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Application of Web-based Knowledge Management Systems in The Mineral Industry

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ABSTRACT: Knowledge Management has been shown to benefit many large corporate companies by using the intellectual capital of the firm. The data, information and knowledge captured in a firm in terms of explicit and tacit knowledge can be used to gain competitive advantage. The use of electronic information systems using corporate intranets and the Internet can help facilitate the management of knowledge in terms of sharing best practise, globalisation, rapid change in technology, downsizing, managing information and communication overload experienced by many companies.

The paper discusses the application of web-based intranets linked to knowledge management systems to provide codification of knowledge and models for converting this knowledge into a corporate resource. A case study to demonstrate the application of multimedia using metaphors, models and narratives to exchange and synthesise knowledge is discussed with reference to the minerals industry.

1 INTRODUCTION

The value of knowledge as a commercial asset within an organisation is well known and the exploitation can give competitive edge and reputation to the organisation and is usually referred to as intellectual capital [Botktn 1999]. The knowledge could be through information collated by organization and expertise of their staff, built up over many year from custom and practise. Knowledge Management (KM) is a process that helps an organisation identify, select, organise, disseminate and transfer important information and expertise that is contained in the organisation usually in unstructured format. The structuring of knowledge in an effective way will assist in problem solving, dynamic learning, strategic planning and decision-making. The application of using this knowledge in a structured way to give commercial value through its reuse throughout an organisation is referred to as a Knowledge Management Systems (KMS) [Turbin et al 2002]. In information systems it is useful to distinguish between knowledge, data and information. Data tends to be simple observations, which are easily captured and consist of facts, measurements and statistics, while information is structured or processed data within a time frame of applicability. Knowledge is information with the most value, that is contextual, relevant and actionable and which is difficult to capture electronically, hard to structure and highly personal and tacit. Over time, information accumulates within an organization and tends to decay, while knowledge evolves and if managed correctly could produce intellectual capital [Davenport 1997, Turbin et al 2002]. The pharmaceutical company Hoffman-La Roche developed a web-based knowledge management system supplied by Skila Inc, called Global Healthcare Intelligence Platform (GHIP) to integrate documents from multiple repositories. This helped to reduce the filing time for Federal Drug Administration (FDA) approval for new drugs reducing the time from 18 months to 90 days [Shand 2000]. Ernest and Young, one of the big five accountancy and financial services companies, implemented a state of the art knowledge management system, which allowed the organisation to globally share leading practises and intelligence, and contributed to the success of the company increasing its US revenues by up to 24% in 1997. Nike one of the world's largest sportswear companies with sales of $9 billion in 1997 have implemented a system to recommend to their customers their shoe size and also allow them to design their own trainers. When Nike are extracting information about their customer shoe size and footwear design they are able to interpret this information to determine the most popular footwear size, colour, style and design etc which results in better sales revenues [http://www.fhwa.dot.gov/km/. www.nike.com]. In the US it is suggested that 55% of the labour force consists of knowledge and information workers and that 60% of the gross domestic products comes form the knowledge and information sectors of finance and publishing. Many US companies now have Chief Knowledge Officers (CKO) and Knowledge Engineers (KE) that are used to design systems through eliciting knowledge from specialists. Knowledge management has an important role within companies particularly in e-business since success is critically dependent on staff knowledge concerning the micro-environment concerning customers, suppliers, intermediates and competitors in order to shape internal processes to deliver customer value [Saunders 2000]. Some management theorists believe that these knowledge assets are as important for competitive advantage and survival, if not more important than physical and financial assets [Laudon and Laudon 2002, Barnes 2002].

2 EXPLICIT AND TACIT KNOWLEDGE

Knowledge in an organisation can be distinguished between two types explicit and tacit knowledge [Nonaka and Takeuchi 1995]. which is outlined as follows:

- Explicit knowledge maybe organised, expressed and communicated relatively easily and transferred through digital means. This has been a traditional aspect of IT and would include databases, manuals, financial reports and articles etc, basically some form of documentation.
- Tacit knowledge is usually in the domain of subjective, cognitive and experimental learning and includes experience, expertise, know-how. intuition, and trade secrets. It can be fuzzy, often complex and unrecorded. An analogy would be the ability to ride a bicycle, snow board or fly a jumbo jet but which would be difficult to explain to someone else via an email.

All organisations have both explicit and tacit knowledge, usually it is the tacit knowledge that tends to give sustained competitive advantage, because it is difficult to replicate by competitors and can produce a strategic knowledge management environment. However explicit knowledge may also produce competitive advantage in the form of patents and/or copyright and although it is in the public domain it is less easy for competitors to use because the originating company exclusively owns it. Some aspects of organisational knowledge cannot be captured easily or codified especially tacit knowledge and the information that organisations finally manage to capture may become outdated as environments change. A key challenge in knowledge management is to make appropriate tacit knowledge explicit and powerful. [Nonaka and Takeuchi 1995, Laudon and Laudon 2002, Lynch 200.3].

A widespread model on knowledge creation after Nonaka and Takeuchi [1995] is outlined in Figure 1.

		To: Tacit Knowledge	To: Explicit Knowledge
From	**Tacit Knowledge**	**Socialisation** Transferring tacit knowledge through shared experiences, apprenticeships, mentoring relationships, on the job training, 'talking at the water cooler'	**Externalisa tion** Articulating and thereby capturing tacit knowledge through use of metaphors, analogies and models
From	**Explicit Knowledge**	**Internalisation** Converting explicit knowledge into tacit knowledge; learning by doing: studying previously captured explicit knowledge (manuals, documentation) to gain technical know-how	**Combination** Combing existing explicit knowledge through exchange and synthesis into new explicit knowledge

Figure I Four Modes of' Knowledge Conversion [Nonaka and Takeuchi 1995] edge is called socialisation i.e. sharing experiences and observation, imitation and practise. This could include capturing knowledge using videotapes of a story for example in the use of dowels to control floor heave and improve stability of roadways etc. Tacit knowledge to explicit knowledge called externalisation is the sharing of metaphors and models during social interaction. Externalisation is considered do be difficult and costly because of the elusive nature of tacit knowledge. Explicit knowledge to tacit knowledge called internalization, for example after studying manuals or documentation to gain technical know how of a particular equipment an engineer with prior knowledge may combine this new knowledge to diagnose a mal-function that would have resulted in production failure. Explicit knowledge to explicit knowledge, called combination, to exchange and synthesis and to produce new explicit knowledge.

Capturing knowledge by itself is pointless it must be shared within the organisation to have any value. The process of representation of knowledge in a manner that can easily accessed and transferred is referred to as codification [Davenport and Prusak 1998]. While some explicit knowledge may lead itself to codification. Tacit knowledge tends to be subjective and difficult to transmit and some theorist suggests it would be difficult to be copied outside the human mind. A key challenge in developing knowledge management systems is to make appropriate tacit knowledge explicit to gain competitive advantage similar to the Hoffman-La Roche Global Healthcare Intelligence Platform to gain competitive advantage [Shand 2000].

3 STAGES OF IMPLEMENTING KNOWLEDGE MANAGEMENT SYSTEMS

In determining how knowledge management could be applied to an organisation the following four stages can be used as basis of knowledge management assessment and are outlined as follows:

1. Determine the business goals that knowledge management (KM) could assist, thereby providing competitive advantage.
2. Illicit and determine what knowledge management systems are available in and outside the organisation to achieve the business goals
3. Evaluate the knowledge collected to achieving the business goals of the organisation.
4. Codification of explicit and tacit knowledge so that it can be utilised by the company.

3.1. Determining Business Coals

Application portfolio matrix techniques have been widely used in Information System (IS)/lnformation Technology (IT), and are useful to formulate the application of knowledge management and to achieve a consensus on strategy. The matrix or Strategic Grid (SG) is a similar concept to Boston Matrix (BM) for product portfolios analysis [McFarlan 1984, Ward and Peppard 2002].

Figure 2 outlines a typical analysis that could be used to assist in identifying business goals of knowledge management for an organization. SG shows application of knowledge management systems that could contribute to the competitive advantage of a company particularly in strategic (sometimes referred to as star) and high potential areas (problem child) using entrepreneurial or technology driven innovation. In the support (traditional) areas these are typically systems operating as islands of technology whereas the key operational area (factory) forms the backbone of the production type of applications This concept can enable discussion on a consensus of strategy for the organisation in terms of KM positioning and allow management a pertinent number of discrete options for high-level direction. The matrix should be used in conjunction with internal Strengths, Weakness, and external environment based analysis namely Opportunities and Threats (SWOT) analysis to determine the position of current application and to assist future visionary competitive advantage of KM applications to an organisation. Just classifying current and future application into a 2*2 matrix is of little value unless it causes each application to be managed more effectively. In this context it is suggested that the strength and weakness where possible should be related to Critical Success Factors (CSF) analysis to link KM projects to business objectives. An example based on the information depicted in Figure 2 would be a Virtual Reality System (VRS) where KM could be achieved by building a 3-D graphical simulator of a longwall transfer operation. This would assist in achieving a reduction in transfer time particularly in situations where only one longwall is the main method of production.

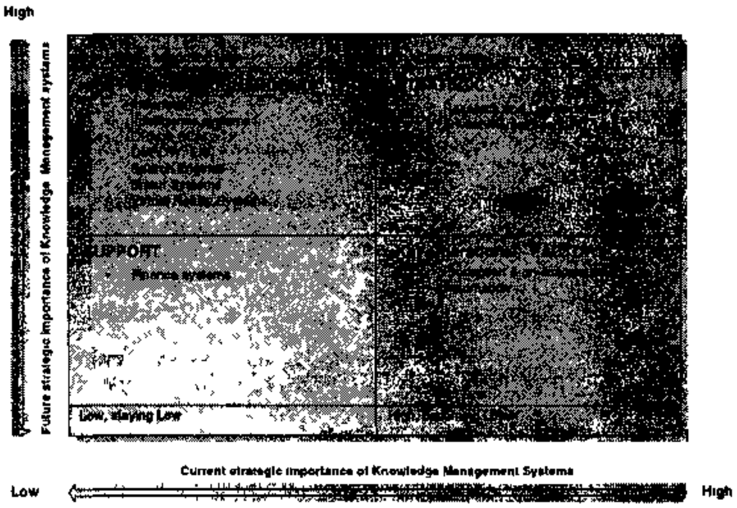

Figure 2 Application Portfolio Matrix for Knowledge Management (KM)

The SWOT in conjunction with CSF analysis on aspects such as performance of transfer, accident prevention etc in utilising knowledge management could be quantified in relation to the business goals of the company. This would be particularly important in situations where only one longwall is the mam method of production. In large organisations the operation can typically be composed of multiple Business Units (BU). in these cases, composite analysis using the matrix maybe needed for the enterprise.

3.2 *Illicit and Determine Knowledge Management Systems*

This would involve analysing and searching for appropriate KM systems available in the market either by developing or customising appropriate software systems [Vince 1999]. In the case of virtual reality systems (VRS) there are various 3-D systems in the market for 3-D layouts including tunnelling, process plants, office layout etc [http://www.web3d.org, http://www.parallelgraphics.com, http://www.virtex.co.uk]. Alternatively you could use Virtual Reality Modelling Language (VRML) enabling Internet browsers to interact with 3-D environments such as World Up and World2 World to develop appropriate systems [http://www.sense8.com/].

3.3 *Evaluating the Knowledge*

This can be achieved from an engineering first principles approach with the purpose of communicating between the technical and non-technical specialist and the needs of the stakeholders of the system. One useful tool is the rich picture developed from a soft system approach which can be used to outline the problem situation in a pictorial form using symbols and pictures with a minimum amount of text [Checkland 1981]. In developing a rich picture it is important to use the terminology and vocabulary applicable to the situation, and also to outline and identify any problems and sources of conflict affecting the knowledge management environment.

3.4 *Codification of Explicit and Tacit Knowledge*

The purpose would be to codify the explicit and tacit knowledge to determine 'best practice' which is the most successful solution or problem solving method that can be developed by an organisation. In addition to improving existing work practices the knowledge can be preserved as 'organisational memory' to train future employees [Laudon and Laudon 2002]. Anecdotal evidence suggests that case studies indicate a combination of 'hard' information (reports and memo etc) and 'soft' information (ideas gossip and opinion) in combination produce the best result. In the case of using a Virtual Reality System to convey knowledge, best practice could be to use a 3-D graphical representation of a mine layout incorporating multimedia features such as voice over narratives and alpha blending of video clips etc. This could then be linked in to corporate intranets to disseminate the knowledge throughout the organisation using e-Leaming.

4 APPLICATION OF KM IN MINING OPERATION

In mining and tunnelling industry, the stability of the .structure surrounding an excavation represent a major challenge to successful operation of the excavated facility. In coal mining operations the stability of roadways is important from both safety and productivity aspects of the operation. Thus implementation of an effective support programme is paramount for the economic viability of the mine. The cost of accident related compensations is on the rise and a significant component of such claim is attributed to falls of roadway roof /rib falls. For example, the Lost Time Injuries (LTD claims related to falls of rocks in 2001-02, in the category of fall, slip and trip mechanism, amounted to 28 % of all claims lodged in NSW, Australia. The underground coal mines use rectangular roadway shapes supported with bolts, and straps. The length of the bolts and their numbers per line of installation across the roadway is dependent on the prevailing geological conditions and manager's support rules. The manager's support rules is usually developed based on the past experience in the mine and in surrounding local mines and beyond. Thus it is abundantly obvious that the manager's rules falls with in the frame of tacit knowledge as being the information based on experience, know how, and trade secret. Publicising the manager's rules to the interested parties, represents a means of communicating this knowledge in an explicit manner. Advancing the process for wider circulation can best be made as a website which can be set up with the relevant information as demonstrated by the following case study.

Case Study: - Support Management Plan Application in an Underground Coal Mine, NSW, Australia

The homepage of the mine's strata management for this panel is shown in Figure 3. An underground coal mine was experiencing poor ground control conditions at the roadways serving a retreating longwall face. The mine (Mine X) was situated some 50 km south of Sydney, and mined coal form 3.3 m thick seam which was situated some 500 m below the ground surface. The longwall face was accessed by two entry headings from either side. Each twin entry heading was intersected by cross cuts at 75 m intervals leaving pillars of 35 m wide. Each road way was 5.5 m wide and 3.3 m high. The roadways and intersections were supported with a combination of bolts, steel straps (W Straps) and wire mesh, both at the roof and ribs. The primary roof supports consisted of six, 2.4 m long bolts per row. The minimum length of W straps installed was 4.6 m. The roadside (rib) reinforcement consisted of W straps, wire mesh and 1.2 m long bolts made from mild steel, fibreglass or plastic.

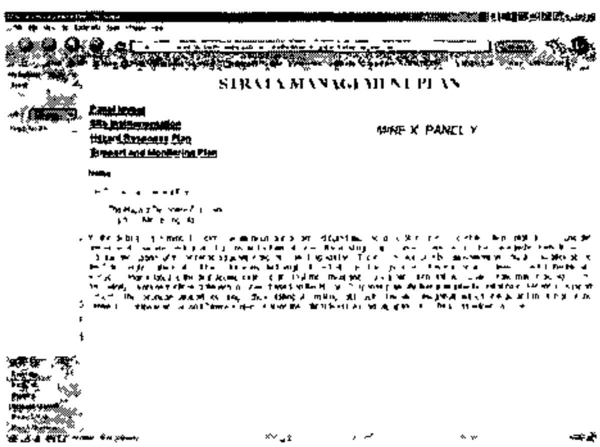

Figure 3 Homepage of Mine X Strata Management Plan (SMP)

During retreat mining of the longwall faces the panel entries were found to deteriorate significantly affecting mining operation, threatening the economic viability of the mine. As a consequence a programme of geotechnical investigation was undertaken to assess the effective support needs of the mine. A roadway section was appropriately selected to conduct the experimental study of the support integrity. The site was situated out bye of a retreating longwall panel. From the mine's SMP homepage (Figure 3), the panel layout can be accessed and displayed (Figure 4).

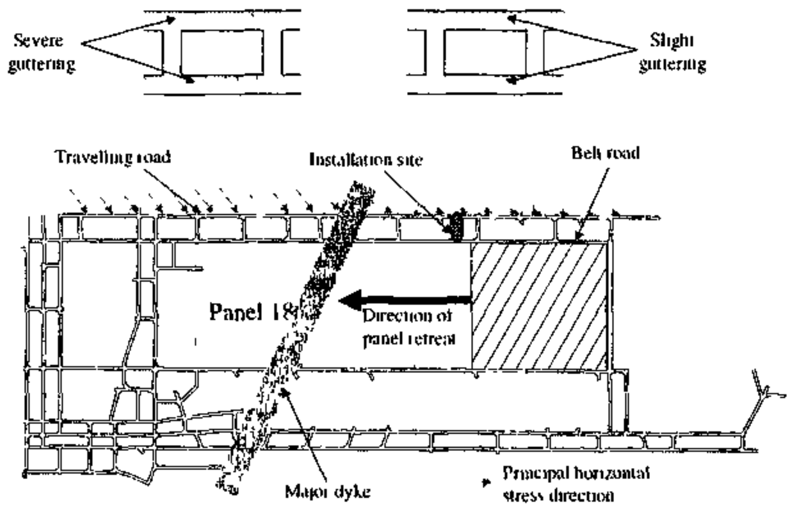

Figure 4 Mine X longwall panel layout

A major dyke intersected both roadways, and there was also a major high horizontal stress acting 45 ° to the direction of mining until it hit the dyke zone, thereafter it swung to run almost parallel to panel direction of the travel road. The magnitude of the high horizontal stress was estimated around 35 MPa, which was equivalent to almost 4 times the vertical stress. The width of the dyke varied between 0.8 m and 1.5 meters. The size and direction of the horizontal stress is shown in Figure 4. The programme of field instrumentation consisted of installing 6 x 2 4m strained gauged bolts (2 rows ot 3 bolts, a meter between rows) with corresponding extensometcrs in between and aligned with the two strain gauged bolts. The instrumentation was carried out in both the travel and belt roads and was close to intersection No 7. From the mine's SMP homepage (Figure 3), the details of the instrumentation of the site can be accessed and displayed (Figure 5).

An important aspect of the Strata Management Plan was that, it followed initially the mine management support rules and preceded with the recommendations, when the ground conditions deteriorated. It should also be emphasised that the support management plan would have the approval of the Mine manager as well as the District Inspector of the Mine, and at times the Check Inspector of the mine representing miners union.

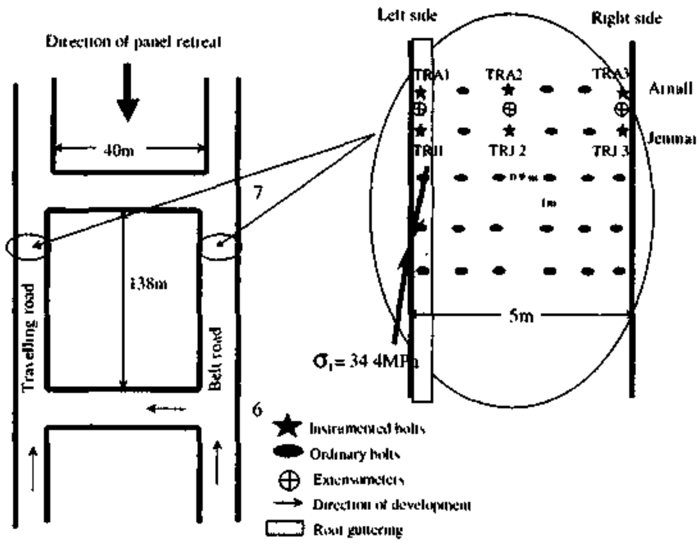

Figure 5. Details of instrumentation of site layout

From the homepage of the mine's SMP website, the following two PDF files SMP plans are hyper linked:

- Hazard response plan (Table 1)
- Support and monitoring plan (Table 2)

5 CONCLUDING REMARKS

The paper outlined the importance of knowledge management in minerals engineering and discussed how it can be used to give competitive advantage. Explicit and tacit knowledge has been discussed indicating the challenges posed in capturing and converting tacit knowledge for use within the organization. The paper has demonstrated how knowledge from the effect of a dyke can be linked to intranets for the benefit of the company via e-Learning. The major difficulty was to develop a culture in an enterprise to codify the knowledge to gain competitive advantage. The old adage that 'knowledge is power' needs to be moderated to benefit from knowledge management. Consideration of the benefits of knowledge management has prompted some visionary organizations to appoint a Chief Knowledge Engineer to champion the pursuit of competitive advantage through knowledge management. The mining industry has generally a good reputation of sharing knowledge particularly in relation to education and safety issues. Some companies have used incentives to capture and disseminate best practice and to ensure that the threats of sharing information were minimized in the organization.

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Table I MINE X - Strata Management Plan

HAZARD RESPONSE PLAN – Maingate 18 Panel
as per "Location Plan" SR-250D

HAZARD INDICATOR	HAZARD RESPONSE TRIGGERS	HAZARD RESPONSE
Dısplacement *Effective for monitoring tools installed within 20m of the advancing face otherwise refer to Displacement Rate triggers*	<u>Total</u> >100mm *if not supported with supplementary cables* *(@ 0 5m horizon or closest anchor within ± 0 2m)*	Site inspection & roadway mapping by area Coordinator &/or Mining Engineer to assess any immediate action(s) as required *(eg continue to monitor increase monitoring frequency install additional monitoring tools &/or supplementary support)*
Dısplacement Rate *Require at least 5 data sets to establish roof displacement trends*	<u>Accelerating</u> >2mm/week <u>Linear</u> ≥ 1mm/wk over 12 weeks ≥ 2mm/wk over 6 weeks ≥ 3-5mm/wk over 4 weeks > 5mm/wk over 3 weeks	Implement Strata Management team meeting to review roof monitoring trending & roadway mapping to determine appropriate action(s) as required Time frame to install supplementary support team member responsibilities and monitoring program to be signed off and implemented Set time for next meeting to assess response success
Roadway Mapping	**Support Deformation:** Inversion of support bearing plates - failure of roof supports <u>Strata Failure</u> - fretting of roof &/or ribs roof sagging &/or guttering - tension fractures structures *(i e faults & dykes)* <u>Roadway Width</u> >5 5m	Deputy shall notify Shift Undermanager for inspection of deteriorating roof and slides UMIC shall be notified Site inspection & roadway mapping by area Coordinator &/or Mining Engineer to assess any immediate action(s) as required *(eg install monitoring tool monitor at increased frequency increase primary support &/or set supplementary support)*

Reaısteıed Mine Manager Date / /

N>

Table 2. MINE X - Strata Management Plan – Support and Monitoring

SUPPORT / MONITORING PLAN Maingate 18		
HEADING	**CUT THROUGH**	**INTERSECTIONS**
PRIMARY SUPPORT 6 x 2 4m roof bolts x 1 in row spacing to be installed with Machine mounted hydraulic bolting rigs (Wide head ABM 20 or I2CM20) 8 x 4.2m roof bolts x lm to be installed when using hand held bolters (CM72) Mesh modules or straps	*1.1.1 Primary Support* 6 x 2.4 roof bolts x Im row spacing to be installed with Machine mounted hydraulic bolting rigs (Wide head ABM 20 or I2CM20) 8 x 2.4m roof bolts x 1 m to be installed when using hand held bolters (CM72) mesh modules or straps	*1.1.2 Primary Support* 6 x 2.4 roof bolts x 1 in row spacing to be installed with Machine mounted hydraulic bolting rigs (Wide head ABM 20 or 12CM20) 8 x 2.4m roof bolts x Im to be installed when using hand held bolters (CM72) mesh modules or straps
Secondary Support Monitor and assess. Install as required by the Plan	*Set ondary Support* Monitor and assess. Install as required by the Plan	*Secondary Support* Monitor and assess. Install as required by the Plan
Monitoring Eveiy 100m of panel advance	*1.1.3 Monitoring* each cut through	*Monitoring* Each intersection where a breakaway is formed. As determined by Strata Management Team
Primary Support Notes: *refer to Manager's Support Rules for roof & rib bolt location 1* *all roof bolts to be installed with 120mm' x 10mm thick bearing plates or plates of equivalent strength* *ensure that bolts are pre-tensioned to the optimum speı ıfu allons*	***Secondary Support Notes:*** *all cable bolts to be encapsulated to >l.5m.* *all type & location of cable bolts will be determined by Sırata Management Team & a Initialised plan shall be implemented.*	***Roof Monitoring Notes:*** *Additional monitoring tools installed as per SMT* *location of monitoring tools to be communicated on Weekly Planning Sheet.* *Extensometers or tell-tales / rockets are to be used for roof monitoring. Tools specified above must be installed within 20m of fat e unless spct ified otherwise.*

Registered Mine Manager........................Date:........./...../.