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PROBLEMS OF THE PROTECTION OF MINING TERRAINS IN THE MINING INDUSTRY OF ZINC AND LEAD ORES

The paper characterizes conditionality of underground exploitation of zinc and lead ores and its peculiar results on terrain surface. The problems to reveal discontinuous deformations, methods of prevention and liquidation of these phenomena are presented using a mining region in Poland as an example. Old, historic mining activities are a particular problem in this region. Negative results of former mining practice are observed at the present time. Depletion of zinc and lead ore deposits and partially economic reasons lead to liquidation of some mining areas. In particular, such liquidation requires security of the underground parts of a mine, balancing water relations and reclamation of terrain surface. Mining operations within the borders of discussed region require coordination of tasks in the framework of current exploitation and actions towards creating a proper infrastructure and management of the area.

Характеризуется обусловленность подземной разработки линковых и свинцовых руд и ее специфическое влияние на земную поверхность. Описаны проблемы обнаружения неоднородных деформаций, методов их предотвращения и ликвидации на примере горнодобывающего региона Польши. Исторические горно-промышленные работы представляют особую проблему для данного региона. В настоящее время наблюдаются негативные результаты добычных работ. Истощение месторождений цинковых и свинцовых руд и частично экономические причины привели к ликвидации целых горно-промышленных регионов. Такая ликвидация требует обеспечения безопасности подземной части шахт, приведения водного режима в норму и рекультивации земель. Горные работы в пределах границ описываемого региона требуют координации работ в рамках текущей эксплуатации месторождений и действий, направленных на создание соответствующей инфраструктуры и системы управления в регионе.

INTRODUCTION

As a result of mining the rock mass and the surface of the area are subdued to deformations. The character of these changes depends on geological conditions, depth of exploitation, methods of taking out the product and the way of mining. Traditionally, the history of mining the ores of zinc and lead in Poland can be divided into the period of old historic mining and the period of contemporary exploitation. In both periods different ways of mining were applied, but they often resulted in discontinuous deformations on the surface, such as funnels and cavities. The process of making discontinuous deformations was eliminated in 1990s due to abandoning caving exploitation and the application of hydraulic stowing only.

OLD HISTORIC MINING

The term „old, historic mining" refers to mining activities before 1968. The beginning of this period dates back to 12th century. At the beginning zinc and lead ores were mined in strip mines in the region of ore-bearing dolostones. Later on underground working started. The system of exploitation was the following: the ore was mined from shafts reaching seam floor situated over the water-bearing level. After removing the ore the shaft lining was dismantled and mining continued in the neighbourhood. Later on the system of exploitation was modified. The hollows were made in the form of one main shaft and several side shafts. The ore mining above the water-bearing level continued until

the beginning of 16th century. When the resources were running out, the building tunnels to drain the water bearing level started, as well as „windows"(small shafts) were built. The location of windows is today marked by cavities and funnels. In the second half of 16th century multi-shaft mines with tunnels were built and the exploitation of ore took place in many workings at the same time. In the 17th century, because of Swedish invasions and floods, ore mining significantly decreased and shafts were silted, which resulted in flooding many mines. Again the development of zinc and lead mining took place in 19th century, when old tunnels were partially de-silted and new draining tunnels were made. In this period mainly calamine ore was mined. It was obtained by underground mining and strip mining, as well as by the exploitation of some waste heaps on the surface. In underground mining small shafts were made, they were joint together with headings and cross headings. Search headings were also made. The exploitation of deeper parts of the deposit, because of a high content of water in the rock mass was only possible after building a gallery, which, together with windows allowed lowering the level of mine waters and allowed the access to deeper parts of the deposit. Due to calamine mining the surface of the area was deformed on a large scale. This was caused by resource grabbing and selective exploitation. Since 1940s the mines were subsequently drained. After World War II the mining of sulphide ores and limonite was carried out. At the beginning, a shortwall system with caving was applied, and then stowing was introduced. In 1960s deep mining started and systems of mechanized mining were introduced

CONTEMPORARY MINING

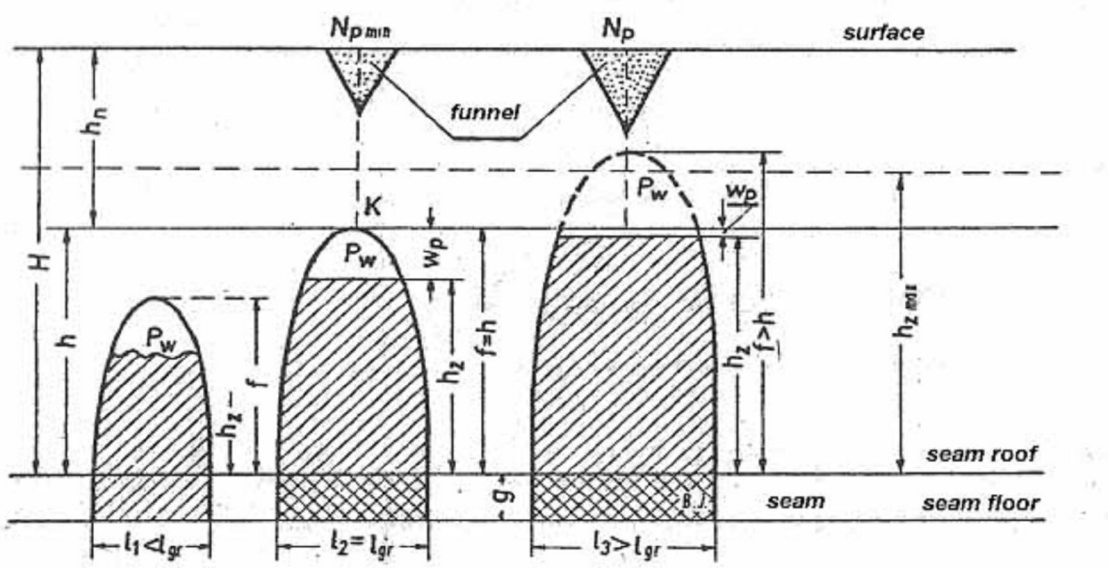
Contemporary mining of zinc and lead ores covers the period after 1968. At the beginning zinc and lead ores were mined by caving, but this way of exploitation was very unfavourable for the environment. It left many funnels and cavities on the surface of the area. Thus, since the beginning of 1990s only room-and-pillar system with hydraulic stowing has been applied.

This limits the impact of mining on the surface of the area to small continuous deformations and prevents dangerous and difficult to liquidate discontinuous deformations to happen.

DISCONTINUOUS DEFORMATIONS

Discontinuous deformations on the surface of the area are made during shallow (up to several dozens metres deep) exploitation of zinc and lead ores, carried out under the rock layers of low endurance parameters and often additionally weakened by natural dilatations (cracks, cavities, karst caverns). In that case the loss of the stability of the ceiling can take place and consequently the working will collapse and cavities, funnels and other forms of discontinuous deformations will appear on the surface. Such processes can take place directly after making a heading or after a long (sometimes very long) period of time, mainly due to washing out pieces of rocks from the overburden layers. Thus nowadays funnels and cavities can be formed in places where centuries ago there were shafts, sumps and tunnels and connected with them shallow horizontal workings.

A theoretical model of the formation of funnels and cavities (W. Janusz and A. Jarosz's model) is based on the theory of a pressure arch. Over the cavity in the rock mass the zone of decompressed rocks in the ellipsoid shape is formed (figure). In this zone rock material is crushed, get cracks and disintegrates. Then it falls on the bottom of the cavity making the zone of caving of the height h_z. Over the caving zone a secondary void is formed – P_w. The roof over the cavity comes to a shape close to an elliptical bowl of height f. If the thickness of the dense rocks h over the cavity is not big enough, the continuity of the rocks can break and the rocks of a loose overburden h_n can move towards the void. The result of this process is a funnel N_p on the surface of the area.



The course of changes in the rock mass over the primary void in case of a small thickness of a dense rock mass

The traces of old historical mining can now be observed in the form of a characteristic roughness of the area and smoothed and shallowed forms of discontinuous deformations ranging from several dozens centimetres to several metres. Old workings were, to a large extent self-stowed due to the collapse of the roof rocks of filling with pulp. However, the penetration of water inside the rock mass, in particular during intensive precipitation and changes of the level of ground waters can still activate the phenomena leading into discontinuous deformations over old historical workings.

Funnels and cavities occurring in the areas of contemporary exploitation of zinc and lead are larger. They were however gradually liquidated by filling with sand or taking out loose overburden to the stiff layers to secure from the collapse over the voids existing in this overburden. Nowadays, there are discontinuous deformations on the surface, related to current exploitation of the deposit.

THE LIQUIDATION OF THE MINE

The main cause of putting the zinc and lead mine into the state of liquidation was running out of the resources and the necessity to protect the environment and rehabilitate mining areas where negative consequences of contemporary and historical mining could be seen. The programme of liquidation includes: the liquidation of underground workings through stowing or filling with sand or gangue, liquidation of surface objects, repairing of mining damage, rehabilitation of areas degraded by mining and securing from the results of the liquidation. Because of very high inflow of underground water it is necessary to keep the drainage system (water tunnels and chambers) until the end of the liquidation period. Liquidation works should be carried out parallel to the rehabilitation and removal of the remains of the deposit from protecting pillars and ventilation headings. At present the majority of discontinuous deformations caused by contemporary mining was liquidated and the area of the liquidated mine is being rehabilitated.

CONCLUSIONS

The ores of zinc and lead were mined in Poland already in 12th century. From the beginning of 19th century the mining of calamine ores started and after WW II sulphide ores and limonite were mined. The exploitation of these ores results in the deformations of the surface of the area. A substantial threat connected with old historic mining is the possibility of discontinuous deformations resulting from the reactivation of shallow workings. The con-

temporary exploitation with a caving method resulted in cavities and funnels. They mainly occurred in forest areas. The liquidation of these deformations and the rehabilitation of the area made these terrains suitable for forestry. The purpose of the carried out liquidation of the mine is the neutralization of negative results of mining and bringing the area to the state allowing a proper management.

LITERATURE

Janusz W., Jarosz A., 1976 – Nieciągłe deformacje powierzchni wywołane płytką podziemną eksploatacją górniczą. Mat. Konferencji „Budownictwo na terenach o dużych deformacjach powierzchni". Katowice.

Ostrowski J. i inni, 1999 – Prognoza w zakresie przewidywanych kategorii przydatności terenu do zabudowy w aspekcie dokonanej eksploatacji rud Zn – Pb oraz skutków oddziaływania starego historycznego kopalnictwa w związku z likwidacją kopalni „Olkusz". AGH Kraków (niepublikowana).

Popiołek E. i inni, 2000 – Ocena wpływu likwidowanego rejonu „Olkusz" kopalni „Olkusz – Pomorzany" na środowisko i obiekty powierzchniowe. AGH Kraków (niepublikowane).

Sepiał J., Włodarz B., 2002 – Techniczno – ekonomiczne aspekty likwidacji kopalń olkusko – bolesławskiego rejonu kruszconośnego. Conference Proceedings from the International Conference Mineral Resources of the Slovak Republic. Demanovska Dolina – Slovak Republic, 17-18 October.

Waś P., 2005 – Likwidacja kopalni „Olkusz" jako proces usuwania negatywnych skutków historycznego i współczesnego górnictwa rud cynku i ołowiu. Praca dyplomowa pod kierunkiem J. Ostrowskiego. AGH Kraków (niepublikowana).