Introduction

Venetia mine is located on the farm VENETIA 103MS, situated in the Northern Province of South Africa, approximately 27 km south of the confluence of the Shashe and Limpopo rivers, 80 km west of the town of Messina and 40 km east of the farming community, Alldays, as shown in Figure 1.

Pre-stripping and construction commenced in 1990 phasing the mine into full production in 1993. The workforce is housed in Messina, Alldays and Lebowa and is bussed to and from the mine daily.

Geology

Venetia mine consists of a cluster of 14 kimberlite pipes (see Figure 2), varying in size from <1 ha to 12.5 ha. The two largest kimberlites, K001 and K002 being 12.5 ha and 5 ha respectively, form the basis of the mine plan, with the remainder of the satellite kimberlites being mined as the open pit expands. The kimberlites appear to be contained within the centre of a synformal structure.

Gneiss, biotite schist and amphibolites mainly comprise the complex jointed host rock, which is further complicated by unfavourably orientated metamorphic layering in the southern region, which causes planar failure. Deformation of the country rock is extremely complex and typical of the Limpopo Metamorphic terrane in which it is situated. The intact rock strengths of the country rock types varies from 100 MPa to in excess of 300 MPa.

Venetia currently mines some 29 million tonnes per annum of which 4.2 million tonnes is ore sent for processing.

Whittle Four-D optimization

Whittle Four-D optimization was performed on the K001 and K002 kimberlites to determine the final economic shell and push back limits (see Figure 3). The slope angles for the various regions in the pit were, at the time, under review. To assess the potential impact on waste tonnes of the flattening angles, a series of scenarios were run in Whittle by modifying the slope zones in the parameter file accordingly, as shown in Table I.

Concentric mining

Open pit design and planning at Venetia mine has, in the past, been based on a conventional concentric mining method. The concentric mining principle mines a waste cut or pushback 360° around the orebody. Each mining cut becomes progressively larger as the pit gets deeper.

In order to maintain ore feed to the plant, waste stripping increases significantly year on year as the pit depth increases. Cost profiles mirror waste stripping profiles therefore in

Synopsis

In today's high tech world, systems are getting bigger, faster, better.

To remain at the leading edge, in any business, depends on accurate but flexible design thereby allowing operational managers to provide alternatives to improve their operations. The ultimate goal is to deliver to plan, with optimum economics.

Mining is no different, with falling prices and escalating costs, improved margins become the focal objective. There are many ways to achieve this, ranging from operational efficiency improvements through production scenarios to planning initiatives. Of all, planning usually receives the least attention, yet it is the area of most influence on the NPV of the reserve. With computer technology, numerous concepts and iterations are possible thereby closing the gap between optimal and actual design.

This paper discusses the application of the split shell design at the De Beers Venetia open pit in South Africa.
Split shell open pit design concept applied at De Beers Venetia Mine, South Africa

Concentric mining, although traditional, workable and proven, once critically examined, has operational downsides. These range from high stripping ratios earlier in the life of mine, concurrent mining of different pushbacks which results in the congestion of mining activities, waste dilution on top of ore and temporary ramp closure from blast spillage, all of which reduce efficiencies and increase cost. Robin Kear, a mining advisor to the mine, proposed the split shell concept. Design work and planning was initiated to prove up the applicability of this method at Venetia Mine. It was found that split shells obviate some of the constraints associated with concentric mining and based on this, further investigations were initiated to determine whether the value of the reserve could be improved.

**Split shell concept**

Split shell mining departs from the conventional concentric method of waste stripping.

pursuit of better returns, mine design criteria and philosophies were investigated.
The concept is based on the principle of splitting a pit shell along an axis, creating two separate push-backs and joining the opposite halves of each design.

The direct benefit of the split shell design is that it allows for waste stripping to be deferred from the early part of the waste cut life, without putting exposed ore at risk for mining. The concept also incorporates various operational advantages, such as:

- Unobstructed ore haul route access due to waste mining taking place on the opposite side of the pit to that of the ore ramp
- Reduced waste spillage on ore access ramps
- Improved operational efficiencies due to less congestion of equipment in working areas
- Increased flexibility in both operations and future planning, since the mining cut is split and is not being mined at once
- Reduced Business Risk Period (BRP)
- Reduced waste tonnage profile due to the split in the mining cut and hence capital and operating cost.

The process is iterative and generally follows the sequence described below:

- Assess the current design, taking cognisance of the current mining status. This will establish if a split is possible at all on the remaining mine life. In some cases, mining has advanced beyond a point that will allow ramp configurations necessary for the successful split
- Re-design current mining cut, modifying ramps if necessary
- Determine the most suitable ‘split axis’ of the orebody taking cognisance of geometry, grade, rock type characteristics for plant blending purposes and finally ore release extent
- Assess the country rock for competence, fault planes, jointing and stability, which may influence on which side of the shell the first split will be mined.
- Conduct multiple pit designs incorporating the ramp configuration rules that obey the split axis determined in the previous stages.
- Split and merge the different designs, evaluating the resultant ‘joined split shell’ each time to determine the optimum designs available for splitting.
- Select the optimum split designs and sequence these interim shells to determine the bottleneck, which will ultimately feed into the short-term plans. On certain large deposits, multiple splits are possible.

The split shell design does not significantly alter the size of the final pit shell nor does it reduce total tonnes mined—it is merely a re-schedule of intermediate cuts or pushbacks and is illustrated in Figure 4 below.

### Push-back /waste cut determination

The correct push-back distance or waste cut is determined by a number of factors such as equipment size, final planned depth, production rate, ramp geometry, market confidence, etc. and is a calculated risk that the management team must take. These factors need to be considered when sizing and determining the split axis. The split shell presents opportunities to target higher graded areas while deferring waste which in turn defers cost and can bring revenue forward. Once the particular cut has commenced, the mine is to some extent committed to the mining of that entire cut, as capital expenditure and infrastructure will be required to maintain production for the duration of that particular cut. In other words, the costs may be sunk up-front. In concentric mining, the capital, infrastructure and time committed is virtually double that of a split shell.

Large waste cuts do have more associated ore and have the advantage of establishing roadways and services (pumping columns, etc.) for longer periods, but there is a price to pay—increased stripping. Planners on many large open pit mines tend to be conservative when determining push-back distance and take wider waste cuts than the required minimum resulting in increased risk due to the

---

**Table I**

<table>
<thead>
<tr>
<th>Units</th>
<th>Whittle shell (degrees)</th>
<th>Whittle shell (S)–(N)</th>
<th>Whittle shell (S)–(N)</th>
<th>Whittle shell (S)–(N)</th>
<th>Current final pit design (S)–(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td></td>
<td>35°–40° (N)</td>
<td>40°–45° (N)</td>
<td>45°–50° (N)</td>
<td>36°–40° (N)</td>
</tr>
<tr>
<td>K001/K002 kmberlite tons (000s tons)</td>
<td>84 710</td>
<td>85 473</td>
<td>86 379</td>
<td>85 132</td>
<td></td>
</tr>
<tr>
<td>Satellite kmberlite tons (000s tons)</td>
<td>16 685</td>
<td>15 958</td>
<td>15 727</td>
<td>13 278</td>
<td></td>
</tr>
<tr>
<td>Total kmberlite tons (000s tons)</td>
<td>101 395</td>
<td>101 431</td>
<td>102 106</td>
<td>98 410</td>
<td></td>
</tr>
<tr>
<td>Waste tons (000s tons)</td>
<td>690 899</td>
<td>566 927</td>
<td>468 783</td>
<td>669 270</td>
<td></td>
</tr>
<tr>
<td>Strip ratio (waste : ore)</td>
<td>6.72</td>
<td>5.59</td>
<td>4.59</td>
<td>6.80</td>
<td></td>
</tr>
<tr>
<td>Life of mine Minimum production scenario (years)</td>
<td>31.49</td>
<td>31.50</td>
<td>31.71</td>
<td>30.56</td>
<td></td>
</tr>
<tr>
<td>Realistic production scenario (years)</td>
<td>29.75</td>
<td>29.76</td>
<td>29.97</td>
<td>28.85</td>
<td></td>
</tr>
<tr>
<td>Maximum production scenario (years)</td>
<td>22.83</td>
<td>22.84</td>
<td>23.00</td>
<td>22.14</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4**—Schematic showing the difference between conventional concentric mining and split mining
Split shell open pit design concept applied at De Beers Venetia Mine, South Africa

longevity of that cut, requiring higher instantaneous stripping ratios and early capital expenditure. Concentric mining compounds this scenario. Quite often, due to the deposit wealth, inefficiencies from over-stripping is masked. In view of current market conditions, the size of the cut, hence life is a risk management must take. The basis for an assessment of risk is associated with a period of time for which development costs are acceptable.

The Business Risk Period (BRP) is one of the most fundamental parameters which needs to be defined for any business, and represents the period of time over which an owner is prepared to invest capital. (Seymour 1997).

Development of split shells takes one waste cut design, splits it, resulting in separate mining cuts. This effectively divides the operating life of each waste cut according to the limits of the split shell without affecting the overall life of the waste cut. By mining the split shell, waste stripping is deferred thereby reducing high instantaneous stripping ratios, BFRs are reduced improving flexibility while still allowing for the establishment of semi-permanent roadways and services. All of these factors contribute favourably to operating efficiency and NPV.

Impact of ramps on optimal pits

Having discussed the theory behind optimal pits, the mining engineer has to transform this optimal pit into a practical pit, without deviating too much from the mathematical optimum. Whittle Four-D will determine the blocks which are mineable and when they should be mined, but how to mine these is determined by the mining engineer. The evolution from theoretical pits to practical pits could take several stages, but often some of the stages are omitted due to time constraints.

Given an optimal pit design from Whittle, there are a range of ramp designs and configurations that could be generated, but to choose the optimal ramp design which maximizes profitability and practicality is the trick. Considerations such as width, gradient and direction all need to be evaluated and only by adopting an iterative approach and running a series of ramp designs can the optimum design be achieved.

Ramp configuration, for the success of the split shell design, is one of the critical factors to determine. Once the correct split axis has been decided, as described earlier, the ramps have to be configured in such a way that cross-over points are established at the edges of the split axis, and these effectively form transition points. During the mining of the first split, these ramp transition points will take the form of switch-backs, and although they will reduce truck cycle times slightly, the economic benefits derived from deferred waste stripping far outweigh any haul cycle inefficiencies. The ramp system in the second split, when mined down, will merge to form one common ramp system, since they were originally designed as one in the whole waste cut prior to the split.

One of the benefits of the split shell is the multiple ramp required in the splits which increases flexibility for access to the working areas and reduces the risk of ramp failure. Ramp failure on concentric designs has longer-term effects than that on the split shell design. Losing a segment of a concentric ramp usually means use of the entire ramp is lost until repairs can be effected. Loss of a ramp segment on the split shell only isolates that small portion of ramp between cross-over points and not the entire ramp system, therefore business risk is reduced.

Haulroad width is a design parameter that has a significant effect on the final pit perimeter and any increase in width will result in a commensurate increase in waste tonnage. An exercise was conducted to determine the effects of ramp widths on final design and tonnes, based on a 400 metre deep pit. The results concluded that 3 metre increase in ramp width, pushed out the final pit limit by some 16 metres, which resulted in an additional 20 million tonnes of waste rock. It is therefore important to ascertain all design criteria and ensure upper limits of the design envelope are being pushed while remaining within acceptable factors of safety before any design work is performed, otherwise benefits from improved design such as split shells will be lost.

Due to the multiple ramp system in the split shell design, certain ramps could be designated one way, allowing either full up or empty down passage. This does provide the opportunity to reduce ramp width considerably which would further improve economics, however, practical aspects of this will have to be considered.

Venetia Mine—a case study

Whittle Four-D optimization was run on Venetia mine, determining the final economic pit shell. Analysis was further conducted on the optimum shell to establish optimal push back limits or waste cuts. In total, four waste cuts were established, and concentric practical pits were designed from these Whittle shells using the Gencom mine planning software (see Figure 5).

Cut one had been mined before split shells were introduced resulting in the concept being applied on the remaining 3 cuts.

The Venetia orebody geometry lends itself to split shell mining with the natural split running along the longitudinal axis, however iterations were still performed and analysed to determine the best practical split axis, all the time taking cognisance of geometric, plant blending, grade and ore release constraints. As it was, the final split did run east/west across the orebody as shown in Figure 6.

Having determined the split, the next step was to ascertain on which side the first split would be taken, either north or south. As mentioned previously, many factors influence this decision such as:

➤ Current pit status—on which side is it best to modify the existing ramps?
➤ Geotechnical issues—are there any areas of the pit that have deteriorated such that the only way to make them safe require mining back to stable ground?
➤ Orebody geometry and grade distribution across the orebody—will the split ensure adequate ore release at the required grade and blend?

Taking cognisance of the above reasons and considering the poorer host rock conditions in the south, as described in the geology section, it was decided that Cut two north would remain while Cut three south is mined. Ramp modifications to the concentric designs were necessary to accommodate the split shell in both Cut two and Cut three. As mentioned previously, ramps play an important role in the success of a
split shell and need to undergo a series of designs to ensure the optimum ramp configuration is achieved. The first stage was to modify the ramps on the concentric cut designs ensuring that access to the bottom of Cut two was possible from the north split, and to the bottom of Cut three south. Ramp modifications usually require establishment of switchbacks on the current mining cut and on larger cuts, cross-over or transition points. Attention must be given to ensure that flat sections on the cross-over points are minimized as they tend to push out the shell perimeters in these areas which could increase waste tonnes and operationally, they increase wear and tear on haultruck transmissions. As can be seen in Figure 7, Venetia mine required slight modifications to the current concentric designs. Cut two ramp systems for both the K001 and K002 pits required changes by inserting switchbacks thereby keeping the ramps north of the split. Cut three required a completely new ramp to be inserted on the southern side thereby providing access to the K002 pit from the south. The insertion of this Cut three ramp did increase waste tonnes slightly, although by having an additional ramp meant that the safety berm in the original design could be removed. This marginally offset the increased waste tonnage required for the ramp.

The next phase was to split the shells along the axis and stitch them together ensuring that practical and workable merging was achieved. This operation was carried out using the Gemcom software. Figure 8 shows how the two shells were split and eventually re-joined as one, known as the Cut three south split.

It is clear in the split shell design that there are two independent ramp systems. Ore will be hauled out of the pit using one ramp system, in this case the Cut two north ramp, while waste is hauled from the pit via the other ramp system, in this case Cut three south, as shown in Figure 9. As mining develops, the south split advances, gets deeper and will eventually begin to expose ore. When this occurs, it is said the ‘bottleneck’ has been reached. The bottleneck is the point
Split shell open pit design concept applied at De Beers Venetia Mine, South Africa

Figure 7—Cut two and three ramp re-design to accommodate the split shell design

Figure 8—Splitting and joining the shells

Figure 9—Showing dedicated haul routes for ore and waste in the split shell
at which the split being mined, in Venetia’s case Cut three south, starts exposing ore causing Cut two north and Cut three south to merge at the ore working levels. Once sufficient ore is exposed on the south to sustain plant feed, mining of ore, and thus the ore haul route will transfer to the southern side utilizing the southern split ramp system.

Balancing the splits

Having determined the split shells and ramp systems, the final stage is to correctly balance the splits. This process involves trading one split off against the other to ensure that the economics are balanced such that one split is not ultra efficient while the opposite split is uneconomical. A series of trade-offs are required by adjusting the working levels between the Cut two north and Cut three south splits—this process actually moves the bottleneck higher or lower between the two cuts being mined. Adjustments to the bottleneck can have major effects on the associated ore and waste assigned to a particular split and therefore the economics of such are extremely sensitive and play a major role in the split efficiency. The amount of ore associated with the Cut three south split will determine the timing of commencing the Cut three north stripping to ensure the Cut three north and Cut three south bottleneck is met. Balancing and optimizing the splits efficiently, due to the number of iterations, requires user-friendly mine planning software that provides rapid yet accurate results. Gecomm mine planning software has proven to be very useful in this regard.

Risks

Introducing a new concept such as the split shell, particularly being such a radical departure from the ‘traditional’ concentric method, requires buy-in from all stakeholders, those being head office, mine management and production crews. Every stone had to be turned when looking for what can go wrong. After many what-ifs and detailed analysis there was only one point of concern, being that only one ramp system is present from the main pit interchange to the bottom of the pit. Where this occurs in Cut three south design is well into the developed pit—bench 13. By that stage, blasting should be of a standard that maintains sidewall and ramp integrity and geotechnical information will be updated on an ongoing basis allowing for minor changes to design here and there. In addition, if the situation becomes critical, there is room to insert a ramp on the northern side if required, or alternatively accelerate the northern split. Risk for the split shell at Venetia was reduced when compared to the risk assessment associated with the concentric mining method.

Results

The adoption of the split shell concept reduced capital and operating expenditure at Venetia mine in 1999 by approximately 25%, reduced the five-year earthmoving fleet over the next 5 years by some 30% and improved the Cut three NPV by approximately 8%. Table I and Graph 1 demonstrate that through an iterative process, the peak mining rate has been reduced from 32 million tonnes, as required in the 1998 concentric plan, to 20 million tonnes per annum in the revised split shell. Essentially, the waste contained in the peak period in the years 1999 to 2005, as shown in the 1998 plan, have been deferred to the later years in the life of the mine. This reduction in waste tonnes has reduced earthmoving requirements (trucks and shovel) hence capital expenditure, reduced working costs and optimized equipment usage by providing a plan that has consistent tonnage for longer periods. All of these factors have improved the workability of the plan and ultimately improved the economics.

Arriving at the optimum design is an iterative process. The tonnage profile below Table II shows what was achieved on the first pass of the split shell.

You will note that the first three-years, tonnes are the same in both split shell scenarios as these were the minimum tonnes required to convert from concentric design to split shell design. Longer-term benefits, tonnes and haultruck reductions, are shown for the life of Cut 3 on the following two graphs.

Subsequent planning, focusing on an NPV+ principle has shown that the split shell design has allowed for ‘grade profiling’ in which revenue is pulled forward and has further improved the NPV of the mine.

Conclusions

The exercise at Venetia Mine proved that split shell concepts are possible provided the skills and expertise are available,
Split shell open pit design concept applied at De Beers Venetia Mine, South Africa

<table>
<thead>
<tr>
<th>Table II</th>
<th>Summary of split shell results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario</td>
<td>Unit</td>
</tr>
<tr>
<td>1998 Concentric plan</td>
<td>(Tonnes x 10^6)</td>
</tr>
<tr>
<td>Final split shell</td>
<td>(Tonnes x 10^6)</td>
</tr>
<tr>
<td>Variance</td>
<td>(Tonnes x 10^6)</td>
</tr>
<tr>
<td>Prog. variance</td>
<td>(Tonnes x 10^6)</td>
</tr>
</tbody>
</table>

Earth-moving equipment reductions as a result of reduced tonnes from the split shell

<table>
<thead>
<tr>
<th>Haultrucks</th>
<th>Face shovels</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>-6</td>
<td>-1</td>
</tr>
<tr>
<td>-8</td>
<td>-1</td>
</tr>
<tr>
<td>-8</td>
<td>-1</td>
</tr>
<tr>
<td>-9</td>
<td>-1</td>
</tr>
</tbody>
</table>

1st Split shell | (Tonnes x 10^6) | 12.9 | 15.3 | 19.5 | 23.5 | 25.5 |

and in time, Whittle would require to consider this concept in its application. Theoretically, the economics of the pits improve with the split shell concept, therefore, if applied in the optimization stage, a deeper pit should result.

The main achievements of split-shells at Venetia Mine have been:

➤ The immediate savings on the operation’s cashflow by means of reduced working costs and deferment of capital expenditure and
➤ The improvement of the overall mining economics, and as a result could possibly delay underground mining from post-Cut three (as currently indicated) to post-Cut four.

Acknowledgements

The authors would like to thank the management of De Beers for giving permission to publish and present this paper.

Reference


TUKS mining professor first South African president of ISRM*

History was made at the recent International Society for Rock Mechanics (ISRM) Council meeting in Beijing, when Professor Nielen van der Merwe, Head of the Department of Mining Engineering at the University of Pretoria, was elected the next president of the ISRM. This is the first time that a South African will serve in this capacity. All the previous ISRM presidents came from the northern hemisphere.

The ISRM has about 5000 members in 45 countries, including the USA, Australia, most European countries and Asia. It is the recognized international body for all rock engineers, including both mining and civil engineering.

Prof. Van der Merwe received his B.Sc. (Eng) (Mining) from the University of Pretoria, and his M.Sc. (Eng) and Ph.D. from the University of the Witwatersrand. Before being appointed Head of the Mining Engineering Department in March 2001, he worked at CSIR Mining Technology, Sasol Coal Division and Gencor.

Prof. Van der Merwe was chairperson of the South African National Institute for Rock Engineering (SANIRE) and was also its first president. He founded the first regional branches of SANIRE and also national groups of the ISRM in Ghana and Zambia. He served on the International Society for Rock Mechanics Board as vice president for Africa for the 1995–1999 term. In this time he established the concept of interest groups in the ISRM.

He will now rejoin the ISRM Board for a two-year transitional period and officially assume office in 2003. His term will run until after the ISRM Congress in Lisbon in 2007.

Prof. Nielen says that his immediate aim is to support the current president, Dr Marc Panet of France, in the ISRM transformation in which Dr Güner Gürtunca of the CSIR, current vice president for Africa, plays a leading role. In the long term, he believes, the ISRM should be an organization for the members, more supportive and less prescriptive.

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Split shell open pit design concept applied at De Beers Venetia Mine, South Africa
SAIMM and IMM (Zimbabwe Branch)*
Copper, Cobalt, Nickel and Zinc Recovery Conference
16–18 July 2001, Victoria Falls, Zimbabwe

98 Delegates, with 64 from South Africa, 11 from Zimbabwe, 10 from Zambia, 4 from the DRC, 2 from Australia and 1 each from Botswana, Finland, Germany, Greece, Israel, Sweden and the USA attended the Copper, Cobalt, Nickel and Zinc Recovery Conference held at the Victoria Falls, Zimbabwe.

The conference started with most of the South African delegates meeting at Johannesburg International for a charter flight to Victoria Falls. Thus the spirit of the conference also started with a meeting up of old friends and the discussion of metallurgy.

The conference was opened by Mr Kitikiti, Permanent Secretary of the Department of Mines, who apologized for the absence of the Minister of Mines. He highlighted the importance of mining to the region and the benefits of a low cost for electricity. He spoke of the need for sustainable development, including both the environment and social aspects. He emphasized the need to apply appropriate technology and the need to link R&D to the requirements of small-scale mining as is being carried out by a Mintek initiative. With a widespread deficiency of skills and expertise he called for an increase in regional co-operation in training for the minerals industry.

David Murangari, CEO of the Chamber of Mines of Zimbabwe gave the Keynote Address outlining the challenges for the development of mining in the SADAC region. He spoke of the challenges faced by the industry with low metal prices and increasingly complex and lower grade orebodies. He spoke of the Global Mining Initiative and the call for sustainable development. He emphasized the importance of mining to the GDP of the countries in the region and the need to increase investment for which user-friendly legislative systems and a reduction in perceived political risk were required. The SADAC countries wanted to make investors comfortable to develop new mines. The tasks that he saw as important were the need to create work after mining ceases and the need for industry to work with local communities. He told of how illegal gold panners had been used to repair dams, make bricks and grow vegetables. Unfortunately there had been a migration of skills to South Africa and Botswana. He reiterated Mr Kitikiti’s call for intensified effort in training and skills development, including multi-skilling. HIV/AIDS remained an issue of great concern.

A good variety of papers were presented, which created useful questions and discussion. Both the fundamental and operating experience of submerged arc furnaces, including the treatment of slags and feed preparation were covered in three papers. A paper from Anglo Platinum described test work to improve granulation of matte.

Eight papers were presented on various aspects of Resin-in-Pulp (RIP), Ion Exchange (IX) and Molecule Recognition Technology (MRT) showing the increasing importance of this field of activity. All metals covered at the conference were reviewed. Pulsed column technology and the removal of Ni by ISEP continuous ion exchange were also described.

Five papers came from the DRC, covering a diverse range of topics, which included pyrite and cobalt flotation, sulphur dioxide as reducing agent in cobalt leaching, electro leaching and pyrometallurgical treatment of copper slags. It was good to make contact with metallurgical people from this region and see that they are getting back into the mainstream of the minerals industry and keen to be part of Southern African initiatives.

To potential advantages of hydrometallurgy over the more well known pyrometallurgical process route was covered in an excellent paper by Whyte et al. on the production of copper from Konkola copper concentrates and Chingola refractory ore.

In the field of electrowinning technology, the re-use of anodic oxygen from Co/Ni was proposed and an overview of World and African Copper EW was provided.

Although not presented, the Anglo American Research Laboratories provided an interesting paper on the improvements that might be achieved in flotation by interparticle milling.

An attempt to quantify the morphology of nickel crystals was described in a paper by Lewis of UCT so that the morphology of the crystal structures can be related to the processing conditions.

An interesting paper described fully automatic analytical facilities, and the latest developments in Larox filters, Wemco cells and polymer concrete cells were given.

Descriptive papers covered the Mt Gordon copper operations of Western Metals, process selection for the Gamsberg zinc refinery and processing improvements at Rosh Pinah. An interesting paper from Black Mountain described the benefits of blending different ore types to optimize feed to the plant.

Together metallurgists from the countries in southern Africa to meet for technical sessions, discussions and social events. The venue of the Elephant Hills Hotel at the Victoria Falls was ideal, because it provided an attractive and isolated enough location for participants to concentrate on the conference with leisure activities for themselves and accompanying persons. I trust this will provide enough incentive for future conference of this nature. Noel O’Brien and Catherine McInnes must be thanked and congratulated for organizing so successful a conference.

The conference was sponsored by Anglo American Corporation, BioMetallurgical, Dowding Reynard & Associates, Hatch Africa (Pty) Ltd, Innovative Met Products (Pty) Ltd, Iscor Ltd, Larox Southern Africa (Pty) Ltd, Lonmin Platinum, LTA Process Engineering Ltd, Mintek, and Outokumpu Technology (Pty) Ltd. Most of these companies had displays which created interest and discussion the tea/coffee breaks.

The social events were very well organized and attended. At the Gala dinner the delegates were entertained with an excellent presentation on the Painted Hunting Dogs of Hwange by Greg Rasmussen, an international authority who has been working with the dogs for over 10 years. As a token of appreciation, a lively and competitive auction of a painting by a local artist, donated by SNC-Lavalin South Africa, raised over R10 000 for the project. ◆