1 Introduction

1.1 Problem statement

Rockfalls and rockbursts continue to account for the single largest cause contributing towards the toll of injuries and fatalities suffered by the workforce during deep-level mining operations. Of the 1800 rock-related fatalities recorded since 1990, approximately 56 % occurred in the stope face area. A large number of these occur within 2,5 m of the stope face, between the face and first line of permanent support. Face area support is installed to reduce the hazards associated with cleaning and drilling in the immediate face area. In many cases, however, the immediate face area support is inadequate to (i) carry the imposed loads, (ii) yield progressively during dynamic (rockburst) loading conditions, and/or (iii) provide sufficient areal coverage. Figures 1.2.1 and 1.2.2 illustrate results of analyses on fatalities that occurred in the immediate vicinity of the stope face and stope back areas (1990 – 1997 fatality data). From the figures it is evident that most fatalities occur within 3 m from the stope face.

The objective of this project is to gain further insights into the performance requirements of immediate face area support systems. A support design methodology is developed, resulting in improved and optimised face area support, which will ultimately lead to a reduction in rock related accidents.

The work encompasses a review of current face area support practice and systems, and quantifies their load carrying capacity, energy absorption capacity during dynamic loading and suitability for high stoping widths (>2 m). To this end laboratory test data of actual face area support units deformed under quasi-static and dynamic (3 m/s deformation rate) conditions is used.

Special reference is given to rockbolting and expertise developed in GAP 335 (Tunnel Support Project, Haile *et al.*, 1998) is applied and further advanced to investigate the interaction of rockbolts with the hangingwall rock mass. Based on underground observations, literature reviews and numerical modelling, hangingwall deformation mechanisms are identified and their impact on rockbolt performance requirements quantified. An important output of this project is the classification of strata conditions, which are most suitable for specific face area support system types (for example, rock bolting).

Operational constraints applicable to face area support (for example, speed of installation, drilling constraints, etc.) are identified, and recommendations regarding solutions on how to overcome the constraints are made. Particular periods in the production cycle, when face area support systems are least able to satisfy their performance requirements, are identified.

The risks of injury associated with the current face area support systems are evaluated quantitatively in SIMRAC project GAP513a (SRK, 1999). The sensitivities of the risks of injury to underlying strata characteristics, support installation constraints and types of personnel exposure are evaluated on the same basis.

The main output of this project is a design methodology, which takes into account the requirements of face area support systems. The methodology is based in part on the work done in GAP 330 (Stope Face Support Systems, Daehnke *et al.*, 1998), and takes into account support resistance and energy absorption requirements, as well as recommended support types and spacing thereof in terms of the least likelihood of injury. The methodology is geotechnical area specific and face area support requirements vary from one geotechnical area to any other.

1.2 Scope of Project

SIMRAC Project GAP 606, titled ‘Support technologies to cater for falls of ground in the immediate face area’, is managed and coordinated by CSIR: Division of Mining Technology, in collaboration with SRK consultants. The main objective of the project is to investigate current and possible alternative face area support systems. The project consists of six enabling outputs. These were defined in the project proposal, and are addresses in the relevant sections of this report as follows.

EO1 Using a survey, review the current face area support practice and systems.
(Addressed in Chapter 2 of this report)

Step 1.1 Review current face area support systems (including rockbolting) by surveying the codes of practice, discussions with rock engineers and underground observations.

Step 1.2 Review current face area support systems for high stoping widths (>2 m).

Step 1.3 Review the yieldability of current face area support systems (using laboratory tests and evaluations where necessary).

EO2 Identify strata conditions which are most suitable for particular face area support systems, for example rockbolting.
(Addressed in Chapter 3 of this report)

Step 2.1 Identify and classify typical strata conditions and quantify their support requirements.

Step 2.2 Identify face area support systems that are most suitable to meet the support requirements of the various strata conditions.

Step 2.3 Review possible alternative support technologies in concept, that may assist in alleviating rockfall and rockburst problems.

EO3 Identify hangingwall deformation mechanisms and their impact on tendon performance requirements.
(Addressed in Chapter 4 of this report)

Step 3.1 Using numerical modeling and underground observations, investigate hangingwall deformation mechanisms and quantify their impact on rockbolt performance requirements.

EO4 Identify operational constraints applicable to face area support systems.
(Addressed in Chapter 5 of this report)

Step 4.1 Identify operational constraints applicable to various face area support systems.

Step 4.2 Recommend solutions to overcome the operational constraints.

EO5 Identify periods in the production cycle when face area support systems are least able to meet their performance requirements.
(Addressed in Chapter 6 of this report)

Step 5.1 Identify particular periods in the production cycle when face area support systems are least able to satisfy their performance requirements.

EO6 Develop a methodology to determine the requirements of face area support systems for various situations.
(SRK contribution: reviewed in Chapter 7 of this report; complete report given in GAP606 Volume II)

Step 6.1 Adapt and/or extend procedures for determining probabilities of excavation instability.

Step 6.2 Quantification of risks of injury associated with current supports for specific classes of strata conditions, deformation mechanisms, support installation constraints and types of exposure.

Step 6.3 Determination of classes of application for which current supports are most suitable in terms of the least likelihood of injury.

Step 6.4 Specification of a design methodology for determining the optimum temporary support system to cater for rockfall and/or rockburst conditions in terms of the least likelihood of injury.

Step 6.5 Recommend a programme of field trials to verify and calibrate the design methodology.

The final chapter (Chapter 8) summarises the work done for each enabling output, and reviews the salient findings and recommendations for further research work. For a brief summary of the principal findings of this project, it is recommended that the reader focus his/her attention on Chapter 8.

In the mining industry, tendon type support systems are generally referred to as rockbolts. The term ‘tendon’, as opposed to ‘rockbolt’, is, however, a more generic description of this type of internal support system (for example, cables are, strictly speaking, not a type of rockbolt). In the original project definition SIMRAC used the more widely applied term ‘rockbolt’ as the generic description of internal support systems. In this report both terms, i.e. ‘tendon’ and ‘rockbolt’, are used interchangeably, and both refer to the generic description of internal support systems.

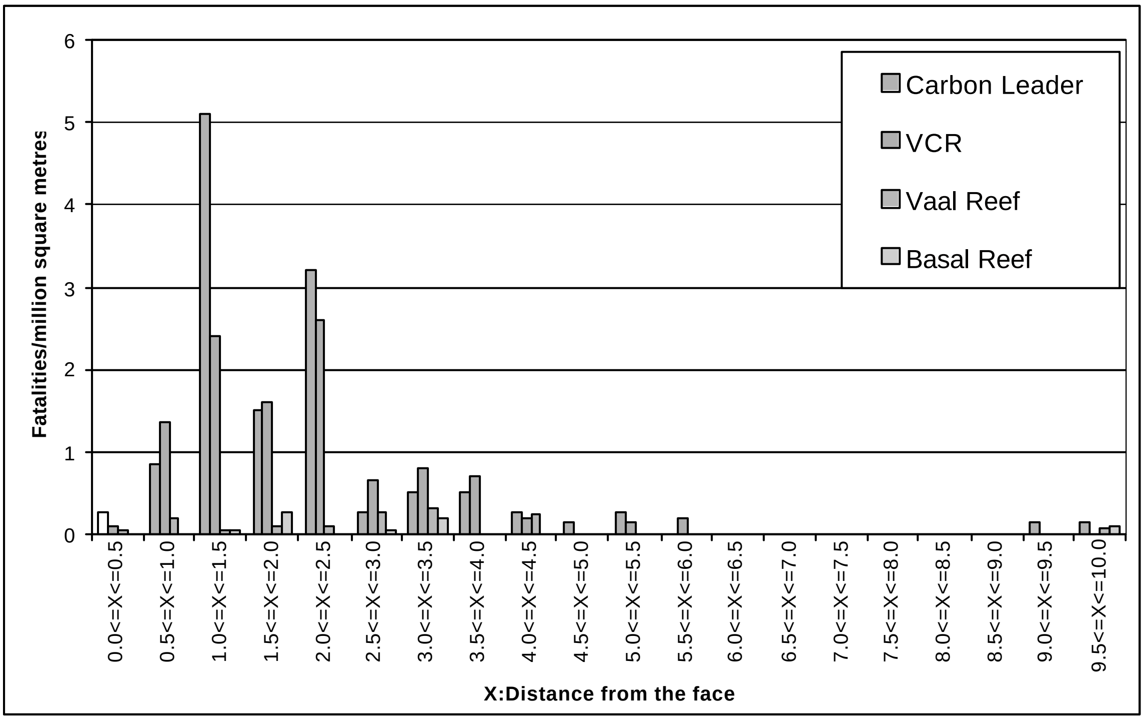

Figure 1.2.1 Distance of fatalities from the stope face for Carbon Leader, VCR, Vaal Reef and Basal Reef rockbursts.

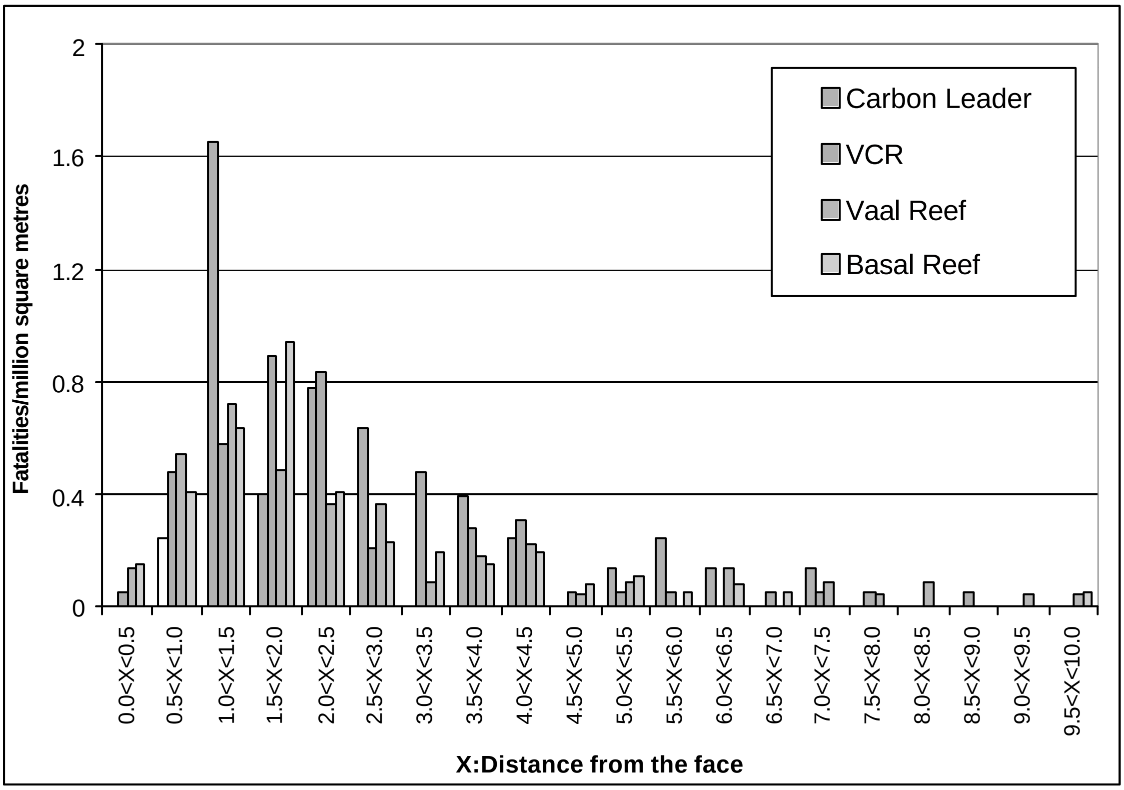

Figure 1.2.2 Distance of fatalities from the stope face for Carbon Leader, VCR, Vaal Reef and Basal Reef rockfalls.