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TITLE Mining of the 94 East faces, TauTona

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CSIR Division of Mining Technology

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Introduction.

At the request of Mr Naismith, a CSIR team visited the 94E1 and 94E2 panels mining the Carbon Leader Reef in the north –east corner of Tau Tona shaft pillar on the 14th December 2001 to study the damage due to a rockburst and to recommend any steps that might reduce the potential for further rockburst damage.

The CSIR representatives were:

Dr. S.M. Spottiswoode.

Dr. M .K .C. Roberts.

The following persons from the mine accompanied them:

Mr. S. Murphy – Rock Mechanics Manager.

Mr. R. Saunders - Section Manager

Mr W Keefe – Acting Mine Overseer

Seismicity

A seismic event with M=2.5 occurred on the 4th December 2001 at 15:56 before the blast was due to go off. It located in front of the 94E1 and 94E2 panels about 88m in the footwall of the reef. The event caused substantial damage to these panels. The seismic details provided by the mine suggested that the source was close and parallel to the two advancing panels, with all the available evidence supporting this mechanism. The seismic data provided by the mine looked good, except that the event itself was not listed in the data file provided by the mine ("xevntqry.txt").

1. The hypocentral location was close to the advancing faces.
2. Both possible fault planes of the moment tensor solution were nearly parallel to the overall face (longwall) direction
3. The given source dimension was almost as large as the longwall length
4. The damage was mostly in the face area and was similar along the entire face length

Description of damage as seen along the route of the visit

The visit travelled up a travelling way accessing the top strike gully to panel 94E1. We went down the face about 25 m until the face was blocked and then travelled along the 94E1 and 94E2 strike gullies and inspected the face areas near the ends of these gullies. Together with the abovementioned mine personnel, the following observations were made, introduced in order of initial observation, during this visit:

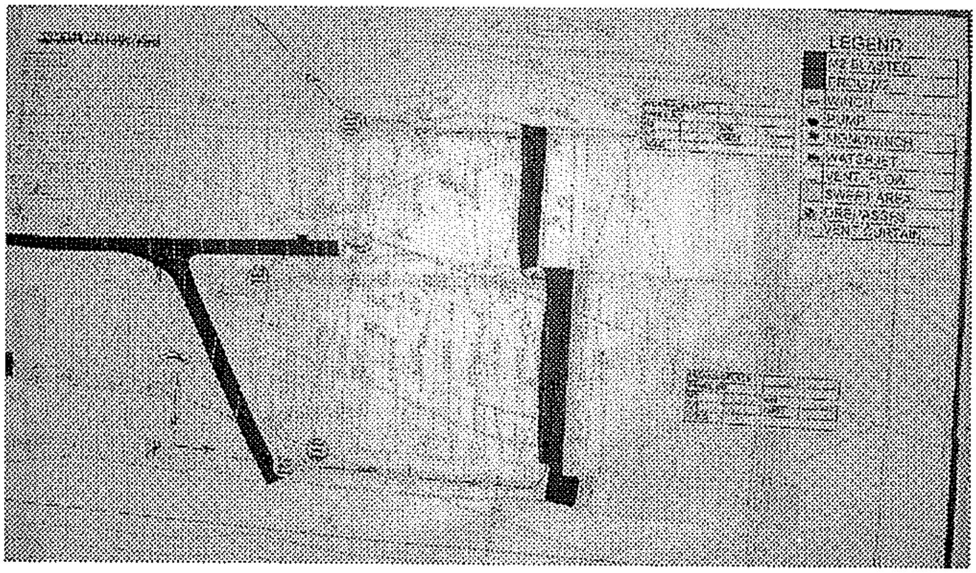

Figure 1. A mine plan showing the east panels.

1. Mining-induced fracturing extended some 20m down-dip from the old edge of the shaft pillar, as observed in the access dip travelling way and down the 94E2 face. The strike orientation of these stress-induced fractures was parallel to the strike of the reef and therefore parallel to the pillar edge.
2. One strike gully fall-out was up to the top of the Green Bar. Sets were being built and the space above would be filled with aerated cement, which is a standard method of repairing gully hanging wall fall out on Tau Tona.
3. Backfill in the panels was within 3m of the face and usually well up to the hanging wall. At one place it was observed that the fill did not make contact with the hanging wall, but this did not see to cause any localised problems.
4. Hanging-wall fall-out was very limited as evidenced by lack of noticeable doming between the elongate support units and also by the presence of paint lines used to mark the drill-hole position. The height of fall-out from the roof was less than 10cm on average.
5. The face had been drilled with two lines of holes and charged up, but the charges had not detonated. Only the top row of holes was visible, with the bottom row totally obscured by broken rock.
6. The blast connections to the top row of holes were not cut off, indicating that the face had not burst out.
7. The amount of rock on the floor was more than that that had come from the hanging wall and the face. It had therefore been ejected from the foot wall. As the stope had been cleaned with water jetting, we could only conclude that most of the foot-wall rubble had been lifted out during the event.
8. The hanging-wall was intensely fractured throughout, but looked very stable. The fractures were all close to vertical and it is assumed that horizontal skin stresses created by the backfill held the fractured ground together.
9. Closure was minimal in the 94E2 panel but far more pronounced in the lower 94E1 panel. This was perhaps counter-intuitive given the higher expected ERR

on the 94E2 (top) panel. A simple explanation is that, prior to the event, there was a more extensive region of fracturing ahead of the 94E2 panel. Closure in 94E2 was estimated as 200mm. In places some of the elongates had fallen out. Fall-outs of elongate support elements are not uncommon occurrences during rockbursts. The reasons for these fall-outs are complex and could result from one or more of the following, *inter alia*: FOG cantilevering over part or all of the support element; ride motion during the dynamic event; opening during the seismic event; squeezing out of elongates placed adjacent to backfill; poor installation. Many of these effects could be countered by the use of headboards and/or footboards.

History of strong ground motion.

Peak velocities were measure in 94E panels between November 2000 and August 2001 as part of SIMRAC project GAP709. 10 events produced strong ground motion in excess of 1 m/s during the 330 days of recording. Figure 2 shows the rate at which peak velocities were measured to have exceeded values ranging from 10 mm/s to 3 m/s. Although there was a sharp change in slope suggesting that the maximum PPV might be 3 m/s, the data alone cannot be used to exclude the possibility of exceeding 3 m/s at some stage.

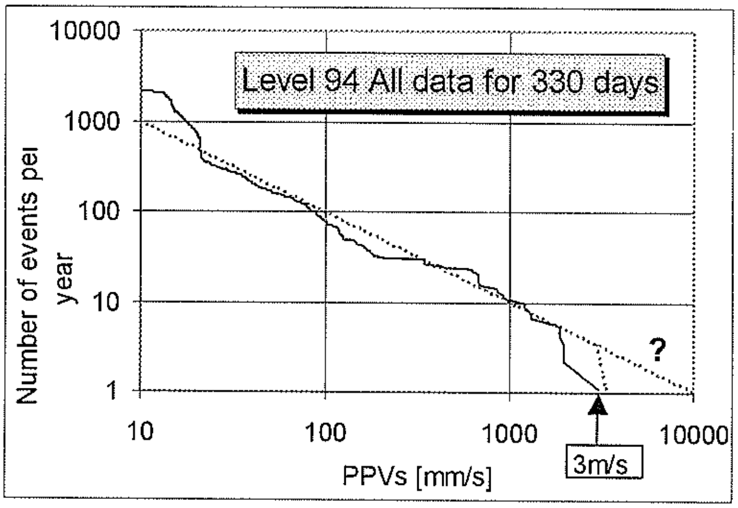

Figure 2. Incidence of strong ground motion recorded by Peak Velocity Detectors in 94E, all data. From GAP709 final report (in preparation).

Suggested rockburst mechanism

The seismic event of the 4th December 2001 at 15:56 occurred on a structure sub-parallel to the face. As there was no known geological structure sub-parallel to the face, in accordance with good mining practice, the event created its own shear zone in previously competent rock as suggested above in the section on seismicity. Very high ground accelerations were needed for the type of footwall heave and bulking that was observed. As suggested McGarr (2001), higher stress drops and ground velocities are expected from failure of intact rock than from slip of previous (weak) geological features. This evidence points to mining induced slip of a structure ahead of and sub parallel to the stope faces. The fact that both faces were affected to a similar degree also supports the assumption that the damage was caused by a mining-induced slip event in previously unfailed rock ahead of and sub parallel to the stope faces.

Geological features could well have been mobilised during the event (Murphy, 2001), but slip on them could not have resulted in the observed damage. Firstly, such slip would not have resulted in the extreme damage to the footwall and secondly, none of the features was close to parallel to the overall face direction. The report by Murphy (2001) provided a maximum estimated seismic moment of 4.0E9, equivalent to M=0.4 by doing ESS studies on three faults in the area. This also supports the exclusion of previously identified faults as causing the event.

From the observed damage it was clear that the event caused rapid bulking of the footwall under high acceleration. In places, the remaining stope width was less than ±70cm. If persons were in the panels at the time of the event it could have resulted in injury or death.

The intense support at the face and the clamping effect of the backfill were very effective in limited the degree of hanging-wall fall-outs. A small reason for the damage to the footwall was that the footwall is not barred. The fundamental processes of the footwall rubbelisation are not understood.

Recommendations

The recommendations address two issues; the first is to reduce the possibility of such damage occurring again and the second is to lessen the chances of injury to persons due to dynamic footwall heave should an event occur again

1. **Stop the bottom panel, 94E1 and mine the top panel, 94E2, through to limit.** The rational behind this recommendation is that the overall face length will be reduced from the present 80 m (panels 94E1 and 94E2) to 30 m (94E2 only). Should a face-parallel slip occur in future it would affect a length of 30 m and not 80 m. This would result in a smaller event for similar distance of event from face and therefore lower accelerations thereby limiting the bulking of the footwall. There are also commonly recognised benefits of reduced face length in remnant conditions. The extraction of the bottom 94E1 panel can be considered later on the basis of the experience while mining 94E2. Decisions regarding whether and how to mine the bottom 94E1 panel will be based on analysis of the success, or otherwise, of the remaining panel 94E2.

2. **To improve alternate access to the top panel, a mid-panel escape way may be used.** We suggest that the advantages of the improved access and escape will exceed the disadvantage of softening the backfill. The small amount by which the top (93E2) panel currently lags the 94E1 panel should not necessitate any additional special precautions. The final abutment length created when 94E2 reaches its final planned limit will be less than the total current face length and therefore is not expected to result in any unusually large seismicity and the abutment itself.

3. **Increased the stoping width from the current 0.9 m to 1.3 m**. From the observed damage it was clear that the event caused rapid bulking of the footwall under high acceleration. In order to reduce this damaging effect on persons being projected onto the hanging wall, it is recommended that the stoping width be increased from the current 0.9 m to 1.3 m. This increase will not compromise the existing support system. The high closure rate should provide sufficient stress on the elongates even though they will be longer. . By providing more space between

the heads of the workers and the roof, the possibility of head and neck injuries will be reduced if rapid footwall heave does happen again.

Acknowledgements

We would like to thank Messrs, Murphy, Saunders and Keefe for their essential assistance during our brief visit to the site and for discussions afterwards.

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McGarr, A. Control of strong ground motion of mining-induced earthquakes by the strength of the seismogenic rock mass. Rockbursts and Seismicity in Mines – RaSiM5, SA Inst. Min. Metall., 2001.

Figure 3. Photograph taken in panel 94E1 looking down towards a person in the bottom strike gully. Note the rubble on the footwall derived from rubbelised footwall rocks. .

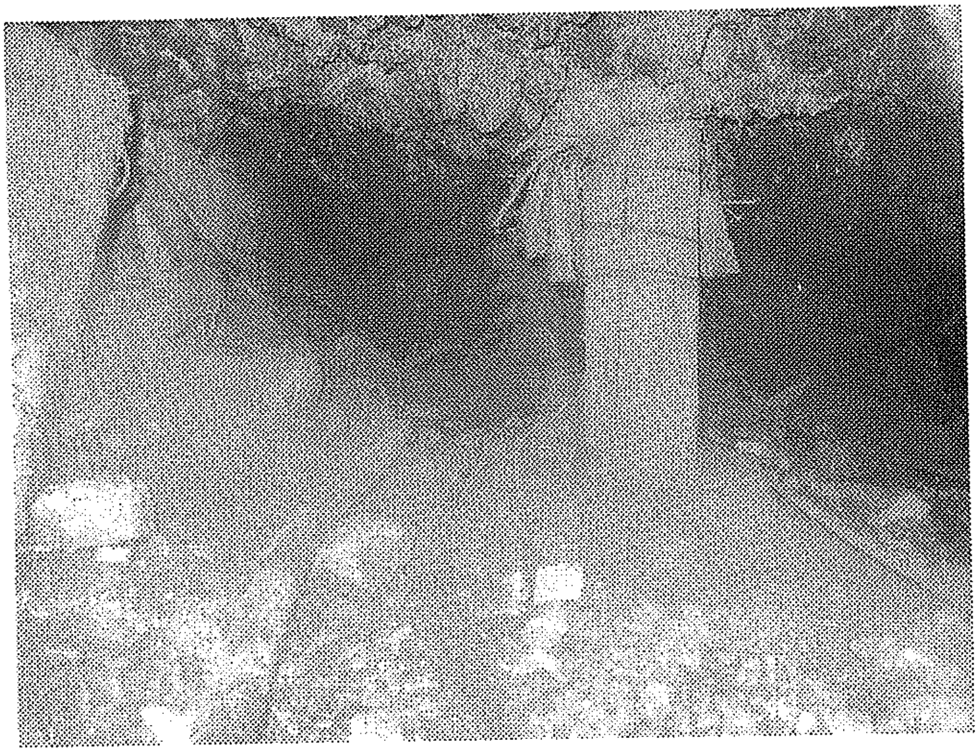

Figure 4. Photograph taken in the lower portion of panel 94E1 looking updip. The closure shown on the elongate showed that it performed well. Note again the rubbelised footwall rocks.

Dr. S.M. Spottiswoode. Dr. M .K .C. Roberts.