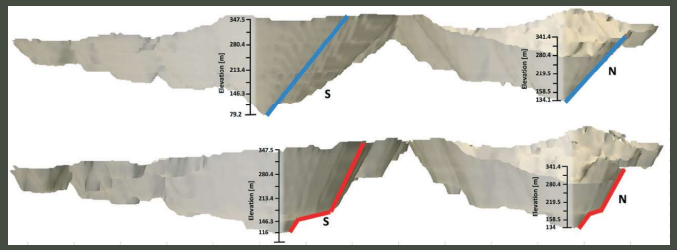
Case study 3:
the McLaughlin gold mine

The work, performed in collaboration with Itasca and SRK Consulting, will be published Open Access in the proceedings of the *Int Slope stability in Mining Conference 2021* in Perth (acgsurfacemining.com/). The block model and economic data for the mine were taken from MineLib, a publically available repository of open pit mine data (mansci-web.uai.cl/minelib/ mclaughlin.xhtml). This means that the design and calculations reported in the paper can be replicated by anyone. The two independent designs were carried out using Geovia Whittle. The results are summarised in the table below.

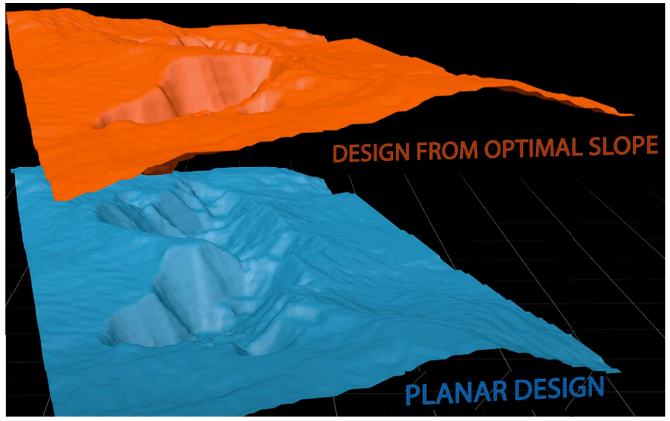
UPL output	Planar pit walls	Optimal pit walls
Ore [Mt]	82.154	72.405
Waste [Mt]	67.559	49.311
SR [-]	0.82	0.68
NPV [USD]	209,359,372	268,562,363
NPV increase [%]	28.3	
Energy: Opt – Pln [MJ]	-6.916×10^{8}	
Carbon footprint: Opt – Pln [Mt CO2 eq]	-1.486	

The Factor of Safety of the profiles calculated by OptimalSlope was verified by stability analyses performed by Rocscience Slide 2 and FLAC3D. The Ultimate Pit Limit obtained are reported below.

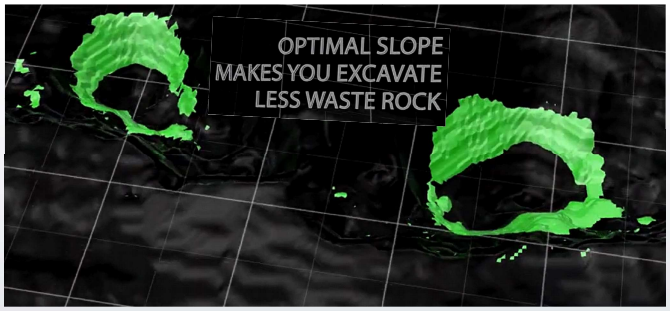


Ultimate Pit Limit of a) traditional design b) design with optimal profiles.

OptimalSlope is a stand-alone application deployed on the cloud.



3D pit obtained from traditional design (in blue) and optimal pitwall slopes (in red).



3D visualisation of the wasterock volume saved by optimal pitwalls (in green).

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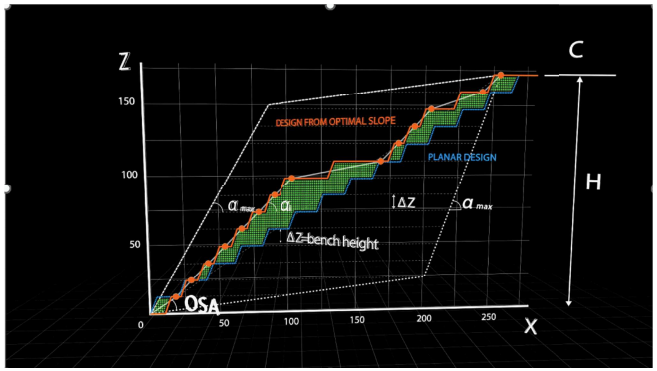
OPTIMAL SLOPE

Software for the determination of optimal profiles for slopes and pitwalls

OUR VISION

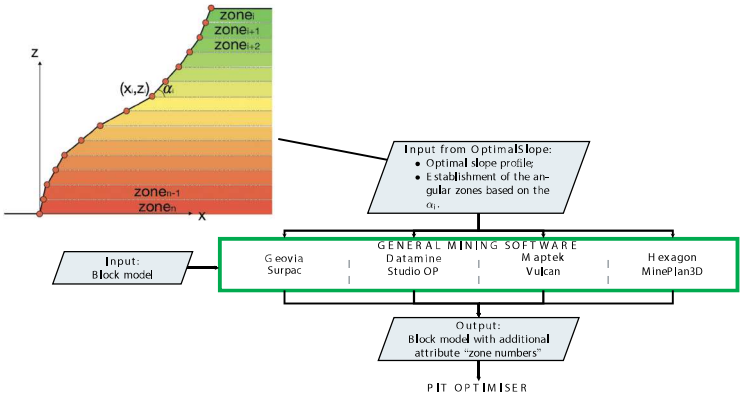
Automating the design of optimal pitwalls
to increase mine profitability
& reduce carbon footprint

OptimalSlope finds the safe steepest profile (i.e. the profile with highest Overall Slope Angle) in each mine sector for an assigned stratigraphy, pitwall height and target Factor of Safety. The geotechnical data (rock strength and unit weight) for each lithology can be specified manually or read directly from the block model.



Comparison between the planar pitwall profile from traditional design (in blue) and optimal pitwall (in red, dots representing the xi, zi coordinates of mid-bench): the green area shows the saved rockwaste.

The output of OptimalSlope is the geometry of the pitwall for each sector which is specified in terms of slope inclination for each row of the block model. Then strategic life-of-mine planning can be performed by the commercial pit optimiser of choice.



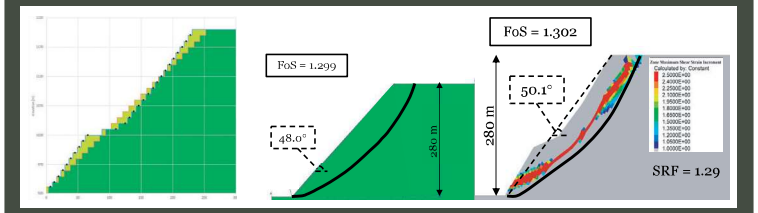
Flow chart illustrating how OptimalSlope interacts with General Mining Software and pit optimisers.

Case study 1: Copper Mine

The work on this case study is published in the SME Journal *Mining, Metallurgy & Exploration*. The block model, geotechnical and economic data were provided by AMTC (University of Santiago, Chile). To showcase the gains achievable by OptimalSlope, two independent designs were carried out using Geovia Whittle: first employing planar pitwalls as per traditional methodology, and secondly adopting the optimal pitwall profiles from OptimalSlope. The results are summarised in the table below.

UPL output	Planar pitwalls		Optimal pitwalls	
	S1	S2	S1	S2
OSA [deg]	48	43.8	50.1	51.3
H_{UPL} [m]	270	220	280	150
Waste [t]	23,707,500		20,651,462	
Ore [t]	59,314,446		59,232,285	
SR [-]	0.40		0.35	
NPV [USD]	34,561,747		46,231,284	
NPV increase [%]	33.8			
IRR [%]	13.9		15.8	
Life [y]	12.22		12.12	
Payback [y]	3.89		3.57	

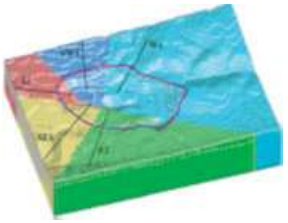
A representative 2D cross-section was assumed for the design of the pitwall in each mine sector. The Factor of Safety (FoS) of the profiles calculated by OptimalSlope was verified by stability analyses performed by Rocscience Slide 2 and FLAC3D in collaboration with Itasca Chile.



UPL pitwalls for sector S1: a) visual comparison between the planar pitwall in orange and optimal pitwall in blue; b) & c) failure mechanism (black line) and FoS determined by Slide2 for the planar and optimal profile; c) shear strains determined by Finite Difference Method with Shear Strength Reduction (FLAC3D) for the optimal profile.

Case study 2: Gold Mine

The work on this case study is published in the *CIM Journal*. The block model, geotechnical and economic data for the mine were provided by Kinross. To showcase the gains achievable by OptimalSlope, two independent designs were carried out (one for the traditional pitwalls and one for optimal pitwalls) using Datamine. Due to the complex geology the pit was divided into five geotechnical sectors, each requiring a different pitwall profile, see below:

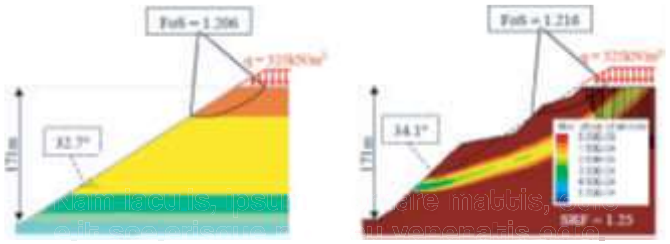


Pit sector	Planar pitwalls	Optimal pitwalls
W1	27	30.8
SW1	34.4	50.1
S1	44.7	44.7
SE1	34.6	38.6
E2	32.7	34.1

The results are summarised in the table below

UPL output	Planar pitwalls	Optimal pitwalls
Ore [Mt]	21,419,848	22,104,813
Waste [Mt]	66,853,379	64,490,746
SR [-]	3.12	2.92
NPV [USD]	26,045,669	39,761,671
NPV increase [%]	52.7	

The Factor of Safety of the profiles calculated by OptimalSlope was verified by stability analyses performed by Rocscience Slide 2 and FLAC3D.



Sector E2: a) planar profile (4 rock layers); b) optimal profile