



**Implementation of innovative mining method
(Underhand Mining below Cemented Paste Fill)
at
Sindesar Khurd mine**



Underhand mining at SKM

Introduction

Under hand mining

Geological settings

Numerical modeling results

After blast results

Conclusions



Introduction | SK Mine

Access

- 2 Declines (5.5m W X 5.0m H)
- Shaft (7.5m dia, 1051m depth, Man & material winding)

Method

- Sublevel Blasthole Stopping with Backfilling (Paste-fill)

Ore extraction

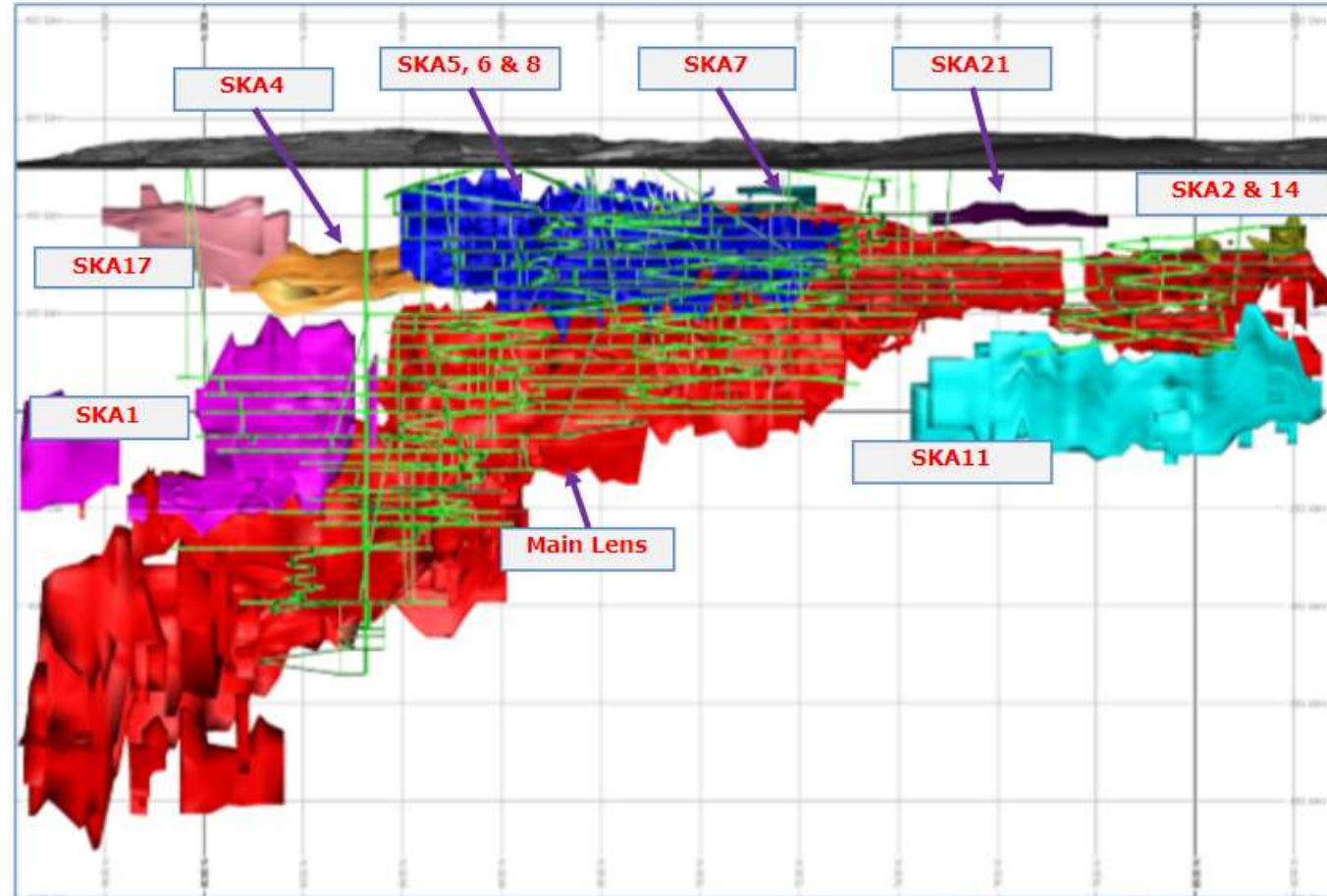
- Shaft: 3.0mtpa
- Declines: 3.0mtpa

Ventilation

- 9 Return Air Raises (1350 m³/sec)
- 10 Fresh Air intakes
- Peripheral type

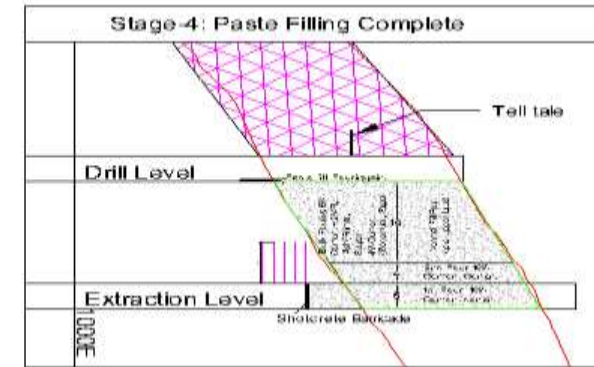
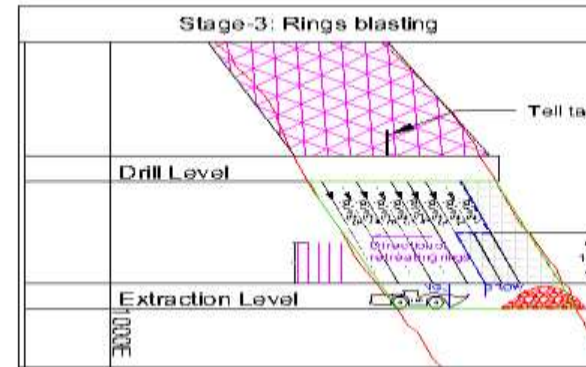
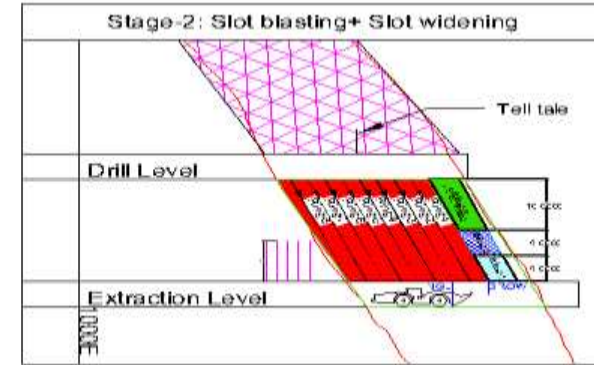
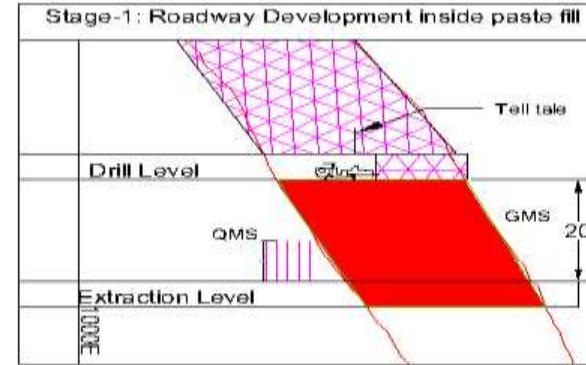
Designing

- Numerical modeling (CIMFR, Beck Engg.)
- Latest Software (Datamine, Deswik, Flac-3D, Leapfrog)



Underhand Mining

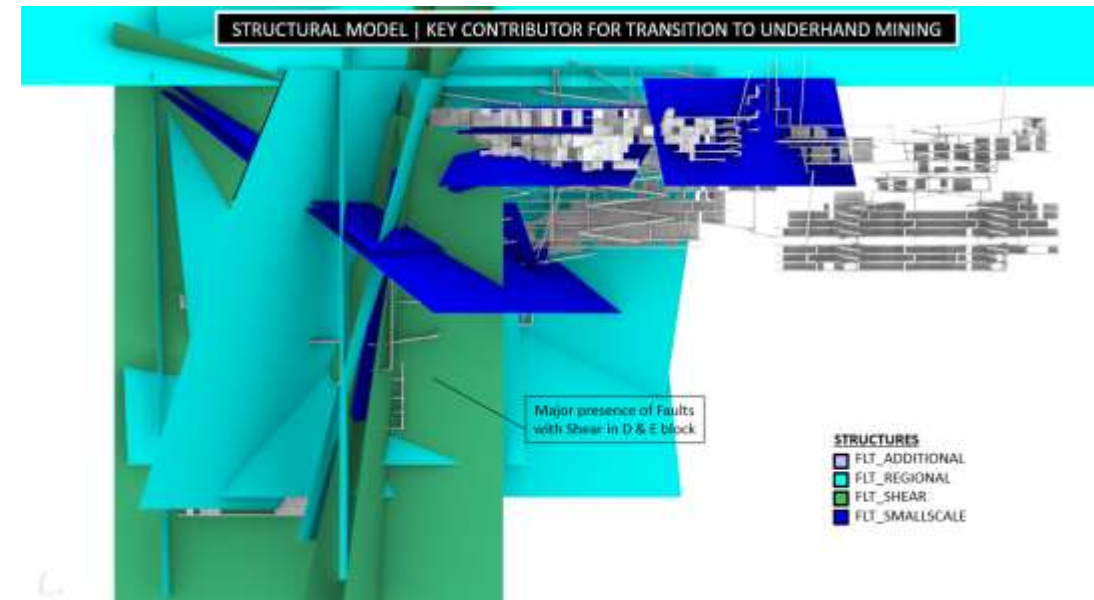
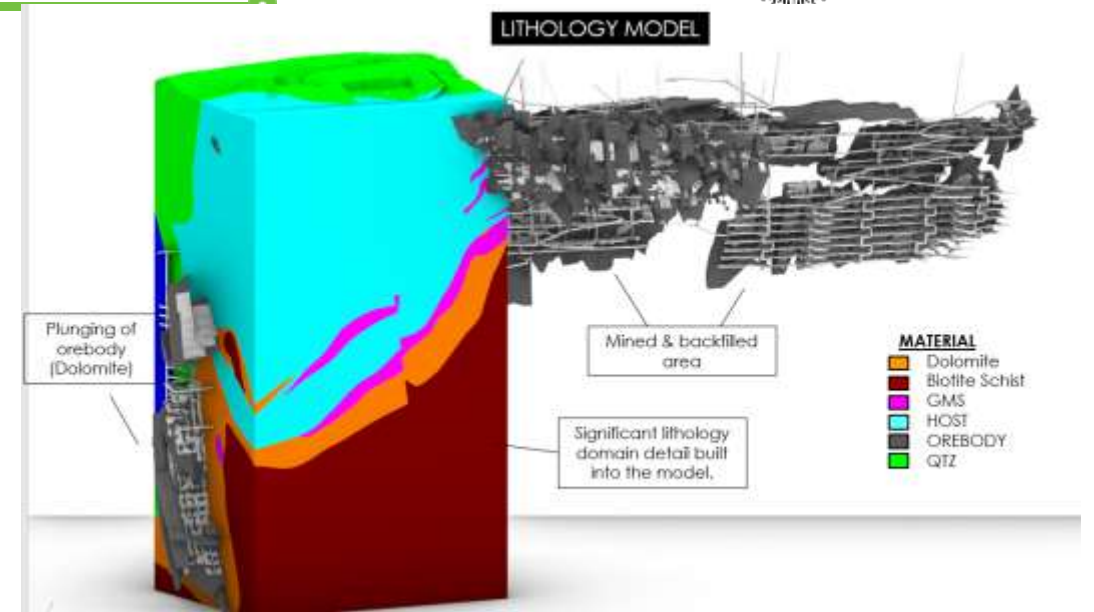
- Underhand mining is used to extract ore in deep high stress mines, allowing mines to manage the stress and minimise development in weak damaged rock masses.
- The top-down sequence involves the development of a roadway inside the CPF (Cemented paste fill) of the overlying stope which has been previously extracted and backfilled. This development is used for production drilling and charging the lower development is used for ore mucking.
- The CPF must be strong enough to permit development mining and prevent failure of the CPF crown exposed when extracting the underlying stope. Monitoring of the stresses and deformation in the CPF during stoping is important.



Underhand mining below CPF

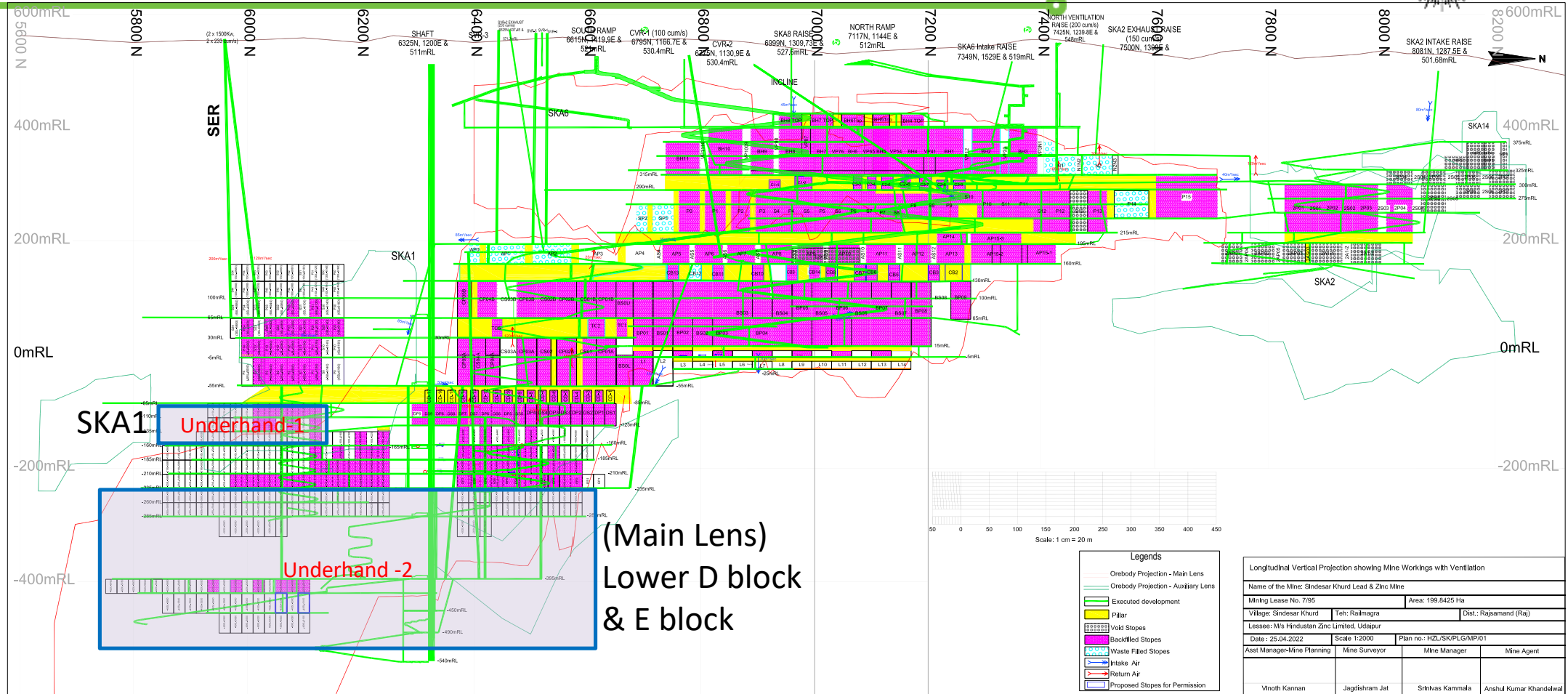
Mine Geology

- The SKM orebody is in the central part of the eastern limb of a major syn-formal fold.
- The lithologies encountered at SKM are.
 - Calcareous Quartz Biotite Schist (1)
 - Calc-Silicate Bearing Dolomite (2) which is the main orebody host
 - Calcareous Garnet Biotite Schist with Dolomite (2A)
 - Graphite Mica Schist (3A)
 - Quartz Mica Schist (3B)
 - Chert/Quartzite (3C)
- The area is structurally complex, and this complexity increases to the south with multiple folding phases and faulting affecting the orebody.
- The orebody widths are typically 30m but with significant variation occurring along strike and dip.
- The orebody strikes between N10°E and N15°E, and the dips vary from 45°-60° to the west to steeply east dipping
- In the southern section the orebody plunges to the south and has a steep easterly dip
- The orebody remains open at depth



Lithology & Structural Models SKM

Challenges as SKM goes Deeper



(Main Lens)
Lower D block
& E block

- The SKM operation has a track record of producing safely from an underground mine for 15 years
- As we go deeper in Lower D block & E block at SKM
 - We are likely to face more structural complexity with increasing folding and faulting
 - Higher stress with increasing depth
 - High anticipated changes in stress in overhand mining
- To continue safe operation in Lower D block & E block, it is required to go for Underhand Mining as per the scientific studies.



Numerical modelling

- Underhand mining may require re-opening of roadways in pastefill. **The minimum strength requirement for enabling development roadways of 5m×5m in paste fill has been evaluated to the 0.78 MPa UCS for a safety factor of 1.5.**
- An SSR using split-sets, wire mesh and shotcrete has been recommended for development roadways of 5m×5m in pastefill.
- While backfilling, a minimum plug height of 9.0m needs to be maintained.
- The modelling results indicate that the **extraction of the orebody directly below a paste filled stopes doesn't cause any significant yielding in the overlying paste-fill material.** In fact, the paste artificial roof shows better stability as compared to the rock mass. Due to the lower elastic properties of the paste-fill material the **stress builds up within the paste-fill is much lower** as compared to the rock mass.
- The **stability of the paste filled stope back** is anticipated to be quite good, in fact **better than the rock mass stope back** for a paste plug fill having a UCS of **1.0 MPa.** Hence considering a **safety factor of 1.5**, the required UCS of plug fill for enabling underhand mining shall be 1.5 MPa.

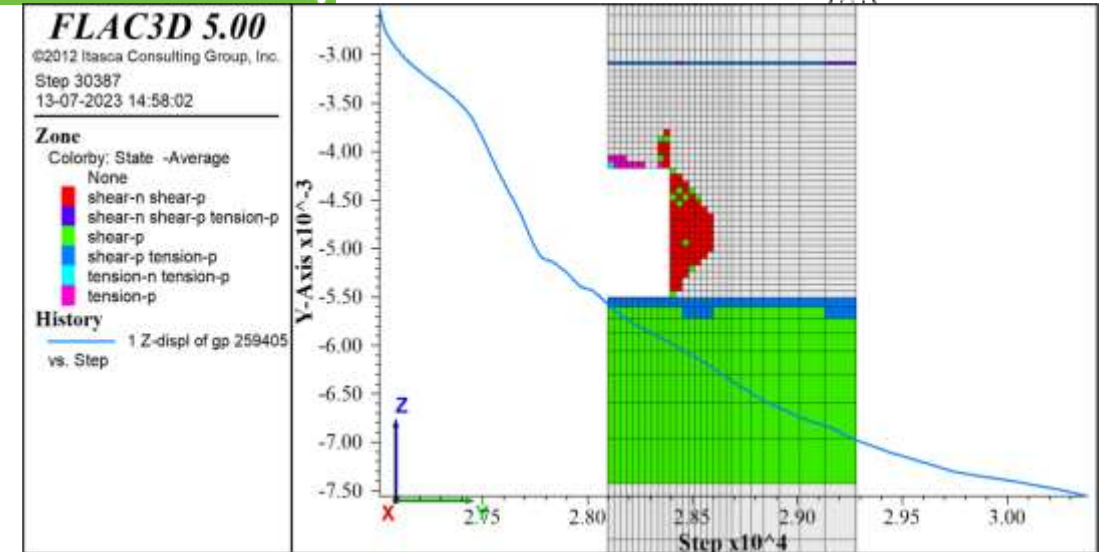
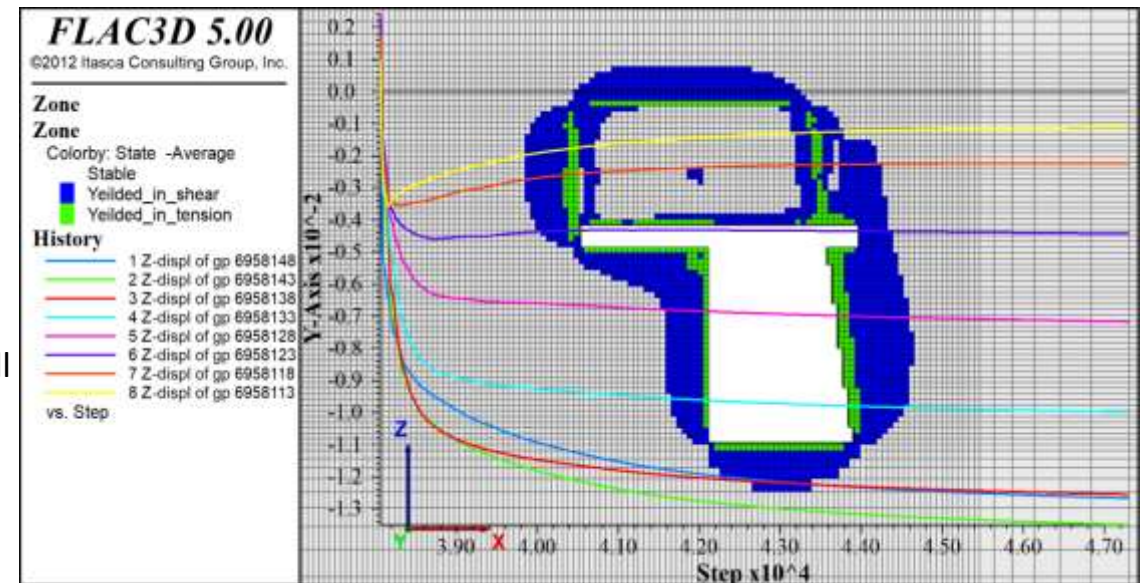
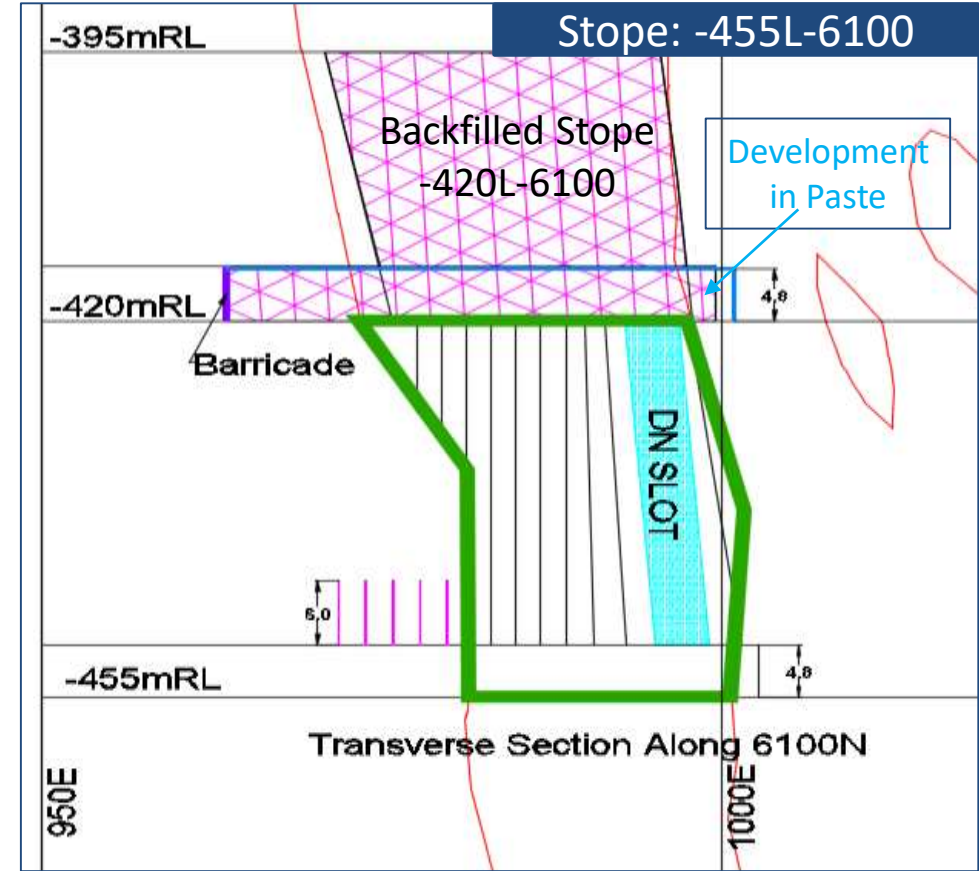
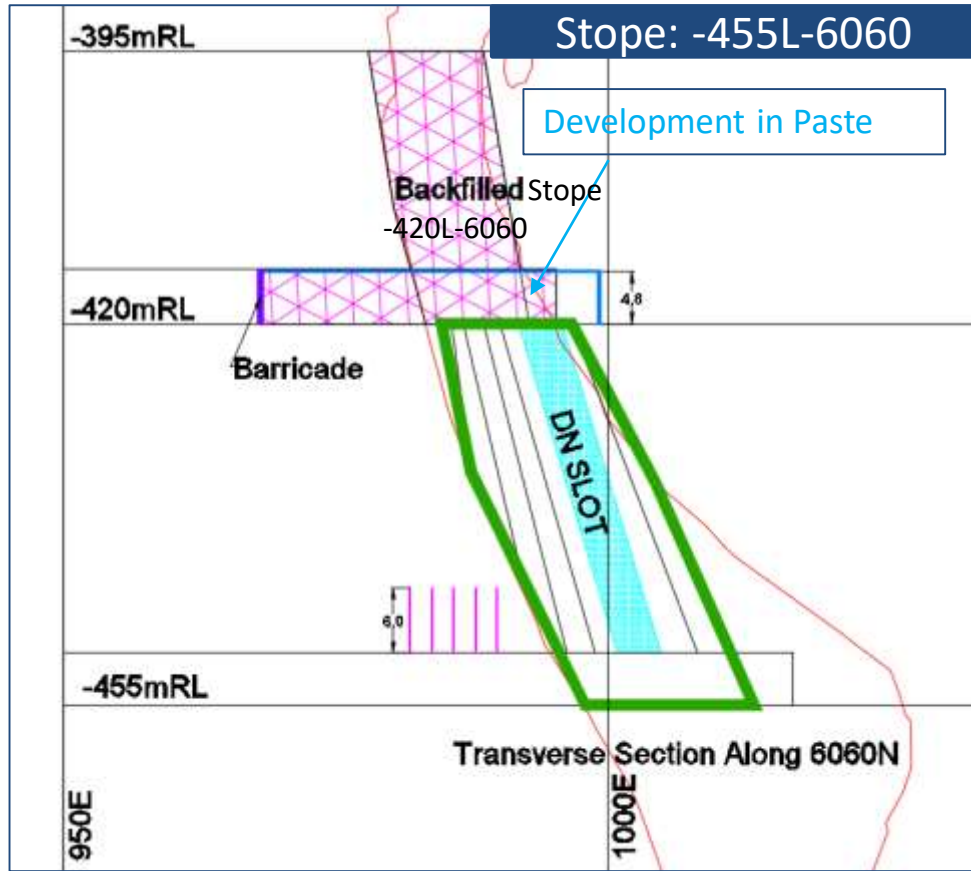


Figure : Roadway of 5m x 5m in plug fill of 9m Plug



Stope Cross-Section

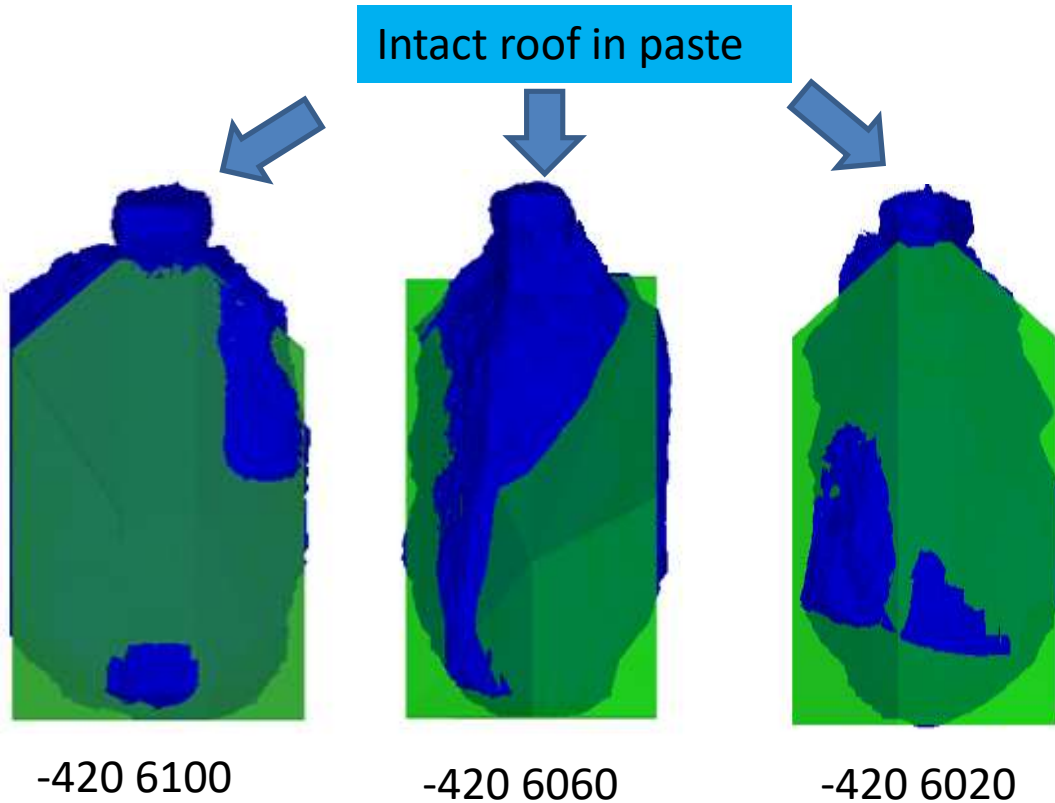


Development & Stopping under Paste fill



CMS results of stope after blasting

No major over breaks were found between actual shape and planned Mine boundary. The CMS scans along with the planned mine boundary are shown in the figures below



CMS scans of the stopes along with the planned mine boundary



HINDUSTAN ZINC
Zinc & Silver of India

THANKS

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