APPLICATION OF A THIN SPRAYED LINER (TSL) IN VCR GULLIES BEHIND ADVANCING STOPE PANELS AT SAVUKA GOLD MINE

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ABSTRACT: In order to address ground condition problems in gullies, the Rock Engineering Department at Savuka Gold Mine tested a thin-sprayed liner (TSL) on the VCR reef horizon. By nature the VCR hangingwall is extremely jointed and incorporates calcite veining, which creates bad ground conditions, especially in back areas of gullies. By applying a thin-sprayed liner on the gully hangingwall we attempted to prevent deterioration of ground conditions. Results from testing indicate that deterioration of the gully hangingwall was arrested where the TSL was applied in back areas and deterioration of the gully hangingwall was prevented where the TSL was applied concurrent behind mining faces.

1. Introduction

Savuka Gold Mine is situated in the Carletonville district of Gauteng Province in South Africa. Two gold bearing reef horizons being exploited are the Ventersdorp Contact Reef (VCR) and Carbon Leader Reef (CLR).

This paper discusses results of testing conducted on a Thin Sprayed Liner (TSL) on the VCR at Savuka Gold Mine. Tests were done in the 31 Line in three (3) gullies situated approximately 2200m below surface. The longwall mining method is employed to extract the ore body. The dip and strike span in the area of concern is 215m and 230m respectively. (See Fig 1)

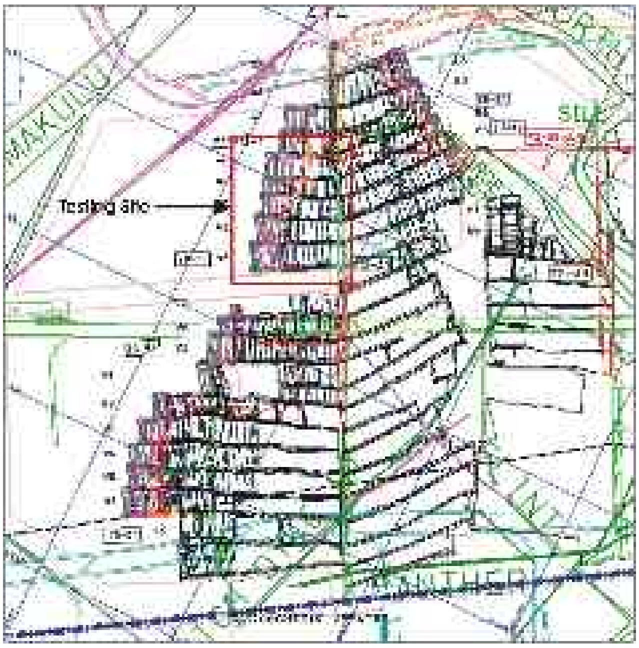

Fig 1: Plan of area where test were conducted.

The TSL was applied in the gullies to attempt to address very poor ground condition of the gully hangingwall. The aim of the test was twofold, firstly to determine whether the TSL would be able to stop further deterioration of the hangingwall in back areas and secondly to determine whether the TSL could prevent deterioration of the hangingwall if applied close behind advancing stope faces.

The product that was tested is TunnelGuard, which is a cementitious super skin membrane with a water-based synthetic latex binder combined with polypropylene micro fibres. The product is non-toxic and non-flammable.

The TSL is applied with a compressed air driven pump and nozzle.

The product is packaged in 25kg and 12,5kg polypropylene bags including the cementitious material and the latex binder.

2. Geology

The immediate hangingwall and footwall consists of Alberton lava and Elsburg quartzite respectively. Alberton lava is normally very competent with a Uniaxial Compressive Strength (UCS) of 268 MPa in general. Elsburg quartzite has a UCS of 282 MPa. Two major joint sets intersect the area striking west-southwest and north south. A number of flow planes are present further reducing the competency of the lava hangingwall. Photo 1 illustrates the condition of the hangingwall in W1 gully. Calcite veining is present on joints and flow planes reducing the cohesion on these planes.

Photo 1: Condition of W1 gully hangingwall.

3. Testing Methodology

As stated the TSL was applied in back areas of the W1 gully where the hangingwall had deteriorated to determine whether it will prevent any further deterioration of the hangingwall. The TSL was also applied close to advancing stope faces, on relatively "fresh" rock, to determine whether it would be able to prevent deterioration of the rockmass as observed in back areas of the gullies. Testing included the following:

- Visual observations by members of the rock engineering department.
- Photographs
- Evaluating effects of seismicity in the area
- Time studies
- Assessment of ease of transportation of aggregate as well as pump
- In-situ bond strength tests
- Assessment of blast damage
- Actual cost R/m^2 for both backlog and current spraying.

4. Results

4.1. Backlog Spraying

Initial testing was conducted in the back area of 70/31 W1 gully where the hangingwall conditions had deteriorated extensively. A total of 86m of backlog spraying were done. The gully hangingwall inclusive of the areas between gully pack support above and below the gully was sprayed. Following application of the TSL no further time dependant deterioration and unravelling of the hangingwall was observed over a 5-month period.

In W5 gully the TSL was applied to the hangingwall as well as the gully sidewalls below the packs. This was done to attempt to prevent scaling of the gully sidewalls below the packs. If sidewalls below the gully pack support start to scale it renders the pack support ineffective which in turn results in poor hangingwall conditions. No further scaling was observed below the gully pack support for the portion where the TSL was applied. Photo's 2 and 3 were taken in W1 gully and illustrate the condition of the hangingwall before and after application of the TSL.

Photo 2: Condition of W1 gully hangingwall before application of TSL.

Photo 3: Condition of W1 gully hangingwall following application of TSL.

4.2. Current Spraying

During the second phase of the testing the TSL was kept close behind the advancing mining faces. Again the gully hangingwall inclusive of the areas between the gully pack support were sprayed. In general the TSL was kept within 10m of the gully face position. Three gullies were sprayed and there was a significant improvement in the ground conditions.
Photo 4 illustrates the condition of the W1 gully where the TSL was applied close to the advancing faces.

Photo 4: Condition of W1 gully hangingwall following application of TSL close to advancing stope face.

4.3. Bond Strengths

Bond strength tests were conducted by Indy Rock as part of a larger SIMRAC project SIM 02 02 06 on TSL's. A small disk (39mm dia.) is glued to the TSL with an epoxy and left for 24 hours to cure. On the following shift the TSL is scored in a square 50mm x 80mm to define the maximum extent of TSL that can be removed and pulled off with a hydraulic pull tester. In total 17 tests were conducted in W1 gully. Photo 5 shows how the pull test is conducted.
Results of pull tests are summarized in Table 1.
The average bond strength was 1.44 MPa with a standard deviation of 0.71 MPa.

Photo 5: Pull tester used to determine in-situ bond strengths.

4.4. Blast Damage

The product is blast resistant and can be applied close to the advancing faces. Minor damage was observed due to the impact of flyrock but is easily re-sprayed.
The concussion and windblast did not result in the de-bonding of the product.

4.5. Transport

The TSL is packaged in 12.5kg polypropylene bags. The bags are robust enough to be transported by means of a mono winch onto the reef horizon.
Material inside the bag is placed in a heavy-duty plastic bag to protect it from water and moisture, however, the product should be stored in a dry area.
On-reef the bags are transported by hand to where it is required. The latex binder is supplied in 2,5 litre bottles and is included inside the bag.
The pump can split into two parts for ease of handling. Two persons are required to transport the pump from gully to gully. During the testing phase a crew of three persons were used to transport and apply the TSL.

4.6. Costs

Material costs were determined for both backlog and the current spraying and the results are summarized in Table 2. A total of 120m of gully hangingwall was sprayed of which 86m was backlog spraying. Seven hundred (700) bags were used for the testing period @ R72/bag.

Table 2: Summary of material costs for backlog and current spraying.

Description	Cost/Lin m	Cost/m2
Backlog	237	72
Current	178	54

The cost/linear metre is based on the 3,3m^2 available area between packs per linear meter of gully. Labour costs must be added if contractors are used to apply the TSL.

4.7. Seismic Damage

On 31 March a seismic event with magnitude 1,5 caused rockburst damage in the W1 gully. The damage was in the form of shakedown from the face of a brow and a portion of the hangingwall. Following the event the area was re-sprayed and no further deterioration was observed to date. One can only speculate whether the TSL reduced the severity of the rockburst damage.

Photo 6 & 7 illustrates the extent of the damage following the seismic event.

Photo 6: Rockburst damage caused to a brow in the W1 gully.

Photo 7: Rockburst damage caused to hangingwall of the W1 gully next to a strike stabilizing pillar.

Table 1: Results of bond strengths in W1 gully.

DISK NO	DESCR	DATE	CURING	Gauge MPa	Piston Dia. (mm)	Disk Dia. (mm)	Thickness (mm)	Rock Surface	Sample Recovered
SVB1	Peg V6763 -1m	09-Feb-04	72Hr+	0.80	30.00	39.00	2.50	Substrate clean	
SVB2		09-Feb-04	72Hr+	1.20	30.00	39.00	2.50	Substrate clean	
SVB3		09-Feb-04	72Hr+	1.40	30.00	39.00	2.50	Substrate clean	
SVB4		09-Feb-04	72Hr+	1.20	30.00	39.00	4.00	Substrate clean	
SVB5		09-Feb-04	72Hr+	1.60	30.00	39.00	2.00	Substrate clean	
SVB6		09-Feb-04	72Hr+	1.60	30.00	39.00	2.00	Substrate clean	
SVB7		09-Feb-04	72Hr+	<0.2	30.00	39.00	3.00	Substrate clean	PBH
SVB8		09-Feb-04	72Hr+	1.80	30.00	39.00	4.00	Substrate clean	
SVB9		09-Feb-04	72Hr+	2.00	30.00	39.00	2.00	Substrate clean	
SVB10		09-Feb-04	72Hr+	2.60	30.00	39.00	2.00	Substrate clean	
SVB11		09-Feb-04	72Hr+	2.40	30.00	39.00	2.50	Substrate clean	
SVB12		09-Feb-04	72Hr+	0.20	30.00	39.00	2.00	Substrate clean	
SVB13		09-Feb-04	72Hr+	0.60	30.00	39.00	2.50	Substrate clean	
SVB14		09-Feb-04	72Hr+	1.60	30.00	39.00	1.00	Substrate clean	
SVB15		09-Feb-04	72Hr+	2.00	30.00	39.00	2.00	Substrate clean	
SVB16		09-Feb-04	72Hr+	1.80	30.00	39.00	1.50	Substrate clean	
SVB17		09-Feb-04	72Hr+	0.20	30.00	39.00	1.00	Substrate clean	
SVB18	CALIBRATION	09-Feb-04	72Hr+	4.60	30.00	39.00		Substrate clean	Rock failed in tension
Average				1.44					
Std. Deviation				0.71					

*PHB = No gauge reading possible - sample de- bonds by hand pulling or thread tightening

4.8. Time Studies

The time to perform different operations is summarized in table 3.

Table 3: Time taken for different operations.

Description	Time
Transport machine from gully to gully	Av. 3 hr's (Dependant on conditions and distance)
Preparation to spray	20 min
Spraying of TSL	30 min/20m^2
Rig down and clean	1 hr
Setting time of TSL	4 hr to blast on

5. Advantages and Disadvantages

Some of the advantages are:

- Prevents time dependant deterioration of gully hangingwall.
- Stops further deterioration of damaged hangingwall.
- Prevents scaling of gully sidewalls below the packs.
- Serves as an early warning indication of ground movement, i.e. when cracks start to appear in the TSL.
- Reduces time spent on early examination.
- Prevents costly rehabilitation of back areas with sets estimated @ R800/m excluding labour cost.
- Reduces the risk of FOG or a rockburst and associated accidents.

Some of the disadvantages are:

- Additional transport of material in vertical and horizontal sections.
- Interrupts production cycles if not planned properly.
- Workers can become complacent on drilling and support standards.

6. Risks

Some of the risks or unintended consequences identified during the testing phase include the following:

- Substrate preparation is very important. If substrate is not barred and washed properly it has an adverse affect on bond strength. People can then work under hangingwall that is not supported.
- False sense of security where TSL was applied which resulted in poor support installation and blasting practices.
- If contractors are used there can be a focus on revenue generation to the detriment of quality.

7. Conclusions

- TSL is blast resistant and can be applied close to the mining face.
- Substrate preparation is very important. The rock mass must be properly washed before application to prevent poor bond strengths.
- TSL stopped the deterioration of the gully hangingwall conditions where applied in the back areas.
- TSL prevented deterioration of the gully hangingwall and sidewalls where applied concurrent with the advancing faces.

8. Acknowledgements

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9. References

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