DATA COLLECTION AND PROCESSING PARAMETERS for the MALVERN SEISMIC REFLECTION TRAVERSE

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INTRODUCTION

Since the completion of the Malvern seismic reflection traverse during the summer of 1981, the Iowa Geological Survey (IGS) has received numerous inquiries from private geophysical consulting firms and other exploration oriented companies. Most often, information is requested concerning the data collection and processing parameters with the intention being to reprocess the original data to meet the specific purposes of each firm. Prior to this report, the information necessary to carry out the data processing was not available in a single document.

This report is therefore intended to be a convenient compilation of all methods and parameters employed for the Malvern traverse. Brief justifications for the determination of the various parameters are illustrated and some general interpretations are offered. Any use of trade names is for descriptive purposes only and does not imply endorsement by IGS.

LOCATION AND GEOLOGIC SETTING

The Malvern traverse is located in Mills County, Iowa, beginning at the common corner of sections 2, 3, 10, and 11, T. 71N., R. 41W., and ending at the common corner of sections 2 and 3, T. 70N., R. 41W. (figure 1).

This location was chosen to study in detail the Thurman-Redfield structural zone which forms the northwestern boundary of the Forest City basin in southwestern Iowa. Within this zone, complex faulting and folding were expected, associated with the Central North American Rift System, a late Precambrian structural feature. Bedrock in this area is overlain by up to 100 meters of loess and glacial till, and the crystalline basement is located 1500 meters or more below the surface. Table 1 generalizes the entire stratigraphic column of southwest Iowa.

Table 1: Stratigraphic Column of Southwest Iowa. (Modified from Culbert, 1976).

System	Series	Formation/Group	Approximate Thickness (meters)
Quaternary	Pleistocene	Undifferentiated	0-60
Cretaceous	Lower	Dakota Fm.	0-8
Pennsylvanian	Virgilian	Undifferentiated	95-136
	Missourian	Undifferentiated	82-148
	Des Moinesian-Atokan	Undifferentiated	194-288
Mississippian	Meramec	Undifferentiated	18-43
	Osage	Undifferentiated	37-59
	Kinderhook	Undifferentiated	29-89
Devonian	Upper	"Upper shale unit"	0-38
	Middle	"Lower Carbonate Unit"	102-180
Silurian	Undifferentiated	Undifferentiated	0-86
Ordovician	Cincinnatian	Maquoketa Fm.	76-82
	Champlanian	Galena Fm.	22-30
		Decorah Fm.	12-22
		Plattevile Fm.	0-12
		St. Peter Ss.	5-10
	Canadian	Prairie du Chien Group	15-87
Cambrian	St. Croixan	Jordan Ss.	0-12
		St. Lawrence Fm.	0-30
		Franconia Fm.	0-70
		Dresbach Group	0-101
Precambrian	Keweenawan	"Red Clastics"	0-12,000
		Volcanics	0-17,000
	(?)	Plutonics and Metamorphics	(?)

PRELIMINARY SYNTHETIC WORK

Velocity control in southwest Iowa is scarce with only one sonic log available from a deep well located in section 2, T. 73N., R. 36W. in Montgomery County, Iowa. This location is over 50 kilometers to the east-northeast of the Malvern traverse and the subsequent extrapolation may or may not be valid.

The seismic velocities of specific geologic units were interpreted from the sonic log or inferred from characteristic velocity tables. Figure 2 shows typical geologic units, lithologies, velocities, and reflection coefficients for southwest Iowa. This model was converted to a reflectivity log or a log of reflection coefficients (figure 3), using program CONLOG2 written by R. A. Black at IGS for use on the Perkin-Elmer 3220 minicomputer. Convolution of this log with an input wavlet using program CONSIP2, also written by Black, produced the synthetic seismogram shown in figure 4.

FIELD EQUIPMENT

Seismograph and Digital Recorder

The Malvern data were collected using a 12-channel recording system. A Geometrics ES 1210F seismograph was chosen for its analogue filtering capability and variable gain controls for each channel. This unit records 1024 10-bit words per channel yielding a 1 millisecond sample rate for a 1 second record. The seismograph was interfaced with a Geometrics G724S digital recorder which stores all data from the seismograph's memory on DC100 digital cassette tapes.

Cables and Geophones

Two cables were used for signal input at different locations along the Malvern traverse (see Field Parameters section for more details). Both were 12-channel cables, however, the first had stations (take outs) spaced at 15.2 meters (50 feet) while the second had a 16.8 meter (55 foot) station spacing. Connected to each cable station was a 5-element linear array of Geospace 20Hz geophones.

Seismic Energy Source

After some experimentation with a variety of energy sources, 200 grain per inch Ensign-Bickford Primacord was chosen primarily for its velocity and frequency content but also in consideration of safety, legal, and environmental factors. The use of this source required that a shot hole 5 cm (2 inches) in diameter be augered to a depth of about 1 meter (3.5 feet). A 1.2 meter (4 foot) length of Primacord was folded to produce a compact charge, taped to an electric blasting cap and lowered to the bottom of the hole which was then backfilled with water prior to detonation. The shots were fired using a Geometrics high voltage blaster which simultaneously fired the shot and started the seismograph's recording sequence.

Portable Microcomputer

At the end of each data collecting day, the digital recorder was interfaced with an Apple II microcomputer and the data on cassettes were transferred to mini-floppy diskettes. This was accomplished via an RS232 port and program NIMTODISK developed by Dr. James Hunter of the Geological Survey of Canada (GSC). This program parses each record, transferring only every other sample to diskette so that all records were stored with a 2 millisecond sample rate.

FIELD PARAMETERS

Some field parameters were altered during the corse of the data collection at Malvern. After performing a standard noise test, the following initial parameters were chosen and used for records 1 through 22:

Shot Offset	152.4 m (500 ft.)
Station Spacing	15.2 m (50 ft.)
Geophone Spacing	6.1 m (20 ft.)
Filter	80 or 90Hz B.P. rolling off @ 6dB/octave
Notch Filter	60Hz; In
Gains	60-66 dB
Time Scale	1 second
Delay	0

For record 23 the shot offset was changed to 122 meters (400 feet), and this offset was used for all remaining records. For records 272 through 464 a 16.8 meter (55 feet) station spacing was used. All other parameters remained constant. The method in which the changes were made is explained in the following section.

600% CDP GEOMETRY

Figure 5 illustrates the procedure followed at Malvern for 600% (6-fold) data collection. Note that the first station at the north end of the traverse was channel 12 on record 1. After each recording the cable and shot point were moved one station spacing to the south for the next recording. This technique was used for the entire traverse except where offset or station spacings were changed.

The change in the shot offset for records 23 through 464 was accomplished by making the normal cable move of one station spacing to the north or toward the cable. The only other change made was after recording record 271 when the first cable malfunctioned and was replaced with one having a 16.8 meter (55 foot) station spacing.

Technically the shot offset should also have been changed at the time the new cable was employed. The fact that it was not changed was an oversight. A 134 meter (440 feet) offset would have maintained the CDP geometry more accurately, however, it is felt that the difference in travel time, considering the velocity environment at Malvern, is insignificant.

DATA PROCESSING

The 464 records stored on floppy diskettes were subsequently read to a 9-track tape in SEG Y format using program TAPGEN written by Chris Hall at IGS. This was accomplished through the use of a phone modem interconnecting the Apple II with the Prime 750 computer system at the University of Iowa computer center. Copies of this tape are available at IGS for the costs of the tape, copying, and handling.

The original data processing was performed by Rob Torrey of Seismograph Services Corporation in Tulsa, Oklahoma. Processing parameters can be found listed in sequence on the side panel of the final section and in figure 6.

INTERPRETATIONS

In generating the synthetic seismogram (fig. 3) it was assumed that the shot and geophone were in the same location (normal incidence). In practice, an offset of 122 meters was used for data collection. This can result in lower velocity reflections from shallower layers being overtaken and masked by higher velocity arrivals from deeper layers. Figure 7 illustrates this phenomenon on a synthetic field seismogram generated by the Apple II using program TX MULTIMODEL developed at the Geological Survey of Canada. This, in part, explains why the Kansas City Group bedrock reflection does not appear on the final section.

The interpreted final section shows reflections from several sedimentary horizons with the crystalline basement reflector at approximately 700 milliseconds (approximately 1450 meters). Interpreted faults show displacements up to 30 milliseconds (about 55 meters) and folded features can be inferred as well. Fault interpretations are based on discontinuous or offset reflections and were not interpreted where strictly vertical discordance was present over the entire section. This vertical shifting by a constant time factor is probably a statics problem attributed to weathering layer thickness anomalies or near surface velocity anomalies.

REFERENCES CITED

Culbert, L. B., 1976, A Gravity Survey in the Northern Part of the Forest City Basin in Southwest Iowa: M.S. thesis, University of Iowa, 101 p.

Dobrin, M. B., 1976, Introduction to Geophysical Prospecting, 3rd Edition: McGraw-Hill, 630 p.

Logel, J. D., 1982, Use of an Engineering Seismograph for Subsurface Investigation Along the Thurman-Redfield Structural Zone, Southwest Iowa: M.S. thesis, University of Iowa, 78 p.

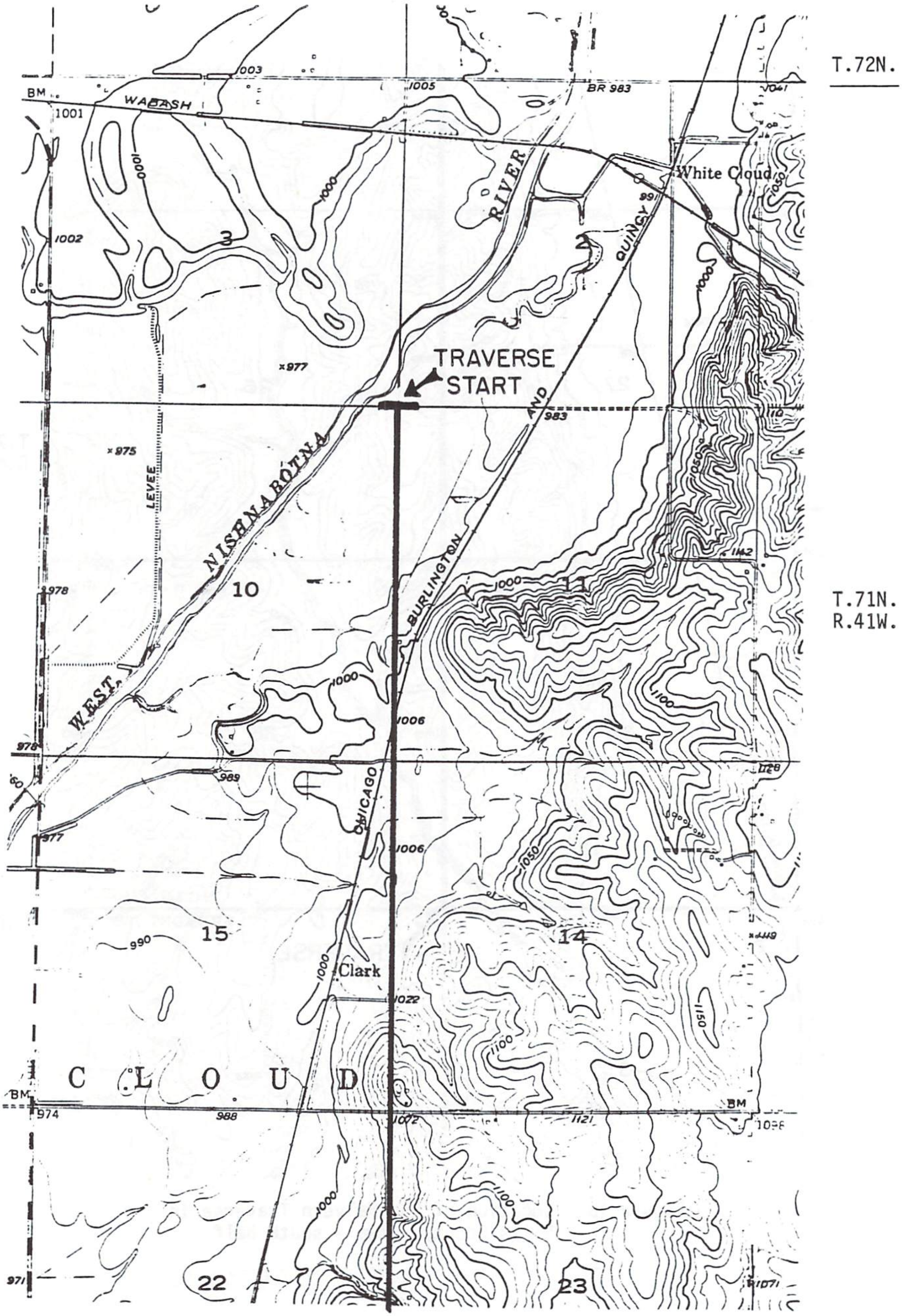


Figure 1a. Location of the Malvern Traverse in
Mills County, Iowa - north half

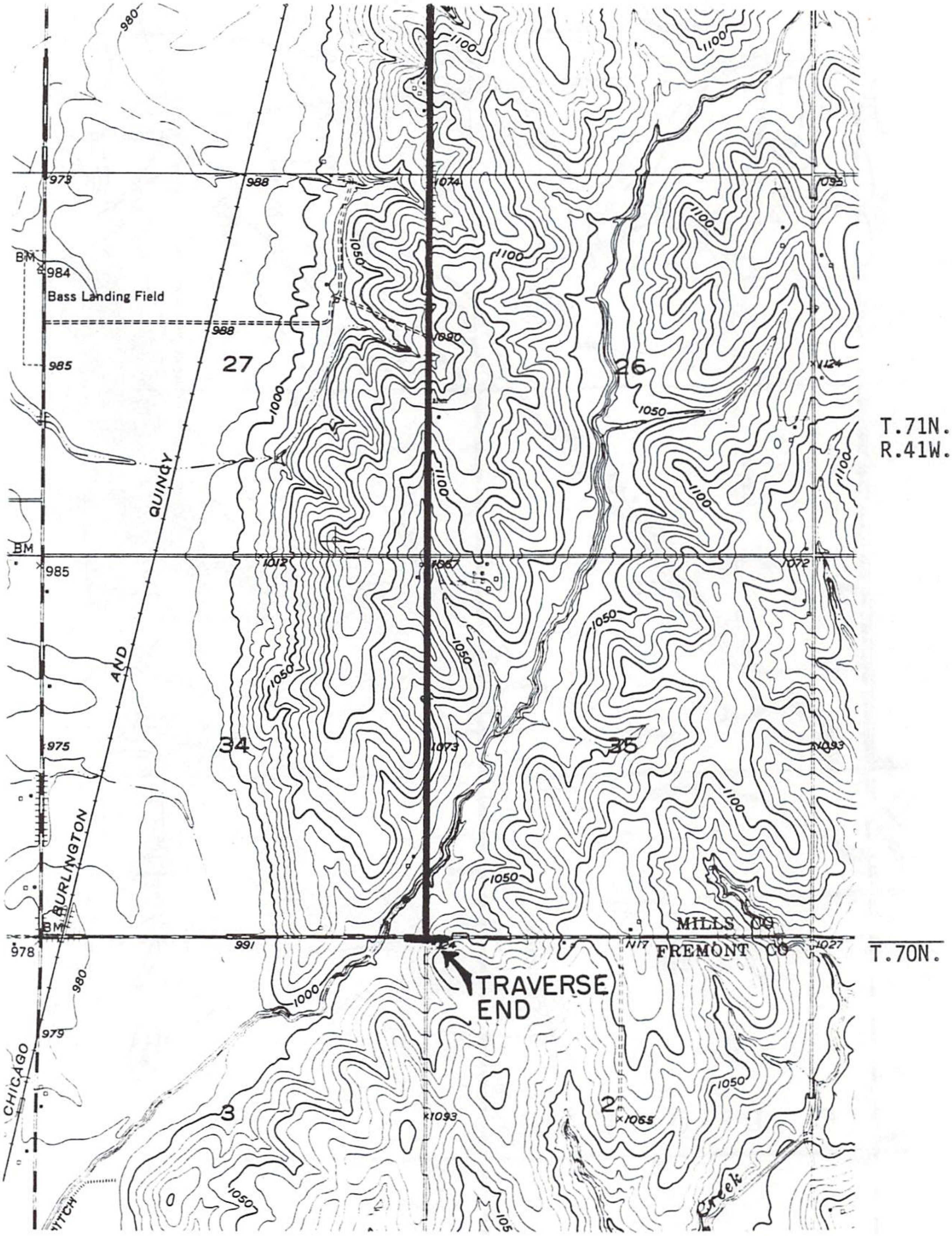


Figure 1b. Location of the Malvern Traverse in Mills County, Iowa - south half

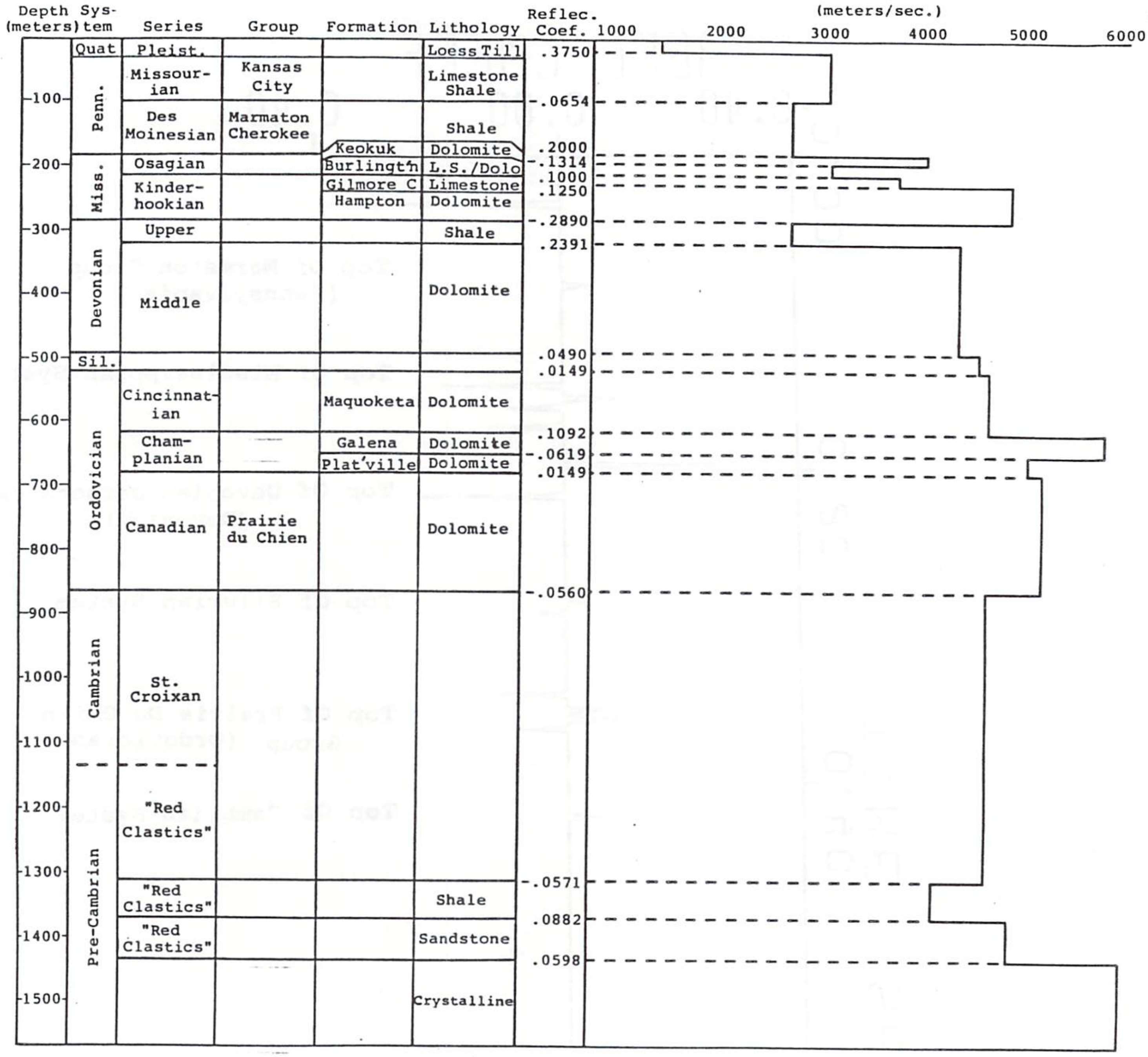


Figure 2. Hypothetical geologic section from Malvern, Iowa, with characteristic velocities, lithologies, and reflection coefficients.

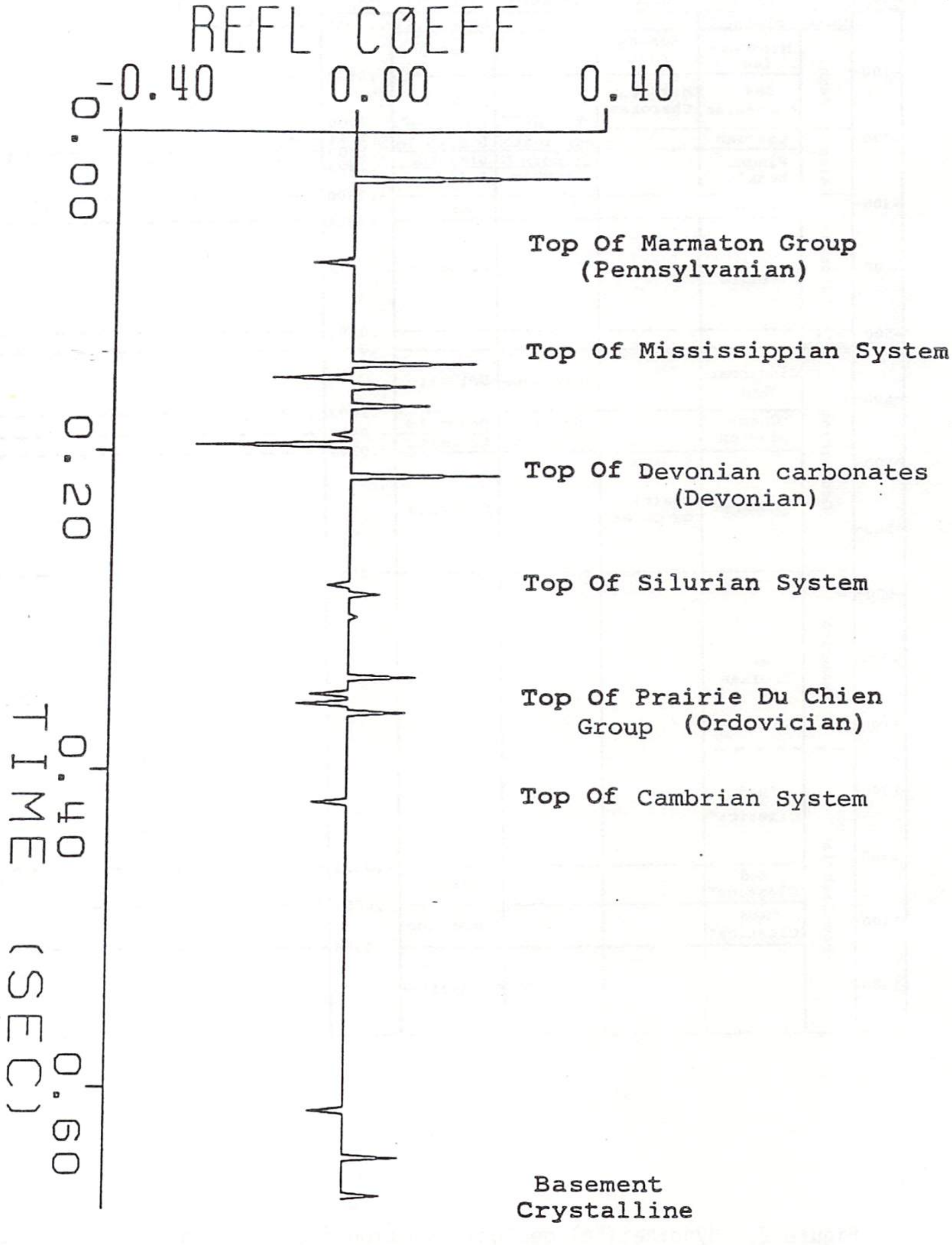


Figure 3. Reflectivity log for Malvern model.

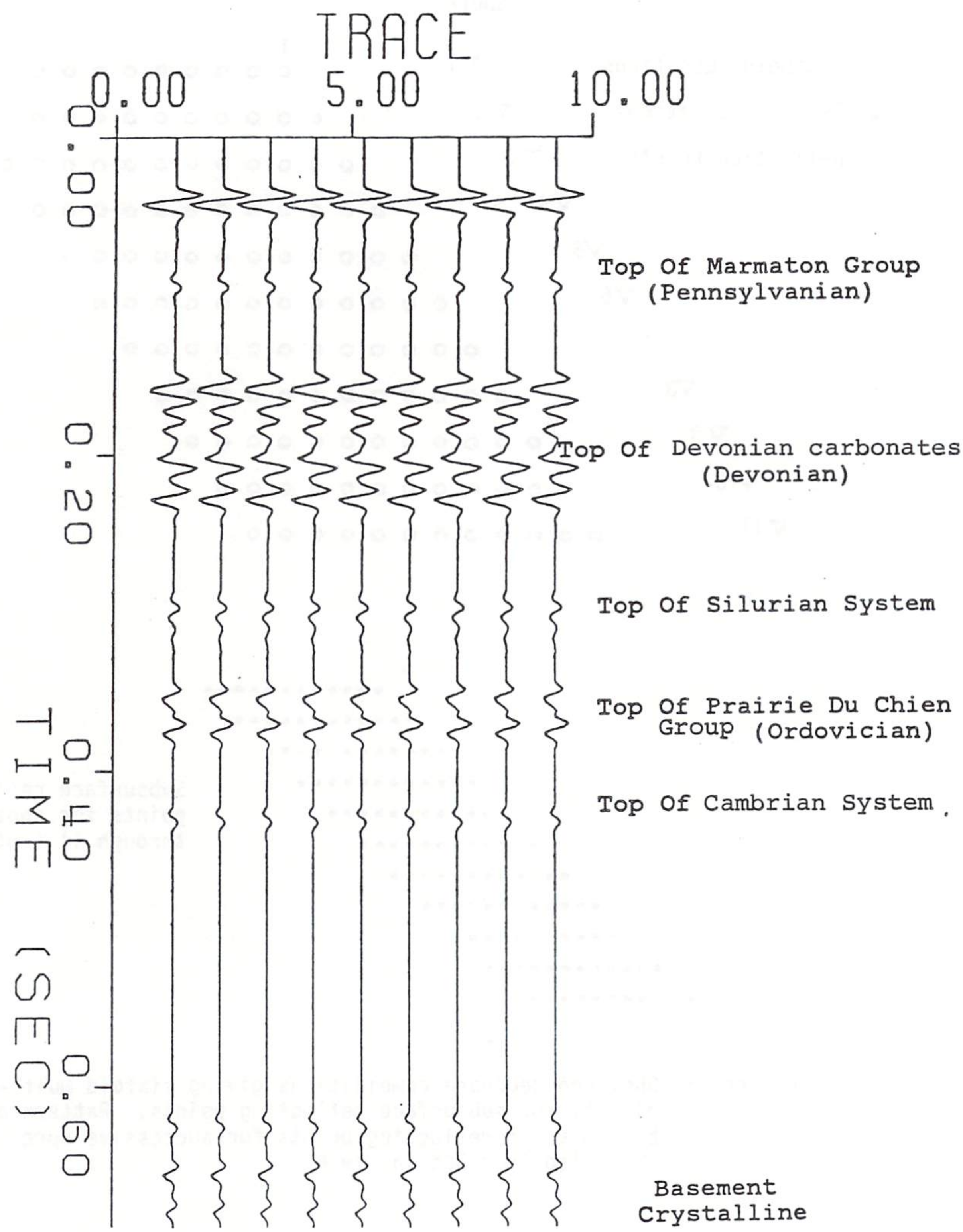
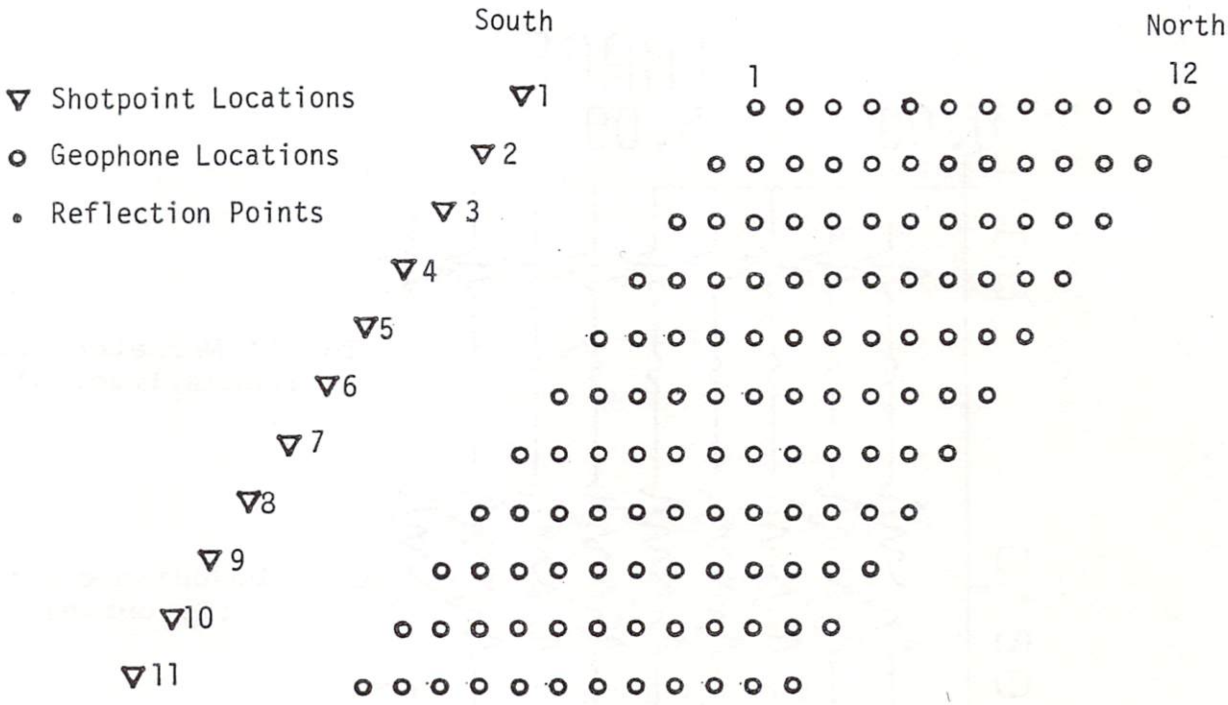
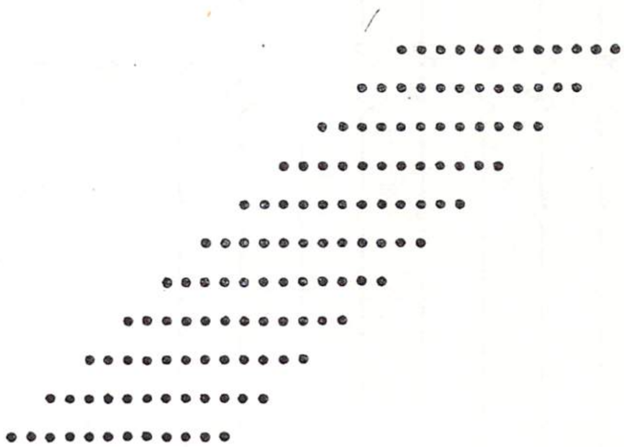


Figure 4. Synthetic seismogram for Malvern model.





Subsurface reflection points for shots 1 (top) through 11 (bottom).

Figure 5: Shot and geophone combinations giving sixfold multiplicity for subsurface reflecting points. Pattern at bottom shows reflecting points for successive spreads. (Modified from Dobrin, 1976)

FOR: UNIVERSITY OF IOWA
PROSPECT: MALVERN
AREA: SOUTHWEST IOWA

PROCESSED BY SSC WITH

THE PHOENIX I

SSC PARTY PT
TULSA, OKLAHOMA
CONTRACT NO.

RECORDED JUNE, 1981 PROCESSED FEBRUARY, 1982

PROCESSING PARAMETERS IN SEQUENCE

REFORMAT	SEGY FIX @ 2 MS SAMPLING CONVERT TO IBM FLOAT
CDP SORT	DATUM = +1000 FT. VELOCITY = 6000 FT./SEC.
FILTER	18-24-100-110 HZ.
SCALE	300 MS. AGC
DECONVOLUTION	DESIGN: 100-800 MS. OPERATOR: 100 MS. GAP: 16 MS.
VELOCITY ANALYSIS	CONSTANT VELOCITY STACKS
NORMAL MOVEOUT	RMS TWO-WAY
MUTE	NEAR OFFSET= 80 MS. FAR= 160 MS.
AUTOMATIC STATICS	SURFACE CONSISTENT: DESIGN 280 TO 800 MS. CDP ALIGNMENT: 7 TRACE PILOT 280-800 MS.
STACK	6 FOLD 1/ROOT(N) COMPENSATION
SCALE	300 MS. AGC
DISPLAY	16 TRACES PER INCH 10 INCHES PER SECOND

Figure 6. Processing parameters.

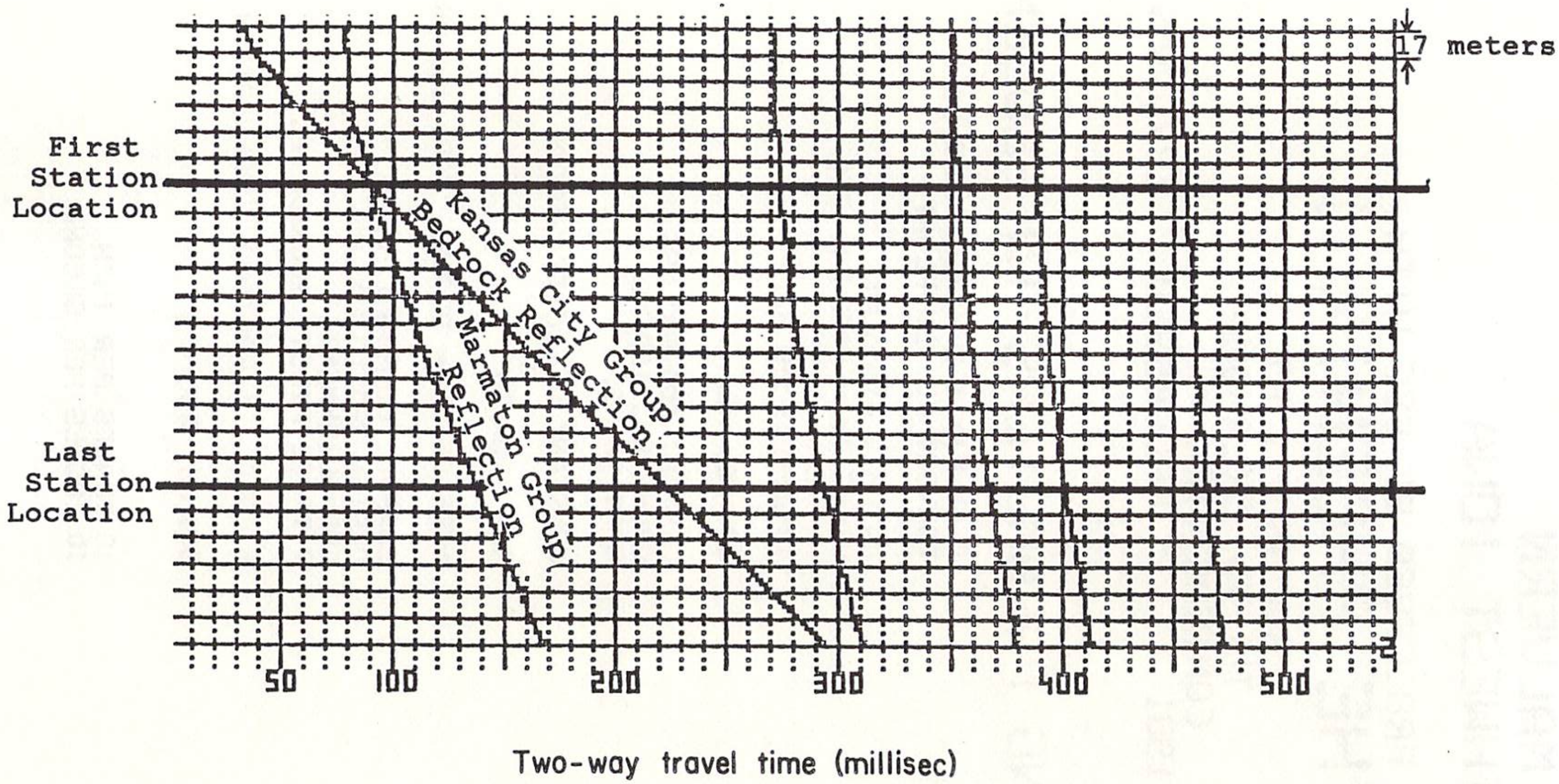


Figure 7. Synthetic field seismogram demonstrating why bedrock reflection does not appear on record sections.

LINE 1 — FINAL

FOR: UNIVERSITY OF IOWA
PROSPECT: MALVERN
AREA: SOUTHWEST IOWA

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FIELD PARAMETERS

SOURCE

SHOT INTERVAL	50 FT.
SHOT PATTERN	SINGLE HOLE
SHOTS PER STATION	1
AVG. HOLE DEPTH	4 FT.
CHARGE SIZE	PRIMACORD

RECEIVER

STATION INTERVAL	50 FT. TO STA. 271; 55 FT. TO EOL
GEOPHONE PATTERN	5 PHONES LINEAR OVER 80 FT.
MIDPOINT OF GEOPHONE ARRAY	PATTERN CENTER

RECORDING

CONFIGURATION	END-ON; PULLING CABLE
NEAR AND FAR OFFSET	500-1100 FT. TYPICAL
INSTRUMENT TYPE	GEOMETRICS 1210F
RECORD LENGTH	1 SEC.
SAMPLE RATE	1 MS.
NUMBER OF TRACES	12
AMPLIFIERS	BINARY GAIN
RECORDING FILTERS	80 HZ. 6 DB. HIGH CUT; 60 HZ. NOTCH
GEOPHONE FREQUENCY	20 HZ. GEOSPACE HSJ
PROGRESSION	NORTH TO SOUTH
RECORDED BY	UNIVERSITY OF IOWA

PROCESSING PARAMETERS IN SEQUENCE

REFORMAT	SEGY FIX @ 2 MS SAMPLING CONVERT TO IBM FLOAT
CDP SORT	DATUM = +1000 FT. VELOCITY = 6000 FT./SEC.
FILTER	18-24-100-110 HZ.
SCALE	300 MS. AGC
DECONVOLUTION	DESIGN: 100-800 MS. OPERATOR: 100 MS. GAP: 16 MS.
VELOCITY ANALYSIS	CONSTANT VELOCITY STACKS
NORMAL MOVEOUT	RMS TWO-WAY
MUTE	NEAR OFFSET= 80 MS. FAR= 160 MS.
AUTOMATIC STATICS	SURFACE CONSISTENT: DESIGN 280 TO 800 MS. CDP ALIGNMENT: 7 TRACE PILOT 280-800 MS.
STACK	6 FOLD 1/ROOT(N) COMPENSATION
SCALE	300 MS. AGC
DISPLAY	16 TRACES PER INCH 10 INCHES PER SECOND