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TWENTY FIVE YEARS OF MECHANISATION OF TABULAR OREBODIES IN SOUTH AFRICAN GOLD AND PLATINUM MINES

K.A.RHODES: OCTOBER 2015

DECLARATION

I declare that this thesis is my own unaided work. It is being submitted for the degree of Doctor of Engineering at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

……

K.A.Rhodes

.....day of…….2015

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Twenty Five Years of Mechanisation of Tabular Orebodies in South African Gold and Platinum Mines

An Executive Summary

Twenty Five Years of Mechanisation of Tabular Orebodies in South African Gold and Platinum Mines: An Executive Summary

This executive summary to my treatise, **Twenty Five Years of Mechanisation of Tabular Orebodies in South African Gold and Platinum Mines by K.A.Rhodes,** is intended to co-ordinate the documentation and in so doing link the narrative in the chapters of the body of work with the published papers and, further, will demonstrate the pioneering work carried out by myself on mechanisation on gold and platinum mines in South Africa.

In addition to my published technical papers there is a wealth of internal reports in the treatise, written and compiled by me, which set out to explain step by step my arguments for the change from conventional mining to trackless mechanised methods.

Following graduation I have had six decades of experience in the mining industry; with more than forty years in senior management and as a consultant in diverse mining operations in southern Africa. The first twenty five years of my professional career included wide experience in mechanisation on coal and copper mines under varying conditions. In later years I successfully motivated for and introduced a full range of trackless equipment for wide reef stoping and subsequently for narrow reef stoping at Randfontein Estates Gold Mine (REGM). Based on my experience at REGM and immediately following my time there I was responsible, as the mine manager, for the design of the first totally trackless gold mine in South Africa at the H.J.Joel Gold Mine in the Orange Free State. All these projects were planned and managed by myself from the outset.

Later when working as an independent mining consultant, I also believed that there was a need to introduce mechanisation at Rustenburg Platinum Mines in order to improve productivity and reduce operating costs. I therefore investigated the availability to the industry of trackless equipment capable of working on the reef horizon in narrow width conditions. My investigative report led to the introduction of a full suite of low profile trackless equipment at the (then) new Waterval Mine at Rustenburg where I was responsible as the mining consultant for the design and development of the Waterval Mine up to steady state production.

1. Cooke 2 Shaft, Randfontein Estates Gold Mine

In August 1983 I was appointed manager mining at Cooke 2 Shaft, Randfontein Estates Gold Mine. From the day of my first visit underground to a wide reef E8 stope at Cooke 2 Shaft I was determined to introduce mechanisation to that specific reef horizon as soon as I could. My experience with mechanised mining methods, before my appointment at Cooke 2 Shaft, would provide the basis for my pioneering the mechanisation of flat dipping tabular orebodies on the gold mines of Johannesburg Consolidated Investment Company Limited (JCI).

1.1 E8 Wide Reef Project

In the conventional wide reef E8 stopes at Cooke 2 Shaft there was excessive waste dilution primarily caused by the necessity for ultra deep advanced strike gulleys (ASG's), these being required to provide capacity for scraper winch cleaning; a scrutiny of the photographs in the treatise show the general conditions in the stopes at that time. If mechanised equipment were employed there would be no such dilution. Also the use of equipment designed for wide reef conditions, for instance the E8 reef where the stoping width was 2 to 4 metres, would make work more productive and safer. There was, therefore, no doubt in my mind that mechanisation was the better option

In order to motivate the change to mechanisation I submitted several reports over a three month period, from November 1983 to January 1984, with final approval being given for a capital vote in early May 1984. However, the project really began in December 1983 when verbal approval to purchase LHD's and electro-hydraulic face rigs was given.

Phase 1: 1984

From the outset there were certain specific issues to be understood if the project was to be a success: technical knowledge; engineering maintenance; operator skills. An important technical aspect in 1984 was the introduction of the Nonel blasting system to the project.

Technical Knowledge

It was important to me, and for the success of the project, to ensure that supervisors and management, both mining and engineering, obtained an understanding of trackless mechanised mining; in terms of

this, the original equipment manufacturers (OEM's) did provide for basic appreciation courses for these officials. However, I also made it possible for senior officials (and myself) to visit mechanised base metal and diamond mines in order to give them a wider knowledge of trackless mining.I believe these visits, sometimes taking place over several days, were invaluable in that persons were able to gain technical knowledge and they also engendered positive team commitment, specifically between mining and engineering disciplines, and the realisation that mechanised mining dictated that a 'hands-on' management style would have to be adopted.

Engineering Maintenance

The main engineering issue in trackless mining was that workshops had to be provided from the very beginning of the project and a high standard of maintenance work carried out by qualified and experienced artisans was a pre-requisite. Most importantly there had to be a commitment by mining managers to the engineering function.

Operating Skills

In terms of operator skills, before the machines were delivered to the mine I made the early appointment of a mechanical equipment overseer (MES); this appointment was made in order to maintain driver discipline which I considered extremely important at the start-up of a new trackless project where there was going to be a risk of damage and abuse of equipment due to limited operators' skills.

Nonel

During 1984 blasting trials were taking place at Cooke 2 with Nonel, a non-electric ignition system that could guarantee sequential firing and eliminate cut-offs. This controlled experimentation work was under my control and would prove important for the E8 trackless project. The test work on Nonel long period delays (LPD's) proved not just their viability but that they would be necessary in order to maximise advance and justify the drilling of long rounds with an electro-hydraulic drill rig; Nonel short period delays (SPD's) would provide ideal muckpile conditions when blasting the stope panels due to the throw and fragmentation of the blast. A technical paper ***"The Use of Nonel at Cooke 2 Shaft, Randfontein Estates Gold Mining Company,***

Witwatersrand Limited", based on the trials under my control, was written by myself and presented to the Association of Mine Managers (AMMSA) and published in their transactions in 1986; refer to **Appendix 1.3** in **Chapter 1**.

Phase 2: 1985

Early in 1985 the equipment fleet requirements were finalised in terms of an extensive analysis of performance parameters; bearing in mind that the largest size machine would be selected but always taking cognizance of the optimum size of the fleet to maintain operational flexibility and also the planned excavation dimensions.

Construction of the workshops was well advanced and a diesel fuel pipeline system had been completed for the automatic delivery of fuel from surface storage tanks direct to the underground working area.

At this time comprehensive information on the life of sub-assemblies, LHD buckets and tyres was being captured and a monthly report on costs, availabilities and equipment history was issued.

The trackless operation was proving to be safer and as the year progressed there were many standard instructions issued by myself; these were necessary for a trackless method of mining where skills were still limited and they were also critical for the safe operation of machines.

In 1986 I wrote and presented a technical paper "***Wide Reef Mechanised Room and Pillar Operations at Cooke 2 Shaft, Randfontein Estates Gold Mining Company, Witwatersrand, Limited***" to the Association of Mine Managers and it was published in their transactions of 1986; refer to **Appendix 1.4** in **Chapter 1**. It can be recorded that this paper was adjudged by AMMSA as the best technical paper for 1986 and I was awarded the gold medal for that year.

1.2 UEIA Narrow Reef Mechanisation

The E8 Project at Cooke 2 Shaft had provided for total mechanisation on a wide reef tabular orebody employing a full suite of equipment including LHD's, trucks, electro-hydraulic drill rigs and utility vehicles.

However in 1985, with the wide reef project successfully underway, it was my intention to introduce mechanisation to narrow reef conditions which would prove to be the first large scale operation of its kind on South African gold mines.

For this new project I argued that the geology of the reef in that area of the mine that was targeted would favour the introduction of trackless mechanised mining methods (TM3). Conventional mining of the area would have necessitated further significant footwall development. Also working costs could be reduced markedly, primarily because footwall development would be considerably less and there would be a significantly lower labour complement.

I submitted my motivational report for this project at the end of January 1985, immediately followed by an application for a capital vote. Formal approval was given in April 1985.

At the very early stage of the motivation of trackless mining in narrow reef conditions I was fully aware that the operation of large mechanised machines working on the reef horizon to exploit a reef channel of only 105 cms would be criticised by opponents of change. However, I believed that reef dilution could be controlled by handling waste and reef separately when carrying out on-reef development. In fact, in an analysis, I argued that dilution from mechanised mining need not be greater than for conventional mining and thus the operation of large machines to exploit a narrow reef channel need not necessarily imply higher waste dilution. I was fully cognizant that strict management control would be necessary; in this respect detailed calculations were set out in my motivation.

Full details of the planning of this project are set out in the technical paper "***Planning for a Trackless Access Stoping Operation in Narrow Reef Conditions***" written by myself and submitted to the Association of Mine Managers in 1986; refer to **Appendix 1.5** in **Chapter 1**, the paper later being withdrawn for confidentiality reasons by the parent company JCI. However after such a long period of time, and following the demise of JCI, I believe that I have the right to include the paper in this treatise.

1.3 101 Level Streamlined Gathering Haulage

With the majority of ore reserves at Cooke 2 Shaft being a considerable distance (3,5kms) from the shaft system there had become a need for a more efficient ore clearance system. Therefore it was axiomatic, that with the geographic expansion of mining taking place from the trackless projects, that the work already planned for before my arrival at Cooke 2 Shaft would be inadequate and further substantial upgrading of 101 Level haulage would be necessary; if this work was not done then the five year plan at the shaft would be jeopardised. I therefore set out a detailed motivation for this work in order to establish a definitive streamlined haulage which would serve as a gathering haulage for both the new mechanised projects. Towards the end of 1985, before I was transferred from Cooke 2 Shaft to the H.J.Joel Gold Mine, this work was completed and the streamlined haulage was operational.

1.4 Cooke 2 Shaft: Final Note

Nearing the end of 1985 I had been at Cooke 2 Shaft for two years and I was to be transferred to the H.J.Joel Gold Mine, JCI's new mine in the Orange Free State (OFS). In my two years at Cooke 2 Shaft I believe that significant progress had been made with mechanisation: the wide reef project was well on its way to achieving steady state production which was expected in January 1986 and, further, the narrow reef project had commenced under my direction.

I would like to re-iterate what I say in Chapter 3 of the exposition, that both these trackless projects came about from my own initiatives and were designed, planned and managed by myself whilst at the same time being responsible for all operations at Cooke 2 Shaft.

Although at that time I believed I had not completed all the work I had set out to do at Cooke 2 Shaft, specifically the narrow reef project, I was about to start the biggest challenge of my mining career.

2. Design, Planning and Management of the H.J.Joel Gold Mine in the Orange Free State

In late August 1985 I was transferred to the new JCI mine in the OFS as project manager, later to be appointed as mine manager: shaft sinking at

the H.J.Joel Gold Mine had not started but the mine had been planned for in the Feasibility Study as a conventional gold mine.

When I was transferred to H.J.Joel I was given no directive to re-plan the mine for trackless mining; the mine was about to start shaft sinking and conventional mining methods would be practised. On my own initiative I took it upon myself to review the design of the mine with the purpose of changing to trackless mechanised mining methods. After my two years of pioneering trackless mining at Cooke 2 Shaft I had no intention of abandoning my efforts to further advance mechanisation within the JCI Group; this appointment would give me the opportunity to design a new mine based on trackless mining methods from the outset. My first motivational report was submitted on 19 September 1985, within weeks of my appointment at H.J.Joel Mine.

In January 1986 final recommendations were given and a final motivation report "Proposed Trackless Access Gathering Haulage Mining Operations at the H.J.Joel Project" by K.A.Rhodes, dated 31 January 1986 was submitted, and a copy is included in this treatise. Following submission of this report I attended an Executive Committee meeting of the JCI Board and gave my presentation of a comparison of conventional and trackless methods. The recommendation of the committee was "*that all further planning associated with the Joel Mine be based on trackless mechanised methods*"**.**

2.1 Shaft Sinking and Mid-Shaft Loading

During the time I was writing my motivational reports for the trackless design, shaft sinking was taking place. After a pre-sink and the erection of headgears, the main sink commenced in early January 1986.

The establishment of Mid-Shaft Loading (MSL) enabled access development to the reef horizon and on reef development to be carried out, thereby providing for ore reserves while at the same time allowing sinking operations at both shafts to continue. When the shaft system was commissioned in late 1988 more than 6000 metres of MSL development had been carried out and this made it possible for first reef production to be brought forward by one year.

The work of sinking two shafts with their associated station excavation work on four levels and concurrent MSL development on two levels proved to be extremely complex. The safety of persons working in the shafts and in the MSL development was of crucial importance and in terms of the necessity to avoid an inrush of water from the underground aquifers, the constant danger of methane emissions and complicated changing ventilation conditions a 'hands-on' style of management was essential.

Full details of shaft sinking and MSL operations can be seen in the technical paper written by myself "***Shaft Sinking and Mid-Shaft Loading at H.J.Joel Gold Mine, Orange Free State, South Africa****":* refer to **Appendix 1.6** in **Chapter 1**. This paper was written for and published by the Institution of Mining Engineers in the United Kingdom in 1988.

2.2 Development of the Mine

In 1987 and 1988, during the development of the mine and the build-up to production, there was a substantial learning curve to be overcome for both mining and engineering personnel, most of whom were experiencing trackless mechanisation for the very first time. There were many technical issues which required the attention of myself and also my subordinate managers and these are discussed in some detail in the text of the exposition. There were also people issues which were crucial for success of the project and I would like to briefly summarise some of these below.

- Recruitment and retention of supervisory personnel was not easy: normally for a new mine starting up certain Group employees would be transferred from operating mines but due to the distance of H.J.Joel from other JCI mines this proved to be difficult.
- In the first year of operation there was a 60% turnover of supervisory staff.
- New employees intended to be trained as operators were hard to find in the OFS: as an example, the number of persons failing the psychometric testing was alarmingly high.
- Following completion of their training it was never easy to maintain the complement of operators due to absenteeism (weekends and Mondays);

high desertion rate; recruits new to underground work were leaving due to their inability to adjust to the conditions.

- Recruitment of artisans was a special challenge; attempts were made to recruit overseas which were only partially successful and there was a heavy reliance on contract labour brokers.
- On a new mine employing trackless mining, which was a different mining method for almost everybody at H.J.Joel, skills training was vital. It was a responsibility of the OEM's to provide training for drivers. Also programmes were developed for supervisory officials and management in order to give them technical knowledge.
- Many standards for the operation and maintenance of trackless equipment had to be developed; initially these were hand-written by myself. Some of these standard instructions can be seen in this treatise.
- Standards compliance juxtaposed with the formal training programmes provided the basis for the Mechanical Equipment Supervisor (MES) to control damage and prevent abuse of expensive equipment. Damage to equipment, when employing operators with low to average skills at the start-up of a new trackless mine, was inevitable but without the influence of an appointed MES from the outset, who strictly supervised the training programmes and enforced the written standards, the availability and utilization of equipment would have spiralled downwards and out of control.
- In order to help front line supervisors, a supervision report for trackless operations was designed specifically for development.
- Mining managers, firstly, had to have the required engineering technical knowledge in order to be able to manage and direct mechanised operations and secondly, they had to be committed to the engineering function. Mining managers were responsible for the operations and production whilst engineering managers were responsible for the maintenance and therefore the availability of the machines. Both had their independent responsibilities but they had to work as a team and it was my job to ensure that this happened.
- With a committed higher management team it was necessary to maintain morale throughout the organisation, from the top down to the lowest level. In this respect it was also vital to have regular briefings to emphasise production objectives and safety standards; these would be at end of month gatherings for motivation and morale building. Managers' addresses would explain overall monthly performance and

always motivate for a higher achievement.

These problems and some solutions have been fully discussed in Chapter 5 of the treatise.

2.3 Trackless Mining Symposium 1988

At the Trackless Mining Symposium held in Johannesburg in February 1988 I wrote and presented the paper "***The Design of a New Trackless Gold Mine***". The paper was published in the transactions of AMMSA and is included as **Appendix 1.7** in **Chapter 1**. This paper was adjudged to be the best paper presented at the symposium and I was awarded a special medal.

2.4 End of 1988

The H.J.Joel Gold Mine, the first totally trackless gold mine in South Africa, was officially opened by the JCI Chairman on 21 October 1988, just over three years after I submitted my first motivational report for a change in the design of the mine from conventional mining to trackless mechanised mining methods.

3. The Waterval Mine, Rustenburg Platinum Mines

In the late 1990's when I was working as an independent consultant, I formed my own single member consultancy, KAR Mining Consultant cc. Having undertaken several consultancy assignments for Anglo American Platinum Limited (Amplats) I was of the opinion that they should give consideration to the application of trackless mechanised mining, specifically for the UG2 Reef, a wider reef than the extensively mined Merensky Reef. It was with this in mind that I carried out an investigation into the availability of equipment capable of working in a mining height of 1,5 metres, later increased to 1,8 metres. At that time, fifteen years ago, there were very few machines available to work in narrow heights, these being restricted to some LHD's working on South Africa's chrome mines. However, during this investigation I learned that low profile equipment was operating in Poland's copper mines and it was clear to me that this should be followed up.

Following my visit to Poland and the submission of my investigative report, I was able to set out recommendations for a new trackless mine design for the Waterval Mine, Rustenburg Platinum Mines (RPM).

3.1 The Design of the Waterval Mine

I had proposed a room and pillar design at Waterval, a method well known to me, but not the stepped room and pillar method I had opted for at Cooke 2 Shaft REGM, but the standard layout; this decision being due to my later experience gained with trackless equipment on flat dipping reefs. At Cooke 2 Shaft I had decided to establish flat footwalls in the stepped layout but my experience had now shown that trackless machines could operate on true dip up to 10°; the UG2 Reef dip at RPM was of the order of 10° and at Cooke 2 Shaft the E8 Reef was 2° - 10°. This then was the difference of design between the two projects; all operations at Waterval were on full dip.

Equipment Selection

The selection of equipment, at that time in early 2001, was still limited to only a few proven machines, in fact the final decision on a roofbolter only took place six months later. In the end a single OEM was nominated for the total fleet of equipment for the mine, providing for the mechanisation of all operations.

Ore Clearance

Although I had planned for truck haulage at both REGM and H.J.Joel my design for Waterval provided for conveyors. The main reason for this was that with all operations planned to be on the reef horizon and the channel width of the UG2 being only 80cms, with a planned stoping width of 180cms, the dilution was already more than 100%. Nevertheless, considering some of the problems encountered with the conveyors at Waterval, in hindsight, I could have put forward an argument for the use of trucks.

Almost immediately after I had completed my work for Amplats at Waterval I advised the Board of Impala Platinum Mines to plan for trucks (LHD into trucks direct to surface) at their Ngezi Mine in Zimbabwe and they still use trucks today. Some time later I carried out a detailed exercise comparing ore clearance by truck, conveyors and vertical shafts and the findings were clear that for a relatively shallow operation direct trucking to surface would prove the most beneficial.

3.2 Management of the Start-Up of a New Mine

Very few mining engineers will get the opportunity in their entire career to manage the start-up of a new mine. To manage a mine from its beginning is quite different from being appointed as manager of an established mine. When I was the responsible manager at Otjihase Copper Mine and later the mine manager of H.J.Joel Gold Mine decisions had to be made quickly and in terms of a clear line management structure: it had to be obvious to everyone who was the person in charge. Waterval was different for me, I was the consultant and therefore the technical advisor but not the manager. At Waterval an outside consultancy, independent from the mine management, was appointed to manage the project with a contracting company, responsible to the consultancy, carrying out the underground work. This organisational structure at Waterval did not, in my opinion, meet the requirements of a normal line management organisation. Nevertheless, in any organisational structure it is crucial to ensure what are the powers and authority of any delegated person in order to mitigate any confusion or misunderstanding.

Notwithstanding, the Waterval Mine was commissioned as a totally trackless platinum mine at steady state production, less than four years after I submitted my investigative report into the availability of low profile trackless equipment. I was the technical advisor and consultant for the project from start up to steady state production.

4. Other Mechanisation Projects and Trials

Since forming my own consultancy nearly twenty years ago I have been involved with the project design and management of numerous diverse operations on gold, platinum, diamonds, chrome and copper mines. In Chapter 7 of the exposition reference is generally focussed on my work in narrow reefs on platinum mines in South Africa. However, as an exception, I have made reference to my design work at the Legadembi Gold Mine in Ethiopia which I consider has relevance to this exposition.

I would now like to summarise my work on platinum mines with tunnel boring machines, long hole stoping methods, trucks for ore clearance to surface and refer to my design work at Legadembi.

4.1 Styldrift Mine

For three years I was involved as the consultant mining engineer for Amplats for their new project, the Styldrift Mine. Initially the mine had been planned for a conventional multi-level vertical shaft system to exploit the 0,9 metre wide Merensky Reef. However, a study of the geological data available did suggest that there was a substantial block of ground in the middle of the farm with a wide channel of about 2,0 metres, which convinced me that trackless mining methods would be preferable to any conventional mining method. Following acceptance of this change it was further proposed by myself to change from a vertical shaft to a decline, this would have many advantages for trackless mechanised mining. I then proposed, for the first time on a South African mine, that the mine should be developed from surface by a tunnel boring machine (TBM) and this was accepted in August 1999. Following this decision, design work commenced based on a trackless mine with twin access declines developed by TBM's; later this was to change to a single larger diameter decline.

Following completion of the mine design a technical audit, carried out by Anglo American Technical Services in July 2000, could not find any technical issues which could jeopardise the project. After this very positive audit, negotiations commenced with TBM contracting companies and negotiations were entered into with a Joint Venture involving four companies; these discussions culminated in a draft contract document being agreed to in July 2001. However, in late 2001 when the Royal Bafokeng Nation became involved for the first time, circumstances changed. Throughout 2002 discussions were held, without my direct involvement, and by the end of that year my design of Styldrift, which had been approved by Anglo American Corporation had been abandoned. If the project had gone ahead, as I originally planned, it would have been the first trackless underground mine in South Africa to be developed by TBM from surface; a revolutionary change of mind set.

4.2 Bafokeng Rasimone Reef Boring Project

In late 2000 I was designated as project manager at Bafokeng Rasimone Mine for the boring of a reef raise by TBM. There were many lessons to be learnt from this project but it was a success in spite of the work being done by an old machine. However, no further projects of this kind have

taken place. There is a detailed description of this project in Chapter 7 of the treatise and it has further been documented in a paper presented to the 6th International Symposium on Mine Mechanisation and Automation, South African Institute of Mining and Metallurgy in September 2001. The paper was written by myself assisted by Mr Peter Horrell (80%/20% respectively), a TBM consultant who was an advisor to me on the project. The paper is entitled "***Reef Development with a Tunnel Boring Machine on a South African Platinum Mine***" by M.Stander, K.Rhodes, P.Horrell, D.Sammons, G.Harrison, J.Dean: refer to **Appendix 1.8** in **Chapter 1**. Mr Stander, the Mine Manager of the mine presented the paper; he and the other persons (other than P.Horrell) were Amplats employees and had no involvement in compiling the paper.

4.3 BorPak Boring Machine

Before my involvement in the above TBM project I prepared a report for Amplats in 1999 on the BorPak blind borer for the development of stope raises and ore pass development. The BorPak was first introduced to the mining industry in 1992 at the Mining Show in Las Vegas and at the time I wrote my report only three machines had been or were in operation; I had the opportunity to see one of these units working in Zimbabwe at the Hartley Mine. My report concluded that the BorPak could be financially justified and I recommended that a rail mounted unit should be purchased for the rapid opening up of face at existing mines. A trackless unit could also have been used on any new greenfields project. Unfortunately no further action was taken by Amplats.

4.4 Long Hole Stoping

Trials of long hole stoping methods (LHS) are not new in South African gold mines; such trials have been documented in the Association of Mine Managers of South Africa (AMMSA) transactions more than fifty years ago but they did not get acceptance in the industry. All these trials employed conventional equipment and I had asked myself, as far back as 1993, whether results could be different if modern trackless equipment, specifically rigs which had the capability of drilling accurate long holes, were used. My investigation into long hole drilling techniques was recorded in a report to Amplats in 1996 which recommended further trials with trackless equipment. Trials at Union Section, RPM, based on a proposal submitted by myself, took place in late 1998. These trials were

not a total success as the drill rig used was a standard long hole rig for large open stopes and therefore was not ideal. Nevertheless, following my discussions with the management of Rustenburg Platinum Mines (RPM) in 1999, further trials took place at Boschfontein Decline Section utilizing a newly designed low profile drill rig; these trials could claim overall success and in my opinion justified further continuance with the LHS method. Notwithstanding the success of the trials at Boschfontein and my subsequent motivational reports to pursue the LHS method, LHS has not found favour on platinum mines.

4.5 Hybrid Mining with Trucks

In 2001 I completed a mine design for the new Boschfontein East and West Mines at RPM based on the hybrid layout I had first introduced at Cooke 2 Shaft, REGM, but which included ore clearance to surface by truck. Although this concept was not initially well received I was able to show later that the most viable option for ore clearance, on a new mine developed by decline from surface, would be by truck to surface at the outset and later, at a stage to be determined, by truck to a common tipping point and then to surface by conveyor; this conclusion was supported by a study led by myself with the assistance of specialised computer modelling and is included in Volume 4.

4.6 Legadembi Gold Mine, Ethiopia

In late 2004 I made my first consultancy visit to Ethiopia where Midroc Gold Mine PLC was starting the development of a new underground gold mine. Subsequently I was the project manager for the underground mining design of the new Legadembi Gold Mine near Shakisso in southern Ethiopia. During the early design work it became clear that the near vertical main orebody had a width of 30 metres for over half its length. Geotechnical analysis further indicated that a maximum allowable span would be only 14 metres and in terms of the selection of a mining method this information was highly significant. Exercises to determine the stoping method had shown that the favoured option would be a horizontal cut and fill method; the mine would be fully mechanised. It was further dictated that in-stope pillars had to be provided for due to the orebody width far exceeding the maximum permissible span. In effect the design would provide for a series of

trackless room and pillar stoping operations in vertical lifts with fill. The merits and demerits of various options for the size of the pillars are the main thrust of the paper "***Design of In Stope Pillars in Cut and Fill Mining for a Gold Mine in Ethiopia***" by K.A.Rhodes and T.Rangasamy (50%/50% contributions) delivered at the 5th International Conference MassMin 2008 in Lulea, Sweden and organised by Lulea University of Technology; the paper was published in the transactions of the conference. Refer to **Appendix 1.9** in **Chapter 1**.

4.7 Summary

In Chapter 7 of my treatise I have set out to document my initiatives to pioneer the use of TBM's on new platinum mines. I have also described my direct involvement with successful trials on long hole stoping; a mining method which is still unproven as a production method for narrow flat dipping orebodies. In this ten year period there were partial successes; truck hauling to surface did become an accepted ore clearance method. However with TBM's and LHS no real progress was made. I have learnt over the years that pioneering work is best achieved by a 'champion' who is in the direct line of management, with the determination and the authority to make things happen; this was the case when I was at Cooke 2 Shaft, REGM and at the H.J.Joel Gold Mine where I was in direct control of the operations. As a consultant one is a technical advisor; however even then success can be achieved as my experience at Waterval Mine has shown.

5. Some Final Thoughts

In 1988 at the Association of Mine Managers Symposium on trackless mining there was a distinct air of euphoria regarding mechanisation, specifically on gold mines, with the President of AMMSA at that time, stating that the industry was *"entering a new era of technique".* It was always to be expected that it would take some time for the new trackless methods to become established. However, the industry in general did not have that time but more importantly did not have the will to go through the learning curve necessary to entrench trackless mining on gold mines specifically. Today in South Africa, with the gold mining industry having been decimated in recent decades, the focus on any mechanisation of tabular reefs is on the platinum mines. It must be argued further that if trackless mining had expanded after the 1980's on gold and platinum mines and the mechanisation of stope face

drilling had been allowed to evolve, one would have to ask, in hindsight, whether the tragic incident at Marikana in 2012 involving the rock drill operators on the Lonmin mines, and which preceded the longest strike in the history of mining in South Africa on the platinum mines in 2014, could have been avoided.

In conclusion, I believe that now is the right time for a new era of mechanisation on the platinum mines in South Africa. Any repetition of the industrial action of 2014 will be crippling to the platinum mines and, therefore, there is very good reason for the platinum producers to introduce mechanisation as soon as practicable in order to provide for a more skilled labour force who would earn higher wages and in turn could create profit to enable the producers to create more opportunities for employment.