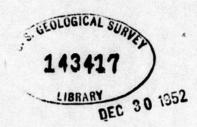
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U.S. Geological Burry, Section of Geophysics [Reports - Tennessee]

ELECTRICAL RESISTIVITY INVESTIGATIONS
AT MEMOPHIS, AND BOLIVAR, TENNESSEE.



By H. Cecil Spicer Geophysicist



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U. S. DEPARTMENT OF THE INTERIOR
Geological Survey
1947

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ELECTRICAL RESISTIVITY INVESTIGATIONS AT MEMPHIS, AND BOLIVAR, TENNESSEE

By H. Cecil Spicer

Introduction

This geophysical investigation was undertaken upon request of Elliott M. Cushing of the Ground Mater Division Office at Memphis, Tennessee. The field work was performed during the period March 13 to 28, 1947; the apparent resistivity curves were interpreted during Movember and December; and the report was written subsequent to the interpretation of the curves.

The writer is grateful to Elliott M. Cushing and his staff for the splendid cooperation and generous assistance extended to him in obtaining the measurements. It is also a pleasure to acknowledge the assistance of George J. Edwards in obtaining the field measurements.

Field Measurements

The instrument used for the resistivity measurements was the Gish-Roomey Earth Resistivity Apparatus manufactured by the Geophysical Instrument Company of Arlington, Va. The electrodes were copper-clad steel rods with steel driving heads and were pushed or driven into the earth to make contact for the potential and current connections. The earth around the electrodes was wetted and tamped whenever better contact was needed.

Portable reels of wire were used to make contact between the instrument and the electrodes.

4

The character of the earth materials and of certain geological formations was of primary importance in these investigations; therefore, depth profiling was used throughout. A modification of the Lee variation of the Wenner electrode configuration was used, and the electrode spacings expanded cutward from the central station. Three apparent resistivity curves were obtained at each station with this method; one in each direction from the center and one over the full interval distance. These are termed the P1, P2, and Full curves. Bearings for the line direction are referred to P1 and are corrected for declination. Power for driving the instrument was supplied by the truck battery, and current to pass through the earth for the resistivity measurements was provided by a bank of extra-heavy duty "B" batteries. Fundamental technique of operation is described by the maker of the instrument or will be found in the literature; as for example, Heiland.

1/ Heiland, C. A., Geophysical exploration; Prentice-Hall, 1940.

Interpretation of the Resistivity Curves

The resistivity curves were interpreted, in part, by means of procecures explained in the literature. A suggestive list of references on interpretation is given which is not intended to be complete.2/

Roman, Irwin, Some interpretations of earth resistivity data; A.I.M.E. Transactions, vol. 110, p. 183, 1954.

^{2/} Hummel, J. N., A theoretical study of apparent resistivity in surface potential methods; A.I.M.E. Tech. Pub. No. 418, 1951.

Roman, Irwin, How to compute tables for determining electrical resistivity of underlying beds and their application to geophysical problems; U. S. Dept. Commerce, Bur. Mines, Tech. Paper No. 502, 1931.

4

Roman, Irwin, Superposition in the interpretation of two-layer earth-resistivity curves; U.S.G.S. Bull. 927-A, 18 pp., 1941.

Tagg, G. F., Interpretation of earth resistivity ourves; A.I.M.E. Tech. Pub. No. 755, 1937.

Watson, R. J., A contribution to the theory of the interpretation of resistivity measurements obtained from surface potential observations; A.I.M.B. Tech. Pub. No. 518, 1934.

Watson, R. J. and Johnson, J. F., On the extension of two-layer methods of interpretation of earth resistivity data to three and more layers; Geophysics, 5, 1, 7-21, 1938.

The methods described in the references cited are founded upon theoretical and mathematical considerations, and have been found to be more reliable, on the whole, than any of the empirical methods that have been advanced. Furthermore, all of the above methods are based upon the theory of images and apply to two, three, or more layers.

Summary of the Results - Memphis, Tennessee

The electrical resistivity measurements at Memphis were taken east of the city limits and extending to Collierville. The resistivity line centers were usually located on commecting reads to U. S. Highway No. 72 at suitable places for making the depth profile measurements. These locations are shown on Figure 1 along with the locations of drill holes in the area. This area was chosen for the initial measurements because of the control available in the form of drill logs. However, it was known that there were extremely wide variations in the geological materials here.

Because of the proximity of city improvements, metal fences and metal fence posts, ground-return power lines, and buried telephone cables, considerable difficulty was experienced in the location of suitable places to make measurements. However, only one line was started that had to be abandoned because of interference. Experience has shown that resistivity results in or near cities may oftentimes be of somewhat questionable value

because of the interference from power distribution networks and buried conductors.

The main purpose of the resistivity observations near Memphis was to try to obtain correlation between the resistivity interpretations and the drill logs from the wells in the area. It is apparent from the map,

Figure 1, that it was not possible to locate the resistivity line centers near the drill holes and, as a result, the correlation is not very close.

A secondary purpose was to familiarize the staff of the Memphis Ground

Water Office with the techniques of laying out lines and taking observations.

The important water-bearing sand in this area was at a depth beyond the present facilities of the geophysical equipment; the restraining factor being lack of communication for the great spread of electrodes needed.

The interpretations from the apparent resistivity curves are compared to the drillers' logs in Figures 2, 3, 4, and 5. The number included with each material of the resistivity interpretations is the computed resistivity in 10³ ohm cms. The complete interpretations of the curves will be found in the following section, the apparent resistivity curves are in the next section, and this section is followed by the drillers' logs.

It is almost without exception that a good aquifer has a high resistivity. Using this fact as a basis for judgement, it is possible to classify the locations tested by the resistivity method. The best location is undoubtedly R.L. 13 below 315 ft. Second best is shared by two lines: R.L. 9, 15.5' - 260'; and R.L. 13, 148' - 250'. For shallow wells, there are three others that appear to be in this same category: R.L. 8, 16' - 66'; R.L. 10, 13' - 108'; and R.L. 13, 21' - 140'. The third best location is also shared by several tests: R.L. 10, 170' - 400'; R.L. 2, 212' - 500'; R.L. 6, 312' - 500'; and R.L. 2, 140' - 202'. A thin shallow

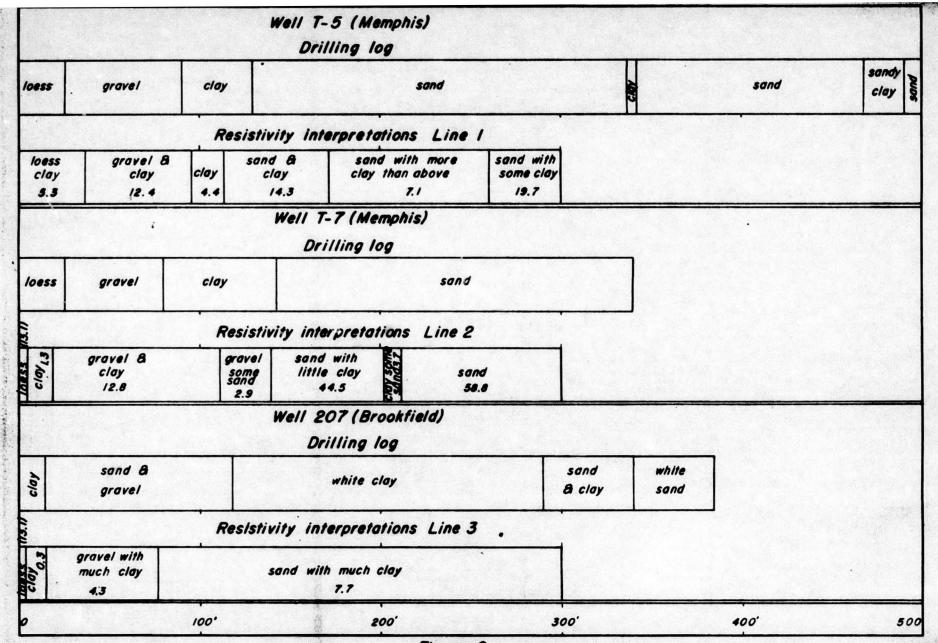


Figure 2
Comparison of drill logs and interpretations, Memphis
Resistivity in 10 ohm cms

			Well 168(Germantown) Drilling log					
	sand				blue clay	sand blue clay		
			ons Line 4	erpretati	sistivity into	Res		
			ualitative)		clay	sand & clay	gravel and clay	loess clay grave
			Well 168 (Germantown) Drilling log					
			end	coarse sa		blue clay	sand	
		Resistivity interpretations Line 5						
					clay		vel, large int of clay 8.6	gr
		av.		(Mempl	Well 1-3 Drill			
mucky sand hop clay sou	sand	clay	sand	clay	sand	clay	and and avei	6
		6	ations Line	nterpret	sistivity in	. Re		
ess clay than above 50.4	sand and clay 8.9				and sand h clay 14.1	with	cloy 1.6	
400' 500	300'		200'		0 100'			

Figure 3

Comparison of drill logs and interpretations, Memphis

Resistivity in 10⁸ ohm cms

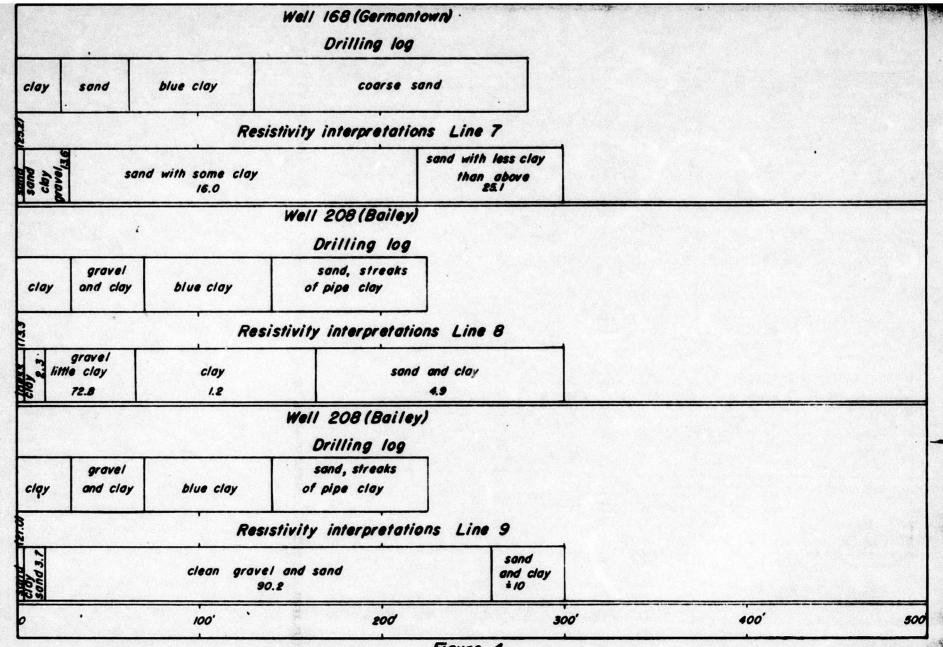


Figure 4
Comparison of drill logs and interpretations, Memphis
Resistivity in 10³ ohm cms

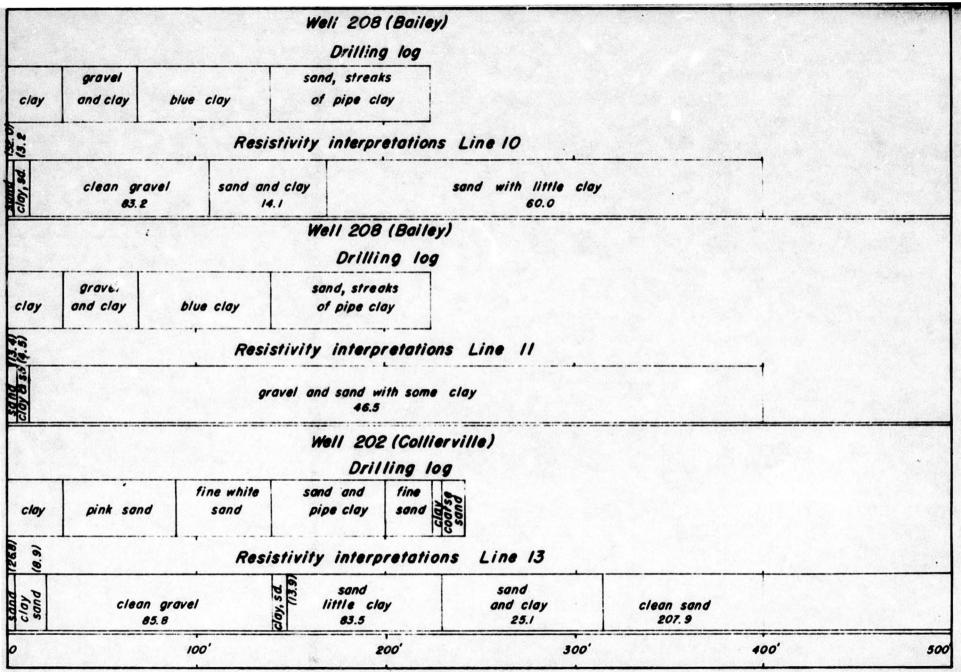


Figure 5
Comparison of drill logs and interpretations, Memphis
Resistivity in 10³ ohm cms

layer having similar properties is noted on R.L. 7, 14' - 29'. All of the remaining layers are considered to be poor possibilities for development as an aquifer, but it is entirely possible that some of them would yield a small amount of water. However, the quality would probably be poor.

A study of the curves and the graphical presentation of the interpretations shows that the best aquifers at depths of less than 400 ft. are to be found in the area near the city of Collierville. Seemingly, this zone begins about 4 to 5 miles west of the city of Collierville and extends generally eastward, but its extent was not determined beyond Collierville.

It should also be pointed out that the graphical presentation of the interpretations shows that the beds, insofar as their electrical characteristics are concerned, are discontinuous, and probably they are more or less lens-like or in the shape of tongues. Not enough work was done to ascertain the correctness of this postulate, but the drill logs and resistivity work indicate the very definite possibility that such is the condition in the upper few hundred feet.

Conclusion

The geophysical work done in the vicinity of Memphis, Tennessee, showe that it is possible to evaluate locations for drilling water wells, and to indicate the most favorable somes in which water will be found in the event drilling is to be performed. Thus, in practice, much time and money can be saved by investigating sites, using electrical resistivity methods, before drilling is started. Then, only the sites having favorable indications as determined by the geophysical survey would need be drilled.

Interpretations of the Apparent Resistivity Curves Memphis, Tenn.

Line 1.

Location: 0.2 mile B. of Getwell St. along S. side of Dunn St.

N. of test wells #5 and #6. P. - N. 85° B.

Blectrical depth profile:

0 - 37' loss and clay.

37' - 96' gravel and clay.

96' - 114' clay.

114' - 172' sand and clay.

172' - 261' sand with more clay than above.

261' - 300' sand with some clay.

Line 2.

Location: 0.2 mile N. of Willow Road along E. side of Mt. Moriah Road. E. of test well #7. P, - N. 20 W.

Electrical depth profile:

0 - 5' losss.

5' - 19' clay.

19' - 112' gravel and clay.

112' - 140' clay with some sand.

140' - 202' sand with little clay.

202' - 212' clay with some sand.

212' - 300' sand.

 \mathbf{P}_1 and \mathbf{P}_2 curves indicate considerable variation in materials on both ends of the profile.

Line 3.

Location: 1.25 miles S. of Park Road along W. side of Ridgeway Road. N.W. of well #207. P1 - N. 30 W.

Blectrical depth profile:

0 - 4' loss.

4' - 15' clay.

15' - 77' gravel with much clay.

77' - 500' sand with much clay.

Line 4.

Location: 0.45 mile W. of Houard Road on M. side of McVay Road.

8.W. of well \$168. P1 - N. 90° E., P2 - S. 88° W.

Blectrical depth profile: (Qualitative interpretation)

0 - 35' variable surface layers; loss, clay, gravel.

35' - 65' gravel and clay.

65' - 150' sand and clay.

150' - 200' clay.

Line 5.

Location: Along S. side of Germantown Road 1.15 miles N. of U.S.

Highway No. 72. N.E. of well #168. P1 - N. 10° E.

Electrical depth profile:

0 - 5' loss and sand.

5' - 10' olay.

10' - 81' gravel with large amount of clay.

81' - 200' clay.

Line 6.

Location: In Shelby County Penal Farm 0.15 mile W. of Germantown Road entrance. S. of well #1-3. P1 - N. 86° E.

Electrical depth profile:

0 - 4' losss, some sand.

4' - 17! clay.

17' - 138' gravel and sand with clay.

138' - 312' sand, clay.

512' - 500' sand with little clay.

Line 7.

Location: 0.2 mile N. of Cox Road on B. side of Callis cut-off.

S. of well #168. P, - M. 2º W.

Electrical depth profile:

0 - 4' sand and losss.

4' - 14' sand and olay.

14' - 29' gravel.

29' - 220' sand with some clay.

220' - 300' sand with less clay than above.

P2 curve indicates a much higher content of clay in 29' - 280' layer.

Line 8.

<u>Location</u>: Along W. side of Bobo Road O.2 mile N. of intersection with Winchester Road. W. of well #208. P_1 - N. 0° E.

Electrical depth profile:

0 - 4.4' loss and sand.

4.4' + 16' olay.

16' - 66' gravel, very little clay.

66' - 165' olay.

165' - 300' sand and clay.

Clay layer, 66' - 165' is shallower on P2 than on P1.

Line 9.

Location: 0.34 mile W. of Houston Levee Road along Winchester Road thence S. 0.1 mile in open field. S.W. of well #208. $P_1 - N. 7^{\circ}$ W. Electrical depth profile:

- 0 4' sand and losss.
- 4' 15.5' clay and sand.

15.5' -= 260' clean gravel and sand.

= 260' - 300' probably sand and clay.

Line 10.

Location: 0.32 mile N. of U.S. Highway 72 on W. side of Bailey Station Road, 90' S. of S.B.T. Co. pole #5. P_1 - N. 7° E. Blectrical depth profile:

- 0 4' sand and losss.
- 4' 13' clay and sand.

13' - 108' clean gravel.

108' - 170' sand and clay.

170' - 400' sand with little clay.

Line 11.

Location: 0.28 mile N. of U.S. Highway 72 along E. side of Bray Station Road. P1 - N. 30 W.

Electrical depth profile:

- 0 6' sand and losss.
- 6' 12' clay and sand.
- 12' 400' gravel and sand with some clay.

A metal road culvert distorted the electric field and the interpretations may be in error.

Line 12.

Location: Along W. side of State Highway 57. 0.4 mile E. of intersection with U.S. Highway 72. P1 - E.

Electrical depth profile:

Line abandoned because of some undetermined subsurface interference.

Line 13.

Location: 0.15 mile W. of Peterson Lake Road along S. side of White Road. P_1 - N. 88° E.

Electrical depth profile:

0 - 5' sand and losss.

5' - 21' clay and sand.

21' - 140' gravel, clean.

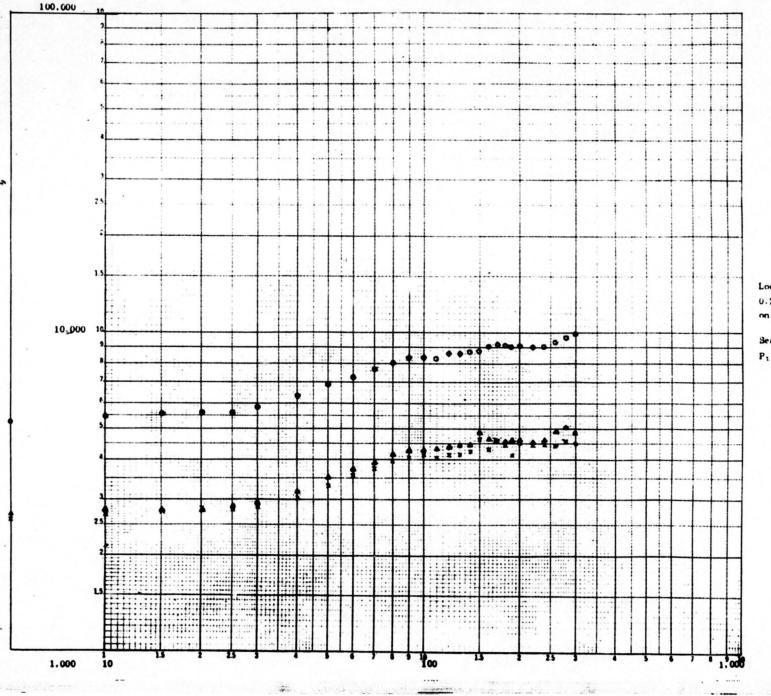
140' - 148' clay and sand.

148' - 230' sand, little clay.

250' - 315' sand and clay.

315' - 400' clean sand.

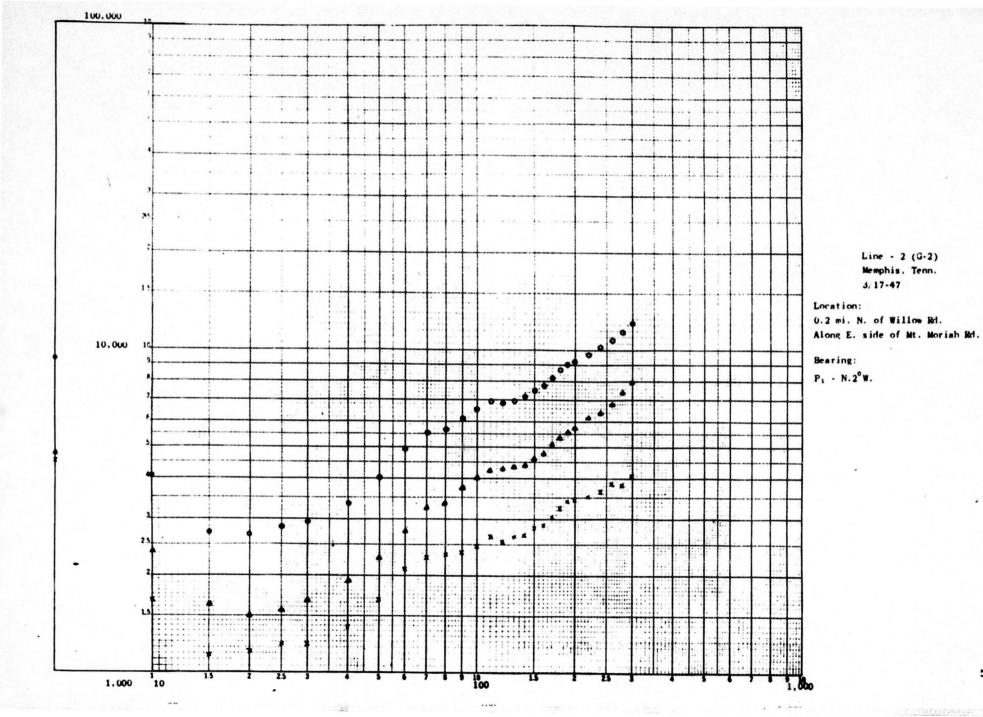
The P_1 curve indicates that the 315' - 400' sand layer is a better aquifer in this direction than in the P_2 direction.

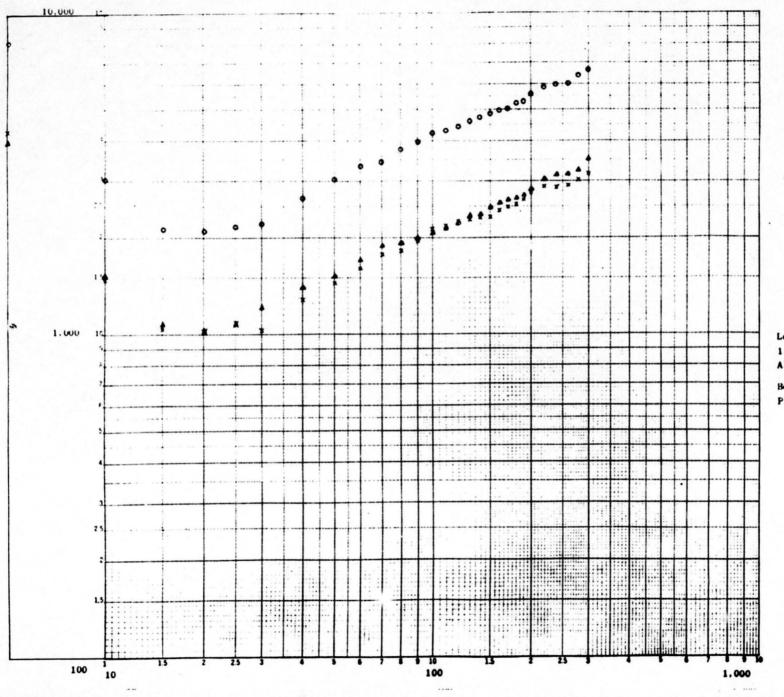


Line - 1 (G-2) Memphis, Tenn. 3 17-47

Location: 0.2 mi. E. of Getwell St on Dunn St. S. side.

Searing: P₁ - N.85 E.





Line - 3 (G-2) Memphis, Tenn. 3/17-47

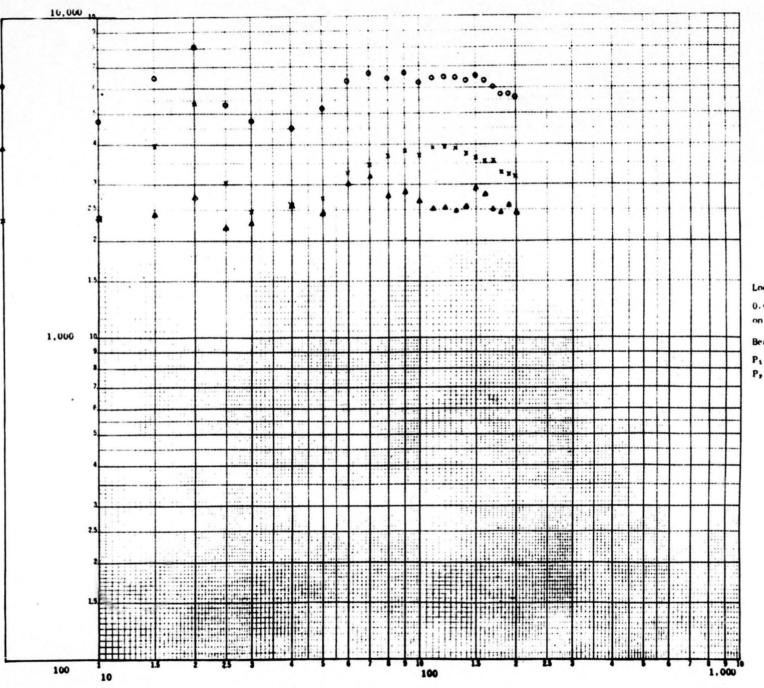
Location:

1.23 mi. S. of Park kd. Along W. side of Ridgeway Rd.

Bearing:

P. . N. 30 W.

=



Line - 4 (G-2) Memphis, Tenn. 3, 18-47

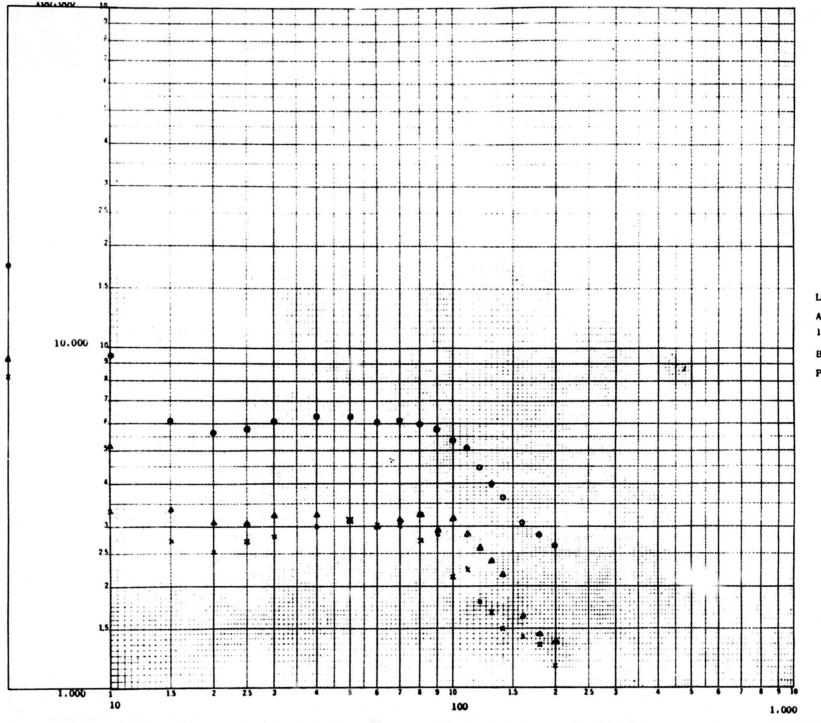
Location:

0.45 mi. W. of Howard Rd. on N. side of McUay.

Bearing:

P₁ - N90°E. P₂ - S88°W.

5



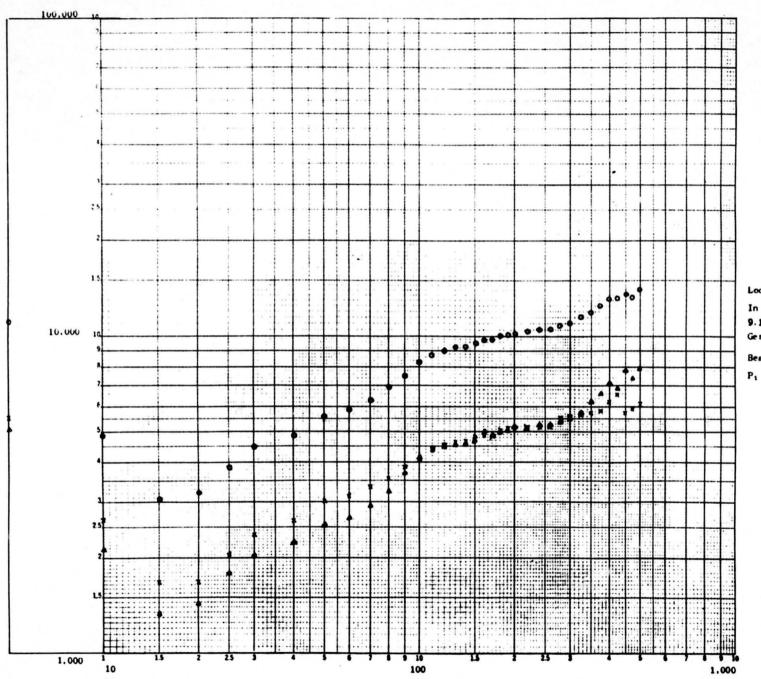
Line - 5 (G-2) Memphis, Tenn. 3.18-47

Location:

Along S. side of Germantown Rd. 1.15 mi. N. of U.S. Hiway No. 72.

Bearing:

P. - N. 10° E.



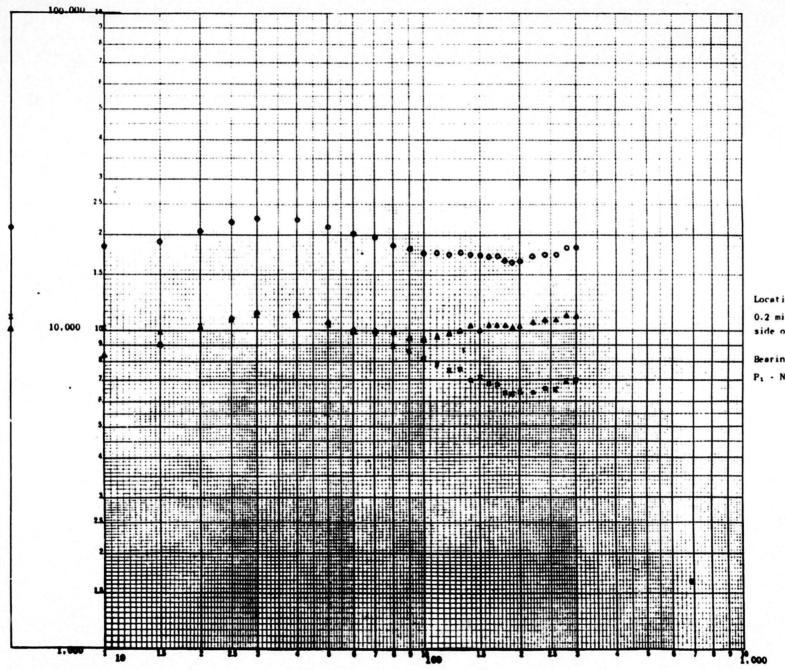
Line - 6 (G-2) Memphis, Tenn. 3-18-47

Location:

In Shelby County Penal Farm 9.15 mi. W. of entrance on Germantown Rd.

Bearing:

P1 - N. 86° E.



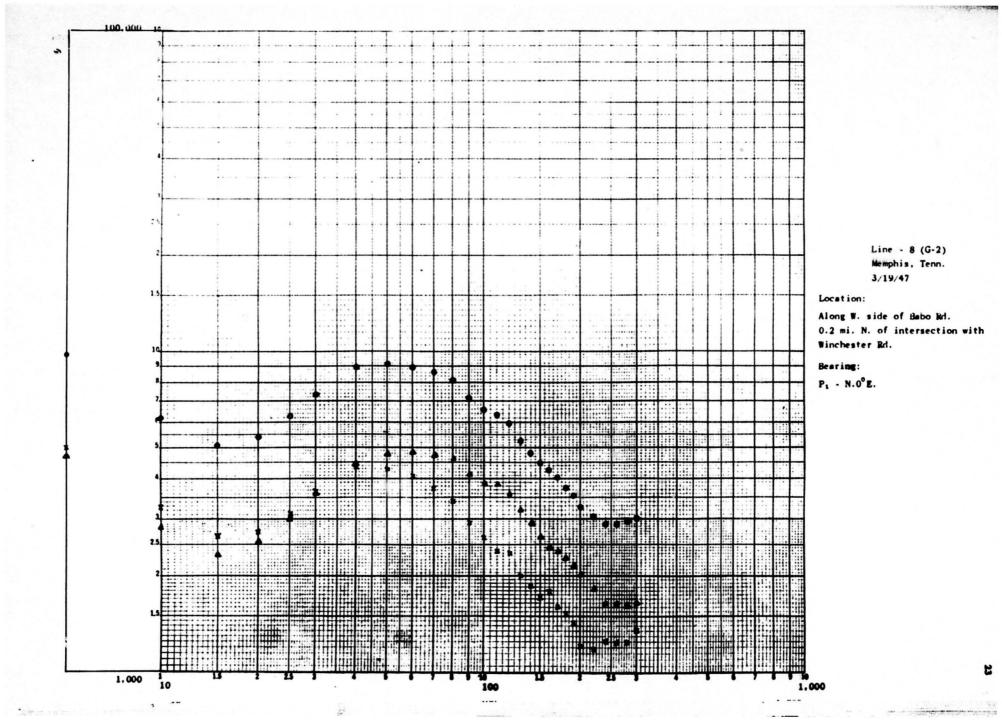
THE RESERVE

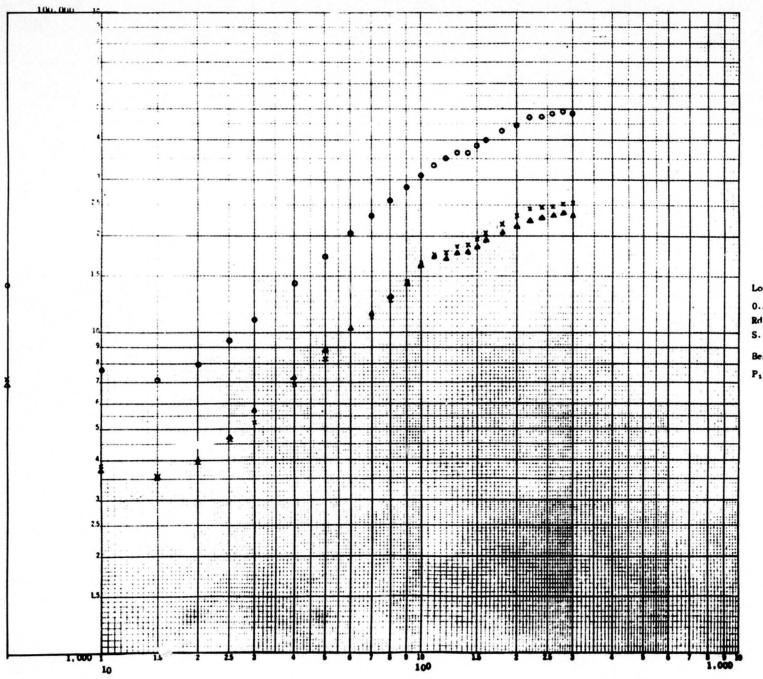
Line - 7 (G-2) Memphis, Tenn. 3-19-47

Location:

0.2 mi. N. of Cox Rd. on E. side of Callis cut off.

Bearing: P1 - N. 2° W.





Line - 9 (G-2) Memphis, Tenn. 3/19/47

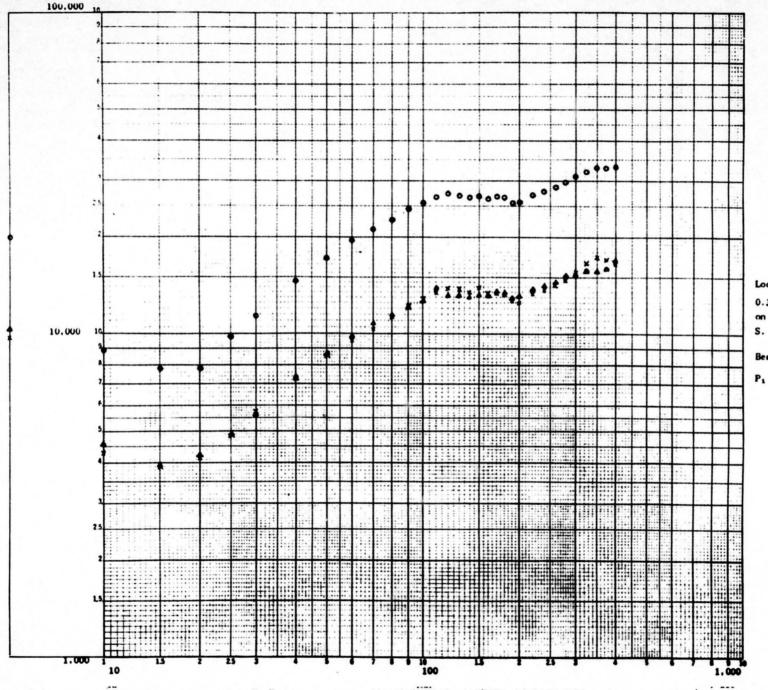
Location:

0.34 mi. W. of Houston. Levee Rd. along Winchester Rd. thence S. 0.1 mi. in open field.

Bearing:

P1 - N.7°W.

¥



Line - 10 (G-2) Memphis, Tenn. 3/20/47

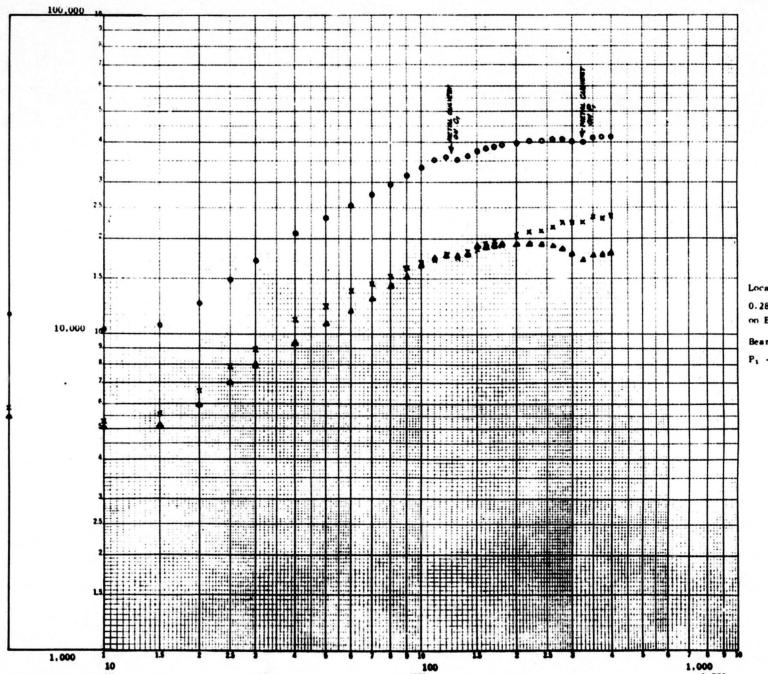
Location:

0.32 mi. N. of U.S. Hiway No. 72 on W. side of Bailey sta. Rd. 90' S. of S.B.T. Co. Pole No. 5.

Bearing:

P1 - N.7°E.

Z



Line - 11 (G-2) Memphis, Tenn. 3, 20, 47

Location:

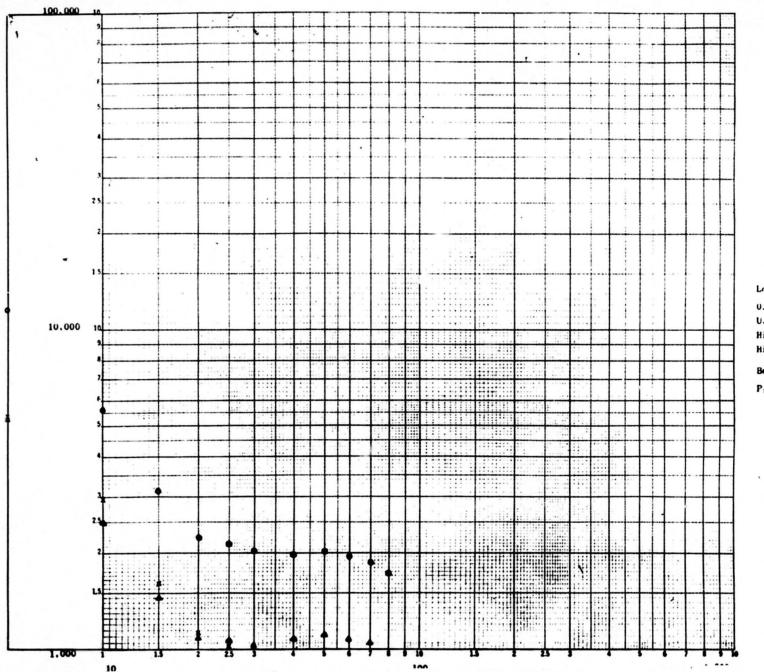
0.28 mi. N. of U.S. Hiway No. 72 on E. side of Bray Sta. Rd.

Bearing:

P1 - N.3 W.

.

8





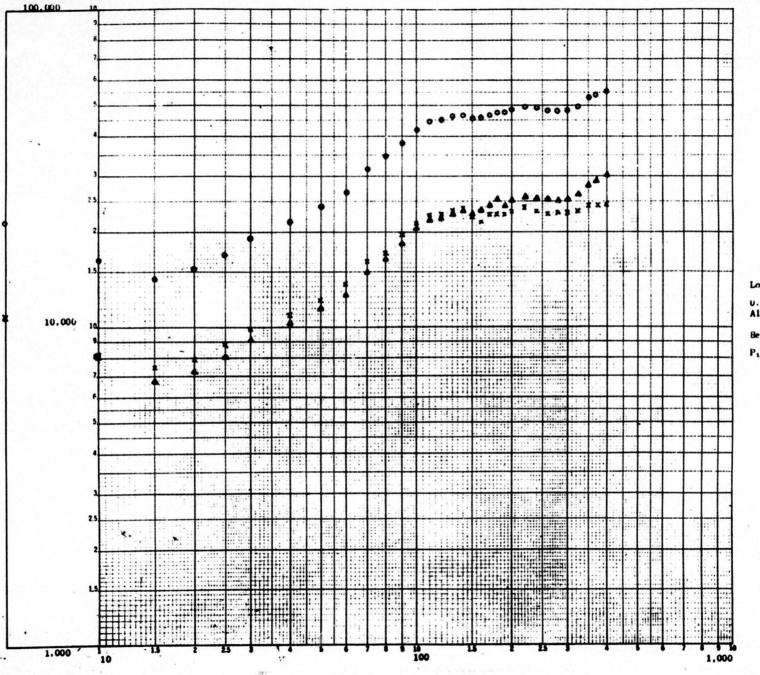
Line - 12 (G-2) Memphis, Tenn. 3,20,47

Location:

U.S. Hiway No. 72 and State Hiway No. 57 along N. side of Hiway No. 57.

Bearing:

P1 - approx. E.



Line - 13 (G-2) Memphis, Tenn. 3/21/47

Location:

U.15 mi. W. of Peterson Lake Rd. Along S. side of White Rd.

Bearing:

P. - N. 88° E.

Well logs

Near resistivity line 1, Memphis T-6, Driller's log

0 - 26' loess.

26' - 79' gravel.

79' - 135' clay.

135' - 272' sand; sandy clay 190' - 210'.

272' - 298' clay.

298' - 336' sand.

336' - 349' clay.

349' - 384' sand.

384' - 389' clay.

389' - 436' sandy clay.

436' - 452' clay.

452' - 475' clay; 3' of sand between layers.

475' - 524' sand.

524' - 540' lignite and clay.

540' - 777' sand; 20' sandy clay at 595'; streak of clay at 665'.

777' - 793' sandy clay.

793' - 813' sand.

813' - 847' lignite and sand.

847' - 860' sand.

860' - 871' lignite.

871' - 880' sand.

880' - 917' clay.

Near resistivity line 1, Memphis T-5, Driller's log

0 - 26' loss.

26' - 91' gravel.

91' - 130' clay.

130' - 337' sand.

337' - 342' olay.

342' - 468' sand.

468' - 490' sandy clay.

490' - 500' sand.

Near resistivity line 2, Memphis T-7, Driller's log

0 - 26' loss.

26' - 80' gravel.

80' - 143' clay.

143' - 340' sand.

Near resistivity line 3, Memphis 207, Driller's log

0 - 15' clay.

15' - 118' sand and gravel, some boulders.

118' - 290' white clay.

290' - 300' gravel and clay.

300' - 340' interstratified sand and clay.

340' - 385' white sand.

Near resistivity lines 4, 5 and 7, Memphis 168, Driller's log

0 - 25' clay.

25' - 63' sand.

63' - 131' blue clay.

131' - 281' coarse sand.

Near resistivity line 6, Memphis 1-3, Driller's log

0 - 15' olay.

15' - 45' sand and gravel.

45' - 120' clay.

120' - 185' sand.

185' - 210' clay.

210' - 258' sand.

258' - 348' clay.

348' - 400' sand.

400' - 440' mucky sand.

440' - 460' muddy sand.

460' - 492' brown clay.

492' - 493' rock.

493' - 507' clay.

507' - 580' sand.

Near resistivity lines 8, 9, 10 and 11, Memphis 208, Driller's log

0 - 30' clay.

30' - '70' gravel and clay.

70' - 140' blue clay.

140' - 225' sand, streaks of pipe clay.

Near resistivity line 13, Memphis 202, Driller's log

0 - 30' yellow clay.

30' - 90' pink sand.

90' - 140' fine white sand.

140' - 200' sand and pipe clay.

200' - 225' fine sand.

225' - 230' white clay.

230' - 242' good coarse sand.

T-3, Driller's log

0 -- 24' soil.

24' - 82' gravel.

82' - 185' clay,

185' - 204' sand.

204' - 255' clay; lower 20' sandy.

255' - 265' sand.

265' - 280' clay.

280' - 318' sand.

318' - 405' clay.

14 1

405' - 439' sand.

439' - 458' clay.

458' - 533' sand.

212, Driller's log

0 - 25' soil.

25' - 60' dry sand.

60' - 80' fine sand and clay.

80' - 150' blue clay.

150' - 300' blue quick sand.

300' - 450' sand and blue clay.

450' - 537' water sand.

40, Driller's log

0 - 8' red clay.

8' - 40' sand and gravel.

40' - 50' yellow clay.

50' - 116' blue clay.

116' - 142' clay with sandy streaks.

142' - 202' hard packed sand, water bearing.

202' - 232' white clay.

232' - 240' sand rock.

240' - 252' sand with clay streaks.

252' - 272' hard packed sand.

272' - 302' coarse water bearing sand.

302' - 352' sand; fine at bottom.

18' - 65' sand and gravel.

65' - 178' clay.

178' - 320' sand.

320' - 465' clay.

465' - 480' sand.

480' - 550' clay.

550' - 580' sand.

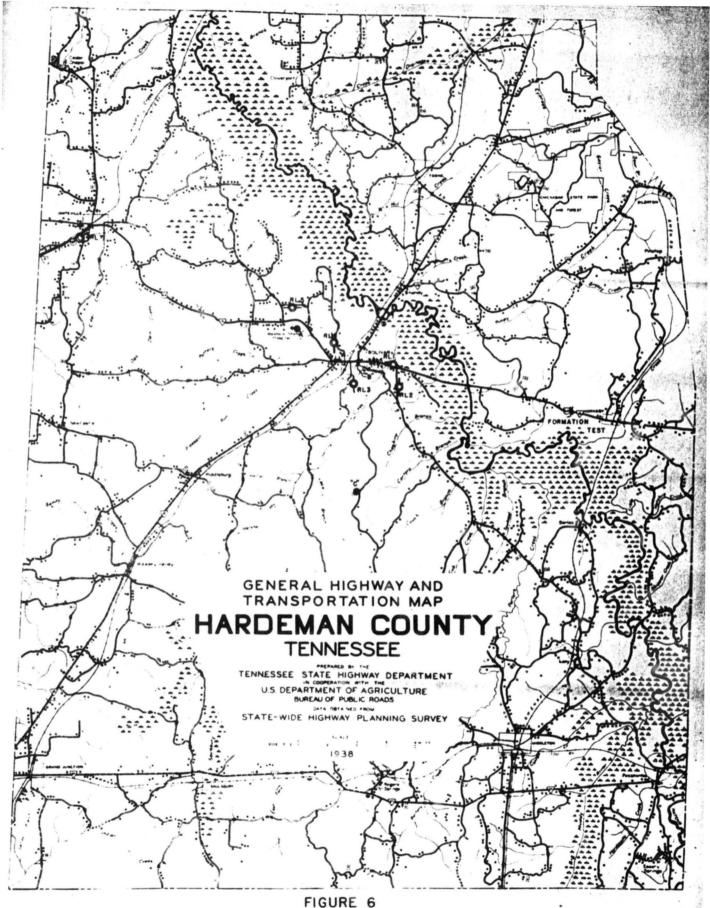
Summary of the Results - Bolivar, Tennessee

Before the depth-profile measurements were started in the Bolivar area, some preliminary work was done to ascertain the electrical characteristics of the particular formation to be studied. The Porter Creek creek outcomes a few miles east of Bolivar, and a particularly good exposure was found in a road-out about 7 miles east of the city limits. The blue clay of this formation has a low resistivity in both the dry and moist state. Tests on the moderately dry blue-clay of the exposure gave a resistivity of 810 ohm cms; while the moist in-place clay tested 150 to 160 ohm cms. In the geophysical measurements, then, it can be expected that this formation will be relatively uniform and can be identified by its inherently low resistivity.

The depth profile measurements taken in the vicinity of Bolivar, and in Hardeman County, are shown on Figure 6. The location of wells for which logs were available are also included on the map. The geophysical measurements extended to the west into Fayette County, and Figure 7 shows their location and the location of the wells in the county.

A single depth profile was completed to the east of the Porter's Creek formation outcrop. It was located just a few miles east of Selmer in McNairy County. This location is not shown on the figures, but is described in the interpretations.

The interpretations from the apparent resistivity curves are compared with the drill logs in Figures 8 and 9. As in the Eemphis area, locations had to be selected as free as possible from interference from power lines, conductors, etc.; consequently, the resistivity line centers



LOCATION OF RESISTIVITY LINES AND RELATED DRILL HOLES, BOLIVAR, TENNESSEE.

24 246 2

City of Bolivar "B" on map				
Drilling log, water well				
clay sand pups	shale cse.	too	ugh clay(soapstone)	
Resistivity interpretations Line I				
gravel los and clay clay 77.4	and sand			
Resistivity interpretations Line 2				
Sand, clean 110.0	clay 0.5			
Resistivity interpretations Line 3				
sond, loss clay clay clay	clay and shale 2.6			
0	200' 20	00' 30	0' 400	o' 50 <i>0</i>

Figure 8 Comparison of drill logs and interpretations, Bolivar Resistivity in 10³ ohm cms

are not close to drill holes. It is noted that the resulting geophysical interpretations do not closely correlate the drill log information. The resistivities in 10^3 ohm cms. are included on this figure with the interpretations.

In order to depict more clearly the top boundary of the Porter's Creek class formation as determined by resistivity methods, Figure 10 was prepared with each resistivity station indicated to scale, and also with respect to altitude. There are two possible interpretations given for R.L. 6; one is obtained from the depth obtained from the interpretations of the full curve, and the other from the P₂ curve. The three curves for this line shows that the top boundary of the Porter's Creek formation is much deeper below the surface to the sc theast of the center than to the northwest.

The thickest part of the formation then appears to lie northwest of the resistivity station. Because of the wide lateral spread of the resistivity lines from a straight line, no attempt has been made to project them on an east-west line.

Descriptive interpretations and resistivity curves will be found in the next succeeding sections, and these in turn are followed by well logs.

The resistivity depth profile east of Selmer shows no indication of the Porter's Creek formation if the same criterion is used here as elsewhere in this study. None of the materials to a depth of 400 ft. have a resistivity low enough to be considered similar. The log of a well near Selmer will be found in the section of well logs appended.

The interpretations reveal the possibility of several good water-well sites. They are listed in descending order of appraised value. R.L. 5, 295' - 445'; R.L. 7, 155' - 310'; R.L. 4, 185' - 435'; R.L. 7, 480' - 725'; R.L. 5, 15' - 165'; R.L. 6, 415' - 525'.

. 4

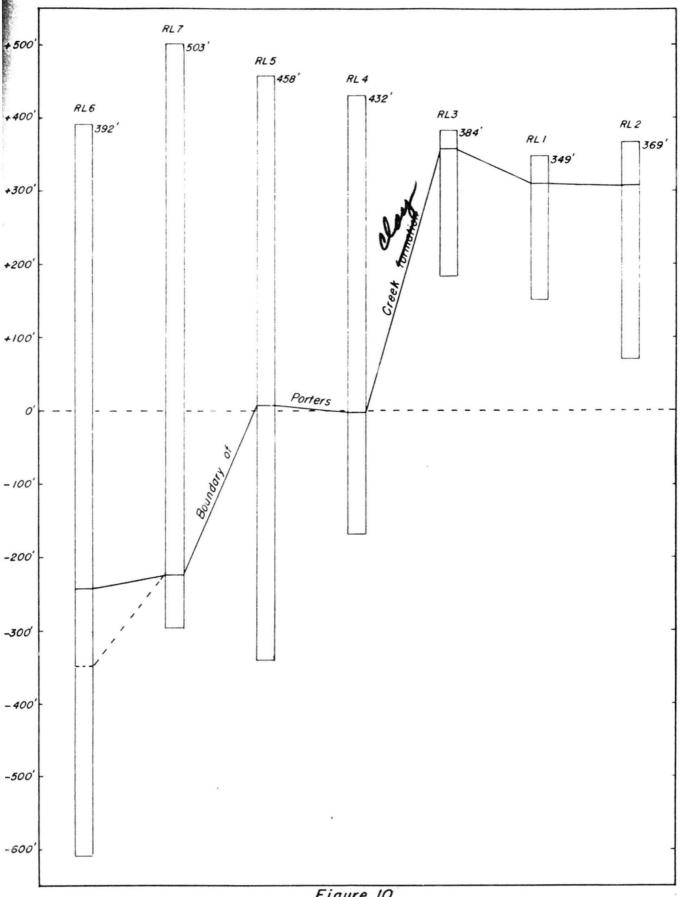


Figure 10
Porters Creek formation boundary as
determined by resistivity methods

Conclusion

It has been demonstrated that it is possible to trace a geological formation from the outcrop at the surface to a point where the formation is deeply buried by means of electrical resistivity techniques. However, in this general area when the formation under study reaches depths greater than 1,000 ft., there is some possibility that it will be more difficult to trace because of more clay layers appearing to the west. These clay materials also have a low resistivity and they conduct large amounts of electrical energy; consequently, much higher wattage will be necessary to reach these depths. Such high current is necessary in order to obtain sufficient potential drop across the electrodes so that it can be measured.

Interpretations of the Apparent Resistivity Curves Bolivar, Tenn.

Line 1.

<u>Location</u>: 0.3 mile E. of the center of the 2nd bridge E. of Bolivar along the N. side of Highway 64. P_1 - S. 57° E. Altitude - 349'. Electrical depth profile:

0 - 6.5' soil and silt.

6.5' - 8.5' clay and sand.

8.5' - 38' gravel and clay.

38' - 200' clay and sand.

Line 2.

Location: First side road S. after 2nd bridge E. of Bolivar, thence 0.6 mile S. of Highway 64 along E. side of road. $P_1 - N$. 10° E. Altitude - 369'.

Electrical depth profile:

0 - 4' soil and sand.

4' - 15.5' clay and sand.

15.5' - 62' sand, clean.

62' - 300' clay.

Line 3.

Location: 0.73 mile S. of Bolivar on S. Union Street, thence 200' N. of road in a field. P_1 - S. 40° E. Altitude - 384'.

Electrical depth profile:

0 - 13' soil and sand.

13' - 26' sand and clay.

26' - 44' clay.

. 4

44' - 300' clay and shale.

Line 4.

Location: 0.9 mile N. of Highway 64 on W. side of road along western city limits boundary. P₁ - N. 0° E. Altitude - 432'. Restricted depth profile:

0 - 11' soil and sand.

11' - 185' sand, little clay.

185' - 435' sand, clean.

435' - 600' clay.

Clay layer is steeply tilted; N. end about 480', S. end about 490'.
Line 5.

Location: W. of Bolivar on Highway 64, N. along first road W. of State Hospital 0.5 mile, thence 0.32 mile E. along S. side of road in edge of field. P_1 - N. 90° E. Altitude - 458'.

Electrical depth profile:

0 - 13.5' soil and sand.

13.5' - 165' sand, little clay.

165' - 295' sand and clay.

295' - 445' sand, clean,

445' - 800' clay.

Line 6.

Location: 2.1 miles N. of Highway 76 at Lacona, thence 0.08 mile W. and 250' S. in a pasture; 50' E. of stream. P₁ - N. 17° W. Altitude - 392'.

Electrical depth profile:

0 - 7.5' soil and sand.

7.5' - 15' sand and clay.

15' - 21' clay.

21' - 385' sand, some clay.

385' - 415' clay and sand.

415' - 525' sand, little clay.

525' - 1000' olay and sand.

Another sand or gravel layer is apparent on the P_2 curve at approximately 675' - 750' with clay below that. The layer is not continuous and does not appear on the P_1 curve. Average depth to Porter's Creek clay 633'.

Line 7.

Location: 0.5 mile W. of railroad station in Whiteville along S. side of Highway 64. $P_1 = N.60^{\circ}$ E. Altitude = 502'.

Electrical depth profile:

0 - 18.5' soil and sand.

18.5' - 155' sand, little clay.

155' - 310' sand, clean.

310' - 480' clay and sand.

480' - 725' sand, clean.

725' - 800' clay.

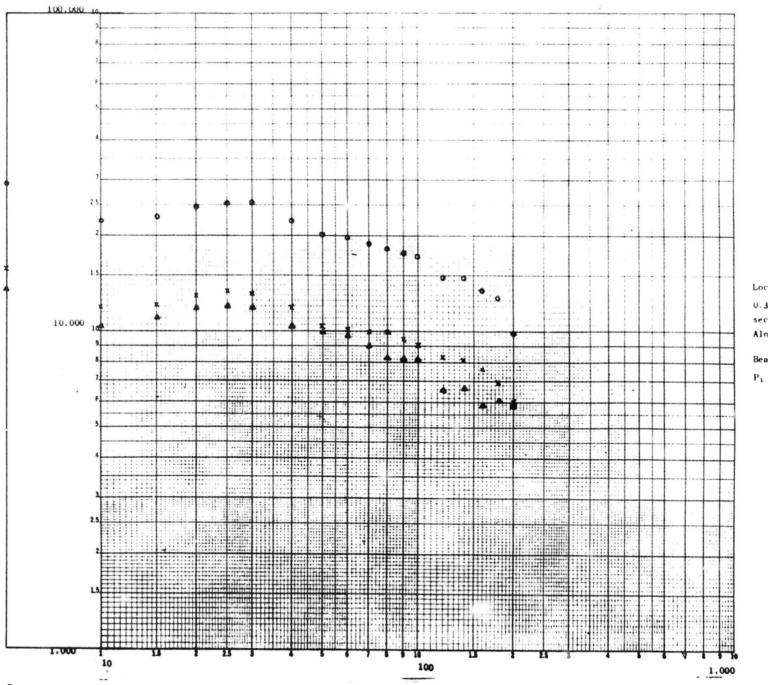
Line 8.

Location: 3.3 miles E. of Selmer Court House on Highway 64 and 0.3 mile S. on dirt road, thence W. in pasture about 200'. P₁ - N. 28° W. Elevation 489'.

. 4

Electrical depth profile:

- 0 4' soil and silt.
- 4' 17' clay and sand.
- 17' 41' sand and clay.
- 41' 145' clay with little sand.
- 145' 400' sand and clay.



Line 1 (G-2) Bolivar, Tenn. 3-25-47

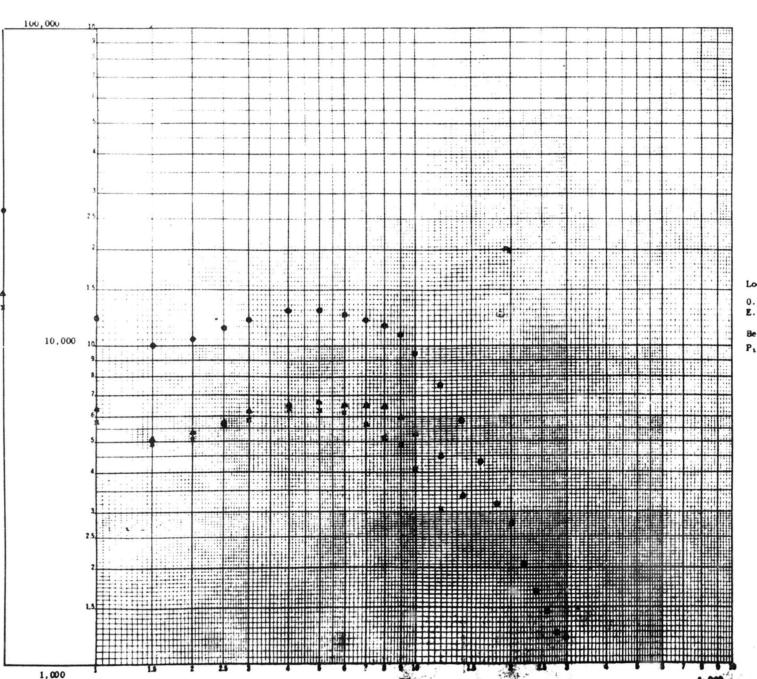
Location:

0.3 mi. E. of the center of the second Bridge E. of Bolivar.
Along N. side of Hiway 64.

Bearing:

P1 - S. 75 E.

47



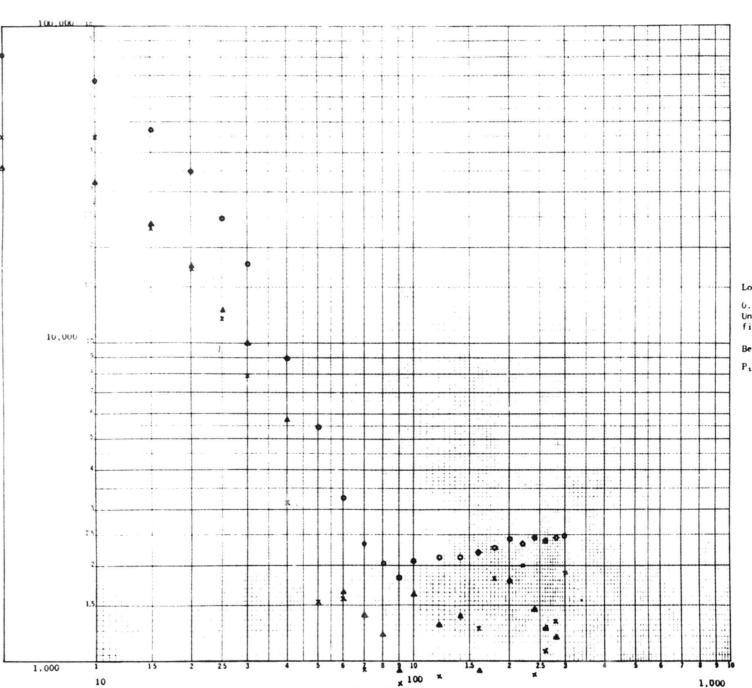
Line 2 (G-2) Boliver, Tenn. 3-25-47

Location:

0.6 mi. S. on First side Rd. E. of Bolivar on E. side of Rd.

Bearing:

P1 - N. 100 E.



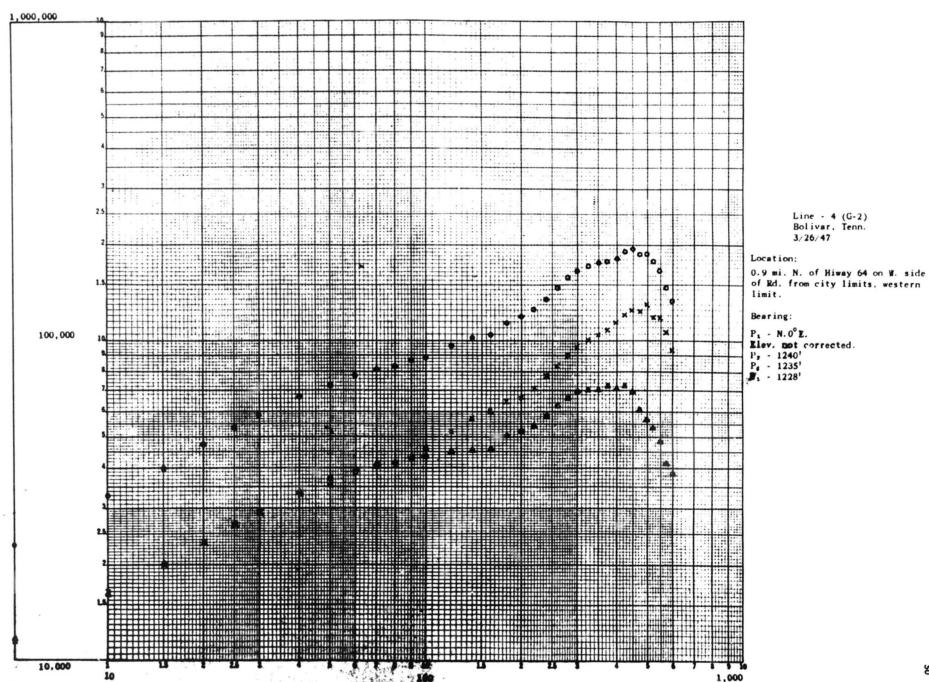
Line - 3 (G-2) Bolivar, Tenn. 3/25/47

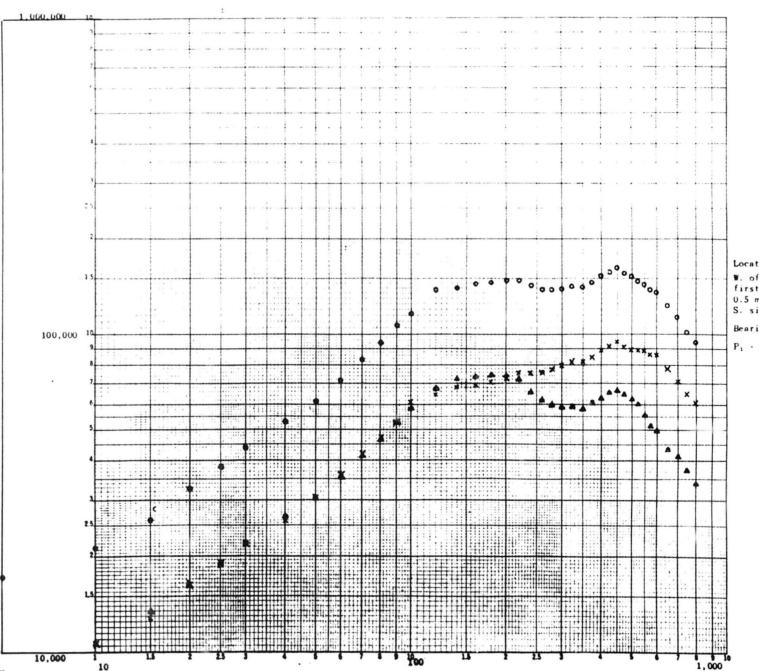
Location:

0.73 mi. S. of Bolivar on S. Union St. 200'N. of Rd. in a field 20' S. of a small stream.

Bearing:

P. - S. 40°E.





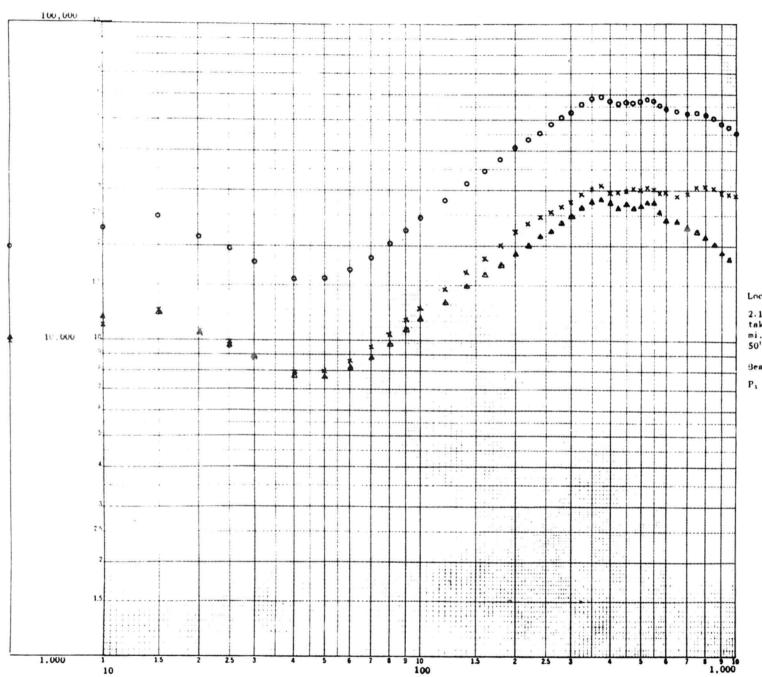
Line - 5 (G-2) Bolivar. Tenn. 3 26 47

Location:

W. of Bolivar on Hiway 64, N. on first road W. of State Hospital 0.5 mi., thence 0.32 mi. E. along S. side of Rd. in edge of field.

Bearing:

P. . N. 90°E



3

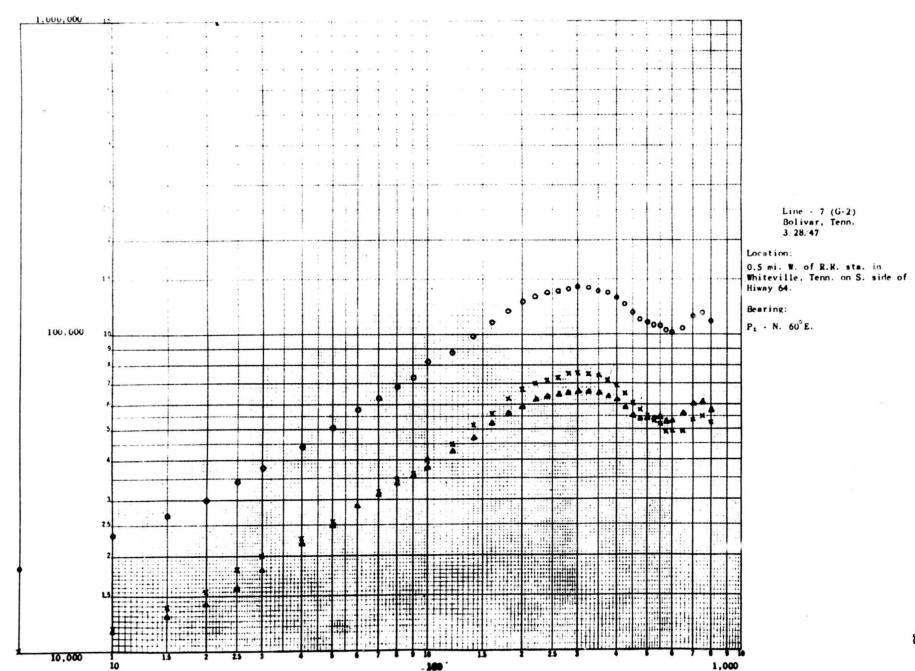
Line - 6 (G-2) Bolivar, Tenn. 3-27-47

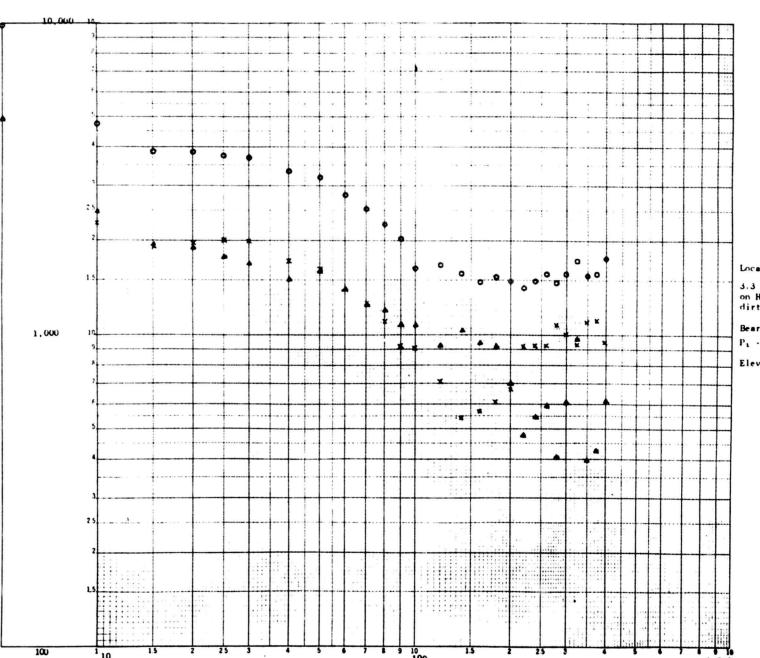
Location:

2.1 mi. N. of Locone (Distance taken from Hiway 76) thence 0.08 mi. W. in a pasture, then 250' S. 50' E. of stream.

Bearing:

P1 - N.17°W.





Line - 8 (G-2) Bolivar, Tenn. 3/28/47

Location:

3.3 mi. W. of Selmer Court House on Hiway 64, thence 0.3 mi. S on dirt kd. thence W. in pasture 200'

Bearing:

P1 - N. 28° W.

Elev. 489'

"A" on map

Well 4, Western State Hospital From samples, by F. G. Wells. Water Supply Paper 656.

- 0 10' clay loam.
- 10' 20' medium grained quartz sand, water bearing.
- 20' 30' slightly finer red quartz sand, water bearing.
- 30' 40' medium grained white quartz sand, water bearing.
- 40' 65' coarse white sand, water bearing.
- 65' 90' very coarse white sand, water bearing.
- 90' 100' medium grained white sand, water bearing.
- 100' 108' coarse white sand with pebbles, water bearing.
- 108' 120' very fine white sand grading into play, some muscovite, water bearing.
- 120' 150' slightly finer sand, water bearing.
- 150' 172' brown micaceous sandy clay.
- 172' 207' dove-gray clay.
- 207' 232' fine grained yellowish sand, water bearing.
- 232' 256' fi grained white sand, water bearing.
- 256' 316' dirty gray medium grained sand, water bearing.
- 316' 545' dark gray clay (Porter)s Creek clay).
- 545' 550' medium grained salt and pepper sand, water bearing.
- 550' 615' gray speckled argillaceous sand, water bearing.
- 615' 654' salt and pepper medium grained argillaceous sand streaked with brown, water bearing.

"B" on map

City of Bolivar water well, driller's log.

- 0 20' red clay.
- 20' 60' sand and clay.
- 60' 75' sand.
- 75' 80' pipe clay.
- 80' 175' shale.
- 175' 195' coarse salt and pepper sand.
- 195' 495' tough clay (soapstone).

"C" on map

Spring Creek Development Company
Hardemann County, Tenn. Water Supply Paper 656.

- 0 2' soil, sandy loam (Holly Springs sand).
- 2' 16' soapstone (Porter's Creek clay).
- 16' 22' quicksand.
- 22' 104' soft gray lime.
- 104' 120' sand, green, water.
- 120' 129' sandstone, soft, blue.
- 129' 146' lime, soft, blue (Clayton formation).
- 146' 250' lime, soft, gray.
- 250' 260' gray sandy marl (Owl Creek tongue).
- 260' 311' shale, black, hard.
- 311' 370' sand, salt and pepper, water.
- 370' 412' shale, black, hard.
- 412' 418' sand, coarse, brown, shells.

418' - 434' marl, sandy, gray (McNairy sand member)
434' - 450' sand, brown. water

(Log continues to 1,340' but is not of importance to the interpretation of the resistivity curves.)

"D" on map

Hey-Fey Oil and Gas Company, Bailey Morrison No. 1.

0 - 250' surface clay and sand.

250' - 300' sand and gravel.

300' - 460' hard sand.

460' - 475' gumbo.

475' - 545' tough gumbo.

545' - 656' sand and gumbo.

656' - 700' sand.

700' - 750' hard gumbo.

750' - 800' black gumbo.

800' - 820' gummy shale.

820' - 822' coarse black shale

822' - 862' rock.

862' - 890' hard black shale.

890' - 892' packed sand.

892' - 924' sand rock.

924' - 1364' tough black gumbo.

1064' - 1124' hard sand.

(Log continues to 1765' but is not of importance to the interpretation of the resistivity curves.)

"E" on map

Anderson and Kerr Drilling Company, P. P. Beasley No. 1-B.

0 - 300' surface.

300' - 394' sand, shells.

394' - 473' sandy shale.

473' - 474' iron rock.

474' - 516' sandy shale.

516' - 762' shale.

762' - 770' hard sand.

770' - 785' sandy shale.

785' - 830' sand and shells.

830' - 940' hard sand.

940' - 960' sandy shale.

960' - 1049' hard sand.

1049' - 1094' shale.

1094' - 1096' sand, lime, hard.

1096' - 1128' white sand.

1128' - 1150' clay and sand.

1150' - 1265' white sand.

1265' - 1275' hard sand.

1275' - 1390' sandy shale.

1390' - 1440' sand.

1440' - 1450' clay.

1450' - 1480' sand, clay.

1480' - 1492' sand.

1492' - 1643' sticky clay.

E' on map

Anderson and Kerr Drilling Company, P. P. Beasley No. 1-A

0 - 107' surface.

107' - 378' sand.

378' - 618' clay and shells.

618' - 930' shale and shells.

930' - 940' hard lime.

940' - 960' broken lime and sand.

960' - 1099' shale and shells.

1099' - 1311' shale and sand.

1311' - 1370' sand.

1370' - 1458' black shale and shells.

1458' - 1485' shale and gumbo.

1485' - 1507' black shale.

1507' - 1540' gumbo.

"F" on map

M. J. Kissick et al., J. B. Claxton No. 1.

0 - 15' soft reddish clay.

15' - 200' sand and gravel.

200' - 483' fine water sand and gravel.

483' - 505' blue clay.

505' - 650' sandy shale.

650' - 665' gumbo, blue, hard.

665' - 750' sandy shale.

750' - 850' sandy shale, streaks of gumbo.

. 4

850' - 1125' blue sandy shale.

1125' - 1200' gumbo, blue, hard.

1200' - 1245' hard blue shale.

1245' - 1252' hard packed sand, show of gas.

1252' - 1325' sandy shale.

1725' - 1328' hard rock.

1328' - 1450' sandy shale.

1450' - 1454' hard rock.

1454' - 1475' shale and boulders.

1475' - 1478' hard rock.

1478' - 1600' soft blue shale.

Selmer Ice Company water well. Selmer, Tenn. Water Supply Paper 656.

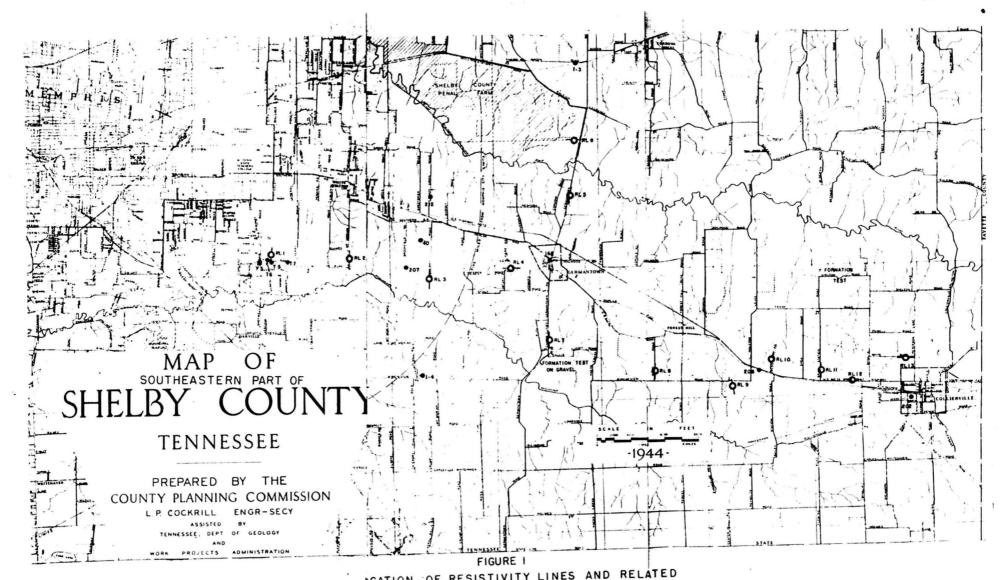
0 - 10' soil.

10' - 60' sand, water bearing.

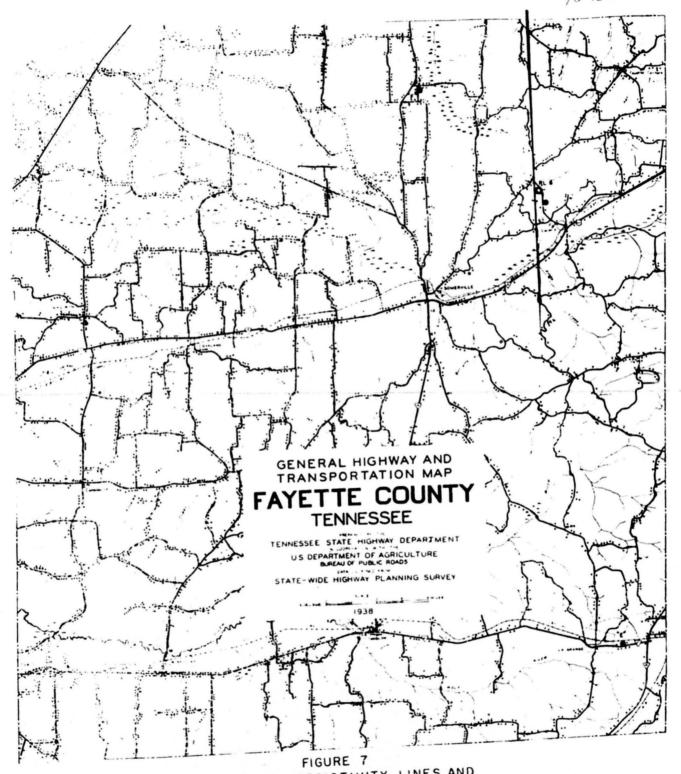
60' - 90' sandy clay.

90' - 390' clay containing shells.

390' - 400' sand, water bearing.



DRILL HOLES, MEMPHIS, TENNESSEE.



RELATED DRILL HOLES, BOLIVAR.

Figure 9

Comparison of drill logs and interpretations, Bolivar Resistivity in 10³ ohm cms