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Mine design, scheduling, and modifying factors methodology applied to big blocks compared with Individual panels

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Abstract

Over the past couple of years, Anglo Platinum has made extensive use of technology within the core disciplines (geology, evaluation, survey, and planning) that collectively form part of mineral resource management (MRM). While these technologies were primarily developed to enable geology, evaluation, survey, and planning to carry out their daily tasks, with the main objective of supporting the mine's production effort, they have also enhanced the disciplines' ability to produce the required outputs within the annual business planning cycle. Anglo Platinum has developed a very comprehensive business planning process, and these technologies play a vital role in enabling both the quality and quantity of inputs into the process, and also the value-add of the final product. This prompted a question regarding the practical application of the CADSMine software. If we changed our thinking in how we applied the software, would it be possible to further improve on the time taken to deliver a business plan? In changing the current planning approach, would we be able to further simplify the process? Is there a way to reduce the data generated in order to enhance the time taken to do reporting, as the CADSMine software is totally network dependent? Less data should equal faster reporting. This paper focuses on the practical application of the CADSMine software, and demonstrates the value-add to the business planning process that can be gained if the mine design methodology is changed from individual panels to bigger blocks representing a raise line.

Introduction

The compilation of the annual life-of-mine plan is time-consuming, and there is seldom time to subject the life-of-mine base case to more than one or two iterations before the deadline. Optimization occurs by luck rather than by design. Frequently the final plan is arrived at by tweaking numbers in spreadsheets – not backed up by scheduled extraction plans.

By changing the approach of doing the life-of-mine planning, not per panel but rather in bigger blocks, a significant amount of time can be saved in the compilation of a life-of mine plan. The change in methodology will enable the planners to do more iterations, as the methodology applied enables the planners to apply different extraction rates quite easily and quickly, which is not the case when the plan is done per panel.

Level of detail required

What detail is important for a long-term plan?

When compiling a life-of-mine plan, what detail is required? For the first five years it is important to do the plan per panel, as the first three years is required in greater detail for budget purposes. Years four and five of the life-of-mine plan are also done per panel as this drives the generation of ore reserves in greater detail. From year five to the end of the life-of-mine it is basically the metal content and tons to concentrator that drive the strategic planning.

The life-of-mine plan is reported in monthly periods up to year five; thereafter annual figures are used. The 'reduced' level of detail required from year five to the end of life makes one question the methodology of doing the life-of-mine plan in panels. If we rather do the mine design in bigger blocks, representing a raise line on a half level, a lot of time can be saved in the mine design, scheduling, and reporting processes. This, incidentally, is the way production personnel would view a plan. They don't get bogged down in looking at the long-term plan, at the panel level of detail. They look rather at areas available and the number of crews that would be used to extract an area. The methodology described in this paper applies the same principal. A block will be the reserve generated on each side of a raise from level to level.

An additional advantage of this approach is that it is relatively quick to apply rate changes to a bigger block, which is not the case if the scheduling is done per panel using manual dependencies. If the scheduling is changed on a plan done per panel with manual dependencies, the scheduling of that plan basically has to be repeated as the crew moves are modelled in a sequential manner. If the plan was done in big blocks, only the rate applied need to be changed as this is based on a calculation method and is not driven by crew moves in a sequential manner. This methodology mimics the Carbon14 and Datamine EPS scheduler functionality of doing crew scheduling, in a manual graphics-driven manner.

As the evaluation results are obtained from a resource model in which the smallest block size is 250 m by 250 m, there will be virtually no difference in the level of detail obtained when using either method for the mine designs. There may be differences in the result related to the spatial position. In Figure 1, which shows the SAMREC reserve categories, the Proven blocks are 250 m by 250 m. The Probable blocks are 500 m by 500 m. Due to the large block sizes employed, the evaluation detail will not be significantly impacted upon by the use of different mine design models (panel vs. big blocks).

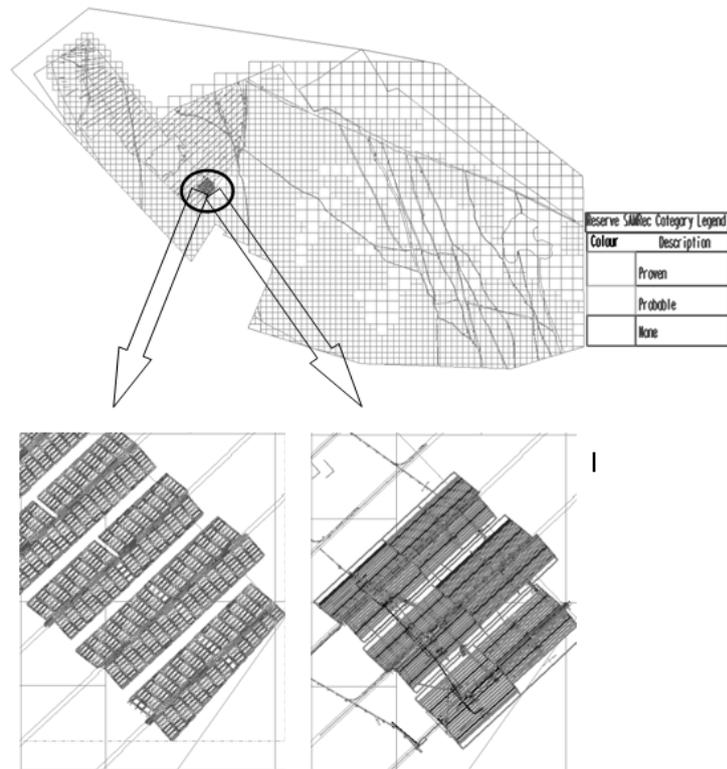


Figure 1 Panels against SAMREC

vs. big blocks grid

Mine design

Individual panels vs. big blocks

For the budget period and up to the first five years of the life-of-mine plan, the mine designs are done per panel. The mine designs will have a solid pillar between panels. The ventilation holings are not represented as part of the mine design and are accounted for by the application of modifying factors. Development methodology for short- and long-term plans remains unchanged.

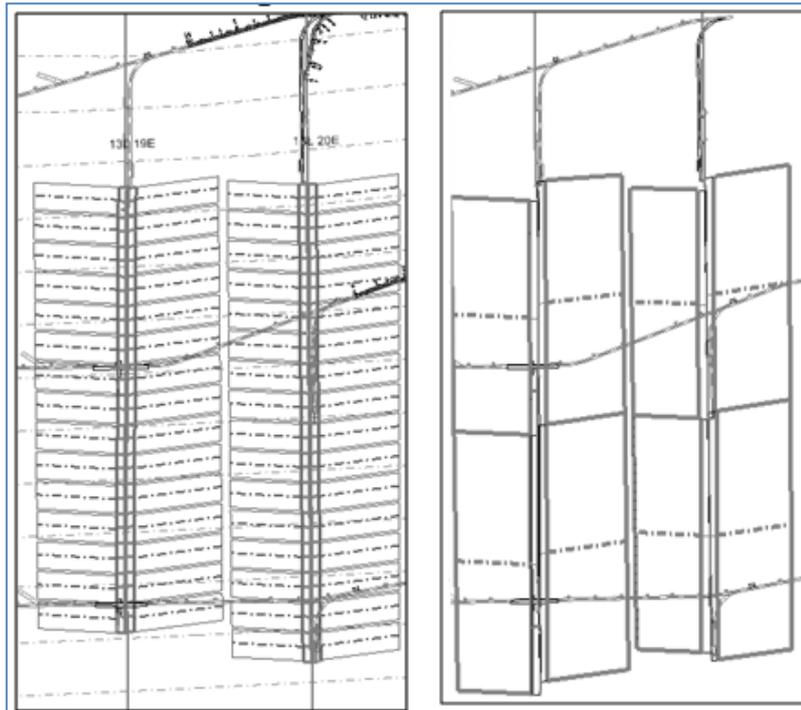


Figure 2. Panels

Figure 3. Big blocks

- Designs for big blocks reduce the number of mine designs in the CADSmine file.
- Using big blocks, no modifying factor is required for ventilation holings, as this is part of the mine design
- A comparison between 124 individual stoping and ledging panels and 16 mine designs obtained when designed as big blocks is shown in Figure 2 and Figure 3
- The face advance angle with big blocks should be parallel to the shape of the final excavation.

From year five to the end of the life-of-mine the mine, designs for ledging and stoping operations will be done in bigger blocks representing a raise line on a half level. The *in situ* ventilation pillars that will not be extracted as well as the major unknown geology will be accounted for in the model by applying a percentage extraction rule when doing the scheduling of the plan. The shadow pillar at the end of the mine design block will therefore represent the major unknown geological discounted area, as well as the ventilation pillars that will be left *in situ*.

The gully width assigned to the mine design element of the big block needs to represent the combined width of the number of panels making up the big block.

Modifying factors

Individual panels

- Minor unknown geological discount (faults smaller than 1 m which are not visible on the plan) is catered for in the resource model (batch)
- Major unknown geological discounted area is allowed for by applying an extraction percentage rule when scheduling. It is visible as the shadow block at the end of the mine design that is left un-scheduled
- Known geological discounted area (faults, dykes, and other known geological discounted discontinuities) is represented in the structure file of the resource model
- The ventilation holings that are not visible or represented in the model are accounted for as a positive figure in the modifying factors menu and reported on the production and evaluation report based on a calculation that is done in the database.

Big blocks

- Minor unknown geological discount (faults smaller than 1 m that are not visible on the plan) is catered for in the resource model (batch)
- Major unknown geological discounted area is catered for by applying an extraction percentage rule when scheduling. It is visible as the shadow block at the end of the mine design that is left un-scheduled
- Known geological discounted area (faults, dykes, and other known geological discontinuities) are catered for in the structure file of the resource model
- Off-reef mining – this factor must not be used as it will lead to double accounting
- The in-stope ventilation pillars that are left *in situ* are catered for by applying an extraction percentage rule. This is in addition to the extraction percentage that is applied for the major unknown geological discounted area. It is visible on the plan as part of the shadow block at the end of the mine design that is left unscheduled
- As the ventilation holings are included in the mine design of the big blocks, the model accounts for the ventilation holings and no modifying factor needs to be applied in the in-stope pillar box on the stoping factors window when scheduling mine designs with the big block method
- Stopping winch chambers width entered on the big block needs to be representative of the number of panels represented by the big block.

Scheduling

Scheduling budget up to year five of the life-of-mine plan

Ventilation holings that are not included in the mine design model as part of the mine design are added as a positive modifying factor.

If the scheduling is done with manual dependencies it is not possible to increase the number of crews applied to a half level without doing the scheduling over with new dependencies.

If the extraction sequence is changed by rock engineering, the planner would have to reschedule all the panels in the raise line.

Scheduling of big blocks

The scheduling of the big blocks is done on a monthly calendar.

No in-stope modifying factor needs to be applied for pillars, as the portion left *in situ* are accounted for in the shadow pillar area left at the end of the mine design element, which represents the major unknown geological discounted area as well as the ventilation pillars left *in situ*.

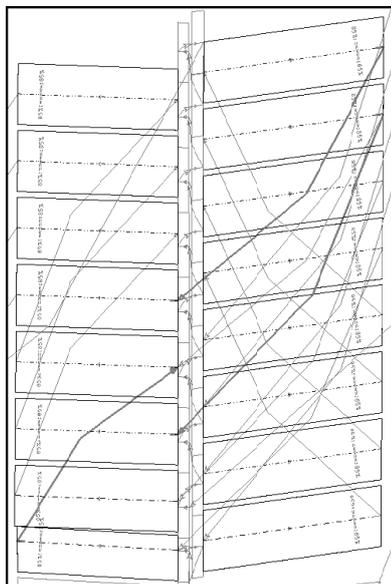
The ventilation holings are accounted for in the mine design of the big block, as it covers the whole area.

A schedule result period with this methodology represents the number of crews assigned to that raise line. Due to the change in methodology applied, a change in crew efficiency is quite quick to simulate by just changing the extraction rate of the block.

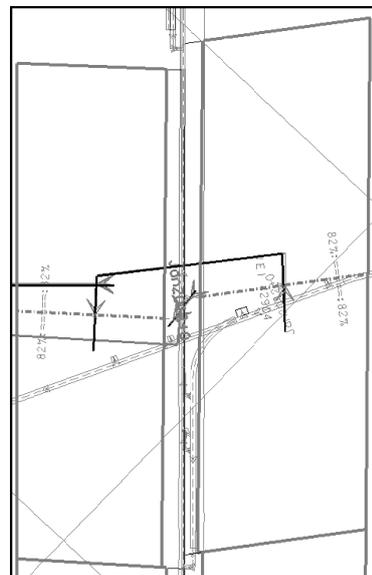
This methodology significantly reduces the amount of rules and dependencies in the schedule file, due to the fact that there are fewer mine designs in the file and each block represents four to five crews.

A change the extraction sequence requires the change of only one dependency..

The data generated with the scheduling of the big blocks is greatly reduced, as one scheduled polygon represents four to five crews. This means a reduction from five to one in the number of database records compared to the database generated by individual panels.



**Figure 4 Scheduling rules
– panels**



**Figure 5. Scheduling rules
-bBig blocks**

The scheduling rules placed on the panels as shown in Figure 4 are the following:

- 32 dependency arrows
- 16 extraction percentage rules
- 32 mine design element.

The scheduling rules placed on the big block mine design (Figure 5) are the following rules:

- 2 crew priority rules
- 2 extraction percentage rules
- 4 mine design element rules.

Due to the reduction in number of mine designs and scheduling methodology, the process is simplified, and the time required to do the scheduling is greatly reduced.

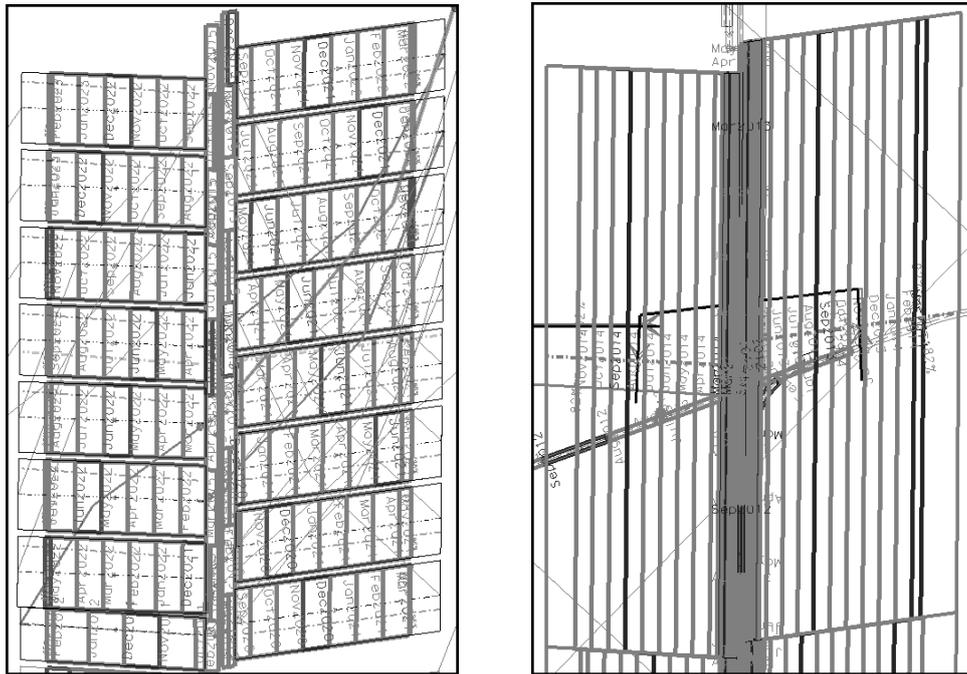


Figure 6. Scheduling rules – panels vs. big blocks

The number of the schedule result periods created was reduced by 80 per cent for the stoping panels. This will have an impact on the time required to do the reporting, as smaller databases will reduce the time required to query the results from the SQL database.

Scheduled results

Scheduled results –individual panels vs. big blocks

A comparison was made between the individual panel and big block methodologies by conducting a mine design on an area covering two half levels and seven raise lines. The results are shown in Table I.

Table I. Scheduling results for individual panels compared to big blocks

% Diff	Individual panels	Big blocks
Stope cut tot. area	645 235 m ²	649 753 m ² 0.7%
Stope cut tot. content	10 640 902 g	10 600 854 g -0.4%
Face length	67 620 m	114 498 m 69%

There was a very good correlation in results obtained for area (square metres) and mineral content, with a percentage difference of only 0.7 per cent and -0.4 per cent for area and mineral content in grams respectively.

The discrepancy in face length is due to the fact that there are nine individual panels in the raise line being mined with five crews. Therefore, not all the panels will be mined in one time period. The big block method simulates the mining of the full face length of the raise in one time period, which results in an overstated face length figure being reported.

To solve this, face length mined will be calculated by the following formula:

$$Fl = m^2/m$$

where Fl = Face length mined; m^2 = Total stope cut area; m = Average face advance

The calculated face length mined will yield an accurate result only if there is no change in crew efficiency planned.

Conclusion

The big block methodology enable Mine planners using CADSmine software to complete life-of-mine plans in a shorter time, compared to the traditional approach where all panels are designed as individual panels. The big block methodology requires fewer mine designs to be created, less scheduling rules to be placed, and generates a significantly smaller amount of data in the database. The big block methodology enables the mine planner to create various scenarios in a shorter time, as compared to the individual panel method. To change the number of crews mining on a half level requires only a change in the extraction rate, whereas the traditional approach will require that the schedule extraction sequence be recreated if the number of crews needs to be changed from four to five, for example.

By using the big block methodology, significant gains in productivity can be achieved while producing a life-of-mine plan of similar quality to that produced by the individual panel methodology.

Reference

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The Author



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Started my career in the Mining industry in 1988 as a Learner Official Mining at Harmony Gold Mine, after two years I made a career change to the Sampling department. I joined Goldfields in 1992 as Senior Sampler at Deelkraal Gold Mine. I was transferred to Libanon on promotion as a Sectional sampler in 1993. A year later, I joined Anglo Gold as a Surveyor at Mponeng Mine. During my time at Mponeng mine, I completed my National Higher Diploma Mineral Resource Management and shortly thereafter was transferred to Savuka to gain experience in the planning department. I obtained my Mine Surveyor's Certificate of Competency in 2003. In 2005, I was transferred back to Mponeng as a Senior Mine Planner. In 2007, I was transferred on promotion to Moab Khotsoeng Mine as a Survey and Planning Manager. I joined AngloPlatinum in September 2011 where my current role is a Planning Analyst.