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TECHNICAL NOTE TN-23

COMPARISON OF GEOELECTRIC SECTIONS OBTAINED ACROSS A FAULT WITH EM39 BOREHOLE INDUCTION LOGGER AND TEM47 TIME-DOMAIN SYSTEM IN CENTRAL LOOP SOUNDING MODE

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SUMMARY

Both TEM47 time-domain EM resistivity soundings and EM39 borehole induction conductivity logs were obtained on either side of a shallow fault that had been located using conventional resistivity profiling.

The conductivity logs from seven PCV-cased boreholes, of various depths, (1) are shown to be in good agreement with the known stratigraphy, (2) are highly correlated on both sides of the fault and (3) clearly indicate the vertical extent of the fault throw.

Four TEM47 central-loop soundings were carried out on either side of the fault, two near the fault and two more distant, in order to (1) evaluate the lateral resolution of the central loop sounding technique and (2) to determine whether the fault could be identified by the change in interpreted geoelectric section on either side. Using 19 x 19 m transmitter loops the sounding data demonstrated that measurements could be made at least as close as 20 m to the updip side and 60 m to the downdip side without appreciable influence from the fault itself. Conversely, the sounding data was significantly different on either side of the fault, clearly signalling the presence of the fault.

Finally, the geoelectric sections obtained from the conductivity logs on both sides of the fault were used as starting models with which to invert the TEM47 sounding data using the Interpex TEMIX program. In both cases the inversions generated a geoelectric section (1) the calculated time-domain responses from which were in good agreement with the measured data taken with the TEM47, and (2) the vertical structures of which were still in good agreement with the measured EM39 data.

All of these features of the test survey are illustrated in the accompanying figures.

Appreciation is extended to staff of the British Geological Survey (Keyworth) who suggested the site, supplied site data and assisted in the survey.

F I G U R E S

Figure #

1. Site location at Down Ampney, U.K. showing resistivity profile lines (A-A etc), location of interpreted fault, and location of TEM47 central-loop sounding transmitter loops 1 and 2. Survey area has very low relief.

2. Detail of portion of Figure 1 showing location of fault, approximate location of TEM47 transmitter loops 3 and 4, and location of 4" diameter PVC-cased boreholes.

3. Lithological logs on either side of, and transecting, the Down Ampney fault.

4. EM39 induction logs of boreholes 1 and 2 on either side of the fault. Note the high degree of correlation in response beyond 14 m in hole 1 and 62 m in hole 2, indicating a vertical throw of 48 m, (in accord with Figure 3), and the overall correlation with lithology shown in Figure 3.

5. Expanded plot of response of EM39 log of hole 2 from 60 m to end. Also shown is an interpreted geoelectric section, and calculated forward solution for this section (which takes into account the EM39 instrument response function), and which gives good agreement with the survey data. Some lithological units are tentatively identified on the basis of conductivity. Note the vertical resolution, generally of the order of 20 cm.

6. Detailed EM39 logs from holes 1, 6, 5, 3, 8 and 7. Note correlation in the Oxford clay. Note also that Kellaways clay in hole 7 has been slightly compressed (compare thickness with hole 1) but that depth of the Kellaways clay/ Cornbrash limestone interface (at 32.5 m in both holes 1 and 7) is uninfluenced by presence of nearby fault.

7. Geonics Gamma 39 natural gamma-ray log of hole 2. Note correlation of response with EM39 log (Figure 4) in clay-rich regions.

Continued......

8. TEM47 survey data from loops 1-4 plotted as apparent resistivity (using late-stage definition) versus time. Note similarity between loops 1 and 2, loops 3 and 4, but significant differences between loops 2 and 3.

9. EM39 logs for holes 1 and 2 with data "blocked" to form starting model for TEM47 inversion using TEMIX.

10a. Comparison of measured TEM47 response, loop 1, with calculated response using geoelectric section from "blocked" EM39 data, hole 2 (Figure 9). Agreement is encouraging but not yet satisfactory.

10b. Comparison of measured TEM47 response, loop 1, after 2 iterations of TEMIX using data of Figure 9, 10a as starting model. RMS error is now 4.5%, considered satisfactory. New geoelectric model is on right. Note that it is still in good agreement with EM39 data from hole 2 (Figure 10a); major change is progressive reduction in depth to each layer so that depth to 34 ohm-m layer has decreased from 81 m to 71 m. This is possible, in view of the lateral distance of 200 m between loop 1 and hole 2 (Figure 1).

10c. Comparison of measured TEM47 response, loop 1, with response from simplified 3-layered version of model of Figure 10b to see if all the layers are necessary. Fit is definitely poorer than Figure 10b.

11a. Comparison of measured TEM47 response, loop 4, with calculated response using geoelectric section from "blocked" EM39 data, hole 1 (Figure 9). Agreement is poor.

11b. Comparison of measured TEM47 response, loop 4, after 2 iterations of TEMIX using data of Figure 9, 11a as starting model. RMS error is now 5.2% considered reasonable. New geoelectric model is again on right and similar remarks apply as for Figure 10b except that depth has uniformly increased so that depth to last layer has increased from 42 to 45 m, a trend consistent with Figure 6.

11c. Comparison of measured TEM47 response, loop 4, with response from simplified 3-layered version of Figure 11b to see if all layers are necessary. Response is essentially same as Figure 11b so for this case some degree of equivalence is evident.

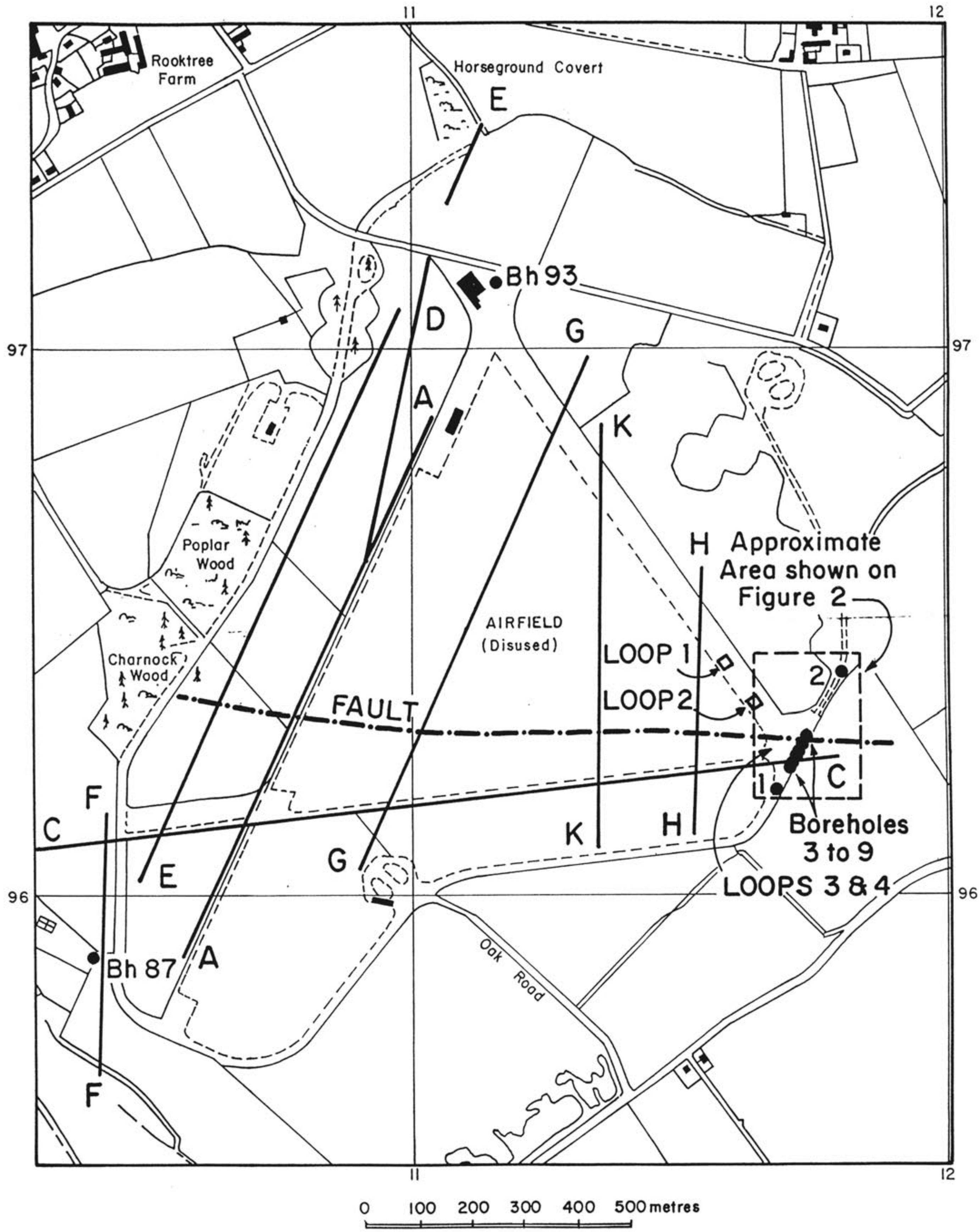


Figure 1 Approximate location of Transmitter Loops 1 and 2

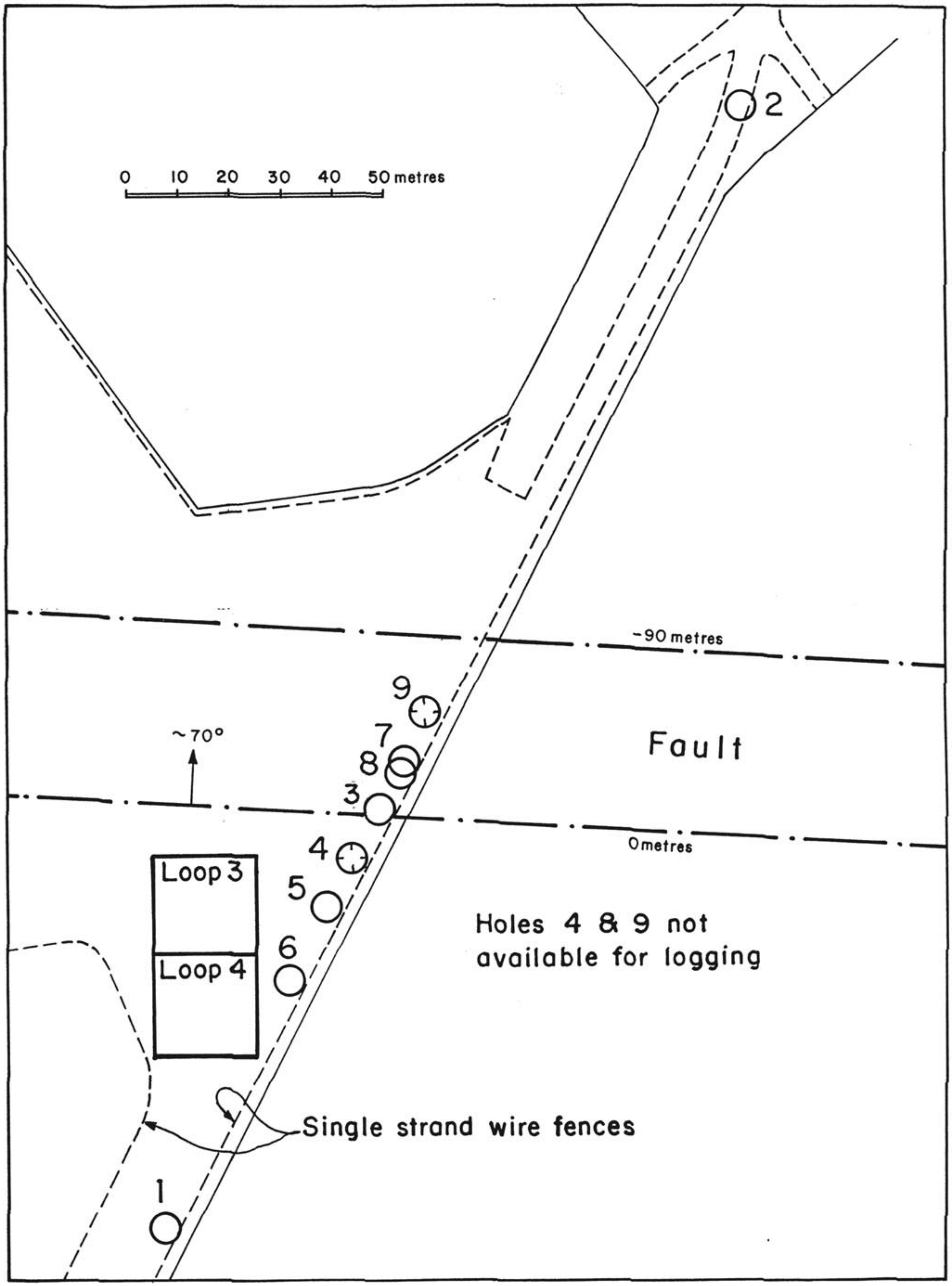
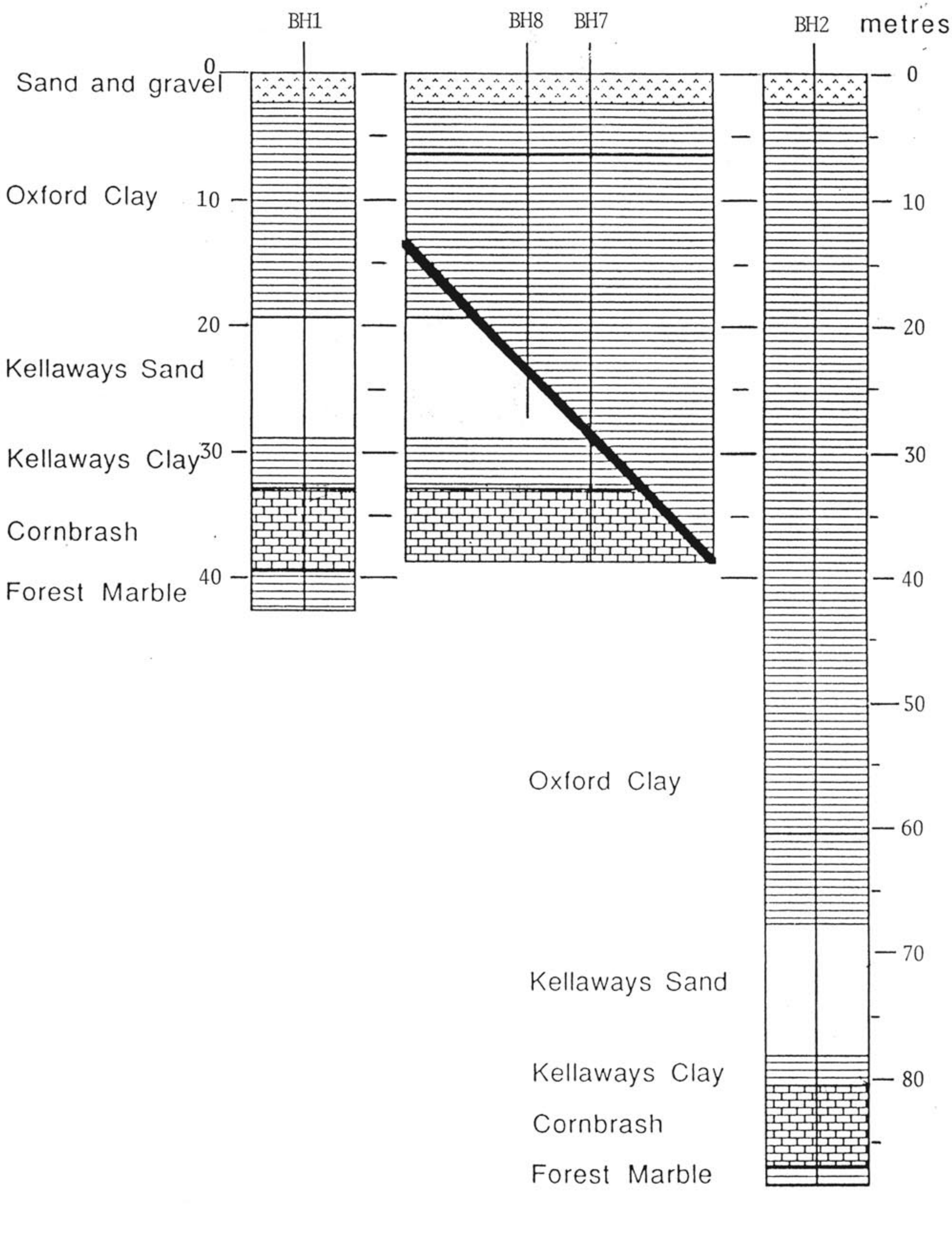


Figure 2 Approximate location of Transmitter Loops 3 and 4, and location of Boreholes 1, 6, 5, 3, 8, 7 & 2



THE DOWN AMPNEY FAULT

Figure 3

DOWNAMPNEY

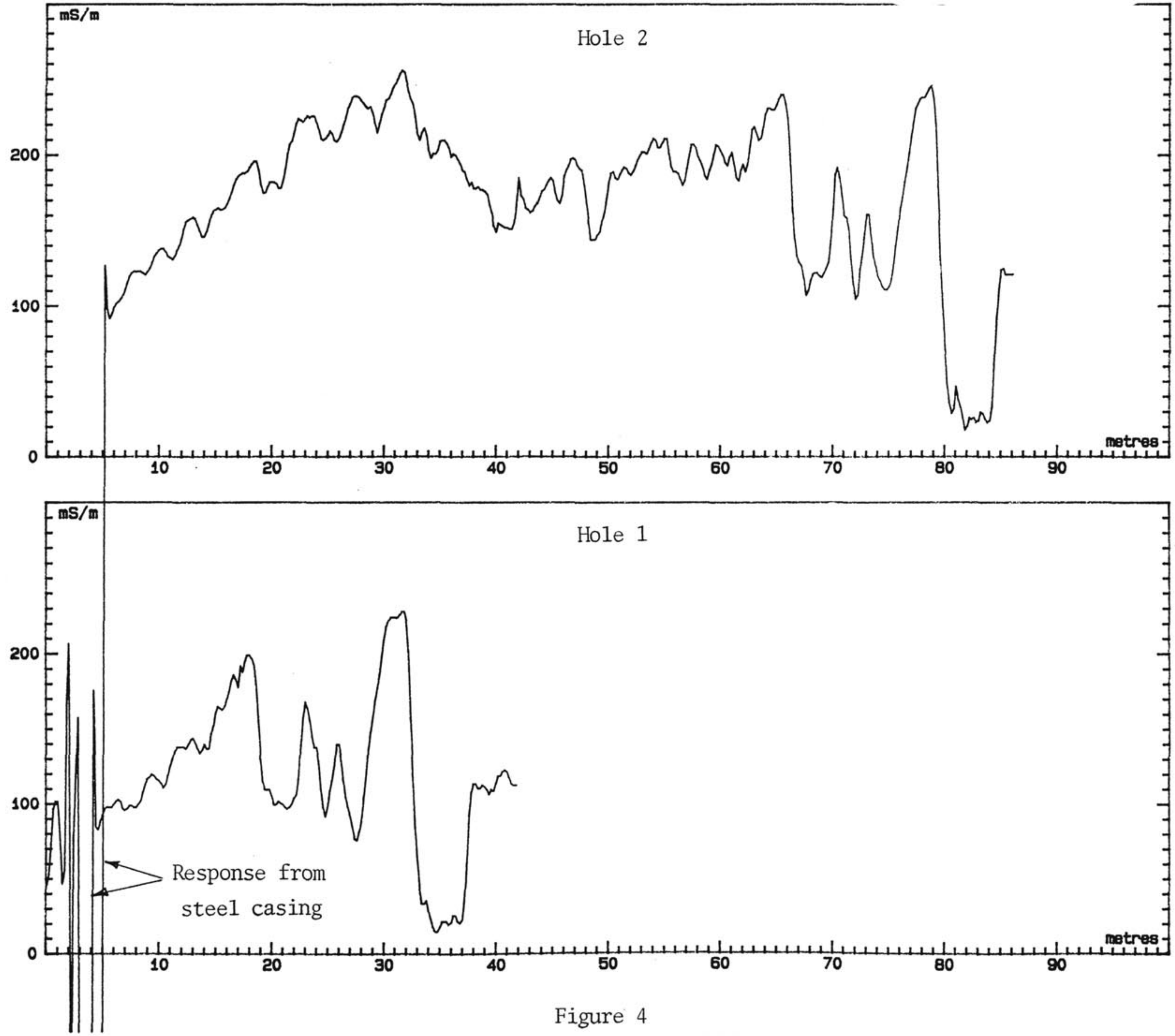
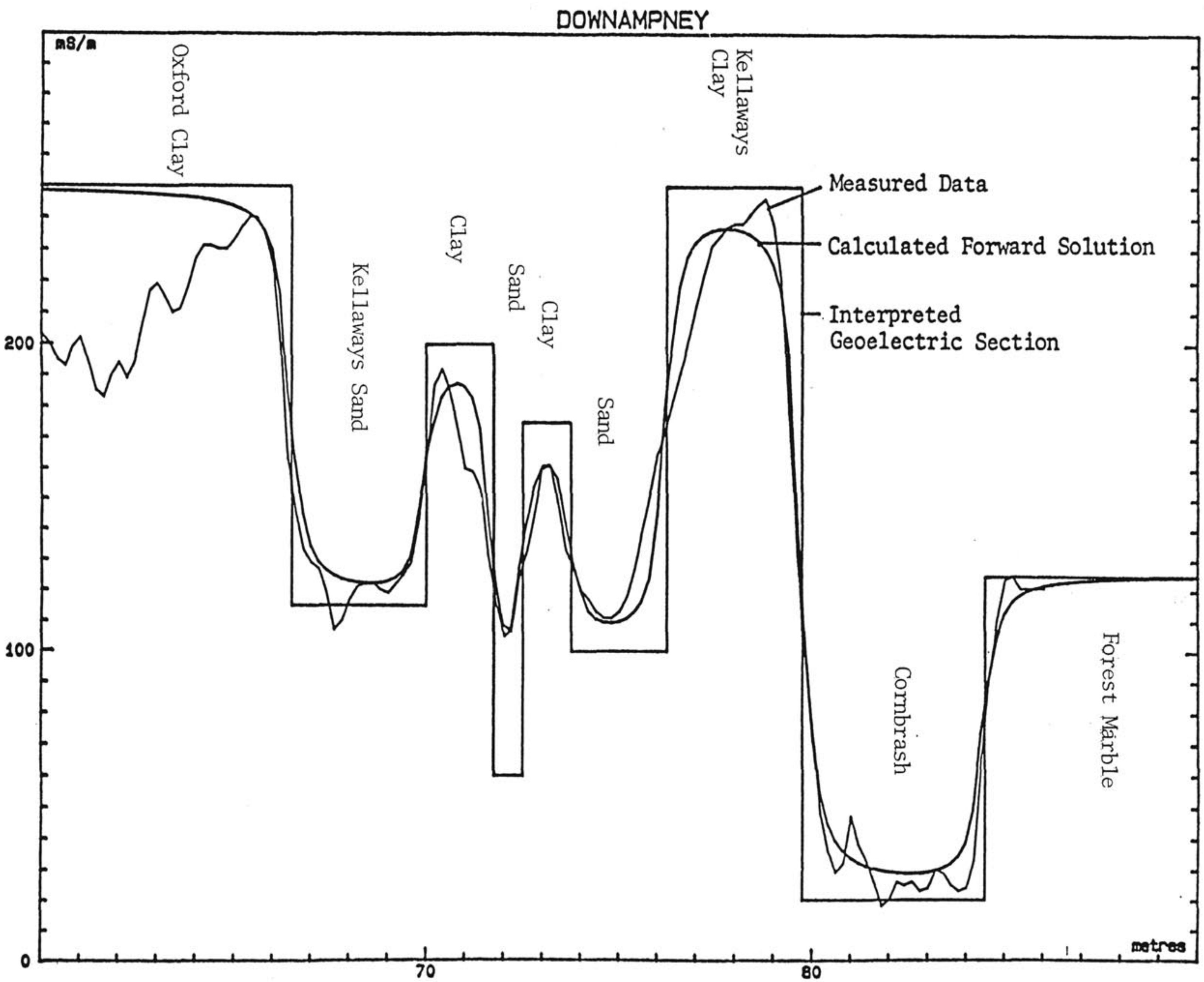
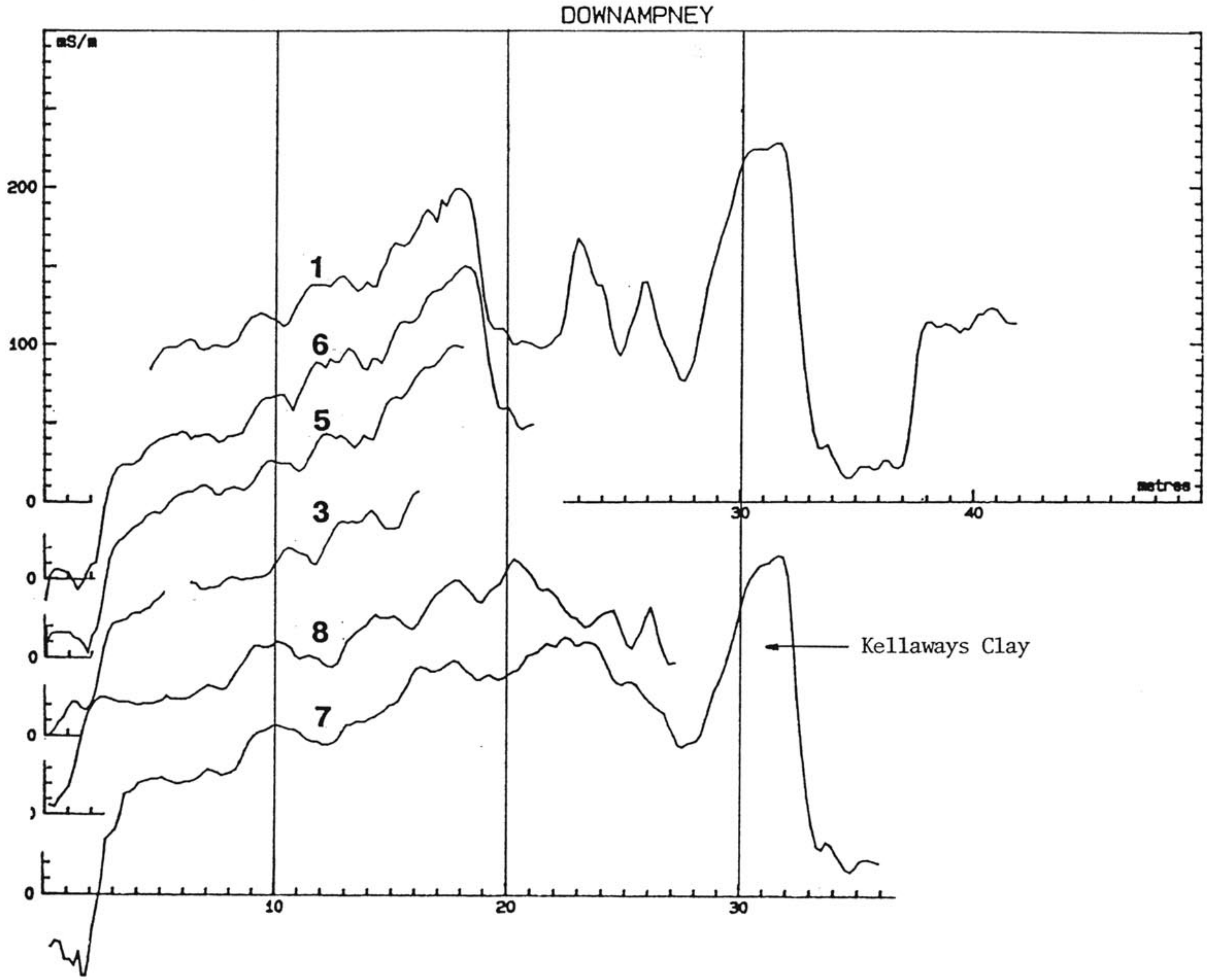


Figure 4



DOWNAMPNEY
mS/m
200
100
0
70
80
metres
Oxford Clay
Kellaways Sand
Clay
Sand
Clay
Sand
Kellaways Clay
Cornbrash
Forest Marble
Measured Data
Calculated Forward Solution
Interpreted Geoelectric Section

Figure 5



Stacked Profiles
Borehole Logs 1,6,5,3,8,7

Each log offset by 50 mS/m
to facilitate comparison

Figure 6

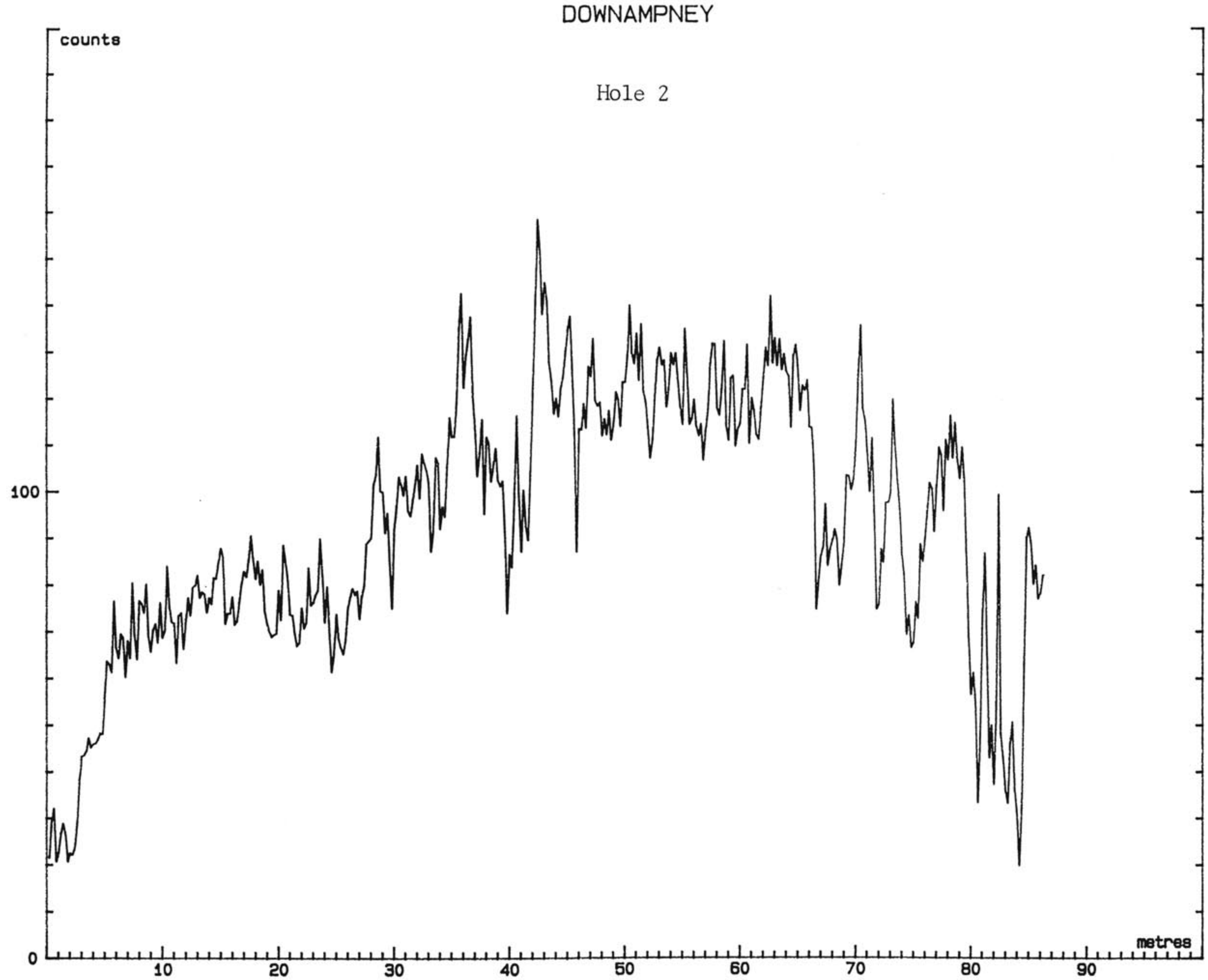


Figure 7

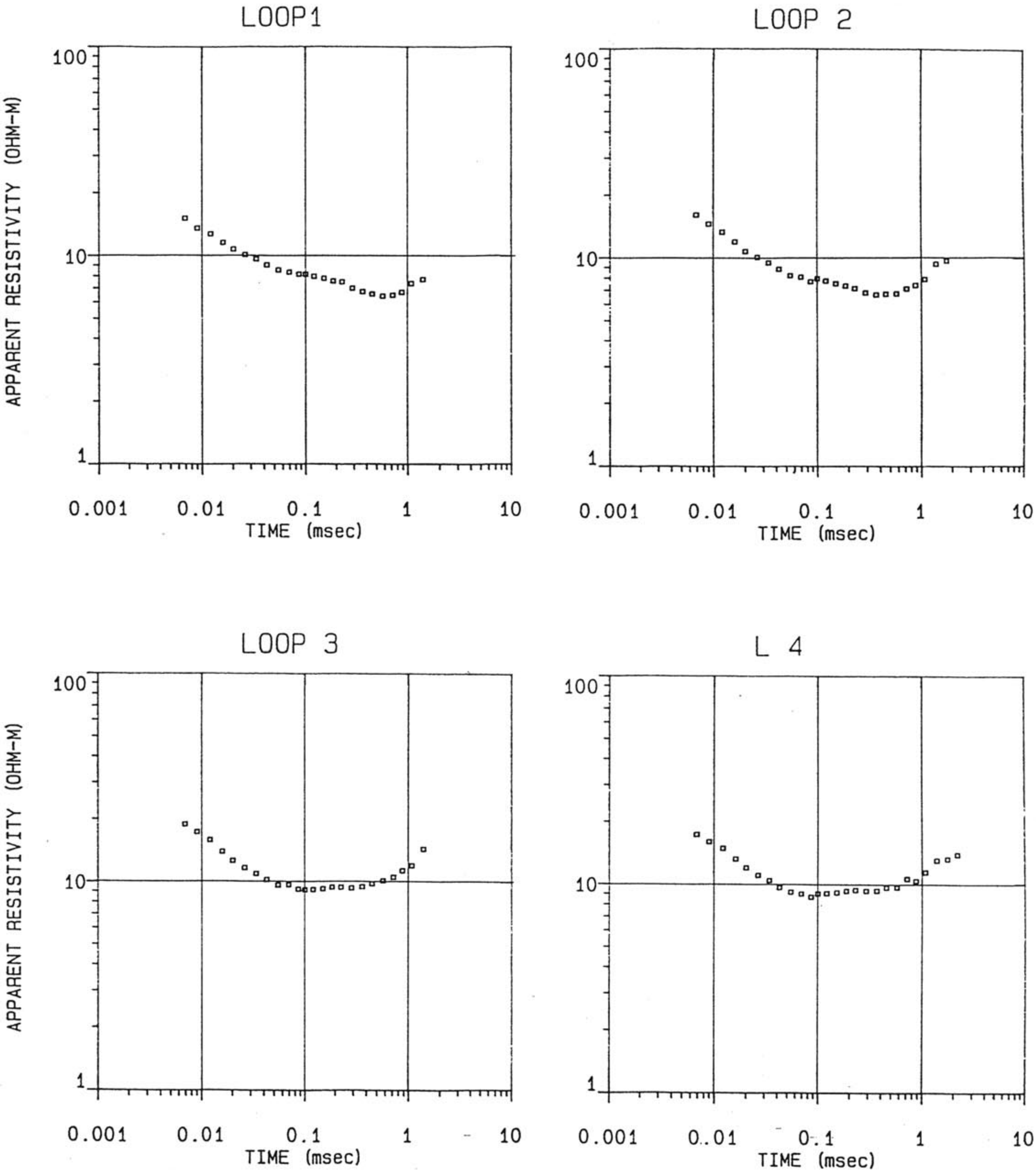

LOOP1
LOOP 2
LOOP 3
L 4
APPARENT RESISTIVITY (OHM-M)
100
10
1
0.001
0.01
0.1
1
10
TIME (msec)

Figure 8

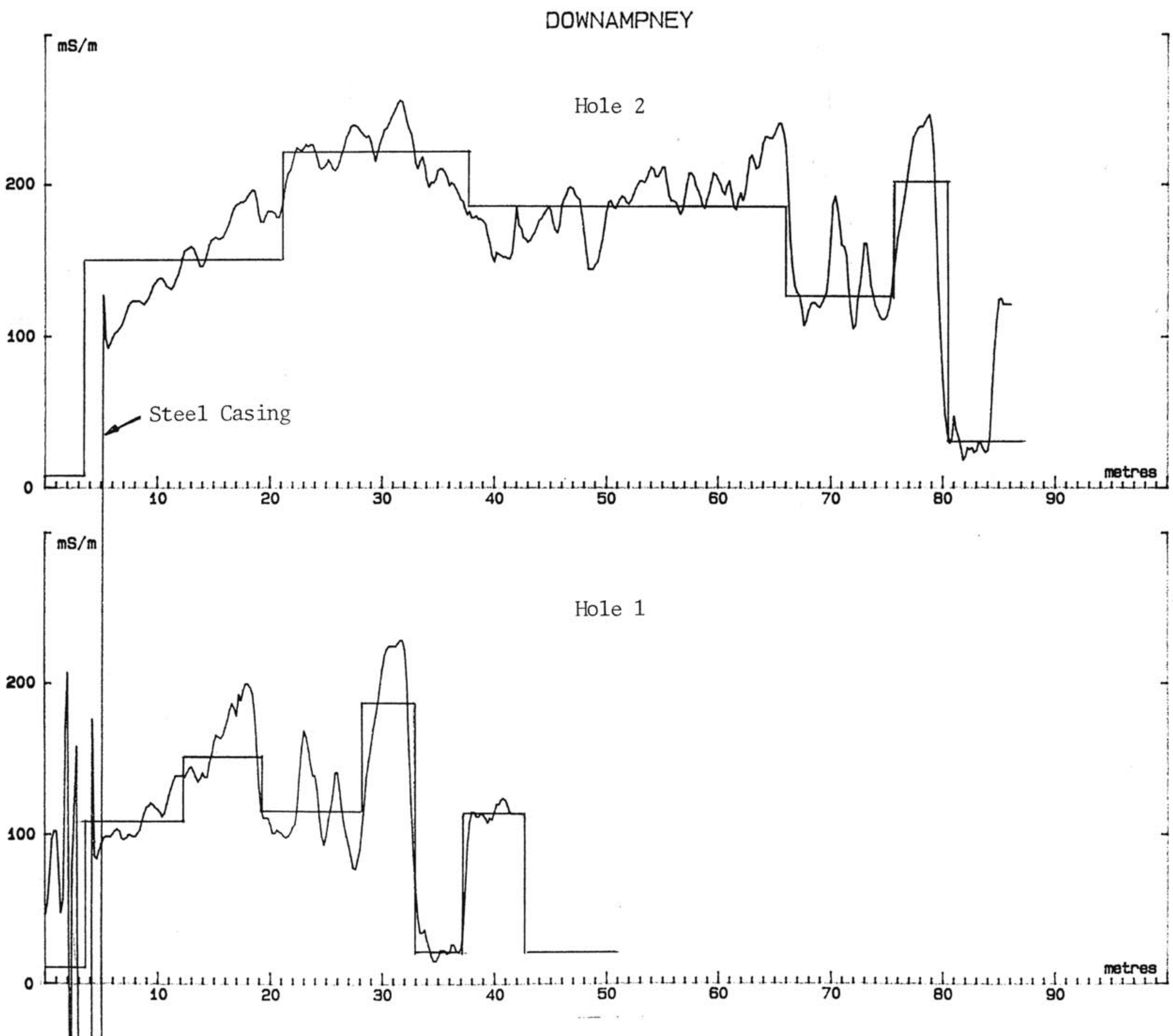

DOWNAMPNEY
Hole 2
Steel Casing
Hole 1
mS/m
200
100
0
10
20
30
40
50
60
70
80
90
metres

Figure 9

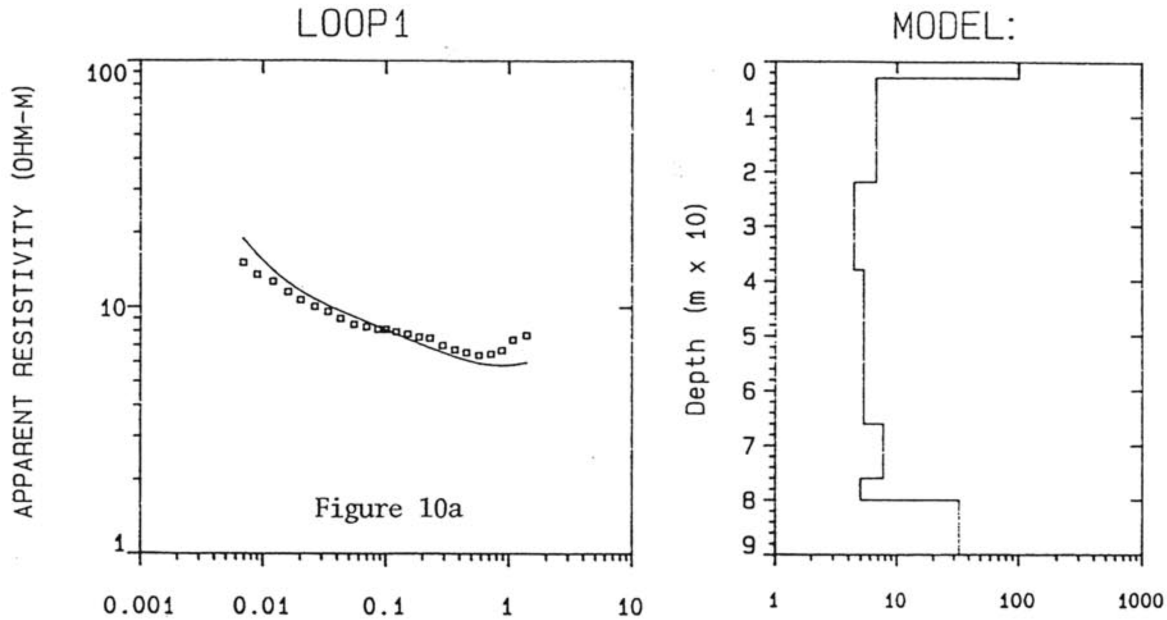


Figure 10a

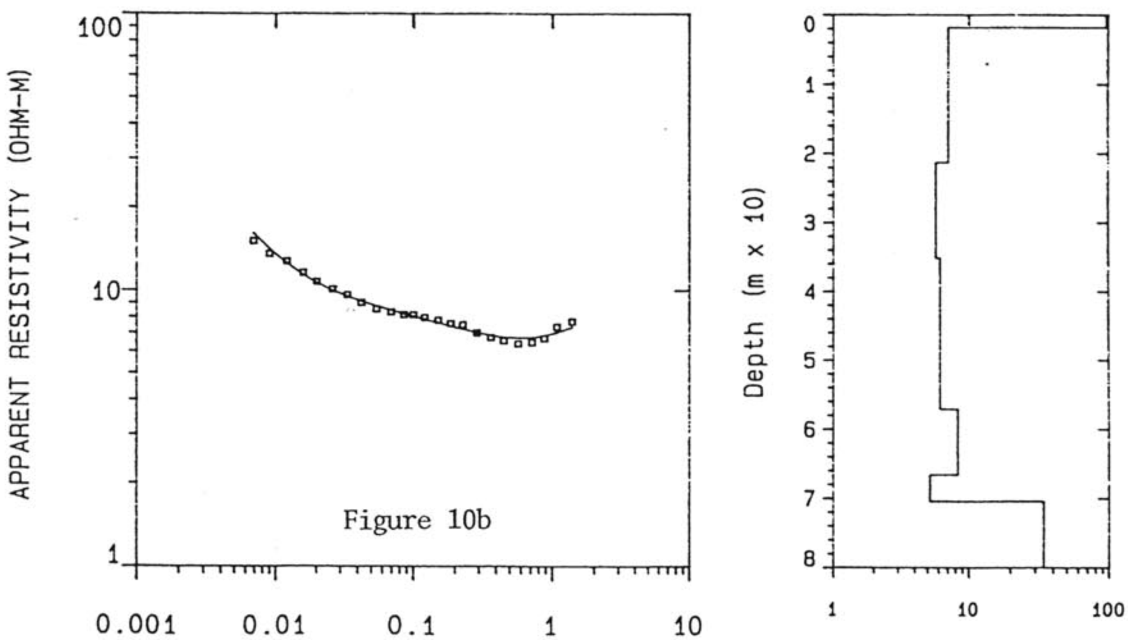


Figure 10b

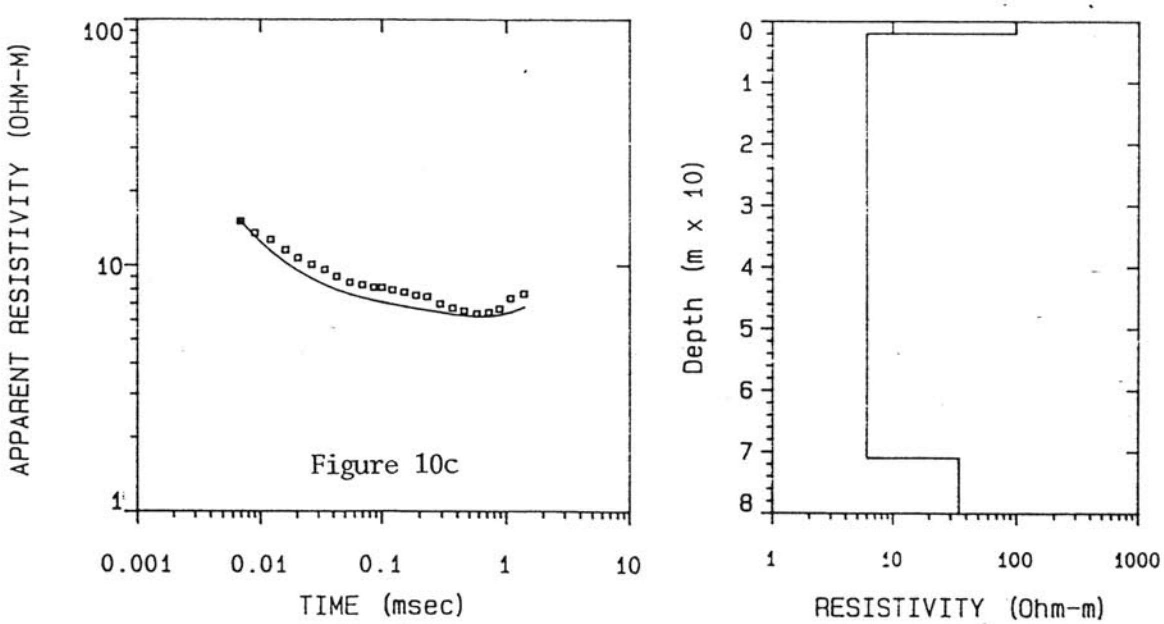


Figure 10c

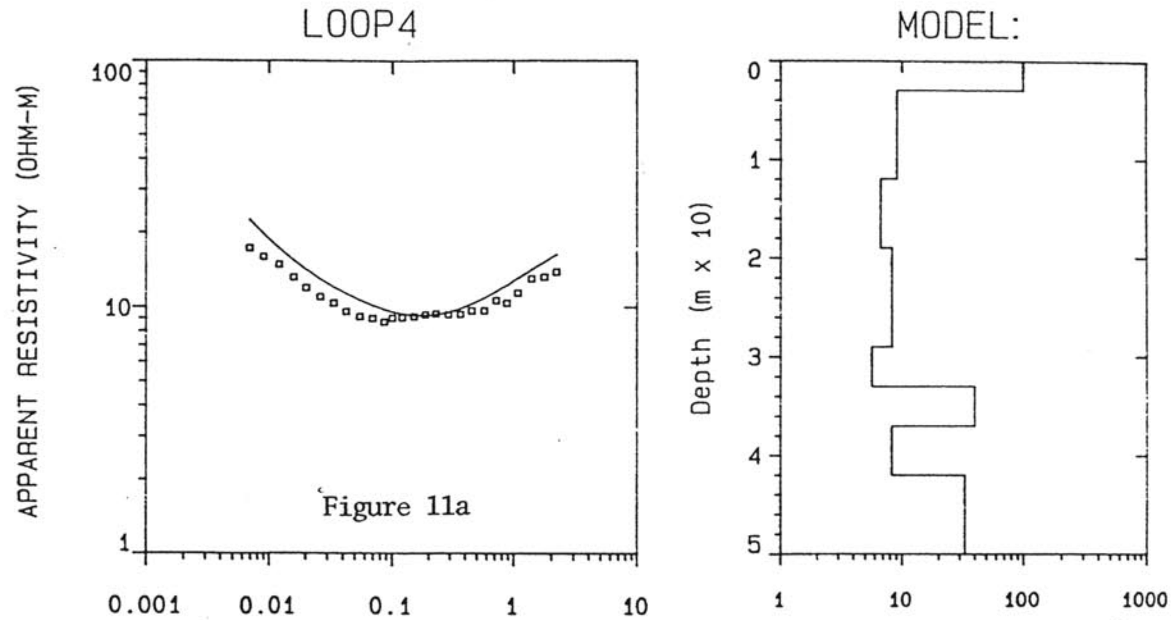


Figure 11a

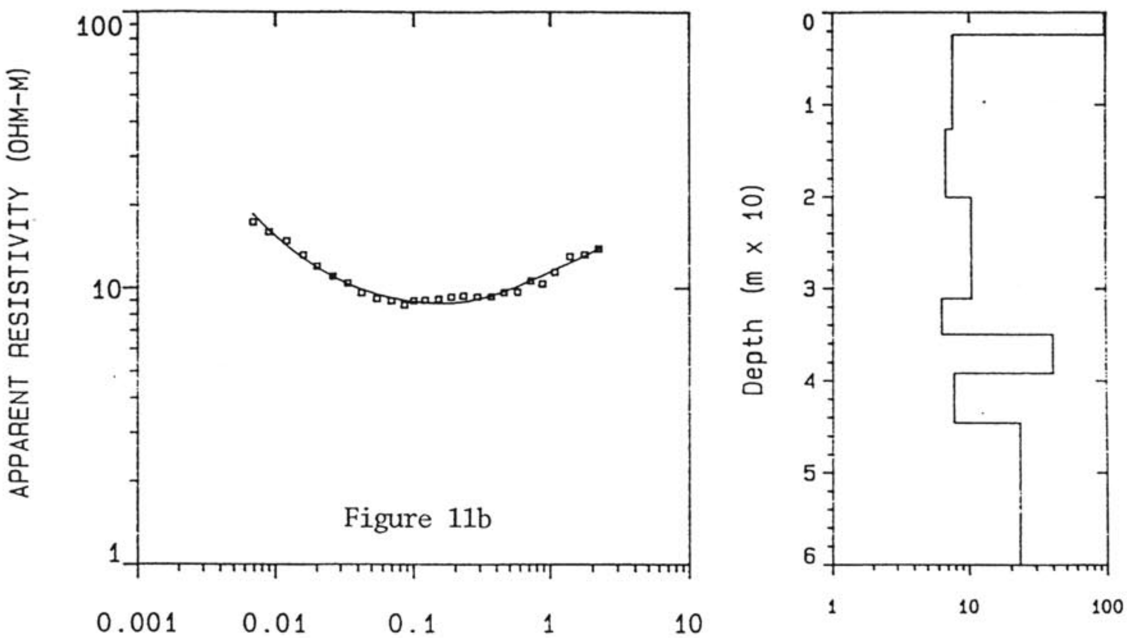


Figure 11b

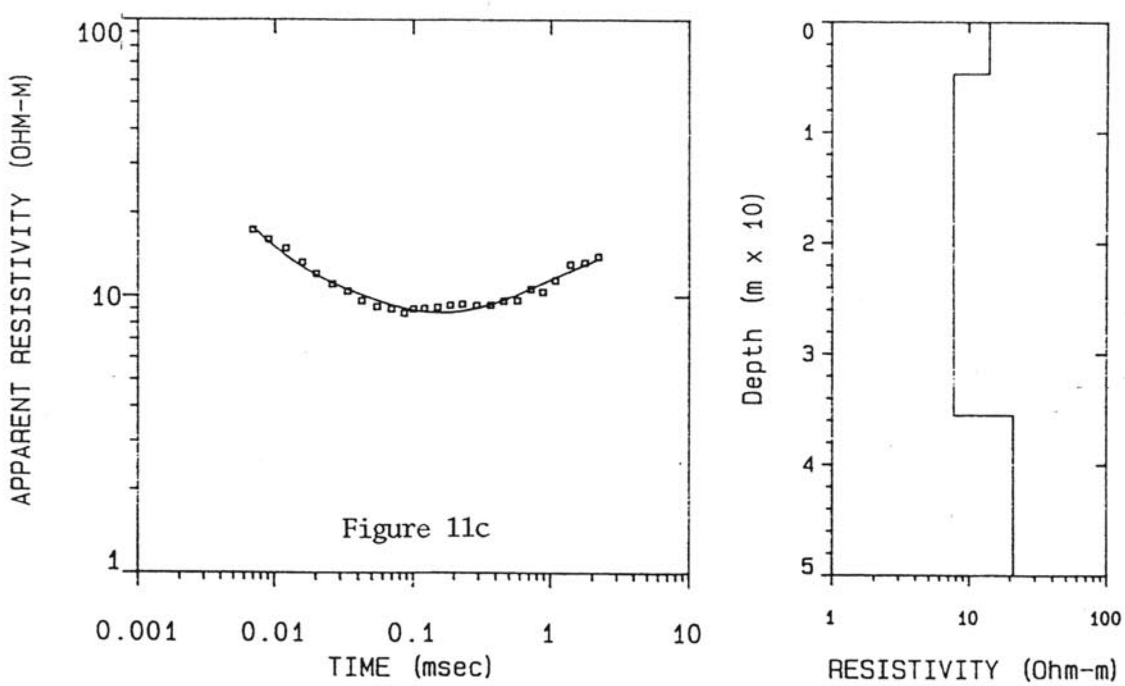


Figure 11c