SOME PROBLEMS IN MINING SCIENCE

N. A. Chinakal

Translated from Fiziko-Tekhnicheskie Problemy Razrabotki Poleznykh Iskopaemykh, No. 1, pp. 7-12, January-February, 1965

Mining science is a branch of knowledge with a unique character and an outstandingly great importance for the national economy. It studies a strictly delimited region of natural phenomena, and the knowledge gained is applied for the benefit of the nation's wealth. Mobilizing the work of other disciplines such as physics, mathematics, chemistry and mechanics, it is called upon to meet the demands of industry and to assist with technical progress in mining.

Processes taking place deep in the earth's crust, caused by natural factors and evoked by human activities, are not only unusually complex and variable in space and time, but also difficult of access for direct observation and hard to reproduce in laboratory conditions. The principal difficulty is to obtain reliable conclusions and generalizations, and for this purpose a large number of facts must be accumulated. But facts are accumulated very slowly with the development of the various branches of the mining industry.

The present state of mining science can be considered as a transitional stage between the accumulation of facts and the formation of theoretical generalizations and interpretations. The more factual material and direct observations we have, the faster and more successful will be the development of mining science. This must be our main aim.

In our studies of processes taking place deep in the earth's crust, a crucial factor is the depth. At different depths, the same processes will develop in different ways and to different extents. The physical and mechanical properties of rocks and minerals vary with the depth, as do likewise the pressure and temperature of the rocks, the evolution of gas, the appearance of sudden outbursts of coal and gas, blow-outs of methane, shock bumps and other complications.

The problems of supporting the workings and goaf become more and more acute with increasing depth. While in the upper horizons the workings can even be maintained without supports, it becomes more difficult to support them at greater depths. In the upper horizons, the workings and extraction faces can be adequately supported by leaving pillars of the mineral. In deep workings, pillars cannot fulfill this function, so that the problem of protecting the workings becomes more urgent. The question is now being discussed of replacing timber supports by metal, concrete, ferroconcrete, or even supports made with new synthetic materials. Supports in deep horizons must fulfill two diametrically opposed demands—they must be strong, yet yielding. The most important problem of mining science is to study the state of the rocks and how it is affected by mining operations in media with varying physico-mechanical characteristics, taking account of the gravitational force of these rocks, and their tectonic stresses, preserved in the crust from past mountain-building processes and tectonic disturbances. This is one of the very important problems on whose solution depends the future progress of mining technique.

In technological processes associated with mineral extraction, a uniquely important part is played by the evolution of various gases, especially methane (CH₄), which is also violently evolved in blow-outs and sudden outbursts of coal and gas. These processes present a very complex problem which is being studied by such research institutes as the Skochinskii Mining Institute in Moscow, the VNIMI Mining Industry Research Institute in Leningrad, the MakNII Institute in the Donbass, the VostNII Institute in Kuzbass and several others.

Methane, hydrogen and heavy hydrocarbons are emitted not only in coal deposits but also in mineral and ore deposits. Little attention has been paid to the geochemistry and geology of gases in such deposits, and the nature and intensity of gas evolution, and research in these fields must be extended, since without it we cannot achieve adequate safety in working the deep horizons of projected pits. Even at the depths now worked, gas pressure reaches 50-70 atm, so that the drainage zone of the rocks surrounding the extracted seam increases and so does the influx of gas to the workings. This process is complicated by the fact that in many deposits there are unworked fine seams.
This can cause a 70-80% increase in methane evolution in a contiguous extraction seam. Tens of thousands of cubic meters of methane is evolved per day from these sources, constituting up to 50-60 cubic meters per ton of coal extracted. The problem thus arises of degassing the seam and making use of the gas so obtained.

Modern working methods have increased the rate of advance of extraction and development faces, leading to a marked increase in coal extraction from a single face, and this causes a relatively greater evolution of methane from the coal obtained. The methane content at the face thus sometimes reaches 20% or more. The crushing of a large amount of coal per unit time by modern machinery also increases the rate of dust formation. More ventilation air is needed when the extraction rate is greater—and this in turn increases the formation of dust.

The rapid air currents cause coughs and colds to the miners, while the extra dust may cause silicosis and anthracosis. Thus urgent problems include working safety, dust suppression, methane removal, breeding fires, and ventilation.

Much has already been done, but more remains to do, especially in Siberia, where about 80% of all the resources of hard coals (coking coal) are concentrated.

As an example of scientific interest, let us consider Noril'sk. The formation of flammable gases in the depths of coal deposits is usually associated with regional metamorphism. In the Noril'sk region, this process has been complicated by the intrusion of igneous rocks and the phenomenon of permafrost. The thermal action of the intrusives on the coal seam caused intense methane formation. The upper boundary of the methane-bearing zone rises almost everywhere to the permafrost. Zones of nitrogen-methane and carboxy-nitrogen gases were retained for the most part in the frozen coals. When the coal seams are worked, methane also penetrates the ore deposits. The Noril'sk region is thus an example of unique complexity in the phenomena studied by mining science and in their relations to geological factors.

Special attention should be paid to the prevention of gas emission in coal deposits, where there are not only comparatively quiet evolution of large quantities of methane, but also sudden outbursts of coal and gas.

According to results obtained by A. A. Skochinskii, V. V. Khodot, M. F. Yanovskaya and others, outburst-prone and non-outburst-prone seams differ very little in gas capacity; however, the coals of the dangerous seams are characterized by high gas desorption rate, faulting and a high proportion of disrupted bands. The intensity of sudden outbursts of coal and gas depends on the gas dynamics of the seam near the face. Different amounts of methane are emitted in different pits, and even in different sections of the same seam.

G. N. Feit writes that "most outbursts took place from causes which depended mainly on the mechanical properties and structures of the coal seams themselves". R. M. Krivevskii and V. I. Mikhailov propose characterizing the resistance of a seam to outbursts only by the preparation coefficient, i.e., the ratio of the thickness of the disrupted bands to the total seam thickness. In the Central Donbass region it was found that the preparation coefficient of the danger zones is on average three times less than that for the safe zones. The strength properties and structure of the seam determine its resistance to applied loads. Thus the resistance depends on the seam's strength, thickness, the friction at the contacts between the seam and the surrounding rocks and between individual members of the seam, its structure and angle of dip. All these properties vary with the dip and along the strike, which hinders their study, the use of rigorous mathematical methods and the prognosis of sudden outbursts of coal and gas.

Coal is a collector of gases. Its collecting characteristics are determined by its properties as a sorbent and as a filtering medium. While the sorbent properties of natural coal depend mainly on its fine structure and are determined by the initial substance and the degree of metamorphism, the filtering properties are mainly determined by the seam's tectonic history, which has led to some particular degree of faulting.

In investigating these complex phenomena account must be taken of the temperature coefficient, which varies with the depth and region. Changes of temperature cause changes in the density and viscosity of the gas, and thus in the processes associated with its migration and the formation of potential gas capacity in the seam. Academician S. A. Khrystianovich and P. Ya. Kochina, who discussed the distribution of gas in the seam near the face, quite correctly consider that changes in the gas state in such cases are isothermic, i.e., they have $T = \text{const.}$, since the seam temperature can be considered as reliably constant only at a single depth along the strike. According to A. E. Petrosyan, whose results refer to the Donets-Makeevka region of the Donbass, with increase of the depth at which the seam lies from 100 to 2100 m, the methane density increases by a factor of 17 owing to temperature changes.