8/30/78 - Errata - "Documentation of a Finite Element Program for Solution of Geophysical Problems Governed by the Inhomogeneous 2-D Scalar Helmholtz Equation" by John A. Stodt

Page 2 - Table I

Problem	
TM-MT	$p = -\hat{y}$ should read $p = -\hat{z}$
Line Source	$S = I\sigma(x)\delta(z)$ should read $S = I\delta(x)\delta(z)$

Page 3 - The second sentence should be replaced by "Any or all of σ, μ, and ε, may be considered piecewise constant functions of position, with suitable modifications to the input. The program is currently set up for conductivity variation."

Page 4 - Paragraph 2
The statement "The Greenfield algorithm (see e.g. Swift, 1967 - Appendix 3) is then used to solve the linear system of equations," should be replaced by "A modification of Gaussian elimination applicable to the solution of symmetric banded systems (see Cook, 1974, p. 47) is then used to solve the linear system of equations.". The actual method implemented in this program does not make use of Greenfield's factorization scheme.

Reference: Cook, Robert D., 1974. Concepts and Applications of Finite Element Analysis. John Wiley and Sons, Inc., New York, 402 p.

Page 18 - Figure 4
The node numbering for the quadrilateral element is inconsistent with the global numbering scheme described in figure 2. Note this correction and the correction to the form of the coefficient matrix in the revised figure 4.

Page 20 - Figure 5
Rows 3 and 4 and Columns 3 and 4 of the 5 x 5 matrix must be interchanged to make it compatible with the corrected node numbering scheme of figure 4. Note also the modification to the reduced 4 x 4 matrix.

Page 25 - After re-examining the auxiliary field calculations for the TM mode problem, I see no reason to include the one or two node air layer for this problem as long as the derivatives are calculated one node below the air earth-interface. One can experiment with this by setting M1=0 for no air layer.

Program listing - I have discovered an error in the program listing in the section where the element matrices are loaded into the global matrix. The programming error will not affect results from the program unless different conductivities are specified in triangles 1 and 3 of the quadrilateral element of figure 4. This would occur, for example, if one were trying to model a sloping interface. Corrections to the code are required on pages 37 and 41 of the listing. These corrected pages are provided, with the corrected lines of code highlighted. Sample runs for a sloping contact for both the TE and TM magnetotelluric problems are included from both the uncorrected and corrected versions of the program.

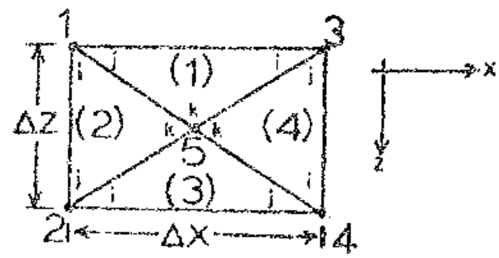
WE WISH TO MINIMIZE IN SOME SENSE THE ERROR ε.

LET'S TAKE $$\langle N_n^e \varepsilon \rangle = \iint_e N_n^e \varepsilon \, dx\, dz = 0 \qquad n = i, j, k$$

CARRYING OUT THE INTEGRATIONS:

$$\left\{ \frac{-1}{4K\Delta} \begin{bmatrix} B_i^2 + C_i^2 & B_iB_j + C_iC_j & B_iB_k + C_iC_k \\ & B_j^2 + C_j^2 & B_jB_k + C_jC_k \\ & & B_k^2 + C_k^2 \end{bmatrix} + \frac{P\Delta}{12} \begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix} \right\} \begin{bmatrix} \tilde{F}_i \\ \tilde{F}_j \\ \tilde{F}_k \end{bmatrix} = \begin{bmatrix} S_i \\ S_j \\ S_k \end{bmatrix}$$

IT'S MORE EFFICIENT TO DEAL WITH QUADRALATERAL ELEMENTS



THE COEFFICIENT MATRIX FOR THIS ELEMENT HAS THE FORM

$$\left[\begin{array}{cccc|c} A & B & C & O & D \\ & E & O & F & G \\ & & H & I & J \\ & & & K & L \\ \hline & & & & M \end{array}\right] \equiv \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \end{bmatrix}$$

Figure 4. Matrix equations associated with a triangular element; formation of quadrilateral element and associated matrix equation from combination of four triangular elements.

$$\begin{bmatrix}
-\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}+\frac{\Delta X}{\Delta Z}\right)\frac{(K_1+K_2)}{K_1K_2}+\frac{\Delta X\Delta Z}{24}(P_1+P_2) & -\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}-\frac{\Delta X}{\Delta Z}\right)\frac{1}{K_2}+\frac{\Delta X\Delta Z}{48}P_2 & \frac{1}{4}\left(\frac{\Delta Z}{\Delta X}-\frac{\Delta X}{\Delta Z}\right)\frac{1}{K_1}+\frac{\Delta X\Delta Z}{48}P_1 & 0 & \frac{1}{2}\left(\frac{\Delta X}{K_1\Delta Z}+\frac{\Delta Z}{K_2\Delta X}\right)+\frac{\Delta X\Delta Z}{48}(P_1+P_2) \\
 & -\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}+\frac{\Delta X}{\Delta Z}\right)\frac{(K_2+K_3)}{K_2K_3}+\frac{\Delta X\Delta Z}{24}(P_2+P_3) & 0 & \frac{1}{4}\left(\frac{\Delta Z}{\Delta X}-\frac{\Delta X}{\Delta Z}\right)\frac{1}{K_3}+\frac{\Delta X\Delta Z}{48}P_3 & \frac{1}{2}\left(\frac{\Delta X}{K_3\Delta Z}+\frac{\Delta Z}{K_2\Delta X}\right)+\frac{\Delta X\Delta Z}{48}(P_2+P_3) \\
 & & -\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}+\frac{\Delta X}{\Delta Z}\right)\frac{(K_1+K_4)}{K_1K_4}+\frac{\Delta X\Delta Z}{24}(P_1+P_4) & -\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}-\frac{\Delta X}{\Delta Z}\right)\frac{1}{K_4}+\frac{\Delta X\Delta Z}{48}P_4 & \frac{1}{2}\left(\frac{\Delta X}{K_1\Delta Z}+\frac{\Delta Z}{K_4\Delta X}\right)+\frac{\Delta X\Delta Z}{48}(P_1+P_4) \\
 & \text{SYMMETRIC} & & -\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}+\frac{\Delta X}{\Delta Z}\right)\frac{(K_3+K_4)}{K_3K_4}+\frac{\Delta X\Delta Z}{24}(P_3+P_4) & \frac{1}{2}\left(\frac{\Delta X}{K_3\Delta Z}+\frac{\Delta Z}{K_4\Delta X}\right)+\frac{\Delta X\Delta Z}{48}(P_3+P_4) \\
 & & & & -\frac{\Delta X}{\Delta Z}\left(\frac{K_1+K_3}{K_1K_3}\right)-\frac{\Delta Z}{\Delta X}\left(\frac{K_2+K_4}{K_2K_4}\right)+\frac{\Delta X\Delta Z}{24}(P_1+P_2+P_3+P_4)
\end{bmatrix}$$

$$\frac{1}{4}\left(\frac{\Delta Z}{\Delta X}+\frac{\Delta X}{\Delta Z}\right)\frac{(K_1+K_2)}{K_1K_2}+\frac{\Delta X\Delta Z}{24}(P_1+P_2)$$

STATIC CONDENSATION:

$$\begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \end{bmatrix}\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \end{bmatrix}$$

ELIMINATE X_2:

$$\left[K_{11}-K_{12}K_{22}^{-1}K_{21}\right]\left[X_1\right]=\left[R_1-K_{12}K_{22}^{-1}R_2\right]$$

OR:

$$[\tilde{K}][\tilde{X}]=[\tilde{R}]$$

WHERE

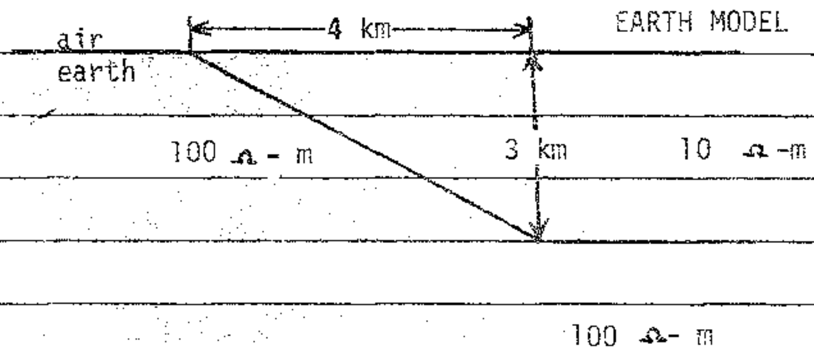
$$[\tilde{K}] = \begin{bmatrix}
A-\frac{D^2}{M} & B-\frac{GD}{M} & C-\frac{JD}{M} & -\frac{LD}{M} \\
 & E-\frac{G^2}{M} & -\frac{JG}{M} & F-\frac{LG}{M} \\
 & & H-\frac{J^2}{M} & I-\frac{LJ}{M} \\
 & & & K-\frac{L^2}{M}
\end{bmatrix}$$

Figure 5. Explicit form of the 5 x 5 coefficient matrix associated with the quadrilateral element of figure 4. Process of static condensation to reduce this matrix to a 4 x 4.

Appendix III - Program Listing

```
STUDT*PWLS1(1).MAIN1
C     THIS PROGRAM SOLVES THE TWO DIMENSIONAL LINE SOURCE AND TE AN
C     MAGNETOTELLURIC PROBLEM ACCORDING TO WHETHER THE INPUT PARAME
C     IDX=1,2, OR 3. THE FINITE ELEMENT METHOD IS USED WITH LINEAR
C     BASIS FUNCTIONS, MKS UNITS AND EXP(+JWT) TIME DEPENDENCE IS
C     ASSUMED. THE + COORDINATE DIRECTIONS FOR THE L.S. AND TE PROB
C     ARE X-NORTH, Y-EAST, Z-DOWN. FOR THE TM PROBLEM THEY ARE X-EA
C     Y-SOUTH, Z-DOWN. THE STRIKE DIRECTION IS ASSUMED N-S. THE ORI
C     IS AT THE LEFT EDGE OF THE MESH AT THE AIR-EARTH INTERFACE.
C
      PARAMETER IP1=31,IP4=50,IP6=30
     $,IP2=IP1*IP4,IP3=IP1+2,IP5=2*IP3
      PARAMETER NLAYR=3
      PARAMETER NLYR=NLAYR-1,NK=NLAYR+1,MDIM=2*NLAYR
      COMPLEX CK(4),CP(4),CK12,CK13,CK14,CK23,CK24,CK34,CP12,CP23,C
 ---> $CP14,CP1234,A11,A12,A13,A15,A22,A24,A25,A33,A34,A35,A44,A45,A
     $E11,G11,C11,H11,E22,H22,C22,E33,G33,E44,BC(IP4),
     $BC1(IP4),S1(IP2,5),S2(IP5,IP3),S(IP3,IP3),R(IP2),R1(IP5),ZERO
      COMPLEX XE(MDIM),XK(NK),DUM(MDIM,MDIM),EFLD,HFLD
      DIMENSION H(NLYR),P(NLAYR)
      COMMON/BLK2/DUM,XE,XK
      COMMON/BLK3/H,W
      COMMON/BLK1/S,S2,R,R1,NT1,NF1,NCOL1,NS1,NEQ1
      COMMON/BLK4/WU,WE,RHO,CK,CP
      COMMON/BLK5/XX,ZZ,BC,BC1,NTART,NODEX,NODEX1,NODEZ
      COMMON/BLK6/IDX,L,M
      INTEGER NPT(IP1,4,IP4),NX(IP6),NZ(IP6)
      REAL DELTAX(IP4),DELTAZ(IP1),DELX(IP6),DELZ(IP6),RHO(IP1,4,IP
     $,Y(10),XX(IP4),ZZ(IP4),RE(IP4),AIE(IP4)
C
C     ***************************************************************
C
      ZERO=(0.,0.)
      ELARGE=10E+15
      READ 1 IDX,NODEX,NODEZ,NXX,NZZ,NRES,M1,NPRINT,LINE1,LINE2
      READ 4 (Y(I),I=1,NRES),F          @INPUT MESH CONDUCTIVITIES
      READ 1 (NX(I),I=1,NXX)
      READ 4 (DELX(I),I=1,NXX)
      READ 1 (NZ(I),I=1,NZZ)
      READ 4 (DELZ(I),I=1,NZZ)
      NODEX1=NODEX-1
      NODEZ1=NODEZ-1
      DO 29 I=1,NODEZ1
      DO 29 L=1,4
      READ 48 (NPT(I,L,J),J=1,NODEX1)
29    CONTINUE
      PRINT 20 IDX
      PRINT 410 NODEX,NODEZ,NXX,NZZ,NRES,M1,NPRINT,LINE1,LINE2
      PRINT 420
      PRINT 300 (Y(I),I=1,NRES),F
      PRINT 430
      PRINT 1 (NX(I),I=1,NXX)
      PRINT 440
      PRINT 300 (DELX(I),I=1,NXX)
      PRINT 450
      PRINT 1 (NZ(I),I=1,NZZ)
      PRINT 460
```

```
      CK14=(CK(1)+CK(4))/(CK(1)*CK(4))
      CK23=(CK(2)+CK(3))/(CK(2)*CK(3))
      CK24=(CK(2)+CK(4))/(CK(2)*CK(4))
      CK34=(CK(3)+CK(4))/(CK(3)*CK(4))
      CP12=CP(1)+CP(2)
      CP23=CP(2)+CP(3)
      CP34=CP(3)+CP(4)
      CP14=CP(1)+CP(4)
      CP1234=CP12+CP34
C
C     THESE ARE THE ELEMENTS OF THE 5 X 5 MATRIX.
C
      A11=A*CK12+2.*C*CP12
      A12=-B/CK(2)+C*CP(2)
      A13=B/CK(1)+C*CP(1)
      A15=DELXZ/CK(1)+DELZX/CK(2)+C*CP12
      A22=A*CK23+2.*C*CP23
      A24=B/CK(3)+C*CP(3)
      A25=DELXZ/CK(3)+DELZX/CK(2)+C*CP23
      A33=A*CK14+2.*C*CP14
      A34=-B/CK(4)+C*CP(4)
      A35=DELXZ/CK(1)+DELZX/CK(4)+C*CP14
      A44=A*CK34+2.*C*CP34
      A45=DELXZ/CK(3)+DELZX/CK(4)+C*CP34
      A55=2.*(C*CP1234-DELXZ*CK13-DELZX*CK24)
C
C     THESE ARE THE ELEMENTS OF THE 4 X 4 CONDENSED MATRIX.
C
      E11=A11-A15*A15/A55
      G11=A12-A15*A25/A55
      C11=A13-A15*A35/A55
      H11=-A15*A45/A55
      E22=A22-A25*A25/A55
      H22=-A25*A35/A55
      C22=A24-A25*A45/A55
      E33=A33-A35*A35/A55
      G33=A34-A35*A45/A55
      E44=A44-A45*A45/A55
C
C     THIS SECTION LOADS THE ELEMENT MATRICIES INTO THE GLOBAL MATRI
C
      S1(L1,1)=S1(L1,1)+E11
      S1(L1,2)=S1(L1,2)+G11
      S1(L1,4)=S1(L1,4)+C11
      S1(L1,5)=S1(L1,5)+H11
      L2=L1+1
      S1(L2,1)=S1(L2,1)+E22
      S1(L2,3)=S1(L2,3)+H22
      S1(L2,4)=S1(L2,4)+C22
      L3=L1+NODEZ
      S1(L3,1)=S1(L3,1)+E33
      S1(L3,2)=S1(L3,2)+G33
      L4=L3+1
      S1(L4,1)=S1(L4,1)+E44
   13 L1=L1+1
      IF(IDX.NE.1)GO TO 14
```

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[illegible]
[illegible]
[illegible]
[illegible]
PARAMETER [illegible] 2
[illegible] 31
BLOCKS HORIZONTALLY= 17  BLOCKS VERTICALLY= 20
[illegible] 4  BLOCKS OF AIR= 9  [illegible] 0
[illegible]
[illegible] CONDUCTIVITIES AND FREQUENCY
   [illegible]   .1000-01   .1000+00   .1000-01   .1000+01
NUMBERS OF EQUAL SIZED INCREMENTS HORIZONTALLY
   3  [illegible]  1  1  3  2  3  1  3  1  5  5  3
SIZE OF THE INCREMENTS IN EACH HORIZONTAL BLOCK(M)
   [illegible]   [illegible]   [illegible]   .3000+03   .7500+02   .2000+02   .5000+01   .4000+01   .1200+02   .3500+02
   .1...+05   .3240+03   .9720+03   .3240+03   .1000+04   .3000+04   .1000+05
NUMBERS OF EQUAL SIZED INCREMENTS VERTICALLY
   [illegible]  3  2  3  1  3  1  1  1  2  3
SIZE OF THE INCREMENTS IN EACH VERTICAL BLOCK(M)
   [illegible]   [illegible]   .3000+04   .1000+04   .3000+03   .1000+03   .3000+02   .1000+02   .3000+01   .3500+01
   [illegible]   [illegible]   [illegible]   .2430+03   .7290+03   .2430+03   .2500+03   .1000+04   .3000+04   .1000+05
FINITE ELEMENT MESH CONNECTIVITY CODE
   [illegible] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   [illegible]
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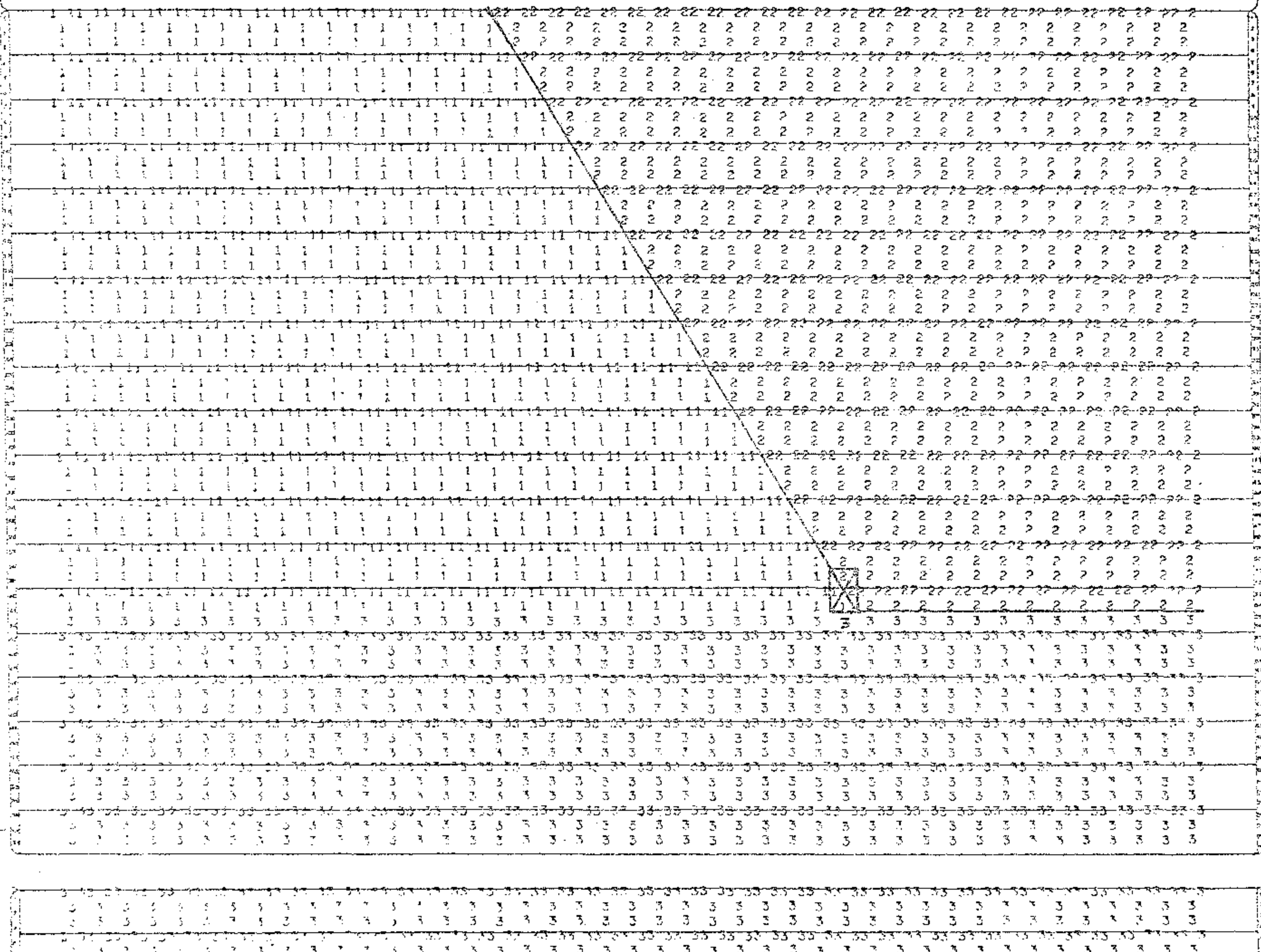

LEFT [illegible] INTERFACE DEPTHS[illegible] AND RESISTIVITIES corrected results - TE mode

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[illegible]	[illegible]	.170-05	.137-02	.799+02	.532-02	.870-04	.532-02	.643+00	.109-03	.106-03	.149-03	.453+02	98.996	44.351
[illegible]	[illegible]	[illegible]	[illegible]	.262+02	.525-02	.953-04	.525-02	.484+00	.103-03	.106-03	.148-03	.457+02	100.629	45.190
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-17.[illegible]	.150-05	.761-04	.761-04	.899+02	.514-02	.152-03	.515-02	.159+01	.992-04	.106-03	.145-03	.469+02	100.766	45.196
[illegible]	[illegible]	.111-05	.111-03	.944+02	.509-02	.189-03	.509-02	.213+01	.971-04	.106-03	.144-03	.475+02	101.093	45.365
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[illegible]	.754-03	.823-03	.876-03	.152+03	.452-02	.723-04	.452-02	.923+00	.728-04	.891-04	.115-03	.507+02	81.932	49.825
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[illegible]	.147-02	.172-02	.193-02	.177+03	.472-02	-.561-04	.473-02	-.681+00	.659-04	.675-04	.943-04	.457+02	50.465	45.398
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[illegible]	.214-02	-.111-05	.214-02	-.180+03	.483-02	.130-05	.483-02	.166-01	.654-04	.659-04	.931-04	.450+02	47.175	45.021
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[illegible]	.21[illegible]-02	[illegible]	.21[illegible]-02	-.179+03	.491-02	.635-04	.491-02	.739+00	.655-04	.654-04	.929-04	.448+02	45.322	44.039
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[illegible]	[illegible]	[illegible]	.151-02	.164+03	.666-02	.226-03	.666-02	.194+01	.595-04	.402-04	.718-04	.340+02	14.729	32.055
2.[illegible]	[illegible]	[illegible]	.173-02	.164+03	.668-02	-.2[illegible]-03	.668-02	-.180+01	.524-04	.331-04	.620-04	.323+02	10.392	34.143
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[illegible]	[illegible]	[illegible]	.619-03	.858+02	.607-02	-.616-03	.610-02	-.580+01	.402-04	.302-04	.503-04	.369+02	8.612	42.729
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.311-04	[illegible]	[illegible]	8.779	[illegible]
[illegible]	.521-13	.173-05	.173-03	.849+02	.572-02	-.481-03	.575-02	-.482+01	.366-04	.319-04	.485-04	.411+02	8.861	45.960
[illegible]	[illegible]	[illegible]	.157-04	.864+02	.566-02	-.393-03	.569-02	-.404+01	.359-04	.323-04	.485-04	.422+02	9.313	46.292
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.325-04	[illegible]	[illegible]	[illegible]	[illegible]
11.[illegible]	.077-05	[illegible]	.251-04	.917+02	.551-02	-.219-03	.552-02	-.228+01	.349-04	.332-04	.481-04	.456+02	9.627	45.863
14.[illegible]	[illegible]	.214-14	.219-04	.971+02	.547-02	-.164-03	.547-02	-.172+01	.343-04	.331-04	.477-04	.440+02	9.607	45.493
17.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.338-04	.330-04	.473-04	[illegible]	[illegible]	[illegible]
[illegible]	.164-16	.170-06	.150-06	.907+02	.549-02	-.101-03	.551-02	-.107+01	.335-04	.330-04	.470-04	.498+02	9.584	45.697
23.[illegible]	[illegible]	[illegible]	[illegible]	.803+02	.538-02	-.768-04	.538-02	-.817+00	.332-04	.330-04	.468-04	.449+02	9.500	45.673
[illegible]	[illegible]	[illegible]	[illegible]	.914+02	.553-02	[illegible]	.553-02	-.451+00	.327-04	.330-04	.465-04	.455+02	[illegible]	[illegible]
[illegible]	.026-16	.252-05	.265-05	.717+02	.534-02	.152-04	.534-02	.163+00	.324-04	.330-04	.463-04	.455+02	9.496	45.359

3

uncorrected results - TE mode

[illegible]	RE(RZ)	IM(RZ)	|RZ|	PHZ	RE(ETR)	IM(ETR)	|ETR|	PHZ	RE(EPL)	IM(EPL)	|EPL|	PHZ	RP,RES.	RPRZ(Z)
-4[illegible].[illegible]70	.251-15	.129-03	.131-03	.790+02	.552-02	.820-04	.552-02	.882+00	.105-03	.106-03	.149-03	.453+02	99.907	44.391
-3[illegible]	.178-15	.249-03	.249-03	.861+02	.525-02	.443-04	.525-02	.483+00	.103-03	.106-03	.148-03	.457+02	100.627	45.780
-2[illegible]	[illegible]	.503-03	.503-03	.872+02	.519-02	.122-03	.519-02	.135+01	.101-03	.106-03	.146-03	.464+02	100.385	45.895
-17.174	.398-15	.759-03	.759-03	.898+02	.515-02	.151-03	.515-02	.169+01	.992-04	.106-03	.145-03	.469+02	100.768	45.195
-1[illegible]	.[illegible]21-15	.110-03	.110-03	.903+02	.509-02	.199-03	.509-02	.213+01	.971-04	.106-03	.144-03	.475+02	101.096	45.352
-11.[illegible]	[illegible]-04	.165-03	.164-03	.102+03	.499-02	.225-03	.5[illegible]-02	.258+01	.940-04	.106-03	.145-03	.483+02	101.[illegible]	45.737
-[illegible]	.110-[illegible]	.245-03	.270-03	.115+03	.486-02	.244-03	.487-02	.287+01	.893-04	.104-03	.137-03	.494+02	100.448	46.576
-[illegible]	[illegible]	.251-03	.252-03	.129+03	.470-02	.216-03	.470-02	.263+01	.824-04	.100-03	.130-03	.506+02	96.377	47.948
[illegible]	[illegible]-03	[illegible]	.[illegible]7-03	.130+03	.464-02	.182-03	[illegible]	.225+01	.795-04	.977-04	.126-03	.509+02	9[illegible].212	48.611
-5.476	.[illegible]5-03	.421-03	.651-03	.142+03	.458-02	.176-03	.458-02	.175+01	.763-04	.942-04	.121-03	.510+02	89.716	49.285
-2.[illegible]36	.[illegible]51-03	[illegible]	.362-03	.150+03	.453-02	.731-04	.453-02	.926+00	.720-04	.892-04	.115-03	.509+02	81.[illegible]	49.853
-1.[illegible]	[illegible]-02	[illegible]-03	.116-02	.157+03	.451-02	-.334-05	.451-02	-.425-01	.694-04	.723-04	.100-03	.499+02	72.[illegible]	[illegible]
-.[illegible]7[illegible]	[illegible]	.256-03	.166-02	.171+03	.450-02	-.722-05	.450-02	-.902+00	.664-04	.721-04	.981-04	.474+02	57.[illegible]57	48.281
-.175	.1[illegible]5-12	.115-03	.193-02	.177+03	.473-02	-.567-04	.473-02	-.687+00	.659-04	.690-04	.957-04	.459+02	5[illegible].765	46.566
[illegible]	[illegible]	[illegible]-03	[illegible]	.179+03	.479-02	-.250-06	.479-02	-.278+00	.659-04	.668-04	.938-04	.454+02	4[illegible].577	45.725
-[illegible]	[illegible]-02	.271-04	.210-02	.179+03	.492-02	-.756-05	.492-02	-.900-01	.659-04	.665-04	.936-04	.453+02	47.886	45.379
-[illegible]	[illegible]-02	.1[illegible]1-03	.210-02	.180+03	.493-02	-.250-05	.493-02	-.296-02	.659-04	.664-04	.935-04	.453+02	47.[illegible]54	45.257
-[illegible]	.21[illegible]-02	.3[illegible]6-03	.21[illegible]-02	.180+03	.494-02	.720-05	.494-02	.802-01	.659-04	.669-04	.935-04	.452+02	47.[illegible]	45.1[illegible]
-[illegible]	.211-02	-.[illegible]-05	.211-02	-.180+03	.497-02	.540-06	.497-02	.411+00	.659-04	.662-04	.934-04	.451+02	46.513	44.729
-.[illegible]40	.212-02	-.1[illegible]-03	.212-02	-.180+03	.499-02	.502-04	.499-02	.691+00	.659-04	.660-04	.932-04	.451+02	45.767	44.361
-[illegible]	.212-02	-.1[illegible]	.213-02	-.170+03	[illegible]	.755-0[illegible]	.4[illegible]5-02	.925+00	.659-04	.656-04	.931-04	.450+02	[illegible]	[illegible]
.05[illegible]	.210-02	-.[illegible]3-05	.215-02	-.180+03	.501-02	.134-03	.502-02	.153+01	.659-04	.652-04	.926-04	.447+02	43.209	43.167
.[illegible]35	.21[illegible]-02	.703-05	.216-02	.180+03	.50[illegible]-02	.136-03	.509-02	.210+01	.659-04	.646-04	.922-04	.444+02	41.619	42.327
[illegible]	[illegible]7-02	[illegible]	.217-02	.178+03	.525-02	.298-03	.529-02	.323+01	.658-04	.627-04	.909-04	.436+02	37.432	40.373
.2[illegible]	.21[illegible]-02	.127-03	.215-02	.177+03	.545-02	.392-03	.546-02	.401+01	.659-04	.609-04	.896-04	.428+02	34.[illegible]4	38.771
.2[illegible]	.211-02	.209-03	.212-02	.175+03	.560-02	.435-03	.562-02	.444+01	.656-04	.590-04	.883-04	.420+02	31.[illegible]72	37.541
[illegible]	[illegible]-02	[illegible]-03	[illegible]	.168+03	.597-02	[illegible]-03	.599-02	.452+01	.6[illegible]-04	.538-04	.843-04	.397+02	25.049	35.[illegible]
1.0[illegible]	.1[illegible]2-02	.75[illegible]-03	.154-02	.149+03	.659-02	.221-03	.659-02	.199+01	.597-04	.419-04	.724-04	.345+02	15.291	32.51[illegible]
2.52[illegible]	[illegible]2-03	.873-03	.11[illegible]-02	.128+03	.668-02	-.197-03	.668-02	-.169+01	.527-04	.336-04	.625-04	.325+02	11.[illegible]86	3[illegible].[illegible]85
3.[illegible]	[illegible]	.727-03	[illegible]	[illegible]	.?56-02	-.594-03	.6[illegible]8-02	-.837+01	.463-04	.3[illegible]6-04	.595-04	.3[illegible]4+02	[illegible]	[illegible]
3.[illegible]	[illegible]	.[illegible]71-03	.[illegible]0[illegible]-03	.[illegible]8[illegible]+02	.636-02	-.552-03	.639-02	-.497+01	.445-04	.302-04	.538-04	.342+02	[illegible]4	39.137
4.[illegible]	[illegible]	.417-03	.421-03	.[illegible]24+02	.60[illegible]-02	-.614-03	.611-02	-.577+01	.4[illegible]4-04	.303-04	.505-04	.369+02	9.637	42.5[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]54+02	.587-02	-.5[illegible]-03	.590-02	-.559+01	.379-04	.321-04	.491-04	.39[illegible]+02	[illegible]	[illegible]
5.[illegible]	[illegible]	.126-03	.1[illegible]5-03	.[illegible]2+02	.572-02	-.494-03	.574-02	-.493+01	.366-04	.319-04	.486-04	.411+02	[illegible]61	45.[illegible]23
7.[illegible]24	[illegible]	.078-0[illegible]	.0[illegible]1-0[illegible]	.470+02	.564-02	-.400-03	.565-02	-.406+01	.359-04	.325-04	.485-04	.427+02	[illegible].312	46.216
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.55[illegible]-02	-.331-03	.5[illegible]-02	-.3[illegible]+01	.356-04	.32[illegible]-04	.48[illegible]-04	.42[illegible]+02	[illegible]	[illegible]
1[illegible]	[illegible]	.2[illegible]2-0[illegible]	.2[illegible]5-0[illegible]	.[illegible]20+02	.55[illegible]-02	-.229-03	.552-02	-.229+01	.349-04	.332-04	.4[illegible]1-04	.436+02	[illegible].627	45.[illegible]64
14.[illegible]	.275-[illegible]5	.21[illegible]-04	.2[illegible]1-04	.[illegible]72+02	.547-02	-.165-03	.5[illegible]7-02	-.172+01	.343-04	.331-04	.477-04	.440+02	9.607	45.695
[illegible]	[illegible]	.177-04	.17[illegible]-0[illegible]	[illegible]+02	.5[illegible]3-02	-.129-03	[illegible]	-.136+01	.338-04	.330-04	.473-04	.443+02	[illegible]	[illegible]
20.[illegible]2[illegible]	.10[illegible]	.131-03	.131-03	.9[illegible]9+02	.540-02	-.101-03	.541-02	-.107+01	.335-04	.330-04	.47[illegible]-04	.446+02	9.584	45.697
23.[illegible]2[illegible]	.2[illegible]3-[illegible]6	.1[illegible]1-04	.1[illegible]1-04	.934+02	.538-02	-.769-04	.55[illegible]-02	-.819+00	.332-04	.330-04	.468-04	.449+02	[illegible].590	45.673
33.[illegible]2[illegible]	.127-[illegible]	.[illegible]57-05	.[illegible]57-05	.[illegible]15+02	.533-02	-.421-04	.533-02	-.452+00	.327-04	.330-04	.465-04	.453+02	[illegible].613	[illegible].795
[illegible]3.[illegible]2[illegible]	.[illegible]62-[illegible]6	.2[illegible]3-05	.2[illegible]6-05	.7[illegible]0+02	.534-02	.152-04	.534-02	.163+00	.324-04	.330-04	.453-04	.455+02	[illegible].406	45.359

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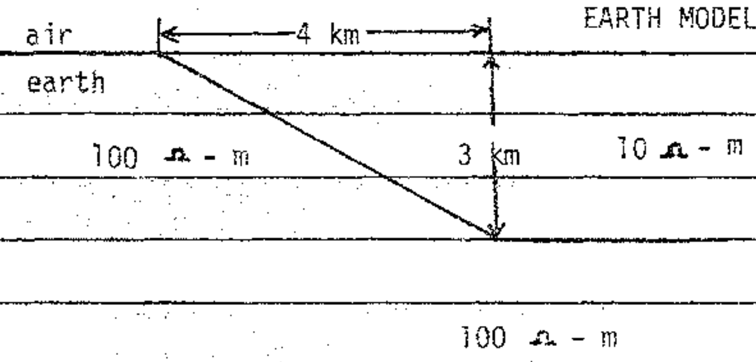


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SIZE OF THE INCREMENTS IN EACH HORIZONTAL BLOCK(M)
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      [illegible]      .3240+03      .9720+03      .3240+03      .1000+04      .3000+04      .1000+05
NUMBERS OF EQUAL SIZED INCREMENTS VERTICALLY
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SIZE OF THE INCREMENTS IN EACH VERTICAL BLOCK(M)
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      [illegible]      [illegible]      .1000+05
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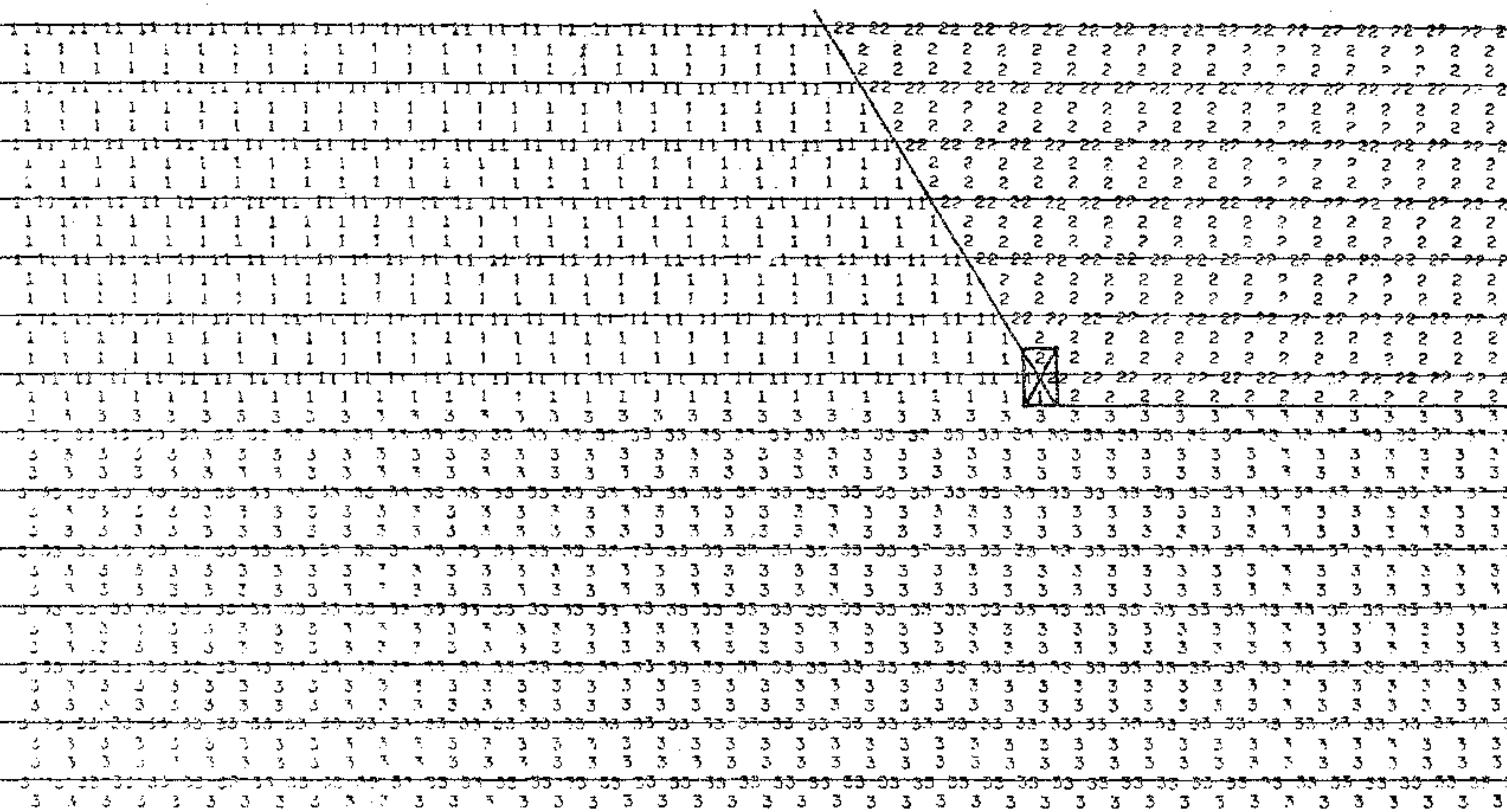

LEFT EDGE INTERFACE DEPTHS(M) AND RESISTIVITIES

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.1000+03 .1000+03 .1000+03

RIGHT EDGE INTERFACE DEPTHS(M) AND RESISTIVITIES

[illegible] [illegible]

.1000+02 .1000+03 .1000+03

corrected results - TM mode

FREQ	RE(FZ)	IM(FZ)	|FZ|	PHZ	RE(FTP)	IM(FTP)	|FTP|	PHI	RE(FPL)	IM(FPL)	|FPL|	PHZ	AP.RES.	PHZ(Z)
-41.476	-.373-12	.503-13	.375-12	.176+03	.106-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.805	44.915
-39.476	-.394-11	-.972-14	.262-11	-.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.627	44.918
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.747	44.919
-17.475	-.291-11	-.130-15	.291-11	-.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.720	44.934
-14.475	-.979-11	.770-15	.979-11	.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.578	44.950
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.165	44.919
-9.476	-.329-24	-.502-16	.502-16	-.900+02	.105-03	.104-03	.148-03	.447+02	.531-02	-.280-06	.531-02	-.302-02	99.398	44.676
-5.475	.034-10	-.417-14	.034-10	-.287-02	.107-03	.102-03	.148-03	.437+02	.531-02	-.280-06	.531-02	-.302-02	98.157	43.658
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.429+02	.531-02	-.280-06	.531-02	-.302-02	[illegible]	42.895
-3.476	-.204-10	-.179-15	.204-10	-.180+03	.112-03	.999-04	.150-03	.417+02	.531-02	-.280-06	.531-02	-.302-02	101.245	41.735
-2.476	.291-10	-.175-14	.291-10	-.345-02	.118-03	.992-04	.154-03	.400+02	.531-02	-.280-05	.531-02	-.302-02	107.004	40.019
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.165-03	.375+02	.531-02	-.280-06	.531-02	-.302-02	[illegible]	[illegible]
-.476	[illegible]	-.120-13	.416-10	-.180+03	.178-03	.118-03	.213-03	.337+02	.531-02	-.280-06	.531-02	-.302-02	204.515	33.477
-.176	[illegible]	-.274-13	.419-09	-.222+01	.259-03	.163-03	.306-03	.322+02	.531-02	-.280-06	.531-02	-.302-02	420.416	32.252
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.319+02	.531-02	-.280-06	.531-02	-.302-02	[illegible]	[illegible]
-.081	-.367-08	-.876-16	.367-08	-.179+03	.563-03	.350-03	.663-03	.318+02	.531-02	-.280-06	.531-02	-.302-02	1975.855	31.842
-.076	-.274-08	-.142-07	.274-08	-.177+03	.799-03	.495-03	.939-03	.318+02	.531-02	-.280-06	.531-02	-.302-02	3959.826	31.829
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.116-03	.722-04	.137-03	.318+02	.531-02	-.280-06	.531-02	-.302-02	[illegible]	[illegible]
[illegible]	.149-09	-.143-09	.206-09	.446+02	.976-04	.606-04	.115-03	.319+02	.531-02	-.280-06	.531-02	-.302-02	59.317	31.850
[illegible]	-.437-09	-.626-09	.772-09	-.124+03	.651-04	.530-04	.100-03	.319+02	.531-02	-.280-06	.531-02	-.303-02	45.197	31.913
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.771-04	[illegible]	[illegible]	.320+02	.531-02	-.282-06	.531-02	-.304-02	[illegible]	31.998
[illegible]	.259-07	.256-07	.365-07	.447+02	.646-04	.497-04	.762-04	.323+02	.531-02	-.264-06	.531-02	-.285-02	26.970	32.263
[illegible]	.150-07	.391-07	.510-07	.686+02	.577-04	.369-04	.685-04	.326+02	.531-02	-.970-07	.531-02	-.105-02	21.103	32.504
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.477-04	.318-04	.574-04	.337+02	.531-02	-.966-07	.531-02	-.955-03	14.795	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-.173+03	.427-04	.298-04	.521-04	.349+02	.531-02	-.883-07	.531-02	-.953-03	12.193	34.877
[illegible]	[illegible]	.176-10	[illegible]	[illegible]	.395-04	.268-04	.438-04	.361+02	.531-02	-.880-07	.531-02	-.950-03	10.715	36.104
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.531-02	-.880-07	.531-02	-.950-03	9.775	[illegible]
[illegible]	.229-12	.709-16	.310-12	.153+01	.297-04	.313-04	.431-04	.464+02	.531-02	-.880-07	.531-02	-.950-03	9.362	46.429
[illegible]	.496-12	-.127-14	.470-12	-.971-01	.302-04	.338-04	.453-04	.482+02	.531-02	-.880-07	.531-02	-.950-03	9.234	48.158
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.476+02	.531-02	-.880-07	.531-02	-.950-03	[illegible]	47.797
3.924	.219-11	[illegible]	.219-11	-.173-02	.319-04	.349-04	.472-04	.475+02	.531-02	-.880-07	.531-02	-.950-03	10.014	47.408
4.924	.582-11	-.133-16	.582-11	-.131-02	.327-04	.345-04	.475-04	.466+02	.531-02	-.880-07	.531-02	-.950-03	10.158	46.598
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.460+02	.531-02	-.880-07	.531-02	-.950-03	[illegible]	[illegible]
5.924	.116-11	-.950-17	.116-11	-.437-03	.329-04	.337-04	.471-04	.457+02	.531-02	-.880-07	.531-02	-.950-03	9.956	45.659
7.924	-.611-11	.111-15	.611-11	.180+03	.328-04	.334-04	.468-04	.455+02	.531-02	-.880-07	.531-02	-.950-03	9.937	45.591
[illegible]	[illegible]	.279-17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.455+02	.531-02	-.880-07	.531-02	-.950-03	9.768	45.517
11.924	.473-12	-.112-16	.473-12	-.777-03	.323-04	.331-04	.462-04	.456+02	.531-02	-.880-07	.531-02	-.950-03	9.615	45.635
[illegible]	-.121-12	[illegible]	.121-12	.180+03	.322-04	.331-04	.462-04	.455+02	.531-02	-.880-07	.531-02	-.950-03	9.593	45.810
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.462-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.602	[illegible]
[illegible]	.970-13	.157-15	.970-13	.927-01	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.613	45.908
[illegible]	-.273-12	.185-19	.273-12	.180+03	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.617	45.896
[illegible]	.407-12	.107-19	.407-12	.150+00	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.619	45.869
[illegible]	.873-13	-.635-14	.875-13	-.417+01	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.621	45.915

NORMAL EXIT. TIME. 2*212 MILLISECONDS.

uncorrected results - TM mode

DEPT	RE(FZ)	IM(FZ)	|FZ|	PHZ	RE(FIP)	IM(FIP)	|FIP|	PHZ	RE(FPL)	IM(FPL)	|FPL|	PHZ	AP.RES.	PHZ(Z)
-[illegible].476	-.574-12	.539-17	.975-12	.170+03	.106-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.885	44.915
-31.476	-.252-11	-.962-1?	.262-11	-.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.627	44.918
-20.476	-.1??-11	-.1??-1?	.1??-11	-.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.767	44.917
-17.476	-.291-11	-.139-14	.291-11	-.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.720	44.934
-14.476	-.970-11	.770-15	.970-11	.180+03	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.580	44.950
-11.476	.970-12	.592-15	.970-12	.350-02	.105-03	.105-03	.149-03	.449+02	.531-02	-.280-06	.531-02	-.302-02	99.160	44.919
-8.476	-.124-24	-.592-16	.592-16	-.900+02	.105-03	.104-03	.148-03	.447+02	.531-02	-.280-06	.531-02	-.302-02	99.486	44.680
-5.476	.33?-16	-.417-14	.636-16	-.287-02	.107-03	.102-03	.148-03	.437+02	.531-02	-.280-06	.531-02	-.302-02	99.164	43.679
-4.476	.4??-15	-.2??-14	.4??-15	-.3??-02	.109-03	.101-03	.148-03	.426+02	.531-02	-.280-06	.531-02	-.302-02	99.076	42.925
-3.476	-.204-10	-.355-15	.204-10	.180+03	.112-03	.100-03	.150-03	.416+02	.531-02	-.280-06	.531-02	-.302-02	101.172	41.811
-2.476	.291-10	-.175-16	.291-10	-.750-02	.116-03	.994-04	.154-03	.402+02	.531-02	-.280-06	.531-02	-.302-02	106.731	40.172
-1.476	.196-10	-.170-14	.196-10	-.609-02	.130-03	.101-03	.164-03	.378+02	.531-02	-.280-06	.531-02	-.302-02	121.274	37.808
-.476	-.406-10	-.376-14	.406-10	-.180+03	.172-03	.119-03	.209-03	.346+02	.531-02	-.280-06	.531-02	-.302-02	196.339	34.554
-.276	.499-09	-.271-12	.499-09	-.719-01	.243-03	.161-03	.291-03	.335+02	.531-02	-.280-06	.531-02	-.302-02	381.703	33.517
-.[illegible]	-.332-07	-.[illegible]	.332-07	-.180+03	.345-03	.228-03	.412-03	.333+02	.531-02	-.280-06	.531-02	-.302-02	753.016	33.317
-.[illegible]	.367-09	-.476-19	.367-09	-.179+03	.496-03	.319-03	.591-03	.333+02	.531-02	-.280-06	.531-02	-.302-02	1516.740	33.284
-.076	-.236-0?	-.152-09	.236-0?	-.177+03	.646-03	.420-03	.773-03	.333+02	.531-02	-.280-06	.531-02	-.302-02	2685.607	33.283
-.[illegible]	-.776-10	-.[illegible]-11	.776-10	-.181+03	.966-04	.634-04	.116-03	.333+02	.531-02	-.280-06	.531-02	-.302-02	59.007	33.295
-.[illegible]	.14?-09	-.143-09	.209-09	-.446+02	.105-03	.690-04	.125-03	.333+02	.531-02	-.280-06	.531-02	-.302-02	70.500	33.393
-.[illegible]	.[illegible]	.[illegible]	.772-09	-.123+03	.836-04	.550-04	.100-03	.336+02	.531-02	-.280-06	.531-02	-.303-02	48.095	33.360
-.[illegible]	.[illegible]	.[illegible]	.576-0?	.455+02	.740-04	.489-04	.887-04	.334+02	.531-02	-.282-06	.531-02	-.304-02	35.339	33.404
.[illegible]	.257-07	.256-07	.364-07	.447+02	.644-04	.429-04	.773-04	.337+02	.531-02	-.264-06	.531-02	-.285-02	26.881	33.653
.[illegible]	.350-07	.231-07	.500-07	.446+02	.568-04	.383-04	.695-04	.340+02	.531-02	-.970-07	.531-02	-.105-02	21.116	33.941
.[illegible]	.[illegible]	.[illegible]	.[illegible]	.4??+0?	.496-04	.344-04	.603-04	.347+02	.531-02	-.866-07	.531-02	-.935-03	16.342	34.723
.[illegible]	-.629-10	-.[illegible]	.[illegible]-10	-.133+03	.436-04	.315-04	.538-04	.359+02	.531-02	-.883-07	.531-02	-.953-03	13.011	35.872
.[illegible]	.509-10	.170-1?	.535-10	.185+02	.397-04	.303-04	.497-04	.371+02	.531-02	-.880-07	.531-02	-.950-03	11.106	37.063
.[illegible]	.[illegible]	-.[illegible]-12	.[illegible]	.179+03	.3??-04	.2??-04	.457-04	.397+02	.531-02	-.880-07	.531-02	-.950-03	9.[illegible]	39.678
1.026	.239-12	.700-14	.360-12	.153+01	.324-04	.310-04	.449-04	.437+02	.531-02	-.880-07	.531-02	-.950-03	9.029	43.742
2.026	.6??-12	-.130-14	.6??-12	-.866-01	.311-04	.339-04	.456-04	.467+02	.531-02	-.880-07	.531-02	-.950-03	9.255	46.742
3.026	.235-10	-.523-15	.235-10	-.125-02	.315-04	.341-04	.465-04	.472+02	.531-02	-.880-07	.531-02	-.950-03	9.730	47.193
4.026	.210-10	-.465-15	.210-10	-.160-02	.319-04	.343-04	.469-04	.471+02	.531-02	-.880-07	.531-02	-.950-03	9.865	47.076
5.026	.582-12	-.174-16	.582-12	-.175-02	.326-04	.343-04	.473-04	.465+02	.531-02	-.880-07	.531-02	-.950-03	10.054	46.463
5.026	.291-12	-.[illegible]-17	.291-12	-.175-02	.329-04	.337-04	.470-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	10.030	45.933
6.026	.116-11	-.[illegible]-17	.216-11	-.437-03	.329-04	.336-04	.470-04	.457+02	.531-02	-.880-07	.531-02	-.950-03	9.926	45.656
7.026	-.611-11	.1?7-15	.611-11	.180+03	.327-04	.334-04	.467-04	.456+02	.531-02	-.880-07	.531-02	-.950-03	9.820	45.556
[illegible]	-.[illegible]	.223-15	.[illegible]	.190+03	.326-04	.33?-04	.465-04	.455+02	.531-02	-.880-07	.531-02	-.950-03	9.737	45.525
11.026	.[illegible]-12	-.130-16	.673-12	-.777-03	.323-04	.331-04	.462-04	.456+02	.531-02	-.880-07	.531-02	-.950-03	9.612	45.646
14.026	-.[illegible]-12	.[illegible]-17	.194-12	.180+03	.322-04	.331-04	.462-04	.458+02	.531-02	-.880-07	.531-02	-.950-03	9.593	45.815
17.026	.673-12	-.[illegible]-15	.673-12	-.772-02	.322-04	.332-04	.462-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.602	45.887
20.026	.970-13	.157-15	.970-13	.927-01	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.613	45.908
23.026	-.273-12	.199-15	.273-12	.180+03	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.617	45.906
33.026	.407-12	.107-14	.407-12	.150+00	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.619	45.869
43.026	.273-12	-.676-14	.275-12	-.417+01	.322-04	.332-04	.463-04	.459+02	.531-02	-.880-07	.531-02	-.950-03	9.621	45.915

NORMAL EXIT. TIME: 27300 MILLISECONDS.