Journal of Advanced Computer Science and Technology, 2 (2) (2013) 59-67
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Automation of the interpolation of pre-processor basic data for program complex “press 3D URAL”

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Abstract

To automate the process of forming the baseline data pre-processing software package block PRESS 3D URAL [1], designed to solve engineering problems of Mining Geomechanics encouraged to use triangulation objects 2D space mining plans and their subsequent transformation into a 3D computational model.

Keywords: *Automation interpolation, 3D Ural complex, mining geomechanics.*

1 Introduction

The relevance of the process of automating the production of baseline information is to reduce labor and time costs when dealing with a different kind of engineering problems. This problem becomes particularly acute when creating baseline data objects in the 3D geometric space in addressing regional challenges with a sharp change in the object's properties. In doing so, created a database of objects strict requirements adopted to the calculation method of the CPU (computer) unit.

In mining the greatest popularity was got by finite element methods (FEM) and boundary integral equations (SMI) for the calculation of the stress and strain of rocks, as well as modeling dynamic problems. This applies to both flat and, in recent years, spatial tasks on calculating stresses and strains around, passing in an array of rocks. The most effective is the use of numerical methods for solving differential equations. However, the use of numerical finite element method (FEM) in 3D tasks is very labor intensive, especially from the perspective of paging space on finite elements, their pairing, the source and the analysis of the information received. Therefore, the effective application of a calculation method depends on understanding the problem. In meeting the challenges of mining should be borne in mind that the accuracy of calculation will depend on the quality of the initial information provided by various services of mines (mine, geological, hydrogeological, etc.), design and research institutes.

Experience in conducting research work on mining enterprises in Russia had shown that for specific tasks by current and prospective (monitoring) a projection for strained and impact of dangerous condition and geomechanical justification safe parameters of structural development systems it has become necessary to use technical information 2D plans of mining, the miners used in mining. To work with mining plans greatest attraction has become the method of boundary integral equations. As a result of research it was decided to create software package that includes the interlocking blocks we, and postprocessor data processor.

This article focuses on the automation of creating baseline data pre-processing software PRESS block 3D URAL (see fig. 1), designed to measure the stress-strain State, sustainability and impact hazards of massive of rocks and pillars for various purposes with an aggregate view of the wide range of geological and geotechnical factors: arbitrary spatial configurations developed space, boundary-value of ore deposits (coal), pillars and other supporting elements; random location relative to the edges of the structural elements of the developed space; various physical and mechanical properties of the enclosing rocks and ores (coal); variable capacity of the ore (coal); parameter handling events and tectonic disturbances.

Objects «supporting elements» are related to structural elements of design are carriers, supporting constructions (ore deposit, interchamber and barrier pillars, swathes of nonindustrial mineralization rock mass) with the following properties: dimensions (width, length, and capacity) and location in 3D space, physical and mechanical properties of ore or rock.

Objects «mined-out space» relate to structural elements of development systems belonging to mined-out space (clearing room, for the development of various purposes, etc.) and have the following characteristics: geometrical sizes (width, length and height) and location in 3D space, physicomechanical properties of rocks from the mine roof (fig. 1). Loading values for ground stope directly depend on the interaction of the mine roof and ground ore deposits. Accounting for the effects of this interaction is affected by the displacement.

Parameters of tectonic disturbances include the following properties: appearance; type; elements of the occurrence; the angle of internal friction and adhesion of breeds of a seam of tectonic dislocation.

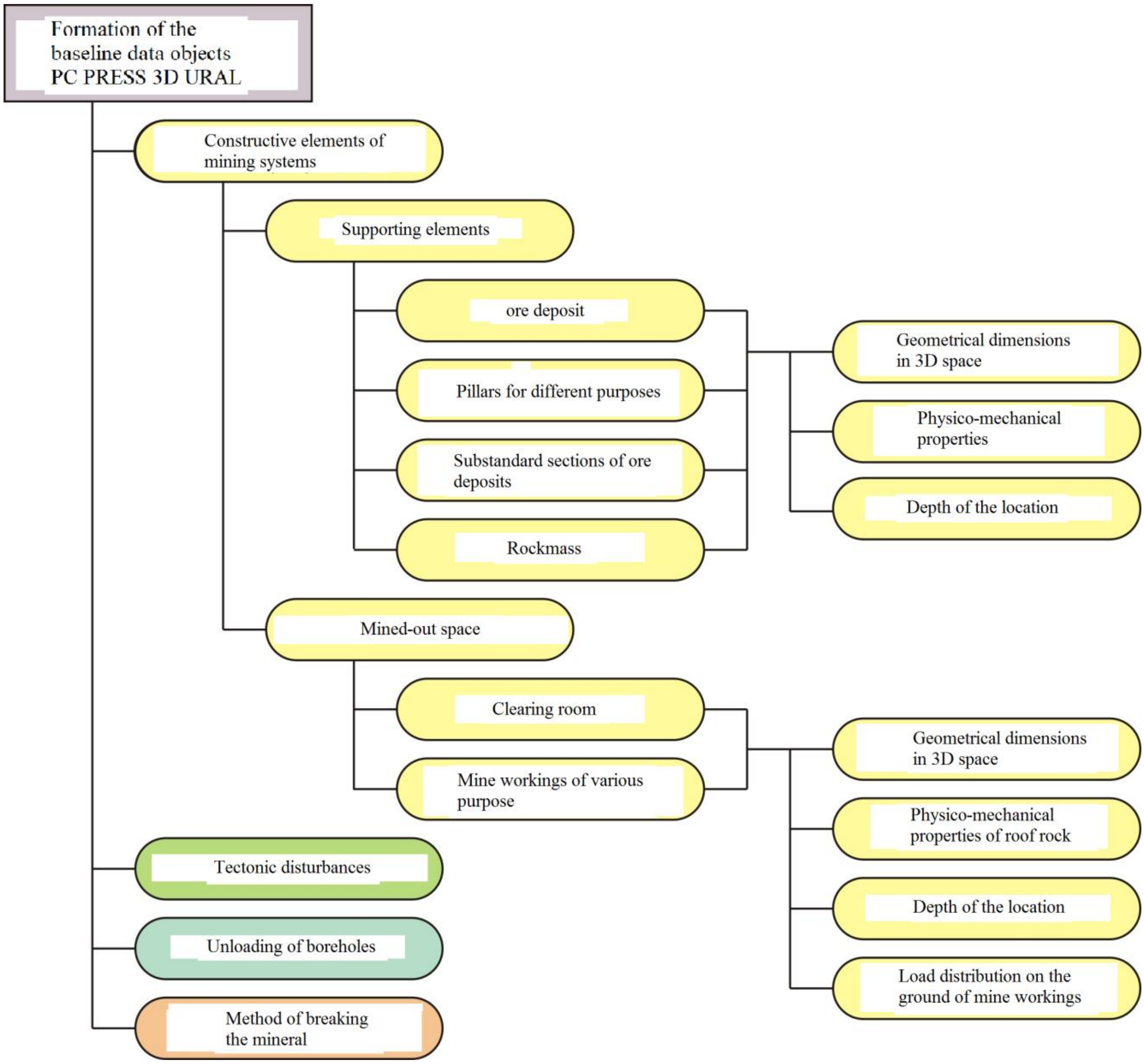

Fig. 1: Block diagram of preprocessing unit

Parameters of preventive measures target the unloading of dangerous ore-rock mass concentrations of rock pressure, mainly due to the drilling of large-diameter pore include the following properties: pore diameter, pore spacing.

Parameters blasting breaking include the following features: dynamic coefficient of ores and rocks, the thickness of the fall layer, parameters of drilling and blasting operations certificate.

From the analysis of the block diagram (fig. 1) shows that the preparation of the necessary background information for further calculations without addressing the issue of automation will be a difficult and time-consuming process.

2 Preliminary notes

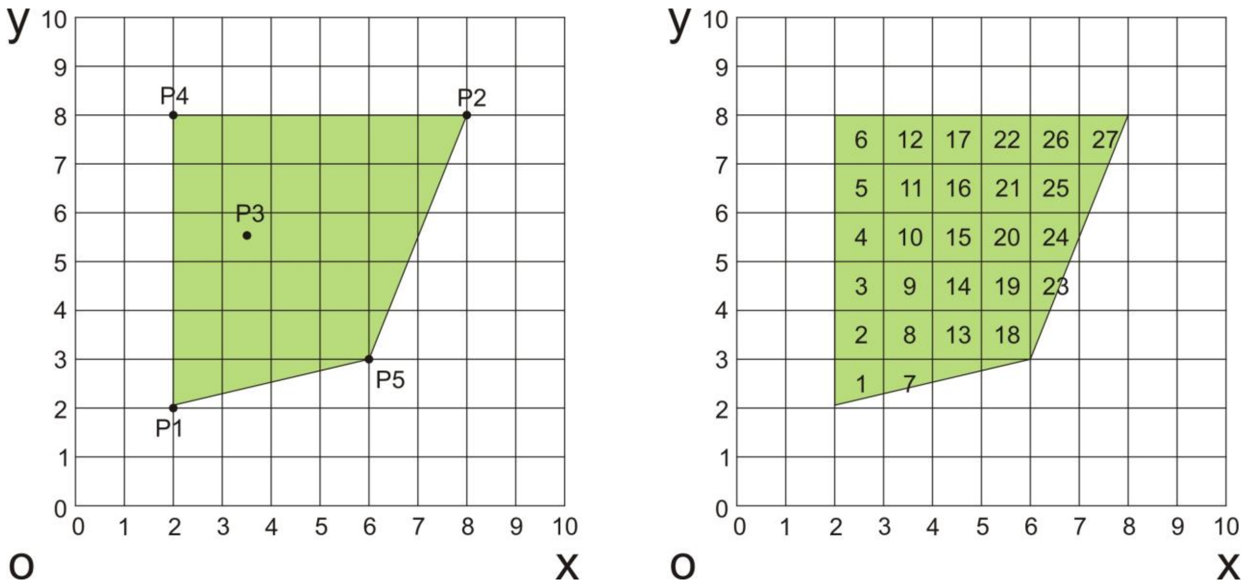

Fig. 2: Investigating interpolation data area

Table 1: Baseline data points that specify the function

№ of Points	x	y	Value of function P
1	2	2	10
2	8	8	1
3	3.5	5.5	7
4	2	8	5
5	6	3	3

3 A step before the final submission

Software module and algorithm testing results

A software module for automatic interpolation of initial data forms part of the software package PRESS 3D URAL, written in Pascal, and provides the implementation of two main procedures:

- **Create_Triangles,** used to create triangles (triangulation) within the study area (see fig. 2);
- **Interpolation_value,** used to interpolate the values of elements covering the study area.

Implementation of procedures **Create_Triangles** to create triangles (triangulation) within the study area is shown below.

```
procedure Create_Triangles;
var
   i, j, k: integer;
begin
   count := 0;
   for i := 1 to num_pnt do
   begin
```

```
        for j := 1 to num_pnt do
        begin
            for k := 1 to num_pnt do
            begin
                if (i <> j) and (i <> k) and (j <> k) then
                begin
          // A. Procedure for the formation of the original data points
          proc_init_data_pnt;
          // B. Procedure for the formation of triangle vertices
          proc_init_data_tr(i, j, k);
          // C. Auxiliary procedure for finding a point inside the triangle
          proc_pnt_in_tr(var_x_A, var_y_A, var_x_B, var_y_B, var_x_C, var_y_C);
          // D. Procedure for determination of the directions of location of triangle vertices
          proc_init_tr(var_x_A, var_y_A, var_x_B, var_y_B, var_x_C, var_y_C);
          // E. Procedure for computing the determinant circle
          proc_det;
          // F. Procedure for verifying the directions of the triangle vertices
          proc_prov;
          // G. Procedure for determining if the remaining points in the circle
          proc_prov_pnt_tr(i, j, k);
       end;
            end;
        end;
    end;
    // H. Procedure for creating a vector triangle
    proc_create_tr;
end;
```

When implementing the procedure Create_Triangles obtained the following 4 results of the triangle (fig. 3)

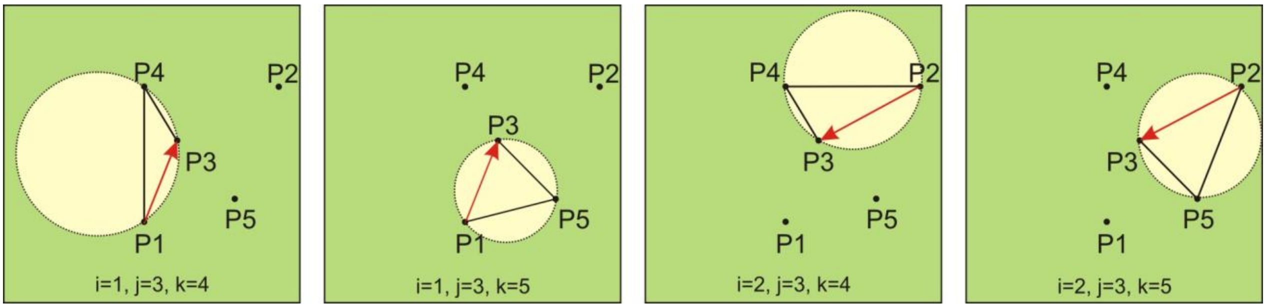

Fig. 3: The resulting triangles

Implementing procedures for Interpolation_value for interpolation function values in the elements of study area is shown below.

```
procedure Interpolation_value;
var
  i, j: integer;
begin
  // I. Procedure for the formation of initial data points of the elements of interpolation
  proc_init_value_elem;
  for i := 1 to num_elem do
  begin
    var_x_elem := vec_elem_coord_x[i];
    var_y_elem := vec_elem_coord_y[i];
    for j := 1 to count do
    begin
      // J. Procedure for the formation of initial data points of the triangles
      proc_init_value_tr(j);
      // K. Procedure for the construction of triangles and find the desired function values
      Build_tr;
    end;
    // Result for the interpolation of the function values
    vec_elem_value_P[i] := StrToFloat(Format('%4.1f', [Res_value_P]));
  end;
end;
```

When implementing procedures **Interpolation_value** the following results were obtained by interpolating values from functions (fig. 4).

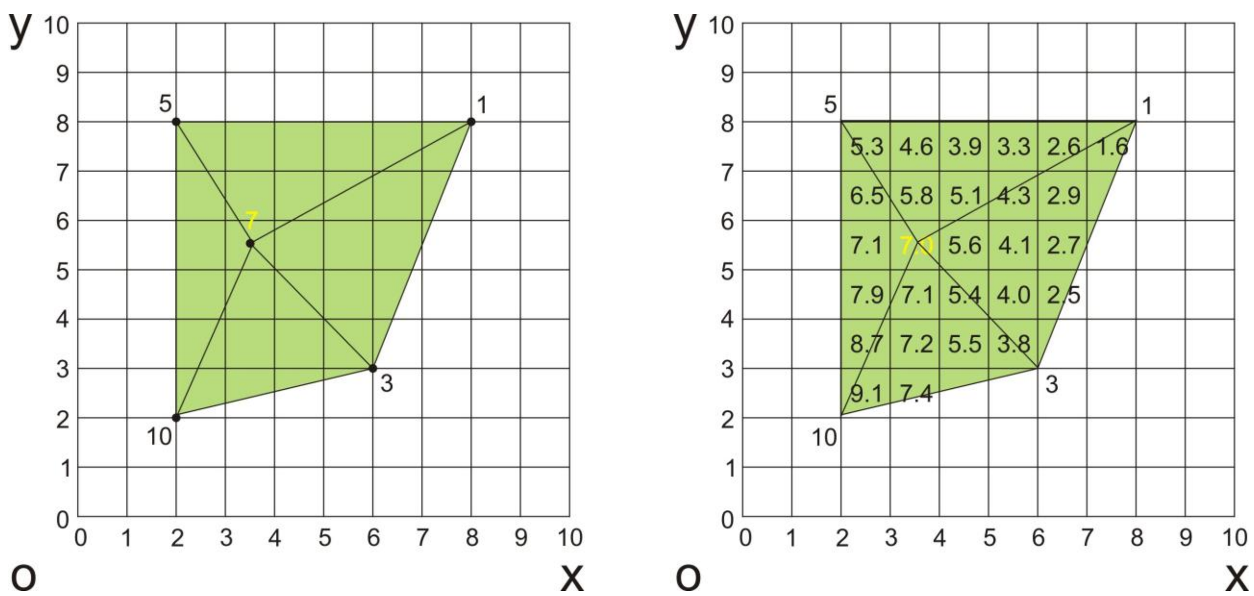

Fig. 4: Results of interpolation

4 Main results

Practical application of automated source data interpolation

Let us consider the application of the method on the example of interpolation of the input data for the objects of «Supporting elements» on the property «Geometrical dimensions in 3D space» and «the Depth of the location. » Width and length of the object shall be adopted in accordance with the projections of the constructive elements of the mining plan operations. The capacity of the «m» ore deposits, the height of the pillars of various purposes shall be adopted in accordance with the data of surveying measurements of mining workings heights and clearing room, imposed during their sinking of mining operations plan (fig. 4). Similarly, at the plan of mining operations are processed by taking account the depth point of the «H» location of objects.

From fig. 5 it follows that the "Capacity" and "Depth" vary in a significant range within the entire area. At the same time, it should be noted that the averaging of data to make it easier to enter the input information is invalid as it will lead in the future to further incorrect calculation, since the height of elements affects them and the depth of the deformation properties of the location of the elements on the value of the source of stress condition.

For ease of implementation of the method of boundary elements, associated with the calculation of double integrals, the study area is divided into rectangular or square in shape. On the one hand, this leads to some errors due to the inability to accurately cover the square or rectangular elements of complex configuration of domains, but on the other hand in 2 times reduces the computational elements compared with elements of triangular shape, which greatly affects the reduction of calculation time, but also eliminates certain difficulties with interpretation of the output results.

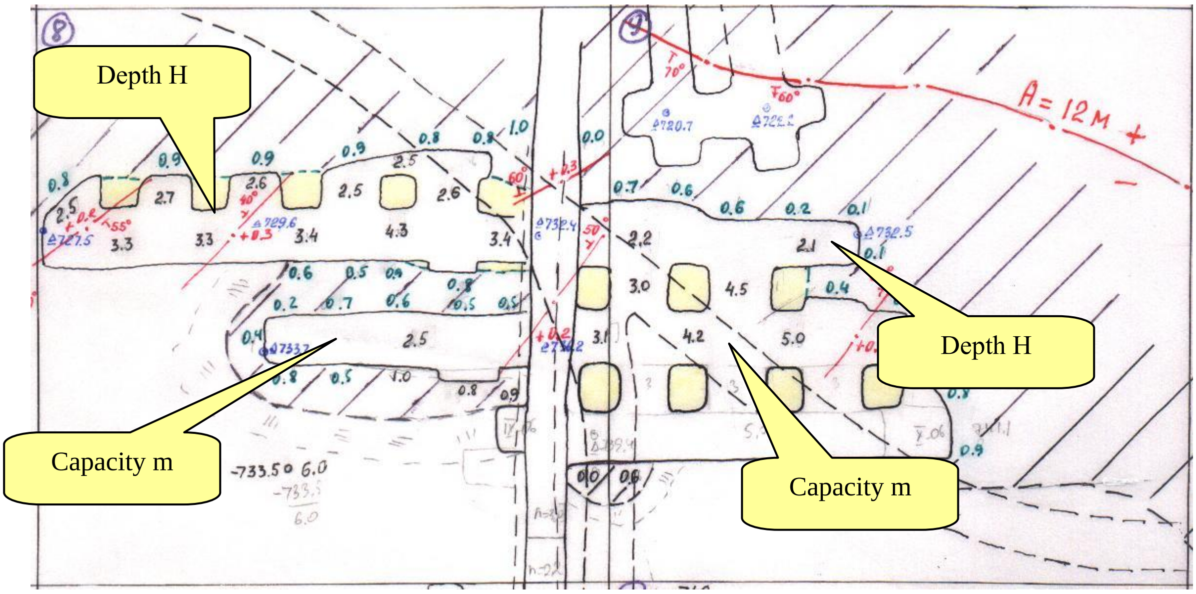

Fig. 5: Plan of mining operations

Preprocessor block PRESS 3D URAL is based on the technology of mining plan covering electronic grid boundary elements (fig. 6), which are objects with a set of unique properties. Thus, the structural elements of development systems are divided into many independent objects, each of which must be given certain properties.

Coordinates «x, y» of any object within the boundaries of the plan of mining operations are automatically determined by the program. At the same time, the objects "Supporting elements" have the property of "Capacity", and the objects" mined-out space" have property of "Height". In case, if Deposit capacity is less than minimum designed height of the mining workings, the property «Height» object to « mined-out space » is set to a value equal to the minimum designed height.

As noted above, for each type of factors creates a separate component for storing information about that factor. Creating a separate component of each factor is necessary to ensure the interactive capability adjustments by moving it within the boundaries of the area, as well as changing numeric parameters. This idea is implemented in the following way. Within the boundaries of the area at the points which are known according to the mining plan values such as the capacity of the ore deposit, height chambers drifts placed the necessary components of objects, and then they are assigned specific numeric values. Prerequisite is a separate component placement facility in every corner property line. This requirement is necessary to comply with complete coverage of all the triangles of the triangulation of elements (objects) of the electronic grid. The connection object components in triangles and to further the interpolation values are carried out automatically.

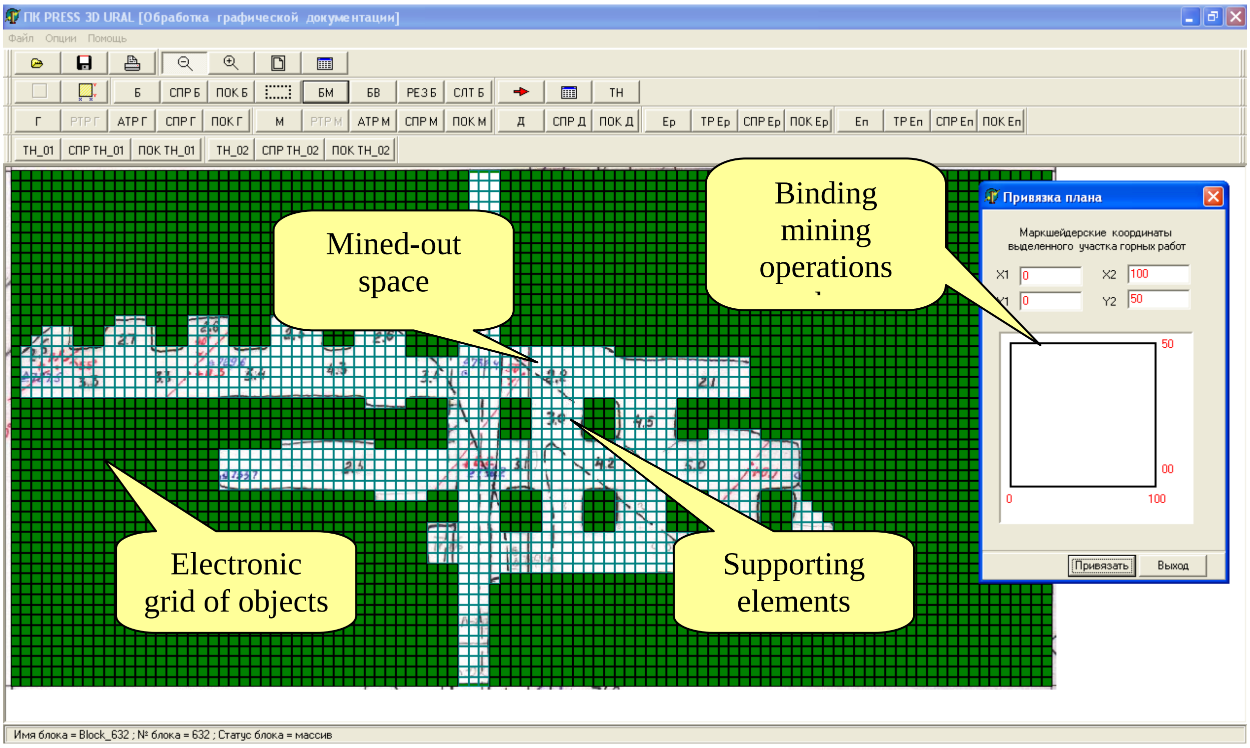

Fig. 6: Mining plan Covering electronic grid boundary elements (objects)

In fig. 7 it is shown a picture of the resulting triangulation object components "Depth".

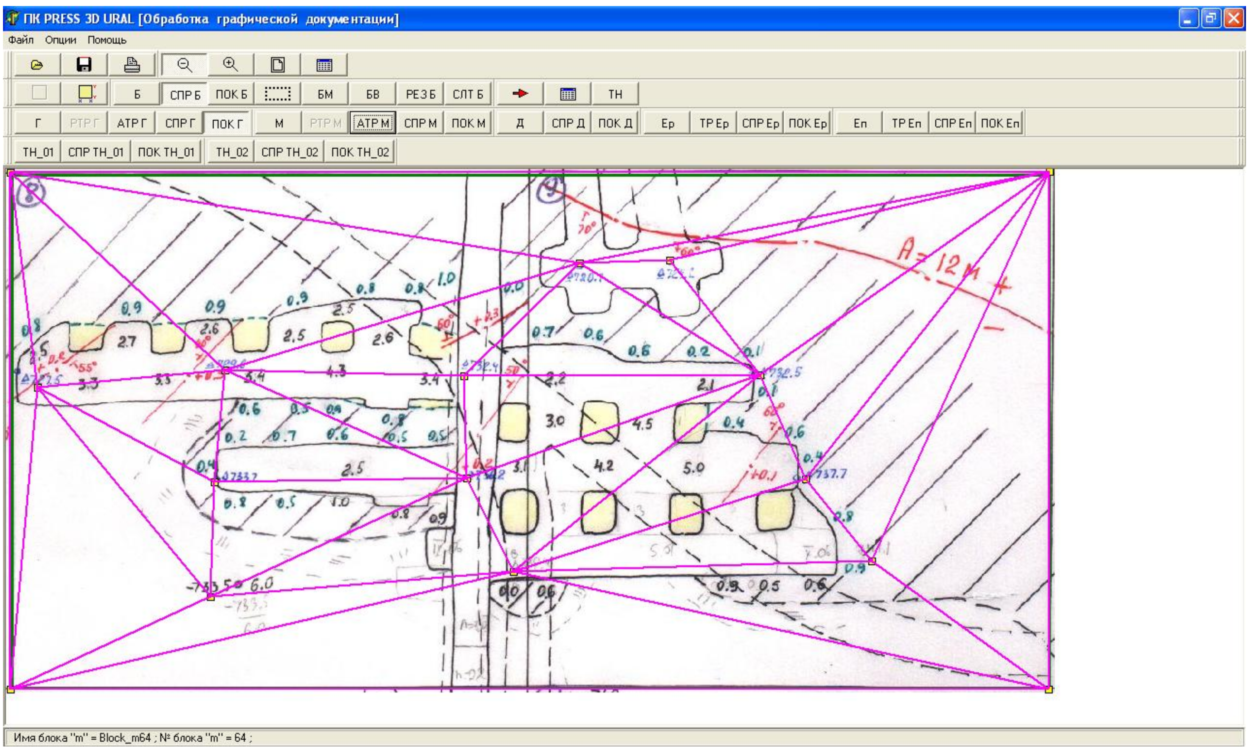

Fig. 7: Results of the triangulation object components "Depth"

In fig. 8 shows a picture of the results of boundary elements resulting from the interpolation of the input data objects "depth". Wave distribution of result values "depths" in elements related to the uneven deposition of ore body in 3D space.

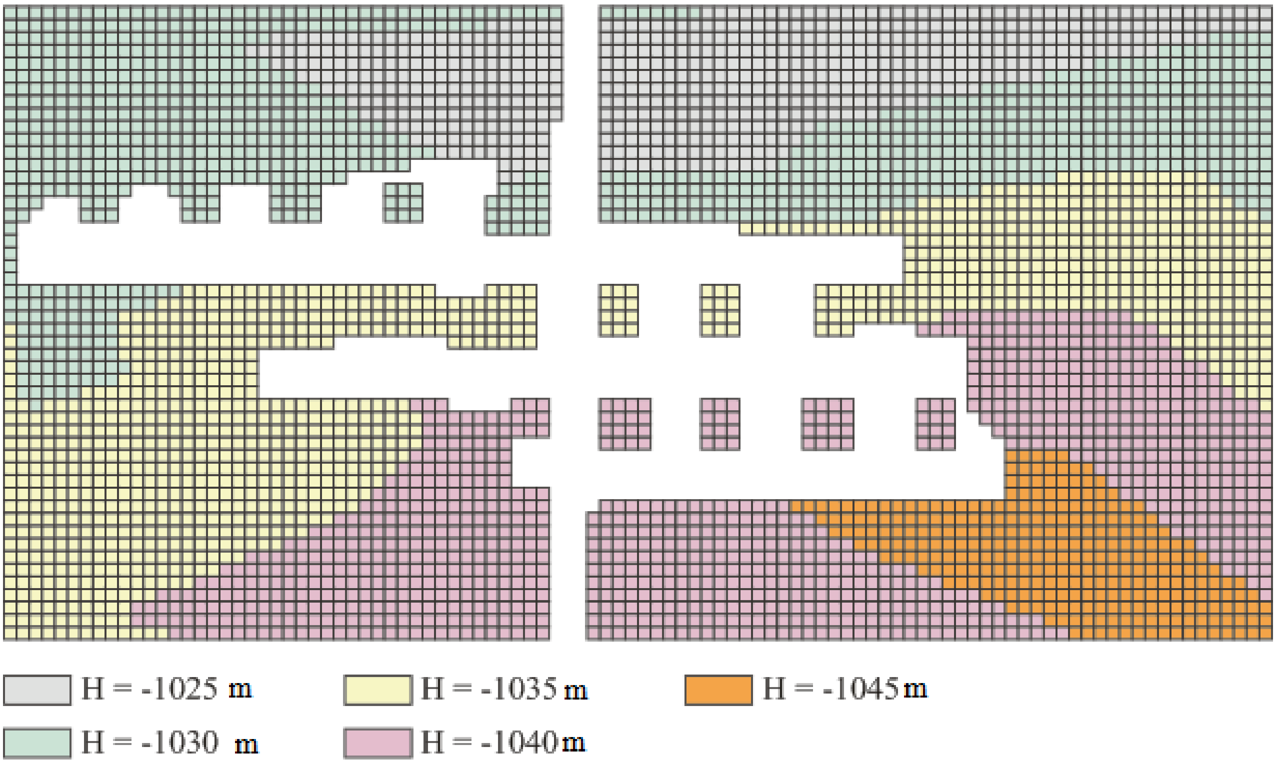

Fig. 8: Results of interpolation input data objects "Depth"

In fig. 9 shows a picture of the resulting triangulation object components 'capacity.' Analysis of fig. 9 shows a sharp change hypsometry (capacity) of ore deposits within the study area.

In fig. 10 shows a picture of the results of boundary elements resulting from the interpolation of input data of the "capacity" button. Discrete distribution of result values "power" in the elements associated with sharply uneven capacity of the ore body and the interchamber pillars in 3D space.

5 Conclusion

In this section you should present the conclusion of the paper. Conclusions must focus on the novelty and exceptional results you acquired. Allow a sufficient space in the article for conclusions. Do not repeat the contents of Introduction or the Abstract. Focus on the essential things of your article.

Studies have shown that the full preparation of baseline data on the components of "depth" and "capacity" within the study area of 5000 m^2 and 5000 designed elements covered with geometrical dimensions of 1x1 m was spent not more than 60 minutes. Thus, for the preparation of input data for engineering tasks as in mining and other industries is well suited to automated processes, including the process of interpolation.

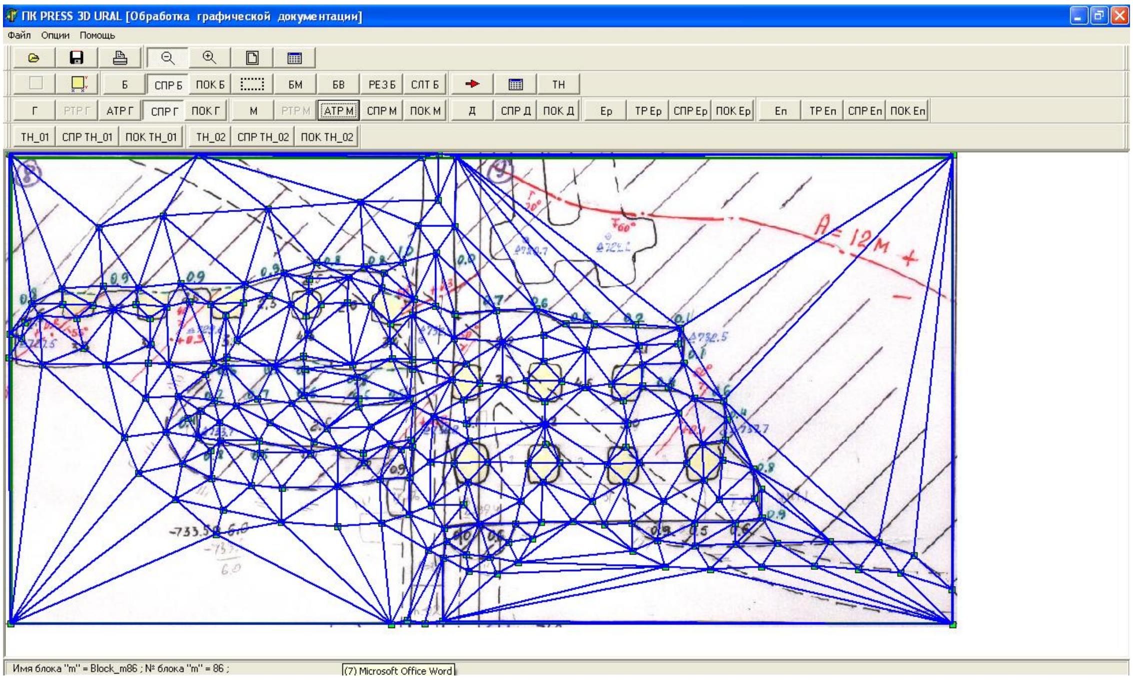

Fig. 9: Results of triangulation object components "Capacity"

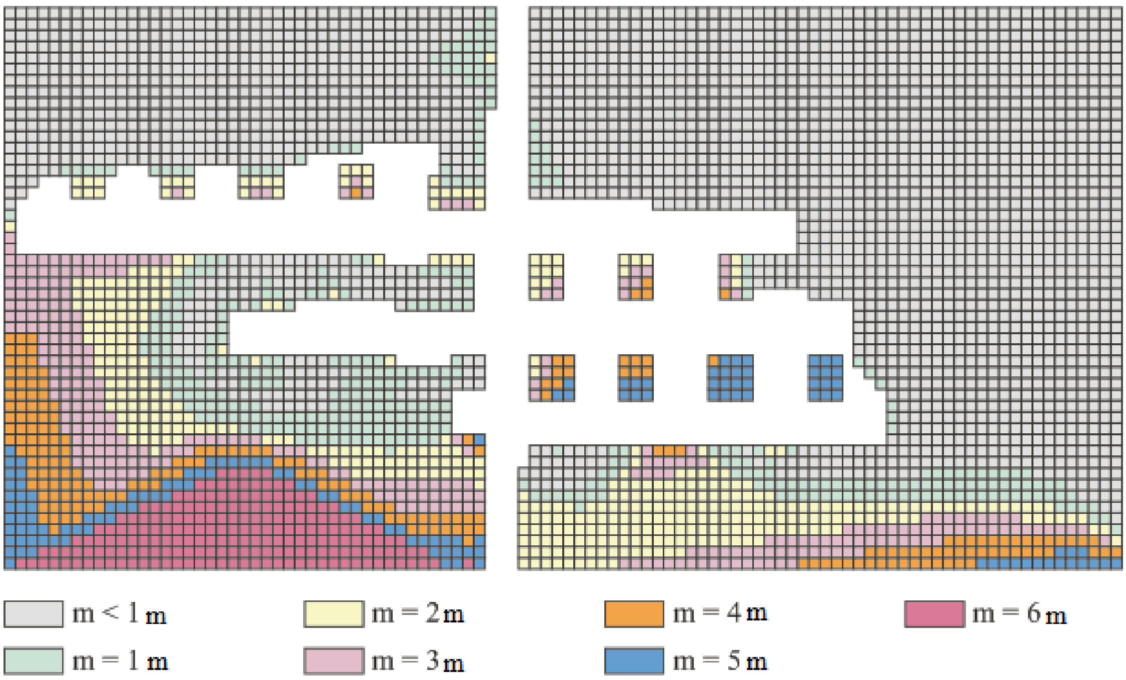

Fig. 10: Results of interpolation object components “Capacity”

Acknowledgements

The work was supported by the German Academic Exchange Service (DAAD) in 2010-2013 during a scientific work at the TU Bergakademie Freiberg - the University of Resources.

References

[1] Computer program «PRESS 3D URAL». State registration certificate № 2012618481 from 19.09.2012, Rospatent, 2012.