DPM Double Post Mining

Disrupt# Mining 2018

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DPM Mining Presentation

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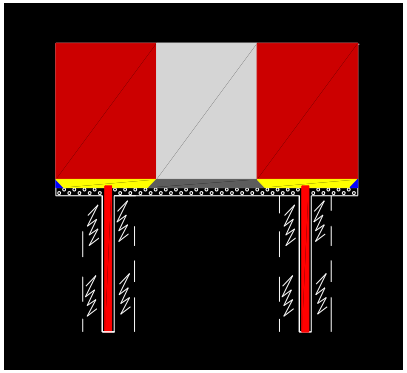
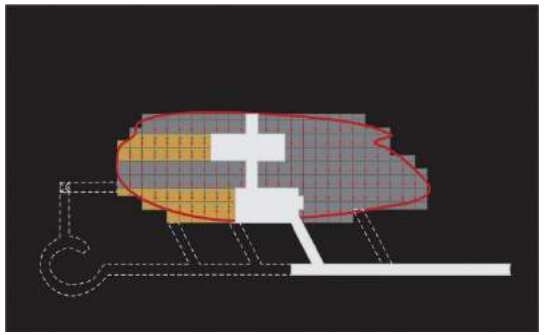
DPM Inventing a New Mining Method

- **Introduction**: C Gryba has invented, patented globally and then lead a team of mining and backfill experts to extensively computer model the new top down DPM mining method, detail engineer the DPM system components, designed a 24 inch diameter post hole drill, and then successfully supervised a 30 room **proof of concept** test mine with Penoles in Zacatecas Mexico over a 4 year period.
- **Potential $ Impact on the Mining Industry for mid sized high grade orebodies**: Current example: over the past 3 years a new 100 million ton base metal orebody has been drilled off and PEA modelled at a 10,000tpd mine mill rate; 20 year life, $500 million Capex, assuming blasthole stoping at $45t, total operating costs of $60t with about 15% dilution and 80% ore recovery of the NI 43 101 geological block model. DPM can easily reduce dilution by 10% and increase ore recovery by 15% vs blasthole stoping. The effect on the after- tax ROI NPV is as follows:
    - **The PEA HG option gives a ROI of 42% with a NPV@8% of $1,300,000,000**
    - **A DPM PEA would give a ROI of 56% with a NPV@8% of $2,050,000,000**
- **DPM is a "Step Change" or "Disruptive Technology**" that on a financial basis can easily increase the after tax NPV of an orebody by 50% by just reducing dilution and improving mine recovery. DPM provides a new platform for advancing remote, mechanical, robodic or autonomous mining as explained in the following 4 pages.
- **The Pitch**: negotiate a $1,000,000 investment to advance the DPM mining method. Mining under a concrete roof is an improved, safe work environment for women; mining, geology and automation students can advance the DPM computer modelling; and elimination of 10% dilution reduces the carbon footprint by 10%.

DPM Creating a Mining "Spreadsheet"

- Three main concepts were required to invent the new mining method – mainly pre posting the next lower lift of mining, developing a continuous posting concrete floor system and making the backfill self supporting so it doesn't crush the posts.
- The easiest way to visualize DPM mining is imagine excavating a car parkade from the top down with 6m high posts and filled with cemented rock fill (CRF).
- The 1st thumbnail slide below shows, drifting trough ore to install a 7.5m grid of 400t capacity pre-caste posts and pouring a concrete floor on top of the posts.
- The center slide shows mining the 2rd DPM lift with the double posting in place and the 1st lift tight filled with CRF; mining is ideal for battery powered equipment.
- The 3rd side shows a plan view of 15m wide panel mining under the pre posted concrete roof using ramp access to mine the entire 6m lift to the limits of the orebody. Backfilled panels become temporary pillars allowing 100% ore extraction.
- **The red dots on slide 3 are the posts that match the corners of 1,200t ore blocks.**

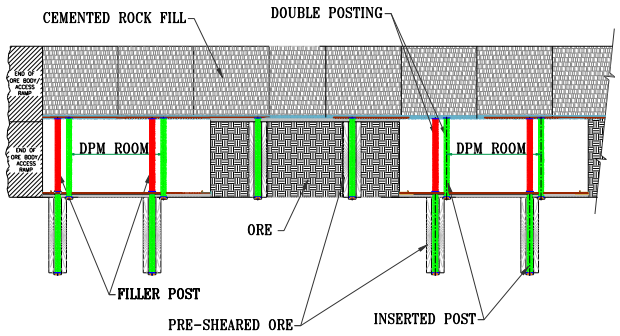


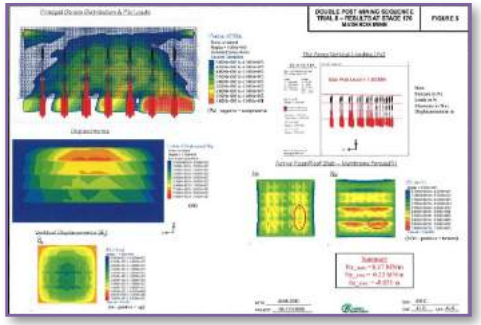


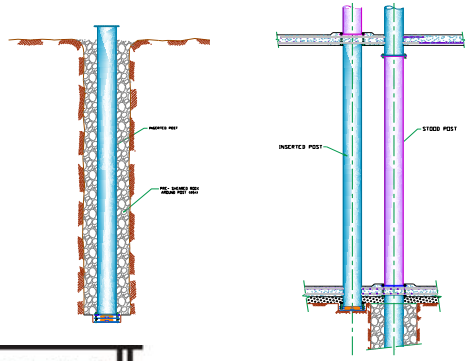
DPM Double Post Mining

DPM Backfill “CRF Silo” Solution

- To generate a “mining productivity” breakthrough; DPM is designed to mine panels 2 or 3 geological blocks wide or 15 to 20+ meters wide, with the CRF designed to self support thus not crushing the posts and concrete roof.
- A model of a 60m wide x 80m long x 60m high orebody; was computer mined round by round using 10 different % cement mixes of paste or CRF backfill. The 10 runs took 45 days of computer calculation time; a very “**big data**” analysis.
- The optimum solution generated was that if 6% CRF was allowed to move 25 to 50 mm it would be mainly self supporting and only load the posts 150 to 200 tons. A compressible concrete post was designed by bolting a module of 400t capacity plastic springs to the bottom flange; load cells monitor loading.
- The 1st slide below shows a section view of DPM panel mining, the center slide shows the FLAC 3D modelling and the 3rd and 4th – the DPM posts with compression pads. The heaviest CRF loads are on the 1st DPM mining lift.
- **Proof of Concept – mine a 15m wide panel on a 1st DPM mining lift.**







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DPM Penoles "Proof of Concept"

- Penoles from Mexico funded a DPM feasibility study, the backfill modelling, plus detailed engineering, purchased the equipment and contracted test mining of 30 DPM 1200t ore blocks. The pictures below show the DPM design is conservative.
- The 1st slide below shows the Cubex – Sandvik "automated" designed 24 inch ITH drill set up to drill a 6m post hole. A DPM post hole can be drilled in 2 - 3 hours.
- The 2nd slide shows pouring a section of the concrete floor on top of the posts. DPM designed a fiber optic – 3D load cell package with cables installed in the posts to measure in real time the loading on posts, floor steel, stope walls and in the CRF.
- Slides 3 and 4 shows pictures of the DPM posts exposed when mining a 2 room wide panel under the concrete roof; pictures are at 90 degrees to each other.
- Because DPM mines 6m high lifts – close to 100% ore recovery is possible as thin areas or narrow veins at the edges of the orebody can be mined conventionally.




DPM Autonomous Mining Platform

- DPM creates a mining “spreadsheet” that connects all the traditional mining “big data” from “mining silos” to create a higher productivity; safer mining system and the “life of mine” plan can be updated daily using the geological block modelling program with new drilling, production or milling or cost data.
- allows close to 100% geological recovery of a suitable orebody with close to zero CRF or waste rock dilution except a bit along the perimeter walls.
- To cost a DPM mining only requires costing 1 DPM ore block using dr & CRF fill and 1 DPM ore block mined under the concrete roof. The example 100 million ton orebody would have 20,000 blocks mined with drift & fill mining and 60,000 DPM rooms. You can design “robots” to do the same thing 60,000 or more times.
- To efficiently remote or autonomous mine you require fiber optics – wiffy and camera coverage close to the mining face. The DPM compression pad is unbolted prior to bolting the top of the





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DPM Inventing a New Mining Method

- **Introduction** : C Gryba has invented, patented the system globally and then lead a team of mining and backfill experts to extensively computer model the top down DPM mining method, then detailed engineered the DPM system components, built a 24 inch diameter post hole drill, and than completed a 30 room proof of concept test mine with Penoles in Zacatecas Mexico over a 4 year period.
- **Potential $ Impact on the Mining Industry**: An example; over the past 3 years an new 100 million ton base metal orebody has been dilled off and a PEA modelled $500 million Capex for 10,000tpd mine mill rate, blasthole stoping at $45t, 10 -15% dilution and 80% recovery of the NI 43 101 geological block model with $200 ore.
    - **The PEA gives a ROI of 27% with a NPV@8% of $1,200,000,000**
- **Disrupt Technology** : DPM at the can mine the same areas of the orebody over the same 20 year life with at least 10% less dilution and recover 15% more of the geological block model tonnage with the same CAPEX and mine - mill cost of $45t.
    - **A DPM PEA would give a ROI of 37% with a NPV@ 8% of $1,700,000,000.**
- **DPM is a "Step Change Technology**" : on a financial basis by increasing the NPV 60% by just reducing dilution and improving mine recovery; cost a single DPM room and you have costed the entire orebody. On a technical basis DPM is more "Disruptive" as it provides a "real time" fiber optics platform for remote mining, robodic or autonomous mining and uses the power of a proven geological software packages to immediately update the life of mine financial plan.

DPM Inventing a New Mining Method

- Introduction : C Gryba has invented, patented the system globally and then lead a team of mining and backfill experts to extensively computer model the DPM system, then detailed engineered the system components, built a 24 inch diameter post hole drill, and than completed a 30 room proof of concept test mine with Penoles in Zacatecas Mexico over a 4 year period.
- Potential Impact on mining industry: The bottom line is that new mining method has to improve the economics of an orebody – this incudes safety, improving ore recovery and mine life, reducing dilution, increased miner productivity per manshift and shorter preproduction CAPEX work.
- DPM is designed to mine mid sized orebodies from the top down in 6m high lifts
- C. Gryba has invented and designed the first modern Autonomous Mining Platform using the “big data” information from the “silos” of R&D and technical information built up over the past 30 years.
- C. gryba has developed a new mining system, method or platform that mines the orebody in horizontal lifts to the limits of the ore zone at every 6m elevation. The top 6 meters of the orebody is mined in any horizontal direction by standard drift and fill mining using cemented rock fill (CRF) as backfill. DPM mines 1,000tthis incudes improved safety and productivity, improving ore recovery and mine life, reducing dilution, increased miner productivity per manshift and shorter preproduction CAPEX work. A modern mid sized mine could use a combination of blasthole stoping with paste fill, room and pillar mining with 25% non recoverable pillars or drift and fill mining with paste of CRF.

- Where the orebody is more than 10m thick or wide, 3 additional steps are added prior to backfilling; namely, drill .5m diameter x 6m deep post hole on 7.5m centers, inset a 400t capacity pre-caste concrete post in each hole and pour an concrete floor on top of the posts prior to filling with jammed CRF.
- C. gryba has invented a simple way to overlap the concrete floor steel to create a continuous concrete floor to the limits of the orebody on that 6m lift. When you go to mine the next lower 6m lift; you have a continuous concrete roof supported by the grid of 400t capacity posts. The continuous roof allows panels 15 or more meters wide to be mined in any direction.

DPM Inventing a New Mining Method

- C Gryba has invented, patented the system globally and then lead a team of mining and backfill experts to extensively computer model the DPM system, then detailed engineered the system components, built a 24 inch diameter post hole drill, and than completed a 30 room proof of concept test mine with Penoles in Zacatecas Mexico over a 4 year period.
- C. gryba has ivenetd and designed the first modern Autonomous mmining platform using the silo's of big data The new mining method is mining a 800 to 1200t cell spreadsheet and mines orebodies from the top down under a pre posted concrete floor, the space between the 7.5m grid of 6m high concrete posts matches the corners of the geological blocks in 3D space.
- Typical competitive mining methods such as blasthole stoping with paste fill or room and pillar mining have 5 to 25% dilution and recover 80 to 90 % of the geological tonnage. DPM's stoping plan is the geological block model thus DPM recovers 100% of the ore on a 6m lift with only a small amount of wall rock dilution on the perimeter blocks. Internal waste or low grade blocks can be mined used for backfill thus maximizing the grade to the mill.
- The following 4 pages describe the "disruptive" new, totally different mining method or platform that solves many difficult mining problems. For example, DPM is designed to mine 100% of the orebody or stoping area in 1 pass of mining from the top down with no pillars. Safety is enhanced as other than 1 lift of traditional drift and fill mining all other mining to the bottom of that stoping area is under a pre posted concrete roof that is totally instrumented to monitor backfill, concrete floor and post loads loads in real time.
- Mining Economics 101: The bottom line is that new mining method has to improve the ROI NPV economics of mining an orebody. The DPM mining method allows mining close to 100% of the geological model of a orebody with close to zero dilution and no pillars.

DPM Inventing a New Mining Method

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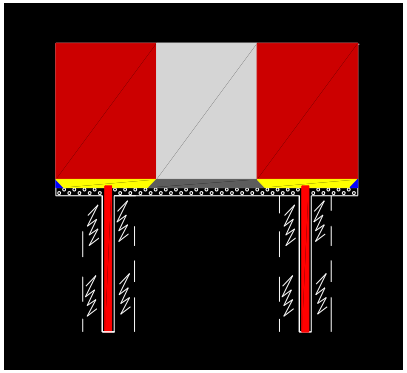
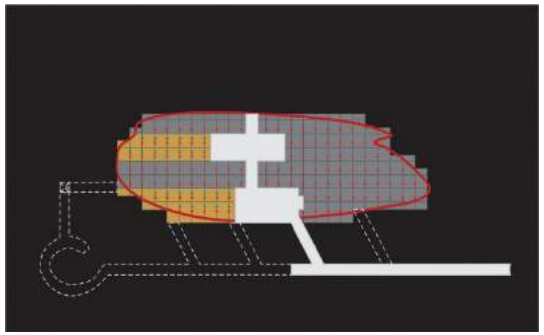
DPM – Simple Mine design

- DPM mines a 7.5m x 7.5m x 6m high geological block model from the top down. Rerunning the geological block model with new data; updates the mining plan.
- The top lift is drift and fill mining with cemented rock fill (CRF) but prior to filling a grid of 6m x .5m diameter pre-caste concrete posts are installed into the next lower and a continuous steel reinforced concrete floor is poured on top of the posts.
- A unique system of alternating 2 posts gives a continuous posting system.
- DPM mining is well suited to battery powered, robotic or mechanical mining as the ore is mined under the pre posted concrete roof. The first cartoon (section views) below shows installing a grid of posts at the corner of each geological block, the second, typical drilling operation on the third DPM lift and the third section, shows mining down 8 lifts using a footwall ramp in white and the yellow ventilation – service raise system caste into the brown colored CRF.





DPM Double Post Mining

DPM

- During the past year; C Gryba has financially modelled a 100 million to base metal orebody that independent consultants using traditional blasthole stoping with paste fill is expected to have 10% to 15% grade dilution and recover 85 to 90% of the geological tonnage. The mineable reserves would then add 5% backfill dilution and recover 95% of stoped tonnage.
- The base case for a 10,000 tpd mine assuming about $500 million Capex, $500 million sustaining capital, $200 ore and $45 operating costs – the Base Case PEA high grade option @ 8% discount rate gave a NPV of $1,270,000,000 after tax and a IRR of 42% over a 20 year life. DPM using the same mining costs but with 10% less dilution and 15% higher mining recovery – gave NPV @8% of $2,060, 000,000 or $790,000,000 higher or 62% higher return for share holders.
- In addition to the increase in NPV – the entire mine was designed for electric trolley or battery equipment. Ventelation requiremts drop 50%, mine developemet 40 to 50 %, a hybreid trolley – battery truck system ramp system was designed to truck 12 to 15,000tpd from to a depth of 1200m. Posts – remove compression pad and install a lidar, camera, survery module – plug into the fiber optic – communication system. Mining under concrete eliminates cut lose raises, long drill holes, cable bolting, 70% of rockbolting, most screening and shotcreteing

DPM

- If every second 15m wide panel is mined and backfilled the intermediate panels than can be mined thus 100% of a 6m lift is mined in one pass of mining – no permanent pillars.
- As with the 1st lift, a post hole is drilled beside every post, a 400t pre caste post installed and on top of the inserted post a filler post is bolted to the concrete roof. Then the floor steel mesh panels are installed, the concrete floor poured and the panel is than filled with CRF.
- Thus simply by alternating 2 pre-caste posts in the same grid location and bolting the posts together allows a continuous posting system to be installed plus all the concrete floors are bolted together making a very strong roof over the mining area.
- Mining an orebody down in 6m lifts makes the orebody shape look like a modem underground car parkade with the space between the floors and posts filled with CRF rather than cars. The natural of miners, rock mechanic and backfill engineers and mining engineers is that the weight of the CRF will simply crush the 400t posts.

DPM

- The “big data” in the “rock mechanics – backfill silo” from modelling blasthole and drift and fill stopes using both CRF and paste fill has generated a lot of data on how backfill and rock mechanics interact. This is where big data provides the solution – you have to make the CRF mainly self supporting, so that the concrete floors and 400t posts can support the residual load without crushing.
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DPM

- The mining industry is concentrating on big data, fiber optics, autonomous equipment from ODM's, cloud storage, from to move the industry forward.
- C Gryba has combined "big data" from a wide range of "siloed" mining technologies to invent a new modern mining method that is designed to provide a platform for efficient mechanical mining, autonomous, robodic or battery/trolley equipment that is totally connected to a fiber optics – camera system – load cell system with real time data feeds to a surface control room.
- Three well proven silo's that C Gryba tapped:
- Geological block modeling programs totally handle all computerized geological information, mill recoveries, cost data and can be quickly rerun and accurately updated as soon as new data in inputted. By setting the geological block size to the mining stope size with the exact same dimensions – the mine plan can be continuously updated for the remaining life of mine.
- The second silo that C Gryba tapped into is the enormous backfill – rock mechanics data base and enormously powerful computer packages that conventional mining methods such as blasthole, undercut and fill and room and pillar and other mining research using paste and CRF; has generated over the past 30 years. The new (DPM) mining method is designed to mine from the top or the ore zone downward, whereby with 1 lift of drift and fill mining allows the installation of a grid of pre-caste posts with a continuous steel reinforced concrete floor poured on top of the posts; all lower lifts of mining is than under a post supported concrete roof. Think of a car parkade with a grid of posts and filled with CRF rather than cars; with mining progressing down under the bottom floor of the parkade which already has the support posts in the next 6m thickness of ore.
- The design loading of car parkade filled with cars is equivalent to having a load of .3m of paste or CRF on each floor. If you load the floors with 6m of paste fill or CRF you would simply crush the posts unless you can make the fill self supporting. Even if the fill is mainly self supporting what would be the residual loading on the posts and the concrete roofs. We laid out a preliminary DPM mine design, .4m x 6m posts, .25m thick concrete floors, 7.5m x7.5m post spacing than computer modelled mining 80 rooms x 6 lifts round by round using 10 different % of cemented paste or rock fill. Each FLAC 3D computer run took 4.5 days on average thus a total 45 days of continuous computing time. To put that in prospective a rock mechanic analysis of a 100,000,000 ton open pit would take perhaps 1 day of number crunching time and a push back could be done over night
- The net result was that if one used typical 6% cemented rock fill (CRF) and allowed it to move 25 to 50 mm it would load the posts to 150 to 200 tons if the posts can compress the same 25 to 50mm.. If the posts can't compress than they would crush. The solution was designing a plastic compression pad assembly that could handle 400t of compression,
- The new mining method is mining a 800 to 1200t cell spreadsheet and mines orebodies from the top down under a pre posted concrete floor, the space between the 7.5m grid of 6m high concrete posts matches the corners of the geological blocks in 3D space.

DPM Proof of Concept Done

- C Gryba invented and patented a new mining method about 25 years ago. The DPM mining method mines 7.5m x7.5m x 6m high stopes from the top down under a pre posted concrete floor with CRF used as backfill.
- The main design parameter that required solving is how to make cemented rock fill self supporting so that the concrete floors and 400t capacity pre-caste concrete posts are not crushed.
- FLAC 3D computer modelling calculated that if 6% CRF is allowed to move 25 to 50 mm; it in effect becomes self supporting over a 15m width and loading on the concrete posts is less than 200 tonnes.
- Penoles in Mexico funded a feasibility study and then a proof of concept 30 room test mine in Zacatecas Mexico. The DPM mining method worked as designed; 400t capacity plastic springs allowed the pre-caste concrete posts to compress up to 100mm thus the CRF and concrete floors stayed totally intact over 15m widths.
- DPM is the only new mining method invented in the past 50 years and mining 800 to 1200 tonne ore blocks from the top down totally changes how one can mine mid sized orebodies like Voisey Bay, Cortez or Pretium.

DPM

- DPM mines an entire 6m lift or ore blocks in one pass to the perimeter of the orebody at that elevation. You cannot have dilution between individual ore blocks, the concrete floor eliminate backfill dilution and perimeter waste rock dilution on a 6m high wall is limited is less than .2m. If you have 200 ore blocks on a 6m lift; wall dilution is 1 % in total which can easily be offset removing the equivalent of 1 room of internal waste or sub ore grade ore.
- Blast hole stoping with paste fill is the standard mining method and a after 50 years since Inco invented the method; a typical mid sized orebody is mined with a minimum of 10% wall rock and backfill dilution and at maximum 85% of the ore is recovered.
- Over the past year a DPM trade off study has been done on a 100 million ton base metal orebody. The financial effect of recovering 100% of the geological ore at close to zero dilution is enormous.

DPM

- The invention of a new U/G mining method potentially changes how one does mine design. Geologist and mining engineering students now have a totally engineered mining method to evaluate with their modelling programs. The geological block model becomes the DPM stoping plan in 3D. Each DPM room is standard thus every component can be computer modeled and all components can be printed out using a 3D printer.
- Remote mining depends on getting fiber optic cables & cameras close to the face so that an operator on surface can see what the machine is doing. Production long hole blasts, secondary blasting of oversize makes keeping fiber optic cables and cameras
- The DPM instrumentation posts are designed with electrical conduit pathways thus if one unbolts the DPM plastic compression pad assembly - a camera, lidar or other instrumentation assembly can be plugged into the fiber optics system and bolted to the 12mm thick steel flange at the bottom of the concrete post that projects ½ meter below the concrete roof. You can easily design to have one or more cameras as close as 7.5m of any DPM face as required.

DPM

- When only looking at saving 10% dilution or increasing the ore grade to the mill by 10% plus mining the same orebody at 15% higher ore recovery – increases the NPV 60% vs the base case that is substantial.
- What other things does the DPM platform disrupt: a 100 million ton orebody has about 80,000 DPM blocks, if the orebody averages 24m thick than 60,000 of the DPM blocks are mined under a concrete roof each with 2 drift rounds or slashes. If you are doing something 60,000 times; exactly the same way you can design a robot to do the work
- Each DPM room is exactly the same; 2 posts, 15m3 of concrete floors, 700t of 6% CRF, 1500 # of floor steel and 1 – 6m deep post hole. The floor steel is ½ inch x 6 inch x 6 inch 8ft x 20ft sheets of welded steel mesh.

DPM

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