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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　Pardon Sinkala

学 位 論 文 題 名

Prediction of Rockburst at Mufulira Mine, Copperbelt, Zambia
(ザンビア共和国カッパーベルトに位置するムフリラ鉱山における山はねの予測)

In January 2018, Mufulira mine recorded a rockburst at 1440 mL underground with a magnitude of 2.8. Therefore, the authors conducted a study on the M2.8 based on field investigation, rock testing, and numerical elastic stress analysis. They calculated the normal stress to the orebody at the M2.8 rockburst and its variation with face advance by the 3-D DDM. However, the elastically predicted stress at the rockburst site was not very high and barely increased with the face advance. This study applies DDM with a larger model to investigate other rockburst events from 2016 to 2018 and re-examine the M2.8 rockburst. To obtain more accurate stress distribution at the rockburst face, 2-D elastic FEM analysis was carried out, representing the stress concentration inferred by DDM. Again it was shown that normal stress value or its increase with face advance cannot explain rockburst occurrences. Therefore, the creep damage model is proposed under an assumption that the rockbursts could be brittle creep failure of the relatively intact rock mass. Cumulative rock damage was evaluated for the edge elements of each sidewall of the mining drives, based on the normal stresses by 3-D DDM. In order to obtain more accurate prediction of rockbursts, an elastoplastic analysis was also carried out.
The main findings are as follows;
Rockburst did not occur in the chain pillars or at the mining face, but mainly in the mining drives along diminishing pillars or ahead of the mining face. RQD suggested that the rock mass in the rockburst areas was relatively intact. Laboratory tests confirmed that the rock at Mufulira mine is very strong and brittle. Mine-wide elastic stress analyses for the rockburst sites by 3-D Displacement Discontinuity Method (DDM) indicated very high stress in the chain pillars and low-stress concentration at the sites of rockburst at the initial mining stage, but later, the stress levels gradually increased with progress in mining. However, there was no apparent positive correlation between the elastically calculated stress values and the occurrences of rockbursts.
The 2-D elastic FEM analysis indicated some stress increase with face advance for the rockburst in the vicinity of the mining face. However, stress severity indicated almost no increase, implying that the rockbursts cannot be explained as an instantaneous rock mass failure due to stress increase by mining. Therefore, a creep damage model was proposed and rockburst occurrences were well hindcasted.

Changing the mining sequence can decrease potential rockbursting for some rockburst cases. Complete elimination of pillars where applicable can decrease potential rockbursting. Elasto-plastic analysis could not predict the M2.8 successfully.

A method to estimate the volume of the rockburst source was proposed, and a likely result was obtained.