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Influence of the stress state in a coal bump-prone deep coalbed: A case study

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ABSTRACT

The effect of stress is one of the main natural factors that exerts a significant influence in coal bumps and rock bursts, especially in deep coalbeds. Sublevel caving is one of the methods that most influences this stress state and is therefore an extremely important parameter to consider when trying to improve mining conditions in mines with high methane content. This paper presents a practical case to illustrate the stress behavior of sub-vertical coalbeds in deep mines. The site study included two different locations, in two mines in the Riosa-Olloniego coalfield (Asturias, Spain) that are presently being mined by the sublevel caving method at a depth of around 1000 m. The research analyzed the influence that the caving of a particular panel of coal has on the upper and lower sublevels of the coalbed itself, as well as of neighboring coalbeds, with the aim of comparing different mining sequences. The site measurements carried out had two aims: to test the influence of adjacent workings on the 8th Coalbed and its coal-bearing strata and to verify the influence of the stress–strain change on the occurrence of coal bumps. Besides fulfilling these objectives, the work has also provided data for the calibration of possible numerical models that allow the simulation of present and future situations in the mine and has contributed to improving safety conditions of mining works in coal bump-prone deep coalbeds.

1. Introduction

The mining of deep coalbeds is exceptionally difficult for a number of reasons [1]. High rock stresses are inevitable at great depths, making sudden explosive failures, rockbursts and coal bumps much more likely to occur because stresses increase not only in the rock, but also in the coalbed itself. Moreover, the underground working environment is challenging in the extreme. This means that the mining of deep mines is only profitable for technologically advanced methods, when the ore has a high added value or when the strategic need for these mines justifies their exploitation. This is the case of the 8th Coalbed in San Nicolás and Montsacro mines (Asturias, Spain). Its mining is justified despite a number of negative factors that make said mining difficult: great depth, methane gas content and risk of occurrence of what is generically designated as gas outbursts (including coal bumps, dust explosions and gas and rock bursts).

This risk depends on a series of factors, usually present in combination, that may be classified as factors arising from the mining work itself and naturally occurring factors [2]. The latter are: geological features, gas content, the structure of the coal itself (especially its porosity, desorption kinetics and permeability), the stress state of the coalbed and its surrounding rock mass, roof and floor.

The technical experts in charge of the above-mentioned mines had been estimating the stress state of the coalbed by means of Russian calculations based on face end projections, to establish potential risk areas [3]. These overstressed areas are related to overlapping of workings, interrupted headings of coal face workings, still unmined coalbeds and coal pillars abandoned unmined as protective areas (for example, areas under crosscuts or fan stations). However, theoretical calculations still remain mere estimations. They may give a qualitative idea of what is occurring, but do not generally provide quantitative information. They also present inaccuracies when the conditions are different to the ones for which they were formulated.

Case studies [4,5] demonstrate the value of multi-parameter measurement campaigns in assessing the influence of underground excavations and in providing a base for safe operation and control. Measuring stress changes has proved to be useful in order to provide an accurate picture of mining-induced stress changes, as well as their interest for model calibration and verification of final designs [6].

In fact, many techniques have been used in the determination of *in situ* stress over the past 35 years. The four direct methods proposed [7] to measure stress and recommended by the ISRM [8] are: flatjack test, hydraulic fracturing test, USBM overcoring torpedo and CSIRO overcoring gauge. Those based on the recovery principle are the most commonly used [9].

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However, during the present study, it was not possible to use overcoring techniques, due to the difficulties that overcoring entails and to the lack of adequate equipment and previous experiences. In fact, an absolute lack of data from instrumentation was observed in the area, since stress values or deformations had never been measured before at a great depth in Spanish mining (and not even in less deep coalbeds when referring to coal). This need of information together with the difficulties of the overcoring technique have justified this study, aimed at encountering other alternatives that incorporate the measurement of the variation in the stress–strain state of the rock mass. Moreover, measuring changes in the stress state could be considered a step forward and would serve to the main scope, to determine the best mining sequence among different options.

The field studies, consisting of the installation of instrumentation devices and the taking of measurements, presented an added difficulty, as they had to be carried out under arduous conditions: in a deep coal mine, in a manifestly aggressive atmosphere (dust, humidity, heat, etc.), far from the mine shaft (which made operations extremely difficult in the case of unforeseen events), in a reduced space and with the proviso of not interfering with production work in the mine. The field studies were completed with the gathering of data: on a daily basis in some cases, weekly in others and monthly or bimonthly in the case of the most costly measuring equipment.

After describing the area in which the work was performed and its most significant geomechanical properties, this study focuses in the measurement of stress changes and deformation, describing the results obtained. Finally, the main conclusions drawn from the study are summarized.

2. Site description

The burst-prone Eighth Coalbed (8th Coalbed) is mined by two different mines in Asturias: San Nicolás (Ablaña, Mieres) and Montsacro (Riosa), in the coalfield of Riosa-Olloniego. It belongs to a series of 10.26 m total thickness in San Nicolás and 15.13 m at Montsacro [10] in the Southwest of the Central Asturian Coal Basin, the largest coal basin in the Cantabrian Mountains [11]. Fig. 1 shows the location of the coalfield in Spain and a detail of the area of study.

The 8th Coalbed, with a dip of 70–80° oriented to the north and an average thickness of 2.5 m, has a geological floor formed by lutite (slates) and a hanging wall or roof of sandstone. In the Central Asturian Coal Basin, both the porosity and permeability of the coal-bearing strata are very low, and the main paths for methane flow are open fractures [12]. The main coal properties related to gas were analyzed during the research. The average coal porosity is 7.5% and coal gas content is between 4.95 and 8.10 m^3/t,

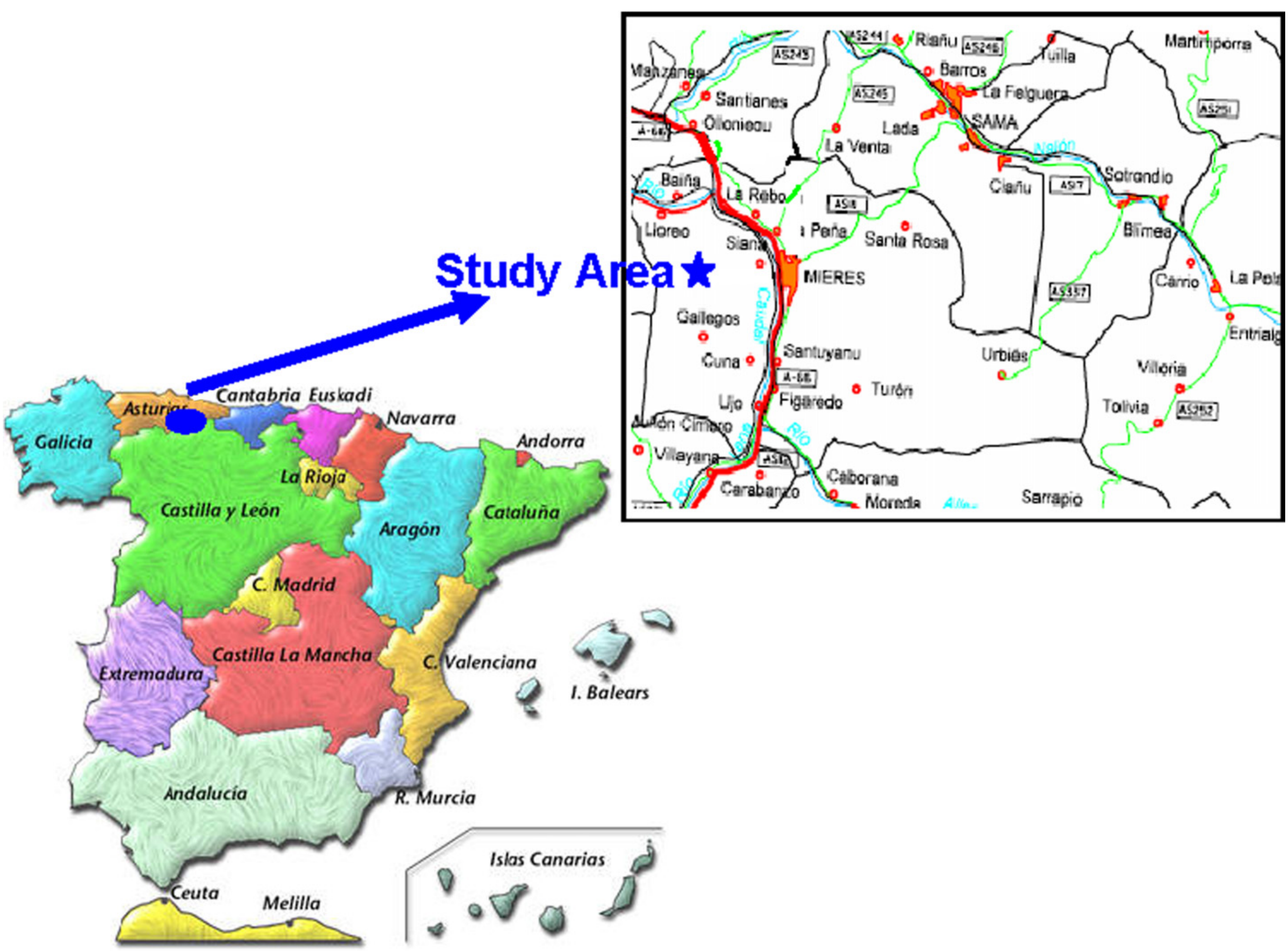

Fig. 1. Location Riosa-Olloniego coalfield in Spain and study area.