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Long-hole destress blasting for rockburst control during deep underground coal mining

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ABSTRACT

The Lazy Colliery in the Ostrava–Karvina Coalfield of the Upper Silesian Coal Basin adopted modern longwall technology for an underground extraction of coal seam No. 504. This coal seam is located at a cover depth of around 700 m. The seam thickness varied from 3.1 m to 5.0 m in the selected longwall panel. Two overlying coal seams, Nos. 512 and 530 experienced mining at average heights of 58 m and 75 m, respectively, from the planned working horizon of the seam No. 504. The proposed longwall panel was adversely situated below goaf edges of the workings in these two overlying extracted seams. An analysis of the inter-burden rock mass among these coal seams showed the presence of strong, massive strata of sandstones and conglomerates with uniaxial compressive strength values between 70 MPa and 120 MPa. The stress is measured at different mining stages by Compact Conical-ended Borehole Monitoring (CCBM). A simple laboratory test of the coal sample found a high value of the ratio of the elastic deformation to the total deformation (>0.8), indicating the energy-storing characteristic (prone to burst/bump) of the coal seam. Under the existing geo-mining conditions of the site a suitable destress blasting (long-hole drilling and blasting) design is adopted to pre-fracture the identified competent strata from both gate roads in advance. The total length of the panel could be extracted without any bump/rockburst after the destress blasting. The efficiency of the adopted destress blasting at the different mining stages is evaluated in terms seismic effect (*SE*), which is calculated through the available seismic monitoring data and weight of the charged explosive. A systematic adoption of the destress rock blasting led the 300 m long longwall panel to be smoothly extracted without any further rockbursts.

1. Introduction

The hard coal reserve of the Upper Silesian Coal Basin (USCB) is shared by the Czech Republic and Poland. In this coal basin, longwall is a dominant underground mining method. The Czech part of the USCB, known as the Ostrava–Karvina Coalfield (OKC), lies in the northeastern part of the country (Fig. 1). Underground mining of different coal seams took place in the OKC for more than 200 years. The exhaustion of the upper seams due to the continuing coal mining activity for such a long period of time has shifted the activity to a greater depth (>600 m). Under the existing mining and geological conditions of the Karvina sub-basin of the USCB, underground extraction of the coal in this basin is typically accompanied by rockbursts, which are also referred to as coal bumps. The first rockbursts occurred in the coalfield in 1912 [1]. Different attempts have been made to address rockbursts during underground coal mining in both the Czech [2–5] and the Polish [6,7] part of the USCB.

There are various rock mechanics challenges associated with the underground mining of a deep-seated coal seam [8–11]. By analysing geotechnical data from different mines, Chase et al. [12] find that the nature of the overlying strata plays a significant role in the success of the underground mining of the deep coal seams. Based on an examination of the geotechnical data of several mines, rockbursts are the major problem during the underground coal mining of deep coal seams under strong roof strata (Fig. 2).

During the different underground coalmining activities in the OKC, rockbursts are more frequent when the mining depth exceeds 600 m. Depth alone creates a high mining-induced stress [10], which increases the chance of rockbursts occurrence. Underground extraction of the coalfield's bottom coal seam (No. 504) also met two overlying worked-out coal seams, which consisted of a number of left-out barrier pillars and ribs with high stress concentrations. The existence of these stressed pillars/ribs over the mining activities in No. 504 seam also became a contributing factor for the rockbursts. As per the site's existing stratigraphic

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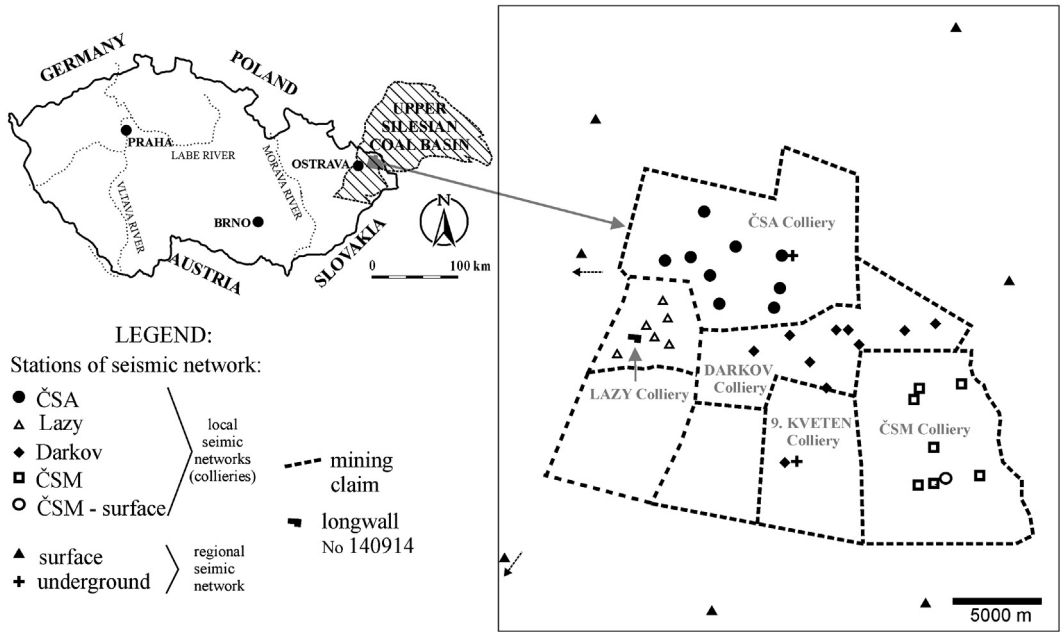

Fig. 1. Location of the Upper Silesian Coal Basin and map of seismic networks in Karvina sub-basin.

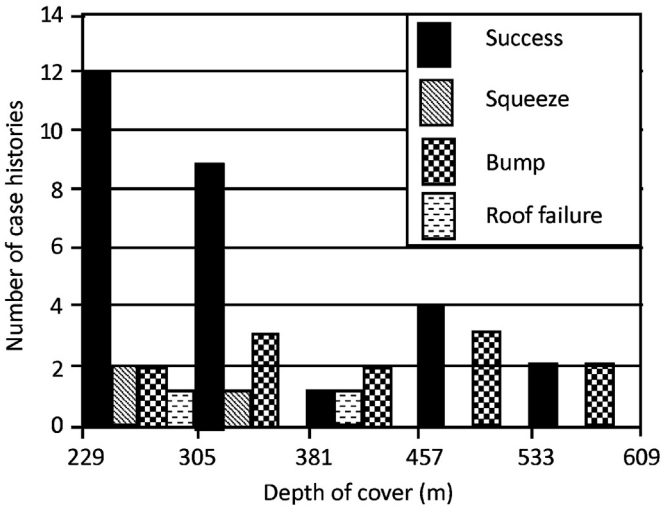

Fig. 2. An analysis of performance of underground coal mining at deep cover and under strong roof rock [after 12].

conditions, the present mining horizon of the OKC was confronted with competent overlying rock strata. The presence of these rigid overlying rock strata at this horizon resulted in dynamic loading during their caving, which also increased the chance of a rockburst occurrence.

Active and passive approaches were adopted to control the increasing frequency of rockbursts at the present working horizon. The rockburst impact can be reduced by passive approaches such as improvement in mining and support system. However, for a difficult site like coal seam No. 504 of the Lazy colliery, an active approach (destress rock blasting) is needed to reduce the rockburst frequency. Destress rock blasting is predominantly used in the high rockburst risk conditions of underground ore mining [13]. Destress rock blasting has been used in underground coal mining in the Czech part of the USCB since 1990 to prevent rockbursts [14–17 and 34]. More than 2000 destress rock blastings occurred in this region between 1990 and 2010 [18] to control rockbursts.

This paper presents a case study dealing with a deep longwall mining of a thick coal seam, seam No. 504, under difficult geological and mining conditions. Successful application of the destress rock blasting technique is done to control rockbursts during the deep underground longwall coal mining under competent overlying strata in the OKC. The performance of the adopted destress rock blasting approach is assessed by seismic monitoring, the seismic effect of the destress rock blasting and in situ stress measurements, which are mentioned in this paper.

2. Site details

Lazy Colliery in the OKC adopted longwall mining to extract underground coal from panel No. 140 914 of coal seam No. 504. The length of the longwall panel was 300 m, and the width varied from 109 m to 189 m. The panel was situated in the 9th mining block, which is in the western part of the colliery. The borders of the 9th mining block are created by the tectonic fault C on the north, the tectonic fault Ceres on the south, the Orlova Structure on the west and a safety shaft pillar on the east (Fig. 3). Mining in this panel began on 2 November 2006 and was completed on 15 June 2007. The entire thickness of the panel's coal seam was extracted by a fully mechanised longwall face with caving.

The thickness of the panel's coal seam varied from 3.1 m to 5.0 m. Double drum shearer KGS 445 RW (FAMUR Inc., Katowice, Poland) was deployed to extract a 3.5 m thick portion of the coal. The length of the longwall face varied from 109 m to 189 m, which was supported by the self-advancing high load capacity chock shields MEOS 17/37/05 (Ostroj Opava Inc., Opava, Czech Republic). Ninety chock-shields, each of 82-tonne load bearing capacity and with two legs, were erected to cover the entire length of the face. A chain conveyor of PF 4/1032 (DBT GmbH, Lünen, Germany) with a 2500 t hourly capacity was used to evacuate the dislodged coal from the face.

2.1. Geology

Existing geological and mining conditions of the coal seam No. 504 at Lazy Colliery make underground extraction of this coal