The country rocks of most coal deposits are split by fissures of various origins. The density and size of the fissures and their cohesion depend on the particular geological conditions. Calculation of the limiting permissible exposure of such roof rock is of importance for mining practice.

Borisov and Kuznetsov [1, 2] have discussed the fundamental laws of the mechanics of fissured rocks and the nature of their interaction with the supports. These authors compare the action of the individual roof beds with that of a three-jointed arch. This theory is valid and is confirmed by numerous laboratory and field investigations.

The condition of equilibrium of a three-jointed arch with no supports is governed by the equality of the thrust in the middle joint, due to the action of the weight of the rock within the given bed, to the reaction of the rock under compression and crushing. The horizontal thrust is determined by the usual formulas of the strength of materials, and depends on the span of the working, the density of the rock, the thickness of the bed, the displacement of the roof, and the nature of the applied load.

The area of the middle joint, on which depends the horizontal thrust, is determined empirically [2], and Borisov [1] finds the height of the region of interaction of the blocks, which corresponds to the area of the joint per unit length of the working, starting from their geometry. The authors assumed the height of the region of contact of the blocks at the abutments of the arch to be twice as great as the height of the region of contact of the blocks at the joint.

The expressions derived require some adjustment, because they are based on the assumption that the blocks are tightly pressed against one another, and that as the middle joint sinks the region of the contact decreases from half the stratum thickness to zero. In this case the roof has maximum supporting capacity with minimum deformation. However, field and laboratory observations show that the supporting capacities of fissured roofs, when they are deformed within certain limits, begin by increasing.

An illustration is afforded by the deposits of the north east, where the fissure gape of the coal seams and rock strata is very large and reaches 0.5-1.5 m[3]. In many cases the fissures are filled with ice, clay, etc. We sometimes encounter open fissures, which are due to degradation of frozen ground at a given depth or to its thawing by the access of warm air through the working. In the Chul'man pit (Chul'man coalfield) a coal seam about 3.0 m thick lies almost horizontally (0-4 deg). The roof rocks are aleurolite and sandstone. The thickness of individual beds of the immediate roof varies from 0.2 to 1.0-1.5 m. There is often a false roof of aleurolite, 0.2 m thick. The country rocks are split up by fissures perpendicular to the stratification. The density of fissures is from 0.2 to 3.0 per meter. The gape of the cracks is 0.2-0.5 cm.

Mining operations are carried out in the zone of the near-zero temperatures, and therefore the fissures are partly filled with loose ice and partly open. Despite the high strength of the immediate-roof rock (the compressive strength of aleurolite exceeds 400 kgf/cm² and that of sandstone exceeds 700 kgf/cm²), the limiting spans of the unsupported roof...
roofs are short. A block of aleurolite caves in working slightly more than one meter wide, while for sandstone the stable span is 5–6 m.

The presence of free fissures of certain dimensions in the roofs indicates that the schemes suggested in [1, 2] are only particular cases of a more general scheme of the action of a fissured roof. Figure 1 shows the scheme of action of a three-jointed arch made of two separated blocks, split up by fissures of width \( K \).

The action of the blocks is the same in the left-hand and right-hand parts of the arch if they are of the same size, and therefore, we shall consider only one (the left-hand) side of the arch. The width \( L/2 \) of the block is practically equal to the half-span of the working; \( h \), the height of the block, corresponds to the thickness of the rock bed; and \( y \) is the sag of the middle joint or the deformation of the roof at the center of the working. When the blocks rotate about axes at the sides of the working, the material at the joint (crown) and abutments of the arch becomes crumpled. We can determine the size of the zone of crumpling by starting with the geometrical construction shown in Fig. 1 (line ENF).

\[
ENF = EN + NF; \tag{1}
\]

\[
EN = C'N \tan C'E; \tag{2}
\]

\[
NF = \frac{C'N}{\tan NFC'}; \tag{3}
\]

\[
\angle N C'E = \angle NFC' = \angle DAD' = \theta_n; \tag{4}
\]

whence

\[
EN = C'N \tan \theta_n; \tag{5}
\]

\[
NF = \frac{C'N}{\tan \theta_n}; \tag{6}
\]

\[
ENF = C'N \tan \theta_n + \frac{C'N}{\tan \theta_n} = 2 \frac{C'N}{\sin 2 \theta_n}; \tag{7}
\]

\[
C'N = MN C' - MN = MN C' - \left( \frac{L}{2} + \frac{K}{2} \right) = MN C' - \frac{L + K}{2}; \tag{8}
\]

\[
MNC' = AC' \sin \angle MAC' = AC' \sin (\theta_0 + \theta_n); \tag{9}
\]

\[
AC' = AC = \sqrt{AB^2 + BC^2} = \sqrt{h^2 + \frac{L^2}{4}}; \tag{10}
\]

\[
MNC' = \sqrt{h^2 + \frac{L^2}{4}} \sin (\theta_0 + \theta_n); \tag{11}
\]