This paper reports the results of a comprehensive study of the properties of burst-hazardous (BH) and non-burst-hazardous (NBH) sandstones of the Donbass. The study was conducted to determine the significant indicators and characteristics for a reliable differentiation of the sandstones.

The folded structure of the Donbass is an intensely dislocated region which makes up part of the Eastern European platform. According to the general geotectonic analysis, the rocks forming the Donets folded structure experienced, during Carboniferous time and later, intensive tectonic deformations due to regional compression. As a result, they were broken by linear faults complicated by numerous longitudinal overthrust faults and transverse rupture faults. This study was conducted on a sandstone bed C\textsubscript{2} of the suite h\textsubscript{\textsuperscript{4}}Sh\textsubscript{7} in the Petrovskaya-Quebekaya mine located in a low-angle strip of Carboniferous rocks on the southern side of the Kal'mius-Toretsk depression. This bed presents the highest burst hazard in this region because of its gas releases.

The sandstones of the suite h\textsubscript{\textsuperscript{4}}Sh\textsubscript{7} were formed in submerged and subaerial portions of a delta. Periodically, the influence of saline seawater resulted in a widespread occurrence, inside the sandstone bed, of siderite and the precipitation of calcite in the cement. The layers containing basal-pore carbonate cement typically occur in the roof and base of the coal bed at the contact with argillite, which is probably related to material migrating from clay beds into sandstone at the early stages of postsedimentary change. The sandstone bed h\textsubscript{\textsuperscript{4}}Sh\textsubscript{7} of the Middle Carboniferous in the southwestern Donbass thus has a multifacies structure with a variety of petrographic features and different degrees of burst hazard across the section. The middle of the section (15-25 m) presents the highest burst hazard, while the lower (20-25 m) and upper (2-12 m) sections are not hazardous or may "produce" microbursts [1].

### Petrographic Study of Undeformed Samples

Mineralogically, the burst-hazardous sandstones are feldspar-quartz varieties with an admixture of clastics of rock fragments and allotogenic micas. The terrigenous component (75-85\%) consists of clastic and secondary quartz (35-65\%), feldspar (plagioclase, orthoclase, and microcline, 15-25\%), rock fragments (sila, microquartzite, clay-sililc schist, 5-30\%), and mica (mainly muscovite, less often biotite, 1-5\%). The cement (15-25\%) is of the interstitial or contact-interstitial type. It consists of the prevalent clay matter: hydromica, mixed-layer hydromica-montmorillonite units with a minor presence of swelling components, and an admixture of kaolinite and chlorite, and also finely dispersed quartz and carbonate. Cementless conjugation of grains is seen locally.
The basic fissure parameters determined in nonstandard polished sections according to the method developed at the Institute of Geologic Exploration [2] are the following: crack permeability (Kp) 1.0 mD; porosity 0.002-0.2%; volume density of open cracks (To) 5-10/1/m. Open and bituminous-filled cracks occur mainly along the bedding, less often across it. Mineralized (impermeable) cracks display various orientations, mainly dipping at a high angle. According to Smekhov's classification [2], these are porous reservoir sandstones.

Non-burst-hazardous (NBH) sandstones are distinguished from the BH variety by the following mineralogic features: a lowered content of clastic and secondary quartz, micaceous minerals, smaller mean grain size, and shorter contacts between grains. The overall content of the clastic component is 50-70%; that of cement, 30-50%. Cement is basal or basal-interstitial. It consists of clay-carbonate, with a minor presence of kaolinite, chlorite, and silica. NBH sandstones have low porosity and permeability due to the high content of carbonate in the cement. Fine-grained carbonate minerals typically behave aggressively, corroding and replacing both the cement and clastics of various composition. Locally, calcite grows into large polycrystals with a close contact of units. NBH sandstones according to Smekhov's classification are categorized as cap rocks.

The petrographic features of BH and NBH sandstones are given in Table 1.

The sandstones have undergone catagenetic alteration (the nearest coal seams corresponding to the late catagenesis zone are of the fat grade). The deep catagenetic processes have greatly reduced the filtration rate and capacity of the rocks, sealing their interstices and increasing strength. The presence of authigenic quartz, up to 1-7%, in BH sandstones led to a loss of plasticity and the formation of dense brittle consolidated varieties. The retention of a high granular porosity (4.5-8.7%) was promoted by the large bed thickness combined with quartzification and the presence of light crude oil in primary micropores, which had migrated through joints and localized in the fissured decompacted zone of Mushketov and Koksovi thrusts during late catagenesis.

**STUDY OF MECHANICAL AND FILTRATIONAL PROPERTIES**

Dense macroscopically unfi ssured specimens were taken for the tests, making it possible to trace the origin and development of deformatonal cracking and evaluate its influence on the permeability of the bed as occurring in situ. The specimens were shaped as 70 mm long cylinders 30 mm in diameter.

These were done in a high-pressure rigid unit [3] which provided a controllable loading both to the limit and beyond the ultimate strength of the specimens. The deformation and destruction of the specimens took place under axial pressure for various hydrostatic pressures—5, 10, 25, and 50 MPa. The tests were conducted with filtration of inert gas (nitrogen) perpendicular to the axial load. The pressure (Pf) of the gas being filtered remained constant at the input (2.5 MPa).

During the tests we recorded the axial stress experienced by the specimen (σx, MPa), the relative longitudinal (εx) and transverse (εz) deformation, and the gas flow rate through the specimen, evaluated by the coefficient Kf, mD. The data were used to plot standard deformation diagrams for BH and NBH sandstones under nonuniform triaxial compression (Figs. 1a and b).

On the curve representing the process of specimen loading a linear segment complying with Hooke's law is seen.

After the elastic limit is reached, residual deformations appear which are accompanied by a loosening of the material [4].

At all levels of hydrostatic pressure, a maximum of axial pressure corresponding to the ultimate strength is seen on the curves, followed by a drop in the sandstone's permeability.

The descending branch of the curve is referred to as the transcritical deformation region, it is followed by a horizontal segment called the residual strength region. The carrying capacity on the residual strength segment is determined by the forces of friction on the destruction surface after the coherence has been lost. In all instances, the destruction surfaces were planes cut at an angle of 30-45° with respect to the axial stress. The angle increased with increased hydrostatic pressure and tended toward 45°.

Figure 2 shows the same "stress-strain" relationship for both sandstone varieties, tested under lateral pressure of 10 MPa. The difference from Fig. 1 consists in the fact that the transverse deformation curves are based on the readings of two extension gauges which recorded the highest (curve 1) and lowest (curve 2)