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GEOPHYSICAL INVESTIGATIONS OF POSSIBLE RECENT GROUND DEFORMATION AND NEOTECTONISM IN WHITE COUNTY, ILLINOIS

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ABSTRACT

In White County, Illinois, in the lower Wabash Valley, are two sites where suspected neotectonism and ground deformation associated with historical seismicity created by earthquakes warrant geophysical investigations. At the first site an escarpment in Holocene sediments is closely aligned with a part of the Herald-Phillipstown Fault Zone in the Wabash Valley Fault System. Investigations of the first site indicated that the escarpment was created primarily by recent erosion indirectly related to past tectonism in the region. An eyewitness account from a man who lived near the second site during the December 16, 1811, earthquake in the New Madrid Seismic Zone tells of a fissure and sand blows created by the earthquake. At the second site an elongated, surficial sand body, possibly the remnant of a sand blow, was discovered. This discovery supports the eyewitness account about the effects of the New Madrid earthquake.

INTRODUCTION

In east-central White County, Illinois, there is a surficial feature known as the Meadow Bank (fig. 1). It is an escarpment, 15 to 20 feet high, trending N25°E and extending continuously from the southwest quarter of Section 9, T6S, R10E, to the southeast quarter of Section 14, T5S, R10E, a distance of about 5.5 miles. At a point in the northwest quarter of Section 23, T5S, R10E, the Meadow Bank bifurcates. One part continues northeastward in the same direction as the main scarp. The other part, the Sandhill Cemetery scarp, swings to the east in an arcuate manner northeastward to a point in the northwest quarter of Section 13, T5S, R10E, where it was obliterated by an oxbow formed by the Wabash River.

The Meadow Bank and the Sandhill Cemetery scarp are about 1 mile east of and closely parallel to the trace of the Herald-Phillipstown Fault Zone mapped on the Pennsylvanian age West Franklin Limestone Member of the Modesto Formation (fig. 1). (For simplicity, the Herald-Phillipstown Fault Zone is represented in many figures as a single fault trace on the West Franklin Limestone. A more realistic description of this fault zone is in Drilling and Logging.) The Herald-Phillipstown Fault Zone is one of the high angle normal faults of the Wabash Valley Fault System. The close parallelism of the Meadow Bank and the Sandhill Cemetery scarp to the Herald-Phillipstown Fault Zone raises questions: Are these surficial features genetically related to the Herald-Phillipstown Fault Zone or some parallel, but unknown fault? Do these features represent surficial expression of recent reactivation along preexisting faults? Or are these features simply recent erosional features? If they are erosional features, does the parallelism to the Herald-Phillipstown Fault Zone indicate that the erosional pattern was controlled by preexisting structural features?

Geomorphic features such as the Meadow Bank and Sandhill Cemetery scarp are interesting; but if they are related to the tectonic history of an area, and perhaps even neotectonism, they are relevant to an earthquake hazard reduction program and warrant more investigation. In this study the investigation consisted of vertical electrical soundings (VES), seismic refraction profiling, and drilling and downhole logging in Hawthorne Township (T5S R10E), where the Meadow Bank and the Sandhill Cemetery scarp are nearly parallel to the trace of the Herald-Phillipstown Fault Zone on the top of the West Franklin Limestone.

The second part of this study is also in the Hawthorne Township area of White County, Illinois. An account from a man who lived there during the catastrophic New Madrid earthquakes in the winter of 1811–1812 tells of a fissure and sand blows appearing between the Meadow Bank and the Wabash River (Berry 1908). These observations, if verified in the geologic record, can help us understand the seismicity of the central Mississippi Valley. Such features demonstrate that a tremendous amount of strain energy was released during the New Madrid earthquakes of 1811–1812. The observations also help understand the ability of the midcontinental crust to efficiently transmit seismic energy over great distances, and the deleterious reaction of thick alluvial deposits (even at relatively large epicentral distances). Hawthorne Township is approximately 130 miles from the epicenter of the third and largest of the three great New Madrid earthquakes (February 7, 1812, body wave magnitude 7.4) (Stover et al. 1979a, 1979b). However, the fissure and sand blows in the eyewitness account may have been caused by seismic events in the Wabash Valley that were triggered by the larger events in the New Madrid area.

To find remnants of the fissure and the sand blows mentioned in the eyewitness account, the ISGS performed extensive constant-electrode-separation resistivity profiling in the northwest quarter of Section 35, Hawthorne Township, an area specifically mentioned in the account.

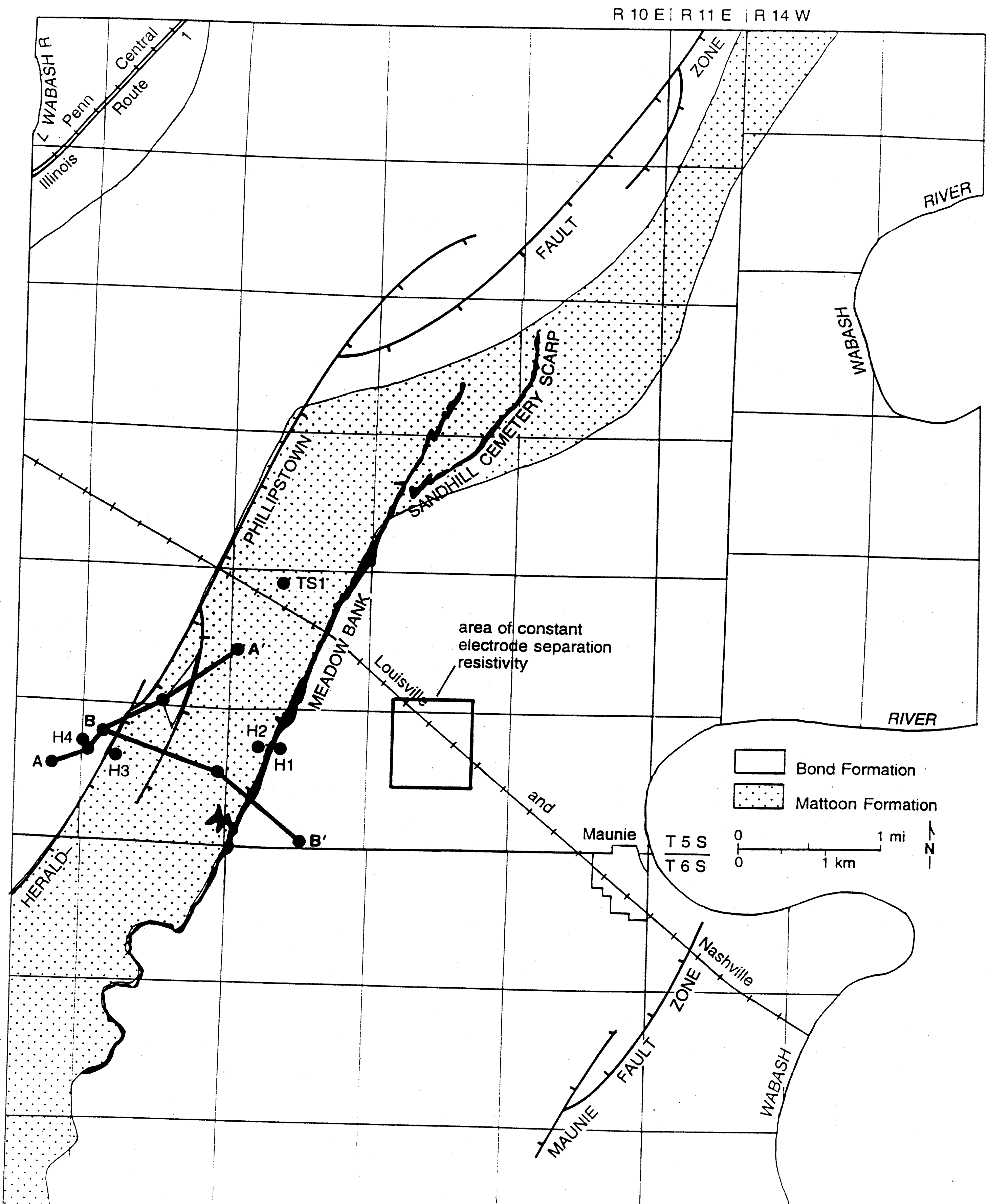


Figure 1 Geologic map of the study area (modified from Willman and others 1967) showing the locations of drill holes used in the study (including new test borings H1-H4), cross sections A–A′ and B–B′, and the area where constant-electrode-separation resistivity profiling was performed.

THE HERALD-PHILLIPSTOWN FAULT ZONE AND THE MEADOW BANK

Geologic Setting

The study area is in the Wabash Valley Fault System (figs. 1 and 2). This system has subparallel, high angle normal faults that have vertical displacements as great as 480 feet. The faults bound horsts and grabens within the Paleozoic-aged bedrock and commonly overlap one another in map view. Small cross-faults may connect these overlapping segments. The age of faulting in the Paleozoic rocks is post-Pennsylvanian and pre-Pleistocene (Bristol and Treworgy 1979, Nelson and Lumm 1984, Treworgy 1988). No recent faulting in the Wabash Valley Fault System has been found.

This investigation examined two fault zones in the Wabash Valley Fault System, the Herald-Phillipstown Fault Zone and the Maunie Fault Zone, and the graben bounded by these faults in east-central White County, Illinois. The Herald-Phillipstown Fault Zone is a set of two overlapping, generally parallel, arcuate faults (fig. 2). The fault segments dip at very high angles to the east and strike north-northeast from Section 34, T7S, R9E, in northern Gallatin County, through White County, and terminate just within Wabash County, Section 16, T2S, R14W, a distance of 31 miles. Displacements along the fault segments reach about 350 feet in Section 18, T6S, R10E, White County, and diminish rapidly southward and more gradually northward (Bristol and Treworgy 1979). The Maunie Fault Zone is two overlapping parallel fault segments about 5 miles east of the Herald-Phillipstown Fault Zone (fig. 2). The fault segments in Illinois extend north-northeast for about 15 miles from northeastern Gallatin County to east-central White County. The southern end of the southern fault segment bifurcates in the shallower Pennsylvanian strata (an apparently common phenomenon, Bristol and Treworgy 1979). This bifurcation extends about 2 miles farther south than the single trace in the Mississippian-age Beech Creek Limestone. The fault appears to terminate at the Illinois-Indiana state line in Section 16, T5S, R14W. Displacements along the fault segments range up to 175 feet in Section 10, T7S, R10E, and decrease to the north and south (Bristol and Treworgy 1979).

The bedrock surface in the study area is made of rocks from the Pennsylvanian-age Mattoon and Bond Formations of the McLeansboro Group (figs. 1 and 3). A variety of lithologies may form the bedrock surface. Pryor (1956) presented a cross section demonstrating that the Mt. Carmel Sandstone Member of the Bond Formation forms the bedrock surface on the western or upthrown side of the Herald-Phillipstown Fault Zone; whereas a shale or a thin sandstone of the Mattoon Formation forms the bedrock surface on the eastern or downthrown side in Section 15, T5S, R10E. Five miles to the east, the bedrock surface on both the upthrown (eastern) and downthrown (western) sides of the Maunie Fault Zone is composed of shale overlying the Mt. Carmel Sandstone.

Structure maps and geophysical logs from oil wells in the study area were reviewed for this project. Detailed work maps of the West Franklin Limestone (prepared for Bristol and Treworgy 1979) on file at the ISGS indicate that the Herald-Phillipstown Fault Zone is more complex than shown by Bristol and Treworgy (1979). For example, several small en echelon faults lie to the east of the master fault near a bend in the fault zone in Sections 28 and 33 Hawthorne Township (T5S, R10E).

Two cross sections (A–A′ and B–B′) (figs. 1, 4, and 5) were constructed from area geophysical logs (SP and Resistivity) to show general structural and stratigraphic relationships of the upper bedrock. Cross section A–A′ (fig. 4) crosses the Herald-Phillipstown Fault Zone and intersects seismic refraction line D (see Seismic Refraction Profiling) near test boring H4 (see Drilling and logging). The Williams B2 well penetrates the Herald-Phillipstown fault zone at a depth of approximately 470 feet, where there is approximately 140 feet of stratigraphic section missing from just above the West Franklin Limestone Member of the Modesto Formation. Rocks of the Mattoon Formation form the bedrock surface immediately east of the Herald-Phillipstown Fault Zone. A southwestern component of regional dip is indicated between the Williams B2 well and the Brimblecomb B3 well to the northeast. Rocks of the Bond Formation return to the bedrock surface near the Brimblecomb B3 well. A second normal fault (downthrown to the east and probably subparallel to the major fault trace) is inferred between the Brimblecomb B3 well and the H. P. Land No. 1 well based on the relative positions of the Shoal Creek and West Franklin Limestones. This latter fault is consistent with data used to construct detailed structure maps of this area (Bristol and Treworgy 1979).

Cross section B–B′ (fig. 5) extends from the Williams B2 well southeastward to the Du Vall well east of the Meadow Bank. The main fault trace of the Herald-Phillipstown Fault Zone is penetrated by the Williams B2 well, as shown in figure 5. A second normal fault is inferred between the Williams B2 well and the Rice well to the east-southeast. Downthrow of 110 feet to the east is indicated.

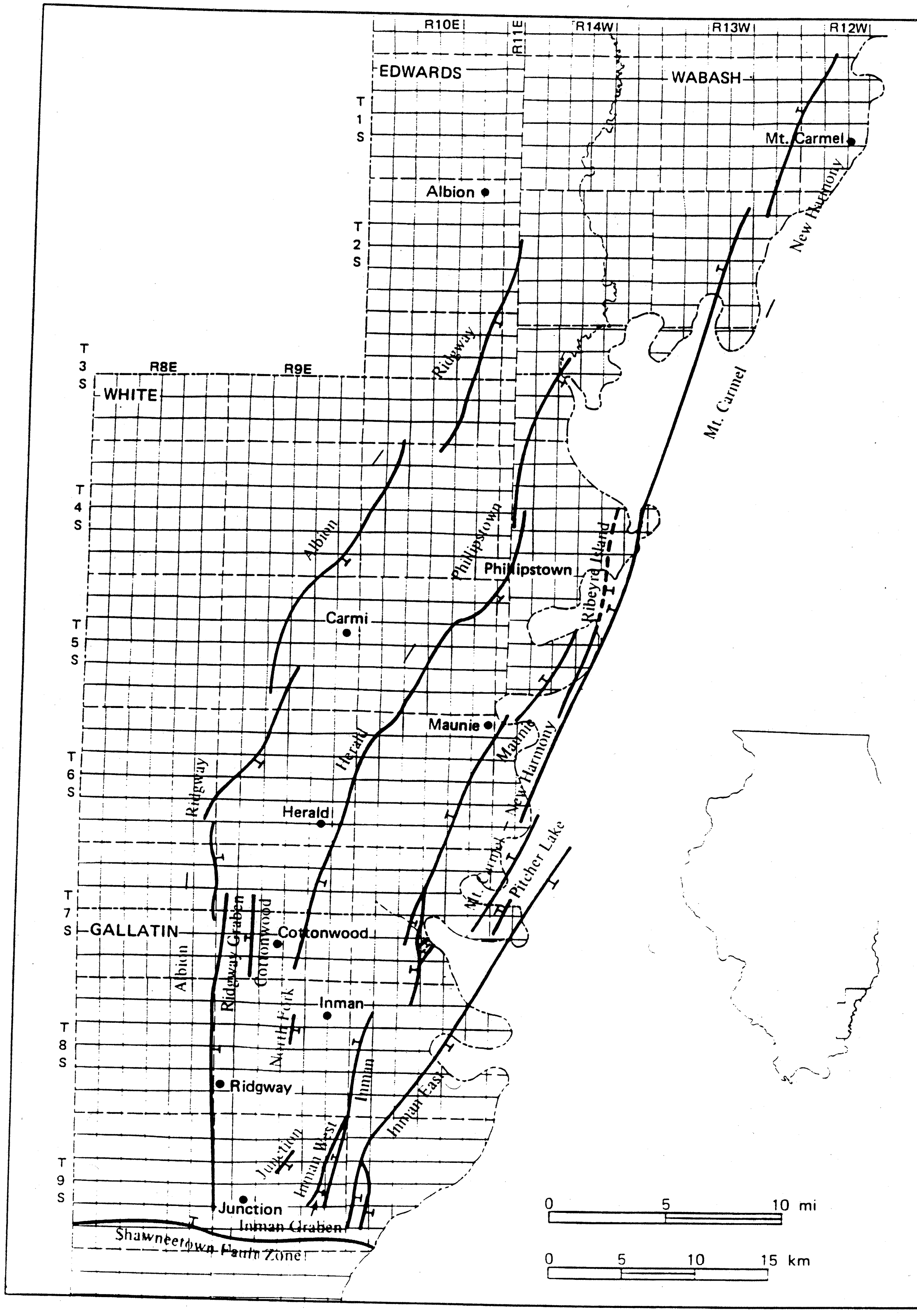
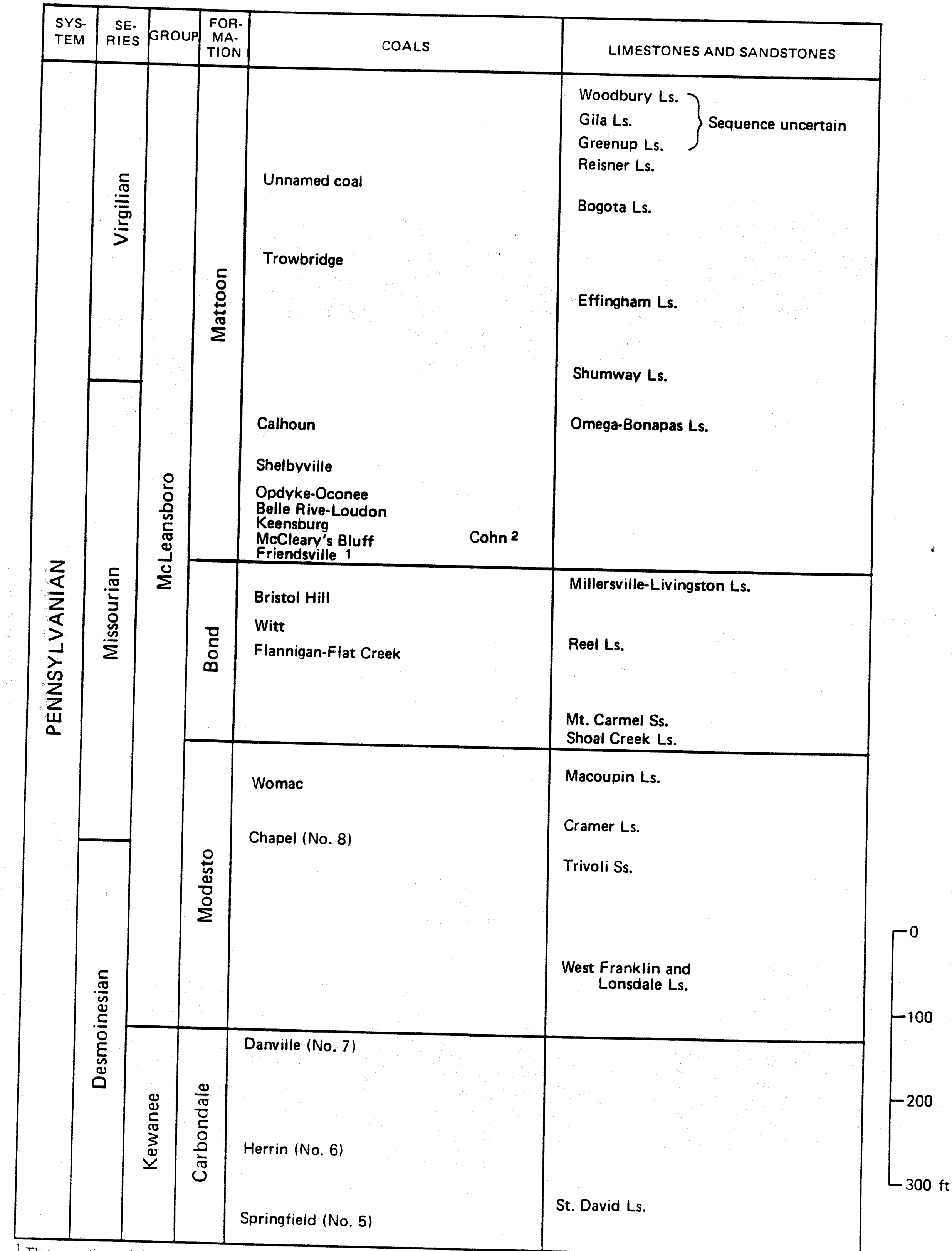


Figure 2 Locations and names of major structures in the Wabash Valley Fault System (Bristol and Treworgy 1979).



[1] The position of the Friendsville Coal relative to the Millersville Limestone is not certain.
[2] The position of the Cohn Coal relative to other coals in the lower Mattoon Formation is not certain.

Figure 3 Generalized stratigraphic column showing positions of named Pennsylvanian members mentioned in this report (Nance and Treworgy 1981).

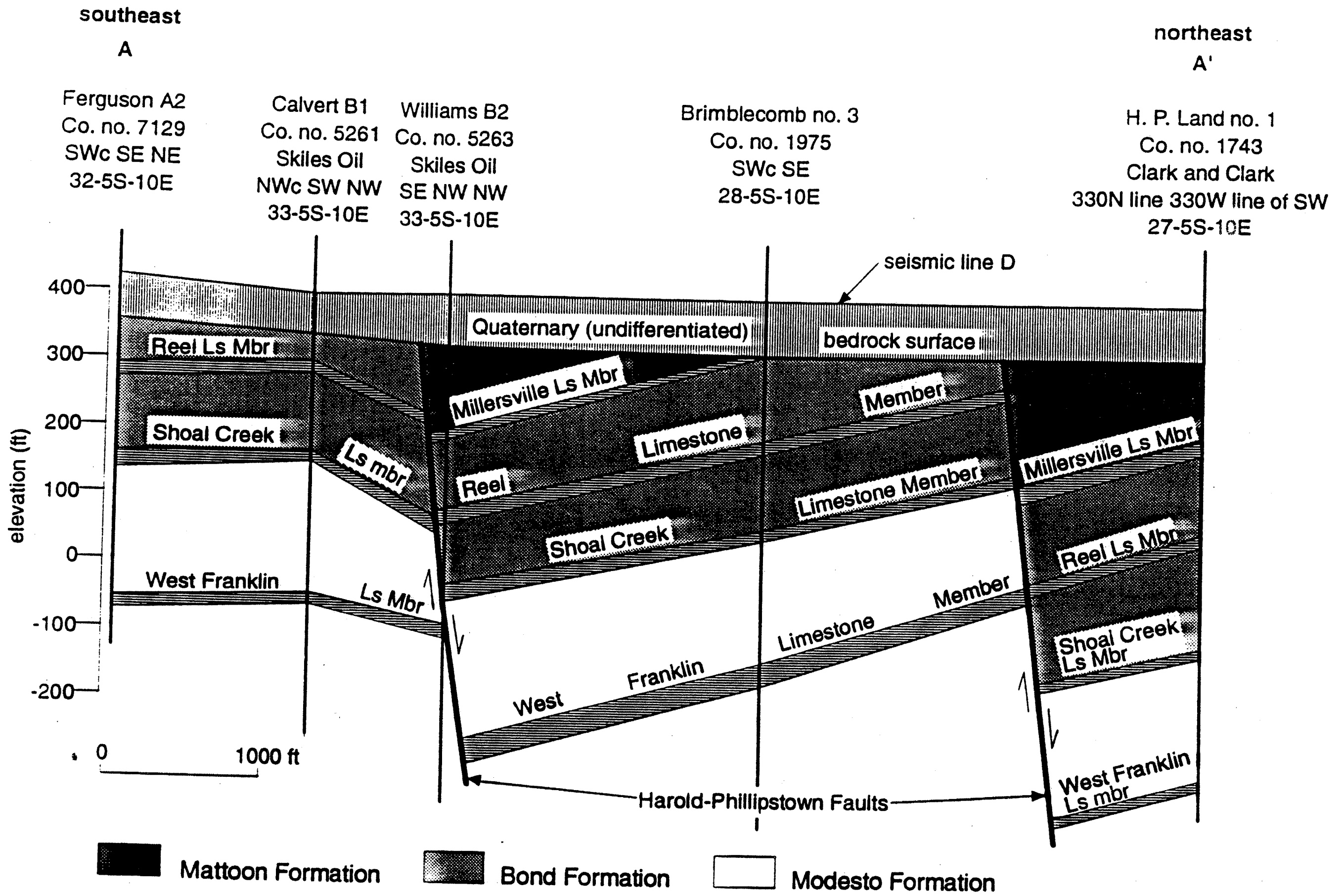


Figure 4 Cross section A–A′ showing structural and stratigraphic relationships of the upper bedrock (see fig. 1 for location).

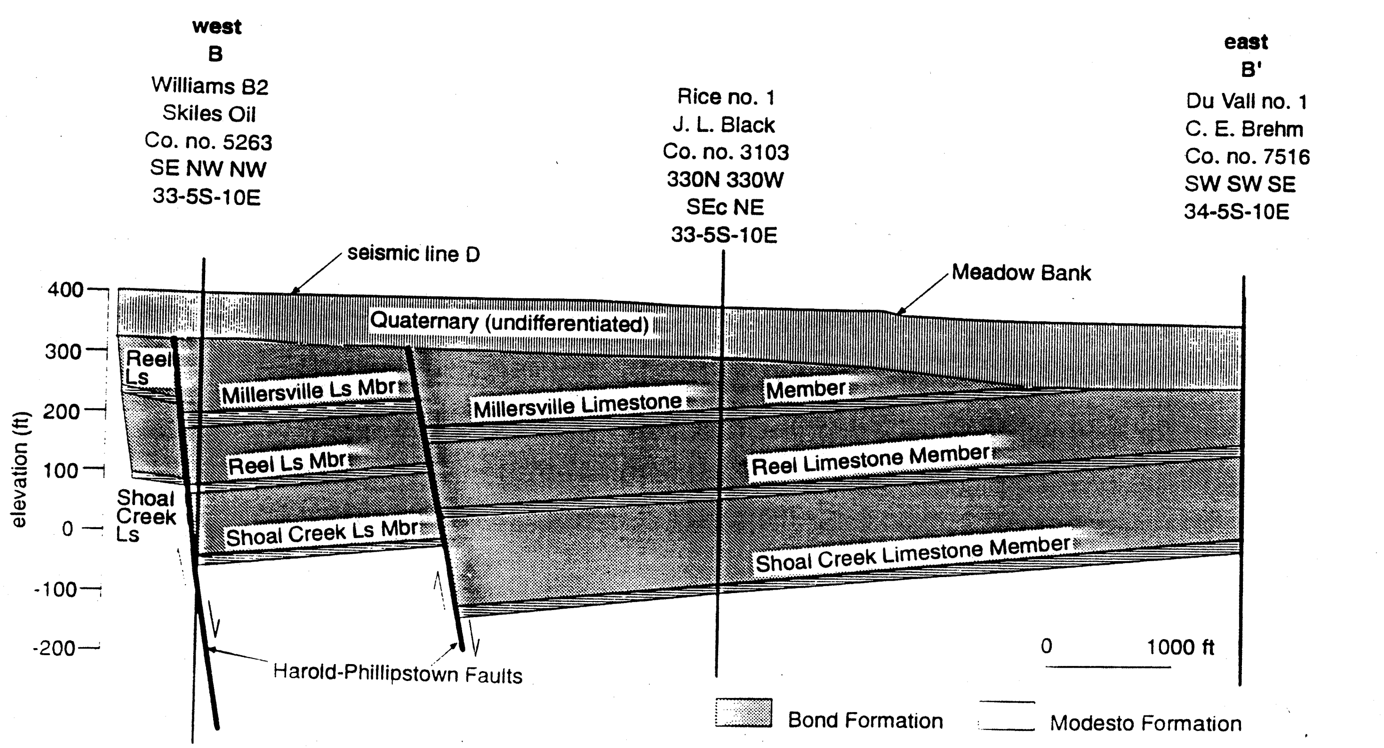


Figure 5 Cross section B–B′ showing structural and stratigraphic relationships of the upper bedrock (see fig. 1 for location).

The study area is mostly in the Wabash River Valley (fig. 1), which has occupied approximately the same location since before Illinoian glaciation (Fidlar 1936, Fidlar 1948). Up to 150 feet of glacial drift rests on the bedrock surface in the study area (Horberg 1950, Pryor 1956, Piskin and Bergstrom 1975). Fine-grained glacial till of Illinoian-age occurs in the uplands to the northwest, but does not extend into the study area. West of the Meadow Bank are silty remnants of Wisconsinan slack-water lake deposits. According to Fidlar (1948), the Meadow Bank may be a remnant of the late Wisconsinan Maumee Terrace. In late Wisconsinan time, the meltwaters from the retreating continental glacier collected at the southern edge of the ice cap to form Lake Maumee, of which the present Lake Erie is a remnant. Lake Maumee overflowed the lake basin in the vicinity of Fort Wayne, Indiana, and poured across the land to join the present route of the Wabash River at Huntington, Indiana. These flood waters may have erased traces of earlier erosional terraces developed in the alluvial fill, and cut a lower level. East of Meadow Bank, sandy alluvial terraces and silty or clayey bottomlands extend to the modern river channel at the eastern edge of the study area. Eolian silt covers the bedrock uplands in the extreme southwestern part of the study area, and several sand dunes occur on the former lake bed and terrace deposits.

Vertical Electrical Sounding

Vertical electrical soundings (VES) were made in Hawthorne Township (T5S R10E), White County, to obtain information about the shallow geologic framework of this area where the parallelism of the Meadow Bank to the Herald-Phillipstown Fault Zone is so apparent (fig. 6). The soundings were made with an ABEM Terrameter SAS System, Model 300B. Forty-five stations were arranged in five east–west lines (A through E) crossing the Meadow Bank and the trace of the Herald-Phillipstown Fault Zone on the top of the West Franklin Limestone. A Wenner electrode configuration with a-spacings expanded in increments of 10 feet to a maximum of 150 feet was used. The maximum a-spacing was large enough to assure that inversion of field data provided depth to bedrock and the resistivity of the rocks that form the bedrock surface. Lateral spacing between VES stations was approximately 0.25 miles. Inversion of the field data was done by using a technique developed by Zohdy and Bisdorf (1975). This technique provides layering parameters (thicknesses and resistivities) for a series of horizontal layers below the center stake of the Wenner electrode configuration.

Inversions of the VES data along lines A through E are shown in figure 7. West of the Meadow Bank the near-surface layers have very large resistivity values. Values greater than 2,000 ohm-feet are common, with one value as large as 4,164 ohm-feet. These high resistivity values are normally associated with the type of well sorted, coarse grained sediments in high energy depositional environments. Some shallow high resistivity readings may be due to unsaturated conditions in the near surface. To the east of the Meadow Bank the near-surface layers have resistivity values that are also indicative of sandy deposits, but with considerably more fine grained material than the near surface deposits to the west of the Meadow Bank.

The contrasting character of the valley fill deposits on opposite sides of the Meadow Bank can be seen on a horizontal slice map showing "true" resistivity distribution at an elevation of 350 feet above mean sea level (msl) (fig. 6). The expression, "true" resistivity, means the resistivity value determined by the inversion of VES data. The elevation used in figure 6 is well above the highest bedrock elevation and well below the lowest elevation of the earth's surface in the study area. At 350 feet above msl all resistivity values greater than 500 ohm-feet occur west of the Meadow Bank. Resistivity values of rocks of the bedrock surface are quite similar to those of valley fill deposits to the east of the Meadow Bank (fig. 7). Such values indicate that the bedrock surface is made of clastic rocks, but further differentiation of these rocks can not be determined by resistivity values alone. The composition of the bedrock surface will be discussed further in Seismic Refraction Profiling and Drilling and Logging.

The contrast in compositions of the near-surface deposits on opposite sides of the Meadow Bank suggests that depositional environments in which the sediments were laid down were quite different. Elevation of the bedrock surface to the east of the Meadow Bank is less than to the west. This might indicate that at one time the type of sandy deposits to the west of the Meadow Bank covered the area to the east; and an erosional episode, such as the Maumee Flood, removed not only the very sandy deposits, but all other unlithified deposits. Such an episode may have removed some of the more erodible clastic rocks forming the bedrock surface to the east of the Meadow Bank before fine grain sediments now present were deposited.

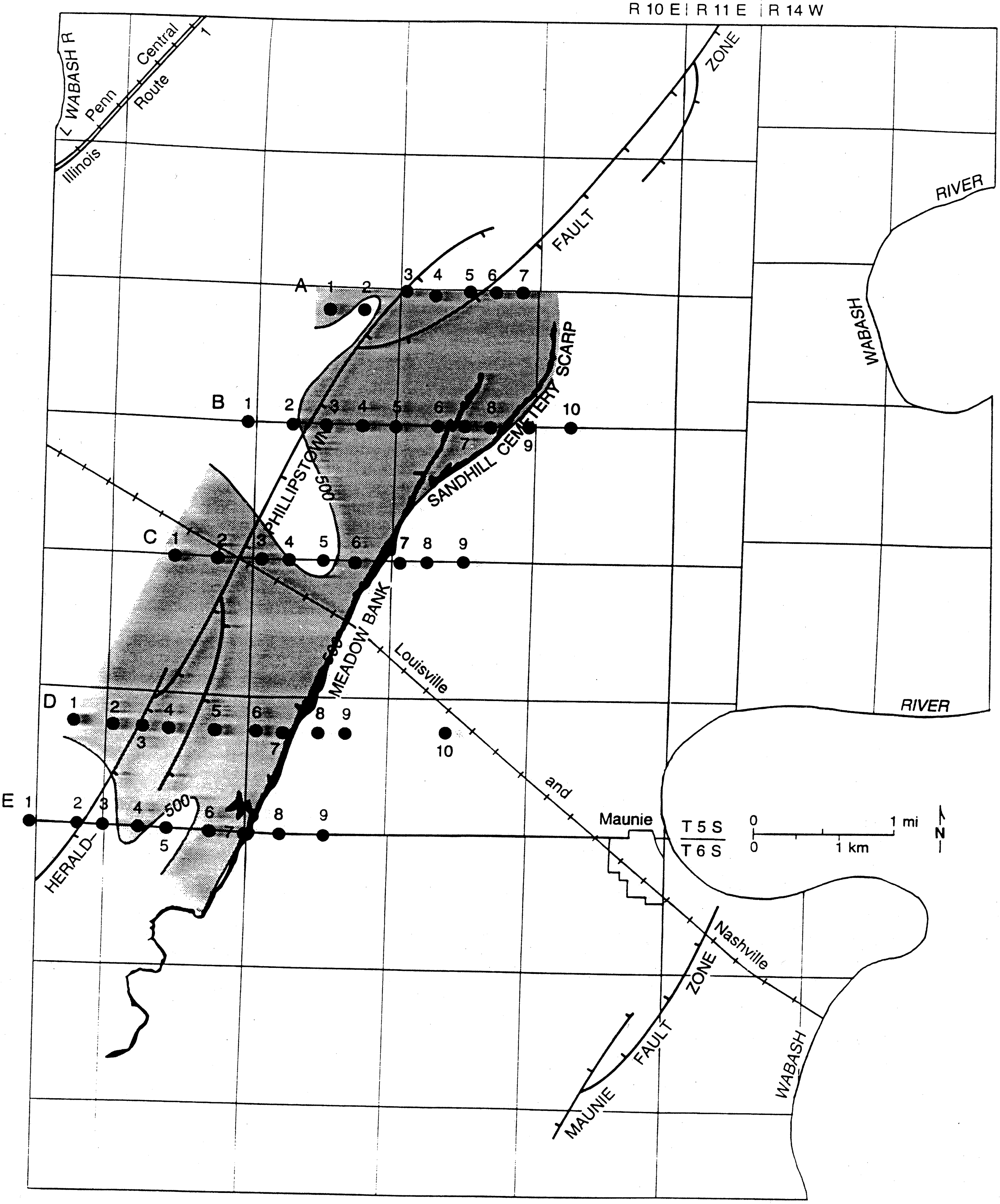


Figure 6 Locations of the vertical electrical soundings (VES) in the study area and the distribution of resistivity readings greater than 500 ohm-feet at 350 feet above msl in the study area.

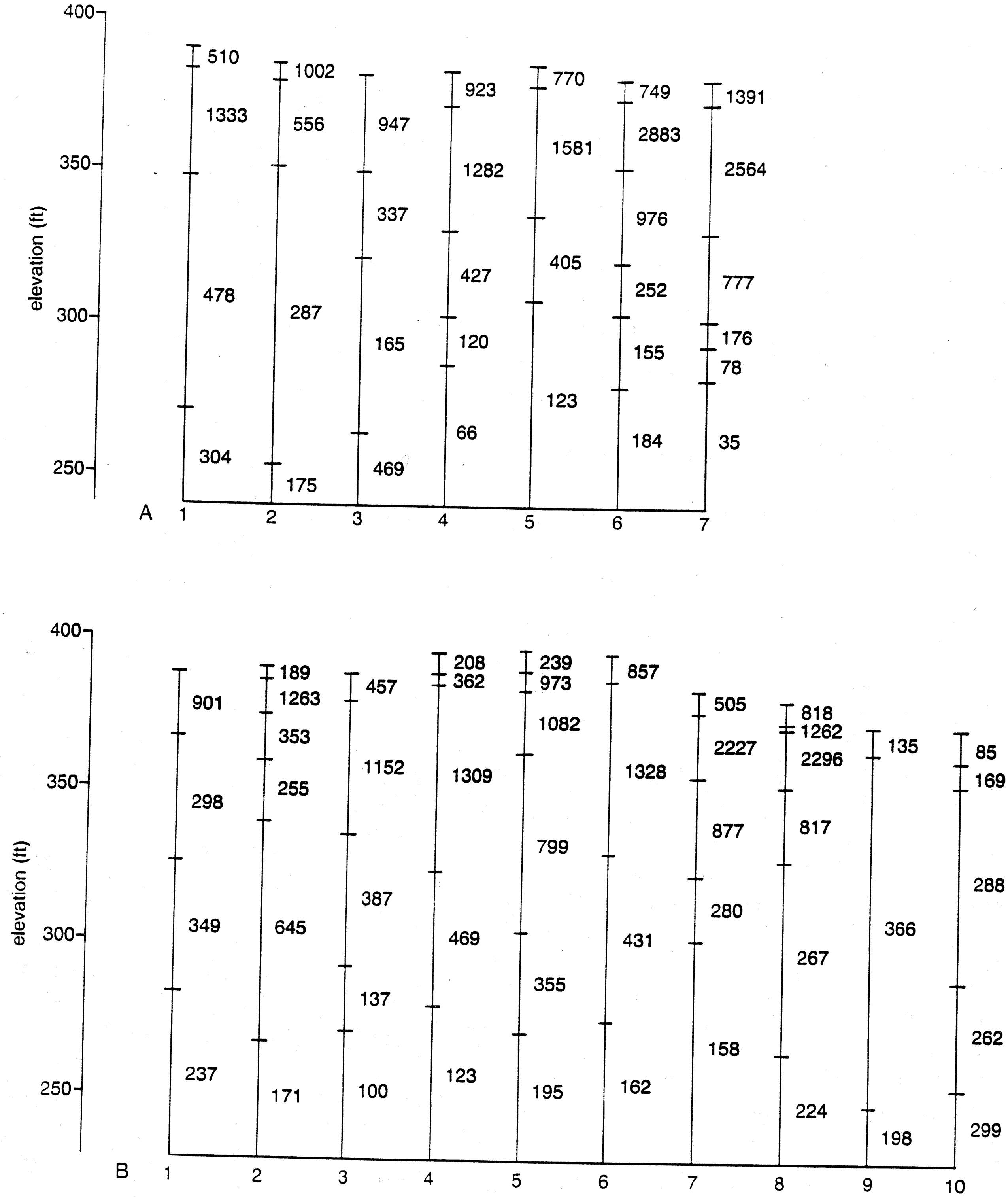


Figure 7 Inversions of vertical electrical soundings (ohm-ft) along lines A through E (see fig. 6 for locations).

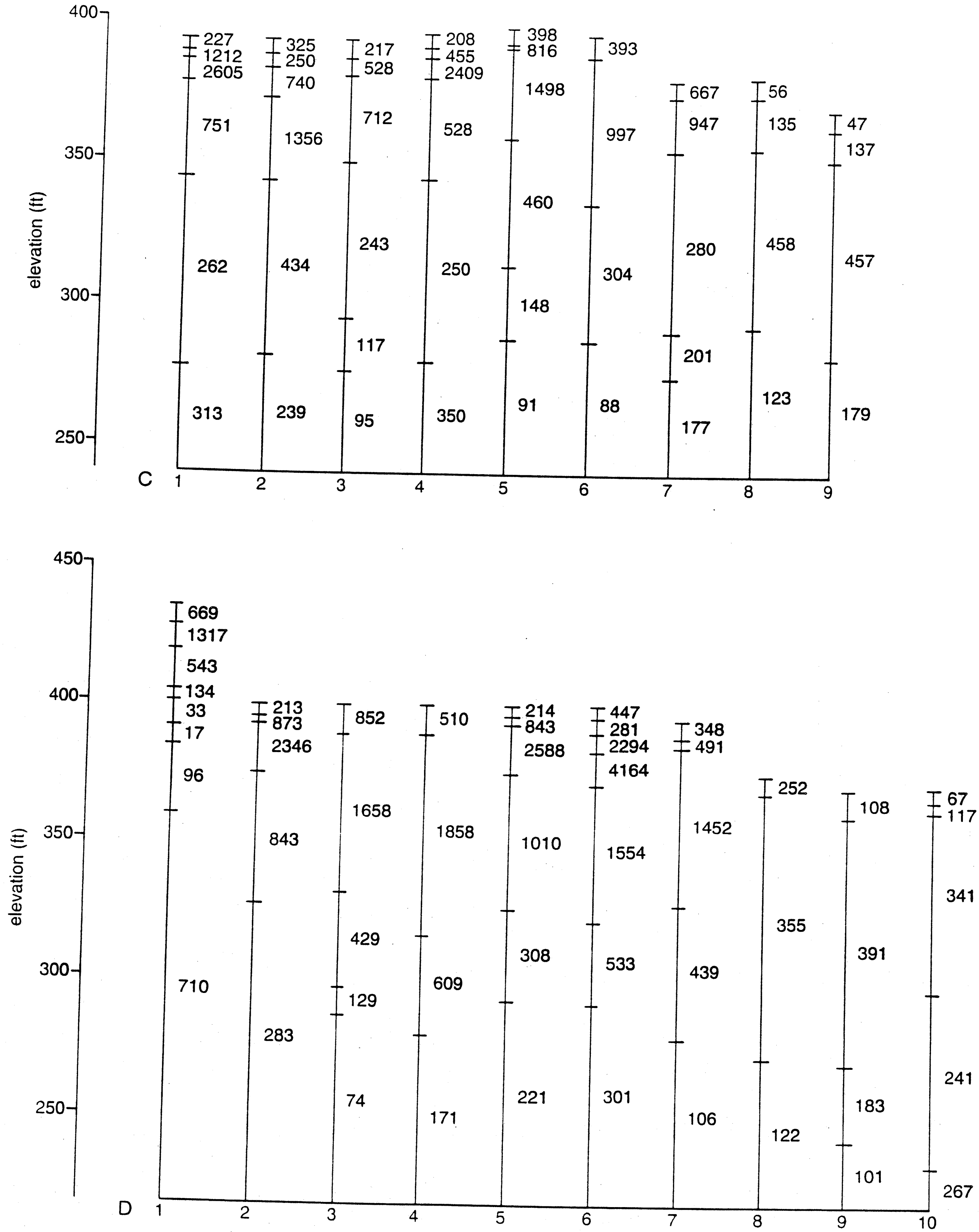


Figure 7 continued

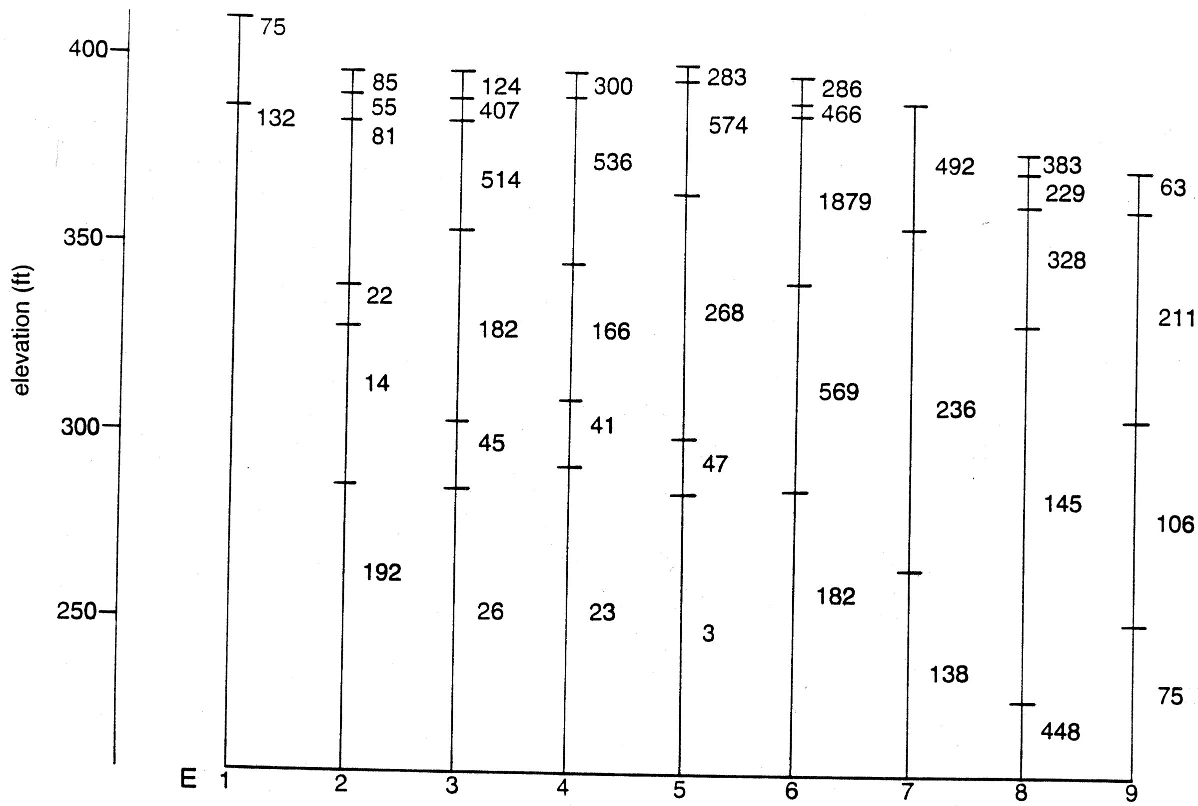


Figure 7 continued

Seismic Refraction Profiling

Continuous seismic refraction profiling was done along two east–west lines (coincident with VES lines B and D) in Hawthorne Township (fig. 8). These lines cross the Meadow Bank and the trace of the Herald-Phillipstown Fault Zone on the top of the West Franklin Limestone.

An EG&G Geometrics Model 2415F 24-channel signal enhancement seismograph and a Geometrics DMT-911 tape recorder were used to acquire the data. Sensor geophones (14 Hz) were spaced 50 feet apart. The energy sources, either 0.33 or 1.0 pound of Kinepak 2-component explosives, were placed in hand augered holes 5 feet deep. All records were 0.250 seconds in length, and all records were saved on ASCII data files for processing. Inversion of the seismic refraction data was done using SIPT2 V-3.2, an interactive computer program. This program is based on a published program, SIPT (Scott 1977). The inversion algorithm uses the delay-time method (Pakiser and Black 1957) to obtain a first-approximation depth model, which is improved by a series of ray-tracing and model-adjustment iterations that minimize discrepancies between field-measured times and corresponding times traced through the cross sectional depth model.

The inversion of the seismic refraction data gathered along lines B and D is shown in fig. 9. The near surface deposits are three layers with different velocities. The lowest layer corresponds to rocks making up the bedrock. Resting on the bedrock surface is a layer mainly of water-saturated sands and gravels. The uppermost layer is not unlike the underlying layer, but it is above the water table. As expected in such coarse grained deposits, the water table is flat. Hand augered shot holes along lines B and D encountered dry, sandy deposits to a depth of 5 feet.

The velocities of rocks making up the bedrock surface along lines B and D are typical for Pennsylvanian clastics. Four test holes drilled into the bedrock along line D encountered sandy shale at the bedrock surface (See Drilling and Logging). Along line B the rocks of the bedrock surface have a mean velocity of 10,095 feet per second (ft/s) and range from 9,800 to 10,500 ft/s. Along line D the mean velocity is 10,037 ft/s, and the range is from 9,800 to 10,250 ft/s. The slight variation in velocities along lines B and D cannot be used to indicate where faults have intersected bedrock surface. Where a known fault (the Herald-Phillipstown Fault Zone) has been crossed by the seismic refraction lines B and D (fig. 9), rocks of similar lithology must have been brought into juxtaposition to form the bedrock surface.

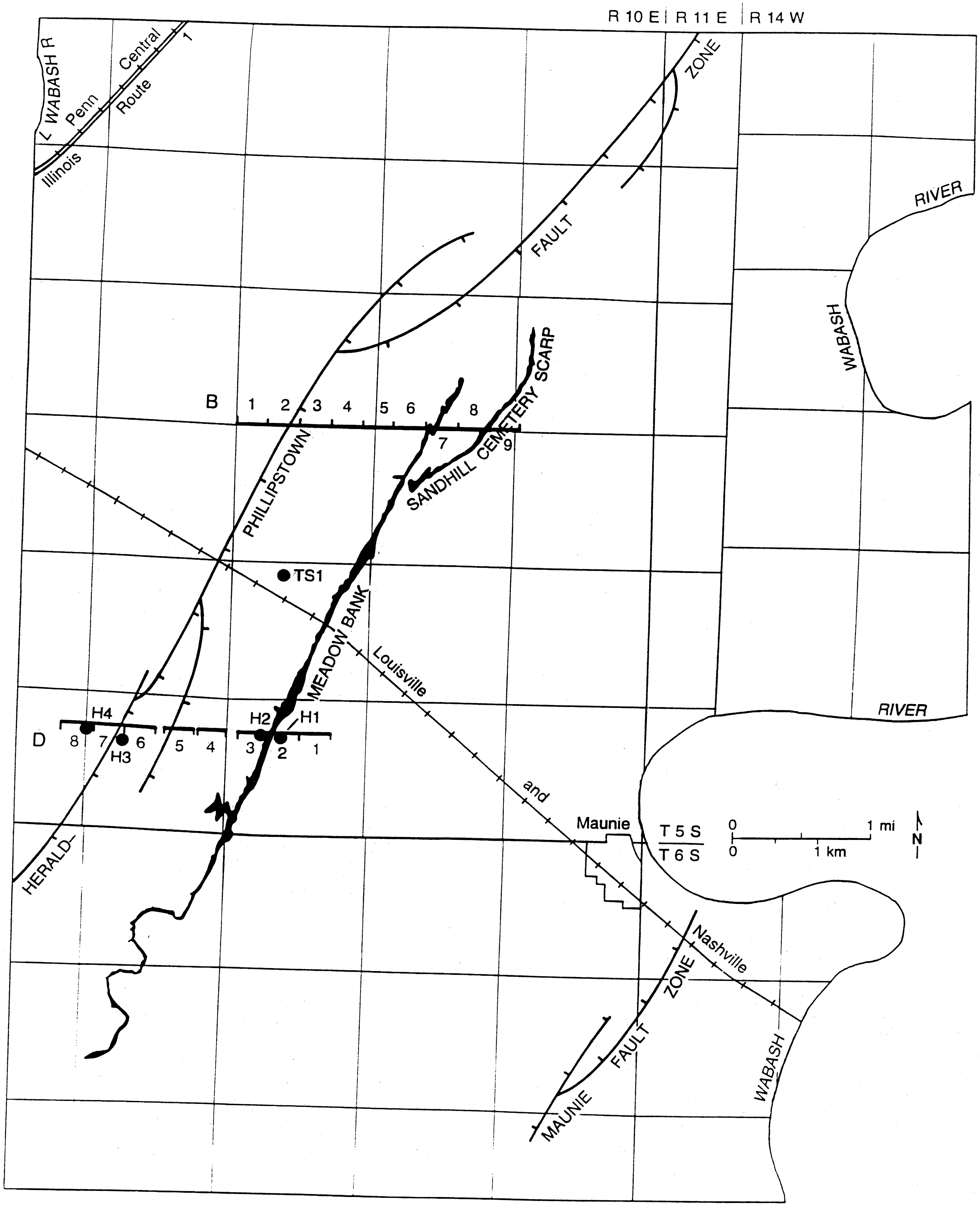


Figure 8 Locations of the seismic refraction profiles in the study area.

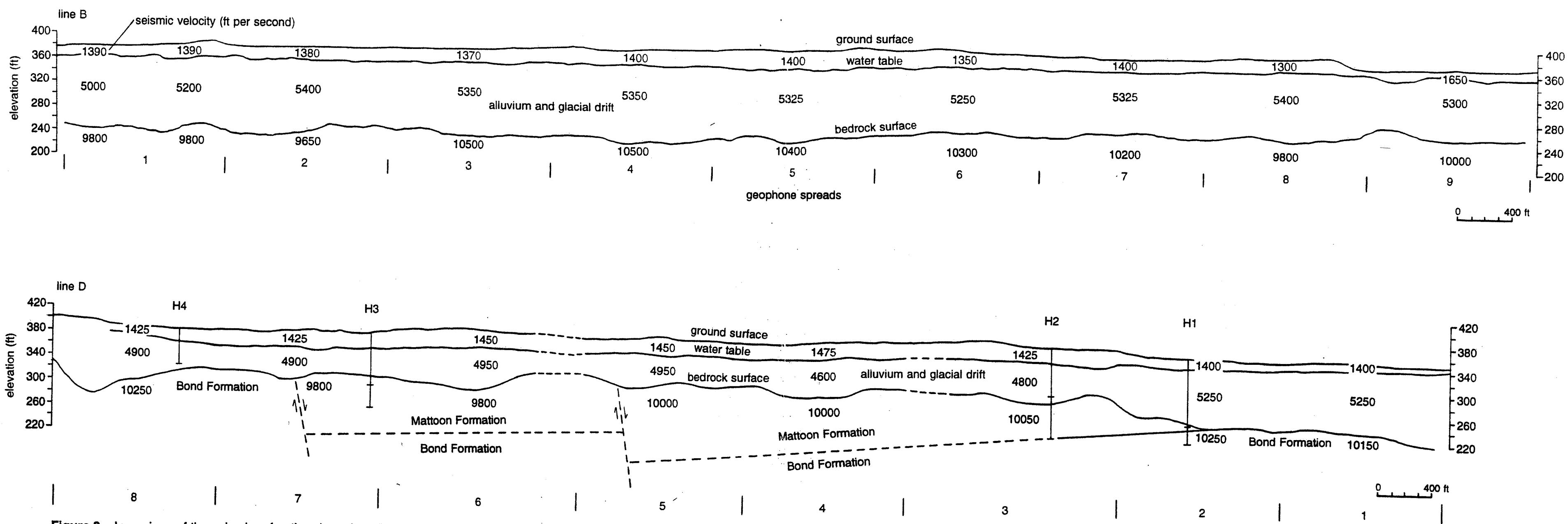


Figure 9 Inversions of the seismic refraction data along lines B and D (see fig. 8 for locations).

The velocities of the water-saturated valley-fill deposits along lines B and D are also consistent. The mean velocity along line B is 5,290 ft/s with a range from 5,000 to 5,400 ft/s. Along line D the mean velocity is 4,950 ft/s with a range from 4,600 to 5,250 ft/s. The slight variation of the velocity of this layer, with no apparent trend, is unexpected because the inversion of the VES data along lines B and D (fig. 7) shows that the resistivities and grain sizes of materials making up this layer are considerably smaller to the east of the Meadow Bank. Resistivity in this example is a better parameter than velocity for detecting variation in lithology.

The velocities of the valley-fill deposits above the water table along lines B and D are different from those below the water table. However, there is little lateral variation of the velocity in this unsaturated layer. The mean velocity along line B is 1,403 ft/s with a range from 1,300 to 1,650 ft/s. Along line D the mean velocity is 1,431 ft/s and the range is from 1,400 to 1,475 ft/s. The small variation in the velocity of this surficial layer is surprising because the inversion of the VES data (fig. 7) shows that resistivity values and grain sizes of the deposits making up this layer are appreciably smaller to the east of the Meadow Bank. The water table is flat in the study area because of the coarse-grained nature of the valley fill deposits. The thickness of the unsaturated layer varies directly with topographic relief. Where the topographic elevation is least, so is the thickness of the unsaturated layer (e. g., to the east of the Meadow Bank).

Inversion of the seismic refraction data gathered along lines B and D (fig. 9) indicates there are no sharp declivities on the bedrock surface, even where the lines cross the Herald-Phillipstown Fault Zone. The smoothness and slight variation of the velocity of the bedrock surface make the recognition of faults intersecting the bedrock surface difficult, if not impossible. More information is necessary to assess faulting and subsequent movement, especially in the Meadow Bank.

Drilling and Logging

Four test holes (H1-H4) were drilled into bedrock along resistivity and seismic line D (fig. 1). Along with sampling of drill cuttings, natural gamma logs were run in each hole (see Appendix A). These studies were done to confirm the interpretation of the surficial geophysical surveys, complement the existing stratigraphic and structural information, and provide better understanding of the Meadow Bank and Herald-Phillipstown Fault Zone and any relationship between them. Two of the test holes, H1 and H2, were located just to the east and just to the west of the Meadow Bank. The other two test holes, H3 and H4, were drilled just to the east and just to the west of the trace of the master fault of the Herald-Phillipstown Fault Zone.

A stratigraphic log available from core taken from a test hole, TS-1, at the nearby Pattiki Mine in the northwest quarter of Section 27, T5S, R10E (figs. 1 and 10), provided stratigraphic context for the test borings H1-H4. The log shows that the bedrock surface at the Pattiki Mine is 308 feet above msl and composed of shale of the Mattoon Formation. The Millersville Limestone Member at the top of the Bond Formation is shown as two layers of limestone separated by a layer of sandstone between 155 and 173 feet above msl.The Shoal Creek Limestone Member at the base of the Bond Formation is 103 to 109 feet below msl.

Coal seams in test borings H2 and H3 and a black shale in test boring H4 (fig. 1) helped in understanding structural and stratigraphic framework of the study area. Organic matter was analyzed for spore count to identify strata (R. Peppers, ISGS, personal communication 1993). The coal in test boring H2, penetrated at 300 feet above msl is the equivalent of the Keensburg Coal Member of the Mattoon Formation. The coal in test boring H3, penetrated at 331 feet above msl is probably the equivalent of the Oconee Coal Member of the Mattoon Formation. The Oconee Coal, based on stratigraphic evidence, is approximately 120 feet above the Millersville Limestone in the study area. Spores in the black shale penetrated at 332 feet above msl in test boring H4 were not well preserved, but are probably equivalent to fauna in coal found below the La Salle Limestone Member of the Bond Formation in northern Illinois. The La Salle Limestone is correlated with the Millersville Limestone in the study area.

The data gathered in test borings H1 and H2 are compatible with cross section B–B′ (fig. 5), which shows the Mattoon Formation to be at the bedrock surface in that area. To the east, possibly beneath seismic refraction profile D1, regional dip brings rocks of the Bond Formation up to the bedrock surface. The Millersville Limestone, encountered in both borings, is 18 feet deeper in H2 than in H1, implying a westward dip of 1.5° toward the Herald-Phillipstown Fault Zone.

Test boring H4 is to the west of the main fault of the Herald-Phillipstown Fault Zone. Here the rocks at the bedrock surface belong to the Bond Formation, probably those overlying the Reel Limestone Member. Test boring H3 is located east of the main fault; but west of a subsidiary fault both faults are downthrown to the east. At the bedrock surface test boring H3 encountered rocks of the Mattoon Formation, not unlike the shallow bedrock in test boring TS1 at the Pattiki Mine.

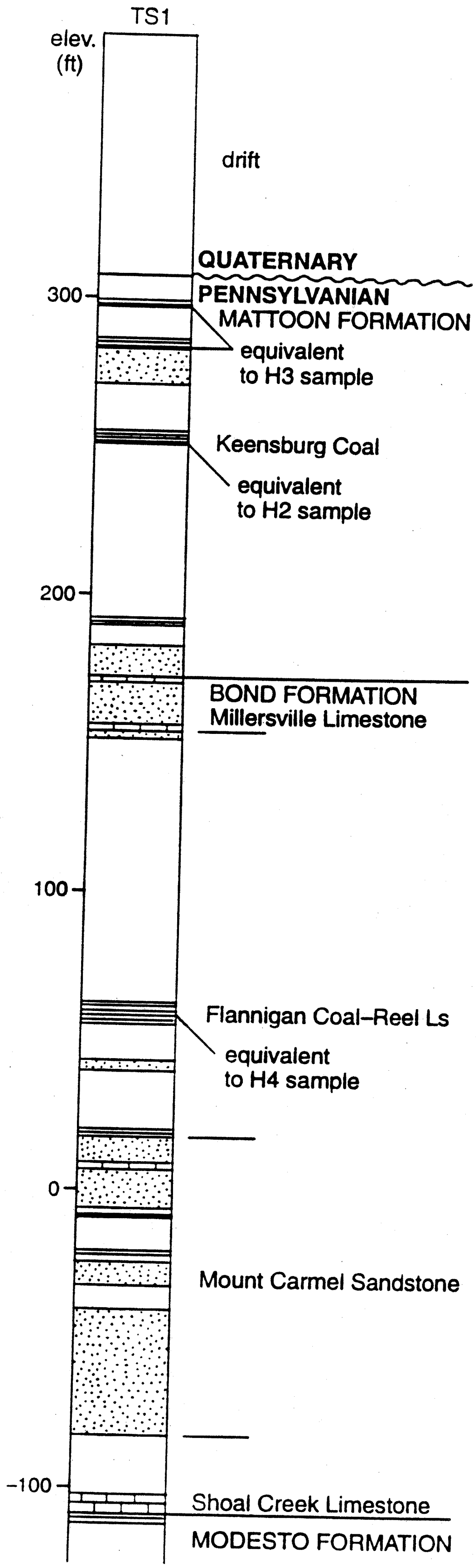
The seismic velocities of the rocks of the bedrock surface along lines B and D are generally associated with Pennsylvanian shales. However, at the eastern end of line D (seismic refraction profiles D1 and D2) the velocities of the rocks at the bedrock surface are slightly greater, indicating that these rocks are more calcareous. These rocks are likely the Millersville Limestone. This limestone is 73 feet below the bedrock in test boring H2 and 6 feet below the bedrock surface in test boring H1. The Millersville Limestone here consists of 10 to 15 feet of thinly bedded sandy limestone, coal, and sandstone.

The seismic velocity of the rocks of the bedrock surface below seismic refraction profile D8, at the western end of line D, is greater than those below profiles D6 and D7. This is consistent with the fact that test boring H4 encountered hard shale at the bedrock surface, in contrast to the soft shale penetrated in test boring H3. Variation in the lithology of the rocks forming the bedrock surface in the Herald-Phillipstown Fault Zone is to be expected because this fault zone is composed of a master fault and several parallel subsidiary faults.

POSSIBLE FISSURES AND SAND BLOWS FROM THE NEW MADRID EARTHQUAKES

Background

In 1857 Daniel Berry (1908) interviewed Yearby Land and his mother, who lived in White County, Illinois, at Big Prairie (fig. 1) during the catastrophic earthquake sequence in the winter of 1811–1812. Among the recollections of Mr. Land, who was 11 at the time, was the following: "In the prairie, about 2 miles east of my father's house, a big crack was made in the ground, and you could not see the bottom of it. The ground on the south side of the creek (crack) sunk down about 2 feet."



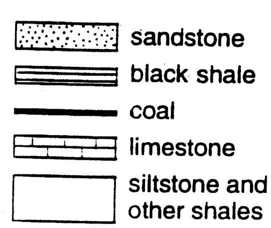


Figure 10 Graphic log from test boring TS1 near the Pattiki Mine (NW Sec. 27, T5S, R10E).

Berry said the crack was well-defined when he saw it in 1858:

> Across a field that sloped upward to the north was a well-marked line of uplift and downfall," Berry said. "The lower side to the south. This line extended eastward through the woodland and was lost in some swamp land further on. It could be traced about 2 miles. The field was in cultivation for wheat when I first saw it, and the slope of the uplift, on the northern side was about 6 feet long, as it had been worked down in cultivation. This crack was on the land afterward owned by Mr. Jacob Parker in the northwest quarter of Section 35, T5S, R10E, 3rd p.m.

According to Land, piles and piles of pure, snow-white sand were "heaved up." This phraseology and a cryptic statement by Berry that piles of sand showed "evidence of water" seem to indicate that sand blows were prevalent in this area.

A similar account of the fissure and sand blows was reported by Interstate Publishing Company (1883). Although this account is unattributed, it is likely another version of the Yearby Land story. According to this version, the original crack was about 0.25 miles long.

Constant-Electrode-Separation Resistivity Profiling

An attempt was made to validate Land's recollections. Five north–south constant-electrode-separation resistivity lines were run in Sections 26 and 35 of Hawthorne Township (fig. 1). A Wenner electrode configuration with an a-spacing of 10 feet was used. Apparent resistivity readings were made every 10 feet. This scheme was adequate to determine significant lateral changes in the resistivity (lithology) of the near surface materials.

Along four of the lines (A, C, D, and E) there were occasional high and low apparent resistivity spikes too narrow and small to be significant (fig. 11). This is also true along much of line B, but near the northern end of this line there is a positive apparent resistivity anomaly, about 500 ohm-feet greater than the background apparent resistivities and about 140 feet wide north to south. This anomaly corresponds to a sizeable body of coarse grained material at the earth's surface.

Subsequent constant-electrode-separation profiling over and around the area where the large positive anomaly was encountered has determined its maximum amplitude and lateral extent (fig. 12). The maximum apparent resistivity value is over 900 ohm-feet. The area enclosed by the 200 ohm-feet contour is 5 times longer east to west than north to south. The vertical extent of the material causing this anomaly was determined by VES near the center of the anomaly. A Wenner electrode configuration was expanded in an east–west direction. The a-spacings were incremented by 5 feet at first, and later by 10 and 20 feet. This was done so that inversion of the VES data would provide detailed information about the near-surface deposits. The maximum a-spacing was 160 feet. The VES curve of apparent resistivity versus a-spacing and the inversion is shown in figure 13. There are two thin, high resistivity layers at the earth's surface that correspond to the anomaly-causing body. The upper layer has a resistivity of 819 ohm-feet and a thickness of 3 feet. The lower layer has a resistivity of 612 ohm-feet and a thickness of 2 feet. These layers are in sharp contrast to the two surficial layers at nearby VES station D10 (67 ohm-feet and 5 feet thick over 117 ohm-feet and 4 feet thick), which represent most of the surficial materials in this part of the region.

The sand body causing this resistivity anomaly may have been deposited by normal fluvial processes. Its long, narrow shape is not unlike a part of one of the many meander scars scattered over the landscape. But it is just as likely that this deposit is a sand blow, such as those described by Yearby Land. During the 1811–1812 New Madrid earthquake sequence all the necessary ingredients to produce such a feature may have been in place. Intensity values in the area of Carmi, Illinois, could have been as great as IX on the Modified Mercalli Intensity Scale, more than enough to fracture coherent clay and silt deposits and cause liquefaction of subjacent water-saturated sand deposits. The location, shape, and orientation of this sand body make it conceivable that this feature is closely related to the fracture noted by Mr. Land in the northwest corner of Section 35, Hawthorne Township. Detailed sampling and analyses of this sand body are needed to ascertain its nature. Constant-electrode-separation resistivity profiling was successful in finding and determining the dimensions of a surficial sand body.Other anomalous sand bodies could be found in this manner or, perhaps more expeditiously, by using electromagnetic techniques.

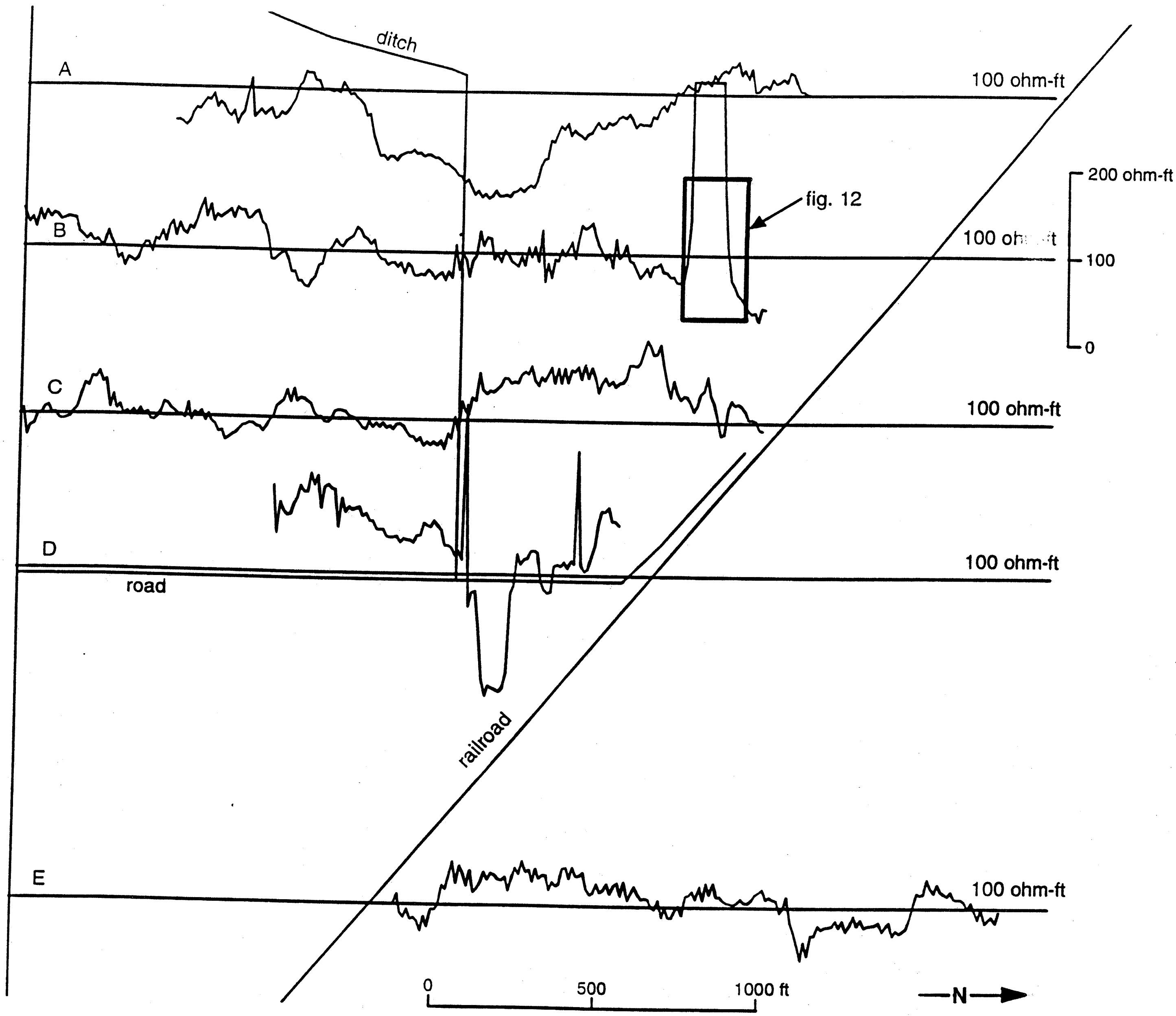


Figure 11 Apparent resistivity values along lines where constant-electrode-separation resistivity profiling was performed (lines A through E).

GENERAL CONCLUSIONS

It appears that the prominent surficial feature known as the Meadow Bank is an erosional feature that may have been formed during a late Quartenary event like the Maumee flood. The close parallelism of the Meadow Bank and the Herald-Phillipstown Fault Zone in Hawthorne Township (T5S, R10E) White County, Illinois suggests that the processes which formed the Meadow Bank were influenced by faulting and/or jointing related to the Herald-Phillipstown Fault Zone. Seismic refraction profiling confirmed by drilling records across the Meadow Bank indicates that the bedrock surface is lower to the east of this linear surficial feature. Softer clastic sediments making up the bedrock surface to the east of the Meadow Bank could have been removed during an erosional event such as the Maumee flood. Downhole logs indicate the region is crossed by a series of parallel faults rather than a single fault. No evidence to support recent movement along preexisting or newly formed faults in this region was found in this study.

Constant-electrode-separation resistivity profiling in the Wabash Valley east of the Meadow Bank has succeeded in finding and determining the dimensions of a surficial sand body. This body could be the remnants of a sand blow such as that described by an eyewitness of the 1811–1812 New Madrid earthquake sequence.

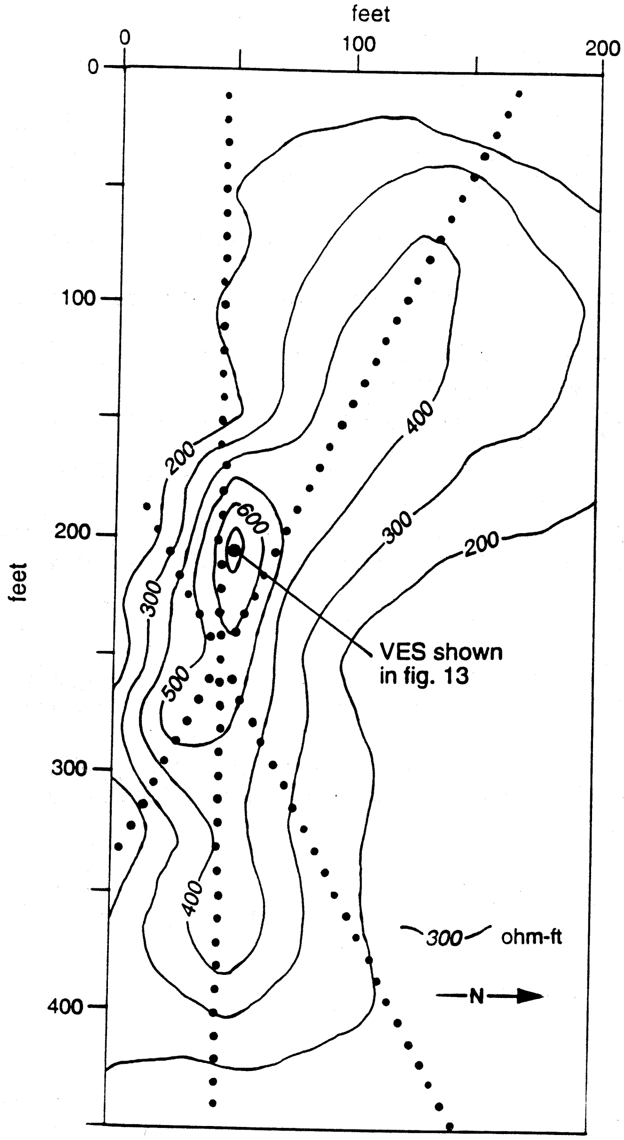


Figure 12 Positive apparent resistivity anomaly near the north end of line B (NW Sec. 35, T5S, R10E).

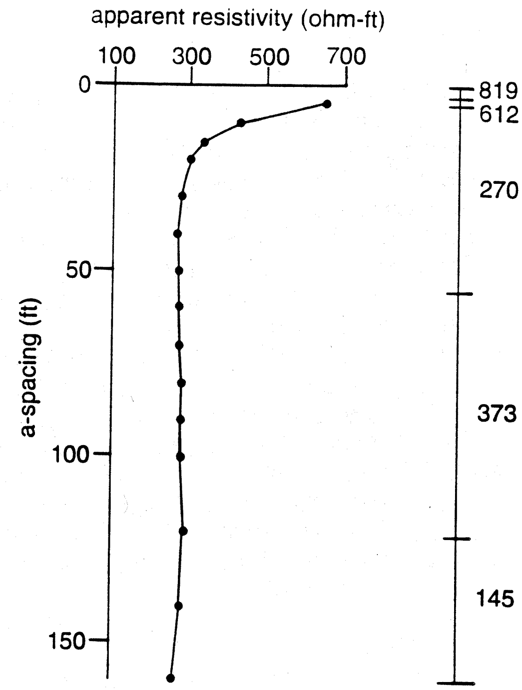


Figure 13 Vertical electrical soundings (VES) over the positive apparent resistivity anomaly near the northern end of line B; VES curve and inversion.

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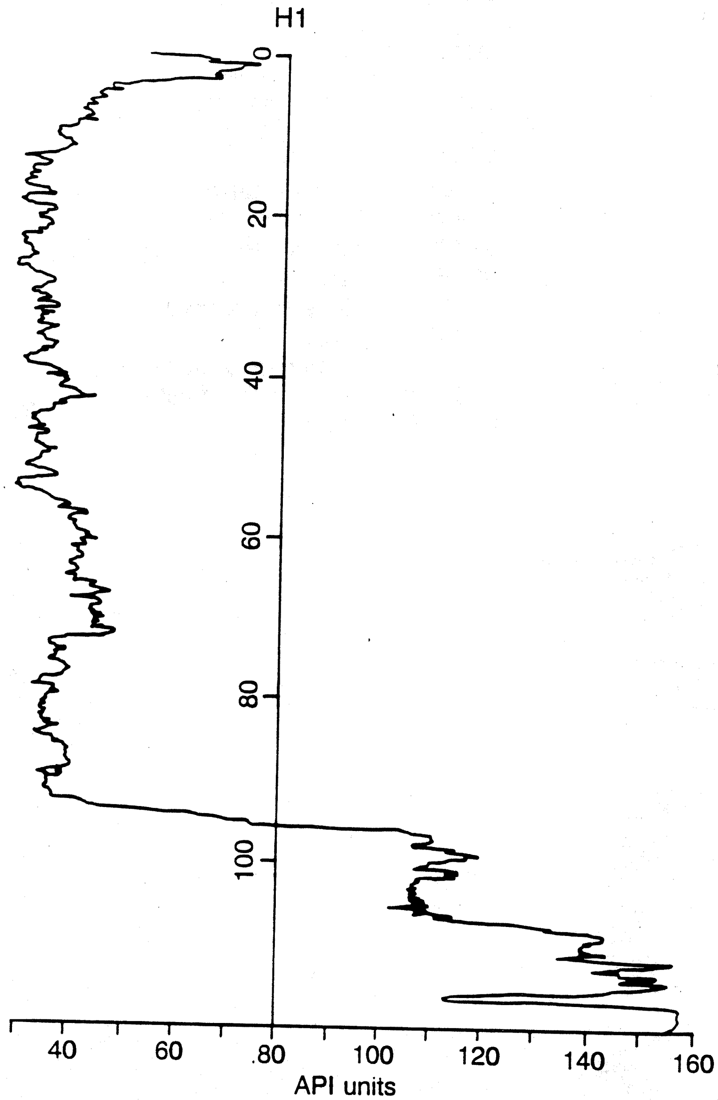
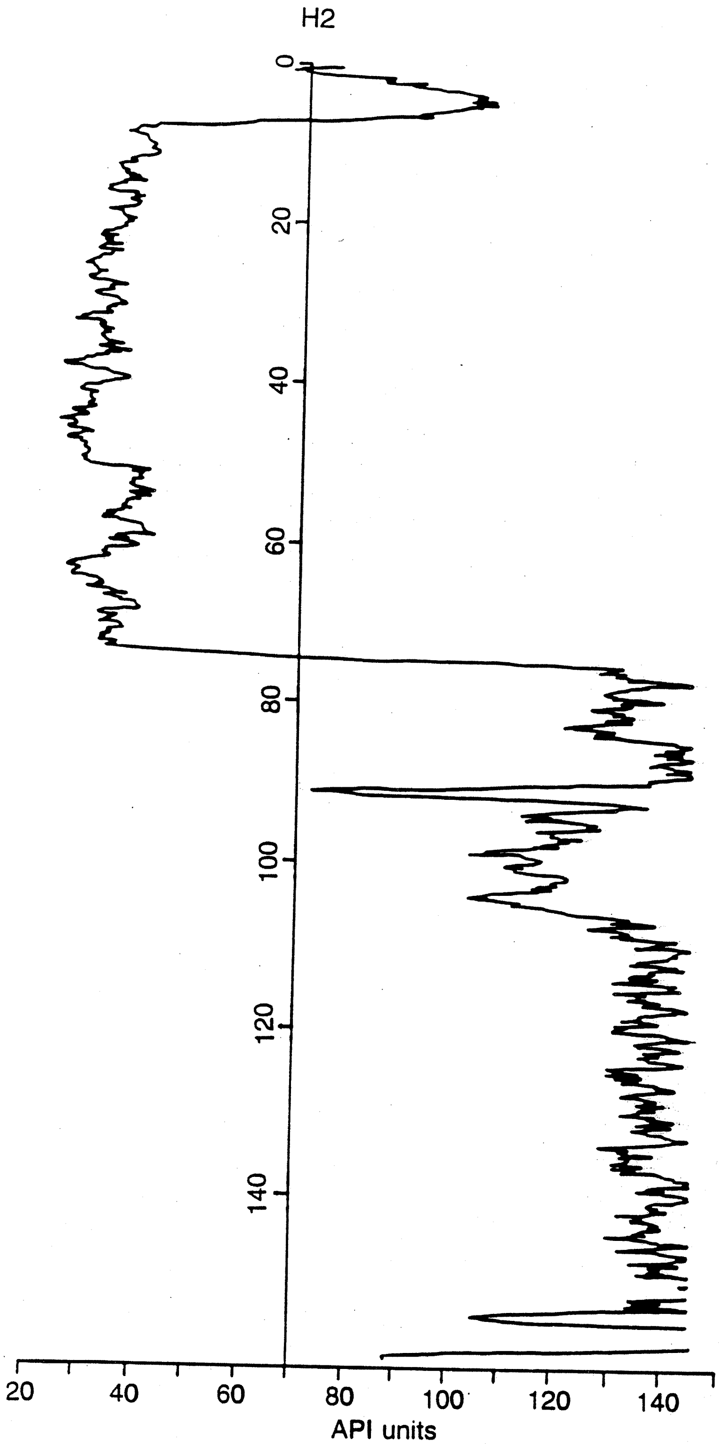
APPENDIX Natural gamma logs and drilling records for test borings H1 – H4



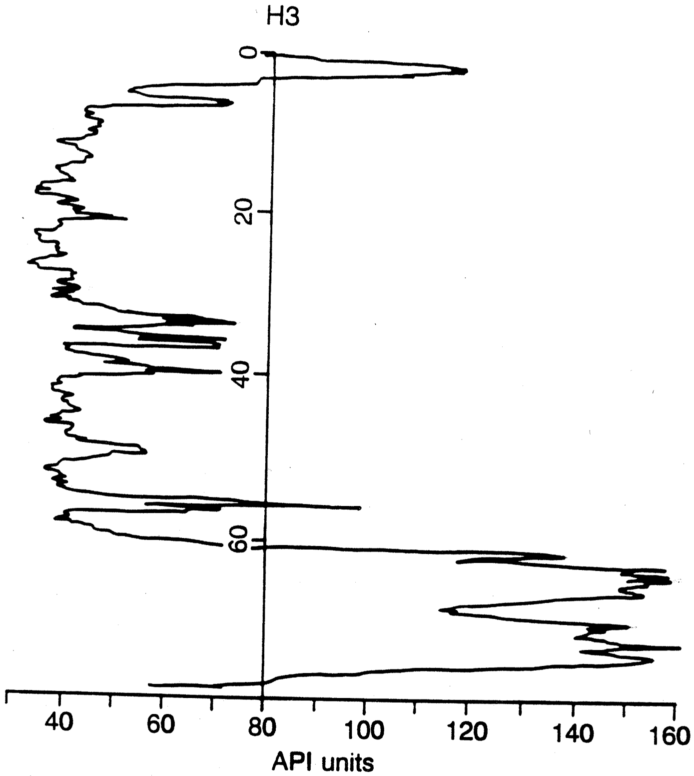
TEST BORING H1
600 ft W and 35 ft S NE cor SE NW
Sec. 34, T5S, R10E, White County, IL
Surface elevation 378.3 ft above msl

Depth (ft)	Material
0-5	Soil
5-10	Coarse sand, some gravel
10-25	Fine sand
25-6	Medium to coarse sand
68-97	Coarse sand and gravel
97-111	Gray clay
111-117	Gray Shale
117-122	Limestone with shale partings
122-140	Sandy shale



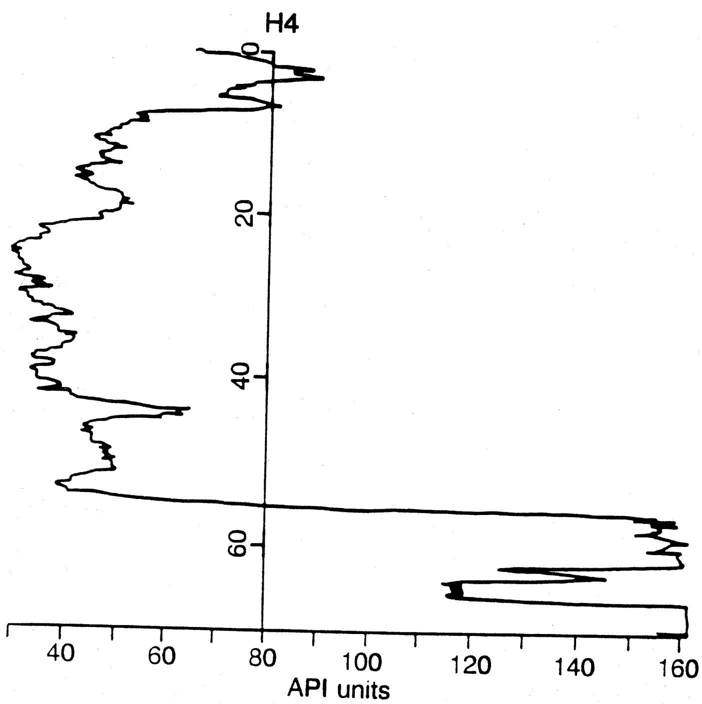
TEST BORING H2
50 ft S of NW cor SW NW
Sec. 34, T5S, R10E, White County, IL
Surface elevation 391.4 ft above msl

Depth (ft)	Material
0-9	Brown silty clay
9-25	Sand and gravel
25-27	Gravel
27-40	Coarse sand
40-50	Fine to medium sand
50-68	Coarse sand and gravel
68-75	Gravel
75-92	Gray sandy shale
92-93.5	Coal
93.5-148	Gray sandy shale
148-154	Shale with limestone partings
154-160	Gray shale



TEST BORING H3
SE cor NE SW NW
Sec. 33, T5S, R10E, White County, IL
Surface elevation 394.4 ft above msl

Depth (ft)	Material
0-7	Light brown silty clay
7-10	Medium to coarse sand
10-16	Fine sand
16-44	Sand and gravel
44-52	Fine to medium white sand
52-62	Fine to medium gray sand
62-63	Soft gray shale
63-63.5	Coal
63.5-78	Soft gray shale
78-79	Hard brown shale
79-79.5	Coal
79.5-80	Hard brown shale



TEST BORING H4
25 ft S and 25 ft E NW cor NW SW NW
Sec. 33, T5S, R10E, White County, IL
Surface elevation 398.3 ft above msl

Depth (ft)	Material
0-9	Yellowish brown clayey sand
9-33	Fine yellow sand
33-37	Coarse sand
37-42	Gravel
42-55	Coarse sand with some clay
55-58	Hard dark gray shale
58-66	Hard dark gray to black shale with interbedd limestone
66.5-80	Soft gray shale