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ОБОСНОВАНИЕ РАЦИОНАЛЬНЫХ ЗНАЧЕНИЙ УГЛА НАКЛОНА ЗАДНЕГО ОГРАЖДЕНИЯ И ТРАЕКТОРИИ ДВИЖЕНИЯ ПЕРЕКРЫТИЯ ЩИТОВОЙ СЕКЦИИ МЕХАНИЗИРОВАННОЙ КРЕПИ

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Аннотация: Критериями эффективной работы щитовых механизированных крепей считается угол наклона заднего ограждения относительно перекрытия и траектория движения перекрытия в плоскости, перпендикулярной груди забоя. Обоснованы значения угла наклона заднего ограждения относительно перекрытия для минимально вынимаемой мощности пласта и для минимальной высоты секции крепи. Для максимального значения коэффициента трения породы по стали $f = 0{,}4$ угол наклона заднего ограждения относительно перекрытия секции крепи для минимально вынимаемой мощности пласта должен быть не менее 22°, а для минимальной высоты секции крепи не менее 14–15°, что соответствует, коэффициенту трения $f = 0{,}25–0{,}26$. Установлено, что основной причиной неудовлетворительной работы механизированных крепей, отрабатывающих пласты с неустойчивой либо трещиноватой непосредственной кровлей, является смещение перекрытия в сторону выработанного пространства при посадке секции крепи. В идеале смещений перекрытия вдоль кровли быть не должно, но достичь этого во всем диапазоне раздвижности секции крепи за счет конструктивных решений не удается. Однако смещение перекрытия только в сторону забоя при опускании секции крепи во всём диапазоне её раздвижности возможно, так как это не сказывается отрицательно на нагруженности крепи. Представлена совершенная траектория движения перекрытия, исключающая перемещение перекрытия при посадке секции крепи в сторону выработанного пространства, полученная обоснованным выбором конструктивных и кинематических параметров заднего ограждения и других элементов, влияющих на формирование данной траектории.

Ключевые слова: щитовая механизированная крепь, угол наклона заднего ограждения, диапазон раздвижности, смещение перекрытия, выработанное пространство, лемнискат, горизонтально-растягивающие напряжения, высота секции крепи, траектория движения перекрытия.

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Justification of rational caving shield angles and canopy paths of displacement in powered roof supports

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Abstract: The criteria of effective operation of powered roof supports (shields) are the angle of the caving shield inclination relative to the canopy and the trajectory of the canopy displacement in the plane perpendicular to the longwall face. The values of the inclination angle of the caving shield relative to the canopy are substantiated for the minimum mineable thickness of coal seams and for the minimum height of the powered support unit. For the maximum rock—steel friction coefficient $f = 0.4$, the angle of the caving shield inclination relative to the canopy should be at least 22° for the minimum mineable thickness of seams and at least 14–15° for the minimum height of shields, which corresponds to the friction coefficient $f = 0.25–0.26$. It is found that the main cause of the unsatisfactory operation of powered roof supports in coal mining under unstable or fractured immediate roof is the displacement of the canopy towards the goaf during powered support setting. Ideally, there should be no canopy displacements along the roof, but this is unachievable within the whole range of the shield support expandability due to the structural concept. However, it is allowable that the canopy displaces towards the face during the shield support setting over the whole range of its expandability since this has no adverse effect on the load applied to the support unit. The perfect trajectory of the canopy displacement is presented. The trajectory eliminates the canopy displacement towards the goaf during the shield support setting, and is achieved via the reasonable selection of the structural and kinematic parameters of the caving shield and other elements influencing formation of this trajectory.

Key words: powered roof support (shield), caving shield inclination angle, expandability range, canopy displacement, goaf space, lemniscate, horizontal tensile stresses, shield support height, canopy displacement trajectory.

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Introduction

For thin and medium-thick coal seam mining, highly efficient powered roof support systems consisting of single-row two-leg and two-row four-leg shields are designed. However, when a coal seam has a minimum allowable thickness for a shield, and an unstable or fractured immediate roof, the efficiency of the whole roof support system drops, i.e., its productivity decreases [1—4].

The causes of unsatisfactory operation of powered roof supports in thin coal seams are:

- the decrease in the angle of inclination of the caving shield relative to the canopy and, as a result, the increase in the load on the shield due to the larger contact

area between the roof rocks and the shield and owing to the higher resistance force to broken rock flow along the caving shield to the coal seam floor;

- the possible displacement of the canopy of the support unit towards the goaf during roof caving due to rotation of rods of the four-bar linkage towards the coal seam floor.

The angle of inclination of the caving shield relative to the canopy in some powered roof support models (BS2.1X (Germany); 1KD90C; Don-Faliya 5; GLINNIK 06/15 (Poland) is from 4 to 6° when the shield is folded and is 9.5 to 12.5° at the minimum thickness of coal seams.

In mining coal seams having minimum allowable thickness, with block-by-block caving of immediate roof, transition of caved rocks from the supporting part of the canopy to the caving shield and, as a result, the increase in the load on the shield leads to the greater yielding and to the loss of hydraulic expandability of the hydraulic legs, to the rigid setting of the powered support unit, to the emergency condition in the longwall face area and to the increase in the manual labor content to disengage the shield.

This is due to the fact that the small angles of inclination of the caving shield relative to the canopy contribute to a direct increase in the length of the canopy by a portion of the caving shield.

In addition, a significant effect is exerted on the fractured immediate roof during its caving by the displacement of the canopy of the powered support unit towards the goaf, which induces the horizontal tensile stresses that contribute to jointing and rock falls in the face strip of the roof [5 — 8].

Therefore, for the effective operation of powered roof supports, the four-bar linkage of the caving shield should ensure displacement of the canopy towards the face during the shield support expansion, while the inclination of the caving shield should provide the reduced width of the working area, i.e. the supported width of the roof.

The objective of the research is to substantiate the rational values of inclination of the caving shield of a powered roof support unit, such that to ensure efficiency of the powered roof support in mining thin and medium-thick coal seams with unstable or fractured immediate roof, and the canopy displacement trajectory (leminscate) of the shield depending on its expandability, without displacement of the canopy towards the goaf during expansion of the powered roof support unit.

To achieve this objective, it is necessary to fulfill the following main tasks:

- to analyze the results of operation of powered roof supports in coal mining under unstable or fractured immediate roof in order to determine the effect of the caving shield angle on performance of powered support units;
- to find the rational values for the angles of the caving shield inclination of a powered support unit for coal mining under unstable or fractured immediate roof;
- to substantiate the leminscate trajectory with regard to the powered roof support unit subject to its expandability, which eliminates displacement of the canopy towards the goaf.

Research methods: analysis and generalization of information contained in reference sources, kinetostatic analysis.

Results

The critical cause of unsatisfactory operation of BS2.1X powered shield (Germany) [9] in Zapadnaya mine of Gukovugol was the displacement of the canopy towards the goaf due to the irrational angle of the caving shield inclination relative to the canopy during expansion of the support unit within the whole range of mineable seam thicknesses, which resulted in the rigid expansion of the support unit and, thereby in the longwall downtime for the

support unit to be disengaged. The angle of the caving shield inclination relative to the canopy of BS2.1X shield support is 4° when folded and is 9.5° for the minimum mineable thickness. Such inclination of the caving shield at the minimum mineable thickness of coal seams led to an increase in the width of the supported roof and, accordingly, to an increase in the roof load on the powered support unit. In order to avoid rigid expansion of the shield support units in the areas of the minimum mineable thickness, the seam floor overcutting was undertaken. In addition, the seam roof was heavily jointed and the displacement of the canopy towards the goaf during the shield support expansion contributed to opening of cracks in the immediate roof and to roof rock falls in the face strip.

The units of the powered roof supports (shields) are quite complex link-motion mechanisms [10]. The linear and angular movements of such structures depend on many factors that must be taken into account when designing such mechanisms or selecting available machines for specific operating conditions.

Fig. 1 shows a single-row powered support unit GLINNIK 06/15 (Poland) identical to BS2.1X unit, with the caving shield inclination angle Ψ to the canopy of 5° at the minimum height of 600 mm.

During excavation of coal seam k2n with a thickness of 0.8 – 1.25 m by MKD90SN plough assembly in Zamchalovskaya mine of Zamchalovsky Anthracite, expansion of 1KD90S shield was rigid. The angle of inclination of the caving shield of 1KD90S support unit is 6° in the folded position and is 12° at the minimum mineable thickness.

The geological conditions of operation of MKD90SN assembly were as follows:

- the immediate roof of the coal seam was medium-stable. Discontinuity of the immediate roof occurred in the form of its destruction into blocks with a width equal to the advance step of the powered support units;
- everywhere in the face there were small-amplitude upthrusts of the coal seam (H = 0.1 – 0.3 m), forming “lips” on the floor every 3 – 7 m down the dip, which complicated operation of the longwall assembly.

The rigid expansion of the support units occurred due to an increase in the roof load on the support during mining operations at the minimum coal seam thickness. The load on the support and, accordingly, the support resistance for the conditions of Zamchalovskaya mine is determined from the formula [11]:

$$Q_{\sup} = \gamma \cdot m_B \cdot l \cdot \left[\frac{n_2}{2} + n_1 \cdot \left(1 - \rho \cdot Atg\Psi_j\right) \right] \text{kN/m}, \quad (1)$$

where: m_B is the height of blocks, approximately equal to the thickness of the immediate roof, m; l is the width of a block, usu-

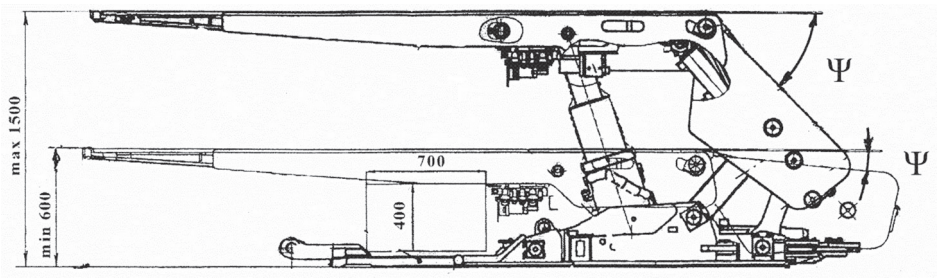

Fig. 1. GLINIK 06/15 support unit (Poland)
Рис. 1. Секция крепи GLINNIK 06/15 (Польша)

ally equal to the advance step of the support unit, m; n_1 and n_2 are the number of blocks supported by the support unit and hanging behind the support unit, respectively, $n_1 = R/l$ and $n_2 = (2-2.5)\cdot n_1$; R is the maximum width of the working space in the face, m; $\rho = 0.75$ is the rock friction coefficient; $\Psi_j = (70-80°)$ is the angle of joints forming the blocks.

It follows from formula (1) that the load on the support unit depends on the number of blocks supported by the support unit, n_1, and hanging behind the unit, n_2. As a result of the increased load on the support, the caving shield angle Ψ relative to the canopy was reduced to minimum values, which increased the projection of the caving shield length on the plane of the seam floor, and, as a result, the number of the blocks supported by the support unit grew (Fig. 2).

The increase in the number of blocks thanks to the caving shield leads to an increase in the roof load on the support by 29 – 34%.

The block diagram of discontinuity in the bottom layers of the roof in Fig. 2 will take place only at a certain friction force F_{fr} dependent on the friction coefficient f between rocks and steel and on the caving shield angle Ψ. The coefficient of rock – steel friction depends on the moisture content of rocks and is $f = 0.15 - 0.4$. The maximum friction coefficient $f = 0.4$ corresponds to the friction of dry rock on steel [12, 13].

The correlation of the friction coefficient and the angle of inclination of the the caving shield [14] is given by:

$$f = tg\Psi, \text{ then } \Psi = arctg\, f, \text{ grades.} \quad (2)$$

At the friction coefficient $f = 0.4$, the caving shield inclination is $\Psi = 21.8°$.

Therefore, one of the main criteria for the effective operation of the powered support units can be considered the value of the caving shield angle relative to the canopy. In this case, the angle of the caving shield inclination should be at least 22° at the minimum mineable thickness mmin and at least 14 – 15° at the minimum height of the support unit, Hmin, which corresponds to the friction coefficient $f = 0.25 - 0.26$, and this is proved by operation of shield support units.

In Kuzbass mines, the main cause of unsatisfactory operation of various powered support units such as M138 (Fig. 3) in medium-thick coal seams with unstable or fractured immediate roof was the canopy displacement ΔX_A towards the the goaf during expansion, which was accompa-

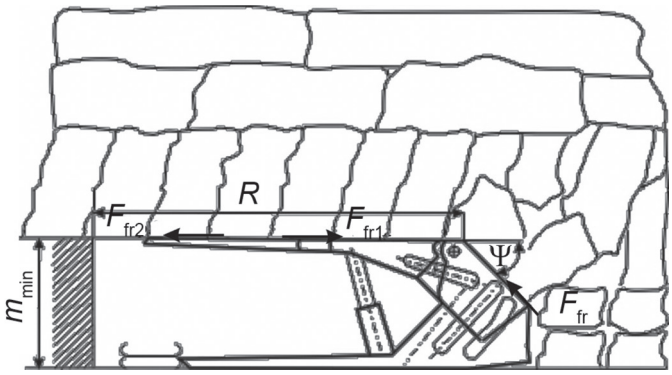

Fig. 2. Block diagram of discontinuity in bottom roof layers when using shield support

Рис. 2. Блочная схема нарушения сплошности нижних слоев кровли при использовании щитовой механизированной крепи

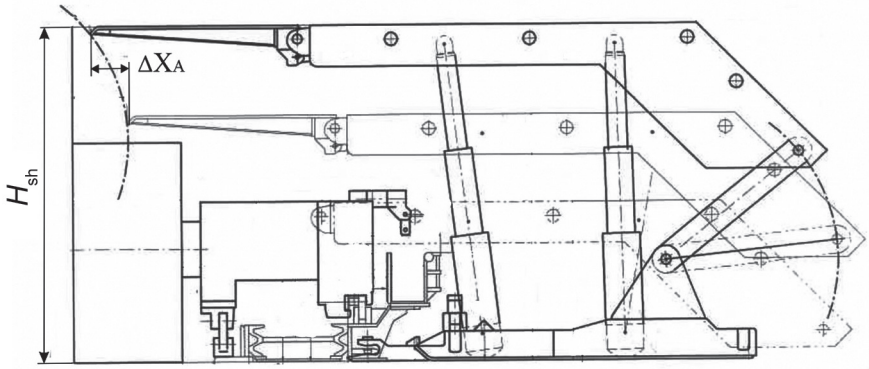

Fig. 3. Powered support unit M138

Рис. 3. Секция механизированной крепи М138 в составе комбайнового комплекса

nied by rock falls in the face strip of coal [15—18]. The displacement resulted from incorrect choice of the shield support unit design.

Fig. 4, *a* shows the trajectory of the canopy in the single-row two-leg shield of KMP 06/15 support (designed by JSC PNIUI), obtained from the kinetostatic analysis. The trajectory is a lemniscate dependent on the shield expandability, i.e. on the shield height H_{sh}. The significant displacements ΔX_A of the canopy towards the goaf are reflective of inexpediency of using such powered roof support units in coal seams with unstable or fractured roof as this leads to delamination and falls of roof rocks in the face strip.

When the support unit is set in site I–I, the canopy displacement ΔX_A is directed towards the face. In this case, the friction force $F_{fr.1}$ between the canopy and roof rocks is directed towards the goaf. In site II–II, the canopy displaces towards the goaf and the friction force $F_{fr.2}$ is directed towards the face (Fig. 2).

The analysis of loading of the shield support unit shows that the direction of the canopy displacement has no influence on the load-bearing capacity of the support unit. At the same time, the direction of the forces $F_{fr.1}$ and $F_{fr.2}$ has a significant effect on the redistribution and magnitude of forces in the elements of the support unit, especially in the rods of the four-linkage mechanism.

The calculations show that the forces in the rods of the caving shield when the canopy is displaced towards the goaf by 25% or more exceed the forces in the rod when the canopy is shifted towards the face.

Therefore, the criterion for the correct choice of a support unit design for the specified conditions is the direction of the canopy dispacement X_A only towards the face along the roof during expansion of the support unit within the whole range of the shield expandability H_{sh} [19, 20].

An example of the correct design of the powered support units by the criterion of the canopy displacement only towards the face during expansion can be considered the designs of single-row shield support units 1KT125 and 2KT125 by JSC ShakhtNUI.

The distinctive feature of these shields is their wide range of expandability, up to 750—1520 mm for 1KT125 unit and 1200—2500 mm for 2KT125.

The expandabilities of the shield units and the trajectories of their canopies are governed by the design parameters of the four-linkage mechanism of the caving shield, i.e. by the lengths of the rods and by their installation coordinates on the bases

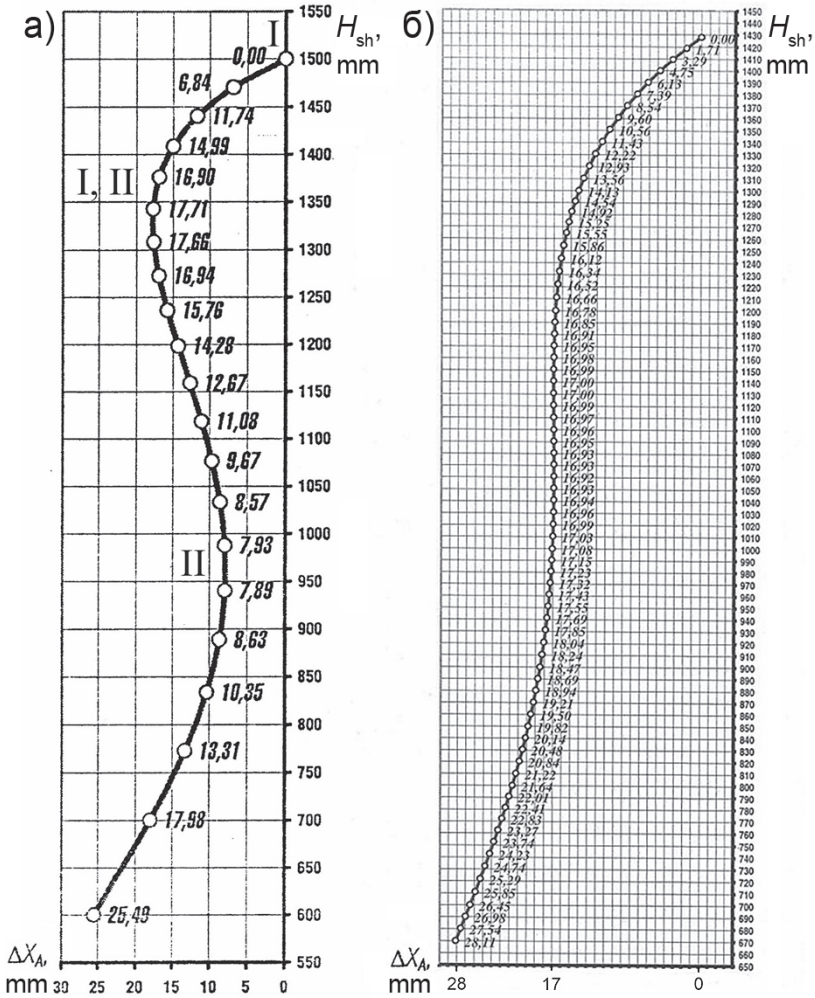

Fig. 4. Trajectories of canopies of shield support units along immediate roof (ΔX_A) versus shield expandability (H_{sh}): support unit KMP 06/15 (a); support unit 1KT125 (b)

Рис. 4. Траектории движения перекрытий щитовых секций крепи вдоль кровли (ΔX_A) в зависимости от их раздвижности ($H_{кр}$): крепи КМП 06/15 (а); крепи 1КТ125 (б)

and on the caving shields, which must be taken into account in design of such power support units.

Fig. 4, *b* shows the trajectory of the canopy of shield support unit 1KT125 versus the shield expandability H_{sh}. Such trajectory makes it possible to eliminate stratifications and rock falls in the immediate roof of the seam and in the face strip of the roof due to the canopy displacement ΔX_A only towards the face during expansion of the powered support unit.

Conclusions

1. The causes of unsatisfactory operation of powered support shields when mining thin and medium thickness coal seams with unstable or fractured immediate roofs are the small angles of inclination of the caving shield relative to the

canopy and the canopy displacement towards the goaf during expansion.

2. The rational values of the angles of the caving shield inclination relative to the canopy should be at least 22° at the minimum mineable thickness of seams and at least 14—15° at the minimum height of the support unit.

3. The improvement of the trajectory of the canopy (lemniscate), depending on shield expandability, such that to exclude the canopy displacement towards the goaf during expansion, is achieved owing to the correct selection of the design parameters of the powered shield, as illustrated by operation 1KT125 powered support unit.

СПИСОК ЛИТЕРАТУРЫ

1. *Kazanin O. I.*, *Sidorenko A. A.*, *Drebenstadt C. I.* Intensive underground mining technologies: Challenges and prospects for the coal mines in Russia // Acta Montanistica Slovaca. 2021, vol. 26, no. 1, pp. 60—69. DOI: 10.46544/AMS.v26i1.05.

2. *Brodny J.* Analysis of the impact of unscheduled downtimes on their availability in machine operations // MAPE. 2018, vol. 1, no. 1, pp. 145—151. DOI: 10.2478/mape-2018-0019.

3. *Sinha S.*, *Chugh Y. P.* Validation of critical strain technique for assessing stability of coal mine intersections and its potential for development of roof control plans // Journal of Rock Mechanics and Geotechnical Engineering. 2018, vol. 10, no. 2, pp. 380—389. DOI: 10.1016/j.jrmge.2017.10.003.

4. *Szurgacz D., Brodny J.* Analysis of the influence of dynamic load on the work parameters of a powered roof support's hydraulic leg // Sustainability. 2019, vol. 11, no. 9, article 2570. DOI: 10.3390/su11092570.

5. *Казанин О. И.*, *Сидоренко А. А. Мешков А. А.* Организационно-технологические принципы реализации потенциала современного высокопроизводительного очистного оборудования // Уголь. — 2019. — № 12. — С. 4—12. DOI: 10.18796/0041-5790-2019-12-4-13.

6. *Задков Д. А.*, *Габов В. В.*, *Бабырь Н. В.*, *Стебнев А. В.*, *Теремецкая В. А.* Энергоэффективная секция механизированной крепи очистного комплекса, адаптивная к условиям эксплуатации // Горный информационно-аналитический бюллетень. — 2022. — № 6. — С. 46—61. DOI: 10.25018/0236_1493_2022_6_0_46.

7. *Buyalich G. D.*, *Buyalich K. G.*, Umrikhina V. Yu. Study of falling roof vibrations in a production face at roof support resistance in the form of concentrated force // IOP Conference Series: Materials Science and Engineering. 2016, vol. 142, no. 1, article 012120. DOI: 10.1088/1757899X/142/1/012120.

8. *Матвеев В. А.*, *Турук Ю. В.* Новый подход к решению проблемы прогнозирования геомеханических процессов в кровле очистного забоя / Перспективные технологии добычи и использования углей Донбасса: материалы Международного научно-практического семинара. — Новочеркасск: ЮРГТУ (НПИ), 2009. — С. 145—155.

9. *Хорин В. Н.* Расчет и конструирование механизированных крепей. — М.: Недра, 1988. — 256 с.

10. *Яблонский А. А.*, *Никифорова В. М.* Курс теоретической механики, ч. 1. — М.: Высшая школа, 1977. — 368 с.

11. *Коровкин Ю. А.* Механизированные крепи очистных забоев. — М.: Недра, 1990. — 414 с.

12. *Sobik L., Brodny J., Buyalich G., Strelnikov P.* Analysis of methane hazard in longwall working equipped with a powered longwall complex // E3S Web of Conferences. 2020, vol. 174, article 01011. DOI: 10.1051/e3sconf/202017401011.

13. *Shurygin D. N.*, *Vlasenko S. V.*, *Turbor I. A.* An establishment of dependencies of mutual influence of geological and mining factors on the stress-strain state of the rock mass // IOP Conference Series: Earth and Environmental Science. 2019, vol. 272, no. 2, article 022235. DOI: 10.1088/1755-1315/272/2/022235.

14. *Габов В. В.* Адаптация секции, механизированной крепи совершенствованием механической характеристики гидропривода ее гидростоек // Горное оборудование и электромеханика. — 2016. — № 3. — С. 28—34.

15. *Babyr N. V.*, *Korolev A. I.* Enhancement of powered cleaning equipment with the view of mining and geological conditions // IOP Conference Series: Earth and Environmental Science. 2018, vol. 194, no. 3, pp. 1504—1510. DOI: 10.1088/1755-1315/194/3/032004.

16. *Козлов В. В.* Анализ динамики нагружения секции крепи при движении механизированного комплекса по криволинейной траектории // Уголь. — 2019. — № 12. — С. 38—39. DOI: 10.18796/0041-5790-2019-12-38-39.

17. *Szurgacz D., Brodny J.* Adapting the powered roof support to diverse mining and geological conditions // Energies. 2020, vol. 405, no. 13. DOI: 10.3390/en13020405.

18. *Павленко М. В., Хайдина М. П., Кузиев Д. А., Пихторинский Д., Муратов А. З.* Факторы воздействия комбайна при добыче угля на увеличение метаноотдачи массива в рабочее пространство лавы // Уголь. — 2019. — № 4. — С. 8—11. DOI: 10.18796/0041-5790-2019-4-8-11.

19. *Gendler S. G., Prokhorova E. A.* Risk-based methodology for determining priority directions for improving occupational safety in the mining industry of the Arctic Zone // Resources. 2021, vol. 3, no. 10, pp. 1—14. DOI: 10.3390/resources10030020.

20. *Thang P. D., Thang H. H., Phuc L. Q.* Technological solutions for intensive working of medium thick inclined coal seams in difficult conditions in the mines of the Quang Ninh coal basin // Устойчивое развитие горных территорий. 2019. — Т. 11. — № 1. — С. 105—109. ГИАБ

REFERENCES

1. Kazanin O. I., Sidorenko A. A., Drebenstadt C. I. Intensive underground mining technologies: Challenges and prospects for the coal mines in Russia. *Acta Montanistica Slovaca*. 2021, vol. 26, no. 1, pp. 60—69. DOI: 10.46544/AMS.v26i1.05.

2. Brodny J. Analysis of the impact of unscheduled downtimes on their availability in machine operations. *MAPE*. 2018, vol. 1, no. 1, pp. 145—151. DOI: 10.2478/mape-2018-0019.

3. Sinha S., Chugh Y. P. Validation of critical strain technique for assessing stability of coal mine intersections and its potential for development of roof control plans. *Journal of Rock Mechanics and Geotechnical Engineering*. 2018, vol. 10, no. 2, pp. 380—389. DOI: 10.1016/j.jrmge.2017.10.003.

4. Szurgacz D., Brodny J. Analysis of the influence of dynamic load on the work parameters of a powered roof support's hydraulic leg. *Sustainability*. 2019, vol. 11, no. 9, article 2570. DOI: 10.3390/ su11092570.

5. Kazanin O. I., Sidorenko A. A. Meshkov A. A. Organizational and technological principles of realizing the potential of modern high-performance stoping equipment. *Ugol'*. 2019, no. 12, pp. 4—12. [In Russ]. DOI: 10.18796/0041-5790-2019-12-4-13.

6. Zadkov D. A., Gabov V. V., Babyr N. V., Stebnev A. V., Teremetskaya V. A. Adaptable and energy-efficient powered roof support unit. *MIAB. Mining Inf. Anal. Bull.* 2022, no. 6, pp. 46—61. [In Russ]. DOI: 10.25018/0236_1493_2022_6_0_46.

7. Buyalich G. D., Buyalich K. G., Umrikhina V. Yu. Study of falling roof vibrations in a production face at roof support resistance in the form of concentrated force. *IOP Conference Series: Materials Science and Engineering*. 2016, vol. 142, no. 1, article 012120. DOI: 10.1088/1757899X/142/1/012120.

8. Matveev V. A., Turuk Yu. V. A new approach to solving the problem of forecasting geomechanical processes in the atmosphere of a clean face. *Perspektivnye tekhnologii dobychi i ispol'zovaniya ugley Donbassa: materialy Mezhdunarodnogo nauchno-prakticheskogo seminara* [Promising technologies for the extraction and use of Donbass coal: Materials of International Scientific Practice Seminar], Novocherkassk, YuRGTU (NPI), 2009, pp. 145—155. [In Russ].

9. Khorin V. N. *Raschet i konstruirovanie mekhanizirovannykh krepey* [Calculation and design of mechanized support units], Moscow, Nedra, 1988, 256 p.

10. Yablonskiy A. A., Nikiforova V. M. *Kurs teoreticheskoy mekhaniki*, ch. 1 [Course of theoretical mechanics, part 1], Moscow, Vysshaya shkola, 1977, 368 p.

11. Korovkin Yu. A. *Mekhanizirovannye krepi ochistnykh zaboev* [Mechanized supports of mining faces], Moscow, Nedra, 1990, 414 p.

12. Sobik L., Brodny J., Buyalich G., Strelnikov P. Analysis of methane hazard in longwall working equipped with a powered longwall complex. *E3S Web of Conferences*. 2020, vol. 174, article 01011. DOI: 10.1051/e3sconf/202017401011.

13. Shurygin D. N., Vlasenko S. V., Turbor I. A. An establishment of dependencies of mutual influence of geological and mining factors on the stress-strain state of the rock mass. *IOP Conference Series: Earth and Environmental Science*. 2019, vol. 272, no. 2, article 022235. DOI: 10.1088/1755-1315/272/2/022235.

14. Gabov V. V. Adaptation of the section, mechanized support by improving the mechanical characteristics of the hydraulic drive of its hydraulic pillars. *Mining Equipment and Electromechanics*. 2016, no. 3, pp. 28—34. [In Russ].

15. Babyr N. V., Korolev A. I. Enhancement of powered cleaning equipment with the view of mining and geological conditions. *IOP Conference Series: Earth and Environmental Science*. 2018, vol. 194, no. 3, pp. 1504 – 1510. DOI: 10.1088/1755-1315/194/3/032004.

16. Kozlov V. V. Analysis of the dynamics of the loading of the support section during the movement of a mechanized complex along a curved trajectory. *Ugol'*. 2019, no. 12, pp. 38 – 39. [In Russ]. DOI: 10.18796/0041-5790-2019-12-38-39.

17. Szurgacz D., Brodny J. Adapting the powered roof support to diverse mining and geological conditions. *Energies*. 2020, vol. 405, no. 13. DOI: 10.3390/en13020405.

18. Pavlenko M. V., Khaidina M. P., Kuziev D. A., Pihtorinskiy D., Muratov A. Z. Impacts of the combine harvester in the production of coal to increase methane recovery array in the workspace lava. *Ugol'*. 2019, no. 4, pp. 8 – 11. [In Russ]. DOI: 10.18796/0041-5790-2019-4-8-11.

19. Gendler S. G., Prokhorova E. A. Risk-based methodology for determining priority directions for improving occupational safety in the mining industry of the Arctic Zone. *Resources*. 2021, vol. 3, no. 10, pp. 1 – 14. DOI: 10.3390/resources10030020.

20. Thang P. D., Thang H. H., Phuc L. Q. Technological solutions for intensive working of medium thick inclined coal seams in difficult conditions in the mines of the Quang Ninh coal basin. *Sustainable Development of Mountain Territories*. 2019, vol. 11, no. 1, pp. 105 – 109.

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ОТДЕЛЬНЫЕ СТАТЬИ ГОРНОГО ИНФОРМАЦИОННО-АНАЛИТИЧЕСКОГО БЮЛЛЕТЕНЯ (СПЕЦИАЛЬНЫЙ ВЫПУСК)

СПЕКТРОСКОПИЯ БЛАГОРОДНЫХ КОРУНДОВ МИРА

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Проведен анализ применения физических методов исследования минералов для их диагностики. Описаны методы для получения спектров различного типа (комбинационного рассеяния, люминесценции и поглощения) в оптическом диапазоне: в ультрафиолетовом, видимом, а также ИК диапазоне, являющемся основным (базовым) методом количественного анализа состояния примесей в корундах Cr, V, Ti, Fe, Mn. Спектроскопия комбинационного рассеяния является относительно новым методом исследования минералов, получившим широкое распространение в настоящее время. Рассмотрены основные характеристики показателей цвета различных минералов. Показана необходимость применения объективных методов оценки структурных характеристик минералов. Показана четкая генетическая детерминированность химизма, физических свойств и парагенетических минеральных ассоциаций благородных корундов различного генезиса.

Ключевые слова: диагностика драгоценных камней, природные минералы, синтетические кристаллы, спектроскопия комбинационного рассеяния, люминесцентный анализ.

SPECTROSCOPY OF NOBLE CORUNDUMS OF THE WORLD

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The analysis of the application of physical methods of mineral research for their diagnosis is carried out. Methods for obtaining spectra of various types (Raman scattering, luminescence and absorption) in the optical range are described: in the ultraviolet, visible, and IR ranges, which is the main (basic) method for quantitative analysis of the state of impurities in Cr, V, Ti, Fe, Mn corundums. Raman spectroscopy is relatively new the method of mineral research, which is widely used at the present time. The main characteristics of the color indicators of various minerals are considered. The necessity of using objective methods for assessing the structural characteristics of minerals is shown. A clear genetic determinism of the chemistry, physical properties and paragenetic mineral associations of noble corundums of various genesis is shown.

Key words: diagnostics of precious stones, natural minerals, synthetic crystals, raman spectroscopy, luminescent analysis.