U.S. Dept. of Interior
Geological Survey
Denver, Colorado

Interpretation of Electromagnetic Soundings in the Raft River Geothermal Area, Idaho

by

Walter L. Anderson

OPEN-FILE REPORT No. 77-557

1977

Interpretation of Electromagnetic Soundings in the Raft River Geothermal Area, Idaho

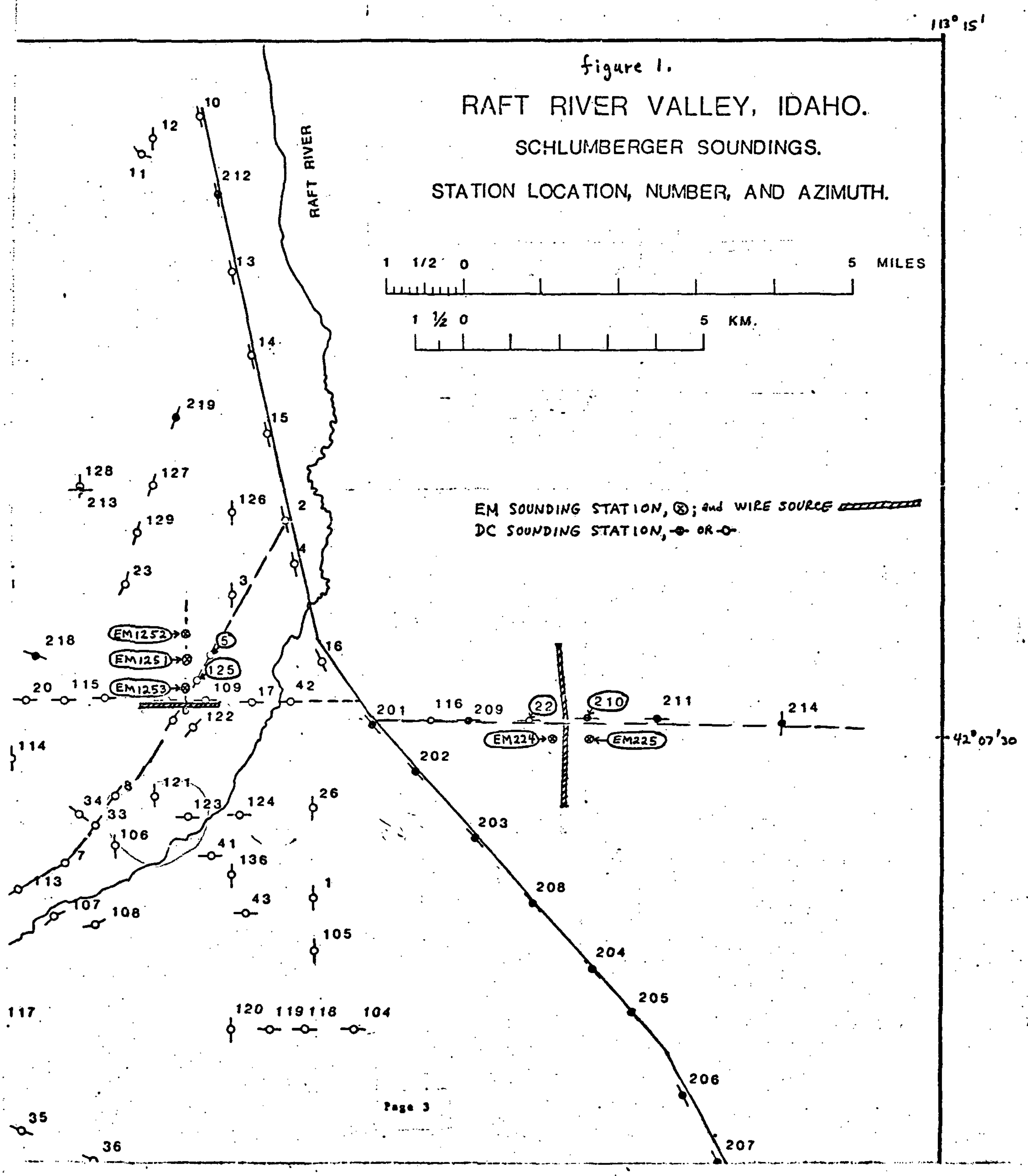
by Walter L. Anderson

During the period 9/28/76 to 10/11/76, a small electromagnetic (EM) controlled source survey was conducted in the Raft River Valley, near Malta, Idaho. The purpose of the survey was: (1) to field test U.S. Geological Survey extra-low-frequency (ELF) equipment using a grounded wire source and receiver loop configuration (which is designed to measure the vertical magnetic field (Hz) at the loop center for various frequencies); (2) to present an example of the EM sounding data and interpretations using the inversion program developed by Anderson (1977); and (3) to graphically compare the EM results with DC Schlumberger results, obtained by Zohdy, et.al. (1975), and Zohdy and Bisdorf (1976), for a geothermal environment.

Five ELF frequency soundings were made using a grounded wire source with a minimum length of 1480 meters and a maximum length of 3057 meters. The grounded (square) receiver loop was approximately 30 meters per side for all stations. These soundings were made with a minimum separation (between the line source and loop) of 250 meters and a maximum separation of 1003 meters. The maximum frequency range for each sounding was from 1 hertz to 2000 hertz, with 12 points per decade (some repeated points were used, and some points were deleted due to erronous observations).

Figure 1 shows the location of the five EM stations: EM1251, EM1252, EM1253, EM224, and EM225. The orientation of the wire source is indicated by a hachured line, and the center of the receiver loop is denoted by an ⊗. Other numbers in figure 1 represent DC station numbers, where the DC results have been published by Zohdy et.al. (1975) for numbers 1 to 136, and Zohdy and Bisdorf (1976) for numbers 137 to 219.

The observed amplitude and phase frequency soundings were adjusted at each EM station using predetermined equipment calibration curves. This was followed by normalizing the amplitudes by the primary Hz field, and making linear phase drift corrections. The appendix shows the adjusted observed values plotted at the bottom of the symbols "0".


113° 15'
figure 1.
RAFT RIVER VALLEY, IDAHO.
SCHLUMBERGER SOUNDINGS.
STATION LOCATION, NUMBER, AND AZIMUTH.
1 1/2 0 5 MILES
1 ½ 0 5 KM.
RAFT RIVER
EM SOUNDING STATION, ⊗; and WIRE SOURCE
DC SOUNDING STATION, -●- OR -○-
42° 07' 30
EM1252
EM1251
EM1253
EM224
EM225
Pocatello
AMS

The least squares EM station results, obtained by an inversion program by Anderson (1977), are given in sets of three plots in the appendix -- least squares phase solution with residuals, least squares amplitude solution with residuals, and the EM layer solution superimposed over the nearest DC layer solution (taken from Zohdy, et.al. 1975, and/or Zohdy and Bisdorf, 1976). The notation "model 6.5", for example, denotes a 6-layer model, version 5.

The inversion program (Anderson, 1977) was run for each EM station independently, but both amplitude and phase data were used simultaneously in the least squares method. Some minor weighting of the data was done. Comparison of the EM and DC results is generally fair, considering the relative poor positioning of the EM and DC stations. Ideal station positions were not possible due to local effects (i.e., roads, power lines, buried cables, etc).

An attempt to compare numerical or statistical bounds for EM and DC layer solutions was not done, since statistical information is not available for the DC solutions. However, all EM station results generally showed less resolvability of the deeper layer parameters over the upper layer parameters; this qualitative pattern would be expected for the frequency range and separations used.

The calculations were done using the Cyber 74-28 and Honeywell 68/80 computer systems*, and the plots were produced using an AJ832 terminal (plot resolution 1/60 inch x-direction, 1/40 inch y-direction).

---

* Use of brand names in this report is for descriptive purposes only and in no way constitutes endorsement by the U.S. Geological Survey.

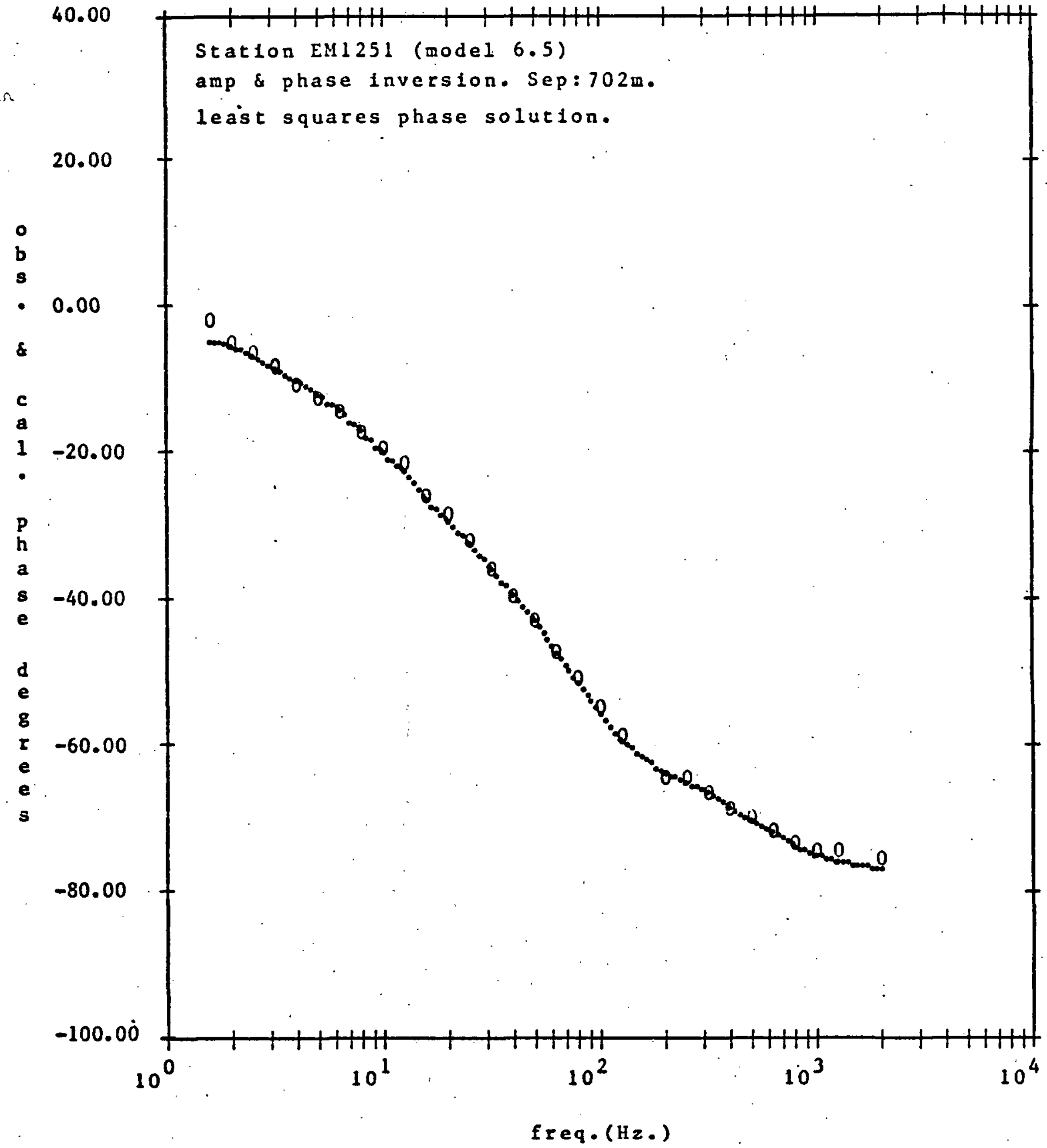
References

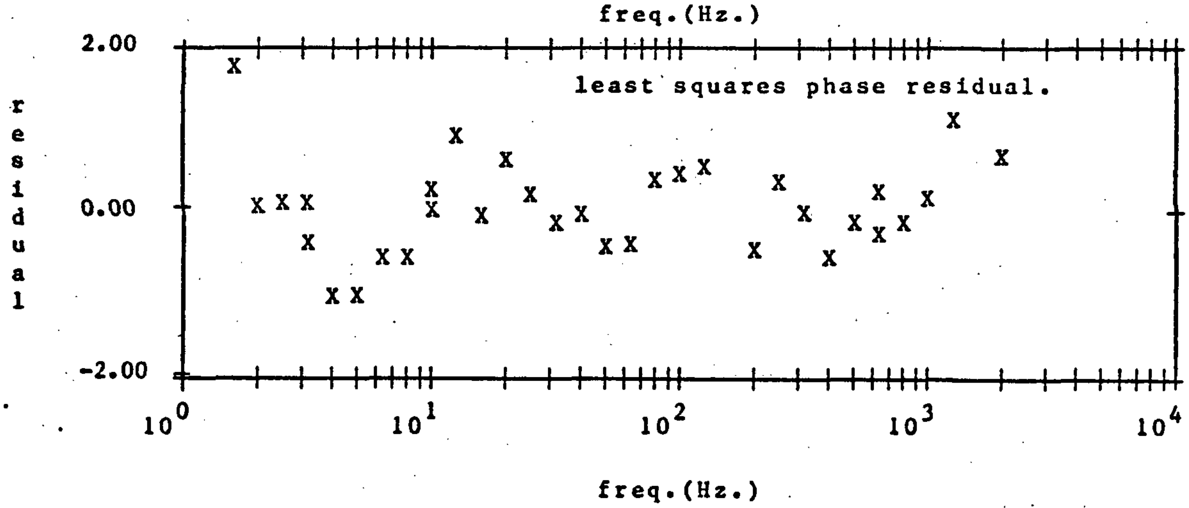
Anderson, W.L., 1977, Marquardt inversion of vertical magnetic field measurements from a grounded wire source: U.S. Geol. Survey Rept. USGS-GD-77-033, 76p. available from U.S. Dept. Comm. Natl. Tech. Inf. Service, Springfield, Va., 22161 as Rept. PB-263-924/AS.

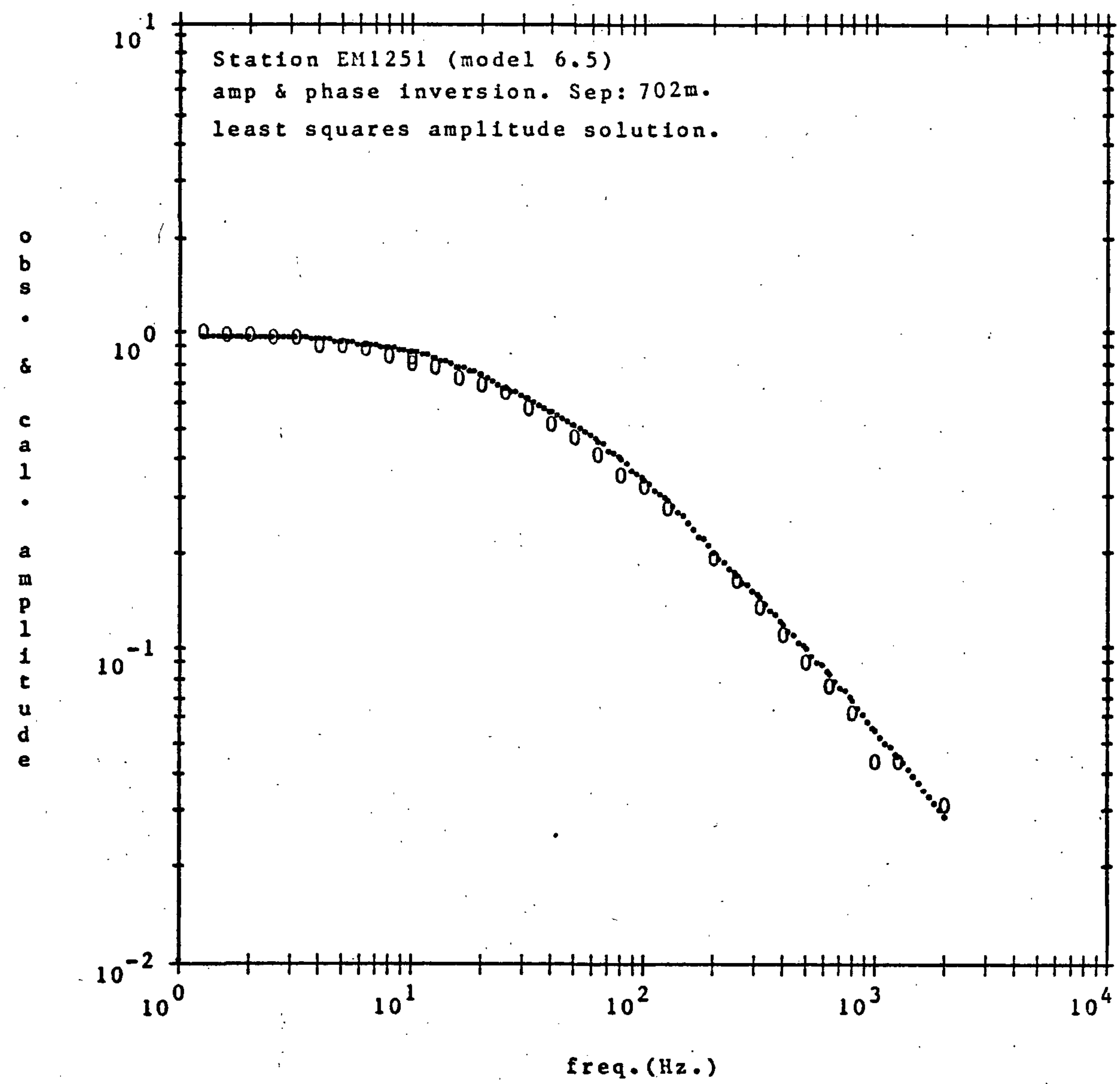
Zohdy, A.A.R, Jackson, D.B, Bisdorf, R.J., 1975, Schlumberger soundings and total field measurements in the Raft River geothermal area, Idaho: U.S. Geol. Survey Open-File Rept. 75-130, 5p., +136 text figures, +3 pl.

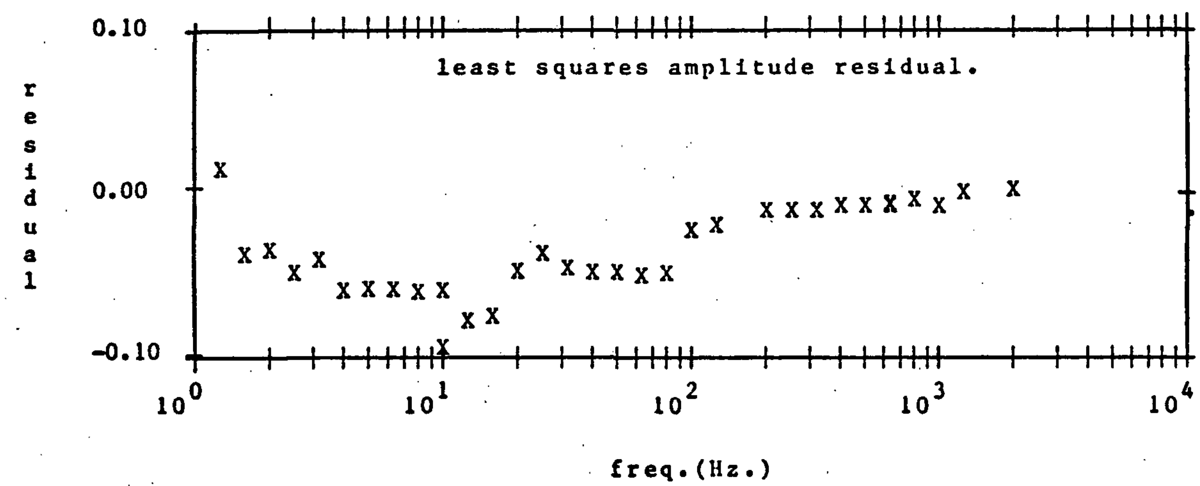
Zohdy, A.A.R., and Bisdorf, R.J., 1976, Schlumberger soundings in the upper Raft River, and Raft River valleys, Idaho and Utah: U.S. Geol. Survey Open-File Rept. 76-92, 6 p., +71 text figures, +1 pl.

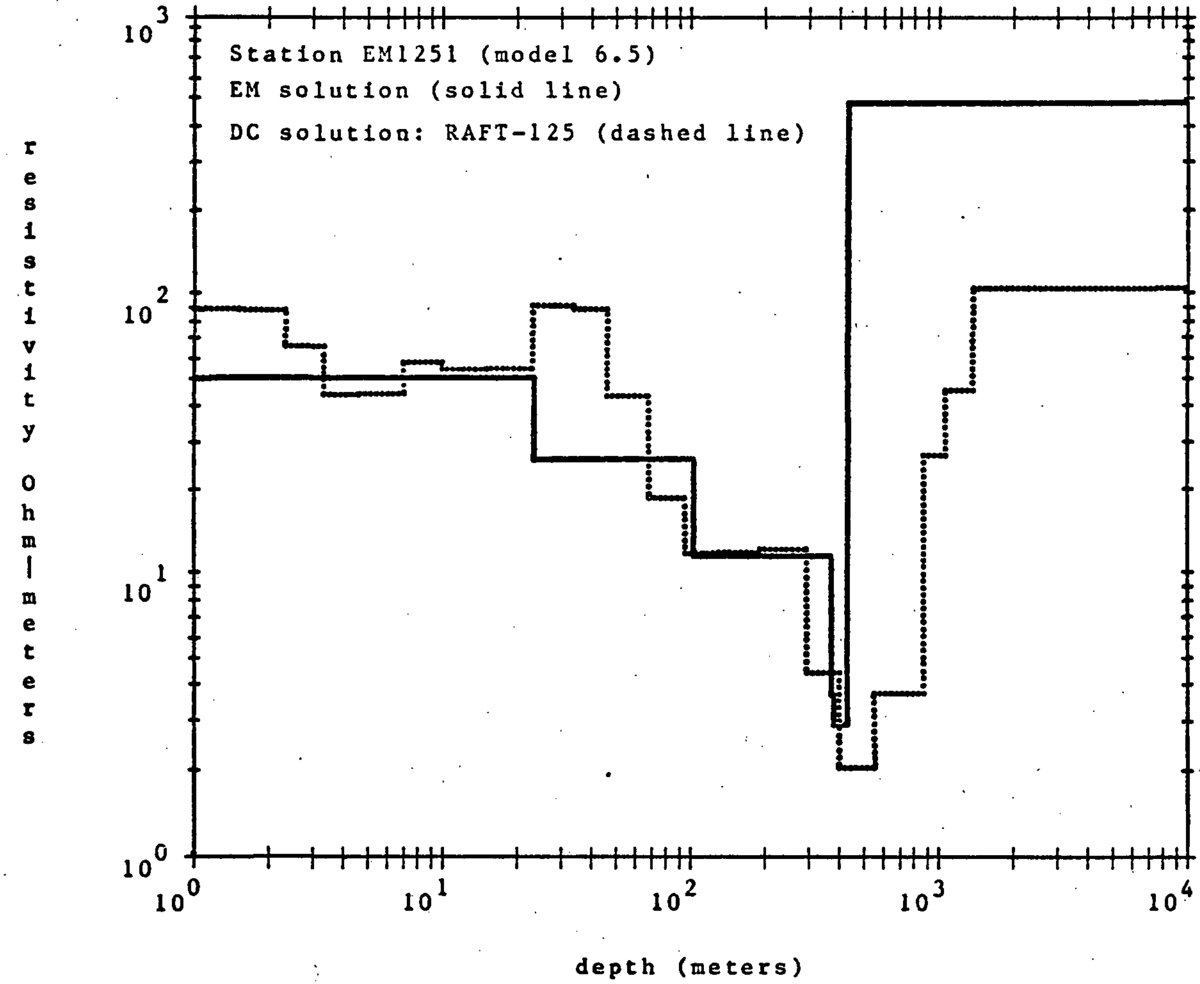
Appendix

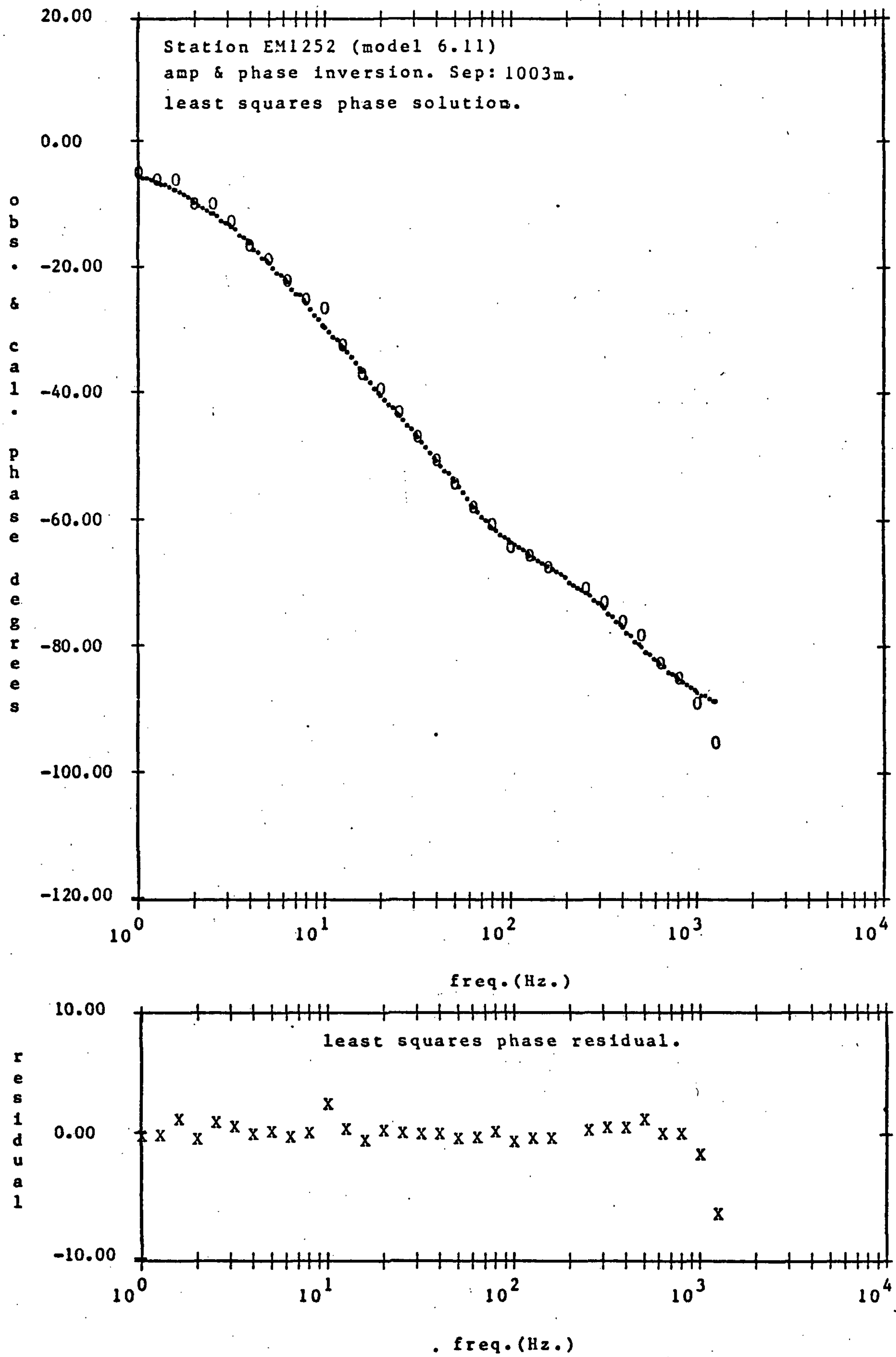

Station EM1251 (model 6.5)
amp & phase inversion. Sep:702m.
least squares phase solution.
obs. & cal. phase degrees
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)

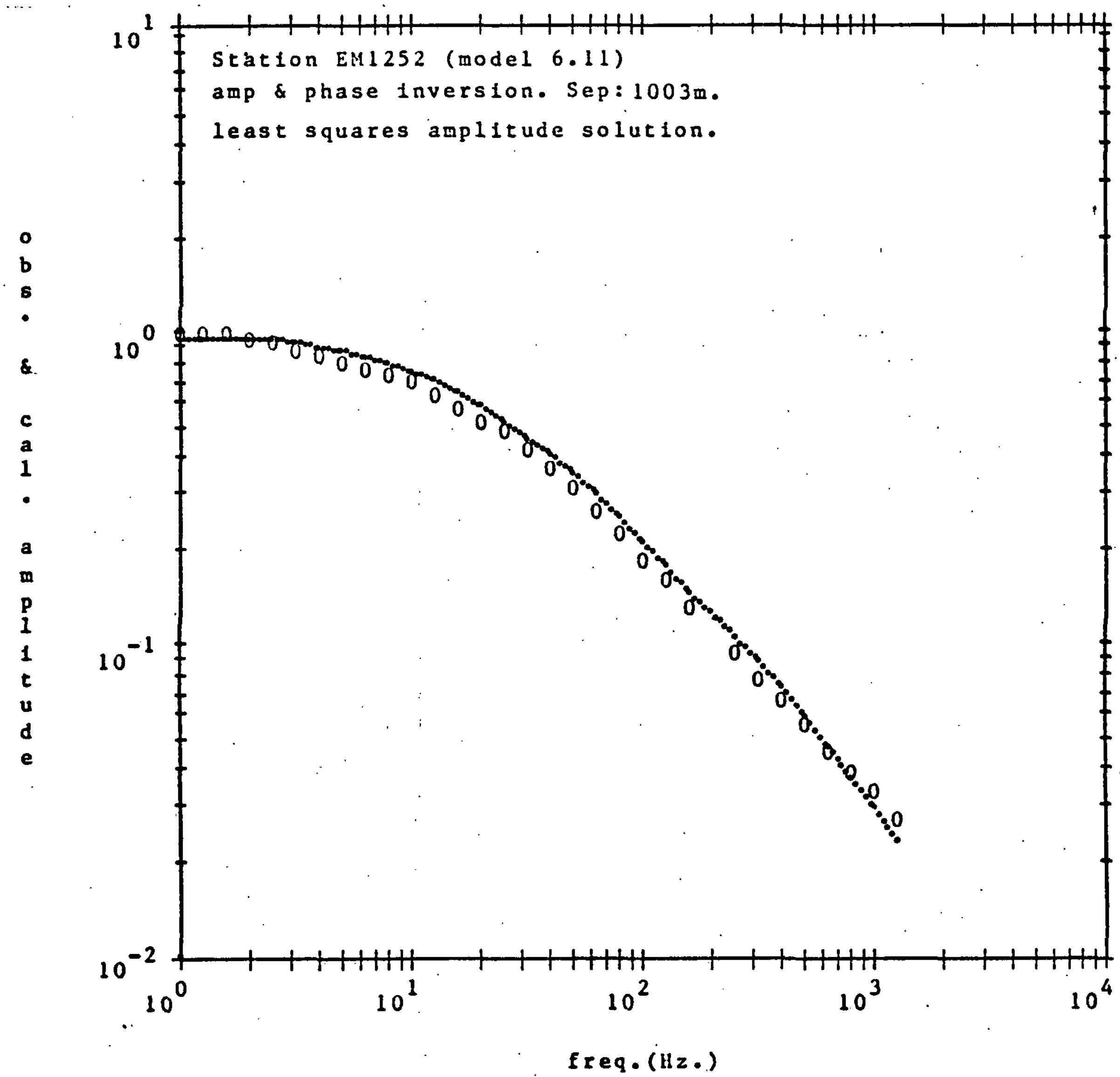

least squares phase residual.
residual
2.00
0.00
-2.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)

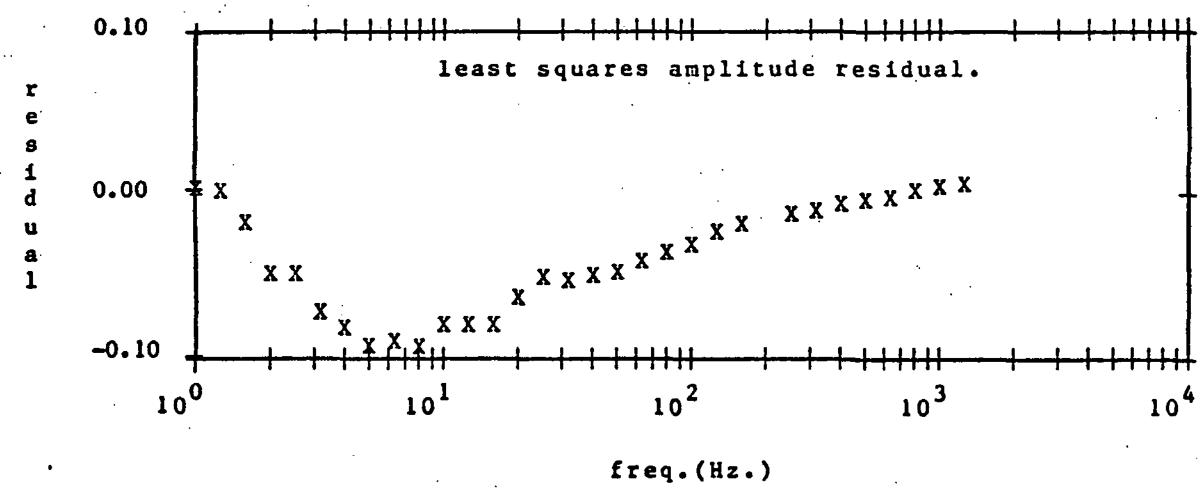

Station EM1251 (model 6.5)
amp & phase inversion. Sep: 702m.
least squares amplitude solution.
obs. & cal. amplitude
10^1
10^0
10^{-1}
10^{-2}
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)

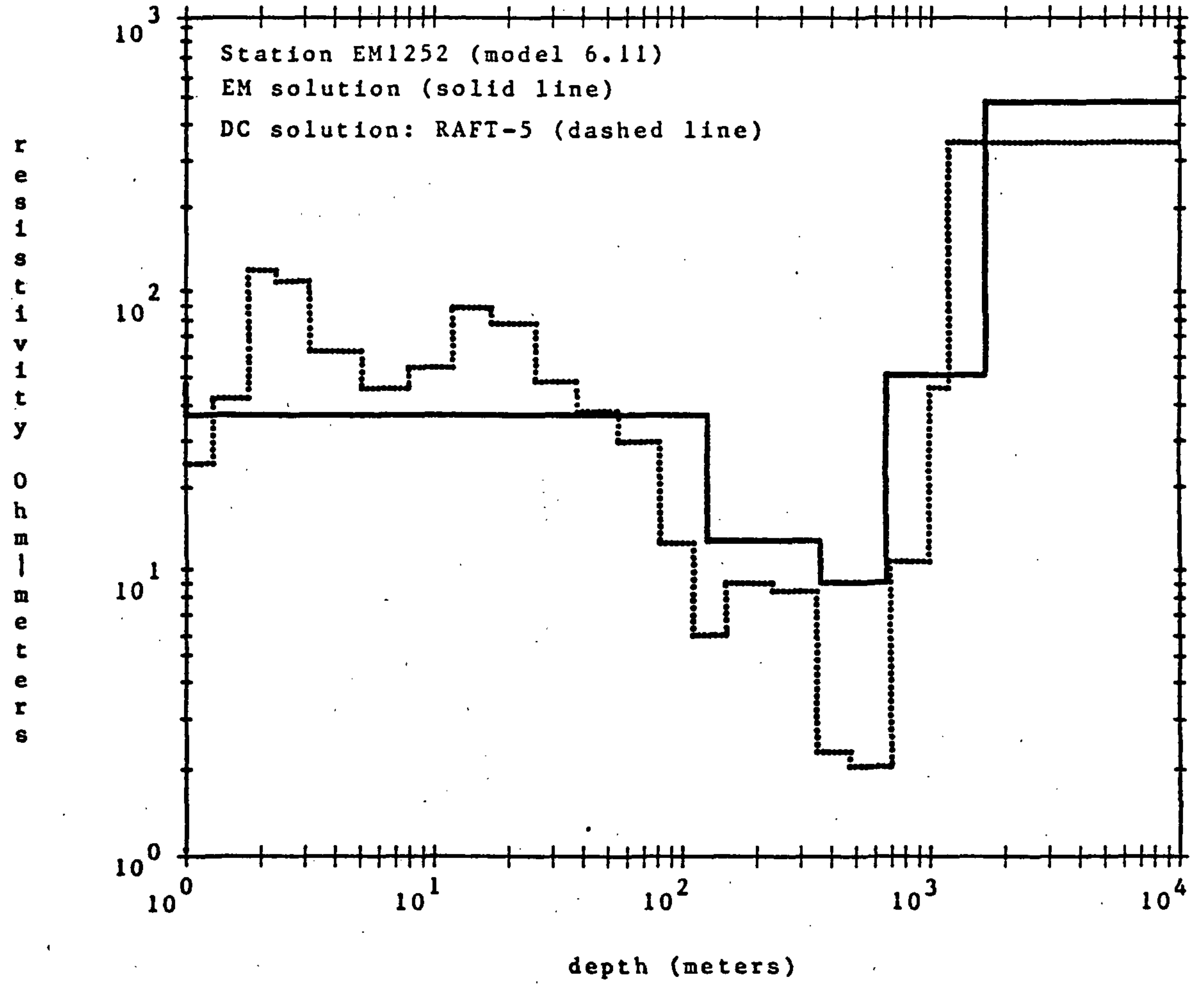

least squares amplitude residual.
residual
0.10
0.00
-0.10
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)


Station EM1251 (model 6.5)
EM solution (solid line)
DC solution: RAFT-125 (dashed line)
resistivity Ohm-meters
depth (meters)
10^0
10^1
10^2
10^3
10^4

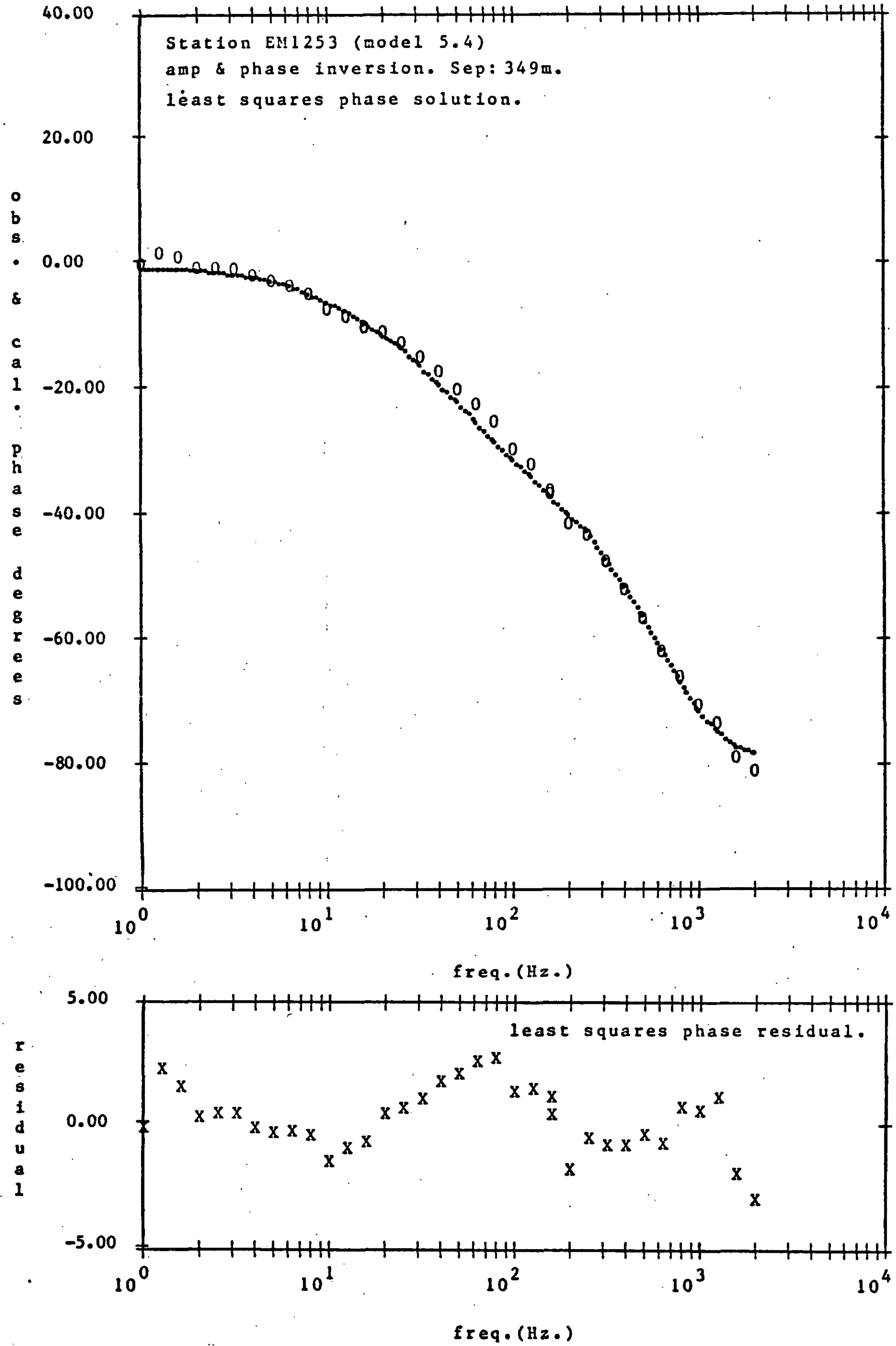

Station EM1252 (model 6.11)
amp & phase inversion. Sep: 1003m.
least squares phase solution.
obs. & cal. phase degrees
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
freq.(Hz.)
least squares phase residual.
residual
10.00
0.00
-10.00
freq.(Hz.)

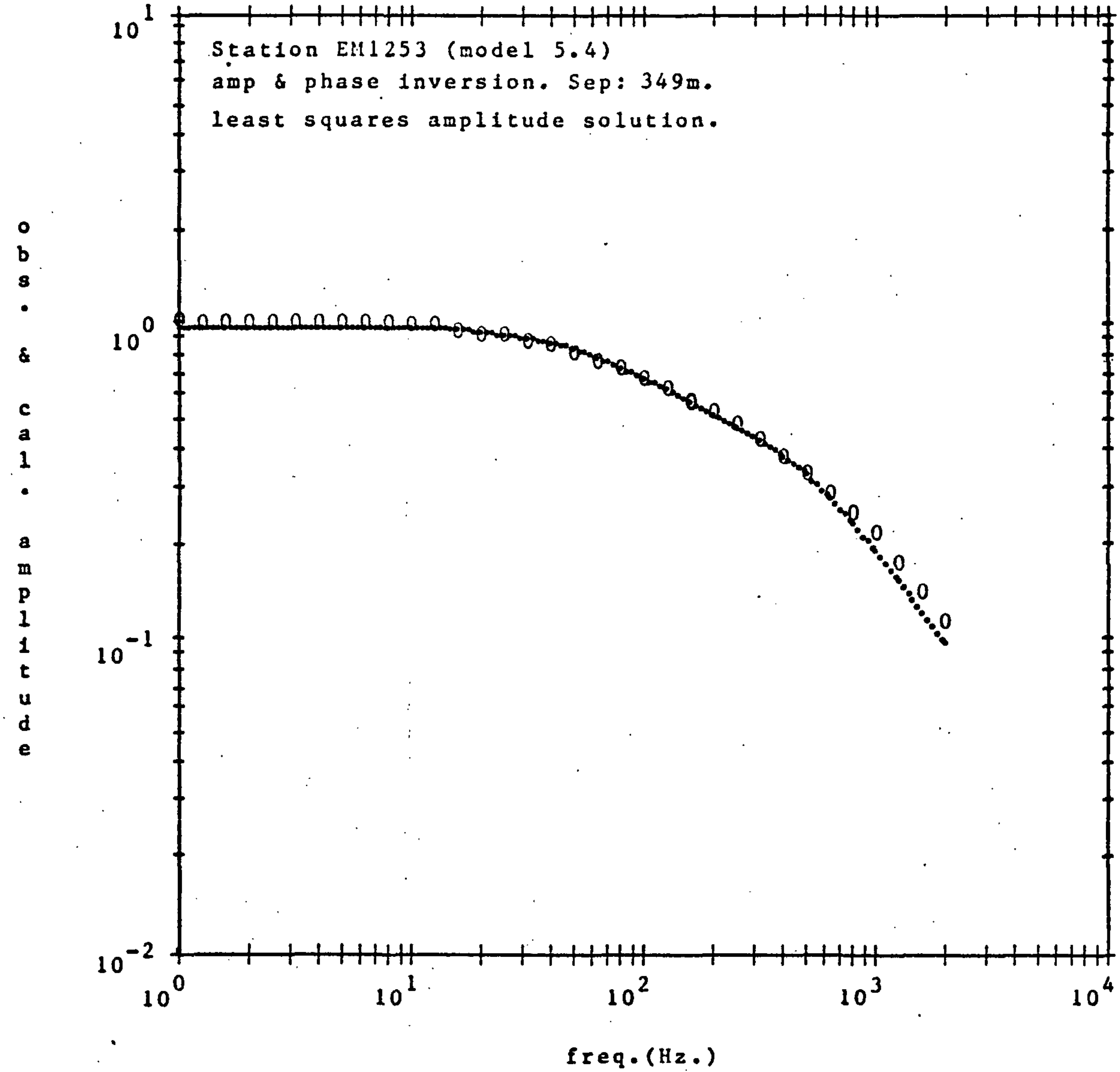

Station EM1252 (model 6.11)
amp & phase inversion. Sep:1003m.
least squares amplitude solution.
obs. & cal. amplitude
freq.(Hz.)

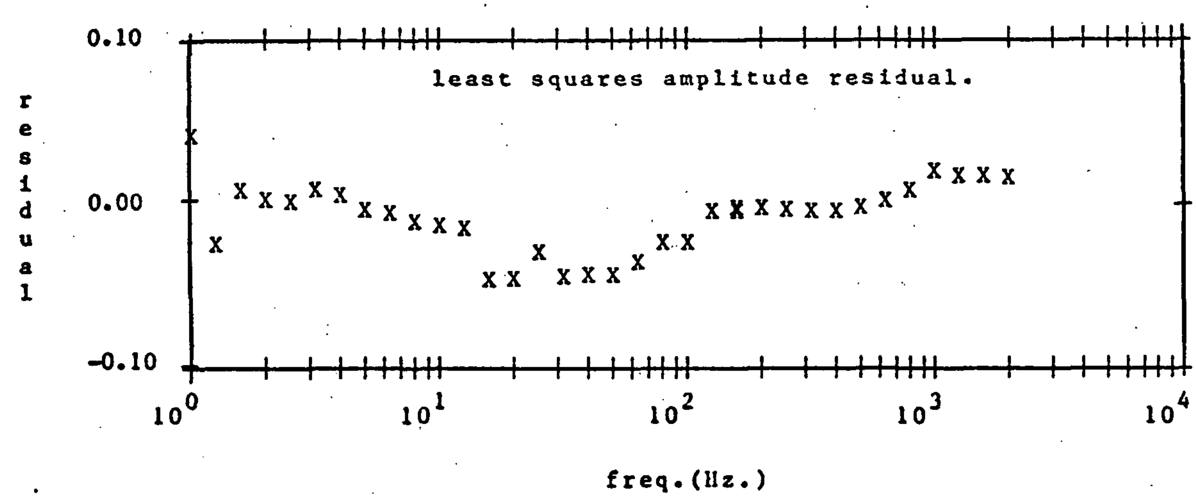

least squares amplitude residual.
residual
0.10
0.00
-0.10
freq.(Hz.)

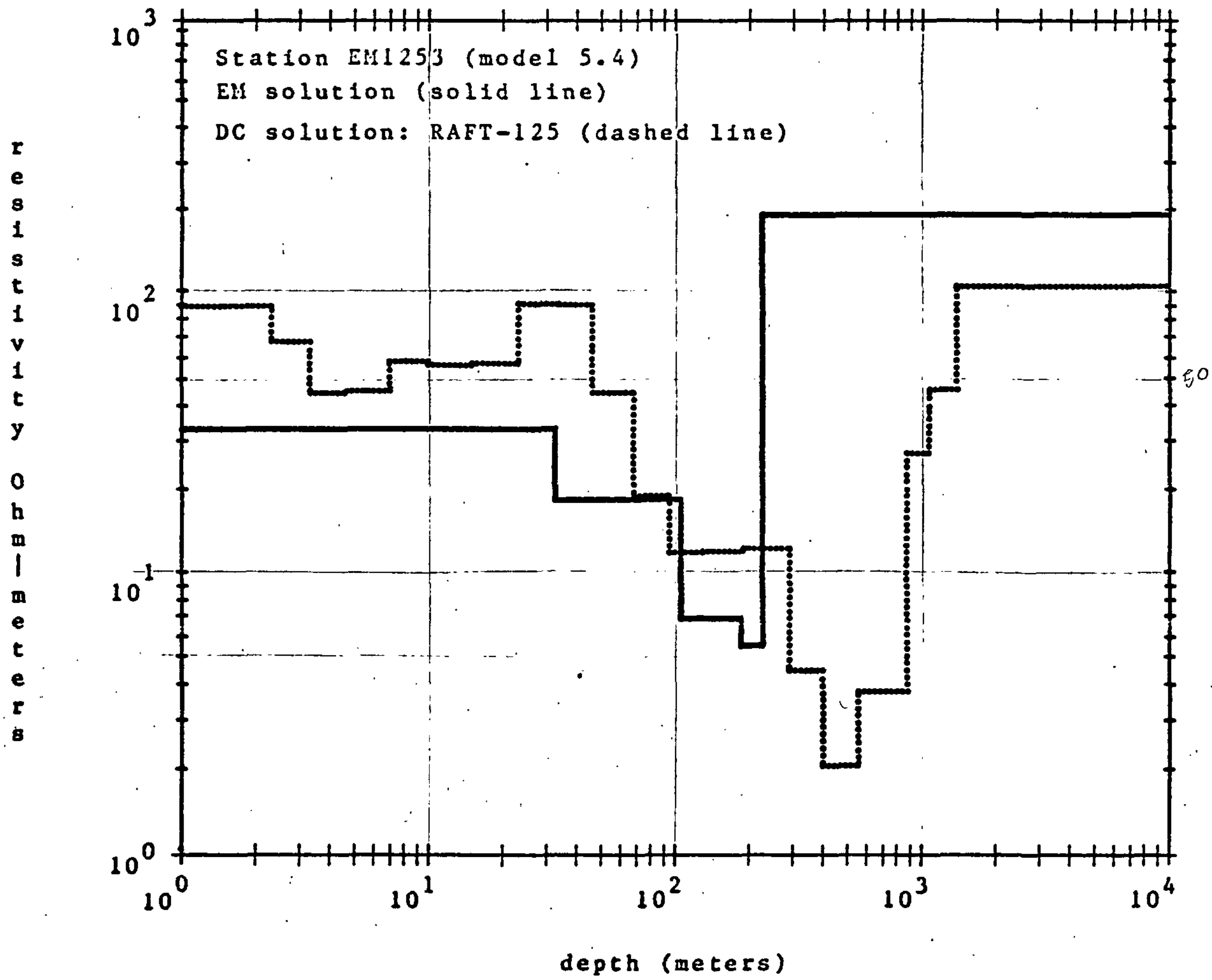


Station EM1252 (model 6.11)
EM solution (solid line)
DC solution: RAFT-5 (dashed line)
resistivity Ohm-meters
depth (meters)
10^0
10^1
10^2
10^3
10^4

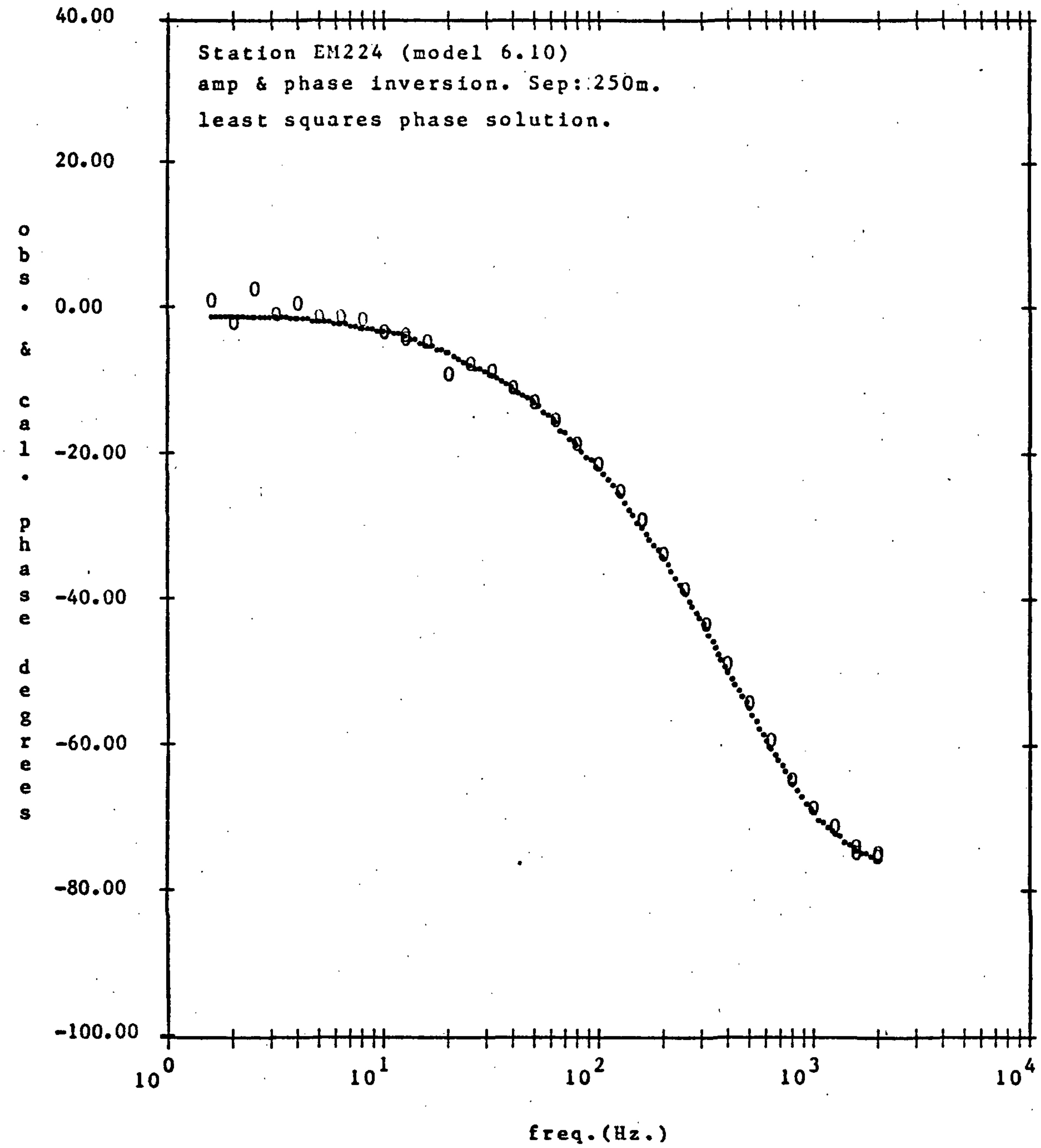

Station EM1253 (model 5.4)
amp & phase inversion. Sep: 349m.
least squares phase solution.
obs. & cal. phase degrees
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)
least squares phase residual.
residual
5.00
0.00
-5.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)

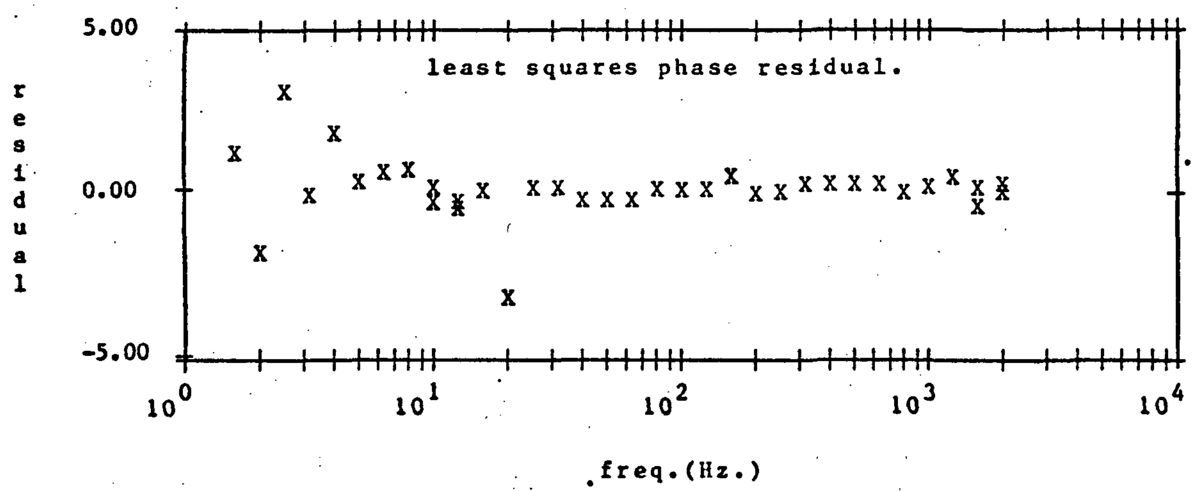

Station EM1253 (model 5.4)
amp & phase inversion. Sep: 349m.
least squares amplitude solution.
obs. & cal. amplitude
freq.(Hz.)

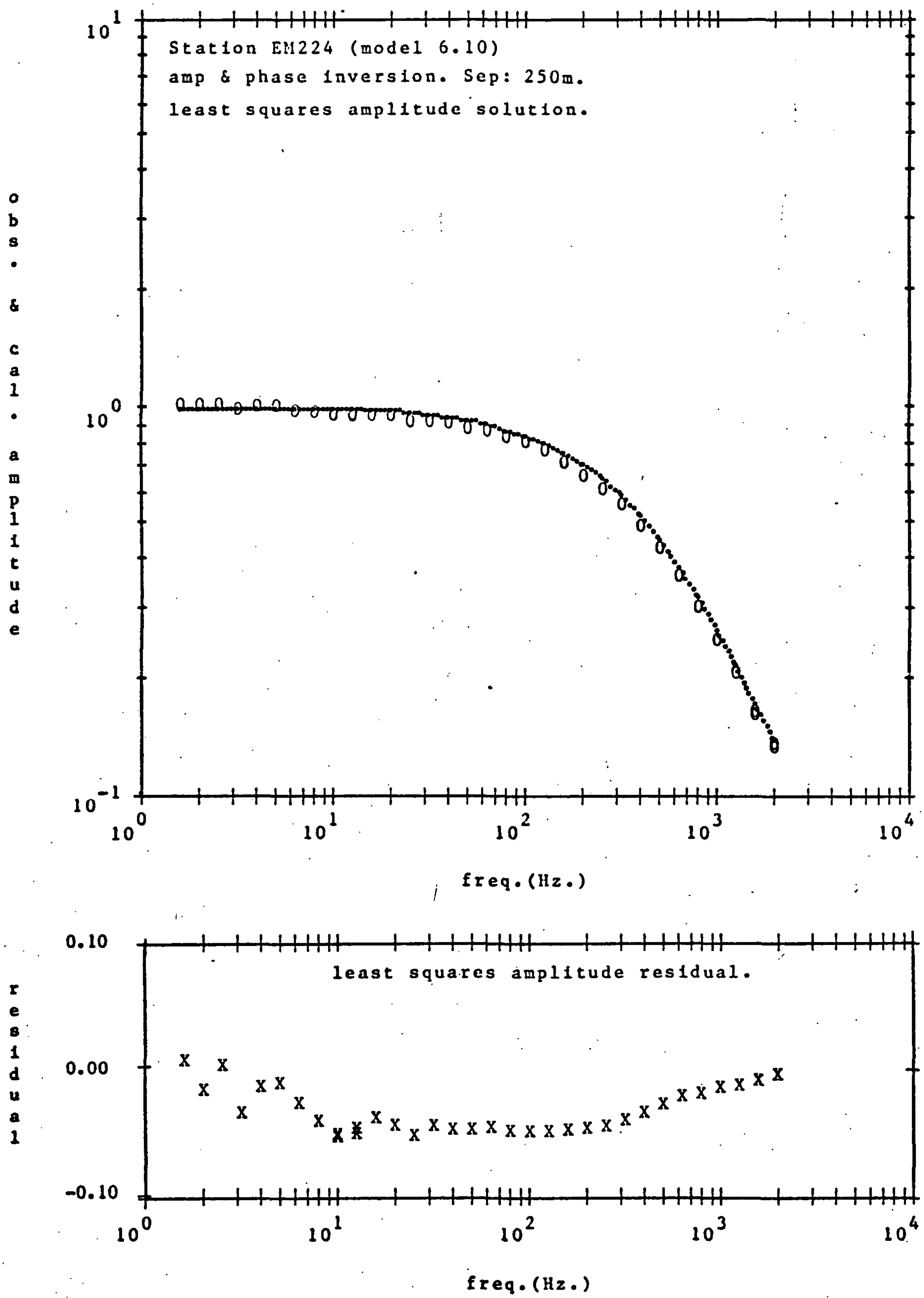

least squares amplitude residual.
residual
0.10
0.00
-0.10
freq.(Hz.)



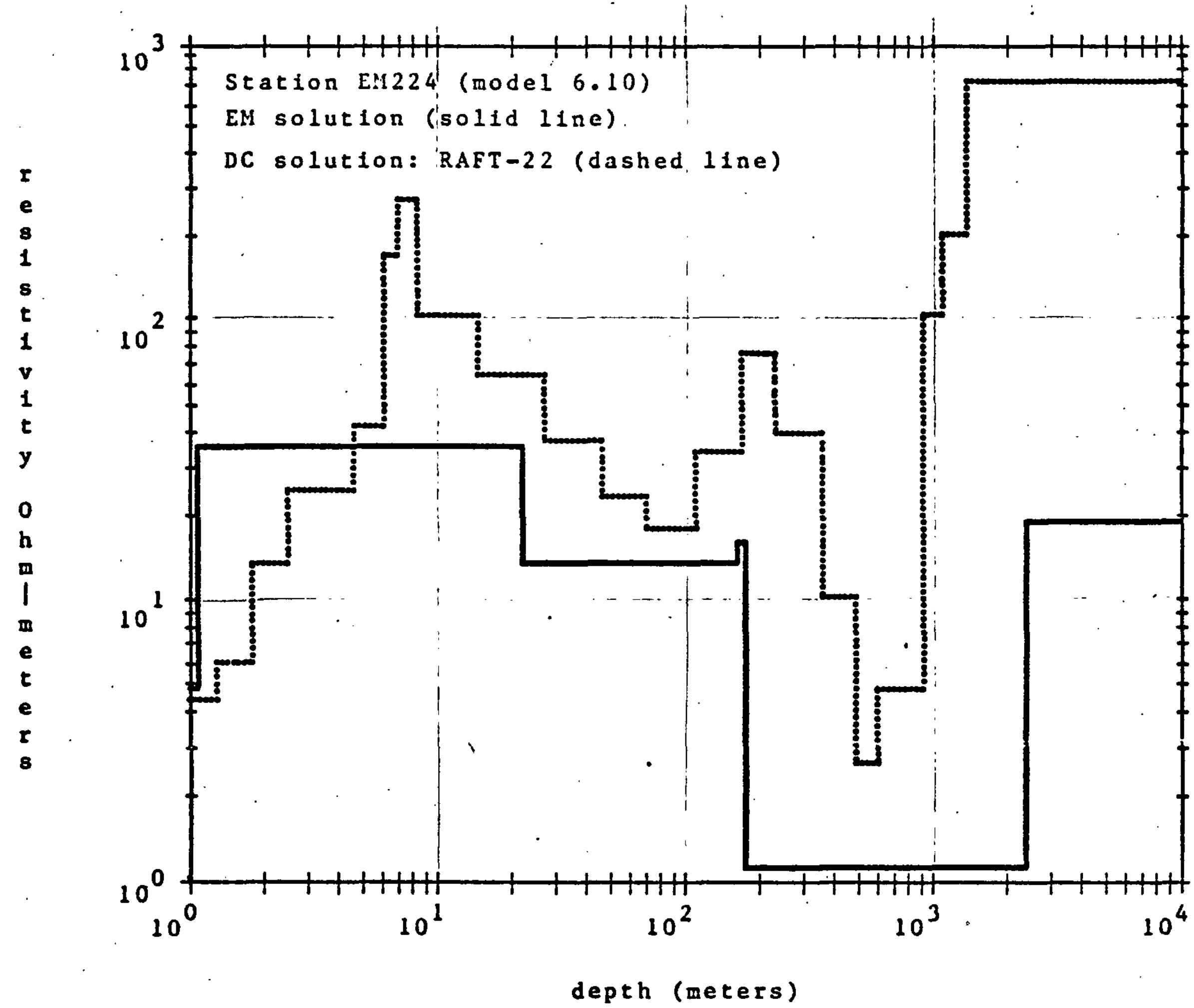
Station EM1253 (model 5.4)
EM solution (solid line)
DC solution: RAFT-125 (dashed line)
resistivity Ohm-meters
depth (meters)
10^0
10^1
10^2
10^3
10^4
50

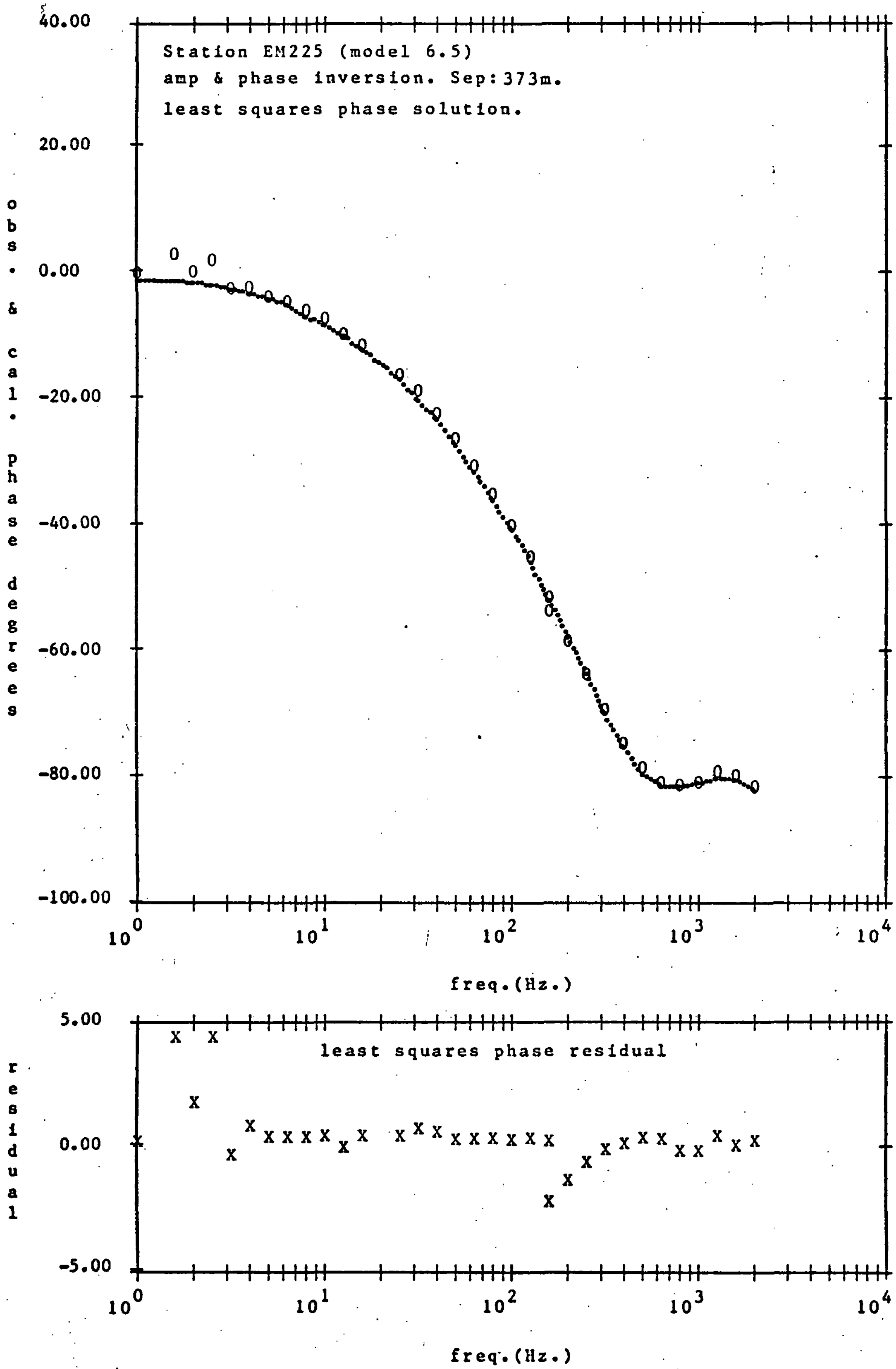

Station EM224 (model 6.10)
amp & phase inversion. Sep: 250m.
least squares phase solution.
obs. & cal. phase degrees
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)

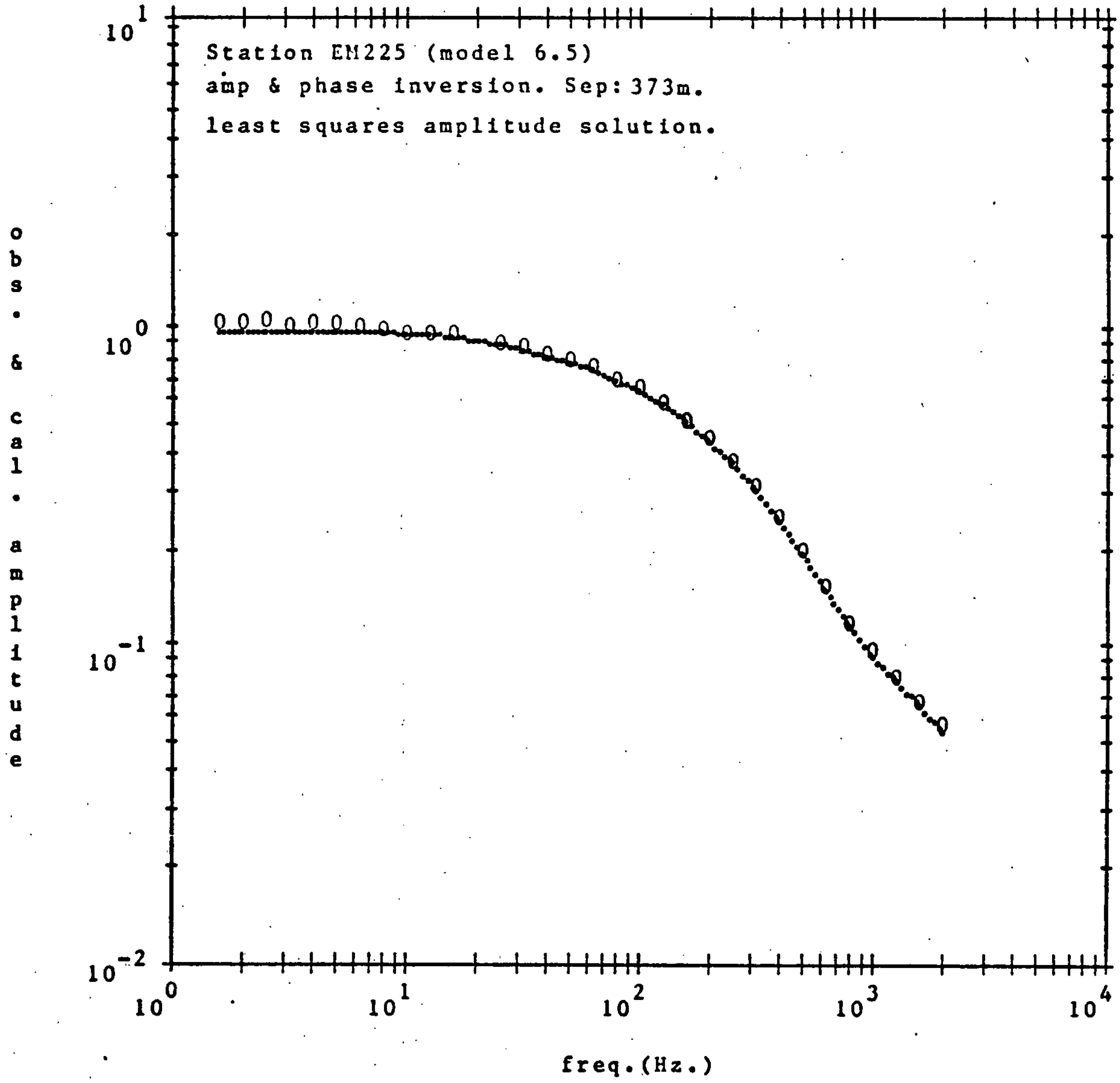

least squares phase residual.
residual
5.00
0.00
-5.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)

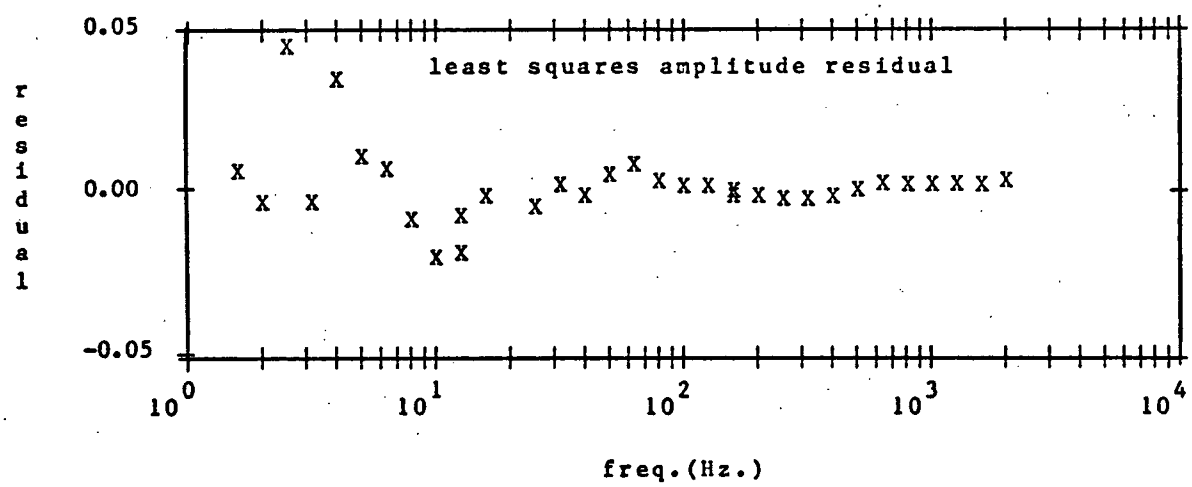


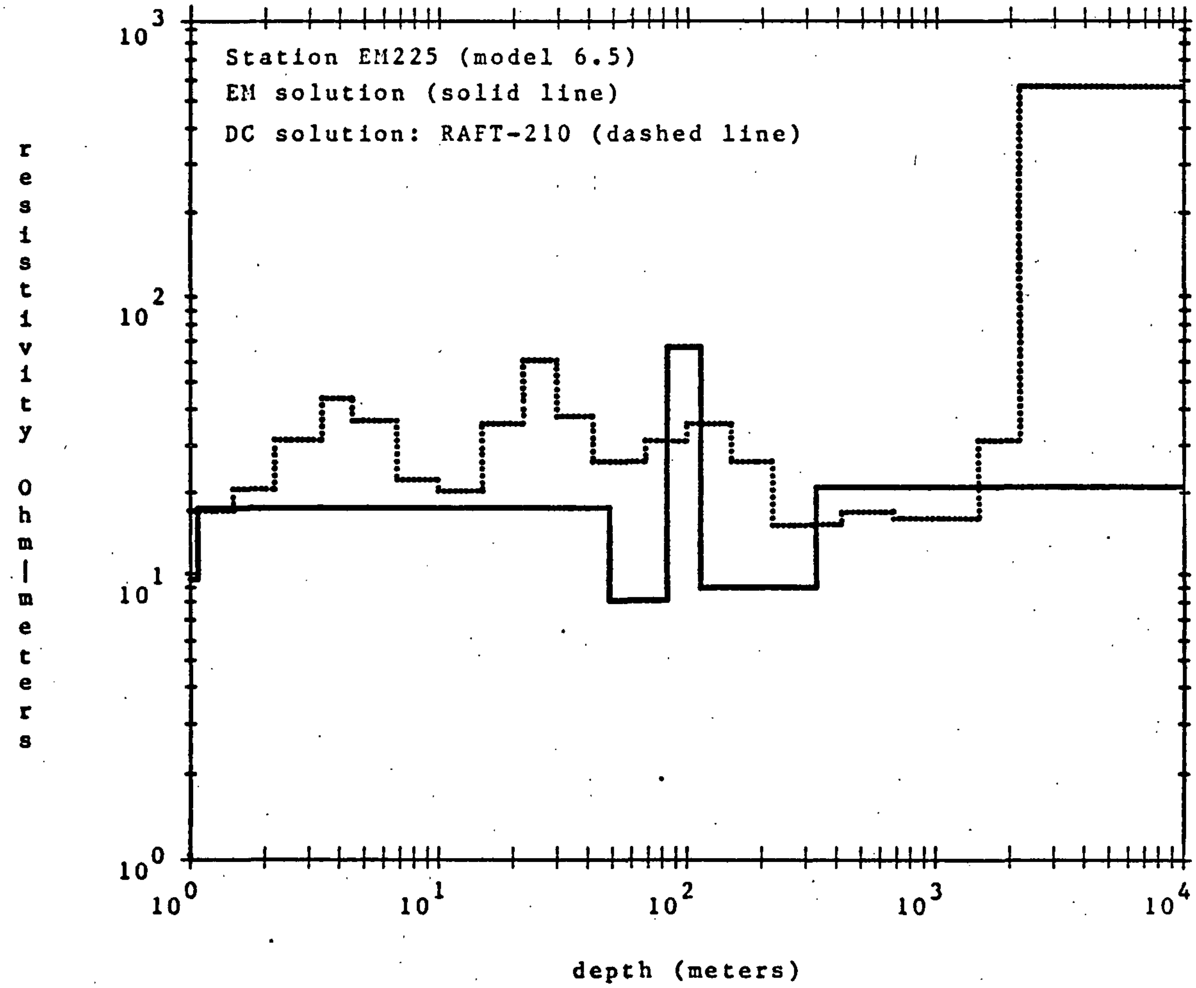
Station EM224 (model 6.10)
amp & phase inversion. Sep: 250m.
least squares amplitude solution.
obs. & cal. amplitude
10^1
10^0
10^{-1}
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)
least squares amplitude residual.
residual
0.10
0.00
-0.10
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)


Station EM224 (model 6.10)
EM solution (solid line)
DC solution: RAFT-22 (dashed line)
resistivity Ohm-meters
depth (meters)
10^0
10^1
10^2
10^3
10^4


Station EM225 (model 6.5)
amp & phase inversion. Sep:373m.
least squares phase solution.
obs. & cal. phase degrees
40.00
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)
least squares phase residual
residual
5.00
0.00
-5.00
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)


Station EM225 (model 6.5)
amp & phase inversion. Sep: 373m.
least squares amplitude solution.
obs. & cal. amplitude
10^1
10^0
10^{-1}
10^{-2}
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)


least squares amplitude residual
residual
0.05
0.00
-0.05
10^0
10^1
10^2
10^3
10^4
freq.(Hz.)


Station EM225 (model 6.5)
EM solution (solid line)
DC solution: RAFT-210 (dashed line)
resistivity ohm-meters
10^0
10^1
10^2
10^3
10^0
10^1
10^2
10^3
10^4
depth (meters)