U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

MISCELLANEOUS HIGH-RESOLUTION SEISMIC-REFLECTION RECONNAISSANCE SURVEYS IN THE MISSISSIPPI VALLEY GRABEN: WESTERN TENNESSEE, NORTHEAST ARKANSAS, AND SOUTHEAST MISSOURI

by

Jack K. Odum[1], William J. Stephenson[1], Eugene A. Luzietti[2],

Kaye M. Shedlock[1], David M. Worley[1], and Robert A. Williams[1]

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[1]Denver, Colorado

[2]Chevron, USA Inc.
P.O. Box 6056
New Orleans, LA 70174

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MISCELLANEOUS HIGH-RESOLUTION SEISMIC-REFLECTION RECONNAISSANCE SURVEYS IN THE MISSISSIPPI VALLEY GRABEN: WESTERN TENNESSEE, NORTHEAST ARKANSAS, AND SOUTHEAST MISSOURI

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INTRODUCTION

The northern Mississippi Embayment was rocked by hundreds of small earthquakes and three high-magnitude events during the winter of 1811-1812. Although a large amount of the regional strain energy may have been dissipated by the three large earthquake events, an instrumentally defined pattern of concentrated modern seismic activity (the New Madrid seismic zone (NMSZ)) still exists within the northern Mississppi Embayment (fig. 1) (Stauder and others, 1976; Johnston and Nava, 1990; Chiu and others, 1992). The NMSZ, geographically encompassing parts of southeastern Missouri, western Tennessee, and northeastern Arkansas, is largely confined within the aeromagnetically and gravitationally defined boundaries of the Mississippi Valley graben, a crustal flaw beneath the Mississippi Embayment in the central United States. The NMSZ is widely recognized as being the most seismically active region east of the Rocky Mountains (Thomas, 1991; Johnston and Nava, 1990).

Even though the 1811-1812 New Madrid earthquakes are thought to be among the strongest historical events to have occurred within a stable continental setting (Johnston and Kanter, 1990), very little surficial and(or) near-surface deformation exists today to document this sequence of strong ground-shaking events. Thick deposits of unconsolidated Quaternary-Holocene alluvium and lateral planation, accompanied by cut-and-fill channeling of the ancestral and modern Mississippi and Ohio Rivers, make it difficult to identify evidence of seismogenic deformation in the near-surface strata. The most common and widespread surficial evidence includes sandblow deposits and fissures, earthquake-induced landslides along river bluffs, sunken terrain (sloughs), and small (generally less than 10 m) upwarps.

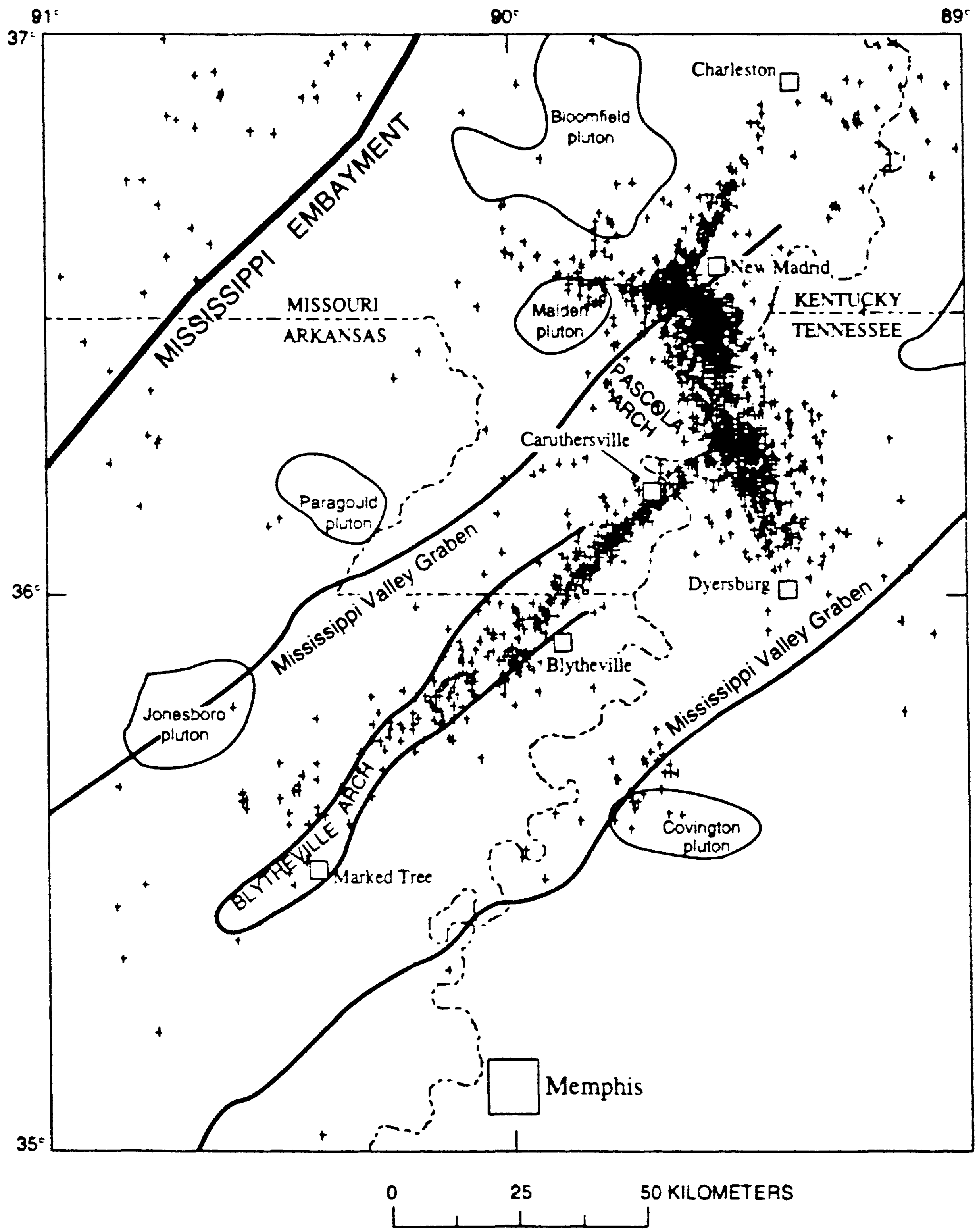

Figure 1. Regional map of the northern Mississippi Embayment showing Mississippi Valley graben boundaries and inferred plutons (Hildenbrand, 1985), Blytheville arch (Hamilton and McKeown, 1988), and epicenters (crosses) of earthquakes of M $\geq$ 1.5 (Andrews and others, 1985).

One component necessary for evaluating the seismic-hazard potential of the New Madrid seismic zone (NMSZ), with respect to the urban centers and industrial complexes of the upper Mississippi Embayment, is an understanding of the style, extent, mode of origin, and age of near-surface (surface to 1 km deep) deformational features (warping and faulting) and their relationship to deeper rift fault systems. To facilitate this understanding, the U.S. Geological Survey (USGS), in cooperation with the Center for Earthquake Research Information (CERI-Memphis State University), the University of Arkansas, and Southern Illinois University, acquired over 100 km of Mini-Sosie high-resolution seismic-reflection data during the 1990 and 1991 field seasons.

These Mini-Sosie surveys generally targeted surficial features (observed on airphoto and remote-sensing images) of possible seismogenic origin as well as structural anomalies observed on Vibroseis reflection profiles. Interpretations and discussions of the majority of these Mini-Sosie acquired profiles have been, or are in the process of being, published in the form of site-specific studies (Luzietti and Harding, 1991; Luzietti and others, 1992; Schweig and others, 1992; Sexton and others, 1992, VanArsdale and others, 1992). This open-file report presents uninterpreted, stacked seismic sections, field acquisition parameters, and detailed survey location maps for previously unpublished profiles.

REGIONAL SEISMIC DATA

Different styles of seismic-reflection surveys have been used to image the Mississippi Valley graben structures. Interpretations based upon hundreds of kilometers of Vibroseis seismic-reflection surveys within the graben and across its boundaries have been presented by Crone and Brockman (1982), Hamilton and McKeown (1988), Hamilton and Zoback (1982), and Crone (1992). These Vibroseis records (5-second two-way travel time (TWTT)) provide an image of lower Paleozoic and upper Cretaceous strata deposited within and overlapping the subsiding graben structure. Primarily, the Vibroseis data is biased to accentuate two strong reflectors: (1) the major unconformity between lower Paleozoic carbonates and Upper Cretaceous strata and (2) the unconformity between the upper Cretaceous and Tertiary strata (Crone, 1992). However, poor resolution of upper Tertiary and Quaternary reflectors by the Vibroseis data make it impossible to resolve questions of near-surface (less than 1 km) deformation and faulting, hence the need for Mini-Sosie high-resolution seismic data.

MINI-SOSIE DATA ACQUISITION AND PROCESSING

The Mini-Sosie method typically uses three portable, hand-operated, nondestructive earth tampers (Wackers) as a source of random pulse energy.

Sensors mounted on the footpads of each earth tamper transmit, by way of backpack-mounted radio transmitters, the exact impact time to a recording truck. For a single shot point, impact time signals and return data are stored in temporary memory. The seismic record written to tape for a specific shot point is produced by a cross-correlation process. This process time-shifts the return data sample, associated with an impact, to the equivalent sample of the initial impact, then sums the samples (Barbier, 1983; Wiles, 1979). By summing as many as 2,000 seismic records obtained over a several-minute (2-3) time period, the Mini-Sosie method effectively reduces the effects of cultural noise sources (Stephenson and others, 1992).

The field operations used to obtain the data presented in this report are similar to those outlined by Wiles (1979), and Table 1 lists data-acquisition parameters for the individual profiles presented in this paper. All surveys used 28 Hz geophones. The surveys were generally conducted along dirt roads or the shoulders of paved highways, and were designed to image reflectors between 50 and 800 m in depth. Elevations for datum-statics corrections were surveyed to ±5 cm. The geometery used provided 12-fold common midpoint (CMP) coverage. The field data was processed with a standard sequence of processing steps outlined by Yilmaz (1987). These processing steps include tape reformat, spectral whitening before stack, CMP sort, constant velocity analysis, normal moveout corrections, residual stactics corrections, CMP stack, and post-stack gap deconvolution.

DATA PRESENTATION

Figure 2 shows the approximate location of the eleven Mini-Sosie high-resolution seismic-reflection profiles presented in this paper. Profiles GL-6, GL-30, GL-31, GL-32, and GL-33 image strata within a several-kilometer-wide zone representing the surface projection of the aeromagnetically and gravitationally defined northwest Mississippi Valley graben margin. Profile GL-14 targeted surface lineations southeast of Reelfoot Lake. Profiles GL-26, GL-28, and GL-29 targeted the southeast margin of the Blytheville arch. Profile GL-25 is located toward the southwest end of the Crittenden County fault zone. The GL-34 reconnaissance line was located near the Fort Pillow test well and in an area generally lacking high-resolution data.

The appendix contains an enlargment of the USGS Topographic Quadrangle with the start and finish points of each profile marked. Each map is followed by an uninterpreted, migrated, and depth-converted profile.

Table 1. *Data acquisition parameters*

Parameter	Source type	Source array	Source duration	Source point interval	Geophone array	Geophone group spacing	Geophone configuration	Field Filters	Recording	Sampling rate	Trace length	Migrated	Depth-Converted
GL-6	3 earth compactors	1.5-m spacing parallel to profile line	2000 impulses/ shot point	9.14 m	1-m point area	9.14 m	24 channel, end-on	60-180 Hz band pass, 24 db/ octave	I/O DHR 2400	1 ms	1,000 ms	Yes	Yes
GL-14	Do	do	do	15.24 m	do	15.24 m	15.24 m	40-180	40-180	40-180	40-180	Yes	Yes
GL-25	do	do	do	do	do	do	do	do	do	do	do	Yes	Yes
GL-26	do	do	do	do	do	do	do	40-120	40-120	40-120	40-120	Yes	No
GL-28	do	do	do	do	do	do	do	do	do	do	do	Yes	No
GL-29	do	do	do	do	do	do	do	do	do	do	do	Yes	No
GL-30	do	3.0 m	do	do	do	do	do	do	do	do	do	Yes	Yes
GL-31	do	do	do	do	do	do	do	40-180	40-180	40-180	40-180	Yes	Yes
GL-32	do	4.6 m	do	do	do	do	do	40-120	40-120	40-120	40-120	Yes	Yes
GL-33	do	do	do	do	do	do	do	do	do	do	do	Yes	Yes
GL-34	do	3.0 m	do	do	do	do	do	40-120	40-120	40-120	40-120	No	Yes

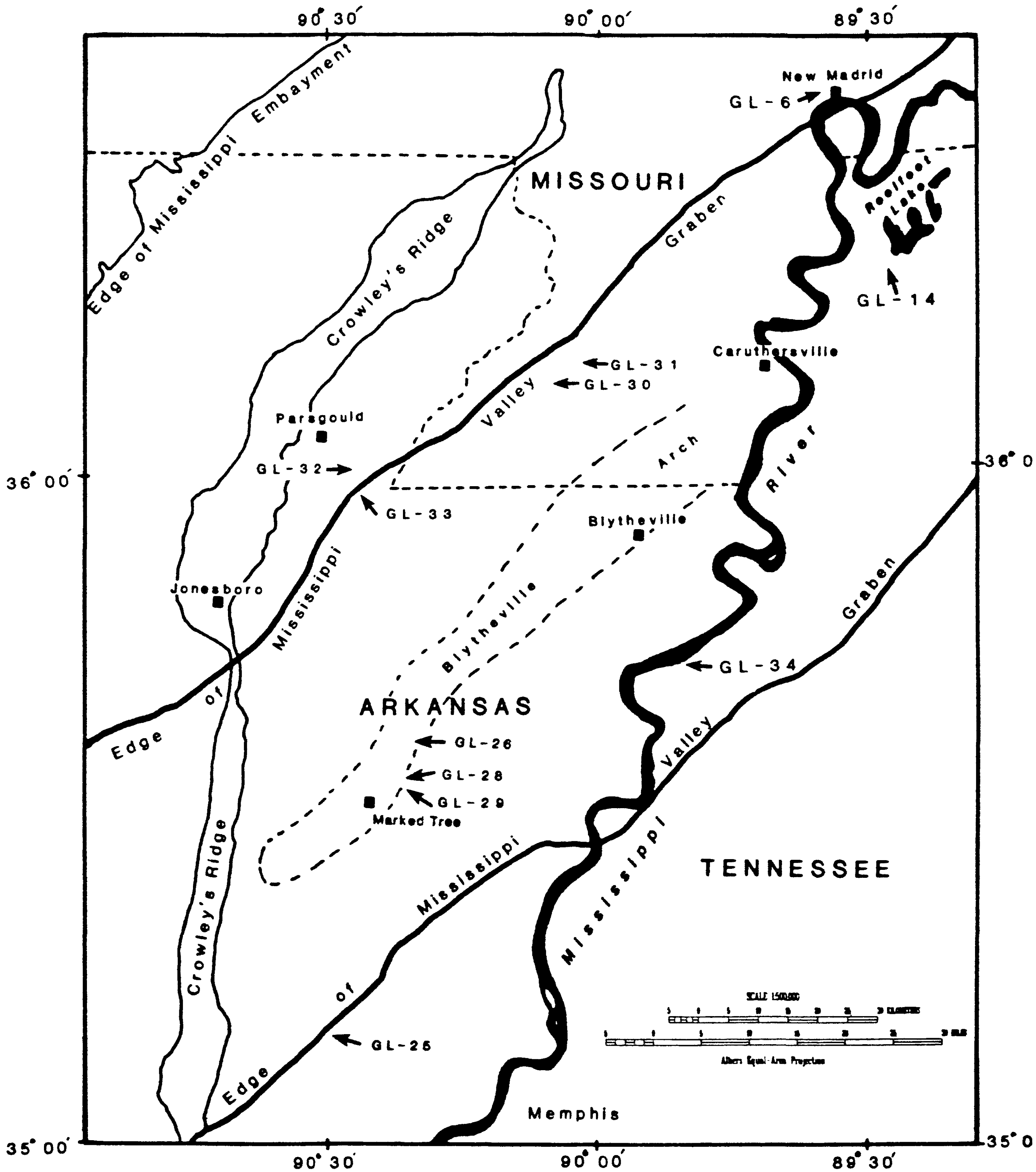

Figure 2. Approximate location (arrow point) of USGS Mini-Sosie seismic-reflection profiles presented in this report.

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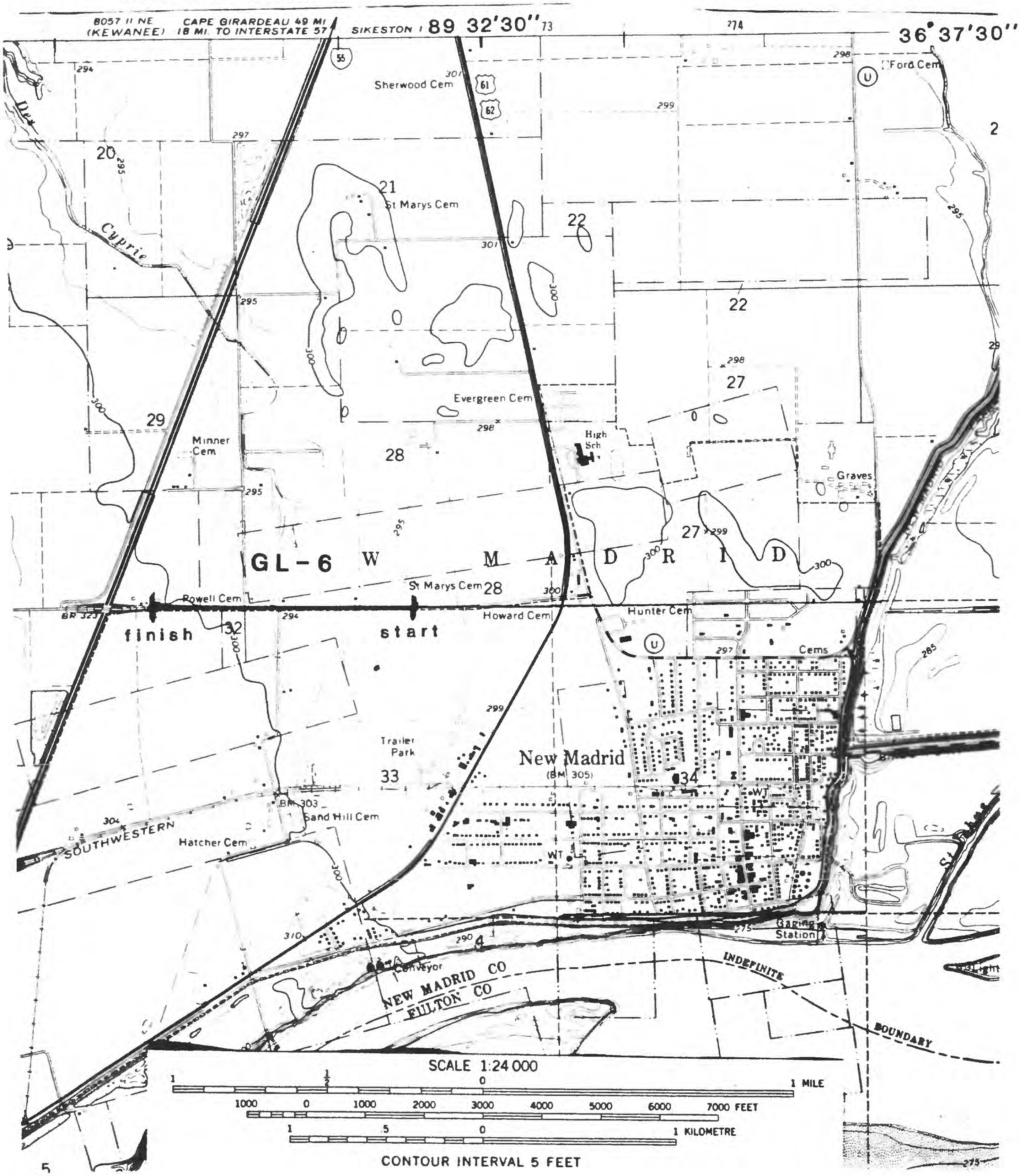
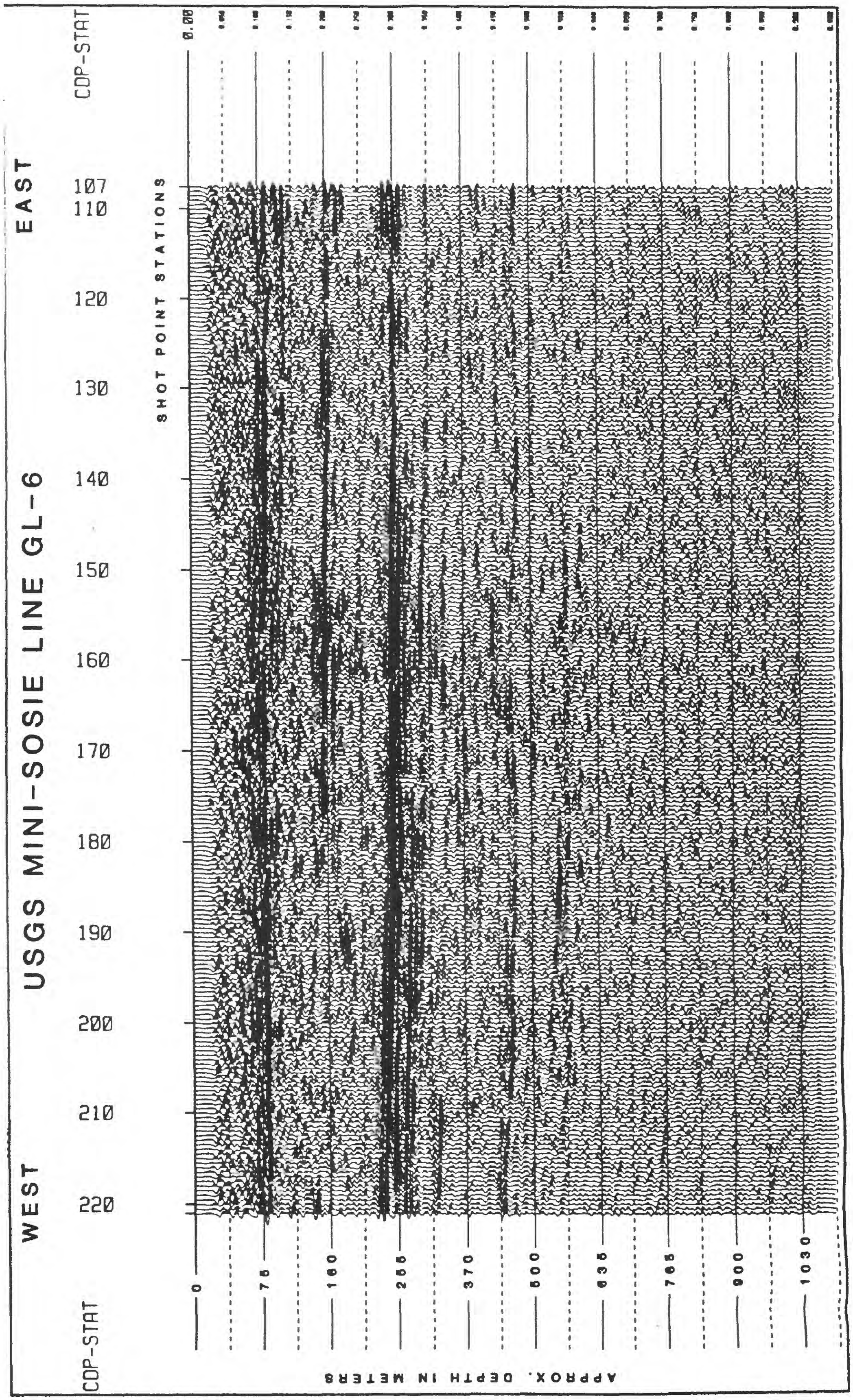
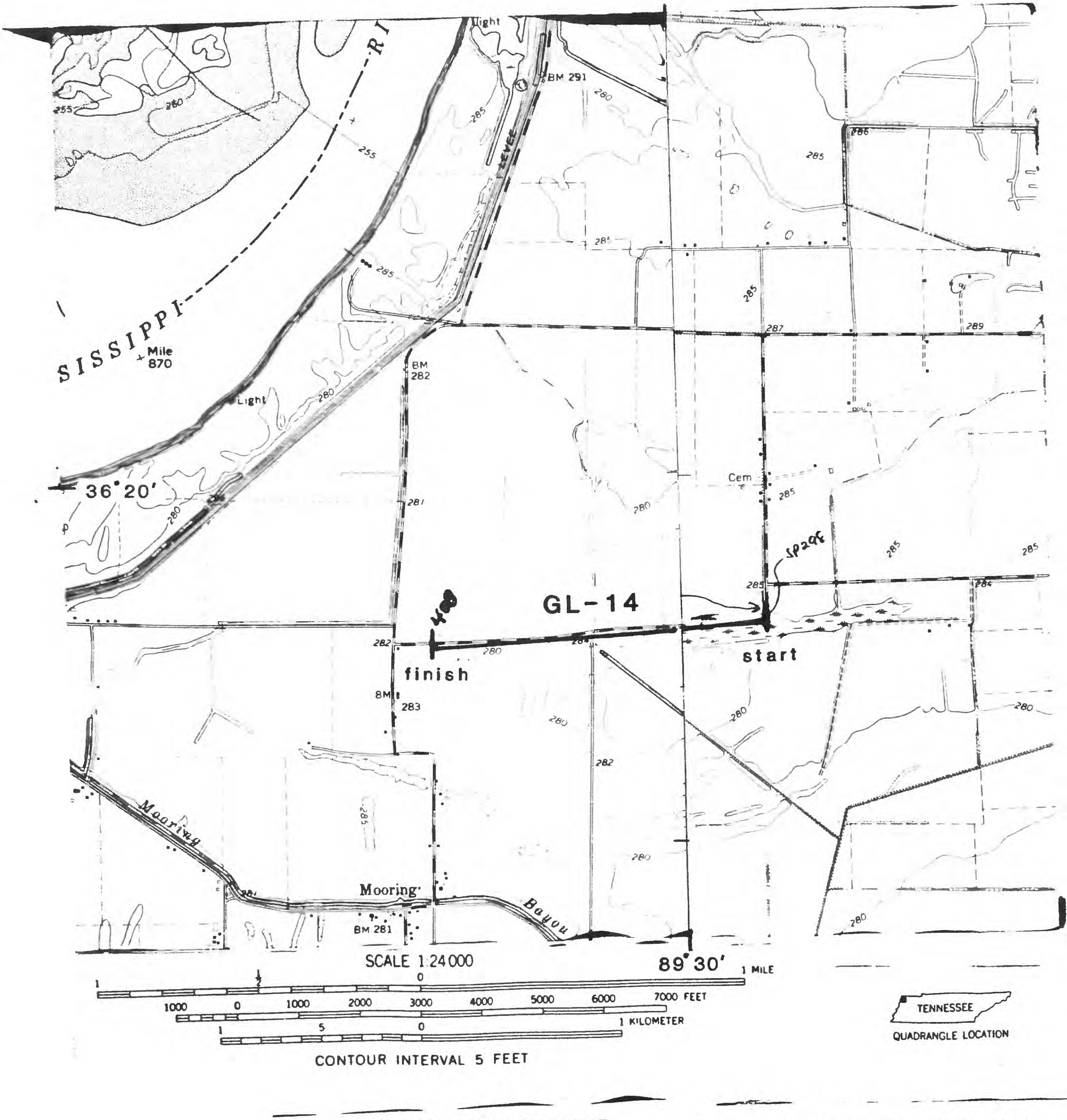
APPENDIX

(Survey locations and reflection profiles)

NEW MADRID QUADRANGLE
MISSOURI–KENTUCKY
7.5 MINUTE SERIES (TOPOGRAPHIC)
SE/4 NEW MADRID 15' QUADRANGLE

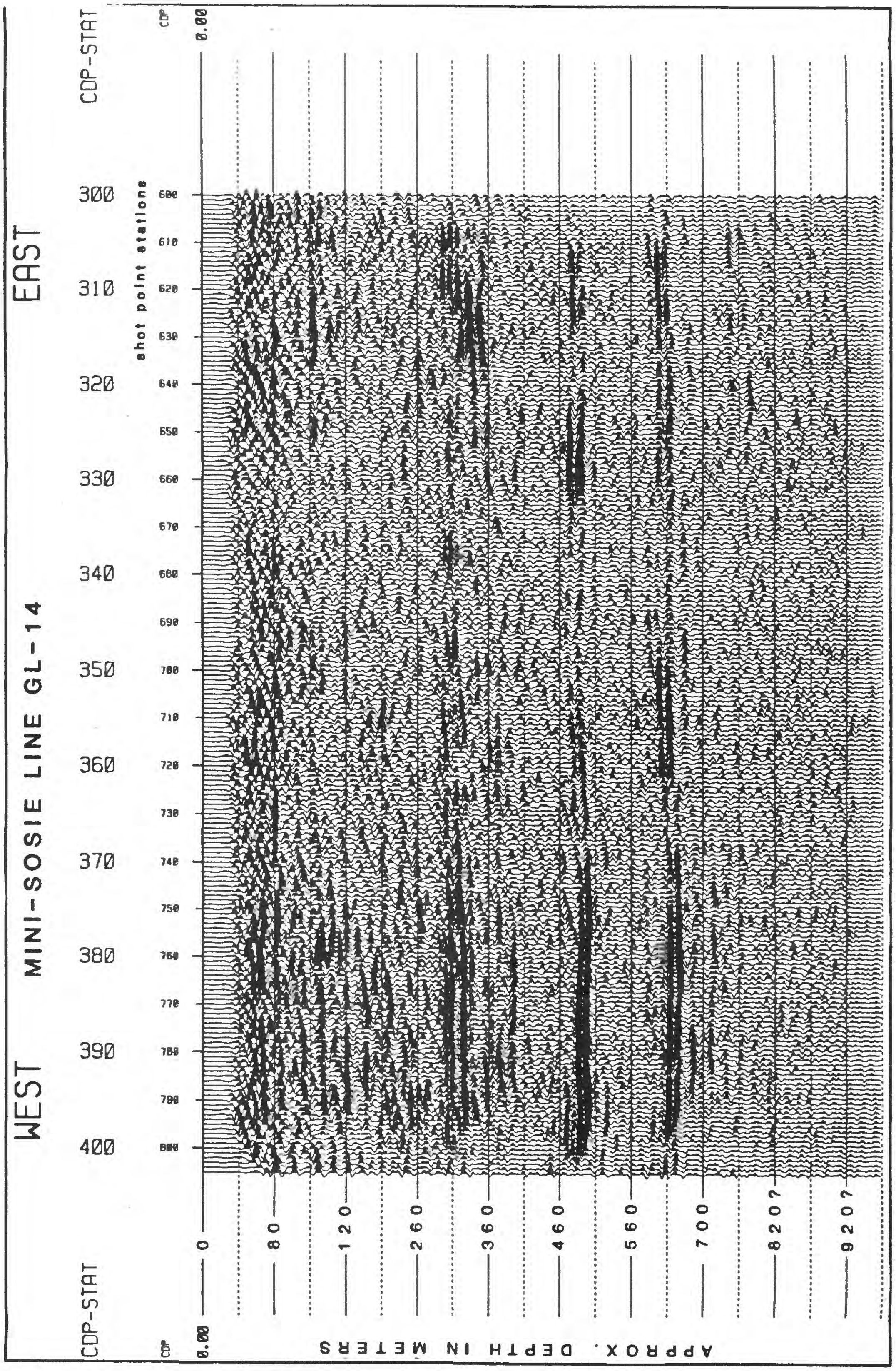



USGS MINI-SOSIE LINE GL-6
WEST
EAST
CDP-STAT
SHOT POINT STATIONS
107 110 120 130 140 150 160 170 180 190 200 210 220
0 75 160 255 370 500 635 765 900 1030
APPROX. DEPTH IN METERS

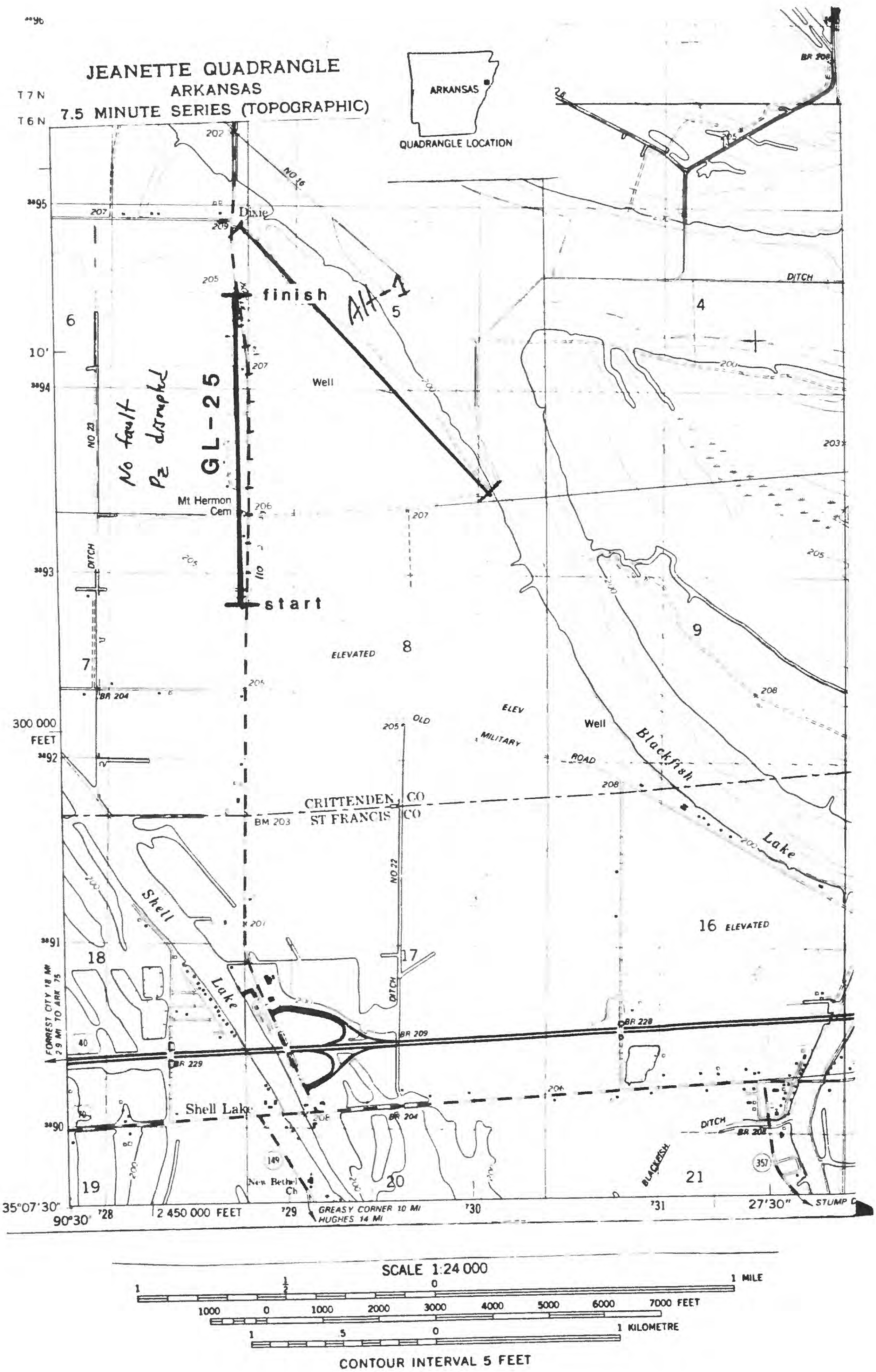


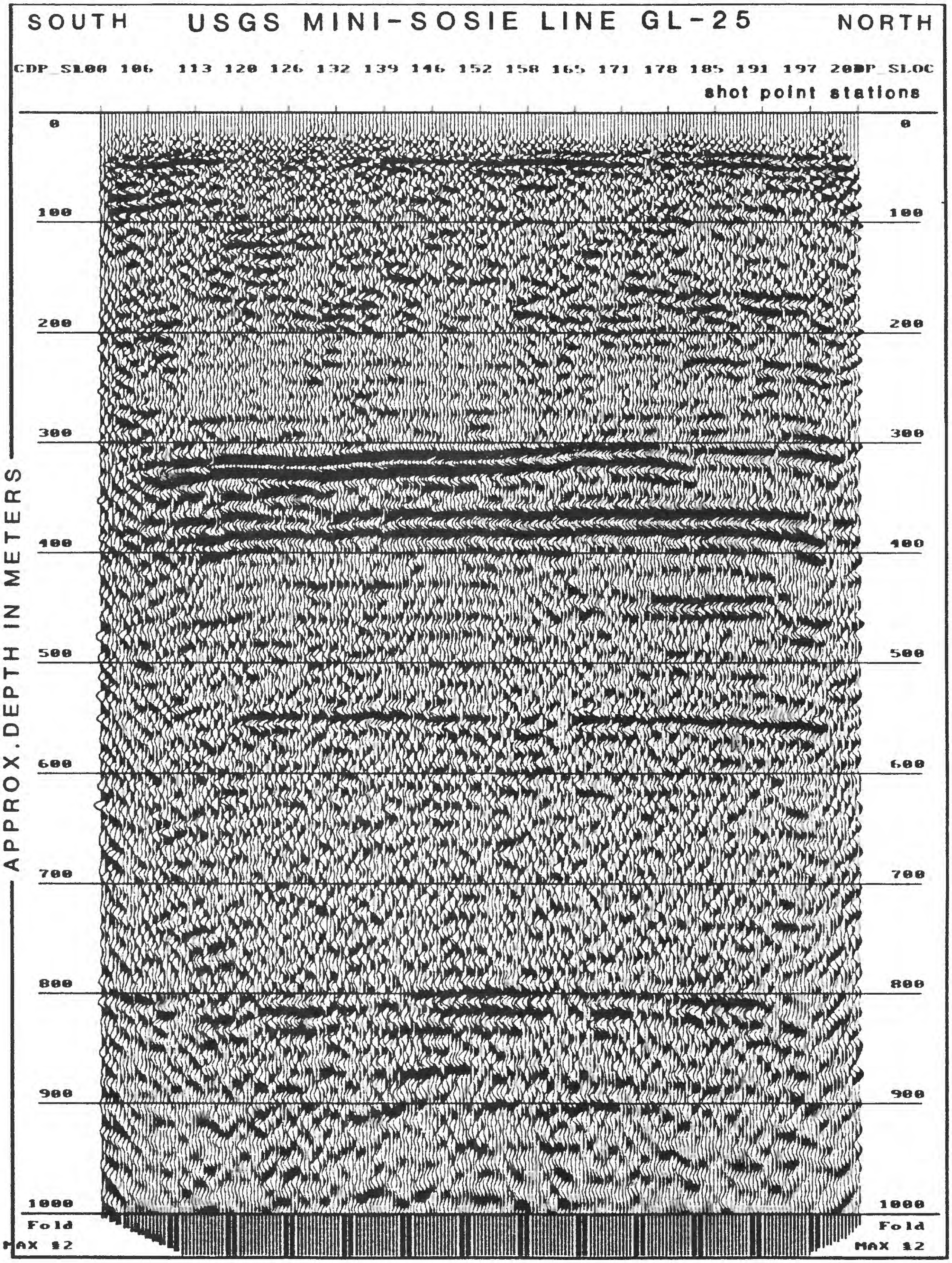
MOORING QUADRANGLE
TENNESSEE-MISSOURI
7.5 MINUTE SERIES (TOPOGRAPHIC)

RIDGELY QUADRANGLE
TENNESSEE
7.5 MINUTE SERIES (TOPOGRAPHIC)



WEST
EAST
MINI-SOSIE LINE GL-14
CDP-STAT
CDP-STAT
300
310
320
330
340
350
360
370
380
390
400
shot point stations
600
610
620
630
640
650
660
670
680
690
700
710
720
730
740
750
760
770
780
790
800
APPROX. DEPTH IN METERS
0
80
120
260
360
460
560
700
820?
920?


JEANETTE QUADRANGLE
ARKANSAS
7.5 MINUTE SERIES (TOPOGRAPHIC)
ARKANSAS
QUADRANGLE LOCATION
T7N
T6N
finish
start
Alt-1
GL-25
No fault
Pz disrupted
Dixie
Well
Mt Hermon Cem
ELEVATED
ELEV
OLD MILITARY ROAD
Blackfish Lake
CRITTENDEN CO
ST FRANCIS CO
BM 203
Shell Lake
16 ELEVATED
DITCH
New Bethel Ch
GREASY CORNER 10 MI
HUGHES 14 MI
FORREST CITY 18 MI
2.9 MI TO ARK 75
300 000 FEET
2 450 000 FEET
35°07'30"
90°30'
27'30"
STUMP C
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETRE
CONTOUR INTERVAL 5 FEET


SOUTH
USGS MINI-SOSIE LINE GL-25
NORTH
CDP_SLOC 100 106 113 120 126 132 139 146 152 158 165 171 178 185 191 197 203 CDP_SLOC
shot point stations
0
100
200
300
400
500
600
700
800
900
1000
APPROX. DEPTH IN METERS
Fold
MAX 12

UNITED STATES
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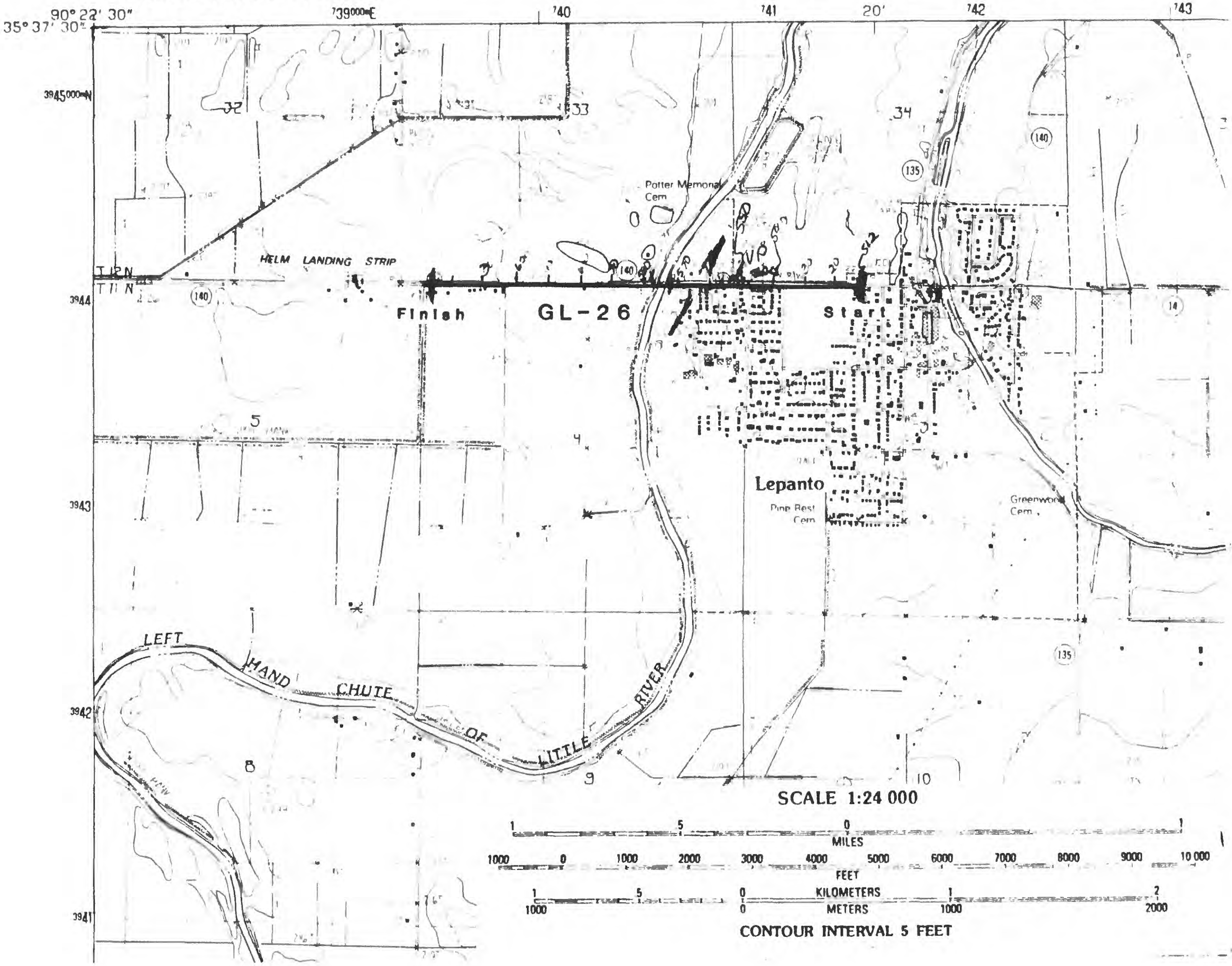
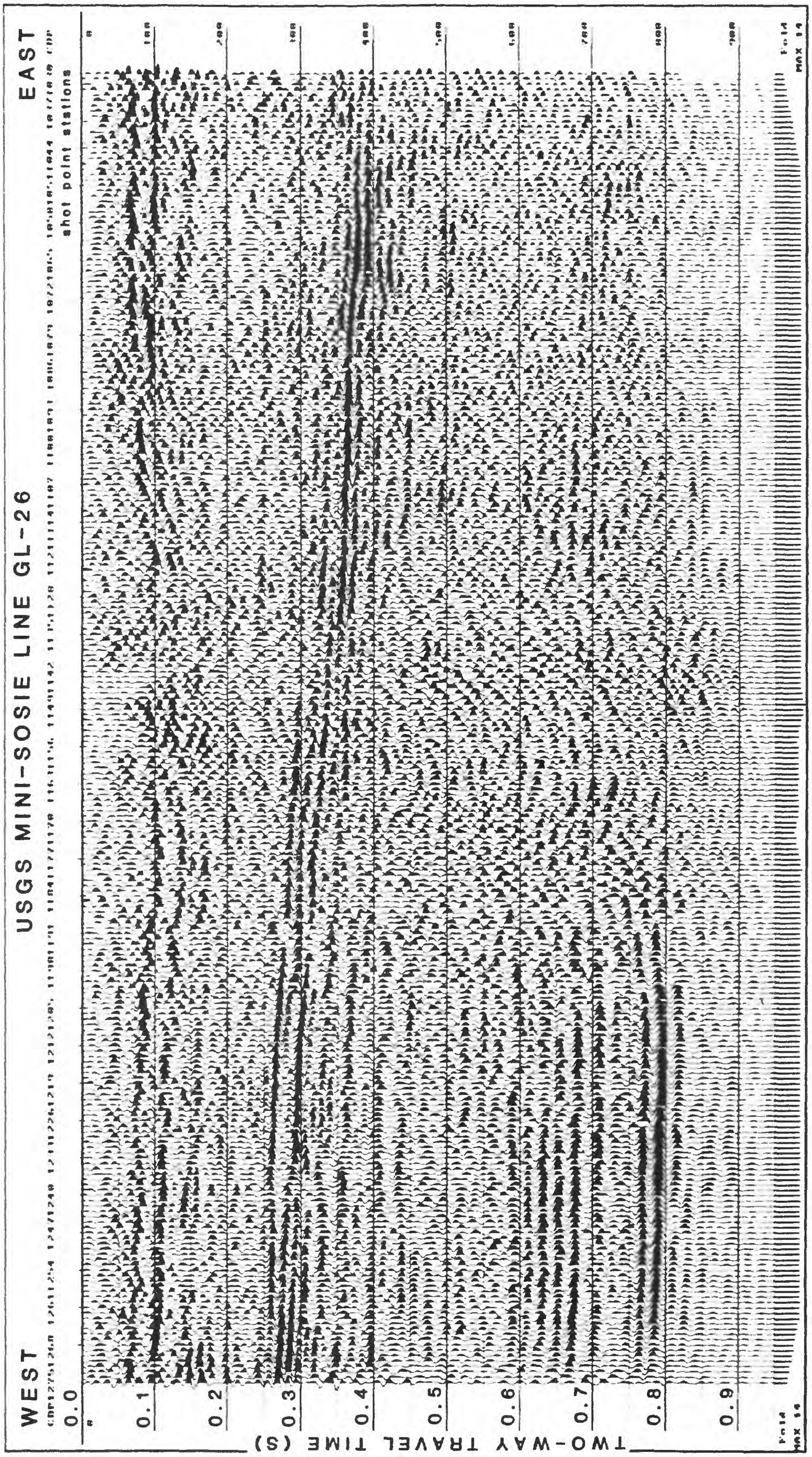
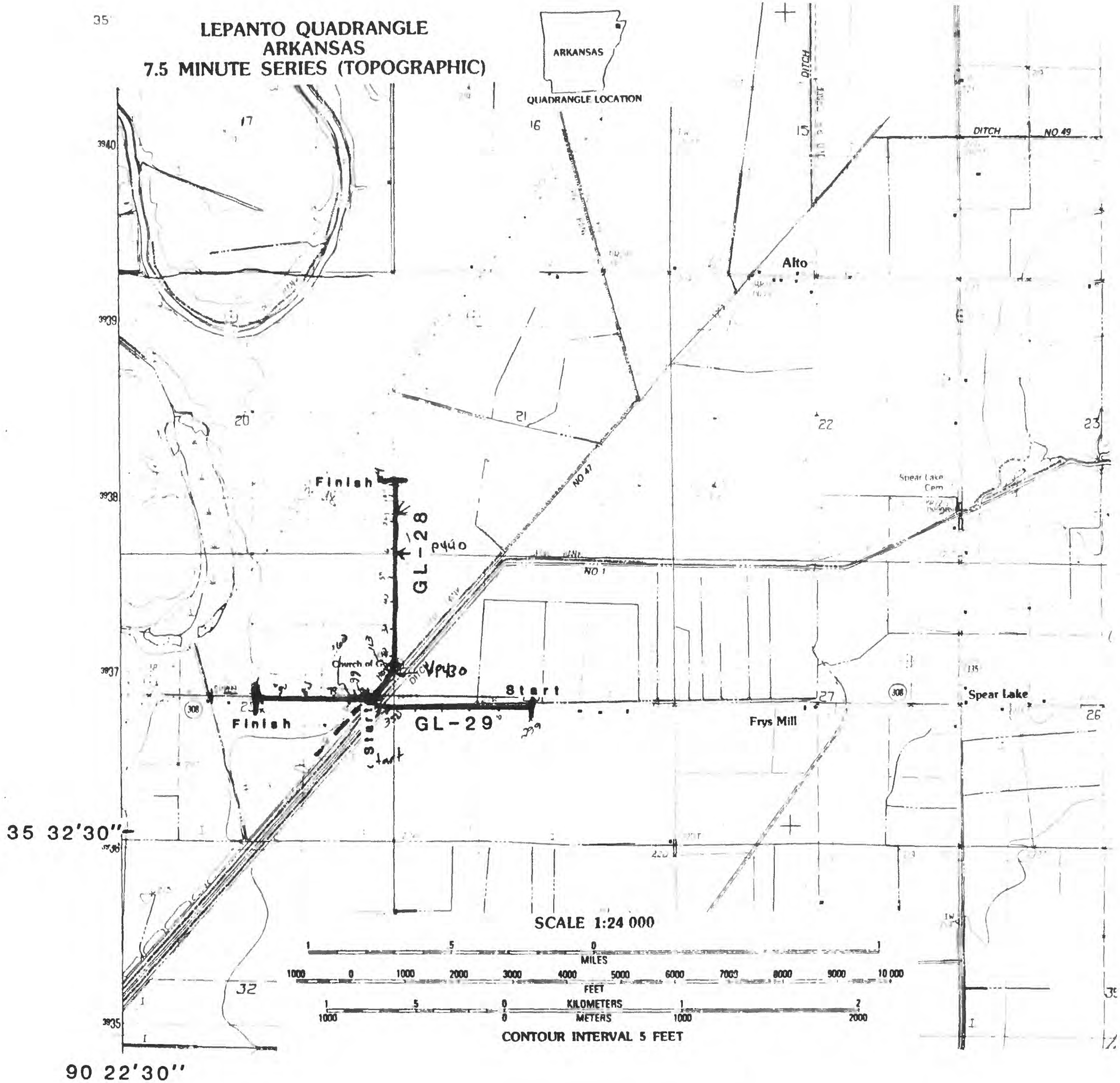
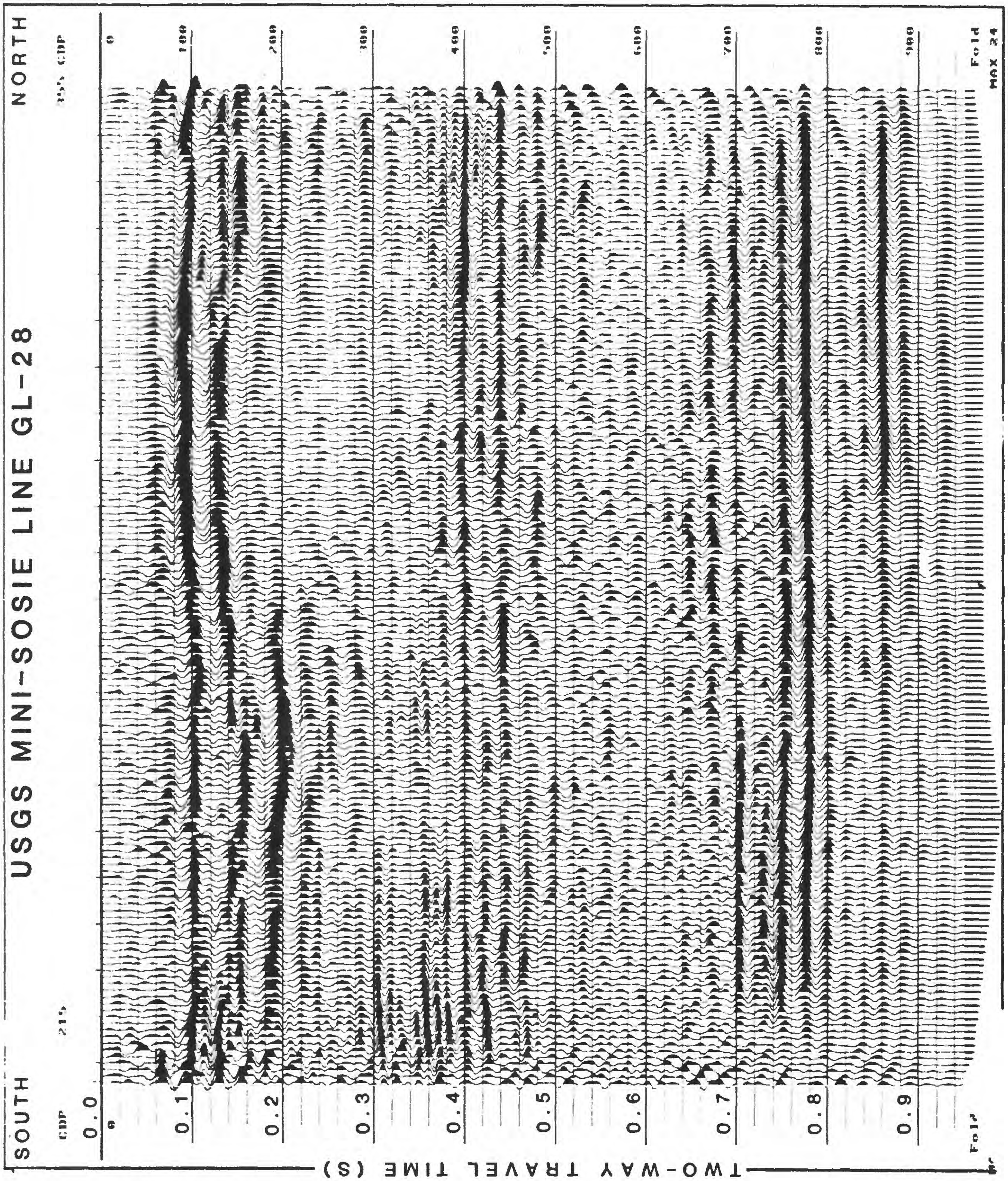
LEPANTO QUADRANGLE
ARKANSAS
7.5 MINUTE SERIES (TOPOGRAPHIC)

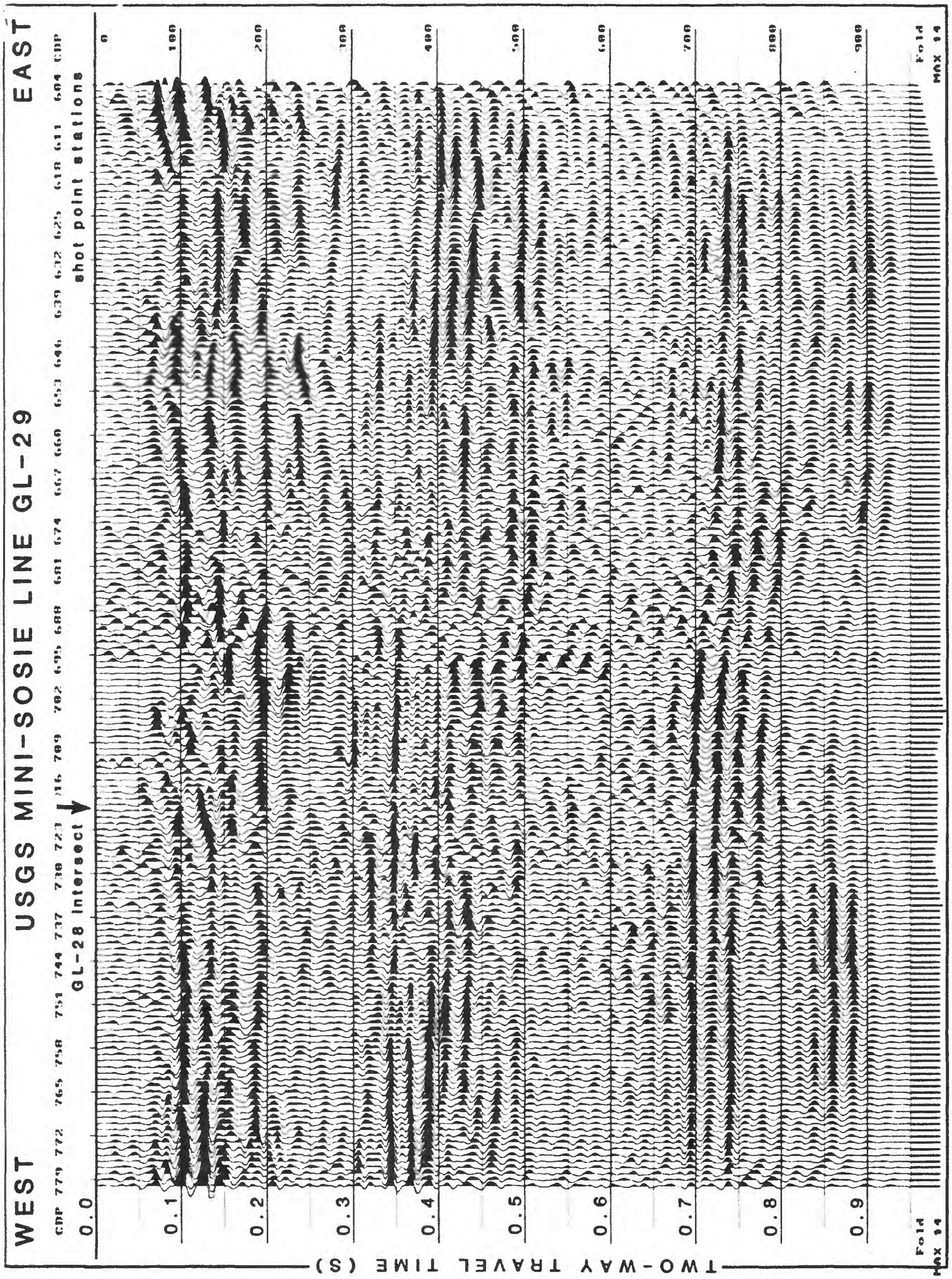



USGS MINI-SOSIE LINE GL-26
WEST
EAST
shot point stations
TWO-WAY TRAVEL TIME (S)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

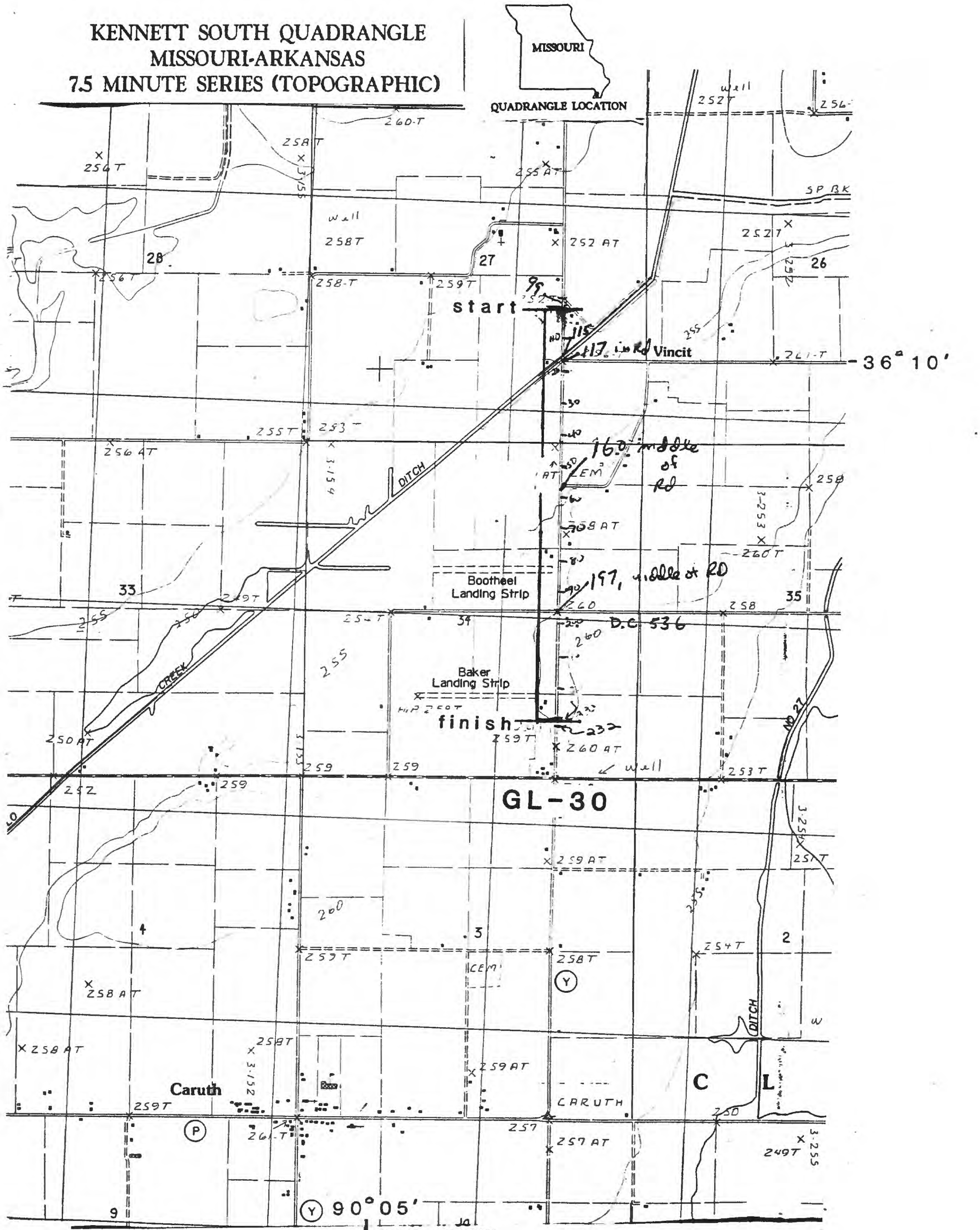

LEPANTO QUADRANGLE
ARKANSAS
7.5 MINUTE SERIES (TOPOGRAPHIC)
ARKANSAS
QUADRANGLE LOCATION
DITCH NO 49
NO 47
NO 1
Alto
Spear Lake Cem
Spear Lake
Frys Mill
Church of God
Finish
GL-28
P440
VP430
Start
Finish
GL-29
Start
SCALE 1:24 000
MILES
FEET
KILOMETERS
METERS
CONTOUR INTERVAL 5 FEET
35 32'30"
90 22'30"



USGS MINI-SOSIE LINE GL-28
SOUTH
NORTH
CDP
CDP
TWO-WAY TRAVEL TIME (S)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
100
200
300
400
500
600
700
800
900
Fold
MAX 24


WEST
USGS MINI-SOSIE LINE GL-29
EAST
GL-28 Intersect
shot point stations
CDP
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
TWO-WAY TRAVEL TIME (S)
Fold
MAX 14

KENNETT SOUTH QUADRANGLE
MISSOURI-ARKANSAS
7.5 MINUTE SERIES (TOPOGRAPHIC)



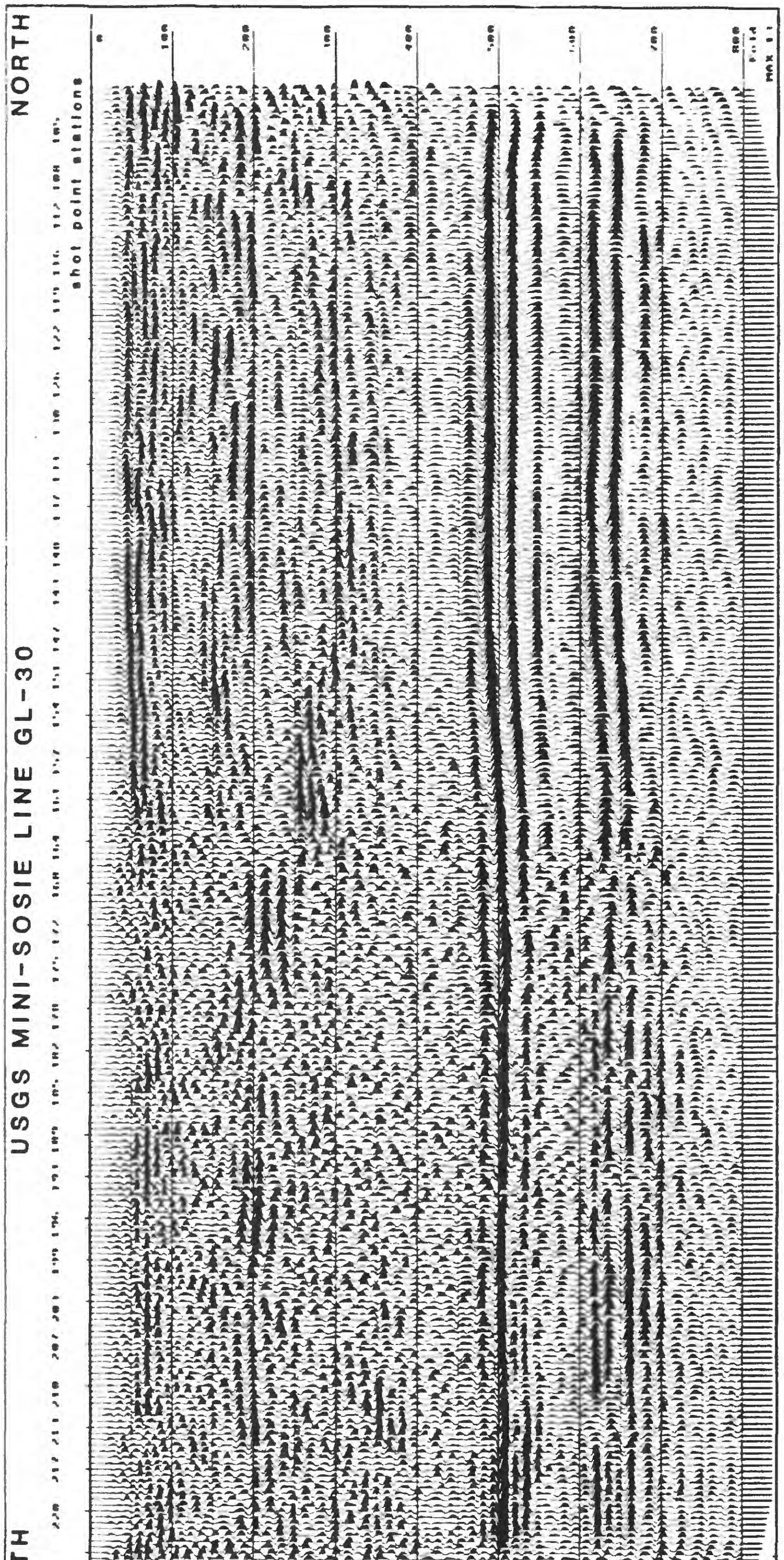
SCALE 1:24 000

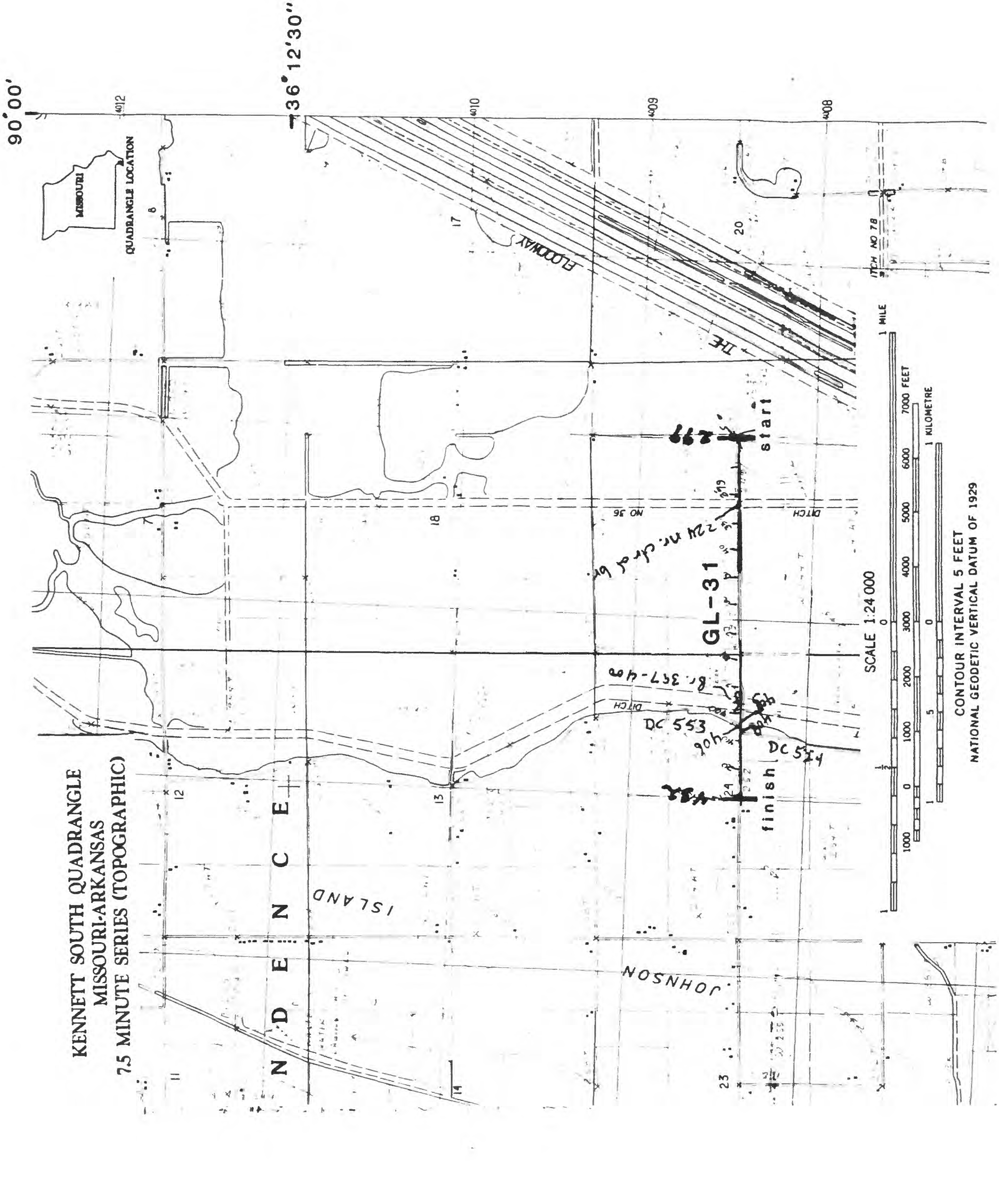
1 ½ 0 1 MILE

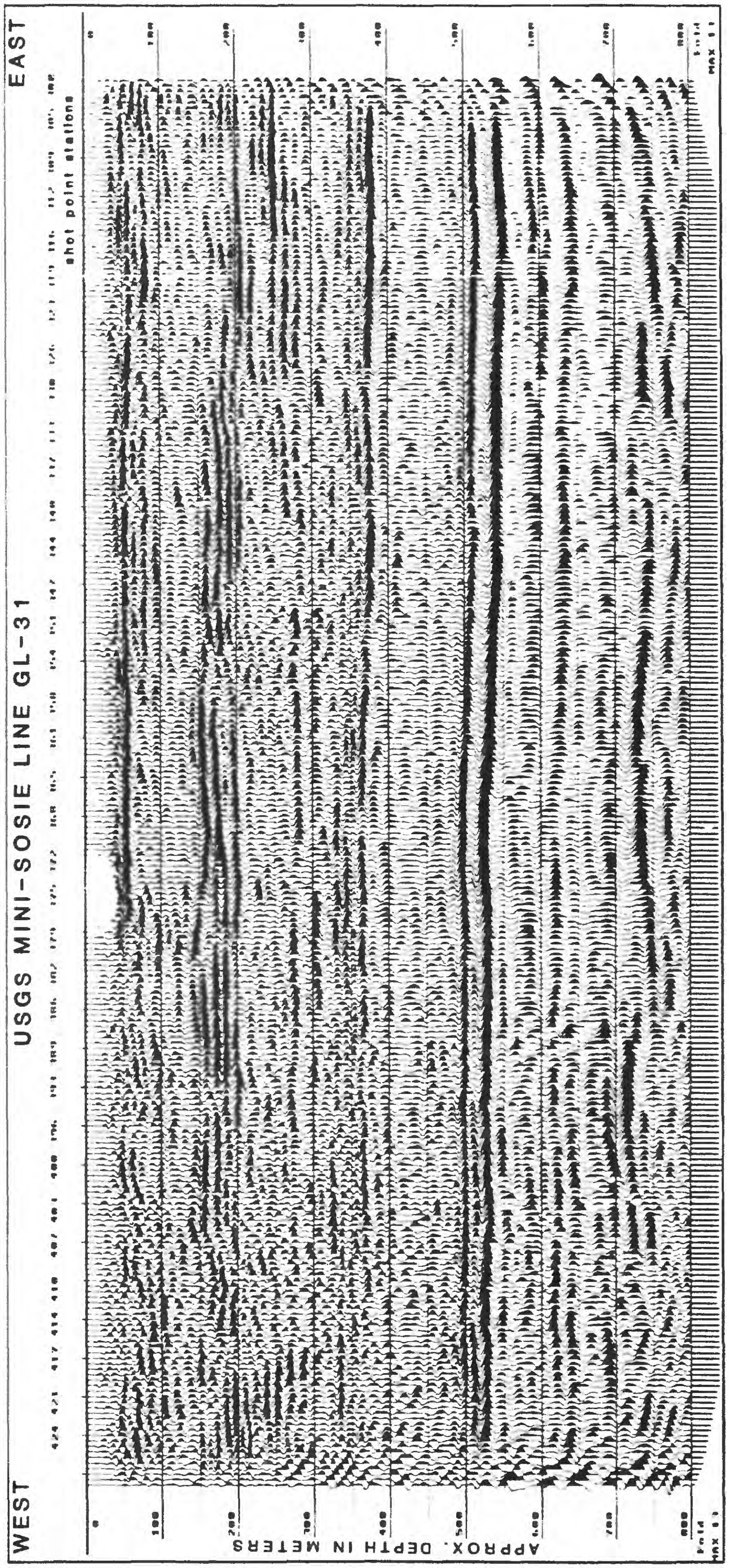
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

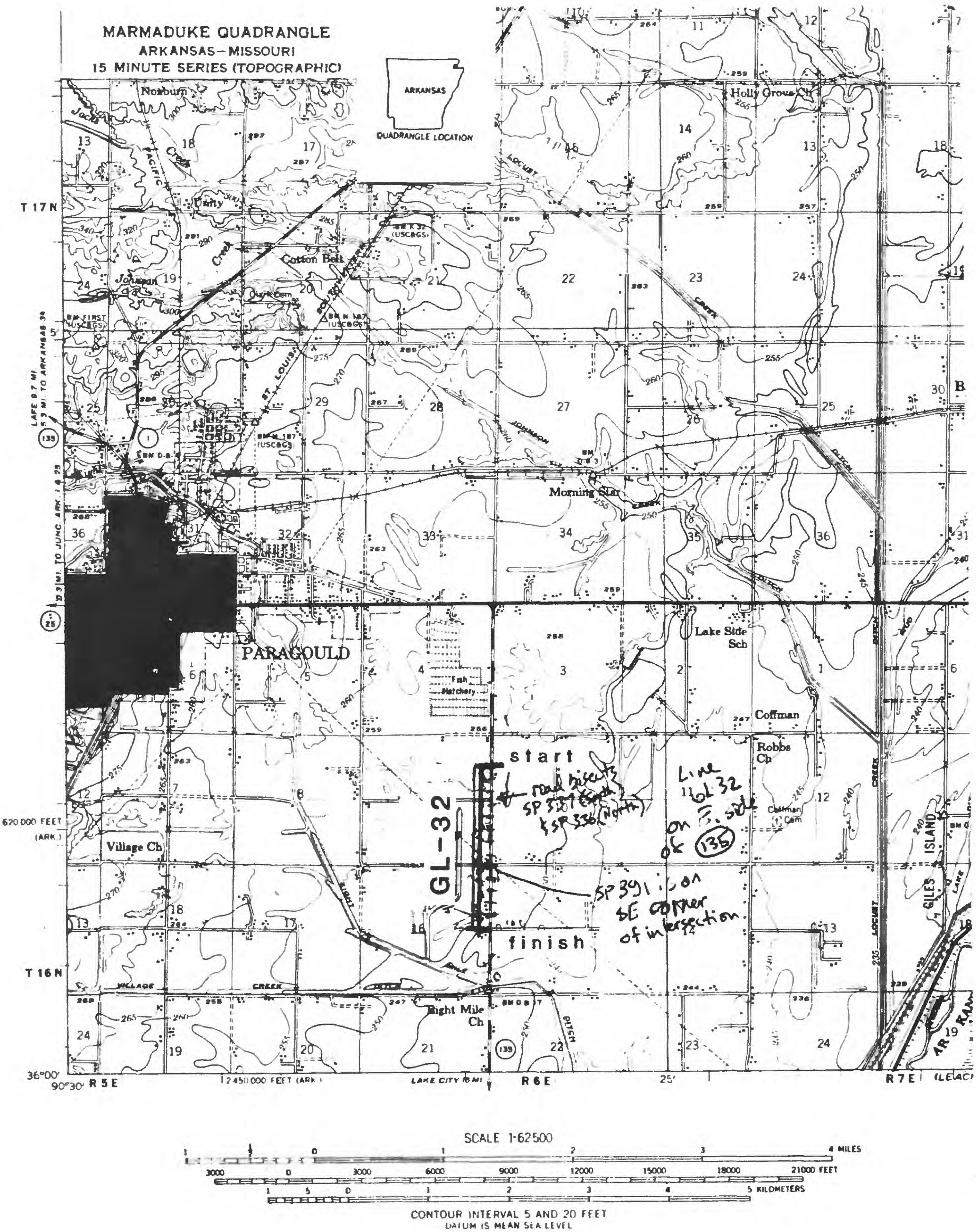
1 .5 0 1 KILOMETRE

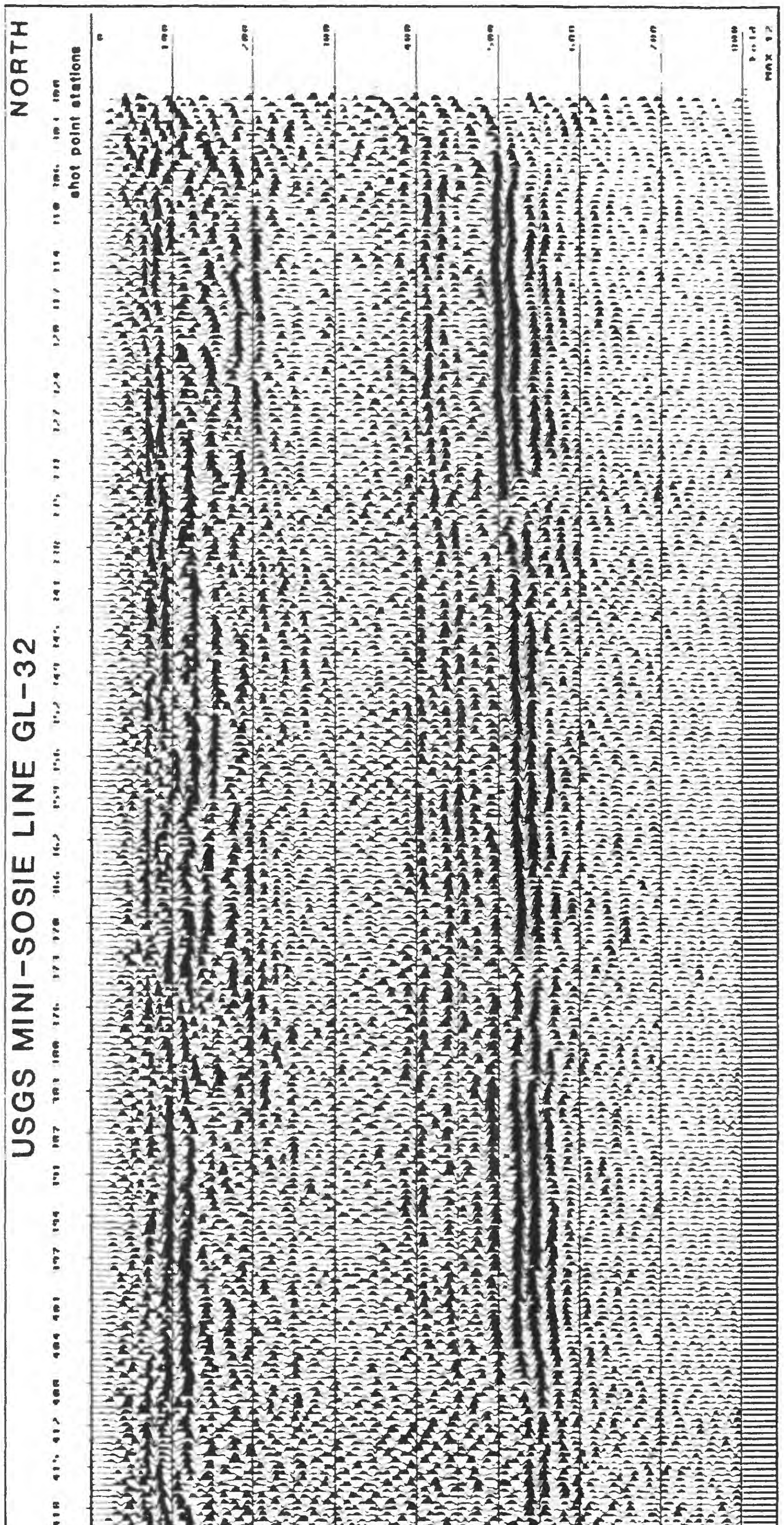
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929


USGS MINI-SOSIE LINE GL-30
SOUTH
NORTH
shot point stations
APPROX. DEPTH IN METERS
0
100
200
300
400
500
600
700
800

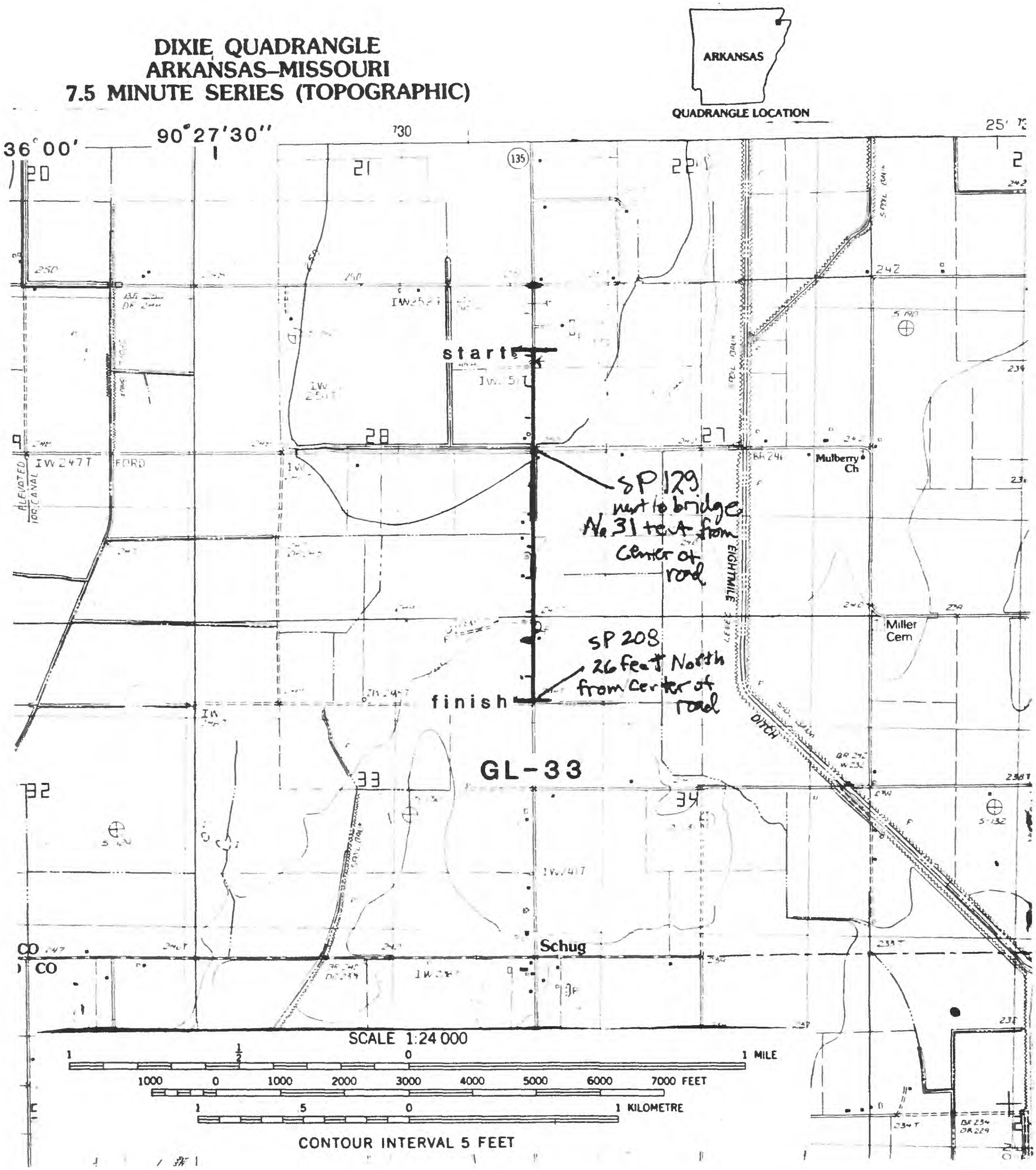

KENNETT SOUTH QUADRANGLE
MISSOURI-ARKANSAS
7.5 MINUTE SERIES (TOPOGRAPHIC)
90°00'
36°12'30"
MISSOURI
QUADRANGLE LOCATION
THE FLOODWAY
ISLAND
JOHNSON
DITCH
NO 36
GL-31
start
finish
DC 553
DC 554
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETRE
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

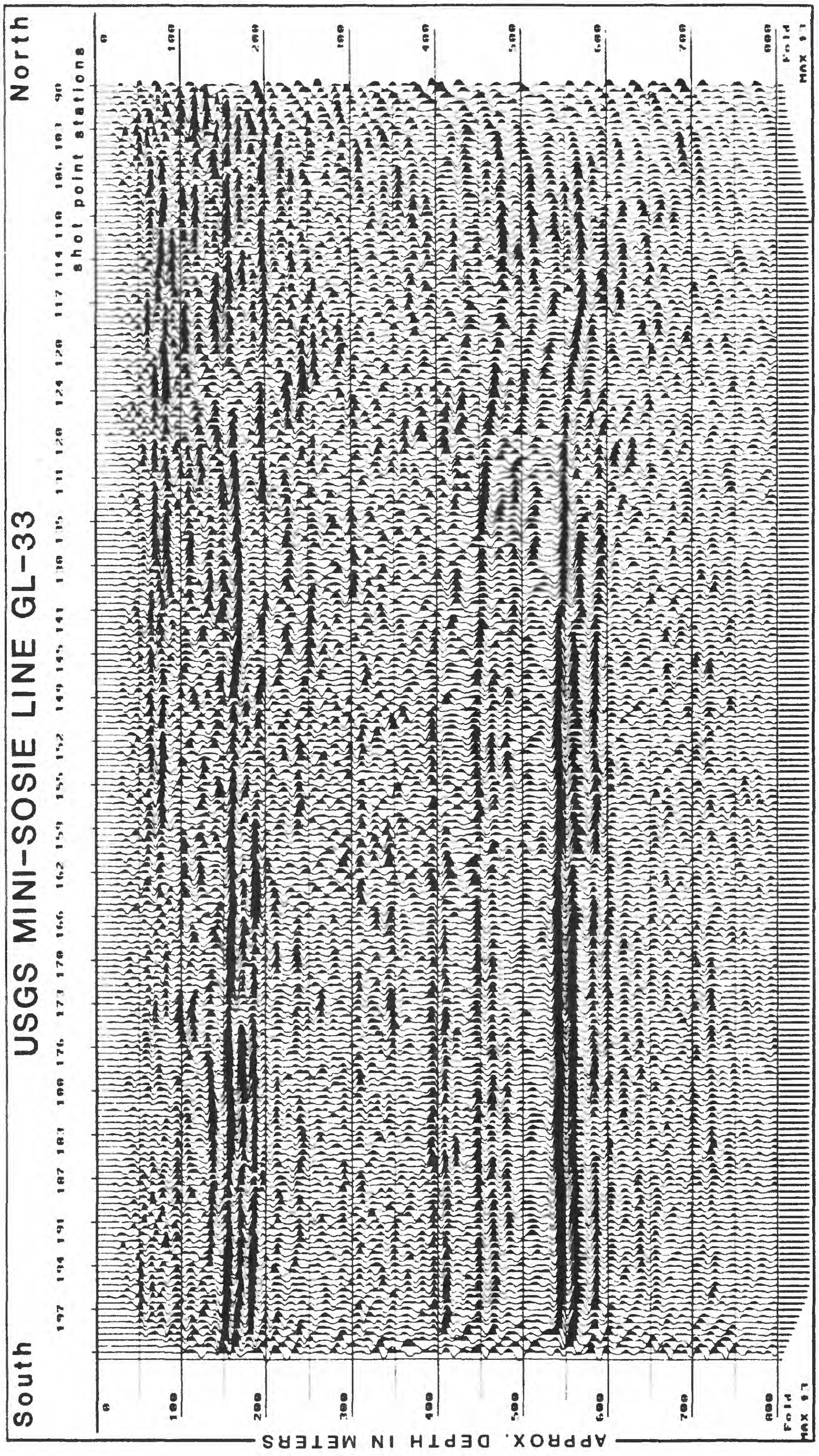

USGS MINI-SOSIE LINE GL-31
WEST
EAST
shot point stations
APPROX. DEPTH IN METERS

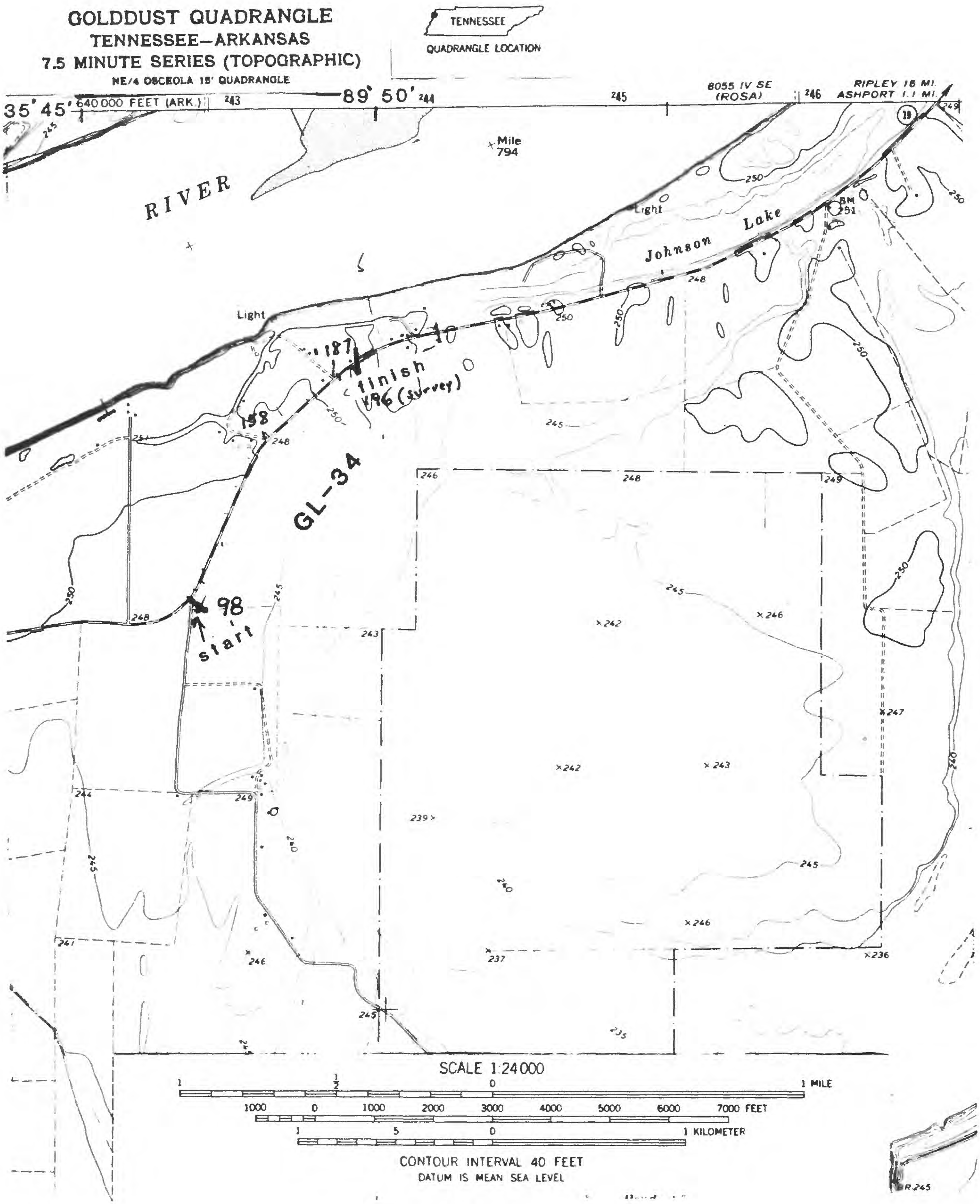

MARMADUKE QUADRANGLE
ARKANSAS–MISSOURI
15 MINUTE SERIES (TOPOGRAPHIC)
ARKANSAS
QUADRANGLE LOCATION
PARAGOULD
Cotton Belt
Morning Star
Lake Side Sch
Coffman
Robbs Ch
Village Ch
Eight Mile Ch
Holly Grove Ch
Fish Hatchery
start
GL-32
finish
road bisects SP 320 (South) & SP 336 (North)
Line GL 32 on E. side of 135
SP 391 is on SE corner of intersection
T 17 N
T 16 N
R 5 E
R 6 E
R 7 E
36°00′
90°30′
620 000 FEET (ARK.)
2 450 000 FEET (ARK.)
SCALE 1:62500
4 MILES
21000 FEET
5 KILOMETERS
CONTOUR INTERVAL 5 AND 20 FEET
DATUM IS MEAN SEA LEVEL

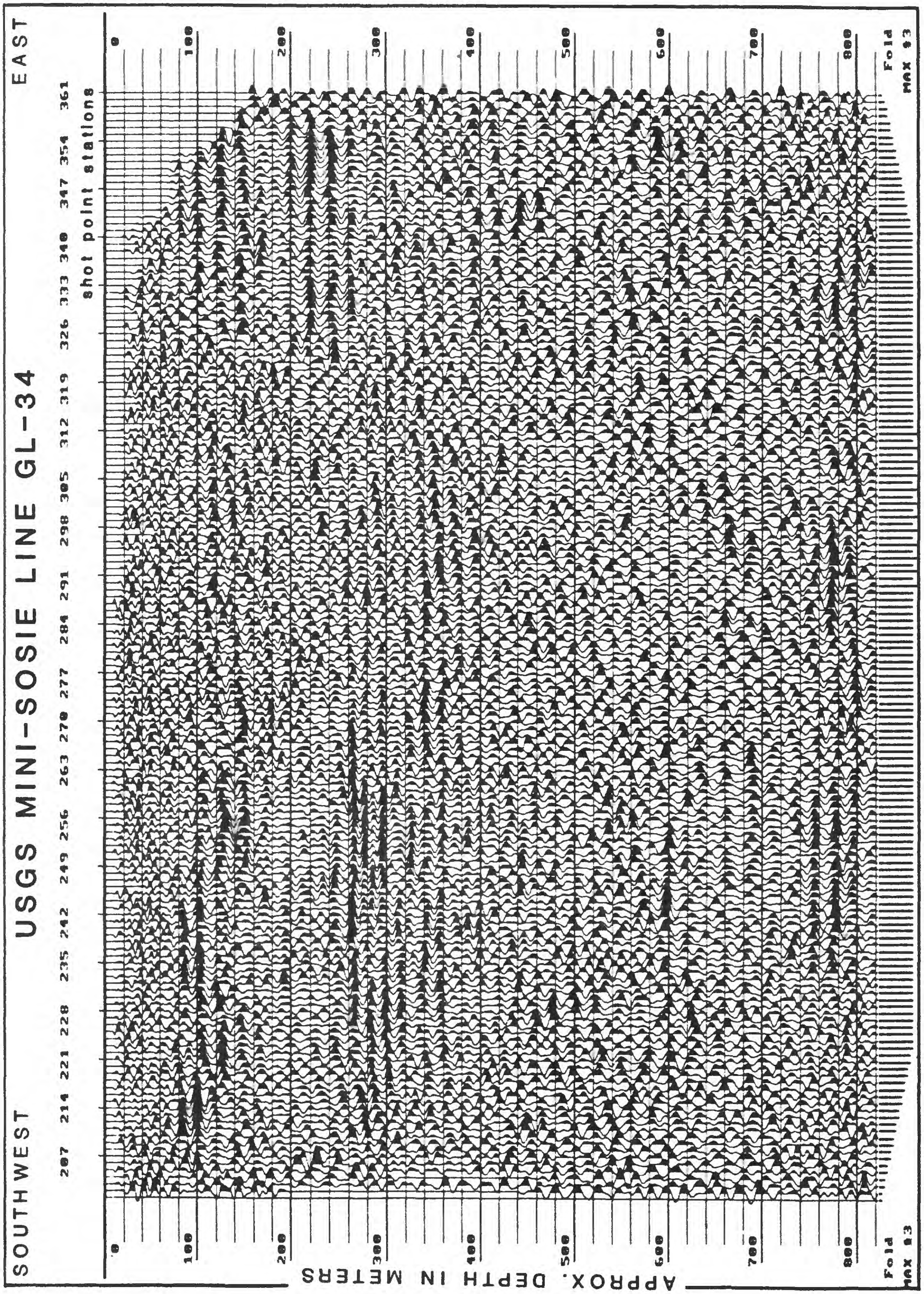

USGS MINI-SOSIE LINE GL-32
SOUTH
NORTH
shot point stations
APPROX. DEPTH IN METERS

DIXIE QUADRANGLE
ARKANSAS–MISSOURI
7.5 MINUTE SERIES (TOPOGRAPHIC)




USGS MINI-SOSIE LINE GL-33
South
North
shot point stations
APPROX. DEPTH IN METERS
0
100
200
300
400
500
600
700
800
Fold


GOLDDUST QUADRANGLE
TENNESSEE–ARKANSAS
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE/4 OSCEOLA 15' QUADRANGLE
TENNESSEE
QUADRANGLE LOCATION
35°45'
640 000 FEET (ARK.)
89°50'
8055 IV SE
(ROSA)
RIPLEY 16 MI.
ASHPORT 1.1 MI.
RIVER
Mile
794
Light
Johnson Lake
BM
251
187
10
finish
196 (survey)
158
GL-34
98
start
SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL


SOUTHWEST
USGS MINI-SOSIE LINE GL-34
EAST
207 214 221 228 235 242 249 256 263 270 277 284 291 298 305 312 319 326 333 340 347 354 361
shot point stations
0 100 200 300 400 500 600 700 800
Fold
APPROX. DEPTH IN METERS