

## ***TomoDC* Version 1.2 Release Note**

The most important feature of Version 1.2 is to be able to handle the data using the **inclined or crooked borehole(s)**. This release note explains this new function and some other updated features that are not explained TomoDC help system.

### **1. Inclined or crooked borehole data**

Sometimes, we must image subsurface structure using inclined borehole, especially in the case of natural resources exploration. This new version is updated to meet this requirement. In order to describe an inclined borehole, borehole electrode position must be defined not only by the depth in borehole but also by the horizontal deviation from the vertical axis, or x coordinate. For this, the *data file format 12000* is newly devised to define the borehole electrode position in x-z coordinate. By defining the electrode position in x-z coordinate, we can also image the subsurface structure more precisely, when boreholes are deviated severely on x-z plane. In TomoDC inversion program, the FEM mesh system will be automatically adjusted so that the real electrode positions coincide with the corresponding nodal points precisely.

### **2. TomoDC data file format for crooked or inclined boreholes (Format 12000)**

<b>LineContents</b>	<b>Type</b>
<b>1 12000</b> File format version identifier.	<b>(integer)</b>
<b>2 TxHoleName</b> Name of borehole 1 (reference hole).	<b>(CHARACTER)</b>
<b>3 TxHoleNo, X, Y, Z, Depth</b> <b>TxHoleNo:</b> fixed as 1, <b>X, Y, Z:</b> x, y, z coordinate of hole 1 in meter. <b>Depth:</b> depth of hole 1 in meter.	<b>(integer, real, real, real)</b>
<b>4 RxHoleName</b>	<b>(CHARACTER)</b>

Name of borehole 2

**5 RxHoleNo, X, Y, Z, Depth** (integer, real, real, real)

**RxHoleNo**: fixed as 2

**X, Y, Z**: x, y, z coordinate of hole 2 in meter.

**Depth**: depth of hole 2 in meter.

Note) Coordinates of hole 1 and 2 will be used to calculate the distance between Hole 1 and hole 2, and to construct 3-d fence diagram image by the program *TomoDC3DF*. Z means elevation, and it will be used to describe surface topography together with the arrays **SfElevX**, and **SfElevZ** described in line 13.

**6 NoOfTxPoles** (integer)

No. of electrodes installed in borehole 1

**7 (TxPoleXPos(i), TxPoleDpt(i), I = 1, NoOfTxPoles)** (real, real)

Arrays defining the electrode positions installed in borehole 1. **TxPoleXPos(i)** is the horizontal deviation from the imaginary vertical borehole axis at the location of electrode i, and all the values of the array **TxPoleXPos** will be zero if the borehole is vertical. And the positive **TxPoleXPos(i)** means the borehole deviates towards the borehole 2 at the location of electrode i. **TxPoleDpt(i)** is the vertical depth of the electrode i. By defining these two variables, we can describe the borehole inclined or crooked on x-z plane. Please refer to figure 1. It is strongly recommended that the **TxPoleDpt** be in equal spacing and in ascending order.

**8 NoOfRxPoles** (INTEGER)

No. of electrodes installed in borehole 2.

**9 (RxPoleXPos(i), RxPoleDpt(i), I = 1, NoOfRxPoles)** (real, real)

Arrays to define the coordinates of electrodes installed in borehole 2. **RxPoleXPos(i)** is the horizontal deviation from the imaginary vertical borehole axis at the location of electrode i, and all the values of the array **RxPoleXPos** will be zero if the borehole 2 is vertical. And the negative **RxPoleXPos(i)** means the borehole deviates towards the borehole 1 at the location of electrode i. **RxPoleDpt(i)** is the vertical depth of the electrode i. Please refer to figure 1. It is strongly recommended that the **RxPoleDpt** be in equal spacing and in ascending order.

If **NoOfRxPoles** =0, this line must be omitted.

**10 NoOfSfPoles** (INTEGER)

No. of electrodes install on surface.

- 11 (SfPoleXPos(i), I = 1, NoOfRxPoles) (real)**  
Array to define the x coordinate of the electrodes installed on surface. The reference of **SfPoleXPos(i)** is the top of the borehole 1. Therefore, **SfPoleXPos(i)=0** means that the surface electrode i is installed at the top of borehole 1. Refer to figure 2.  
Please note that the elevation of the surface electrode is not defined here, but is interpolated using the array **SfElevX(i), SfElevZ(i)** of line 13.  
If **NoOfSfPoles =0**, this line must be omitted.
- 12 NoOfSfElev (INTEGER)**  
No. of surface positions defining surface topography.
- 13 (SfElevX(i), SfElevZ(i), I = 1, NoOfSfElev) (real, real)**  
x (**SfElevX**), z (**SfElevZ**) pair to define surface topography. **SfElevX** is defined in the same way of **SfPoleXpos**. **SfElevZ** means elevation. These arrays need not be in equal spacing.  
If **NoOfSfElev == 0**, this line must be omitted, and the surface topography will be defined by the straight line defined by the 3-d coordinates of borehole 1 and 2 (variables of line 3 and 5). If there is only one borehole (Borehole 1), and if **NoOfSfElev == 0**, horizontally flat surface assumed.
- 14 Blank line**
- 15 Blank line**
- 16 Blank line**
- 17 Blank line**
- 18 Blank line**
- 19 NoOfData, DataMode (INTEGER, INTEGER)**  
**NoOfData**: total number of measured data.  
**DataMode**: data type.  
**DataMode = 0**, measured data = apparent resistivity (ohm-m) only,  
**DataMode = 1**, measured data = measured potential (V/A) only,  
**DataMode = 2**, measured data = apparent resistivity and measured potential,
- 20 C1(1), C2(1), P1(1), P2(1), AppR(1), DelV(1) (integer, integer, integer, integer, real, real)**  
:  
:

Electrode position and measured data. The positions of the four electrodes are defined by the variables, **C1**, **C2**, **P1**, and **P2** as following. One line contains only one data set.

**AppR**: Apparent resistivity in ohm-m. (if **DataMode** = 1, omitted)

**DelV**: Potential difference in V/A. (if **DataMode** = 0, omitted)

**C1**: Electrode no. \*) of positive current electrode.

**C2**: Electrode no. \*) of negative current electrode.

**P1**: Electrode no. \*) of positive potential electrode.

**P2**: Electrode no. \*) of negative potential electrode.

**\*) Electrode no.**

Electrode no. (<= 1000): electrode installed at borehole 1.

Electrode no. (>1000, and <=10000): electrode installed at borehole 2.

Electrode no. (>10000): electrode installed on surface.

Electrode no. (=0): remote electrode.

Let's consider the example case of electrodes installed in following manner. By the values of **TxPoleXPos**, and **RxPoleXPos**, we can see that the borehole 1 is crooked, and borehole 2 is vertical.

**NoOfTxPoles** = 5

**TxPoleXPos** = 0. 1. -1. -1.5 -2.

**TxPoleDpt** = 2. 4. 6. 8. 10.

**NoOfRxPoles** = 5

**RxPoleXPos** = 0. 0. 0. 0. 0.

**RxPoleDpt** = 2. 4. 6. 8. 10.

**NoOfSfPoles** = 2

**SfPoleXPos** = -2. 10.

**DataMode** = 2

In this case, the following data set

**2 0 1004 0 567. 0.123**

means that

**C1** electrode is the 2'nd pole installed at 4 m depth of borehole 1,

**C2** electrode is remote electrode,

**P1** electrode is the 4'th pole installed at 8 m depth of borehole 2,

**P2** electrode is remote electrode. Therefore, we can recognize that pole-pole array is used for this crosshole measurement value, i.e., apparent resistivity 567 ohm-m, potential difference 0.123 V/A.

And

**10001 0 3 4 123. 0.456**

means that

**C1** electrode is the 1<sup>st</sup> pole installed on surface, 2 m apart from borehole 1, opposite side of borehole 2,

**C2** electrode is remote electrode,

**P1** electrode is the 3<sup>rd</sup> pole installed at 6 m depth of borehole 2,

**P2** electrode is the 4<sup>th</sup> pole installed at 8 m depth of borehole 2,

Therefore, we can recognize that pole-dipole array is used for this surface-to-hole measurement value, i.e., apparent resistivity 123 ohm-m, potential difference 0.456 V/A. In this manner, we can define any kinds of data acquisition method.

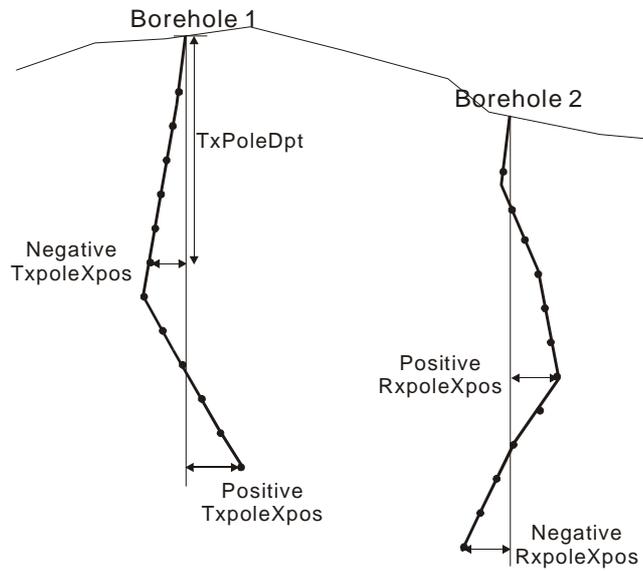


Fig. 1.

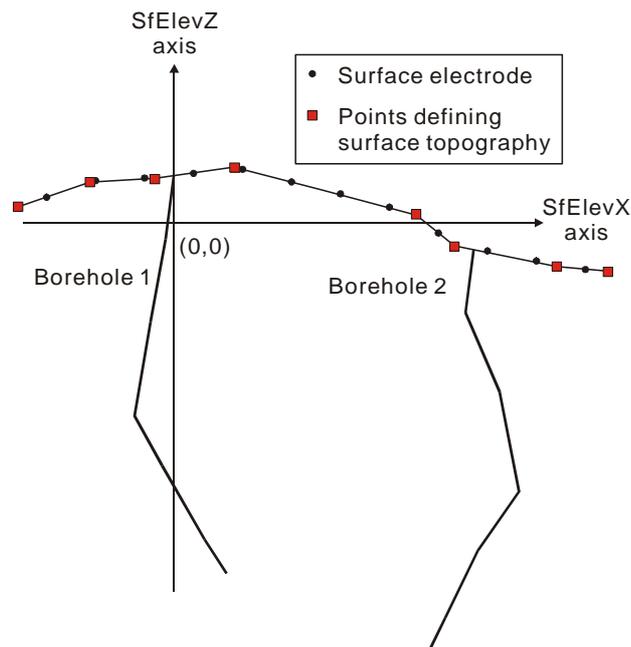


Fig. 2

Data example)

12000

Hole1

1 24. 0.0 0.0 20.

Hole2

2 36. 0.0 0.0 24.

5

0.0 4.0 -1.0 8.0  
-3.0 12.0 -4.0 16.0  
-5.0 20.

6

0.0 4.0  
0.0 8.0  
1. 12  
-1.0 16.  
-1.0 20.0  
0.0 24.0

19

-24.0 -20.0 -16.0 -12.0 -8.0  
-4.0 0.0 4.0 8.0 12.0  
16.0 20.0 24.0 28.0 32.0  
36.0 40.0 44.0 48.0

0

603

2

1	0	1001	1002	82.1169	0.184773E-01
1	0	1002	1003	106.7217	0.558792E-01
1	0	1003	1004	-727.2873	-0.249860E-01
1	0	1004	1005	214.6865	0.953594E-01
1	0	1005	1006	229.3382	0.121342E+00

:  
:  
:

### 3. Definition of apparent resistivity

Since the borehole electrode position is defined by the depth as well as x coordinate, it had better to change the definition of apparent resistivity to incorporate x coordinate of borehole electrode.

X coordinates and depths (not z coordinates) of the electrodes are used for the calculation of apparent resistivity in TomoDC. It means that the surface topography is assumed to be flat in the calculation of apparent resistivity. And, an image source is also considered for the borehole current electrode. Thus, the apparent resistivity in TomoDC is defined by the following equation. When **DataMode** in TomoDC data file is 1, i.e., the data file contains only the measured potential difference, TomoDC calculates apparent resistivity according to the following equation, and uses them for the inversion. And when **DataMode** is 1, or 2, i.e., the data file contains the apparent resistivity data, TomoDC uses them as input data for inversion.

$$\rho_a = \frac{4\pi}{G} \Delta V$$

where,

$$G = \frac{1}{r_{P_1}^{C_1}} + \frac{1}{(r_{P_1}^{C_1})_{imag}} - \frac{1}{r_{P_2}^{C_1}} - \frac{1}{(r_{P_2}^{C_1})_{imag}} - \frac{1}{r_{P_1}^{C_2}} - \frac{1}{(r_{P_1}^{C_2})_{imag}} + \frac{1}{r_{P_2}^{C_2}} + \frac{1}{(r_{P_2}^{C_2})_{imag}},$$

and

$$r_{P_j}^{C_i} = \sqrt{(x_{C_i} - x_{P_j})^2 + (d_{C_i} - d_{P_j})^2}$$

$$(r_{P_j}^{C_i})_{imag} = \sqrt{(x_{C_i} - x_{P_j})^2 + (d_{C_i} + d_{P_j})^2},$$

$x_{C_i}$  = x coordinate of positive ( $i=1$ ) or negative ( $i=2$ ) current electrode,

$x_{P_j}$  = x coordinate of positive ( $j=1$ ) or negative ( $j=2$ ) potential electrode,

$d_{C_i}$  = depth of positive ( $i=1$ ) or negative ( $i=2$ ) current electrode,

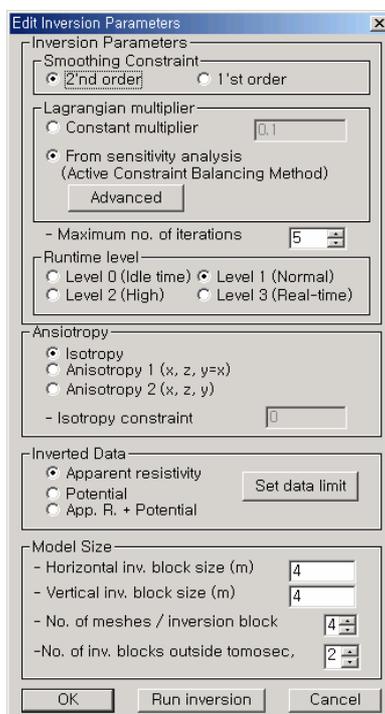
$d_{P_j}$  = depth of positive ( $j=1$ ) or negative ( $j=2$ ) potential electrode.

## 4. Additional updated features

### 4-1. Edit Inversion Parameters (Dialog Box)

New parameter, *Runtime level*, added to handle the priority level of TomoDC inversion program.

- 1) *Level 0 (Idle time)* makes the inversion program to run only when the system is idle.
- 2) *Level 1 (Normal)* makes the inversion program to run in normal state.
- 3) *Level 2 (High)* makes the inversion program to run in high priority level.
- 4) *Level 3 (Real-time)* makes the inversion program to run in the highest possible priority level. All the windows programs including operating system will be nearly stopped. For example, the mouse may be unresponsive.



### 4-2. Edit Drawing Parameters (Dialog Box), Annotation dialog box

New checkboxes, *Show FEM mesh*, *Show electrodes*, are added.

The option of *Show mesh* cannot be applied to the inverted results by the earlier version of TomoDC.

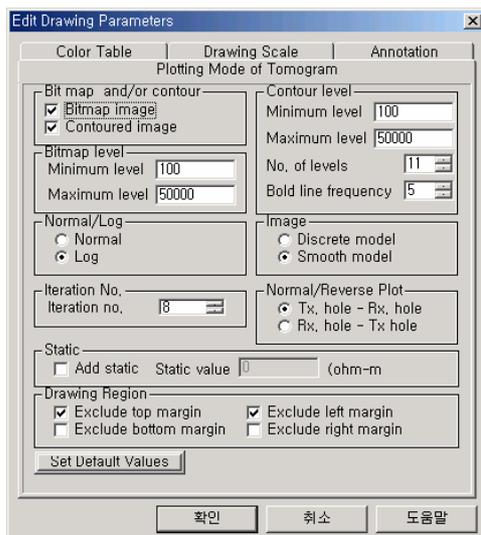
### 4-3. Edit Drawing Parameters (Dialog Box), Plotting Mode of Tomogram dialog box

#### - Drawing Region

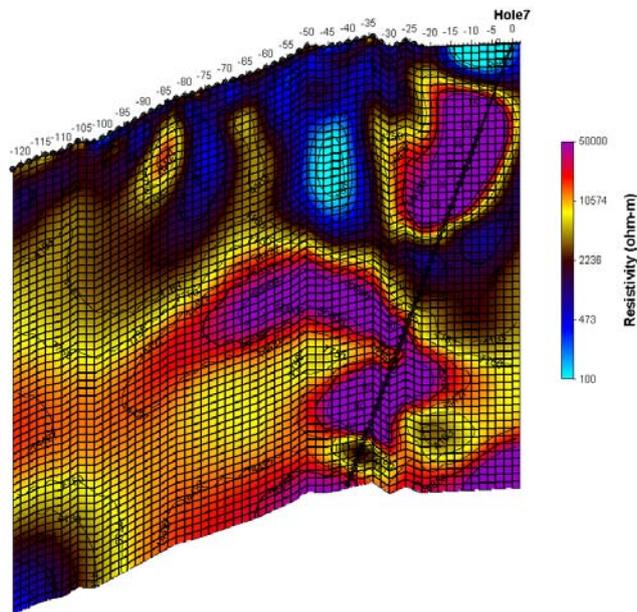
- 1) *Exclude top margin*: If this option is checked, and if positive current and potential electrodes were not

installed at surface, the upper boundary of TomoDC image becomes the line defined by the topmost electrode positions installed at two boreholes.

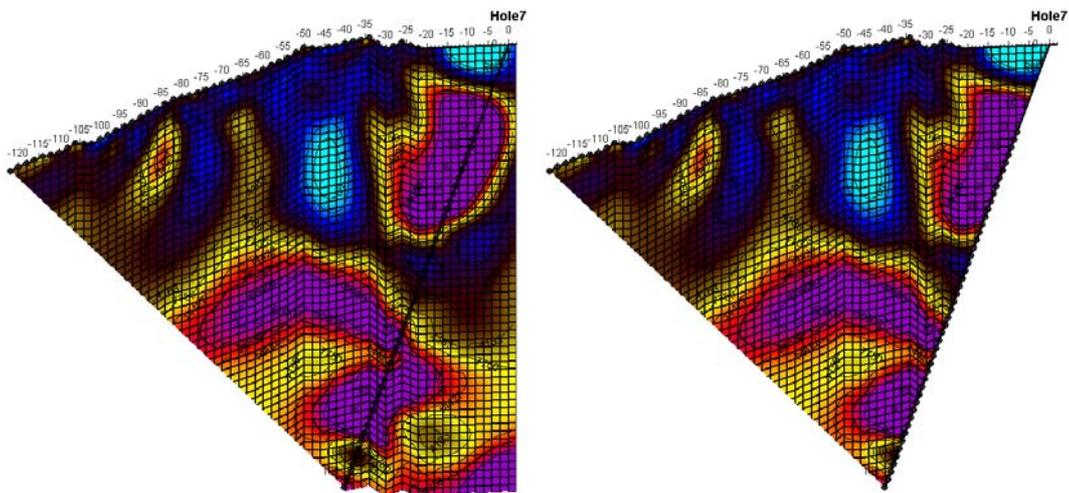
- 2) *Exclude bottom margin*: If this option is checked, the lower boundary of TomoDC image becomes the line defined by the bottommost electrode positions installed at two boreholes. If only one borehole is used, for instance hole-to-surface survey, this option
- 3) *Exclude left margin*: If this option is checked, the left boundary of TomoDC image is defined by the line connecting the leftmost surface electrode and the bottommost electrode of Tx. borehole. If there is no surface electrode or all the surface electrodes are installed at the right side of Tx. borehole, Tx. borehole itself becomes the boundary.
- 4) *Exclude right margin*: If this option is checked, the right boundary of TomoDC image is defined by the line connecting the rightmost surface electrode and the bottommost electrode of Rx. borehole. If there is no surface electrode or all the surface electrodes are installed at the left side of Rx. borehole, Rx. borehole itself becomes the boundary.



The following figure illustrates these options using hole-to-surface data.



(a) *Exclude left margin = false, Exclude right margin = false.*



(b) *Exclude left margin = true, Exclude right margin = false.* (c) *Exclude left margin = true, Exclude right margin = true.*

The 3-D fence diagram program, Tomo3DF is not updated to handle the inversion results of the newer version. The Tomo3DF will be updated and distributed as soon as possible.

Any comment or bug report of this software is really appreciated any time. Please send us e-mail.

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Jung-Ho Kim

[jungho@kigam.re.kr](mailto:jungho@kigam.re.kr)

## ***TomoDC Version 1.1 Release Note***

The updated version includes more functions and utilities than what explained in TomoDC help system. The recently added functions are as follows.

1. The new command ***File / Close all*** command closes all opened windows.

### ***2. View and Edit Tomo Data (Dialog Box)***

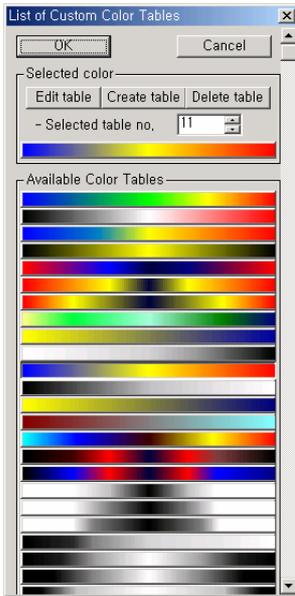
- The user can draw the tomography data in either normal or logarithmic scale by selecting *Normal* or *Logarithmic* option in ***Edit Drawing Parameters (Edit Tomo Data)*** dialog box. This option is valid only for *CrossPlot* mode. Negative values will be drawn in block color, when selecting the logarithmic option.
- *Delete data* mode is added for easier data editing. When this mode is activated, you can delete the tomography data just by clicking left mouse button.

### ***3. Updated features of the user specified color table (Custom Color Table)***

- The user can define color tables as wanted, or select the predefined one stored in the custom color list. Clicking the *set color* button in ***Color Table*** dialog box, ***List of Custom Color Table*** dialog box will be shown. In addition to the function of selecting an existing table, the dialog box gives the ways of creating a new custom color table and editing the previously defined one.

#### ***3-1. List of Custom Color Table (new dialog box)***

- *Available Color Tables* shows the list of the currently available color tables. You can select the one in this list just by clicking the wanted table.
- Also, you can select the color table by *changing Selected table no.*
- *Edit table* button provides a way to edit the currently selected color table on ***Set Custom Color Freely*** dialog box.
- *Create table* button creates the new color table on ***Set Custom Color Freely*** dialog box.
- *Delete table* button remove the selected color in the list of Available Color Tables.
- *OK* button stores the edited or created table in disk file. Therefore, user can insert the new color table into the color table list or change a color table.



### 3-2. Set Custom Color Freely (updated dialog box)

- *Reverse color* button reverse the color table.
- The use can also edit the color table by dragging the tick mark indicating the reference color.

## 4. Anisotropy inversion of tomography data

The anisotropy inversion code is being developed. Currently available version is based on the finite difference approximation. The options on the anisotropy are disabled on the *Edit Inversion Parameters* dialog box. After finalizing the development on the inversion code based on the finite element approximation, these options will be enabled. If you want to the currently available version of anisotropy inversion, i.e., the program based the finite difference method, please send E-mail to the developer.

Any comment or bug report of this software is really appreciated any time. Please send us e-mail. E-mail address is [jungho@kigam.re.kr](mailto:jungho@kigam.re.kr).

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Jung-Ho Kim