BURSTS OF COAL AND GAS

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An analysis of the distribution of gas and rock pressure in the face zone of the coal seam, in conjunction with its structure, is used as a basis for describing their interaction and redistribution characteristics, which determine the occurrence of bursts of coal and gas.

During underground working, the load on the seam at the face is governed mainly by the conditions at its interface with the surrounding strata and by the bearing strength of the coal [1]. As a rule, these conditions are such that a relaxation zone always forms in the vicinity of the waste, where the strata exert less pressure on the seam than before mining began. The result of this relaxation is that the individual pores and cracks open up, combine, and form part of the general filtration system of the pore channels. Gas emission from the coal face into the waste is therefore due to its movement chiefly in the relaxation zone in the immediate vicinity of the face; outside this area there is scarcely any gas movement. Furthermore, even at fairly great depths, the pores and the system of cracks containing gas can be completely isolated so that no gas movement will be observed outside this relaxation zone.

In such a case, gas movement may not necessarily occur throughout the relaxation zone but only in the sector adjoining the face where relaxation causes the pores and cracks to coalesce into a system of filtration channels. Here the gas pressure in the pores falls mainly as a result of emission into the waste. In the remainder of the relaxation zone, where permeability is zero, the gas pressure only decreases owing to expansion of the pores and the system of cracks containing gas. Figure 1 plots typical gas pressure distribution curves for a coal seam, calculated in [2] with allowance for seam relaxation in the face zone; it gives a stress curve (dashed line) showing the compression of the seam along the strike for comparison. This stress, and the pressure imposed by the rock on the seam, is counteracted by \( \sigma_t \), the gas component of the stresses, which is determined by the gas pressure in the pores, i.e.

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\sigma_t = (1 - \chi)p \quad (0 \leq \chi \leq 1),
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where \( \chi \) is that part of the sectional area of the seam not occupied by pores and gas-filled cracks. This depends on the relaxation of the seam and the amount of fissuring and therefore the distance from the face.

Figure 1 also shows the curve of \( \sigma_t \), calculated in [1]. It is characteristic of the distribution of \( \sigma_t \) that it is always considerably smaller than the compressive stresses; it is very small in the vicinity of the face and only displays a marked increase ahead of the boundary of the relaxation zone, where it reaches a maximum and then falls to its original value in the unworked seam.

This mutual distribution of compressive stresses and the gas component of the stresses, which opposes the compression of the seam, is usually characteristic not only of winning faces but also of coal development workings. As the face advances and is accompanied by a more or less uniform squeezing-out of the coal, there generally occurs a redistribution of the relationships between the compressive stresses and the gas component of the stresses which

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opposes them; however, the qualitative aspects of their reciprocal distribution are always retained. The coal seam remains under hydrostatic compression, regardless of the opposition by gaseous forces. Each coal element within the seam is in equilibrium, so, without violating the conditions which define the stress in the seam at the face, it may be assumed that the seam cannot undergo disintegration as a result of the stresses operating within it. To put this another way, the coal ahead of the face, exposed to hydrostatic compression, cannot undergo disintegration until one of the conditions determining its equilibrium, and the seam stress corresponding to that condition, is disturbed.

Analysis of the numerous descriptions of bursts, underground observations [3,4], theoretical research, and calculations [1, 5], have shown that during mining, the seam (or individual bands in it) undergoes an erratic overburden pressure effect in relation to the advancing face. Sometimes there is a rapid and brief slide of the seam (or band) towards the waste. In some cases this slide area of the seam in the face zone spreads deep into the solid to a distance several times greater than the seam thickness and is always accompanied by a marked drop in the pressure exerted on the seam by the rock in the face zone. This is basically caused by loss of cohesion at the rock/seam interface or at the contact between the bands in the seam [1, 5]. This rapid and brief slide effect, together with the slide occurring at the interfaces between the rock beds (with loss of cohesion), is a typical manifestation of the rock's structural characteristics and the mining of sheet deposits.

The brief slide experienced by the seam being worked, which is accompanied by loss of cohesion at the interface and an additional fall in the pressure exerted by the rock on the seam in the face zone, has a decisive effect on busts of coal and gas. By and large, the essence of this phenomenon is that, as a result of this additional fall in pressure on the seam, during the slide the gas component \( \sigma_g \) in the seam ahead of the face can exceed the compressive stresses along the strike. The gas in the seam is therefore capable of initiating a burst [1, 5, 6].

In actual fact, during the seam slide (accompanied by an additional relaxation effect in the face zone) the filtration capacity of the coal, the pore space, and the seam section area in contact with gas all increase. This process occurs very rapidly in comparison with the typical time needed for gas to migrate; therefore the distribution of the gas in the coal during this slide movement remains practically unchanged. The increase in the pore space is therefore accompanied by a fall in gas pressure in the pores. However, the drop in pressure of the gas prevents marked desorption of gas. Here, we are dealing mainly with the kinetics of gas sorption, because the fall in gas pressure in the pores during their expansion depends on the rapidity of liberation of the absorbed gas. Thus, in coals with rapid sorption kinetics the fall in gas pressure in the expanding pores during relaxation is less than that in coals with slower sorption kinetics. Despite the fall in gas pressure in the pores the gas component of the stresses counteracting the compressive stresses remains unchanged and may even increase during coal relaxation because the sectional area of the seam in contact with the gas increases stress redistribution in the face zone of a coal seam when it slides towards the goaf (cf. Fig. 2).

From the graphs provided (constructed from calculations in [1, 2]) it is clear that during this additional fall in the pressure exerted by the rock on the seam (as a result of the slide towards the waste) it is only in the deeper parts of the rock that a region may form in which the compressive stresses fall below the gas component of the opposing stresses. It follows that the total gas pressure over the whole seam section in this region will be greater than the friction forces preventing seam movement along the slip planes towards the waste. As a result of seam slide and the accompanying additional relaxation of the seam at the face, a region where the gas sets the sector of the seam face dividing this region from the waste in motion, is formed deep within the rock; in a number of cases it ensures that this breaks off into the waste. At the same time the gas "sweeps away" the broken coal.

The occurrence of a rapid and brief sliding movement of the seam, accompanied by an additional fall in the rock pressure on the seam, does not always lead to the relationships plotted in Fig. 2. As was shown above, this depends on the extent of the seam slide ahead of the face, on the corresponding additional relaxation of the seam, and on the gas pressure and sorption kinetics, i.e. during seam slide the qualitative relationship between the