NUREG/CR-0449

AN INTEGRATED GEOPHYSICAL AND GEOLOGICAL STUDY OF THE TECTONIC FRAMEWORK OF THE 38TH PARALLEL LINEAMENT IN THE VICINITY OF ITS INTERSECTION WITH THE EXTENSION OF THE NEW MADRID FAULT ZONE

L.W. Braile W.J. Hinze
G.R. Keller E.K. Lidiak

Purdue University

7812040064

Prepared for

U.S. Nuclear Regulatory Commission

Available from
National Technical Information Service
Springfield, Virginia 22161
Price: Printed Copy $5.25 ; Microfiche $3.00

The price of this document for requesters outside of the North American Continent can be obtained from the National Technical Information Service.

NUREG/CR-0449

AN INTEGRATED GEOPHYSICAL AND GEOLOGICAL STUDY OF THE TECTONIC FRAMEWORK OF THE 38TH PARALLEL LINEAMENT IN THE VICINITY OF ITS INTERSECTION WITH THE EXTENSION OF THE NEW MADRID FAULT ZONE

L.W. Braile and J.H. Hinze*

G.R. Keller
University of Texas - El Paso
E.G. Lidiak
University of Pittsburgh

Manuscript Completed: June 1978
Date Published: September 1978

Purdue University*
Department of Geosciences
West Lafayette, Indiana 47907

Prepared for
Division of Reactor Safety Research
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Under Contract No. AT(49-24)-0323

PREFACE

This report is an annual report of work currently in progress. Interpretations of collected data are necessarily preliminary and are subject to modification as the research program progresses.

This project is a part of the New Madrid Seismotectonic Study, which is coordinated by T.C. Buschbach, Illinois Geological Survey, and is funded in part by the U.S. Nuclear Regulatory Commission.

ABSTRACT

Extensive gravity and aeromagnetic surveys have been conducted in critical areas of Kentucky, Illinois, and Indiana centering around the intersection of the 38th Parallel Lineament and the extension of the New Madrid Fault Zone. Available aeromagnetic maps have been digitized and these data have been processed by a suite of computer programs developed for this purpose. Seismic equipment has been prepared for crustal seismic studies and a 150 km long seismic refraction line has been observed along the Wabash River Valley Fault System. Preliminary basement rock and configuration maps have been prepared based on studies of the samples derived from basement drill holes. Interpretation of these data are only at a preliminary stage, but studies to this date indicate that the 38th Parallel Lineament features extend as far north as 39°N and a subtle northeasterly-striking magnetic and gravity anomaly cuts across Indiana from the southwest corner of the state, roughly on strike with the New Madrid Seismic Zone.

INTRODUCTION

Geologic structures and contemporary seismic activity of mid-North America reflect a long and complex midplate tectonism which is incompletely understood. In recent years increasing attention has been devoted to specifying this tectonism and understanding its origins. Two of the most important tectonic features of the continental interior are the New Madrid Fault Zone and the 38th Parallel Lineament. These features, especially their zone of intersection (Figure 1), have been under intensive study over the past several years (Heyl, 1972, Buschbach, 1977; Hildenbrand and others, 1978; Hinze and others, 1977) and are the subject of an integrated on-going program by a consortium of geoscience investigators.

The 38th Parallel Lineament is a band of geologic features extending across eastern U.S. along the 38th parallel of latitude. It is manifested in many ways, but primarily by a series of east-west trending fault zones which were active at least through the Paleozoic era. It may represent a Precambrian fracture zone or crustal boundary extending deeply into the crust and possibly the mantle. The northeasterly-trending New Madrid Fault Zone has been the site of several intermediate and major earthquakes in historic time and is the most seismically active area in eastern North America. The trend of the New Madrid Fault Zone extends into southern Illinois and Indiana and the Wabash River Valley Fault System. This trend intersects the 38th Parallel Lineament in the vicinity of the confluence of the Wabash and Ohio Rivers. Additional details of these tectonic features are discussed by Hinze and others (1977). Fundamental questions of the New Madrid Fault Zone are its extension to the northeast and the nature of its intersection with the 38th Parallel Lineament. These questions are particularly significant to the evaluation of the earthquake risk in the region.

In 1976 L.W. Braile and W.J. Hinze of Purdue University, G.R. Keller of the University of Texas at El Paso, and E.G. Lidiak of the University of Pittsburgh initiated an integrated geological study of the tectonic framework of the 38th Parallel Lineament in the vicinity of its intersection with the extension of the New Madrid Fault Zone. Each of these investigators brings a particular expertise to the program which complement each other, have a long-standing interest in the geodynamics of the interior of the North American continent, and have demonstrated that they can work together productively.
The objectives of this study are to investigate the tectonic and geologic history of the 38th Parallel Lineament and the extension of the New Madrid Fault Zone and associated features, and to determine the variations in structure and properties of the crust and their relationship to the regional contemporary geodynamics. To accomplish these goals several hypotheses have been considered as the source of the

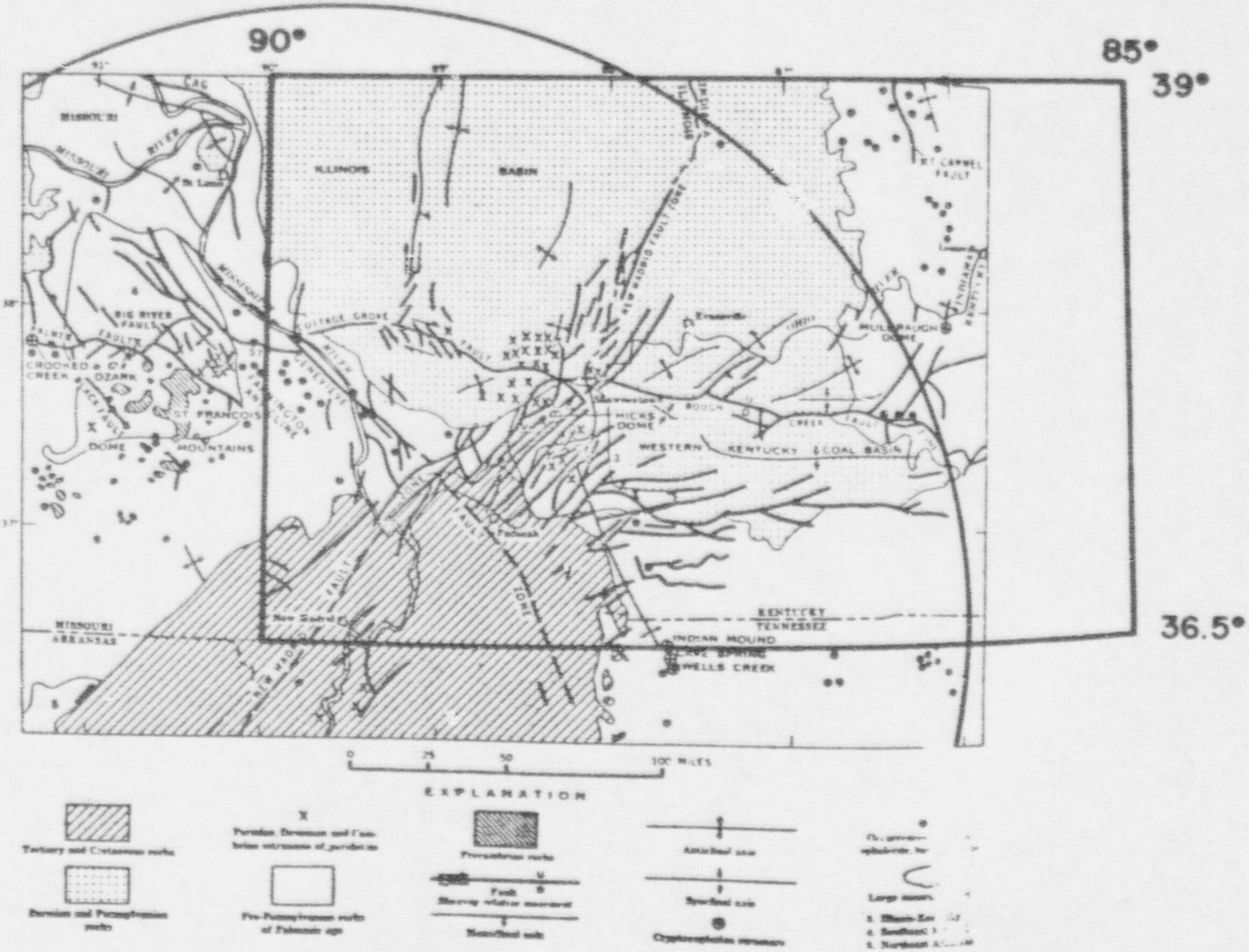
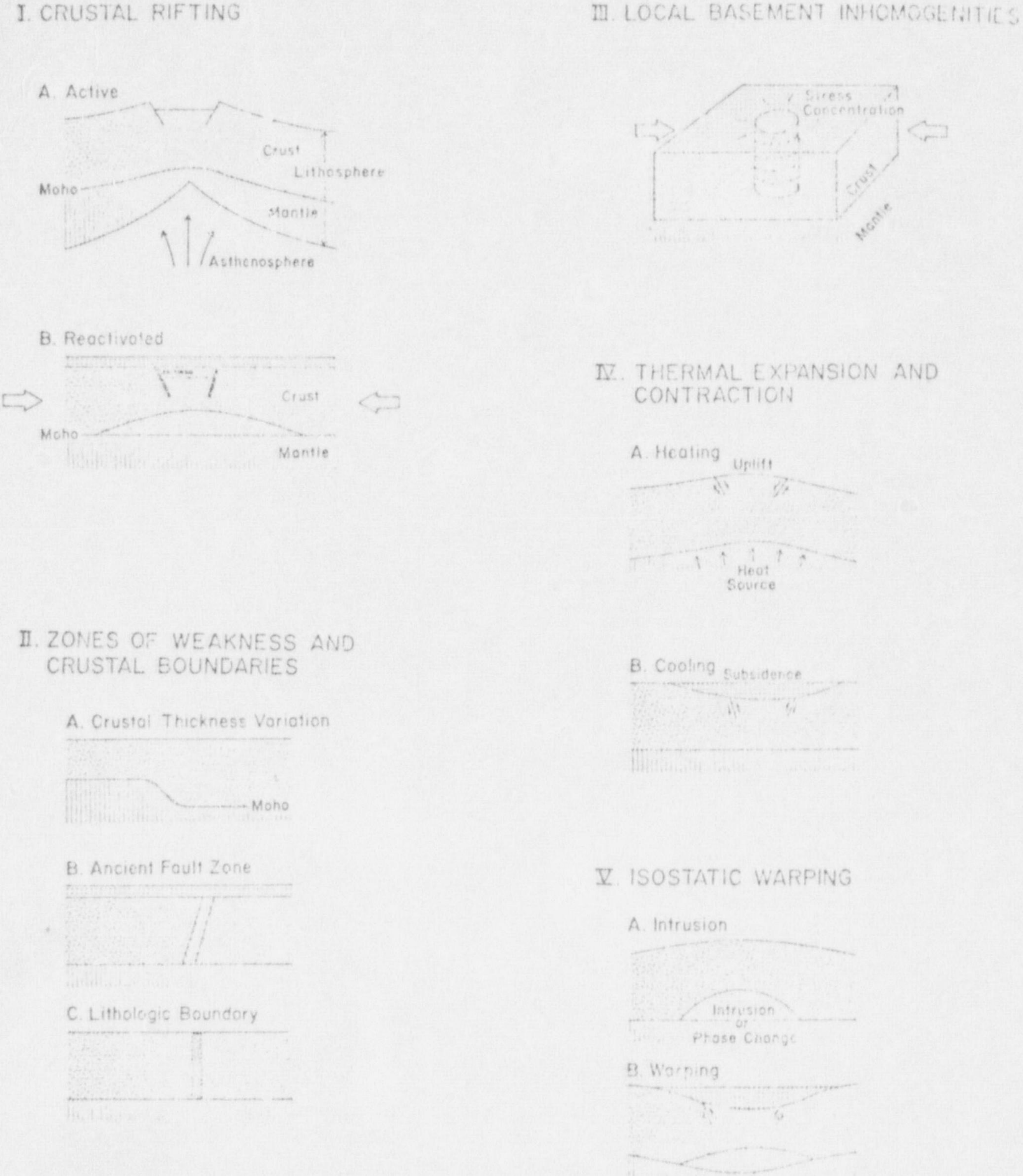


Figure 1. Map showing study area as well as segment of circle of 200 mile radius around New Madrid. Base map is generalized tectonic map of the 38th Parallel Lineament and New Madrid Fault Zone from Heyl, 1972.



Schematic diagram illustrating the mechanisms which have been proposed to explain the tectonism in the Midcontinent of North America.

Figure 2

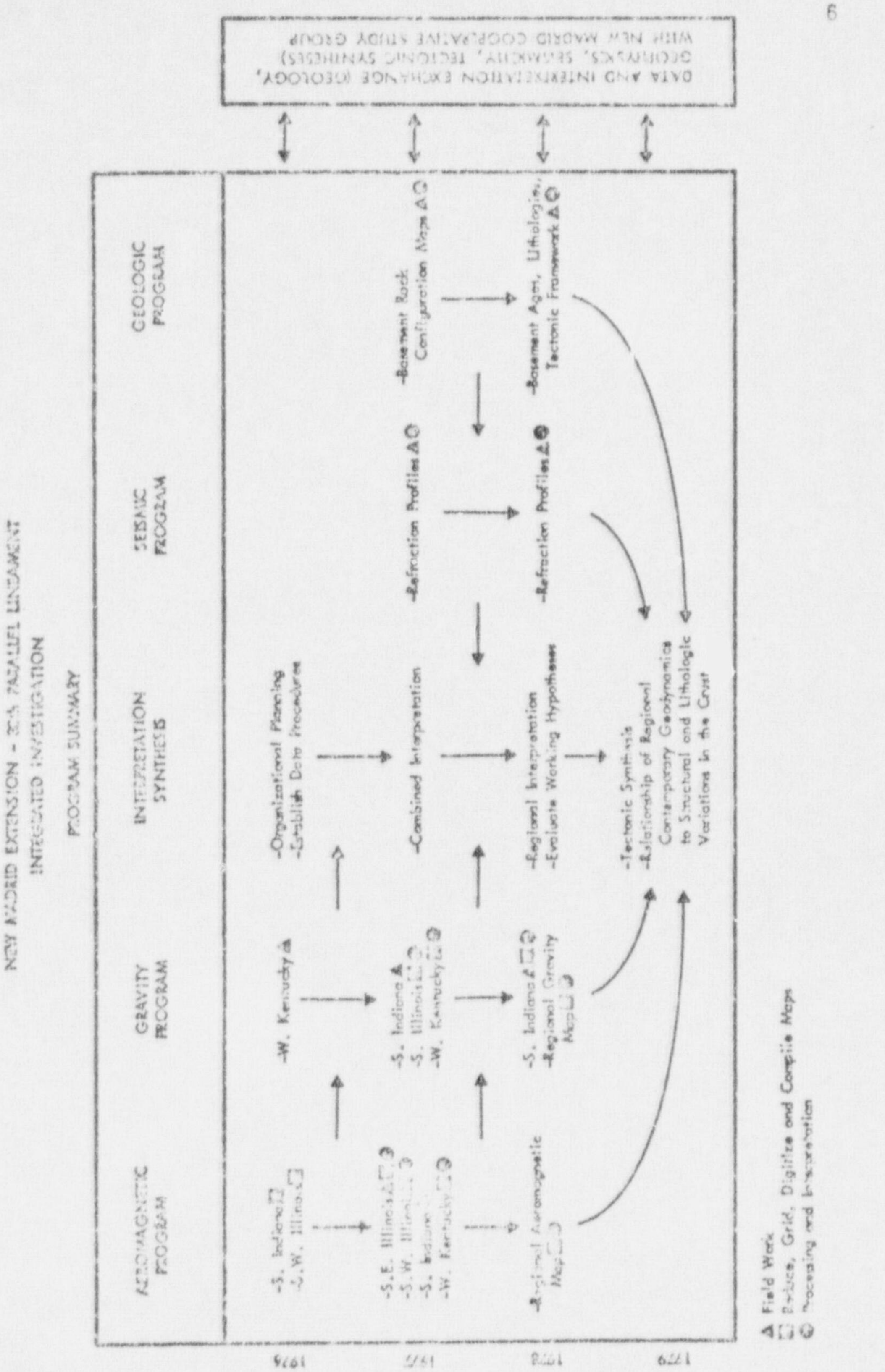


Figure 3

Flow chart which schematically summarizes the New Madrid Extension - 38th Parallel Lineament Program.

contemporary tectonism. These hypotheses which include crustal rifting, regional thermal expansion and contraction, crustal boundaries and zones of weakness, local basement inhomogenities, and isostatic warping are reviewed by Hinze and others (1977) and are illustrated schematically in Figure 2. Consideration of them has led to the design of a comprehensive, integrated data collection, synthesis and interpretation program. A flow chart which schematically summarizes the program elements and an approximate time scale for their completion is shown in Figure 3. The principal area of interest (Figure 1) is bounded by 85°W and 90°W longitude and 36°30'N and 39°N latitude. Studies to date confirm the importance of investigating this entire area because of the need to develop regional relationships.

The principal progress in this research program has been in acquiring and synthesizing critical magnetic, gravity, and geologic data; preparing the crustal seismic refraction instrumentation; and preliminary interpretation of the available data. The following sections of this report describe the progress and results to date. Oral presentations on the results of the study have been made to the New Madrid Study Group during this fiscal year at West Lafayette, Indiana on 28 September, 1977, St. Louis, Missouri on 7 March, 1978, and on 3 May, 1978 in Silver Springs, Maryland. In addition, five technical papers that were derived directly from this study were presented by the principles of this program at the Third Annual Midwest American Geophysical

Union Meeting, 26-28 September, 1977 (Figure 4) and one U.S. Nuclear Regulatory Commission Technical Report was published.

Gravity - The status of gravity coverage over the study area and environs is shown in Figure 5. During the current fiscal year approximately 1550 gravity stations were established in Kentucky and 1900 stations in Indiana. These stations are located at known elevation sites at intervals of 2 to 3 km and are gravimetically tied together and to the national network. The principal facts of these stations have been assembled and preliminary Bouguer gravity anomaly maps have been prepared. The preliminary Bouguer gravity anomaly map of north-central Kentucky is shown in Figure 6 and the map of southwestern Indiana is presented in Figure 7. It is particularly interesting to note that the gravity contours of the relative positive anomaly along the Wabash River at the western margin of Figure 7 parallel the Wabash River Valley Fault System and the occurrence of a strong local relative positive gravity anomaly centered at 87°W longitude and 38°N latitude which may be derived from a mafic intrusive source. This map also points up the importance of synthesizing the gravity anomaly data from adjacent surveys because many significant anomalies overlap the survey boundaries. Thus, procedures and computer algorithms have been developed for plotting, gridding, and contouring multi-survey gravity anomaly data within one degree latitude

A TECTONIC OVERVIEW OF THE CENTRAL MIDCONTINENT

G. R. Keller (Department of Geological Sciences, The University of Texas at El Paso, El Paso, Texas 79968)

W. J. Hinze and L. W. Braile (Department of Geosciences, Purdue University, West Lafayette, Indiana 47907)
E. G. Lidiak (Department of Earth and Planetary Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania 15260)

The contemporary geodynamics of plate interiors has received increased attention recently. The central midcontinent region of North America is such an area and its tectonic history is particularly important because of the hazard posed by the New Madrid Seismic Zone and the substantial natural resources present. Models which have been suggested to explain the contemporary tectonism of this area generally are related to three principal hypotheses: (1) resurgent tectonics, (2) thermal expansion and contraction, and (3) isostatic warping. The first of these hypotheses emphasizes crustal rifting (including aulacogen development) and its relation to crustal boundaries, ancient zones of weakness, and local basement inhomogeneities. A second hypothesis is based on the idea that thermal variations (caused by igneous intrusion, local heat flow perturbations, or by mantle penetrative convection) produce regional tension and compression that result in deformation of the crust. The third model, isostatic warping, considers the effects of regional variations in crustal loading and unloading and the possible relationship to warping of the crust, faulting, and earthquake activity. The present evidence is insufficent to evaluate fully these hypotheses, but it is apparent that a satisfactory working tectonic model for the Midcontinent should be based on the concepts of plate tectonics and must consider the lateral and vertical variations in composition and physical properties, fault zones and intraplate boundaries imposed by past deformational and thermal events. Thus an understanding of the contemporary tectonism of this area requires definition of the tectonic history and sequence of events which have resulted in the present geologic setting in the craton of the North American Plate.

A REVISED MAGNETIC ANOMALY MAP OF INDIANA

R.E. Richardson, Jr. (Dept. of Geosciences, Purdue Univ., West Lafayette, Ind. 47907)
D.W. Turner
W.J. Hinze (same as above)
L.W. Braile

The total magnetic intensity map of Indiana has been digitized at a 2 km interval as an aid in geologically interpreting this aeromagnetic map. A geomagnetic reference field appropriate to the observation period of the aeromagnetic survey (late 1940's) has been subtracted from the digital data and a revised total magnetic intensity anomaly map has been prepared. The geological implications of this map are discussed with emphasis on the southern half of the State utilizing analytical maps derived from the digital data. Enhancement of the geological interpretation of the aeromagnetic survey by methods made possible by the digital data are emphasized.

The original and upward continued data show predominantly northerly striking anomalies along the southern boundary of the state except in the extreme southwestern corner where a northeast trend in these anomalies is evident. The latter trends may represent structures in the basement that are associated with the Wabash River fault zone. Two easterly striking minimums are evident trending across the southern half of the state. A smaller wavelength minimum centered about 38°20'N latitude truncates the north-striking anomalies. The previously mentioned northeast trending anomalies although not terminated by this minimum are truncated by a broader wavelength negative anomaly which is centered about 39°N. These easterly striking features may reflect buried basement features associated with the 38th parallel lineament.

RIFTING IN THE MIDCONTINENT

E.G. Lidiak (Dept. of Earth & Planetary Sciences, Univ. of Pittsburgh, Pittsburgh, PA 15219)
G.R. Keller (Dept. of Geological Sci., Univ. of Texas, El Paso, TX 79910)
L.W. Braile
W.J. Hinze (both at: Dept. of Geosciences, Purdue Univ., West Lafayette, IN 47907)

Rifts are important tectonic features that are developed both along continental margins and in continental interiors. They are important because they play a significant role in deciphering tectonic history and localizing earth resources.

Rift zones are probably more common in the midcontinent than generally realized. However, they may be difficult to recognize because of burial beneath younger deposits, superimposed structures, and subsequent changes in the properties of the underlying crust and upper mantle. Also rifts have a variable geological and geophysical expression due to stage of development at arrestment, depth of erosion or burial, age, and mode of origin. It may thus be particularly important to distinguish between rifts formed by different mechanisms. For example "dynamic" rifts formed by forces originating from mass transfer within the asthenosphere are expected to have different deep crustal properties than "passive" rifts caused by forces originating within the lithosphere.

Although dating of rifts is subject to considerable uncertainty, a chronological catalog of recognized rifts of the central and eastern midcontinent has been prepared based on a variety of geological and geophysical evidence. The list which includes more than 20 rifts exclusive of Late Precambrian and Triassic grabens along the continental margin at time of break-up shows that Late Precambrian and Eocambrian rifts are more common, more widely spread and are marked by greater igneous activity than subsequent rifts.

GRIDDING METHODS FOR GEOLOGICAL AND GEOPHYSICAL DATA

Lawrence W. Braile (Department of Geosciences, Purdue University, West Lafayette, IN 47907)

Interpolation of randomly-spaced two-dimensional data on a rectangular grid - gridding - is a useful numerical procedure which facilitates subsequent processing such as filtering, contouring by hand or machine, and comparison with other data. Common problems in gridding methods for geological and geophysical data are: (1) obtaining accuracy in regions of sparse data, (2) representing short wavelength features in the data while also avoiding introduction of spurious features in the gridded surface, and (3) interpolation near the edges of the sampled area. Four gridding methods were analyzed and their performance compared by application to the same data set. The four methods are: (1) weighted average of closest points, (2) weighted average of three closest points with some azimuth control, (3) local polynomial surface fitting, and (4) piecewise cubic polynomial interpolation along profiles. The local polynomial surface fitting method, which was developed for this study, is shown to be more versatile and results in a more accurate grid surface than the other gridding techniques investigated.

AN AEROMAGNETIC AND GRAVITY STUDY OF FEATURES ALONG THE 38th PARALLEL LINEAMENT IN WESTERN KENTUCKY

R. W. Johnson (Tennessee Valley Authority, 160 Liberty Building, Knoxville, Tennessee 37902

G. R. Keller (Department of Geological Sciences, University of Texas at El Paso, El Paso, Texas 79968

Aeromagnetic and gravity surveys have recently been completed for the area of Kentucky west of 86°W longitude. A 1 mile (1.6 km) flight line spacing was maintained in the aeromagnetic survey and a ~2 mile (3.2 km) station spacing was maintained in the gravity survey. These data correlate very well and outline the major geological features in the area. The Rough Creek Fault Zone is clearly shown to be related to the northern boundary fault of a major east-west trending graben which is approximately 5 km (15,000 ft) deep in places. The geometry of the southern boundary of this graben differs from the geometry indicated by surface faulting. The graben is flanked by several magnetic and gravity highs which suggest igneous activity was associated with its formation. Farther west lies another prominent linear magnetic and gravity anomaly. This anomaly trends northwest-southeast and appears to be a buried extension of the St. Genevieve fault.

Figure 4

Abstracts of technical papers derived from on-going study that were presented at the Third Annual Midwest American Geophysical Union Meeting, 26-28 September, 1977.

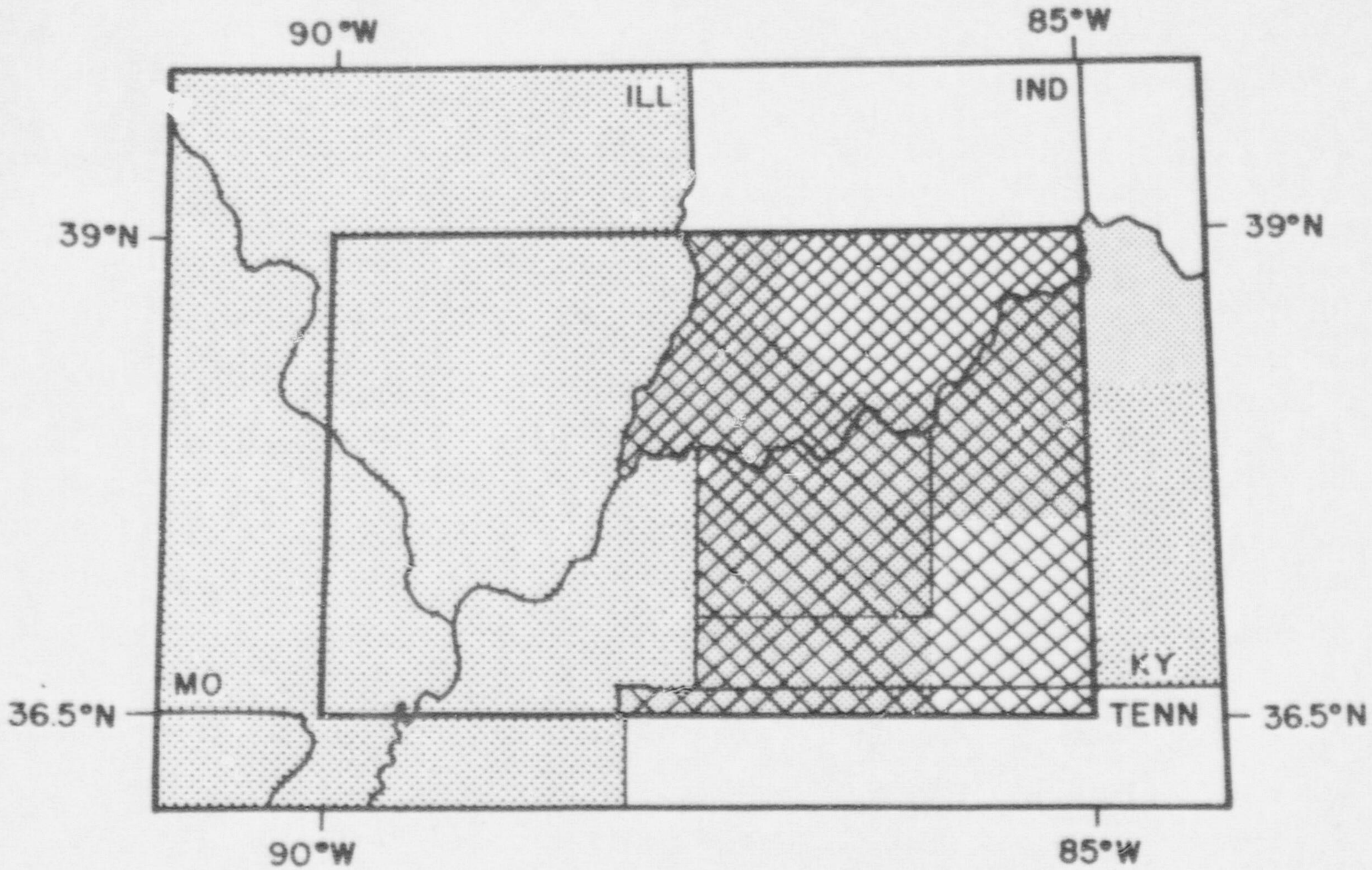


Figure 5

Map indicating status of detailed gravity observations within the study area which is shown by rectangle. Coarse dotted pattern indicates area of complete coverage before study was initiated. Fine dotted pattern indicates data obtained to date as part of study. Cross-hatched pattern indicates area covered by original study plan.


CINCINNATI
OHIO
INDIANA
LOUISVILLE
40
50
60
70
Bouguer Gravity Map of
a Portion of
North-Central
Kentucky
Density=2.67 gm/cc Contour Interval=2 mgal.
Sea Level Datum 1967 Reference Field

Figure 6

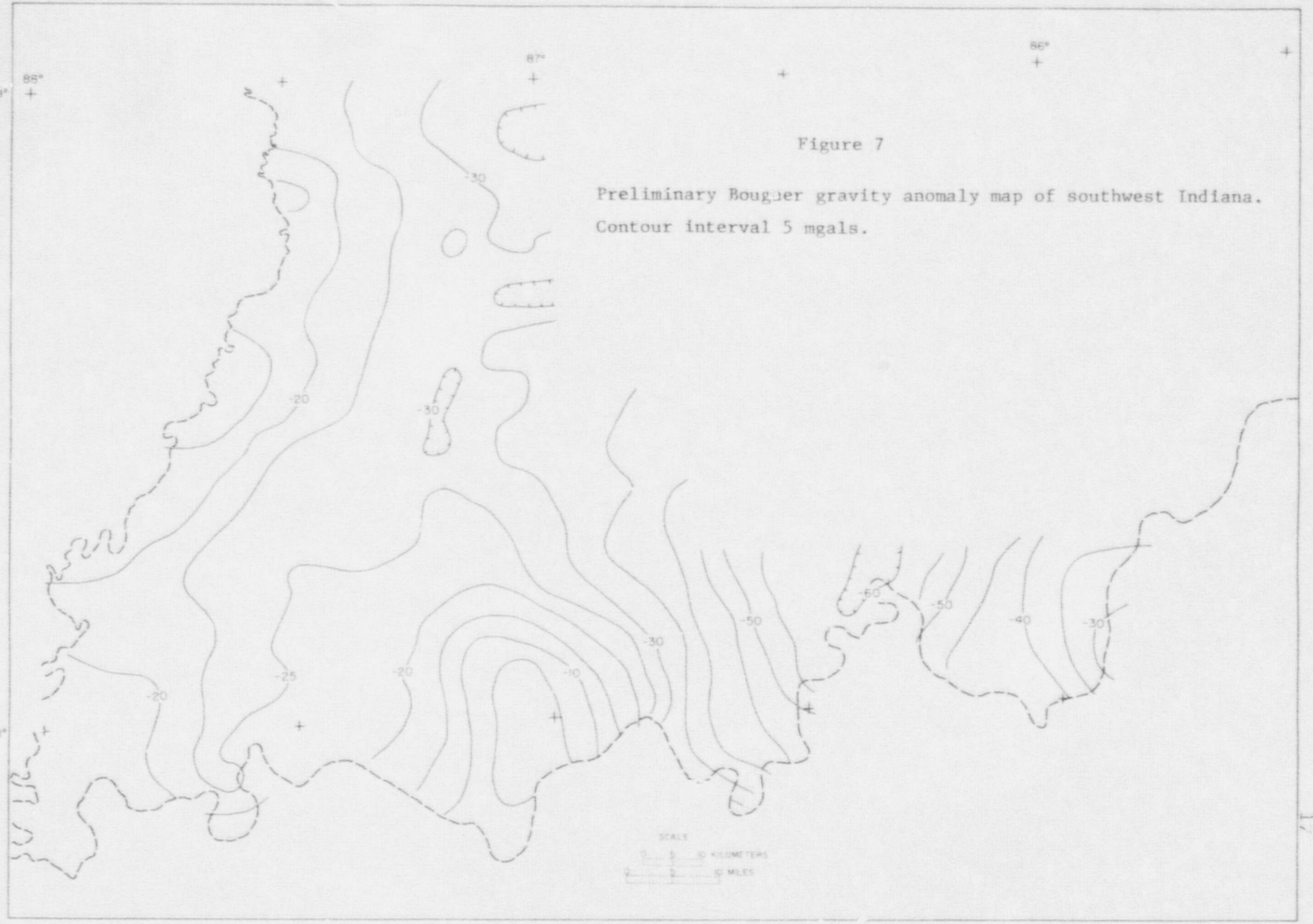


Figure 7

Preliminary Bouguer gravity anomaly map of southwest Indiana. Contour interval 5 mgals.

Figure 8

Bouguer gravity anomaly values of the Dyersburg Sheet, 36°-37° N. and 88°-90° W.

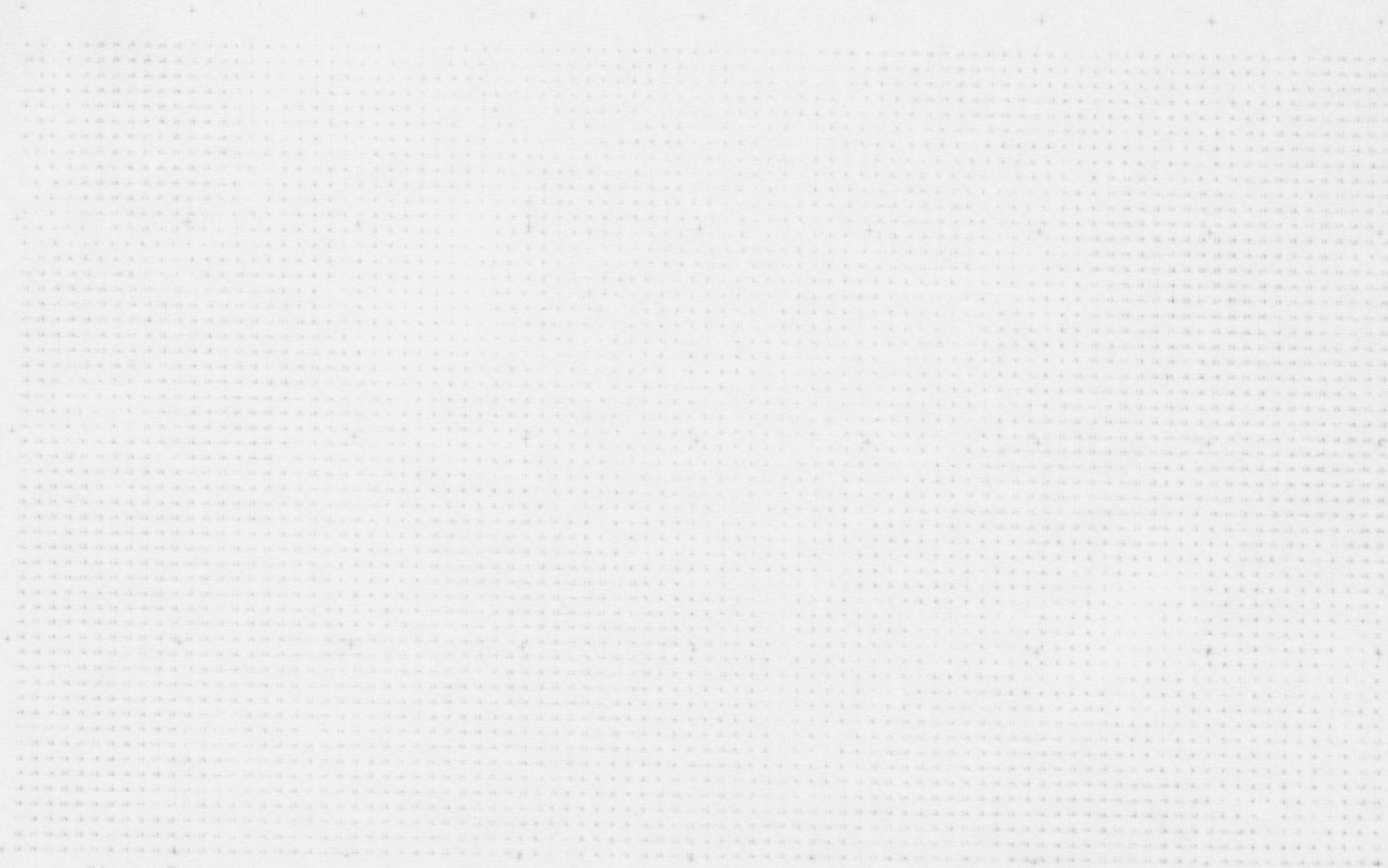


Figure 9

Gridded Bouguer gravity anomaly values at 2 km interval over the Dyersburg Sheet, 36°-37° N. and 88°-90° W.

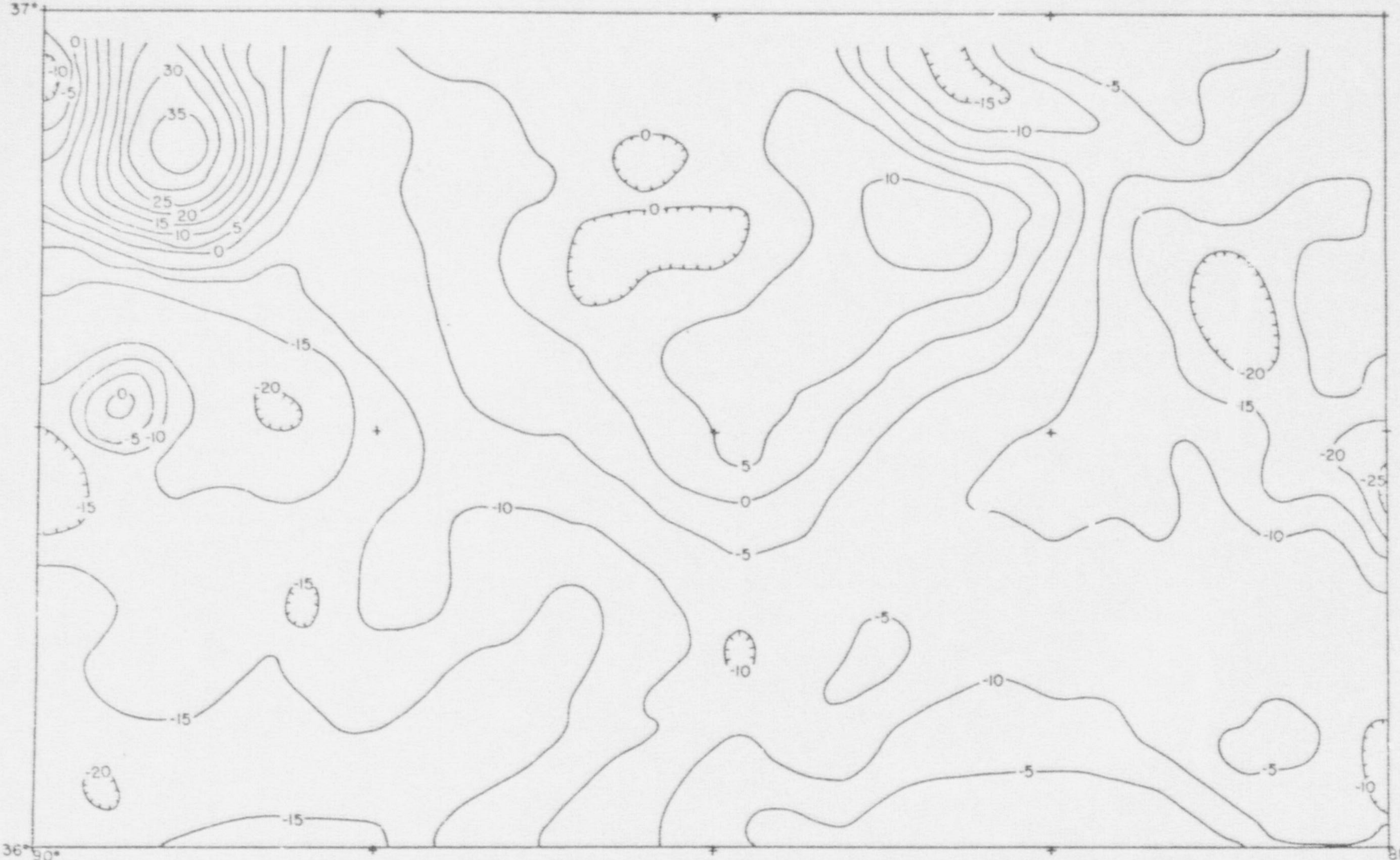


Figure 10

Bouguer gravity anomaly map of Dyersburg Sheet, 36°-37° N. and 88°-90° W. Contour interval 5 mgal.

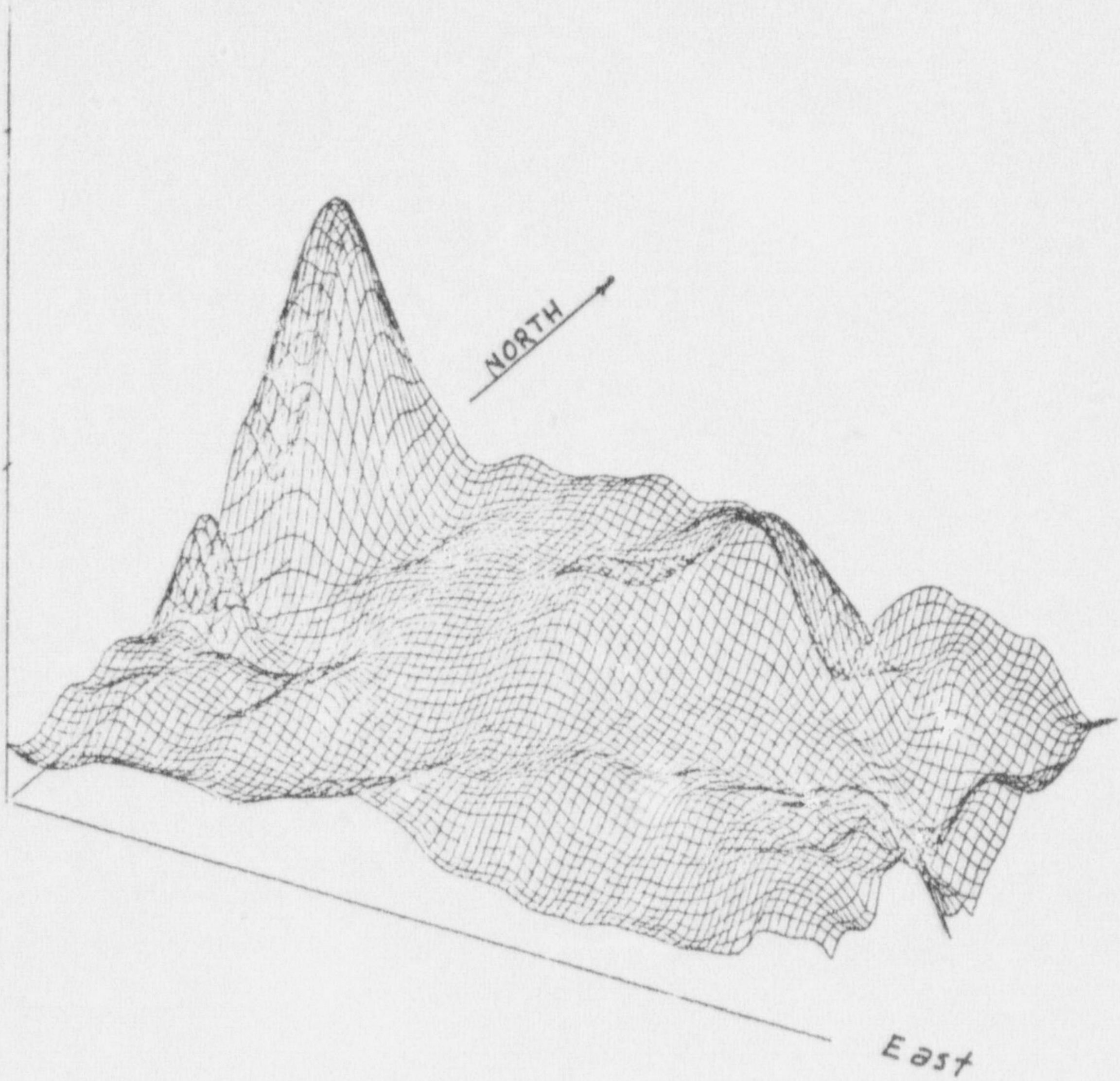


Figure 11

Bouguer gravity anomaly diagram of Dyersburg Sheet, 36°-37° N. and 88°-90° W.

and two degree longitude quadrangles. The results of these procedures are illustrated by the examples shown in Figure 8 through 11. Figure 8 shows the position and Bouguer gravity anomaly value (rounded to the nearest milligal) of stations within the Dyersburg sheet (36°-37°N and 88°-90°W). These values gridded at a 2 km interval are shown in Figure 9. The contoured values are shown in Figure 10 and illustrated in a perspective diagram in Figure 11. Figure 12 is the combined Bouguer gravity anomaly map of the Paducah and Dyersburg quadrangles. With the use of data from adjacent quadrangles, the edge effect on these quadrangles is essentially eliminated. A master gravity data file is being prepared of the study area and adjacent regions for preparation of gravity anomaly maps. The number of stations in the master data file in each one-quarter of a 7.5' quadrangle is illustrated in Figure 13. Blanks indicate no stations are available and overprints indicate more than nine stations. The recently acquired gravity data have not been included in the file because these data are currently undergoing quality checks. Comparison of Figure 7, the Bouguer gravity anomaly map of southwestern Indiana, with the previously available Bouguer gravity anomaly map of Indiana, Figure 14, indicates several major differences due to the limited number of stations previously available. Local anomalies and gradients have been altered and anomalies based on a few erroneous values have been removed. Thus, the on-going gravity program serves a particular important role.

Figure 12 Bouguer gravity anomaly map of the Dyersburg and Paducah Sheets

Figure 13

Gravity station density plot. Each digit indicates the number of gravity stations within one-fourth of a 7.5' quadrangle. Overprints indicate more than nine stations. Recently observed data in Indiana not included.

BOUGUER GRAVITY MAP
OF INDIANA
CONTOUR INTERVAL = 5 milligals

Figure 14

Magnetic - The status of aeromagnetic coverage over the study area and environs is shown in Figure 15. During the current fiscal year the crosshatched area of this figure, southeast Illinois south of 39°N latitude and east of 89°W longitude, was covered with a total magnetic intensity survey along north-south flight lines separated by 1 mile (1.6 km) at an elevation of 1500 ft (457 m) AMSL. The procedure used in the reduction of the data of this survey is shown in Figure 16. The resulting anomaly map is shown in Figure 17. The southeast Illinois magnetic anomaly map is shown with the southwest Illinois magnetic anomaly map in Figure 18. The southwest Illinois map has now been digitized at a 2 km interval and will be processed with the southeast Illinois and surrounding magnetic data to produce a quasi-consistent data set and interpretational maps. This is necessary because of the inconsistent specifications of the adjacent surveys which prevent detailed comparison of adjoining maps and data sets. However, the consistency of the contours on either side of the join along 89°W longitude suggests that the necessary modifications will not be major.

The aeromagnetic survey of Indiana flown by the U.S. Geological Survey in the late 1940's has been digitized from the total magnetic intensity map and gridded on a 2 km interval. This survey was flown at 1000 ft (305 m) AMT along north-south tracts spaced at 1 mile (1.6 km) intervals. Investigation of the available geomagnetic reference fields (Regan and Cain, 1975) suggested that the optimum field to remove

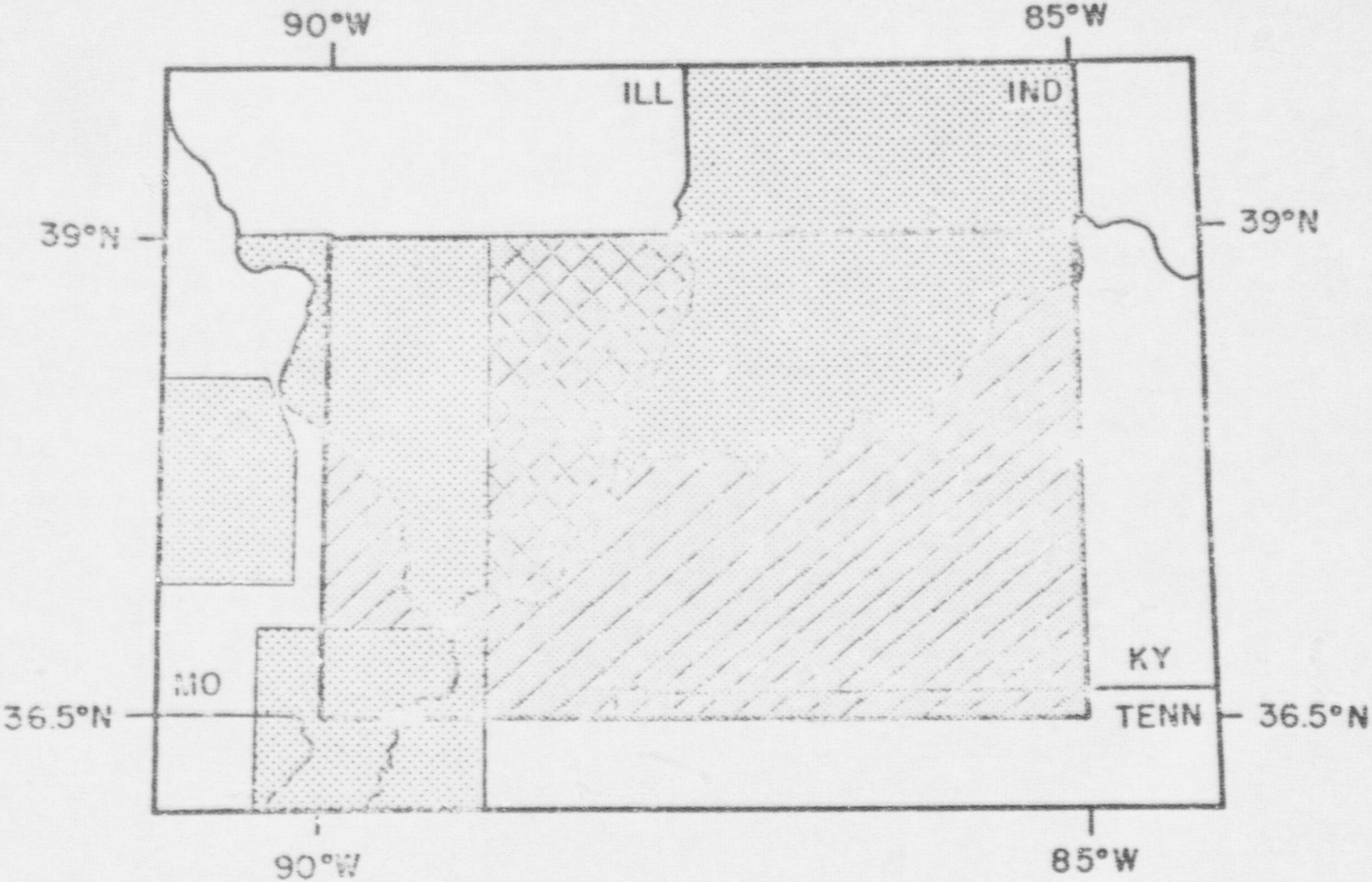


Figure 15 Map indicating status of aeromagnetic coverage within the study area which is shown by the rectangle. Coarse dotted pattern indicates area of coverage before study was initiated. Fine dotted pattern indicates recently acquired data. Diagonal pattern indicates data acquired by funding external to study. Cross-hatched patterns indicates data acquired by funding internal to study.

MAGNETIC DATA REDUCTION PROCEDURE

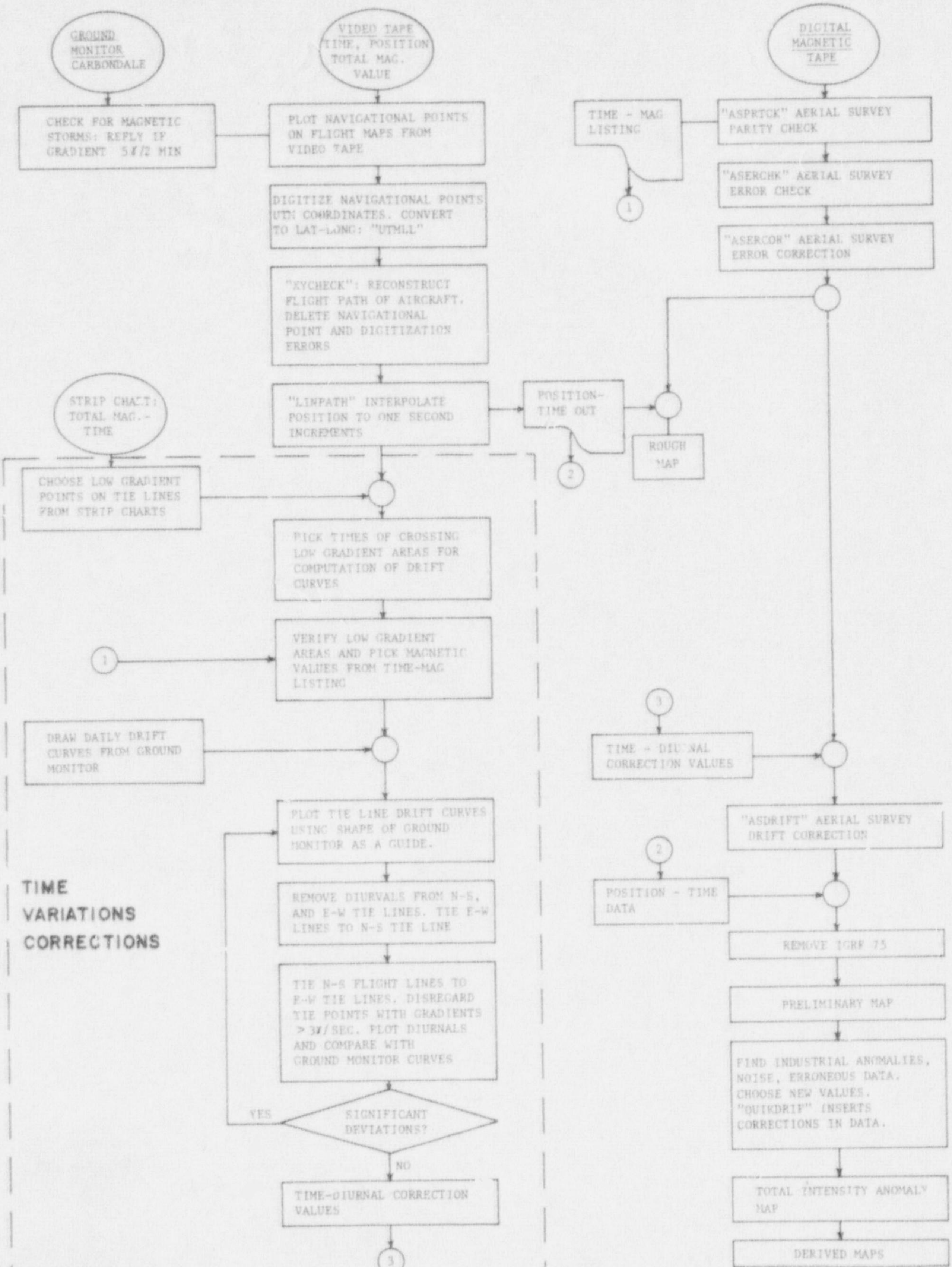


Figure 16

Figure 17

Total magnetic intensity anomaly map of southeastern Illinois.

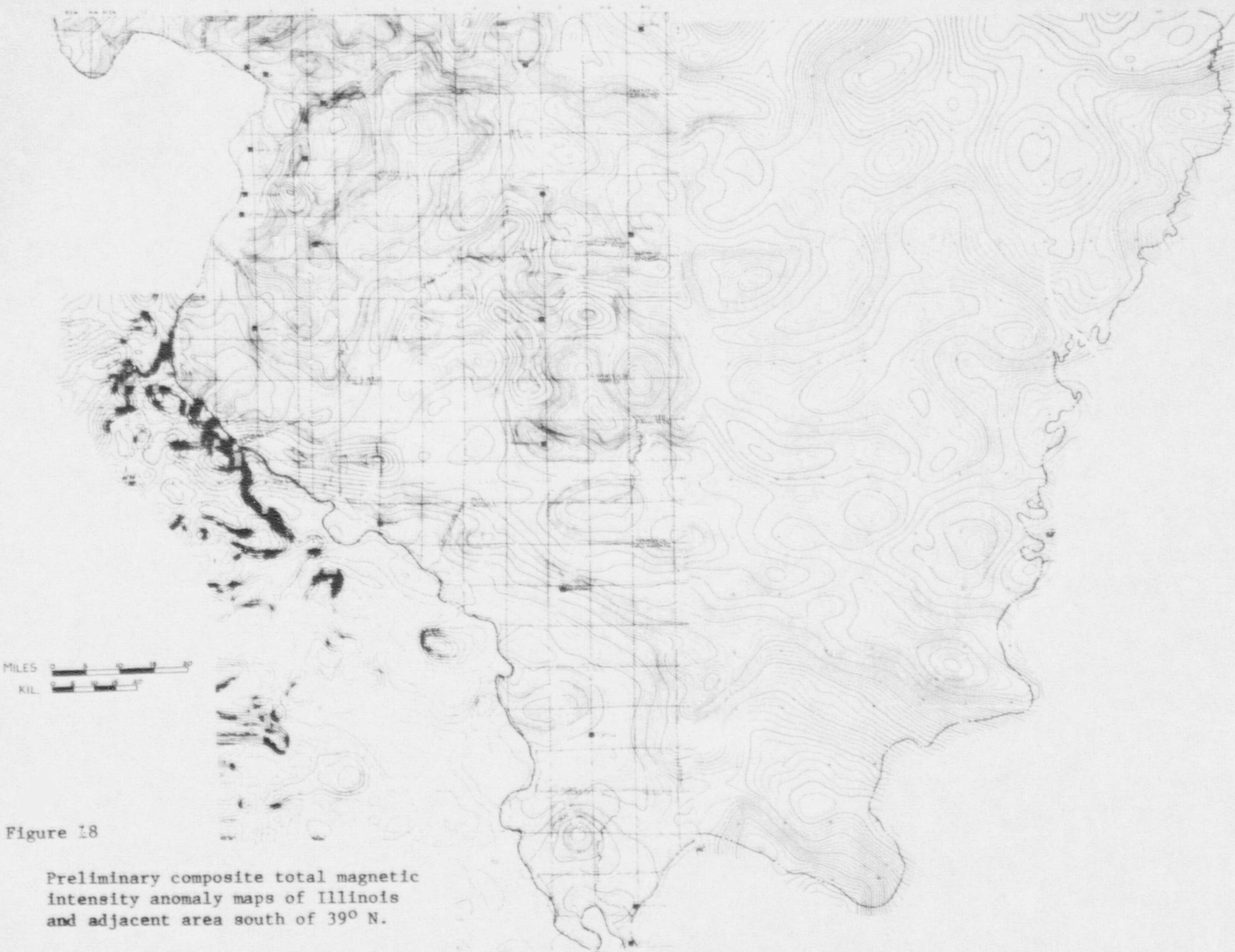


Figure 18

Preliminary composite total magnetic intensity anomaly maps of Illinois and adjacent area south of 39° N.

from the survey data to obtain an anomaly map is the field based on the GSFC (12/66) model. This field adjusted to the time of the Indiana survey is illustrated in Figure 19. It has been used to obtain a magnetic anomaly map. The individual segments of this map, as keyed to location in Figure 20, are shown in reduced form in Figures 21-29. The maps overlap slightly for ease in compositing into maps covering larger areas.

The Indiana magnetic anomaly map has been processed to enhance certain anomalies and patterns and subdue others. The data have been upward continued to elevations of 2, 5, 10, and 20 km (Figures 30-33 respectively) to eliminate sucessively longer wavelength anomaly data. Upward continuation serves as a very efficient short wavelength cut filter. In an effort to emphasize the directional trends of anomalies, the Indiana magnetic anomaly data has been strike pass filtered in the northwest, north, northeast, and east directions (Figures 34-37 respectively). A second vertical derivative map of the total magnetic intensity anomaly (Figure 38) has also been prepared as an aid in interpretation. Finally, synchronized north-south magnetic anomaly profiles have been prepared in groups of ten (Figures 39 and 40) to assist in locating correlative anomaly trends.

The Kentucky magnetic coverage shown on the magnetic status map (Figure 13) will soon be released through the cooperative action of the State of Kentucky and the Tennessee Valley Authority. The other coverage in the New Madrid area

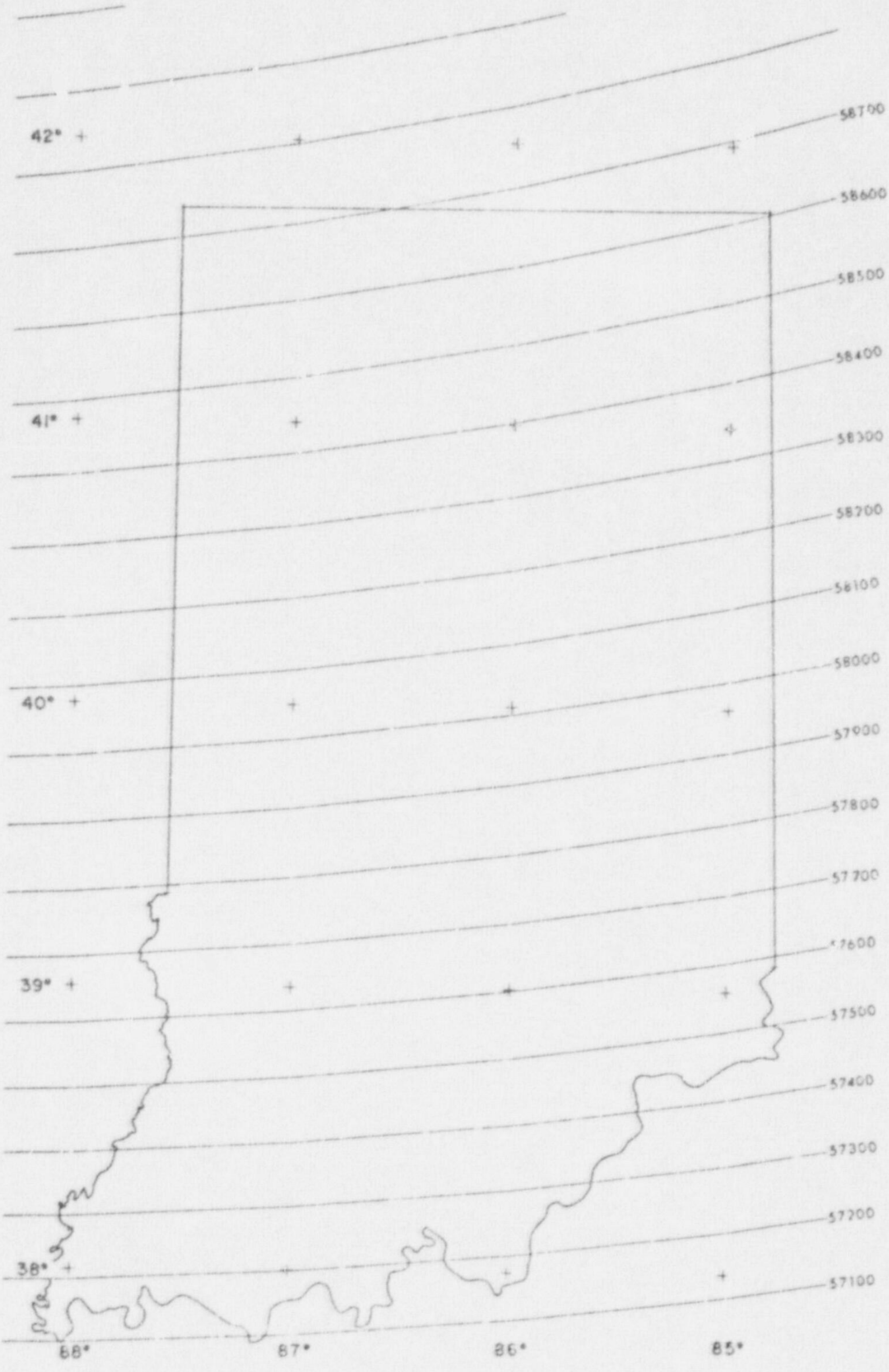


Figure 19 Total magnetic field over the State of Indiana calculated from the GSFC (12/66) model date = 1947, altitude = 1700 ft (0.518 km), contour interval is 100 gammas

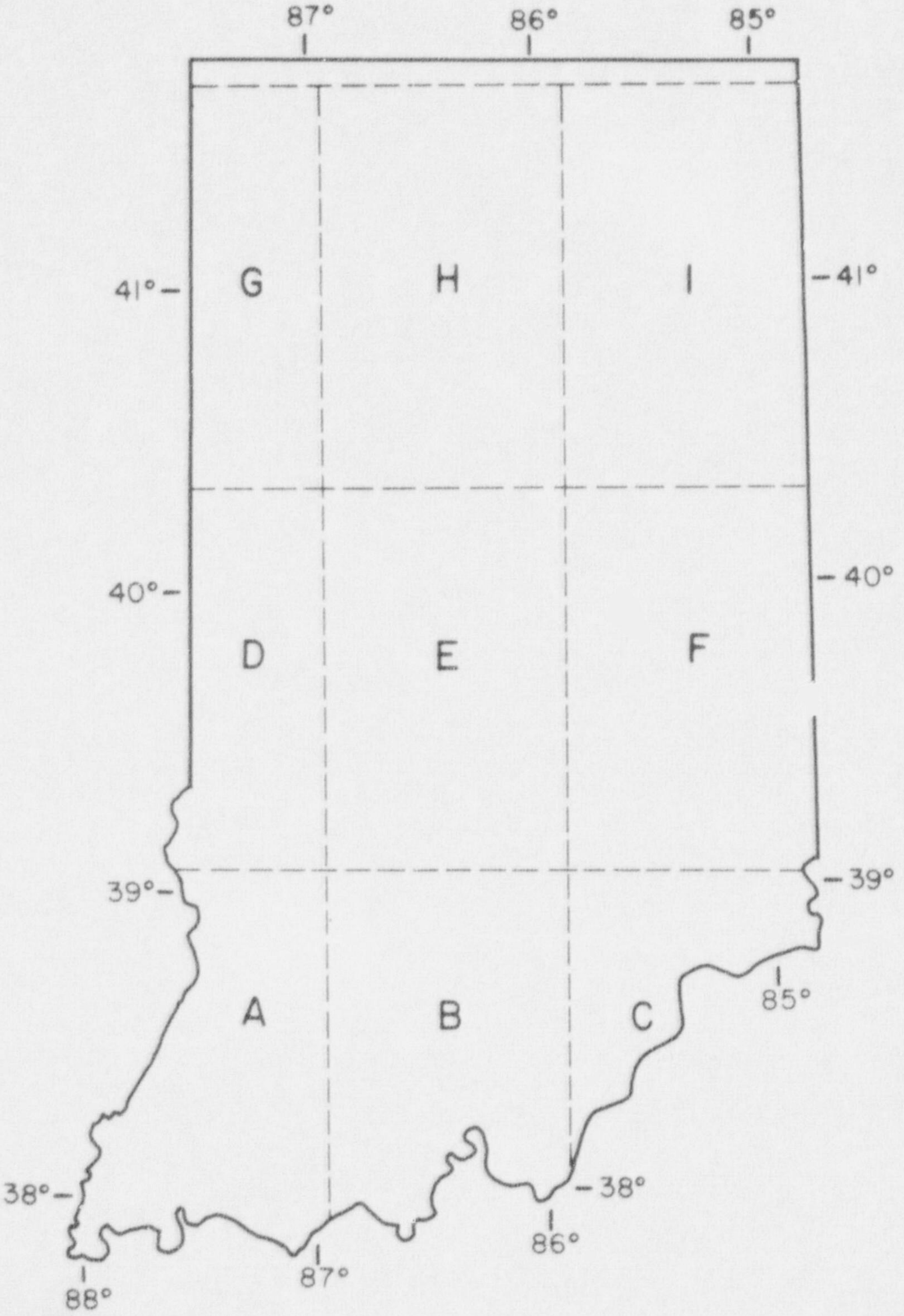


Figure 20 Map key to individual total magnetic intensity anomaly maps of Indiana.

Figure 21-29 Total magnetic intensity anomaly map of segment A of Indiana. Top of page is north and plus marks indicate corners of 7.5' quadrangles. Contour interval is 20 gammas. Anomaly map determined by removal of GSFC (12/66) magnetic field from data observed at 1000 ft (305 m) AMT along north-south flight lines spaced at 1 mile (1.6 km) intervals .


800
700
700
600
1000
800
1100
1000
1000
800
900
800
900
1000
900
1100
900
900
1000
1200
1000
800
1300
900
800
1000

Figure 21


800
600
700
800
1000
1200
1300
600
700
1100
1100
900
900
800
800
700
600
700
500
600
800
900
1000
1100
1300
1500
1600
700
600
1600
1600
700
600
800
900
1500

Figure 22


300
300
400
600
800
1000
900
700
700
800
500
700
800
600
600
500
700
900
1100
1300
1500
1600
1400

Figure 23

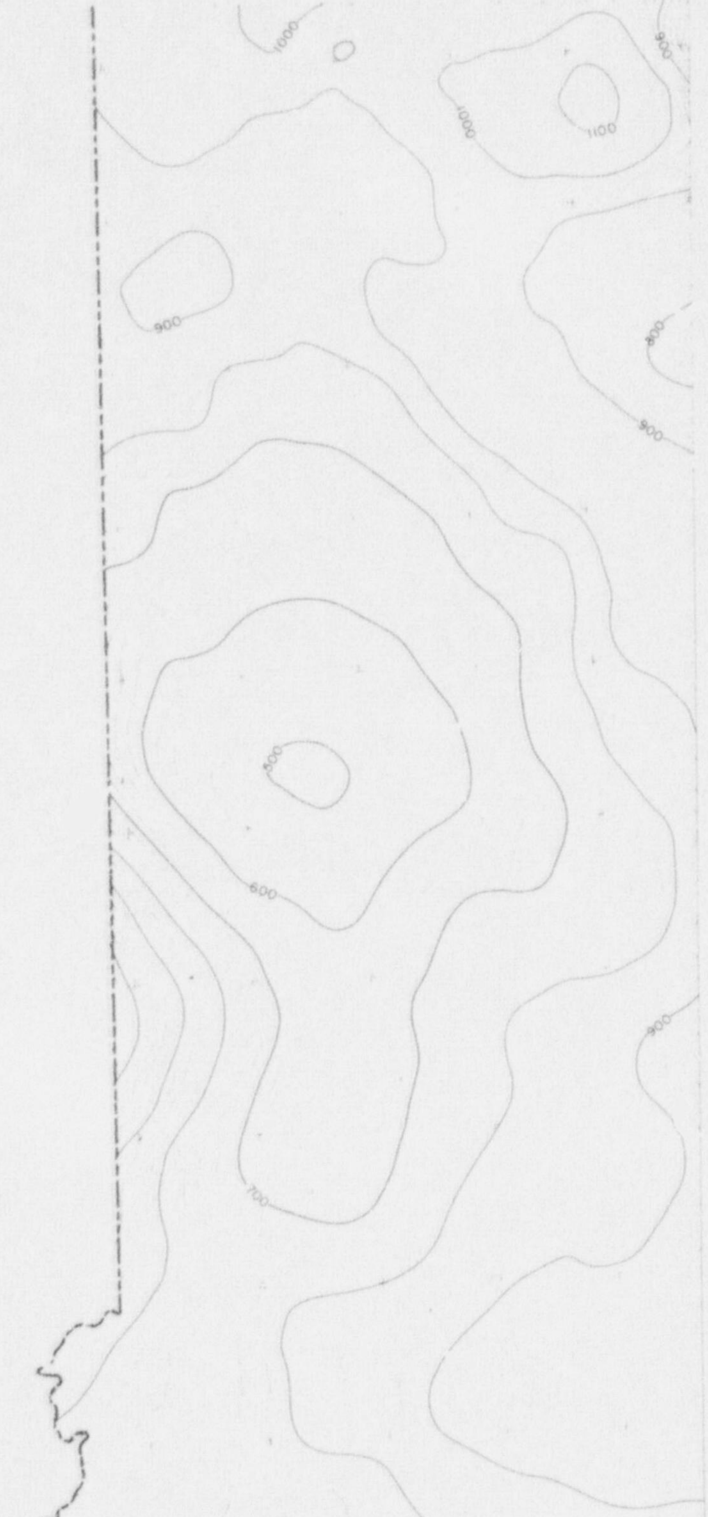


Figure 24

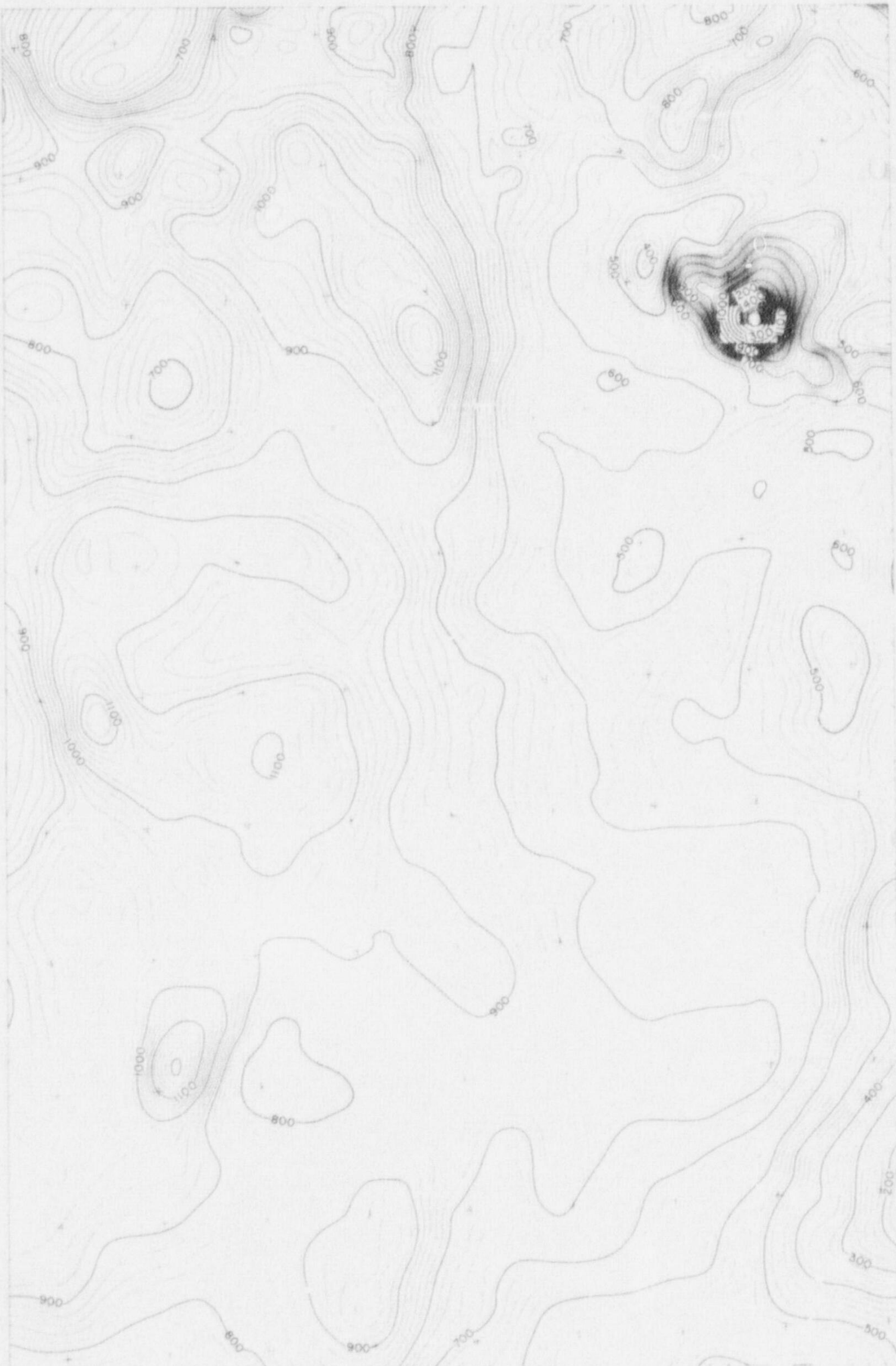


Figure 25

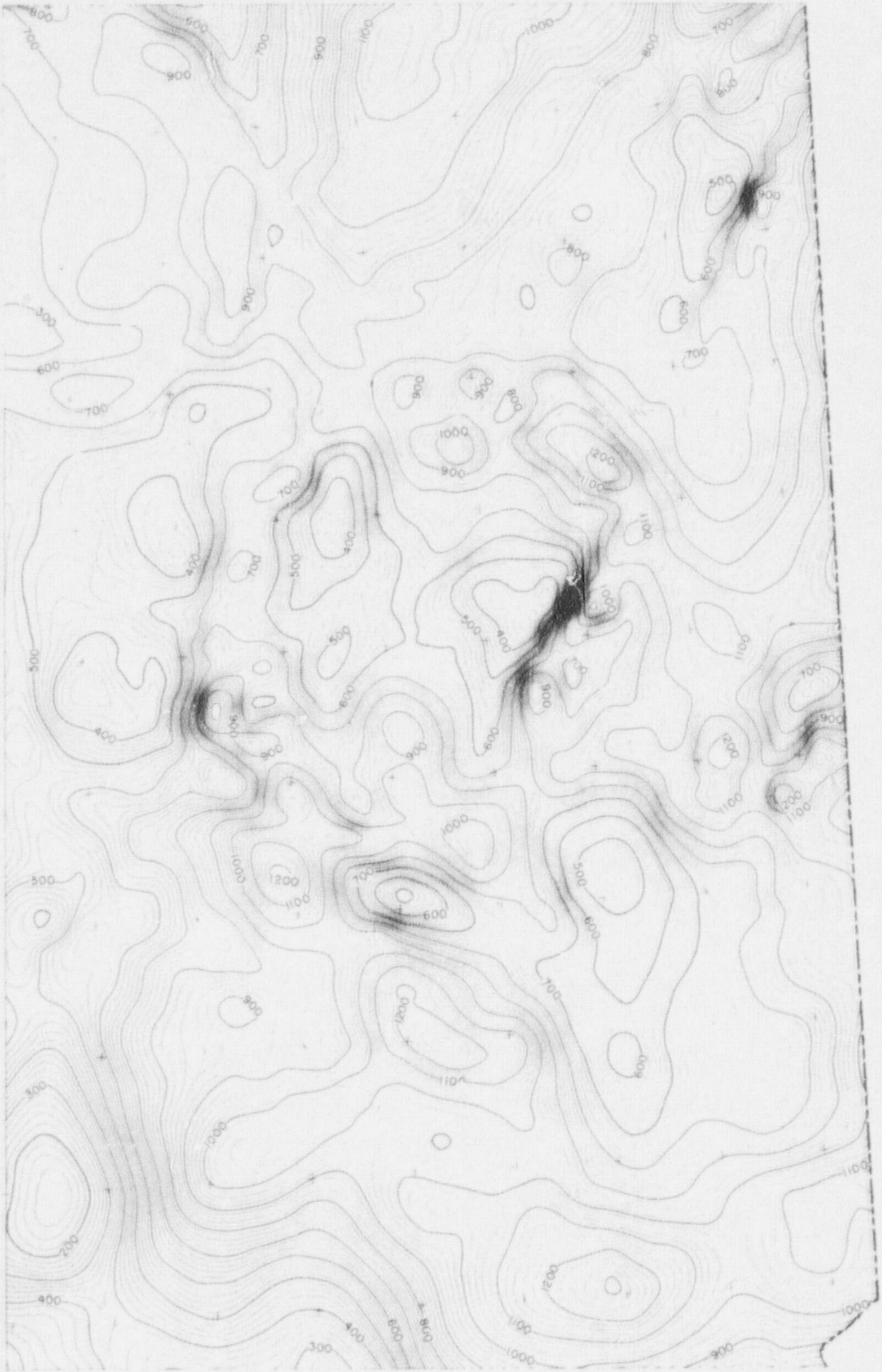


Figure 26

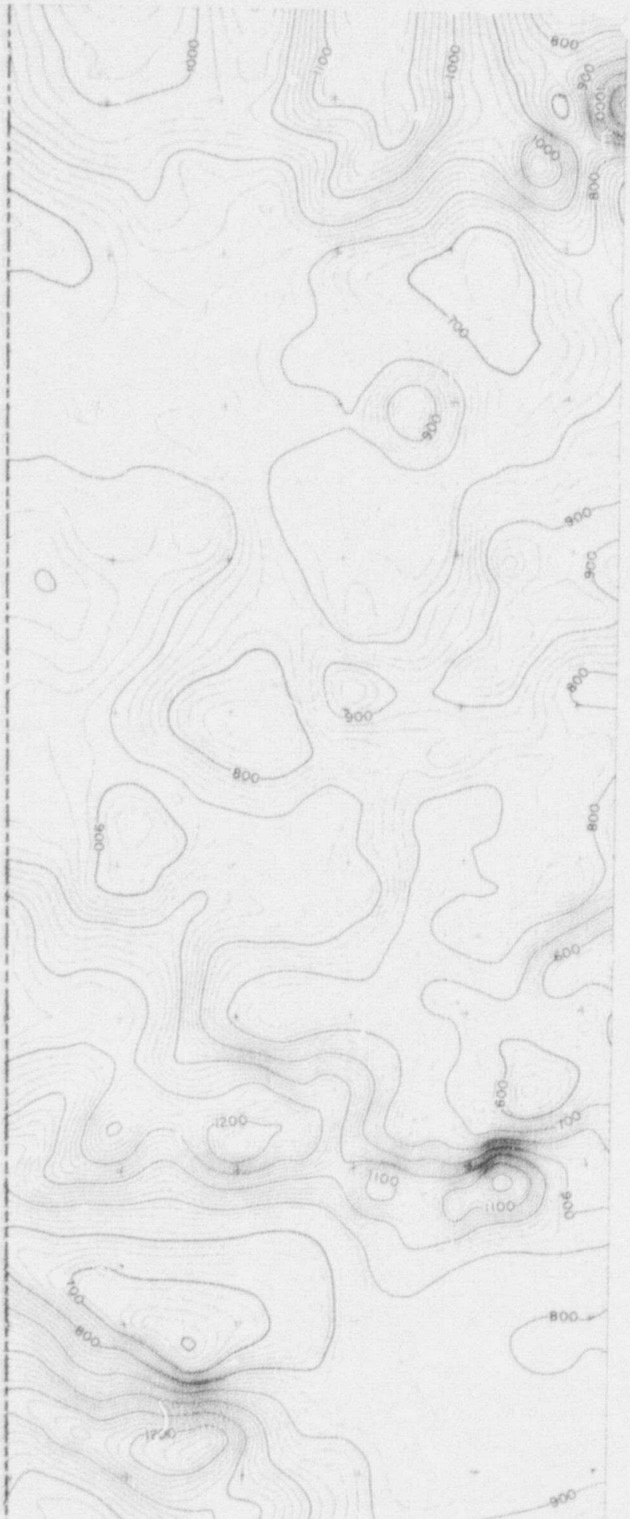

1000
1100
1000
800
900
1000
1000
800
700
900
900
900
800
900
800
900
800
600
600
700
1200
1100
1100
900
700
800
800
1200
900
1000

Figure 27

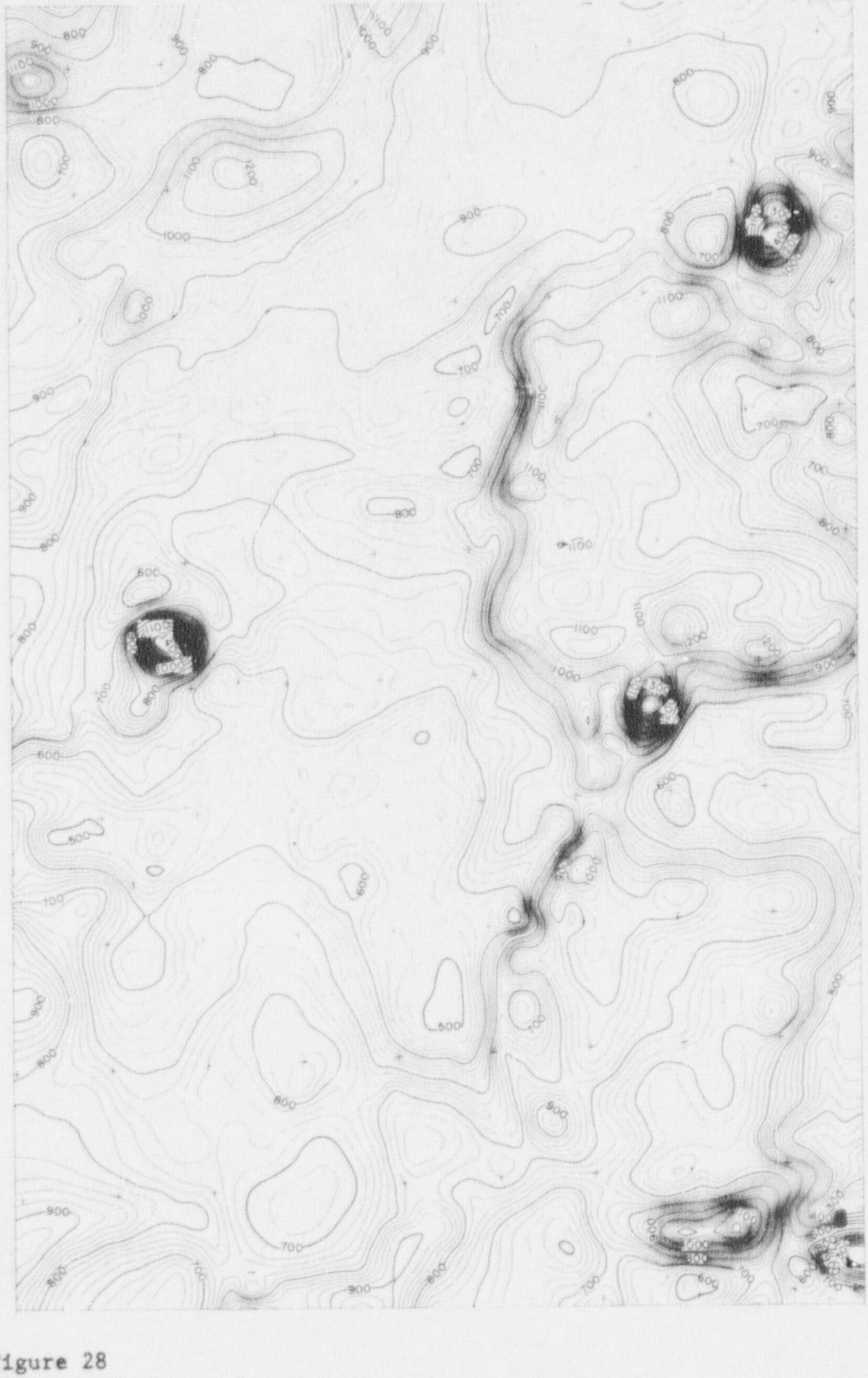

900
800
1100
1000
800
700
1100
1200
1000
900
800
1000
700
900
800
700
1100
1100
800
600
800
700
600
500
500
700
900
800
900
800
700
900
800
700
600

Figure 28

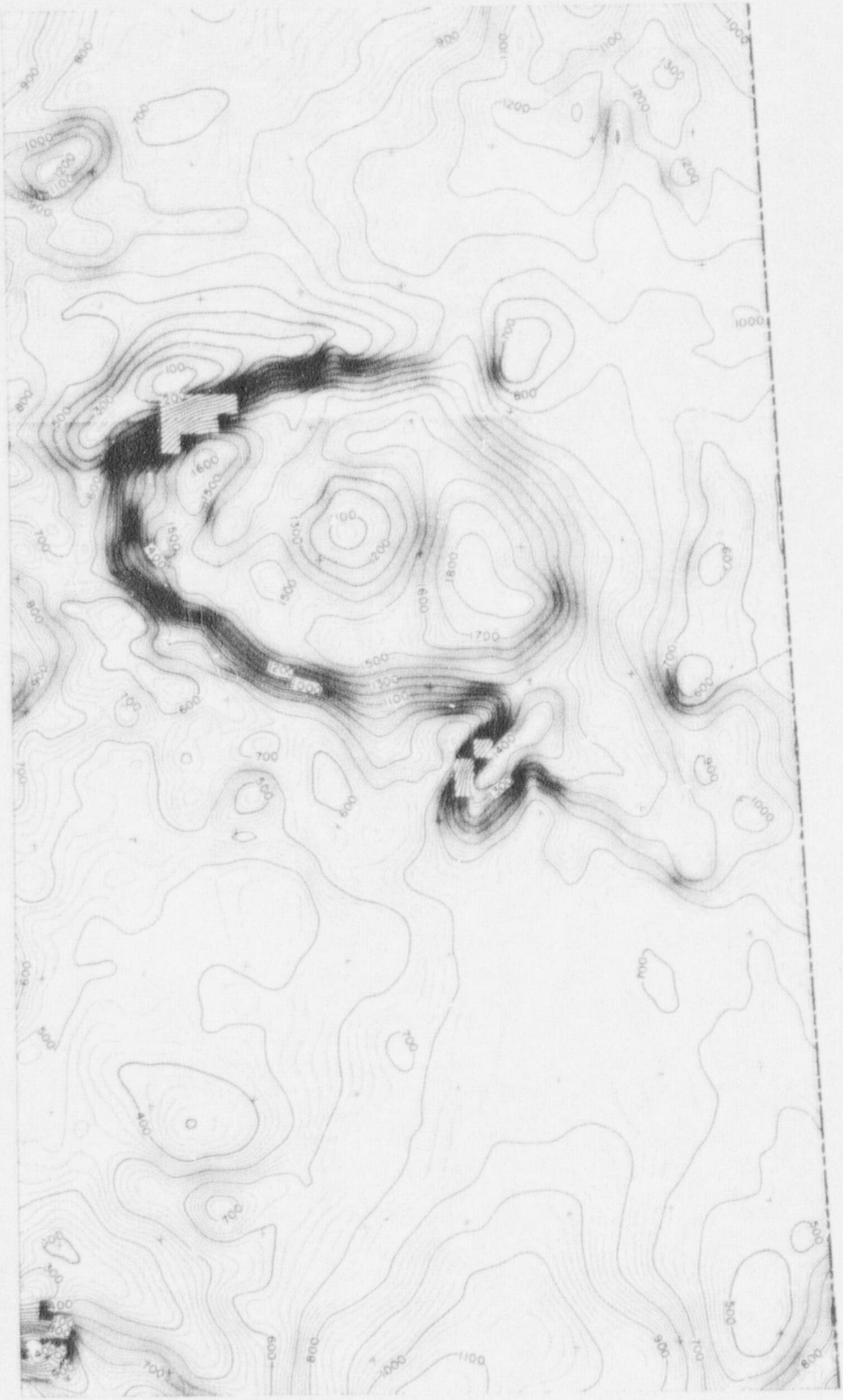
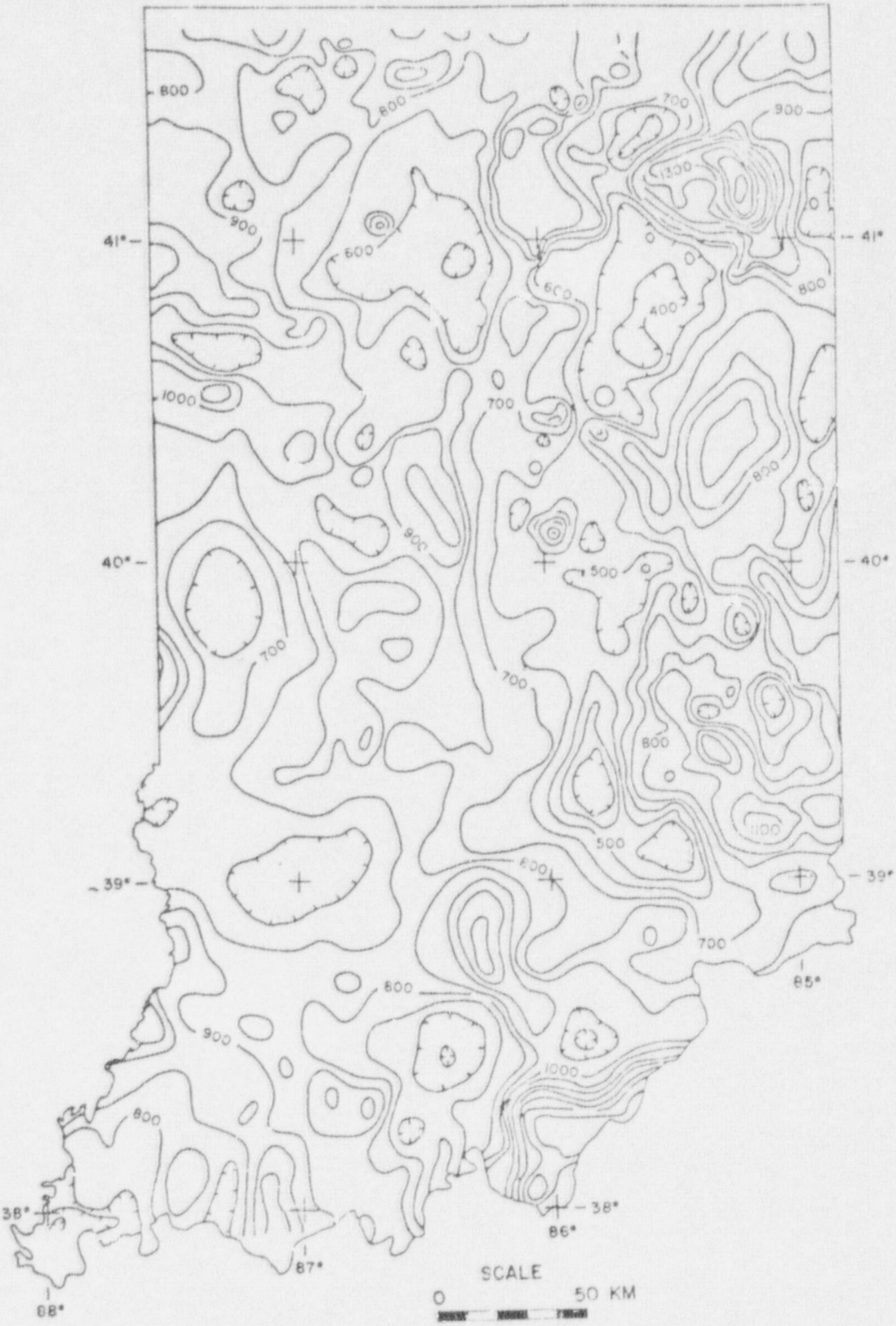


Figure 29

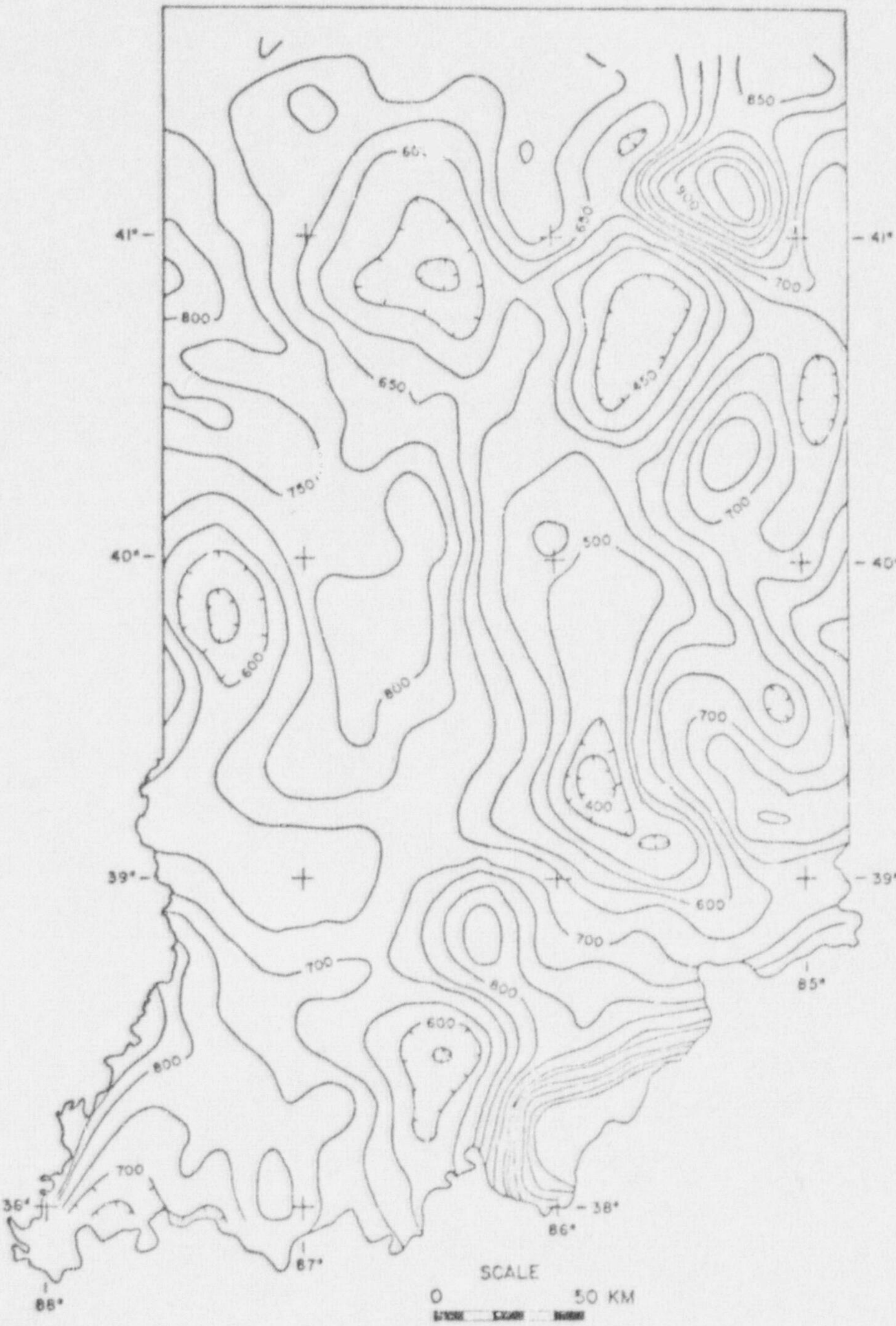


INDIANA AEROMAGNETIC ANOMALY MAP
REDUCED TO THE POLE, UPWARD CONTINUED TO 2 KM
CONTOUR INTERVAL = 100 GAMMAS

Figure 30

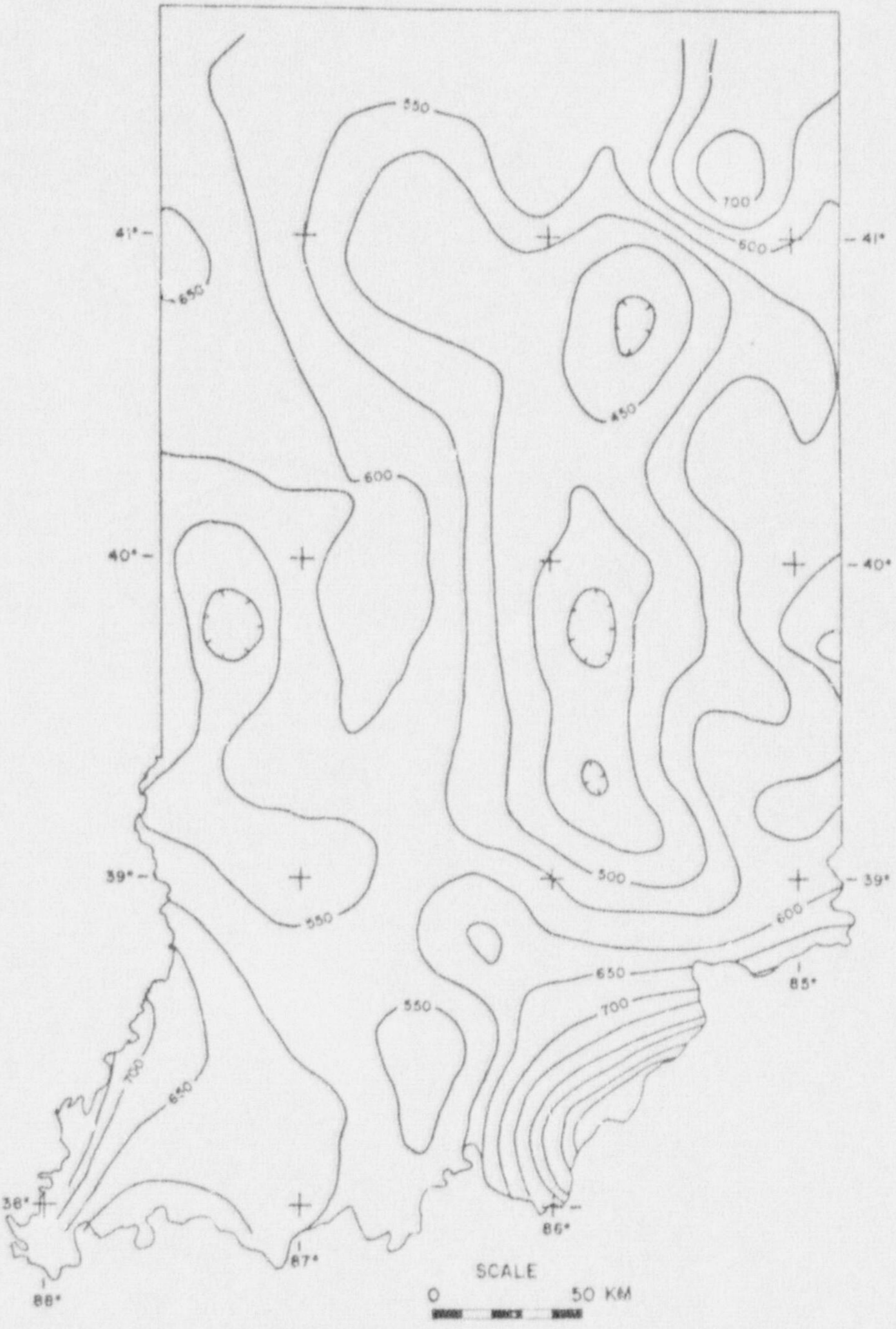
INDIANA AEROMAGNETIC ANOMALY MAP
REDUCED TO THE POLE, UPWARD CONTINUED TO 5 KM
CONTOUR INTERVAL = 100 GAMMAS

Figure 31



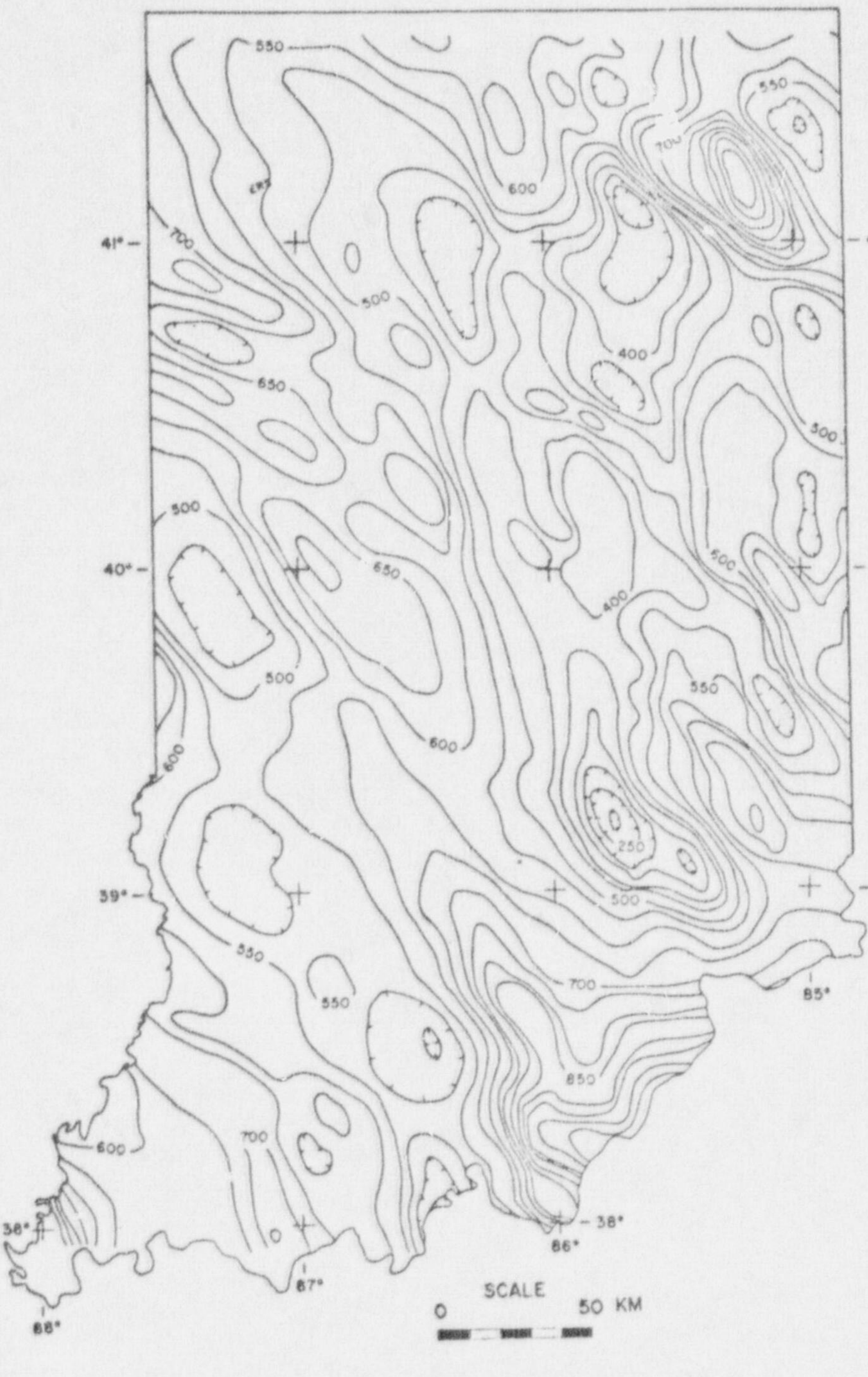
INDIANA AEROMAGNETIC ANOMALY MAP
REDUCED TO THE POLE, UPWARD CONTINUED TO 10 KM
CONTOUR INTERVAL = 50 GAMMAS

Figure 32



INDIANA AEROMAGNETIC ANOMALY MAP
REDUCED TO THE POLE, UPWARD CONTINUED TO 20 KM
CONTOUR INTERVAL = 50 GAMMAS

Figure 33

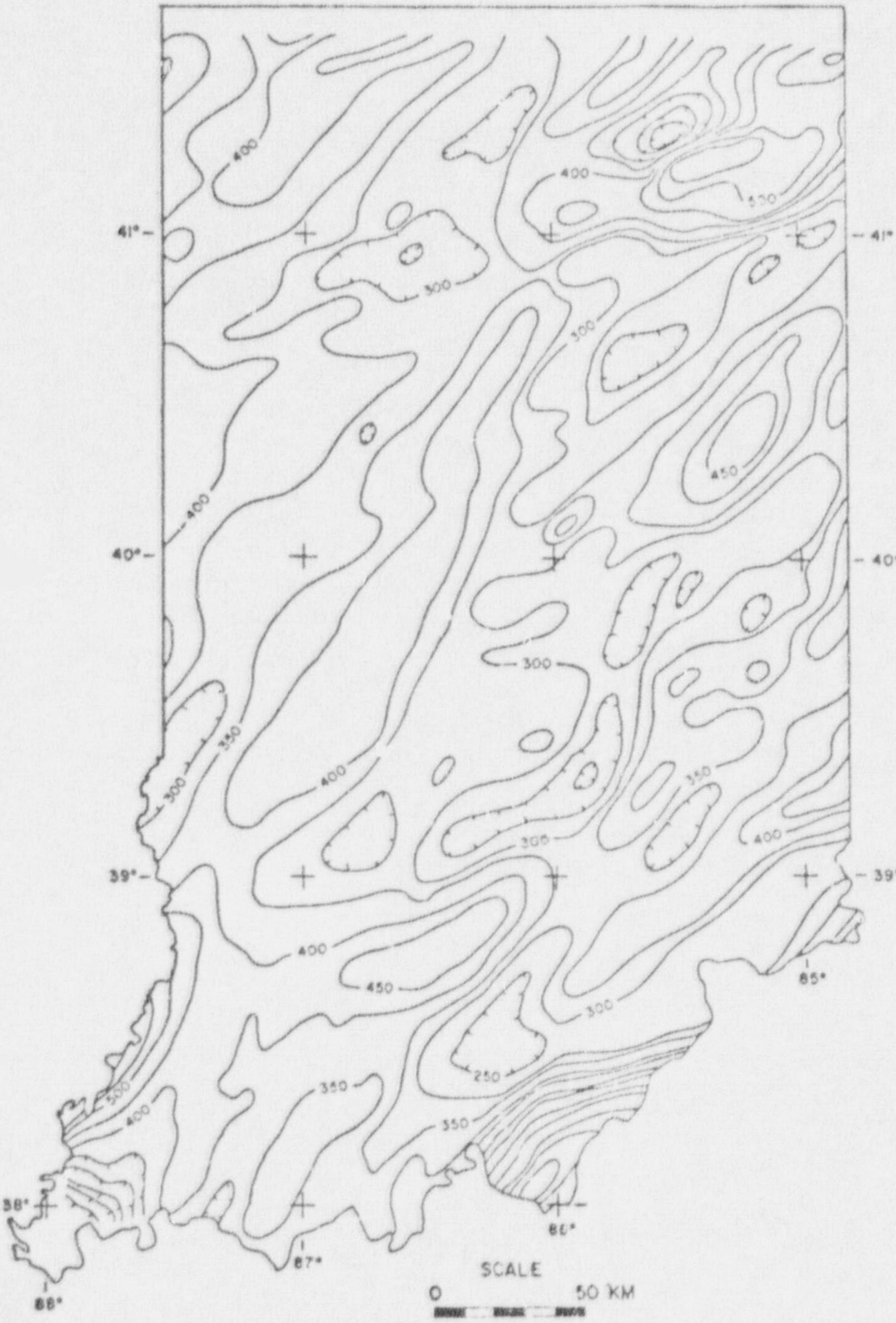


INDIANA AEROMAGNETIC ANOMALY MAP
UPWARD CONTINUED TO 5 KM, NW-SE STRIKE PASS
CONTOUR INTERVAL = 50 GAMMAS

Figure 34

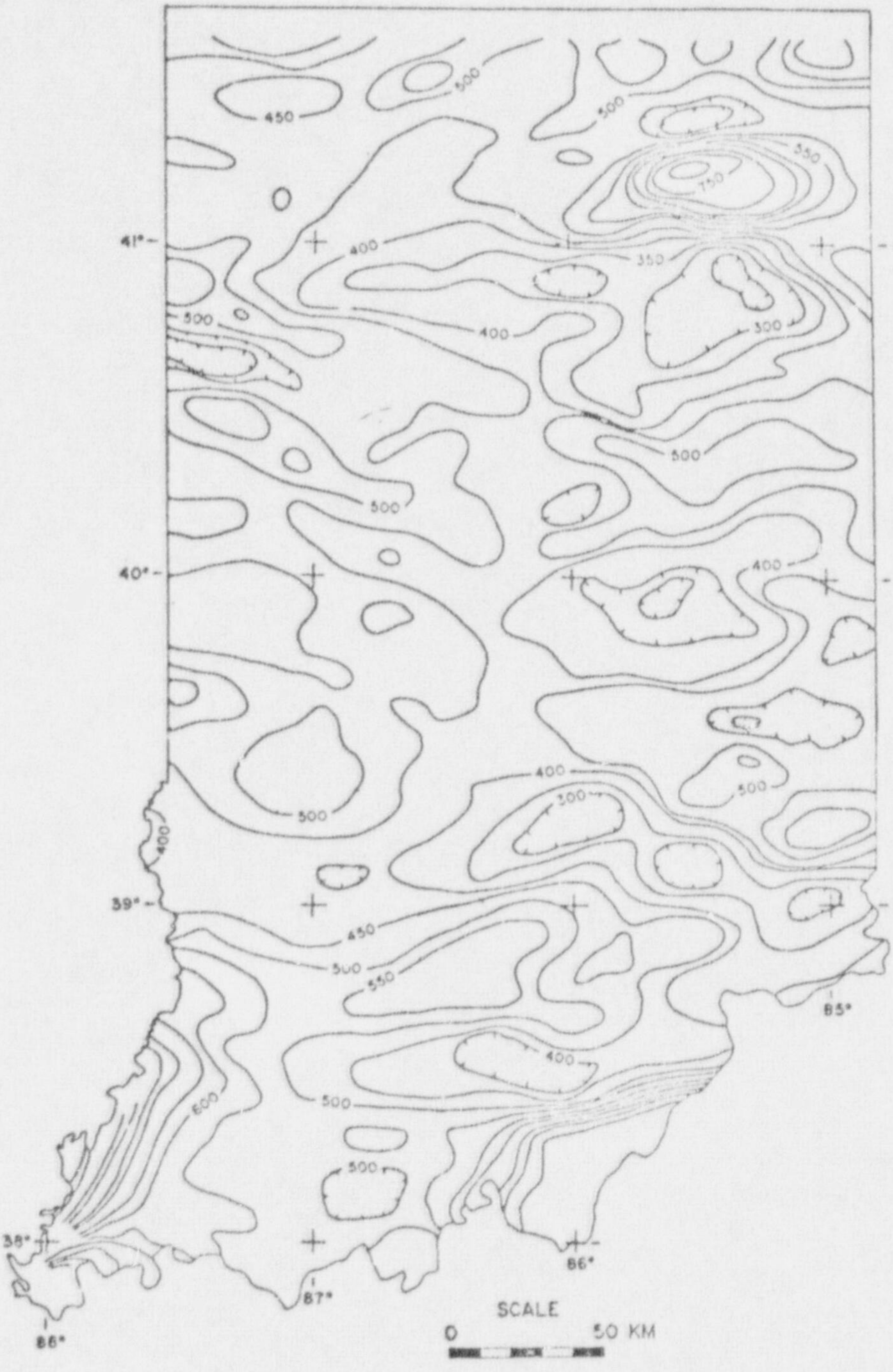
INDIANA AEROMAGNETIC ANOMALY MAP
UPWARD CONTINUED TO 5 KM, N-S STRIKE PASS
CONTOUR INTERVAL = 50 GAMMAS

Figure 35



INDIANA AEROMAGNETIC ANOMALY MAP
UPWARD CONTINUED TO 5 KM, NE-SW STRIKE PASS
CONTOUR INTERVAL = 50 GAMMAS

Figure 36



INDIANA AEROMAGNETIC ANOMALY MAP
UPWARD CONTINUED TO 5 KM, E-W STRIKE PASS
CONTOUR INTERVAL = 50 GAMMAS

Figure 37

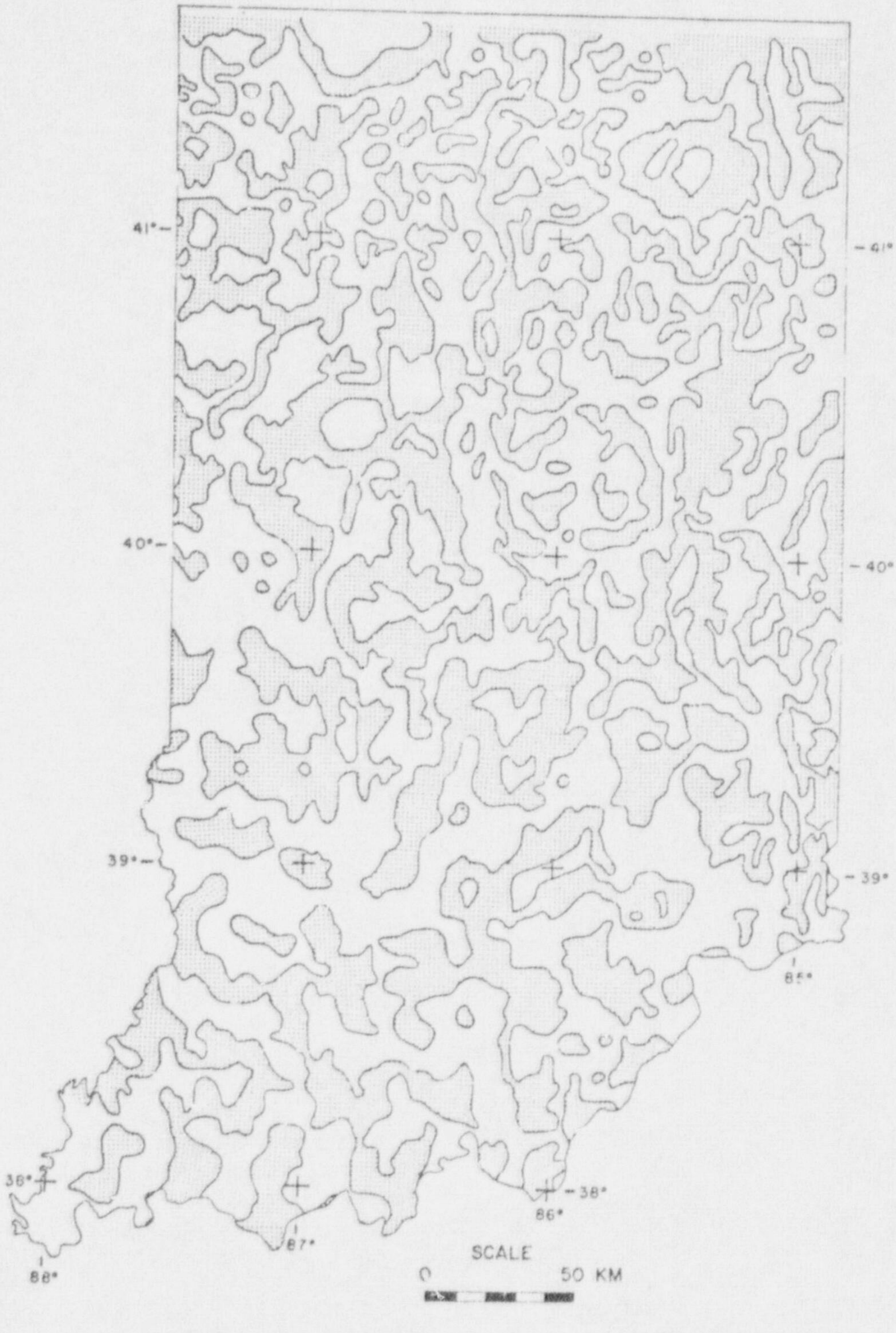


Figure 38

Second vertical derivative of the total magnetic intensity anomaly based on data observed at 2 km. Contours are zero second vertical derivative values. Patterned areas are positive values.

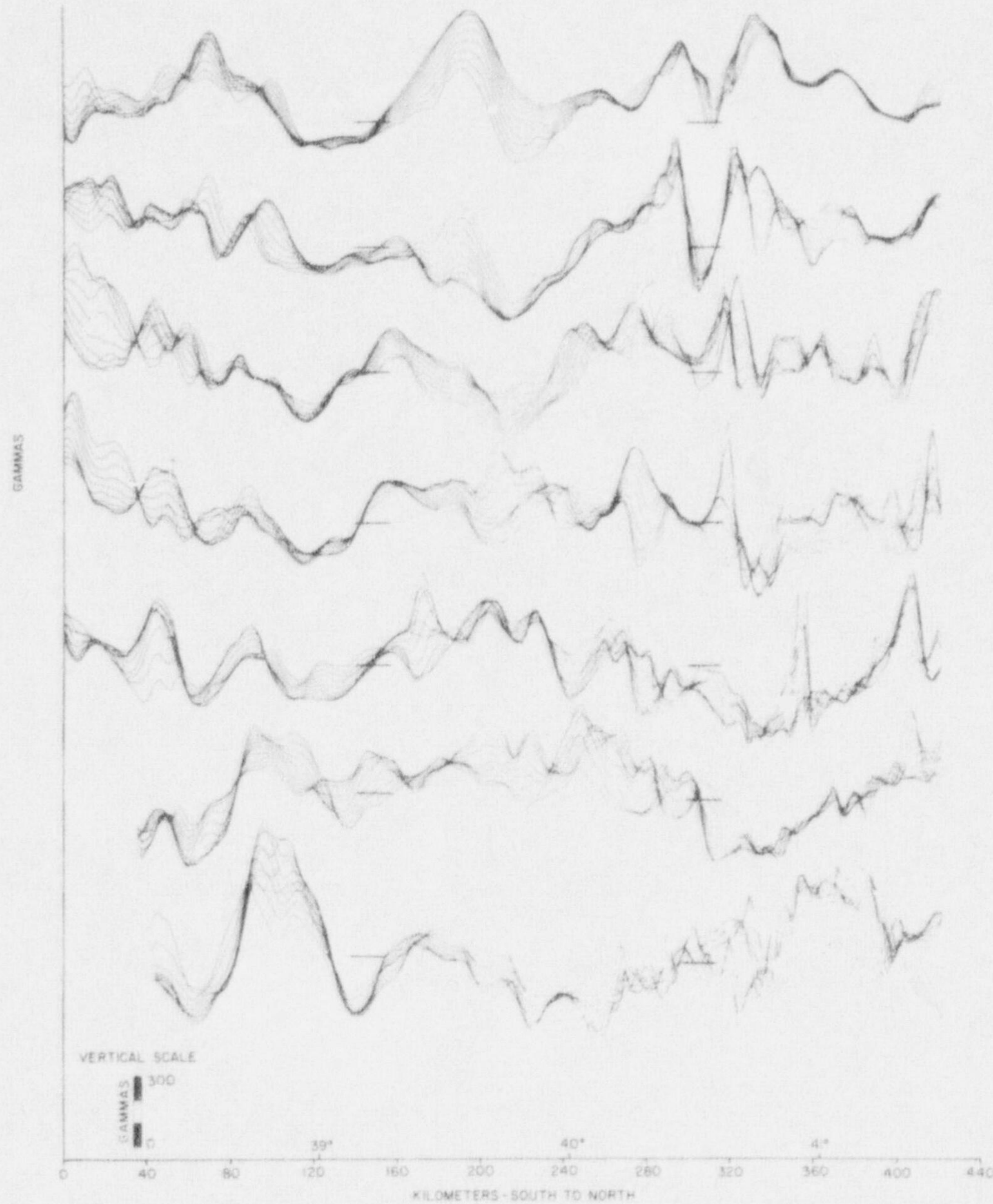


Figure 39 Stacked north-south total magnetic intensity anomaly profiles at 2 km spacing in groups of ten adjacent profiles based on data observed at 1000 ft AMT. Upper group of profiles commences at approximately 87°35'W longitude and lowest group is located at approximately 86°15'W. Horizontal lines are common arbitrary datum of 800 gammas.

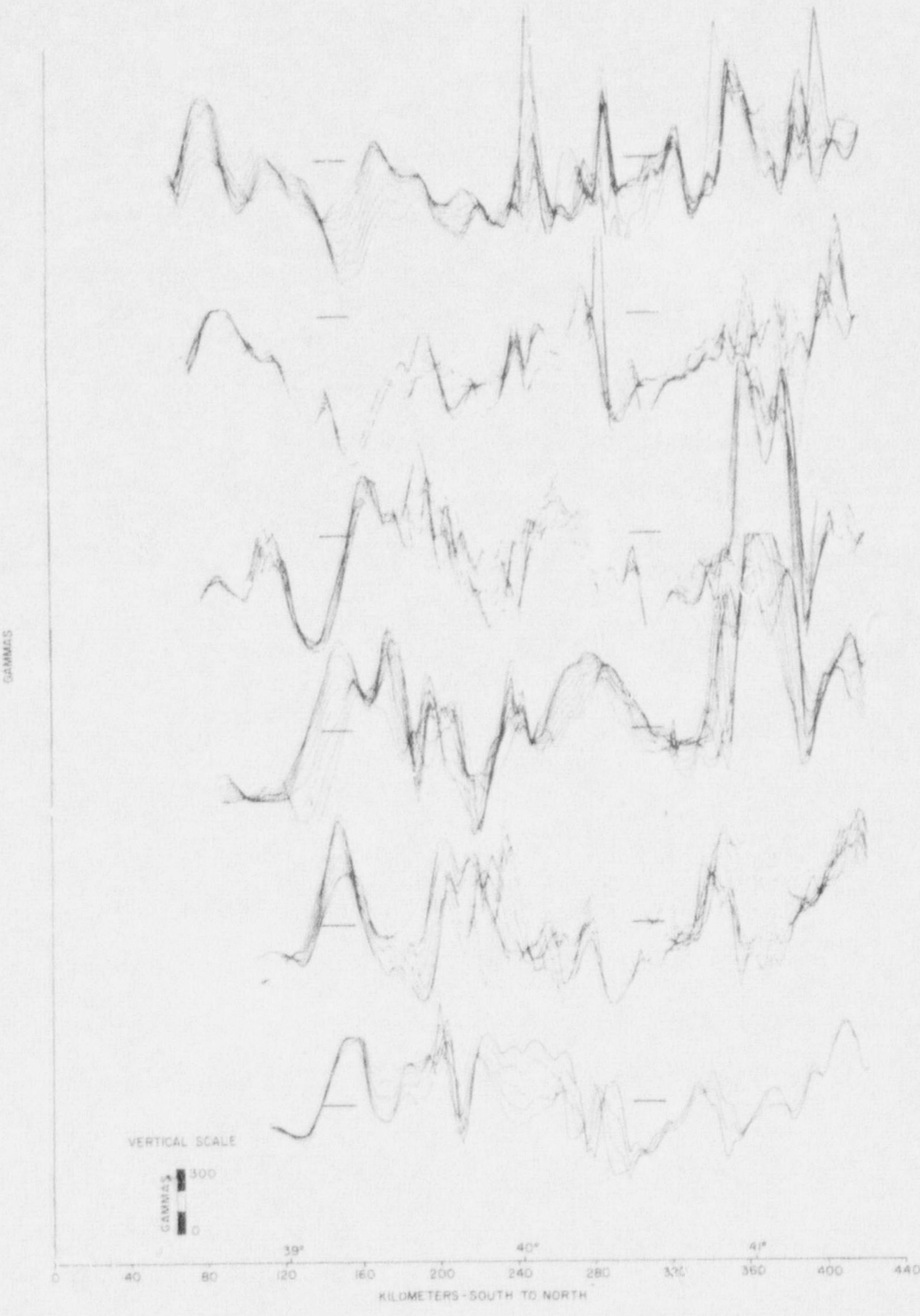


Figure 40 Stacked north-south total magnetic intensity anomaly profiles at 2 km spacing in groups of ten adjacent profiles based on data observed at 1000 ft AMT. Upper group of profiles commences at approximately 86°15'W longitude and lowest group is located at Indiana-Ohio boundary. Horizontal lines are common arbitrary datum of 800 gammas.

and in Missouri is being made available by the U.S. Geological Survey.

Seismic Refraction - During the last year, seismic refraction instrumentation has been developed and built for FM tape recording of crustal studies profiles. The seismic refraction equipment is based around the Sprengnether MEQ 800 seismograph and S-7000 seismometer. Seven of these instruments are available for use (four owned by Purdue, three owned by UTEP). The units have been designed and built for FM tape recording to increase the quality of data recorded in the field. A schematic diagram of the seismograph system is shown in Figure 41. In addition, two playback units and two blast recorders have been constructed for use in conjunction with the seismographs for refraction profiling using quarry and mine blasts as sources. One crustal seismic refraction line has been recorded along the Wabash River Valley Fault System in Indiana. The sources (strip coal mine blasts) and recording locations are shown in Figure 42 and examples of the recorded seismic traces are presented in Figure 43. The analysis of this refraction line has not been completed.

Basement Geology - During the past fiscal year, samples of available subsurface basement rocks in the study area and environs were obtained and detailed petrographic studies have been conducted on them. Figure 44 shows the distribution of the drill holes to basement and the predominant basement

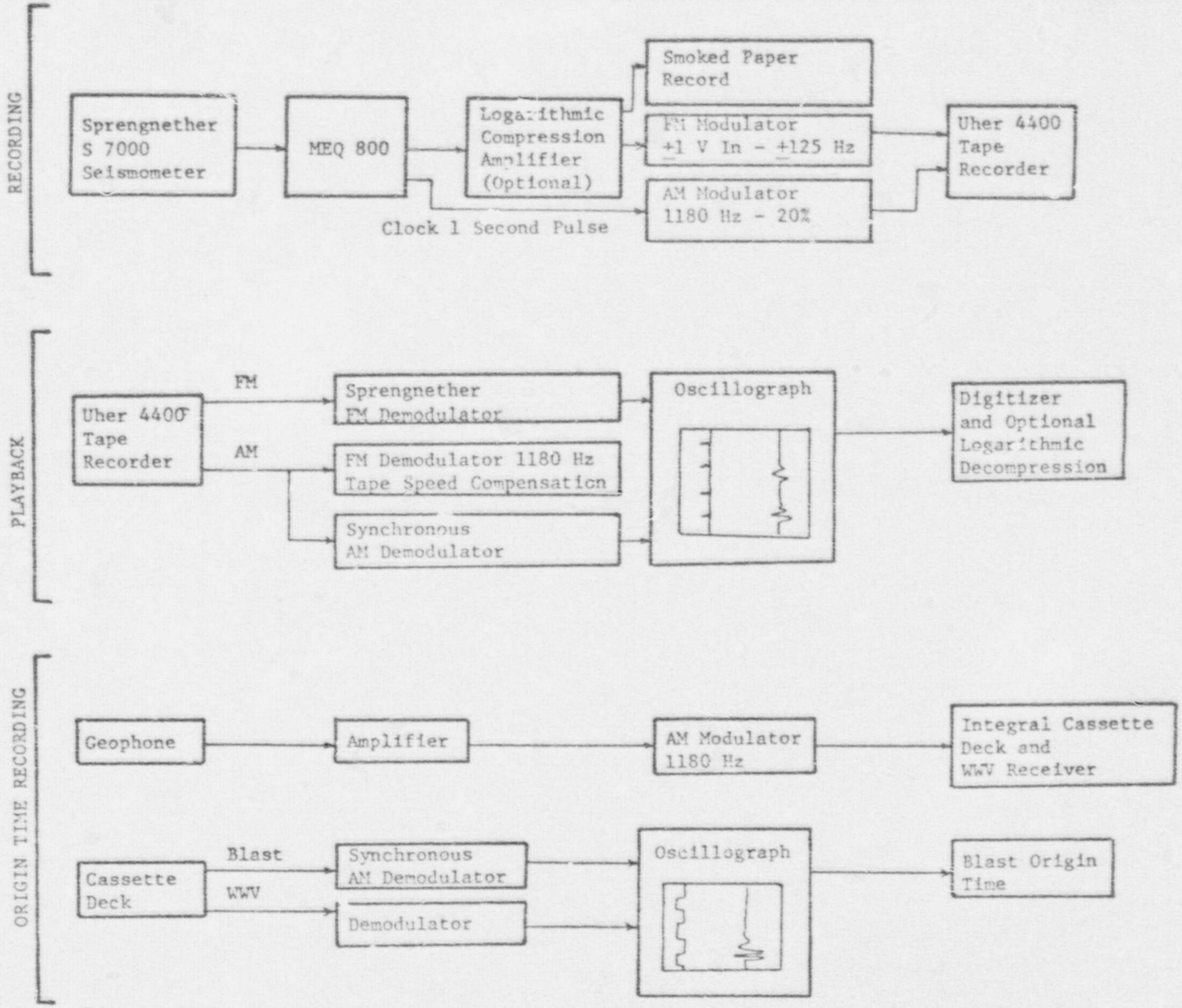


Figure 41

Schematic diagram showing seismograph instrumentation to be utilized for crustal seismic refraction profiling.

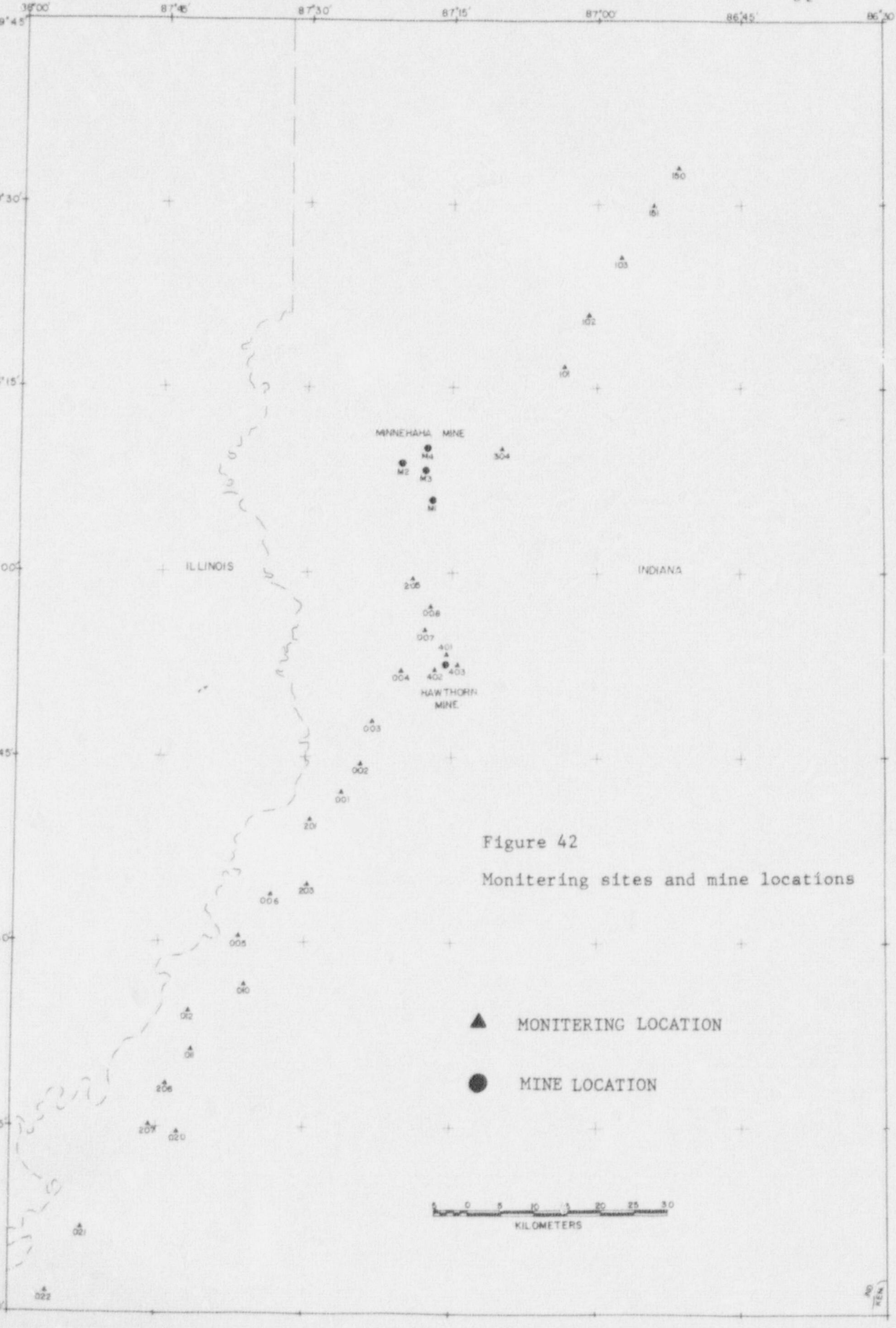


Figure 42
Monitering sites and mine locations

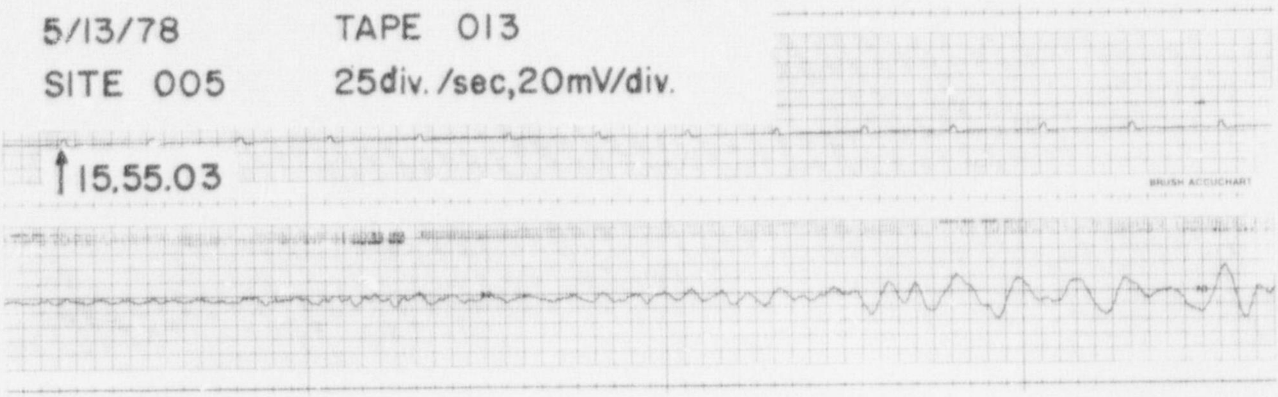
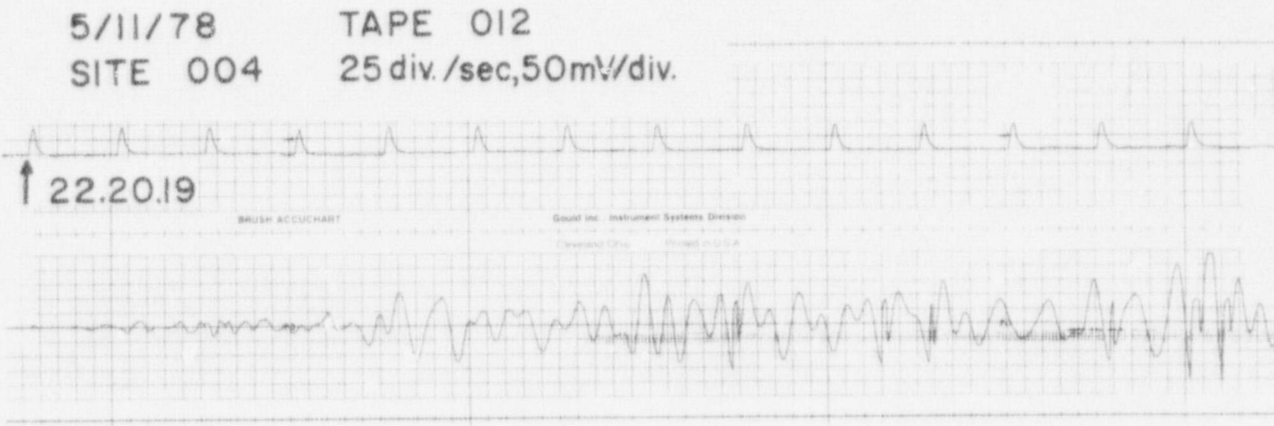
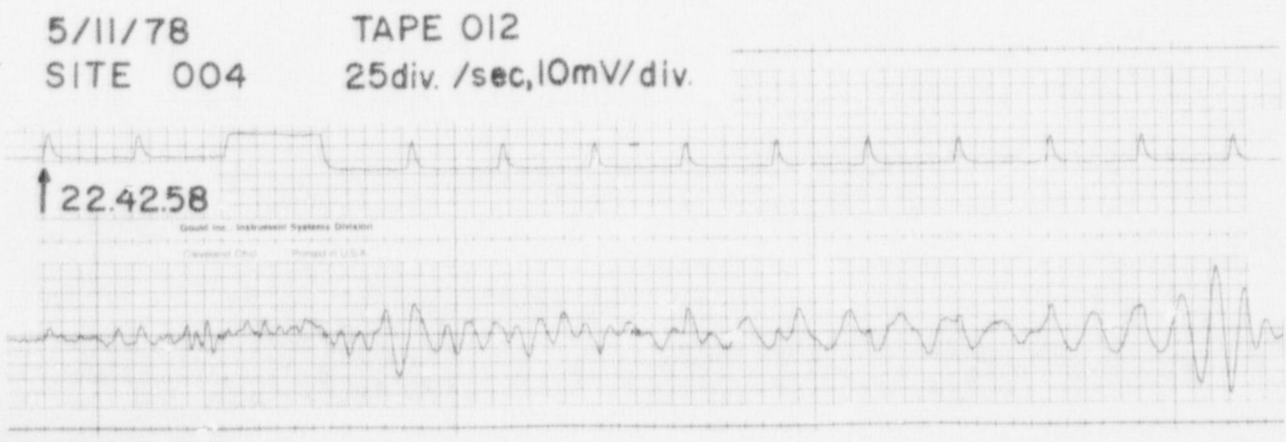


Figure 43a Representative seismic records





5/11/78 TAPE 012
SITE 004 25div./sec,20mV/div.

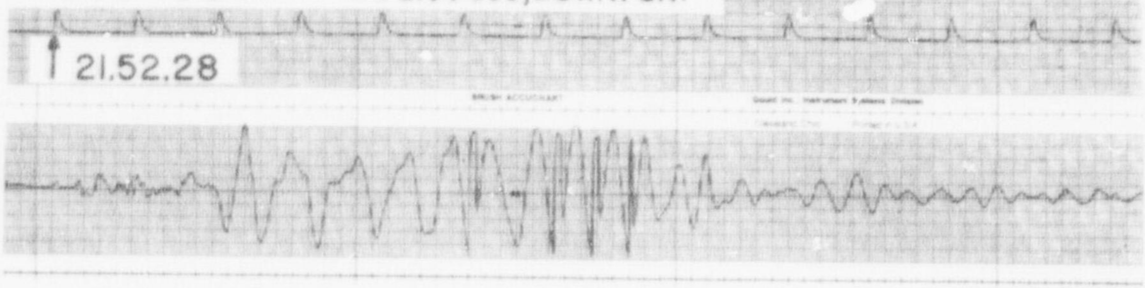
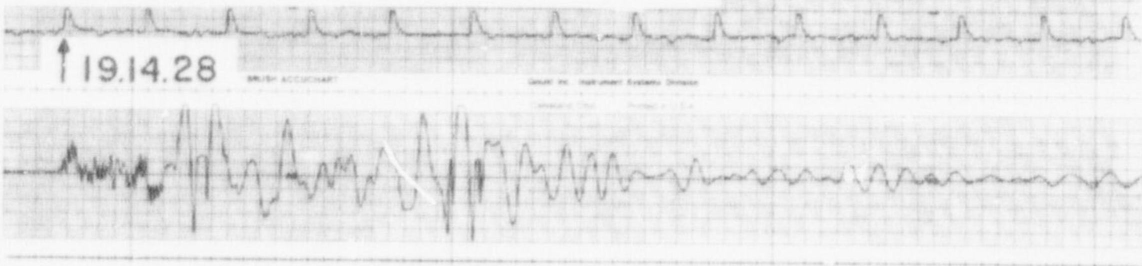
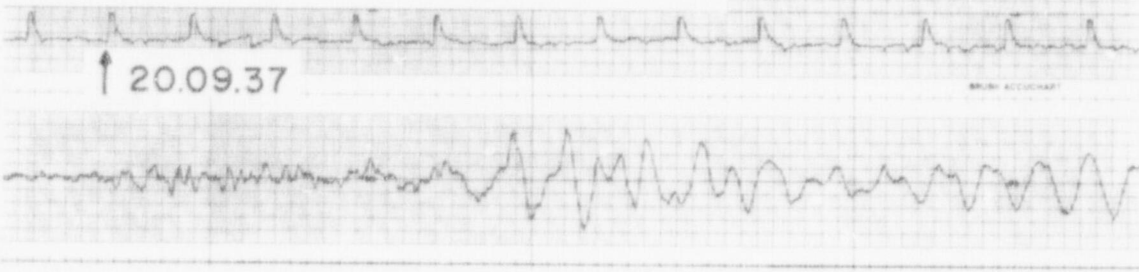


Figure 43b

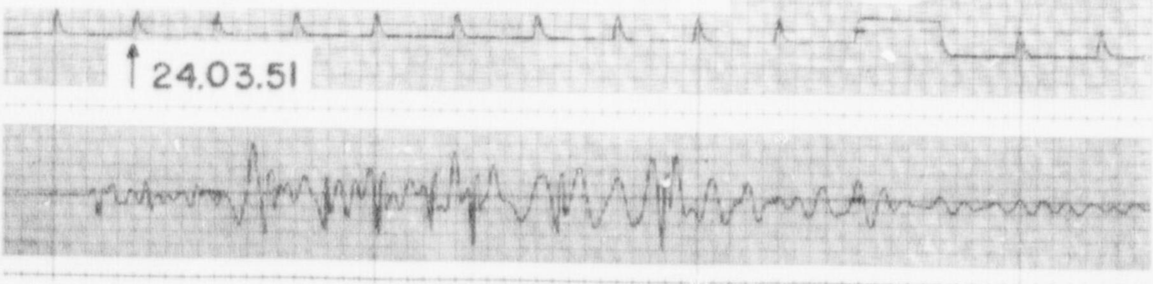
5/12/78 TAPE 211
SITE 007 25div./sec,50mV/div.

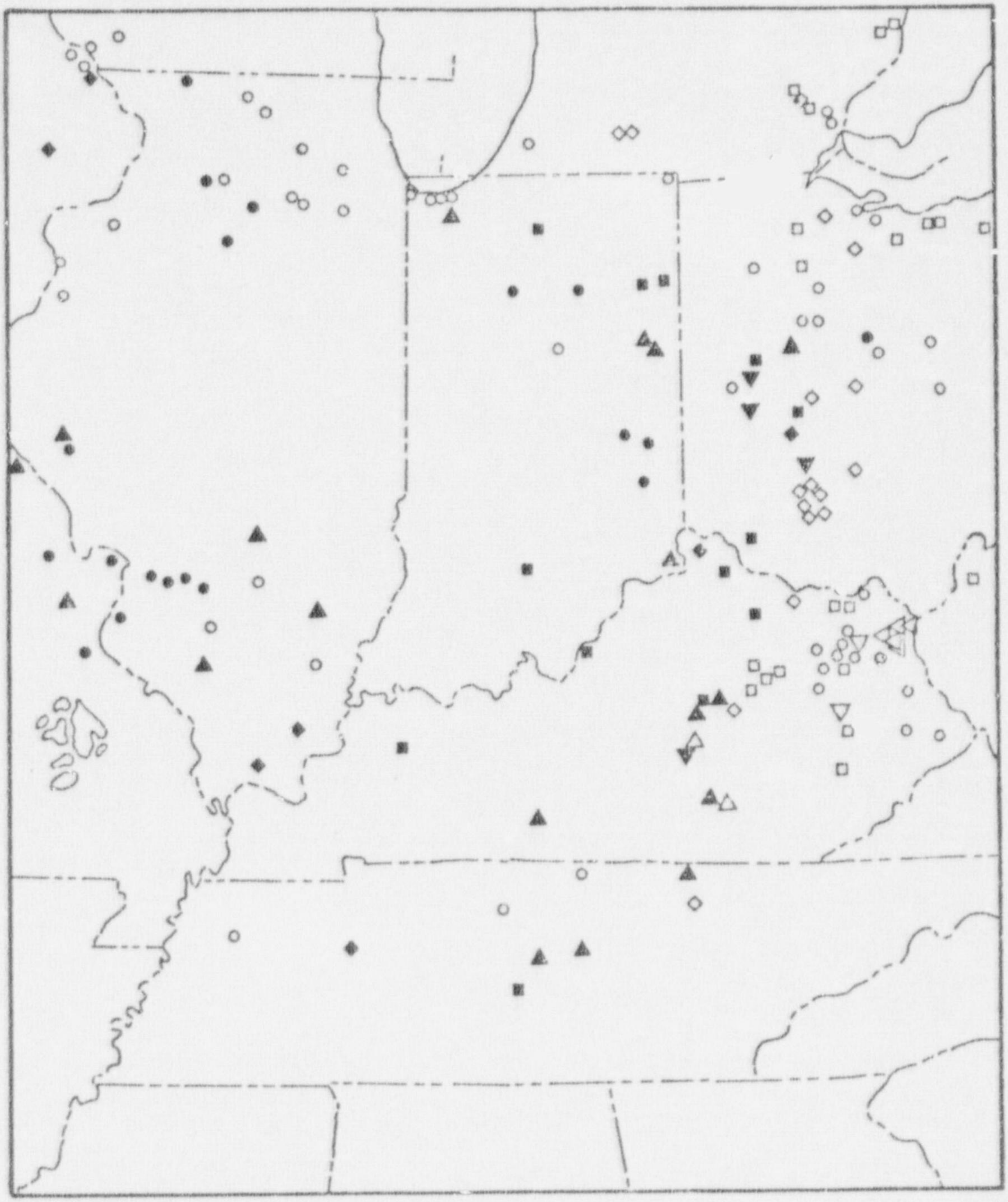


5/17/78 TAPE 211
SITE 007 25div./sec,20mV/div.



5/11/78 TAPE 012
SITE 004 25 div./sec,50mV/div.





Sedimentary Rock ◆
Basalt ■
Rhyolite ▲
Trachyte ▼
One-Feldspar Granite ●
Anorthosite ◁
Gabbro or Diorite ▽
Two-Feldspar Granite ○
Low Grade Metamorphic Rock △
Medium Grade Metamorphic Rock ◇
Granitic Gneiss □

Figure 44

Distribution of wells to basement and basement rock type, East-Central United States.

rock lithology encountered in each well. A preliminary basement rock lithologic map has also been prepared and is presented as Figure 45 and its legend is given in Figure 46. This map is based on Figure 44 and preliminary correlation of rock type with small-scale regional Bouguer gravity anomaly maps. Revision of this map is continuing as new samples and data become available. A map showing the configuration of the basement surface for the region is also being compiled.

Sampling of the ultramafic and mafic intrusions in the Upper Mississippi Embayment areas has also been initiated and petrographic studies are underway.

Interpretation - Although the primary emphasis during the past fiscal year has been on preparation for field studies and acquisition, reduction and presentation of data, considerable progress has been made in preparing data sets for interpretation and conducting preliminary interpretation. The preliminary basement rock map, Figure 45, is an excellent example.

The report entitled "A Tectonic Overview of the Central Midcontinent" has been modified and published as a U.S. Nuclear Regulatory Commission Technical Report NUREG-0382 (R6A). It is being additionally modified and supplemented for consideration as a scientific journal article. Accompanying the Tectonic Overview is a comprehensive bibliography of references on the structure, tectonics, basement and geophysics of the New Madrid Seismic Zone and adjacent areas.

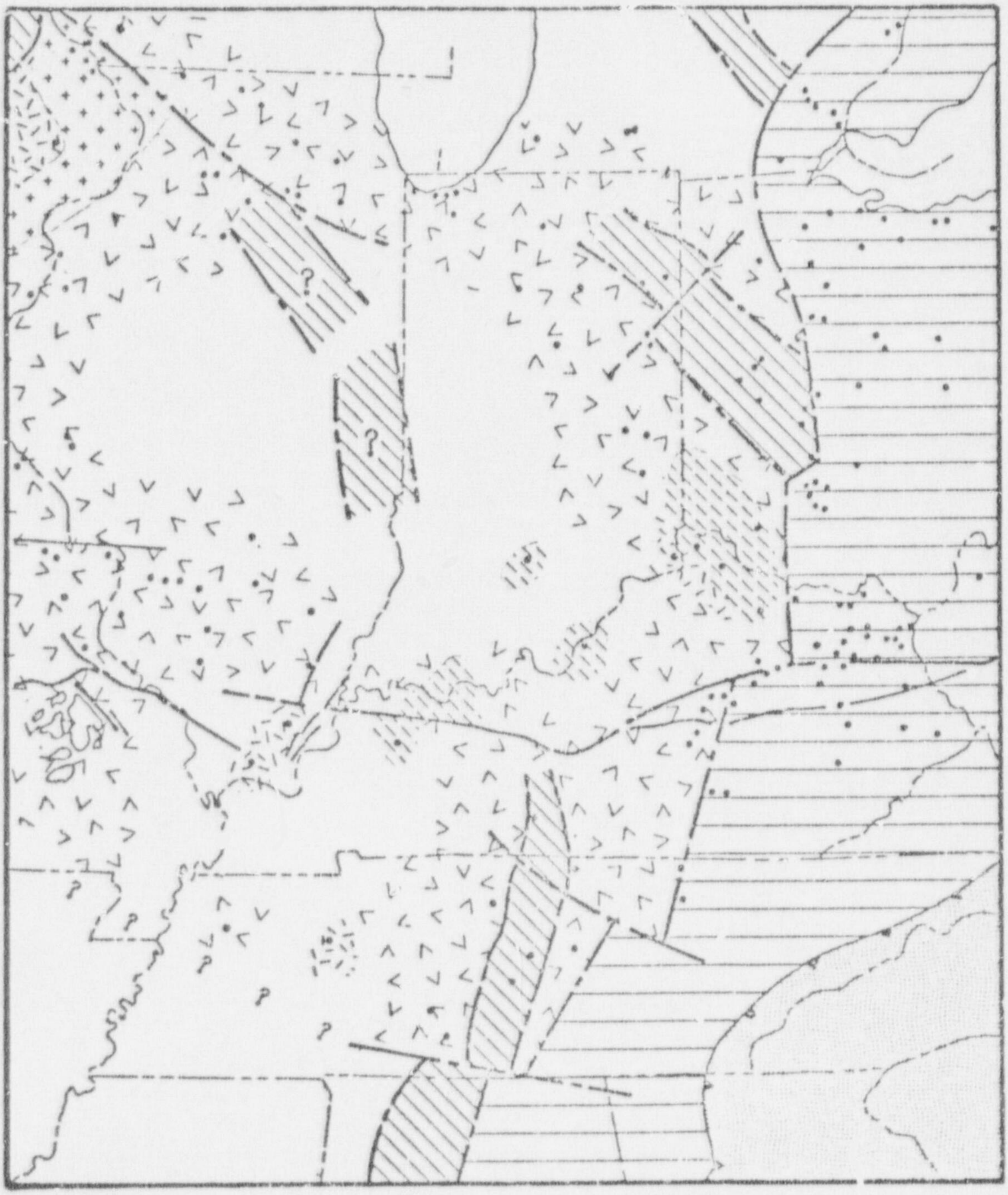
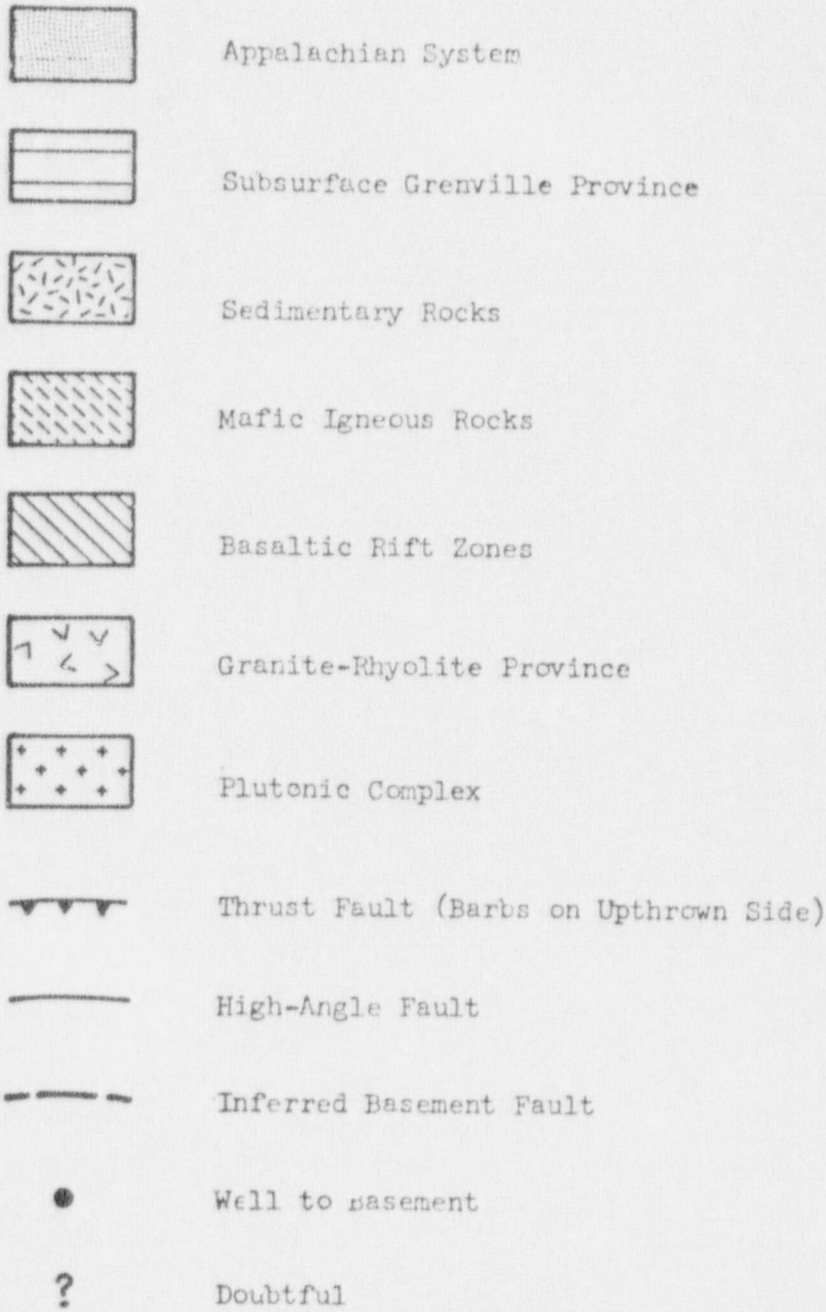


Figure 45

Preliminary basement rock map, East-Central United Stat‹ s.



Legend for basement rock map of East-Central United States.

Figure 46

Each of these references is encoded with a group of digital classifiers that permit rapid access to the particulars of the reference. The list of classifiers is presented in Figure 47.

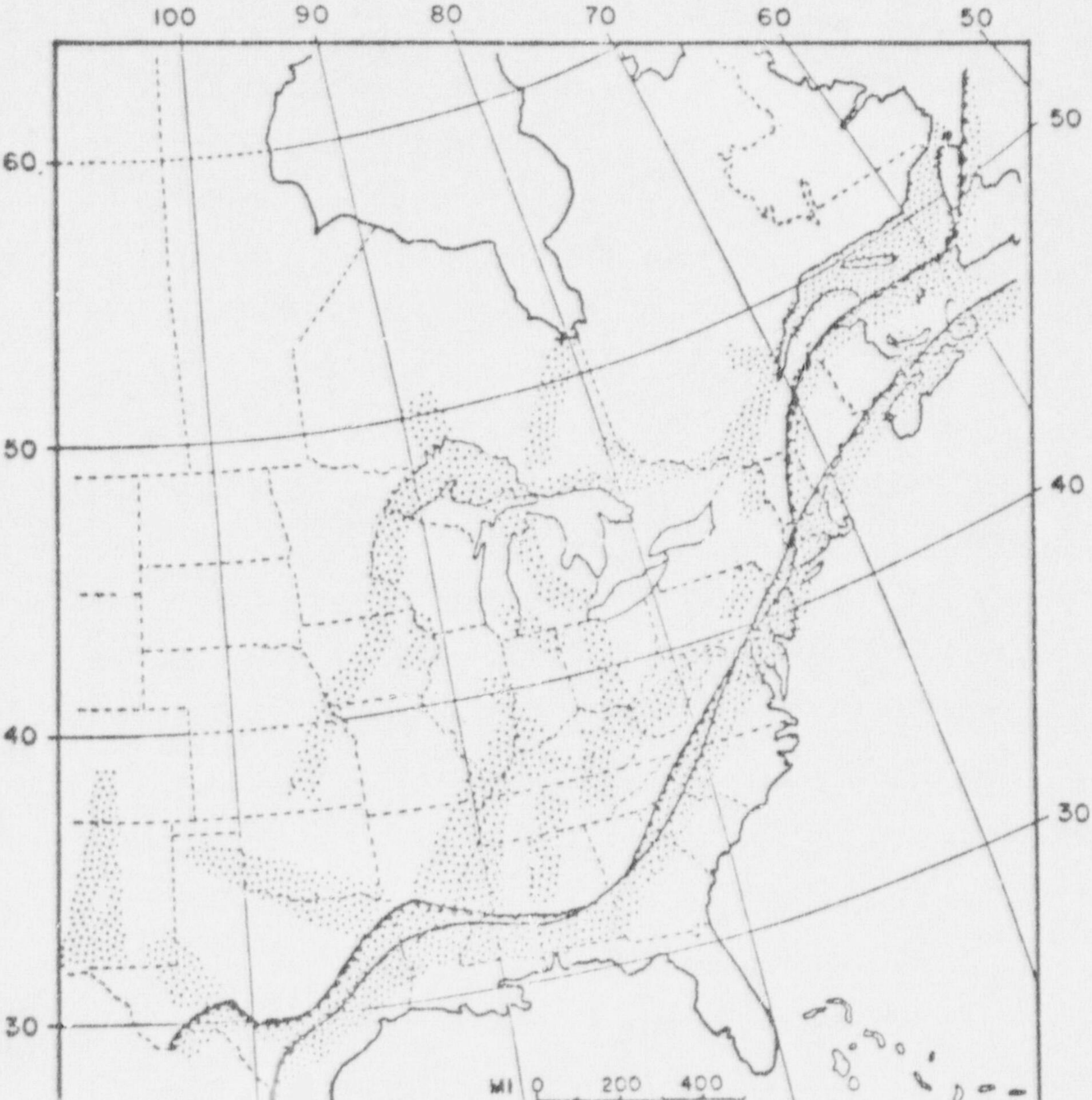
An important element of the Tectonic Overview is a discussion of the possible mechanisms for the contemporary geodynamics of the midcontinent. It has become evident from this review and midcontinent geophysical studies that continental rifting may play a very significant role either directly or indirectly in this tectonism. Thus, a review has been initiated of continental rifts - their origin, surface and deep crustal manifestation, and occurrence in the central and eastern midcontinent. Figure 48 shows the location of all possible rifts identified in the central and eastern midcontinent. The abstract of a preliminary paper presented on this topic is given on Figure 4.

Additional interpretation of geophysical data are reported in the abstracts (Figure 4) of papers presented by Richardson and others (1977) and Johnson and Keller (1977). There are many features of the geophysical maps which are of great geologic interest that have been discussed in a preliminary manner in these papers. Some of the more interesting occur in Indiana. Tentatively, a northeast striking feature has been identified extending across the State from the southwestern corner. It has been observed by the change of wave-number characteristics and termination of anomalies on the magnetic anomaly map and

CLASSIFIER FOR SELECTED REFERENCES ON THE STRUCTURE, TECTONICS, BASEMENT AND GEOPHYSICS OF THE NEW MADRID SEISMIC ZONE AND ADJACENT AREAS.

ID	LOCATION	STRUCTURE	AGE	DATA TYPE	PHYSICAL PROPERTIES	ILLUSTRATIONS	SPECIFIC FEATURES	GENERAL SUBJECTS
	MIDWEST MISSISSIPPI EMBAYMENT ARKANSAS ILLINOIS INDIANA KENTUCKY MISSISSIPPI MISSOURI OHIO TENNESSEE OTHER	BASEMENT CRYPTOVOLCANIC FAULTS AND LINEAMENTS INTRUSIVES RIFTS SEDIMENTARY	PRECAMBRIAN PALEOZOIC MESOZOIC CENOZOIC RECENT	AEROMAGNETIC GROUND MAGNETIC CRUSTAL SEISMIC SEISMICITY STRESS ANALYSIS ELECTRICAL GEOCHRONOLOGY GRAVITY HEAT FLOW REMOTE SENSING SUBSURFACE GEOLOGY VERTICAL MOVEMENT SURFACE GEOLOGY [illegible]	DENSITY GEOCHEMISTRY MINERALIZATION PETROLOGY REMANENT MAGNETIC SUSCEPTIBILITY VELOCITY	BASEMENT CONFIGURATION - MAPS BASEMENT LITHOLOGY + MAPS GEOLOGICAL CROSS-SECTIONS GEOPHYSICAL CONTOUR MAPS STRUCTURAL CONTOUR-ISOPACH MAPS GEOLOGIC MAPS [illegible]	GRENVILLE FRONT 38th PARALLEL LINEAMENT NEW MADRID MISSISSIPPI EMBAYMENT ST. FRANCOIS MTNS.	GEODYNAMICS RIFTING THEORY THERMAL EVOLUTION PRESENT TECTONICS WARPING THEORY STRATIGRAPHY EARTHQUAKE PREDICTION

Figure 47



Preliminary map of continental rifts of the midcontinent .

Figure 48

the various derived maps illustrated previously. It is also discernable in the Bouguer gravity anomaly map (Figure 14). This feature (Figure 49) is particularly notable because of its association with the Wabash River Valley Fault System and because it is on strike and has characteristics in common with the geophysical expression of the New Madrid Seismic Zone. However, a direct connection has not been observed between these two features. Future composited geophysical maps will be studied for a possible connection. Figure 49 also shows the interpreted position of two linear east-west striking magnetic minima that extend discontinuously across the State. The positions of these minima are also indicated on the stacked grouped magnetic anomaly profiles shown in Figure 50 and 51. These minima may represent the northern extremeties of the tectonism associated with the 38th Parallel Lineament.

Major Products - The major products completed to date include the following:

1) Develop computer codes for gridding, contouring, and processing gravity and magnetic data.
2) Prepare Bouguer gravity anomaly maps of western Kentucky.
3) Conduct gravity survey of central Kentucky and southwestern Indiana, reduce data and prepare preliminary Bouguer gravity anomaly maps.

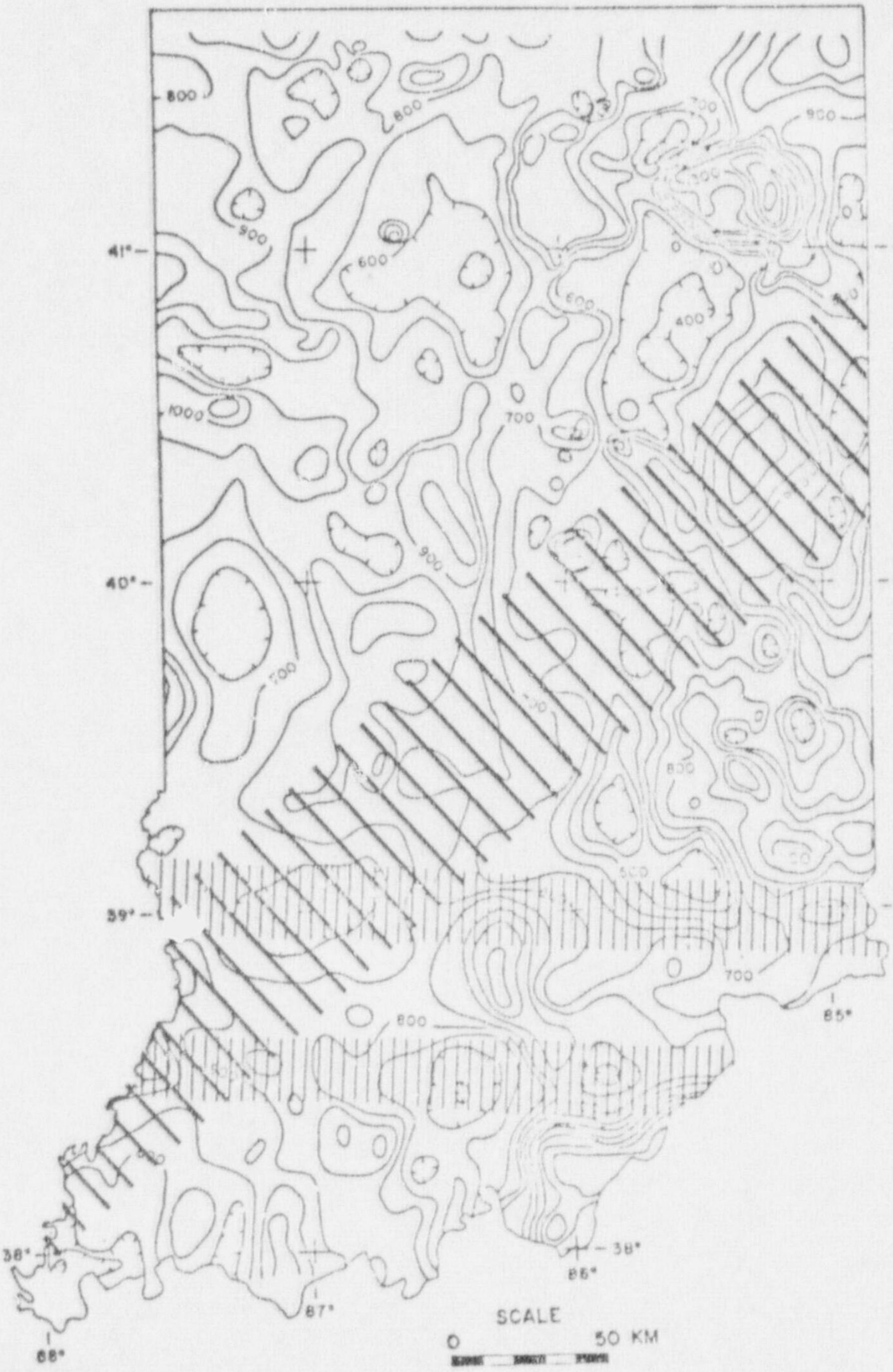


Figure 49

Patterned areas identify interpreted anomalous trends

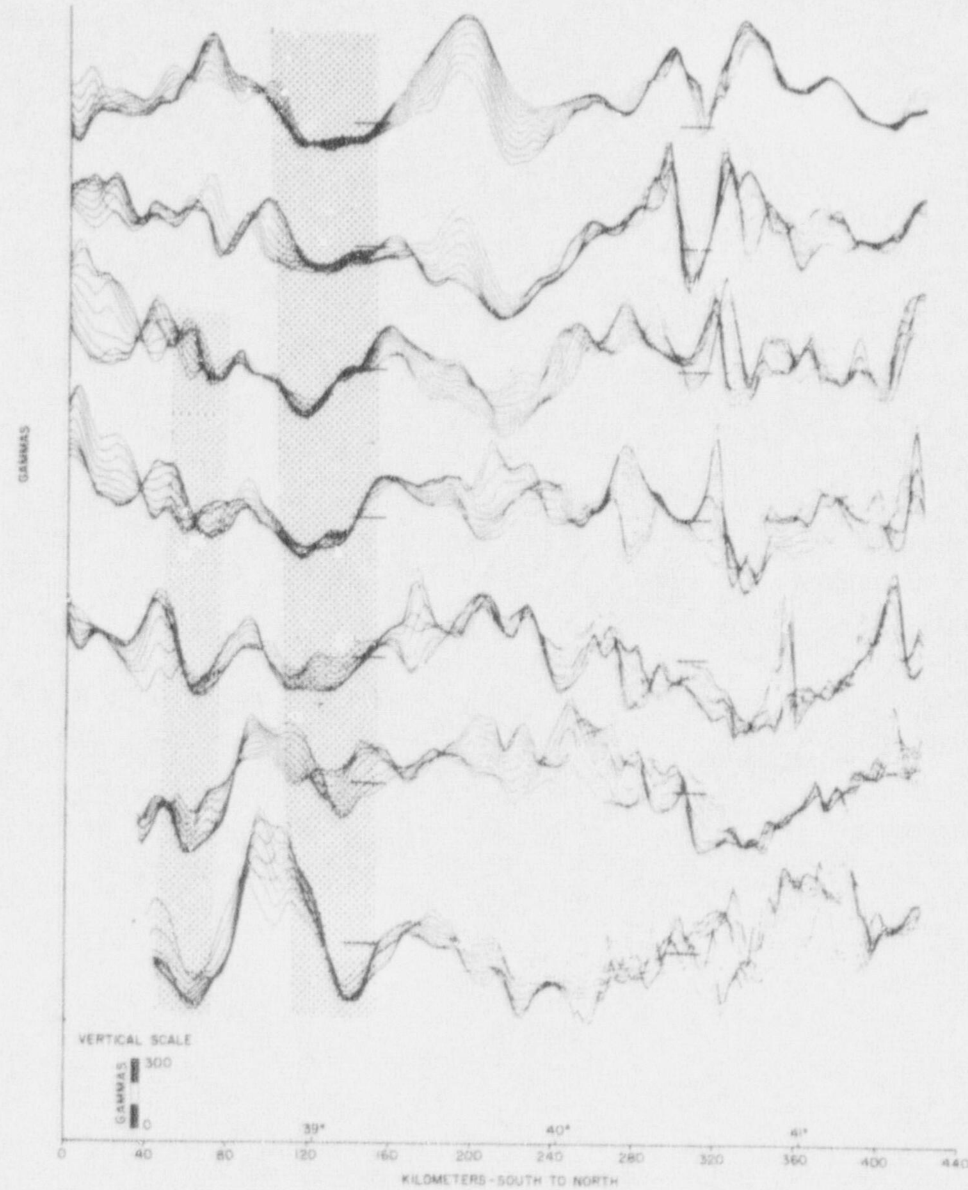


Figure 50 Stacked north-south total magnetic intensity anomaly profiles at 2 km spacing in groups of ten adjacent profiles based on data observed at 1000 ft AMT. Upper group of profiles commences at approximately 87°35'W longitude and lowest group is located at approximately 86°15'W. Horizontal lines are common arbitrary datum of 800 gammas. Patterned areas delineate interpreted continuous east-west striking magnetic minima

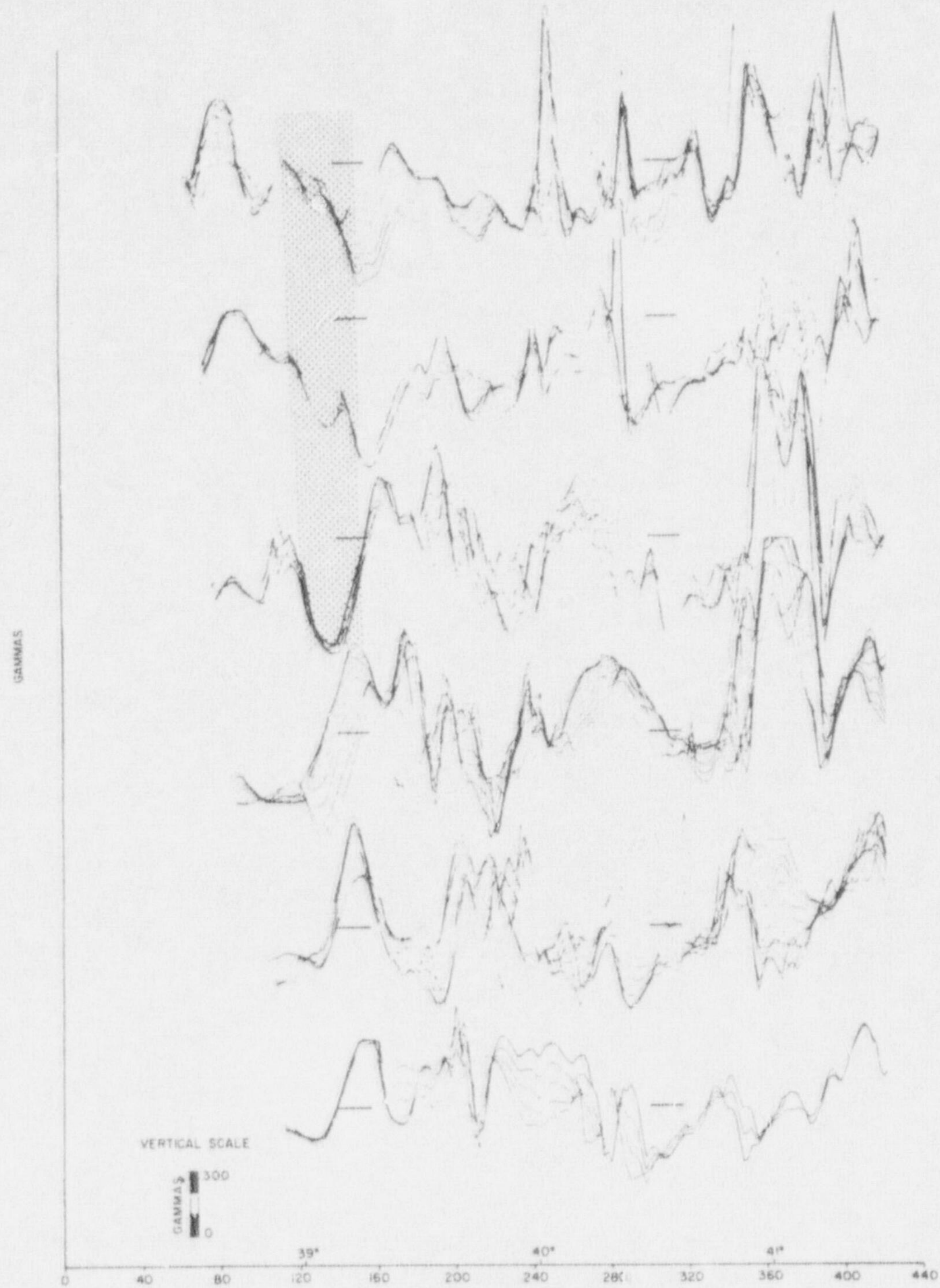


Figure 51 Stacked north-south total magnetic intensity anomaly profiles at 2 km spacing in groups of ten adjacent profiles based on data observed at 100 ft AMT. Upper group of profiles commences at approximately 86°15'W longitude and lowest group is located at Indiana-Ohio boundary. Horizontal lines are common arbitrary datum of 800 gammas. Patterned area delineate interpreted continuous east-west striking magnetic minimum .

4) Prepare Bouguer gravity anomaly maps of Dyersburg Sheet (88°-90°W and 36°-37°N) and Paducah Sheet (88°-90°W and 37°-38°N).
5) Digitize and grid southwestern Illinois (south of 39°N and west of 89°W) aeromagnetic data.
6) Digitize and grid Indiana aeromagnetic data. Analyze geomagnetic field removal problem and prepare total magnetic intensity anomaly map. Prepare interpretational maps (filter, second derivative, etc.) and preliminary interpretation.
7) Conduct aeromagnetic survey of southeastern Illinois (south of 39°N and east of 89°W), reduce data, and prepare anomaly map. Complete aeromagnetic tie lines across Illinois and Indiana.
8) Prepare seismic equipment for crustal seismic studies and conduct a refraction line along Wabash River Valley Fault System.
9) Prepare preliminary basement rock and configuration of basement surface maps from basement drill hole records and samples.
10) Prepare bibliography on tectonics of the New Madrid area.
11) Prepare "Tectonic Overview of the Central Midcontinent".
12) Initiate petrologic investigation of the ultramafic and mafic intrusions of the midcontinent.

REFERENCES

Buschbach, T.C., 1977. New Madrid Seismotectonic Study, Activities during fiscal year 1977: U.S. Nuclear Regulatory Commission Report NUREG-0379, 61 p.

Heyl, A.V., 1972. The 38th Parallel Lineament and its relationship to ore deposits: Econ. Geology, v. 67, pp. 879-894.

Hildenbrand, T.G., M.F. Kane, and W. Stauder, S.J., 1978. Magnetic and gravity anomalies in the northern Mississippi Embayment and their spatial relation to seismicity: U.S.G.S. Map MF-914.

Hinze, W.J., L.W. Braile, G.R. Keller and E.G. Lidiak, 1977. A tectonic overview of the central midcontinent: U.S. Nuclear Regulatory Commission Report NUREG-0382 (R6A), 106 p.

Regan, R.D. and J.C. Cain, 1975. The use of geomagnetic field models in magnetic surveys: Geophysics, v. 40, pp. 621-629.

Stearns, R.G. and C.W. Wilson, Jr., 1972. Relationships of earthquakes and geology in west Tennesses and adjacent areas: Tennessee Valley Authority, 128 p.

NRC FORM 335 (7-77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by DDC): NUREG/CR-0449

4. TITLE AND SUBTITLE (Add Volume No., if appropriate): AN INTEGRATED GEOPHYSICAL AND GEOLOGICAL STUDY OF THE TECTONIC FRAMEWORK OF THE 38TH PARRALLEL LINEAMENT IN THE VICINITY OF ITS INTERSECTION WITH THE EXTENSION OF THE NEW MADRID FAULT ZONE.

2. (Leave blank)

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S): L. W. BRAILE W.J. HINZE G.R. KELLER: and E.G. Lidiak

5. DATE REPORT COMPLETED: MONTH June | YEAR 1978

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Purdue University
Department of Geosciences
West Lafayette, Indiana 47907

DATE REPORT ISSUED: MONTH | YEAR

6. (Leave blank)

8. (Leave blank)

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Office of Nuclear Regulatory Research
Division of Reactor Safety Research
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.: AT(49-24)-0323

13. TYPE OF REPORT: GEOTECHNICAL

PERIOD COVERED (Inclusive dates): June 1977-June 1978

15. SUPPLEMENTARY NOTES

14. (Leave blank)

16. ABSTRACT (200 words or less) Remote sensing surveys in areas of project study have been conducted. Aeromagnetic maps have been digitized and processed by computer programs. Seismic profiling has begun and a refraction line run along the Wabash River Valley Fault system. Preliminary basement rock and configuration maps were made from drill hole sample data. Data interpretation is in a preliminary stage but suggest that 38th parallel Lineament features extend to 39°N and a northeasterly-striking magnetic and gravity anomaly crosses the southwest corner of Indiana on strike with the New Madrid Seismic Zone.

17. KEY WORDS AND DOCUMENT ANALYSIS
Mississippi Valley; New Madrid, Fault, Seismic, Wabash Valley Aeromagnetic; Gravity, Tectonic

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT

19. SECURITY CLASS (This report): Unclassified

20. SECURITY CLASS (This page): Unclassified

21. NO. OF PAGES

22. PRICE: $

NRC FORM 335 (7-77)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. NUCLEAR REGULATORY
COMMISSION

U.S. MAIL