

Model: Shrinkage Stope Evaluation
Level: Macro

Operating procedures

Introduction

The goal of the model is to evaluate the total stope production by taking into account the required development work and the impact of the work schedules. Many cells in the spreadsheet were left empty to allow users to personalize the model according to their needs.

This document will help users by:

- describing the approach used to perform the evaluation calculations;
- giving a description of the worksheets in the “Excel” file and their functions;
- identifying the types of required data and indicating where to insert them; and
- describing the different sections of the model.

1. Approach of the model

The model presents the key factors regarding the evaluation of a stope. The development and mining productivities are not calculated, but they represent data to be entered.

The approach of this model is based on an ore reserve block before its development and mining. The model takes into account the factors related to development, dilution, as well as the development and production work schedules, together with the grade and mill recovery.

2. Notification

The present model does not perform any automatic verification to notify users when they enter incorrect data. Consequently, it is very important to take the time to verify the entered data.

The results obtained from this model cannot replace a detailed study required for a feasibility study. Natural Resources Canada does not assume any liability for any direct or indirect consequence deemed to have occurred due to the use of the results obtained from this model.

3. Worksheets

The file contains three worksheets: Stope, Development and Drawings. Here are their main functions and a brief description of each worksheet:

Stope: Calculation of the summary of tonnes, grade, ounces from the development and the stope. In this worksheet, users can calculate a required number of stopes in relation to a production objective and an evaluation of the required backfill volume for the same stope.

Development: Calculation of the lost tonnage inside the stope between the drawpoints and the tonnage for different raise configurations.

Drawings: Illustrations of the common mining steps by uppers and breasts.

Please note that the “Stope” worksheet is independent from the “Development” worksheet, except for the physical parameters of the stope.

4. Sections of the model

The “Stope” worksheet comprises four sections and a compilation. The sections appear in the following logical order:

- Physical parameters of the stope
- Stope development
 - Development parameters
 - Required development
 - Development schedule parameters
 - Calculation of the development time
- Stope production calculation
 - Mining parameters
 - Stope life calculation
 - Calculation of production with relation to the number of active stopes
 - Calculation of the number of stopes in the development phase to maintain the production rate
- Backfilling
 - Calculation of the volume to backfill
 - Calculation of the time required to backfill
- Compilation.

4.1 Description of the sections of the model

In this document, a description of the different sections of the model is given for each worksheet, as they appear in the “Excel” file.

4.1.1 “Stope” worksheet

The stope evaluation model is presented in the “Stope” worksheet.

4.1.1.1 Physical parameters of the stope

This section allows users to enter different parameters, such as dimensioning, density, grade and extra dilution to calculate the stope tonnage and milled grade. The entered height must be measured vertically between the lower drift floor and the upper drift roof. If these drifts are already excavated, the vertical distance must be measured from the lower drift roof to the upper drift floor. In the case where no opening is made in the ore, the vertical distance must be measured from the lower drift floor to the upper drift roof.

4.1.1.2 Stope development

- Development parameters

This section is used as a reference to estimate the time required for the stope development under consideration. The entered data in the table must come from the user's operations or from typical sources corresponding to the user's operating conditions. It should be noted that this table is not linked to the other sections of the model.

- Required development

This section is designed to quickly evaluate the generated lengths, tonnage, grade and dilution which are required to calculate the production. The entered data is directly related to the level through which access is given to the working area and through which the excavated material will be hauled.

- Development schedule parameters

This section only deals with development and the data should be entered in the appropriate cells. Depending on the mining operations, the development and production work schedules can be different.

However, it is important to specify that the present model is only designed to give an overview and does not represent a detailed monthly development plan. Consequently, the number of working days per month can comprise a decimal point (250 days/12 months = 20.8 days per month).

The entered percentage for contingency purposes must reflect the mean deviation observed during the development phase of the user's operation. This percentage will be used to calculate the stope development time estimate.

- Calculation of the development time

The same table is reproduced for the upper and lower levels to allow users to enter the schedule, productivities, the estimate of the required number of days for the various installations, as well as the sequence.

The total time for the development work is usually influenced by the lower level because it controls the access to the stope, in addition to all material and muck handling for the entire development between the two levels. The entered sequence in the last column of both upper and lower levels must represent the critical path. It should be noted that the sequence does not take into account the availability of the development teams unless users wish to control it with the sequence. The model also allows to carry out parallel developments by using the same corresponding value. The estimate of the time required for the installations corresponds to predictable delays.

Lastly, a summary of the estimate of the time per level also shows the contingency calculated on the basis of the total days required. After having calculated the total per level, the highest result of the two levels is then entered in the "Development time" cell.

4.1.1.3 Stope production calculation

This section is used to calculate the predictable production rate in relation to the planned development, mining and ore drawing productivities. The development estimates are based on the data and calculations from the previous sections.

The calculation approach includes four subsections, namely:

- mining parameters;
- stope life calculation;
- calculation of production with relation to the number of active stopes; and
- calculation of the number of stopes in the development phase to maintain the production rate.

The results from the first two subsections are entered in the compilation at the end of the "Stope" worksheet. However, the last two subsections are presented for guidance purposes only in view of the fact that all stopes are assumed to be identical.

- Mining parameters

In this section, users must enter the productivity data, the number of men per shift, the number of shifts per day, the number of working days per month and the milling days per year. It should be noted that the number of working days per month represents an average just like in the “Development schedule parameters” section.

- Stope life calculation

This section uses the data already entered to calculate the stope life for production purposes. However, users must enter the following data:

- The lost tonnage between the drawpoints; and
- The drawn tonnage per shift in the final mucking phase.

The stope life in the production phase represents the time where miners are working in the stope. The final mucking time of the stope corresponds to the time required to draw the residual tonnage once the miners have finished mining the stope.

It should be noted that the drawing rate during production is directly proportional to the manpower productivity in the stope and to the swell factor. As to the final mucking time, it is generally attributable to the equipment drawing capacity, to the hauling distance between the stope and the dumping point, as well as to the equipment flow in the haulage drift. This estimate must be entered in the model in the “Tonnes/shift (final mucking of the stope)” cell.

The lost tonnage between the drawpoints is sometimes difficult to evaluate. To help users perform this calculation, it is suggested to use the “Physical parameters” section in the “Development” worksheet. This item will be explained in subsection 4.1.2 of this document.

The model subsequently calculates the time required to muck the rest of the stope in terms of working days or months, allowing users to prepare the work schedule for the stope.

- Calculation of production with relation to the number of active stopes

This section calculates the required number of active stopes to achieve a production objective. This objective takes into account the drawn tonnes during production and final mucking.

It is important to mention that the model assumes that the work schedule is the same for production and ore mucking, and that the configuration and the productivity are the same for all stopes. Consequently, the calculated tonnage in this section helps to quickly arrive at the approximate number of required stopes. It is therefore important to bear in mind the “production/final mucking” ratio which is characteristic to an operation as it takes into account the configuration, the mucking capacity and the planned dilution.

- Calculation of the number of stopes in the development phase to maintain the production rate

In the previous section, a number of active stopes was estimated. On the basis of this number and the data related to development, the model subsequently calculates the number of stopes to plan in the development phase to maintain a constant production rate in shrinkage stope.

It is also important to mention that this estimate assumes that the work schedule is the same for production and development, and that the development time is the same for each stope. Consequently, the estimate calculated in this section will merely help users to visualize the impact of the development sequence on production. This is due to the fact that the development planning of a mine generally involves several teams and several stopes.

4.1.1.4 Backfilling

The “Backfilling” section is used to instantly evaluate the volume to backfill and the required time. For numerous mining operations, it is not necessary to fill in this section in view of the fact that they do not backfill their empty stopes.

- Calculation of the volume to backfill

The model uses the mined tonnage from the stope to evaluate the volume to backfill. In order to obtain better results, users must enter the dimensions of the other openings which are backfilled at the same time as the stope to arrive at a representative total volume. The tonnage conversion into volume (m^3) is calculated on the basis of the density of the in situ rock (t/m^3).

- Calculation of the time required to backfill

In this section, users must enter the parameters for the construction of various barricades and the data related to the backfilling time. The model calculates the total time required

(barricades and backfilling) for the stope on the basis of this data. The calculation of the time in terms of months is based on the development schedule.

4.1.1.5 Compilation

The “Compilation” section gathers the various pertinent data to conduct an economic evaluation of the stope and its development. In this entire section, users only have to enter a single data, namely the mill recovery percentage to calculate the produced ounces in order to evaluate the revenues and the costs per ounce.

4.1.2 “Development” worksheet

This worksheet is divided into two parts: the first one deals with the tonnage calculation and the actual spacing between the drawpoints, and the second one illustrates the different raise configuration possibilities.

4.1.2.1 Drawpoint parameters

The purpose of this section is to calculate the ore tonnage that cannot be recovered between the drawpoints in certain cases, in view of the potential rock fall hazards.

- Physical parameters

The stope dimensioning parameters are already entered in view of the links created with the “Stope” worksheet. Users must pay special attention to the following drawpoint parameters:

- planned spacing;
- width;
- length; and
- friction angle of the ore.

The table appearing under the drawpoint parameters shows three typical drawpoint configurations, that they be present or not at both ends of the stope. Users only have to enter the number of drawpoints for the stope in question and the model will calculate the actual spacing between the drawpoints, as well as the residual ore tonnage between them. This tonnage can then be entered manually in the “Stope” worksheet in cell “D118” to obtain a representative estimate of conditions to be expected.

4.1.2.2 Raise configurations depending on its position in relation to the stope

- Central raise in the ore

This section is used to calculate the actual length of the raise with relation to the dip and the vertical difference.

- Central raise in the waste in a wall with regularly spaced sub-levels

In some mining operations, the raise can be situated outside the mineralized zone and is normally parallel to the vein. In that case, a small sub-level is necessary to connect with the stope at regular intervals. This section then allows to control the dip of the raise, as well as the dimensions and the number of sub-levels to obtain the actual spacing between them. Afterwards, users only have to enter the number of sub-levels to obtain:

- the actual vertical spacing between the sub-levels;
- the actual thickness of the pillar between the raise and the stope; and
- a compilation of the lengths and the produced tonnage from the sub-levels and the raise.

- Raise in the ore at one end with sub-levels

This section is used in the same way as the previous section while, at the same time, taking into consideration the grade of the mined ore.

This approach is used when a raise is common to two stopes. It is then possible to mine both stopes simultaneously with a single access.

5. Using the model

The shrinkage stope evaluation model allows to calculate:

- the lengths, tonnage, average grade and produced ounces through stope development;
- the development time of that stope in relation to the entered sequence;
- the stope life (active and final mucking);
- an estimate of the required number of stopes to achieve a production objective;
- an estimate of the number of stopes in the development phase to maintain a production rate; and
- a compilation to be used towards the economic evaluation of a change in the mining method.

On the basis of this data, it is possible to quickly evaluate the required number of stopes to obtain a production rate, as well as the required number of stopes in the development phase to maintain it. Obviously, this evaluation cannot replace a detailed study, which examines the entire mine, but it allows to easily identify possible improvement alternatives.

In the “Stope production calculation” section of the “Stope” worksheet, a quick evaluation method, using ratios to determine the required number of stopes, is not often used within the industry. However, the latter has the advantage of being able to compare different alternatives very quickly, which allows to verify whether or not the planning objective can be achieved during production. For an operating mine, the ratios must be calculated on the basis of the annual production planning.

Finally, the “Development” worksheet allows to easily calculate the different drawpoint alternatives which are always present when designing the stope. It is important to point out that, in the event where users are unable to recover the broken ore in front of the drawpoints inside the stope, the base of every ore stockpile left between the drawpoints will then have to overlap. Users must accordingly enter a very low drawpoint width to characterize this instance. The calculation method will be valid up to a width equal to ‘0’.