# Room-and-pillar mining of thick coal seams in the conditions of high gas dynamic hazard in Kuzbass

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**Abstract**. Room-and-pillar coal mining is effective in the areas unsuitable for fully mechanized longwalling. This mining method has advantages and disadvantages. The application of the room-and-pillar technique to mining of thick coal seams in the conditions of high gas dynamic hazard is face \d with such problems as impossibility of full-height extraction; heading without preliminary prediction of rock bursts and outbursts, or without early prevention of floor fracturing, etc. The ways to solve such problems in terms of coal mines in Kuzbass could be useful for mines in other regions.

## 1. Introduction

By expert estimates, to 30–40% of coal reserves in Kuzbass occur in subsoil areas unsuitable for fully mechanized longwalling. Such areas of coal seams are limited in size to 400–600 m, have irregular shapes and contain geological discontinuities. It is economically inefficient to use the system of longwall mining in such areas due to huge amount of assembling, low labor productivity and high cost of coal.

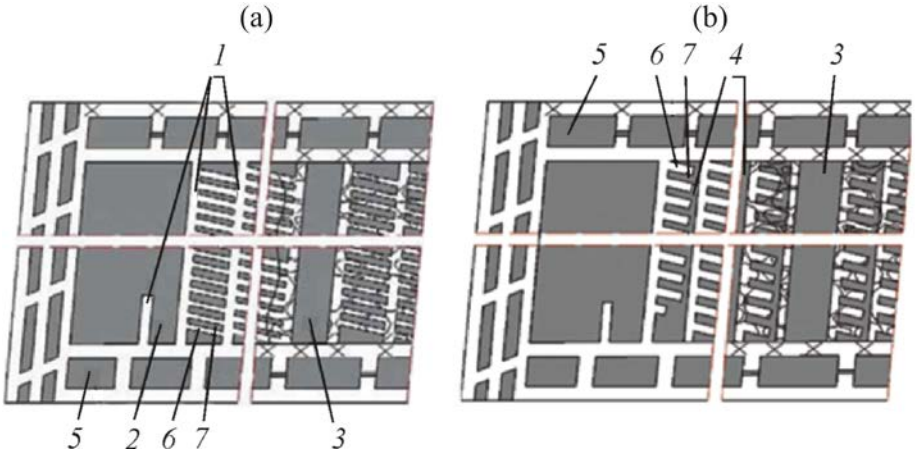


**Figure 1.** Room and pillar mining flow charts: (a) through entry ways in pillars; (b) blind entry ways in pillars; *1*—room; *2*—extraction panel; *3*—safety pillar; *4*—rib pillars; *5*—protective pillars; *6*—entry way; *7*—pillars protecting miners and machines from roof fall.

In such conditions in flat-dipping and inclined seams, it is possible to employ shortwall systems, in particular, room and pillar mining (RPM) [1]. In this technology, coal is first extracted from rooms separated by pillars. Heading is followed by coal loading to self-propelling cars for hauling to conveying lines. Roof support method is rock bolting. After heading and extraction of two–three rooms, coal is extracted from rib pillars (Figure 1) [2, 3].

Advantages of RPM include:

—mineability of difficult-to-extract reserves, increment in marketable coal output and extension of mine life;

—next-level efficiency of subsoil management;

—capital cost saving due to elimination of purchase of expensive heading equipment.

Disadvantages of RPM are:

—relatively high loss of coal without extraction panels;

—complex control of behavior of pillars and risks of roof falls in rooms;

—purchase of roof support equipment and large amount of roof support activities;

—measure to combat inflammation of coal remaining in mined-out voids.

Application of RPM method in Kunetsk Coal Basin is restrained by the:

—absence of legislation, regulations and procedures for shorwall mine planning and design;

—prohibition of use of RPM in rockburst-hazardous coal mining until recently;

—difficult ground conditions of coal seams (steep dip angles, high gas and water content; high jointing of enclosing rocks; weak roof rocks, structure of coal deposits as strata series);

—unsuitability of available machines for RPM.

## 2. Room and pillar mining projects in Russia

The countries with the mature coal industry (USA, Australia, South Africa, etc.) widely use room and pillar method of coal mining [4, 5]. This choice is facilitated by the more favorable ground conditions as against Kuzbass and by dynamic support of operations by science and technology. Structurally uniform enclosing rocks of high quality reduce the risk of sudden roof falls in rooms and save cost of roof support. Dedicated machinery opens wide prospects for mechanization of room and pillar mining [6, 7].

Rooms are extracted by heading machines equipped with coal cutter jigs. From a heading machine to a conveyor line, coal is hauled in shuttling self-propelling cars. Roof support is carried out using special high-productive roof bolters [8]. Such equipment is not manufactured in Russia (except for the cars), which affects efficiency of room and pillar mines. Furthermore, in recent decade, foreign mines increasingly use mobile electro-hydraulic roof supports (Figure 2) [9].

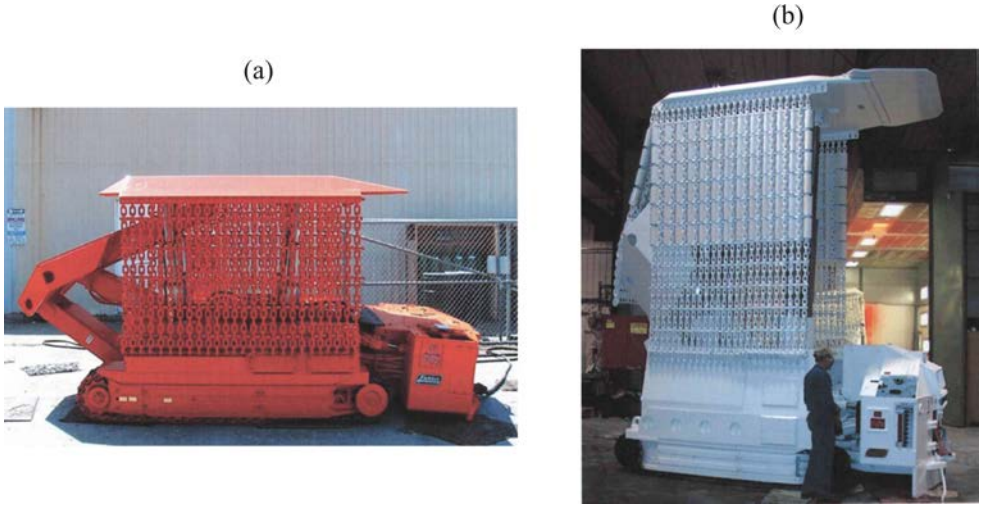


**Figure 2.** Mobile Roof Support MRS by USA with extended height of (a) 1.6 m and (b) 5 m.

The mobile roof supports eliminate the major disadvantage of RPM—high loss of coal. The mobile roof supports are placed under caving line in a room [10]. After heading machine cuts an entry way in the pillar, the support is advanced behind the machine along the room and protects potential caving zone. Coal reserves are extracted from pillars by sequential mining of entry ways with roof support in the rooms. Such mobile roof supports enable nearly complete extraction of coal from rib pillars. Coal extraction ratio in a panel has risen to 90–95%. This is comparable with the longwall system performance, which improves prospects of shortwalling.

Earlier in Kuzbass, RPM was used in Usinskaya, Sibirginskaya and Raspadskaya coal mines [11]. At the present time, Lenin and Raspadskaya-Koksovaya mines take advantage of this technology. Raspadskaya-Koksovaya mine employs RPM in experimental extraction of coal in gently dipping seam III with a dip angle of 1–12 ° thickness of 10 m. The seam is categorized as prone to rockbusting, gas outbursting and spontaneous combustion [12].

The RPM flow chart is planned and designed with scientific support provided by the VostNII and VNIMI research institutions. Parameters of RPM are determined by numerical modeling of geomechanic behavior of coal and rocks [13–15]. The technology is subjected to commercial-scale trial with heavy scientific work load on evaluation of safety of shortwalling [3, 16, 17].

The application of RPM in Raspadskaya-Koksovaya mine deals with the problems described below.

1. It is required to cut the seam by layers 3.6 m thick stage-wise undercutting of rooms (Figure 3) [18].

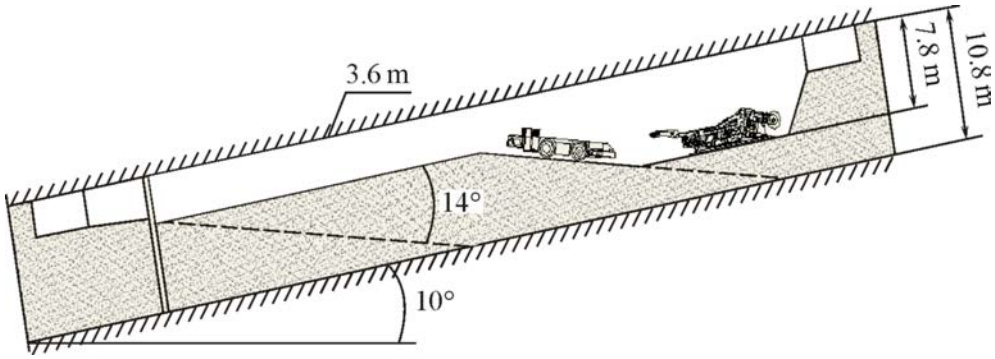


**Figure 3.** Layer-by-layer cutting of coal in a room in Raspadskaya-Koksovaya mine.

2. It absolutely necessary to predict rock bursts and outbursts. Making rocks rockburst-nonhazardous involves preventive control (Figure 4a) and perimeter drilling of safety pillars (Figure 4b) [18, 19].

3. It is required to drill holes in the room floor to prevent fracturing. In view of the earlier gas dynamic phenomena accompanied by huge methane emissions, it is necessary to drill destressing and drainage holes per each 6 m of heading (Figure 4c) [19].

4. Safety pillars should be left after 5–6 rooms are extracted. These pillars ensure temporal support in case that primary span of the mane roof collapse is exceeded.

5. Configuration of extraction panels should be planned wit regard to cleavages. The undertaken re-arrangement of rooms has resulted in higher stability of roof and sidewalls.

Nonetheless, despite these difficulties, RPM has application prospects in Russia. This is backed up with the experience of the technology application in difficult conditions of Olzherass coal field as well as with the international experience and increasing technical capabilities of efficient coal mining [4, 10, 18– 20].

For example, Mezhegeiugol and Denisovskaya mines in Tyva and Yakutia, respectively, operating in stable host rocks and using modern import equipment annually enjoy increment in coal production output. Successful negotiations and future purchase of mobile roof support in USA promise an increase in extraction of coal reserves from pillars.

Russian scientists contribute to expansion of technological capabilities of RPM. The VostNII institute has undertaken R&D aimed to design an advanced rock cutting tool [21] and simpler and cheaper mobile roof support capable to prevent roof falls in rooms during extraction of coal from pillars. These projects will enable substituting the expensive foreign equipment [22]. Manufacture of RPM equipment by Russian machine building plants will expand capabilities and improve efficiency of the technology.

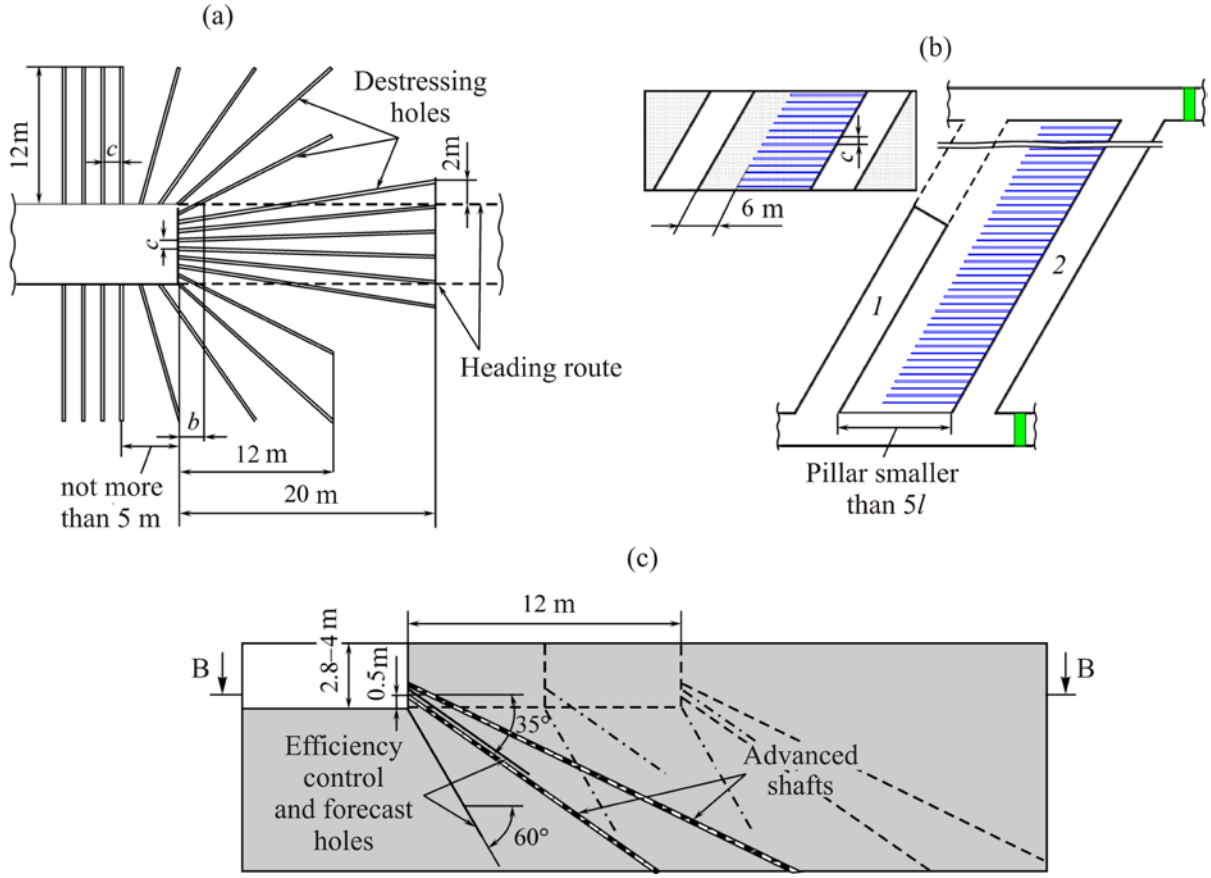


**Figure 4.** Destressing drilling: (a) heading; (b) treatment of safety pillar; (c) treatment of upper layer floor.

## 3. Conclusions

1. The method of room and pillar mining has been successfully used for many years in coal mines abroad (USA, Australia, South Africa), which is facilitated by easy ground conditions of coal strata and dynamic support of mining from the side of science and technology.
2. In Kuzbass mines, RPM application requires handling some engineering problems governed by complex nature of coal and rock mass in the Kuznetsk basin, which involves implementation of extra amount of work promoting safety but reducing efficiency of coal production.
3. The problems connected with the proper provision of RPM necessitate manufacture of special-purpose equipment in Russia. The global politics (sanctions and countersanctions) facilitates the execution of the task as foreign equipment leaves the Russian market and the domestic industry is motivated toward innovations.
4. Russian scientists are prepared and can design promising and efficient machines, facilities and technologies to support coal mines and promote expansion of application field of RPM.

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