Welcome to the 3rd Limpopo Minerals Conference and Trade Show – 2015

Sincere greetings to the Honourable, MEC responsible for Economic Development Environment and Tourism, Departmental Heads and Officers of LEDET, delegates, speakers and the media.

Welcome to Mokopane, the heartland of the long established minerals industry in central Limpopo and to this beautifully refurbished Park Hotel.

Like the 2nd Conference, the 2015 meeting represents another milestone for the formal partnership between the Fossil Fuel Foundation and the Limpopo Provincial Government and specifically LEDET. The “buy in” to this which commenced in 2012 is now firmly entrenched in the annual calendar of the Limpopo Province’s minerals industry.

In 2012 the FFF asserted, hopefully, that this partnership would result in outcomes that could improve the lives of the Limpopo people in both the short and long term. It is the intention of this meeting to cement this objective by giving increased time and attention to discussion forums the end of each day. The forums are intended to provide concrete points of reference for the industry to benchmark itself as it evolves over the next few years.

It is right that Government gets behind development initiatives during tough times when the private sector is under stress, probably more so than ever before in the last 40 years. We ask you to join us over the next three days not to merely listen to the well prepared talks but to engage and challenge the speakers to substantiate their talks with relevant questions and comments.

Even more than in 2013 we hope over the next three days to try and unpack at least some of the most pressing issues that are affecting the growth and development of Limpopo. Mining continues to play a key and integral role in the development of South Africa. How this plays out, particularly in Limpopo, will either contribute to the maintenance of social stability or not. The 21st Century mine is no longer an isolated point source of income to the shareholders and Country. It must aim to become part of the social and economic fabric of its host area. In doing so its success should surely be measured in its ability to generate peripheral development and be part of a sustainable evolutionary process within the Province and Country in which it operates.

No longer can mines operate in isolation, even if they chose to. The social and labour plans they are required to develop should mitigate their impacts and leave positive legacies on which the surrounding populations can continue to live and grow. Never again should a mining industry leave a “Witwatersrand”, “Witbank” or a “Penge”, where the devastation from pollution continues to haunt the surrounding populations as well as causing negative downstream legacies as have the gold, coal and asbestos mines done.

The biodiversity and visual splendour of Limpopo lures a softer investment. The Province’s holiday, commercial and business destinations continues to excite interest and mining must clearly embrace these opportunities offered in the region.

Mining is part of Limpopo’s endowment. The province holds possibly 80% of the mineable coal resources of South Africa, in three large coal basins, two thirds of the platinum group metals, a third of the Country’s chromium deposits the broader human and economic development remains nodal (Steelpoort, Lephalale, Mokopane) with Polokwane remaining the ever growing commercial hub of the Province.

The Waterberg in the west remains host to the only operating coal mine in the Province, while platinum, chrome and magnetite provide extensive strips of mining development from Steelpoort to Zebediela and then from south of Mokopane to beyond Blooberg in the north-west of the Waterberg mountains. The promise of mines north of the Soutpansberg remains a tantalizing prospect. However with all these developments, the tension continues to grow between them and farming, eco-tourism and the challenge to retain biodiversity in this richly diverse region of South Africa.
The challenge to the delegates at Limpopo Minerals Conference and Trade Show 2015 and Government, is for all players to lock horns and look for solutions that will set the Province up to be ready for the next minerals boom, and above all, be prepared to absorb the demands that arise as mining projects in the pipeline come to fruition, bringing with them ever increasing infrastructural demands and socio-economic tensions.

The challenges will continue to grow and it will require bold and imaginative initiatives from Government, business, NGOs and civil society to establish a harmonized working relationship that encourages investment while keeping the boarder human issues, the need to produce food while managing the environmental impacts central to the processes.

The complex interactions between these latter imperatives and the impact that mining will have on the demand for highly trained people, transport, water supply and the reticulation of power to the region need to be carefully understood, unpacked and built into implementable development models in the Province and the Country. Of these, the demand for and supply of water is probably the most critical issue, not just for mining but also for the wellbeing of the rapidly growing population drawn to the region by the promise of work.

As before the sub-title of our conference:

“Of minerals, man and water – a tense trilogy” remains apt

Last but not least, we are thrilled to welcome our first contingent of students to our parallel “Limpopo Students in Mining Conference” this year from the universities of Limpopo, Venda, Wits, and UJ.

I look forward to meeting and debating with you over the next three days and hopefully on an ongoing basis thereafter

Oliver Barker
General Manager,
Limpopo Minerals Conference and Trade Show 2015

November 2015
Honourable Mr Seaparo Sekoati, MEC – Department of Economic Development, Environment and Tourism

Seaparo Charles Sekoati is currently the MEC responsible for Economic Development Environment and Tourism, a department that has a strategic mandate to help promote economic development and growth in the province. He has throughout his career established a track record in the organisation and in government. He has served in various positions; the following are the positions he has held:

- Labour Officer: SASCO (University of The North)
- Deputy Chairperson: ANC Provincial Youth League
- Chairperson: Youth Commission
- MEC: Department of Health and Social Development (Limpopo)
- Member of the Limpopo Provincial Legislature

He holds amongst other studies a BA Degree attained from the University of the North and a Master’s Degree in Development from the same institution.

David Brown, Chief Executive Officer and Executive Director – Coal of Africa Limited

Mr Brown is a Chartered Accountant and completed his articles with Ernst & Young, graduating from the University of Cape Town. Mr Brown joined Coal of Africa following a tenure of almost 14 years at Impala Platinum Holdings Limited (Implats). He joined the Impala Group in 1999 and served as chief financial officer and financial director of Impala Platinum Holdings Ltd before being appointed chief executive officer in 2006. He is currently an independent non-executive director of Vodacom Group Limited as well as non-executive director of EDCON Holdings Limited. In the past he has served as a non-executive director of Simmer & Jack Limited and ASX listed Zimplats Holdings Limited.

Oliver Barker, Banzi Geotechnics cc

Oliver Barker is a graduate of the University of the Witwatersrand with a BSc (Hons) Geology and MSc. He is a registered natural scientist, (Pri. Sc. Nat) and is a registered member of the AEG, SAIEG and IAEG. He is a Fellow of SANIRE, SAIEG and the Geological Society of S.A., a member of the Ground Water Division of the GSSA and of the IAIA (SA) and is a founder member of the Fossil Fuel Foundation.
THE MINERAL ABUNDANCE OF THE LIMPOPO PROVINCE

Oliver Barker*1,1, Limpopo Economic development Agency2
1Managing Member, Banzi Geotechnics cc, Johannesburg, 2122, South Africa.
2Limpopo Development Agency, Limpopo Government, Polokwane, Limpopo Province, RSA

ABSTRACT

The Limpopo Province is located in the northern part of South Africa separated from Botswana and Zimbabwe by the Limpopo River in the west and north and by the Kruger National Park in the east the 5th largest province in South Africa with a surface area of 125,754 km2. It has a spars rail network and a limited hard surfaced road network that reflects the effects of topography with high mountain ranges and extensive ridges separating low-lying areas of rural farming activity (subsistence, dry land and irrigation).

It is within this broadly diverse environment that the mining industry has been woven for over a 144 years since the first discovery of gold in South Africa was made at the Eersteling prospect 20 km north east of Mokopane.

Today, Limpopo is host 26 different minerals. Limpopo’s Coalfields hold more than 76% of the remaining coal resources in South Africa. Over 55 PGM prospects and 4 enormous PGM mines plus one of the richest diamond and copper/phosphate mines at Venetia and Palabora are located in Limpopo. Over 130km of surface outcrop of chrome seams extend from Steepoort in the south to Zebediela in the north west. The optimal and sustainable development of this treasure chest of possibilities is thus not negotiable if Limpopo wishes to avoid the historical mistakes of its neighbouring provinces.

This paper profiles the key aspects of this treasure trove and attempts to set the scene for the evaluation of the role of the minerals industry within the context of South Africa and above all within the Provincial setting in which these deposits and mines are located.

Ronald Marais, Eskom

Ronald Henry Marais (M’1969) was born in Johannesburg, South Africa, on November 4, 1969. He graduated from the Witwatersrand Technikon and continued his studies at the Pretoria Technikon. He has a BTech degree in power engineering and is registered as a Technologist at ESCA.

His employment experience of 24 year in the power industry included GEC Alsthom Measurements, Eskom Protection Application, Eskom Central Grid Planning/Performance and Eskom Transmission Grid Planning.

He currently heads the Strategy Grid Planning section within Transmission Grid Planning. Key focus area within Eskom include Strategic grid planning of the South Africa transmission power network, Southern African Energy strategic planning, Strategy and business plan formulation and implementation, Long term transmission and power system design and Stakeholder Relationship Management. He is the Southern Africa CIGRE C1 representative, participates in the DOE rebid process and chairs the Southern African Power Pool Planning Sub-Committee.

PRESENTATION SUMMARY: ESKOM'S OVERALL COUNTRY STRATEGY PERSPECTIVE

The presentation will cover Unlocking Grid Capacity in a changing power landscape for future Demand and Independent Power Producers
Dalton Matshidza, Eskom

Dalton Dovhani Matshidza was born in Nzhelele, South Africa, on January 2, 1976. He received a B-Tech degree in electrical power engineering from the Tshwane University of Technology, Pretoria, RSA, in 2002. He also received an M.Eng, Master degree in electrical power engineering from the University of the Witwatersrand in 2011. He is registered as a Professional Engineering Technologist at ESCA.

His employment experience of 16 year in the power industry included, Eskom Distribution Plant Engineering, Eskom Distribution Network Planning and Eskom Transmission Grid Planning. He is currently working in the Infrastructure Investment Planning section within Transmission Grid Planning. Key focus area within Infrastructure Investment Planning include: Initiating of strengthening projects, Compiling reports for Generation integration projects to the national grid, Compiling customer feasibility quotes and budget quotes and Providing inputs to the Transmission Development Plans.

TEN YEAR DEVELOPMENT PLAN OF TRANSMISSIN IN LIMPOPO
THE OBJECTIVE OF THE PRESENTATION IS TO:

- Share the transmission planning assumptions for Limpopo Operating Unit
- Share the Limpopo Operating Unit transmission network constraints
- Present the proposed Limpopo Operating Unit Transmission Development Plans
- To solicit comments and inputs from stakeholders on the Transmission Plans

Camille Kraak, SRK Consulting

MSc Geology from the University of Pretoria
Camille Kraak is currently at SRK Consulting, Johannesburg, for their Water and Engineering Geology departments. She completed her undergrad and post grad studies in Geology at the University of Pretoria from 2004 till 2010, and completed her MSc in Geology part time in 2014. She has a keen interest in 3D geological modelling using Leapfrog Geo, and has utilized this program to assist in the tailings dam design and estimation of clay resources and bedrock depths. She has also assisted in the geological modelling of various mines in order to import into Hyrdogeological modelling software for mine dewatering management.

A PROVISIONAL BASIN ANALYSIS OF THE KAROO SUPERGROUP, SPRINGBOK FLATS BASIN, SOUTH AFRICA

The Springbok Flats (SBF) Basin is one of the smaller basins associated with the Karoo basins of the Late Carboniferous–Middle Jurassic age interval. The preserved SBF basin is a topographically flat area with very few outcrops. It has a NE-SW orientation and is approximately 205 km long and 30 km wide. This study is based on borehole log data captured by the Council for Geoscience, which has been collected from various exploration companies throughout the history of the investigation of the SBF Basin area.

The purpose of this study is to identify an evolutionary history of the basin by utilising methods of basin analysis and literature search, and to establish how the basin relates to other Karoo Supergroup basins in southern Africa. The postulated genetic model of a retro-arc fore-bulge rift basin was compared to the inferred depositional environments.

The geophysical interpretations and structural contour maps of the various strata indicate the presence of the major Zebedelia Fault, which is part of the Thabazimbi Murchison Lineament (TML) relay system. This fault runs along the northern boundary of the basin and has caused the strata of the SBF Basin to be down-faulted by 800 to 1000 metres. The isopachs of the identified Karoo successions do not indicate
thickening towards this lineament, which suggests that the faulting along this lineament post-dates the Karoo sedimentation.

The Thabazimbi Murchison Lineament played a significant role during the later stages of the SBF sedimentation. Once the depocentre became more centrally located in the depository, it began to migrate towards the TML. Although the major faulting was yet to occur, the weakness in the craton was apparent. During the breakup of Gondwana, the Zebedelia Fault shifted the strata down and allowed the extrusion of the Letaba Basalt, along with the multi-intrusion of dykes throughout the strata.

The onset of the deposition of the Karoo Stratigraphy in the SBF was due to uplift resulting from the mid-carboniferous assembly of Pangea. During the Lower Karoo deposition, lithospheric subsidence was facilitated by crustal-scale faults, resulting in the deposition of the glacial Dwyka and Lower Ecca sediments. Flexural subsidence was occurring in the forebulge due to the relaxing of the initial compression of the Cape Fold Belt (CFB). The later Ecca succession was characterized by large subsidence with little accompanying brittle deformation. The lower Beaufort was a deltaic basin and was terminated towards the end of the Permian period, identified by a significant loss of fauna and flora. There was a ±3 km uplift, known as the Namaqua Uplift and erosion north of the fold belt. This marked the structural inversion during deposition of the Beaufort Group and Early Molteno Formation. These uplift events resulted in uplift in the foredeep which resulted in the compression of the forebulge during the deposition of the Molteno Formation. Once these events subsided, the forebulge relaxed and underwent subsidence and extension. Elliot Formation formed during this unloading of structural relief and relaxation of basin-forming stresses. The upper Elliot and Clarens formations and Letaba Basalts exhibit the transition from sinistral strain of the late Karoo Basin to the dextral tectonics of the Gondwana breakup that terminated the basin deposition.

Day One
Session 3

Peet Meyer, PC Meyer Consulting

Peet Meyer studied at the University of Pretoria and started his working career in 1990 with Anglo American Corporation as exploration geologist in the coal division. After 5 years he left to start up his own business which he was forced to close in 2000 as a result of similar economic conditions and mining recession as experience in 2015.

In the year 2000 he joined Total Coal as operations geologist and learnt all about coal mining, particularly the joys and tears of thin seam coal mining. During this time he completed a M.Sc in Earth Science Practice and Management, specializing in the economics of thin seam coal mining.

In 2005 he joined BHP Billiton as Chief Geologist at Optimum Coal. During this time he got exposure to opencast mining and realised that larger is not always better or nice.

His exposure to junior exploration companies started in 2006 when he joined Aquila Resources as Exploration Manager for their coal properties in Mozambique and Botswana, as well as iron ore in the Northern Cape.

He left in 2007 and started consulting and contracting on coal exploration and mining studies to various companies active in Mozambique, Botswana and South Africa. Since that period he did work in about all the coalfields of Southern Africa with specific focus on coking coal exploration.

PC Meyer is a member of the South African Geological Society and SACNASP registered competent person.
THE GENERAL GEOLOGY OF THE SOUTPANSBERG COALFIELD

PC Meyer
PC Meyer Consulting, Emalahleni, 1035, Republic of South Africa.

ABSTRACT

The Soutpansberg Coalfield is hosted in the Karoo Supergroup of the Limpopo Province in South Africa, within Soutpansberg Supergroup sub-basins. The sub-basins preserves a heterogeneous succession of Upper Palaeozoic to Lower Mesozoic sedimentary and volcanic rocks of the Karoo Supergroup. Because the area is largely covered by the Quaternary Kalahari Group sands, the stratigraphy of the succession is not as well understood as compared to the Main Karoo Basin in South Africa.

The Soutpansberg sandstones consist immature sub-litharenite, sub-arkose and minor arkosic arenites in nature, dominated by angular to sub-angular detrital grains, sourced from recycled orogens, craton interior to transitional continental. It is postulated that the sedimentary source for the basin comes from an uplifted basement areas dominated by sedimentary rocks and/or granite-gneiss rocks. The subsidence of the basin is believed to be initiated by tectonic faults of basement blocks rather than sediment burial.

The Soutpansberg Coalfield can be divided into three coalfields namely the Pafuri (Eastern Soutpansberg), Tshipise (Central Soutpansberg) and Mopane (Western Soutpansberg) Coalfields. The location and shape of the Soutpansberg Coalfield were controlled by ENE-WSW faults that follow the trend of the Limpopo Belt. The Pafuri extends eastwards into the Kruger National Park. The only area where coal has been exploited is at the Tshikondeni Colliery, defunct and currently being rehabilitated, in the Pafuri sub-basin. The surface geology is dominated by Karoo Supergroup rocks overlain by Quaternary sediments. The sequence has been extensively faulted, with structures being pre-, syn- and post-depositional. Dolerite intrusions are also common.

Coals occur in the sandstone-rich Madzaringwe and overlying Mikambeni Formations. The Main seam is up to 3.5 m thick and is a composite seam made up of several coal bands interbedded with carbonaceous shale. At the base is the Tshidzi Formation which comprises diamictite interbedded with relatively coarse-grained sandstones.

The Tshipise Basin has a similar stratigraphy to the easterly located Pafuri deposit, except that the coal-bearing sequence is thinner and the coals are more intimately interlaminated with the mudrock/shale and siltstone. In the middle of the basin are outcrops of Soutpansberg Group and Beit Bridge Complex rocks. The coal seams seams/zones consist of alternating bands of coal and mudstone.

The Mopane Basin is located west of Tshipise and northwest of Waterpoort. Rocks of the Karoo Supergroup strike east-west and dip towards the north at angles of up to 120°. The area has been broken up into fault blocks into a number of strike faults. South of the area the Karoo sediments are absent due to uplift and erosion, leaving exposed Beit Bridge Complex and Waterberg Group rocks. The arenaceous Madzaringwe Formation occurs occasionally and is sometimes absent due to non-deposition or pinch-out of this unit from east to west. This deposit is also fault bounded.

The stratigraphic succession of Karoo Supergroup, from the base up, consists of the Tshidzi Formation which generally comprises diamictite set in an argillaceous matrix, interbedded with relatively coarse-grained sandstones in places. The Madzaringwe Formation comprises up to 200 m of alternating feldspathic, often cross bedded sandstone, siltstone and shale containing coal seams. The basal 25 to 35 m of the formation consist of carbonaceous shale and thin coal seams. The main coal zone occurs between 85 and 100 m above the carbonaceous zone and is generally 2 to 3 m thick. The top of the
formation comprises 10 to 15 m thick massive, coarse-grained micaceous feldspathic sandstone. The Mikambeni Formation consists of three recognizable units: a lower unit of alternating black shale and grey, feldspathic sandstone 15 to 20 m thick; a 50 m thick middle unit of black carbonaceous shale with occasional bright coal seams and an upper unit comprising dark grey mudstone with plant fragments and occasional bright coal. The formation attains a thickness of up to 150 m. This whole sequence is capped by the basalts of the Letaba Formation.

The stratigraphy and correlations of the various seams over the coalfields of South Africa is illustrated in Figure 1 and Table 1.

Figure 1. Stratigraphy and correlation of the Main Karoo Basin and the Northern sub-basins. Highlighted is the Soutpansberg Basin.

Table 1. Chronological Table of the Soutpansberg Coalfield.

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<thead>
<tr>
<th>PERIOD</th>
<th>FORMATION</th>
<th>SOUPANSBERG COALFIELD</th>
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<td></td>
<td></td>
<td>LITHOLOGY</td>
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<tr>
<td>JURASSIC</td>
<td>Jozini</td>
<td>basalt</td>
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<td></td>
<td>Letaba</td>
<td>basalt</td>
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<td>TRIASSIC</td>
<td>Claarne</td>
<td>Sandstone</td>
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<td></td>
<td>Boschkopoot</td>
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<td>Klapperfontein</td>
<td>sandstone and shale</td>
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<td>Solsindie</td>
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<td>PERMIAN</td>
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<td></td>
<td>Mikambeni</td>
<td>sandstone, shale and</td>
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<tr>
<td></td>
<td>Madzaringwe</td>
<td>coal</td>
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<td></td>
<td>Tshidzi</td>
<td>Diamictite</td>
</tr>
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</table>

In summary, in the coal basin can be divided into three chronological and lithological units which makes up the Karoo Supergroup:

- Permian Period which consists of the Tshidzi Formation dominated by diamictite, Madzaringwe, Mikambeni and Fripp Formations dominated by sandstone, shale,
conglomerates and coal.

- Triassic Period which consists of the Solitude, Klopperfontein, Bosbokpoort and Clarens Formations dominated by sandstone and shale.
- Jurassic Period which consists of the basaltic Letaba and Jozini Formations.

The Soutpansberg Coalfield was extensively explored by Iscor in the 1970s and 1980s. The only mine to have operated in the Soutpansberg Coalfield, was the Exxaro (previously ISCOR) owned Tshikondeni Mine which is in the process of being closed and rehabilitated. Most of the recent exploration in this coalfield was done by Coal of Africa Limited (CoAL), Rio Tinto Mining (RTM) and Signet Coking Coal. CoAL acquired the RTM project area, known as Chapudi, in November 2010.

*Corresponding author: PC Meyer, PC Meyer Consulting, Phone: +27 82 8916485. Email: peet@coal-consulting.com

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**Johan De Korte, CSIR**

**Short history of work experience**

- Graduated from Univ. of Pretoria at end of 1976.
- Started work with Anglo American Coal Division at Bank Colliery.
- Worked at various Anglo plants
- Moved to the CSIR in September 1989.
- Currently employed by the Centre for Mining Innovation at the CSIR

**Duties in current position**

- Responsible for coal preparation research work carried out under Coaltech collaborative research program and other contract research
- Training and development of junior coal preparation researchers
- Consulting work
- Ad hoc lecturing at universities

**ABSTRACT: DRY PROCESSING – A VIABLE OPTION FOR WATERBERG COAL?**

Much of South Africa’s future coal will be mined from the Waterberg coal field. Most of the coal from this region will require processing in order to meet the strict quality demands of the markets into which the coal will be sold.

Current day coal processing techniques are based on dense medium processing – a process that requires significant quantities of water. It is, however, anticipated that water will be both scarce and expensive in the Waterberg area and therefore the coal processing industry has been investigating dry coal processing technologies for the past few years. Dry processing offers a number of benefits. In addition to not requiring water, the technique is less expensive than dense medium processing - both in terms of capital cost and operating cost. An added benefit when preparing coal for use in power stations is the lower moisture content of the final product.

To date two dry processing technologies have been investigated by Coaltech and its members, namely the FGX unit and X-ray sorting. Both of these technologies have potential application in the South African coal industry and both techniques have already found limited application in the Witbank/Highveld region. Unfortunately, the separation efficiency of both these dry processes is not nearly as good as that of dense medium processing and, as a result, it is difficult to effectively beneficiate coals with a high near-dense content – such as the raw coals from the Waterberg.
There is a third, as yet unproven, dry beneficiation technology namely dry dense medium separation which holds the potential of good separation efficiency and this process may be applicable in the Waterberg. Coaltech and its members are currently investigating this technology.

The presentation will give an overview of the advantages and disadvantages of dry processing technologies being evaluated for possible application in the Waterberg.

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Rowan Karstel, RSVENCO Consulting

Rowan is a dedicated team player, results focused and a highly motivated individual with a Bachelor of Science degree in Mining and Civil Engineering from the University of Pretoria, a Master’s degree in Mineral Economics from the University of the Witwatersrand and holds an MBA from the University of Stellenbosch.

A VIABLE ALTERNATIVE TO MINE THE WATERBURG COAL UNDER THE CURRENT ECONOMIC CLIMATE

The Waterberg Coalfield has been estimated to hold about 50 billion tons, of which about a quarter could be extracted using **opencast mining**. The coal in the Waterberg Coalfield in the Lephalale region is well known for its “barcode” type stratigraphy which makes the raw coal quality particularly poor. This is counteracted by the fact that the coal is relatively shallow and the strip ratios are therefore very low which allows for coal to be mined cheaply and allows for the production of a cost effective but low yielding product coal.

The second constraint in the Waterberg is infrastructure like rail capacity, distance to port and water supply. Government is working on options to address the challenges but in the medium term it will be a constraint to develop projects.

Finally, the saleable products are typically a low yield Power Station (Eskom) and an Indian market spec. export product. Due to the low export yield and under the current coal pricing models it is very difficult to justify a return on the projects that is acceptable to funders.

One option is to develop and Independent Power Producer (“IPP”) on the Waterberg coal reserve in the short term. Once the infrastructure constraints are solved and the export market becomes more bullish the mine can be fully developed to extract the export portion of the reserve. This falls in line with the South African Department of Energy (DOE) process of a 2,500MW Coal Baseload IPP Procurement Program that started in 2014.

What is key in developing the mine plan is to optimise the coal product mix between IPP, Eskom and export coal. Eskom runs on Pulverised Coal (“PC”) Technology Power Plant boilers while the new IPP technology is based on Circulating Fluidised Bed (“CFBC”) technology. It is a well-established fact that the upper zones of the Waterberg coals are more reactive than the lower benches and as such are preferable for use in PC boilers.

A significant development in emissions legislation in South Africa in 2012 and in the Power Plant lending (finance) community in general has led to the requirement that Power Plants curb Sulphur Dioxide and Nitrous Oxide emissions. In the case of the former this adds significant additional costs to the Power Plant operation in the form of needing to use and therefore purchase sorbents (limestone) for sulphur abatement. The cost of the limestone therefore needs to be weighed up against the cost associated with processing the coal to remove the sulphur prior to it going up the stack.
To maximise the investment potential over time a two stage approach is followed:

- The life of mine starts off with selecting the right IPP technology taking into account the environmental legislation and the DOE coal base load tender process.
- Once the infrastructure constraints are resolved and export market recovered the life of mine plan is updated to cater for Eskom and Export products and maximising the overall yield. In the process cognisance will be taken of the reactivity of the upper and lower coal benches.

The Waterberg Coal Field sits with huge open cut reserves that will replace the Witbank coal field in the next 10 – 15 years. The challenge is to follow the right start-up strategy in the current depressed coal market and buying time for the infrastructure constraints to be resolved.

By following the above methodology a workable financial solution will be put on the table to develop South Africa’s largest coal block.

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**Professor Dirk van Reenen, University of Johannesburg**

Dirk van Reenen is professor of Geology at the University of Johannesburg (UJ) where he has been employed since 1971. His employment at this institution included a three-year stretch as HOD of the Department of Geology and a six-year stretch as Dean of the Faculty of Science. His research interest as a metamorphic petrologist/field geologist focuses on studying the complex geological issues related to the origin and evolution of the Archaean granulite facies terrane of the Limpopo Complex of southern Africa and the relationship with the juxtaposed granite-greenstone terrane of the northern Kaapvaal craton. An integral part of this research that is undertaken in collaboration with colleagues at UJ and at universities in the USA, Russia, Japan, Switzerland, and Australia, comprises the study of gold mineralization that characterizes both the Giyani Greenstone Belt on the northern Kaapvaal craton and the juxtaposed Southern Marginal Zone of the Limpopo Complex. Apart from numerous publications (more than 80) in international peer-reviewed journals, his research also resulted in publication of three special issues of international journals for which he acted as the senior guest editor, namely two issues of Precambrian Research (1992, 2014) and Memoir 207 of the Geological Society of America (2011). The results of his collaborative research have also been presented at international conferences and at numerous international field workshops where the main objectives have been to present all recent research data to the international community for critical scrutiny in the field.

Dirk has been married to Wilna for 45 years and the couple has three daughters and a son. They are presently living in Parys.

**OVERVIEW OF GOLD MINERALIZATION AND MINING IN THE GIYANI GOLD BELT AND ADJACENT SOUTHERN MARGINAL ZONE OF THE LIMPOPO COMPLEX OF SOUTHERN AFRICA.**

Dirk D. van Reenen and C. Andre Smit

Department of Geology, University of Johannesburg, 10 November 2015.

Staff (C. Roering, D.D. van Reenen and C.A. Smit) graduate students and post-doctoral associates at the department of Geology, University of Johannesburg (previously Rand Afrikaans University) have been conducting research in the Giyani greenstone belt (GGB) and adjacent Southern Marginal Zone (SMZ) of the Limpopo Complex (LC) since the early 1970’s. The overall aim of this research is threefold: firstly, to provide answers to outstanding issues concerning the geotectonic relationship of two closely associated but diverse geological terranes, secondly, to contribute to understanding the nature of geological processes that operated in Earth’s deep crust, including the origin and setting of gold mineralization that occur within both the GGB and in the SMZ, and finally, to develop a geotectonic model for the evolution of the LC. This
longtime interdisciplinary research has been done in collaboration with research associates from universities from all over the world and has also been supported by the then Geological Survey of South Africa, the CSIR, and various mining companies including Mining Corporation, Goldfields of South Africa, Rand Mines, Shell Exploration, Phelps Dodge, and OTR. The research involved regional and detailed field and structural mapping of the entire GGB and adjacent SMZ [1, 2, 3] as well as petrological, geochemical, geochronological, and geophysical studies [4, 5]. These results confirmed the presence of a shallow north-dipping sole thrust, the Hout River Shear Zone (HRSZ) that separates two juxtaposed but diverse geological terranes. It also showed that the GGB occupies the footwall section of the HRSZ whereas the overriding SMZ occupies the hanging wall section. Of importance to the geneses of gold mineralization is that geophysical and petrological studies indicated the presence of greenstone material that at depth underlies much of the southern (rehydrated) part of the SMZ (Fig. 1) [4, 5].

Various gold producing mines and gold prospects that have been studied as an integral part of this research include the following:

**A. GGB – Footwall section of the HRSZ**

- **Fumani** – Free milling Au in quartz veins and as Au inclusions in pyrrotite and arsenopyrite in altered BIF. This deposit produced ~45 000 g Au at 4.2 g/t between 1933 and 1961, and ~274 000 g Au at 3.96 g/t between 1979 and 1982 [6, 7, 8].
- **Birthday** – Free milling Au in quartz veins and as inclusions in silicate minerals in Hbl-Bt-Pl-Cc-Qtz schist (altered amphibolite) [9].
- **Klein Letaba** – Free milling Au in quartz veins and silicate minerals, and as inclusions in pyrrotite, arsenopyrite, and löllingite in altered Hbl-Bt-Qtz schist [10].
- **Franke** (next to Klein Letaba) - Free milling Au in quartz veins and in silicate minerals and inclusions in pyrrotite, arsenopyrite, and löllingite in altered BIF (Mt-Grt-Bt-Pl gneiss) [11].

**B. SMZ – Hanging wall section of the HRSZ.**

- **Doornhoek** – Free milling Au in quartz veins and in silicate minerals and as inclusions in arsenopyrite, pyrrotite and löllingite in altered BIF. The presence of prograde zoned hydrothermal garnet characterized by inclusions of Au, arsenopyrite, pyrrotite and löllingite that are restricted to a specific growth zone provides supporting evidence for the epigenetic nature of this unique high-temperature gold mineralization [12].
- **Louis Moore** – Free milling Au in quartz veins and in silicate minerals in altered ultramafic gneiss (Ol-Opx-Chl-Bt-Cc schist) [13, 14].
- **New Union/Osprey** – Free milling Au in quartz veins and as inclusions in silicate minerals in altered BIF and in Grt-Hbl-Qtz-Pl gneiss [13, 14].

An important conclusion is that although the studied gold deposits reflect major differences in wall-rock lithology and occur in diverse geotectonic settings (GGB versus the SMZ), the deposits share similar structural, mineralogical, and fluid inclusion features, indicating a common link with a distinct mineralization event (5, 13, 14).

**A.** The ore bodies are syntectonic and located within east-west trending, steeply north-dipping ductile shear zones with oblique to reverse vergence towards the south. These mineralized shear zones are steeply dipping satellites of the flatly north-dipping sole thrust (HRSZ) [5, 13, 14]. Gold mineralization occurs both in the footwall section of the north-dipping HRSZ (GGB) and in the hanging wall section (SMZ) [5, 13, 14].

**B.** Gold occur as free milling in silicate minerals in altered wall rock and in associated quartz veins, or as inclusions in sulphides (arsenopyrite, pyrrotite, löllingite).

**C.** Gold mineralizing fluids infiltrated wall rock at middle - to upper amphibolite facies conditions (~500 – 600°C) as is indicated by the associated wall-rock alteration. Wall rocks at all deposits are typically enriched in CO₂, K₂O, and S, resulting in extensive biotite and carbonate alteration, which is common to Archean lode-gold deposits world wide.
D. Syntectonic gold-bearing quartz in all deposits typically comprises CO$_2$-rich and aqueous fluid inclusions of varying salinity that also characterize unmineralized the retrograde equivalents of granulite in the SMZ (Fig. 1) [5, 12, 13, 14].

E. The minimum age obtained from Rb/Sr dating of muscovite in pegmatite that intrudes mineralized shear zones at different localities is ~2.65Ga [5, 13, 14].

Three significant observations regarding the nature and occurrences of the studied gold mineralization are indicated: firstly, that gold mineralization in both the hanging wall (SMZ) and footwall (GGB) sections of the HRSZ share similar structural and metamorphic/metamorphic features as well as similar sulphide mineralization and fluid inclusions. Secondly, similar features also characterize high temperature unmineralized shear zone-hosted metamorphic alteration of grey gneisses studied at various localities within the SMZ [5, 14]. Finally, similar fluid inclusions also characterize unmineralized rehydrated granulite in the SMZ (Fig. 1). This data imply a direct link of gold mineralization with the thrust-controlled exhumation of the SMZ in the interval 2.69-2.62Ga) (Fig. 1) [5, 14].

With this geotectonic scenario in mind [4, 5, 14] it is suggested that gold was dissolved from underlying greenstone belt material into brine fluids during prograde metamorphism linked to emplacement of hot SMZ granulite onto cool greenstone along the HRSZ sole thrust. The gold-bearing fluid released from devolatilization of the underlying greenstone was subsequently focused into the HRSZ and its satellite shear zones. Gold-mineralization in the footwall (GGB) of the HRSZ (Fumani, Birthday, Klein Letaba, Franke) thus occurred during the prograde metamorphic stage whereas mineralization in the hanging wall (SMZ) (Louis Moore, Osprey, Doornhoek) occurred during the retrograde stage when the hot infiltrating fluids released from the footwall of the HRSZ reacted with hot overriding granulite to establish the zone of rehydrated granulite (Fig. 1). Petrological and geochronological evidence for a direct thermo-dynamic link between the prograde event that affected the footwall lithologies and the retrograde event that affected the hanging lithologies is provided by a detailed petrological study of a locality in the Khavagari hills of the GGB near Klein Letaba mine (Fig. 1) [4, 5].

Finally, available data strongly suggest that the HRSZ acted as the first-order control of gold mineralization that characterizes both the GGB (footwall of the HRSZ) and the rehydrated portion of the SMZ of the LC (hanging wall of the HRSZ) (Fig. 1).


ABSTRACT

A Department of Geology existed at the University of the North, but this was closed in 1995, along with several other academic departments that were considered too small to be viable, as part of a the Department of Higher Education National Rationalisation programme. However, when the University of Limpopo was created in 2005 it was realised that, in the mineral rich Limpopo Province. There was a need for Geology in the tertiary education curriculum and Dr. G. Ekosse was recruited to restart the programme. Initially Geology was included in the general BSc Degree combined with either Physics or Chemistry, and the first intake of student entered the programme in 2008. In 2009 Dr. Ekosse moved to the Walter Sisulu University (previous the University of Transkei Campus of the University of Fort Hare) and it became apparent that a more specialised qualification was required for student to progress in both academia and industry. Professor J.N. Dunlevey was recruited in late 2010, and as part of the 2011 University of Limpopo Faculty of Science and Agriculture Curriculum Review restructured the undergraduate Geology Programme to the ‘double major’ BSc Geology model utilised at most other South African universities, and expanded the BSc Honours Geology programme. These changes and the revised curriculum were finally approved late 2014 and the first students enrolled in the new programmes in 2015.

The major difference between the ‘new’ 3 year BSc Geology degree and the ‘old’3 year General BSc (with geology) is that the time devoted to geology has been doubled. The first year of studies remains unaltered, with students taking Geology 1, Maths 1, Chemistry 1, Physics 1 and the SHEL (Social, Health, Environment and Life) modules. However, in the second year a choice of either Chemistry 2 or Physics 2 is combined with two Geology courses (Geology 2 and Economic Geology 2); while in the third year of study only modules in Geology 3 and Economic Geology 3 are studied. This increase in the Geology modules during second and third year effectively double the geology content of the programme with a student obtaining ⅔ of the degree credit points from geology based modules.

The changes to the one year BSc Honours degree consist of adding additional specialisations in mining and mineral processing. In addition to the BSc Honours Geology, which parallels the academic training presented at most other universities, the BSc Honours Geology and Mining, and BSc Honours Mineral Processing and Beneficiation have been introduced. The Geology and Mining includes aspects of ore reserve calculations, mining law and SHE not normal presented, while the Mineral Processing and Beneficiation relates to aspects of extracting the valuable minerals from the ore - gangue mixture and enhancing the value of mined products, particularly industrial minerals.

Corresponding author: J.N. Dunlevey Geology Division, School of Physical and Mineral Sciences University of Limpopo, Phone: + 015 268 3483. Email: John.Dunlevey@ul.ac.za
Ndivhuwo Nemapate, University of Venda

Nemapate Ndivhuwo is a Lab Technician in the Department of Mining and Environmental Geology, School of Environmental Sciences, University of Venda. He has Honours in Mining and Environmental Geology and he is currently registered for a masters degree programme in Environmental Geology in the same Department. His research work focuses on the “Evaluation of economic potential of gold tailings dams: a case study of Klein Letaba tailings dam.” He has attended training courses related to his research work at Set Point Laboratory in Johannesburg and Geo-lab in Pretoria. This year, he attended a postgraduate conference at Walter Sisulu University, East London and also presented a paper at the Wits University organised by the Center of Excellence for integrated Mineral and Energy Research Analysis (CIMERA). He will be presenting a scientific paper at the International Conference in Bengalore, India between 24th – 27th November 2015. He is a member of the Geological Society of South Africa (GSSA).

EVALUATION OF THE ECONOMIC POTENTIAL OF GOLD TAILINGS IN THE GIYANI GOLD BELT: A CASE STUDY OF KLEIN LETABA TAILINGS DAM, LIMPOPO PROVINCE, SOUTH AFRICA

Ndivhuwo Nemapate and Jason S. Ogola

Department of Mining and Environmental Geology, School of Environmental Sciences, University of Venda, Private Bag X5050, Thohoyandou 0950, ogolaj@univen.ac.za

Abstract

In South Africa there are about 6,000 abandoned mines and the cost of their rehabilitation is about R30 billion. The main concern here is the tailings dams, most of which are associated with gold mining. Consequently, there is need to identify new strategies for the rehabilitation of such tailings dams. One such strategy is to undertake feasibility study of reprocessing gold tailings dams and extract gold, while converting the residue to a construction material.

The study focused on the evaluation of gold and heavy metals at Klein Letaba tailings dam within the Giyani greenstone belt as a step for preparing the tailings dam for a clean-up during which gold can be recovered to offset the cost of rehabilitation. The work involved augering, profile logging and sampling up to a depth of 8 m along three profiles. A total of 95 samples were analysed for heavy metals, using atomic absorption spectrometry and 24 samples for gold analysis by fire assay. The tonnage for the heavy metals was rather low, for example, 2183 tons As, 667 tons Cr and 306 tons Mn. However, Au was 699 kg, which at the current gold price would be about US$ 30.7 million. Reprocessing of gold is therefore recommended, during which, the tailings could be used for the manufacture of bricks and tiles.

Professor Jason Ogola, University of Venda

Jason Samuel Ogola is a Professor of Economic Geology/Mining Geology. He has had long working experience at the tertiary level, over 30 years, initially at the University of Nairobi and later at the University of Venda since the year 2000, where he started the Department of Mining and Environmental Geology in 2000 and in 2003 became the Dean of the School of Environmental Sciences (2003-2012). His areas of research include mineral exploration and mining impacts with emphasis on tailings dams and waste rock dumps. He has to his credit over 40 publications in refereed journals, refereed conference proceedings, book chapters and book including publications on climate change. He has presented over 80 papers at national and international conferences and has supervised and graduated 17 masters and 2 Ph.Ds. He has had wide collaboration with professional colleagues from Wits University;
University of Cape Town; St. Andrews University (Britain); Colorado School of Mines (USA); University of Göttingen, Technical University of Clausthal, University of Applied Sciences Ostwestfalen-Lippe and University of Applied Sciences and Arts (HAWK) (Germany) as well as Water Research Commission, Council for Scientific and Industrial Research (CSIR), Council for Geoscience, Pulles Howard & De Lange Pty (Johannesburg), Department of Minerals and Energy/Mineral Resources. Currently, he represents the University of Venda at the Centre of Excellence for Integrated Mineral and Energy Research Analysis (CIMERA) as an Established Researcher, and at the Applied Centre for Climate & Earth Systems Science (ACCESS). He is a member of a number of National and international professional bodies, including GSSA, SACNASP, Kenya National Academy of Science (KNAS).

MINE TAILINGS AND THEIR POTENTIAL IMPACTS: A CASE STUDY OF SOUTH AFRICAN GOLD TAILINGS DAMS

Ogola, J.S. Department of Mining and Environmental Geology, School of Environmental Sciences

University of Venda, Private Bag X5050, South Africa, ogola@univen.ac.za

Abstract

Gold mine tailings dams contain fine material from the processing plant, cyanide residue from gold processing, uranium residue, and residue containing mercury from artisanal gold processing. Infiltration of water through tailings material is determined by tailings particle size, distribution and porosity as well as climate and oxygen diffusion. Gold mining is generally associated with heavy metals mainly Pb, Zn, Cu, As, Co, Cd that can have negative impact on human health. In South Africa there are about 6,000 abandoned mines and the cost of their rehabilitation is about US$3 billion (R 30 billion). Most of the tailings dams are of gold mining, especially within the Witwatersrand Basin. Three strategies are considered to deal with AMD; decant prevention and management, ingress control of mine flooding and water quality management. More work is also directed towards the understanding of the processes and mechanisms of AMD. A study of the acid mine generation within the Witwatersrand Basin revealed that flow of oxygen in the Witwatersrand tailings dams is controlled by secondary porosity; and the average oxidized zone on average is 2.4 m, but ranges from 2.2 to 3.5 m.

Key words: Mine tailings, potential impacts, heavy metals, Witwatersrand Basin

Day Two
Session 1

Paul Kapelus, Synergy Global Consulting

Paul has a 23 year career in the field of business and society. His focus has been in the natural resources sectors, working with mining, oil, gas, agriculture and forestry. Paul’s work has focussed on how companies intersect with development and the strategies that need to be considered, designed and implemented. He has experience in partnership design and implementation, conflict resolution, bankable feasibility studies, social and human rights assessments, sustainability reporting and assurance, design of management systems, stakeholder engagement strategies and plans, design and management of trusts and foundations, training, coaching, and recruitment. Paul works at the level of the executive, middle management as well as supervisors from head office through to operational sites. He has worked with business, civil society and government sectors and is often in socially complex situations with the mandate to diagnose situations that might become a risk for companies and provide value adding mitigation strategies. As a qualified mediator he has experience with working with companies in strong governance environments as well weak governance, conflict and post conflict situations. He was elected as a Young Global Leader by the World Economic Forum in 2006 and in 2008 awarded the Desmond Tutu Leadership Fellowship. He has published papers in various leading journals.
**Day Two**  
**Session 2**

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**Danie Otto, Digby Wells**

Danie Otto manages the Specialist Departments at Digby Wells. He holds an M.Sc in Environmental Management with B.Sc Hons (Linnology, Geomorphology, GIS and Environmental Management) and B.Sc (Botany and Geography & Environmental Management). He is a biogeomorphologist that specialises in ecology of wetlands and rehabilitation. He has been a registered Professional Natural Scientist since 2002.

Danie has 17 years of experience in the mining industry in environmental and specialist assessments, management plans, audits, rehabilitation, and research.

He has experience in 8 countries and his experience is in the environmental sector of coal, gold, platinum (PGMs), diamonds, asbestos, rock, clay & sand quarries, copper, phosphate, andalusite, base metals, heavy minerals (titanium), uranium, pyrophyllite, chrome, nickel etc.

He has wetland and geomorphology working experience across Africa including specialist environmental input into various water resource related studies. These vary from studies of the wetlands of the Kruger National Park to swamp forests in central Africa to alpine systems in Lesotho.

**PRESENTATION SUMMARY: REGIONAL BIODIVERSITY MANAGEMENT ISSUES**

The Limpopo Province’s total size is 125,754 km² and is characterised by very distinct and intensive land use practices, these being Agriculture, Mining and Game Farming. Part of this province, the Waterberg district a 14 500km² area of spectacular scenery and biodiversity also contributes a large percentage to the total coal reserves of South Africa. Herein lies the two opposing forces jostling for position in the far north, biodiversity rich landscapes that are valuable to Tourism and rich mineral deposits, desperately needed by the country. We are working through a paradigm shift where the mining industry are beginning to understand the importance of mine site rehabilitation along with all that it encompasses. The industry is moving away from being an exploitative one with short and narrow benefits to a more sustainable extractive industry with greater benefits for a broader set of stakeholders. This requires a team effort as we can do a better job when we work together to plan for conservation, offsetting, restoration and rehabilitation.

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**Lysette Rothmann-Guest**

Lysette is a senior stakeholder engagement consultant with 26 years’ experience in stakeholder engagement and environmental management. She began her career with the design of stakeholder engagement processes in water resource development in the public sector. Her expertise includes design and implementation of stakeholder engagement processes and engagement facilitation for Environmental and Social Impact Assessments (ESIAs) in Africa and South Africa, in compliance with international good practice and in country regulatory requirements. Lysette also worked closely with international consortium teams to develop innovative stakeholder engagement processes for implementing new technologies in the South African Context. She obtained her BL degree Honours in Landscape Architecture (including Environmental Management) from the University of Pretoria.
EARLY STAKEHOLDER ENGAGEMENT AS A STRATEGIC APPROACH TO BUILDING RELATIONSHIPS

Lysette Rothmann-Guest, Vassie Maharaj and Elna de Beer
SRK Consulting, Johannesburg, Strategic Stakeholder Engagement Consultants, +27 11 441 1111, lrothmann-guest@srk.co.za, vmaharaj@srk.co.za, edebeer@srk.co.za

ABSTRACT

There is a growing awareness in the global mining industry that early stakeholder engagement is vital to build the foundation of a mining company’s Social Licence to Operate (SLO). This awareness is especially relevant to junior miners who are often involved in early exploration and project planning activities.

Both major and junior mining companies are increasingly moving away from undertaking stakeholder engagement for the sole purpose of legal compliance in the short term. Companies have realised that a SLO is earned through local communities’ broad acceptance of a project by actively cultivating meaningful relationships between the mine and the receiving community. The thinking behind this process is that trust cannot be built if either party does not honour and respect the other’s values, customs and traditions from the beginning and foster the relationship step by step into the future. Furthermore, developing beneficial stakeholder relationships simply makes good business sense. This is especially true when stakeholder engagement and community investment is seen through the lens of risk management and when mutually beneficial opportunities are pursued.

Many of these views on shared value and partnerships are being successfully implemented by mining companies around the world. Another benefit is that these approaches are aligned with lender requirements of financial institutions such as the World Bank, on which many emerging mining companies depend for project funding.

Junior miners may have heard about popular industry concepts of Social Licence to Operate, strategic community investment, stakeholder mapping and analysis, risk and opportunity screening, or grievance management, but may find it challenging to put it into practice. SRK has fulfilled an advisory and capacity building role in the mining industry for the past 30 years to support companies in implementing good practice approaches, strategies and tools to ensure effective stakeholder engagement. This has resulted in these mining companies achieving more favourable levels of a Social Licence to Operate.

The paper reflects on some of the good practice approaches and tools to assist emerging mining companies in building strong relationships and manage project risks and opportunities; from reconnaissance through feasibility, construction, operation to project closure and beyond.

Riëtha Oosthuizen, CSIR

Riëtha Oosthuizen is a Senior Researcher with the Climate Studies, Modelling and Environmental Health Research Group at the CSIR in Pretoria. Riëtha holds an MMedSc from the University of KwaZulu Natal. Her masters focused on the respiratory health status of adults who grew up in an air quality priority area in South Africa. She is registered with the Health Professions Council of South Africa as a medical scientist. For the past 22 years, Riëtha’s research has focused on air pollution and human health. She has experience in human health risk assessments and the factors influencing risk.
PRESENTATION SUMMARY: ENVIRONMENTAL HEALTH IMPLICATIONS OF MINING, INCLUDING AIR QUALITY: LEPHALALE CASE STUDY

Health impacts of mines are assessed to maximise health gain and reduce negative health impacts. The main steps followed in such an assessment will be discussed in terms of Environmental Health Areas (EHAs) as recommended by the International Finance Corporation (IFC). This process also includes a health action plan and a plan for monitoring and evaluation. Different indicators relevant to each EHA will be briefly discussed. These indicators refer to factors that are modifiers of health such as age, existing diseases, life style and socio-economic conditions. The main focus of the presentation will however be to describe environmental pollution that may result from mining activities, with specific reference to air pollutants, and their impacts on human health.

Marcus Wiley P.E, TCG Global, USA and Gary Williams, TCG Projects, RSA

Marcus (Mark) Wiley is a registered professional mining engineer with over 42 years’ experience in the coal business. Mark is the Chairman of TCG Global, LLC based in Denver, Colorado. Since 1981, Mark has provided professional engineering services to the mining and power industry, with a primary focus on coal. In 2000, Mark started a PhD program at the Colorado School of Mines. He has several issued patents in gasification around the world including South Africa. Co-author, Gary Williams is the TCG Global partner for Africa.

Gary is the Managing Director of Titanium VC 1 Ltd, an approved Sect. 12J Venture Capital Company. He is also the founder and Managing Director of TCG Projects.
Gary graduated with a Bachelor of Commerce Degree and later Honors Degree from the University of South Africa by the time he completed articles with Cassells De Kooker CA (SA). In 1993 he joined Vodacom as a Chief Accountant for a number of years, after which he returned to the professional environment and joined the Management Consulting Practice of Deloitte & Touche. With an entrepreneurial inclination, Gary later started his own specialized Management Consulting Business. Accumulating more than 20 years business experience in local and international markets, across various industries ranging from small to fortune 500 companies, Gary has a proven track record demonstrating the ability to successfully manage and deliver complex business projects.

HIGH-EFFICIENCY LOW-EMISSIONS TECHNOLOGY IS THE BRIDGE TO THE ENERGY FUTURE

Co-Authors: Marcus Wiley P.E. & Gary Williams

Abstract:

In support of the IEA’s (International Energy Agency) Technology Roadmap for High-Efficiency, Low Emissions Coal-Fired Power Generation. This presentation focuses on how a Steam Reforming Gasifier, producing clean SynGas, can have a 62.5% reduction of CO2 over conventional coal. Coal is the largest source of power globally and, given its wide availability and relatively low cost, it is likely to remain so for the foreseeable future. The High-Efficiency, Low-Emissions Coal-Fired Power Generation Roadmap describes the steps necessary to adopt and further develop technologies to improve the efficiency of the global fleet of coal. To generate the same amount of electricity, a more efficient coal-fired unit will burn less fuel, emit less carbon, release less local air pollutants, consume less water and have a smaller footprint.
Three Learning Objectives the Audience will take home:

- Gasification by pyrolytic process does not require Oxygen plant and is modularized with factory assembled modules making for easy shipment and site construction. The site footprint is very compact.
- CO2 emissions are substantially reduced vs. other conventional coal fired plants, this is ideal for IPP applications suitable for power generation at Mining or Industrial Process plants.
- Packaged Gas Turbines can be fuelled with Hydrogen rich clean Syngas producing 50MW from the 500 tpd coal gasification process with high efficiency using ORC power recovery vs. a steam/water cycle reducing operating and maintenance costs.

*Corresponding author: Gary Williams, TCG Global LLC, & TCG Projects LTD, Denver, USA, Phone: +27 12 8800123. Email: gwilliams@tcgenergy.com

Day Two
Session 3

Philip Ramphisa, Ivanplats

Mr. Phillip Ramphisa is a professional natural scientist registered with the South African Council for Natural and Scientific Professions (SACNASP). He has over 10 years’ experience in sustainability including stakeholder engagement, environmental management and community development (including enterprise development) from a consulting and a mining background.

Mr. Ramphisa has assisted various mining companies to create shared value through the implementation of environmental management plans, the development and implementation of the social and labour plans as well as the implementation of local economic development projects. He has extensive experience in stakeholder engagement including the engagement of local government, communities and government for the compliance and implementation of the EMPs as well as SLPs in the mining industry.

Mr. Ramphisa holds an MSc in Environmental Management from the University of Johannesburg and as well as a Master of Business Administration (MBA) from the University of the Witwatersrand.

Louise Nicolai, Boikarabelo Coal Mine

Louise van den Berg-Nicolai is the Senior Environmental Officer for Ledjadja Coal (Pty) Ltd.’s Boikarabelo Coal Mine in Lephalale, Limpopo Province. Boikarabelo Coal Mine is the first junior mining house to get into the construction phase within the Waterberg Coal block. Louise has been on site as the environmental office from the onset of construction in 2013. She has, however been involved in the project from the conceptual phase and managed all of the environmental licensing processes for the project which in itself took over five years.

Louise has an MSc in Environmental Management from Imperial College, University of London and has over ten years’ experience in the environmental management industry. Currently as the appointed environmental officer for the Boikarabelo Coal Mine, Louise’s responsibility includes the development and
implementation of an environmental management system for the mine to ensure continued compliance. She also oversees the management of the Resgen farms.

PRESENTATION SUMMARY: BOIKARABELO COAL MINE AND ENVIRONMENTAL MANAGEMENT

Boikarabelo Coal Mine has initiated construction with some initial work been undertaken on site. Construction has not been smooth with the main contractor going into liquidation as well as delays in the funding of the greater project. Even though construction has been delayed the environmental management on site has been progressing with some exciting initiatives been planned and some implemented to ensure the Boikarabelo Coal Mine progresses forward while being responsible for their impact on the environment. Ledjadja Coal has undertaken additional biodiversity investigations for potential off setting, has developed and implemented the initial phases of a detailed Environmental Management System and has designed an onsite waste management facility and nursery. Boikarabelo Coal Mine is also participating in developing a Waterberg Coalfield Rehabilitation forum to try and encourage collaboration between players to achieve sustainable development of the Waterberg Coalfield.

Kumari Pillay, Coal of Africa Limited

A passion for environmentalism has led to Ms Kumari Pillay embarking on a career in environmental management. Beginning her career as an Environmental Management Coordinator in the gold mining industry, Kumari has proceeded to working in a variety of industries including FMCG, Production and Manufacturing. Kumari’s natural strength as a team-player has been further supplemented by her exposure to working in different countries, building on her cultural sensitivity and understanding. With qualifications in environmental management (BSc and BSc Hons) and safety, and her belief that sustainable development is a process that must transcend the operational boundaries and furthermore include not just the ecosystem but the social, cultural and economic aspects as well, Kumari has progressed her career from environmental management to safety and sustainable development. Ms Pillay now occupies the position of Group Safety and Sustainable Development Manager for Coal of Africa. With a career spanning fourteen years, eight of which have been in the mining industry Kumari has acquired sound experience in developing and implementing fit-for-purpose sustainable development strategies and programmes that deliver on effective and financially feasible returns. Kumari is currently studying towards her LLB.

PRESENTATION SUMMARY: PLANNING FOR SUSTAINABLE CLOSURE DURING THE EIA PHASE: A SOUTH AFRICAN CONTEXT

Significant strides have been made toward successful closure planning to enable implementation of closure plans that meet the requirements for environmental rehabilitation as well as management of potential negative environmental impacts. However, there is still substantial room for improving the manner and way in which closure plans are designed, as this regards the development of sustainable closure plans that address not only successful environmental rehabilitation and the implementation of mitigation measure to address negative impacts to the ecosystem, but also closure plans that address the social and economic challenges that go hand-in-hand with mine closure. While the MPRDA requires that applicants for prospecting rights make available the prescribed financial provision for rehabilitation, and best practice prescribes that mines should be designed for closure, there is still a discord seen between legislation, best practice guidelines and successful closure on the ground. This paper focuses on the opportunity to utilise the EIA phase of the application process for environmental authorisations to relook and re-engineer/re-design with sustainable closure in mind.
Peter Sebake, Kodumela Bakomoso Youth Development

He is co-founder and executive chairman of Kodumela Bokamoso Youth Development which was founded in 2009 and focuses on developing young people through education. He has been involved in mentoring, counselling, motivating and teaching young people for more than 17 years. He has been working with Lesego Platinum since 2012 as Stakeholder Engagement Officer dealing with Mphahlele, Tau Mankotsana and Baroka ba Nkwana communities and with the DMR. He grew up in the rural area of De Vrede village around Blouberg Municipality and he is passionate about rural community development. Peter is passionate about seeing communities improved and is gifted at creating positive and lasting relationships with communities for the long term.

PREPARING A LOCAL LIMPOPO COMMUNITY FOR MINING OPERATIONS THROUGH PEOPLE DEVELOPMENT: A CASE STUDY

Peter Sebake
Kodumela Bakomoso Youth Development, Senwabarwana, 0716, Limpopo Province, South Africa

ABSTRACT

Mining companies need to strive to build positive and lasting relationships with the communities of which they form a part. This paper outlines how one such mining company, Lesego Platinum, has partnered with a local NPO, Kodumela Bokamoso Youth Development to achieve this goal. Combining their strengths, this collaborative project called Lesego Education, has partnered with a local community in rural Limpopo as they prepare for the start of mining operations.

Rather than focusing on infrastructure development, Lesego Education has chosen to focus on people development. We have placed particular emphasis on improving schools in the communities surrounding the proposed platinum mine. Lesego has partnered with two education circuits within the Limpopo Education Department, Seotlong (Greater Sekhukhune District) and Mphahlele (Capricorn District) circuits. Working in collaboration with the circuit managers, Lesego Education carries out three main programmes within the approximately 40 schools close to the mine. Our focus is on developing the leaders of these schools (including the principals, deputies, department heads and SGB members), developing teachers (specifically mathematics, science and accountancy teachers) and developing learners (through motivation, awards, an annual career expo and winter schools).

If we can prepare learners to become the future employees of the mine, can equip the schools to uplift the whole community and can make the mine a positive influence within the region, we are successful.

*Corresponding author: Kodumela Bakomoso, +27 82 687 5916, Email: peter.sebake@gmail.com

Day Two
Session 4

Ray Durrheim, University of the Witwatersrand

Ray Durrheim was born in Bloemfontein in 1956. He is a graduate of Stellenbosch (BSc, 1977), Wits (BSc Hons, 1978 and PhD, 1990), Pretoria (MSc, 1984), and UNISA (BA, 1984).

He started his career in 1979 as an exploration geophysicist with Gencor. He was involved in gold, coal and base metal projects, gaining field and interpretation experience in ground and airborne magnetics, gravity, resistivity, CSAMT, IP, ground and airborne EM. During his National Service (1979-81) he was seconded to the Geological Survey, where he conducted geotechnical investigations.
Ray was appointed a lecturer in the Geophysics Department, Witwatersrand University in 1983, where his research activities included investigations of the crust and upper mantle using both explosive and mine tremor energy sources, and the application of the reflection seismic method to gold and platinum exploration. He spent a sabbatical year (1989/90) at the Geophysical Institute in Karlsruhe, Germany and the USGS Office of Earthquakes, Volcanoes and Engineering in Menlo Park, California.

Ray joined CSIR in 1993, where he conducted research in the fields of mine seismology and rockbursting, and managed the DeepMine and FutureMine Collaborative Research Programs. He was seconded to the Mining and Mineral Sciences Laboratories of Natural Resources Canada in Ottawa during 2003. He currently is a Fellow in the CSIR Centre for Mining Innovation.

He was appointed to the Wits/CSIR South African Research Chair in Exploration, Earthquake and Mining Seismology in April 2007. He has continued with mine seismology research at CSIR and taken up teaching, research and supervision responsibilities at Wits.

Day Three
Session 1

Professor Tony Naldrett

Tony Naldrett was born in the UK and received his first degree from the University of Cambridge. He emigrated to Canada in 1957 and obtained a position as a mine geologist in the Falconbridge nickel mines at Sudbury. After studying for his M.Sc and Ph.D. at Queen’s University, and 3 Post-doctoral years with the Carnegie Institution of Washington, he joined the University Of Toronto Department Of Geology in 1967. While there he taught mineral deposits geology and supervised 45 M.Sc., Ph.D. and Post-doctoral students until he retired in 1998. His research has covered Ni-Cu-PGE deposits in Russia, Australia, China, Norway, Southern Africa, South America, the US and Canada, and has resulted in over 250 papers and books, his most recent book being “Magmatic sulfide deposits – geology, geochemistry and exploration” published by Springer Verlag in 2004. He now resides in the UK, but has an honorary professorship at Wits which brings him to Johannesburg at frequent intervals.

AN OVERVIEW OF PLATINUM IN THE BUSHVELD COMPLEX

Anthony J. Naldrett
University of the Witwatersrand

The Bushveld complex contains about 75% of the world’s resources of platinum, 52% of palladium and 82% of rhodium. If one adds the resources in the Great Dyke of Zimbabwe, only 800 km north of the Bushveld, these figures rise to 91%, 62% and 90% respectively. The principal use of these metals is in catalytic converters for automobiles, trucks, etc. Thus Southern Africa is the most important area of the world when it comes to controlling vehicle pollution.

Igneous rocks occur in the earth primarily as felsic bodies (rich in the minerals feldspar and quartz) and mafic (rich in the elements magnesium and iron). The Bushveld complex belongs to the second group and is the largest known body of this type, extending 350 km north-south by 450 km east-west, with a thickness of up to 11 km. Mafic magma rose from depth (originating in the mantle, perhaps 100-200 km deep) and spread out beneath a cover of relatively low density rocks that kept it insulated, causing it to cool slowly. The full 11 km of magma did not intrude all at once; there were up to several hundred successive pulses, most (but not all) of them spreading out above rocks that had formed from the previous pulse. On cooling, these magma pulses crystallised, giving rise to layers with different mineral contents and therefore different colours (shades of grey to black) when examined in outcrop.

Some of the minerals are made of metals with a high economic value and, when these minerals are present in a high enough proportion, the rocks containing them are worth mining as ore. A famous example is chromium that occurs within the mineral chromite. There are over 21 layers rich in chromite four of them are thick enough and contain enough chromite, with the chromite containing enough chromium to be
profitable to mine. Six metals, platinum (Pt), palladium (Pd), rhodium (Rh), ruthenium (Ru), iridium (Ir) and osmium (Os) comprise the so-called platinum group of elements (PGE). In contrast to chromium, these do not occur as obvious concentrations of minerals rich in the metals. Typical chrome ore contains about 30 wt% Cr, while a rich platinum ore contains about 0.0006 wt% (= 6 gm/tonne) Pt, making it much more difficult to identify in the field. The Pt, and other PGE that are usually associated with it, occur as extremely fine (10-100 microns) grains, generally within or around the peripheries of sulfide grains. The sulfide grains are composed primarily of iron (Fe), nickel (Ni), copper (Cu) and, of course, sulfur (S). The reason for this is that as a magma pulse cools it may become saturated in Fe-Ni-Cu-S liquid, which then separates from the magma as very fine (0.1-1mm) liquid droplets. The PGE are highly chalcophile, i.e. they are much happier in a sulfide liquid environment than in their original host, the silicate magma. Thus, they are attracted from the magma into the sulfide liquid, reaching concentrations of up to 1000-6000 gm/tonne. The sulfide liquid has a density of about 4.5 gm/cc compared to the 2.8-3.0 gm/cc of the host magma, so that it tends to settle to the base of the magma pulse. It only takes 0.6% sulfide containing 1000 gm/tonne Pt to produce a rock containing an ore grading 6 gm/tonne Pt, thus the sulfide is a very powerful concentration mechanism for the PGE.

The process of sulfide settling has occurred effectively enough to produce ore grade material in 3 main settlings in the Bushveld complex. These are the Merensky Reef, the UG-2 chromitite and the Platreef. The Merensky Reef is a distinctive horizon, composed mainly of the minerals orthopyroxene and plagioclase, that is likely the result of two or three pulses of particularly PGE-rich, sulfide-saturated mafic silicate magma that spread out over much of the eastern and western chambers of the Bushveld. The combined pulses gave rise to strata 1m to 14 m thick, and 10cm-1m thick horizons in these strata (generally at the base of each identifiable pulse) contain enough PGE-rich sulfide to constitute ore. The UG-2 chromitite is an approximately 60cm-thick horizon of mainly massive chromitite; during its deposition sulfide saturation of the magma was also achieved and these sulfides concentrated sufficient PGE to enrich the chromitite to ore grade. The Platreef sensu stricto occurs in the northern chamber of the Bushveld, extending north from and slightly south of the town of Mokopane, although somewhat similar formations occur elsewhere (e.g. Sheba’s Ridge near Groblersdal). It consists of a series of Bushveld strata that have many similarities with the zone of the Bushveld hosting the principal chromitites and the Merensky Reef (known as the Critical Zone). PGE-rich horizons, up to 10 m thick, occur within these strata. The greater thickness of these horizons in comparison with the Merensky Reef and UG-2 make them amenable to bulk mining and the one mining operation currently active in this environment (Sandsloot) is currently the most profitable of all the Bushveld PGE mines. A second operation is being currently being developed on the Platreef (Ivanplats) and several others are in the wings.

This author has proposed the “pudding basin model” to explain the relationship between the Platreef and the Merensky Reef and UG-2, although his idea is not universally accepted. The model will be illustrated in the talk.

Professor Judith Kinnaird, University of the Witwatersrand

Judith Kinnaird is an Associate Professor of Economic Geology in the School of Geosciences and Director of the Economic Geology Research Institute, University of the Witwatersrand. She was awarded an Honours BSc degree from the University of London, an MSc and PhD from the University of St. Andrews in Scotland, for research on tin-tungsten and columbite-bearing granites in ring complexes in Nigeria. She has taught for the Open University in UK and University College Cork in Ireland where research studies focussed on zinc-lead and copper deposits in Ireland.
PLATINUM MINERALIZATION IN THE NORTHERN LIMB OF THE BUSHVELD COMPLEX WITH A FOCUS ON THE NEW PTM WATERBERG PROJECT

Judith Kinnaird
EGRI/CIMERA School of Geosciences, University of the Witwatersrand

The northern limb of the Bushveld Complex forms the eastern part of what appears to be a much larger ‘basin’, 100 x 130 km and was thought to extend 110 km north of Mokopane. It had been assumed that the exposed limb linked in a westward arcuate form with the Villa Nora segment of Bushveld rocks. However, the discovery in 2011 by Platinum Group Metals (PTM) of buried Bushveld rocks 20 km north of the exposed northern limb, refutes these earlier correlations. Since the discovery, drilling has confirmed the presence of PGE mineralisation along a >17 km long northeast lobate arc. An Inferred Mineral Resource Estimate (dated July 2015) of 246 million tonnes grading 3.25 g/t gives 25.64 million ounces of platinum, palladium and gold with significant copper and nickel credits.

The northern limb is <15 km wide and has a north-south sinuous outcrop with a succession of rocks that differs from those of the eastern and western Bushveld. At the base there may be a thick Lower Zone, which is unmineralised, although this is lacking in the northern part of the limb. Above this, the Platreef is a world-class, composite body that is host to platinum-group element (PGE) and nickel-copper. It occurs at the base of the intrusive rocks on the eastern edge of the northern limb or above the Lower Zone rocks where they occur. The Platreef dips moderately to the west is generally 200-400 m thick although thicker in the south and thinning northwards. The thick Main Zone above the Platreef is up to 3 km thick. In the Marikana area this has been mined for dimension stone, although no quarrying of Main Zone has taken place in the northern limb. The Upper Zone, has >20 magnetite-rich layers, with a potential to produce iron, titanium and vanadium. Red granites above the Upper Zone are being quarried for dimension stone, which is exported around the world.

The Platreef was identified in 1925 by Hans Merensky as host to platinum mineralisation in the northern limb. Mining began in the 1920’s and Potgietersrus Platinums Limited (PPL) acquired almost all key PGE properties in the area by late 1925, when they were taken over by Johannesburg Consolidated Investments (JCI). In Sept 1926, PPL constructed a processing plant and by 1928 had produced 22 500 ounces of platinum from underground workings but mining ceased in May 1930 citing recovery problems and a falling platinum price at the onset of the Great Depression. In 1968, JCI resumed production but underground mining ceased in 1971 because it was difficult to follow the ‘reef’ underground. Exploration resumed in 1976 and in Sept 1990 it was announced that an open pit mine would be developed at PPL. The first blast at Sandsloot took place in February 1992. Since then further pits have developed to the north. The success of the low-cost, high tonnage pits operated by Anglo Platinum coupled with the increase in platinum price, prompted a dramatic revival of exploration activity for Ni-Cu-PGE deposits and the Platreef is now being developed to the south by Ivanplats.

To the far north, the Bushveld succession in the PTM cores comprises an Upper Zone (UZ), a Main Zone and a basal olivine-rich unit that is at least 50 m thick. The UZ varies between 10 and 500 m in thickness but lacks the typical magnetite layers except in one of the early cores in the south of the project area. The MZ rocks are up to 3km thick and are dominated by gabbronorites.

There are at least two ‘mineralized reefs’, an upper T reef and a lower F reef. The T reef, which occurs at the Main Zone-Upper Zone contact is restricted to the southern portion of the project area, whereas the F reef has been intersected over >17 km. The Bushveld succession thickens northwards with greater separation between the two reefs. The T reef at its shallowest is at 140 m in depth. In the discovery hole the T reef is ~30 m thick but northwards thickens to < 50 m thick. It comprises an upper T1 and a lower T2 unit and grade in both is typically 3.4 g/t 3E, although locally with <14 g/t in more northerly cores. Both zones have a consistent and unusual metal ratio of ~50% Pd, ~30% Pt and anomalous 20% Au with 0.1% Ni and 0.17% Cu. The F reef, is typically <10 m thick but in the middle of the current project area, the “Super F reef” thickens to 60 m with grades of 3 g/t over this interval. The metal budget differs from that of the T reef, with 65% Pd, 30% Pt and 5% Au, 0.07% Ni and 0.17% Cu.
Dr Luke Longridge, VMIC

Luke is a geologist. He completed his undergraduate degrees and PhD at Wits University, and has since been developing mineral projects. He currently manages exploration for Bushveld Minerals Limited, as well as advising on various exploration projects in Canada, South Sudan, Namibia and Mozambique and South Africa.

PRESENTATION SUMMARY: MAGNETITE POTENTIAL OF THE UPPER ZONE OF THE BUSHVELD COMPLEX IN THE NORTHERN LIMB

At least 18 individual vanadiferous titano-magnetite layers have been identified in the Upper Zone on the Northern Limb, ranging in thickness from a few cm to 10s of meters. A number of zones with heavily disseminated (but not massive) magnetite are also present. Over the thickness of the Upper Zone, the vanadium content of the magnetite decreases from >2% V2O5 near the base, to <0.3% V2O5 near the top, whilst the titanium content shows an inverse relationship, increasing upwards in the Upper Zone. These magnetite layers have significant economic potential, as they contain elevated levels of Fe, Ti and V that may be exploited. However, there are a number of metallurgical challenges to treating of vanadiferous titano-magnetite ores.

The formation of these magnetite layers is enigmatic, as geochemical indicators (Sr0 and the Cr-content of pyroxenes) show the UZ as a homogeneous magma sheet, devoid of replenishment. The presentation will discuss various models for magnetite formation, recent work on magnetite layers in both the upper and lower parts of the Upper Zone, the economic potential of Bushveld magnetite layers, and metallurgical issues associated with processing of these magnetites.

Day Three
Session 2

Professor Jock Harmer, Rhodes University

Professor Robin Harmer – universally known as “Jock” – holds an MSc in Geology from the University of Natal and a PhD in Geochemistry from the University of Cape Town.

Jock’s initial career was in academia, holding research and teaching positions at the CSIR, the University of Pretoria and the Council for Geoscience.

Joining the minerals industry in 2002 he served as Exploration Manager for 2 junior PGE explorers and since early 2007 he has operated as an independent private consultant working on contracts exploring for platinum group metals, base metals and the rare earth elements in Africa, India and Greenland. During this period he co-founded, and acted as CEO of, Rare Earth International and served as Managing Director of Southern Crown Resources and Technical Director of Galileo Resources.

In 2012 Jock was the SEG’s “Regional VP for Africa Lecturer” delivering lectures on the REE through the region. In May this year he returned to academia as Professor of Exploration Geology and Director of the MSc Program in Exploration and Economic Geology at Rhodes University.

Dr Luke Longridge, VMIC

PRESENTATION SUMMARY: REVITALIZING OLD TIN PROJECTS: RECENT EXPLORATION AT ZAAIPLAATS

The Zaaiplaats and Groenfontein Tin Deposits are examples of endogenic tin mineralisation in highly evolved anorogenic granites of the Bushveld Complex. Both deposits, as well as other granite-hosted tin deposits in the area (e.g. Appingendam and Solomons Tempel) occur in the uppermost parts of composite granite plutons. At Groenfontein, a broad (~800 m x 100 m) zone of outcropping disseminated tin mineralisation has been defined within the Lease Granite. Recent drilling combined with as re-
interpretation of historic data has resulted in a resource of 5995 tons of Sn, at a grade of 0.15% Sn (cut-off 0.1% Sn). Within this, a core zone with higher grades (>0.2% Sn) has been defined. In addition to the disseminated mineralisation, sub-horizontal lenticular orebodies are also found at Groenfontein, at the upper contact between the Lease Granite and the overlying Rashoop Granophyre, and are associated with coarse quartz-feldspar pegmatite. These orebodies are higher-grade than the disseminated mineralisation and formed the focus of previous mining. Hence, they have largely been mined out. At Zaaiplaats, exploration has been focused on the disseminated mineralisation in the Bobbejaankop Granite. Following surface and underground rock chip sampling, underground surveying, and an initial drilling programme, 5 distinct tabular zones of disseminated tin mineralisation have been identified within the Bobbejaankop Granite. Some of this mineralisation has been partially mined, and a maiden mineral resource of 12,452 tons of Sn at an average grade of 0.106 % Sn has been defined. In addition, recent sampling of underground workings in the Lease Granite has revealed significant areas of un-mined Sn mineralisation, associated with Cu and W, which will form the focus for future exploration.

Sonwabile Rasmeni, Mintek

Sonwabile Rasmeni is currently working as a scientist in the Mineralogy Division at Mintek. His previous professional experience includes research and geotechnical trainee at Coega Development Corporation in Port Elizabeth. Sonwabile also worked as a lecturer at University of Fort Hare in Alice. His research interests include; geotechnical investigations, geological field evaluations, environmental mineralogy and process mineralogy. Sonwabile holds an MSc degree in geology from University of Fort Hare and is a registered professional scientist.

ASBESTOS CONTAMINATION ASSESSMENT OF ABANDONED MINE SITES IN THE MAFEFE AREA, LIMPOPO PROVINCE

S. Rasmeni, J. Mogoru, D. Chetty and N. Negota

Mineralogy Division, Mintek, Randburg, South Africa
SonwabileR@mintek.co.za

Asbestos is a commercial term applied to six fibrous silicate minerals: chrysotile, crocidolite, amosite, anthophyllite, tremolite and actinolite. Minerals crystallised with an asbestiform habit are defined by fibres longer than 5 μm with mean aspect ratios of 20:1 to 100:1 or higher. All types of asbestos fibres to some extent are known to cause serious health hazards in humans, but amosite and crocidolite are considered to be the most hazardous asbestos fibres. Although mining of asbestos has long ceased owing to the negative health impact, concerns remain around sites of abandoned/closed down asbestos mines. These require concerted efforts at rehabilitation and monitoring to ensure safe occupation of the surrounding areas. Successful rehabilitation of an asbestos-contaminated environment relies heavily on the understanding of the type of asbestos present, concentrations levels in the environment and extent of contamination.

In this study, field assessment was carried out at seven sites in the Mafefe area of Limpopo Province, where abandoned asbestos mines are present. A total of twelve soil and rock samples suspected to contain asbestos fibres from these closed down mines and their surroundings were collected and analysed using mineralogical techniques. The study was aimed at showing which samples contain asbestos fibres, and where present, providing information on the types of asbestos, their aspect ratio and their abundance relative to other minerals. The mineralogical data from the samples were then related to the considered sites, with recommendations for remediation put forward.

Eight of the twelve samples analysed were shown to contain asbestiform minerals. Fibrous forms of amphiboles such as crocidolite (riebeckite) and amosite (grunerite) were found, as well as small amounts of
chrysotile (a member of the serpentine group). Five of the seven sites were found to be contaminated by asbestiform minerals. Three sites show primary contamination, i.e. where asbestos occurs within the soil, or exposed in rocks that have been water-washed. The problem is exacerbated by the building of houses close to adits/mine shafts/dumps as the community expands, as building activity releases fibres into the air. Two sites show secondary contamination, where building structures contain incorporated asbestiform material, in this case, chrysotile. The presence of asbestos fibres in the five sites poses a threat to people and animals living in the areas. Rehabilitation will have to address containment of the exposed asbestiform minerals in the areas of primary contamination. This will range from simple infilling of trenches to major remediation efforts, given the expansion of the community into the affected areas.

Day Three
Session 3

Trust Muzondo

Was a bursary student for Lonmin. Twenty-four years exploration and mining geology experience having worked for: Lonrho and Trillion Resources (a Canadian minor) in Zimbabwe, Gallery Gold (an Australian minor) in Botswana, PDDE (drilling, geophysical surveying, logging, directional drilling, geological consultancy) in Southern Africa, Letseng Diamonds in Lesotho and Anglo American Platinum in Zimbabwe and RSA.

Married to Mavis and blessed with two daughters.

Mogalakwena is Anglo American Platinum’s and the world’s biggest platinum group elements (PGEs) producer. The production regime at this low grade high tonnage surface producer is anchored in the well planned mechanised mining methods as well as high throughput processing methods employed. The first generation of mining at Mogalakwena as an underground operation was futile. The mine has since seen phenomenal growth in its two decades of operation as a surface mine.

The surface mine started as a contractor-mined 300kt per month operation on a small hill in 1992. Today, over two decades later, mining operations extend over a further 14km northwards with potential to grow southwards a further 6km, too. The operation today mines 9Mt per month almost entirely with nine’s own equipment.

The ore body at Mogalakwena is a large westerly dipping tabular Pyroxenite dominated ore body which lends itself to high tonnage mining. The ore in this exceptional world-class ore body is inherently variable highlighting the need for stringent ore control methods as mining progresses. The strategists and mine planners at Mogalakwena are well aware of the mutual coexistence of mining selectivity with the effectiveness and efficiency of high volume mechanised mining.

The paper showcases the ever evolving strive for optimized ore control and reconciliation methods, whilst allowing large drilling machines, loading and hauling machines to maximize throughput as planned.
Considering a processing bottleneck, the challenge arises to manage and optimise feed quality and PGE grades with due consideration for the remaining low grade deposit and mined low grade tons.

Humbulani Mundalamo, University of Venda

Ms. Rejune Humbulani Mundalamo is a Lecturer of Economic Geology/Medical Geology. She has had long working experience at the tertiary level (15 years) working at the University of Venda since the year 1999, where she started as a laboratory Technician and became a Junior Lecturer in 2008 to 2010 at the Department of Mining and Environmental Geology. Currently she is a Lecturer at the same Department starting from 2010 up to date, teaching general geology, economic geology, petrology, environmental geology and medical geology modules. She is currently finalising her Ph.D. studies focusing on the geology, mineralogy and structural investigation of the Musina copper deposits. Her areas of research include mineral exploration and mining impacts with emphasis on copper deposits, tailings dams and waste rock dumps. She has published in refereed journals and refereed conference proceedings, and has presented several papers at national and international conferences. She has supervised and graduated 12 honours students. She has attended training on her Ph.D. work at University of Göttingen, University of Applied Sciences Ostwestfalen-Lippe (Germany), Council for Geoscience (Pretoria), MINTEK (Johannesburg), SNSA (Pretoria) and Southern mapping (Johannesburg). Currently, she presented her research findings at the Centre of Excellence for Integrated Mineral and Energy Research Analysis (CIMERA) as a student supported by CIMERA. She is a member of professional bodies, including GSSA, MINSA and IMGA.

GEOLOGICAL AND MINERALOGICAL INVESTIGATION OF THE MUSINA COPPER DEPOSITS

Humbulani R. Mundalamo*, 1 and Jason S. Ogola1
1Department of Mining and Environmental Geology, School of Environmental Sciences University of Venda, Thohoyandou 0950, South Africa.

ABSTRACT

Morden mining started in the Musina area from 1906. Mining took place at four main deposits; Campbell, Harper, Messina and Artonvilla. By the time of mine closure in the area in 1992, a total of 40 million tons of sulphide ore had been produced leading to the recovery of about 700,000 tons of copper.

The current study focused on geochemical baseline survey, petrographic investigation, ore mineralogy and ore microscopy. Geochemical analysis of soil samples revealed Cu, As, Ni and Mn with highest concentration levels of 1321, 215, 1004 and 1009 ppm respectively of which are pathfinders of copper, gold and any other sulphide mineralisation. The Musina orebodies occurred as veined and disseminated ores within quartz veins, and amphibolites and metamorphosed limestone respectively. The study confirmed the occurrence of pyrite, chalcopyrite, bornite, chalcocite and covellite copper minerals within the ore with chalcopyrite being the dominant mineral. The analysis of chalcopyrite indicated high content of Cu (18.4%) with some Mo (43 ppm) while Ni, Co, Cd, Ag, Pb, Mn, Mo, Cu, Cr, Zn and As were present in trace amounts. Petrographic investigation revealed the occurrence of garnet and highly stressed massive intergrowths of graphite. The garnets confirmed FeO ranging from 23 to 33 wt% and 5 to 12 wt% MgO implying that the mineral is almadine (Fe3Al2Si3O12).

The study recommended further detailed work on ore mineralogy and ore microscopy, fluid inclusion studies, as well as isotope geochemistry in order to unpack the issues around genesis of the Messina deposits. The anomalous concentrations of Cu, Ni and Mn in soils could be used as precursors for Cu sulphide ore formation in the Musina area.
**Reprocessing of Tailings Dams for Gold and Other Metals: A Case Study of South Africa**

**Tshedza Shavhani** and **Jason S. Ogola***, 1

1Mining and Environmental Geology, Environmental Sciences, University of Venda, Thohoyandou, 0950, South Africa

**Abstract**

Recent technology advancement and increase in gold price have led to an era where the recovery of gold and other metals from tailings is possible at a profit. About 8% of South Africa’s GDP is from the mining industry and this can be increased by reprocessing gold and other heavy metals that occur within tailings dams. This is particularly promising in South Africa where gold mining started over a hundred years ago at a time where technologies for gold recovery were not advanced.

Huge piles of untreated tailings dams have been abandoned whilst others are still being produced all over South Africa, as 40% of gold reserves are found within South Africa. More than 1.7 billion tons of gold tailings dams have been produced in South Africa and they can be refined to produce at least 15 million ounces of gold.

Mine wastes are hazardous to the environment and human health. In 1998 of the 418 million tons of hazardous waste that was produced in South Africa, 90% was from the mining industry. Apart from the mine waste being hazardous, it also destroys the aesthetic value of land by disturbing the landscape and consuming land, thus excludes other land users.

Previous studies done on different gold tailings dams around South Africa indicated the presence of heavy metals such as Pb, As, Cu, Co, Cd, Mn and Ni as well as Au in different quantities. The main focus is therefore on reprocessing of tailings dams with a view to recovering gold and other metals and at the same time rehabilitating such sites by using tailings as building material.

**Key words:** Reprocessing of gold, Hazardous waste, Environmental and health impacts

*Jason S. Ogola: Mining and Environmental Geology, Environmental Sciences, University of Venda, +27768765436, ogolaj@univen.ac.za*

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**Sello Kekana, Ivanplats**
Sello Melvyn Kekana was born on 27 July 1978 in Kgobudi village in Mokopane, South Africa. He started school in Kgopedinota Primary School in Kgobudi Village, and attended higher education at Makgoka High School in Polokwane where he matriculated in 1996. He obtained a National Diploma in Geotechnology and a Bachelor of Technology Degree at Tshwane University of Technology (formerly Technikon Pretoria); and a Master of Science Degree in Geology at the University of Witwatersrand. He was awarded a membership by the Golden Key International Honour Society for his Master of Science Dissertation.

Sello started working as a Technical Officer at the Council for Geoscience (a mineral research company) in Pretoria, in November 2000. He later moved to Khulani Groundwater Consultants in July 2002, where he worked as a Geotechnologist. He then found his home at Ivanhoe Mines in April 2003. In Ivanhoe Mines, Sello occupied various positions from Geologist – Project Manager - General Manager (Mokopane Operations) – Group Manager Geology – Head of Transformation. He worked on the Ivanhoe Mines projects in South Africa, the Democratic Republic of Congo and in Zambia. In South Africa, he initiated and managed the deep drilling project at the company’s Platreef Project, in the Northern Limb of the Bushveld Complex; and led the team that discovered the Flatreef deposit.

PRESENTATION SUMMARY: AN OVERVIEW OF THE IVANPLATS PLATREEF PROJECT

Ivanplats Pty (Ltd) is the South African subsidiary of Ivanhoe Mines, the Vancouver-based, Toronto-listed development company founded by renowned mining entrepreneur Robert Friedland. Ivanplats is advancing the Platreef Project, which includes the underground Flatreef Deposit of thick, platinum-group elements, nickel, copper and gold mineralization in the Northern Limb of the Bushveld Complex, approximately 70 kilometres southwest of Polokwane. The Platreef discovery, now known as the Flatreef Deposit, is amenable to highly mechanized, underground mining methods.

The Platreef Project is 64%-owned by Ivanhoe and 10%-owned by a Japanese consortium of Itochu Corporation; ITC Platinum, an Itochu affiliate; Japan Oil, Gas and Metals National Corporation; and Japan Gas Corporation. The Japanese consortium’s 10% interest in the Platreef Project was acquired in two tranches for a total investment of $290 million. The remaining 26% ownership interest is held by Ivanhoe's broad-based, black economic empowerment (B-BBEE) partners.

Highlights of the Platreef Project include:
- Mining Right executed on 4 November 2014
- 4,855,366 LTIF man-hours achieved to 8 October 2015
- Pre-Feasibility Study (PFS) Technical Report (TR) 43-101 filed
- Shaft 1 construction in progress
- 5 & 70MVA power applications in progress with Eskom
- Zone 1 expansion drilling complete
- Shaft 2 design and engineering in progress
- Shaft 1 stage and hoist winder refurbishment complete
- Initial engagement with potential smelters, traders and end-users
- Social and Labour Plan projects underway
STRUCTURAL AND WEATHERING EFFECTS ON COAL QUALITY IN THE SOUTPANSBERG AND TULI COALFIELDS.

Sphesihle Hlongwane\textsuperscript{a}, Maseda Mphaphuli\textsuperscript{b}, Mandy-Jane T. Sebola\textsuperscript{a} and Gillian Drennan\textsuperscript{a}

\textsuperscript{a} School of Geosciences, University of the Witwatersrand, Johannesburg, P.O. Box 2050 Wits, Wits, South Africa
\textsuperscript{b} Department of Geology, University of Johannesburg, P.O. Box 524, Auckland Park, Johannesburg 2006, South Africa

Preliminary investigations undertaken in the Tshipise and Pafuri sub-basins (Cindi, 2014 & Mahlangu, 2014) indicate that the deposits represent medium sulphur coals; the presence of pyrite has been linked to the flooding of seawater in the coal swamp. Maceral analysis suggests that the coal samples from the Pafuri Sub-basin, on average, have higher vitrinite content than the samples from the Tshipise sub-basin. Vitrinite reflectance suggests that the coal rank increases from west to east (from Tshipise to Pafuri sub-basin). Samples from the Tshipise sub-basin represent medium C bituminous coals while those from the Pafuri sub-basin are medium B bituminous coals. Algal tissue observed from the Pafuri sub-basin and impressions of glossopteris leaves and bark, as well as glossopteris root zones (\textit{Vertebraria}) collected at Vele Colliery indicate that these coals were formed in the presence of fresh water. A possible depositional environment of the coal seams from both sub-basins is a wet forest swamp within the mesotrophic zone (somewhere between a bog forest and a swampy forest).

Coal quality is increasingly becoming a global issue especially for economies that predominately rely on coal-based energy production. South Africa is no exception, more so because it is amongst some of the major coal producing countries. This paper will investigate the effects of weathering and structural control on coal quality, focusing on faults, dykes and sills in the Tuli and Soutpansberg Coalfields. The Tuli and Soutpansberg Coalfields occur in the northern Karoo Basin and are primary producers of South African coking coal. Coal analysed in this investigation is obtained from Makhado and Vele Collieries which are located within the Tshipise and Tuli sub-basins respectively.

Faults and intrusive bodies exert a major structural control on the Tuli and Soutpansberg Coalfields which are preserved within extensive horst and graben systems. Coal quality is affected by the size of a magma channel and the temperature of the parental magma to the intrusion; and these factors change the macerals, volatile matter, moisture and carbon content, calorific value and coal rank thus changing the coal quality. Alteration is extreme adjacent to the intrusion, becoming more moderate further away with little or no alteration furthest from the intrusion. The alteration is controlled by variation in temperature that is highest closer to the intrusion, and decreases away from the intrusion.
The Tshipise Fault is a major SW-NE trending fault, in the Soutpansberg Coalfield. Literature on the Tshipise fault is limited however it is considered a normal slip fault of post Karoo age. Coking properties south of the Tshipise Fault are more developed compared to those on the northern side of the fault. The variation in the coking properties could either be attributed to a change in the depositional environment or the influx of hydrothermal fluids into the coal basin through fluid pathways during faulting, therefore affecting the quality of coal on either side of the Tshipise Fault.

Reported here are the results of detailed petrographic and geochemical analyses conducted on:

1. The freshest to the most weathered coal samples
2. Coal affected by intrusions with increasing distance from the chill margin
3. Coal derived from the southern and northern side of the Tshipise Fault

These results provide a basis on which to assign uses for the coals, based on their inherent properties, and may contribute to a better understanding of the properties of coal in the northern coalfields of South Africa which are currently not that well understood.

References:


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**CLAY MATERIAL OF MIDWAY BRICKS**

Elvis Madigage

1Department of Physics and Geology, University of Limpopo, Private Bag X1106, Sovenga 0721, South Africa.

**ABSTRACT**

This study aimed to investigate the mineralogy and physical properties of different clay bodies in the Midway Quarry located next to the N1 highway 17 km northeast of Mokopane and 44 km southwest of Polokwane, Limpopo Province. Nine clay samples were collected to establish the mineralogy and physical plasticity of the different clay types. Furthermore, to give full description and distribution of the different clay types and select the best clay body that is suitable for brick making. The clay bodies were formed by weathering of Pietersburg Group that is associated with Ysterberg Shear Zone during reactivation during Bushveld time (c.2000 Ma). XRD characterisation of the clays was performed in order to determine their mineralogical composition and physical properties. Mineralogical analysis showed that the clay minerals found are kaolinite, and vermiculite as well as chlorite that are associated with quartz, albite, muscovite, anorthite, and biotite. The kaolinites are formed by the weathering of felsic volcanic and slate of the Ysterberg and Uitkyk Formations while vermiculite formed from weathering of the mafic Mothiba Formation. Liquid limit and plastic limit of clay bodies were done in accordance to ASTM D4318, plasticity index of different clays were found to ranges from 4.1% to 15% (low to medium plastic), and some of the clay body don’t exhibit plasticity due to low content of clay minerals. The results showed that kaolinite has low plasticity as compares to vermiculite.

Fired clay brick and the brick ash samples have also been taken for mineralogical analysis in order to determine the change in clay and mineralogy during drying and firing process. During the firing process
kaolinite changes with increasing temperature to form sillimanite and mullite as ash product. The sillimanite forms as a hard and resistant mineral that found in the fired clay brick. Plastic limit, liquid limit, and plasticity index measured for different clay bodies were compared with the standard measured results in order to determine which clay body is suitable for brick making and none of the clay material exhibit characteristic for brick making as they are highly sandy.

*Corresponding author: Department of Physics and Geology, University of Limpopo, Phone: +27 076 5224523. Email: emadigage@yahoo.com

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**PRECAMBRIAN BIF HOSTED GOLD DEPOSITS IN GREENSTONE TERRANES: APPLICATION TO THE NORTHERN GREENSTONE BELTS**

Caluza Xola*1, Author Name1 and Author Name2

1Department of Physics and Geology/Science and Agriculture/University of Limpopo, Sovenga, 0727, South Africa.

**ABSTRACT**

Archaean banded iron formation hosted gold deposits are recognised throughout the world, these show a close association in space and time, occurring in greenstone terranes of Archaean age. These have been recognised in the stabilised cratons of Australia, Brazil and southern Africa to name a few (Frip, 1976). The Kraaipan greenstone belt of South Africa hosts such gold mineralisation at the Kalgold Mine. The iron rich chemical sediments are interbedded with chert (cf. James 1954). The BIF is considered to represent an Algoma type deposit hence the common association with submarine sediments- greywacke, turbidite sequences and metavolcanics (Hammond and Moore, 2006, Taner, 2015). Mineralogically, banded iron formations are defined by the occurrence and concentration of iron bearing minerals: oxide, carbonate, sulphide and silicate facies (cf Gross, 1965). These deposits are stratigraphically and or structurally controlled, mineralisation is hosted in rocks with lithological and rheological variations. The mineralisation is generally hosted in discrete shearzones and other regional structures. These primary and secondary structures allow for the hydrothermal fluids to scavenge for metals in various source rocks; metabasalts or carbon rich shales as recognised by Pitcairn (2014) and Large et al (2011). The structures allow for hydrothermal-wall rock interactions, hence in favourable lithological or physiochemical (P-T-X) conditions destabilise the gold transporting species (thio-complexes) permitting gold precipitation. However, the timing of gold mineralisation in these deposits remain a topic of debate amongst economic geologists, whether syngenetic or epigenetic to the chemical deposits. Thusfar, all genetical models for gold mineralisation hosted in iron formations are not effective in developing and facilitating exploration targeting. The study hopes to unravel the most effective model through comprehensively understanding the mineralogical, physiochemical conditions of at the Kalgold deposit and generate an effective genetic model to aid in exploration selection areas of greenstone belts of similar characteristics, and can be applied to greenstone belts of the Limpopo Province.

*Caluza Xola: Department of Physics & Geology/ Science &Agriculture/ University of Limpopo, +27815211381. Email: sanzy.caluza@gmail.com
THE GEOLOGY OF THE TULI COALFIELD, LIMPOPO PROVINCE, SOUTH AFRICA

E. Denge*1, and Prof B Millsteed2
1Department of Physics and Geology, University of Limpopo, Limpopo Province, 0727, South Africa.

The Tuli coalfield is a small intracratonic east-west trending, fault controlled depositional basin, which hosts a sedimentary succession correlated to the Karoo Supergroup. The Tuli coalfield is situated in the northern-most extremity of Limpopo Province, South Africa around the triple junction of the borders of South Africa, Botswana and Zimbabwe. It encompasses an area of some 1150 km², with 10% being underlain by economically exploitable coal-bearing strata. The strata present within the basin can be assigned to a Palaeozoic to Mesozoic lithological sequence, which comprise of the Karoo Supergroup, these being the Permian strata of the Tshidzi, Madzaringwe and Mikambeni Formations, the Triassic Fripp, Solitude, Klopperfontein and Bosboksport Formations and the Jurassic Clarens, Letaba and Jozini Formations. The Madzaringwe Formation forms a significant focus of the study, as it has distinct coal seams, termed the Bottom, Middle and Upper coal seams, with the main coal zone located at depth of less than 50 m along the southern margin, but attains a depth of over 300 m near the Limpopo River.

The results presented here represent part of an ongoing MSc study based on the Vele Colliery, Tuli coalfield. The Tuli coalfield contains coal reserves amounting to 721 million tonnes of coking coal. The emphasis of the present study concentrates on stratigraphic correlation, depositional environments, petrography, geochemistry and coal analysis of the Tuli coalfield in order to better understand its genesis. The existing geological literature provides little detail concerning lateral and vertical variation of factors that determine the economic value and potential validation of the coal. It is also expected that analysis and interpretation of both new and historical data will result in a comprehensive understanding of the geology and coal quality of an otherwise poorly understood sedimentary basin.

*Corresponding author: Department of Physics, Geology Division, University of Limpopo Phone: +27 15268 4067 Email: elelwani.denge@ul.ac.za

THE GEOLOGY OF THE UITKYK FORMATION, PIETERSBURG GREENSTONE BELT

Christopher C Jones
Department of Physics and Geology, University of Limpopo
Private Bag X1106, Sovenga, 0727, South Africa

ABSTRACT

The Palaeoarchaean Uitkyk Formation is a very little studied unit of the Pietersburg Group which represents the final and youngest stage of the Swazian Era succession in Limpopo Province. The change to a dominantly sedimentary depositional environment, compared to the older sequence of extrusive igneous rocks indicates a distinct change in environment from a volcanioclastically dominated succession to a rudaceous sedimentary regime. A major change must have occurred in the tectonic scenario, which is believed to be related to subduction processes, but no evidence of these developments has been documented. Furthermore, the distinctive pyrite – gold – Fly Spec Carbon – brannerite mineral association (in the absence of uraninite) is anomalous and indicative of a distinctive non-oxidising depositional environment.

Due to the resemblance of the Uitkyk Formation to the auriferous conglomerates of the Witwatersrand Supergroup, the area was prospected for gold. The auriferous conglomerates have been classified as a
palaeoplacer deposit and geological mapping was carried out by Rand Mines in 1972. Between 1972 and 1974, pitting and trenching exercises were carried out by EBCO Mining. Mining operations were abandoned in the early 1970s due to erratic gold mineralisation and difficult access (the mining operation was 400 m higher than the R101 access road).

The Uitkyk Formation outcrops in a narrow elongate north-east south-west trending zone with a strike length of about 30 km and a maximum thickness of about 1000 m. Due to the erosion resistant nature of the lithological units, the rocks generally form a prominent topological high, which in the Mokopane area is known as Mount Robert, and to the south of Polokwane, Ysterberg and Mount Maré. The Uitkyk Formation is a subunit of the Palaeoarchaean Era (3600 to 3200 Ma) Pietersburg Greenstone Belt (PGB) and is well exposed at Mount Robert, some 15 km north-east of Mokopane. The sedimentary units of the Uitkyk Formation overlie the igneous units of the PGB with an angular unconformity, and the upper contact appears to be a tectonic feature, reported to be a thrust, where the greenstones have overridden the sedimentary succession. The lithological units of the Uitkyk Formation consist of poorly-sorted, matrix-supported polymictic conglomerates, with intraformational shales, quartzites and minor felsic volcanics. The clasts in the conglomeratic members consist of altered greenstone and granite gneiss, while the presence of abundant chloritoid porphyroblasts indicates upper greenschist facies of metamorphism. The mode of gold occurrence and the absence of uraninite indicate a totally different, and earlier, setting to that of the Witwatersrand.

*Department of Physics and Geology University of Limpopo, Phone: +27 (0)15 491 4502. Email: chrisjones@mweb.co.za

INVESTIGATION OF MAGNETIC PROPERTIES OF DYKE SWARMS AROUND TURFLOOP AREA, LIMPOPO PROVINCE

Moswane M.E. and Tessema, A.¹
¹University of Limpopo, Department of Physics and Geology, Private Bag X1106, Sovenga 0721

ABSTRACT

The magnetic properties of dyke swarms around Turfloop area in the Limpopo Province was carried out. The aim of the study is to investigate the magnetic properties and their origin in light of the geological processes that took place during the past crustal evolution of the area. In addition, to understand the origin, mechanism of emplacement and the spatial distribution of the dykes swarm around the study area.

Dyke swarms often record the successive periods of magmatism and volcanism that can be associated with continental rifting events or an impact of mantle plume. Dyke swarms are very important in determining the regional crustal stress patterns through time, and thus they may relate to past plate configurations. The use of airborne and ground magnetic data combined with geologic time derived from the reversal of the polarity of the Earth’s magnetic field may shed light on the timing of magmatism and emplacement of dyke swarms in an area.

In this study, ground magnetic data was acquired around Turfloop area in the Limpopo Province using two proton precision magnetometers. The data was processed in order to enhance linear features which can be interpreted as dykes. In addition, airborne magnetic data with line spacing of 1 km was similarly processed in order to interpret the distribution of dyke swarms in the area. The results of interpretation of both ground and airborne magnetic data, Landsat images and digital elevation model were used to generate the map of the distribution of dyke swarms.
The correlation of linear magnetic signatures with the polarities of the geomagnetic field suggests that the NE-SW and the W-E- striking dykes might possibly intruded the crust at about 178±4.9 Ma.

*Corresponding author: Department of Physics and Geology, Phone: +27 2628 2490. Email: edwardmoswane@gmail.com

PETROLOGY AND PETROGRAPHY OF THE PLATREEF AT TURFSPRUIT FARM, NORTHERN LIMB OF THE BUSHVELD IGNEOUS COMPLEX

Kevin Baloyi and Moosa Khanyi

University of Limpopo Department of Physics and Geology, Private bag X1106, Sovenga 0727

ABSTRACT

Petrologic and Petrographic studies of the Platreef at Turfspruit Farm in the Northern Limb of the Bushveld Igneous Complex were carried out. The study area is located at about 10 km north of Mokopane in the Limpopo Province. The main aim of the study is to investigate the characteristics of the Platreef based on petrological and mineralogical studies in order to understand processes and sequences of geologic events involved in the formation of the reef. Core samples were collected from borehole UMT 062 which intersected the reef at a depth of 800 m. For petrographic studies, six quarter core samples of approximately 10 cm length were selected from the hangingwall, the reef and the footwall. Thin sections and polished sections were prepared and were studied under a petrographic microscope. Thin sections were observed using transmitted and polished sections using reflected light. Pulp samples were collected for XRD analysis for determining mineral composition of the hangingwall, the reef and footwall.

Results from core logging show that borehole UMT 062 has intersected different lithologies of the hangingwall, Platreef and footwall. The hangingwall comprises of Disturbed Zone which is a transition zone between the Platreef and the Main Zone and comprise sequence of pyroxenite and norite alternating with anorthosite. The footwall comprises of calc silicates, parapyroxenite and serpentinite. The Platreef comprises of three lithological units, namely T1, T2 Upper and T2 Lower. T1 comprises of feldspathic pyroxenite, which is the upper most part of the reef. The contact between T1 and T2 Upper is marked by a chromitite stringer, while T2 Upper comprises of pegmatoidal orthopyroxenite. T2 Lower comprises of olivine bearing orthopyroxenite. Petrographic studies proved the olivine bearing orthopyroxenite (NK 004) of T2L to be a harzburgite due to elevated olivine content. Texture observed from thin sections are cumulate, with cumulus pyroxene and interstitial plagioclase consistent with normal crystallization sequence where high temperature minerals are the first to crystallise in a cooling magma. For the renamed olivine bearing orthopyroxenite (NK 004) partial serpentinization is observed whereby orthopyroxene is replaced by the fabric intergrowths of olivine, leaving orthopyroxene as relicts. Similar textures are also observed on rocks of the footwall with the alteration of olivine. The observed cumulate textures attribute to slow crystallisation rates, which allowed pyroxene crystals sufficient time to grow conspicuously. Interstitial plagioclase formed from the secondary crystallisation phase, whereby the liquids within the interstitial volume of the crystallised pyroxene interacted not with the main magma. Therefore the differences in textural traits of the lithologies of the hangingwall, reef and footwall signifies different process involved in the formation of the Platreef.

Corresponding author: Kevin Baloyi, BSc Honours Student University of Limpopo Department of Physics and Geology, Phone: +277 9140 5167 Email: nkholokevin@gmail.com