNM

June 19-20, 1989

Ross does not recommend the extension of the gravity lines to the NW across the proposed structure, since any density contrast may be very small within the volcanics, or very deep (2000 m ±) based on the known geology. If the lines were extended, we would recommend lines 8, 4, and 2 be extended not less than 500 m past the proposed structure, with stations not more than 150 m apart. Care must be taken with elevation and terrain corrections.

I. J. (Jerry) Epperson, Jr
Sr. Res. Engr. Geothermal Div.
P.O. Box 5049
San Ramon, CA 94583-0949
(415) 842-6820


Approximate Location of major structure
by Duncan Foley
L-6
L-8



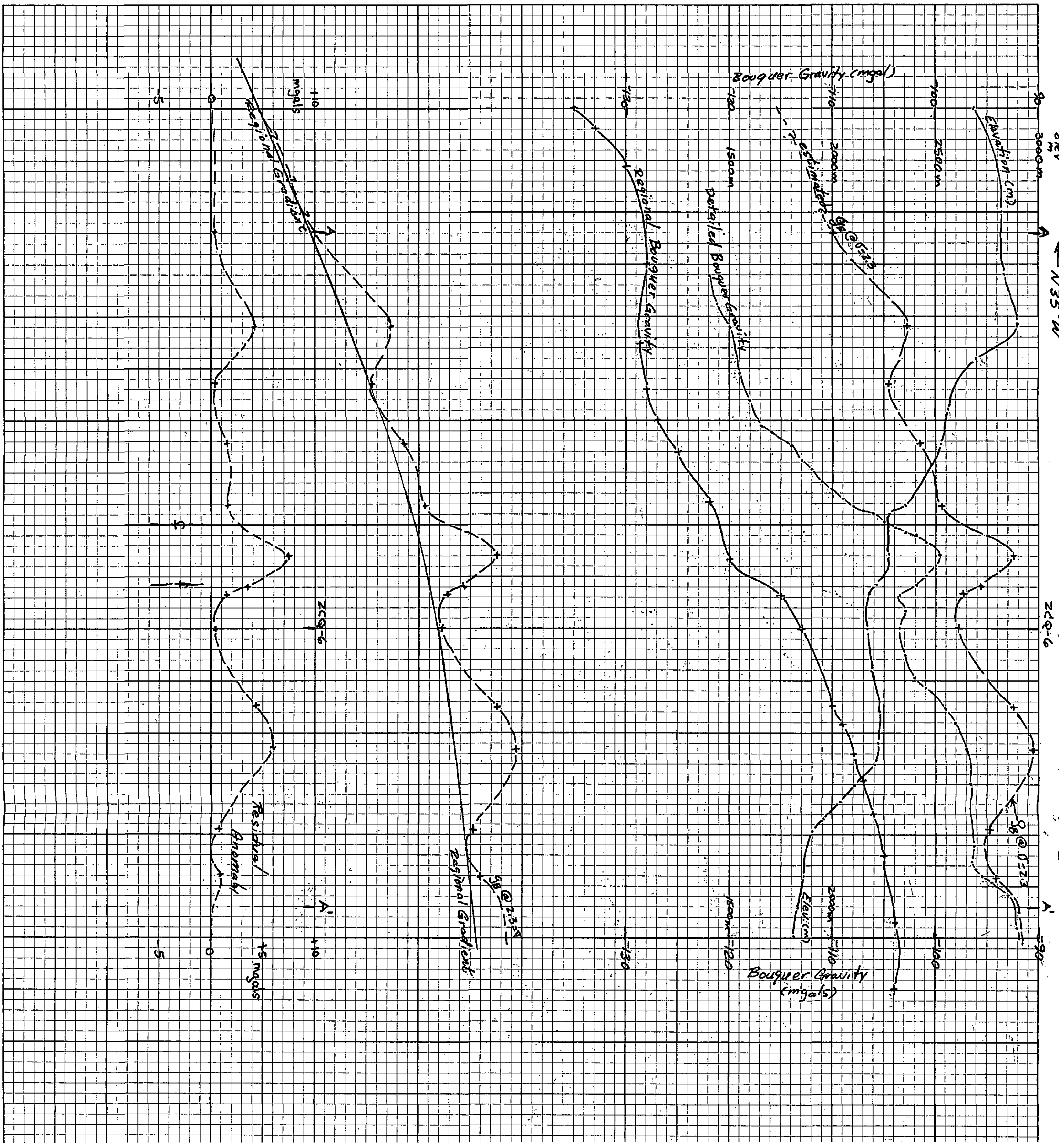
-INDE- INSTITUTO NACIONAL DE ELECTRIFICACION
ZUNI

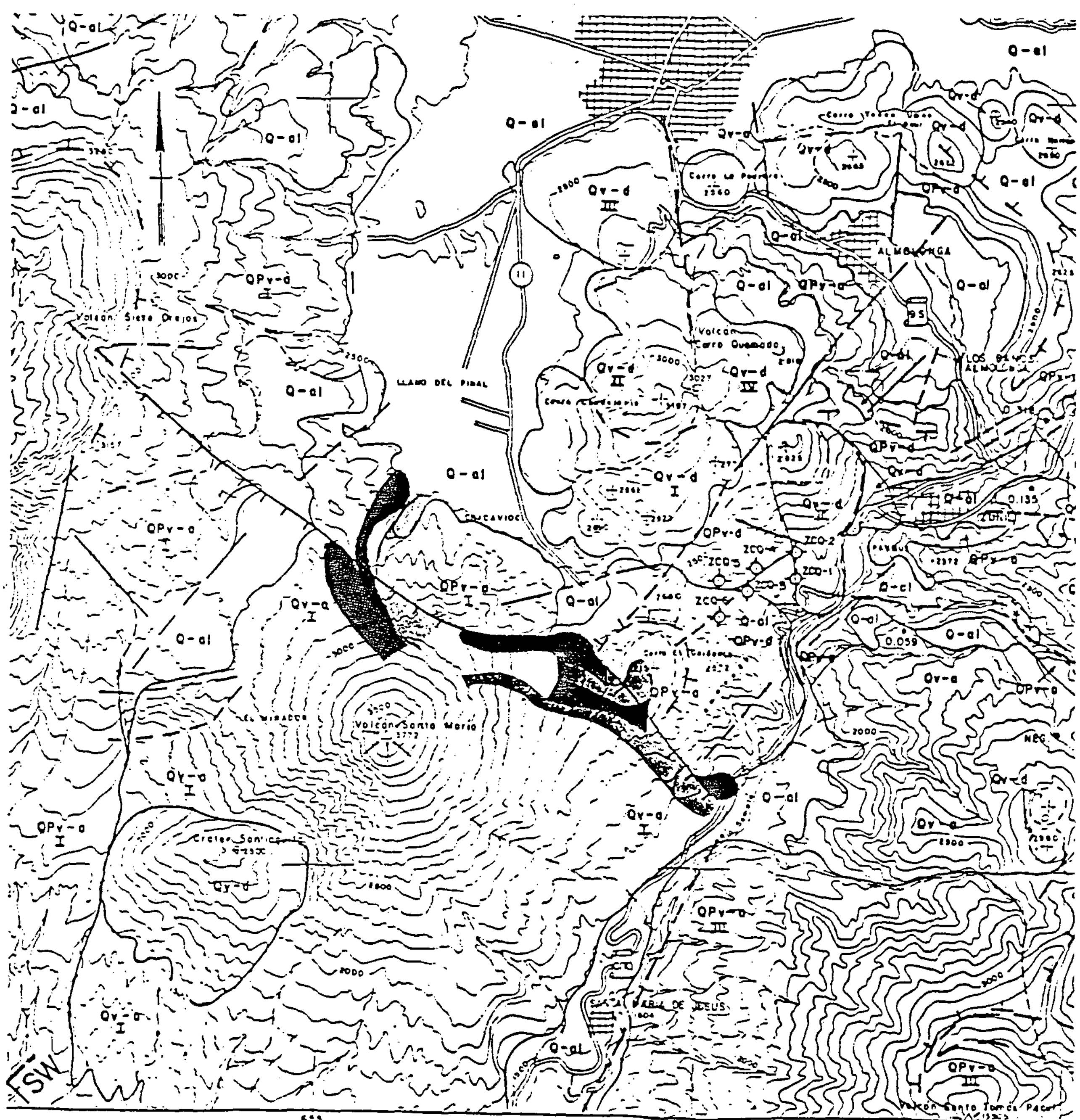
Z-6 $\frac{12.6}{12.0} = 1.05$

6-1 $\frac{4.4}{4.1} = 1.07$ ✓

6-2 $\frac{5.4}{5.0} = 1.08$

107-115 $\frac{13.4}{13.0} = 1.0307$


Bouguer Gravity (mgal)
Elevation (m)
Regional Bouguer Gravity
Detailed Bouguer Gravity
Regional Gradient
Residual Anomaly
mgals
A
A'
ZCQ-6
N35°W
S35°E
Bouguer Gravity (mgals)
Elev. (m)



NOTAS :

- TOMADO DE ROSE (1987) Y BASADA EN LA TOPOGRAFIA
- LAS DIFERENTES SOMBRAS NO TIENEN SIGNIFICADO.
- MAPA BASE: MAPA GEOLOGICO DEL INDE 1981

ELEVATIONS IN METERS

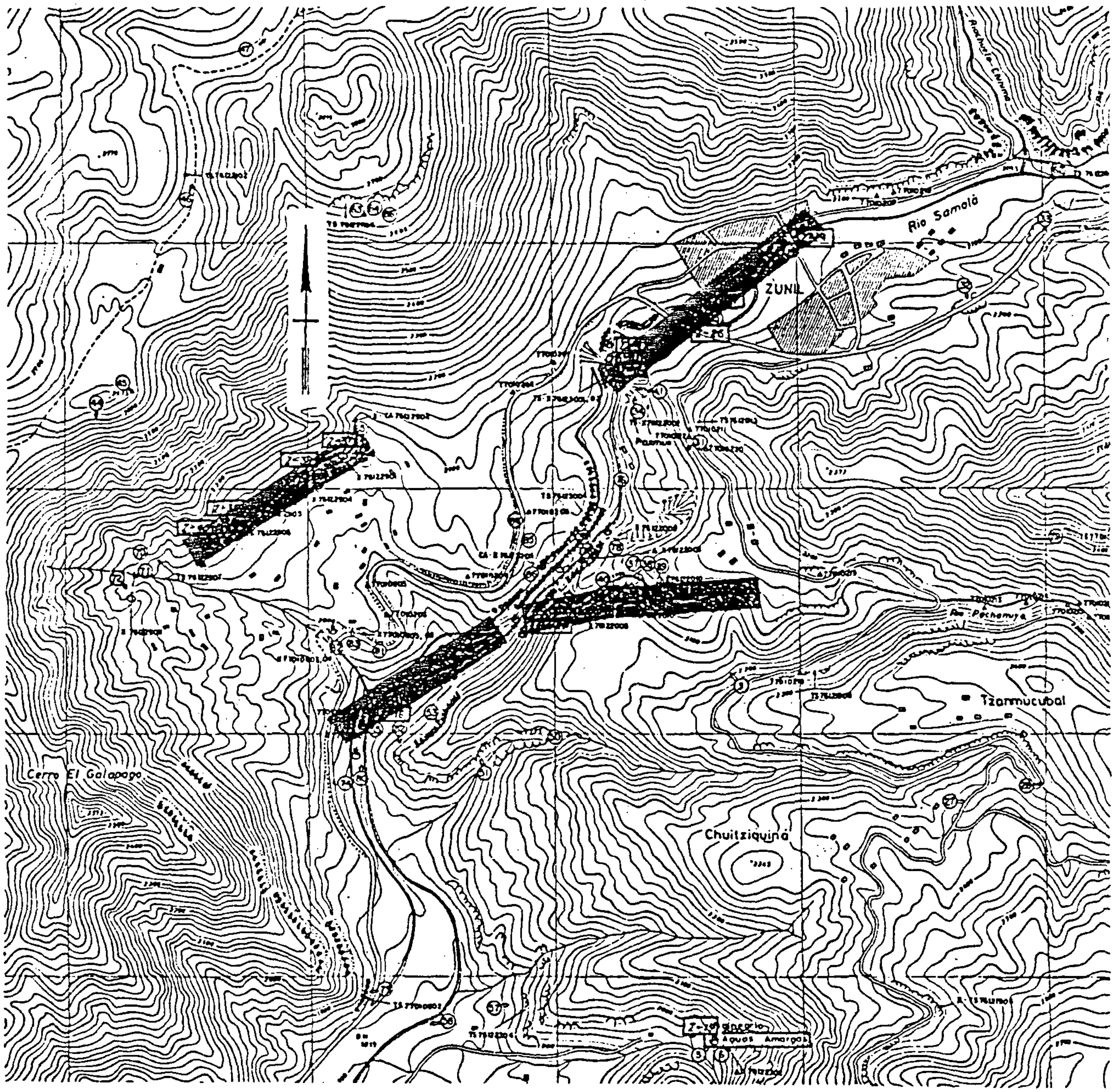
INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

LOCALIZACION PROPUESTA DEL LIMITE DE RECIENTES FLUJOS DE ANDESITA BASALTICA, LANZADOS POR EL VOLCAN SANTA MARIA.

CyM / MKF.

FIGURA: 3.1-2

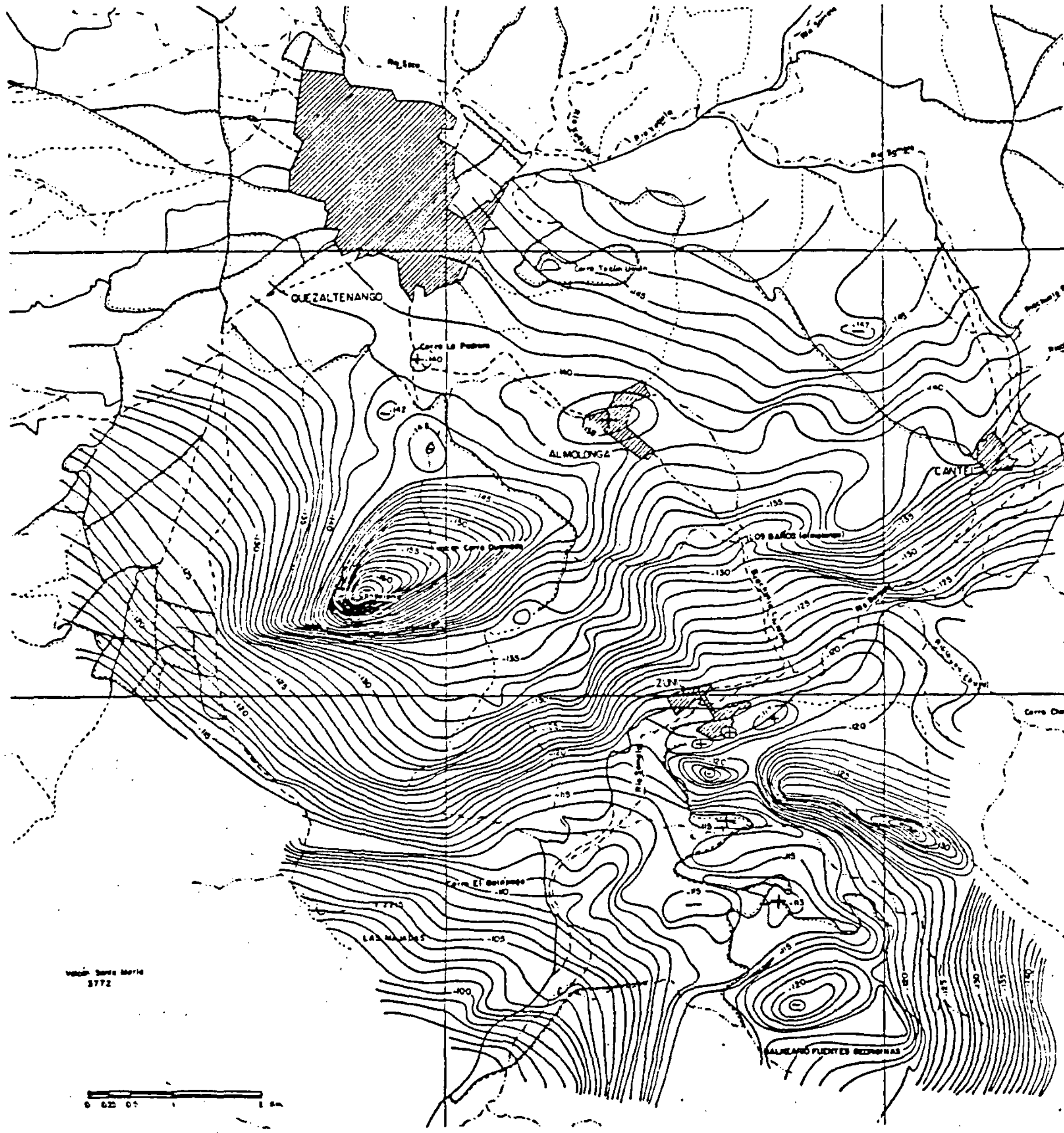


MANIFESTACIONES TERMALES ASOCIADAS A FALLAS PROBABLES.

NOTA:

MAPA BASE: LOCALIZACION DE MANANTIALES DEL AREA DE ZUNIL, INDE 1977.

INSTITUTO NACIONAL DE ELECTRIFICACION INDE GUATEMALA C.A.	
PROYECTO GEOTERMICO ZUNIL I	
ALINEACION DE MANIFESTACIONES TERMALES	
CyM / MKF.	FIGURA: 3.2-1



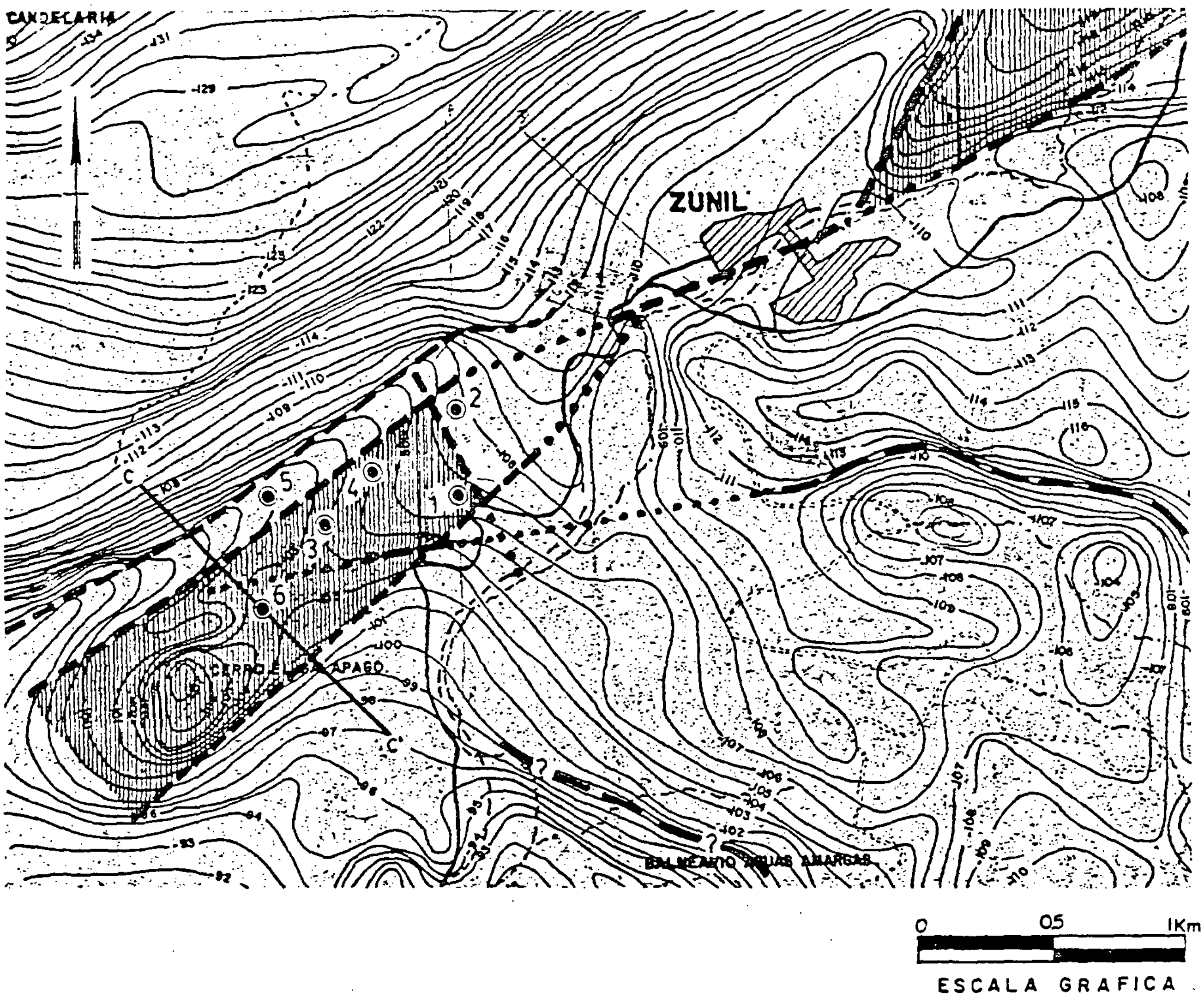
INFORMACION BASE: PLANO INDE POR ING. J. PALMA

INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

MAPA REGIONAL DE ANOMALIAS BOUGUER

CyM/MKF. FIGURA: 3.3-8



SIMBOLOGIA

AREA CON DEPLAZAMIENTO HACIA ABAJO DEL BASAMENTO ASI COMO UN GRABEN.

SECCION

PROBABLE FALLA RELACIONADA A FALLAMIENTO EN EL BASAMENTO. PUNTOS DENOTAN SOSPECHA.

POZO

INFORMACION BASE: PLANO INDE POR ING. J. PALMA

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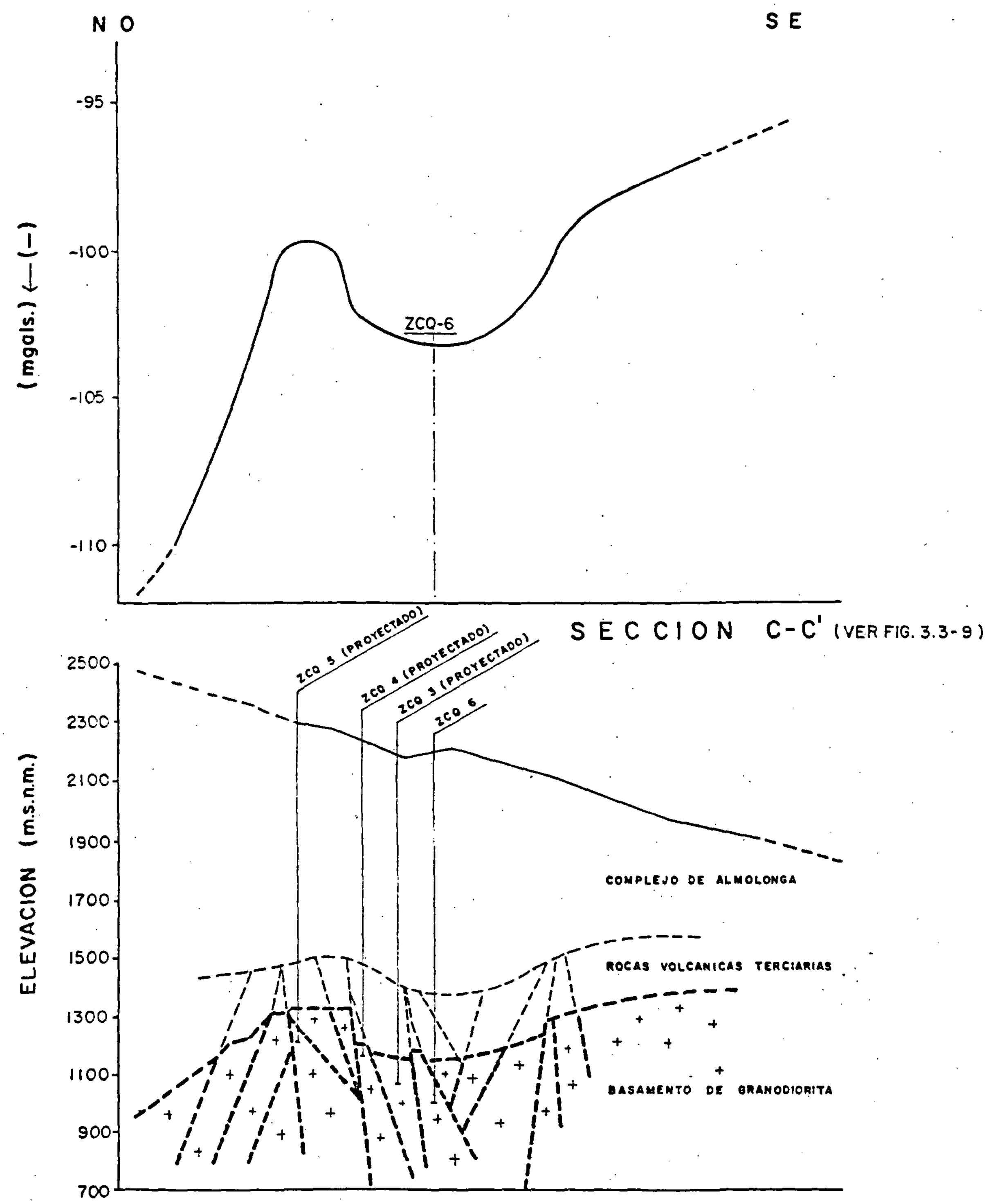
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

MAPA DE ANOMALIAS BOUGUER

CyM/ MKF.

FIGURA: 3.3-9



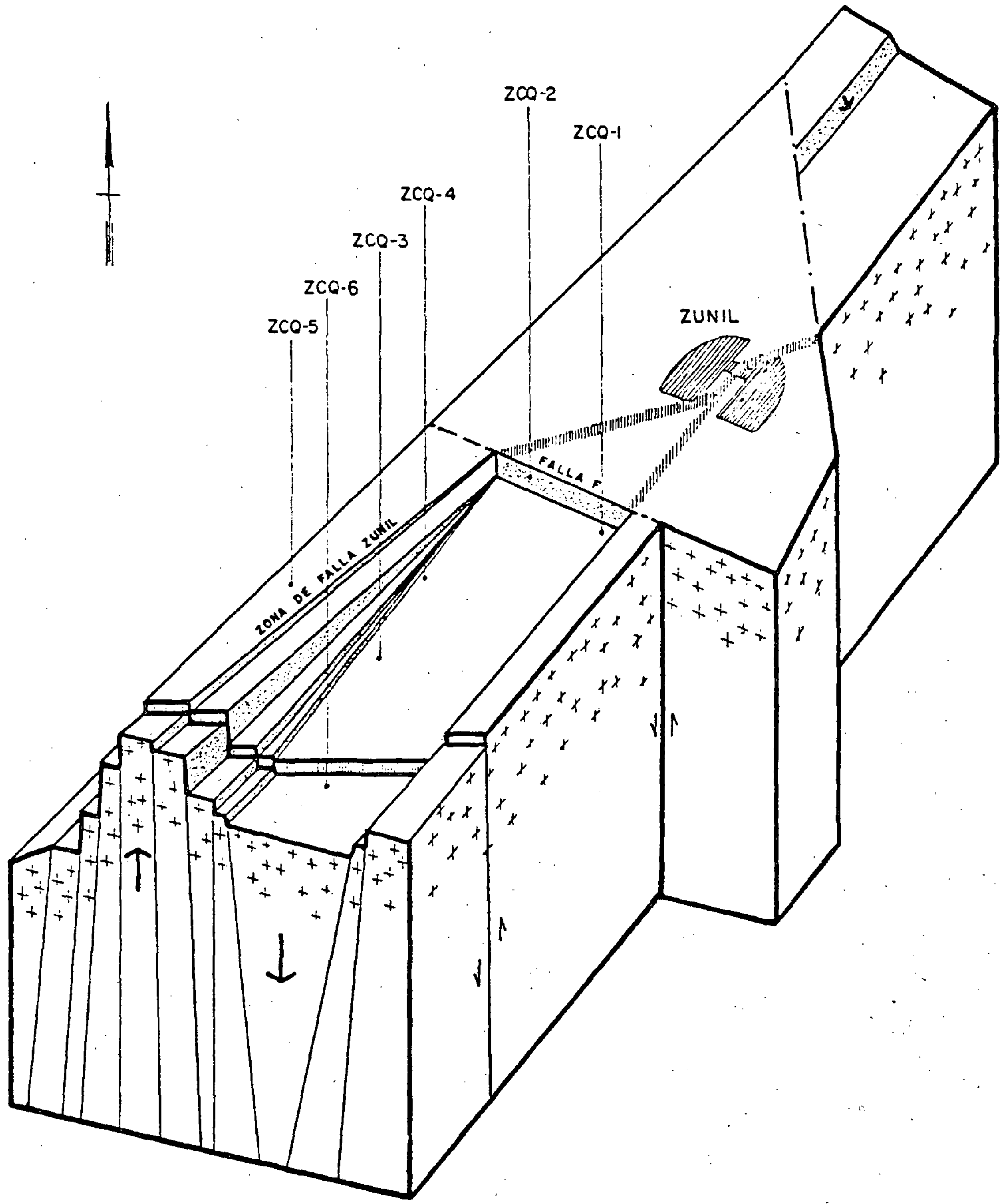
PREPARADO POR: ING. U. CORDON CYM/ MKF

INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

ESQUEMA REPRESENTATIVO DE ANOMALIAS DE LA GRAVEDAD INTERPRETATIVA

CyM/ MKF. FIGURA: 3.3-10



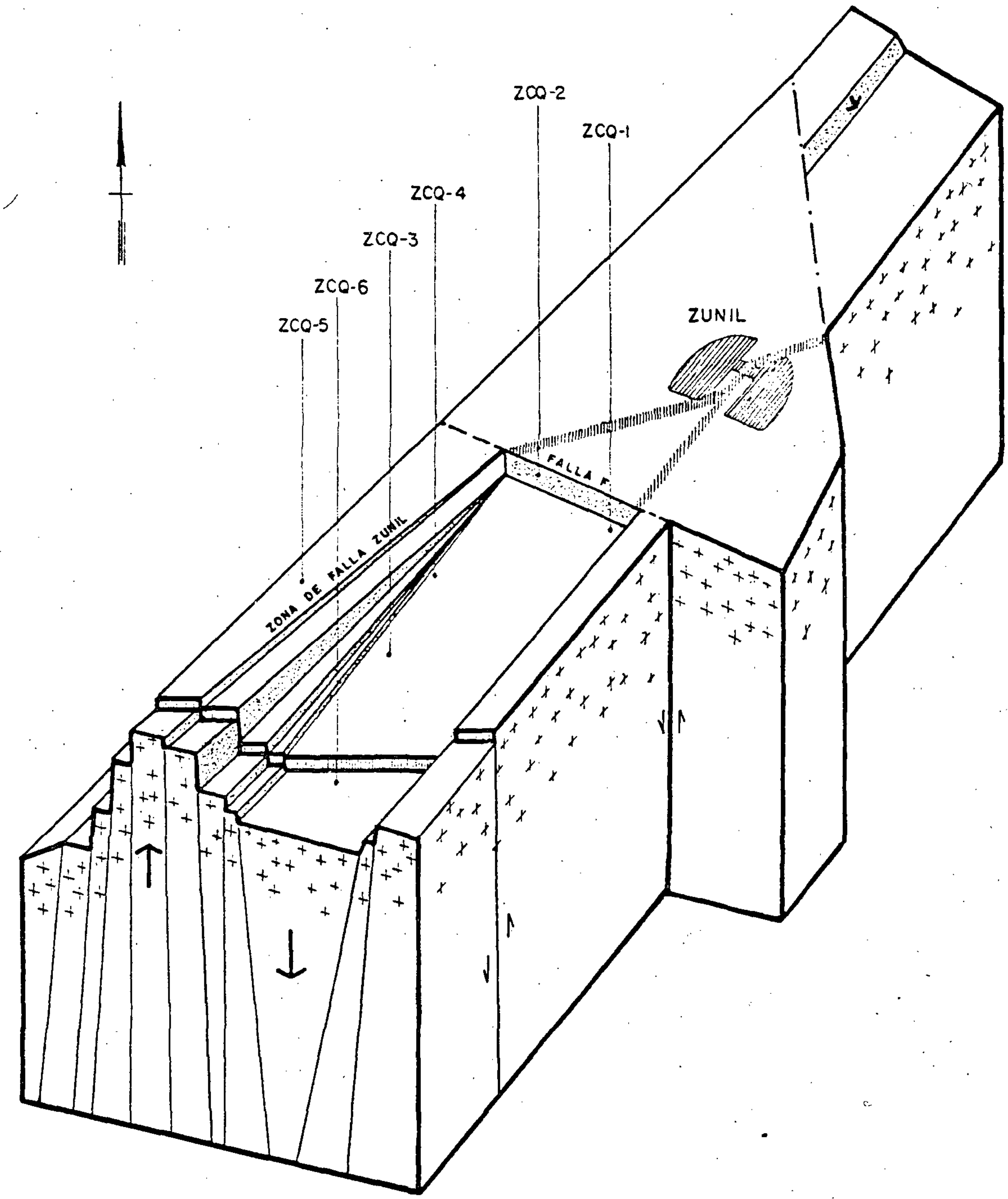
PREPARADO POR: ING. U. CORDON CYM/MKF

INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

MODELO CONCEPTUAL DEL BASAMENTO BASADO EN ANALISIS GRAVIMETRICO

CyM/MKF. FIGURA: 3.3-11



PREPARADO POR: ING. U. CORDON CYM/MKF

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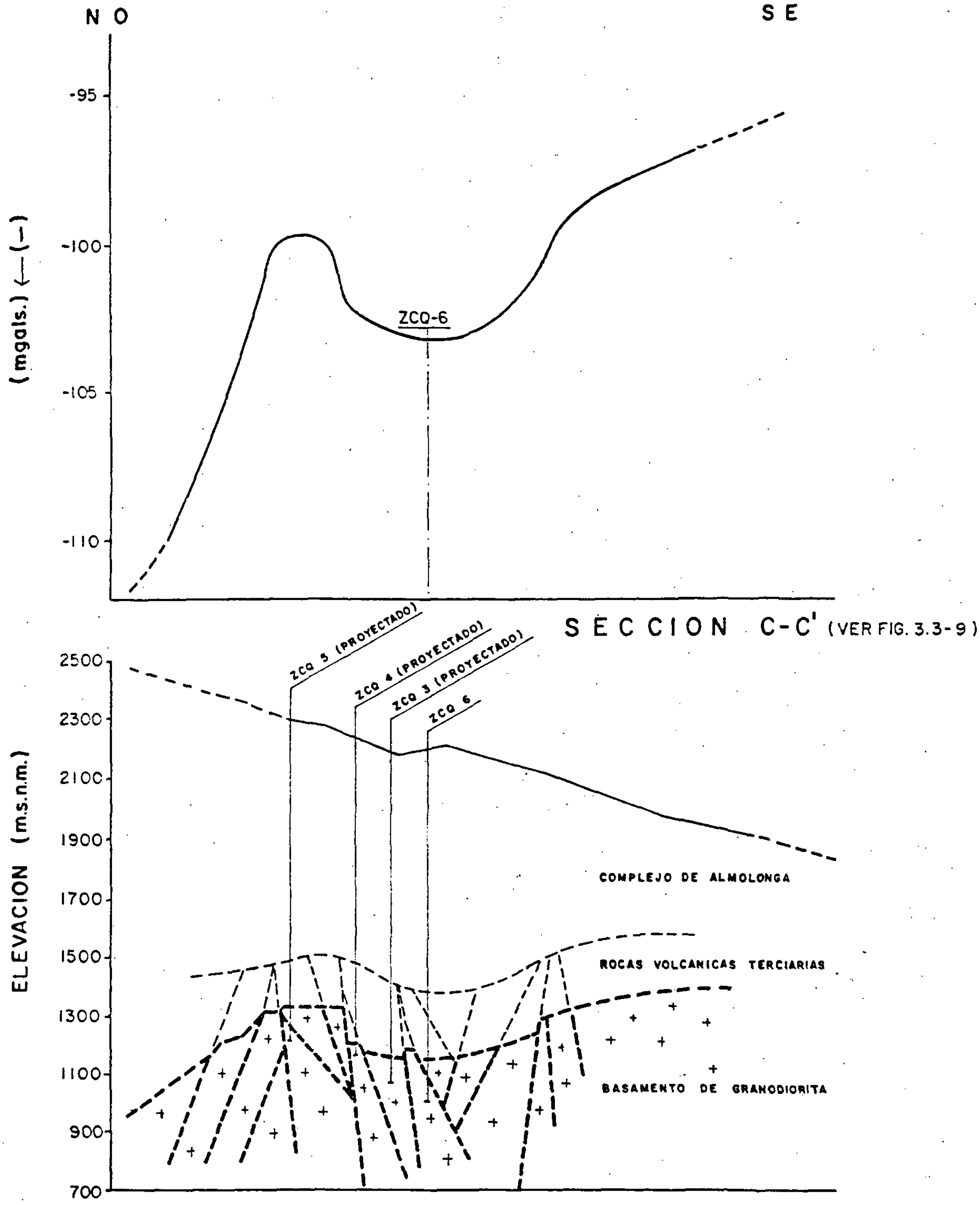

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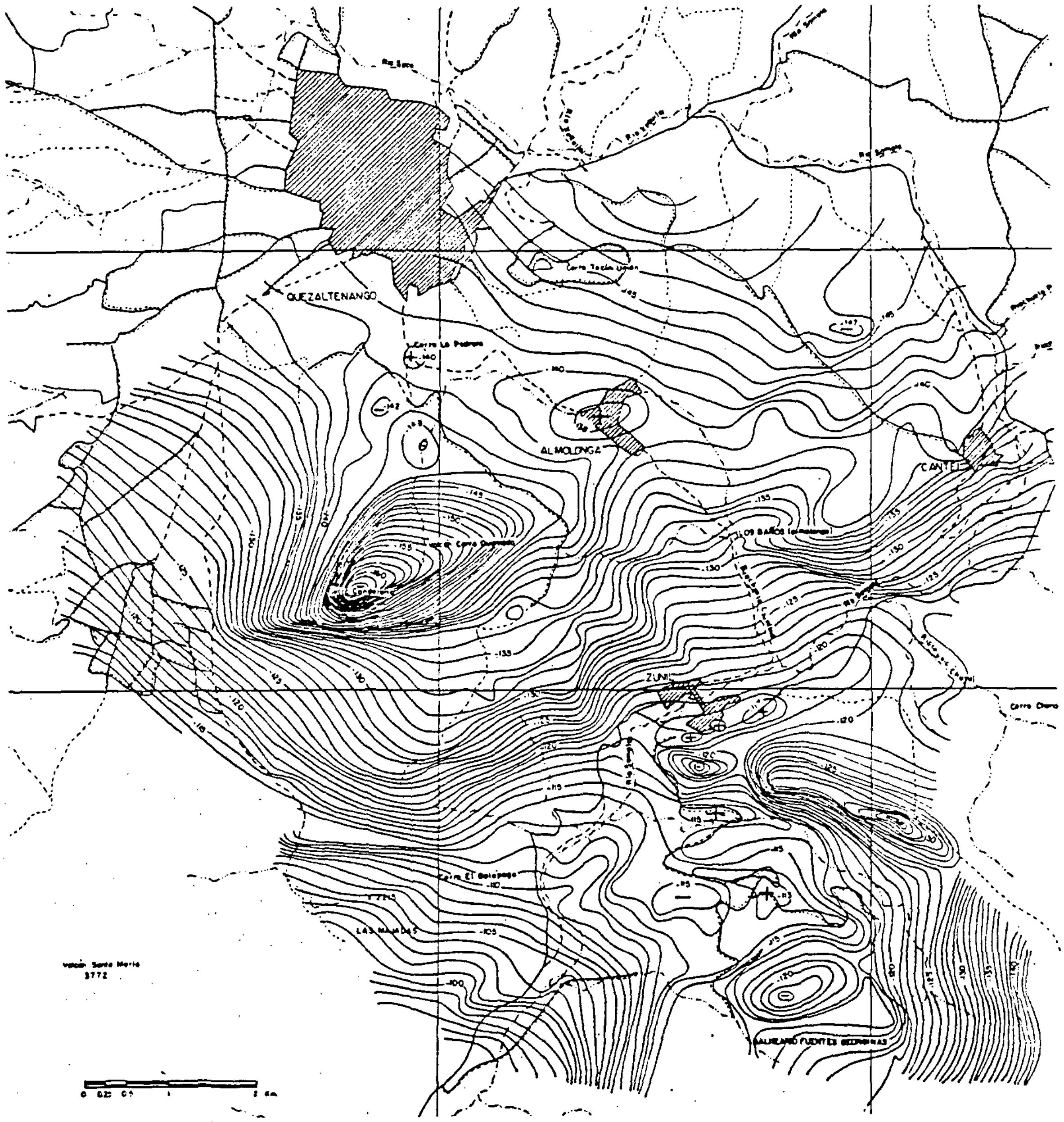


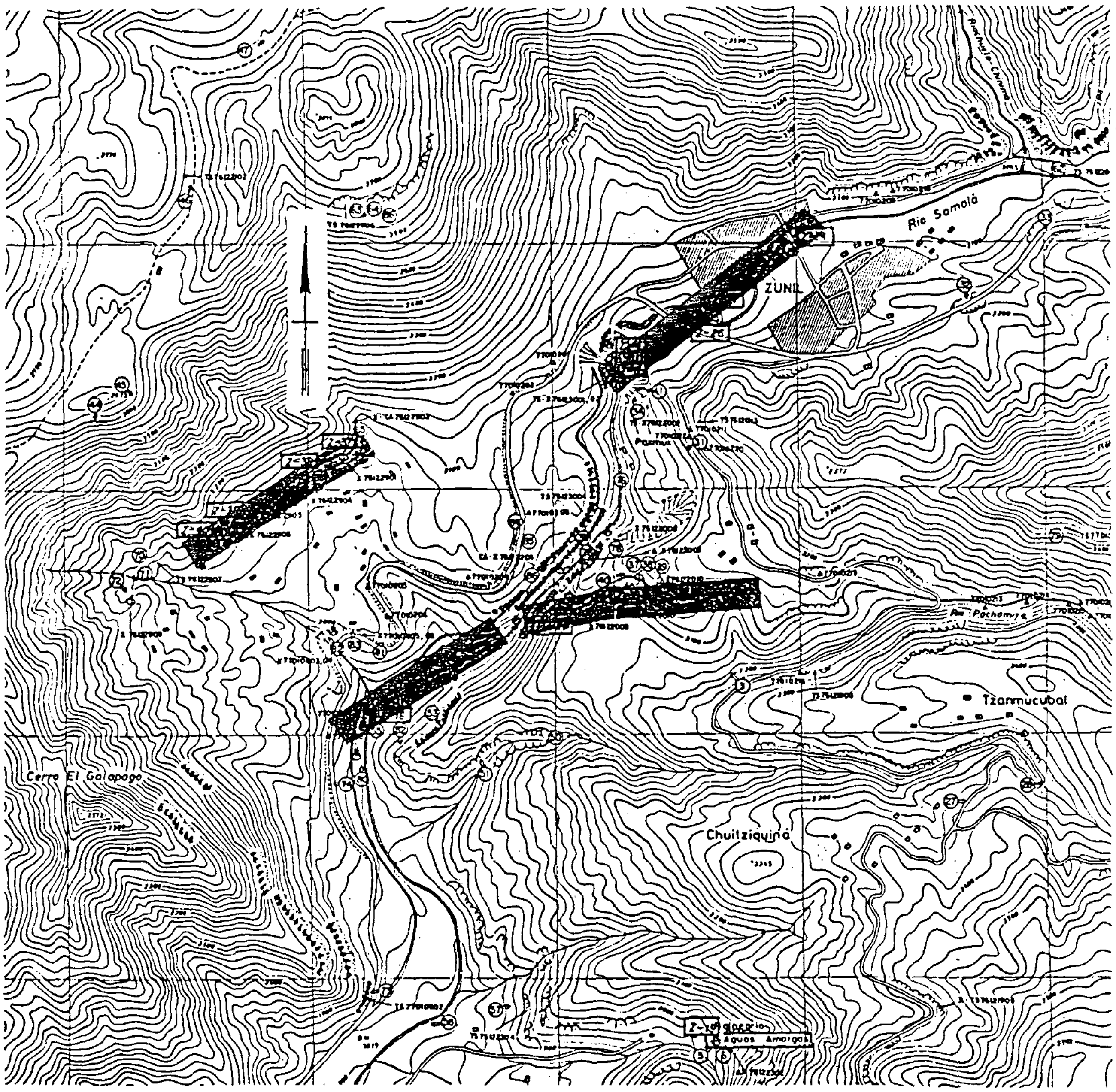
INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

MAPA REGIONAL DE ANOMALIAS BOUGUER

INFORMACION BASE: PLANO INDE POR ING. J. PALMA

CyM/MKF. FIGURA: 3.3-8



0 0.5 1 Km

ESCALA GRAFICA

MANIFESTACIONES TERMALES ASOCIADAS A FALLAS PROBABLES.

NOTA:

MAPA BASE: LOCALIZACION DE MANANTIALES DEL AREA DE ZUNIL, INDE 1977.

INSTITUTO NACIONAL DE ELECTRIFICACION
INDE GUATEMALA C.A.

PROYECTO GEOTERMICO ZUNIL I

ALINEACION DE MANIFESTACIONES TERMALES

CyM/MKF.

FIGURA: 3.2-1

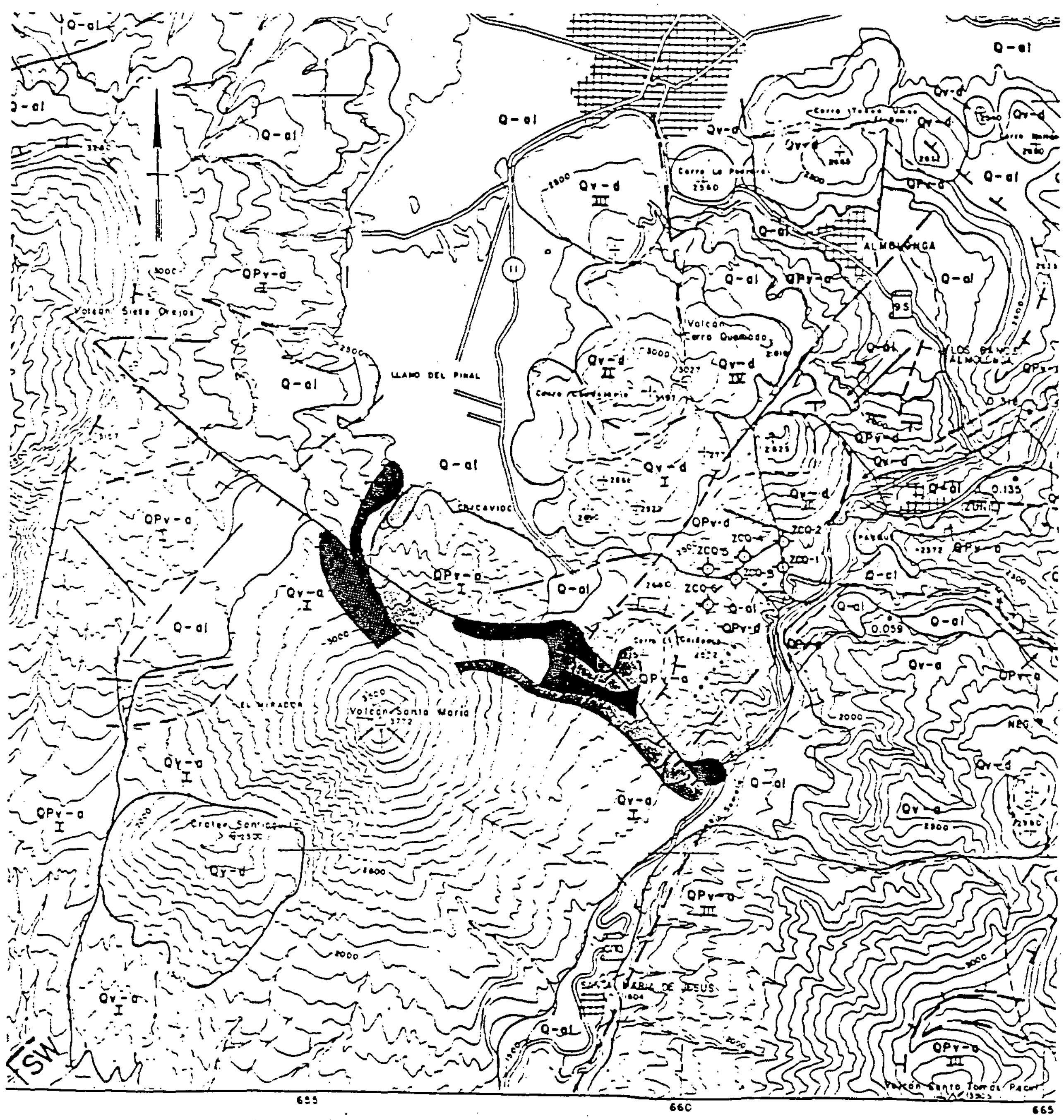


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FIGURA: 3.1-2