Creation Of Three-Dimensional Models Of Structural Array Features

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Summary. When studying a jointing of rocks various methods of measurement of a jointing of rocks are applied. In this article modern technologies on studying of a jointing, and also processing of the obtained data and creation of three-dimensional models of structural features of the massif are considered.
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At the present time, issues such as pressure and displacement of rocks under the influence of underground mining, the stability of pit walls, impossible without the structural features of the array are becoming increasingly clear for the specialists of mining.

Structural features of the array is one of the most important factors determining the geomechanical processes [1,2]. In the study of fracture recommended two different survey methods. They are:

1) the method of point mass measurements of dip planes of weakness;

2) the method of areal structural survey.

The choice of another method from these methods determined by the complexity structure of the rockmass of the studied part of the deposit. Thus, the structure of rock deposits of Chulaktau and the northern pit wall of Aksay, which has a more sustained character, was studied by the method of point mass measurements elements of occurrence of cracks.

Point method of mass measurements of fracture, having a simple structure, characterized by consistency of exceptional items occurrence of planes of weakness, both in area and in depth career, with the number of systems that do not exceed can yield positive results in the rocks 3-4.

With the complex structure of the array with unsustainable elements of occurrence, point method for studying the structure can not be used to determine the nature of the overall structure of the deposit, as in this case it is not possible to establish a connection to the same system for several measuring points.

Method of areal structural survey is used on deposits with unsustainable and complex structure of rocks, in the presence of tectonic dislocation rocks. The main purpose of survey is to establish the regularity of distribution and consistency of the basic systems or groups of planes of weakness, the boundaries of weathered rocks, disjunctive dislocations, etc.

Technique of areal structural survey is based on interval surveying of structural elements outcropping of scarps on each horizon of career. The length of the interval, depending on the nature of the variability of structure can be various. Surveying conducts by using a tape measure and the compass. Establishes the main fracture system on the basis of spot metering element of occurrence and sizes and shapes of structural blocks, the degree of roughness of surface weakening, length of the cracks, material for filling out surfaces weakning for each interval.

The most effective method of direct measurements that received in the practice widespread and extensive coverage in the works are surface mines at a sufficiently large area of outcrop of rocks [3,4].

Methods of measurement of fracture of rocks are reduced mainly to the direct measurements in outcrops at the surface, on the slopes in open pits, along the walls of pits and mine workings, observations on the core samples ща geological wells. On the open cast mining works at a sufficiently large area of outcrop of rock is the most effective method of direct measurements (mass or profile lines) with the help of mountain compass [4].

On opencast deposits production association Zhanatas deposits "Karatau" and "Central" survey of fracture was carried out with mountain compass 2003. Dimensions of structural blocks (the distance between fractures) were measured by a conventional tape measure, incidence angles and azimuths of fractures and their trending were measured by mountain compass. (Figure 1).

Currently, in the manufacturing practices of surveying and geodesic works there are modern electronic devices such as 3d scanner, tacheometer, and others. These devices allow you to get at Surveying object in electronic form. Laser scanning is a technology that allows you to create a digital three-dimensional model of the object, presenting it with a set of points with spatial coordinates.

This technology is based on the use of new surveying instruments as laser scanners that measure the coordinates of points on the surface of the object with high velocity of the order of several tens of thousands of points per second [5].

Figure 1- Survey of rocks by the mountain compass

Ground laser scanning method is widely used to obtain data on the geometric parameters of the quarries, the elements of occurrence of cracks and rupture destructions, rock dumps, tailing pits and other objects placed on the surface. The accuracy of the survey parameters determined by the distance between the device and the surveying subject.

Using the results of the survey laser scanner to get elements of occurrence of cracks and the size of the structural blocks is possible at finding the device from massif to 800 meters. Thus, there is unique possibility get information on the status of massif without direct contact of workers [6]. The proposed method of study using a laser scanner for elements of the occurrence of cracks of rocks are following:

- on the career selected point survey of cracks at flatbed array, which sets out a tripod and set the laser scanner, by which the survey of massif is taken (Figure 2). Surveying distance of the array in this case should not exceed 800 meters;
- turns on the scanner and and takes survey of slope surface of structural features of flatbed massif through the established scanning step;
- then on the PC using the «Maptek I-Site Studio» created a cloud of points with the imposition of photographs;
- is processed obtaining a bulk electronic version of the massif on the computer (Figure 3) in order to obtain the parameters of occurrence of cracks and rupture distractions of the angles of incidence and trending, the size of the structural blocks formed by cracks (Figure 4).

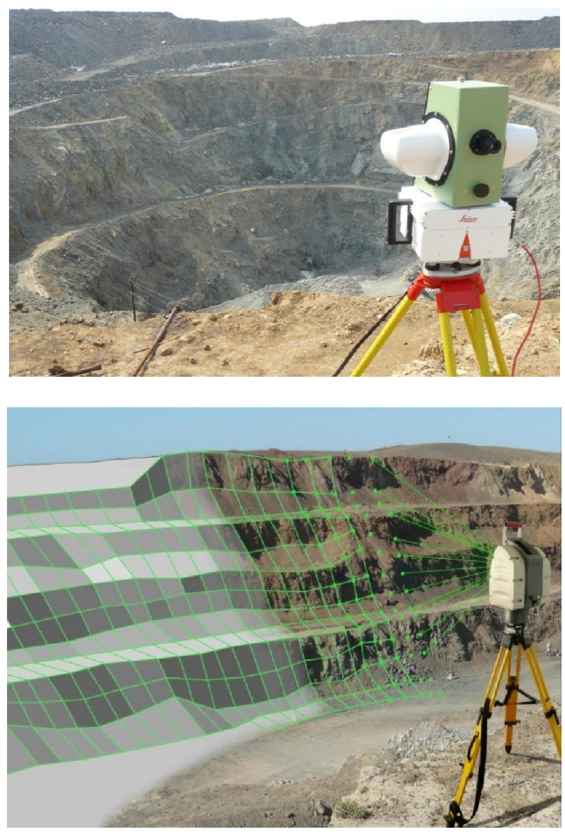

Figure 2- Surveyof flatbed massif career with laser scanner Leica HDS4400

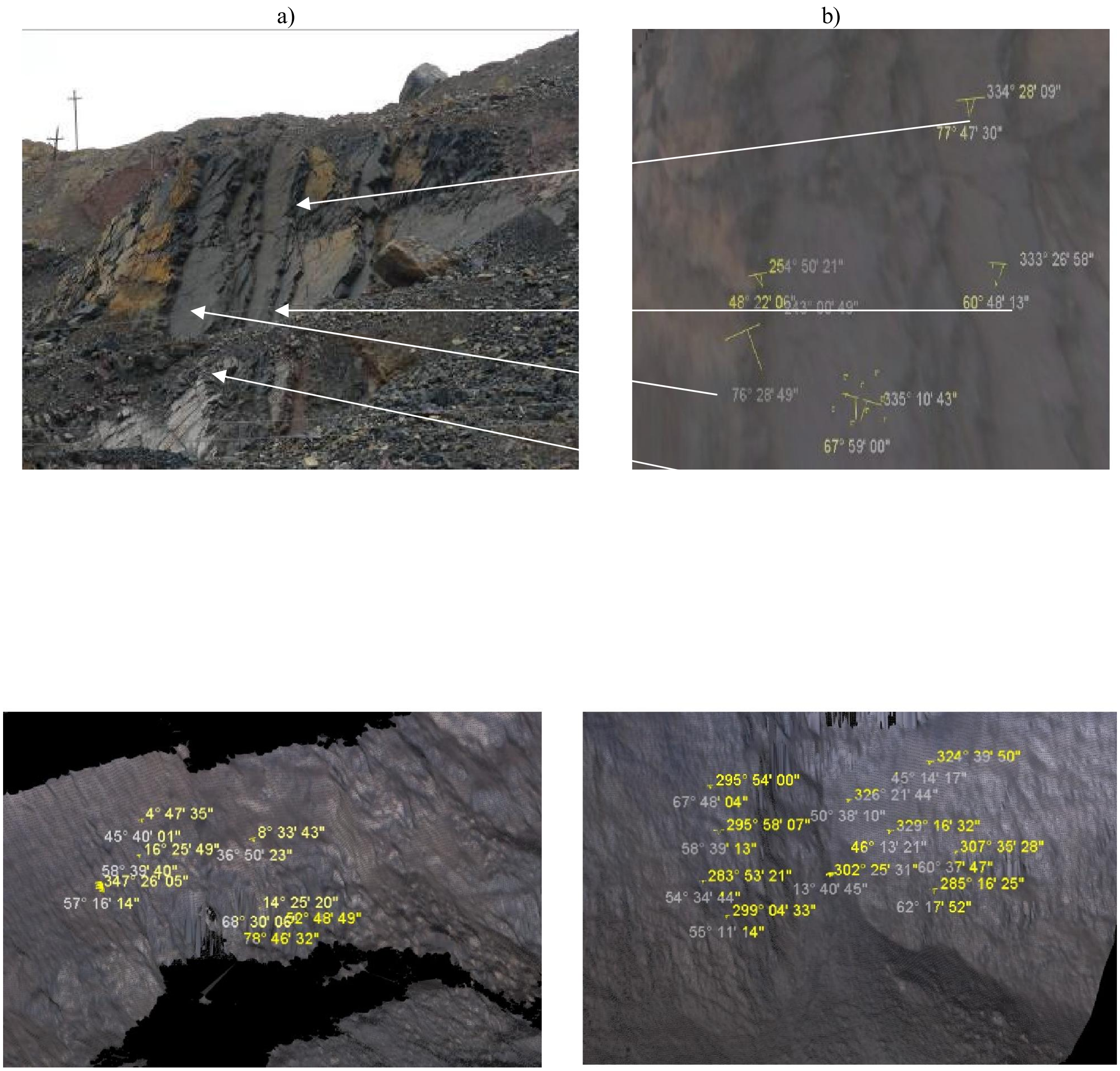

Figure 4- Identification of elements of occurrence cracking

Obtaining a digital model massif career is possible through the use of software complex «MaptekI - SiteStudio» (Figure 5), where the calculated values of the elements of occurrence cracking: the azimuth of trending, the angles of incidence and size of rock blocks. In this case, the digital model contains complete information about massif rocks. By using data-processing rock fracturing, are allocated fracture system, the block size for use in passports of strength related to the array. The results of processing of fracture of rocks by observation stations and their comparison between measurements mountain compass and in laser scanner gave discrepancy in the 3-4%, which is valid [7].

In the study of fracture of rocks accumulated a large number of field measurements. In the first stage of processing the results of measurements of mass occurrence cracking using different pie charts and stereographic grids, which have a number of drawbacks. Statistical processing of scatter chart is to count the number of cracks, which are located at certain intervals of area, that is smoothing is produced, and then carried out the concentration isolines of cracks. All stereographic grids inconvenient, it is very difficult to decipher fracture system that concentrated in the center of grids. In addition, the stereographic grids due to different-sized area of the trapezoid is difficult carrying out smoothing. Rectangular diagram hasn't these kinds of shortcomings.

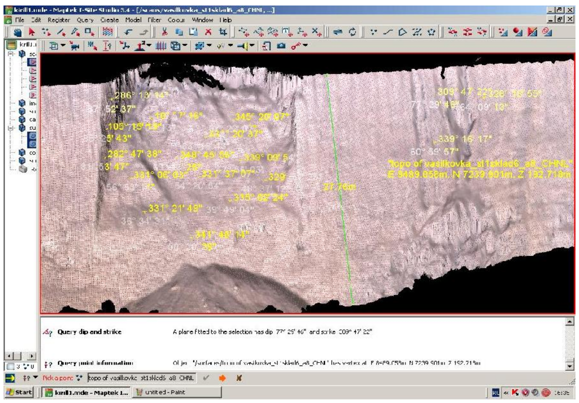

Figure 5 – Identification of elements of occurrence cracking in stations with the help of program «MaptekI-SiteStudio»

This article is describing the methodology of selection of active conjugated fractures (system of fractures) according to the data of field observations with application of GIS-technologies on the basis of use of database of geological-surveyor information.

Methods of rock fracture measurement are basically represent the direct measurements on surface uncovering, open pit slopes, at boring pit walls and mine working walls, and observations of core samples of earth bores. At the openworking explorations with a rather big area of uncovering of rocks the most effective method is the method of direct measurements (mass measurements) with the help of miner's compass or with phototheodolite. During observation of fractures large number of measurements is being accumulated. The processing and summarization of these measurements are performed with the help of pie charts, square diagrams and fracture stereograms. On the basis of these graphs the structure sections and maps for fractures are being constructed.

Square diagrams allow defining the number of conjugated fractures by each gage station and by open pit as a whole; to define the domination of such and such conjugated fractures, elements of their bedding.

The term "conjugated fractures" is usually referred to multiple fractures situated approximately parallel to some definite axis. Let's specify the amount of mentioned definition for the formalized description within a coordinate system of strick azimuth and angle of incidence. From the definition it can be seen that, first, the conjugated fractures consist of separate fractures the attitude of which is uniquely defined by two parameters – strick azimuth and angle of incidence. In the coordinate system the strick azimuth and angle of incidence are reflected by a point and further we shall call them observations.

Second, the conjugated fractures have an axis the attitude of which is also defined by two parameters – its strick azimuth (***A***) and angle of incidence (***δ***). Due to the fact that the axis of conjugated fractures is shown as a point we shall further call it as a center of conjugated fractures.

Third, all fractures presenting in the conjugated fractures should be approximately parallel to its axis, that is the difference between the values of parameters of center and parameters of observations should not exceed a definite value within the limits of which they can be considered parallel. Now, taking into account the mentioned specification we shall formulate the problem description for selection of conjugated fractures according to the field observations data.

<u>Problem Description</u>. On the basis of data received during the field observations it is necessary to identify the conjugated fractures in accordance with the following criteria:

- the position deviation of separate observations from the center of conjugated fractures should not exceed a definite given value (the condition of parallelism);
- the number of observations united into system of observations should not be less than a definite critical value ensuring the reliability of the received data (the condition of representativeness).

<u>Mathematical Problem Statement.</u> In order to formulate the mathematical problem statement for selection of conjugated fractures on the basis of filed observations data we shall introduce the following designations:

Relationship between the objects of analyzed set (points of observation) of Z is determined by the square diagram for fractures (XOY). The axis OX embodies the values of strick azimuth (***A***), the axis OY has the values of angle of incidence (***δ***), and the position of observation point can be uniquely represented by the regular discrete function of the following kind:

$Z = f(x,y,t)$,

here $\boldsymbol{x}$, $\boldsymbol{y}$ – current values of strick azimuth and angle of incidence of observation point $\boldsymbol{Z}$; $\boldsymbol{t}$ – the number of fractures registered at this observation point, that is, the coefficient of significance (density).

For notational convenience, further we shall call this parameter as the significance of observation point. $\boldsymbol{t}$ reflects the actual number of fracture traces with the values of strick azimuth equal to X, and an angle of incidence Y which have been registered during the process of field observations.

Today, having the advanced level of development of scientific and technical progress, thanks to wide implementation of computer technique into practical works the solving of treatment of results of mass measurements of fracture bedding elements has become a process with new qualitative approaches. The methodic of automated drawing of square diagram for fractures has been developed and its block diagram is shown at the Figure 6.

The methodic of automated drawing of "Fracturing Diagram" that we have developed is a computer technology of modeling of structural features.

The main idea of the algorithm is in the following. At the first stage it is aimed on detecting the areas with the biggest concentration of observation points and these areas are further used for finding the optimal way of breaking down the initial set of point into conjugated fractures. After that, on the basis of adaptive adjustment of coordinated of the conjugated fractures center and on the basis of the composition of the objects included into it the search for "real" position of these classes at the coordinate space is being conducted, that is called the optimization of parameters of conjugated fractures.

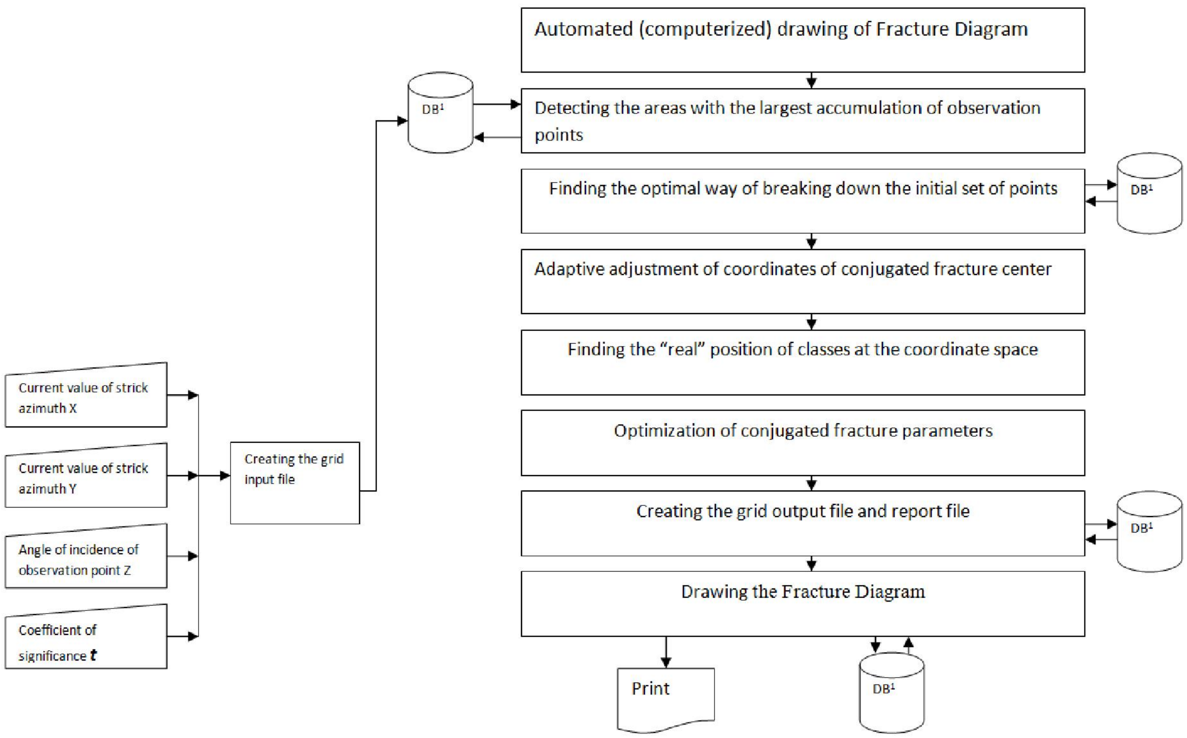

Figure 6- Block Diagram for algorithm of automated methodic of Fracture Diagram drawing.

The statistical treatment of fracture measurements is done by program in three stages. At the first stage the screening-out of "random" measurements is conducted, which don't fall into the accumulation of measurements and, therefore, don't relate to the conjugated fractures.

At the second stage, by method of grouping of the available measurements the selection of conjugated fractures and classification of concrete measurements into systems is being performed. The third stage is a period of obtaining of values describing the statistical characteristics of conjugated fractures.

After that, by interpolation between the grid node points we create the broken lines which are being smoothed with the help of splines (curves which are passing through all given density points). The complex is being realized with the help of the Golden Software Surfer 8.0 program. The Golden Software Surfer 8.0 program is intended for operations with geological, topographic maps and we used it for modeling of structural features of rock massif.

Figure 7 has a square diagram of fractures where the results are imaged in two ways: in isolines (Figure 7, *a*) and in three-dimensional image (Figure7, *b* and *c*).

Thus, after automated (computerized) drawing of Fracturing Diagrams it is defined that for Akzhal deposit the existence 4 main conjugated fractures is characteristic, with the following average values of bedding elements (azimuth, angle of incidence): I (30^o, 55^o), II (125^o, 81^o), III (220^o, 75^o) and IV (310^o, 89^o).

The "The diagram of fracture" is used to enter the primary information measurements of cracking, their statistical processing, construction and printer output diagrams of fracture of the object of study for their subsequent interpretation and use to calculate the parameters sustainable pit walls.

The modern level of development of science and technology involves the use of the mining area of modern research methods based on the use of computer technology. There are a number of foreign software products that implement the three-dimensional modeling of deposits: DataMine (United Kingdom), Techbfse (the USA), Surpac (Australia) and others [8-11]. Perfection of research methods is increasing number of necessary parameters, complicating the test models and their approximation to the actual mining and geological situation of the investigated field. A crucial step in this direction is transition to the three-dimensional modeling of deposits. Working with such models allows not only to quickly solve technical mining tasks, but also opens up broad prospects for researchers to use modern analytical and numerical methods.

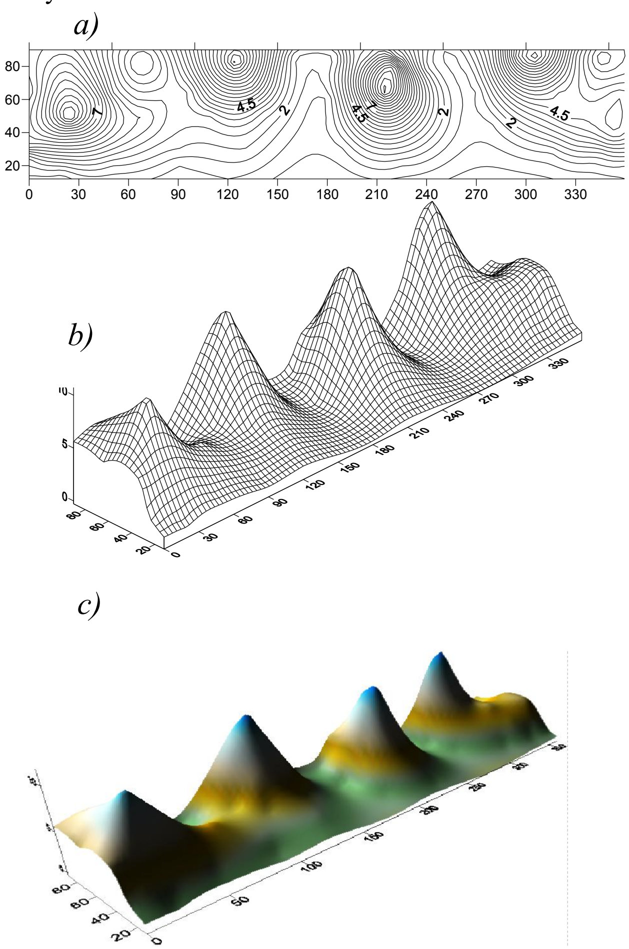

Figure 7– Result Shape

Currently, the use of 3D models in the fields of specialized commercial software systems for a variety of mining tasks for mining operations are known(Figure 8). But they are, as their extractings.

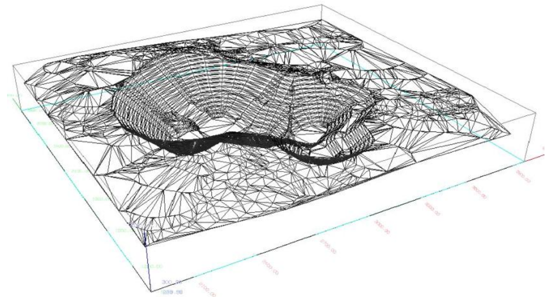

Figure 8 – 3D model of the quarry in the system GEMCOM

Three-dimensional modeling carries significant advantages for research in the field of geomechanics and geometrization of deposits:

- completeness of the analyzed data is closest to the actual mining and geological situations;
- there is possibilities to assess the relative influence of spatial elements of the model;
- is possible development and application of geomechanical methods, taking into account the volumetric distribution of loads;
- clarity and descriptiveness of the model allows to reveal hidden problem areas and determine their parameters.

The initial data for modeling are the results of exploration, the primary operational and geological and graphical information. It could be stratigraphic sections, data from wells, the results of aprobations, geological sections and horizontal plans.

Three-dimensional modeling of ore bodies for the investigation the geomechanical situation was carried out in the field "Akzhal" (Figure 9). Because of the complexity the issues and the above advantages, it was decided to create a digital three-dimensional model of the geological situation of deposits [4].

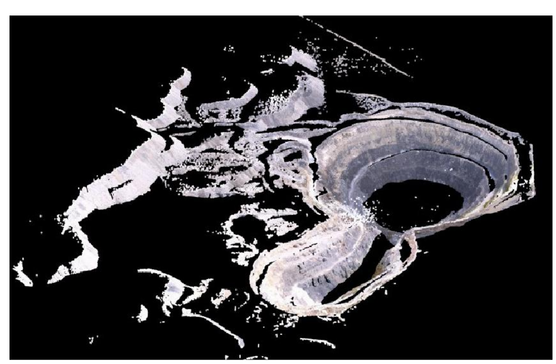

Figure 9 – Three-dimensional model of quarry "East" deposits of Akzhal.

The first stage of modeling is to classify and primary processing of raw data, is to select the necessary and sufficient volume of geological and graphic data and bringing them to a common format that allows for correct The first stage of modeling is to classify and primary processing of raw data, is to select the necessary and sufficient volume of geological and graphic data and bringing them to a common format that allows for correct alignment.

The final stage of modeling was a three-dimensional approximation of the geometric parameters of the structural elements of the model. In this case, the analysis of their relative position and interpolation of contour forming, which creates a wireframe model of the ore bodies (Figure 10).

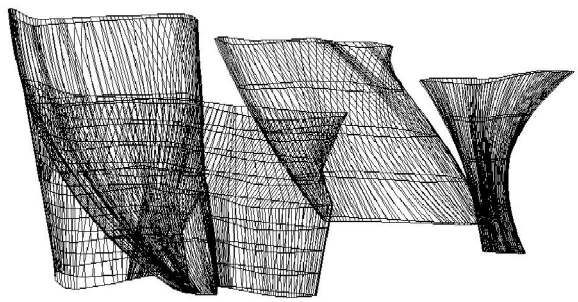

Figure 10 – Wireframe model of the ore bodies of the Central part of the deposit Akzhal.

Based on a wireframe model performs spatial triangulation, as a result of which we obtain a three-dimensional surface of the ore bodies (Figure 11).

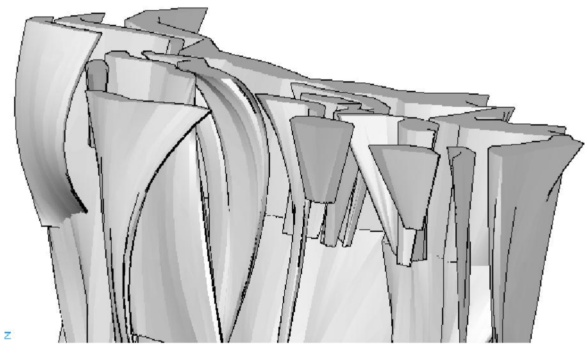

Figure11 – 3D model of the surface of the ore bodies of the Central part of the deposit Akzhal

Development of 3D models of deposits are very relevant scientific and practical task, the successful solution of which depends on the efficiency of the mining companies on the basis of the widespread introduction and use of modern computer technology in the solution of mining- technical and mining-geometric problems [5]. As a result of the research obtained 3D digital models of ore bodies and the main geological elements of Akzhal deposits that allows to integrate them into modern modern apparatus and program complex systems by decision of urgent problems of mining.

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