ROCK MECHANICS AND MINE PRESSURE

CLASSIFICATION OF ROCK BURSTS

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Among the various forms of dynamic manifestations of rock pressure, rock bursts have been moved to the focus of attention of investigators as a specific form of uncontrolled conversion of accumulated potential energy into kinetic energy and brittle destruction, particularly in conjunction with the increasing depth of mining operations and their high concentration.

The store of experience [1, 2] in this area and new results at the juncture between mining and geophysics provide a base for formulating new problems important for practical mining. Among the new results, one should cite the data of Sadovskii [3, 4] on the relationship between earthquake energy and source size and the data of Knoll on similar energy relationships for rock bursts. The dynamics of the evolution of a rock burst and a small-source crustal earthquake are regarded as similar phenomena [4].

Classification of rock bursts has always been an important aspect of their study. Petukhov noted the following facts used by various investigators to classify rock bursts [1]: distance of the burst source from the exposure [2], the site of manifestation of a rock burst [5], the mechanical properties of coal seams [6], and the magnitude of seismic energy [1]. In discussing these factors, Petukhov noted that "none of the classifications proposed covers the entire variety of conditions and manifestations of rock bursts." In the framework of the theory of rock bursts as it existed in 1972, Petukhov believed that two types of classification of rock bursts would be convenient [1]: a) by intensity of manifestation of a rock burst and the resulting destruction, and b) by distribution of rock bursts according to their locations. In [7, 8] two forms of classification of rock bursts were further elaborated.

According to intensity, rock bursts are subdivided into the following groups [1, 7, 8]: bumps, shocks, microbursts, and true bursts. In [9] two groups were added to this classification: spalling and intense loosening.

The classification of bursts by location (or features of the burdening of rocks surrounding a mine) includes seven groups of rock bursts [1]: 1) in solid pillars, 2) in pillars cut through by workings, 3) in pillars separated from the bed by workings, 4) in marginal portions of a coal seam, 5) in workings laid through a coal bed, 6) in workings with destruction of roof or floor of the seam, and 7) workings through the rock. In [8] this classification was made more detailed with specific reference to mines and included the following groups: 1) development and permanent workings, 2) second workings, 3) solid isolated pillars, 4) isolated pillars cut through by workings, 5) pillars separated from the bed by workings, and 6) breakage of roof and floor.

The characteristic physical feature of classification by location (specifics of loading) is the fact that it refers to the conditions of energy influx from the external system -- surrounding rocks -- in an implicit form.

The authors of [8] noted that this "classification according to location does not include rock and tectonic bursts caused by sudden movements (destructions) inside the rock bed."

These classifications were extremely important for the development of safe methods of mining in case of rock bursts in marginal zones. As the mining operations advanced to greater depths, however, the proportion of intense rock bursts increased [10, 11].

Consider the group of "true rock bursts." According to [9], "true rock bursts" are the category comprising all intense dynamic events. The true rock bursts, according to [9],
include dynamic events in the form of destruction of one or two frames of a wooden support system and inrushes of 1-2 m³ of rock (or coal), accompanied by a concussion of the bed with formation of dust and an air wave. Such events are characterized by energies not higher than 10² J. Events with energies of 10⁷-10⁸ J are also classified as true rock bursts in [9]. These events involve the collapse of a series of workings, sometimes with a stoppage of mine work for a long period of time (up to several months). Applying the same term to situations with so widely different consequences, instructions [9] create difficulties with the description of the dynamic events and with the development of actions in preparing forecasts and prevention of these events, as well as elimination of their consequences.

The above classifications do not describe certain dynamic events, such as rock-tectonic bursts, the rock bursts induced by neotectonic processes in the earth's crust [12], and certain other phenomena, i.e., they fail to take into account the energy of the dynamic processes.

The classification and the terminology reflect a variety of views: from the point of view of a mine operator unfamiliar with rock bursts, the inrush of a large volume of rock mass from the wall or roof of a chamber (tens and hundreds of cubic meters) and the fall of this mass on the floor with the resulting concussion and formation of dust and air wave is "rock burst" (or shock), although the separation of this mass from the bed resulted from a prolonged slow process accompanied by gradual formation of fresh destruction surfaces and more likely the movement of blocks along preexisting slackening surfaces.

From the point of view of an investigator, it is more important to describe the visible destruction (the appearance of rock loosening, signs of bumps, and fresh surfaces of displacements) in the focal zone or studies of the focal zone with various existing methods [15].

Table 1 gives a classification of true rock bursts based on three features:

A. the location of the focal zone of a rock burst relative to the mine;
B. interaction (reciprocal effects) of a rock burst and the existing tectonic structure in the part of the bed experiencing the rock burst; and
C. distribution of rock bursts according to the energy released by the dynamic event, including the results of the event over the area and in the volume of the surrounding rocks.

According to the first of these features — the location of the source — three groups of rock bursts are distinguished: in the marginal zone of workings, in pillars, and in the depth of the bed or inside worked-out spaces (it is possible that the last varieties should be considered as separate groups, since their forecasting and prevention are different). The focal zone is defined as the part of the bed corresponding to the position of the center of the rock burst, i.e., the segment where the dynamic process started. The position of the focal zone can usually be recorded exactly by seismic or seismoacoustic techniques.

A dynamic event is classified as a rock burst in the marginal zone if it resulted in the destruction of the wall of a development mine or the wall of a stope. The mechanism of the bursts of this group is determined by the distribution of stresses in the zone of support pressure in the rocks around the development or second working [1, 7, 8] and to an extent may be associated with zonal disintegration.

Dynamic events in pillars are usually different from those in the marginal zone adjacent to the bed. When the roof and the floor consist of thick layers of strong beds (energy accumulators), large pillars may be conducive to accumulation of large quantities of potential elastic energy. The instantaneous (rapid) release of this energy destroys the pillar and induces a strong seismic wave which causes the destruction of the mine area surrounding the pillar.

The dynamic events inside the bed can vary in intensity. The rock bursts of a low intensity in the interior of the bed both ahead of the front of advance and in the worked-out space are usually perceived and registered as bumps. The potentially dynamic developments inside the bed, however, can be associated with the release of large quantities of potential and elastic energy comparable to energy of small-source earthquakes. The resulting seismic waves interacting with the tectonic structure of the surrounding rock bed can cause displacements along the preexisting tectonic faults and cracks and destroy the marginal portions in all weakened zones along the path of its propagation near the source (these effects should not be confused with rock bursts in the marginal zones).