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The Geometrical and Geomechanical Characteristics of Sublevel Caving

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ABSTRACT: During recent years, great attention has been given to high-productivity methods such as sublevel caving. This method accounts for 25 % of the coal mined in the Jiu Valley. This paper deals with the geometrical elements of the mining method depending on the geomechanical characteristics of the coal. A comparison is also made between the high-productivity method and other mining methods, which shows that productivity is ten times higher with the high-productivity method than with the classical methods.

1 INTRODUCTION

The Jiu Valley is the greatest coal basin in Romania, and is a tectonic depression 50 km long with an area of 137 km^2. The mining technologies used in this area are very different because of the very hard conditions and a great depth of working.

Researchers have focused their attention on designing and implementing high-productivity mining methods in the coal industry such as coal and surrounding rocks caving and sublevel caving.

The efficiency of mining activity is a problem which should preoccupy the specialists in the field. The market economy enables competition mechanism and requests low prices and high quality raw-material production.

Taking into account the opportunity of mining the deep coal-deposits in the Jiu Valley effectively, it is necessary to choose and use high-productivity mining-methods. This can be achieved by considering the specific geological and mining conditions and by geomchanical characterization based on a profound study of the coal and surrounding rocks.

The use of the above-mentioned methods has been increasing steadily, accounting for 25 per cent of all Üie mining methods applied in the Jiu Valley Basin. In the future, coal mining will operate in certain competitive conditions, reducing production costs.

The sublevel mining method was first applied in its classical variant without complex mechanization at the Barbateni, Lupeni, Vulcan, Paroseni and Livezeni collieries.

Since 1997, the collieries have progressed to the mechanization of the method. Thus, prop and beam support has been replaced by powered supports consisting of:

SMA-2 powered supports (modified for sublevel caving);
KS-3M cutter-loader;
TR-7A conveyor.

2 THE GEOMETRIC AND GEOMECHANICAL CHARACTERISTICS OF THE MINING METHOD

The sublevel caving-method can be applied with good results in coal seams with a horizontal thickness greater than 4 m and a dip greater than 45°. It has been determined experimentally that the optimum lower limit of the dip of the seams is about 50°-55°; under such conditions, coal losses are at a minimum.

The method can also be applied in lenticular zones, lodes, and pillars where classical methods are not profitable.

The geological-mining conditions as well as the geomechanics of coal and surrounding rocks are influenced by the application of this method.

The accuracy of design as well as optimization of the support parameters depend on the interaction model between the rock massive and the supporting system for all mining methods (Goldan, 1999).

The mining method ensures a considerable reduction in the amount of first mining and coal face work as well as higher labor productivity and output.

The significant parameters related to geometric and geomechanical features of the method are the roof coal height and caving step.

The roof coal height is calculated according to the type of coal face support.

When the face support is rigid, then the height of the roof coal is computed with the Equation I.

$$H_b = 2.12 l_o \sqrt{0.75 - ctg\xi} \quad (1)$$

where: l_o = face width ; ξ = coal caving angle in the roof coal.

In cases where the support has a subsiding bearing, the computation Equation 2 is used for the height of the roof coal.

$$H_b = 1{,}73 l_o \sqrt{0{,}75\left[\frac{1}{1 - \frac{3E_c * I}{K l_o^3}}\right] - ctg\xi} \quad (2)$$

where K - support rigidity; E_c - coal elasticity module; and I - inertia moment of the roof coal.

If the support constitutes an active bearing, then the roof coal height can be determined by Equation 3.

$$H_b = l_o \sqrt{x * ctg\xi - ctg^2\xi} \quad (3)$$

The value of the caving step, x, of the roof coal can be calculated using Equation 4.

$$x = l_o ctg\xi \quad (4)$$

3 THE PARAMETERS OF THE MINING METHOD

The main parameters of the method are:

- the seam thickness: h = 20-60 m;
- seam dip on the strike: a = 4°-7°;
- face height: h^ = 3 m;
- roof coal height: H_b = 15-20m;
- working face length: L_{ab} = 40-60 m;
- mining panel length: Lp= 100-300 m;
- face advancing-step (web width): x = 0.63 m;
- face width: !,, = 5.8-6.5 m;
- coal dislocation from the roof coal is carried by natural caving, drilling blasting, or by water jet under pressure;
- roof control is achieved by complete caving of the roof rocks.

In order to help coal mining, it is necessary to achieve a certain plane of rupture and sliding of coal, all along the face. This plane is achieved artificially, by drilling and blasting.

The working face technology phases, after the caving plane achievement, present the following succession:

- cutting off the coal from the face, using explosives;
- hoisting the cantilever bars and roof lagging;
- evacuating the mined coal and installing the roof bars with hydraulic props;
- moving (advancing or flitting) the conveyor and controlling the roof along the working face. The roof control is achieved by pulling the last row of props and roof so that roof blocks of about one bar length are allowed to cave;
- evacuation of coal from the roof coal. This is made through the eyes of die lagging steel mesh. The spacing of the evacuating eyes is one meter along the and about 0.5 meter lower then the working face roof.

When compared to other frequently used mining methods, the technical economic indicators obtained are clearly superior, as shown in Table 1.

Table I. Frequently used mining methods and their technical characteristics.

No.	Indicator		Mining method: Room	Shortwall	Longwall	Subleve caving: With mechanization	Without mechanization
1.	Wood consumption	mVIOOO t	45-50	8-17	17	2	1.5
2.	Timber consumption	m^3/1000t	12-18	2-7	3^t	3	2.5
3.	Explosives	kg/10001	160-220	280-350	200-250	50-100	20-50
4.	Blasting caps	pieces/ IOOOt	580-800	750-850	700-1000	100-300	50-150
5	Wire metallic	kg/1000 t	500-1200	1550-2600	1500-3000	800-1000	500-700
6.	Slice output	t/day	70	90-100	150-200	i 50-200	250-300
7.	Coal roof output	t/day	-	-	-	600	800
8.	Overall output	t/day	70	90-İ00	150-200	750-800	1050-1100
9.	Number of workers		[6	18	18	25	25
10	Productivity	(/man	4.37	5	8.3-11	30-32	42-44

4 MEASURES AND CONCLUSIONS

In conclusion, the results obtained during the testing period at the mining plants justify the general use of the mining method.

- It is noted that with sublevel caving methods, labour productivity is 3 to 10 times greater than with classical methods. Wood and timber consumption decreases 4 to 25 times with direct bearing on the first cost.
- The volume of first mining is 50 % lower with the proposed mining methods than with the classical methods, while the prime cost per ton of mined-out coal ton is three times lower.
- It should be noted that if the coal face technology is not maintained adequately, coal losses may increase and there is a greater danger of fires occurring.

In order to reduce the danger of fires breaking out, the following measures should be taken:

- the worked-out space should be treated with thermo-power station ashes in a mixture with antipyrogenic substances or chemical foam;
- sealing dams should be built to seal off fires in the access working to the face;
- fire prevention by local inertization with nitrogen;
- gas samples should be taken from the mined-out area for the purpose of monitoring the content of the following gases: carbon monoxide, carbon dioxide, methane, etc.;
- correlation of the technological parameters of the mining method: face length, coal roof height, advance rate.

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