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Fall of ground management in shallow underground hard rock mining: a case study in a chrome mine

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ABSTRACT

Rock fall related hazards will forever be present in the mining industry, therefore it is considered important to have an active fall of ground (FOG) management technique that will help combat such incidents. The Chrome mine has experienced numerous falls of ground incidents in the previous years. This was a major concern, as there was already a ground control and monitoring system in place. The current fall of ground management technique includes visual observations where panels are rated (Panel Risk Rating) based on their geological complexity and compliance to support standards. In addition, monitoring such as Ground Penetrating Radar (GPR), Borehole camera inspections and FOG lights are used. With such defined ground control measures put in place, rock falls continue to occur.

The main aim of this study was to identify loopholes within the current ground control system in order to know how it can be improved to be more efficient. This was achieved by looking at the current FOGs management technique used at the mine together with historical fall of ground database so as to identify the main causes of FOGs. It was found that most falls of ground were due to intersection of joints and flat dipping structures such as domes. Main challenges identified within the current system include:

- Inadequate early entry examination (prominent hazards identified during PRR relate to early entry examination);
- GPR scanning is only conducted on a monthly basis, 10m from the current face to the back area, in strike direction only; and
- FOG lights trigger easily due to blast vibrations.

The above listed challenges can be addressed as follows, to help improve the current system to combat FOGs at the mine.

- By ensuring that early entry examination is conducted adequately by competent and skilled personnel;
- GPR scanning can be conducted in both dip and strike direction, after every 3 blasts (for an average advance per blast of 3m) instead of once a month to avoid leaving out some

areas not scanned (i.e. Portions between the area scanned in the previous month and 10m from the current face area);

- Rocktales can replace FOG lights for continuous ground monitoring.

Having identified the main causes of FOGs, it was noticed that the current ground control and monitoring system did not consider the impact of joint as there was no documented joints data other than that presented in the Mine's Code of Practice. Underground joint mapping was conducted using window mapping to obtain joint data. Furthermore, two methods i.e. brow thickness data and historical fall thickness were used to estimate the overall fallout thickness. Probabilistic approach was used to evaluate rock falls in the North and South sections of the mine. This approach also allows the evaluation of different support systems.

Fallout thickness outcome from both approaches confirmed the estimate from joint data analysis in J-Block. Key block size distribution indicated that about 80% of key blocks formed are $1m^3$ in both sections. Meanwhile fallout thickness evaluations showed that the overall fallout thickness at the Chrome mine is 0.95m. Rock fall probability evaluations indicate that small blocks tend to fall between supports whereas larger blocks fail the support system through rotation. Support failure may occur if the support resistance is smaller than the required resistance. Support layout analysis show that spacing, length and capacity of support units have an effect on stability. These aspects are critical for support design of jointed rock mass. Furthermore, to prevent small blocks from falling between support units, areal coverage (wire mesh, Oslo straps, shotcrete etc.) is suggested in heavily jointed rock masses.

This study has demonstrated that falls of ground management strategies are broad. The more the techniques are applied in a FOG management system, the better the outcome. Moreover, the study showed that the use of joint data can improve the current fall of ground management system at the mine, through its ability to evaluate the stability of excavations. As a result, awareness of the expected key blocks in a particular excavation is achieved, which helps in support design. Therefore, when continuous ground monitoring devices are installed, it will be known that a certain block size has moved. Thus, correct measures can be put in place to minimise rock fall related hazards. The same approach can be utilised while focusing on a single panel rather than the whole mine or section, which is strategic for stability enhancement.