16th INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE SGEM 2016

Book 1

Science and Technologies in Geology, Exploration and Mining

CONFERENCE PROCEEDINGS

Volume II

EXPLORATION & MINING

MINERAL PROCESSING

16th INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE
S G E M 2 0 1 6

SCIENCE AND TECHNOLOGIES IN GEOLOGY,
EXPLORATION AND MINING
CONFERENCE PROCEEDINGS
VOLUME II

- - - - - - - - - - - - - - - - - - - -

EXPLORATION AND MINING

MINERAL PROCESSING

- - - - - - - - - - - - - - - - - - - -

30 June – 6 July, 2016
Albena, Bulgaria

DISCLAIMER

This book contains abstracts and complete papers approved by the Conference Review Committee. Authors are responsible for the content and accuracy.

Opinions expressed may not necessarily reflect the position of the International Scientific Council of SGEM.

Information in the SGEM 2016 Conference Proceedings is subject to change without notice. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose, without the express written permission of the International Scientific Council of SGEM.

Published by STEF92 Technology Ltd., 51 "Alexander Malinov" Blvd., 1712 Sofia, Bulgaria
Total print: 5000

ISBN 978-619-7105-56-8

ISSN 1314-2704

DOI: 10.5593/sgem2016B12

INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE SGEM
Secretariat Bureau

Phone: +359 2 4051 841
Fax: +359 2 4051 865

E-mails: **sgem@sgem.org** | **sgem@stef92.com**
URL: **www.sgem.org**

ORGANIZERS AND SCIENTIFIC PARTNERS

- BULGARIAN ACADEMY OF SCIENCES
- ACADEMY OF SCIENCES OF THE CZECH REPUBLIC
- LATVIAN ACADEMY OF SCIENCES
- POLISH ACADEMY OF SCIENCES
- RUSSIAN ACADEMY OF SCIENCES
- SERBIAN ACADEMY OF SCIENCES AND ARTS
- SLOVAK ACADEMY OF SCIENCES
- NATIONAL ACADEMY OF SCIENCES OF UKRAINE
- INSTITUTE OF WATER PROBLEM AND HYDROPOWER OF NAS KR
- NATIONAL ACADEMY OF SCIENCES OF ARMENIA
- SCIENCE COUNCIL OF JAPAN
- THE WORLD ACADEMY OF SCIENCES (TWAS)
- EUROPEAN ACADEMY OF SCIENCES, ARTS AND LETTERS
- ACADEMY OF SCIENCES OF MOLDOVA
- MONTENEGRIN ACADEMY OF SCIENCES AND ARTS
- CROATIAN ACADEMY OF SCIENCES AND ARTS, CROATIA
- GEORGIAN NATIONAL ACADEMY OF SCIENCES
- ACADEMY OF FINE ARTS AND DESIGN IN BRATISLAVA
- TURKISH ACADEMY OF SCIENCES
- BULGARIAN INDUSTRIAL ASSOCIATION
- BULGARIAN MINISTRY OF ENVIRONMENT AND WATER

HONORED ORGANIZER

BULGARIAN ACADEMY OF SCIENCES

EXCLUSIVE SUPPORTING PARTNER

INTERNATIONAL SCIENTIFIC COMMITTEE
Science and Technologies in Geology, Exploration and Mining

- PROF. JEAN-PIERRE BURG, SWITZERLAND
- ACAD. DMITRY Y. PUSHCHAROVSKY, RUSSIA
- PROF. YEVGENY KONTAR, USA

CONFERENCE PROCEEDINGS CONTENTS

EXPLORATION AND MINING

SECTION

EXPLORATION AND MINING

SPECIFIC CHARACTER OF DONSKOY CHROMITES DEVELOPMENT IN COMPLEX MINING AND GEOLOGICAL CONDITIONS

Dr Prof L. Zherebko[1]
Dr Prof L. Shamganova[1]
Assoc. Prof. G. Jangulova[2]
Dr Prof. Kh. Kassymkanova[2]
PhD student B.Bektur[3]

[1]Institute of mining name after D.A. Kunayev, **Kazakhstan**
[2]KazNU name after Al-Farabi, **Kazakhstan**
[3]KazNRTU name after K.I. Satpayev, **Kazakhstan**

ABSTRACT

While developing ore deposits at the large depths using uncontrolled caving system the geochemical situation at various sections of the mines field will be controversial. As it is evident from the synoptical analysis of the technological schemes of thick ore deposits development at Donskoy MCC fields, their common feature is generation of the mined-out spaces during the second mining, which are compensated with the overlaying rocks mass in the course of uncontrolled caving. This phenomena and its development process have significant meaning in solving the issues of negative technogenic evidences occurrence during underground development of ore deposits.

As the result of second minigs with uncontrolled caving system,the geotechnical and geomechanical processes are developing in the overlaying solid mass causing the solid mass weakening and uncontrolled caving. At the same time the parameters and nature of the caving zones are directly correlating to the sizes of the stoping zone, volumes of the extracted ore mass and geotechnical properties of the overlaying rocks mass.
Keywords. Geomechanical processes, mining system, rock pressure,caving zone.

INTRODUCTION

The issue of caving zones generation is rather complicated and it is nearly impossible to describe the actual situation with the configuration of the weakened zones propagation for each specific case.

The basic volume of chromite ore at the industrial complex is produced by underground mining method at "Molodyozhnaya"mine and the mine "10th anniversary of Kazakhstan independence" commissioned in the end of 2002. 84,7% out of 97,7% of the area reserves subject to deep-mining are concentrated in the last mine field, which is the prerequisite for the main development perspectives of the enterprise and the industry in its entirety.

Currently the system of uncontrolled block caving is used at the mines, which provides for high output at relatively low labor and material resources. This system has its complexities along with advantages. So, in performing the mining works together with the second mining front development, the rapid hydration of the solid mass rocks in the solid massand loss of mechanical constraints are happening, which result into the sudden strength reduction. As the resultgeomechanical situation, stipulated by the increase of the loads to the mine roadways of the stopes is getting complicated. At

SPECIFIC CHARACTER OF DONSKOY CHROMITES DEVELOPMENT IN COMPLEX MINING AND GEOLOGICAL CONDITIONS

Dr Prof L. Zherebko[1]
Dr Prof L. Shamganova[1]
Assoc. Prof. G. Jangulova[2]
Dr Prof. Kh. Kassymkanova[2]
PhD student B.Bektur[3]

[1]Institute of mining name after D.A. Kunayev, **Kazakhstan**
[2]KazNU name after Al-Farabi, **Kazakhstan**
[3]KazNRTU name after K.I. Satpayev, **Kazakhstan**

ABSTRACT

While developing ore deposits at the large depths using uncontrolled caving system the geochemical situation at various sections of the mines field will be controversial. As it is evident from the synoptical analysis of the technological schemes of thick ore deposits development at Donskoy MCC fields, their common feature is generation of the mined-out spaces during the second mining, which are compensated with the overlaying rocks mass in the course of uncontrolled caving. This phenomena and its development process have significant meaning in solving the issues of negative technogenic evidences occurrence during underground development of ore deposits.

As the result of second minigs with uncontrolled caving system,the geotechnical and geomechanical processes are developing in the overlaying solid mass causing the solid mass weakening and uncontrolled caving. At the same time the parameters and nature of the caving zones are directly correlating to the sizes of the stoping zone, volumes of the extracted ore mass and geotechnical properties of the overlaying rocks mass.
Keywords. Geomechanical processes, mining system, rock pressure,caving zone.

INTRODUCTION

The issue of caving zones generation is rather complicated and it is nearly impossible to describe the actual situation with the configuration of the weakened zones propagation for each specific case.

The basic volume of chromite ore at the industrial complex is produced by underground mining method at "Molodyozhnaya"mine and the mine "10th anniversary of Kazakhstan independence" commissioned in the end of 2002. 84,7% out of 97,7% of the area reserves subject to deep-mining are concentrated in the last mine field, which is the prerequisite for the main development perspectives of the enterprise and the industry in its entirety.

Currently the system of uncontrolled block caving is used at the mines, which provides for high output at relatively low labor and material resources. This system has its complexities along with advantages. So, in performing the mining works together with the second mining front development, the rapid hydration of the solid mass rocks in the solid massand loss of mechanical constraints are happening, which result into the sudden strength reduction. As the resultgeomechanical situation, stipulated by the increase of the loads to the mine roadways of the stopes is getting complicated. At that the significant portion of development and preparatory workings is exposed to the non-uniform loads due to redistribution of the rock pressure. These loads cause destruction of up to 60% of fastening volume and malfunctioning. This results into disturbance of the production cycle, decrease of the labor safety and increase of the operational expenses, which are related to re-fastening of the mine roadways, whereas the re-fastening might repeatedly required.

All negative phenomena related to low stability of the solid mass at "Molodyozhnaya" mine could be found at the mine"10th anniversary of Kazakhstan independence". The situation at this mine will become even more complicated due to further decrement of the works front along with the increase of the rock pressure, and this could significantly impede utilization of the designed output.

With regard to the aforesaid these researches are aimed at studying and analysisof the nature and peculiarities of the geomechanical processes occurrence in thesolid mass, hosting the mine workings, based on specific technology of the ore bodies development, as well as elaboration of measures increasing stability of development and preparatory workings in the course of ore deposits drilling at the deep levels of Donskoychromites fields, which will provide for enhancement of occupational safety and smooth operation of the enterprise.

It is required to examine the geomechanical state in these conditions:

- examination of the solid mass structural framework;
- determination of physical and mechanical propertiesor ore and rocks.

Deep mining of the ore deposits at the companies of Donskoy MCC started in 1982 at "Molodyozhnaya" mine, constructed on the basis of the interior of the field named "40th anniversary of Kazakh SSR – Molodyozhnoye".

The mine "10th anniversary of Kazakhstan independence" has been constructed and operated on the basis of the deposits "Pervomaiskoye", №21, "Almaz-Zhemchuzhina" and "Millionnoye" [1], [2].

According to the technical design, mining of the ore body № 22 of "Molodyozhnaya" mine has been initially envisaged to be performed with heading-and-stall development system. The first stope, which was called the pilot stope, was founded at the noth-east flank of the ore body. Room works have been started from establishment of the cut-out raise by bore mining method. However it was not possible to perform it to the designed height due to the wellheads breakdown. Further attempts of the cut-out raise drilling resulted into breakdown of the shrink drift top and consequent increase of the top breakdown height. The first detonations of the cutoff stopes blast holes triggered the significant increase of the shrink drift top breakdown height, solid ore started to chip towards the cutoff stop, the blast holes were completely lost and deformation of the drilling rooms supports reached the critical size. In the course of the consequent blasting and ore drawing, the solid ore was displaced, blasthole rings closest to caving were lost, and in other cases the blast-holes displacement was evidenced. Additional works on the blast-holes recovery and re-drilling were required as the result. Further blasting attempts entailed the complete loss of downholes, in other wells some major displacements were registered. All that resulted into the failure to create the compensatory range. It was suggested to develop the second ore body block № 22 using the forced caving system with ore crushing onto the compressed subsurface with the deep holes ring .

In the course of mine workings and second mining it was evident that the rock mass could be described by uttermost instability. It was due to intensive cleavage, breaking the ore deposits and enclosing rocksinto the blocks, displaced both horizontally and vertically.

Blocks sizes varied from 0,1x0,15x2 m (within the zones of intensive tectonic disturbances and excessive serpentinization) to 1x1x2 m. Each bock was penetrated with dense hairline fractures network.

Second minings were followed by the increase of the rock pressure that resulted into the additional disintegration of the solid ore discreet block structure with hairline fractures opening displacement. Interaggregate ties were disturbed when affected by dynamic loads and the solid ore transformed into the free-running state (in case of intensive cleavage [3].

Sublevel caving method used at "Molodyozhnaya" mine, provided for rather intensive growth of the annual ore production (200-300 thous. Tons per annum) in complicated mining & geological and geomechanical conditions. However, while developing the sublevel caving, the deficiencies of this system have been discovered as well and they include:

– significant losses of ore occurring due to overconsolidation of the broken ore, which worsens its free-running properties during drawing ;

– large scope of preparatory - development operations, restraining the ramp-up of ore production due to complexity of mine openings operability maintenance in rock overpressure conditions;

– significant usage rate of blast-holes and materials in case of low quality breaking of ore associated with the polydimensional propagation of the solid body deformation in vicinity of the mined-out space.

METHODOLOGY

Structural framework of the solid mass is one of the dominant factors defining the strength and stability of underground structures. The structure should be understood as the nature and degree of the solid mass rock jointing, which includes linear dimensions of the joints: their length and thickness, morphological peculiarities of fillers, spatial orientation of joints, their intensity and some other factors characterizing disturbance of the natural environment. Examinationof rock jointing is one of the most labor-intensive processes related to carrying out of numerous in-situ measurements and their consequent statistical manipulation. As is well known the mine works in solid masses with high disturbance and external chaotic stateof rock jointing are carried out on the assumption of outcrops segregation, which, to some extent, narrows the subject of study, allowing to research the limited downholearea only. All of the above entails the increase of researches duration, given that the complexity of the solid mass will require more statistical materials to establish the actual situation.

Statistical studies of the solid mass subdivision anticipateanalysisof in-situ data of the joints spatial orientation, thickness of joints, their intensity, presence of filler, its characteristics and some other morphological peculiarities. Studies and analysisof all these parameters have been done basically according to the data of the mines geological services, which were keeping records of the structural state of the downhole area in the course of mine workings development. According to the results of processing the structural data, the statistical analysiswas carried out as well as the rock jointing key parameters were defined for the sections and mine roadways of various technological designation, drilled in the rock and ore solid masses. Analysisthe joints spatial orientationmade possible the determination of four basic systems having the following parameters.

I system; strike azimuthα = 90-120^0, joints dip anglein this systemvaries within the ranges of 25 to 90^0, basically it equals to δ =70-80^0, less frequently it is δ = 60-70^0.

IIsystem; strike azimuthα = 290-350^0, joints dip rangeis the widest: from 25 to 90^0, more than 80% of jointsare dipping at δ = 70-80^0.

III systemof joints; strike azimuthα = 330-350^0, joints dip anglevaries within the ranges of 0-90^0, predominant dipping δ = 70-80^0, the joints with the dip angle of δ = 50-70^{0}are the most commonly occurring, the vertical ones - are less common.

IV system; strike azimuthα = 180-220^0, dip angleis within the ranges of δ = 25-90^0, more than 80% of joints are dipping at δ = 60-70^0, the less common is δ =80-90^0. This systemis the most pronounced.

Analyzingthe obtained data, it can be stated that the joints with various dip angles, from nearly horizontal to vertical, are found at the researched section of the field. However, the steeply dipping joints with dip angles of δ =70^0 (20,0%), δ =80^0 (17,0%) and δ =75^0 (15,0%) represent the majority. The joints with δ =45^0 (13,0%) are more common. Flat joints with δ =5-20^{0}are less frequent and make all together 1-2% of the total amount of the joints to be examined.

The joints intensity *J* and thickness *m* have been analyzed as well astheir spatial orientation. The results obtained for various sections of the mine field rocks demonstrate the range of *J*value from 5 to 13 pieces per the running meter, and the thickness *m* variesfrom 0,1to 1,4-1,5 cm. According to genetic classification these data refer to the so-called deuterogene joints that break solid massinto separate structural blocks and have major influence on the strength and deformational properties of the solid mass. The initial micro joints are found in the structural blocks, these joints could be described by high intensity varying within *J* = 20-40 pcs.per running meter and low thickness, less than one millimeter. In tectonic zones the jointsthickness reaches*m* = 3,0-5,0 cm, and solid mass at certain sections is shattered and represents the granular medium.

In developing the operational schedules for ore deposits, determination and justification of the stable parameters of the development system structural elements, determination of the rational method for fixing and maintenance of mine roadways it is required to have the insight and comprehensive knowledge of the rock and ore solid mass mechanical state.

The relevancy of studying the mechanical state and processes occurring in the rock solid masses becomes obvious when mining operations are carried out in complex mine& geological conditions (mining depth, structural disturbance of the rocks solid masses, intensive rock jointing, occurrence of rock pressure kick etc.). Improvement of the mining operational schedules is required in this situation. At the same time assessment of the rock solid masses mechanical state would form the basis for the design solutions to be made.

One of the components of the solid mass mechanical condition evaluation is studying and analysisof physical and mechanical propertiesof the rocks forming the rock solid mass.

The basicphysical and mechanical propertiesof the mine rocks, used in designing, calculations, constructions and operation of the underground structures include: strength, deformability, brittle-ductile factors as well as the physical parameters –specific and relative weight, moisture content, moisture absorption, porosity, whereas in performing the special researches, the thermal, electrical and electromagnetic properties of rocks are of certain interest.

The researches were carried out to establish the characteristics of rocks and ore, which are directly related to the strength and deformational values of the solid mass and they are treated as the basic material for performing the calculations and assessment of the mine roadways stability.

The methodical scheme of determining the physical and mechanical properties of the rock and ore materials was based on researches on detailing the characteristics of rocks forming the solid mass.

The expert of the VIOGEM (All Russian scientific and research institute on mineral deposit dewatering, engineering structure protection against underflooding, special mining operations, geomechanics, geophysics, hydraulic, engineering geology and mine surveying), Belgorod have obtained the large scope of experimental data describing the rocks properties. However the researches they did were aimed basically at studying of the wellbores rock material. The obtained data were of certain interest but it did not fully describe the solid mass condition within the mine field.

The specialists of theMining Institute named after D. Kunayev at the RK National Science Academy performed the large scope of researches on determination of physical and mechanical propertiesof ores and rocks of the field at "Molodyozhnaya" mine at the first instance. The obtained data described the rocks properties at the localized sections mainly in the second working zones.

For the purpose of more comprehensive and generalized studies of the rocks at various sections of the mines field, the additional surveys of the mine rocks and ore materials were carried out in less researched areas to establish the compression, tensile and shear strength.

The researches were carried out on the basis of core material in the laboratories of Mining Institute named after D. Kunayev at the RK National Science Academy. The selected rock samples were certified, preserved – packed into the leakproofand water-tight cases and transported to the test site.

The samples of cylindrical shape were manufactured at the core materials testing site with the height *h*to diameter *d*ratio nearly equal to $h : d = 2{,}0$. Samples were tested at 10 and 40-tons press-machines with mechanical registration of loads. Tensometricmethod for registration of elastic and deformational values of the preloaded samples was used in order to ensure the accuracy and reliability of the strength and deformational values of the tested material. Bidimensional tablet potentiometer PDP4-002 was used as the main test equipment. This device allows registration of dependence between two functionally realted parameters in the rectangular coordinates system. The test results were processed at the computer using the specially developed software.

The pull of authors has elaborated the new technology of the high-ore deposits underground development, which provided for the use of the solid ore block structure for uncontrolled caving of ore with the controllable intensity due to the rock pressure concentration in the crest part of the natural self-supporting arch or through prior weakening of the solid ore within the ranges of mine section (panel).

The essence of the technology lies in the following. The ore deposit is divided into the blocks (Figure 1) with haulage crosscuts along the strike. The accepted width of the block is 60m, whereas the length and height are limited with lens-outs along the bottom and side walls accordingly, and vertically. Depending upon the ore deposit width and vertical height the ore reserves in the block vary within 2-3.6 million tons range.

Ore deposit is developed in two continuous fronts from the north-east and south-west flanks towards the center ensuring that no intermediate pillars are left off. This direction of the second mining development has been accepted to increase the mine output due to increase of the haulage crosscuts number.

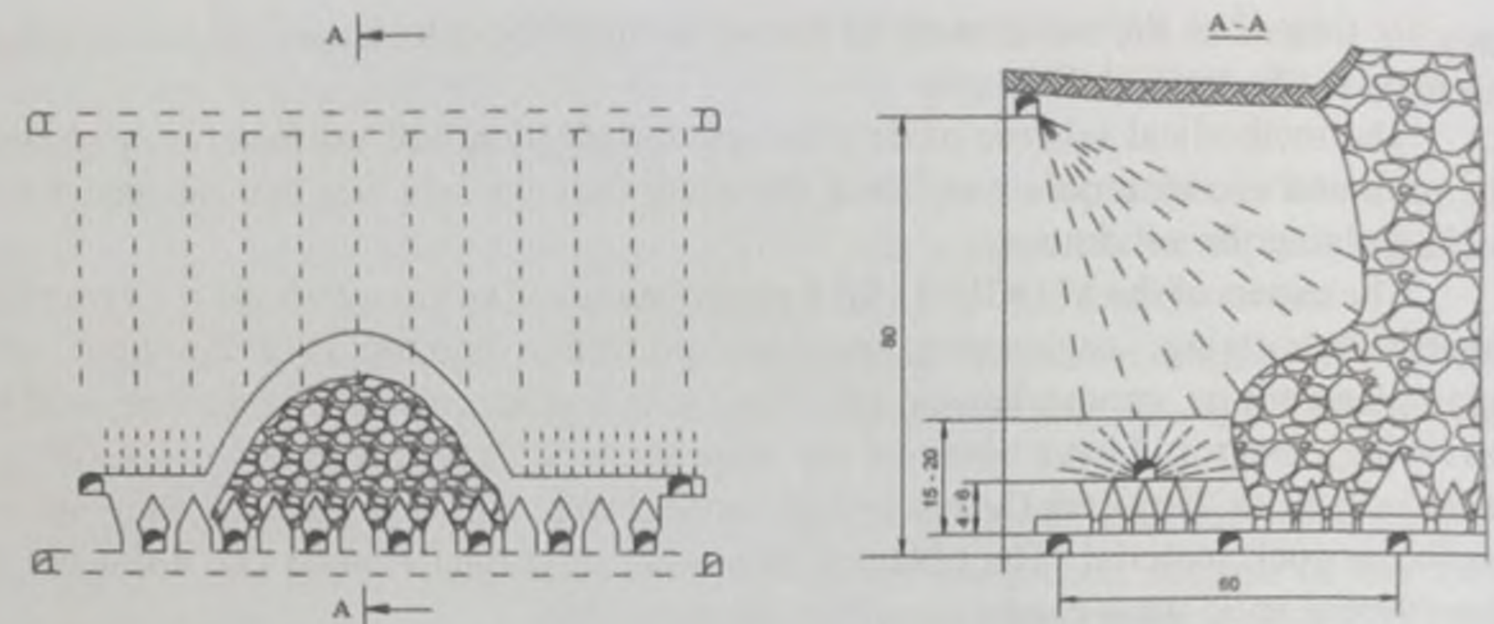


Figure 1 - System with uncontrolled ore caving in "Molodyozhnaya" mine

The accepted works development plan provided for high intensity of second mining and high efficiency at the minimum impact of the rock pressure, which vertical and horizontal components were vectored at the solid ore caving, contributing to the quality of uncontrolled caving and drawing of ore.

First mining works in the block included drilling of scraping drifts, ventilation and utility crosscuts and vibro-hauling units' chambers which will be installed in the roof of the haulage crosscuts. The accepted distance between the haulage crosscuts was 26-30 m in case of the scraper transportation and 22-25 m in case of vibration drawing of ore. The drawpoints were lifted to 4-6m height from the scraper drifts, these drawpoints were consequently transformed into the intake funnels of 5.5-6 m upper diameter. The distance between the drawpoints is 5-6 m.

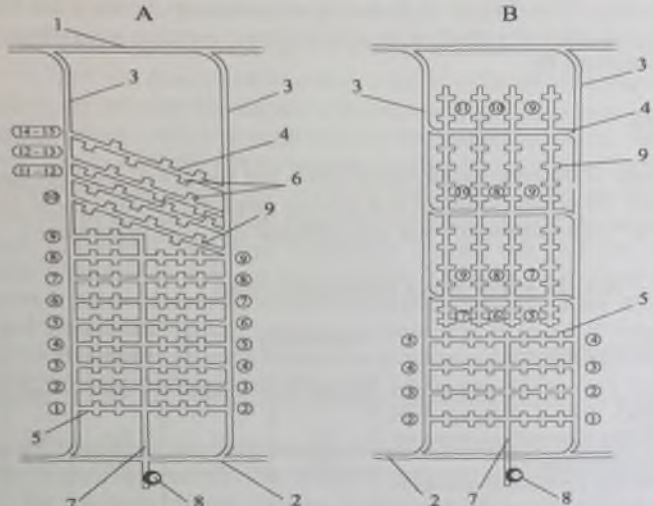
All horizontal access workings were fastened with the metal frames made of replaceable special shapes SVP-22 or SVP-27. The distance between the frames makes normally 0,3 m, and in scraper drifts the double metal fastening was installed and divided with the round timber tightening. In case of this fastening flexibility equaling to 0,2-0,3 mthe structure could withstand the specific load of 0,25-0,3 MPa [4].

The developed technology envisaged the intensification of the solid ore deformation and initiation of the ore uncontrolled caving. Aiming this, the paralleled superimposed bunch holes of 105 mm diameter (5-6 holes) were drilled , charged with the blasting powder when the uncontrolled caving of ore was required and blasted to the height not increasing the height of the natural equilibrYum dome. The artificial local stress points originated, which were acting as catalysts of the solid ore uncontrolled caving in blocks in the crest part of the dome (in the middle of the mine section). This contributed to uncontrolled caving of the solid mass in the given direction and with the intensity determined by the frequency of the blasting charges firing in the bunches of the paralleled superimposed holes.

Second minings started from undercutting of the solid ore to the entire area of the mine section or its parts (panel by panel).

The developed technology provided for ore extraction from subsurface within 86-88 % range. It is partially explained by the fact that ore drawing was carried out at the fragmentation degree of 1,6. Relatively low dilution of drawn ore with enclosing rocks (12-14%) is resulting from the fact that in Kempirsaychromitesfields conditions caving of enclosing rocks require the bigger exposure surfaces comparing to the solid ore [5].

However, regardless comparatively high technical and economical parameters, the applied technology had some disadvantages. Those are low rigidity of the solid mass, disintegration processes running in the second minings impact zone, large ore reserves in the mine sections, long period of haulage crosscuts operation in the bearing pressure zone (8-10 years). Thus the change of crosscuts development scheme was required. The combined crosscut & drifts development of the reserves was used for the blocks 27-30 and 54-57 (Figure 2). Ore drawing was carried out at the scraping crosscuts (block 54-57) or at the drifts – inclines.



1- haulage drift of the bottom wall; 2- haulage drift of the side wall; 3-haulage crosscut; 4-drift-incline; 5-scraping drift; 6-vibro-hauling unit chamber; 7-assembling vent crosscut; 8-vent raise; 9-scraping crosscut (the circled numbers refer to the ore reserves mining sequence for drawing and transporting mine roadways)

Figure 2-Scheme of the combined crosscut & drifts blocks development

Observations of the mine workings fastening deformation evidenced that the vertical pressure in the initial period of the block development depended greatly on the area of the solid ore caving surface. According to the papers, the twofold increase of the horizontal area of the block resulted into the 1,3-1,5-fold increase of the vertical pressure to the drawing mine roadway fastening, the horizontal stresses in the sides of haulage crosscuts were increasing accordingly. In the drawing area the vertical pressure prevailed, which is distributed according to the law approaching to the parabolic law. In the central part of the mine section the pressure is 1,5-1,7 times higher that the pressure at the boundary of the worked-out area. Ore drawing triggered re-allocation of the rock pressure and drop of its absolute value in the drawing area.

In case of no drawing of the caved ore, the additional shattering of the solid ore blocked structure was performed along with the volume increase, which was followed by the kick of vertical pressure to the drawing mine roadways and horizontal loads on the fastening of the haulage mine roadways.

Development of the extraction front in the block in aggregate with the combined crosscut & drifts development ensured not only reduction of the production time of the mine workings in the bearing pressure zone, but also had significant influence on reallocation of the rock pressure promoting the increase of the operational safety of the development and temporary workings. With the earlier applied schemes, the maximum horizontal loads were applied horizontally towards the longitudinal axis of the haulage crosscut, whereas using the diagonal scheme of the second minings development and the combined crosscut & drifts development, the maximum horizontal loads are applied at the angle of 35-50^{0}to the axis of the haulage development working, and the time of the increased rock pressure impact on the mine roadways fastening was reduced by 3-5 times at certain sections [6].

RESULTS

On the basis of the performed systematization and analysis of the solid mass structural framework, the average values of rock jointing parameters at the various sections of the ore field at "Molodyozhnaya" mine were obtained and given in the table 1.

Table 1 – Average values of rock jointing parameters

Sequence No.	Measurements area	Joints density per 1 r.m.		Thickness ofjoints, cm		Dipangle, degree
		Ore	rock	ore	rock	
1	Block bottoms (scraping drifts, drilling utility and vent crosscuts)	10	11	0,6	0,7	60–80
2	Haulagecrosscuts	10	9	0,8	0,7	60–80
3	Haulage horizon level (crossdrifts, hanging- and side-wall drifts)	–	10,5	–	0,7	65–75

As it is evident from the analysisof the Table 1, the basic values of rock jointing for various technological sections, representing the rock and ore solid masses have nearly equivalent values. The difference does not exceed 10%, which provides the possibility and justification to use the averaged geostructural values in relevant calculations.

65 samples have been tested for uniaxial tension when studying the physical and mechanical propertiesof the rocks and ore. In terms of methodology and for the purpose of further detailed analysis of the test results, the test samples have been divided into three conventional groups by the nature of structural framework: monolith, with wedging-out and hairline joints, and the third group – with diagonal joints. Each sample testing included its external definition and, if necessary, sketching-out and measurements of joints parameters and other disturbances. As soon as the testing is completed, the nature of breaking was described and the required measurements were made.

26 ore samples were tested in the first group. The breaking identity was established using the structural factor analyzing. In majority of cases, two pyramids will be formed with the angle at the base varying within 60-65^0, thus representing the standard breaking pattern when there is no grease at the samples edges. The average tensile strength equal to $\sigma'_{cж}$ = 34,0 MPa at the variation coefficient V = 18,4%was obtained for the main group of monolith samples.

The second groupincluded the samples with traces of disturbances, which are basically the joints wedging out and intercrossing the samples with random orientation and number of disturbances. In case the sizes are relatively small, their disturbance factor was maintained. As it was established by the researches, this group of samples nearly equivalently reflects the strength values of individual structural blocks, which are identical with the samples disturbance factors by its composition. Assuming further that the structural block is the bearing component of the structure, its strength is a primary factor for determination of the structure material strength. According to the testing results of this group samples, it should be stated that they will break by ruin-like pattern, forming the randomly shaped fragments. This being said the traces of joints surfaces were visible in the certain blocks. Certain joints and, at first instance, their apexes, represented the stress concentrators and triggered breaking. The average tensile strength equal to $\sigma''_{сж}$ = 24,0MPa at V = 17,5% was determined according to testing of the second group samples.

The third group included the samples with diagonal joints, filled most commonly with deuterogene material, which strength was overwhelmingly below the strength of original material. Hence it appears that the samples were breaking directly along the joints faces. Incorporation of these samples into one group was due to their low strength, which is initially explained by the filler material and the inclination of the jointsplain against the effect of forces. In this case the overall morphology of joints was taken into account, especially,when it referred to thin and uneven joints. The third group joints were of primary concern in terms of studying and evaluation of the strength values of both, the joints filler and the jointsof random morphology, as well as in terms of defining the deformational characteristics of joints themselves and deuterogene material. Averaged tensile strength valuefor the third samples group was equal to $\sigma'''_{сж}$ = 13,5MPaat V= 22,7%.

Similar differentiation was performed in the course of testing the rock samples represented by serpentinites mostly. The averaged valuesfor each group are given for brevity sake. The tensile-tested rock samples amounted to 20 in this series. Averaged strength valuesfor each group have made:

$$\sigma'_{сж} = 68{,}5 \text{ MPa}; \quad V = 24{,}0\%$$
$$\sigma''_{сж} = 26{,}0\text{MPa}; \quad V = 22{,}6\%$$
$$\sigma'''_{сж} = 13{,}2\text{MPa}; \quad V = 20{,}7\%$$

In our opinion,close agreement of the values $\sigma''_{сж}$ и $\sigma'''_{сж}$ for the ore and rocksevidences the identity of the composition and structure of jointsin various materials taken from one section.

In terms of methodology, the testing scheme, recommended by the previously valid State standard, was observed while defining the rocks tensile strength. However, for the cold-technical reasons, it was not always possible to manufacture the samples of one size, i.e. to maintain the height and diameter ratio$h/d \approx$ 1,0. The portion of samples demonstrated the ratioh/d = 0,5-0,6 and their strength values were considered separately followed by adjustment. The disturbed samples were detected with the visual examination with regard to the fracture pattern. While testing 60 ore samples the following strength values were obtained.At the following ratio h/d = 0,9-1,10, theaverage tensile strengthmade σ'_p = 3,60 MPa, whereas ath/d = 0,5-0,6 it was σ''_p = 5,0 MPawith the following variation coefficients: V' = 25,4%, V'' = 27,9% accordingly.

The tensile strength for jointysamples, which were broken along the joints, was equal to σ'''_p = 1,80MPawith the variation ofV''' = 27,6%.

Analyzing the tensile testing results as a whole, it should be mentioned that the values thereof are far from being unambiguous not only in case of a sample geometry changes but also in case of one and the same*h/d*ratio. When excluding the structural disturbances impact, it can be assumed that one of the most significant factors determining the sample strength is the impact of the ore material composition, or, to be more exact, the percentage ratio of certain components.Besides, according to the observations, the ore granularity is role-defining for the strength value not only due to its size but the orientation of grains. These observations have been studied on the basis of special experimental researches. The averaged characteristics of the common systematic pattern could be used as the operating values for practical purposes. In case of the sample geometry changes, the scaling factor has the uttermost significance, as well as some cold-technical reasons, including in particular, misalignment of the sample generating lines and their nonlinearity, which stipulates that even slight curving changes the contacting surface and the specific load, as a consequence. The influence of technical factors increases along with the increase of the sample linear dimensions.

It has been established that tensile strength of the rock samples is slightly higher comparing to ore samples. The averaged parameters have the following values:

$$\sigma'_n = 8{,}4\text{MPa}; \quad V' = 29{,}1\%$$
$$\sigma''_n = 10{,}5\text{MPa}; \quad V'' = 25{,}1\%$$
$$\sigma'''_e = 3{,}6\text{MPa} V''' = 28{,}2\%$$

In comparing the strength values of ore and rock, it can be concluded that stability of the underground structures outcropping would be considerably higher if their immediate roofing is formed with the rock materials.

Shear strength was defined by testing of 22ore samples with the loading matrix of 30^0 – 8 pcs., 45^0 – 6 pcs. 60^0 – 8 pcs.

Standard pressure at the shear plane (σ) was calculated according to the formula

$$\sigma = \frac{P_{max} \cdot cos\,\alpha}{d \cdot h} \quad (1)$$

Ultimate shear stress (τ), corresponding to the standard pressure at the shear plane is calculated according to the formula:

$$\tau = \frac{P_{max} \cdot \sin\alpha}{dh} \quad (2)$$

where P_{max} - is vertical maximum disintegrating force registered with the press weighting device;

α – angle between the shear plane and the horizon, matrix angle;

d -sample diameter;

h -sample height.

The following average values of σ and τ have been obtained for ore material according to the test results.

$$\alpha = 30^0; \sigma = 18{,}4 \text{ MPa}; \ \tau = 10{,}8 \text{ MPa}; V = 19{,}0\%$$
$$\alpha = 45^0; \ \sigma = 7{,}0\text{MPa}; \quad \tau = 10{,}2 \text{ MPa}; V = 22{,}7\%$$

$$\alpha = 60^0;\ \sigma = 2{,}4\text{MPa};\quad \tau = 3{,}6\ \text{MPa};\ V = 29{,}9\%$$

Similar tests have been performed for the rock samples as well. As the resultthe following average values of σ and τ have been obtained for the relevant matrix angles:

$$\alpha = 30^0;\ \sigma = 22{,}6\text{MPa};\ \tau = 12{,}9\ \text{MPa};$$

$$\alpha = 45^0;\ \sigma = 12{,}5\text{MPa};\ \tau = 10{,}8\ \text{MPa};$$

$$\alpha = 60^0;\ \sigma = 4{,}8\text{MPa};\quad \tau = 7{,}2\ \text{MPa}.$$

During the trial and industrial surveys in "Molodyozhnaya" mine, the technology with the improved values of ore instruction has been worked out, which defined prospectivity of using the block caving system in the Donskoy MCC mines. However this technology has the essential complexity, which consists in the following:

Location of mine sections across the ore body and their consequent development inevitably predetermine the occurrence of such geomechanical situation when the haulage crosscut-incline of the developed section will be located in the zone of increased (bearing) pressure, emerging ahead of the extraction front (EXF) and increasing along with the increase of the drilling depth and EXF length, and this complicates and makes more expensive maintenance and operation of the haulage drifts by limiting the application field of this method in the ore bodies of shallow or average depth of occurrence and only in the rock massif of regular and average stability. At the bigger depth (e.g. at the lower levels of "Millionnoye" and "Almaz-Zhemchuzhina" fields located at 1500m depth) and in case of the significant length of EXF the bearing pressure can increase up to such values when maintenance of operability of the crosscut & inclines becomes impossible while using any kind of fastening.

The said disadvantage could be significantly reduced due to application of the method of the thick reclined ore body development suggested by the experts of Mining Institute named adter D. Kunayev [7].

The main idea of the suggested method anticipates that all ore bodies are divided into the longitudinal bands, which are developed in sequences, one by one progressing from one lateral edge of the ore body to another. Mining faces shall be put into operation with not less than two years time interval between commissioning of the adjacent bands. Uncontrolled caving of solid ore and overlying rocks is triggered by generating the undermining area over the ore drawing and transportation level, the band filled with the caved rock is then used as the bearing component of the development system similar to the filling mass as soon as it is compacted under influence of geomechanical processes and packing.

Development of the flat-laying solid ore with longitudinal bands along with the exclusion of the necessity to drill the haulage drifts in the bearing pressure zone and reduce its value due to shortening of EXF length, allows for creating the bands in unstable ore and rocks prone to uncontrolled caving using the caved material (similar to the packs known in the mining industry), avoiding the filling works. This band in case of uncontrolled caving will fill the ore-released space up until self-cleavaging of the roof arch due to its loosening during caving.

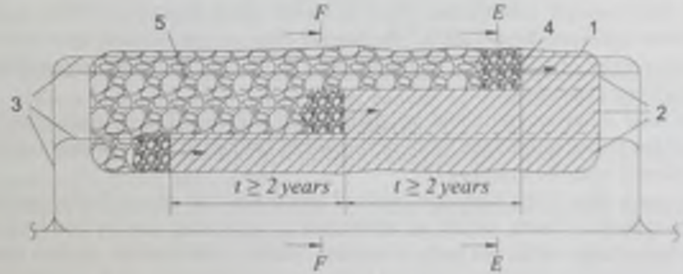
In conditions of unstable rock massif, when it is required to reinforce all mine workings with armored supports and reduce their sections down to the limit, the scraper transportation of ore from drawing mine roadways (orepasses, funnels) to its loading area to the mine haulage mechanisms (ore roll, scraper ramp) would be the most cost efficient and safe. According to the experience at the ore workings, the accepted length of the scraper working (i.e. the longitudinal band width) should be within 30-40m range.

The suggested method is shown in details in the figures 1.4 and 1.5., using the example of the ore body №2 development at "Millionnoye" field.

Ore body № 2 at "Millionnoye" field of Donskoy MCC is flat-laying at 900m length, its thickness is 50 m on average, width is 120 ÷ 130 m, length is 600 m, ores and rocks are classified as unstable. Ore reserves in one longitudinal band of 40 m width would make 4650 thous. tons. The time required for its mining would make 4650/500 ≈ 9 years providing that the second mining performance in one band equals to ~500 thous. tons of ore annually. In dividing the ore body into 3 longitudinal bands during the period of second minings maximum development, all of 3 longitudinal bands could be mined simultaneously, however it is critical to meet the requirement when putting into operation of each consequent band starts 2 years later than the similar start of the previous band at the similar speed of EXF moving in these bands.

It is suggested to implement this method technologically as follows.

Ore body is divided into the longitudinal bands of 30-40 m length (if the scraper transportation of ore is used), then it is required to define their mining sequence (I, II, III) from one lateral outline to another lateral outline of the ore body, mark out the routing of the mine roadway grid of the production level and then perform their drilling (Figure 3).

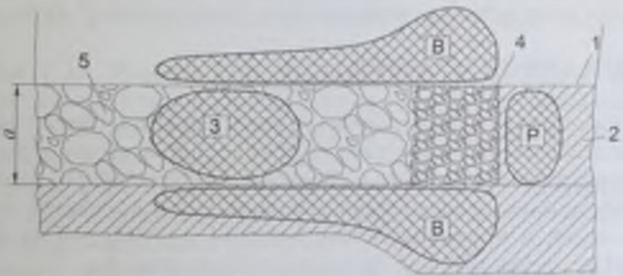


1-ore body; 2-longitudinal bands; 3-production level minings; 4-EXF; 5-mined-out space with caved debris; I, II, III-mining sequence.

Figure 3- The sequence of the ore body breaking into the longitudinal bands and required time intervals between the mining faces in bands.

Moving direction of the extraction front (EXF) in each of longitudinal bands shall be accepted to start at one and the same flank towards the opposite ore body flank with the time interval of their putting into operation t being not less than 2 years. Upon construction of the mine roadways haulage level, putting into operation of the venting scheme for this level on the account of the general mine ventilating current, and the rock mass haulage scheme – due to general internal transport, it is required to proceed with performance of the development and temporary workings at the level of ore drawing and haulage in the longitudinal band I, using the well-known methods comprising the drilling and blasting operations, the solid ore is to be cut off the rock body on the short side of the band, the ore body is blocked out in the form of the cutoff space over the drawing level and, accordingly, the EXF is created with the length equaling to the band width (*a*), ore extraction in this case is carried out along with reclamation of the worked-out area with the caved debris.

Along with EXF moving around the working excavation, the bearing pressure zones are created: zone P in the undisturbed solid mass ahead of EXF, zone B in the undisturbed solid mass from the lateral sides of the band I and zone Z in the caved rocks behind EXF, emerging with the "fadeout" of caving process and development of the superincumbent rock displacement process (Figure 4).



1-ore body; 2-longitudinal band; 3-zone in caved rocks; 4-EXF; 5-caved rocks; P,B-zones in the undisturbed solid mass.

Figure 4 – The horizontal plane projection of the bearing pressure zones location during the development of one longitudinal band.

Similar scheme of the bearing pressure zones location is given in the paper [8-10]

CONCLUSIONS ON THE BASIS OF THE RESEARCH RESULTS

In studying the morphological peculiarities of joints, it has been established that the majority of joints are filled with deuterogene material. The minerals of serpophite group are the basic filler material for the joints both along the ore field and the rock solid mass. Most commonly it is serpohite itself, talc-breunnerite, brucite, meloniteand other claylike fillers;calcite is rather commonly occurring. However the filler thickness varies greatly from a millimeter portion to several centimeters.

In defining the physical and mechanical properties of the rocks and ore, the results of samples laboratory tests provide rather comprehensive outlook of the strength properties of the material forming the solid massand represent the initial data for assessment of the strength and deformation of the solid mass and its elements.

Along with removal of EXF, the caved rock is compacted and looses free-running properties during packing process and chemical decomposition reactions of the least durable minerals (e.g. serpentine in dunites), uncaved portion of superincumbent rock over the tapped zone, as the initially unstable massif is subjected to displacement without disintegration and gradually transfers its weight to the caved rock (in the form of the zone 3), which contributes to its additional compaction and packing. After that the compacted and packed caved rock gains the capacity to take up the load similarly to the filling mass. The time for the caved rock transition into this state makes around 1.5 years since the moment of its caving (according to the observations results of the earth surface movement at "Molodyozhnaya" mine of Donskoy). That's why during mining of the longitudinal band II with the delay from the band's primary mining for not less than 2 years, such caved rocks band would contribute to partial clearing-out of the face working excavation from the weight of the overlaying rock mass. At the same time during these 2 years the rock pressure will be equalized due to relaxation of unstable rock massif and the geomechanical conditions for mining of the next longitudinal band II would be close to the conditions for mining of the longitudinal I. The same phenomena will be observed during mining of the longitudinal III, which excavation should be also carried out with the 2 years delay from the band II [11], [12].

The flowchart of second mining process in each longitudinal band could be accepted similar to the technology implemented at "Molodyozhnaya" mine.

DISCUSSION AND CONCLUSION

The structural pictureof the solid mass reviewed above provides the insight into its quality condition and precludes intensive subdivision of rocks, high weakness of the solid mass, which has significant influence on the underground structures stability. In order to give more comprehensive description of the solid mass and assess its behavior in the process of the mine works, it is essential to have insightful knowledge of its strength and deformational parameters, which are the subject of future researches.

In summary, mining of flat-laying ore body with unstable ore and enclosing rocks using the suggested method allows for arrangement of all mine workings of the haulage and transporting levels beyond the bearing pressure zones, utilization of the predisposition of unstable rock massif for uncontrolled caving in order to reduce rock pressure onto the transporting level in location of the second mining area and, without any additional expenses, allows for setting-up of the bands from the compacted and packed rocks, which perform the functions of filling mass in lieu of extracted ore.

All of the above will allow enhancement of fail- and operational safety of mine workings, reduction of their maintenance costs and exclusion of expenses for cost intensive stowing operations. This method could be used in the course of ore bodies development at Donskoychromites fields.

REFERENCES

[1] Edilbayev I.B., Shashkin V.N., Elpashev G.A. KempirsayChromites- raw material resources base of "Donskoy MCC" JSC /Mining magazine(Gorniy Zhurnal), № 6, 1998, pp.6-8.

[2] Edilbayev I.B., Vozrozhdeniye (1995-2005), Almaty, 2004, pp 57-59.

[3] Chrome of Kazakhstan. Reference book. Under the general editorship of M.I. Gasik, Greenenko V.I., Shashkin V.N., M."Metallurgy", 2001, pp 305-306.

[4] Instruction for calculation of loads to the mine workings fastening in DonskoyMCC

mines conditions. Karaganda, 2004. pp 44-50.
[5] IakovlevYu.I., Zherebko L.N., Dzhangulova G.K., Pivovarova L.M. Perspectives for deep levels mining at DonskoyMCC using caving system. Scientific & technical support of mining practice. Papers of the Mining Institute named after D.Kunayev,V.69, Almaty, 2005, pp 67-70.
[6] Baklashov I.V., Kartoziya B.A. Rock mechanics. M.:"Publishing office of MSMU", 2004, pp 135-138.
[7] Zherebko L.N., Dzhangulova G.K., Pivovarova L.M. Generation of the roof arch in overlaying rock mass formed with layers of various thickness. Scientific & technical support of mining practice. Papers of the Mining Institute named after D.Kunayev, Almaty, V.75, 2008. pp18-21.
[8] IakovlevYu.I., Zherebko L.N., Dzhangulova G.K. Method for development of flat- and deep-laying ore body in unstable rock massif. Materials of theIVth international scientific & practical conference "Problems and ways of sustainable development of the mining industry", Khromtau, 2007, pp 239-245.
[9] Study of the strength and deformational properties of the pit-bottom solid masses of "Centralnaya", "Molodyozhnaya"mines and the solid mass of the rocks and ore bodies of "Centralnaya"mine at Kempirsaychromites fields". Research report, Belgorod, 1985, pp 1-126.
[10] Iakushev L.A., Zherebko L.N., Zinchenko G.N., et al.Study of physical and mechanical properties of the rocks and the solid mass structure of "Molodyozhnaya" mine of Donsky MCC. Research reportof the fund of Mining Institute named after D.Kunayev at the RK National Science Academy, pp 73-75.
[11] Mine rocks, express definitionmethod for the ultimate uniaxial tension and compression. All-Union standard of USSR. Official edition, All-Russian Research Institute of Mining Geomechanics and Survey, 1978, pp 30-38.
[12] Mine rocks, express definition method for the ultimate uniaxial tension and compression. All-Union standard 12.14.116-79. Official edition, All-Russian Research Institute of Mining Geomechanics and Survey, 1978, pp 10-14.

STEF92 Technology Ltd.
Software and Engineering in GeoSciences

ID. No: 102700155
VAT No: BG 102700155
Address: 8000, Bourgas, Zornitza, bl. 15-G, Bulgaria
E-mail: payment@sgem.org

Bank Attributes (euro): **IBAN: BG71UNCR70001522198549, SWIFT: UNCRBGSF, UniCredit Bulbank**
Bank Address: 7 Sveta Nedelya Sq., 1000 Sofia, Bulgaria

INVOICE

No 1000006471
Date: 10.05.2016, Place: Sofia

Company: al-Faraby Kazakh National University
Address: 71 al-Farabi ave.
City: Almaty
Country: Kazakhstan
VAT No: KZ600700099297
Phone: +77017832658
Email: khaini_kamal@mail.ru

No	Description	QTY	Unit Price	Line Total
1	SGEM Registration - Khaini-Kamal Kassymkanova (ID:16277): Publisher	1	190.65 Euro	190.65 Euro
2	Postal service	1	25.63 Euro	25.63 Euro
			Total Sum:	216.28 Euro

With words: two hundred and sixteen Euro and 28 c.

Receiver Name:	Assoc.Prof. Khaini-Kamal Kassymkanova	
	Passport Number:	
Signature:		
Payment Terms:	CARD	
Due Compiler:	Tatyana Ivanova	
Remark:	VAT reverse charge	

IT HAS BEEN A GREAT PLEASURE WORKING FOR YOU! Thank you for your business!