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NRC Research and Technical Assistance Report

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INTERIM REPORT

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To: Director
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Nuclear Regulatory Commission
Washington, D.C.

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During the previous quarter, significant progress has been made on all phases of the contract. The results achieved have been detailed in the "Progress to Date" chapter of the 1979-1980 proposal that has recently been prepared for submission to the Nuclear Regulatory Commission. This chapter and the accompanying figures has been extracted from the proposal and is attached.

In addition a "Bibliography of Studies on Continental Rifts" has been prepared and is attached.

NRC Research and Technical
Assistance Report

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PROGRESS TO DATE

Introduction - The principal progress in this integrated study program has been in acquiring and sythesizing critical magnetic, gravity, and geologic data; conducting crustal seismic investigations; and in interpretation of the available data. The following segments of this section briefly describe the progress and results to data (1 April, 1979) and plans for the last quarter of the 1979 fiscal year.

An oral presentation on the progress and results of the study was made to the New Madrid Study Group at St. Louis, Missouri on 27 September, 1978 and another will be made on 9 April, 1979 in Mountain View, Arkansas. Three technical papers (Figure 4) reporting the results of this study were presented at the Fourth Annual Midwest American Geophysical Union Meeting, 25-27 September, 1978; one paper was presented (Figure 5) at the Geological Society of America annual meeting on 25 October, 1978; one paper (Figure 6) was presented at the International Symposium on the Rio Grande Rift during 8-17 October, 1978; and five papers (Figure 7) will be read before the South-Central Section of the Geological Society of America on 9-10 April, 1979. In addition one Nuclear Regulatory Commission report was published (Braile and others, 1978). A paper entitled "Models for Midcontinent Tectonisms" (Hinze and others, 1979) which is an outgrowth of a previous Nuclear Regulatory Commission Report (Hinze and others, 1977) will soon be published in the National Academy of Sciences' Monograph "Continental Tectonics." Furthermore, three manuscripts by principals of this study have been accepted for publication in a forthcoming U.S. Geological Survey Professional Paper dealing with the New Madrid Seismic Zone. They are "High resolution seismic reflection surveying on Reelfoot Scarp, Northwestern Tennessee" by J. L. Sexton,

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E. P. Frey, and Dave Malicki, "A crustal structure study of the Mississippi Embayment" by C.B. Austin and G.R. Keller, and "The northeastern extension of the New Madrid Fault Zone" by L.W. Braile, W. J. Hinze, G. R. Keller, and E.D. Lidiak.

Gravity - The present status of gravity coverage over the study area is shown in Figure 8. The entire previously delineated area is covered by stations at intervals of 2 to 3 km wherever access and elevations will permit. The observations have been tied together and to the national network. Further, the data have been reduced and the principal facts have been entered into the master data file. The number of stations in the master data file within each 1' quadrangle is illustrated in Figure 9. The system has been made versatile by a scheme which permits data within a specified area to be purged from the file and new data added to the file. The data file is now being gridded at a 2 km interval for further processing and presentation of the data. The data from the recently completed reduction of the Indiana gravity observations are contoured in Figure 10. Minor adjustments have been made to the data of southwestern Indiana which were observed and reduced in the previous fiscal year. These adjustments were made necessary because of the final ties between gravity data sets. The revisions in this map over previous maps prepared from widely-spaced observations are noteworthy and justify the additional observations. A preliminary compilation map of the Bouguer gravity anomaly values from the New Madrid and adjacent area is shown in Figure 11. This map has been used in the preliminary interpretation of the northeast extension of the New Madrid linear tectonic feature (Braile and others, 1979).

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Magnetic - The status of aeromagnetic coverage over the study area and environs is shown in Figure 12. During the current fiscal year the observation and reduction of the survey in southeastern Illinois west of 89° W longitude and south of 39° N latitude has been completed (Figure 13). The survey is based on one mile (1.6 km) north-south flight lines at an elevation of 1500 ft (457 m) AMT (Figure 14) and the mapped data has been corrected for diurnal variations and the updated 1975 IGRF. Two particularly high-frequency anomalies on this map have been verified by ground magnetic observations. The character of these anomalies is strongly suggestive that they originate from highly magnetic igneous bodies intruding the Phanerozoic sedimentary rocks. One of these anomalies coincides with the Omaha Oilfield in Gallatin County. The ground magnetic intensity values and the residual total magnetic intensity anomaly maps and profiles are shown in Figure 15 ,16, 17, and 18. The anomaly in plan view closely resembles the configuration of the Omaha Oilfield where drilling shows mica peroditite bodies within the Devonian sedimentary rock sequence which may explain the abnormal dip within the overlying Mississippian rocks. Preliminary measurements indicate that the igneous rock has a magnetic susceptibility of the order of 10,000 x 10^{-6} emu/cc.

Aeromagnetic tie lines were flown across southwest Illinois and Indiana to obtain data for compositing the three data sets (Figure 14). The Indiana data were previously gridded and processed to assist in interpretation. In the same manner the data of southwest and southeast Illinois were tied together and gridded at a 2 km interval (Figure 19). These data were reduced-to-the-pole (Figure 20) and upward continued to

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elevations of 2,5, 10 and 20 km (Figures 21-24)to eliminate successively 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 southern Illinois anomaly map upward continued to 5 km has been strike pass filtered in the north, east, northeast and northwest directions (Figures 25-28). The total magnetic intensity anomaly data available as of 1 December, 1978 has been composited in a preliminary manner (Figure 29) to complement the composite Bouguer gravity anomaly map in delineating the northeastern extension of the New Madrid linear tectonic feature. Currently, the magnetic data of Kentucky and Tennessee are being tied into the other magnetic anomaly data sets and the data are being gridded for further processing.

Basement Geology - Detailed petrographic and specific gravity studies are underway on samples from selected deep tests in the study area. These studies will lead to a better understanding of the lithologic and density variations between the basement and the overlying units. Preliminary maps showing the correlation between gravity and magnetic anomalies and their relation to known and inferred basement provinces have been prepared. Figure 30 is a detailed map of selected basement and geophysical parameters of the study area, and Figure 31 is a generalized map of inferred basement and geophysical provinces. Evaluation and revision of these maps is continuing.

K-Ar studies of selected basement samples and igneous intrusions are also underway. The completed determination are listed in Table 1.

Study of the structural relations between the igneous intrusions and the

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complex fault pattern is progressing. Preliminary Rose diagrams and histograms of dike and fault orientations between longitudes 88° W - 92° W and latitudes 37° N - 38° N have been compiled. These diagrams will be included in the yearly progress report. Detailed studies of individual fault zones and dike swarms are underway.

A bibliography on continental rifts containing over 1000 citations has been compiled. A manuscript on continental rifting with emphasis on the occurence of rifts in the central and eastern United States is being prepared.

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Seismic Refraction - Seismic refraction profiles have been recorded in the Wabash Valley area (Figure 32)to investigate the deep structure of the crust in the area of the possible northeastern extension of the New Madrid Fault Zone. The seismic record sections are shown in Figures 33,34,and 35. Additional observations are required in order to completely interpret the crustal structure of the area. Seismic refraction field work will be performed during May and June in order to complete these lines and begin additional profiles as described in the Proposed Research Section. Because these lines are not complete, our current analysis and interpretation of these profiles is limited and must be considered as preliminary. The record sections indicate that the paleozoic sedimentary rocks in the Illinois basin have an average velocity of about 5.4 km/sec. The upper crustal velocity is about 6.1 km/sec and a lower crustal layer with a velocity of approximately 6.8 km/sec is present. The early arrivals of the 6.8 km/sec phase on the east/west line relative to the north south line suggest that the lower crustal layer is shallower beneath the east-west line, which for the first 90 km lies within the proposed extension of the New Madrid Fault Zone, than to the west.

Synthetic seismograms have been computed for several crustal models which have been suggested for the Midcontinent area. The synthetics were calculated by a ray theory method and only the primary refracted and reflected arrivals are included. There is general agreement between the observed record sections and the synthetic seismograms for two of the models (Figure 36). In addition to further modeling of the travel-time and amplitude data for the observed seismograms (including seismograms recorded during May and June, 1979), amplitude-distance curves are presently being computed for the purpose of investigating the attenuation of body

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waves in the crust in the midcontinent.

Seismic Reflection - During the past project period we proposed to perform a feasibility study of high resolution seismic reflection profiling on the Mississippi and Ohio Rivers using a small geophysical survey boat. This work was to be accomplished in conjunction with Dr. Richard J. Wold of the U.S. Geological Survey. Due to technical problems with the construction of the geophysical boat and instrumentation, it is now apparent that this work could not be performed prior to the summer of 1980. Because the potential benefits of a high resolution reflection survey are significant to an understanding structures associated with the possible northeastern extension of the New Madrid seismic zone, we have arranged to proceed with a high resolution study during the proposed project period (August, 1979) in a cooperative effort with the University of Wisconsin at Milwaukee (Profs. David Willis and Robert Taylor) and the Illinois Geological Survey (Dr. Dennis Kolata). Travel funds and graduate student salary which was intended for the seismic reflection work in this years budget (1978-1979) will be carried over into the coming project period to partially support the costs of this proposed reflection profiling. A description of the proposed seismic reflection study is contained in the section on Proposed Work in this proposal.

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Interpretation - Considerable progress has been made in the integration and synthesis of geologic and geophysical data relevant to the possible northeastern extension of the New Madrid seismic zone during the past project period. Results and interpretation have been presented at the Midwest American Geophysical Union meeting held in St. Louis in September, 1978 and at the South Central Geological Society of America meeting held in Mountain View, Arkansas in early April, 1979. Abstracts of these papers are shown in Figures 4 and 7. In addition a paper entitled Models for Midcontinent Tectonism which summarizes the Tectonic Overview is to be published in a National Academy of Sciences volume on Continental Tectonics. A bibliography on continental rifts with over 1000 entries has been prepared and is available for distribution to interested geoscientists. A manuscript reporting on our studies of continental rifts and interpretation of rift structures in the midcontinent is presently under preparation and will be completed by June 30, 1979. Three papers from our group are to be published in the U.S. Geological Survey Professional Paper on the New Madrid area which is being edited by L.C. Pakiser and F. A. McKeown. Interpretation of the northeastern extension of the New Madrid Fault Zone has been emphasized in a paper to be published in the U.S.G.S. Professional Paper. The manuscript of this paper was reproduced in the January 1979 Quarterly Report and the abstract is given in Figure 37. The position of this feature and the seismicity are plotted on the Bouguer gravity and magnetic anomaly maps in 38 and 39. We are currently revising the manuscript for publication. The principal conclusion of this paper is that a basement structural feature which has been recognized by Hildenbrand and others (1977) in the New Madrid area on the basis of trends of correlative, positive gravity and magnetic anomalies which are associated with the earthquake

activity in the area can be traced northeastward into southern Indiana at least to 39° N latitude. This suggest that a continuous basement geologic feature extends from the New Madrid area into southern Indiana and may be a primary control on the locations of earthquake activity. The gravity and magnetic signatures of this feature can be seen in the profiles shown in Figure 40. That this northeasterly trend is significant and has a definite correlation with earthquake activity is demonstrated in Figure 41 in which the historical earthquake occurrences reported by Hadley and Devine (1974) show a definite correlation with the proposed northeastern extension of the New Madrid Fault Zone. Two significant implications for future investigations can be derived from interpretation of Figure 41. First, because the historical earthquake record is inadequate and the gravity and magnetic data indicate that the New Madrid Linear Tectonic Feature extends northeastward at least to 39° N latitude, it is imperative that we investigate the northeastern extent of this feature utilizing geological and geophysical data (new gravity observations are proposed for the area between 39° and 40° N latitude in Indiana) and the level of microearthquake seismicity in southern Indiana must be investigated using a seismograph network to search for possible relationships between seismicity and the proposed basement structural feature (Drs. Sexton and Braile are preparing a proposal for operation of a seismic array in southern Indiana).

Secondly, the zone of seismicity (Figure 41) which extends north-northwest from New Madrid along the Mississippi River is presently unexplained and the possible existence of associated basement structural features which may exert a control on the locations of earthquake epicenters should be studied utilizing geophysical and geological data.

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Table 1. Preliminary K-Ar Ages, Eastern Interior United States

Well Name and Location	Rock and Sample Type	Material Analyzed	K-Ar Age (m.y.)
Associated Oil and Gas No. 1 Sells sec. 3-A-54E Pickett Co., Tennessee	coarse-grained granite cuttings	amphibole	1070
Stauffer Chemical No. 1 Fee sec. 16-12S-28E Maury Co., Tennessee	biotite granite cuttings	biotite	1325
NIPSCO No. 1 Ames sec. 21-34N-3E Marshall Co., Indiana	schist(?) core	biotite+ hornblende concentrate	900
Amerada No. 1 Ullman Noble Co., Ohio	quartz diorite core	hornblende	1000

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REGIONAL GRAVITY OF THE WABASH RIVER VALLEY FAULT SYSTEM -- NEW MADRID SEISMIC ZONE

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A comprehensive file of gravity data in the area of the intersection of the 38th Parallel lineament and the Wabash River Valley fault system-New Madrid Seismic Zone is being prepared by merging existing data with new data which is being gathered. A preliminary Bouguer anomaly map of this zone of intersection has been prepared which includes portions of southern Indiana, southern Illinois, and western Kentucky. The advantages of such a data file are evident because many anomalies and trends cross state boundaries. The Rough Creek Graben (Moorman Syncline) is marked by an east-west trending gravity low in western Kentucky flanked by a series of highs which extend into southern Indiana and Illinois. This gravity low extends only a short distance into Illinois before being lost in anomalies associated with the upper Mississippi Embayment. Gravity modeling shows this graben to be approximately 15,000 feet deep. The Wabash River Valley fault system is associated with a complex gravity high. It is presently difficult to assess the relationship of this feature with the gravity low (Hildenbrand and Kane, 1977) associated with the New Madrid seismic zone. However, it is clear that these northeast trending anomalies are interrupted in the area of the 38th Parallel Lineament.

RING MAGNETIC ANOMALIES IN THE CENTRAL MIDCONTINENT

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Four circular magnetic anomalies have been identified on the revised magnetic anomaly map of Indiana. They consist of a series of discontinuous positive magnetic anomalies generally bordered by negative anomalies and ringing a central minimum which approaches regional magnetic levels. The positive anomalies have amplitudes of the order of 200 gammas although locally they attain amplitudes in excess of 1000 gammas. All four anomalies occur in the eastern half of the State, east of a north-south linear trend which terminates the easterly striking anomalies to the west which characterize the anomaly pattern to the north of this area. The most dominant of the ring anomalies is the elliptical-shaped Fort Wayne anomaly which has a correlative 50 mgal anomaly. The three remaining anomalies, each 50 km in diameter, have no correlative gravity anomalies on the available gravity anomaly maps. Modeling the anomalies and their circular pattern suggest that these anomalies are caused by relatively thin volcanic rock deposits or ring dike complexes. In either event the anomalies are probably related to calderas and the Fort Wayne anomaly overlies an elliptical stock of mafic composition rocks. A similar ring magnetic anomaly occurs in southwestern Illinois and a somewhat larger feature occurs in southeastern Indiana astride the Ohio boundary. The interpreted caldera magnetic signatures are believed to be related to anorogenic igneous events dated at about 1.1 to 1.5 b.y. in the Basement Central Province.

A MAGNETIC ANOMALY MAP OF SOUTHEASTERN ILLINOIS

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As part of the study of the intersection of the 38th Parallel Lineament and the extension of the New Madrid Fault Zone, an aeromagnetic survey was made of southeastern Illinois. This survey, south of 39° N, and east of 89° W was initiated to fill in a significant gap in the magnetic coverage in this area. The survey was flown along north-south tracks at one mile spacing at an elevation of 1500' AMSL. The data were reduced in the normal manner with corrections for diurnal fluctuations and the earth's normal magnetic field using the updated 1975 IGRF. The magnetic data have been gridded and composited with the adjacent magnetic surveys of southwest Illinois and southern Indiana and have been subjected to a variety of anomaly enhancement and isolation procedures.

The magnetic anomalies of southeastern Illinois have a marked west northwest, and lesser western trends south of 38° N. The dominant WNW trend extends across the area from the Mississippi River near Chester, Illinois into central Kentucky. Local anomalies occur along this feature which may at least in part be due to intrusives within the Phanerozoic sedimentary section. Northeast magnetic anomaly trends are also present and tend to dominate the area north of 38°. A northeasterly trend of anomalies correlated with the location of the Wabash River Fault System.

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Figure 4

Abstracts of papers presented at the Sept.,1978 AGU meeting in St. Louis, Missouri.

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REGIONAL TECTONICS OF THE CENTRAL MIDCONTINENT, UNITED STATES

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The central Midcontinent region of the United States has received increased attention recently because of the interest in contemporary geodynamics of plate interiors and because of the hazard posed by the New Madrid Seismic Zone. 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 inhomogenities. The 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 insufficient 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.

Figure 5 Abstract of paper presented at the Geological Society of America meeting on 25 October, 1978.

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RIFTING IN THE MIDCONTINENT, U.S.A.

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Rifts are important tectonic features that are developed both along continental margins and in continental interiors. They have a significant role in deciphering tectonic history, including pre-Mesozoic plate tectonics, basinal development, and resurgent tectonics, and in localizing earth resources.

Rift zones are probably more common in the midcontinent of the United States 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. Because of these difficulties a review of the geological and geophysical characteristics of the main continental rifts was made. Geologically, many rifts are characterized by a complex linear graben structure in which normal predominates over reverse and strike-slip faulting, by a similar width (35-60 km.), by compositionally diverse but generally bi-modal igneous activity, by transgressive sedimentation except in initial stages, and by an apparent moderate geothermal gradient that results in appreciable metamorphism only in the deeper structural zones. Rift valleys are present only in the younger active structures; older rifts occur mainly as structurally complex zones without primary topographic expression. The rifting process generally involves both the basement and the overlying strata. The geophysical characteristics are equally distinctive. Active rifts are commonly underlain by an anomalously hot crust and mantle. They are characterized by a thin crust (< 35 km.), low Pn velocity (< 8.0 km./sec), crustal low velocity layers, long wavelength Bouguer gravity lows on which are superimposed local maxima due to igneous activity and minima due to sedimentary graben fill, shallow Curie temperature depths, complex magnetic anomaly patterns, linear bands of shallow seismicity, extensional earthquake foci, and linear heat flow highs.

Complexities in the geological and geophysical expression of rifts are also present and are due to stage of development at arrestment, age, depth of erosion or burial, and mode of origin. For example, older, dormant rifts may be underlain by a more normal, thicker crust and thus lack many of the characteristics of active rifts. Other rifts may be in an intermediate stage of development with the result that the geological and geophysical signatures may vary accordingly. Another factor is that many older rifts, particularly those of Precambrian age, differ from younger rifts in being associated with Bouguer gravity highs rather than lows. This difference generally reflects more voluminous basaltic vulcanism or exposure of deeper

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crustal layers. It may also be 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. Vertical movement in the mantle is of prime importance in the development of "dynamic" rifts, and normal faulting and volcanism are manifestations of this larger feature which involves doming and thinning of crust. Such rifts apparently form by one or more of the following mechanisms: development of large thermal anomalies in the mantle, penetration of an oceanic ridge beneath a continent, formation of aulacogens, complete or incipient break-up of a continent, or spreading behind an active continental margin or island arc structure. In contrast, "passive" rifts form primarily as a result of horizontal movement of lithospheric plates. Such rifts may form by the collision of irregular continental margins or by the complex accomodation of microplates to the movement of larger lithospheric plates.

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.

Figure 6 Abstract of paper presented at the International Symposium on the Rio Grande Rift, 8-17 October, 1978.

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WHAT IS THE NORTHEASTERN EXTENT OF THE NEW MADRID FAULT ZONE?

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The northeastern limit of the New Madrid Fault Zone has been a vexing problem to geoscientists for many years. It is an important question bearing not only on the tectonic history of the Midcontinent but also on seismic regionalization because of the seismicity of the feature in the New Madrid area. Hypotheses which extend the New Madrid Fault Zone to the northeast of the seismic zone have been based on "straight-line" extrapolations to the Wabash River Valley Fault System and in the extreme to the seismicity and rift features of the St Lawrence River Valley. Recent geophysical studies in southern Illinois, western Kentucky, and Indiana investigating the intersection of the extension of the New Madrid Fault Zone with the 38th Parallel Lineament have provided new evidence which suggests that the feature extends northeast of the 38th Parallel Lineament across Indiana. Marginal, northeasterly trending positive gravity and magnetic anomalies bound an area of low gravity and magnetic relief which is correlated with the earthquake epicentral locations. The anomalous gravity and magnetic trends and associated seismicity extends northeastward from the New Madrid Fault Zone into southern Indiana at least to N 39° latitude. The trends are interrupted by anomalies associated with the 38th Parallel Lineament. However these interpretations must remain speculative until further evidence is available and current geophysical investigations are interpreted.

RING MAGNETIC ANOMALIES AS INDICATORS OF BASEMENT CALDERAS IN THE CENTRAL PROVINCE

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Several circular ring magnetic anomalies have been identified in the central Midcontinent region. The anomalies are defined by a circular to elliptical pattern of positive magnetic anomalies generally bordered by negative anomalies and ringing a central minimum. Amplitudes of the anomalies are 200-1000 gammas. The characteristic size of the circular magnetic features is 50 km in diameter. A correlative positive gravity expression is present for some of the ring magnetic anomalies. Based on comparisons with gravity and magnetic signatures of Laramide age and Late Cenozoic calderas and volcanic depressions in the Cordillera and Japan, and modeling of the gravity and magnetic anomalies, the ring magnetic features are interpreted as being caused by thin volcanic rock deposits or ring dike complexes. Although the regional extent of the ring magnetic features in the central Midcontinent is presently unknown, identification of these features in a broad region of the Midcontinent suggests that the calderas may be a widespread feature of the Central Province. The recognition of ring magnetic anomalies is facilitated by high-quality magnetic anomaly maps which are becoming available in the Midcontinent. The volcanic activity is believed to be related to anorogenic igneous events of about 1.3 to 1.5 b.y. age.

GRAVITY STUDIES OF THE WABASH VALLEY FAULT SYSTEM

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Recently completed gravity surveys with a station density of one station per two miles or better in southern Indiana and Kentucky when combined with available data from Illinois provide a comprehensive data set for studying the crustal structure in the vicinity of the Wabash Valley Fault System (WVFS) and 38th Parallel Lineament. This data set has been used to prepare a Bouguer gravity anomaly map and derived maps based on a variety of filtering functions. The derived maps obtained by continuation, gradient, and strike pass techniques are useful in resolving the geological components whose total effect produces the observed gravity anomaly field. The sources of the gravity field particularly those anomalies associated with the WVFS are investigated by modeling which is constrained by magnetic anomaly data, crustal seismic refraction studies, and basement lithologic information. The WVFS occurs along the western margin of a gravity and magnetic minimum which strikes northeasterly. The minimum may be related to a northeasterly extension of the New Madrid Fault System.

CRUSTAL SEISMIC STUDIES IN THE WABASH RIVER VALLEY AREA

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During May and August of 1978, seismic refraction experiments were carried out in the Wabash River Valley Area of Indiana and Illinois. The refraction profiles are part of a geophysical and geological research program directed toward an understanding of the nature of the intersection of the New Madrid Fault Zone and the 38th parallel lineament. The nature of the intersection is relevant to the evaluation of earthquake risk for the region. Previous seismic studies of midcontinent crustal structure by different investigators have indicated the existence of an anomalous possibly localized high velocity (7.3-7.4 km/sec) lower crustal layer. The anomalous high velocity layer may be associated with a proposed (Ervin and McGinnis, 1975) rift for the area. Refraction profiles of the present study are each about 150 km in length. One profile has been located along the axis of the suggested rift. The second line was designed to cross the Wabash River Valley Fault System to investigate the width of a possible crustal anomaly which may be localizing seismic activity. Preliminary results from the seismic refraction lines have been interpreted and compared to existing models of the midcontinent which were derived from seismic refraction and surface wave data.

FEASIBILITY OF HIGH-RESOLUTION SEISMIC REFLECTION SURVEYING IN THE VICINITY OF REELFOOT SCARP IN NORTHWESTERN TENNESSEE

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In an effort to establish the feasibility, desirability, and costs of high-resolution seismic reflection surveying for areas near the New Madrid seismic zone, a survey consisting of three short lines was conducted on Reelfoot scarp. Two lines, each of length 2000 feet, and one line of length 1000 feet were shot in the vicinity of a previous Vibroseis* (*Trademark, Continental Oil Company) survey conducted near the scarp for the US Geological Survey. Comparison of the high resolution seismic section with Vibroseis sections show that shallow (0.06 to 0.30 seconds) are better mapped by the high-resolution method. Strong deep events (0.60 to 0.80 seconds) noted on the Vibroseis sections are also prominent on portions of the high-resolution sections. Evidence for faulting associated with Reelfoot scarp is not resolvable from the present high-resolution data set. This is in part due to limitations associated with field equipment used for drilling of shot holes. A discussion of field methods, problems, and costs will be given.

Figure 7 Abstracts of papers presented at the April, 1979 South-Central Geological Society of America meeting.

POOR ORIGINAL

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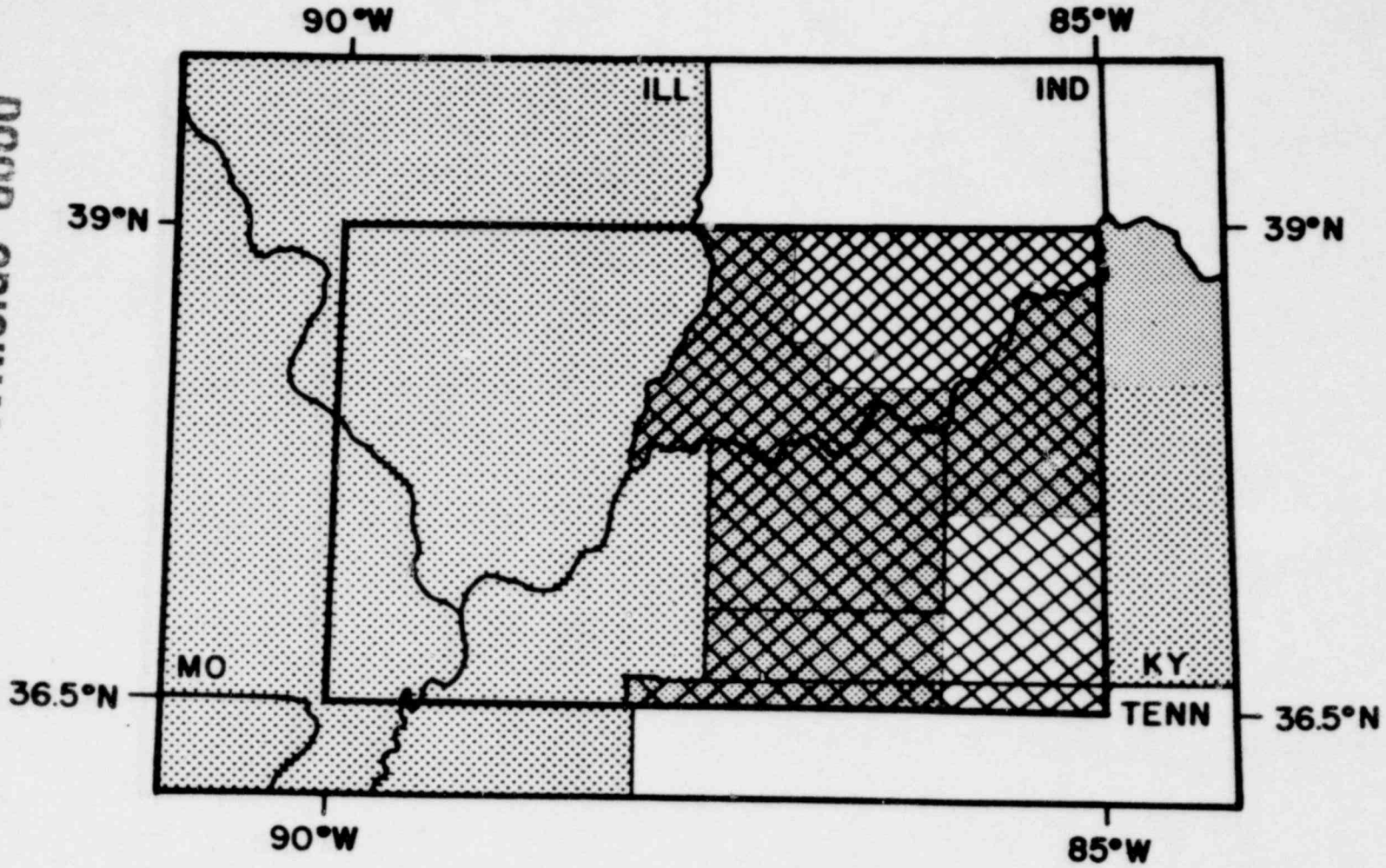

Figure 8

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.

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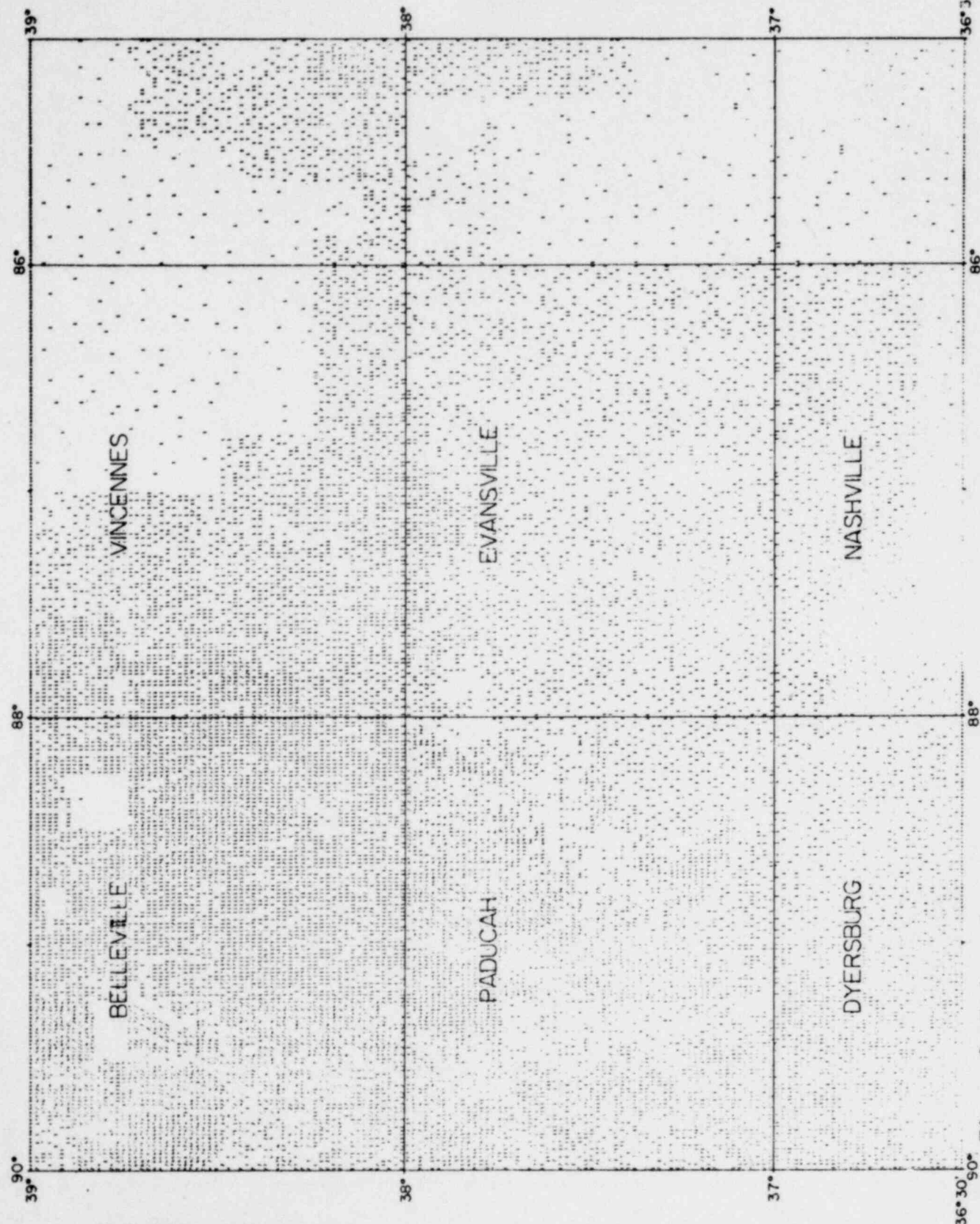

Figure 9 Number of gravity observations per 1' quadrangle in master gravity data file. Recently reduced gravity observations between 38°-39°N latitude and 85°-87°W longitude are not shown on this map.

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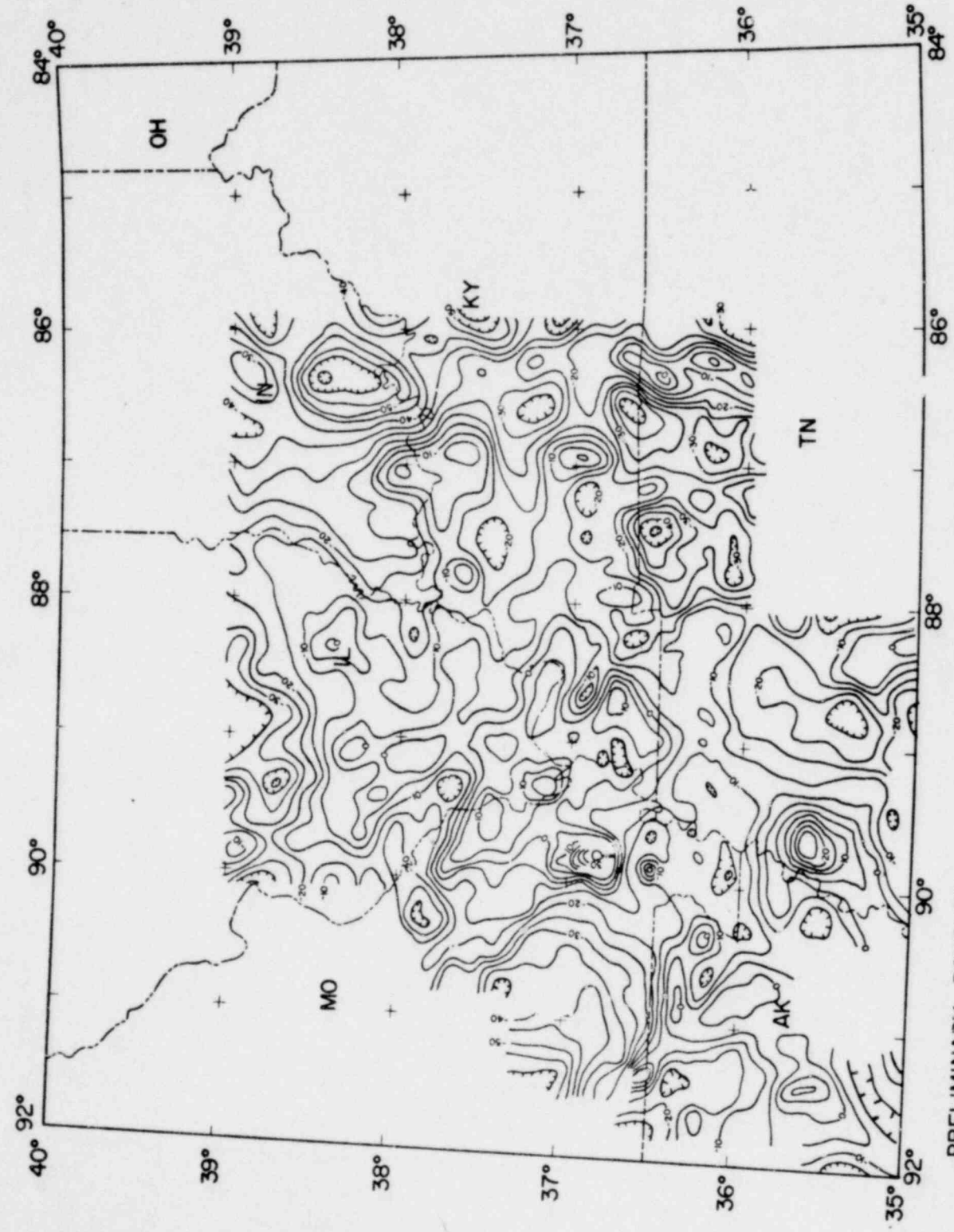

Figure 10 Preliminary Bouguer gravity anomaly map of the New Madrid Fault Zone and surrounding area. Contour interval is 5 mgal.

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POOR ORIGINAL

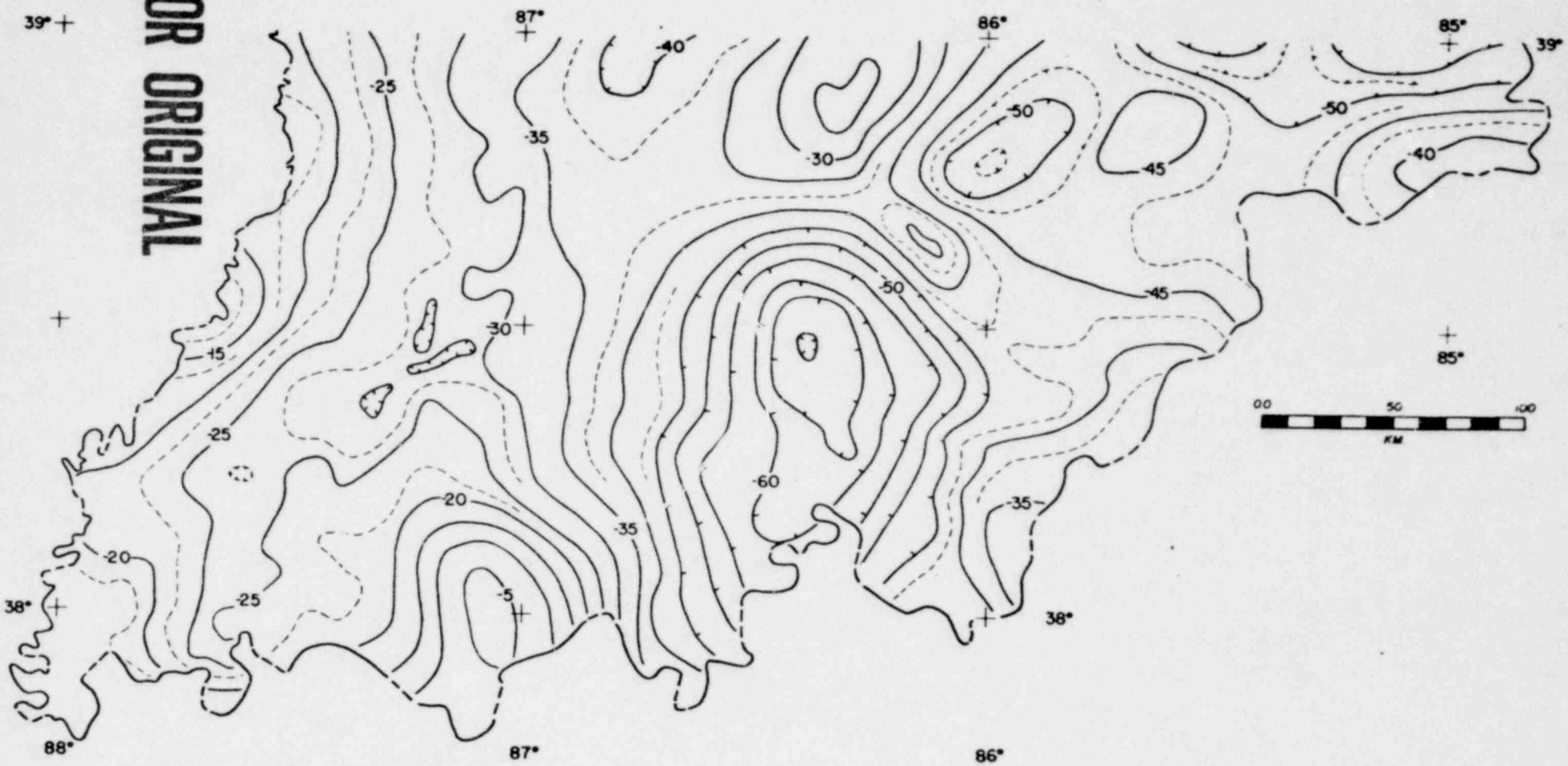

Figure 11 Bouguer gravity map of southern Indiana from data observed at 2-3 km spacing during 1977 and 1978. Contour interval is 5 mgal with supplementary contours at 2.5 mgal interval dashed.

2209 194

POOR ORIGINAL

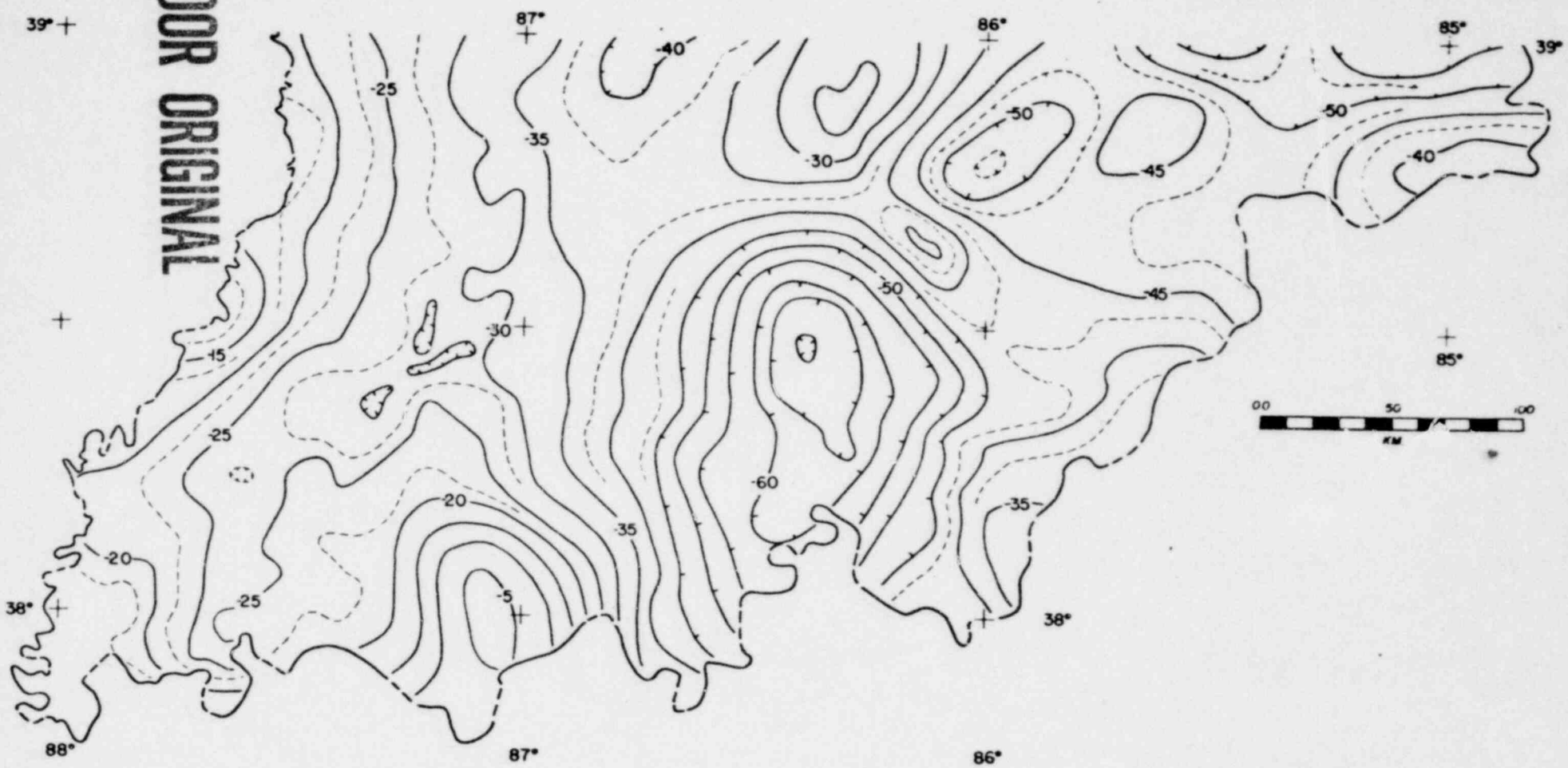

Figure 11 Bouguer gravity map of southern Indiana from data observed at 2-3 km spacing during 1977 and 1978. Contour interval is 5 mgal with supplementary contours at 2.5 mgal interval dashed.

2207 195

POOR ORIGINAL

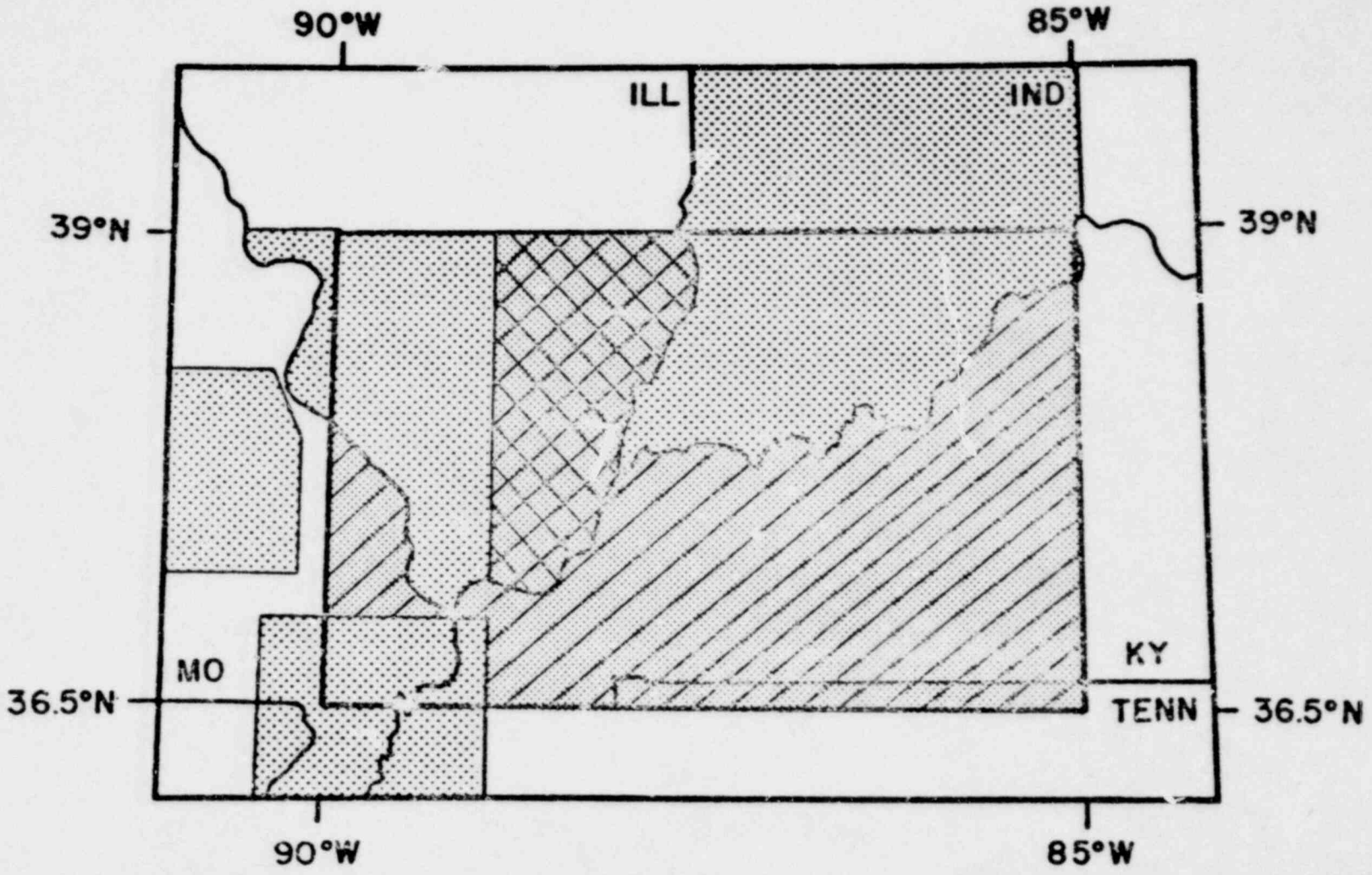

Figure 12 Map indicating status of aeromagnetic coverage within the study area which is shown by the rectangle. Coarse dotted pattern indicates area of coverage before study was initiated. Fine dotted pattern indicates recently acquired data. Diagonal pattern indicates data acquired by funding external to study. Cross-hatched patterns indicates data acquired by funding internal to study.

2209 196

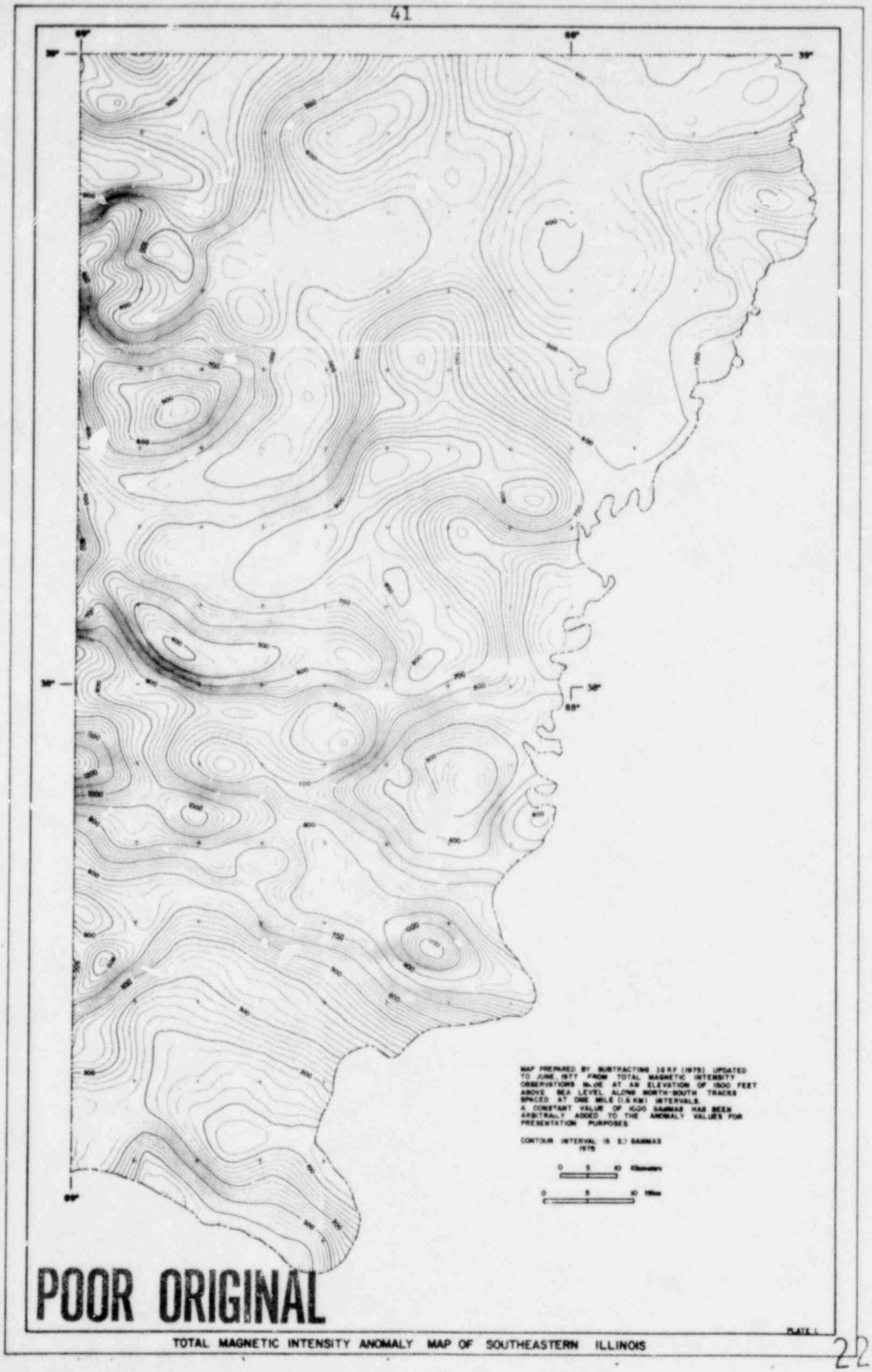

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Figure 13 Total magnetic intensity anomaly map of southeastern Illinois. Contour interval is 20 gammas.

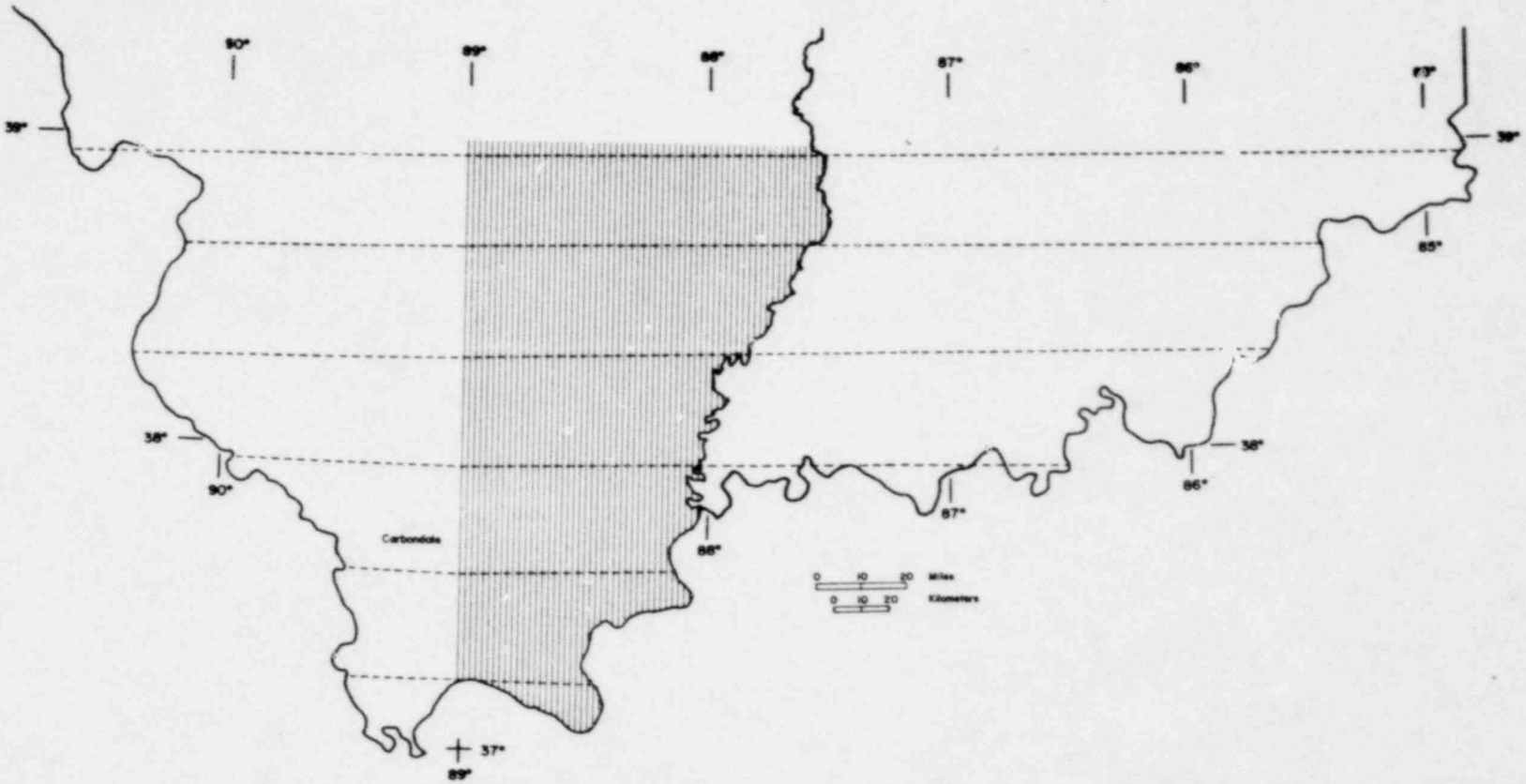
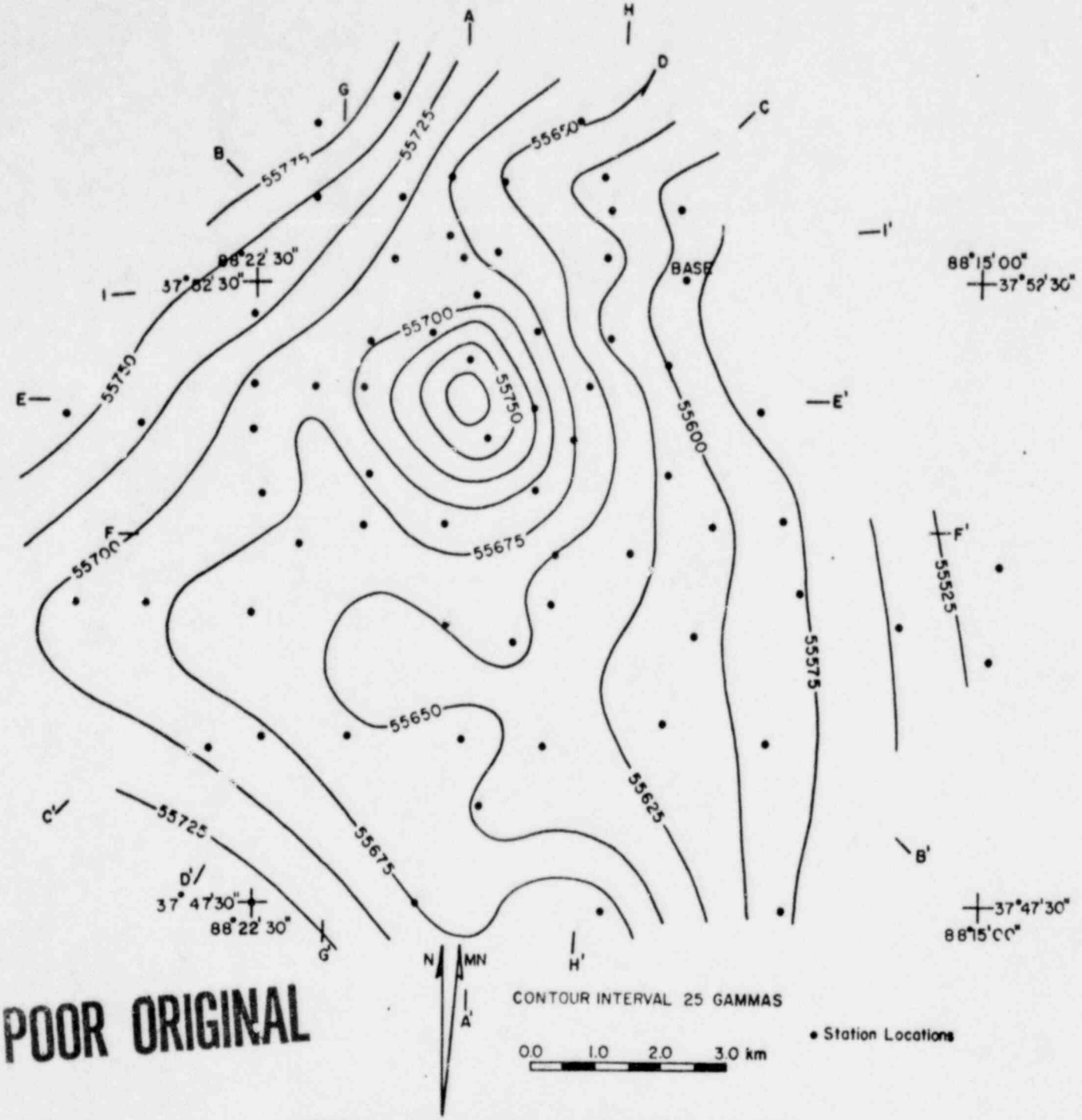


Figure 14 Map indicating the area surveyed, the locations of the tie lines and the location of the ground monitor.

2209 198



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TOTAL INTENSITY MAGNETIC FIELD

OVER THE OMAHA OIL FIELD GALLATIN COUNTY ILLINOIS

1979

Figure 15 Total magnetic intensity anomaly map of Omaha Oilfield, Illinois.

2209 199

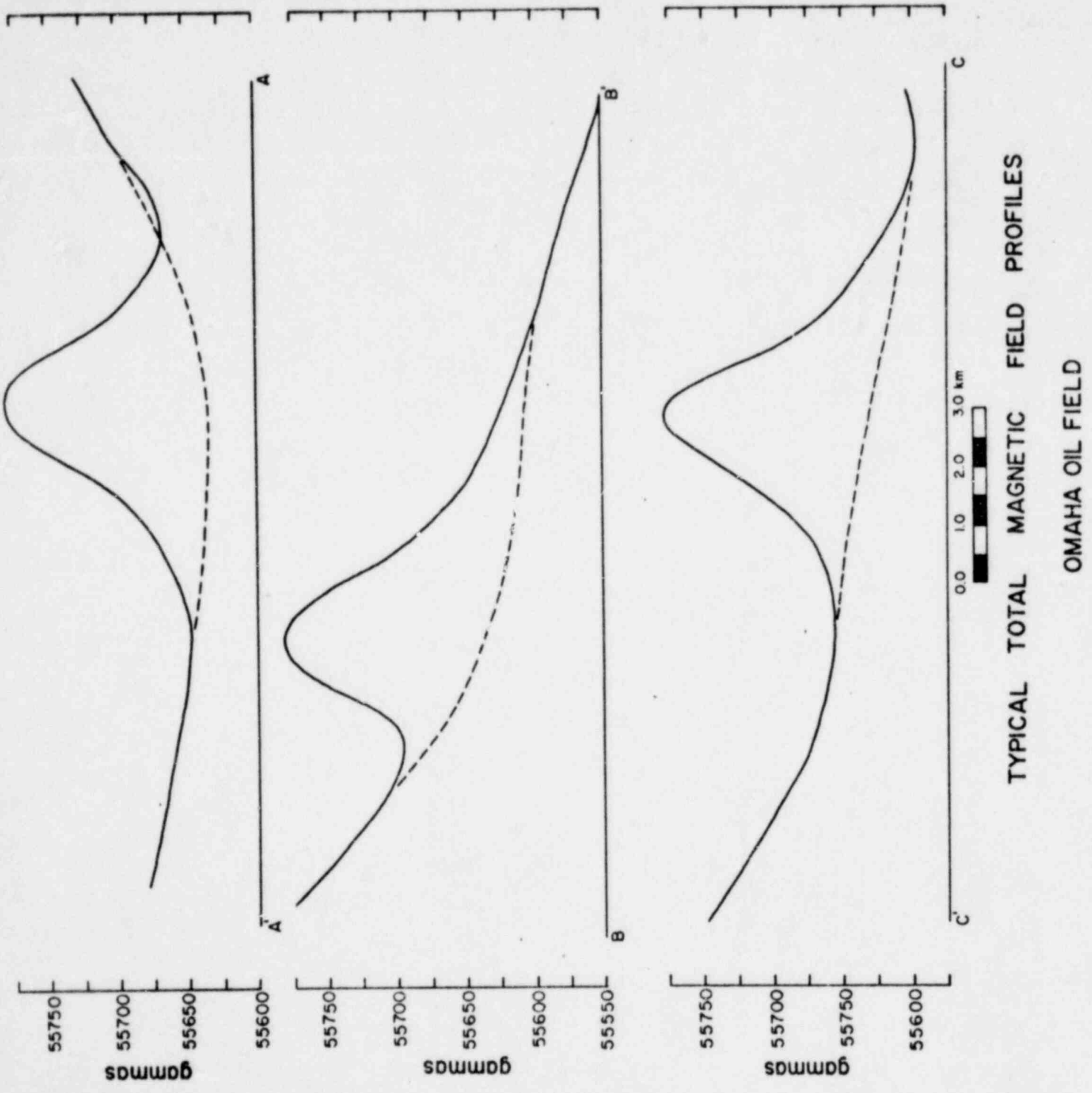
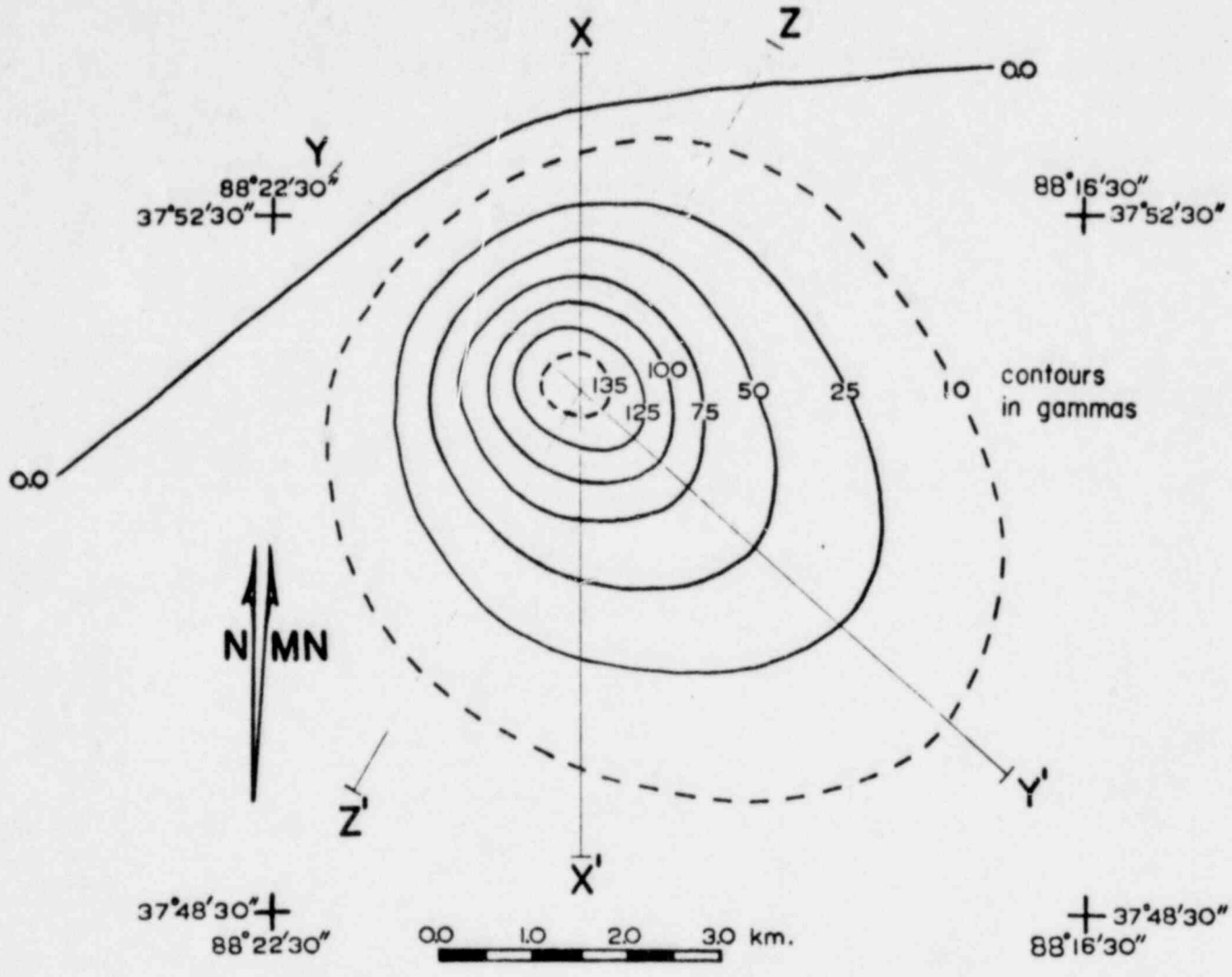


Figure 16 Total magnetic intensity anomaly profiles of Omaha Oilfield, Illinois.

2209 200



RESIDUAL TOTAL INTENSITY MAGNETIC

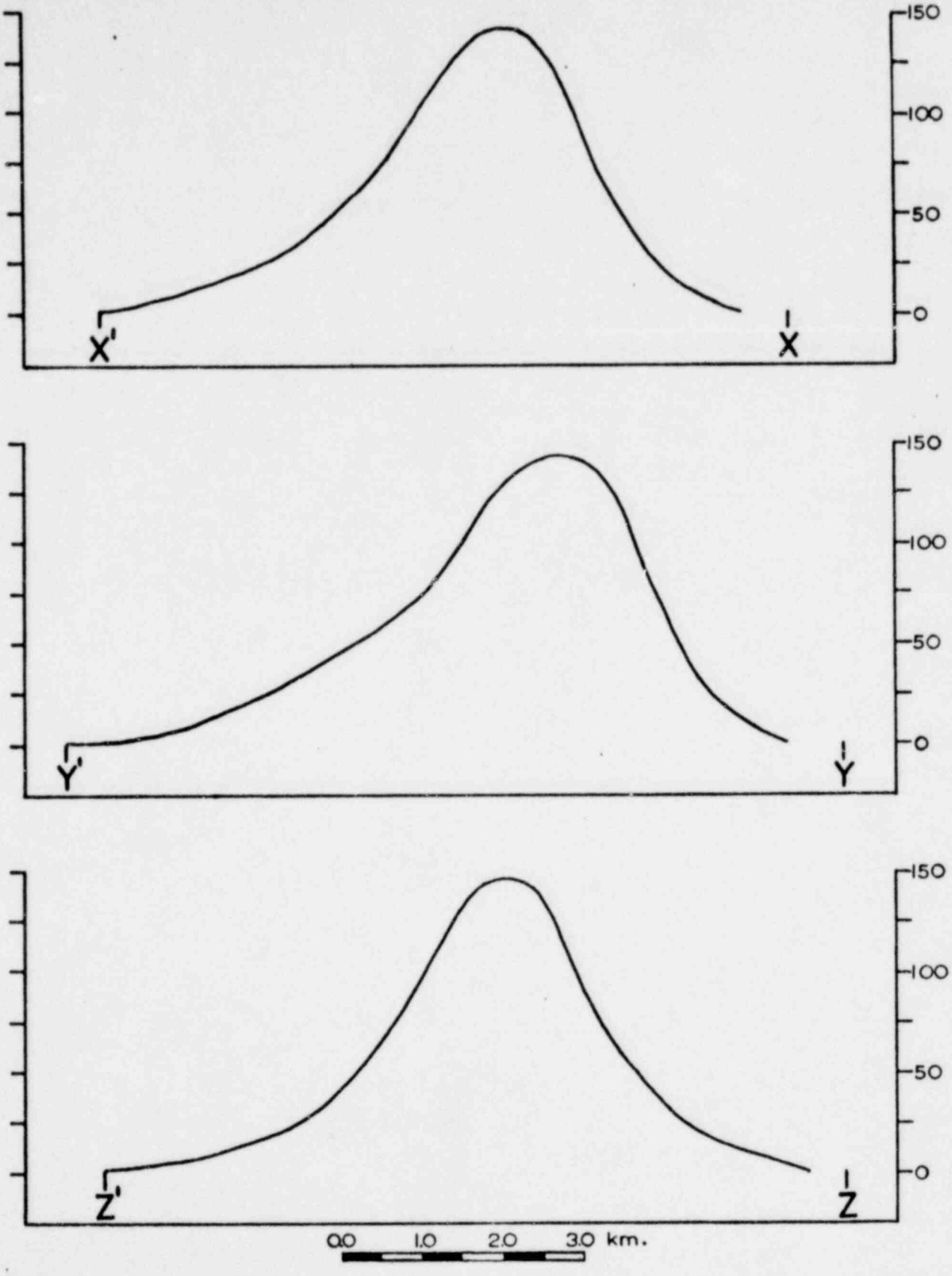
ANOMALY OVER THE OMAHA OIL FIELD

GALLATIN COUNTY, ILLINOIS

1979

2209 201

Figure 17 Residual total magnetic intensity anomaly map of Omaha Oilfield, Illinois.



RESIDUAL MAGNETIC PROFILES

ACROSS THE OMAHA OIL FIELD IN GAMMAS

2209 202

Figure 18 Residual total magnetic intensity anomaly profiles of Omaha Oilfield, Illinois.

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Figure 19 Southern Illinois total intensity magnetic anomaly map. Contour interval = 200 gammas.

2209 203

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Figure 20 Southern Illinois total intensity magnetic anomaly map reduced to the pole. Contour interval = 200 gammas.

2200 204

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Figure 21 Southern Illinois total intensity magnetic anomaly map reduced to the pole, upward continued to 2 km. Contour interval = 100 gammas.

2209 205

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Figure 22 Southern Illinois total intensity magnetic anomaly map reduced to the pole, upward continued to 5 km. Contour interval = 100 gammas.

2209 206

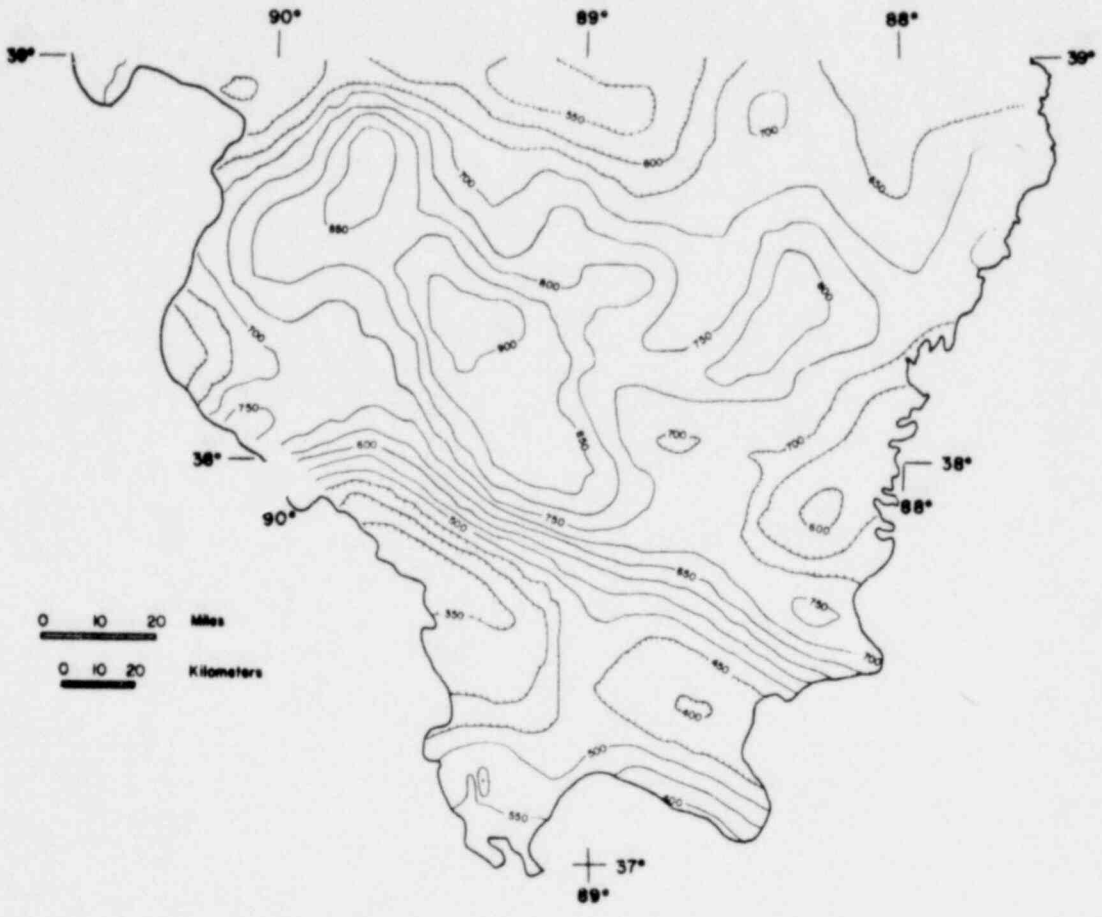

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Figure 23 Southern Illinois total intensity magnetic anomaly map reduced to the pole, upward continued to 10 km. Contour interval = 50 gammas.

2209 207

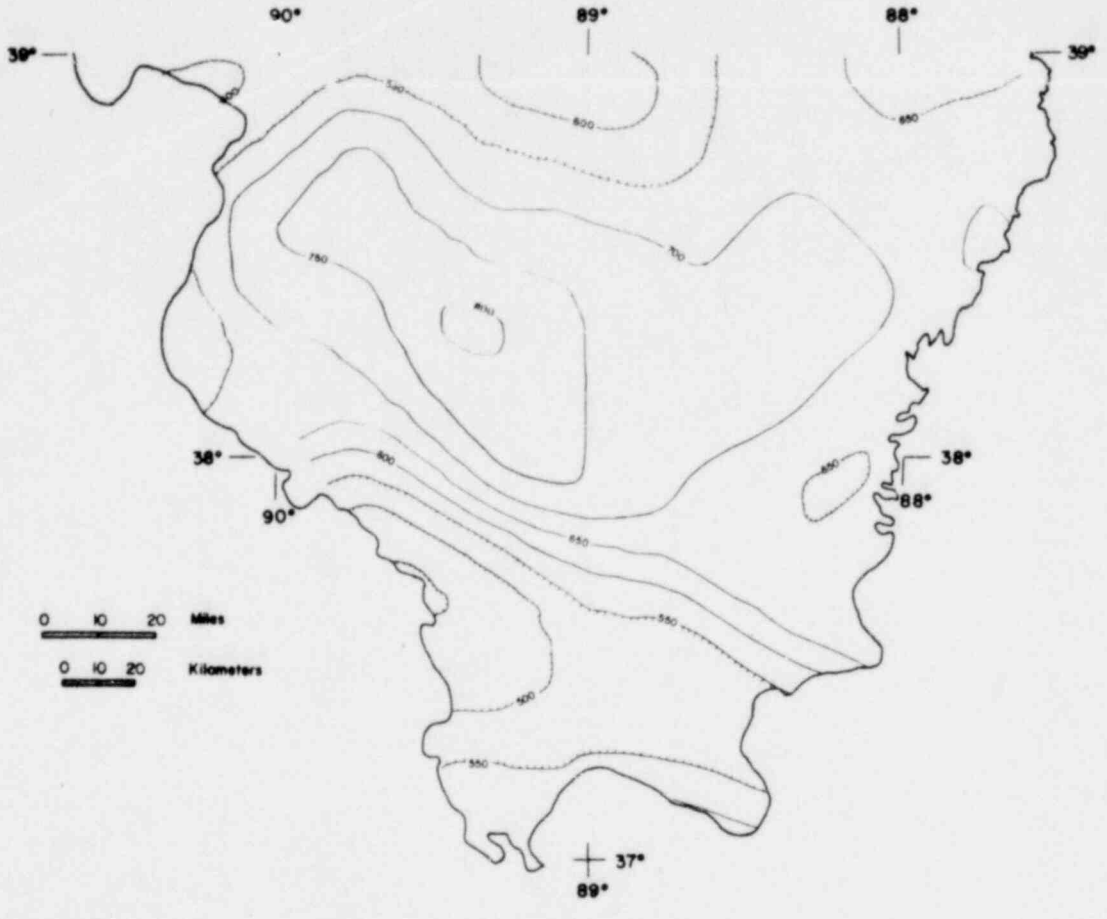

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Figure 24. Southern Illinois total intensity magnetic anomaly map reduced to the pole, upward continued to 20 km. Contour interval = 50 gammas.

2209 208

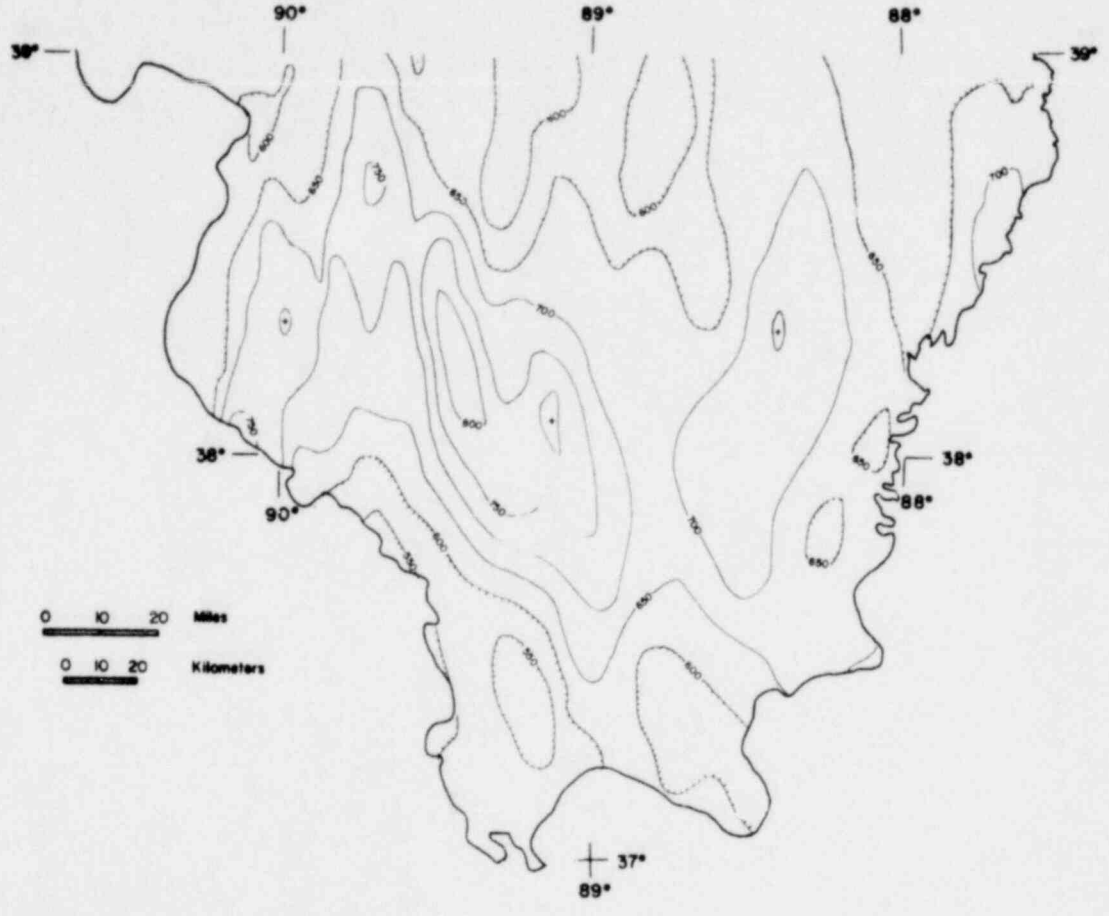

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Figure 25 Southern Illinois total intensity magnetic anomaly map upward continued to 5 km, north-south strike pass. Contour interval = 50 gammas.

2209 209

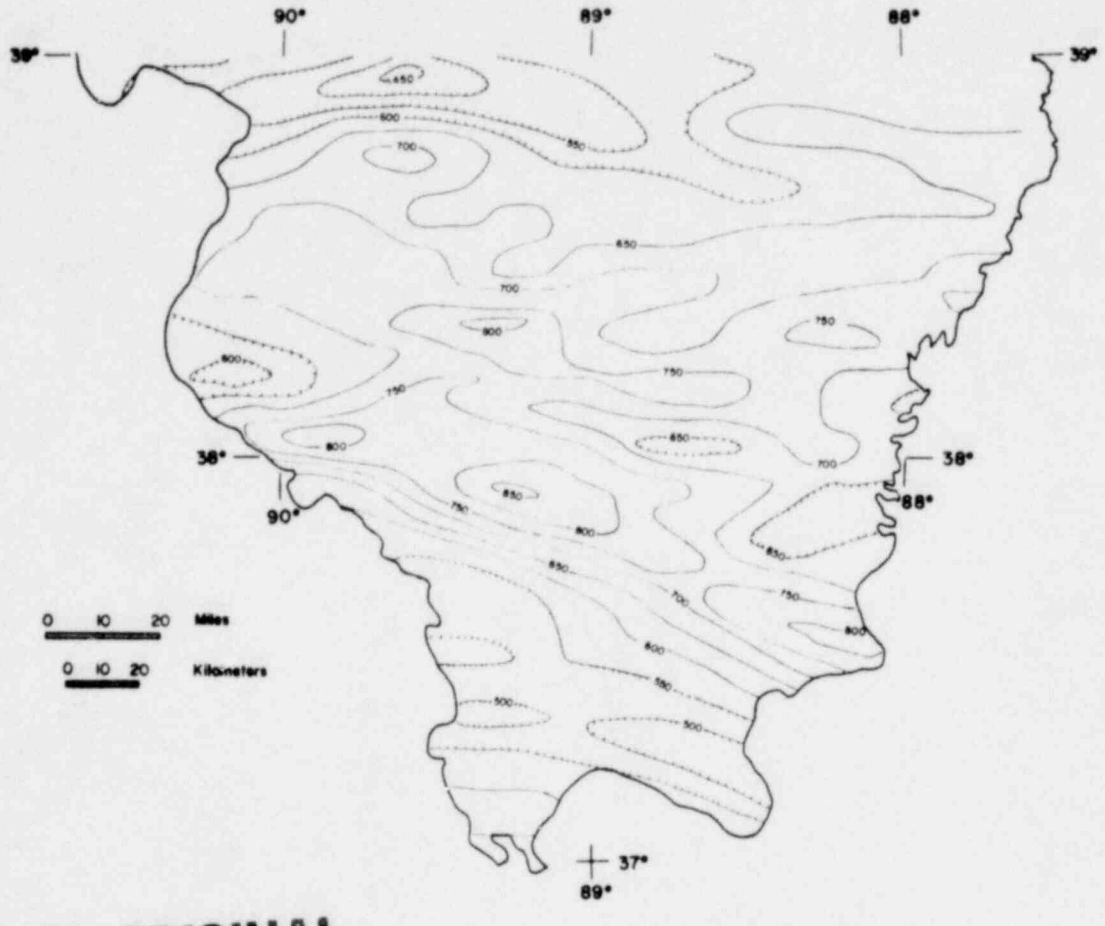

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Figure 26 Southern Illinois total intensity magnetic anomaly map upward continued to 5 km, east-west strike pass. Contour interval = 50 gammas.

2209 210

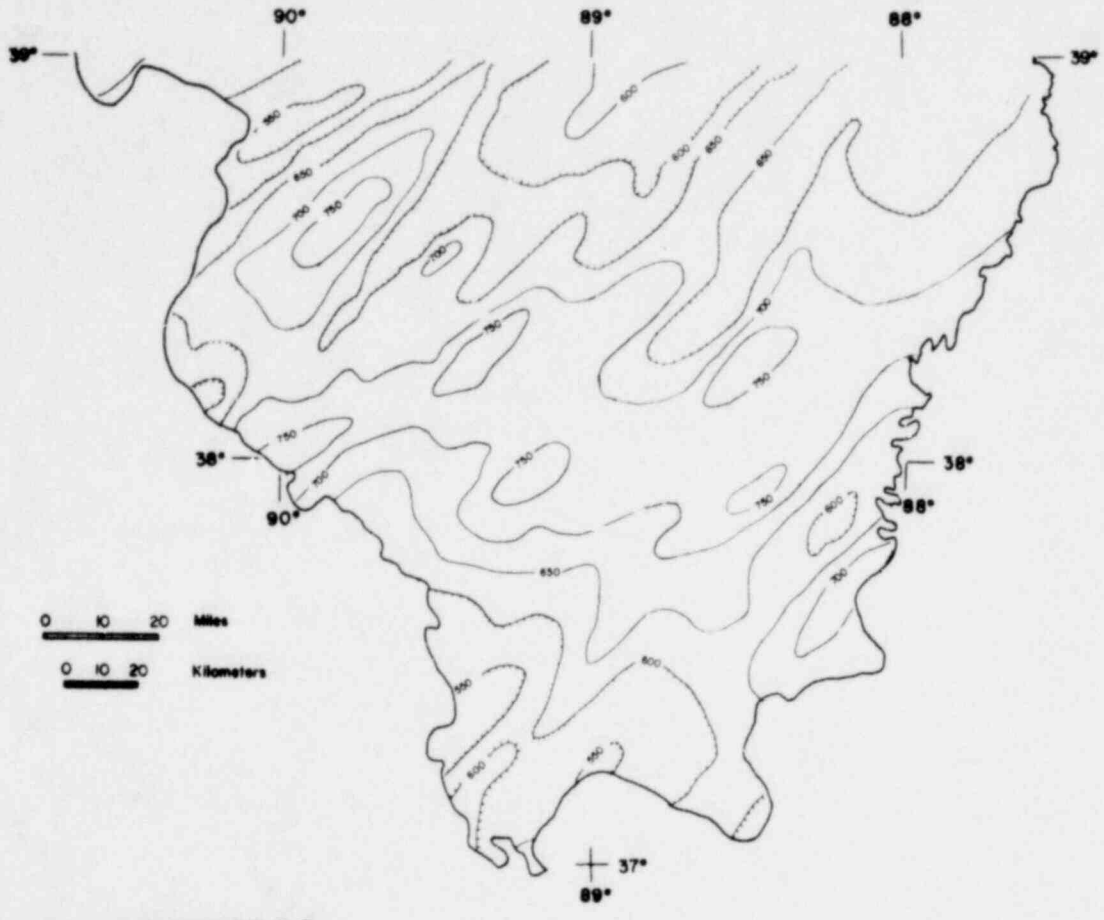

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Figure 27 Southern Illinois total intensity magnetic anomaly map upward continued to 5 km, northeast-southwest strike pass. Contour interval = 50 gammas.

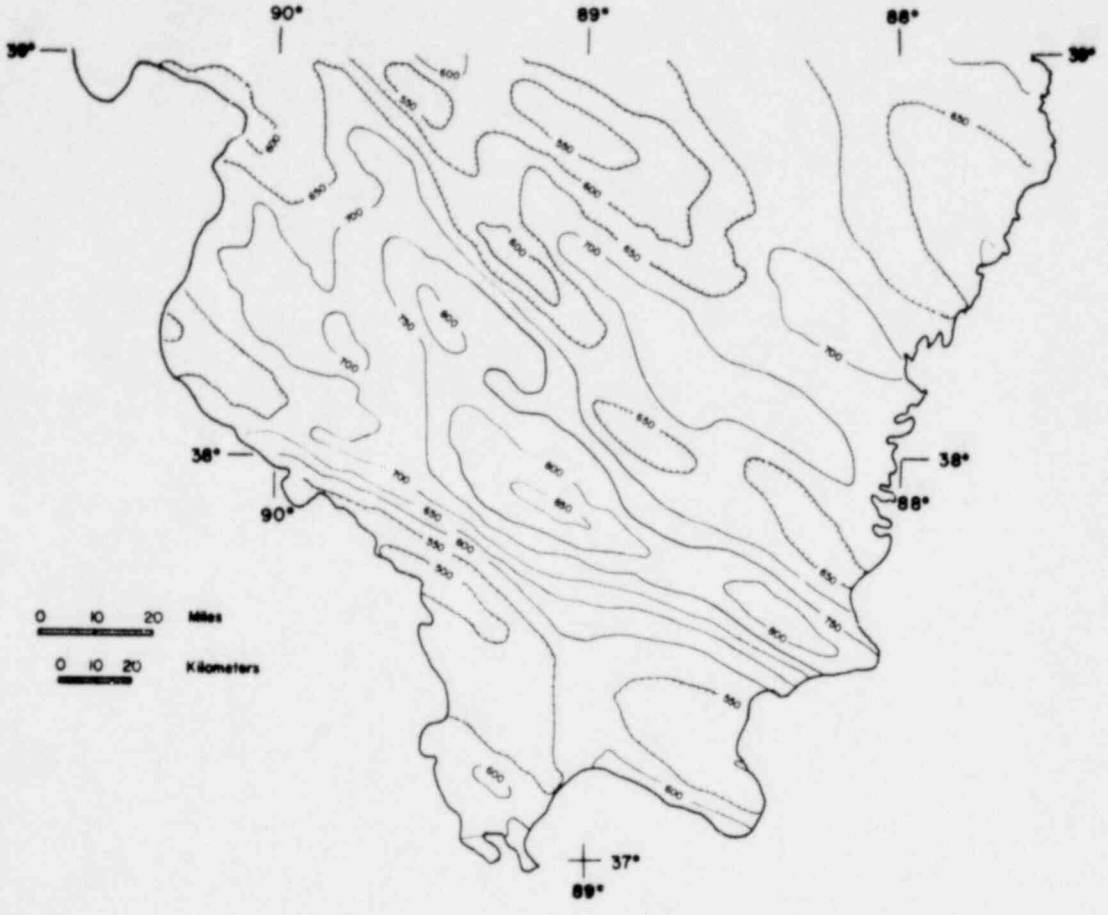

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Figure 28 Southern Illinois total intensity magnetic anomaly map upward continued to 5 km, northwest-southeast strike pass. Contour interval = 50 gammas.

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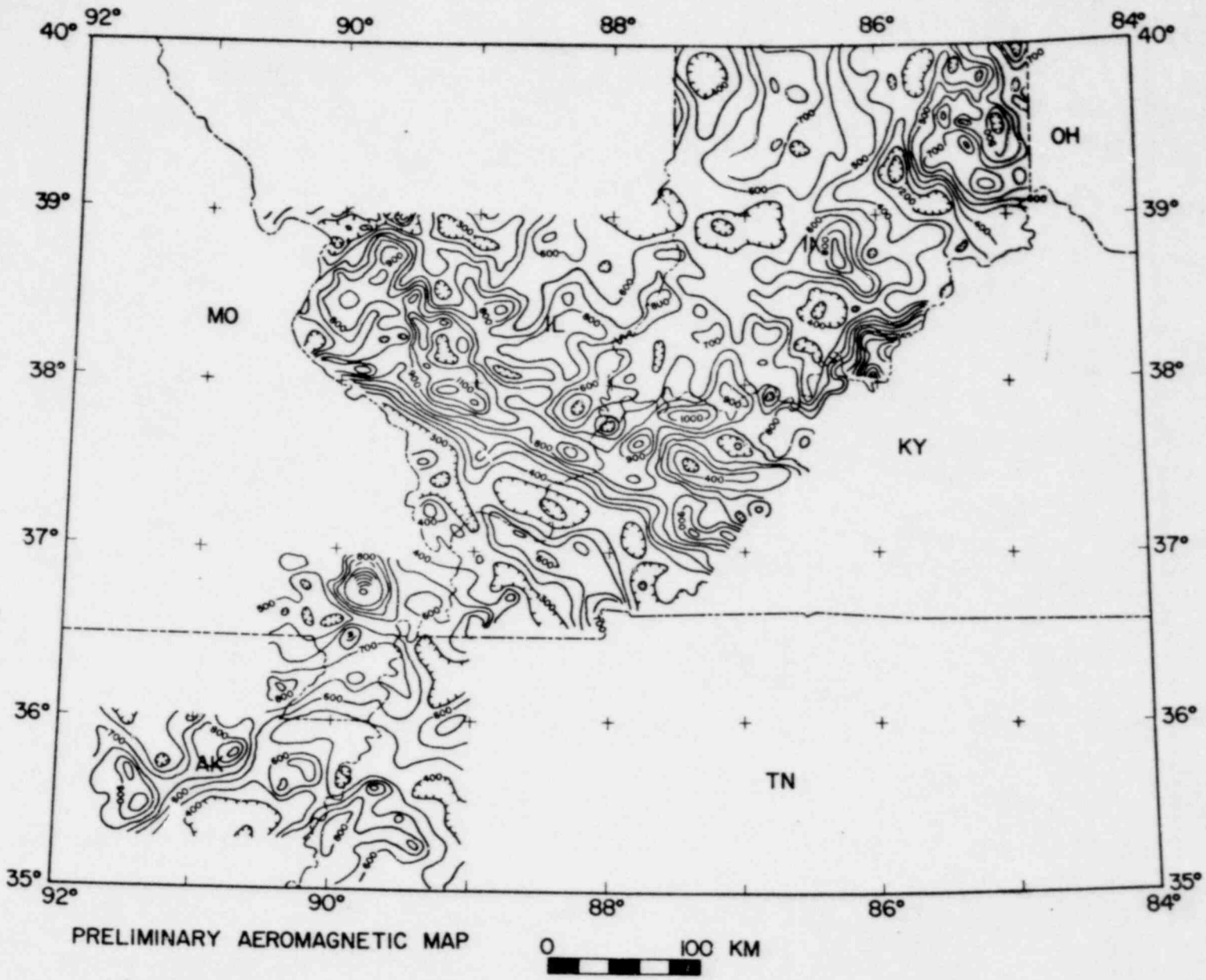

Figure 29 Preliminary total magnetic intensity anomaly map of the New Madrid Fault Zone and surrounding area. Contour interval is 100 gammas. Survey elevation is 2 km.

2209 213

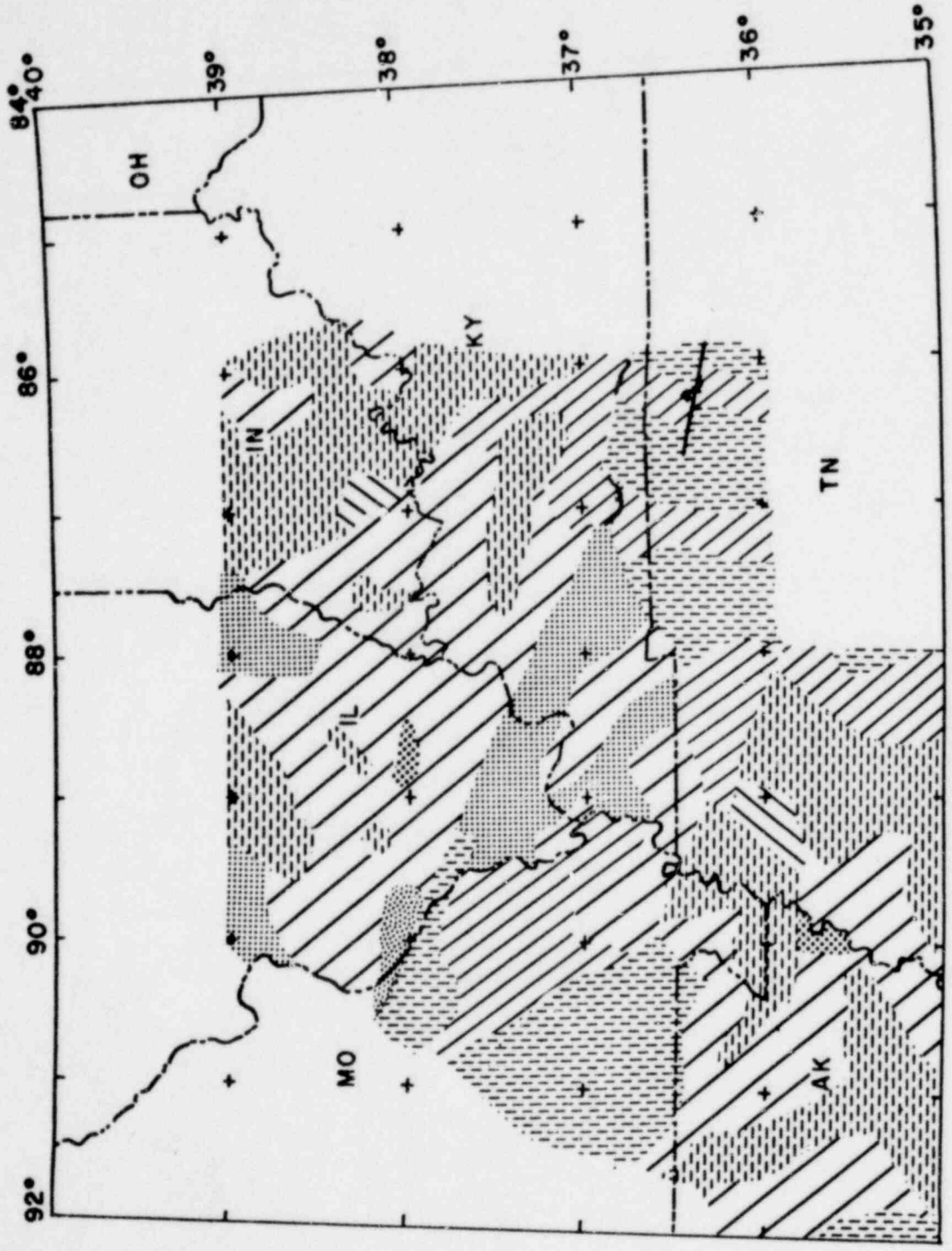

Figure 30 Preliminary Map of Selected Basement and Geophysical Parameters

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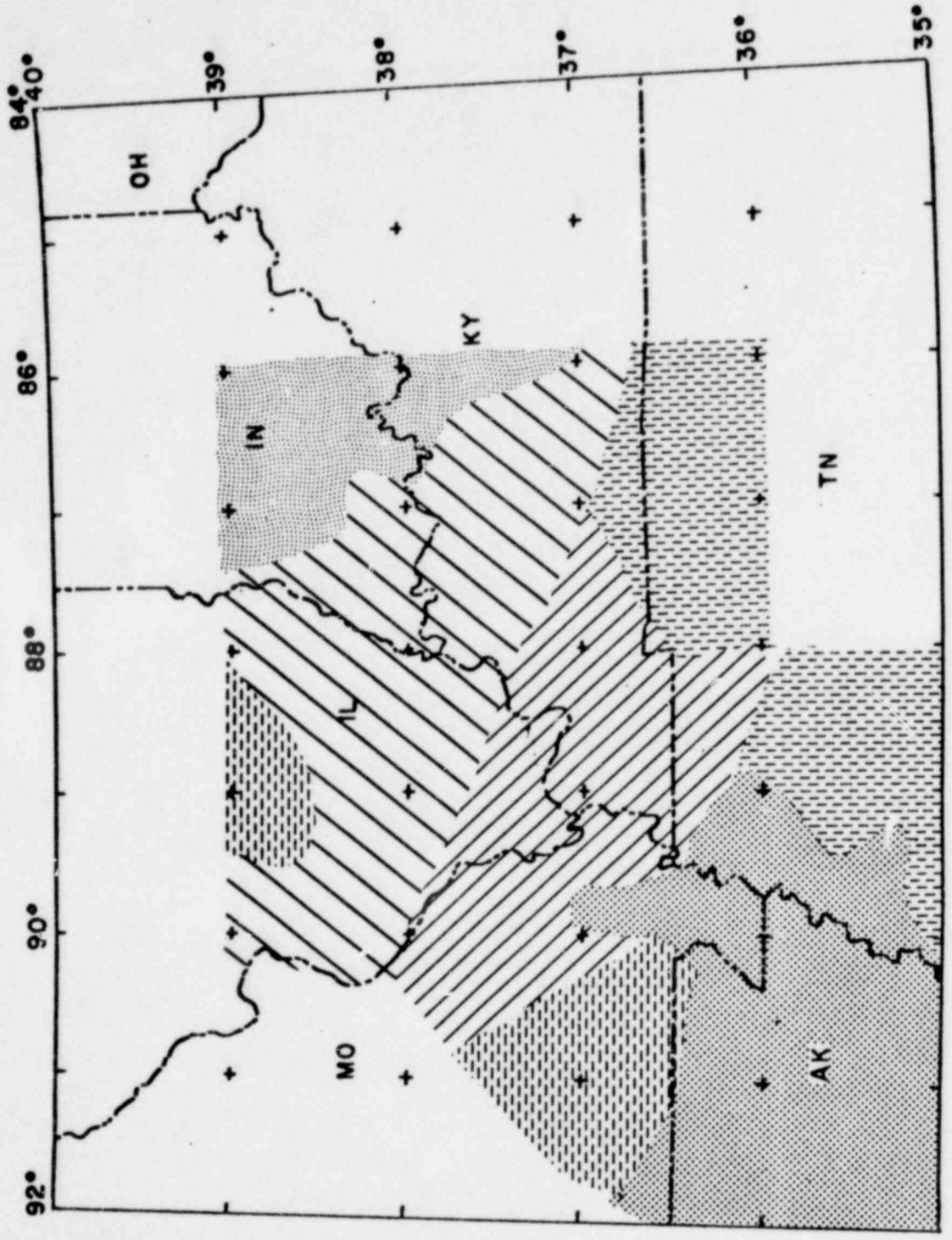

Figure 31 Preliminary Map of Inferred Basement and Geophysical Provinces

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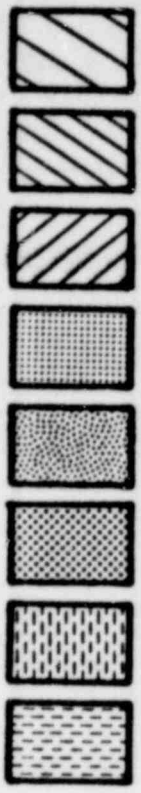
EXPLANATION FOR FIGURE 30



Gravity and Magnetic High

Gravity High

Magnetic High

Gravity High and Magnetic Low

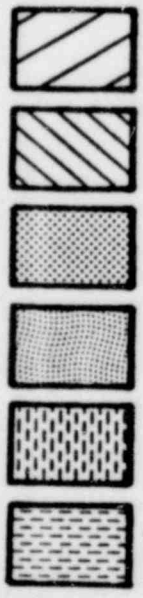
Gravity Low and Magnetic Low

Magnetic Low

Gravity Low

Gravity and Magnetic Low

EXPLANATION FOR FIGURE 31



Gravity and Magnetic Highs

Gravity Highs and Northwest-Trending Magnetic Highs and Lows

Gravity Highs and Circular or Northeast-Trending Magnetic Highs

Gravity and Magnetic Lows with Local Gravity and Magnetic Highs

Gravity Lows and North-Trending Gravity Highs

Gravity Lows

2209 216

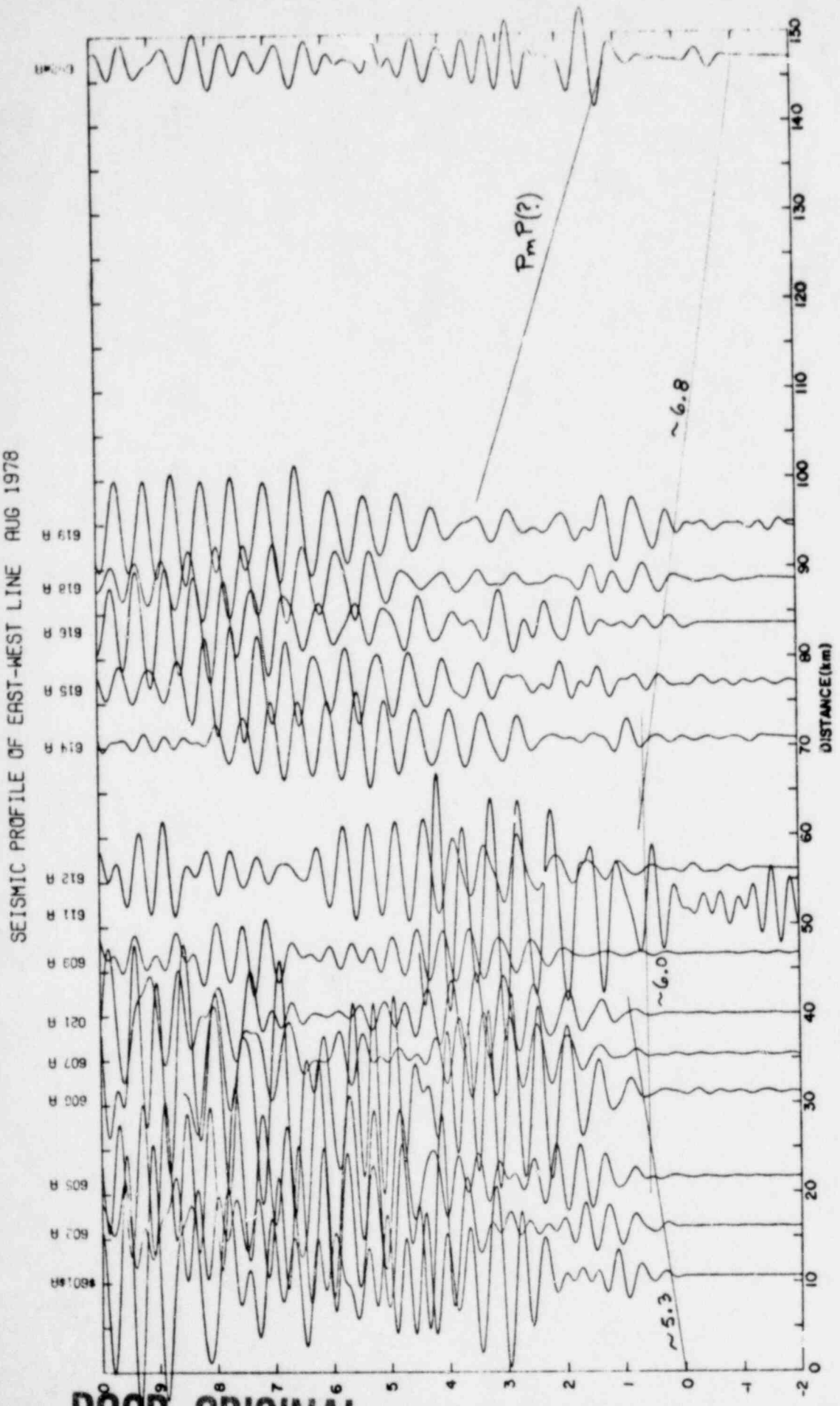


Figure 33 Vertical component seismograms for E-W refraction profile.

2209 217

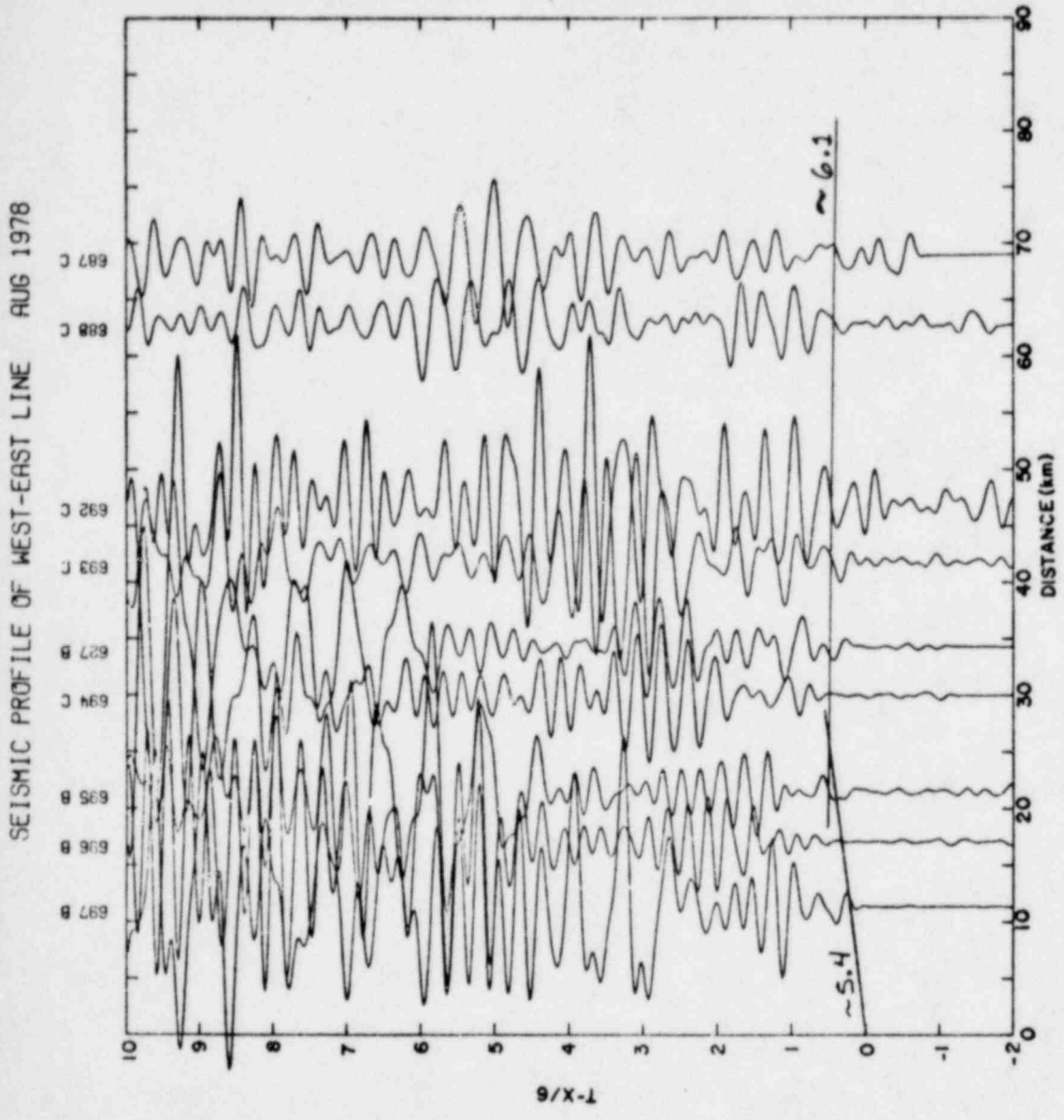


Figure 34 Vertical component seismograms for W-E refraction profile.

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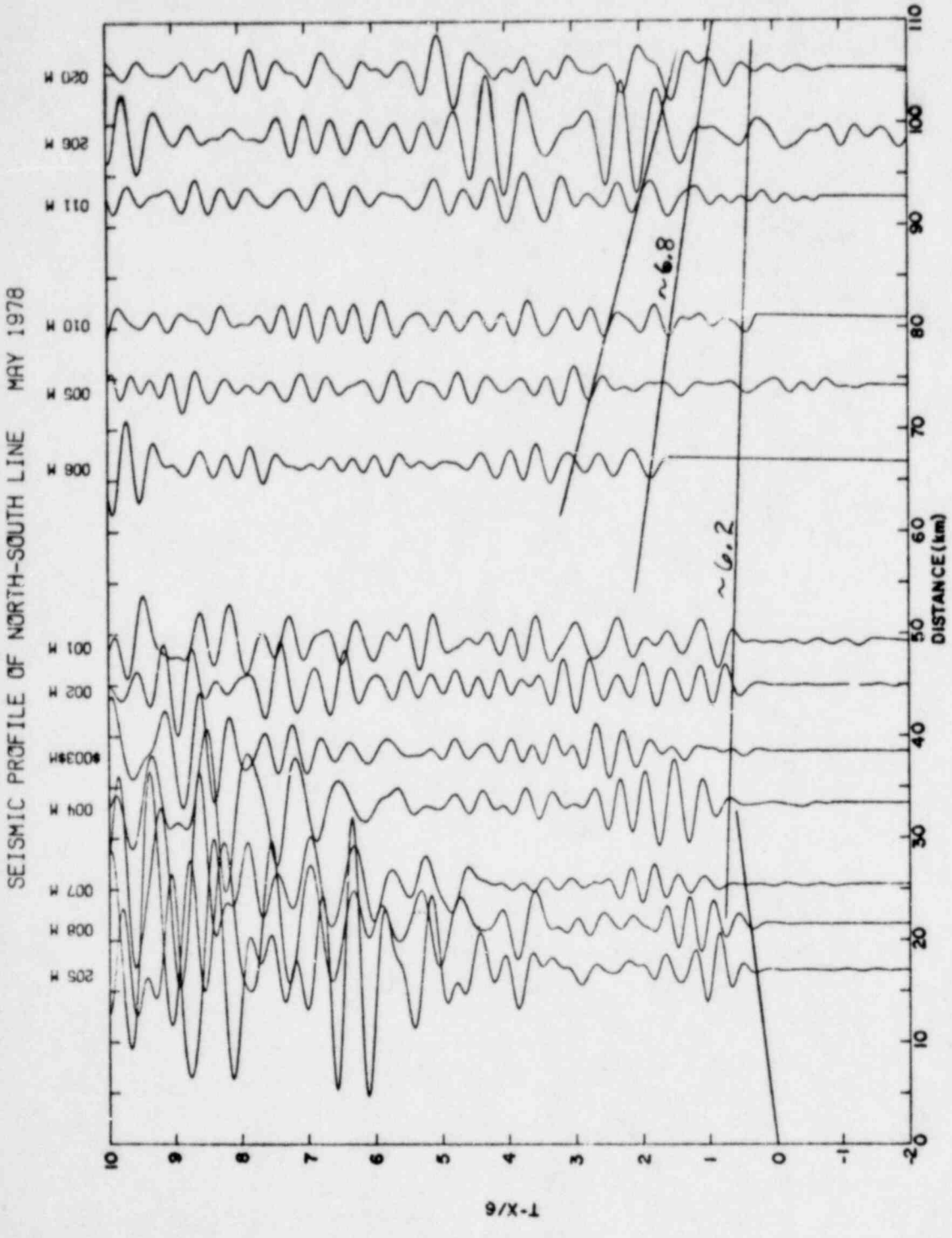

Figure 35 Vertical component seismograms for N-S refraction profile.

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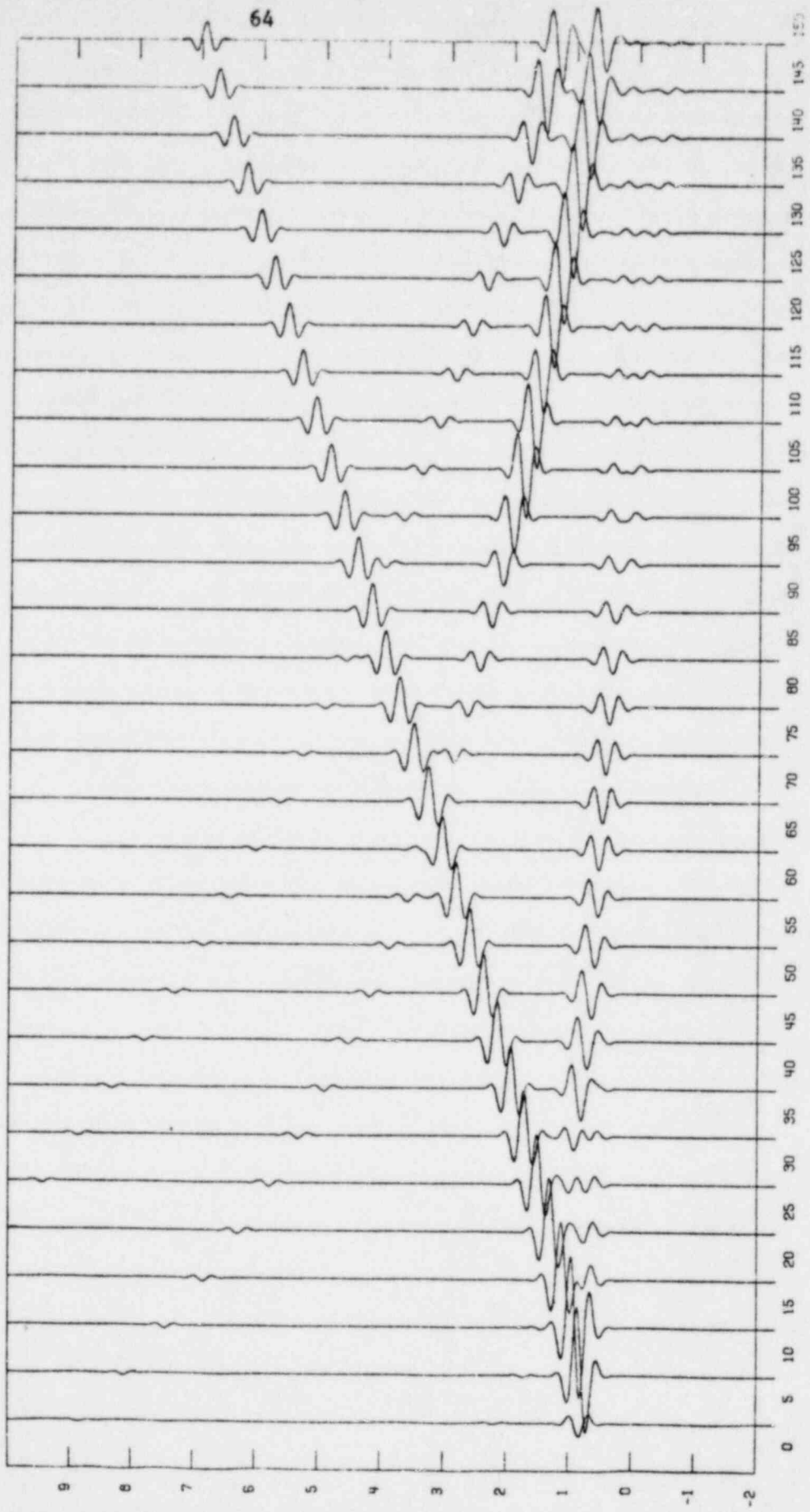

Figure 36 Synthetic Seismogram record sections plotted at the same scale as the observed data (Figures 33,34 and 35) computed for two crustal models which have been proposed for the Midcontinent region.

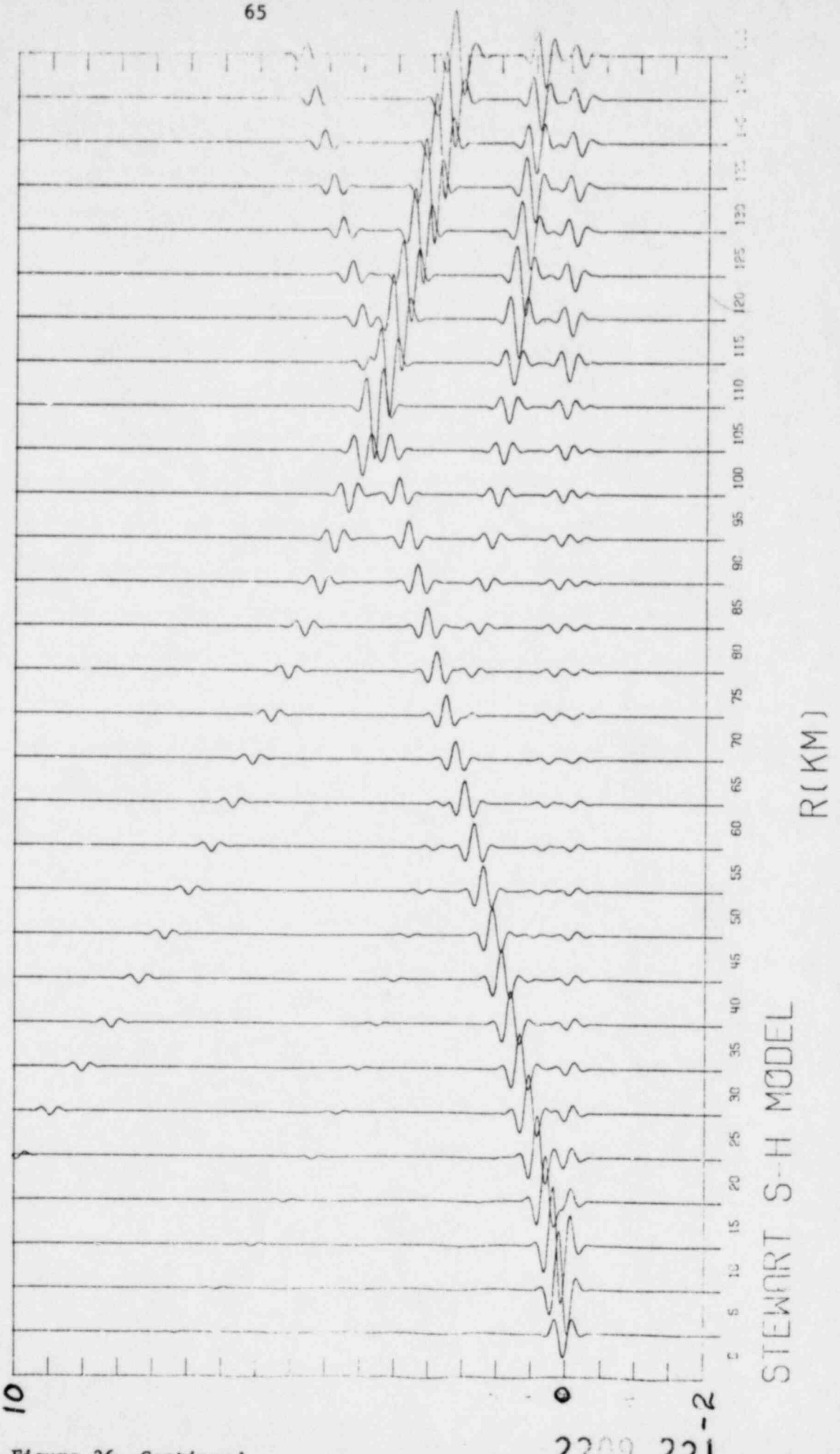

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Figure 36 Continued

THE NORTHEASTERN EXTENSION OF THE NEW MADRID FAULT ZONE

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and
William J. Hinze

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Figure 37 Abstract of manuscript submitted to U. S. Geological Survey Professional Paper on the New Madrid area.

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ABSTRACT

Linear trends of marginal, correlative, positive gravity and magnetic anomalies which bound a central zone of low gravity and magnetic relief and are associated with the New Madrid Seismic Zone can be traced northeastward into southern Indiana at least to 39° N latitude on regional gravity and magnetic maps which are presented here. The anomalies are clearly associated with the trend of earthquake epicenters in the New Madrid area and to the northeast. The northeasterly trend of gravity and magnetic anomalies and the associated epicenters are both deflected at about 36° 30' N latitude. These observations imply that basement structural features are a primary control on the locations of earthquake epicenters in the Midcontinent region. The linear trends of gravity and magnetic anomalies define a basement structural feature which we have termed The New Madrid Linear Tectonic Feature (NMLTF). The NMLTF (from 35° to 39° N) is interpreted as a single structural unit and the existence of earthquake epicenters associated with the NMLTF indicates the possibility that significant earthquake activity may occur along its entire length.

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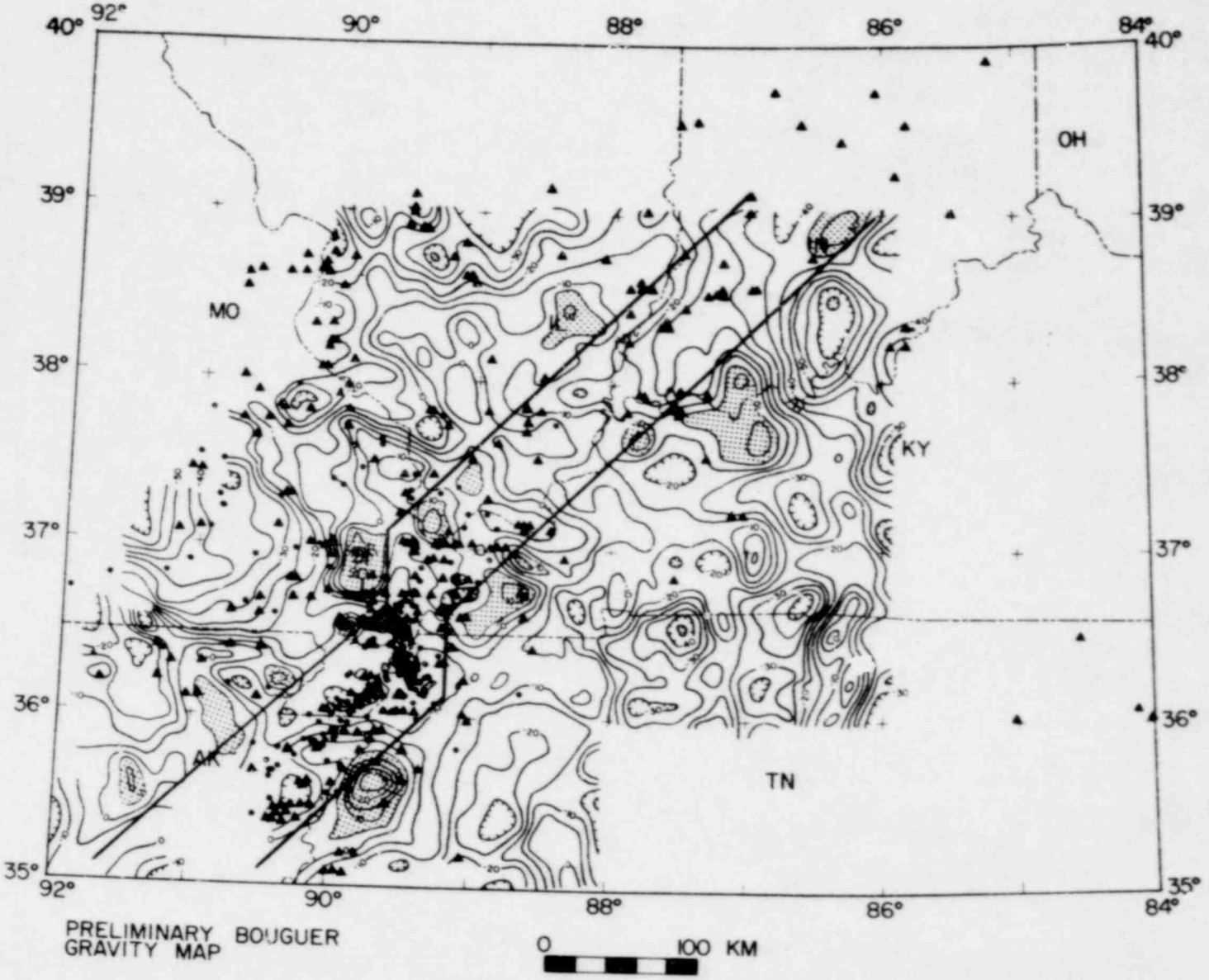

Figure 38 Preliminary Bouguer gravity anomaly map of New Madrid area with positive gravity anomalies which define the NMLTF indicated by heavy lines. Earthquake epicenters are shown by triangles for historical earthquakes and circles for microearthquakes located by St. Louis University seismographs array during a two-year period.

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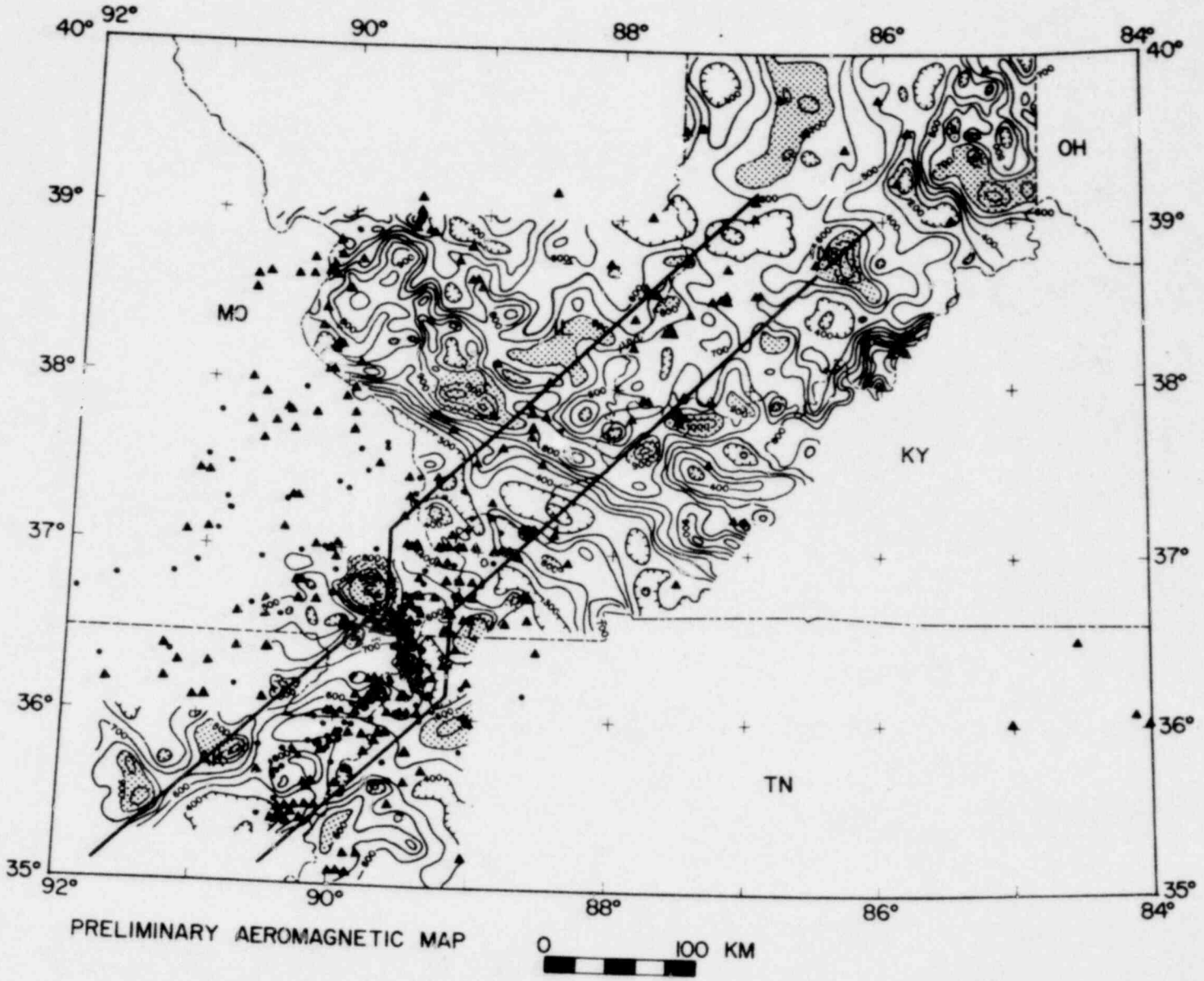

Figure 39 Preliminary total magnetic intensity anomaly map of New Madrid area with positive gravity anomalies which define the NMLTF indicated by heavy lines. Earthquake epicenters are shown by triangles for historical earthquakes and circles for microearthquakes located by St. Louis University seismographs array during a two-year period.

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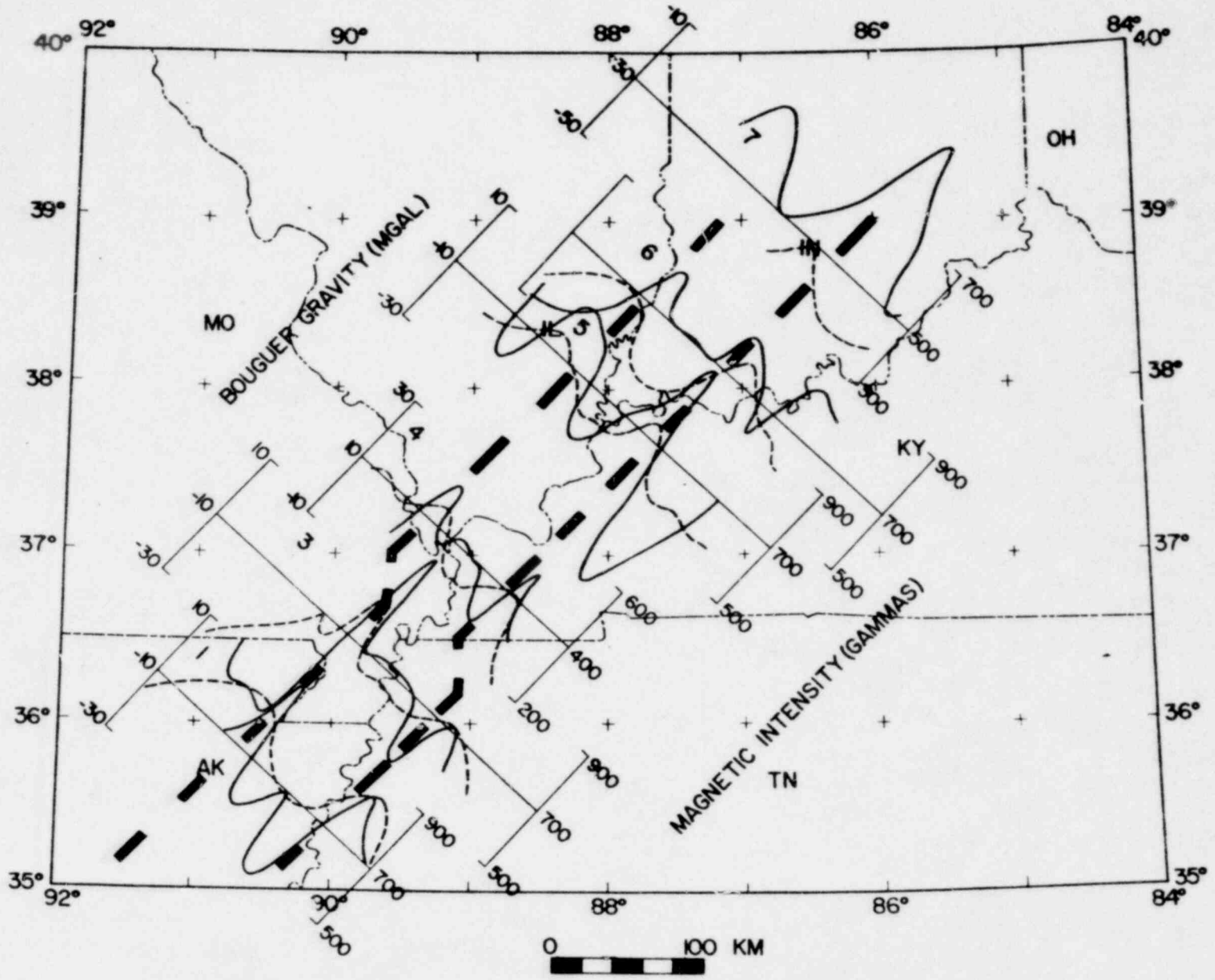

Figure 40 Gravity and magnetic profiles oriented perpendicular to the NMLTF.

2209 226

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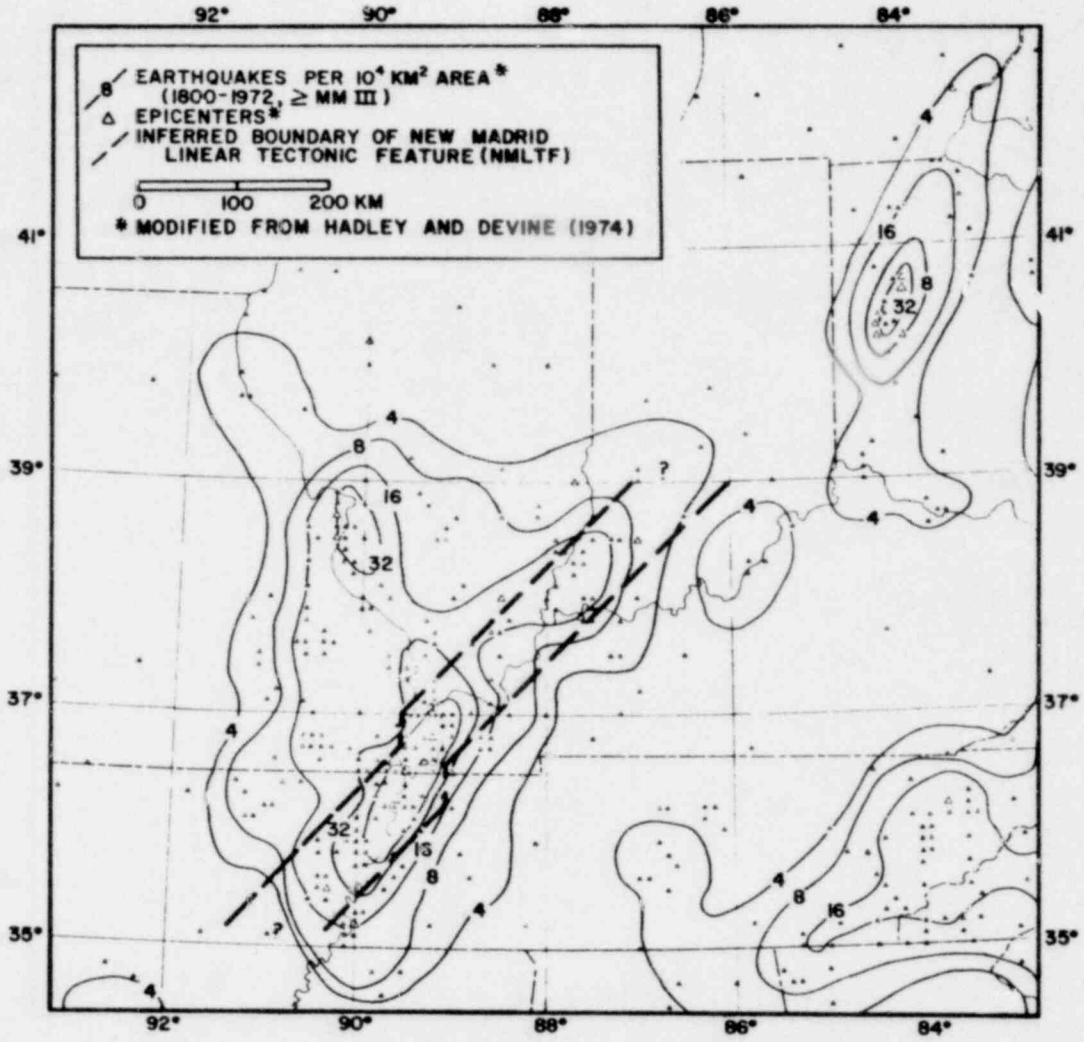

Figure 41 Earthquake epicenters and contours of earthquakes per 10^4 km ^{2} area after Hadley and Devine (1974). Heavy lines are boundary of interpreted NMLTF.

2200 227

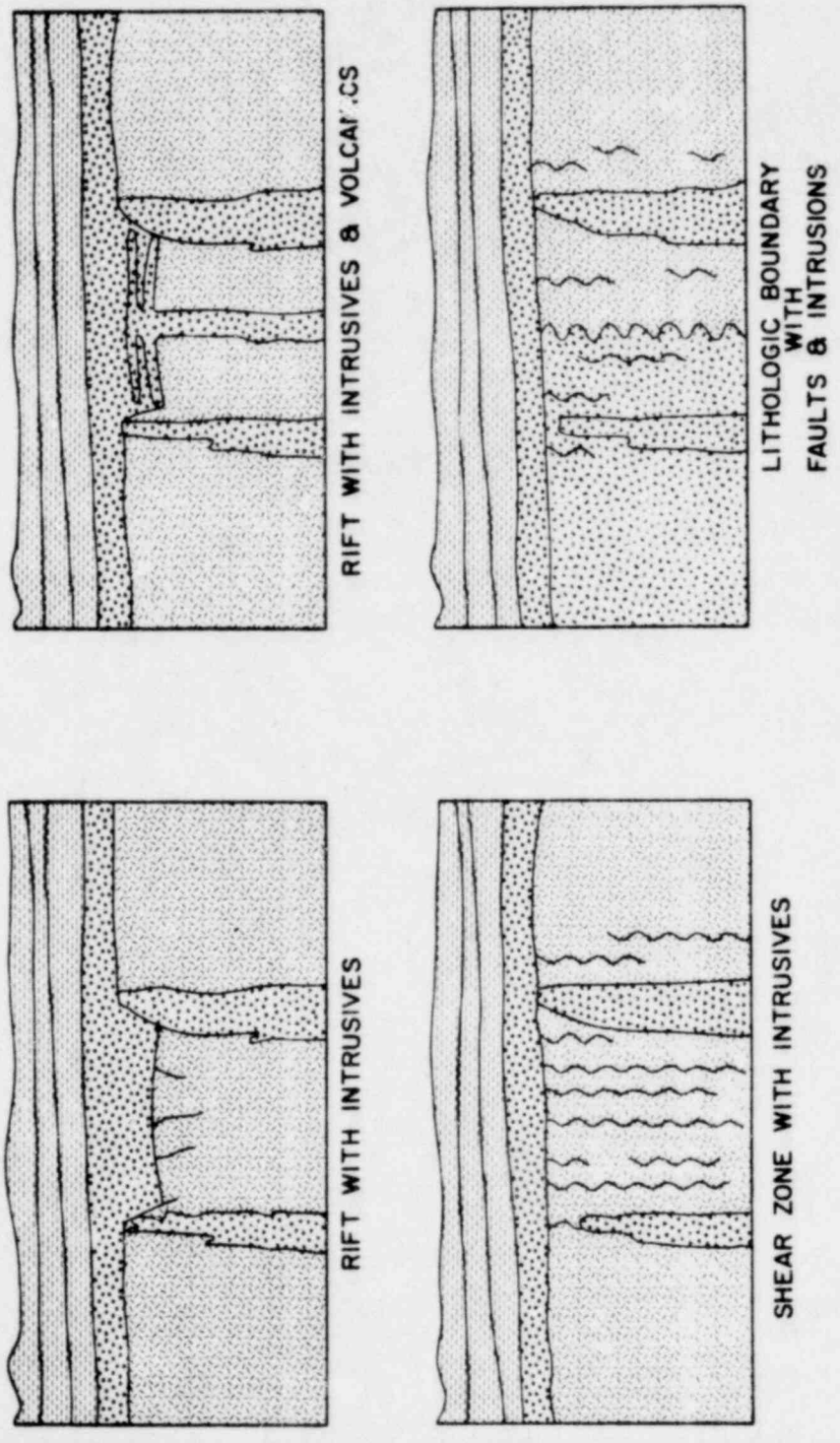

Figure 43 Schematic geologic models representing possible geologic cross sections to explain the positive gravity and magnetic anomalies and central gravity low in the southern Indiana area. Profile is oriented northwesterly and crosses the NMLTF.

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