Program for two-dimensional interpretation of data obtained by gravity and magnetic surveys (polygonal execution)

ZONDPGM

Contents

Program functionality

«ZONDPGM» is computer program for 2D interpretation of profile data obtained by gravity and magnetic surveys. Friendly interface and ample opportunities for data presentation allows solving assigned problem with maximum efficiency. Handy control system allows user to choose the best from geophysical and geological point of view equation from great number of equivalent solutions.

Gravity survey studies gravity anomalies caused by various density inhomogeneities in the medium and excludes earth crust gravity and relief influence by field subtraction and reduction insertion.

Magnetic survey is a traditional method of iron-containing objects exploration. It studies magnetic field of objects which contain ferromagnetic minerals. Interconnection between measured at the surface characteristics and magnetic properties of target medium allows assuming presence of causative magnetic bodies.

Magnetic survey studies total magnetic field which is comprised of earth crust normal field, anomalous field caused by magnetized bodies, and magnetic field variations mostly related to sun activity. Anomalous field is a useful component connected with studied medium. It can be extracted by taking into account normal field and by measuring magnetic variations in study area.

Magnetic susceptibility is set in CGS system ($n*10^{-5}$), density in g/sm^3, measured values in nanotesla or miligal in the program.

Selection of medium model is a crucial issue of inversion process. «ZONDPGM» program replaces anomalous bodies by set of polyhedrons that have infinite extension in perpendicular to profile direction. Each polyhedron has its own geometry, magnetic susceptibility, and density, which are defined during inversion.

Surface relief is quite important for field data interpretation. It is possible to take relief into account in the program which sometimes considerably improves results.

During program development special attention was devoted to a priori information accounting. Considering equivalence of inverse geophysical problems quality of results directly depends on amount of used a priori data. In order to increase interpretation reliability gravity and magnetic surveys should be integrated with other geophysical methods, drilling, and geological investigations. Geophysical and geological interpretation of anomalies needs detailed study of physical properties of rocks and variation trends along the strike and with depth. Program also

allows importing and visualizing data using other methods which makes data interpretation process more integrated.

«ZONDPGM» is easy-to-use instrument for interactive interpretation of data obtained by gravity and magnetic surveys and can be used on IBM-PC compatible PC with Windows system.

System requirements

«ZONDPGM» can be installed on PC with OS Windows 98 and higher. Recommended system parameters are processor P IV-2 GHz, memory 512 Mb, screen resolution 1024 X 768, colour mode – True colour (screen resolution change is not recommended while working with data).

As far as the program is actively using the registry, it is recommended to launch it as administrator (right click on program shortcut – run as administrator), when using higher than Windows XP systems.

Program installation and deinstallation

«ZONDPGM» program is supplied on CD or by internet. Current manual is included in the delivery set. Latest updates of the program can be downloaded from website: www.kaminae.narod.ru.

To install the program copy it from CD to necessary directory (e.g., Zond). To install updates rewrite previous version of the program with the new one.

Secure key SenseLock driver must be installed before starting the program. To do that open SenseLock folder (the driver can be downloaded from CD or website) and run InstWiz3.exe file. After installation of the driver insert key. If everything is all right, a message announcing that the key is detected will appear in the lower system panel.

To uninstall the program delete work directory of the program.

Program registration

For registration click “Registration file” item of the main menu of the program. When a dialog appears, select registration file name, and save it. Created file is transmitted to specified in the contract address. After that user receives unique password which depends on HDD serial

number. Input this password in “Registration” field. The second option is to use the program with supplied SenseLock key inserted in USB-port while working.

Rock density

It is essential to know rock density σ which is the only physical parameter that gravity survey is based on to perform gravity survey and especially to interpret results.

Rock density (or volume weight) is defined as its mass per unit volume. Density unit is g/sm^3. Density is usually measured on samples taken from natural exposures, boreholes or mines. The easiest way to measure density is to weight the sample in the air and in water and then calculate density σ. The most popular and handy device for density measurement is densitometer and it is based on this approach. Densitometer defines density within the accuracy of 0,01 g/sm^3 [Hmelevskoj, 1997].

In order to receive reliable and representative data it is necessary to measure large quantity of samples (up to 50). On the basis of numerous density measurements on samples from the same lithologic sequence variation curve or cross-plot of σ values versus number of samples characterized by current density is created. Curve maximum corresponds to the most probable density value for current rock. There are gravimetric and other geophysical methods of field and borehole density assessment.

Density of rocks and ores depends on chemical-mineral composition, in other words on bulk density of solid particles, porosity, and pore filler composition (water, solutions, oil, gas). Density of volcanic and metamorphic rocks is mostly defined by mineral composition and increases in passing from acidic to base and ultrabasic rocks. Density of sedimentary rocks first of all depends on porosity, water saturation, and in less degree on mineral composition. But it strongly depends on deposits consolidation, their age, and depth of burial (their increase leads to density increase as well). Examples of density are given below [Hmelevskoj, 1997].

Rock	**Density (g/sm^3)**
Oil	0,8 -1,0
Coal	1,0

Water	1,1 - 2
Soil	1,13 - 2,0
Sand	1,4 - 2
Clay	2 - 2,2
Sandstone	1,8 - 2,8
Limestone	2,3 - 3,0
Salt	2,1 - 2,4
Granite	2,4 - 2,9
Gneiss	2,6 - 2,9
Gabbro	2,8 - 3,1
Basalt	2,7 - 3,3
Peridotite	2,8 - 3,4
Copper pyrite	4,1 - 4,3
Magnetite, hematite	4,9 - 5,2
Density of the upper part of the crust (average)	2,67

Magnetic susceptibility of rocks and ores

Magnetic susceptibility χ is the main magnetic property of rocks which characterizes the degree of magnetization of materials and rocks.

It is dimensionless number in SI system. But in practice it is measured in 10^{-5} SI units. It ranges from 0 to 10 units for different rocks. Minerals and rocks are divided in three groups by magnetic susceptibility: diamagnetic, paramagnetic, and ferromagnetic. Diamagnetic rocks have very low magnetic susceptibility (less than 10^{-5} SI units) which has negative value (their magnetization is directed against magnetizing field). Many minerals and rocks such as quartz, mine salt, marble, oil, ice, graphite, gold, silver, lead, copper, etc. are diamagnetic [Hmelevskoj, 1997].

Paramagnetic rocks have positive magnetic susceptibility with low values. The majority of minerals, sedimentary, metamorphic, and volcanic rocks are paramagnetic.

Ferromagnetic minerals (e.g. magnetite, titaniferous magnetite, ilmenite, pyrrhotite) have very large χ values (up to several millions of 10^{-5} SI units).

Magnetic susceptibility of the majority of rocks depends first of all on the presence and percentage of ferromagnetic minerals in their composition.

Table below gives χ values of some rock-forming minerals and rocks. It can be seen from the table that ferromagnetic minerals are strongly magnetic. Ultrabasic and base rocks are characterized by the highest magnetic susceptibility values among other volcanic rocks, acidic rocks are magnetic and weakly magnetic. Magnetic susceptibility of metamorphic rocks is lower than the one of volcanic rocks. Sedimentary rocks with the exception of some sandstones and clays are almost non-magnetic.

Mineral, rock	χ 10^{-5} **(SI units)**	
	measurement range	**average**
Quartz	-	10
Calcite	7 – 12	-
Gypsum	-	12
Coal	-	25
Sphalerite	-	750
Hematite	500 - 50000	6000
Pyrrhotine	10^3-10^7	150000
Ilmenite	$5*10^5$ -$5*10^6$	10^6
Magnetite	10^6-10^7	$5*10^6$
Limestone	25 - 3500	300
Sandstone	0 - 20000	400
Gneiss	100 - 20000	-
Granite	0 - 40000	2000

Diabase	1000 - 15000	5000
Gabbro	1000 - 100000	60000
Basalt	30 - 150000	60000
Peridotite	90000 - 200000	150000
Sedimentary (average)	0 - 5000	1000
Metamorphic (average)	0 - 75000	50000
Acidic volcanic (average)	50 - 80000	8000
Base volcanic (average)	60 - 120000	30000

In order to convert χ values in CGS system which is used in the program magnetic susceptibility in SI units is divided by 4π.

Magnetic susceptibility of para- and ferromagnetic rocks decrease with rising temperature and almost disappears at Curie temperature which ranges from +400 to +700°C for different minerals. Maximum depth of magnetic survey investigation is approximately 25-50 km. Temperature is higher than Curie point at great depth and all occurring there rocks become almost non-magnetic.

Target geological structures and ores with magnetic susceptibility κ are embedded by rocks with magnetic susceptibility χ. This is the reason why similarly to gravity survey redundant or effective magnetic susceptibility $\Delta\chi$ is of interest. Value of $\Delta\chi$ can vary and be positive or negative. Magnetic anomalies appear due to variation of $\Delta\chi$ from zero [Hmelevskoj, 1997].

Creation and opening of data file

To start up « ZONDPGM» it is necessary to create data file of certain format which contains information about measurement parameters and observed values. One file usually contains data obtained from one profile. Text data files created in «ZONDPGM» format have «*.PGM» extension. See **data file format** for details.

For correct running of the program data file must not contain:

- incorrect symbols of records separator (TAB and SPACE use only);

- absurd data values (for example, negative values of apparent resistivity);
- desirably, there must be no more than 15000 observed data values in one file.

Data file format

Program presents universal data format which consists of information about coordinates and relative heights of measurement points. All geometric magnitudes used in the program are set in meters.

PGM program data format

Data text file is divided into three main blocks that contain information about gravity and magnetic measurements as well as profile topography sample_with_combi.

Block of gravity data description starts with *start_d_grav* line. It is followed by lines that contain measurement coordinates and field data. First record is measurement point coordinate (in meters), second record is observed gravity field values (in miliGal), and third record is measurement elevation (in meters) – position of gravimeter sensor element. If gravimeter elevation relative to earth surface is greater than or equal to zero, then measurement elevation is to be greater than or equal to relief excess in current point (set in the latter block) or equal to zero if topography data is absent. In other words this parameter is specified using the same units as topography sample_aero. In the majority of cases gravimeter elevation is constant and it is easier just to enter its value. In order to do this start block of topography description with the following key # (start_topo#) sample_with_topo. Relief excess relative to earth surface should be entered with minus sign in the third column.

Block of gravity data description ends with *end_d_grav* line.

Block of magnetic data description starts with *start_d_mag* line. It is followed by lines that contain measurement coordinates and field data. First record is measurement point coordinate (in meters), second record is observed magnetic field values (in miliGal), and third record is measurement elevation (in meters) – position of magnetometer sensor element. If magnetometer elevation relative to earth surface is greater than or equal to zero, then measurement elevation is to be greater than or equal to relief excess in current point (set in the latter block) or equal to zero if topography data is absent. In other words this parameter is specified using the same units as topography. In the majority of cases magnetometer elevation is constant and it is easier just to enter its value. In order to do this start block of topography description with the following key # (start_topo#). Relief excess relative to earth surface should

be entered with minus sign in the third column. Block of magnetic data description ends with *end_d_mag* line. Each described above block can be absent.

Block of profile topography data starts with *start_topo* line. It is followed by lines that contain relief data. First record is point with known relief excess coordinate (in meters), second record is relief excess. Block of profile topography data ends with *end_topo* line. This block can be absent if there is no relief data. In this case measurement elevations are equal to device elevation.

Sample of data file

```
start_d_grav        ! Indicates start of gravity data description block
      0,00          0,20    -0.100 ! Tool level is 0.1 meter
      111,11        0,42    -0.100
      222,22        1,48    -0.100
      333,33        8,40    -0.100
      444,44        1,99    -0.100
      555,56        0,52    -0.100
      666,67        0,23    -0.100
      777,78        0,13    -0.100
      888,89        0,08    -0.100
      1000,00       0,06    -0.100
end_d_grav          ! Indicates end of gravity data description block

start_d_mag         ! Indicates start of magnetic data description block

      0,00          -0,32   -2,00
      111,11        -0,67   -2,00    ! Tool level is 2 meters
      222,22        -1,84   -2,00
      333,33        10,49   -2,00
      444,44        -1,63   -2,00
      555,56        -0,75   -2,00
      666,67        -0,35   -2,00
      777,78        -0,20   -2,00
      888,89        -0,13   -2,00
      1 000,00      -0,09   -2,00
```

```
end_d_mag              ! Indicates end of magnetic data description block

start_topo#            ! Indicates start of topography data description block
0,00      10,00
111,11    12,00
222,22    15,00
333,33    12,00
444,44    1,00
555,56    1,00
666,67    3,00
777,78    5,00
888,89    7,00
1000,00   9,00
end_topo               ! Indicates end of topography data description block
```

Logging and lithology data file format

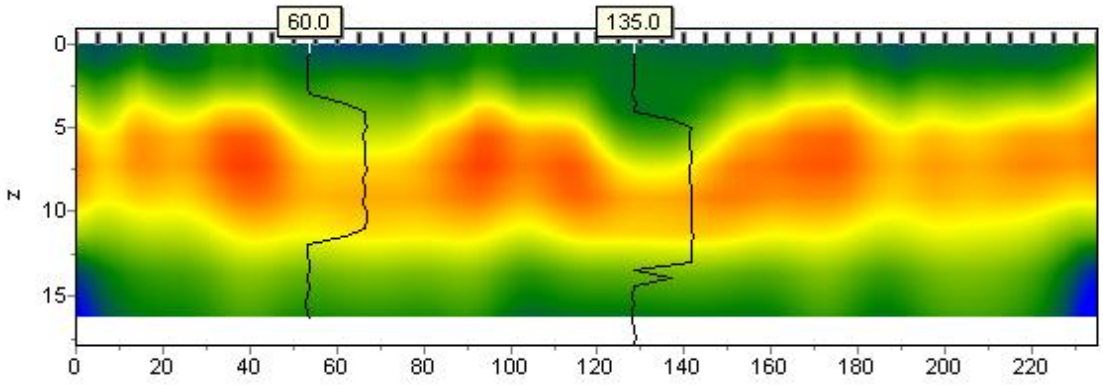
Logging data and lithological columns are hold in certain file formats. First type of files has txt extension; these files contain logging and lithology data. The following structure is used to create logging data file:

First column contains measure point depth (from surface); second column contains well log measurements. Third and forth columns are filled with zeroes.

Logging data sample-file is given below:

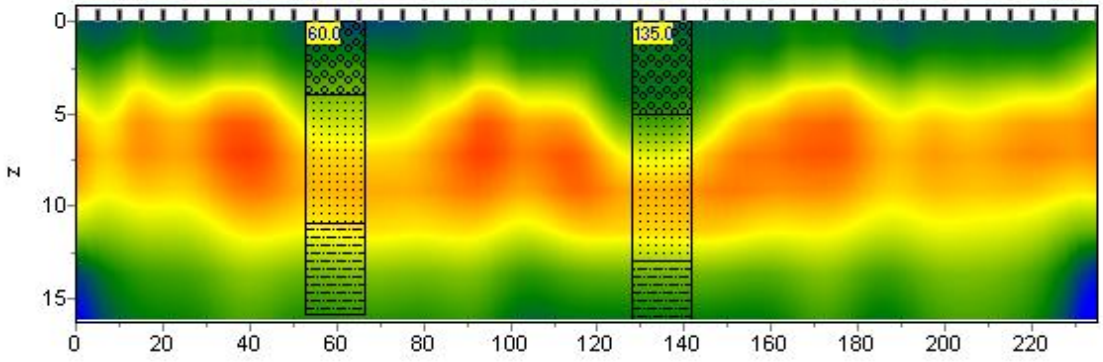
```
0.5     118.3035394  0     0
1       126.9002384  0     0
1.5     123.4170888  0     0
2       116.1519574  0     0
2.5     117.240884   0     0
3       111.9424174  0     0
3.5     142.0405875  0     0
4       125.3686538  0     0
4.5     521.0730567  0     0
```

5	735.5232592	0	0
5.5	707.7315998	0	0
6	706.3561614	0	0
6.5	725.9945623	0	0
7	722.433627	0	0
7.5	717.0991126	0	0
8	716.9836552	0	0
8.5	725.5024012	0	0
9	722.3551713	0	0
9.5	731.5717173	0	0
10	723.5097884	0	0
10.5	726.8844987	0	0
11	725.962034	0	0
11.5	743.2485878	0	0
12	726.4061156	0	0
12.5	734.399887	0	0
13	727.9166309	0	0
13.5	116.1921851	0	0
14	517.9613065	0	0
14.5	125.3706264	0	0
15	111.2952478	0	0
15.5	131.911879	0	0
16	107.9217309	0	0
16.5	114.9327361	0	0
17	134.0939196	0	0
17.5	138.4457143	0	0
18	129.1165104	0	0

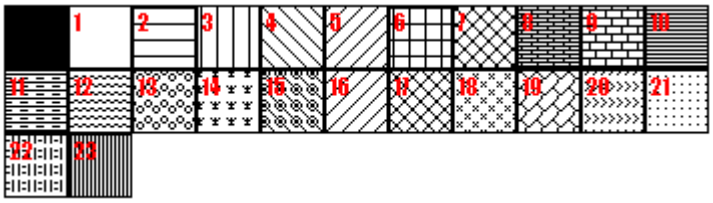


The following structure is used to create lithology data file.

First column contains lithological layer depth (from surface). Second column is filled with zeroes. Third column defines colour of layer for visualization, forth – type of pattern.



First 23 patterns for lithological column creation are given below.



Lithology data sample-file is given below.

0 1 0 13 Top of layer 1

4 1 0 13 Bottom of layer 1

4 1 0 19 Top of layer 2

11 1 0 19 Bottom of layer 2

11 1 0 27 Top of layer 3

16 1 0 27 Bottom of layer 3

Second type of files has *.crt extension; these are control files which specify type of data and way of visualization. Structure of CRT file for lithology and logging data visualization for any quantity of wells is described below.

2280.txt First line – name of logging or lithology data file

скв2280 Second line – well name (is displayed on well)

18 2 2 1 0 1 0 0 Third line contains control parameters -

Record 18 – well coordinate on profile.

2 - image width (in percents to profile length, usually 1 - 20).

2 - type of data visualization 0 - 3.

0 - logging data (as graph); carot1.crt

1 - logging data (interpolated colour column), colour scale of the section is used for visualization; carot2.crt

2 - lithological column; strati.crt

3 - logging data (colour column), colours for data visualization correspond to model colour scale, column colours are selected in compliance with model colour scale;

1 - Logging data normalization parameter 0 - 2.

0,1 - the same minimum and maximum is used for all data;

1,2 - subtract average value from every well log;

0 - Logging method index (if different logging methods are displayed, indices of all methods should be specified) 0 – n-1, where n – number of methods.

1 - Plot colour.

0 - Data scale is logarithmic 0 or linear 1.

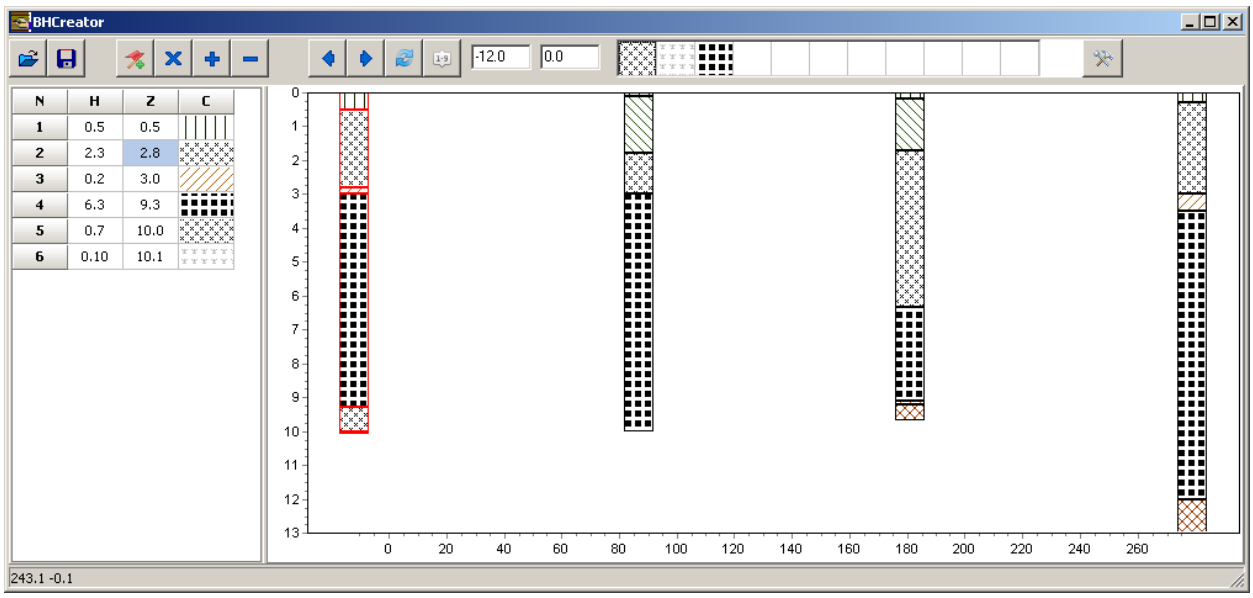
0 – Vertical well shift relative to earth surface.

3246.txt description of the following well on profile

скв3246

102 2 2 1 0 1 0 0

It is recommended to use BHEeditor to create lithology data file.



Data import and export

Import/Export/Carotage data option allows loading logging data or lithological columns (if present) in model window. Logging and lithology data file format is described in Logging and lithology data file format section sample_with_bhdata.

Run **Import/export/ Section/data** option to use a priori information if present as base for model editor. A priori information may include geological, electric or seismic cross-sections and adjacent profile section.

After that load graphic image in *.sec format on scale. sample_with_sectfile.

File *.sec has the following structure:

1st line – image file name;

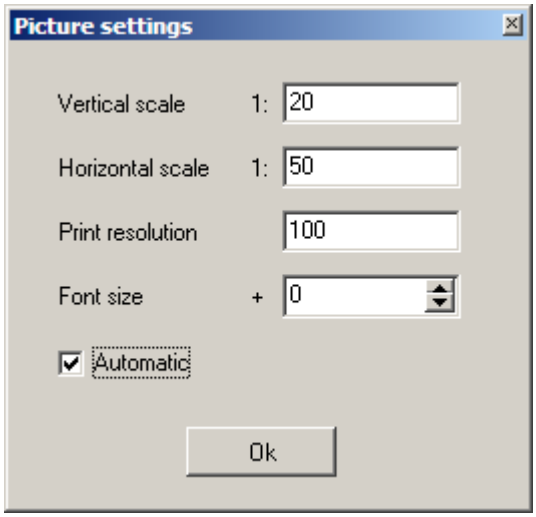
2d line – four coordinates X1 Y1 X2 Y2 of top left and bottom right corner of the image spaced.

sect.emf

0 0 152.4 53.3

If two-column *.dat file is used as imported file, graph connected to the right axis appears in calculated data window (in graphics plot mode).

Output settings dialog allows adjusting vertical scale and horizontal scale, outbound image resolution (in DPI), and font size.



These settings are applied to saved in BMP format model, if Automatic option is ON. Otherwise the same image that is displayed on the screen will be saved.

Interpretation results saving

Profile interpretation result is hold in «ZONDPGM» file format (extension *.PGM). Field data, current subsurface model, and parameters of normal magnetic field are saved in this file. Data from the file are used for further load and subsurface model creation.

Use appropriate main menu item to save interpretation results. Emersed dialog allows choosing different options of saving projects and images in metafiles.

ZONDPGM observed with model	Save observed data and current subsurface model.
ZONDPGM only observed	Save calculated data.
ZONDPGM calculated with model	Save calculated data as observed data and save current model.
ZONDPGM only calculated	Save calculated data as observed data.
Field plot to metafile	Save top window graphic section in WMF format.

Model plot to bitmap	Save bottom window graphic section in BMP format.

Operation procedure of the program

Main Window Toolbar

The toolbar serves to quick run of the most frequently used functions. It contains the following functional buttons (from left to right):

	Enable mode of adding new local polygon.
	Enable mode of polygon deletion.
	Enable mode of associated polygon creation.
	Enable mode of polygon detachment.
	Enable mode of dividing polygon.
	Enable mode of moving unconnected polygon points.
	Enable mode of moving set of connected polygons.
	Enable mode of adding new point to polygon.
	Enable mode of polygon point deletion.
	Enable mode of merging two points.
	Enable mode of separation of connected polygon points.
	Enable mode of moving polygon point.
	Enable mode of fixing/releasing polygon points.
	Run forward modeling process.
	Cancel previous step of model changing.
	Run polygon adjustment process.
 xy	Run polygon geometry adjustment process (left click). Run selection menu of collated coordinates.

Main Menu Functions

The following table lists menu items with their corresponding functions:

File/Open file	Open data file.
File/Save file	Save data.
File/Edit data	Open current data file in Notepad editor.
File/Create survey	Run dialog of synthetic measuring system creation.
File/Print preview	Run printing dialog of program main window.
File/Recent	Open one of recently used files.
File/Reg file	Create registration file.
File/Register	Register program.
File/Exit	Exit program.
Options/Model constructor	Run starting model setup dialog.
Options/Legend visible	Display graphics' legend.
Options/Observation setup	Run normal magnetic field parameters setup dialog.
Advanced/Open in modeling mode	Open data file in modeling mode.
Advanced/Real topo coordinates	Display actual profile excesses.
Import/Export/Carotage data	Open and display logging and lithology data file.
Import/Export /Import section/data	Import any data or model in SectionCor (*.sec) format.^
Import/Export/Remove import	Delete imported data.
Import/Export/Output setting	Outbound picture setup.

^ Imported data file must contain two columns: measurement coordinate and value sample_with_expgr. Free axis of graphics plan serves as vertical axis of imported data.

“Hot” keys

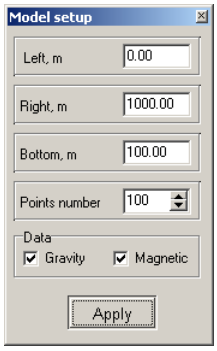
Cursor pad / cursor in model editor	Assignment
Shift / cursor in model editor	Mode of node moving.
Alt / cursor in model editor	Mode of node adding.
Ctrl / cursor in model editor	Mode of node deletion.
Space	Calculate forward problem.

Status panel

Status panel is divided into a few sections which contain different information:

Coordinates.
Model editor mode.
Calculation progress bar.
Additional information.

Right click with SHIFT button pressed on axis or graphic to call pop-up menu which allows opening parameters setup dialog of current object.



As soon as «*.PGM» data file is created, load it using relevant menu item. After successful loading of the file, starting model setup dialog which allows selecting modeling domain parameters and normal field parameters selection window appear. Alternative to using data file is *Create survey* option which allows creating synthetic measuring system and does not need field data.

Left – sets left boundary of modeling domain.

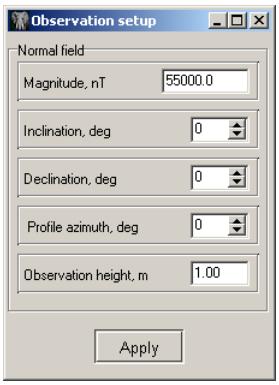
Right - sets right boundary of modeling domain.

Bottom - sets bottom boundary of modeling domain.

Points number – sets number of measurements in data file (when opening file). Sets number of observation points (when creating synthetic measuring system).

Gravity – indicates if there are gravity measurements in the file (when opening file). Specifies if gravity measurements need to be modeled (when creating synthetic measuring system).

Magnetic – indicates if there are magnetic measurements in the file (when opening file). Specified if magnetic measurements need to be modeled (when creating synthetic measuring system).



Magnitude – vector magnitude of normal magnetic field (To), in nT.

Inclination – declination of normal magnetic field, in degrees (Io). It is counted off from horizontal downwards.

Declination – inclination of normal magnetic field, in degrees (Do). It is counted off from north clockwise.

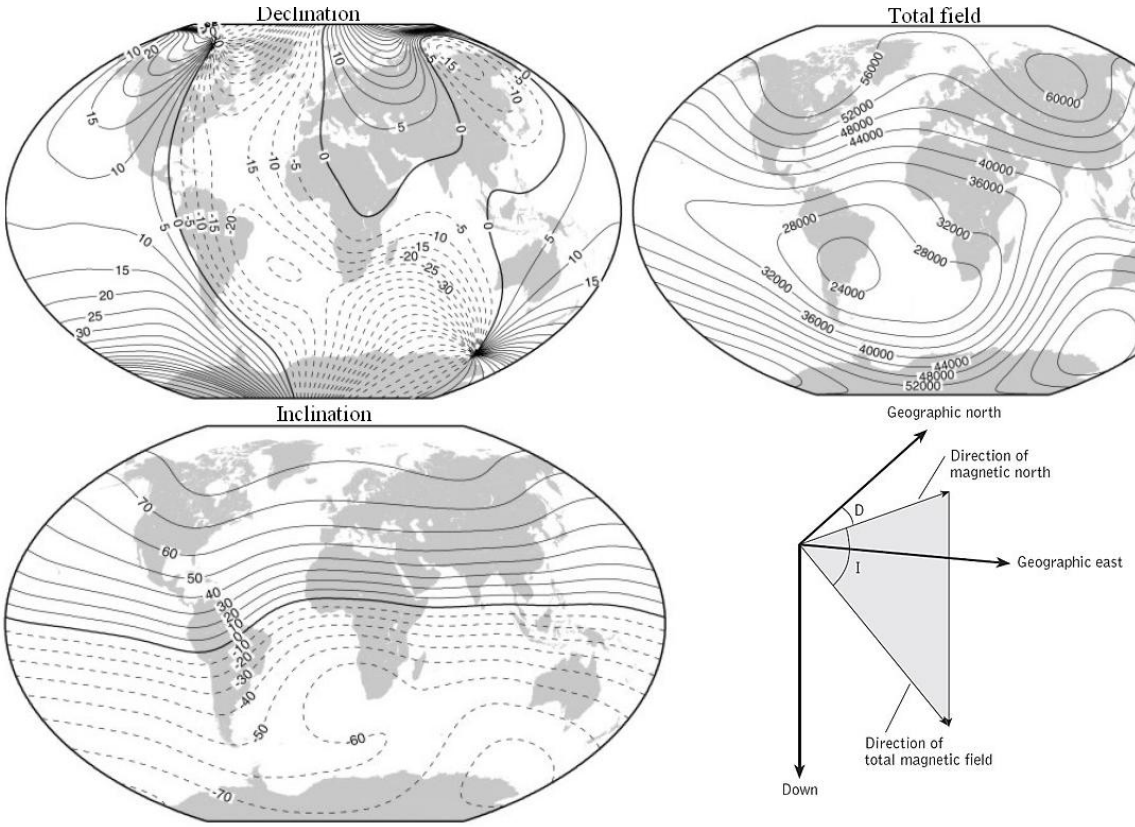
Profile azimuth – profile azimuth, in degrees. It is counted off from north clockwise.

Observation height – observation elevation (positive), in meters. This option is used in case of synthetic measuring system only. Points are located uniformly from left to right model edge in synthetic measuring system. Following call of described dialogs (using *Model setup* or *Observation setup* dialog) will not change measuring system.

Anomalous magnetic field and directional cosines of normal magnetic field components (Cx, Cz) are calculated using the following formulas:

$$\Delta T \approx H_x C_x + H_z C_z,$$
$$C_x = \cos I_0 \cos(A - D_0) \quad \text{and} \quad C_z = \sin I_0$$

Examples of declination, inclination and full magnetic field contours for year 2005 are given below. Present-day values for specific latitude and longitude can be found on specialized web-sites or using GIS packages.



Graphics plan

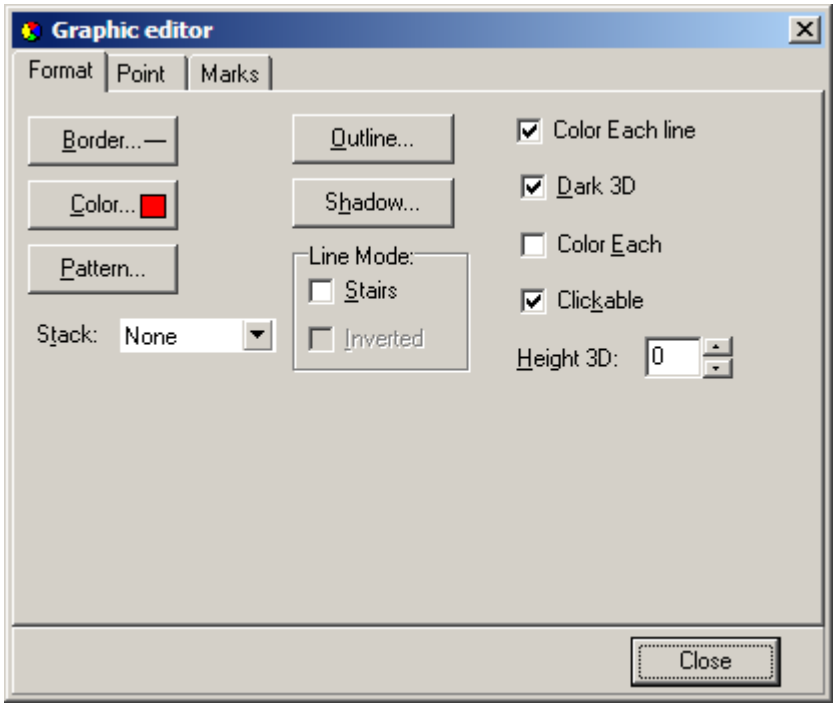
Graphics plan is used for measurement values visualization along profile as graphs.

Mouse clicks are used to **work with graphics plan**. Zooming in or dragging some part is performed with left button pressed. To zoom in a segment move mouse cursor down to the right. To return to primary zoom do the same but with mouse cursor moving up to the left.

Left click on plot point to display electrodes position for active site.

Right click with SHIFT button pressed on necessary graphic to run graphics editor.

Graphics editor



Graphics editor serves for graphic interface adjustment. Right click with SHIFT button pressed on necessary graphic to run it.

Tab **Format** contains connecting line settings.

Button **Border** runs connecting line parameters setup dialog.

Button **Colour** runs colour setup dialog.

Button **Pattern** runs pattern parameters setup dialog.

Button **Outline** runs graphic's connecting line setup dialog.

Button **Shadow** runs shadows setup dialog.

Tab **Point** contains plot point settings.

Option **Visible** is used to show/hide plot points.

Option **Style** sets point shape.

Option **Width** sets point width in display units.

Option **Height** sets point height in display units.

Option **Inflate margins** defines if image size is zoomed in according to point size or not.

Button **Pattern** runs point's colour fill setup dialog.

Button **Border** runs point's outline parameters setup dialog.

Button **Gradient** runs point's gradient colour fill setup dialog.

Tab **Marks** contains settings of graphic's point marking.

Tab **Style**.

Option **Visible** is used to show/hide plot point marking.

Option **Draw every** allows plotting every second, third and so on marking depending on selected value.

Option **Angle** sets point marking rotation angle.

Option **Clipped** defines whether point marking is plotted or not if it is located beyond graphic borders.

Tab **Arrows** allows adjusting arrow from marking to point.

Button **Border** runs arrow line parameters setup dialog.

Button **Pointer** runs arrowhead shape setup dialog (options in tab Point).

Option **Length** sets arrow length.

Option **Distance** sets distance between arrowhead and plot point.

Option **Arrow head** sets type of arrowhead. **None** – arrowhead specified by **Pointer** button is used. **Line** – classic thin arrowhead is used. **Solid** - classic thick arrowhead is used.

Option **Size** sets arrowhead size if classic arrow is used.

Tab **Format** contains graphic settings of marking frame.

Button **Colour** runs frame background colour selection dialog.

Button **Frame** runs frame line setup dialog.

Button **Pattern** runs background parameters setup dialog.

Option **Bevel** sets frame type: usual, elevated or submerged.

Option **Size** sets elevation or submergence level.

Option **Size** rounds frame corners.

Options **Transparent** and **Transparency** sets frame seamlessness degree.

Tab **Text**:

Button **Font** runs marking font setup dialog.

Button **Outline** runs marking letter outline setup dialog.

Option **Inter-char spacing** sets letter spacing for marking text.

Button **Gradient** runs gradient fill for marking text setup dialog.

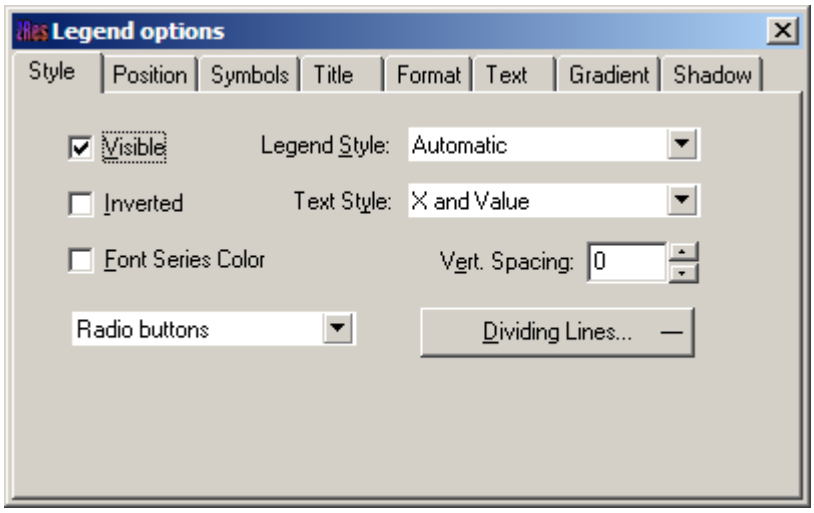
Option **Outline gradient** specifies if gradient fill is used in outline or interior of letters.

Button **Shadow** runs marking text shadow setup dialog.

Tab **Gradient** contains gradient fill settings for frame around markings

Tab **Shadow** contains shadow settings of frame around marking.

Graphic's legend editor



Editor allows adjusting graphic and legend interface. Right click with SHIFT button pressed on legend to the right of the graph to run it..

Pop-up window with the following set of tabs will appear.

Tab **Style** contains settings of legend display, allows choosing data label format and showing boundaries between legend labels and so on.

Tab **Position** serves for choosing legend position relative to graphics plan.

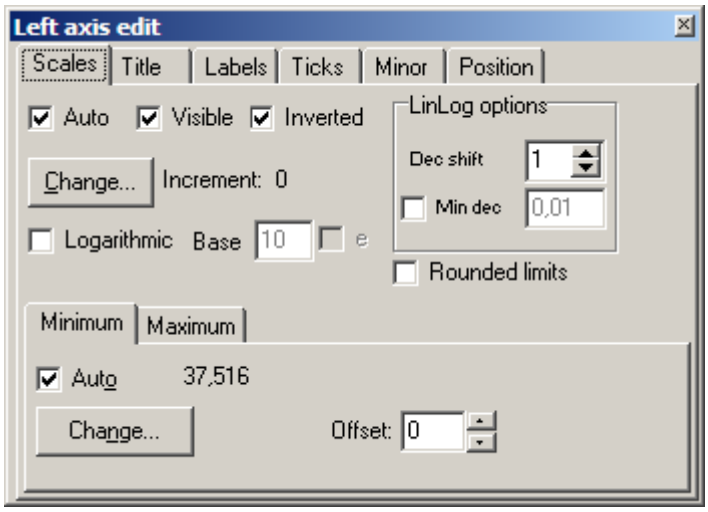
Tab **Symbols** sets legend symbols display parameters.

Tab **Title** specifies legend name and allows adjusting its format.

Tab **Text** serves for adjusting legend label format.

Tabs **Format**, **Gradient** and **Shadow** contain settings of legend window, its gradient fill, and shadow.

Axes editor



Editor is used to adjust graphic and scale axes parameters. Right click on necessary axis with SHIFT button pressed to run it. Pop-up menu with two fields (**Options** and **Default**) appears. The first one runs dialog, the second sets values on default.

First tab of **Scales** dialog contains options for axes scale parameters setup.

Option **Auto** defines how minimum and maximum axis values are chosen. If this option is ON axis limits are set automatically otherwise values from Minimum and Maximum filed specified by user are selected.

Option **Visible** shows/hides selected axis.

Option **Inverted** defines axis orientation.

Button **Increment change** runs dialog for axis label step definition.

Option **Logarithmic** selects logarithmic or linear axis scale. In case of sign-changing scale additionally use options from **LinLog options** field.

Option **Base** sets logarithm base for logarithmic axis.

Field **LinLog options** contains options for linear-logarithmic axis adjustment. Linear-logarithmic scale allows representing sign-changing or zero containing data in logarithmic scale.

Option **Dec Shift** sets indent (in logarithmic decades) relative to maximum axis limit modulo to zero. Minimum decade (prezero) has linear scale, others have logarithmic.

Option **Min dec** sets and fixes minimum (prezero) decade value if option is ON.

Option **Rounded limits** defines whether it is necessary to round minimum and maximum axis values or not.

Fields **Minimum** and **Maximum** contain options for axis limits adjustment.

Option **Auto** defines whether axis limit is selected automatically or using **Change** button.

Option **Offset** sets percentage axis limit shift relative to its actual value.

Tab **Title** contains options for axis header adjustment.

Tab **Style**:

Option **Title** sets axis header text.

Option **Angle** sets header text rotation angle.

Option **Size** sets header text indent. If 0 value is specified it is selected automatically.

Option **Visible** shows/hides axis header.

Tab **Text**:

Button **Font** runs header font setup dialog.

Button **Outline** runs dialog for header letters' outline adjustment.

Option **Inter-char spacing** sets letter spacing in axis header.

Button **Gradient** runs gradient fill setup dialog for header text.

Option **Outline gradient** specifies if gradient fill is used in outline or interior of letters.

Button **Shadow** runs axis header shadow setup dialog.

Tab **Labels** contains options for axis label adjustment.

Tab **Style**:

Option **Visible** shows/hides axes labels.

Option **Multiline** is used for setting multiline axes labels.

Option **Round first** rounds first axis label.

Option **Label on axis** hides labels that go beyond axis.

Option **Alternate** arranges labels in two lines.

Option **Size** sets axis label indent. If 0 value is specified it is selected automatically.

Option **Angle** sets label rotation angle.

Option **Min separation %** sets minimum percentage label spacing.

Tab **Text**:

Button **Font** runs label font setup dialog.

Button **Outline** runs dialog for label letters' outline adjustment.

Option **Inter-char spacing** sets letter spacing in label text.

Button **Gradient** runs label gradient fill setup dialog.

Option **Outline gradient** specifies whether gradient fill is used in outline or interior of letters.

Button **Shadow** runs label shadow setup dialog.

Tab **Ticks** contains options for axis main ticks adjustment.

Button **Axis** runs axis line setup dialog.

Button **Grid** runs line setup dialog for main ticks' grid.

Button **Ticks** runs external main axis tick setup dialog. Option **Len** sets its length.

Button **Inner** runs internal main axis tick setup dialog. Option **Len** sets its length.

Option **Centered** centers grid of axis ticks.

Option **At labels only** displays main axis ticks only if axis labels are present.

Tab **Minor** contains options for axis intermediate ticks adjustment.

Button **Grid** runs line setup dialog for intermediate ticks grid.

Button **Ticks** runs external intermediate axis tick line setup dialog. Option **Len** sets its length.

Button **Minor** runs internal intermediate axis tick line setup dialog. Option **Len** sets its length

Option **Count** sets number of intermediate ticks between main ones.

Tab **Position** defines axis size and position.

Option **Position %** sets axis indent relative to its standard position on graph (in percent to graph size or in screen units depending on selected option Units).

Option **Start %** sets axis start indent relative to its standard position on graph (in percent to graph size).

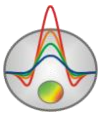
Option **End %** sets axis end indent relative to its standard position on graph (in percent to graph size).

Model editor

Model editor serves to change polygon parameters using mouse.

Double click in different domains of model editor to run context menus that contain options:

Setup	Set logarithmic scale for colour bar.
Print preview	Print model editor.
Save picture	Save model editor in graphics file.
Zoom&scroll Z	Enable zoom and scroll mode.
Equal scale	Display model editor in equal scale axes.



Work with model

Mode **Add polygon**. Press  button in control panel to run it. Left click is used to add new point to polygon. Right click to close polygon (connect start and end point of the polygon). If it is not possible to create local polygon (in other words if there are intersecting borders or other objects in the polygon) the program will not allow user to close polygon. It is preferable to locate points not very close to each other when creating polygons.

Mode **Delete polygon**. Press  button in control panel to run it. This mode is used to delete polygons. Right click on the polygon to delete it. Polygon outline turns red when mouse cursor is positioned inside it.

Mode **Create associated polygon**. Press  button in control panel to run it. This mode is used to create polygon (additional part of polygon) attached to already existent polygon, model edges or relief, in other words to some cojoint model domain. Cojoint model domain means set of polygons and model edges that have shared borders. Left click is used to add new point to polygon. Right click to close polygon (connect start and end point of the polygon across the border of adjacent domain). Start and end (terminal) point of the polygon should be positioned on external boundary (which turns red when bringing mouse cursor closer) of cojoint domain. If it is not possible to create local polygon (in other words if there are intersecting borders or other objects in the polygon) the program will not allow user to close polygon and will delete created points. It is important to note that polygons attached to left, right, and bottom model edges have infinite extension in these directions (in other words they expand over model edges).

Mode **Detach polygon**. Press  button in control panel to run it. This mode is used to detach polygons from set of cojoint polygons and model borders. It should be kept in mind that detached from model borders polygon loses its infinite extension (is limited by model edges then). Right click on polygon to detach it. Polygon outline turns red when mouse cursor is positioned inside it. Then button **Move polygon** can be used to move detached part of the polygon from the main polygon.

Mode **Divide polygon**. Serves to create two domains inside polygon. Press  button in control panel to run it. This mode is used to divide polygon into two new connected polygons. Boundary line is specified using two points on borders or nodes of the necessary polygon. Left click to select first point. Right click to select the second point and divide polygon. If it is not possible to perform this operation (in other words if there are intersecting borders or boundary is

located outside the polygon) the program will not allow user to move polygon and will delete created boundary. Polygon borders and points turn red when approaching mouse cursor.

Mode **Move polygon**. Press  button in control panel to run it. This mode is used to move unconnected polygon points. If the polygon does not have common points with other polygons or model borders it is wholly moved. Left click to select necessary polygon. Then move unconnected part of the polygon following mouse cursor. Right click to select new position of the polygon. If it is not possible to perform this operation (in other words if there are intersecting borders or polygon is located inside another polygon) the program will not allow user to move polygon and will return it to its initial position. Polygon outline turns red when mouse cursor is positioned inside it.

Mode **Move cojoint polygons**. Press  button in control panel to run it. This mode is used to move polygon and all cojoint polygons. Left click to select necessary polygon. Then move cojoint polygons following mouse cursor. Right click to select new position of the polygons. If it is not possible to perform this operation (in other words if there are intersecting borders or polygon is located inside another polygon) the program will not allow user to move polygons and will return them to their initial position. Polygon outline turns red when mouse cursor is positioned inside it.

Mode **Add point**. Press  button in control panel to run it. This mode is used to already existent polygon border. Right click on polygon border to add point. Polygon borders turn red when approaching mouse cursor.

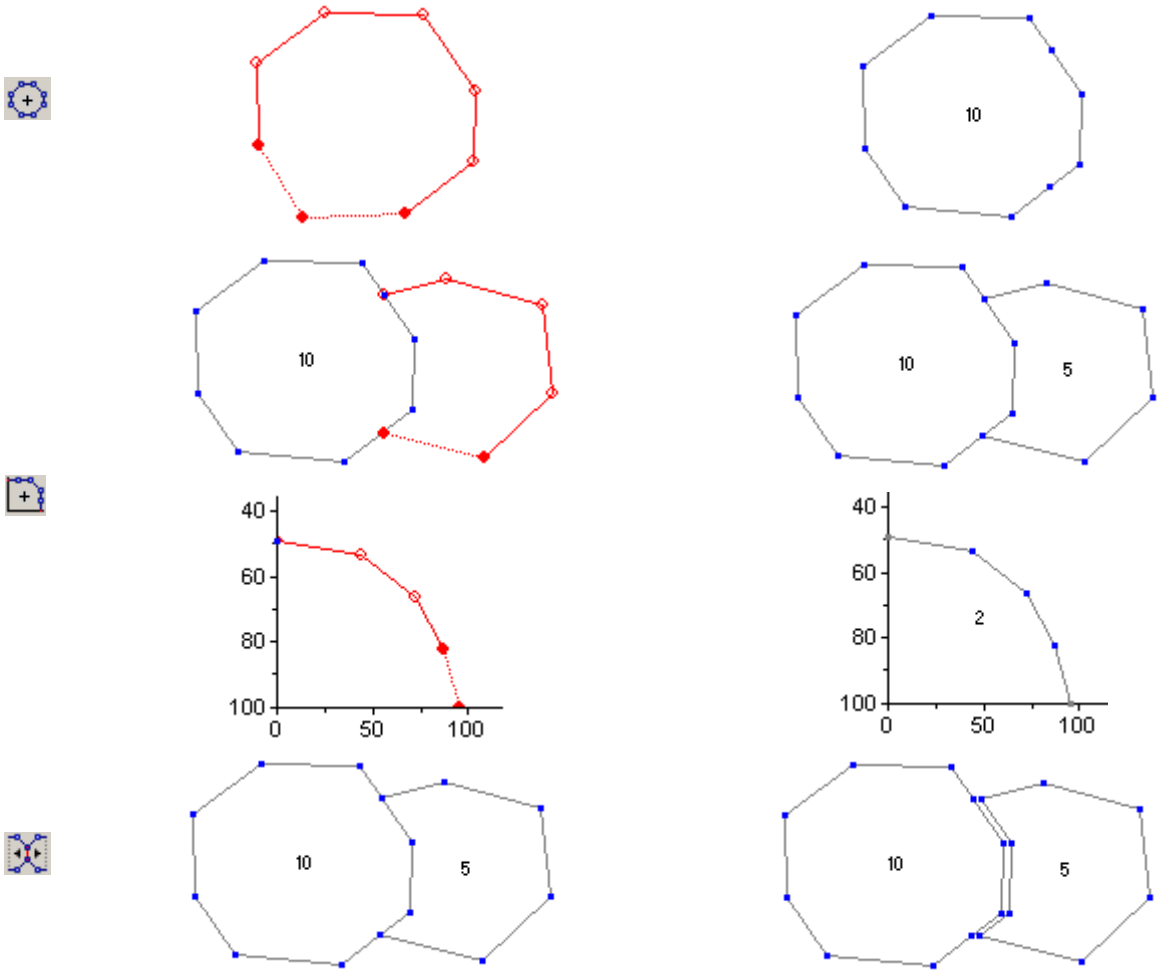
Mode **Delete point**. Press  button in control panel to run it. This mode is used to delete point of already existent polygon. Right click on point to delete it. The operation can not be performed if it causes the following situations: borders intersect, polygon is located inside another polygon or there are less than three points in one polygon. Polygon points turn red when approaching mouse cursor.

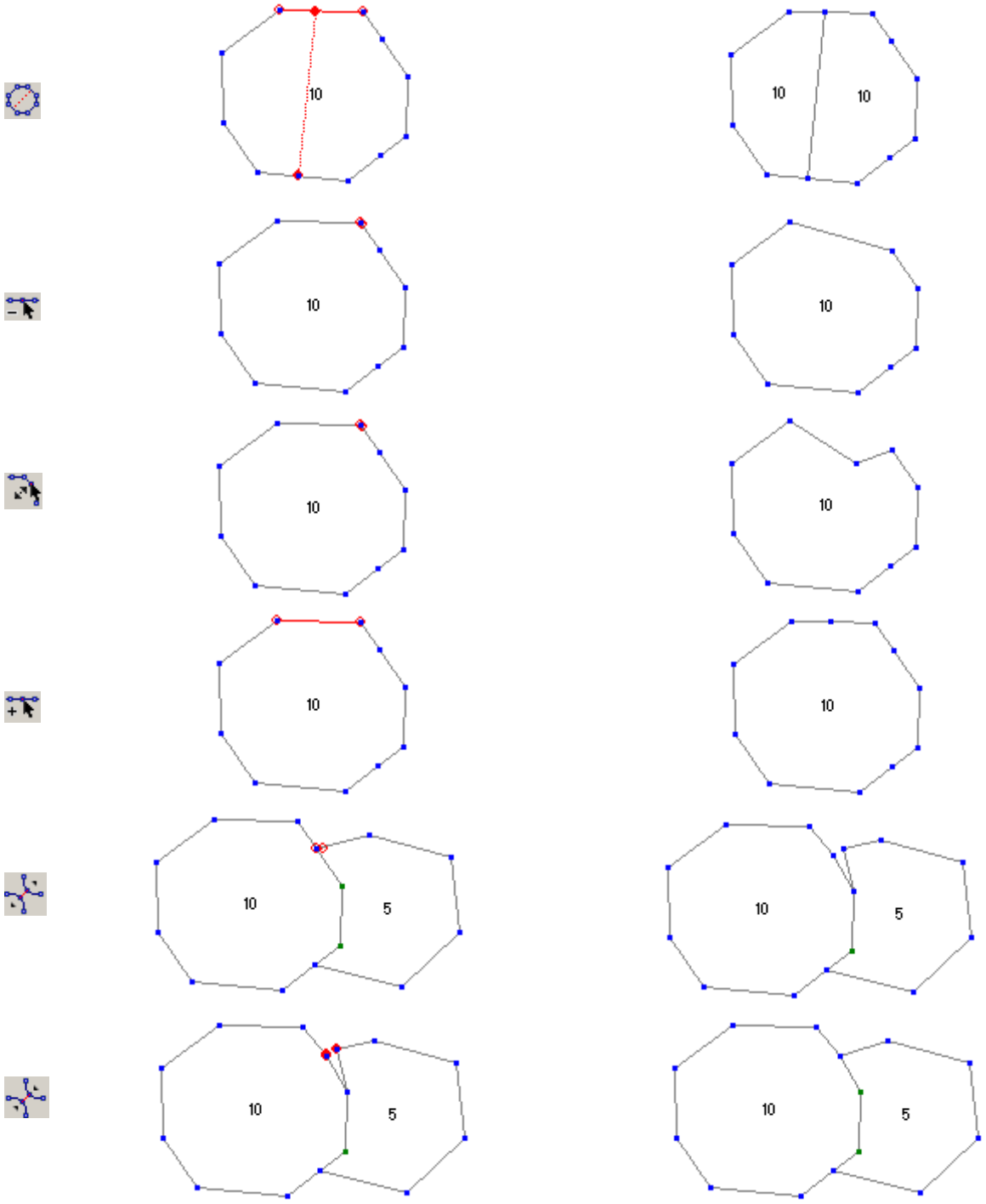
Mode **Merge points**. Press  button in control panel to run it. This mode is used to merge two points in one and attach it to another polygon border or model edge. Left click to select first point of merging. Right click to select second point or border and merge points. . If it is not possible to perform this operation (in other words if there are intersecting borders or there are less than three points in one polygon) the program will not allow user to merge points. Polygon borders and points turn red when approaching mouse cursor.

Mode **Separate connected points**. Press  button in control panel to run it. This mode is used to separate connected points. Right click is used to separate points of cojoint polygon. As a result of this operation one cojoint point is replaced by set of unconnected points, each of them belongs to its own polygon. Polygon points turn red when approaching mouse cursor.

Mode **Move point**. Press  button in control panel to run it. This mode is used to move polygon point. Left click to select necessary point. Then move this point following mouse cursor. Right click to select new position of the point. If it is not possible to perform this operation (in other words if there are intersecting borders) the program will not allow user to move point and will return it to its initial position. Polygon points turn red when approaching mouse cursor.

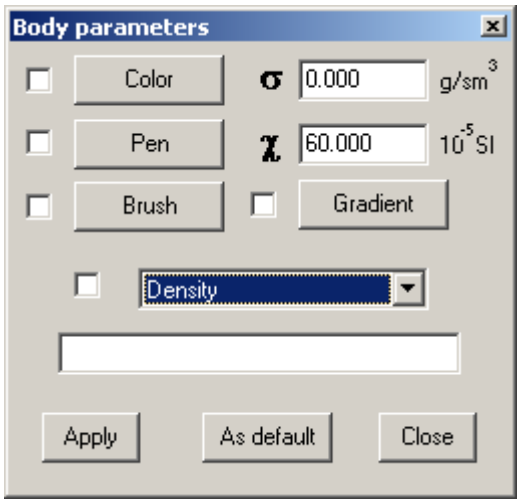
Mode **Fix/Release point**. Press  button in control panel to run it. This mode is used to fix or release polygon points. Right click to fix point, double right click to release it. Fixed points can be moved. Polygon points turn red when approaching mouse cursor.





Polygon parameters setup dialog

This dialog is used to adjust different polygon parameters. Double click on necessary polygon to run it.



Color – runs polygon filling colour setup dialog. If this function is on, specified colour is used in all polygons of the model.

Pen – runs polygon border parameters setup dialog. If this function is on, specified parameters are used in all polygons of the model.

Brush – runs polygon filling setup dialog. If this function is on, specified parameters are used in all polygons of the model.

Gradient – runs polygon gradient filling setup dialog. If this function is on, specified parameters are used in all polygons of the model.

σ – sets polygon density value.

χ – sets polygon magnetic susceptibility value.

The following option specifies type of displayed on polygon label. If this function is on, specified type is used in all polygons of the model.

Field *None* – there is no label on profile.

Field *Parameter1* – polygon density value is displayed on polygon.

Field *Parameter2* – polygon magnetic susceptibility value is displayed on polygon.

Field *All parameters* – polygon density and magnetic susceptibility values are displayed on polygon.

Field *User text* – value of the following field is displayed on polygon. The following option specifies type of displayed on polygon label. If this function is on, specified type is used in all polygons of the model.