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Roof fall Accidents during Rainy Season in Underground Coal Mines in Malawi

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1. Introduction

As Malawi ventures into the mining industry, coal remains the strategic target commodity for the mining sector. There are seven coalfields spread across the country with four coalfields of bituminous coal in the Northern Region. Currently, four underground small-scale coal mining operations are running with additional two open pit coal mines in these coalfields. Two underground mines; Mchenga coal mine and Kaziwiziwi mine, are located in the target area hosting the Livingstonia coalfield.

Considering the scale of operations in the underground coal mines, there is very minimal mechanization and this in turn hampers the total production. The combined coal production is at 11,000 tonnes per year [1]. However, the country is promoting increased coal production aiming for electric power generation but to achieve this, it requires enhancement of safety systems in the underground coal mines. Routine mine inspection reports produced by the Department of Mines indicate a common occurrence of hanging roof fall accidents in the underground coal mines during the rainy season. Mostly, these roof fall collapses have resulted in damage to conveyor belt systems installed in the mines, with two occurrences leading to fatal accidents. In the rainy season of 2014 to 2015 season, two roof falls have been recorded in the underground mines although no fatality was reported.

2. Weather conditions in the Northern Region

The period from October to April is the main rainfall season over Malawi. October therefore marks the beginning of the rainfall season in the country with the main rains arriving mainly from November in the southern region and progressively spreading northwards. During this period, the main rain bearing systems that influence weather over Malawi include the Inter-Tropical Convergence Zone (ITCZ), Congo air mass, Easterly Waves and Tropical Cyclones.

During the period of January to March 2015, the air over Malawi was fairly moist and unstable. The daily relative humidity values had ranged from 62% to 85% at Mzuzu in the Northern region [2]. This was triggered by moderate to heavy rainfall ranging from 88 mm to 110 mm, confined to very few areas in the north and south areas of Malawi. This led to flooding in some areas in the Northern region. In addition to that, recorded air temperatures hovered across the region with a

minimum range of 20°C to 25°C and a maximum range of 30°C to 35°C. (Figure 1)



Fig.1. Relative Humidity and Temperature in the Northern Region 2014-2015 [2]

3. Site and Instrumentation

The study is being conducted in Mchenga and Kaziwiziwi underground coal mines located in the Livingstonia coalfield in Malawi. Stratigraphically, the area is composed of Karroo System strata preserved in a number of N-S trending basins and down-faulted troughs that display faulted relationship to the underlying Basement complex gneisses. The basal beds of the succession consist of conglomerates and sandstones referred to the Dwyka and lower Ecca series. These are overlain by a sequence of carbonaceous shales and coal seams [3]. The roof stratum mainly consists of sandstone and shale (Figure 2).

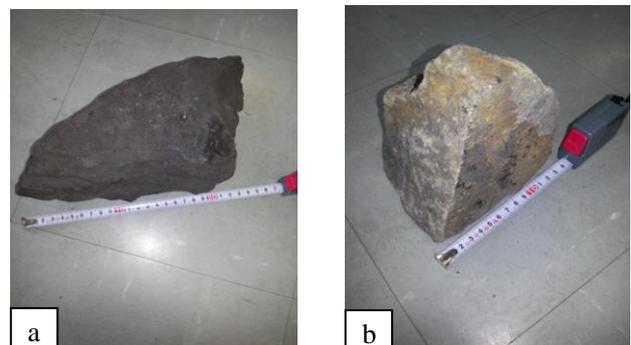


Fig.2. (a) Shale and (b) Sandstone samples from Mchenga Mine

4. In-situ measurement of humidity

Eight coin-type data loggers (Figure 3a) were installed in mine adits of Mchenga Coal Mine at varying levels with an average depth of 130 m from the ground surface. The points had varying

moisture presence to record humidity in and close to the working face. The instruments were fixed in matt packs and accessible points in rocks with a clear exposure to the surrounding atmosphere in the adits (Figure 4). The humidity levels measured in the mine adits will be used as a guide during sample preparation in the laboratory.

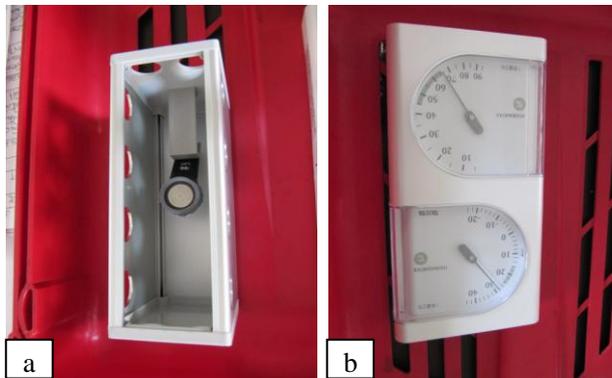


Fig.3. (a) Coin-type data logger and (b) Mechanical hygrometer

In addition to that, three mechanical hygrometers (Figure 3b) were given to mining engineers at both Mchenga Coal Mine and Kaziwiziwi Mine to measure and record humidity and temperature once every week.

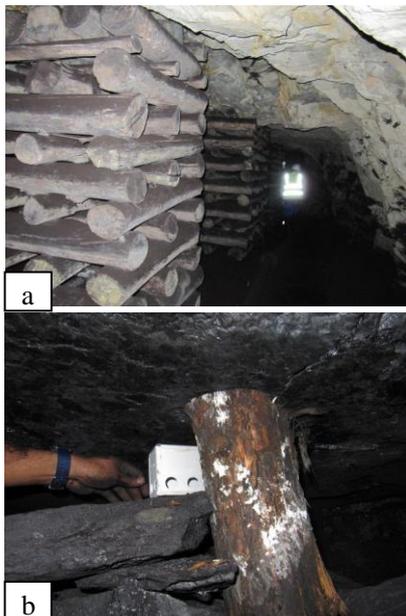


Fig.4. (a) Lower seam adit in Mchenga Coal Mine (b) Fixed in position data logger close to the coal bearing rocks.

5. Analysis of roof fall data

The mining companies keep records of production and accidents/incidents reports. The data from records by the company combined with the inspection reports from the Department of Mines will be analysed to establish a relationship between roof fall frequency and humidity levels in the underground mine adits. This can aid in marking points in the

mines as dangerous or evacuate in relation to the level of humidity, to act as a signal to mine workers to exercise caution.

6. Laboratory test

The collected samples will be treated to different levels of humidity, a constant room temperature and weighed. Twenty samples in total will be produced and five samples will be treated in low humidity of around 10% using desiccant, in medium level humidity of around 60% using Magnesium Nitrate Hexahydrate, and in high humidity level of around 95% using pure water. In addition to that, five samples will be oven dried at 80°C and five more will be saturated in water. At more constant density, the samples will then be tested for tensile strength along the sedimentary plane using the Brazilian test.

For comparison, Neogene tuffaceous Kimachi sandstone from Japan will be tested under the same conditions to compare the differences in the effect of humidity on the tensile strength between the two types of rocks.

7. Consideration of reasonable countermeasures

After the tests and the conclusions are drawn from the experiments, effective and reasonable countermeasures against hanging-roof fall in the underground coal mines will be considered. The suggested measures will have an aim of reducing the humidity in the mine adits such as fans.

8. Concluding Remarks

In order to enhance productivity in the coal mines, the mining companies in Malawi have a duty to ensure safety of the working environment. However, technical support through research is vital to the achievement of this goal. In conclusion, the hanging roof fall accidents in the underground coal mines can be a result of possible weakening of the joints by the high humidity prevailing conditions during the rainy season and countermeasures against these incidents should be applied.

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