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CHALLENGES OF UNDERGROUND MINING OF STEEPLY PITCHING DEPOSITS WITH STOWING IN ANOMALOUS GEOLOGICAL ENVIRONMENT

Annually, Ukraine mines almost 75 – 80 tons of iron ore; moreover, 9 mines extract almost 15 mln tons using under-ground method. Chamber mining and sublevel caving (Kryvyi Rih iron ore deposit) [1]. However, chamber mining with hardening stowing has already been practiced by PJSC “Zaporizkyi Zalizoorudnyi Kombinat” (PJSC “ZZK”). The method provides both stability and gradual increase in output during long period of time. PJSC “ZZK” mining high-grade iron ore of Bilozirka iron-ore district, extracts significant share (i.e. 25%) of Ukrainian ore recovery using underground method. Implementation of the mining system with hardening stowing by PJSC “ZZK” made it possible to achieve more qualitative extraction indices to compare with iron ore mining without stowing in Kryvorizhzhia. Indices of ore losses and its dilution are 2 – 2.3 times less [2]. However, despite the system efficiency, severe problems concerning stability of hanging wall enclosing rocks as well as stowing rock mass arose at the depth of 640 – 940 m. The problems are stipulated by rock pressure and intensified seismic impact of blasting operations resulting in mined ore degradation and reduced performance indicators on the whole [3]. Caving of hanging wall rocks factors into the following: increase in the mined-out area to be stowed; ore degradation and increase in its prime cost; problems connected with iron-ore product grade control in the context of stopes; and decreased safety of development mine workings within hanging wall of the deposit. To identify reasons of reduced stability of natural rock mass and man-made one, it is necessary to analyze mineralogical composition, geological structure, and mode of occurrence of both ore deposit and enclosing rocks.

In terms of horizontal plane of ore deposit as well as in terms of its depth, structure and mineral composition of enclosing rocks along with inclination angle and bedding angle differ greatly. The deposit is a ribbon of ferruginous quartzites in-curved westerly (north westerly-north eastwardly) under total submeridional strike of ferruginous quartzites containing high-grade iron ores. The strike is north westerly (310°) within southern wing; starting from central part, the strike varies its direction to northeast (40°). The same situation is with inclination angle of the ore deposit; it increases its value from south (60 – 65°) to north (80 – 85°). Analysis of changes, taking place in geological structure and mode of occurrence in the strike and in the ore deposit depth, made it possible to identify common tendency of the decreased hardness of hanging wall rocks and inclination angle of the deposit; changes in morphological structure of rock from northern wing to southern one; and increased thickness of the deposit. Ore rock mass and enclosing rocks demonstrate intensive fissuring as well as frequent substitution of rocks with variable hardness characteristics within process parameters of stopes [4]. Faults are not available; however, opening of certain fissures is either in vertical planes or in gently inclined ones with 10 – 20° slope angles within the whole territory of the deposit. Strike of vertical fissures prevails towards 350°; strike of gently inclined ones prevails towards 250 – 275°. Fissure density varies from low fracturing (i.e. up to 2 fissures per meter) to rather heavy one (i.e. 20 fissures per meter). Moreover, the ore body deepening results in the increased zone of unstable low-hard quartz-chlorite-sericite shales within rocks of southern wing. It is 60 m at 400 m depth; 150 m at 640 m depth; 330 m at 740 m depth; and 600 m at 840 m depth.

When 640 – 740 m level was mined, values of ore dilution in chambers, extracted within a contact with hanging wall rocks, achieved sometimes 8%; they were 12% at 740 – 840 m level. It should be noted that often cavings of hanging wall rocks are observed within central and southern parts of the deposit with 550 m length. 70% and more inrushes take place within the sites in the context of all the level chambers. At central and southern sites, where inrushes happen frequently, the deposit curves; strike angle and inclination angle vary as well as morphological composition and rock properties. The fact affords ground to designate the site as transition

zone where various characteristics of the ore deposit enclosing rocks cross. When the deposits sites, where rocks of hanging wall diluted chambers, and changes in geological factors along the ore deposit were compared, it has been determined that concentration of hanging wall rocks experiences its intensification when ferruginous quartzites are substituted by quartz-chlorite-sericite shales; when hardness and stability of enclosing rocks of hanging wall reduce; when inclination of ore deposit decreases; and when thickness of the ore deposit increases and dilution indices significantly as well.

Hence, complex geological and tectonic structure of ore deposit; significant changes in its strike and inclination, in rock hardness, in the ore deposit thickness from western wing to southern one; availability of folding of the ore and rock boundary form anomalous geological environment where gravitation acts on stopes take a new form differing from classic theories and concepts. Iron ore mining under anomalous geological conditions should be based upon innovative scientific approach concerning provision of rock mass stability depending upon a system of the involved mining and geological factors.

Analysis of features concerning ore deposit mining under complex mining and geological conditions makes it possible to insist that such conditions needs scientific substantiation of a mechanism to form load within hanging wall of the deposit on stopes located in a zone of drastic changes in natural environment. Consideration of the aspects will help lay basis for optimization of the order of the reserves mining within the deposit area; parameters of the system to mine and break ore reserves in stopes under varying mining and geological conditions.

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