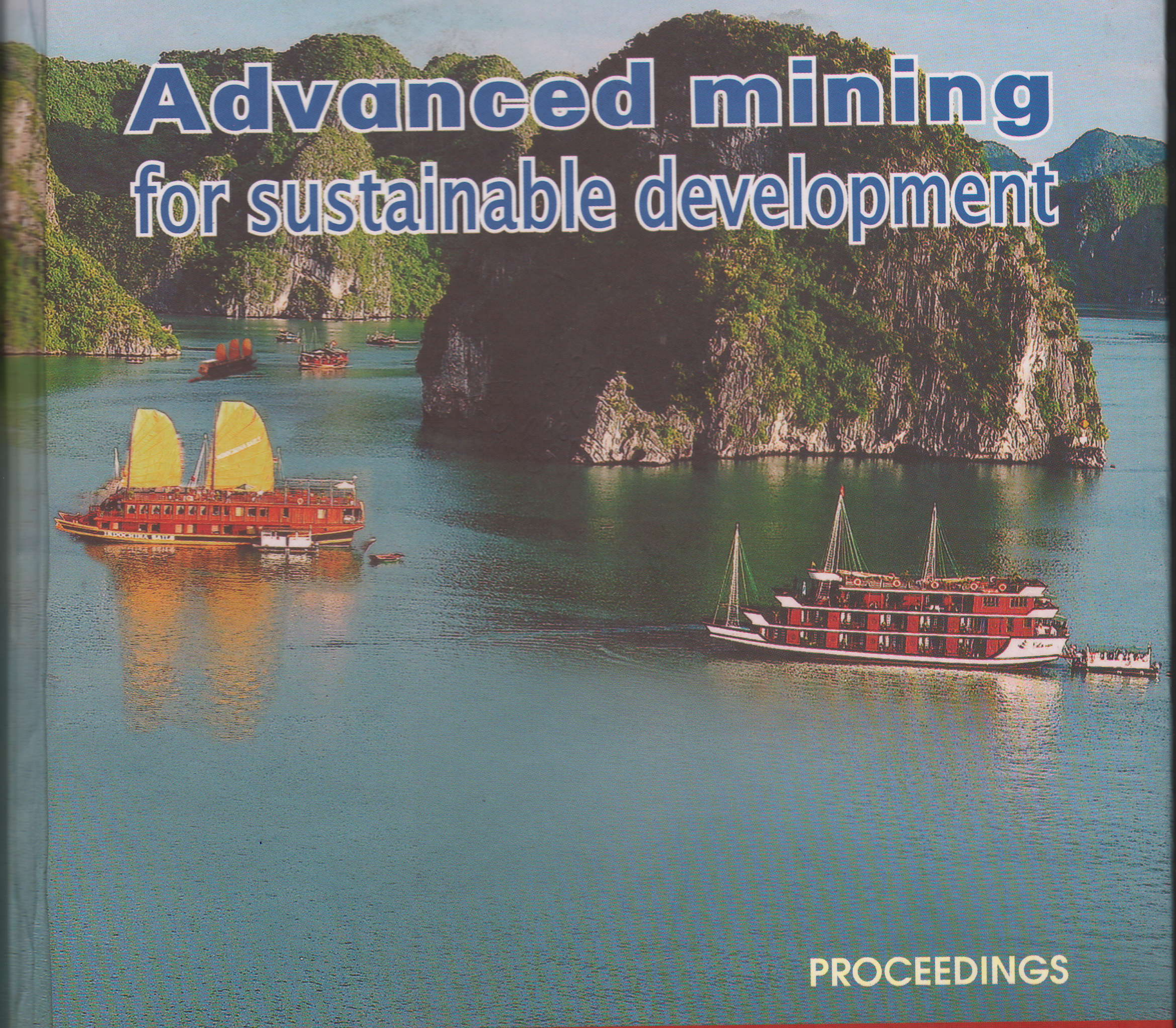
INTERNATIONAL MINING CONFERENCE

Advanced mining for sustainable development



PROCEEDINGS

Ha Long 23-25 Sep. 2010

PREFACE

The Summit of "The Earth on Environment and Development" held in Rio de Janeiro (Brazil) in 1992 and at the World Summit for Sustainable Development" held in Johannesburg (Repulic of South Africa) in 2002 considered "sustainable development" as a progress with the harmonious, reasonable and close combination of three aspects of the development, including; the economic development (especially the economic growth), the social development (especially the implementation of social justice and progress) and the environmental protection (especially the pollution overcoming and prevention, improvement and restoration of the environmental quality; reasonable exploitation and consumption conservation of the natural resources)

Sustainable and reasonable exploitation and consumption conservation of the natural resources in general and of the mineral resources in particular has become an essential issue in the program for the sustainable development in each country and is also a problem with special priority, including the activities in reasonable exploitation and consumption conservation of the mineral resources with high efficiency, improvement of the environmental quality in mineral mining, processing and utilization; restoration and reclamation of the landscapes at the mined areas.

*Therefore, the International Mining Conference 2010 held in Vietnam is under the subject of "**Advanced Mining for Sustainable Development**". This is the first time, the Vietnam Mining Science and Technology Association coordinating with Vietnam National Coal – Mineral Industries Group, Hanoi University of Mining and Geology, Association of Mining Engineers and Technicians of Poland to organize the International Mining Conference. This Conference will be held at the same time with the annual meeting for the members of the International Organizing Committee - World Mining Congress (IOC/WMC) held by the World Mining Congress.*

The Organizing Committee of the International Mining Conference has received more than 200 reports written by over 500 authors from 19 overseas countries including experts, scientists, managers, lecturers from Universities, Research institutes, Companies, Enterprises .....etc. These reports have high scientific quality, imperatively contributing to the "Sustainable development of the mining industry".

However, due to the limited content of the Proceedings, the Scientific Committee of the International Mining Conference has selected 108 reports belonging to all fields for being printed in the Proceedings and 47 reports which will be performed at the plenary session and at the partial sessions as well.

The Organizing Committee of the International Mining Conference would like to express our great thanks to the scientists and speakers for their attendance at this Conference.

The Scientific Committee
of the International Mining Conference 2010

ORGANIZING COMMITTEE

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Co - Chairmen

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Mr. Hoang Van Khanh	Member of the Central Executive Committee of Vietnam Mining Science and Technology Association. Director of Mining Metallurgy Science and Technology

The Conference is under the sponsorship of Vietnam Ministry of Industry and Trade and Vietnam Union of Science and Technology Associations

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POTENTIALITY OF SCIENCE

Organization

The Institute has possessed 14 scientific research departments and three member enterprises:

Development of Mining Technology and Equipment Company
Coal mine safety Center
Center for Industrial explosive materials

Manpower

* The Institute has owned 434 staff, that of which are 12 doctors of science, 24 masters of science and 288 engineers.

Research equipment and laboratories

* The Institute has owned the laboratories with much modern equipment for serving the research fields carried out by Institute:

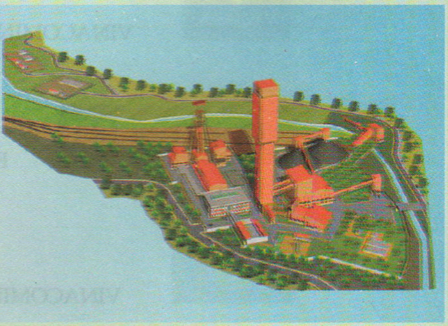
+ The laboratory for physio mechnical properties of coal, rock and minerals;
+ The laboratory for mine environment;
+ The laboratory for mine gas analyse;
+ The laboratory for water coal mixture;
+ The laboratory for explosion proof;
+ The laboratory for electrical equipment testing and adjustment;
+ The laboratory for industrial explosive materials;
+ The laboratory for support materials.

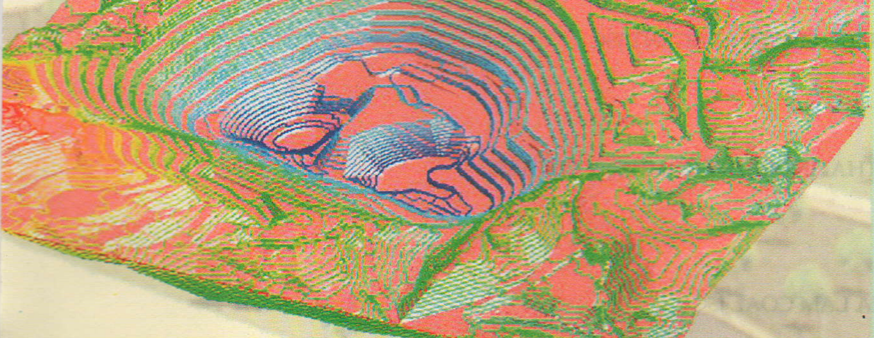
FIELDS OF FUNDAMENTAL ACTIVITIES

- Evaluating mine geological conditions and minerals properties;
- Studying on the application of open and underground coal mining technologies;
- Studying on mine and underground construction technologies;
- Studying on mine electricity and automation;
- Designing, manufacturing mining equipment;
- Studying on mineral processing and metallurgy technology;
- Studying on clean coal technology and coal utilization;
- Studying on mine safety;
- Studying on the technology for testing electrical equipment and industrial explosive materials;
- Studying on the mining environment;
- Studying on the technology for manufacturing, processing and utilizing industrial explosive materials;

INTERNATIONAL COOPERATION

The Institute has research cooperation with many companies, institutes from overseas countries such as China, Poland, Russia, Japan, and Republic of Czechoslovakia in the fields of scientific research and technological transfer.





LETTER OF SUPPORT FROM H.E. MR VU HUY HOANG,
MINISTER OF THE MINISTRY OF INDUSTRY AND TRADE OF VIETNAM

Hanoi, 22nd Sep. 2010

Distinguished Participants of the Conference of "Advanced Mining for Sustainable Development" and the 91st meeting of the World Mining Congress/ International Organizing Committee,

Vietnam is endowed with rich and diversified mineral resources. For years, mining industry has made remarkable contribution to our country's economy, helping stimulate the national industrialization and modernization progress.

As an initiative of the Vietnam Mining Science and Technology Association, international conference on mining science and technology will be organized with prevailing topic "Advanced Mining for Sustainable Development", from 22nd to 25th of September, 2010, in Halong City. In parallel with this conference, Vietnam is honoured to host the 91st meeting of the World Mining Congress/ International Organization Committee.

The Ministry of Industry and Trade of Vietnam would like to express its appreciation for the initiative by the Association and extend warm welcomes to scientists, technologists, managers, representatives of mineral mining and processing companies and mining consultants from all over the world to the above events, which will take place by the beautiful Halong Bay – a World Natural Heritage, just ahead of the Great Festival to celebrate 1000th Year Thanglong –Hanoi. We believe that participants will have good chances to meet, exchange views in order to enhance the cooperation in the field of mining industry, further explore the mining industry as well as the country and the people of Vietnam.

We wish great success to the conference and pleasant stay in Halong Bay and Vietnam for all participants.

Best regards

Vu Huy Hoang
Minister of Ministry of Industry and Trade

OPENING AND WELCOME ADDRESS FOR THE INTERNATIONAL MINING CONFERENCE 2010 IN VIETNAM

By Mr. Doan Van Kien
President of the Vietnam Mining Science and Technology Association

Ladies and Gentlemen !

On behalf of the Organizing Committee of the International Mining Conference, the Vietnam Mining Science and Technology Association and myself, I warmly welcome you, the mining scientists, technologists and managers from Australia, India, Poland, Russia, China, Germany, Canada, Czech Republic, Slovakia, Bulgaria, USA, Korea, Thailand, Japan, Ukraine, Laos and the leaders from the Ministry of Industry and Trade, the Ministry of Environment and Resources, the Ministry of Science and Technology, the Ministry of Interior, the Vietnam Union of Science and Technology Associations, leaders from People's Committee of Quang Ninh province, the representatives from ministries, central and local institutions, associations, from economic groups, Vietnam business enterprises …etc. to this Conference. This is the first time, the Vietnam Mining Science and Technology Association coordinating with Vietnam National Coal – Mineral Industries Group, Hanoi University of Mining and Geology, Association of Mining Engineers and Technicians of Poland to organize the International Mining Conference with the subject "***Advanced Mining for Sustainable Development***", therefore, the presence of the participants from foreign countries and members of the International Organizing Committee - World Mining Congress will be the great stimulation for the Organizing Committee of the International Mining Conference and the Vietnam Mining Science and Technology Association.

Ladies and Gentlemen !

Vietnam is a country having an abundance of mineral resources. Mineral mining activities were carried out over one hundred years ago, but at its beginning period, it was carried out with the manual method in the small scale and not planned as to the scientific standards. Only since 1975, after the unify of the country, the mining scale has been more and more enlarged. Results from the mining industry have greatly contributed to the socio – economic development of the country. However, due to many various reasons, for a long time, the Vietnam mining industry has not obtained its efficiency as desired. At many regions, mining activities have caused bad impacts to environment with low labor productivity; mining technologies have been slowly innovated; the mineral resources has not been recovered and conservated with high efficiency; the labor safety and hygiene and environmental protection have not been much paid attention to at some mine sites; most of mined minerals have not been deeply processed for increasing the value of the minerals before exporting. The just benefits of the people living in the mineral mining areas have been encroached; the social responsibility of the business enterprises has not been fully promoted, causing the inappropriate contradictions among the mutual benefits.

Nowadays, after 20 years of innovation with rapid development paces, the Vietnam mining industry has strongly developed with high efficiency under the strategic directions of Vietnam Government. With great efforts, open pit and underground mines have been exploited at the deep mining levels of 200 ÷ 300m compared with the natural hydraulic flowing level, under the conditions of tropical and monsoon climate, close to seashores with great surface and ground water volume increasingly running into mines. The mineral mining enterprises have developed many concrete programs such as applying the deeply processing technology for minerals; applying advanced mining technologies, friendly to the environment, ensuring the industrial safety and hygiene; warning and effectively treating mine firedamp gases, gradually overcoming unsafe hazards; developing land reclamation, afforestation and improvement of ecological environment within and surrounding the mines for sustainable development of the mining industry, meeting the demands for the present generation and future generation as well. Moreover, the mining enterprises have provided more and more social responsibility to the local inhabitants in the fields of improving living conditions and income; training and employing local manpower; building local schools, hospitals and infrastructure; contributing to the local environmental protection fund, social and cultural funds; ensuring the harmonious benefits of the Government, the mining enterprises, the mining workers and the local inhabitants as well as environmental restoration and conservation. Carrying out these above mentioned tasks need a long procedure with much investment, therefore, it is impossible to meet immediately the requirements from the legal regulations, people and society.

Dear foreign guests !

Nowadays, the whole world is at the integration period. Therefore, the presence of the scientists and international guests at this conference is the great stimulation for the Vietnam mining industry, the Vietnam Mining Science and Technology Association, the mineral mining enterprises as well as the persons who are working for the Vietnam mining industry. At this Conference, we hope to obtain precious information, experiences and new approaching methods from the scientists of the countries having developed mining industries. We are also willing to receive the cooperation and investment from the overseas mining enterprises for Vietnam mineral mining and processing with modern and advanced mining technologies to create the social, economic and environmental efficiency for the Vietnam mining industry, more and more jobs and income for the mining workers, ensuring the energy security for Vietnam country. After many years of mining operation under the difficult conditions, the Vietnam mining workers have strongly grown up and we are willing to be with you in investment in the overseas mining projects for the purpose of mutual development.

I hope that, during the days staying in Vietnam, at the beautiful Halong Bay, the participants will have unforgettable memory, further explore the Vietnam mining industry as well as the country and the friendly people of Vietnam. In high spirits, on behalf of the Organizing Committee of the International Mining Conference and in the name of the President of the Vietnam Mining Science and Technology Association, I declare the open of the International Mining Conference 2010 at Halong in Vietnam.

We wish great success to the conference and good health for all participants !

SECTION IV

GEOMECHANIC AND GEOMATIC ENGINEERING FOR SUSTAINABLE MINING DEVELOPMENT

GEOMECHANICAL FUNDAMENTALS OF PREVENTING THE FORMATION OF CRITICAL EARTH SURFACE DEFORMATIONS OVER THE ABANDONED MINE FIELDS

Dr. Shamaev V.V.
Donetsk National Technical University,Ukraina

Problem actuality. In the majority of mining regions of the world mining operations are carried out at great depth, in difficult mining and geological conditions, under the densely built-up territories, main transport routes, communication systems and other objects. In these conditions the damage from such consequences of mining operations as undermining of natural and engineering objects, underflooding of territories and swamp formation as the result of subsidence, origination of abnormal geodynamical phenomena and others may greatly exceed the profits from mining operations.

Earlier, when mining operations were carried out on the shallow depth, they were followed by considerable earth surface deformations. The zones of deformation concentration formed at this did not stand out from the general background [1].

Mining operation deepening resulted in the increase of the sizes of the displacement trough and the duration of the processes of the solid mass deformation (dozens of months), the general deformation influence on the earth surface became less, but the zones of deformation concentration clearly stand out against this background and these zones have the main negative effect on the condition of natural and engineering objects.

The number of cases when geomechanical processes in the solid masses in which the deformation processes were considered to be finished become active again has increased and in connection with this it is not economically profitable to use protective measures for all the objects in the area of the mining operation influence.

It is logically to assume that under such conditions it is a good practice to use protective measures only for those areas of the mining operation influence where the zones of deformation concentration are expected to form.

Besides that, protective measures should allow us to resume mining of the mineral seams prone to sudden outbursts and violent bumps, that is to prevent the formation of conditions for the development of abnormal geodynamical and geomechanical phenomena under the influence of natural or industrial factors.

That is why the problem of looking into the character and mechanisms of deformation fabric development as the zones where the deformations are concentrated and activated, defining their parameters, types and period of activity on the modern stage of mineral resources exploration is of great actuality. The problem solution will allow us to create the geomechanical principles how to estimate, forecast and control the solid mass state which can provide the effective protection of natural and engineering objects and safety of mining operations as well as reduction of the damage from negative consequences of these operations.

The aim of the work is to develop the geomechanical fundamentals on the base of integrated research of the character and mechanisms of deformation processes taking into account the discrete and wavelike properties of their development.

Research methods. While solving the set tasks the integrated research procedure has been used in the work including:

- reconstruction of tectonic solid mass using the kinematic technique;
- monitoring of deformation processes;
- defining zones of deformation concentration and relatively stable zones of stratification in a solid mass.

During the earliest stages of geomechanics development the mechanisms of rock fall and rock subsidence in workings and on the surface were studied on the base of generalization of the practical experience of mining operations. The considerable contribution into the investigation of the processes of rock displacement and deformation was made by such well known researchers as Avershin S.G., Kazakovskiy D.A., Petukhov I.A., Muller R.A., Kratch G., Turchaninov I.A., Iofis M.A., Medyantsev A.N and others [2, 3].

When mining operation deepening some phenomena occurred which could not be explained from the positions of the existing theories. So, while underworking the objects at depths considerably exceeding the safe ones many structures were severely damaged. At the same time the separate objects among the destroyed ones were not affected by the activity of the destructive deformations. There are known cases of geomechanical process intensification in the abandoned solid masses where mining operations were finished and there were no intensive deformation processes noticed. Consequently, the development of the deformation processes in these conditions takes place in accordance with the other laws earlier unknown.

The processes and phenomena arising in the geological environment are defined, in the first turn, by the environment properties. For geomechanics tasks such environment is a rock mass, representing a block structure. Block structures formed prior to the beginning of deposit development were the result of a long-time evolution and they were formed in such a way as to provide the most economical deformation of some areas of earth crust from the point of view of energy cost. After the mineral deposits have been mined the solid mass structure also aims to achieve the energy balance. The mechanisms of block structure formation on the various scale levels are different; they are defined by the deformation fields and the character of the prevailing type of movement. The changes in a block structure lead to the changes of the environment properties and, consequently, of the behaviour of geomechanical deformation, filtration and other processes.

In a solid mass you can distinguish some competent beds which define the process deforming the beds comprising the mass. A competent bed can withstand the pressure during deformation in such a way that there are only slight changes in its thickness whereas the thickness of the incompetent beds comprising the mass undergoes the changes caused by the uneven loads while deforming.

As a result of the deformation processes taking place in a rock mass, some stratification cavities are formed in it. According to the definition of the international society for rock mechanics (ISRM) a stratification is such a discontinuity in a rock mass which is not connected with any considerable block displacement [4].

Stratification cavities can be caused by natural or industrial processes. Boudinage, bleached zones and similarly are the results of natural processes. Industrial stratification cavities, as a rule, result from mining operations. There is deformation redistribution in a rock mass because of the variability of properties both inside the beds and between the beds, the deformation magnitude in the local volume exceeding by one-two orders the deformation in the homogenous mass which leads to the stratification cavity formation. A.Labass was the first to prove theoretically and give scientific credence to stratification origin in the process of mass deformation [5]. The stratification-generation mechanism for mining of gently sloping coal and potassium beds has already been studied to some extent but the formation of relatively stable zones of stratification in difficult mining and geological conditions of steep beds has had only theoretical justification. As the origination of stratification zones substantially changes the character of deformation processes, the task to locate zones of stratification is the integral part of the research efforts in the area of the main anticline of Donbass.

As the rock mass has an explicitly block structure and it is weakened by tectonic disturbances, the deformation fields are distributed unevenly: the deformation concentrates in the areas of weakness (in the tectonic disturbance boundaries, at block junctions) and in the rest of areas the deformation relatively reduces (in comparison with the average meanings).

It is known that the horizontal displacement magnitudes are influenced by tectonophysical processes (modern geodynamics) and considering their development it is necessary to take into account the vectors of recent tectonical fields. For this purpose in the area of the main anticline on the allotment where the experimental research is supposed to be, the reconstruction of the tectonical fields has been made using the kinematic methods given in [6].

The analysis of satellite observations was used as the additional method to control the earth surface deformation. The contours of maculose structure in the pictures coincide with the location of mine fields. Local anomalies of photo-tone in the ultra-violet and infra-red ranges correspond to the areas of creeping over the underground workings. The active transverse blocks have been defined which cross the zone of the central anticline and which are limited by the thrusts and faults of the north-east and submeridional strike.

The results of the tectonical field reconstruction and satellite observations analysis and the mine maps determined to choose the field of the mine named after Gagarin as the site of experimental research efforts. The mine field is situated within the limits of the Main Donbas anticline and it is characterized with great tectonical disturbance. This is a high density zone with a developed surface and underground infrastructure and complex communication systems. Namely this zone is known for the most substantial and various manifestations of deformation processes. The maximum depth is 972 m. The workings length is 31,8 km. Six coal seams with thickness from 0,4 to 0,87 m and slope angle 65°-

70° have been mined. Among them two seams are prone to sudden outbursts, the other two are prone to rock bumps and one is spontaneous firing hazardous. All the seams are prone to coal-dust explosion. All this causes the substantial energy of the ongoing abnormal geodynamic phenomena (thus, on May 15-th, 1969 on the field of this mine 14 thousand tons of coal were thrown away and 600 thousand m^3 of gas were emitted during the outburst lasting for 32sec.).

The experimental research was carried out on the section of the western mine-take wing. The processes of the solid mass deformation after the end of the primary shield mining and in the condition of coal measures re-mining of outburst-prone seams l_5 "Solyony"», l_4^{H} "Devyatka" and l_3 "Mazurka" were under the investigation. The observed horizons of the massive were 710 –830 m.

The experiment lasted for 27 months. The profiles of earth surface and mining workings were monitored and the processes of the rock mass deformation were controlled [7]. The development of the stratification zones was controlled with the help of microseismic and seismo-acoustic methods, by monitoring bottom – hole deformation gauges, using a borehole scanner, a fiber-optic borehole endoscope as well as by squeezing plasticized mortar into stratification cavities [8].

The observations showed that as a result of a deflection of the bed having a block structure the tension stress appears, the maximum values of which being in the junctions of

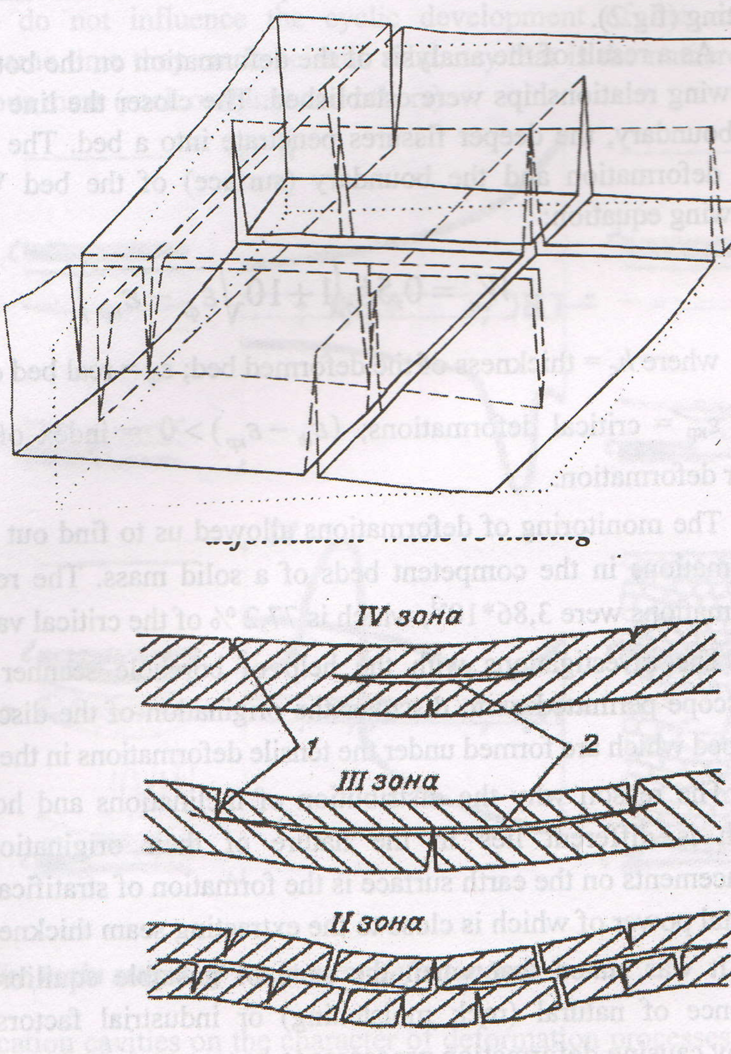


Figure 2. The scheme of fissure and stratification zone origination in a solid mass.

the bed blocks, while in the blocks themselves the deformation magnitude substantially reduces which is the peculiarity of the block mass deformation (fig.1).

The other peculiarity of the development of deformations in a solid mass is that the fissure origination depends not on the value of the breaking strength of the block rock but on the value of the breaking strength of the bonding material filling the block junctions. The sample analysis showed that the material at the block junctions consists of microparticles and its physical properties correspond to liquid rather than to a solid body.

In connection with this the models used to calculate block mass deformation do not allow us to obtain physically correct results.

While further undermining of a block solid mass the location of fissures, as a rule, does not change but these fissures deepen inside the undermined mass up to its complete splitting (fig.2).

As a result of the analysis of the deformation on the boundaries of the mass beds the following relationships were established. The closer the line of zero deformation is to the bed boundary, the deeper fissures penetrate into a bed. The distance between the line of zero deformation and the boundary (surface) of the bed $W_{н}$ can be found from the following equation:

$$W_{н} = 0,5h_c\left(1 + 10\sqrt{\varepsilon_{ф} - \varepsilon_{кр}}\right) \quad (1)$$

where h_c = thickness of the deformed bed; $\varepsilon_{ф}$ = real bed deformations;

$\varepsilon_{кр}$ = critical deformations; $(\varepsilon_{ф} - \varepsilon_{кр}) > 0$ = index of fissure opening in the bed under deformation.

The monitoring of deformations allowed us to find out the parameters of horizontal deformations in the competent beds of a solid mass. The real (actual) values of tensile deformations were $3,86 \cdot 10^{-3}$, which is 77,2 % of the critical values ($\varepsilon_{кр} = 5,0 \cdot 10^{-3}$).

The investigations with the help of borehole scanner and a fiber-optic borehole endoscope permitted us to discover the origination of the discontinuous microfissures in a rock bed which are formed under the tensile deformations in the range $3,25 \cdot 10^{-3} – 3,5 \cdot 10^{-3}$.

The reason why the distribution of inclinations and horizontal displacements in a trough is different lies in the nature of their origination. The reason of vertical displacements on the earth surface is the formation of stratification cavities in a solid mass, the total power of which is close to the extracting seam thickness.

It was stated that when the state of unstable equilibrium is disturbed under the influence of natural (rock moistening) or industrial factors, the stratification cavities destroy causing deformation processes to become active.

It was also stated that the displacement and deformation processes are of a cyclic character and they are followed by the formation of the systems of local fissures and stratification cavities. Processes of mass stratification and deformation begin just after coal extraction and their development is directed along the mine working movement with the drift towards a virgin ground (along a bed course). The mass deformation consists of 4 stages: smooth displacement of rock, stratification development, displacement of stratifications in space and stratification closing (fig 3). During the last stage the stabilization of the geomechanical system state takes place. The duration of each stage is defined by natural and industrial factors, namely, by mining and geological conditions and by the character of the redistribution of deformations in a mass.

"Moire" pulsations of a deformation field can be traced in the pulsations of deformation structures causing the alternating compression and tensile deformations of mass beds. These pulsations do not influence the cyclic development of the main deformation stages but at the same time they cause seismic dilatancy that is the numerous brittle failures of a heterogeneous mass (rock outburst and others).

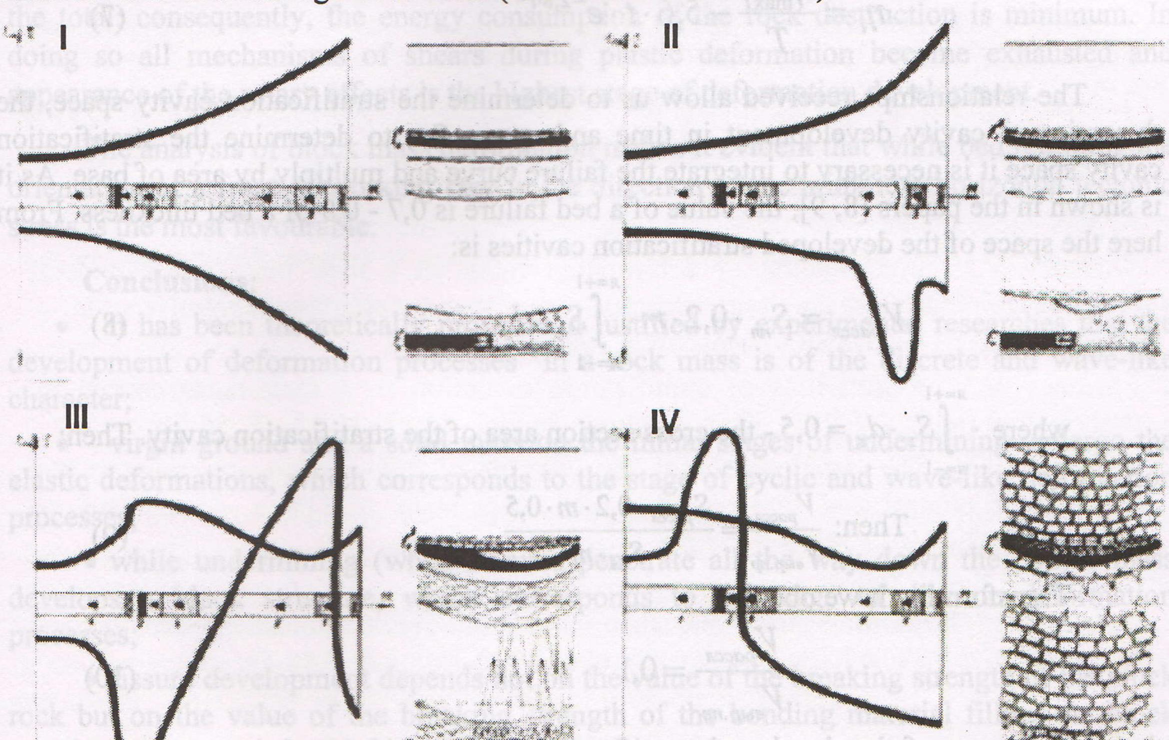


Figure 3. The main stages of rock mass deformation.

The influence of stratification cavities on the character of deformation processes are defined, first of all, by such a parameter as space. It is possible to determine the stratification cavity space on the basis of the results obtained about a mass deformation. The calculation of the rock failure in time can be found from the expressions:

$$\eta_t = \eta_{\max i} \cdot S_t \qquad (2)$$

$$\eta_t' = \frac{\eta_{\max i}}{T} \cdot S_t' \qquad (3)$$

where S_t, S_t' - nondimensional coefficients characterizing the failure and the plug failure unevenness in time:

$$S_t = \cdot e^{-2,8 \cdot t^2} \qquad (4)$$

$$S_t' = -5,6 \cdot t \cdot e^{-2,8 \cdot t^2} \qquad (5)$$

Substituting these expressions in formulas (2) and (3), we can obtain

$$\eta_t = \eta_{\max i} \cdot e^{-2,8 \cdot t^2} \qquad (6)$$

$$\eta_t' = \frac{\eta_{\max i}}{T} - 5,6 \cdot t \cdot e^{-2,8 \cdot t^2} \qquad (7)$$

The relationships received allow us to determine the stratification cavity space, the dynamics of cavity development in time and space. So, to determine the stratification cavity space it is necessary to integrate the failure curve and multiply by area of base. As it is shown in the papers [8, 9], the value of a bed failure is 0,7 - 0,9 of a bed thickness. From here the space of the developed stratification cavities is:

$$V_{рассл} = S_{пл} \cdot 0,2 \cdot m \cdot \int_{я=-1}^{я=+1} S_z \cdot d_z \qquad (8)$$

where $\int_{я=-1}^{я=+1} S_z \cdot d_z = 0,5$ - the cross section area of the stratification cavity. Then:

$$\text{Then: } \frac{V_{рассл}}{V_{выр.пр}} = \frac{S_{рассл} \cdot 0,2 \cdot m \cdot 0,5}{S_{пл} \cdot m} \qquad (9)$$

Transforming it we obtain

$$\frac{V_{рассл}}{V_{выр.пр}} = 0,1 \qquad (10)$$

that is the space of the developed stratification cavity is 10 % of the mined-out space. During the experiment 510 m^3 of special plasticized mortar were squeezed into the stratification zone which was about 12 % of the mined-out space and well agrees with the estimated data. The mode of the mortar squeezing corresponded to the changes of the deformation field.

Mining of the western mine-take wing led to the formation of stratification zones with space more than 5000 m^3 in a mass. Taking into account the quantity of free and physically bonded methane filling these zones, the calorific value of which considerably exceeds coal calorific value it is possible to claim that the application of industrial gas fields is economically sound.

The investigation of the mass deformation field dynamics also gives evidence of a repetitive and cyclic character of the changes of their sizes in space and time. The length of the main wave is 20 – 30 m and the waves with the length of order of first meters are superimposed on it. The given wave lengths well agree with the typical dimensions of the competent beds (sand-rock) as well as with own vibration frequencies of these structural elements which can be considered in some specific cases as fractal zones. When achieving the limit of material flow the deformation velocity in the sliding surface drastically increases [10], that is, the sliding surface itself becomes the generator of a high frequency deformation wave. When the deformation of a rock bed in a mass is considered form the perspective of geodynamics, the localization of deformation is inevitable, that is the given process is energy-profitable. The energy consumption while deforming is proportional to the space deformed and if localized, the space which is deformed is a few percents from the total; consequently, the energy consumption of the rock destruction is minimum. In doing so all mechanisms of shears during plastic deformation become exhausted and appearance of the rotary effects is the highest stage of deformation development.

The analysis of block mass deformation makes it evident that while bed remining the orientation of a front of working face in the direction of the minimum horizontal tectonic stress is the most favourable.

Conclusions:

- it has been theoretically proved and justified by experimental researches that the development of deformation processes in a rock mass is of the discrete and wave-like character;
- virgin ground and a solid mass on the initial stages of undermining undergo the elastic deformations, which corresponds to the stage of cyclic and wave-like deformation processes;
- while undermining (when fissures penetrate all the way down the bed) a mass develops a block structure, which corresponds to the stage of discrete deformation processes;
- fissure development depends not on the value of the breaking strength of the block rock but on the value of the breaking strength of the bonding material filling the block junctions;
- the material at the block junctions consists of microparticles and its physical properties correspond to liquid rather than to a solid body;
- when the mine field becomes abandoned the deformation processes gradually disappear but they are possible to become active again because of the equilibrium state disturbance in the stratification zones or because of induced tectonic deformations.

As the result of the researches which have been done we have created the geomechanical fundamentals treating a mass as a multi-level self-organising system where the stability loss can take place in agreement on some scale levels with clearly defined slowly and quickly passing deformation processes.

The geomechanical fundamentals which have been worked out are the information base to estimate and forecast a mass state as well as to create new effective ways to control the deformation processes in a mass in order to provide the safety of protected natural and engineering objects, the mining operation safety and to reduce the damages from negative consequences of these operations.

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