

Safety in Mines Research Advisory Committee

Final Project Report

CONFIDENTIAL

**Trial training in strata control for
underground workers**

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Research agency: CSIR Division of Mining Technology
Project number: GAP 851
Report number: 2002-0079
Date: October 2002

Executive summary

In-depth assessments of accident records in gold and platinum mines indicate that an improved understanding of rock mechanics among production and service personnel will improve worker safety in relation to the rockburst and rockfall hazard. Workers' lack of competence with respect to certain aspects of strata control increases their, and their fellow workers', exposure to such strata control risks.

To date, however, rock engineering related courses have been mainly aimed at rock engineering personnel, mine management and senior production personnel. It is, therefore, desirable that a course suited to less senior production and service personnel, up to shift supervisor level, be implemented. An appropriate course for this audience is one that focuses on essential strata control and hazard identification information. At the mine where trial training was done courses for team leaders, shift supervisors and miners had been implemented and these courses were used to further enhance training as part of this project.

Recently completed SIMRAC projects GAP609a and GAP609b provide a sound framework (in terms of material and methods respectively) to perform effective training at the required level in gold and platinum mines. However, the results of the research need to be tested and proven, and effectively communicated before they can be generally accepted.

This project, therefore, undertook a trial implementation of purpose-developed training content according to guidelines drawn up under the previous GAP609 projects. To achieve this, a champion mine was selected that had a desire to implement a different approach to training than that currently being pursued. A further requirement was that a flexible organisational structure and work environment existed that could accommodate the, albeit relatively minor, level of intrusion and disruption caused by the implementation and monitoring process. Topics for instruction were chosen, for their relevance and importance, by the project team in consultation with personnel on the selected mine.

A process was then undertaken to 'model' (i.e. identify and describe) the knowledge/expertise necessary for a stope team (team leader plus stope production crew) to achieve the desired level of strata control and hazard identification effectiveness. The experimental training intervention consisted of a selected stope team on the mine being trained and evaluated by a trained facilitator/trainer in respect of the assimilation and application of this knowledge/expertise. A 'control' stope team was also evaluated for comparative purposes.

The following conclusions are drawn from the project work:

- The introduction of basic strata control knowledge to the team leaders directly and to the rest of the workers indirectly made a significant improvement in terms of hazard recognition and the method of coping with the bad ground conditions.
- Positive results are recorded from the implemented training intervention exercise, and the positive impact of this method is evident.
- Topics selected were appropriately focused and targeted the needs well.
- A certain amount of knowledge sustainability was obtained, despite a change of leadership in the tested team.
- Greater significance can be attached to the findings if the trial method is compared with similar measures of conventional training. The comparison with the control stope provided this.

- Setting up a more tightly controlled research project would be difficult to achieve because of the constantly changing work and team environment in underground mining.
- Training alone (even using an appropriate methodology) is not sufficient for success; positive organisational influences are also required.

Taking into account the results of this project, it is highly recommended that:

- similar focused methods of training be implemented on a wide scale (the practicalities of doing so may seem onerous, but since the training is delivered through the team leader, and is based in the working environment, this would not require a great deal of additional personnel); and
- work is done alongside this training to ensure that the team leader has adequate resources and authority to implement what has been learnt.

Additional research in the following areas could supplement the contribution made by the current project work:

- The impact of safe work procedures on production output over the medium to long term.
- The impact of management visibility on safe work.
- The impact and efficiency of initial induction and post leave refresher training currently used.

Acknowledgements

The authors gratefully acknowledge SIMRAC for the funding of this project. The authors specifically wish to acknowledge the high level of co-operation and assistance received from the Lonmin personnel, not to mention flexibility in accommodating a project of this nature.

Contents

	Page
Executive summary.....	ii
Acknowledgements	iv
Contents	v
List of figures	vii
List of tables	viii
1 Introduction.....	1
1.1 Problem statement	1
1.2 Scope of work.....	1
1.3 Report structure.....	2
2 Previous work.....	3
3 Research methodology and experimental approach.....	4
3.1 Methodology.....	4
3.2 Experimental approach.....	4
3.2.1 Selection of training topics.....	5
3.2.2 Selection and development of training material	5
3.2.3 Selection of experimental site.....	6
3.2.4 Selection of trainers and teams.....	6
3.2.5 Method of instruction.....	6
3.2.6 Monitoring and evaluation of trainers and teams	7
(a) Trainer/team evaluation	7
(b) Individual evaluation	7
4 Description of underground site investigations	8
4.1 Description of sites	8
4.1.1 'Training' stopes	8
4.1.2 'Control' stope	8
4.2 Description of investigation procedure	8
4.2.1 Training sites	8
4.2.2 Control site	10
5 Results of underground site investigations	11
5.1 General findings.....	11
5.2 Questionnaires.....	11
5.3 Observations.....	13
5.3.1 General observations in the training stopes	15
(a) Main training site.....	15
(b) Supplementary training site 1	18
(c) Supplementary training site 2	18
5.3.2 General observations in the control stope.....	19
5.3.3 Observations by topic	21
(a) Topic 1: Identifying, marking and support of hazardous joints, domes, discontinuities	21
(b) Topic 2: Support and barring of hangingwall and side wall	21
(c) Topic 3: Tensioning and correct angle of roofbolts	21

(d) Topic 4: Drilling direction, angle, sockets.....	21
(e) Topic 5: Correct installation/orientation/removal of temporary support.....	21
5.3.4 Observation conclusions	22
6 Discussion of findings	22
6.1 Significance of findings	22
6.2 Why the training produced good results.....	22
6.3 Organisational influences	23
7 Technology transfer.....	24
8 Conclusions and recommendations	25
8.1 Conclusions	25
8.2 Recommendations.....	25
8.2.1 Options for further research.....	26
References.....	27
Appendix A Relevance of GAP609b findings	
Appendix B Training/instructional material	
Appendix C Team leader assessment document	
Appendix D Syllabus/measuring modules	
Appendix E Skills evaluation questionnaire	

List of figures

	Page
Figure 5.2.1 Percentage improvement of 'vague'/'unknown' responses for training topics 1 to 5.....	12
Figure 5.2.2 Percentage improvement of 'known' response for training topics 1 to 5.....	12
Figure 5.3.1 Results of observations to measure implementation of new knowledge.....	14
Figure 5.3.2 Results of 'correctness' observations	14
Figure 5.3.3 Roofbolt installation in main training site before training of team leader.....	15
Figure 5.3.4 Support installation in main training site before training of team leader.....	16
Figure 5.3.5 Roofbolt installation in main training site after training of team leader.....	16
Figure 5.3.6 Support installation in main training site after training of team leader.....	17
Figure 5.3.7 Conditions in the face area after replacement team leader took over.....	17
Figure 5.3.8 Conditions in the face area after replacement team leader took over.....	18
Figure 5.3.9 Correctly installed roofbolts in the control stope hangingwall after the safety instruction exercise.....	19
Figure 5.3.10 Roofbolts installed in the back area of the control stope that were loose.....	20
Figure 5.3.11 Roofbolts installed next to a fault plane	20

List of tables

	Page
Table 4.2.1 Frequency of training and evaluation in the main training site	9
Table 5.2.1 Summary of questionnaire responses	11
Table 5.3.1 Evaluation of new knowledge implementation.....	13

1 Introduction

The primary output of GAP851 is trial training in strata control for underground workers.

The secondary outputs are:

- draft on-site training material;
- ‘trained trainers’ at the chosen trial site;
- two technology transfer workshops.

Past studies (e.g. GAP609a and GAP609b) have shown that there is a huge need for this type of training exists. Satisfy the need, and the rock-related accidents will be significantly reduced.

1.1 Problem statement

It is clear from several in-depth assessments of accident records that an improved understanding of rock mechanics among production and service personnel will improve worker safety in relation to the rockburst and rockfall hazard. Workers lack of competence with respect to aspects of strata control increases their, and fellow workers’, exposure to such strata control risks. Rock engineering courses to date have been aimed mainly at rock engineering personnel, mine management and senior production personnel. The potential impact of this study should not be underestimated, particularly as most mine accidents affect production personnel at levels targeted in this project.

It is believed that a course should be developed that is suited to junior production and service personnel. (At the mine where trial training was done courses for team leaders, shift supervisors and miners had been implemented and these courses were used to further enhance training as part of this project).

Such a course would be simplified, focusing on essential information about strata control and hazard identification in gold and platinum mines. SIMRAC projects GAP609a and GAP609b have recently been completed and should provide a sound framework (both in terms of the material and methods respectively) for mines and groups to conduct effective training at this level. The results of these projects need to be tested and proven and effectively communicated before they are generally accepted. The present study set out to do this.

The development and evaluation of virtual reality (VR) training methods for rock engineering hazard recognition, carried out over the past few years, further provides valuable background input to this study.

1.2 Scope of work

This project is concerned with conducting a trial implementation of purpose-developed training content according to guidelines drawn up under the previous GAP609 project.

The project methodology follows the steps below:

- survey and identify a suitable trial site;
- compile site-specific training material and programme;
- ‘train the trainers’ at the trial mine;
- regularly monitor progress and supply updates and additional input as required;
- measure the effectiveness of the programme;
- write up a final report, conclusions and recommendations; and
- conduct two technology transfer workshops.

1.3 Report structure

- Section 1: Introduction and background
- Section 2: Previous work
- Section 3: Research methodology and experimental approach
- Section 4: Description of investigation procedure
- Section 5: Results of underground site investigations
- Section 6: Discussion of findings
- Section 7: Technology transfer
- Section 8: Conclusions and recommendations

2 Previous work

A review (Squelch, 2001) of the GAP609b project findings (Venter, 2000) concluded (cf. Appendix A) that in underground safety the most important learning outcome is to have workers with appropriate safety habits or strategies ingrained in their daily expert behaviour. To approach this ideal it is necessary to institutionalise many of the principles and characteristics related to human learning and performance.

In the Methods and Creative Learning Experiences area, the following is apparent:

- people learn naturally through a process called modelling: formal modelling can enhance this;
- learning is a constant bodywide process;
- learning is best done in the context of work;
- cognitive apprenticeship seems a valid model; and
- combining the above mentioned with African Collective Learning Systems suggests the best practice for learning in the mining industry.

In the Organisational Structure and Learning Culture area, the following is apparent:

- teams should work and learn together;
- the workplace is, in most cases the best place to learn; and
- the 'bottom up' approach to change is compatible with the organisation of people working and learning together.

Other components to consider in the process are:

- performance and competency definitions and models;
- learning paths;
- learning support systems; and
- assessment and evaluation systems.

'Modelling' is proposed as the most appropriate approach to the formulation of a meaningful training system for the target trainee categories. The steps to be taken in the modelling process are identified by Squelch (2001) as:

1. Identify and select experts who consistently exhibit the behaviours of excellence to be modelled.
2. Elicit or extract components of expert behaviour.
3. Synthesise.
4. Test and refine the model.
5. Universalise the model.
6. Design training.
7. Conduct training.
8. Train the trainers.

3 Research methodology and experimental approach

The findings from previous work (section 2) were taken into account when the research methodology and experimental approach were developed for this project. The operational realities that exist on mines were also considered in the planning phase of this project.

3.1 Methodology

The following methodology was pursued in the project:

- Identify possible trial mine sites. Approach mine management, rock engineers and training staff. Choose a mine based mainly on support shown for the project, personnel available, extent of applicability elsewhere and locality.
- Compile site-specific training material and programme and decide upon the methods of training based primarily on the results of SIMRAC project GAP609a and GAP609b.
- 'Train' appropriate personnel (existing trainers) by introducing them to the new material and methods of training.
- Lead the trainers into the programme and regularly monitor progress. Guide, supply updates and any other input that may be necessary to improve the chances of success of the project.
- Measure the effectiveness of the programme in consultation with an industrial psychologist.
- Consolidate the research findings into a final report with conclusions and recommendations.
- Conduct two technology transfer workshops (one Gold, one Platinum) with the assistance of SIMPROSS. This should take place after the SIMGAP committee has passed the final project report.

3.2 Experimental approach

A champion mine was required that had a desire to implement an approach to training different from that currently being pursued. What was also needed was a flexible structure and work environment that could accommodate the, albeit relatively minor, level of intrusion and disruption caused by the implementation and monitoring process.

3.2.1 Selection of training topics

Topics for instruction were selected by the project team, in consultation with mine personnel, for their relevance and importance to the mine. The following topics were chosen:

1. Identification, marking and support of hazardous joints, domes, discontinuities;
2. Loose hangingwall and sidewall not barred out/supported;
3. Roofbolts not tensioned and wrong installation angles;
4. Blast hole drilling direction, angle, sockets; and
5. Correct installation/orientation/removal of temporary support.

3.2.2 Selection and development of training material

Lonmin initiated the development of the basic training material for team leaders, team members, miners and shift supervisors several years ago. Snowden Mining Industry Consultants developed this material for Lonmin with significant input from Lonmin training, production, rock engineering and safety officials.

The approach taken was to develop posters (see examples in Appendix B) that provide specific rock engineering material for production personnel, and that focus on important safety-related topics, with particular emphasis on hazard identification and remediation.

Suitable trainers were then trained and mentored to carry out this training. Supplementary training material, checklists and visual aids were also put together and supplied (see examples in Appendix B and Appendix C). The trainer (instructional) material has colour-coded information: black/blue text represents information; red text describes the hazards; and green text details the appropriate remedial measures (see examples in Appendix B).

At team member/leader level, the topics include the following:

- Identifying/remedying general mining hazards (e.g. drilling direction);
- barring and making safe (e.g. when to bar, barricade, support);
- stope support (e.g. angle and spacing of support);
- hazardous geology (e.g. dome or low angle joint); and
- tunnel support (e.g. support angle).

At miner/shift supervisor level, the above topics are appropriately expanded, and supplemented with the following:

- basic rock mechanics theory (e.g. stress definition);
- stress distribution around excavations (e.g. pillar stress);
- support-unit performance and support design (e.g. 95 per cent fallout thickness criterion, ground condition);
- risk assessment (e.g. panel risk assessment); and
- mine layout principles.

This material formed the basis of the training intervention undertaken for the current project.

3.2.3 Selection of experimental site

The pre-availability of training material particularly suited to conditions in a shallow platinum operation (although broadly applicable to both gold and platinum operations) provided an initial bias towards the selection of a site on a platinum mine.

A number of mines were considered for this training exercise, and the criteria for selection included:

- accessibility to suitable underground site (providing both control and trial groups);
- support for the project objectives from management, training and rock engineering personnel on the mine; and
- infrastructure and culture amenable to the planned training intervention.

Three gold mines and two platinum mines from different mining groups were considered as possible sites. Following detailed discussions with these mines it was decided that one of the platinum operations most closely met the requirements of the project and was therefore chosen as the research site.

3.2.4 Selection of trainers and teams

A meeting was held with the mine manager, safety manager and training manager at the selected mine to agree on site selection, project process, topics for training intervention, and intervention strategy. Thereafter, a mine captain was briefed on the project requirements and on panels chosen in an area (under his responsibility), which had challenging ground conditions, i.e. providing the opportunity to address significant problems. Three crews were identified, in nearby panels on one level, to be trained and mentored. After some further 'searching', another crew/panel was found on a different level, but with similar operating conditions, for use as a control group.

Mr Eric Jaku, a CSIR Miningtek staff member, was allocated the task of trainer (mentor). This role involved working with and coaching the team leader on the selected topics to improve the team leader's own level of training and ability to train team members in an ongoing way. Mr Jaku's role also involved spending time with individual team members.

In preparation for his role on the project, Mr Jaku spent a number of weeks with the mine's training, production and rock engineering personnel to familiarise himself with the operations and relevant standards and procedures. This included attendance of the full mine induction programme.

3.2.5 Method of instruction

Instruction was provided (by Mr Jaku) at the rate of one topic per week, with follow-up in subsequent weeks, as necessary. Each week 'training' shifts (for the scheduled topic) were spent with the team members and, in particular, the team leader of each of the three crews/panels involved in the study. A typical 'training' shift would comprise:

- meeting with team leader/crew at waiting place;
- asking questions – specifically to ascertain current knowledge;
- introducing background/theory/concepts of the applicable topic;
- interrogating problems; and
- addressing ‘why’ type questions to improve crew’s understanding.

This was followed by ‘in the panel’ working with the team leader and relevant team members, depending on their interactions and actions of relevance to the topic of the day. Deficiencies in practice were discussed and improved interactions evaluated and merits/benefits put forward. Particular attention was paid to team leaders, who would ultimately perform the trainer’s role for their teams.

Specific “trainer’s” material (cf. section 3.2.2 and Appendix B) was introduced (by Mr Jaku) each week, and worked through with the team leaders to appropriately identify and handle both routine and out-of-the-ordinary problems. Highlighted in this material are situations where more senior/experienced intervention is required. The effectiveness of this intervention strategy was evaluated on an individual and team basis.

3.2.6 Monitoring and evaluation of trainers and teams

Initially it was envisaged that only trainer/team performance would be measured. However, as the project progressed it became evident that a certain amount of individual assessment could also be achieved.

(a) Trainer/team evaluation

Separate from the weekly training topic instruction activity, each week the ‘trained’ and the ‘control’ panels were visited (by Mr Jaku) and evaluated. Measures (quantified and empirical) were developed to assess the efficiency of the trainer/crew prior to and after the training intervention. These measures continued to be used to assess efficiency after the period of training intervention to obtain an ongoing assessment indicative of training retention time and longer-term effectiveness.

Measurement of the ‘control’ panel took place ‘off-shift’ so as not to influence the behaviour of the control group. The only exception to the ‘no contact’ rule was if a potentially hazardous situation was observed (by Mr Jaku), in which case safety concerns would override this rule and the problem would be communicated either to the night shift crew/supervisor or other appropriate mine officials.

The evaluation forms are reproduced in Appendix D.

(b) Individual evaluation

A questionnaire (see Appendix E) was completed (by Mr Jaku via one-on-one interviews) for each team member and team leader from the ‘trained’ crews and the ‘control’ crew prior to the initiation of the intervention, and again on completion of the intervention. These give information on the efficiency of the training directly and, perhaps indirectly, some measure of the retention time, i.e. by recording how long since the individual underwent mine training (e.g. return from leave) and related information.

4 Description of underground site investigations

The results of the underground training and monitoring exercises are presented in this section.

4.1 Description of sites

4.1.1 'Training' stopes

Three 'training' panels/crews were involved in the project study: at one primary site and two supplementary sites.

The main training stope is situated 446 m below surface and is being mined up-dip on the UG2 mining horizon. The hangingwall and footwall rocks are pyroxenite and pegmatoid, respectively, with the 'triplets' at a distance of 10 cm above reef. The reef dips at 10° and the channel width of 109 cm is carried in a stope width of 131 cm. The panel length is 28 m with a 6-7 m wide dip-pillar between it and adjacent stopes. In-stope support consists of 0.9 m long tensioned rock studs (spaced 1.5 m on dip and strike) and mine sticks (spaced 2.0 m on dip and 1.5 m on strike). Rock studs are installed at a maximum of 2.5 m from the face after the blast. Two rows of temporary face support (Camlok props) are installed 1.5 m from the face (spaced 1.5 m on dip and strike).

4.1.2 'Control' stope

The 'control' stope was chosen on the grounds that it had a similar mining direction, support and conditions to the main training stope. The significant differences are that the stope is situated 480 m below surface; channel and stope widths are both 114 cm; 'triplets' 6 cm above the hangingwall contact; and panel length is 30 m with a 6 m wide dip-pillar between adjacent stopes.

4.2 Description of investigation procedure

Training and evaluation activities were carried out in three sites (one primary and two secondary) and comparative evaluations conducted in a control site.

4.2.1 Training sites

Team leaders in the primary training stope and secondary training stopes were trained in the following topics:

1. Identifying, marking and supporting of hazardous joints, domes, discontinuities;
2. Loose hangingwall and sidewall not barred out/supported;
3. Roofbolts not tensioned and wrong installation angles;
4. Blast hole drilling direction, angle, sockets; and
5. Correct installation/orientation/removal of temporary support.

One topic was covered per week, requiring five weeks of training in total. After each week of training in a particular topic, an evaluation was done on that topic to determine

any improvements made as a result of the training. About two to three days were spent per week conducting training and evaluation in the training stopes. Production was not hampered in any way.

Training was done by means of face-to-face interaction with the relevant stope team leader. The topic of the week was discussed with the use of objects/models and pictures. After this the team leader and the facilitator would proceed to the stope face for further discussion and facilitation using the more 'real life' situation (i.e. the practical component of training). Posing indirect questions related to the discussion that had previously been conducted, tested the team leader's understanding. An informal evaluation of this understanding was then determined and, based on the result, the decision would be made, by the facilitator, as to whether the discussion of the topic needed to be repeated or not. It was also necessary, and was possible, to test (using certain interpersonal techniques) whether the team leader had really understood the theoretical course content as well as its application in a practical context. It was also of utmost importance to emphasise the benefits of applying what had been learnt to reduce the probability of accidents and to improve productivity.

Training of each topic lasted for a week, hence the five-week duration of the training programme. It should be noted that the weeks utilised for training were not consecutive throughout the training period. This, however, has no bearing on the training and evaluation processes. After the evaluation of each topic, any detected irregularities or deviations from the trained procedures were pointed out to the respective team leader.

The training-evaluation method (See Table 4.2.1) was structured so that:

On the first week of training, topic one was discussed.

On the second week, topic two was discussed and topic one was evaluated.

On the third week of training, topic three was discussed and topics two and one were evaluated, and so on.

Table 4.2.1 *Frequency of training and evaluation in the main training site*

Week No.	Topic for training	Topic evaluated
1	1	
2	2	1
3	3	2
4	4	3
5	5	4
6		5

A further evaluation was done about six weeks after the combined training-evaluation period.

Interference in the process occurred when there was a change of people between the gangs e.g. from another production stope to the training stope and vice versa. It is speculated that this change had a significant influence on the overall results as the training is given formally to the team leaders only. It is assumed that the stope workers get this training indirectly by means of safety instructions from their team leader in a practical context only. Therefore, it is believed that the transfer of the trained team leader from the main training stope to night shift had a significant impact on the overall

results. Fortunately, this change only happened after the completion of the training cycle. On the other hand, it is believed that the presence of the trained team leader will be highly beneficial on the night shift in terms of practically addressing the strata control-related problems.

An additional problem encountered in the evaluation process was that it was not possible to count all the roofbolts in the face that were loose in comparison to the ones that were tight and to standard. To overcome this, a reasonable estimate was made of the size of the face area, i.e. the area that is occupied by roofbolts, and this area was used to calculate the total number of bolts. The bolts that were substandard were then counted and divided by the (estimated) total number of bolts in the face area and expressed as a percentage.

4.2.2 Control site

For the purposes of this study a control site is defined as a stope where training is not taking place. The purpose of establishing a control site was to quantify the improvement that occurred in the training stope as workers acquired more practical strata-control knowledge. The ground conditions of the control stope must, however, approximately match those of the training stope. Therefore, the basis for selecting the control stope was that it must have very similar conditions to the main training stope. The factors that were considered in determining its suitability included:

- mining direction;
- intensity of geological discontinuities such as faults, joints, and formation of brows as a result of falls from triplets;
- frequency of dome structures;
- pillar dimensions; and
- depth from surface.

With these criteria in mind, one particular stope was visited as it appeared at first to be ideal for a control stope. It was found, however, after completing a detailed examination of the stope that a *best mining practice* team (comprising a miner and two assistants) had been working there. Their responsibility is to check every action that is undertaken by the stope crew in terms of adherence to mine standards when, for instance, support installation procedures and spacings, barring, examinations and so on are being carried out. Visual examination inside this stope showed that the standard way of doing things conformed to the procedures being taught in the training stope. Thus this stope did not qualify as a control stope and therefore an alternative needed to be found.

The exercise of finding a suitable control stope involved several visits to different stopes in the mine. A suitable site was eventually located. A total of three evaluations were done in this stope. The results of these evaluations were captured on a separate form. Also, the evaluations were done at night so that the day shift crew was not influenced by the knowledge that they were being evaluated.

5 Results of underground site investigations

5.1 General findings

The responses to the questionnaires, as well as the observations generally, show an improvement in understanding by the team that was trained. Understanding of the issues and their remedies, as measured by responses to questionnaires, shows a marked improvement.

Structured observation showed evidence of the improvement of the implementation of this understanding, although this was not highly significant. This is most likely the result of a number of interfering factors, such as change in leadership and availability of resources. In some instances improvements have been sustained over a six-week period despite a change in the leader of the team. These results are represented in tabular and graphic form below.

5.2 Questionnaires

Questionnaire responses are graded as ‘known’, ‘fair’, ‘vague’, or ‘unknown’ depending on the level of knowledge shown by respondents (see Appendix E). The pre-training and closing measure evaluation questionnaires are analysed (Table 5.2.1) and (Figure 5.2.1) on an individual key factor basis (vague and unknown responses being combined). Key factors 1 to 5 correspond to selected training topics 1 to 5 (see section 3.2.1 and 4.2.1).

Table 5.2.1 Summary of questionnaire responses

Level of understanding of all key factors	Pre-training measure			Closing Measure	
	Main Training Stope	Additional Training Stope	Control Stope	Main Training Stope	Percentage Improvement
Percentage vague or unknown	33.0	43.0	29.3	6.7	79.7
Percentage known	47.9	19.3	35.0	75.0	56.6
Key factor 1 vague/unknown (%)	72.2	100.0	42.9	11.1	84.6
Key factor 2 vague/unknown (%)	8.3	39.3	32.1	2.8	66.3
Key factor 3 vague/unknown (%)	43.3	48.6	8.6	8.9	79.4
Key factor 4 vague/unknown (%)	36.7	20.0	34.3	6.7	81.7
Key factor 5 vague/unknown (%)	5.3	19.0	29.3	3.7	30.2
Key factor 1 known (%)	22.2	0.0	28.6	77.8	250.5
Key factor 2 known (%)	62.5	10.7	32.1	94.4	51.0
Key factor 3 known (%)	40.0	8.6	57.1	62.2	55.5
Key factor 4 known (%)	53.3	40.0	31.4	64.4	20.8
Key factor 5 known (%)	57.9	33.3	14.3	85.2	47.2

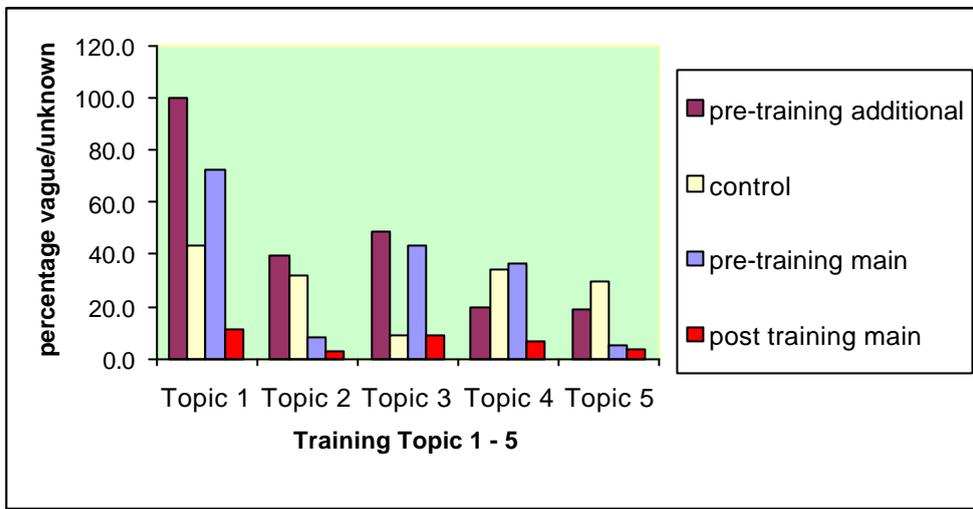


Figure 5.2.1 Percentage improvement of 'vague'/'unknown' responses for training topics 1 to 5.

This analysis shows a significant reduction in the number of responses that were vague or unknown. The reduction is noteworthy if compared to the number of unknown or vague responses made regarding the same stope as well as the additional stope and control stope prior to training. Key factor 1 is noted as the least understood of the five key topics in all stopes, but also as the most improved. However, the observations show that this topic i.e. that of marking hazardous discontinuities, was not properly carried out in any observations except during the training phase.

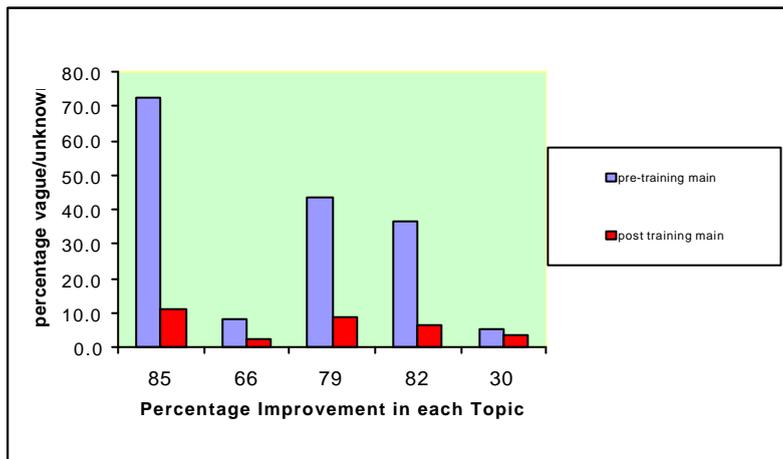


Figure 5.2.2 Percentage improvement of 'known' response for training topics 1 to 5

Figure 5.2.2 shows the improvement in the known correct responses to questions. Again there is a significant improvement in the post training measure and again the first topic is the most improved.

5.3 Observations

Table 5.3.1 gives the results of observations carried out in order to measure the implementation of the knowledge gained. Observations were carried out in the main training stope during the training process, twice in the control stope, and again in both the control stope and main training stope six weeks after training was completed.

Table 5.3.1 Evaluation of new knowledge implementation

Topic	Measure	Implementation of new knowledge % Correct					Training Process Observations % Correct				
		Main pre-training	Control 1	Control 2	Control 6-wks*	Main 6-wks	1	2	3	4	5
1	Number of hazardous discontinuities marked	0	0	0	0	0	0	0	0	100	100
2	How many loose pieces not properly barred out	100	2	100	100	2		0	1	0	0
	Is the correct equipment used	N/A	NO	YES	YES	YES		NO	YES	YES	YES
3	How many bolts are loose visually	90	30	50	99	95				85	100
	How many bolts angle correct	20	90	100	98	98				85	100
	How many bolts are not to standard tension									94	100
4	Are there sockets in the hangingwall	10	10	10	9	3					1
	Is there reef on hangingwall	N/A	100	100	100	100					N
5	How many units are correctly aligned for removal	N/A	N/A	N/A	N/A				95	100	100
	Has the team got correct tools								YES	YES	YES
	Check spacing								70	90	100
*Improvement due to intervention by management											

Figure 5.3.1 shows these results graphically. Photographs were also taken to illustrate the specific points found in the observation (cf. sections 5.3.1 and 5.3.2).

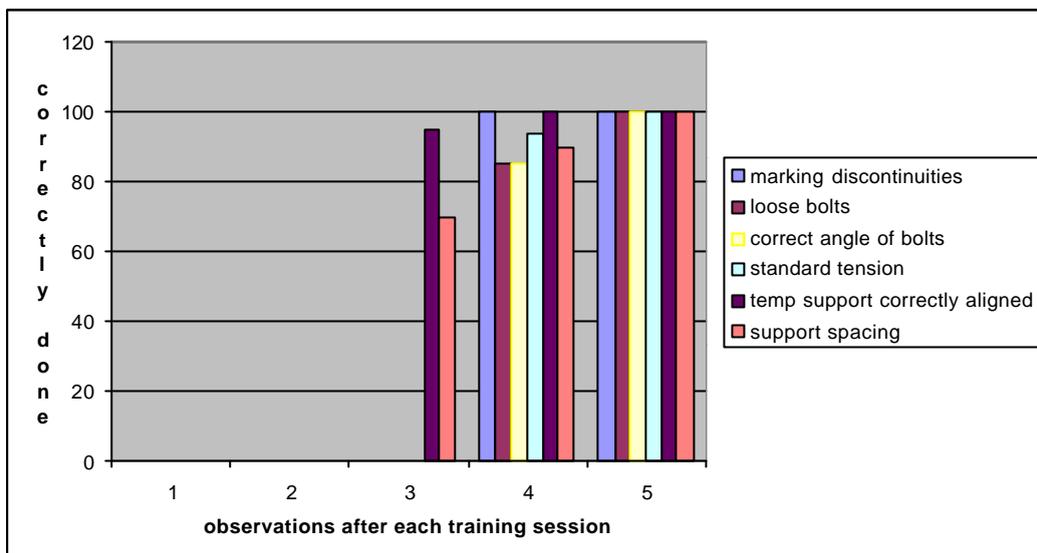


Figure 5.3.1 Results of observations to measure implementation of new knowledge

Figure 5.3.1 indicates 100 per cent correct work practice by the end of the training session on these measures. Of those that were measurable, all had deteriorated by the six-week follow-up measure (cf. Figure 5.3.2). This result might have been influenced by the change of team leader.

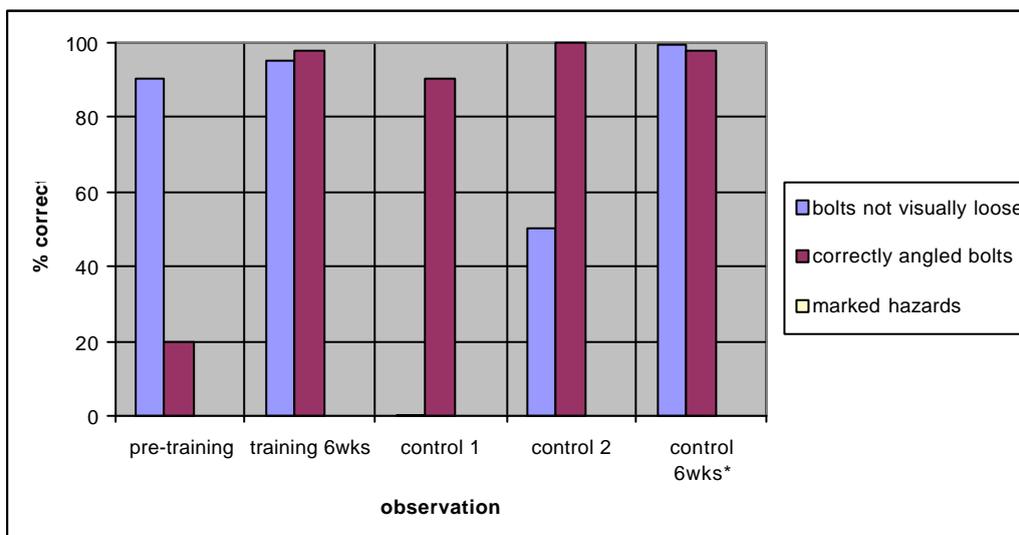


Figure 5.3.2 Results of 'correctness' observations

5.3.1 General observations in the training stopes

The following points were observed during the training process.

(a) Main training site

This stope was being mined up-dip. The operating crew consisted of nine members, of whom three were machine operators, three were general stope workers, two were winch drivers and one was the team leader. An initial questionnaire was completed by the facilitator (Mr Jaku) for all the members (except the winch drivers) before the training started. The team leader was highly motivated and eager to learn and apply this knowledge. However, some problems were experienced with the supply of necessary materials to the stope, a situation that was beyond the control of the team leader. These were reported to the mine overseer and the rock mechanics personnel.

Although the ground conditions were seen to be good in this area, there was a large number of sub-standard support units in place. This was in terms of roofbolt distance to face and the angle of installation. Figure 5.3.3 and Figure 5.3.4 also show that the installation of the roofbolt spherical seat in relation to the washer was not to standard. Some of the elongate units were also not installed perpendicular to the strata.



Figure 5.3.3 *Roofbolt installation in main training site before training of team leader. Shows bolt angle incorrect and not correctly seated.*



Figure 5.3.4 *Support installation in main training site before training of team leader. Shows installation of mine pole as incorrect.*

Observations carried out in the period after the team leader had been trained are photographically recorded in Figure 5.3.5 and Figure 5.3.6. Here the ground conditions were seen to have improved. This is as a result of installing support to standard and applying basic strata-control knowledge.



Figure 5.3.5 *Roofbolt installation in main training site after training of team leader. Support at correct angle.*



Figure 5.3.6 *Support installation in main training site after training of team leader. Shows improved bolt angle to dip of hangingwall.*

Although not a planned part of the evaluation exercise, the replacement of the original team leader by another team leader provided an opportunity to compare the benefits of the training intervention. An observation was, therefore, carried out in the face area after the new team leader took over the mining operations (cf. Figure 5.3.7 and Figure 5.3.8).



Figure 5.3.7 *Conditions in the face area before replacement team leader took over. Minor FOG resulting in the development of a brow.*



Figure 5.3.8 *Conditions in the face area after replacement team leader took over.*

(b) Supplementary training site 1

This stope was being mined on breast and was at the ledging stage. During the training period, it had only been advanced approximately 5 m from the centre gully. The team leader of this stope was trained in all topics, however, he seemed to lack the motivation to participate fully. His pace of improvement was very slow, often giving an excuse when follow-up questions were posed. The support continued to be substandard in this panel, especially the spacing of roofbolts and the angle of stick installation, without any apparent reason for this. From visual observations and from some indirect fact-finding, it would appear that this team leader was reluctant to be trained. A reason for this was not clear.

This stope had different conditions to the main training stope and the control stope, and therefore, could not be used fully for research purposes. Rather, it was an example of a working place where the team leader has a negative attitude towards training, leading to poor results.

(c) Supplementary training site 2

This stope was being mined down-dip as can be seen on the plan. There was a problem with availability of Camlok props of sufficient length at the site. In certain areas, distances of about 5 m between the Camlok props were observed. This occurred mostly where the stoping width was very high and the available props were too short. The general conditions showed that as training progressed the team leader improved in terms of safety. However, the shortages of appropriate material was a problem.

5.3.2 General observations in the control stope

During the last (i.e. six-week follow-up) evaluation visit to the control site, it was generally observed that all the support, that had been sub-standard during the 'training' period, was being corrected. No production blasting had been done for several days while this was taking place. A fact-finding exercise was immediately instituted to determine the cause of this sudden change. The finding was that this stope had been visited by the manager who, upon his arrival, had instructed the crew to stop blasting and update the support installation. According to the responses to the fact-finding exercise, the day of the evaluation visit was the fourth day of the supporting process of the control stope. It was also established that the support material, e.g. longer props, roofbolts, etc., that had previously not been available were made available during the visit by management. Because of this action, the control stope became the best stope. This was in terms of ground conditions due correct barring and with regard to overall support standards (includes support of relatively large geological discontinuities such as faults). This event can, therefore, be classified as a behavioural and/or organisational issue that caused conditions to change suddenly and which would normally not have been the case.



Figure 5.3.9 *Correctly installed roofbolts in the control stope hangingwall after the safety instruction exercise*

On the day of the last observation, the crew was busy installing support in the back area. It was observed that they were working from the face towards the back area. In the face area the hangingwall was safely supported by roofbolts and these were to standard in all aspects. About 6–7 m behind the face most roofbolts were still substandard with respect to angle of installation and tensioning. The following additional photos were taken at a distance of approximately 7 m from the face.



Figure 5.3.10 *Loose roofbolts in the back area of the control stope*

Figure 5.3.10 shows the loose roof bolts in the back area of the control stope. This area was about 6–8 m behind the face when this photo was taken and was the area being re-supported by the crew at the time of the evaluation visit.



Figure 5.3.11 *Roofbolts installed next to a fault plane*

From Figure 5.3.11 it is seen that roofbolts were loose next to the fault plane.

Another important point to note in terms of the training is that one roofbolt had been drilled and installed directly into the fault plane and would have been totally ineffective as a support unit. It was also noted that the stick above the fault plane was not installed

at right angles to the hangingwall. The fault is also not marked/demarcated with paint lines.

From observations made underground, it appears that most of the loose roofbolts can be attributed to the falls that normally occur between the immediate hangingwall and the triplet plane.

5.3.3 Observations by topic

In this section the evaluation observations are reviewed on an individual topic basis.

(a) Topic 1: Identifying, marking and supporting of hazardous joints, domes, discontinuities

There was improvement in this topic, by the end of training, to 100 per cent correct. Some problems were experienced at first with the availability of paint but this was overcome.

The sixth week observation showed that there were again no joints marked. Lack of paint at this stage was apparently the problem.

The control stope showed no improvement over the six-week period.

(b) Topic 2: Support and barring of hangingwall and side wall

Barring did not change significantly. Equipment used at the first training session was deficient (blunt and without gaskets) but after 6 weeks these deficiencies had been corrected.

(c) Topic 3: Tensioning and correct angle of roofbolts

Visibly loose bolts were not a big problem prior to training (90 per cent correct) improving to 100% correct by the end of the training period and then dropping back to 95% at the six week follow-up visit. Data from the control stope suggests roof bolting was a major problem in that stope. This had greatly improved at follow-up due to management intervention as discussed above.

The angle of bolting was a problem before training. This had greatly improved by the end of training and the improvement was maintained after six weeks.

(d) Topic 4: Drilling direction, angle, sockets

The presence of sockets indicated that, before training, drilling into the hangingwall had been a problem. This improved to almost zero by the end of training and some improvement was maintained up to six weeks when a limited number of sockets were observed. The control stope showed poor performance throughout the period.

(e) Topic 5: Correct installation/orientation/removal of temporary support

Temporary support was not observed except during training because the mining sequence meant that this support was not being used at the observation times. During the training observations there was some improvement noted and reflected in Table

5.2.1 above. A problem was experienced in some areas where the Camlok props supplied were too short to accommodate the increased stoping height.

The control panel had improved significantly by the time the six-week follow-up observation was made. This was due to management intervention as described above.

5.3.4 Observation conclusions

On the basis of the observations made underground during training and evaluation sessions, the following conclusions can be made regarding the primary training site:

- The introduction of the basic strata-control knowledge to the team leaders directly and to the rest of the workers indirectly resulted in a significant improvement in terms of hazard recognition and the method of coping with the bad ground conditions.
- Although the lack of materials (e.g. the marking paint for geological discontinuities) was an impediment to the full training assessment, the team leader demonstrated good understanding of the course content and its practical application.

6 Discussion of findings

The results are discussed in relation to the intended outcome of the project.

6.1 Significance of findings

Clearly there were positive results from the work that was done. The topics that were selected were appropriately focused, and targeted the needs well. There was a certain amount of sustainability, despite a change of leadership in the tested team.

The significance of this improvement is not clear unless compared with similar measures of conventional training. The comparison with the control stope does provide this.

A strict analysis of this work, therefore, suggests that the findings should be treated with some degree of caution. However, setting up a more tightly controlled research project would be difficult to achieve because of the constantly changing work and team environment in underground mining.

Nevertheless, the positive impact of this method is shown. This result is not surprising given the findings of work done in other areas of human behaviour. It is recommended that this method be applied widely, and it is predicted that this will have a sustainable positive impact on safe working practices in underground mining teams.

6.2 Why the training produced good results

Key elements of our training method have elsewhere been found to be highly effective in achieving change in the way people work. These include:

1. *Simplification of subject matter into discrete elements that are handled in a way that is appropriate to the level of work of the team leader*

The elements are selected on the basis of their direct influence on accidents. They are separated into modules that do not contain too much information and they are taught in a way that a team leader can easily understand and pass on. The leader also easily sees the importance of the learning.

2. Training an individual directly

This has the advantage of allowing the trainer to easily assess whether or not learning has actually taken place, as well as giving the learner more opportunity to clarify issues he does not understand. Both of these are restricted in the conventional classroom environment.

3. Training in actual conditions

The trainer is able to use real examples and the learner does not have to deal with abstract concepts, which then need to be generalised to his place of work – a process which is often found difficult at this level.

4. Working through the leadership of the team

The result of working through the team leader is that the individual with the authority over the team and the accountability for the team's performance is the one training the team in how they should work. This becomes a part of his leadership work rather than a separate training exercise and tends therefore to enhance the team's working relationship.

5. Measuring actual performance and providing feedback and coaching as a result

In most conventional training situations there is little or no link with measuring actual performance in the workplace. In this method the trainer demonstrates the importance of establishing what is actually happening in the workplace and provides coaching to meet specific needs. In many other training areas (not safety related) it has been shown that the best way to translate learning into actual practice is to have leaders requiring a change in behaviour and measuring whether this change is happening.

6.3 Organisational influences

In many work environments, and even in this project, it has been demonstrated that training is never sufficient, even if a superior methodology is used. As pointed out above one team leader seemed reluctant to accept training for reasons that were difficult to ascertain.

For a sustainable improvement in the way people work, all organisational influences on the way they work have to be optimised. In other words, the employees have to be given the resources, authority and other support needed to put into practice what they have learnt. If this is not done, they will quickly see the training as irrelevant and will revert to whatever they find best suits their given circumstances.

Some examples of organisational influences that have emerged from this and other research work are listed below.

- The requirement of a certain work practice but not supplying the material to carry it out.

- A lack of leadership visibility or presence, which means that the leader does not know how well the work is being done, and the team does not believe the leader is interested in how they are performing.
- Leadership focus on face advance and not on working correctly.
- Poor selection of people for leadership roles, which results in leaders being unable or unwilling to take on the accountability for ensuring the team works according to correct work procedures or, at a higher level, being unable to manage the balance between working safely and production targets, i.e. 'safe production'.
- Managements influence on behaviour.
- Influence of monitoring on behaviour.
- Attitude of Team Leader to training.

7 Technology transfer

Two technology transfer workshops are to be held, in consultation with SIMRAC, at appropriate venues and after approval of this final report.

8 Conclusions and recommendations

The following conclusions and recommendations arise from the project.

8.1 Conclusions

The following conclusions can be drawn from this work:

- The introduction of basic strata control knowledge to the team leaders directly and to the rest of the workers indirectly resulted in a significant improvement in terms of hazard recognition and the method of coping with the bad ground conditions.
- Positive results are recorded from the implemented training intervention exercise, and the positive impact of this method is evident.
- Topics selected were appropriately focused and targeted the needs well.
- A certain amount of knowledge sustainability was obtained, despite a change of leadership in the tested team.
- Greater significance can be attached to the findings if the trial method is compared with similar measures of conventional training. The comparison with the control stope provided this.
- Setting up a more tightly controlled research project would be difficult to achieve because of the constantly changing work and team environment in underground mining.
- Training alone (even using a proven methodology) is not sufficient for success; positive organisational influences are also required, such as availability of all specified or required safety items.

8.2 Recommendations

It is highly recommended that similar focused methods of training be implemented on a wide scale. The practicalities of doing so may seem onerous, but since the training is delivered through the team leader, and is based in the working environment, this would not require a great deal of additional personnel. It is also recommended that work is done alongside this training to ensure that the team leader has adequate resources and authority to implement what has been learnt.

It has been found in a number of mining and manufacturing organisations that sustainable safe work practice is achieved through regular input by people in leadership roles to model the identification and remediation of hazardous conditions and behaviour. This type of input could be a way to build on this training and sustain its outputs. Essentially what this amounts to is a key leadership person visiting the workplaces from time to time and having an informal, non-threatening discussion about the safe work elements that the team leaders have had training in and about any safety issues the team leader or members are facing. The visit by mine management to the control stope is an example of this.

8.2.1 Options for further research

It will be worthwhile to research the following in order to add to the contribution made by this work:

- the impact of safe work procedures on production output over the medium to long term;
- the impact of management visibility on safe work;
- the impact and efficiency of initial induction and post-leave refresher training currently used; and

References

SQUELCH, A. P. 2001. Relevance of GAP609b findings to GAP851 investigation. SIMRAC Interim Project Report GAP 851. CSIR Miningtek, Report No. 2001-0444.

VENTER, A. N. 2000. Recommendations related to the most appropriate techniques for training and education of workers in the Gold and Platinum industries. SIMRAC Final Project Report GAP 609b. ANVITECH, Johannesburg.

Appendix A Relevance of GAP609b findings

Appendix B Training/instructional material

Appendix C Team leader assessment document

Appendix D Syllabus-measuring modules

Appendix E Skills evaluation questionnaire