102001

THE EVALUATION OF MAGNETIC ANOMALIES

OVER ANOMALOUS SEISMIC REFLECTORS

IN A PORTION OF THE GIPPSLAND BASIN,

OFFSHORE SOUTHEASTERN AUSTRALIA

FOR

UNION TEXAS PETROLEUM

March 1984

Submitted by

AERO SERVICE DIVISION

WESTERN GEOPHYSICAL COMPANY OF AMERICA

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INTRODUCTION

The following is a procedural and results summary on the integration of marine magnetic data and seismic data by means of 2-1/2-D forward modeling to evaluate suspect seismic anomalies interpreted from four marine seismic profiles (83P-26, 83A-49, 83P-20A, 83P-17) in the Gippsland Basin, offshore southeastern Australia. The primary objective of the magnetic/seismic correlations was to determine whether strong intrasectional reflectors could be related to the presence of magnetic igneous or volcanic rocks as opposed to relatively non-magnetic carbonates, clastic wedges, or reef structures.

INPUT DATA

All data to be evaluated were supplied to Aero Service Division by Union Texas Petroleum. Both seismic and magnetic data had been collected and processed by Geophysical Service Inc. in March-April of 1983. This report shall be limited to applications made with the magnetic total intensity data. Table I summarizes the important magnetic survey specifications.

TABLE I

DATA ACQUISITION:	G.S.I.
DATE:	MARCH-APRIL 1983
MAGNETOMETER:	GEOMETRICS G803 PROTON PRECESSION MAGNETOMETER RECORDING TO 0.1 GAMMA
AQUISITION:	TO 9-TRACK MAGNETIC TAPE AND MULTI-CHANNEL ANALOG RECORDS
NAVIGATION:	ARGO SYSTEM, CDP POSITIONS
COORDINATION:	UTM COORDINATES, AUSTRALIAN NATIONAL SPHEROID, CENTRAL MERIDIAN OF 147 DEG EAST
LINE SPACING:	VARIABLE
LINE DIRECTION:	NE-SW AND NW-SE
DATA PROCESSING:	TESLA-10 PTY LTD
JOB NUMBER:	TA1044
GRID MESH:	1500 X 1500 METERS
IGRF REMOVED:	1975 MODEL
DATUM ADDED:	2000 GAMMAS

TABLE I (CONTINUED)

CONTOUR INTERVAL: 10 GAMMAS

SCALE: 1:100,000

TRACKLINE DATA
  EXCLUDED FROM MAP: 83P-04A   83P-15A   83A-57   83A-59
                           83A-63   83A-73   83A-75   83A-85
                           83A-89   83A-4A   83A-5   83A-08
                           83A-14   83A-14A   83A-20   83A-22
                           83A-30

Data quality was a point of concern during the course of the project and
caution had to be exercised in the evaluation of many of the small
anomalies. The following exerps from the ECL Australian Pty., Ltd. processing
report will serve to highlight problems that exist in the magnetic data:

"The processing has been complicated by problems due to significant
misties (ranging up to 55 NT in one case). The exact cause of the
misties is not apparent; however, they could be related to either
of the three factors below:

1) Acquisition Errors - The Q.C. Report documents two problems
   with the magnetometer: a)   the original fish had to be
   replaced due to leakage through a ruptured diaphragm; b) the
   watertight plug at the reel had to be replaced.

2) Inadequate Diurnal Control - Diurnal variations are never
   constant from place to place and major changes often occur at
   the coastline. The diurnal variations recorded several hundred
   kilometers from the survey may not be relevant.

3) Magnetic Storm Activity."

"Due to the inevitable distortion of anomalies on the map
introduced by smoothing out the misties, it is recommended that
profiles should be generated for each line (with no levelling) if
any quantitative interpretation is planned."

"A display incorporating tie-line levelling was generated but the
results indicated that by forcing the intersections to tie and
distributing the discrepancies 'new anomalies' were being
introduced that were not apparent on individual profile lines. At
this stage it was decided that the mistie problem could be improved
by application of diurnal corrections.   No adjacent base
magnetometer readings were available for this survey so the best

attempt at obtaining diurnal control was made. Daily analogue records were obtained (after considerable delay) from the Bureau of Mineral Resources (BMR, Canberra) showing readings taken from a station at Toolangi, Victoria (several hundred kilometers from the survey area). These records were digitized and corrections applied to the data accordingly.

In the western and southern parts and parts of the northeast, the diurnal corrections improved the intersection ties and more consistent results were obtained. However, in parts of the eastern area the diurnal corrections actually exacerbated the problem. A more detailed analysis of the misties was needed and data from both NW-SE and NE-SW sets were examined and analyzed. A histogram showing distribution of the misties is presented (see Figure 1 this report). Misties of up to 15 NT were rated acceptable (assuring a 10 + 10 = 14 NT. Fifty-five percent of the intersections were acceptable. The remaining forty-five percent were examined critically."
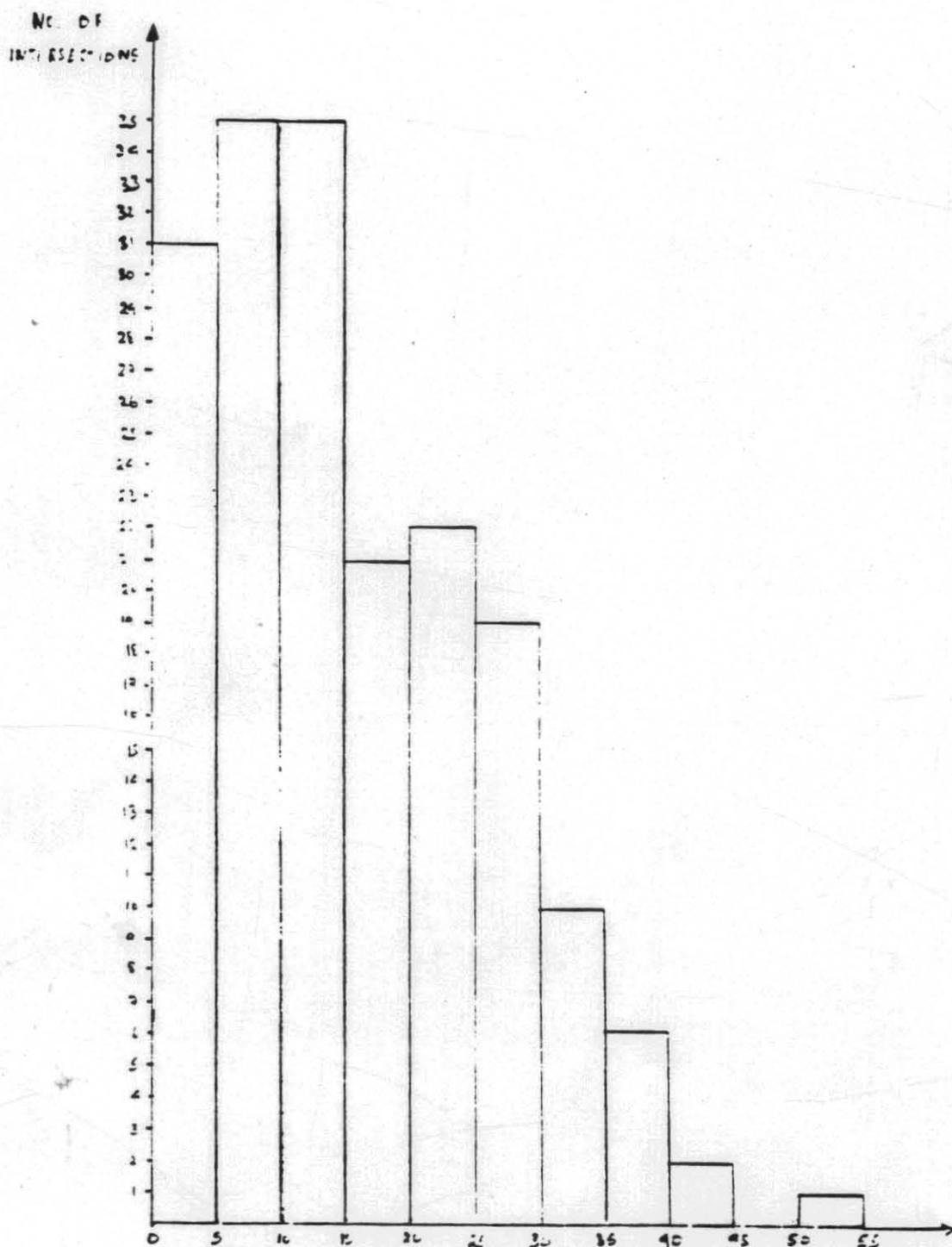
MAGNITUDE OF MISTIE
IN GAMMAS

5 cm

One should note that the anomalies of interest as determined by the 2-1/2-D forward modeling (discussed in the next section) were generally on the order of 5 gammas or less, and that from the information contained in Figure 1, only about seventeen percent (31 out of 182) of the trackline intersections fell within that limit. Eighty-three percent of all other intersections showed a greater error due presumably to acquisition or processing errors. Whereas the input data are considered to be of questionable quality; the results of the modeling should be viewed accordingly.

MODELING PROCEDURE

Magnetic data along the four seismic tracklines were digitized from the 10 gamma total intensity contour map at 1:100,000 scale. It was determined that an interval of 2000 map-feet was sufficient to capture the smallest significant anomaly along those traverses. Between plotted isogams, linear interpolation was applied in order to approximate smooth anomaly profiles.

The interpreted seismic time sections were digitized at a measured horizontal scale of 1:17,400. Only the prominant reflectors interpreted as being related to either basement or the anomalous superbasement sources were digitized.

The method of data integration incorporated the use of a computer-based 2-1/2-D forward modeling program which utilizes the Talwani modeling algorithm presented in Talwani et. al. (1958), Talwani and Hiertzler (1964), and Talwani (1973). Use of this modeling program allows the interpreter to build a dip-line, schematic, geologic model approximated by elongate polygons of various shapes, sizes and density or magnetic characteristics. A synthetic anomaly curve, which is the sum of the contributions of each separate polygon, can then be generated over the entire model. Visual comparison of the modeled anomaly curve with the observed data allows the interpreter to refine the model parameters appropriately. Upon achieving curve-matching, well constrained models can often be good approximations of geologic cross sections.

In the following examples, an attempt was made to isolate the high frequency anomalies such as would be expected to arise from magnetic sources within the sedimentary section. To remove a major portion of the low frequency signal

- 5 -

and, therefore, presumably the major contribution of basement or other regional components, a second or third order polynomial was calculated along each profile and subtracted to produce a high frequency residual curve. Since no information was put in regarding basement composition, curve-matching of the anomalies generated over the small intrasectional sources was performed with the residual curves.

RESULTS

On Figure 2, the digitized basement surface along with a thin slab-like polygon representing the area beneath the interpreted seismic anomaly, is plotted against a horizontal (x) axis and vertical depth axis which have been incremented in thousands of feet (kilofeet). Curve A is the observed magnetic profile digitized from the contour map. Curve B is a calculated 3rd order polynomial surface which was subsequently subtracted from the observed data. Curve C is the calculated residual anomaly which contains the higher frequency anomalies which might be suspected to arise from within the section.
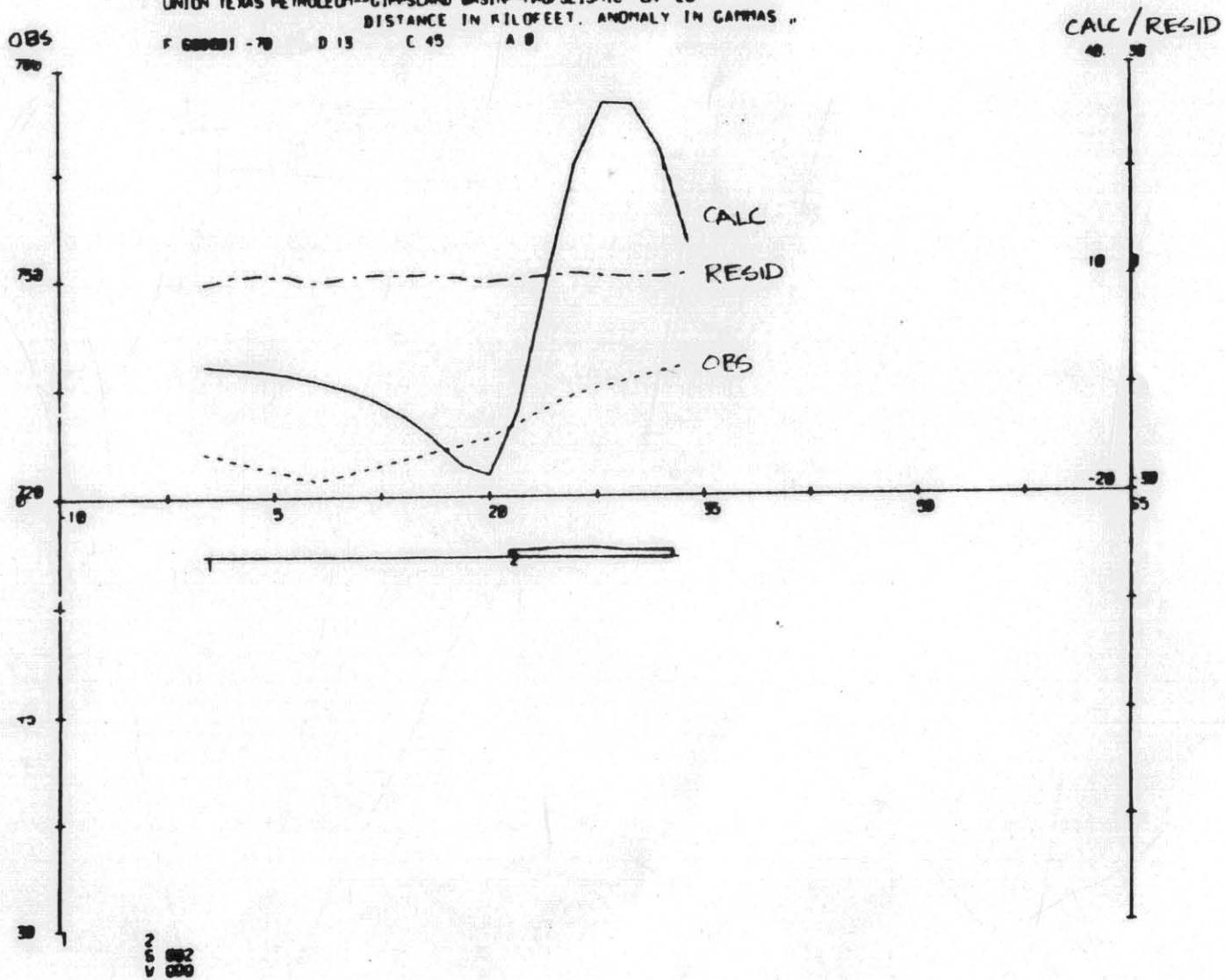
UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAC/SEISMIC--LN 26
DISTANCE IN KILOFEET.

5 cm
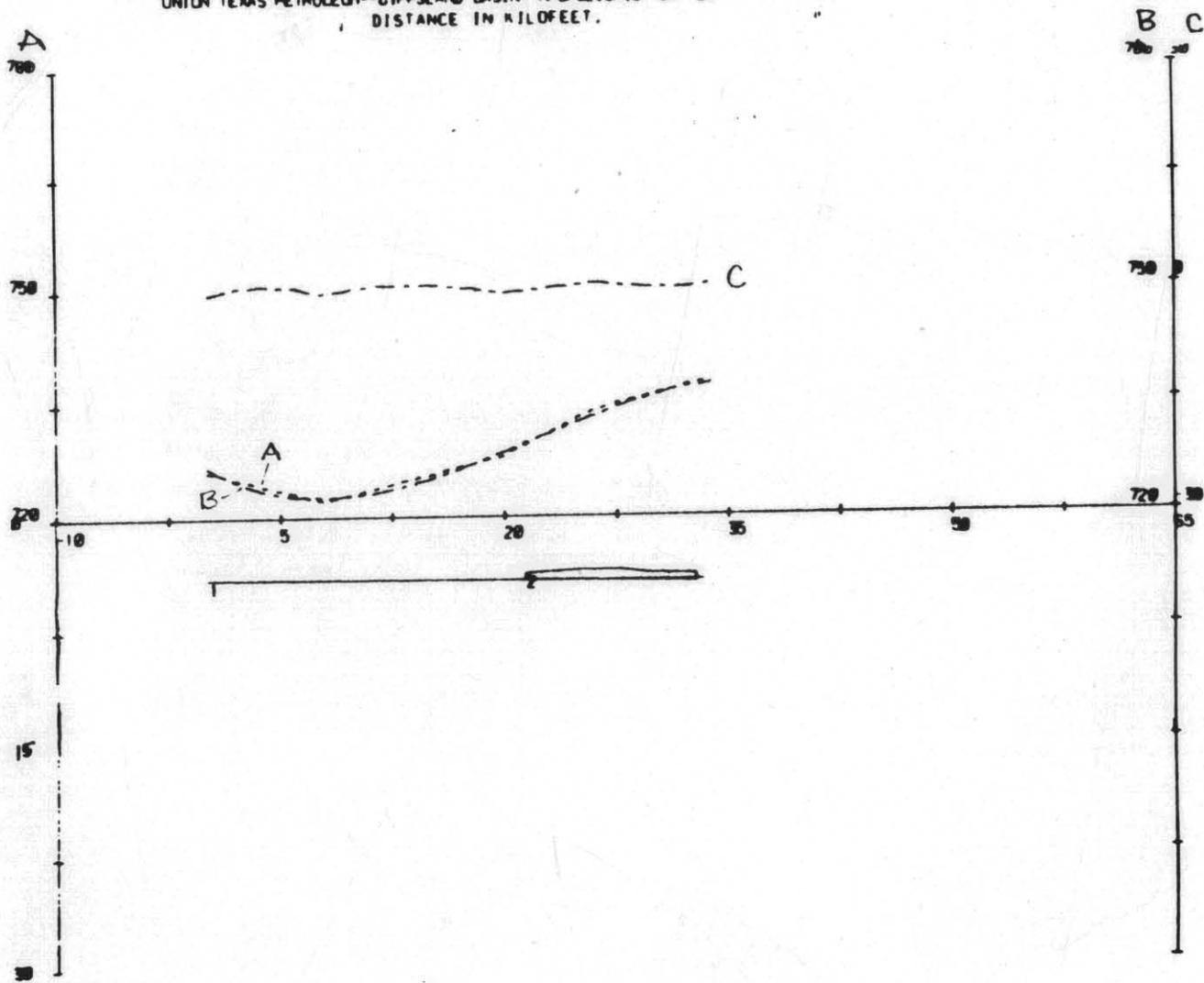
Figures 3, 4, and 5 show comparisons of the synthetic anomaly curve generated by the small polygonal body with the observed and residual magnetic profiles. With magnetic susceptibility contrasts of 2000, 1000, and 100 CGS units assigned to the three figures respectively, the closest match to frequency and amplitude was made with the lowest susceptibility (100 CGS). The results suggest that the interpreted superbasement structure or source is relatively low in magnetic susceptibility and falls well within the range acceptable for a sedimentary source.

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 26
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS ..
F G00001 -70   D 13   C 45   A 0

OBS

CALC/RESID

CALC

RESID

OBS

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 26
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 600001 -70   D 13   C 45   A 0

OBS
700

CALL/RESID
40 50

RESID

CALL

OBS

750

10

0

200
0

-20 -30

10   5   20   35   50   55

15

30

2 S 001
S V 000

102012

5 cm

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 26
DISTANCE IN KILOFEET, ANOMALY IN GAMMAS
F 600001 -70   D 13   C 45   A 0

RESID

CALC

OBS

5 cm
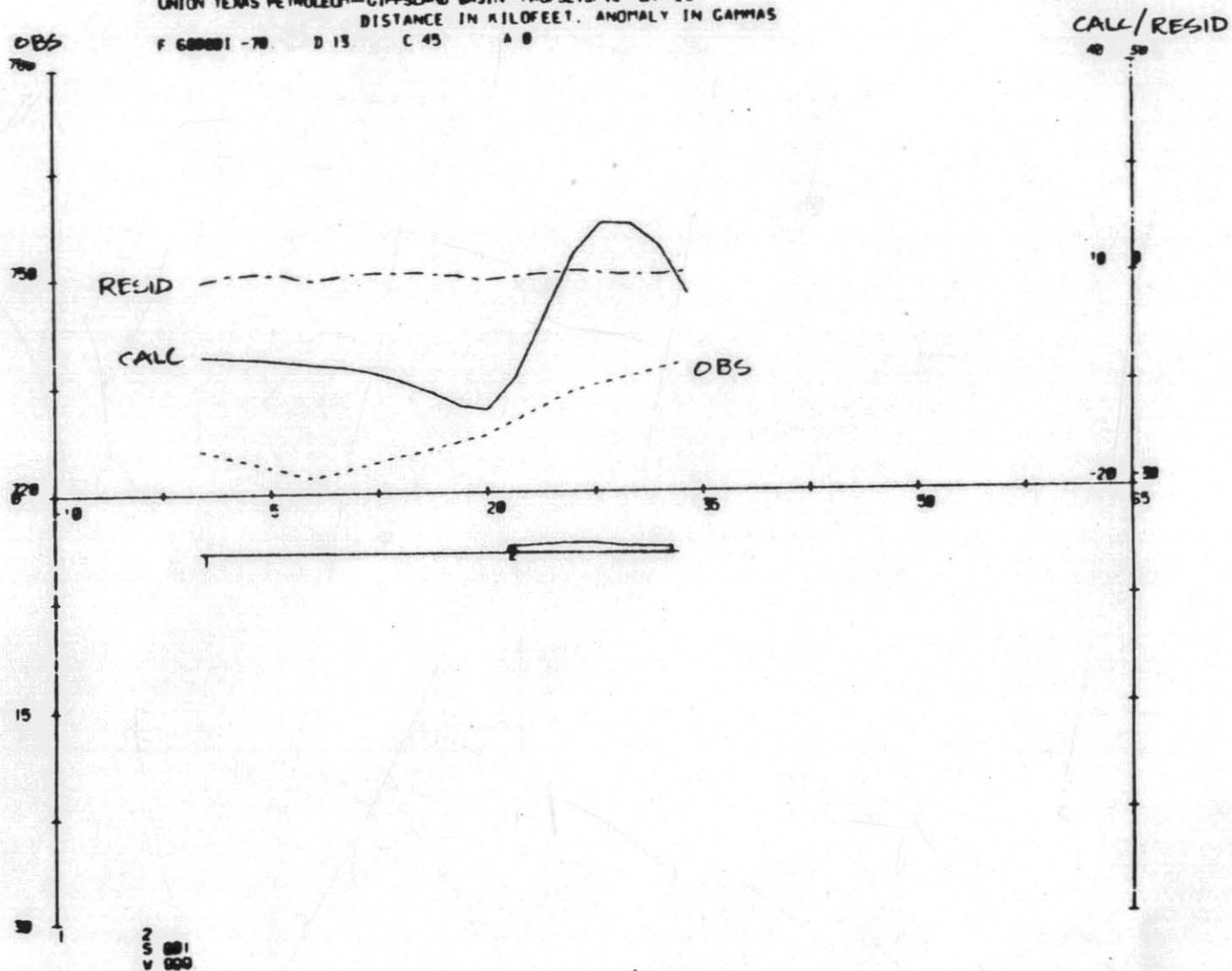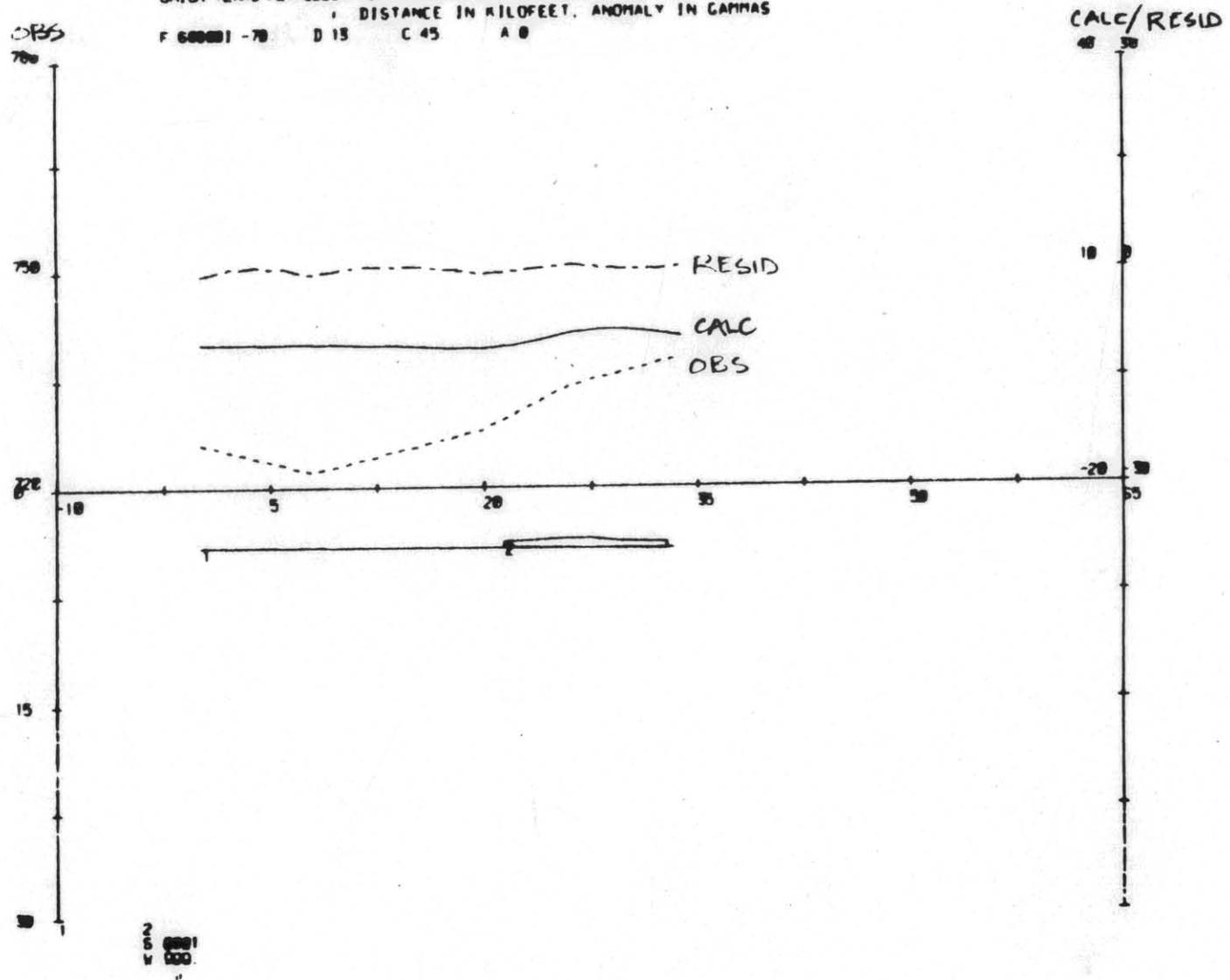
LINE 83A-49

Figure 6 shows the interpreted basement surface and the intrasectional seismic anomaly on line 83-A-49. As in the previous example, Curves A, B and C are the observed magnetic anomaly, the 3rd order polynomial regional, and the calculated residual respectively.
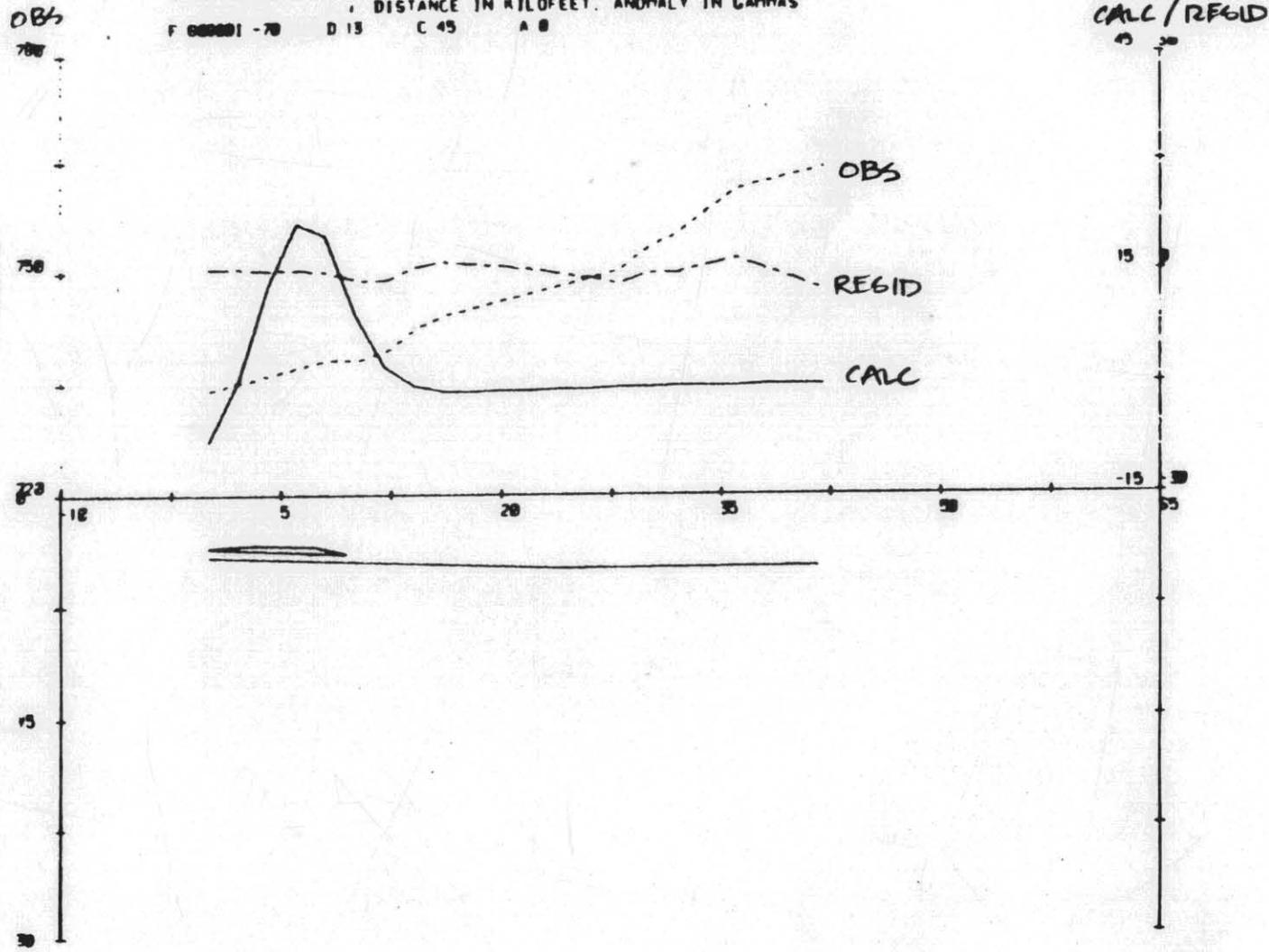
UNION TEXAS PETROLEUM—GIPPSLAND BASIN--MAG/SEISMIC--LN 40
DISTANCE IN KILOFEET

5 cm
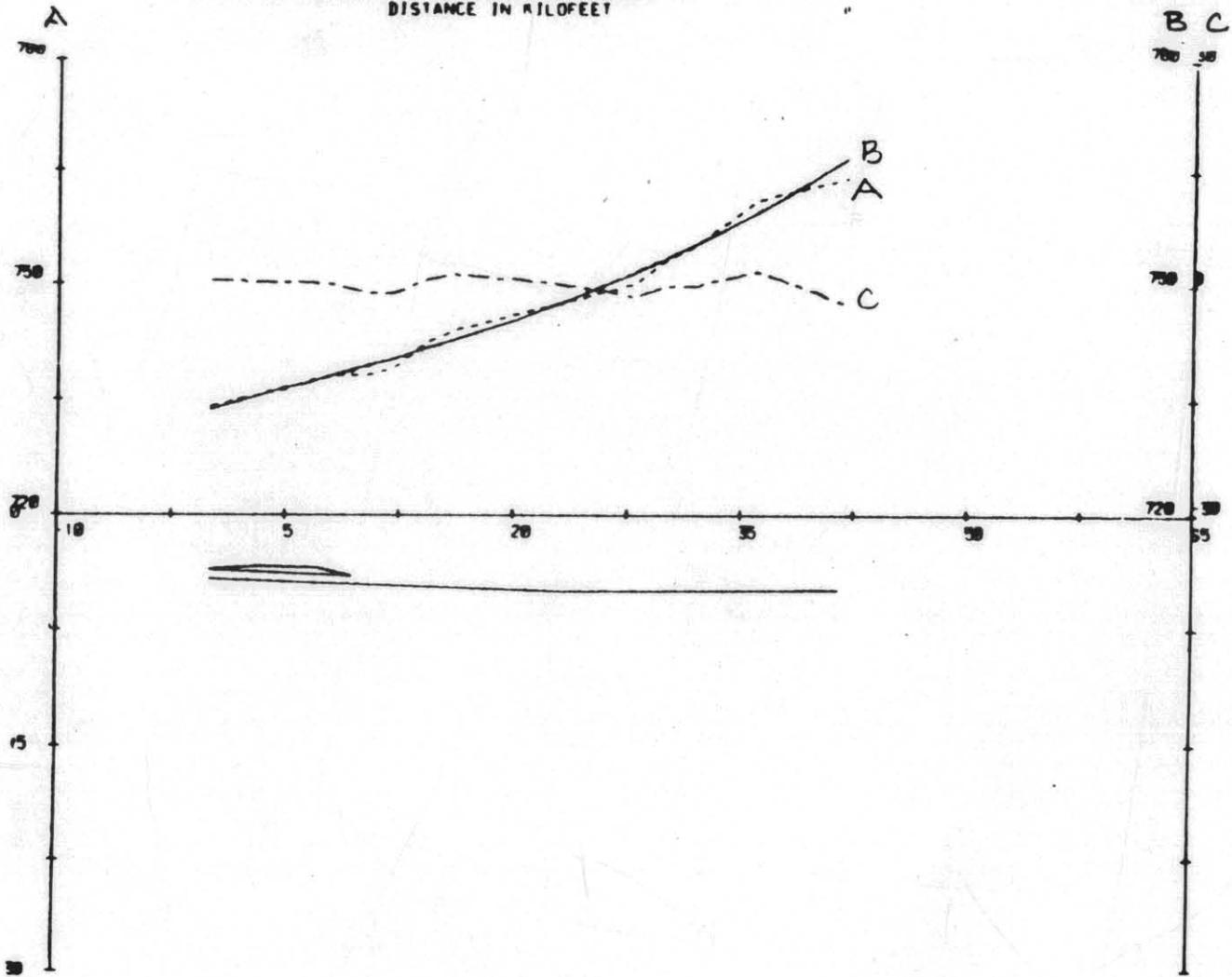
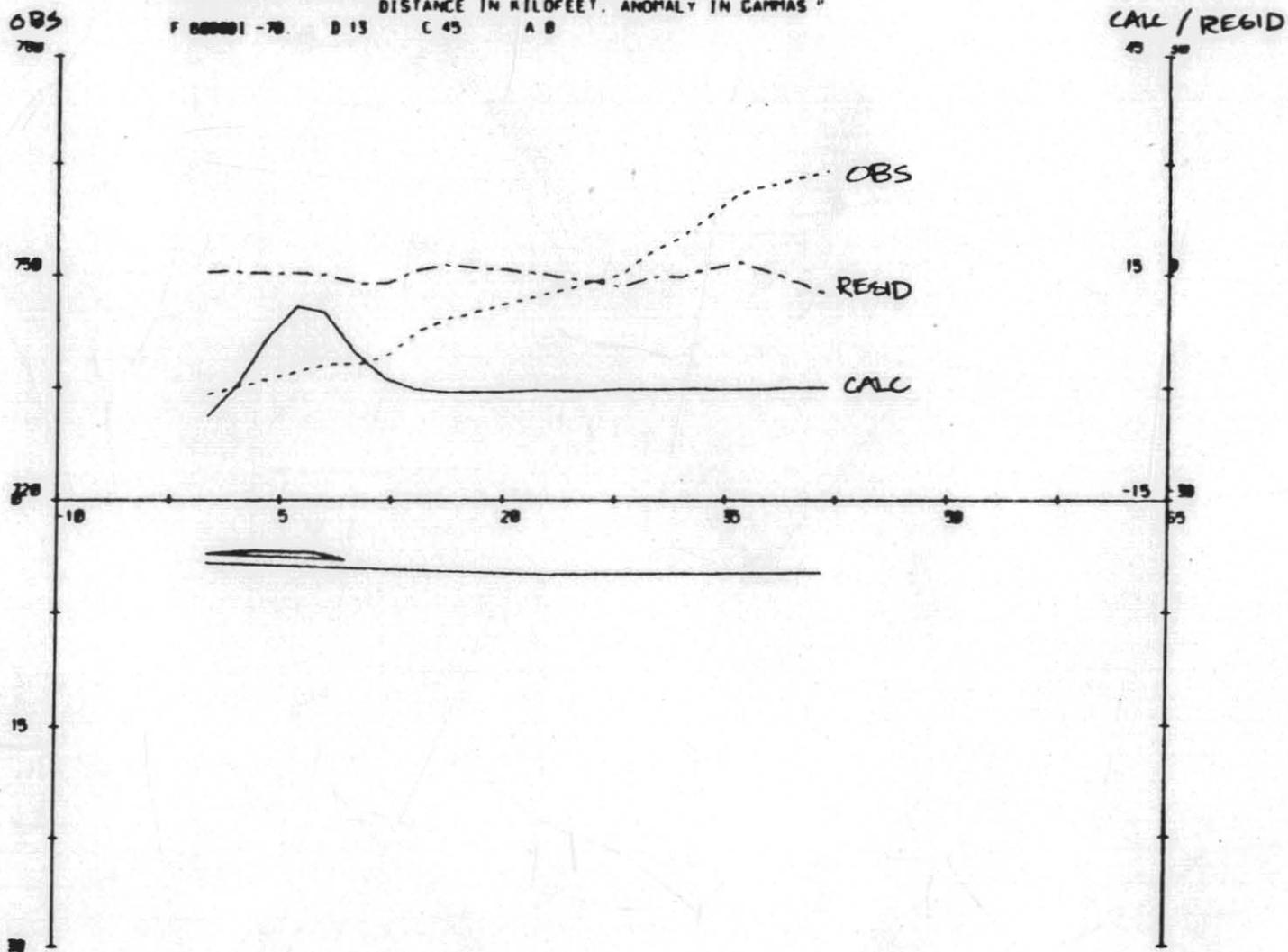Figures 7, 8, 9 and 10 show the anomaly generated by the intrasectional polygon at susceptibilities of 2000, 1000, 500 and 100 CGS units. Similar to the results on Line 26, the closest fit with respect to frequency and amplitude occurs with the 100 CGS factor. Therefore, the anomaly over this source suggests a sedimentary as opposed to a volcanic or igneous origin.

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 40
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 000001 -70   D 13   C 45   A 8
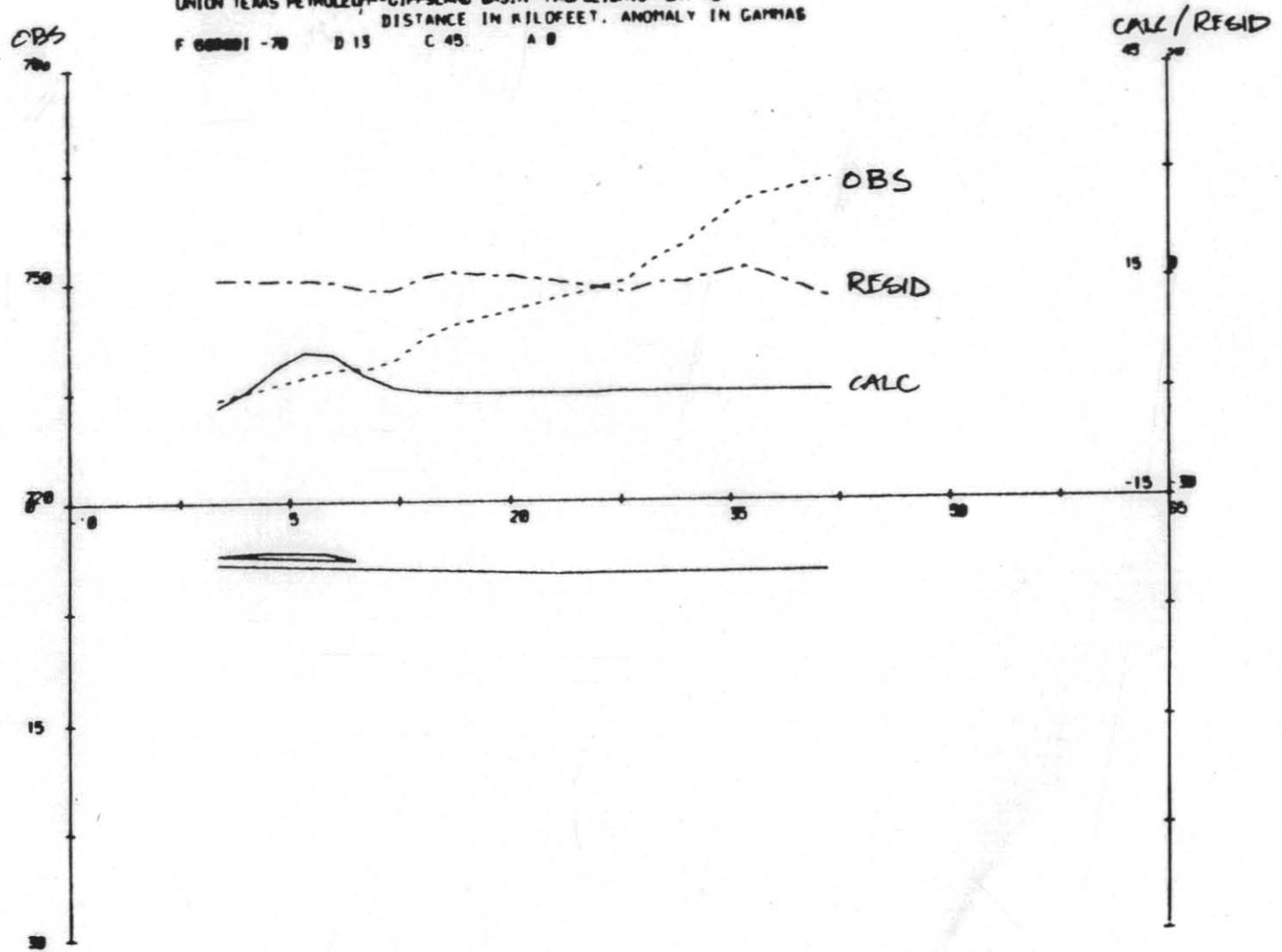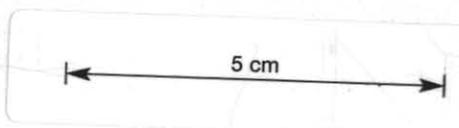
OBS

CALC/REGID

OBS

REGID

CALC

5 cm

UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAG/SEISMIC—LN 40
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 800001 -70.   D 13   C 45   A 0

OBS
700

750

220
0

15

30

CALC / REGID
40   30

15

-15   30

55

OBS

REGID

CALC
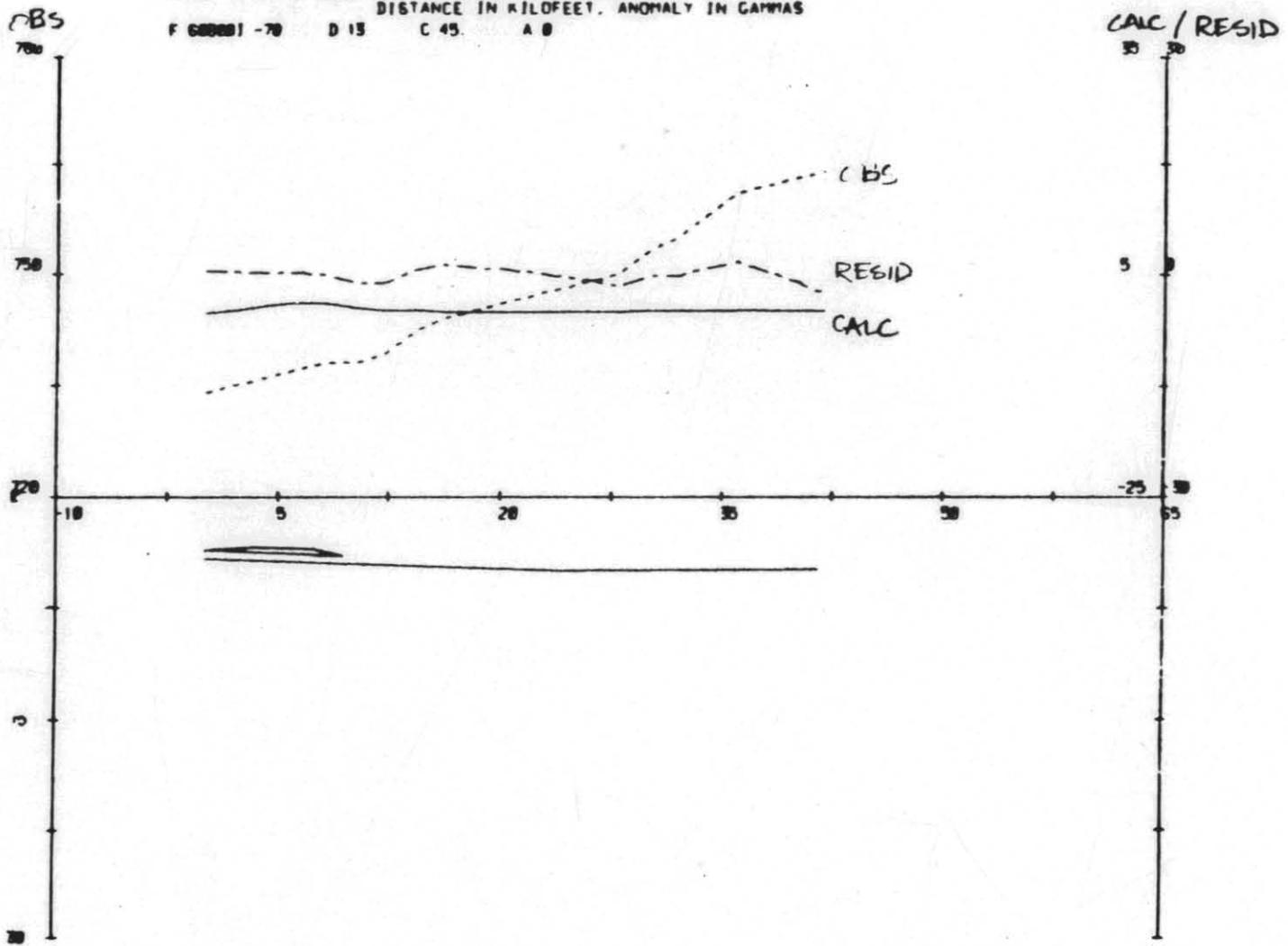
10   5   20   35   50

├──────────── 5 cm ────────────┤

102018

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 40
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 600001 -70   D 15   C 45   A 0

OBS

CALC/REGID

OBS

REGID

CALC

5 cm

UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAG/SEISMIC—LN 40
DISTANCE IN KILOFEET, ANOMALY IN GAMMAS

OBS

F 600001 -70   D 15   C 45.   A 0

CALC / RESID

5 cm

LINE 83P-20A

More difficulty was encountered in the analysis of Line 20A. Figure 11 illustrates the digitized basement surface and intrasectional source plotted along with the observed magnetic anomaly, 3rd order polynomial regional and calculated magnetic profile, Curves A, B, and C respectively.

UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAG/SEISMIC—LN 28A
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 60001 -70. D 15 C 130. A 0
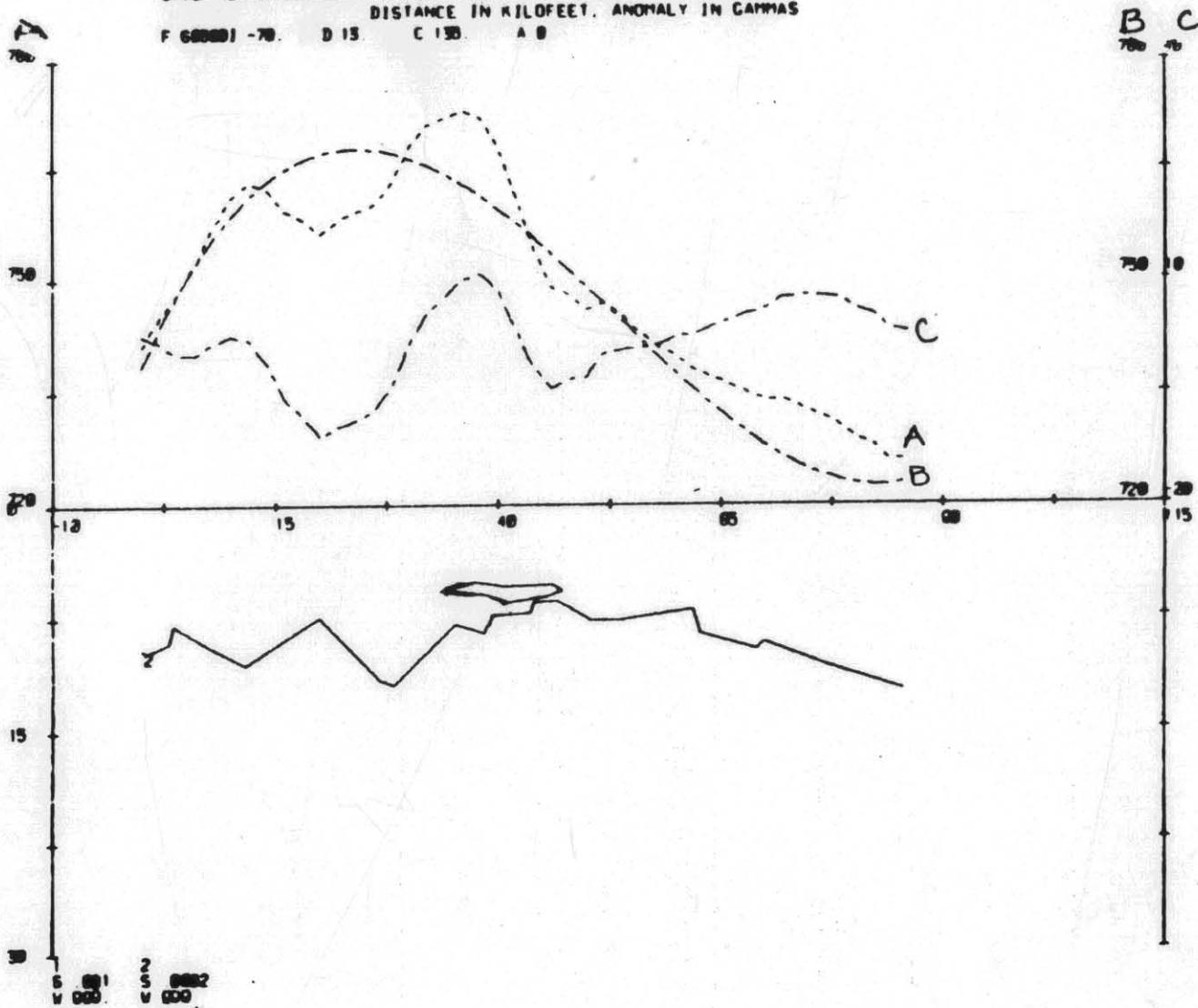
5 cm

After several iterations (not all shown here), it was determined that the large anomaly in the central portion of the line (at I, Figure 12) located directly over the interpreted seismic anomaly could be modeled by utilizing a susceptibility of 800 CGS if the extent of the body was enlarged to the northwest. It is further demonstrated that similar strong reflectors along the discontinuous horizon could account for other magnetic anomalies observed elsewhere on the profile (II and II).

The level shift in the vicinity of anomaly III may be accounted for by the effect of a greater basement contribution along that portion of the line. Not to preclude the alternate possibility of basement source contributions to these anomalies; it is, however, possible to assume that the anomalous seismic reflectors along this line may be related to weak to moderately magnetic volcanic sources such as andesitic or phonolitic flows.

UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAG/SEISMIC—LN 28A
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
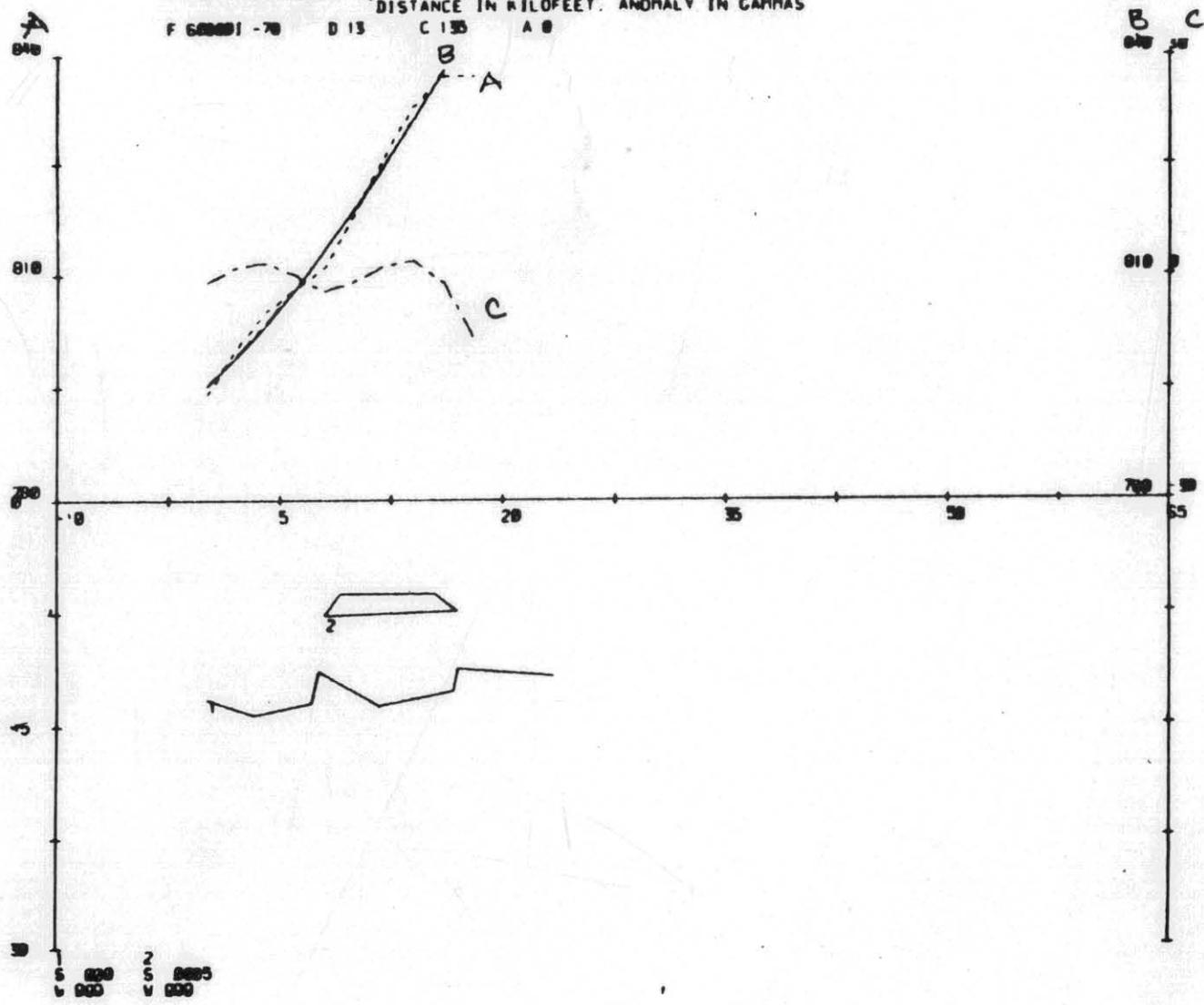F 688891 -78   D 13   C 135   A 0

OBS

CALC/RESID

RESID
CALC
OBS

5 cm
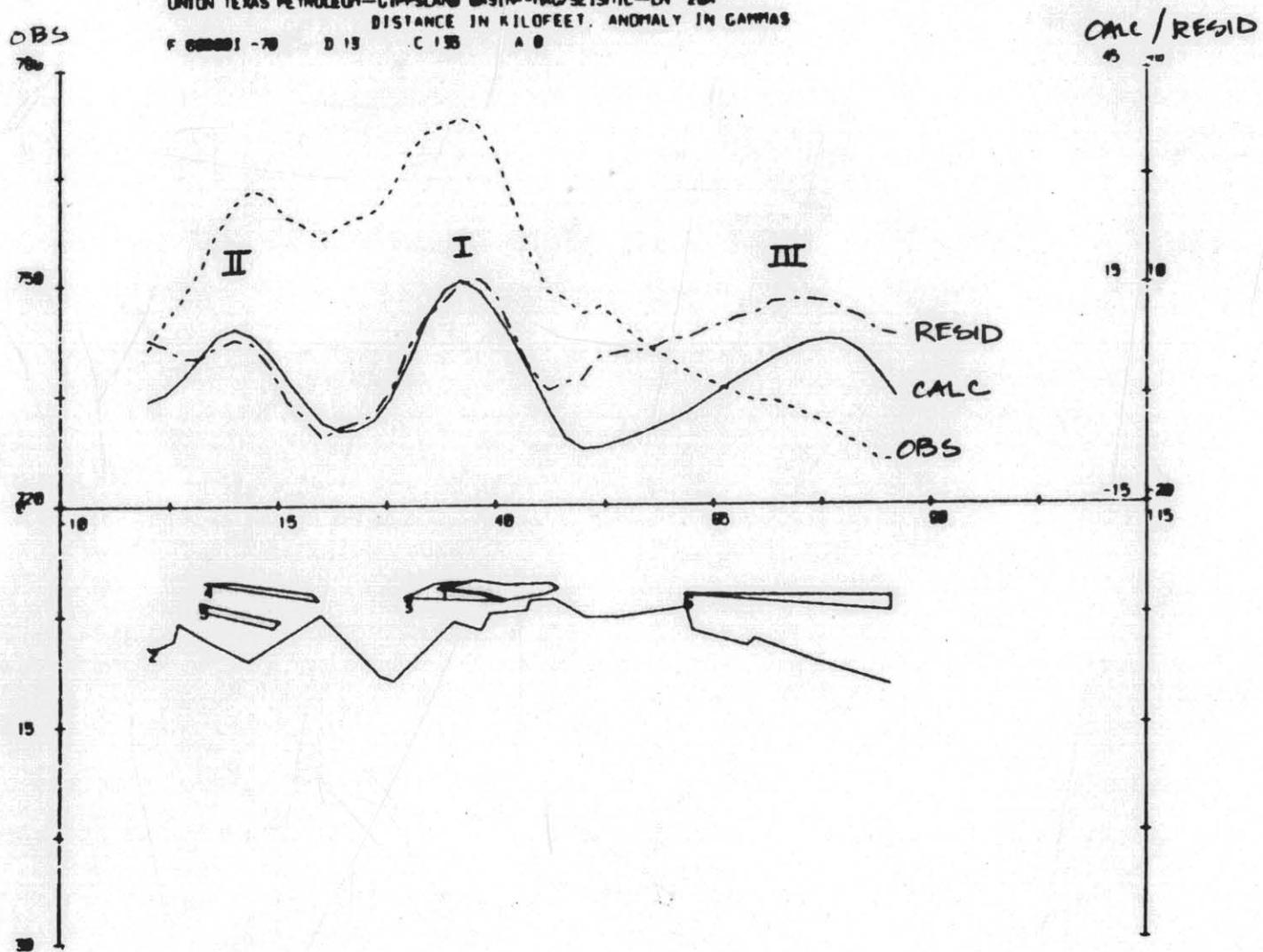
LINE 83P-17

On Figure 13, the digitized basement surface and anomalous intrasectional body are shown with the observed magnetic anomaly (A), the calcuated second order polynomial (B), and the calculated residual (C).
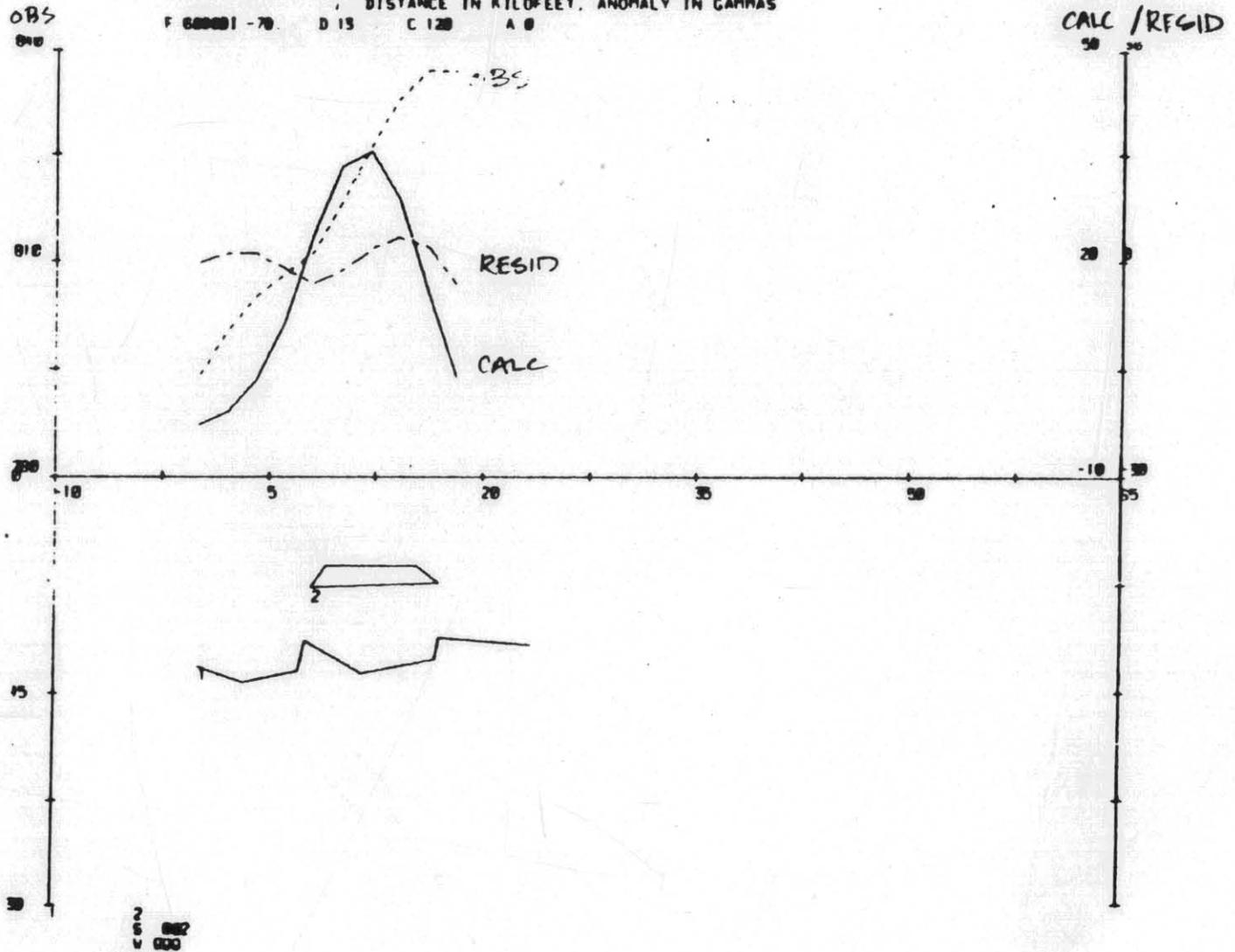
UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 17
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 680001 -70   D 13   C 135   A 0

5 cm

102026

Following the procedure of the previous lines, on Figures 14, 15 and 16, the results of modeling the anomalous polygon with susceptibility contrasts of 2000, 1000, and 500, respectively, are shown.
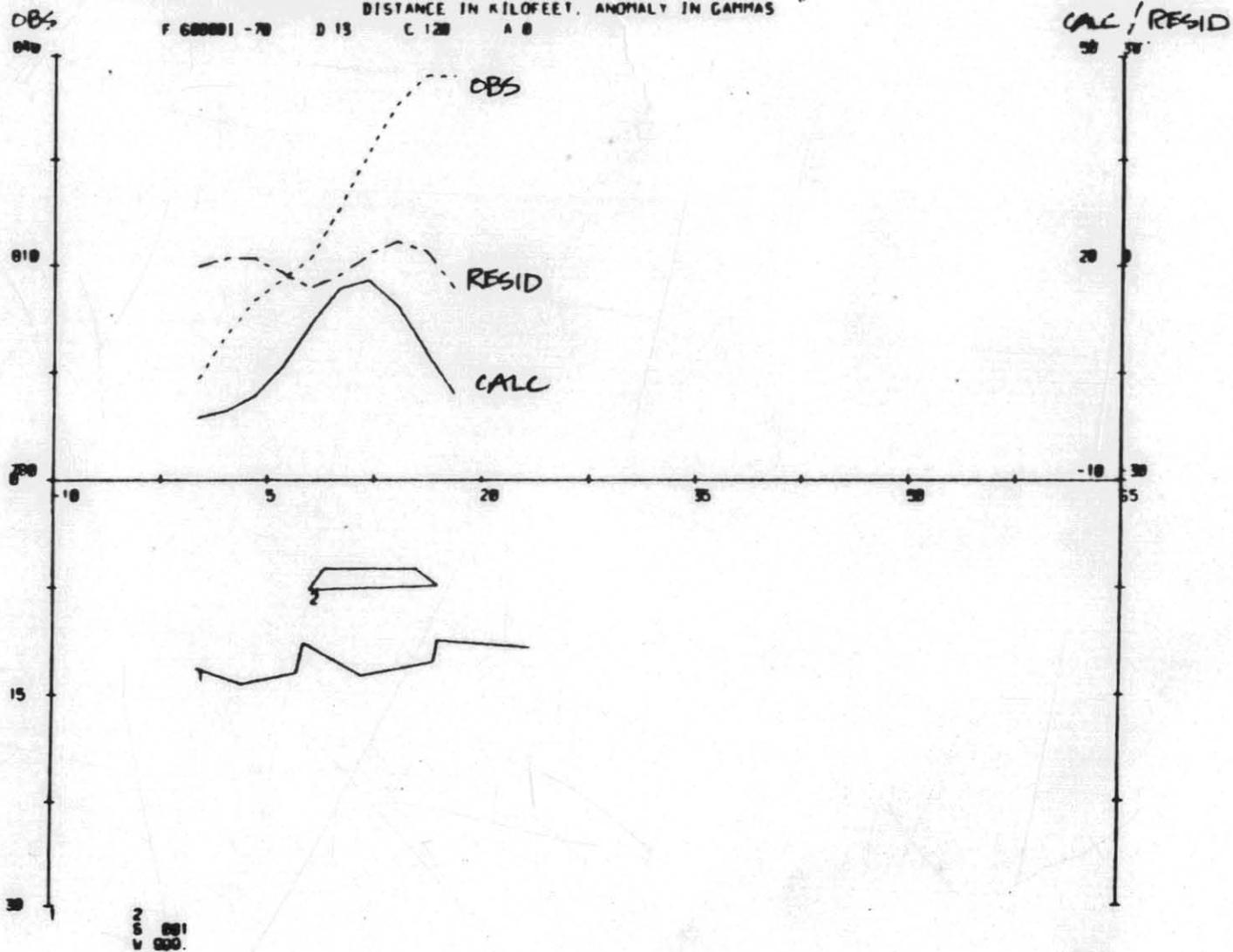
UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAG/SEISMIC—LN. 17
DISTANCE IN KILOFEET, ANOMALY IN GAMMAS
F 600001 -70   D 15   C 120   A 0
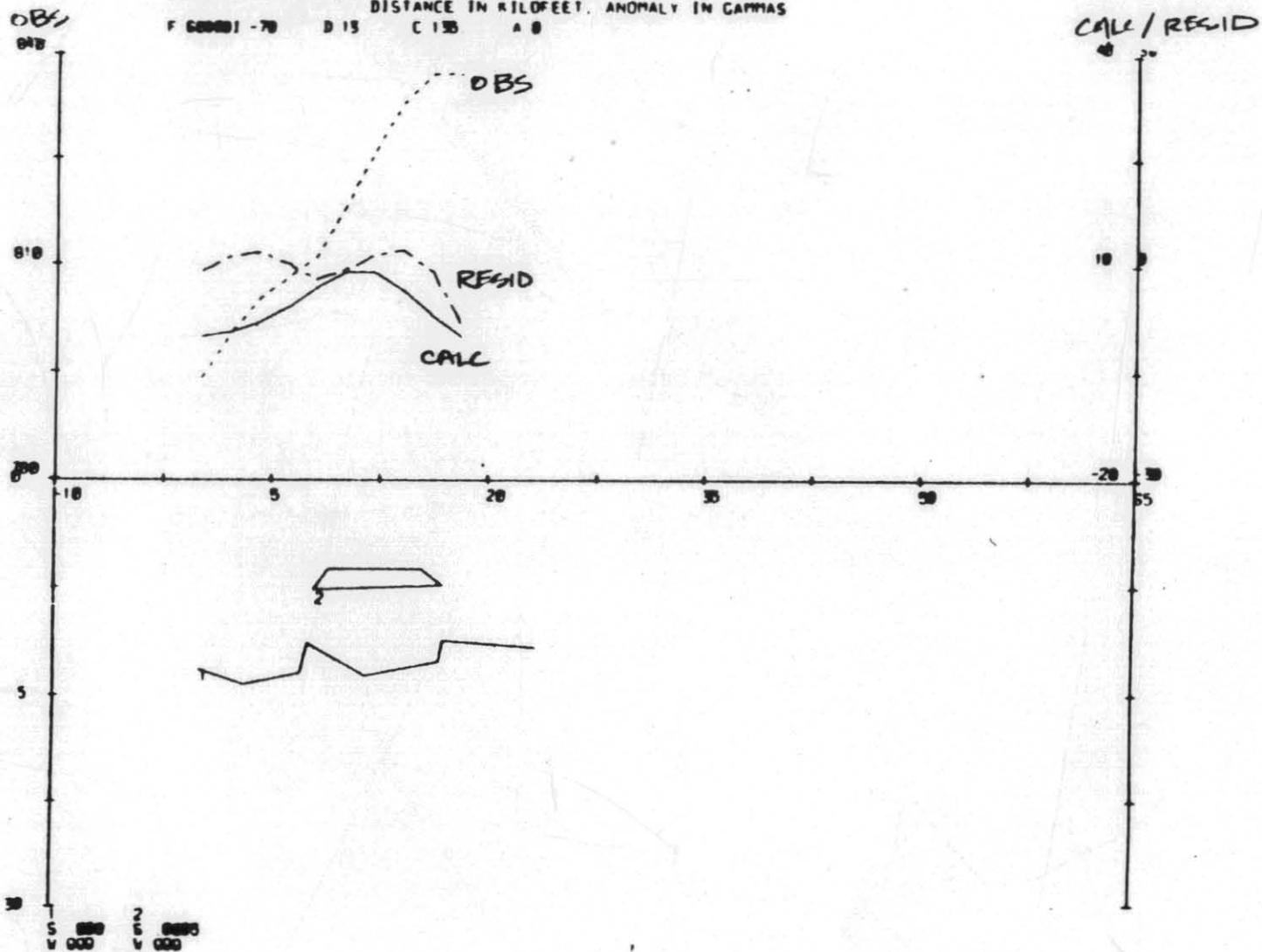
OBS

CALC /RESID

RESID

CALC

OBS

5 cm

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAC/SEISMIC--LN 17
DISTANCE IN KILOFEET, ANOMALY IN GAMMAS
F 600001 -70   D 15   C 120   A 0

OBS

CALC / RESID

OBS

RESID

CALC

5 cm

UNION TEXAS PETROLEUM--GIPPSLAND BASIN--MAG/SEISMIC--LN 17
DISTANCE IN KILOFEET, ANOMALY IN GAMMAS
F 680081-70   D 15   C 155   A 0

OBS

CALC/RESID

OBS

RESID

CALC

5 cm

On Figure 17, an alternate interpretation of the anomalous body is suggested with only the portion of the polygon, labeled 3, having been given any magnetic susceptibility (800 CGS). Such a configuration might be explained by assuming that the magnetic portion of the body is an igneous or volcanic edifice about which a carbonate bank or reef has grown (i.e., the non-magnetic portion).

UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAG/SEISMIC—LN 17
DISTANCE IN KILOFEET. ANOMALY IN GAMMAS
F 60000I -70.   D 13   C 135.   A 0.

OBS.

CALC/RESID

RESID

CALC

E-BS

5 cm
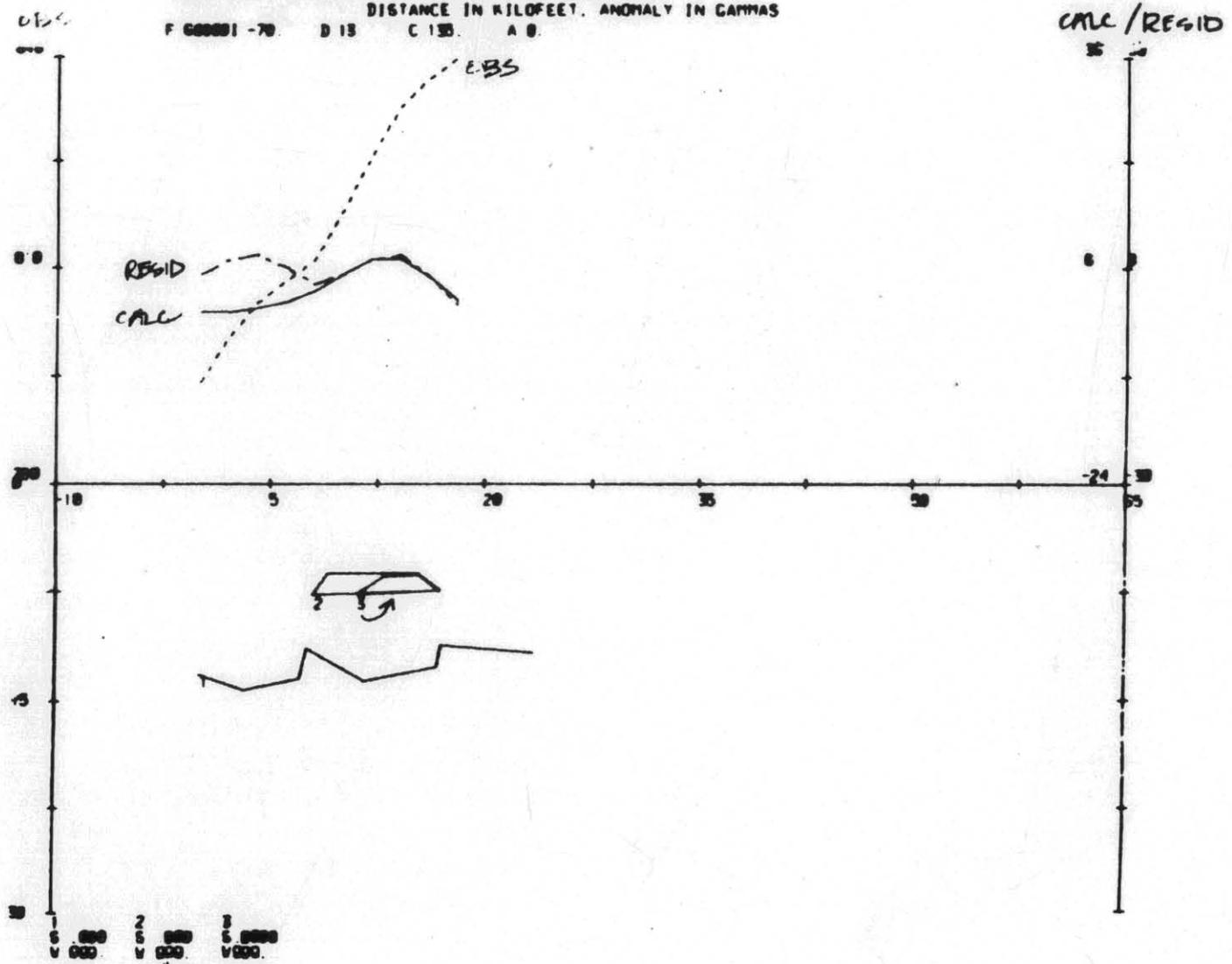
In an attempt to rationalize the existance of the remaining, very similar anomaly on the northwestern end of the line, the possible interpretation suggested for Line 20A was applied. Lines 17 and 20A are parallel and in close proximity to one another. If the suggested magnetic wedge (Figure 12) on the southeastern end of Line 20A continues at approximately the same depth to the south, that same reflective horizon could be, at least in part, magnetic on the northwestern end of Line 17. Figure 18 shows the anomaly generated by placing an additional magnetic source (@ 1200 CGS) along a portion of that horizon. It is therefore possible to also account for these magnetic anomalies by the introduction of weak to moderately magnetic unit (800 $\pm$ 1200 CGS) similar to the case on Line 20A to the immediate north.

UNION TEXAS PETROLEUM—GIPPSLAND BASIN—MAC/SEISMIC—LN 17
DISTANCE IN KILOFEET, ANOMALY IN GAMMAS

5 cm
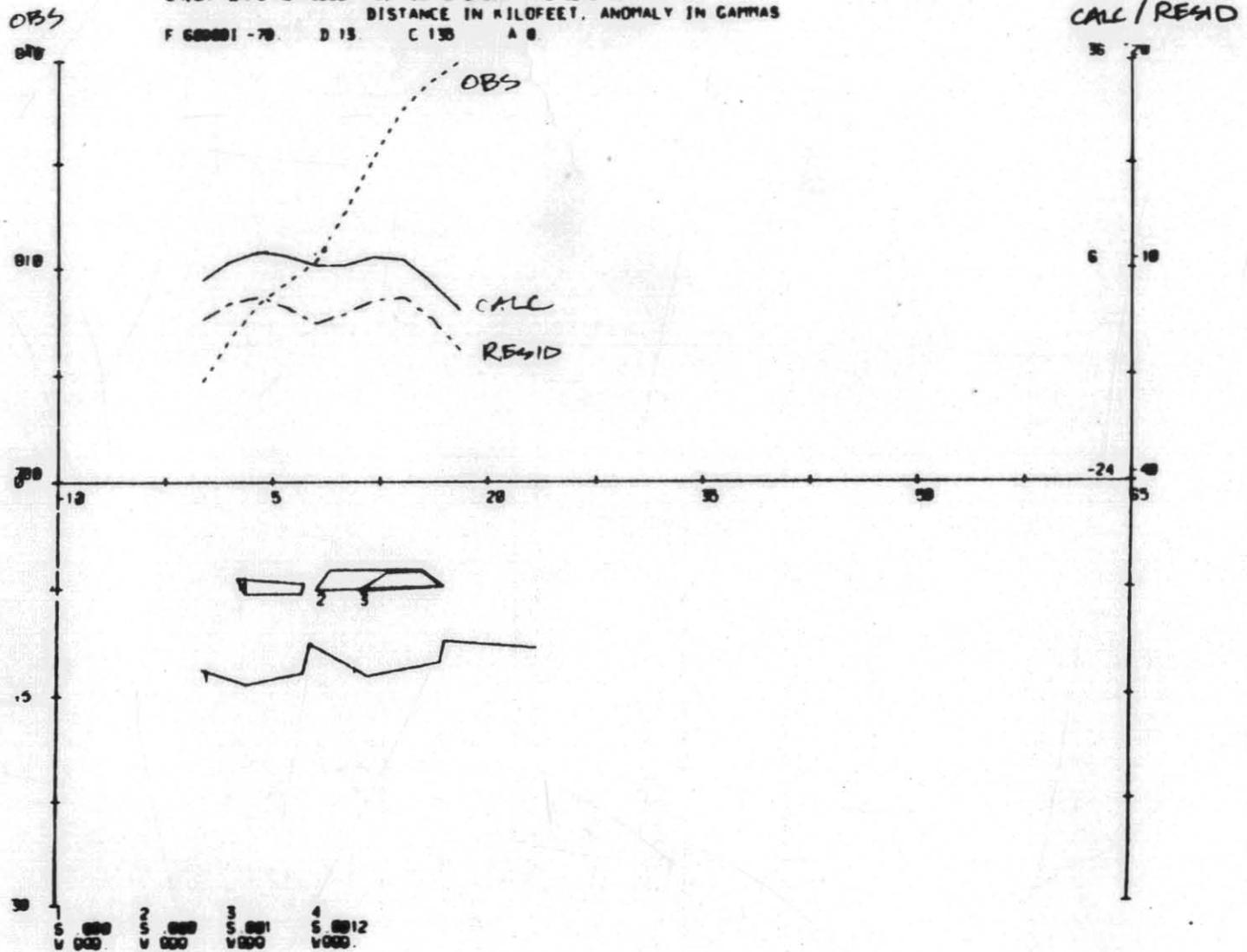
CONCLUSIONS AND RECOMMENDATIONS

Results of modeling marine magnetic profiles along seismic tracklines 83P-26, 83A-49, 83P-20A, and 83P-17 indicate that certain relatively high frequency anomalies ranging from approximately 2 to 5 gammas can be accounted for by assigning various magnetic susceptibilities to bodies previously interpreted as intrasectional or superbasement seismic anomalies.

The 2-1/2-D forward modeling along Lines 26 and 49 suggests that these sources may be of a relatively non-magnetic sedimentary origin. Results of the modeling along Lines 20A and 17, however, indicate that the previously recognized seismic features, as well as other similar reflectors at consistant depths, could possibly be modeled as weakly to moderately magnetic volcanic flows.

Though some consistency seems to exist, in that the more magnetic features are limited to the southern part of the study area, with the non-magnetic features occuring to the north, extreme caution should be exercised in the review of these results. Due to acquisition and reduction problems experienced by the contractor (G.S.I.), as documented in the processing report, it is felt that quantitative interpretation of these data can yield only tenuous results. The above provided modeling results should, therefore, be considered inconclusive. It is recommended that a more tightly constrained and cautiously controlled low altitude aeromagnetic data set be utilized if further investigation is required.

Respectfully submitted by,

J. Gregory Bryan
Geophysicist

Reviewed by,

Glen T. Penfield
Manager of Integrated Interpretation Services
Senior Geophysicist

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