Future Block and Panel Caving Mining Systems and opportunities for rock mechanics inputs

A technical Note

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Background

The notion of the *mine of the future using caving methods* is becoming high priority with most major mining companies globally applying or intending to apply block and panel caving methods because of the need to develop new ways to achieve safer, more sustainable, high value, higher productivity and higher recovery bulk underground mining. This is driven by the continually changing physical (mining and geotechnical) environments in which large deposits which are amenable to bulk mining are being found. The need has been exacerbated by the recent (2008/2009) global downturn in commodity prices where a number of the known deposits under feasibility studies were suddenly deemed to be uneconomic using even current *state-of-the-art* caving practice. The overarching vision is being able to have a sustainable and responsible mass mining future as well as maximising the value of a given deposit. As a result, almost all major bulk underground mining companies now have *innovation groups* addressing aspects of future mining.

Some possibilities being explored for the next generation of underground mass mining activities using block, panel and sublevel caving include:

- continuous extraction as opposed to LHD extraction that has now been used in various forms for about 40 years;
- alternative and stable layouts for high capacity continuous extraction and/or for effective utilisation of automation;
- high capacity *lateral and vertical* material handling systems well-matched to the envisaged high capacity continuous extraction;
- methods or practices to reduce the *ramp-up* time needed to achieve required production rates or targets (rapid cave establishment) thereby achieving early financial returns for investors;
- The feasibility of applying civil engineering construction and rock reinforcement / support systems for continuous undercut development and for the longevity of extraction levels in caving;

- Sustainable *Energy and Water* usage and management consistent with the other global demands for the same resources. This is in addition to other sustainability issues which include environmental, social, climate and economic perspectives;

- at the other end of the mass mining spectra, the feasibility of *in-place* leaching of very low grade porphyry deposits which are considered uneconomic even if mined with the low cost bulk underground caving methods; and

Caving methods have arguably become the underground bulk mining method of choice but even now they are faced with an urgent need for increased safety, environmental stewardship and sustainable mining. In the future it is envisaged that there will be relatively more lower grade, deeper and more competent ore bodies (harder) or orebodies with variable rock mass strengths and geology and in much higher stress and temperature environments as well as increased competition for energy and water usage. All these require new innovations including overall caving mining systems e.g. new extraction level layouts, continuous undercutting techniques, higher capacity and continuous ore handling systems (lateral and vertical), all which collectively call for new techniques to economically design and operate the emerging or new generation of caving mines. It should nevertheless be noted that sectors of the industry are already exploring deposits with such attributes.

Requirements for future mining using new caving methods

Step-change technologies and supporting knowledge to effectively cave the range of the current and new deposits with large footprints and lower grades, and which occur in aggressive geotechnical environments, is therefore required.

Research in caving methods to date

Though the Sustainable Minerals Institute (SMI) of the University of Queensland Australia, a number of major mining companies have been funding research associated with the application of caving methods particularly in strong rock masses. The project was initially called the International Caving Study (ICS) and later the Mass Mining Technology (MMT) project. The supporting companies have included De Beers South Africa, Codelco Chile, Rio Tinto, LKAB, Newcrest Mining Limited, BHPBilliton, Valle Inco, Sandvik Mining and Construction, Orica Australia, Xstrata Copper Queensland and more recently Anglo Base Metals and Atlas Copco. The MMT through research providers such as Itasca Inc, the University of Toronto, The University of Lulea and the WH Bryan Mining and Geology of the SMI and previously the Julius Kruttschnitt Mineral Research Centre (JKMRC) have to date focused on improving the understanding of the key fundamentals of the caving processes in strong rock masses. Such fundamentals include caving mechanics (initiation, propagation and subsidence), gravity flow, primary and secondary fragmentation, preconditioning,

seismicity and confined blasting (for sublevel caving). The list of some of the papers by the different ICS and MMT research providers is included at the end of this summary.

While the outcomes from the MMT 2 as well as its predecessor (the International Caving Study or ICS) will still be crucial inputs to the caving mines of the future, it is necessary to address new or additional issues currently beyond the scope of MMT. Given the emerging new generation of caving operations designated by the author as Super Caves, there is now an urgent need for:

1. Consolidation and application of the increased knowledge in caving fundamentals specifically for future mine design and implementation requirements;
2. Augmenting our fundamental knowledge and methodologies in areas such as *large scale (3D) rock mass fabric characterisation* to better define the rock mass fabric at all scales and corresponding rock mass strengths; *improved rock mass characterisation and rock mass response* based on geophysical methods; *rock mass behaviour and breakage at all scales*, and more *effective utilisation of rock preconditioning techniques* (blasting, hydraulic fracturing or hybrid);
3. New R&D areas including industrial scale measurements and trials to develop the required new mining layouts and compatible material handling systems to help support future caving requirements;
4. Means to achieve more sustainable energy and water usage including effective management of environments, social and general economic issues;
5. Minimise the potential negative impacts (aquifer disturbance, seismicity and surface subsidence) of the new and much larger scale caving systems
6. Implementation of a more integrated bulk mining, milling and processing systems to maximize the value of a given deposit thereby better utilisation of energy and water needed to produce a tonne of ore of a size optimal for lower energy milling;

Because of the depth issues, the need to ensure the longevity of the extraction levels as well as the performance of the large scale caves, there is the opportunity for increased rock mechanics input in terms of modelling, support and rock reinforcement, monitoring and instrumentation for cave performance. The purpose of the presentation associated with this technical note is to explore future rock mechanics input into future block and panel caves and in particular from the civil engineering community.

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