UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

AN EXPERIMENTAL GROUND-MAGNETIC AND VLF-EM TRAVERSE OVER A BURIED PALEOCHANNEL NEAR SALISBURY, MARYLAND

by

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This report is preliminary and has not been edited and reviewed for conformity with U.S. Geological Survey standards and nomenclature.

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Introduction

Since, 1963, the Maryland Geological Survey and the U.S. Geological Survey have been engaged in a study of the Pleistocene Series beneath a 230 square kilometer area around Salisbury, Maryland. (Hansen, 1966; Weigle, 1972; Zohdy and others, 1974, p.56) North of Salisbury a deep Pleistocene paleochannel was discovered; this channel was carved into an erosional plain at the top of the Miocene deposits, was filled and blanketed subsequently with deposits (mostly sand and gravel) of pleistocene age. The channel is a prolific source of ground water, and has been outlined for a least 15 kilometers by means of power-augering and gamma-logging.

A geophysical survey using ground magnetics and VLF-EM was made over the channel in an attempt to see if a more efficient method than augering could be developed to map the paleochannel at depth; the survey traverse was made over one of the better defined parts of the paleochannel (see figure 1.) where airborne magnetics and VLF studies could easily be done as a potential follow-up. We hoped to be able to map resistivity changes between aquifer and aquiclude facies with the VLF-EM, and perhaps identify other facies changes in black-sand concentrations with ground magnetics. The data is presented in Table 1 and plotted in figure 2. The traverse extended from north to south, with station spacing of 100 meters, for an over all length of 4.5 kilometers.

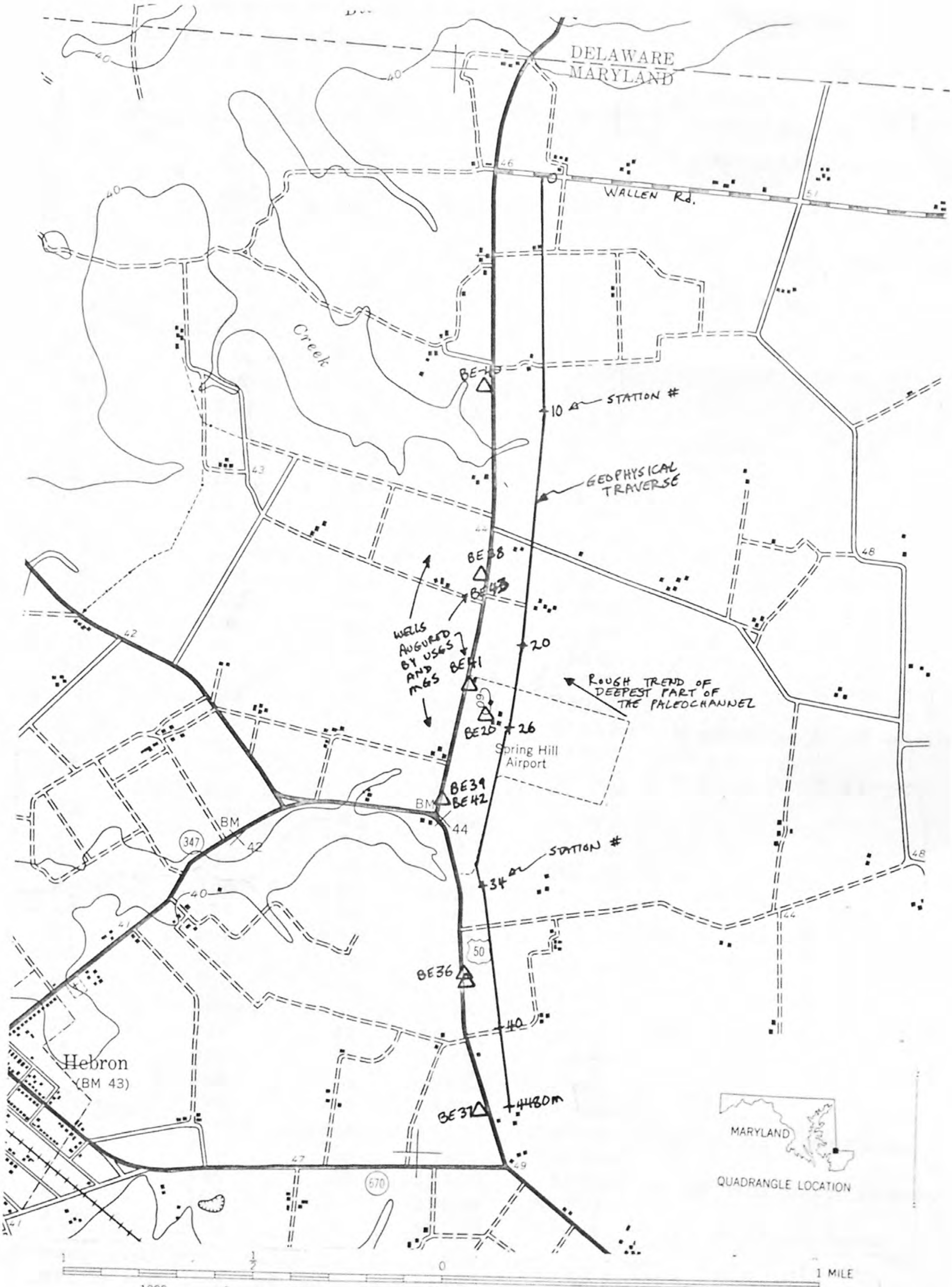


Figure 1.

1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Table 1.

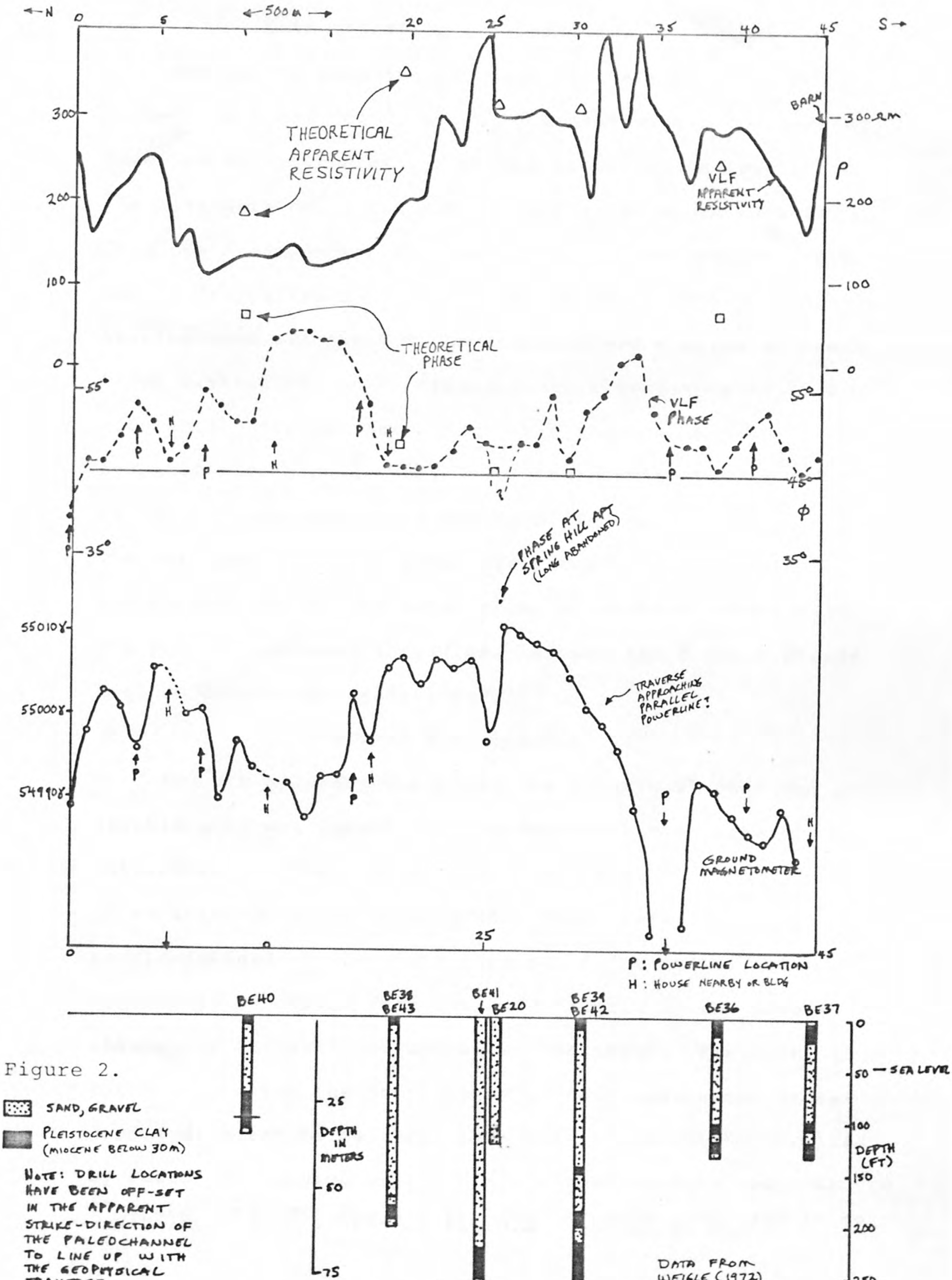
VLF-EM and ground magnetometer surveys of a Paleochannel near Salisbury Maryland, 12 December 1978 (USGS).

Station	Apparent+ Resistivty	VLF# Phase	Ground Mag Data Orig*	Corrected	Location/Culture
0 N	250	38	19952	54989	Powerline/Wallen Rd.
1	160	45	19965	54998	
2	200	45	19971	55003	
3	220	48	19953	55001	
4	250	52	19922	54996	100' s. of powerline
5	250	50	19954	55006	
6	140	45	19690	54939?	near bldg on lawn
7	160	47	19938	55000	
8	110	54	19933	55001	30' s. of powerline
9	130	53	19893	54990	
10	130	50	19919	54997	
11	130	50	19910	54994	
12	130	60	19830	54972	Ditch at 1291M
13	150	61	19896	54992	
14	120	61	19871	54988	
15	120	60	19883	54993	
16	130	60	19889	54993	
17	powerline	noise	19883	55003	50' n. of Little Lane 50' s. of powerline
18	140	52	19855	54997	
19	180	45	19893	55006	
20	200	45	19898	55007	
21	200	45	19886	55004	
22	300	45	19898	55007	
23	260	47	19895	55006	
24	350	50	19896	55007	N. edge neck of woods
25	300	48	19842	54997	
26	300	29	19893	55011	spring hill airpt
27	300	48	19883	55010	
28	310	48	19881	55009	
29	290	54	19873	55008	
30	290	46	19859	55005	
31	200	52	19855	55001	
32	400	54	19847	54999	
33	290	58	19853	54996	
34	400	59	19835	54989	middle of woods
35	300	52	19773	54974	in Edgewood park
36	powerline	noise	19483?	54901?	40' n. of Logcabin rd.
37	220	48	19782	54975	
38	290	48	19853	54992	
39	280	45	19853	54991	
40	290	48	19854	54988	
41	powerline	noise	19856	54986	20' n. of powerline
42	230	52	19850	54985	
43	210	48	19862	54989	e. of old bldg found.
44	160	45	19854	54983	
4480 S	290	47	19242	54829	old chicken barn

Survey conducted along east side of Spring Hill Lane (old 50), station spacing 100 meters going south from Wallen Rd.

+ Apparent resistivity in Ohm-meters; #VLF phase in degrees E-H

* Orig mag on ¼-gamma scale, corrected using observatory drifts. Corrected mag in gammas. Survey on USGS Hebron Quadrangle.



← N
S →
500 m
THEORETICAL APPARENT RESISTIVITY
VLF APPARENT RESISTIVITY
BARN
300 Ωm
ρ
THEORETICAL PHASE
VLF PHASE
φ
55°
45°
35°
PHASE AT SPRING HILL APT (LONG ABANDONED)
TRAVERSE APPROACHING PARALLEL POWERLINE?
GROUND MAGNETOMETER
55010γ
55000γ
54990γ
P : POWERLINE LOCATION
H : HOUSE NEARBY OR BLDG
BE40
BE38 BE43
BE41
BE20
BE39 BE42
BE36
BE37
DEPTH IN METERS
DEPTH (FT)
SEA LEVEL
SAND, GRAVEL
PLEISTOCENE CLAY (MIOCENE BELOW 30 m)
NOTE: DRILL LOCATIONS HAVE BEEN OFF-SET IN THE APPARENT STRIKE-DIRECTION OF THE PALEOCHANNEL TO LINE UP WITH THE GEOPHYSICAL TRAVERSE.
DATA FROM WEIGLE (1972)

Figure 2.

Data gathering and reduction

The ground magnetometer used in the survey was a Geometrics model G816[1.] with ¼-γ sensitivity. The sensing head was maintained at 2.5 meters above ground level, and the data were corrected for diurnal drift using records from the Fredricksburg, Virginia magnetic observatory.* The VLF-EM device was a Geonics model EM16R[1.]. The transmitting station used was the U.S. Navy-maintained station at Jim Creek Washington, which transmits at a frequency of 18.6 kilohertz. Dip and quadrature were recorded but are not reported here because they do not respond to the edges of the paleochannel (they did identify the powerlines). The VLF apparent resistivity was recorded directly in ohm-meters, using a 10-meter probe separation, along with the phase-difference in degrees between the E and H fields used to obtain the resistivies.

Analysis and comments

The VLF apparent resistivities (Figure 2) show considerable scatter, largely independent of human cultural interference. There is a broad high ranging from station 20 or thereabouts to station 44. This resistive high is poorly-defined on the south because of the noise, and appears to be offset from the known limits of the paleochannel by at least 500 meters to the south. The noise in the data exceeds the uncertainty of the measurement procedure (estimated to be about 10%) and is probably controlled by resistive inhomogeneities in the near surface, such as

1\. Brand-names are for descriptive purposes only, and in no way imply endorsement by the U.S. Geological Survey.

lenses of different permeabilities related to depositional history.

The VLF phase data indicate a consistently higher resistivity for the surface layer, (a phase angle of greater than 45° implies a more conductive second layer) and also shows some partial sensitivity to the presence of power-lines, especially on the northern part of the line. The depth to the more conductive second layer can be estimated using nomograms provided by the manufacturer (Geonics, undated). Using the nomograms, and few stations with the phase=45° data, it is possible to derive soundings at several stations along the traverse. With VLF data, one must assume one parameter in order to make a complete interpretation. This can be done by taking the apparent resistivity for phase=45° stations (homogeneous earth), and then using that value for upper-layer true resistivity of nearby stations. Because of the powerlines and other types of interference, only four soundings could be interpreted with any degree of confidence, and are given in table 2.

Table 2.

Station Number	Upper layer Resistivity	Lower layer Resistivity	Depth in Meters *
12	200Ω-m	20Ω-m	22
20	200Ω-m	-----	(55)
28	300Ω-m	200Ω-m	40
39	280Ω-m	-----	(65)

*Depth in meters to the interface for two-layer case, (or depth of effective penetration for a homogeneous case)

The VLF-EM data from table 2 appear to roughly follow the results of the auger-hole logs, except that the end of the paleochannel cannot be resolved on the south. Points are added to figure 2 for comparison to show theore tical calculations for the geometry seen in the auger profiles at the bottom of the figure for an upper-layer resistivity of 300 and a lower-layer resistivity of 20 ohm-meters. These generally show good agreement with the data except at drill hole BE-40. The noise makes it almost impossible to say more about the channel, and lack of auger-holes anywhere else nearby prevents any further immediate efforts to use the VLF in a meaningful way here.

The ground magnetometer was also influenced by noise, especially by powerlines. Most of the data fit within a 20-gamma envelope, when noise-spikes are disregarded, and weakly imply a ten-to-fifteen gamma magnetic high over the paleochannel (see figure 2). Given the powerline density in the area, it is questionable whether an airborne magnetometer could observe this anomaly at 100 meter elevation flightlines. The interference of the powerline along the Spring Hill Lane and at station 36 is especially impressive.

The usefulness of the magnetic and VLF-EM geophysical methods has been only imperfectly demonstrated in this survey. The electrical property contrasts between the paleochannel and the uncut Miocene sediments are apparently not large, and the problems caused by powerlines, houses, and unknown lenses of different materials in the Pleistocene channel-fill may preclude attempts to use airborne devices with any effectiveness. These results do not seem to warrant mobilization of an aircraft to the area. However, if other work were being done nearby, I would recommend that several lines be flown across the strike of the paleochannel. Cross-correlation between lines after an initial few passes might show that another several days' work could map effectively a large area, provided artificial conductors are avoided as much as possible in choosing the flightlines. Further ground magnetic or VLF-EM work does not appear to be warrented because of the tendency of the auger-holes (the check on veracity) to be located along roads where powerlines exist. An alternative approach remains, and that is to experiment with shallow seismic refraction methods to define the sand and gravels. This method is more cumbersome to use, and cannot be used from the air, but nevertheless is not normally affected by powerlines.

Acknowledgements

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