

The Integrated Program Complex of the Composer of Geological Models. Examples of Results

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Abstract. *Examples of use of the integrated program complex of the composer of digital geological and geoecological models are considered. Some variants of one-dimensional, two-dimensional and three-dimensional interactive visualization of studied models, comparisons of results and an accuracy estimation are illustrated. Examples of reception and different ways of evident representation of incisions and cross-sections of three-dimensional objects are considered. Results of work of algorithm of address consolidation of the seismic profiles are presented, the resulted maps of isolines visually illustrate algorithm possibilities.*

1 Introduction

At the given stage in the field of creation of geological, geoecological models following questions are actual: multi-source data coupling, multi-modeling methods integration, multi-resolution visualization and detection, and multidimensional data analysis and application. The most part of the listed questions can be solved with integrated computer system "The generator of the geological model of deposit" (GGMD) use. The structure and functional components of a program complex GGMD are described in [1]. Algorithmic and program realization, technical decisions of a complex is based on combination and integration into one software system the modules of modern versions of computer algebra system (CAS) and geographical information system (GIS). Moreover it should be considered that to solve the problem of processing initial data including the results of remote sensing, seismic and magnetic exploration, simulation, there's no specific GIS to be the full set of space-analytical methods and analysis tools. In many cases it's necessary to combine the tools provided by GIS with programs for static data analysis, tools for mathematically complex computations which include implementations of modern methods and algorithms of analysis and interpretation of spatial data.

2 Model Visualization Tools

More than ten options of 1D, 2D and 3D plots were implemented in GGMD system, including modules for obtaining and designing maps and inserts on them, plots on profiles, 3D visualizations of possible incisions (vertical, horizontal), clipping (simple and complex).

The illustrations of the usage of several visualization tools are given below on example of reference surfaces ([1]), but all the modules of this group can be used for any surface equation or digital description of distribution, which are received or imported into the system.

Profile visualization. Let's mark out the examples of obtaining and configuring geological profiles in the complex of plots – the illustrations are given on pictures fig. 1 – fig. 3. While solving the problems of the geological simulation, profiles are used to visualize the connection between relief and the structure of Earth's crust. Geological profile is a graphic image in vertical plain of subsoil structure and deposits contained in it. In this case, profile – is a line, which is obtained at the intersection of analyzed surface and vertical surface in a given direction.

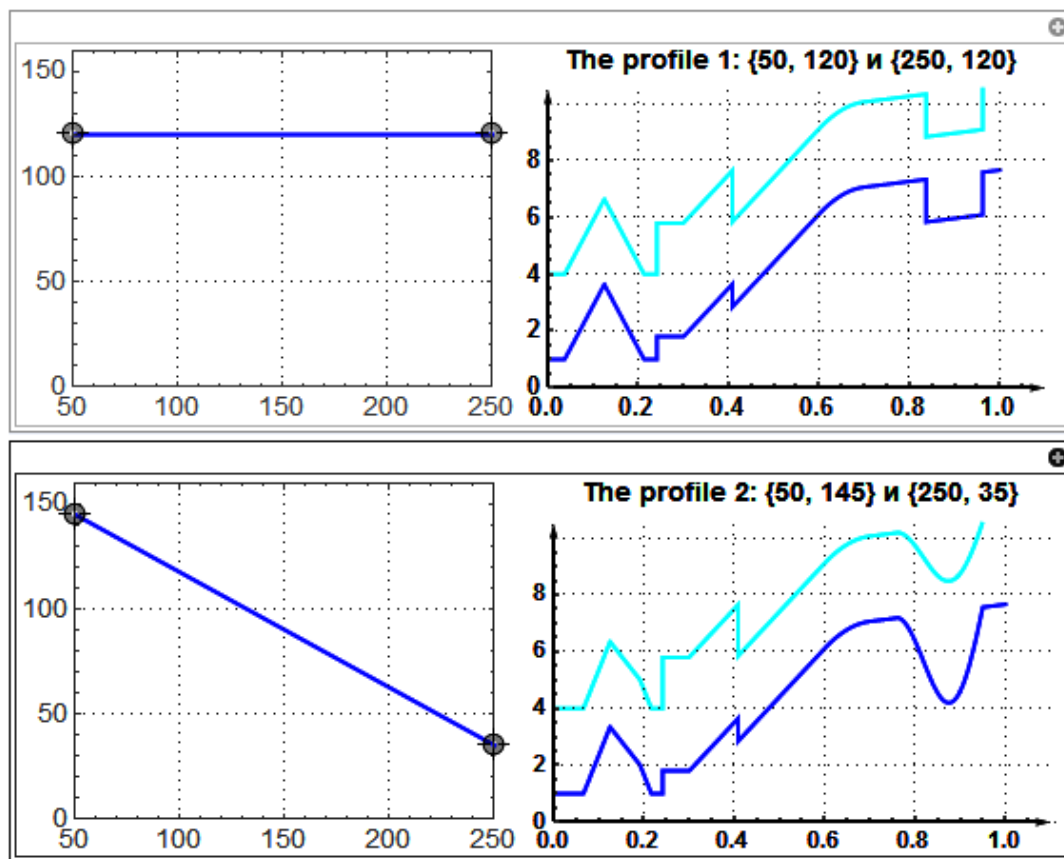


Figure 1: Example of indicating of profiles by locators, graphics of cross-sections.

Let's clarify the main interface options for profile indication. System's user can move the locators (beginning, end of the profile) on a scheme of the modeling plan

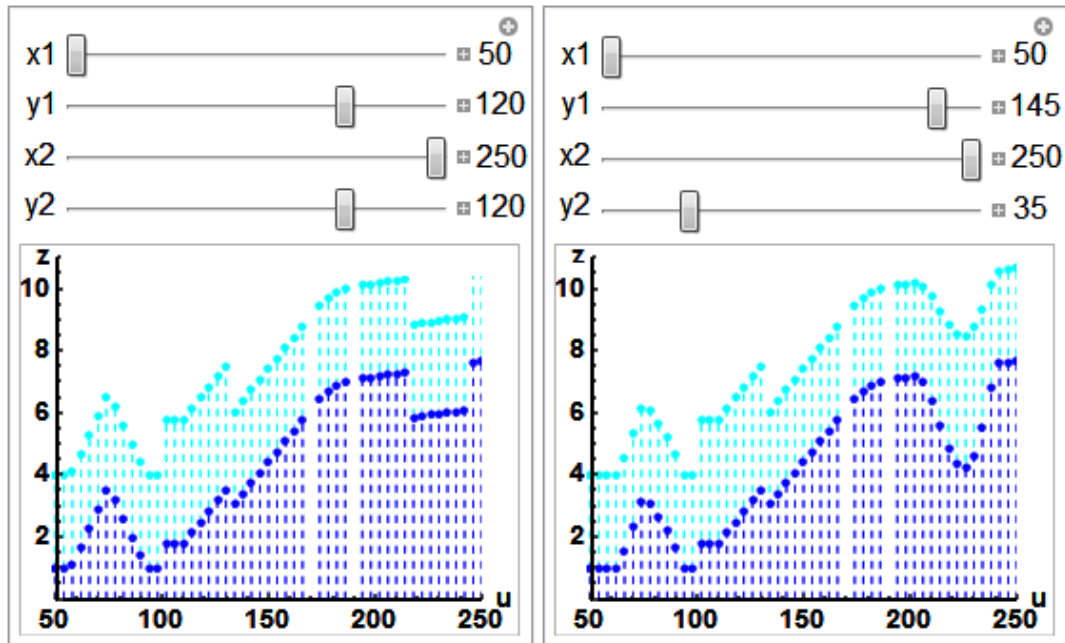


Figure 2: Example of indicating of profiles by scroll boxes, graphics of cross-sections.

(on fig. 1 left), simultaneously distribution of the result function of the model's surface on the chosen direction is drawn on the right part of plot. The beginning and the end of the profile don't need to be at the boundaries of the domain of function, user can choose any part he's interested in, and so can detail function's behavior. In such implementation X-axis is divided by the unit of profile length. In such implementation option there's the way you can compare the levels of surface on the two profiles.

There are screenshots of setting and result panels at the fig. 2. It is illustrated by another option which is provided by corresponding module in GGMD – there is a possibility to specify coordinates of the beginnings and the ends of profiles not by the change of locators' position but by moving the cursor on a scale or correct number input – input field is opened by clicking the plus sign.

In the examples above surface shape is detailed by visualization using 2D and 1D plots. There's an option of visualization using 3D and 1D plots shown on fig. 3. Software module gives for user a possibility to choose the direction (switch – is 2 buttons at the top of a panel) and set a specific position of the cutting plane with slider or by setting correct value. Wherein the section line (magenta dashed) is shown on 3D plot of surface and profile is displayed at the left part of the window.

Visualization of incisions, cross-sections. Examples of graphic illustrations of incisions are shown on pictures fig. 4, 5. There are interactive modules with coordinates dashboard for 3D visualizations of possible incisions (vertical, horizontal), clipping (simple and complex).

Illustrations of simple incisions of a profile (by one vertical section plane) are shown on the fig. 4. Illustration are obtained in an overview angle (-3,-3,1) output.

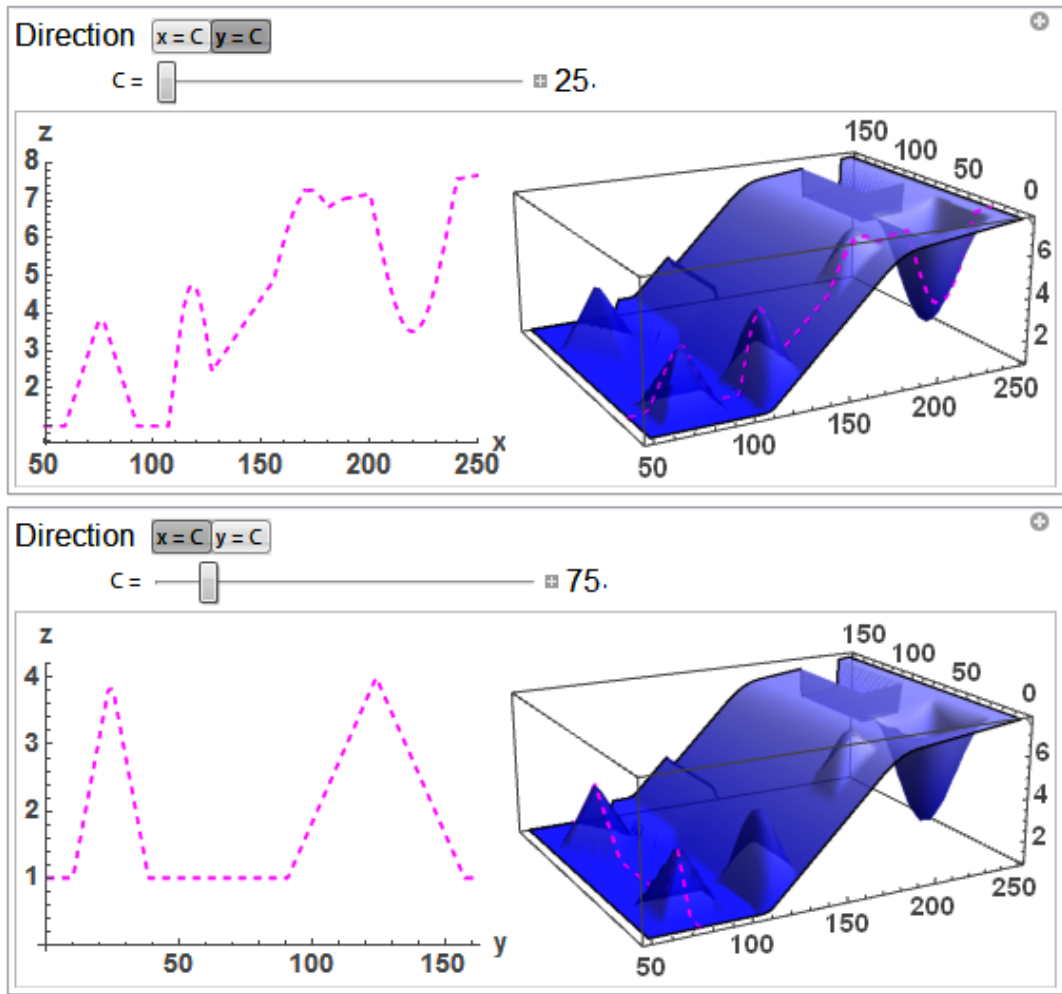


Figure 3: Profile work panel, option of 3D and 1D plots.

Illustrations of complex profile incisions (by several vertical section planes) in several overview angles output are shown on the fig. 5. Equations for sections planes are given in the titles of plots; for the left plot an overview angle is $(-3,1,1)$, for the right one $(-2,2,0.7)$. Given on the pictures formulas for setting incisions can be useful while working (in parallel or separately) in other software systems, in the complex everything is working interactively along with the visual monitoring using plots.

It should be mentioned that module interface at determining incision planes is similar to the tools as on the fig. 4, 5; user performs actions interactively. Also standard tools of system *Mathematica* ([2], [3]) allow, by fixing any configuration of incision planes, to view 3D model of an object by interactive change of angle, scale, relative position. Among the tools for setting the model view there also indicators, drop-down menus, sliders for management / selecting the color scheme of the surface, the level of transparency.

Of course, isoline and zone (density) maps are part of tools for models' visualization, their examples are given below.

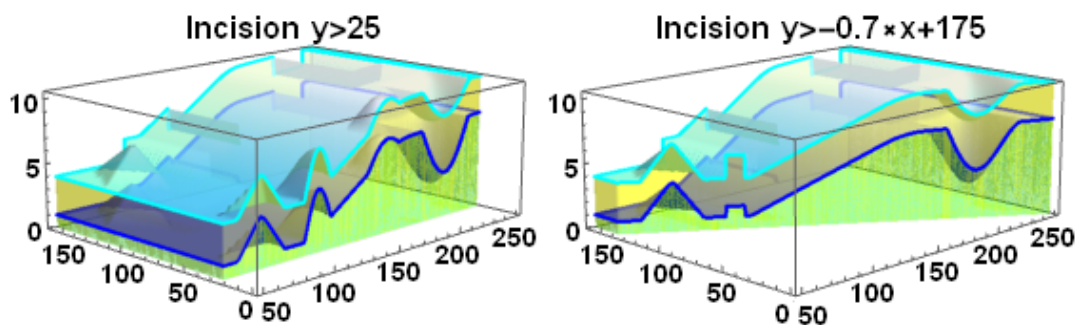


Figure 4: Examples of the output of simple incisions.

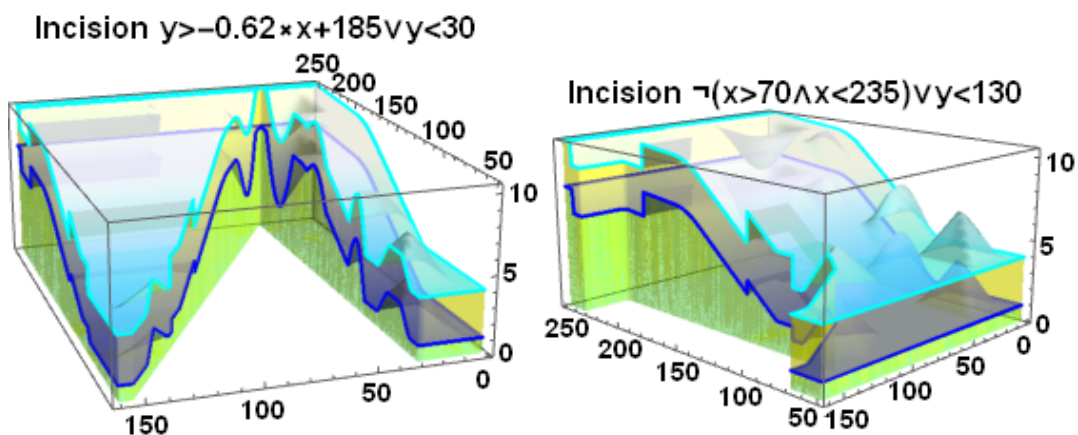


Figure 5: Examples of the output of complex incisions.

3 Tools for Data Capture Simulation and Mapping

While creating geological models the main data sources, which are always present while searching and preparing the objects for oil and gas drilling, are the results of seismic survey, gravity and magnetic surveys. In practice, seismic forecasts are usually ambiguous, unstable because seismic survey has various kind of inaccuracies. From the other side, the direction of improvement of seismic profiling technology is the development and justifications of the method of address compaction of seismic profiles. A part of this technology – is designing of network of seismic profiles with certain density and relative uniformity. In the present work, the issues of seismic survey data preprocessing and designing of network of seismic profiles are not discussed, as this should be a subject for a separate presentation.

The tools of observation profile generator (OPG) of GGMD system, which can be used during estimations of optimization of network of seismic profiles – during “manual” work (an expert interactively determines the scheme) as well as in automatic mode, when executing module of “Adaptation” component while processing

certain initial data offers a choice of several options of schemes, are mentioned and illustrated. The examples below illustrate the tools of OPG module, recommended for maintenance of such analysis graphics.

Let's notice that setting and changing an observation profile scheme in GGMD is similar to setting the profile cross-sections. Directions are defined on the plan (scheme) of domain, on each plan start and end points of a profile as well as the number of measurement points are fixed. Examples are shown on fig. 6 – 8. Let's mark out, that illustrations were prepared not to show qualitative result of model creation but to explain user work steps. Another important aspect – is that fragments of maps are illustrated in isolines, which is 2D graphics, but not three dimensional views, since discussed details are hardly distinguished on 3D images.

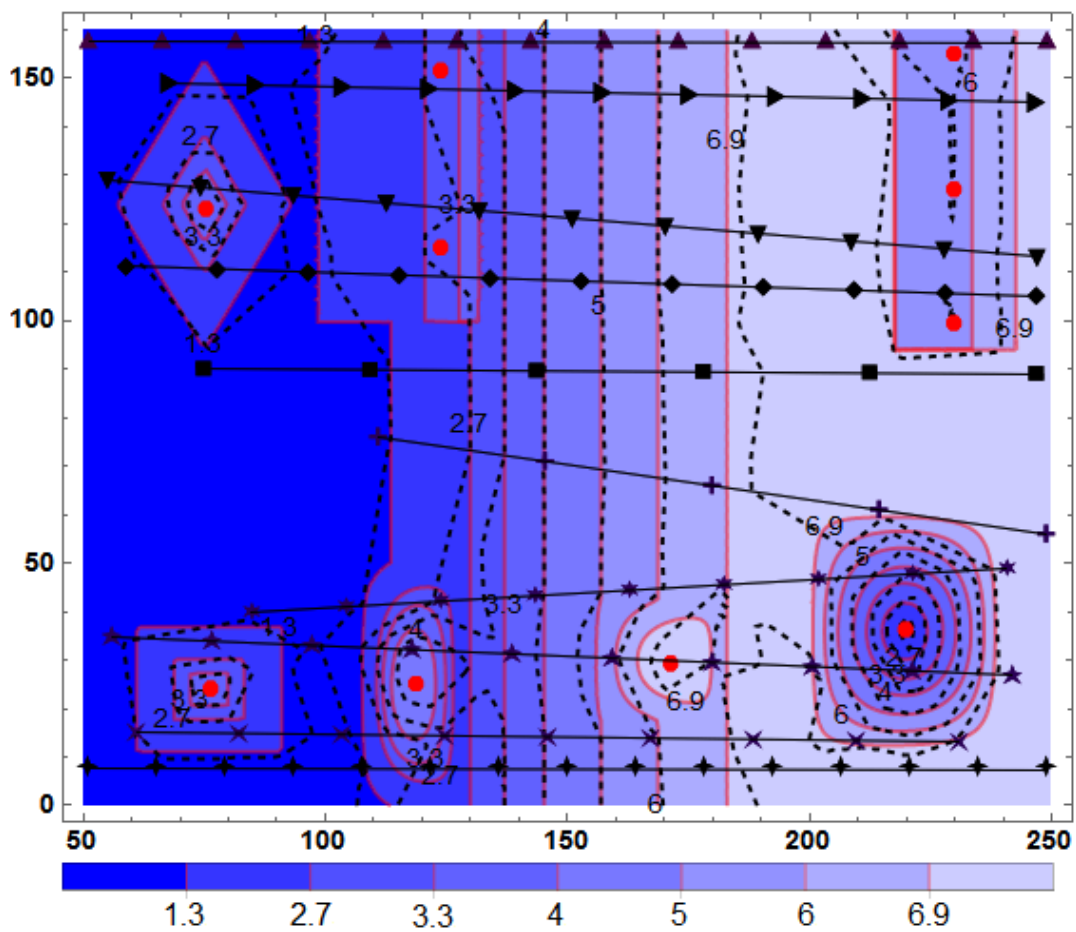


Figure 6: Isolines of reference and reconstructed by 111 nodes fields.

The algorithm of preparing given illustrations is the following. The user, using mentioned above interactive tools, draws profiles scheme, setting for each the number of nodes. In a separate software module of GGMD for each node a triple of numbers is formed: coordinates x and y , calculated value of surface function in point-node. The numbers of profile, node on profile and mentioned triple of numbers are exported in a file, the user chooses a format from offered options; it can also be exported in

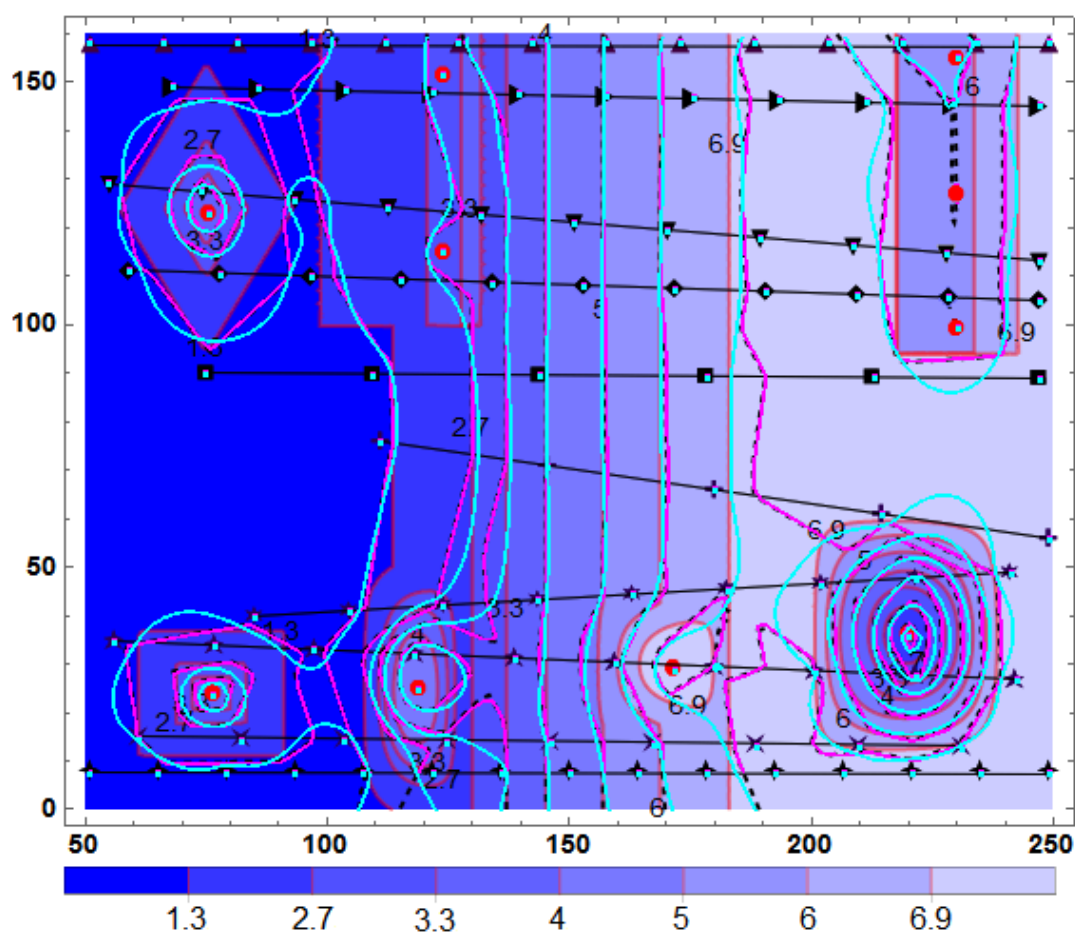


Figure 7: Isolines of reference and reconstructed in Surfer by 111 nodes fields.

.XLS (XLSX, CSV). Let's notice, that such simulation of data obtaining made by surface levels in a measurement point gives an accurate value, but there are separate tools in GGMD for "distortion of observation results" (on each separate profile) by the imposition of noise using sets of different functions with oscillations and random number generator ([4]).

Then the user in available application from a scattered set of measurement points, using one of selected algorithms, builds an approximating digital field. For example in [5], any of the following methods can be used for interpolation, extrapolation: Triangulation with Linear Interpolation, Minimum Curvature, Polynomial Regression, Inverse Distance to a Power, Shepard's Method, Radial Basis Functions, Kriging.

Fig. 6 shows the results of comparison of reference digital field and reconstructed by the set of points on profiles field. The nodes are marked with various black primitives. The scheme of profiles – one of offered by the expert to whom the information on the form of a base surface and position of fragments-indignations has been given. Solid red lines mark isolines of reference digital field, which is built by analytically specified ([1]) distribution $z_{\text{SurfB}}(x,y)$, the levels of isolines were specified and selected so that the non-plateau area is covered with isolines

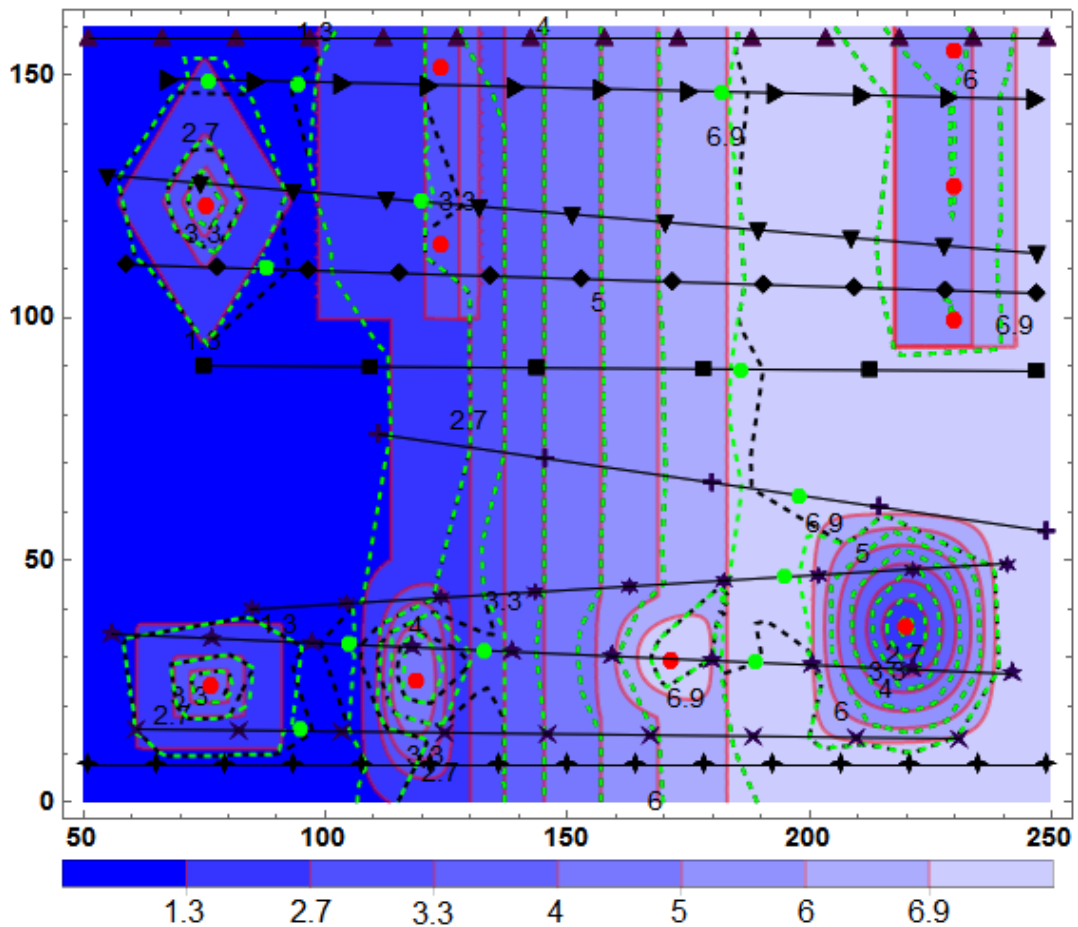


Figure 8: Isolines of reference and reconstructed by 123 nodes fields.

relatively uniformly. Black dashed lines mark isolines of the same levels, but for the functions, formed with second-order interpolation method in the *Mathematica* system. Red circles note representative control points of fragments-indignations which also are used at approximation. In the given example in calculation 111 nodes were considered.

An example on fig. 7 is given for demonstration the different tools of GGMD and options for user actions. Fig. 7 shows the results of comparison of reference digital field and reconstructed fields in Surfer by the same set of points on profiles – Kriging method (magenta isolines) and triangulation with linear interpolation method (cyan isolines) with a grid step 1.0.

The results of proposed and programmed algorithm of address compaction of seismic profiles from a program component “Adaptation” are shown on fig. 8. The nodes of the second profiles scheme are marked with green primitives. It’s important that previously used nodes are saved, the new ones supplemented and all of them are on the same profiles. The complex module in which the algorithm of a method of address consolidation is realized, offers the user for acceptance some variants, one of which is resulted. As in example in fig. 6, but by the second set of points with

measurements isolines of a function, formed by the same method in the *Mathematica* system, are shown with green dashed lines. The comparison of configurations of isolines shows that new digital field reproduces reference field much more accurate.

4 Conclusion

The tools of automated workstation of specialist, who during the computational experiments works out techniques of adaptation of digital fields, which applied to problem of geological models formation, are described and illustrated. The developed integrated computer system gives manipulation possibilities initial data, the analysis and comparison of interpretations and variants of the experts received in the different ways of results and standards. Results of work of algorithm of address consolidation of the seismic profiles are presented, the resulted maps of isolines visually illustrate algorithm possibilities.

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