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RECENT DESTRESS BLASTING WORK AT THE LAISVALL MINE, SWEDEN

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ABSTRACT

Destress blasting was carried out in order to relieve high horizontal stress and to alleviate roof bursts in the Laisvall Mine, Sweden. The mining method utilized in the mine is room and pillar. Measurement results gave indications that it was not only a single mechanism of destressing that became active, but also other mechanisms were contributory.

1 INTRODUCTION

The Laisvall Mine, located in northern Sweden, is a lead and zinc mine. It is owned by the Boliden mining company. The ore is extracted by the room and pillar method. The height of the rooms normally vary between 3 to 7 meters. Due to local and unusual increase in the thickness of the ore body, however, the height of the rooms may reach up to about 24 m. At these locations the ore is mined out by blasting two or even more benches. The width of the drifts and the rooms vary between 8 to 15 meters.

Along with the mine development, since about two decades ago, rock bursts with varying intensity have occurred in the mine. Roof caving, floor heave and bursts of working faces have interrupted the production and lessened the security of the personnel. Relatively high horizontal stress together with the geology are judged to be responsible for the bursts.

It has been observed that bursts occur more frequently in transport drifts with certain directions. It has thus been a remedial measure to orient the major transport drifts at right angle to the direction of the major horizontal stress. In this way the production drifts run along the direction of the major horizontal stress. This measure, however, has not removed the problem. Destress blasting has therefore been adopted to mitigate the bursts, Krauland and Söder(1988).

This article describes a fairly recent destress blast operation which was carried out at the Central ore body, figure 1.

2 MINE GEOLOGY AND THE IN-SITU STRESSES

Lead and zinc deposit occurs in a sandstone formation. The thickness of the formation reaches up to about 40 meters.

The sand stone is interrupted by clayey shales, conglomerates and thin clay bands. The formation is very permeable at some locations.

In-situ stresses have been measured in the mine as early as in 1952. Measurements of stresses obtained by different methods later on were all in good agreement. The major principal stress S1 is horizontal, about 22 MPa and has a direction of N60-70E at the measurement point. The direction of S1, however varies significantly within the mine. The minor principal and horizontal stress S3 is about 9 MPa.

3 THE TEST SITE

The test site is located within the Central ore body and is shown in fig. 1. A cross section of the mine at the test site is shown in figure 2.

When the top bench of the room 19WE was mined out the roof bursted. The depth of the fall-outs reached up to 1.5 m (fig. 1). As soon as the production-blasting of the lower bench started, the roof bursts were intensified. Mining of the lower bench was stopped and it was decided to carry out destress blasting at the site.

4 THE BLAST DESIGN

In order to destress the roof of the room 19WE, 3 rows of bore holes with a bore hole diameter of about 50 mm and a length of 6.7-6.8 m were drilled, obliquely and upwards, from the room 20 WE and into the rib pillar that lies between rooms 20WE and 19WE, fig. 2. The distance between bore holes in each row was about 1.25 m and they covered a length of about 23 m along the pillar.

Each bore holes were charged each with 1 Kg of Bonagel in the bore hole bottom. Bonagel has a detonation velocity of 7500 m/sec. Nonel detonators with a 100 m sec. delay time were used. More details about the blast design is given in Taube et al.(1991).

5 INSTRUMENTATION

6 extensometers were installed in bore holes drilled parallel to the blast holes. Four out of 6 extensometers, Ex1, Ex2, Ex3 and Ex4, with 3 anchoring points almost lay in the same plane as for the lowest row of the blast holes, fig. 3. Extensometers Ex5 & Ex6 with 4 anchoring points almost lay in the same plane as for the middle row of the

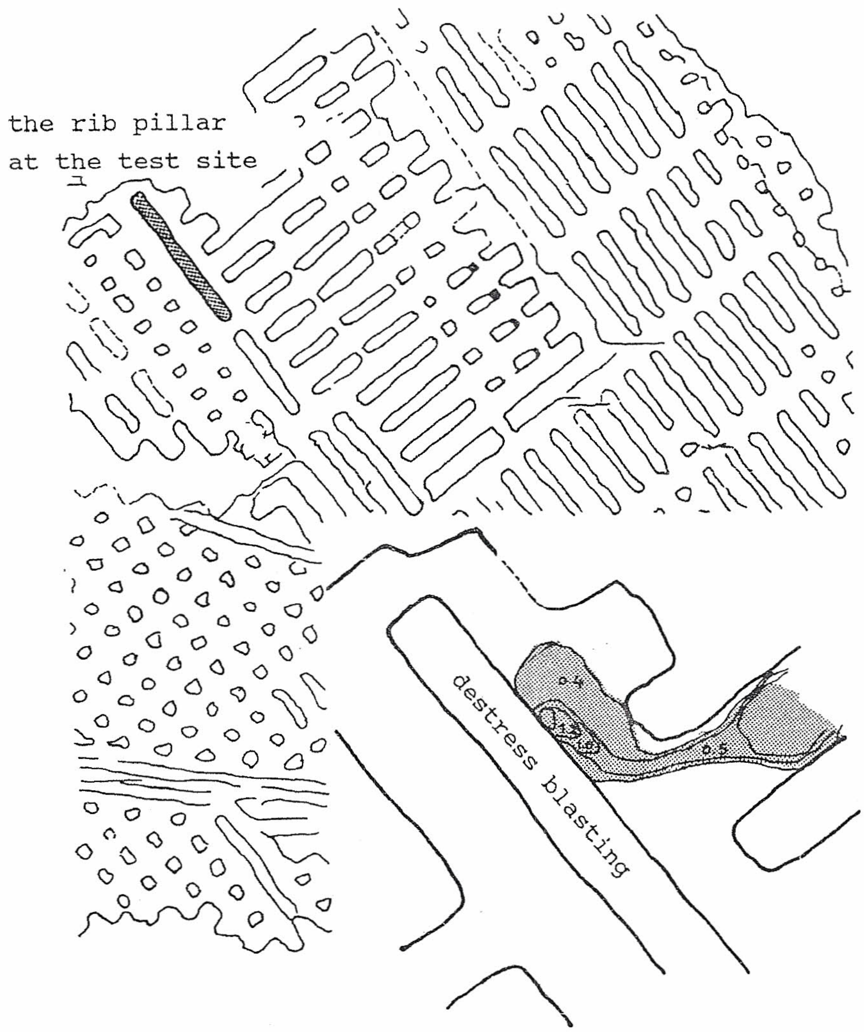

Figure 1. A plan view of the mine within the Central ore body. The rib pillar above which destress blasting was carried out is made dark on this figure. A close-up plan view of the test site is also given in this figure. The caved parts of the roof are shown on the close-up plan view. The depth of the cavings varied between 0.4 to 1.5 m.

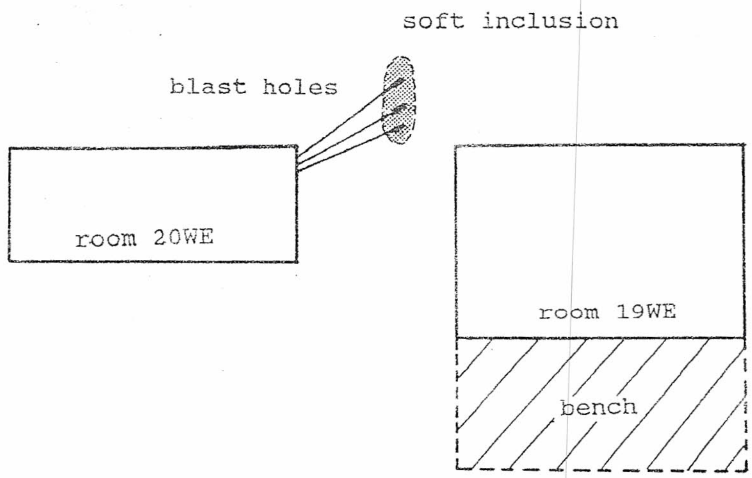

Figure 2. A cross section of the mine at the test site. The blastholes and the postulated soft inclusion are sketched on this figure. The distance between the blastholes on columns was 0.5 m. The distance between the blasthole bottoms (on columns) was approx. 1 m.

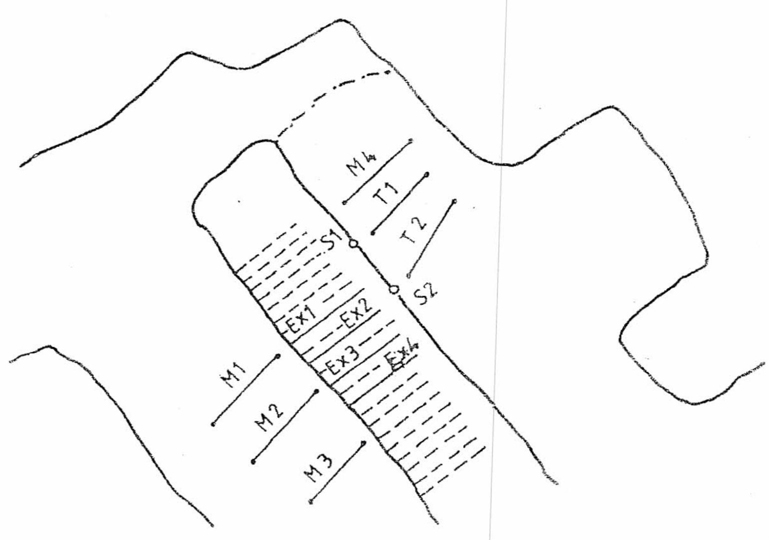

Figure 3. A plan section of the mine at the test site. Broken lines: blastholes, M1, M2, M3, M4, T1 & T2: convergence measurement units, Ex: extensometers, S1 & S2: shear movement measuring set-ups.

blastholes. The two anchoring points farthest from the extensometer heads, spanned over a zone where the "Soft Inclusion" was assumed would be formed.

Two convergence measurement units were provided on the roof of room 19WE. Each unit consisted of two bolts anchored into the roof, a piano wire and a hanging weight that streched the piano wire between the two bolts and over a pulley.

Eight bolts were anchored into the roof of rooms 20WE and 19WE to provide measuring points for convergence measurements along four sections.

Two shear displacement measuring units were installed close to the roof in room 19WE. Each unit was a simple construction consisting of two bolts, at right angle to each other, which were anchored into the roof and the sidewall of the rib pillar. The provision of a dial gauge on each unit made it possible to measure any horizontal displacement of the roof that could occur because of the destress blasting, fig. 3.

6 THE POSTULATED DESTRESS MECHANISM

It was assumed that the destressing would occur at the test area according to the "soft inclusion" model. The presumption was that blasting would create a fracture zone (soft inclusion), at around the bottom of the blasted holes, which could yield (see for example Karowski et al. (1979), Borg(1989)). The concentrated convergence of the fractured zone, if adequate, would then lead to the divergence of the neighbouring rock at the roof and eventually to the destressing of the roof of the room 19WE.

Under these assumptions it was expected that the extensometers would measure convergency across the fractured zone and other units would show some divergency across roofs of rooms 20WE and 19 WE. Horizontal (shear) roof displacement was also envisaged to occur as bore hole endoscopy had shown (Engberg (1989)) that thin, horizontal clay bands lay within the immediate roof and at the interface between the roof and the rib pillar, see fig. 4.

7 MEASUREMENTS

Measurements were taken at different stages along with the blasting and on completion of the blasting.

Blasting was divided into a number of rounds and was carried out in steps. This was done mainly to avoid extra roof damage that might endanger the stability of the mine at the test site. Measurements taken at the end of each blasting round provided a way to monitor the site for safety considerations.

Final measurements were taken on completion of blasting and these formed the basis for evaluations.

Measurement results were not consistent with those one would expect considering the postulated mechanism (Sec.6) as responsible for deformations.
Extensometers showed deformations up to 0.8 mm. Deformations, alternated without

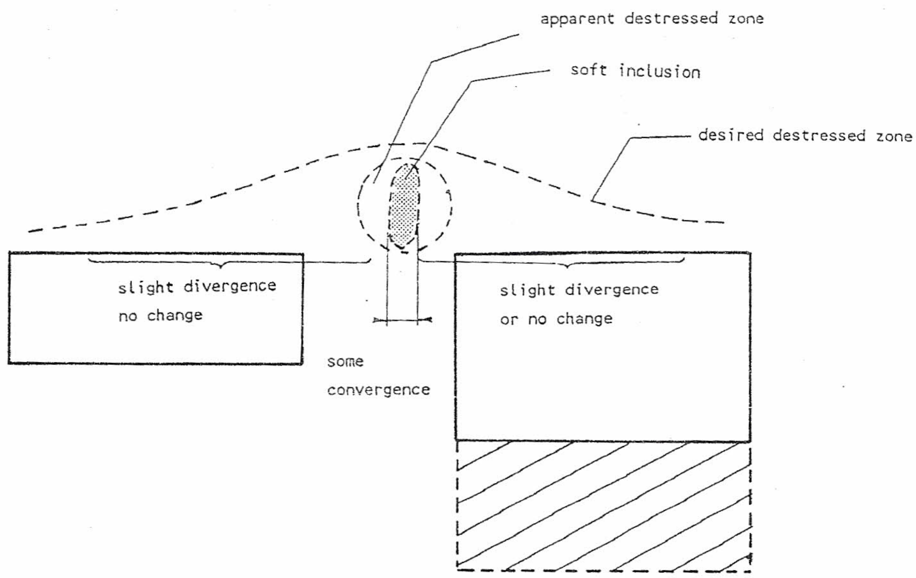

Figure 4. A plan section of the mine at the test site. The figure depicts the expected deformations according to the postulated destressing mechanism.

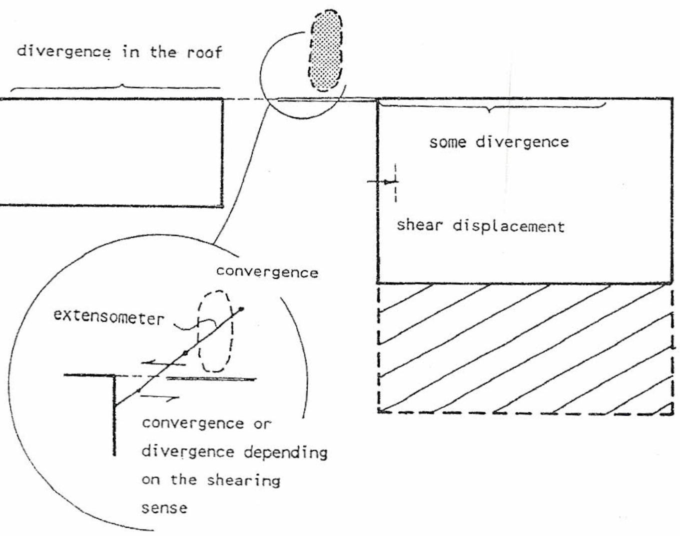

Figure 5. A cross section of the mine at the test site. The figure depicts the expected deformations according to the destressing mechanism described in section 8.1.

		Soft inclusion (Sec. 6)	Shear movement (Sec. 8.1)	Progressive shear failure	Measured final deformation	
	Instrument	Expected deformation	Expected deformation	Expected deformation	Measured deformation	size of deformation (mm)
Room 20WE	M1	none	some div	none	div	*) +0.4-1.2
	M2	"	"	"		
	M3	"	"	"	div	0.5
Rib pillar	E1-L1	con	con	some con	con	-0.3
	E1-L2	div	con	div	div	+0.3
	E2-L1	con	"	some con	-	+0.0
	E2-L2	div	"	div	div	+0.2
	E3-L1	con	"	some con	div	+0.3
	E3-L2	div		div	con	
	E4-L1	con	"	some con	con	-0.1
	E4-L2	div	"	div	con	-0.2
Room 19WE	M4	some div	some div	con		+0.8
	T1	"	some div	con		-0.5
	S1	"	some con	some con/div		+0.5
	T2	"	some div	con		+2.0
	S2	"	some con	some con/div		+0.5

*) approximate values

Table 1. Expected and measured deformations . E1-L1, E2-L2 refer to the two farthest (from the Ex. head) measuring segments of the extensometer Ex1. Likevise is valid for the other extensometers. M1,.., T1,.., S1 etc. are described in Figure 3.

any clear pattern, between convergency and divergency across the soft inclusion and in rock segments lying between anchoring points of the extensometers.

Irregular alternations between convergency and divergency also applied to measurements taken by other devices at subsequent sections. As described in Section 6, convergency was expected across the soft inclusion and always along the soft inclusion. Slight divergency or almost no change was what one expected at the roof of the two rooms and always along the roofs over the length covered by blastholes.

This inconsistency motivated that other mechanisms should be sought that could have also been responsible for the deformations.

Table 1 summarizes the measurement results.

8 DISCUSSION: POSSIBLE DESTRESS MECHANISMS

8.1 Destressing through shear movement

A destress mechanism that was thought might have been responsible for destressing is the occurrence of shear movement at the interface between the roof of rooms 20WE and 19WE and the middle rib pillar. This is a well defined plane with clay fillings.

This became conceivable, as the blasting might have had an "uplift" effect, dynamically decreasing the normal stress across the interface, with the consequence of triggering shear movement. Such shear movement, spreading across the interface, could cause some convergency and divergency according to fig. 5 and table 1.

8.2 Destressing through progressive shear failure prior to destressblasting

Another mechanism for destressing that could be thought of was local destressing through progressive shear failure of the roof over room 19WE. This had led to roof fall-outs with varying intensity prior to any destressing work. Traces of shear failure could also be seen on the unfailed parts of the roof, see fig. 6.

This mode of failure , locally sever, might have resulted in local destressing with the consequence that the surrounding rock converged into the caved parts of the roof.

Under such condition it is probable that the fractured rock within the soft inclusion dilated. This may explain why a couple of extensometers measured divergency over the soft inclusion.

The measured deformations are given in Table 1. This informations is also briefly indicated on fig. 7.

A survey of Table 1 shows that the likelihood that both mechanisms described in 8.1 and 8.2 have been responsible for destressing is adequately high. In locations where the mechanism described in 8.2 is dominant, however, destress blasting has not had any contribution.

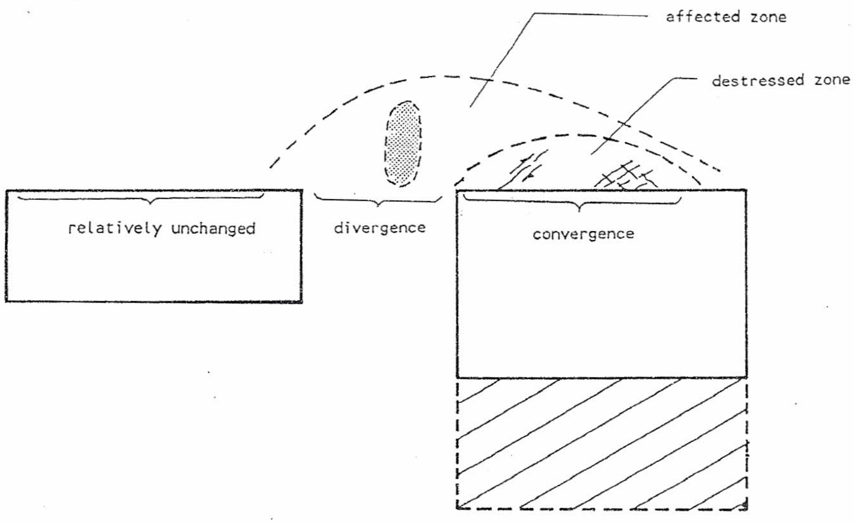

Figure 6. A cross section of the mine at the test site. The figure depicts the expected deformations according to the destressing mechanism described in 8.2.

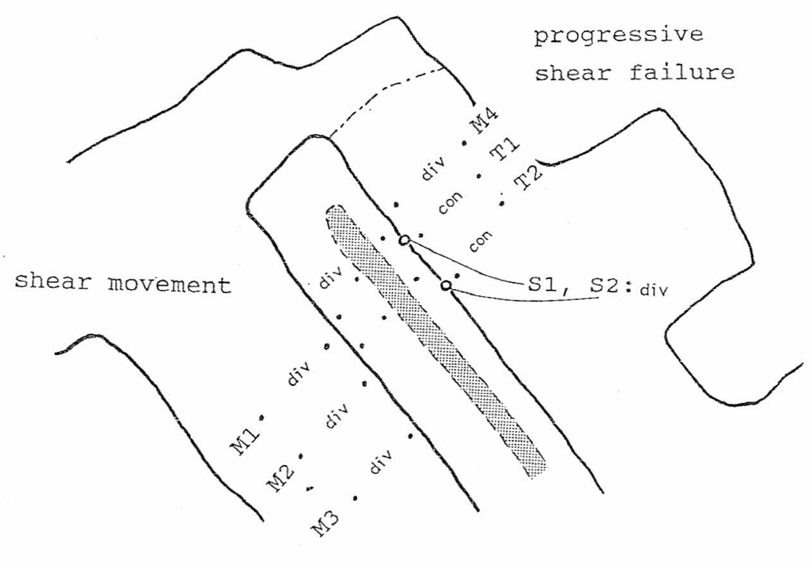

Figure 7. A plan section of the mine at the test site. The measured deformations in terms of divergency and convergency are shown on this figure. Possible destressing mechanisms are also indicated.

Eventhough the idea, that some destressing might have had occurred in direct conjunction with the "Soft Inclusion", can not be totally abandoned, presumably it has not been the dominant mechanism of destressing in this case.

9 CONCLUDING REMARKS

Destress blasting is not by far a well established technique (see for example Scoble et al.(1987) and Hakami et al.(1990)). This is basically because the phenomenon: "blasting within confined and highly stressed volumes of rock" is not well understood. Yet the technique has been employed in several cases successfully. It is believed that the potential this technique can offer is not yet fully exploited. If employed successfully, the technique would offer an economical way to alleviate bursts and other mining problems associated with high stress.

This study also emphasized the role of major discontinuities in relation to destress blasting. Can one achieve controlled destressing by intentionally triggering shear movement along discontinuities by blasting?

ACKNOWLEDGEMENT

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