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Geoscan-M
GEOSCAN-M Ltd.

WIN!
With IPI2Win (MT)

IPI2Win(MT) v. 2.0
User's Guide

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Contents

Introduction.....	3
Product description.....	3
System requirements.....	3
Copyright.....	3
IPI2Win Overview.....	3
Getting started.....	4
Installing IPI2Win(MT).....	4
Uninstalling IPI2Win(MT).....	4
Running IPI2Win(MT).....	4
IPI2Win(MT) Controls.....	4
Data managing.....	7
Understanding data managing.....	7
Specifying the data file.....	7
Specifying topographical features.....	7
Data correction.....	8
Viewing data.....	9
Viewing curves and models.....	9
Viewing cross-sections.....	9
Interpreting sounding data.....	12
Overview.....	12
Creating and editing the model.....	12
Automated curve interpreting.....	13
Interactive semi-automated interpreting.....	13
Additional interpreting tools.....	14
Managing results.....	15
Saving results.....	15
Printing cross-sections.....	15
Saving an image of the cross-section.....	15

Introduction

Product description

IPI2Win(MT) is designed for automated and interactive semi-automated interpreting of magnetotelluric soundings data using amplitude and/or phase curves. IPI2Win(MT) is to be run on an IBM PC -compatible personal computer under Windows '95/'98/NT/2000/XP operating system.

System requirements

IPI2Win can be run on any computer with Windows '95/'98/NT/2000/XP operating system. Monitor should be in 256 colors mode or higher.

Copyright

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IPI2Win was developed using Delphi 5 by the Borland Int. #HDC1350WW10180

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IPI2Win Overview

IPI2Win(MT) is designed for interpreting of magnetotelluric soundings data 1D interpreting along a single profile. It is presumed that a user is an experienced interpreter willing to solve the geological problem posed as well as to fit the sounding curves. Targeting at the geological result is the specific feature distinguishing IPI2Win(MT) among popular programs of automatic inversion.

The special attention is paid to the user-friendly interactive interpreting. Due to handy controls the interpreter is able to choose from a set of equivalent solutions the one best fitting both geophysical data (i. e. providing the least fitting error) and geological data (i. e. geologically sensible resistivity cross-section). Comparing various concepts of the geological structure along the surveyed observation line rather than independent formal sounding curves inversion is the approach implemented in IPI2Win. This approach provides the opportunity to use the *a priory* geological data and extract information to the greatest possible extent in the complicated geological situations.

Getting started

Installing IPI2Win(MT)

IPI2Win is distributed on a single CD. The set also includes this manual and a protective plug.

To install IPI2Win(MT) on your computer insert floppy-disk into the disk drive and run the file INSTALL.EXE by any appropriate means. The command line must be as follows:

```
> drive_letter: INSTALL
```

Type the path to the location where IPI2Win should be installed in the *IPI2Win Setup* window. The path can also be pointed out using the *Browse...* button of that window. After this, click the *Next* button of the window. Read the message and be sure that the program is to be installed to the desired location. If so, click the *Install* button of the window. To change the target location, click the *Back* button of the window. Restart your computer when the installation is finished.

WARNING! While installing the installation program requires permission to install the NOVEX protective plug driver. This driver should be installed, otherwise IPI2Win(MT) will not run.

The *IPI2Win(MT)* group with *IPI2Win(MT)* and *Uninstall IPI2Win(MT)* items will appear in the *Programs* section of the Windows'95 main menu.

IPI2Win(MT) can be installed on any number of computers. Only one copy at a time can be used as a protective plug is needed to run IPI2Win(MT).

The protective plug must be stuck into the parallel (printer) port of the computer where IPI2Win(MT) is to be run. To do this, turn off the power supply of the computer and the printer (if the latter is connected to the computer) properly, detach the printers' parallel data cable from the computer (if the latter is connected to the computer), stick the protective plug into the parallel port of the computer and fasten it, then stick the printers' parallel data cable into the plug (if needed) and fasten it. Then turn on the power supply of the computer and the printer.

Uninstalling IPI2Win(MT)

To uninstall IPI2Win(MT) choose the *Uninstall IPI2Win(MT)* item from the *IPI2Win(MT)* group of the *Programs* section of the Windows'95 main menu.

Running IPI2Win(MT)

Using the created icon is the recommended way of running IPI2Win(MT).

WARNING! Make sure that the protective plug is stuck into the parallel (printer) port of the computer where IPI2Win is run(MT).

If no protective plug is found on the computer, the *Error* window is displayed, containing the message «*This is a protected program*». No further operation is then available. IPI2Win(MT) is terminated after clicking the *OK* button of the *Error* window.

IPI2Win(MT) Controls

This section contains a brief description of IPI2Win(MT) menu items (those of the menu bar are underlined and italicized) with the corresponding hot-keys (in the rectangular brackets [...]) and toolbar buttons (in the figured brackets {...})

File

Open [F3], {New profile} opens data file.

Reopen displays the list of recently opened data files to choose one to open.

Save [F2], {Save } saves current data and result files to the same location

Save as... saves current data and result files to another location

Export displays the list of data formats to choose the mode of saving data

Info... [Ctrl-I] {Profile comments } displays *Information* window to deal comments, sounding names, topography

Print section prints the cross-section(s) displayed in the *Pseudo cross-section and resistivity cross-section* window (this window will be referred to as the cross-section window)

Print curves [Ctrl-P] prints the curves currently displayed and the table of the cross-sections parameters for the corresponding sounding point

Print setup... displays *Print setup* window to change printer and/or page layout

Preview  displays *Print preview* window to see how the active window will be printed

Exit [Alt-X] {Exit } quits IPI2Win and saves results

Edit

Undo [Alt-BkSps] {UnDo } discards the latest change of the model (clicking this button after undoing an operation discards UnDo results).

Restore [Ctrl-F7] restores the model for the sounding point (i. e. discards all the changes of the latest model editing session for the point)

Copy [Ctrl-Ins] {Copy } stores the current model properties and the bitmap image of the current window in the Clipboard; when pasting the bitmap image into another application, use the *Paste Special* menu item of that application

Cut model [Shift-Del] {Cut } clears the current model and stores it in the Clipboard

Paste model [Shift-Ins] {Paste } applies model properties previously stored in the Clipboard to the current sounding

Copy curve stores theoretical curve in the Clipboard; items stored can be pasted into a spreadsheet

Edit file [Ctrl-E] {Edit file } runs Notepad and opens the current data file in it

Copy all model [Ctrl-A] stores model properties for all sounding points in the clipboard; items stored can be pasted into a spreadsheet or a word processor

Delete all results clears models for all sounding point currently displayed in the *Cross-section* window

Copy model&curve stores model properties as the pseudo-log chart and field curve in the Clipboard; items stored can be pasted into a spreadsheet

Resistivity pseudo cross-section stores the bitmap image in the Clipboard without axes labels and text comments

Synthetic curve [Ctrl-T] replaces the field sounding curve at the current sounding point with the theoretical curve for the model with current properties

Point (also available via context menu: click the mouse right button on the curve window)

Next [Ctrl-Left] displays the sounding curve and model properties for the next sounding point of the current data file

Previous [Ctrl-Right] displays the sounding curve and model properties for the previous sounding point of the current data file
First [Home] displays the sounding curve and model properties for the first sounding point of the current data file
Last [End] displays the sounding curve and model properties for the last sounding point of the current data file
Inversion [Space] implements the automated interpretation for the current sounding curve using current model parameters as the initial model; the fitting error is minimized for apparent resistivity or phase or both, according to the current mode
Profile inversion [Ctrl-F3] reduces the fitting error for all the interpreted sounding curves of the currently opened profile using current model parameters for each point as the initial model
Profile interpolation [Shift-Ctrl-F3] implements the automated interpretation for the all the uninterpreted sounding curves of the currently opened profile using model parameters of the interpreted points as the initial model

New model [F7] {New model } implements the automated interpretation for the current sounding curve using the least number of layers principle
Option... displays *Options* window to set the fitting accuracy for using the least number of layers principle
Profile new model [Alt-F3] implements the automated interpretation for the all sounding curves of the currently opened profile using the least number of layers principle

Edit curve [F4] {Edit field curve } displays *Edit field curve* window for manual data correction
Model (also available via context menu: click the mouse right button on the model window)
Chg table [Ctrl-T] switches the modes of the model parameters table (layers in line/column)
Fixing [Ins] fixes the highlighted model parameter for further automated interpreting

Split [Ctrl-N] {Split the layer } splits the current layer in two with parameters depending on those of initial layer
Join [Ctrl-Y] {Join two layers } joins the current layer with the underlying one into one layer with parameters depending on those of initial layers

Minimum sets the least possible (within the equivalence limits) value for the selected model parameter
Maximum sets the greatest possible (within the equivalence limits) value for the selected model parameter

Section (also available via context menu: click the mouse right button on the section window)
Zoom in [Alt-F5] increases the horizontal scale of the cross-section window
Zoom out [Shift-F5] decreases the horizontal scale of the cross-section window
All profile [Ctrl-F5] displays the whole profile in the cross-section window
More depth [Gray -] decreases the vertical scale of the cross-section window
Less depth [Gray +] increases the vertical scale of the cross-section window

Options... [Ctrl-F1] {} displays the *Section options* window for customizing *cross-section* window
Pseudo-section displays apparent the resistivity pseudo cross-section only in the *cross-section* window
Resistivity section displays the resistivity cross-section only in the *cross-section* window
Both sections displays both apparent resistivity pseudo cross-section and resistivity cross-section in the *cross-section* window

Rho k/Phi k [F9], {Section mode } switches apparent resistivity/phase pseudo cross-sections in the *cross-section* window
Lin/Log scale [Ctrl-Shift-Z] switches the linear/logarithmic scale for the apparent resistivity pseudo cross-section vertical axis
Horizontal mirror reverses the order of sounding points in the *cross-section* window

Transformations (available in Section context menu - click the mouse right button on the cross-section) displays the list of apparent resistivity transformations to choose one to display in the *cross-section* window

No transformation {No transformation } restores apparent resistivity pseudo cross-section
Accuracy {Fitting error pseudo section } displays the curve fitting error for all periods of all curves in the form of pseudo cross-section

V-transformation {Vertical derivative transformation } displays the pseudo cross-section of the apparent resistivity/chargeability derivative by the period

H-transformation {Horizontal derivative transformation } displays the pseudo cross-section of the apparent resistivity derivative/chargeability by the sounding point coordinate on the profile

The following items are available via Toolbar only

{Resist. inversion } implements the automated interpretation for the current sounding curve using current model parameters as the initial model; the fitting error is minimized for apparent resistivity only; this mode becomes the current one

{Phase inversion } implements the automated interpretation for the current sounding curve using current model parameters as the initial model; the fitting error is minimized for phase only; this mode becomes the current one

{Full inversion } implements the automated interpretation for the current sounding curve using current model parameters as the initial model; the fitting error is minimized for both apparent resistivity and phase; this mode becomes the current one

Conductance {S(H) } displays the *Conductance* window to calculate the resistivity cross-section conductance up to a given depth and to create a plot along the profile

{Choose component  or } switches the cross-section window to the mode of displaying data and results for both longitudinal and transversal components {}, for longitudinal component only {} or for transversal component only {}

{Period to Depth } switches the apparent resistivity axis labeling between period and effective depth

Options
displays the *Options* window for customizing IPI2Win

Window

Cascade cascades opened windows in a standard Windows fashion
Tile tiles opened windows in a standard Windows fashion
IPI_V6 [Ctrl-6] arranges opened windows like in the IPI v. 6 for DOS
IPI_V7 [Ctrl-7] arranges opened windows like in the IPI v. 7 for DOS
IPI_V8 [Ctrl-8] arranges opened windows in the IPI2Win default fashion
Toolbar displays/hides the toolbar
Status line displays/hides the status line

Help

Contents {*Help contents* } displays the help contents window on the current topic
Search for help on... displays the keyword search window
How to use help displays the help on help window
About displays the developers' information and the program mode and data restrictions
Menu contents and actions may slightly vary depending on the IPI2Win release and/or data formats.

Data managing

Understanding data managing

To start the process of interpreting IPI2Win(MT) needs a data file of the certain format containing the information on the measurement system and apparent resistivity and phase values. The data file format depends on the IPI2Win(MT) release for a certain customer.

Input and output files format

Input and output files are in "ASCII text" standard. They can be prepared with any text processor, which can save as "ASCII text".

The input data should be presented in file with extension "**mt**":

- 1-st line - comment.
- 2-nd line - comment.
- 3-rd line - 1 1 //do not change this line.
- 4-th line - number of points.

Further, for each point :

- point name (<=20 symbols).
- elevation (Y coordinate) [km] and picket (X coordinate) [km].
- number of periods (NT).
- NT lines, each containing square root of period, apparent resistivity (-1 if absent), its accuracy (optional), impedance phase (1 if absent) and phase accuracy (optional).

Notes:

Both accuracy columns should be present at the same time and for all soundings. If they are present, the field data is displayed as error bars, otherwise - as continuous curves. The apparent resistivity accuracy is supposed to have been calculated as $(\max-\min)/\sqrt{(\max*\min)}$, the phase accuracy - as $(\max-\min)$.

The results of interpretation are saved in the model file (***.mod**) :

- 1-st and 2-nd lines - same as in *.mt file.

Further, for each point :

- point name.
- number of layers (NL).
- NL lines with resistivity and thickness of the layer. The last line contains only resistivity.

WARNING! If a data file is copied or moved elsewhere, the corresponding result file must be placed to the same new location as well. Deleting a result file will result in loosing the interpreting results for the corresponding data file.

Specifying the data file

To specify the data file the *Open data file* window is used. Standard Windows navigation capabilities are used to select the disk and the folder containing the desired file as well as its name. Besides that it is possible to pick up one of the recently opened files by choosing the *File*, *Reopen* menu item, and then by choosing the file name from the list or from the drop-down list near the *{New profile}* button in the toolbar.

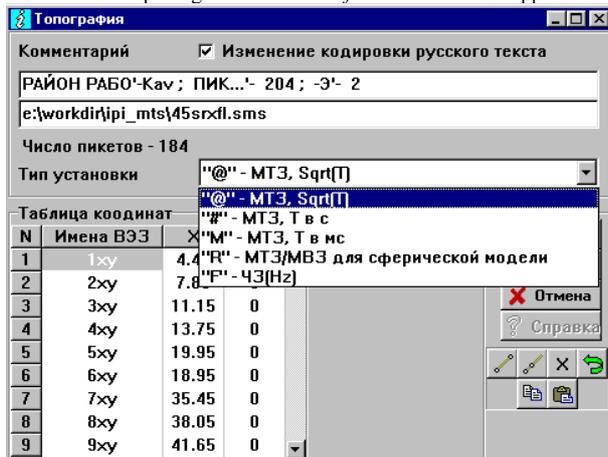
To specify the type of data files to display choose the corresponding item from the *File type* drop-down box.

WARNING! If in the local network, it is possible to open a data file from another computer. Before this, be sure, that both read and write access is provided for the network disk on another workstation.

Specifying topographical features

Identifying the data

After opening a data file the *Information* window appears. This window can also be opened in the course of interpreting.



The *Information* window

The *Profile comment* field contains the two first lines of the opened file. It is possible to edit their contents here. It will be saved to the same file afterwards on exiting IPI2Win or on saving the file.

The mode of displaying sounding curves (horizontal axis labels as \sqrt{T} - «@», T in milliseconds - «M», T in seconds - «#»), as well as for spherical model - «R» or for frequency sounding with horizontal axis labels as frequency - «F») by choosing the desired type from the *Array type* drop-down list.

If the file was opened by mistake it is possible to open another file by clicking the *New* button in the *Information* window.

Specifying point location

The information concerning the sounding points' names, locations and altitudes is displayed in the table. Values can be typed in the table cells. It is possible to use {Copy} and {Paste} buttons of the *Information* window when editing the table cells contents as well as standard Window shortcut keys [Ctrl-Ins] and [Shift-Ins]. Any editing operation can be undone by pressing the {Undo} button of the *Information* window.

The current names of sounding points from the opened file are listed in the *VES name* column of the *Coordinates table* field. The names can be edited by typing new VES name in the selected cell of the column.

The sounding points coordinates along the observation line are listed in the *X* column of the *Coordinates table* field. By default the first point's coordinate is assumed to be 0 and all other points are placed at the distance of 10 kilometers between the neighboring points. These values are coordinates in the «plain mathematical» sense (NOT distances measured on the uneven surface).

The coordinates can be edited by typing new coordinate value in the selected cell of the column. If points are named by their coordinates, the names can be transformed to the coordinates by clicking {*X-coord. from VES names* } button in the *Information* window.

It is also possible to fill the cells of the selected range within the *X* column using extrapolation or interpolation. To extrapolate coordinates: 1) type the coordinates of the 1st and the 2nd points in the corresponding cells of the desired range; 2) select the desired range; 3) click the

{*Extrapolation* } button in the *Information* window. To interpolate coordinates: 1) type the coordinates of the 1st and the last points in the corresponding cells of the desired range; 2) select the desired range; 3) click the {*Interpolation* } button in the *Information* window.

Specifying point altitudes

The sounding points altitudes are listed in the *Z* column of the *Coordinates table* field. By default all the altitudes are assumed to be 0.

The altitude of a point can be edited by typing new value in the selected cell of the column. It is also possible to fill the cells of the selected range within the *Z* column using extrapolation or interpolation.

To extrapolate altitudes: 1) type the altitudes of the 1st and the 2nd points in the corresponding cells of the desired range; 2) select the desired range; 3) click the {*Extrapolation* } button in the *Information* window. To interpolate altitudes: 1) type the altitudes of the 1st and the last points in the corresponding cells of the desired range; 2) select the desired range; 3) click the {*Interpolation* } button in the *Information* window.

Saving and discarding changes

To accept the entered topographical information click the *OK* button in the *Information* window.

To discard all the changes in the topographical information click the *Cancel* button in the *Information* window.

To discard all the change in the topographical information without closing the *Information* window click the {*Undo*} button in the *Information* window.

WARNING! Once entered, all topographical information on sounding points of a certain file is stored in the file with the same name and DPR extension; if the data file is copied or moved elsewhere, dpr-file must be placed to the same new location as well. Deleting dpr-file will result in losing the topographical information concerning the corresponding data file.

Data correction

The the amplitude and phase curves displayed in the curve window can be edited if needed. To edit the displayed curves press the [F4] key, choose the *Point, Edit field curve* menu item or click the {*Edit field curve* } button on the toolbar. The curves will be displayed in the *Edit field curve* window along with the table of abscissa (period square root, period or frequency), apparent resistivity and phase values.

To change an apparent resistivity or phase value on a period drag the corresponding circle, marking the data point, to the appropriate position with a mouse. It is also possible to select the corresponding cell in the table and type a new apparent resistivity value in it. When editing the curve is finished, use the horizontal scrollbar of the *Edit field curve* window to select another curve to edit. Click the *OK* button of the *Edit field curve* window to accept all the changes for all the curves edited or the *Cancel* button of the *Edit field curve* window. All the changes can be discarded by clicking the {*Undo* } button of the *Edit field curve* window.

It possible to copy the apparent resistivity values of the current curve to the Clipboard by clicking the {*Copy*} button of the *Edit field curve* window. To replace the apparent resistivity values for the current curve with those previously copied, click the {*Paste*} button of the *Edit field curve* window.

The scrollbar in the *Information* window can be used to start editing the next or previous sounding curve without closing the *Information* window.

WARNING! After editing the curves, new apparent resistivity and phase values will be saved to the same file. The old apparent resistivity and phase values will be stored in the file with the same name and BAK extension. The bak-file will be overwritten at the next opening the corresponding data file.

Viewing data

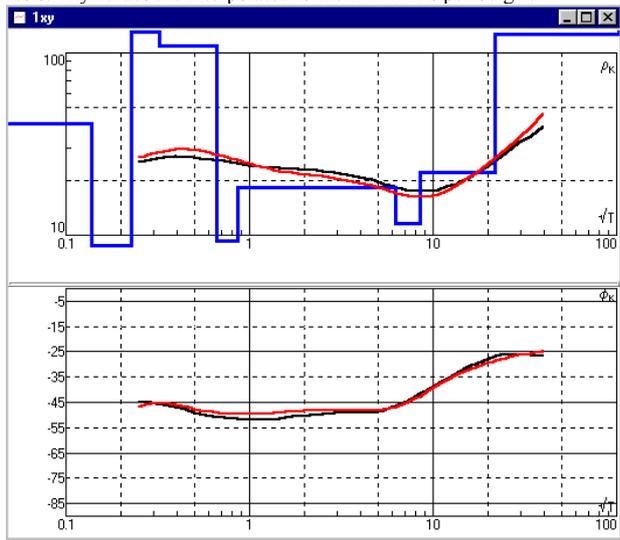
Viewing curves and models

The sounding curve for a certain point is displayed in the curve window titled with the sounding point name. The point name is duplicated in the *Name of VES location* field of the status line immediately below the toolbar. Only one curve can be displayed at a time. The position of the sounding point on the profile is marked by a vertical line on the cross-sections in the cross-section window.

The field values of the apparent resistivity are marked by circles. The curve itself is presented by a black line, which is a smoothing spline on the field values. The curve is plotted in the logarithmic scale for both period and apparent resistivity axes. The number of the orders on either of the axes is determined automatically, so the scale of the curve plot may vary at the different sounding points.

To proceed to the next (previous) sounding point use the scroll bar in the status line or press [Ctrl-Right] ([Ctrl-Left]) key. It is also possible to click a desired sounding point on the pseudo cross-section or on the resistivity cross-section in the *cross-section* window.

WARNING! The set of period values is fixed within IPI2Win. If the actual set of period values differs from that of IPI2Win, the apparent resistivity values are interpolated to the IPI2Win's period grid.

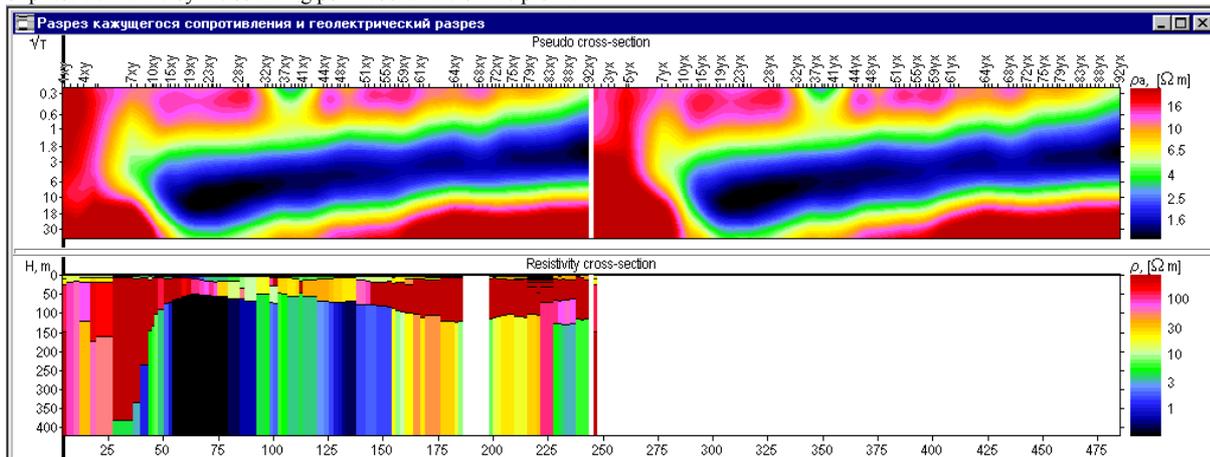


The Curve window

Viewing cross-sections

Overview

The pseudo cross-section of a specified value and/or resistivity cross-section are displayed in the *Pseudo cross-section and resistivity cross-section* window, the latter below the former in the equal horizontal scale. The top horizontal ruler represents the names of the sounding points, while the bottom horizontal ruler represents the coordinates of the sounding points. Vertical line marks the sounding point for which the sounding point is displayed in the curve window. Color scale columns are displayed besides the cross-sections, separately for the apparent resistivity or phase pseudo cross-section and resistivity cross-section. The following values can be displayed in the form of the pseudo cross-section: apparent resistivity (by default) or phase; fitting error for all periods of all curves; apparent resistivity or phase derivative by the period (or other abscissa); apparent resistivity or phase derivative by the sounding point coordinate on the profile.



The *cross-section* window; apparent resistivity for both components is displayed

It is possible to alter the ratio of pseudo cross-section and resistivity cross-section by dragging the divider in the *cross-section* window. To view the pseudo cross-section or the resistivity cross-section only choose the *Section*, *Pseudo-section* or, respectively, the *Section*, *Resistivity section* menu item. Choose the *Section*, *Both sections* menu item to restore the initial cross-section window appearance.

To switch between apparent resistivity and phase pseudo cross-section choose the *Section*, *Rho_k/Phi_k* menu item, or click the {Section mode $\rho \phi$ } button in the toolbar, or press the [F9]. The {Choose component $\begin{matrix} XY \\ YX \end{matrix}$ or $\begin{matrix} XY \\ YX \end{matrix}$ or $\begin{matrix} YX \\ XY \end{matrix}$ } toolbar button switches the cross-section window to the mode of displaying data and results for both longitudinal and transversal components { $\begin{matrix} XY \\ YX \end{matrix}$ }, for longitudinal component only { $\begin{matrix} XY \\ YX \end{matrix}$ } or for transversal component only { $\begin{matrix} YX \\ XY \end{matrix}$ }.

It may be sometimes useful to display the sounding points in the reversed order. To do so choose the *Section, Horizontal mirror* menu item. Using mirroring, mind that on saving the mirrored profile the present sounding points order will be saved.

Scaling the cross-sections

The horizontal and the vertical scales of the cross-sections can be change accordingly to the user’s need. To change the horizontal scale choose the *Section, Zoom in* menu item to increase the scale or the *Section, Zoom out* menu item to decrease the scale, or press the [Alt-F5] or [Shift-F5] keys respectively. It is also possible to mark the desired part of the profile by dragging with a mouse with a left button pressed beginning from some point of the profile; the scale will be changed to display sounding points within the selected area, marked with the rectangle, only. Choose the *Section, All profile* menu item or press the [Ctrl-F5] key to view all the profile again.

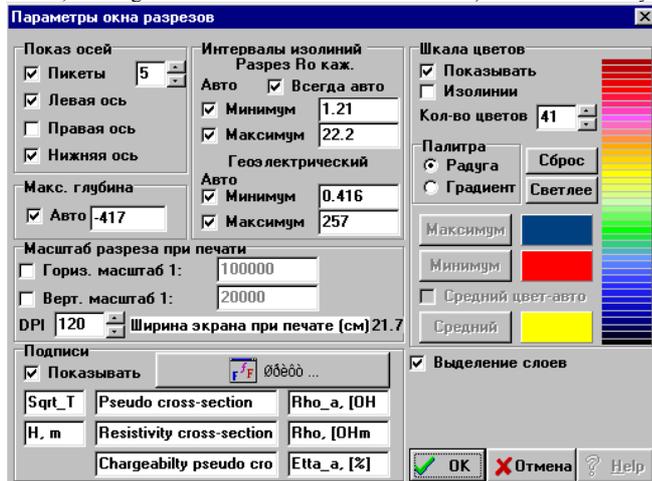
To change the vertical scale choose the *Section, Less depth* menu item to increase the scale or the *Section, More depth* menu item to decrease the scale, or press the [Gray +] or [Gray -] keys on the numeric keypad respectively. It is also possible to mark the desired part of the profile by dragging with a mouse with a left button pressed beginning from some point on the vertical axis of the resistivity cross-section; the scale will be changed to display the cross-section within the selected area, marked with the rectangle, only.

The pseudo cross-section can be displayed in the linear or logarithmic vertical scale. To switch between the linear or logarithmic vertical scale choose the *Section, Lin/log scale* or press the [Ctrl-Shift-Z] key.

The vertical axis can be labeled in terms of periods or effective depths. To switch between these modes, click the {Section mode } toolbar button.

To specify certain horizontal scale value and maximal depth value choose the *Section, Options* menu item, click the {Section options } toolbar button or press the [Ctrl-F1] key; the *Section options* window will appear. To specify a certain horizontal scale, switch on the *Horiz. scale* checkbox of the window and type the desired scale value in the neighboring text box. To specify a certain value of the maximal depth, type the desired value in the text field of the *Maximal depth* field. When the desired values are entered, click the *OK* button of the window. To restore automatic scaling, switch off the *Horiz. scale* checkbox and/or switch on the *Auto* checkbox of the *Maximal depth* field on, then click the *OK* button of the window. To switch between scaled and non-scaled way of displaying the cross-sections without changing the scale, switch on (off) the *Scaled* checkbox in the bottom of the main window of the program.

It is possible to specify the resolution for printing the cross-section. To do this, set the desired resolution value in dots per inch in the *DPI* numeric box of the *Section options* window. The cross-section appearance on the screen will be changed as well. Use Print preview (See «Managing results, Printing cross-sections» section of this Manual) to check whether you succeeded.



The *Section options* window.

Labeling the cross-sections

The labels may appear in the cross-section window. These are sounding point names in the top of the cross-section window, horizontal coordinates in the bottom of the cross-section window, periods near the pseudo cross-section vertical axes and depths (altitudes) near the resistivity (chargeability) cross-section vertical axes. Text comments may be entered as well and the axes may be named. To label the cross-section, choose the

Section, Options menu item, click the {Section options } toolbar button or press the [Ctrl-F1] key; the *Section options* window will appear. Symbol substitutes can be used in labels according to the table:

Symbol substitutes in cross-section labels

Typed in text box	Appears on the cross-section
Rho	ρ
Etta	η
OHm	Ω
Phi	φ
<Symbol>_<Symbol>	<Symbol><Symbol >

To display (remove) labels of a certain type, switch on (off) the corresponding checkbox of the *Axis labels* field of the window. The *MTS labels* check box is for sounding point names, the *Left Axis* and *Right Axis* check boxes are for vertical axes labels, the *Bottom Axis* checkbox is for the horizontal coordinates.

To display (remove) text comments, switch on (off) the *Show titles* checkbox of the *Titles* field of the window. Three rows of text boxes are present in the *Titles* field. The upper row if for the apparent resistivity pseudo cross-section, the lower one is for the resistivity cross-section. The leftmost text box contains the name of the vertical axis of the corresponding cross-section. The rightmost text box contains the name of the color scale column of the corresponding cross-section. The central text box may contain any text to be displayed above the corresponding cross-section (the name of the observation line, etc.). Type the desired text in the corresponding text box, then click the *OK* button of the window.

True Type fonts are used to display (and print) the labels and text comments. To change the font settings, click the *Font* button of the *Titles* field; the standard Windows' *Font* window will appear. The font settings are uniform for all the texts of the cross-section window.

Specifying colors of the cross-section

Color scales are used to represent the resistivity, apparent resistivity and phase values on the cross-sections. The contour levels are estimated automatically using the data limits if the *Auto* checkboxes of the *Contour levels* field of the *Section options* window are switched on. Otherwise the desired values of data limits can be typed in the neighboring text boxes of the field. The default number of contours is 11, it can be altered from 3 to 84 in the *Colors number* numeric field of the *Color scale* field of the *Section options* window. The quantity of levels is arbitrary in the gradient mode (see the next paragraph); it is changed with the 2 quotient in the rainbow mode.

The default or custom color set can be chosen in the *Fill colors* field in the *Color scale* field of the *Section options* window by clicking the *Rainbow* or *Gradient* button respectively. The color set for the rainbow mode is formed by a gradual change of colors from the color, corresponding to the greatest apparent resistivity values, to that corresponding to the smallest, through consequent colors of the solar spectrum. The color set for the gradient mode is formed by a gradual change of colors from the color, corresponding to the greatest apparent resistivity values, to that corresponding to the smallest one, by changing their ratio. To specify color, corresponding to the greatest (smallest) values click the *Maximum (Minimum)* button in the *Color scale* field of the *Section options* window, then click the desired color of the *Color* window and click its *OK* button. The color, corresponding to the average resistivity value can also be specified. To do so, click the *Middle* button of the *Section options* window, then click the desired color of the *Color* window and click its *OK* button. To disable the middle color switch on the *Auto middle color* checkbox in the *Color scale* field.

It may be useful to make the cross-sections more expressive to look at by emphasizing some levels and/or layers with a special color. To do so, click the desired color box in the *Color scale* field of the *Section options* window, then click the desired color of the *Color* window and click its *OK* button.

It is possible to display contour lines on the resistivity cross-section. To do this, switch on the *Show contours* checkbox of the *Color scale* field in the *Section options* window. Displaying contours slows down the drawing of the apparent resistivity pseudo-cross-section.

The layers boundaries in the resistivity cross-section can be drawn in black lines (by default) or not. To switch between these modes switch the *Divide layers* checkbox on (off).

To restore the default mode of displaying the cross-section click the *Reset* button in the *Color scale* field of the *Section options* window.

Interpreting sounding data

Overview

The concept of the profile interpreting is the foundation of IPI2Win(MT). It means that data for a profile are treated as a unity representing the geological structure of the survey area as a whole, rather than a set of independent objects dealt separately. The concept is implemented mainly by using the interactive semi-automated mode rather than the automated interpreting model.

IPI2Win(MT) is capable of solving 1D forward and inverse problems of magnetotelluric sounding.

The inverse problem is solved using a variant of the Newton algorithm of the least number of layers or the regularized fitting minimizing algorithm using Tikhonov's approach to solving incorrect problems. *A priori* information on layers depths and resistivities can be used for regularizing the process of the fitting error minimizing. The inverse problem is solved separately for each sounding curve.

Creating and editing the model

Overview

The model parameters for the current sounding point (the resistivity, the thickness and the upper boundary depth and altitude, and total conductance as well) are presented by a blue line of the pseudo-log plot in the curve window. They are also listed in the table in the separate window titled with the fitting error values (model window). The theoretical sounding curves for the current model parameters values is plotted in red in the curve window. Fitting error values represent the relative difference between the theoretical and field amplitude curves and mean square deviation between the theoretical and field phase curves (in brackets, with «±») for the current sounding point and its current model parameters. Fitting errors are also displayed in the *Fitting error* field of the status line.

At the first opening of the data file the resistivity cross-section is empty. The best fitting two-layered model is automatically suggested for the initial interpreting model of the present sounding point. Model editing involves altering the quantity of layers (from 2 up to 30) by means of splitting or joining them (to add or to remove a layer respectively) and changing the properties of the layers.

Eps = 6.61%(±1.4*)					
N	ρ	h	d	S(H)	Aбс
1	41.2	0.297	0.297	7.22	-0.2973
2	8.75	0.157	0.454	25.1	-0.4541
3	3479	0.169	0.623	25.2	-0.6227
4	109	0.532	1.16	30.1	-1.155
5	9.33	0.301	1.46	62.4	-1.456
6	18.4	6.56	8.01	420	-8.011
7	11.5	2.43	10.4	631	-10.45
8	22.2	13.1	23.6	1223	-23.56
9	127	125	148	2205	-148.1
10	330				

The Model Window

Altering the quantity of the layers

To split the current layer (i. e. the layer, highlighted in the model window) press the [Ctrl-N] keys, choose the *Model, Split* menu item or click the *{Split the layer}* button on the toolbar. The layer is then split in two. The resistivity and chargeability values of these new layers are equal to those of the initial layer. The total thickness of the new layers is equal to that of the initial layer and the ratio of the new layers' thicknesses is 2:3. Splitting the deepest layer (the semi-space) results in adding a layer immediately above the semi-space; the thickness of the layer added is 1.5 of the total thickness of the overlapping layers.

To join two consequent layers (i. e. the layer, highlighted in the model window and the following one) press the [Ctrl-Y] keys, choose the *Model, Join* menu item or click the *{Join two layer}* button on the toolbar. The layers are then united in a single layer. The resistivity of the new layer is the mean geometrical of those of the two initial layers. The chargeability of the new layer is the mean of those of the two initial layers. The thickness of the new layer is equal to the total thickness of the two initial layers. Joining layers is not available if the semi-space is highlighted as the current layer.

Altering the properties of the layer

To edit layer properties click at the desired cell of the table in the model window, type the new value of the parameter in the cell and press the [Enter] key. The theoretical curve will be redrawn for the present values of the model parameters. Use arrow keys to proceed to the next cell in the arrow direction.

It is also possible to alter model parameters by dragging the pseudo-log plot segment with a mouse. The theoretical curve is redrawn synchronously with altering the parameters in this manner. Dragging a vertical segment changes the depth of the corresponding boundary, while dragging a horizontal segment changes the resistivity of the layer. If the [Ctrl] key is pressed while dragging a segment both the resistivity and boundary depth are being altered. If only the boundary depth is to be altered it may be more convenient to drag this boundary in the cross-section window rather than in the cross-section window. Clicking the mouse right button while changing a parameter discards the changes in the model.

Getting a model from another point

The model from the current point is automatically transferred to the next selected sounding point if model is yet empty for it. Consequent curve interpreting takes place usually and thus this effect results in automatic transfer of the model to the next point.

The model for a certain sounding point can also be copied into the Clipboard and then assigned to another sounding point by pasting it from the Clipboard. To do this, select the point with the desired model and choose the *Edit, Copy* menu item, or press [Ctrl-Ins] keys, or click the *{Copy}* button on the toolbar. Then select the sounding point to which the copied model is to be transferred and choose the *Edit, Paste* menu item, or press [Shift-Ins] keys, or click the *{Paste}* button on the toolbar.

Clearing the model

Sometimes it is necessary to delete the model for a certain point, i. e. to start the interpreting «from the very beginning». To do this, select the point with the desired model and choose the *Edit, Cut model* menu item, or press [Shift-Del] keys, or click the *{Cut}* button on the toolbar.

To clear the models for all the points currently displayed in the cross-section window, choose the *Edit, Delete all models* menu item

Discarding the changes

Any completed editing operation can be discarded by pressing the [Alt-Backspace] keys, choosing the *Edit, Undo* menu item or clicking the *{Undo}* button on the toolbar. The editing operation is completed when the [Enter] key is pressed after typing a value in the cell of the table in the

model window or the mouse button is released after dragging the pseudo-log plot segment. Pasting a model from the Clipboard and implementing the automated interpreting of any kind is also a completed editing operation. Only the latest editing operation can be undone.

To discard all model changes for the point made since it was selected choose the *Edit, Restore* menu item

Automated curve interpreting

The least quantity of layers approach for a single point and the whole profile

The most formal way of automated interpreting is applying of the least quantity of layers approach. To implement the automatic interpreting using this approach for a single sounding curve select the sounding point to interpret and choose the *Point, New model* menu item, or press the [F7] key or click the *{Automatic minimization with number of layers selection}* button in the toolbar. A model will be created with the least quantity of layers providing the best fitting of the field curve for the present sounding point and the theoretical one. The least quantity of layers approach is regarded as a know-how by the IPI2Win(MT) developers.

To implement the least quantity of layers approach for all the curves of the profile, which are not interpreted yet, choose the *Point, Profile new model* menu item, or press the [Alt-F3] key.

This approach is likely to introduce the extremely thin layers with extremely great or small resistivity values. The properties of such layers can be edited afterwards manually within the equivalence area. The least quantity of layers approach is to be used to create a rough initial model for the further manual (interactive) interpreting in case there is a lack of *a priori* data. It is also possible to use this approach to estimate the limits of the equivalence area.

Implementing the least quantity of layers approach is controlled by the greatest and the least fitting error values, specifying the limits of the fitting error for the model search. To specify these values choose the *Options* menu item. In the *Options* window click the *New model* tab, then type the new value of the least fitting error value in the *Minimal error (%)* text field, the new value of the greatest fitting error value - in the *Maximal error (%)* text field, the weight of phase data for fitting error minimizing - in the *Phase weight* text field and/or the least possible quantity of layers in the model - in the *Min. layers number* text field of the *Options* window.

Regularized fitting error minimizing (Newton algorithm)

Implementing the Newton algorithm for a single point and the whole profile

Within IPI2Win, regularized fitting error minimizing is actually more frequently applied for the automated curve interpreting than the Newton algorithm. To implement the automatic interpreting using this approach, select the sounding point to interpret, create the initial model by any of the above mentioned means and then choose the *Point, Inversion* menu item, or press the [Space] key, or click the *{Inversion}* button on the toolbar. The parameters of the initial model will be altered to provide the best fitting of the field curve for the present sounding point and the theoretical one. The quantity of layers is not altered.

To implement the same approach to all the curves of the profile, create the initial model by any of the above mentioned means and then choose the *Point, Profile inversion* menu item, or press the [Ctrl-F3] key.

If a similar initial model seems to fit several consequent points, it is possible to make model interpolation for this fragment of the profile. To do this, clear the models for the desired points, then create the initial model for the first point of the fragment and then choose the *Point, Profile interpolation* menu item, or press the [Shift-Ctrl-F3] key.

Automated interpreting can be implemented with minimizing the fitting error for:

- amplitude curves (click the *{Resist. inversion}*  button in the toolbar);
- phase curves (click the *{Phase inversion}*  button in the toolbar);
- both amplitude and phase curves (click the *{Full inversion}*  button in the toolbar);

The initial model is created using the *a priori* data, derived from the geological cross-section and/or the drilling data provided by the customer or available due to other reasons.

Fixing the model parameters

If the certain properties of some layers are known for sure it is possible to fix them before automated interpreting. The fixed parameters are not changed while minimizing fitting error. Fixing the model parameters is the way of more strict and controllable regularization of the minimization process.

To fix a parameter, click the desired cell of the table in the model window, then choose the *Model, Fix* menu item, or press the [Ins] key. To release a fixed parameter, click the cell containing the desired parameter, then do the same action, i. e. choose the *Model, Fix* menu item, or press the [Ins] key.

Interactive semi-automated interpreting

Interactive semi-automated interpreting is the main mode of data interpreting implemented in IPI2Win(MT). This paragraph expresses mainly the authors' approach to the sounding data interpreting.

The process is usually started with visual analysis of the apparent resistivity pseudo cross-section. The zones are distinguished on the observation line with similar types of sounding curves. Some transient palaces usually occur between the neighboring zones. The curves within the zones may be usually interpreted using 1D approach, while the transient curves differ considerably from 1D curves.

Sounding points with typical curves are selected on the observation line for each of the zones distinguished. The curves for these points are interpreted using the *a priori* data available. If the geological cross-section is available from a borehole for the certain sounding points, the initial model for the point is created using its data. The number of layers depths of the boundaries according to the borehole column, while the resistivities are asserted using the litological information. Some geological layers may be joined into uniform geoelectrical layers according to their electrical properties and thus their influence on the sounding curve.

After interpreting the typical curves the models are transferred to other points of the corresponding zones. The model for each curve actually needs editing. Automated interpreting with fixing certain parameters can be applied to do so or manual model editing can be implemented. The interpreting within each zone is thus implemented.

For the curves in transient zones more radical model altering may be needed. The transient curves are interpreted paying attention rather to how the models of the points match the general concept of the geological structure along the observation line than to the fitting error of separate curves.

The geoelectrical cross-section thus obtained is actually regarded as the first-order approximation of the model of the geological structure along the observation line. This cross-section is analyzed taking its geological sense into account and matching of the result obtained and *a priori* data available. Some alterations of the cross-section result usually from such analysis. Some layers, even having no considerable influence on the sounding curves, may be formally introduced into a model if the existence of such layers is taken for sure due to the *a priori* data. During this stage of interpreting more attention is paid to corresponding of the cross-section to the geological situation and its general appearance, but the fitting error is still kept as small as possible.

Additional interpreting tools

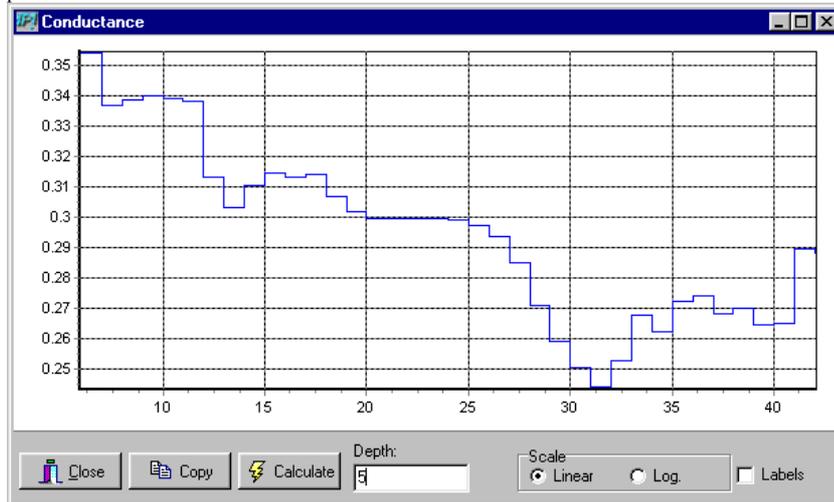
Estimating the equivalence limits

To estimate the equivalence limits for one of the model parameters for a certain point select the sounding point, then choose the cell with the desired parameter. To set the parameter to the greatest value within the equivalence limits choose the *Model, Maximum* menu item or press the [Ctrl-Alt-D] key. To set the parameter to the least value within the equivalence limits choose the *Model, Minimum* menu item or press the [Ctrl-Alt-X] key.

Calculating conductance

To calculate the geoelectrical cross-section conductance to a certain depth click the $\{S(H)\}$ button in the toolbar. The *Conductance* window will appear.

Type the depth value in the Depth text box of the window, then click the $\{\text{Calculate}\}$ button in it. The conductance plot along the profile will appear in the window. Linear or logarithmic scale is available for the plot's conductance (vertical) axis. To choose one of them, check the *Linear* or *Log* item respectively in the *Scale* field of the window. Switching the *Labels* checkbox of the window on causes the sounding point names to be displayed on the plot.



The *Conductance* window

The results can be stored in the Clipboard by clicking the Copy button of the window. The stored values can be pasted then into a spreadsheet or word processor as a table.

Other additional interpreting tools are available in Section context menu - click the mouse right button on the cross-section window.

Fitting error pseudo cross-section

To display the fitting error pseudo-cross section display the desired pseudo cross-section choose the *Transformation>Accuracy* context menu item or click the $\{\text{Fitting error}\}$ button in the toolbar. Examining the fitting error pseudo-cross section may be useful to distinguish the zones along the profile or in some depth (period) intervals, where the fitting error is the greatest. Such zones are likely to be connected with 2D or 3D effects.

Vertical derivative transformation

To display the vertical derivative transformation (derivative by the period) display the desired pseudo cross-section choose the *Transformation>V-Transformation* context menu item or click the $\{\text{Vertical derivative transformation}\}$ button in the toolbar. The derivative can be calculated by the period or by period logarithm. To switch between these modes choose the *Transformation>dR/dLnR* context menu item. Vertical derivative is likely to highlight the characteristic points of sounding curves: extrema as zero points and bendings as extrema.

Horizontal derivative transformation

To display the horizontal derivative transformation display the desired pseudo cross-section choose the *H-Transformation>Transformation* context menu item or click the $\{\text{Horizontal derivative transformation}\}$ button in the toolbar. The extrema of the horizontal derivative are likely to mark the places where one horizontally layered model is changed radically to the other.

Managing results

Saving results

The interpreting results are saved into a file with the same name as the data file currently opened and RES extension. Saving results takes place when a data file is saved, i. e. on implementing Save operation, on exiting IPI2Win(MT) or before opening another data file. No result file is created or saved if none of model parameter for any sounding point was altered. No backup files are created for result files.

The result file is placed into the folder where the corresponding data file is located. If a data file is moved elsewhere the corresponding result file must be moved to the same location. Otherwise the results of interpreting are likely to be lost.

Automatic saving of the files after at certain time intervals is available. To specify the autosave parameters choose the *Options* menu item. In the *Options* window click the *Autosave* tab, then type the new value of the autosaving time interval value in the *Autosave every* text field and switch on the *Autosaving* checkbox to enable autosaving. Switch that checkbox off to disable autosaving.

WARNING! Avoid altering the contents of a result file unless using IPI2Win. The result file format and, particularly, the order of the sounding points must strictly correspond to those in data file.

Printing cross-sections

To print a cross-section (apparent resistivity or phase or any transformation pseudo cross-section, resistivity cross-section or both pseudo cross-section and cross-section), switch to the cross-section window, display the desired cross-sections (see the Viewing cross-sections paragraph) and choose the *File, Print* menu item. The displayed image will be printed on the current printer. To change the printer choose the *File, Print* menu item and choose the desired printer from the *Change printer* drop-down list of the *Print setup* window.

The cross-section is printed on the paper of the size set in the *Paper size* drop-down list of the *Print setup* window. The image may fit a single sheet or to be of a certain horizontal scale (see Customizing IPI2Win(MT) section of this manual for setting scale). It may be useful to see a preview of the page with the cross-sections. To do this, choose the *File, Preview* menu item, or click the {Preview} button in the toolbar.

To save ink when printing on the color printer select the *Section, Options...* menu item and click the *Pale* button of the *Section options* window.

If a table of results is needed in the printed form, choose the *Edit, Copy all model* menu item or press the [Ctrl-A] keys. The parameters of all the models will be stored in the Clipboard. The copied values can be pasted into a spreadsheet or a word processor and then printed from it. General agreements concerning the Clipboard operation should be fulfilled.

Saving an image of the cross-section

A colored bitmap image of a cross-section (apparent resistivity pseudo cross-section, resistivity cross-section or both) can be saved as into the file of the Windows bitmap format (BMP) with the same name as the corresponding dat-file. To do this, switch to the cross-section window, display the desired cross-sections (see the Viewing cross-sections paragraph) and choose the *Edit, Copy* menu item. The bitmap image of the cross-section will be stored in the Clipboard. The image can be pasted into any program capable of managing bitmaps, i. g. graphic application. When pasting a bitmap image from IPI2Win(MT) into another application, use the *Edit, Paste special...* menu item of the corresponding application