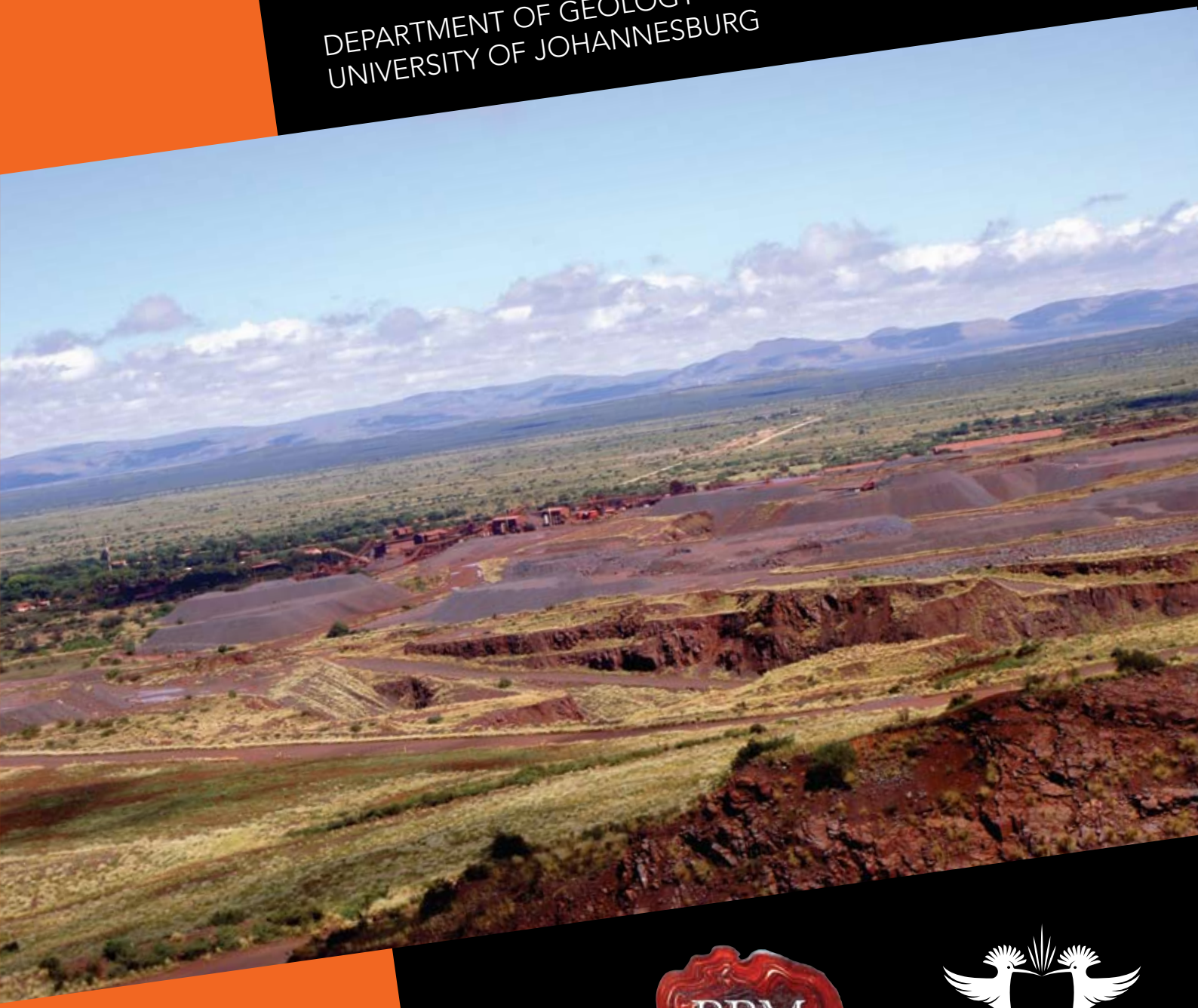
PPM Annual Report 2009

The Annual Report for the Paleoproterozoic Mineralization Research Group

DEPARTMENT OF GEOLOGY
UNIVERSITY OF JOHANNESBURG



PPM

UNIVERSITY OF JOHANNESBURG

The Annual Report of the Paleoproterozoic Mineralization Research (PPM) Group, compiled and edited by **Nic Beukes** and **HM Rajesh**. Layout and design by **HM Rajesh** and the **UJ Graphic Studio**. Cover design by the **UJ Graphic Studio**

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Cover photo: View of the Beeshoek Iron Ore Mine with the Langeberg in the background

INTRODUCTION

The significant growth and development of the PPM Research Group in 2008 was carried over into 2009 with the addition of several new students, academic and contract staff members, exploring new research niches in addition to strengthening our traditional research areas.

During 2009, research focused in five main areas, namely geometallurgy-kimberlite research, metalliferous mineral deposits, paleomagnetism-provenance studies, early Precambrian environments and coal geology (see diagram below).

PPM Research Group (2009) Staff and Students

Leaders of the research group

Prof. Nic Beukes, Prof. Fanus Viljoen

Staff Members

Prof. Bruce Cairncross, Dr. Michiel de Kock, Mr. Michael de Villiers, Prof. Jens Gutzmer
Prof. Jan Kramers, Mr. Mike Knoper, Dr. Hassina Mouri,
Prof. HM Rajesh, Mr. Bertus Smith, Dr. Herman van Niekerk.

Geometallurgy, Kimberlite Research

Team Members
Ms. A Crossingham
Mr. C Greeff
Mr. MC Kambewa
Dr. C McClung
Mr. D Rose
Mr. F van der Merwe

Metalliferous Mineral Deposits

Team Members
Dr. R Bailie
Mr. B Chisonga
Mr. F Kruger
Mr. B Nel
Mr. K Osburn
Mr. JC Beyeme Zogo
Mr. G Tetteh (Ghana)

Paleomagnetism, Provenance Studies

Team Members
Dr. GB Gaucher
Mr. R da Silva
Ms. D Dreyer
Mr. P Fourie
Ms. C Vorster
Mr. H Wabo

Coal Geology

Team Members
Dr. H Tsikos (Rhodes)
Mr. P Meyer
Mr. B van der Walt

Early Precambrian Environments

Team Members
Mr. G Belyanin
Mr. C Blane
Mr. L Cloete
Mr. J Cochrane
Mr. A Gumsley
Mr. B Guy
Mr. M Watts

Technical Support Staff

Mr. M Chakuparira
Mrs. D Khoza
Mr. L Mangwane
Mr. S Maluleke

RESEARCH PROGRESS AND HIGHLIGHTS

Growth in geometallurgical research at the University of Johannesburg

The South African Department of Science and Technology Research Chair in Geometallurgy was originally granted to Jens Gutzmer, starting January 2008, and was transferred to Fanus Viljoen in June of 2008.

The primary thrust of the Research Chair is to develop and apply geometallurgical methods to quantify the mineralogical and textural characteristics of ore bodies, ores, concentrates and successor products in resource types relevant to the South African minerals industry. Currently research is focused on the characterisation of platinum-group element mineralisation within the Merensky Reef and the PlatReef of the Bushveld complex, utilizing mineralogical and geochemical techniques such as X-ray diffraction analysis, scanning electron microscope-based automated mineralogy, and electron microprobe analysis. Research is also focused on aspects of gold, diamond, nickel, and base metal (copper-lead-zinc) mineralisation from a mineralogical perspective, with a view on the optimization of treatment plants and optimized metal recovery.

During 2009 research into automated mineralogy as applied to the characterisation of ores and ore bodies was conducted on an older FEI XL40 Mineral Liberation Analyser which was purchased in 2007 from internal PPM funds and a brand-new 'state-of-the-art' FEI 600F Mineral Liberation Analyser (one of only two such instruments in the country). The latter was purchased late 2008 by the University of Johannesburg in support of the DST Research Chair in Geometallurgy, and was delivered in January 2009. Both instruments are located within the Central Analytical Facility of UJ (Spectrau).

Five MSc projects, three PhD projects, and one Post-Doctoral project progressed during 2009, dealing with gold, platinum, diamond, nickel and base metal mineralisation. These research focus areas will continue into 2010, and will also include an investigation into the liberation characteristics of coal.

Bertus Smith (PhD student), and Alexandra Crossingham (MSc student) attended the FEI Mineral Liberation Analyser users meeting in Toronto, 17-21 August, while Gargi Mishra (PhD student) attended a Process Mineralogy course at the University of Cape Town, 23-27 November.

Fanus Viljoen spent 22-29 August at the UK Diamond Synchrotron outside Oxford imaging inclusions in diamonds utilizing synchrotron X-ray radiation, in collaboration with Prof Moreton Moore of Royal Holloway College, University of London.

Some members of the PPM in the meeting room of the Geology Department

A sample of milled Witwatersrand quartzite, with rock particles imaged on a Mineral Liberation Analyser (MLA) at the University of Johannesburg. The three images (from back to front) demonstrate the mineralogical classification sequence as performed by the instrument software, starting with a back scattered electron (BSE) image showing variations in BSE grey levels within and amongst the rock particles, followed by the mineralogical classification of particles (colour-coded) while the last image (in front) illustrates the mineralogical complexity of an individual rock particle

Underground visit to Lonmin's Marikana Operation, June 2009

Metalliferous mineral deposits

The project sponsored by Assmang on "Evaluation of the iron ore potential of the Asbesheuwels area in Northern Cape Province" advanced as planned. Two MSc theses were completed, with the first drafts of two other Master and one Doctoral thesis completed. Corrections on these should be finalized early next year. One other MSc and a PhD study are currently in progress.

Profs Beukes and Gutzmer also presented part of the International Workshop and Short Course on "Manganese in the 21st Century" in Veszpren, Hungary, early September 2009.

Russell Bailie received his PhD on the Areachap Group in Namaqualand, Craig McClung continued with post-doctoral studies on mineralization in the Bushmanland succession, and Fanie Kruger virtually completed a mineralogical and geochemical study of iron ores associated with zinc mineralization in the Gamsberg area near Aggeneys.

Paleomagnetism and Provenance studies

Problems with construction of the cold-head of the SRM (SQUID) have been sorted out in California, USA and it was delivered to UJ during November 2009. Installation took place in the first week of January 2010. One PhD candidate started with a paleomagnetic study of rocks associated with the Bushveld Complex and Michiel de Kock published a very significant paper on reconstruction of the ancient continent of Vaalbara i.e. the link between parts of Southern Africa and Western Australia at ~2,7 Ga.

With reference to provenance studies Gonzalo Blanco received his PhD at the beginning of 2009. A number of papers were published from his thesis. Pieter Fourie completed the first draft of his MSc on the Bokkeveld Group and Craig Blane is finalizing his MSc on the Witwatersrand succession.

Most significantly Clarisa Vorster and Daphne Dreyer, with help from Dr Herman van Niekerk, are far advanced in obtaining the first accurate U-Pb dates on zircons with the LA-ICP-MS in Spectrau.

Early Precambrian

A special issue of the journal "Precambrian Research" was devoted to initial results of the Agouron Deep Drilling Project near Griquatown in the Northern Cape Province that was managed by Prof Nic Beukes (2003-2007). Profs Andy Knoll from Harvard and Nic Beukes from UJ were guest editors for the special issue.

A very significant paper on the timing of the rise of atmospheric oxygen at around 2,4 Ga, based on multiple sulfur isotope studies was published in the journal "Geology" with Prof Gutzmer and Dr Schroeder (past post-doc in PPM) as co-authors.

Prof Beukes was elected visiting fellow of the Japan Society for the Promotion of Science (JSPS) and as part of the fellowship spend all of March 2009 in Japan presenting a plenary paper at the conference on "The Archean World 2009" in Fukuoka followed by lectures at several other universities and research centers in Japan.

Justin Cochrane received his MSc degree on a study of diagenetic carbonates and biogeochemical cycling of organic matter in selected early Precambrian successions of the Kaapvaal Craton. Bradley Guy successfully upgraded from MSc to PhD with his thesis on multiple sulfur isotope and mineral chemical studies of pyrites in the Witwatersrand succession.

Coal Geology

The work on the gas generation in coal seams by dolerite intrusion was finalised and published, and a paper was delivered at the EGU (European Geosciences Union) General Assembly, in Vienna, Austria in April 2009. Two new post-graduate students were recruited during 2009. Byron van der Walt will commence an MSc examining atypical core sequences in the Permian Vryheid Formation at New Denmark Colliery, and Anglo Coal operation, and Peet Meyer will commence a PhD examining the sedimentology and stratigraphy of part of the Moatize coalfield (Tete Province) in Mozambique.

Opencast coal mining operations in the Witbank coalfield

Awards and other Significant Scientific Events

- Prof Beukes received a Centenary Medal from "Die Suid-Afrikaanse Akademie vir Wetenskap en Kuns", and was again rated A1 scientist by the National Research Foundation (NRF).
- Prof Cairncross received the Presidents Medal from the Geological Society of South Africa for his contribution in publications on minerals of southern Africa and curatorship in various museums of South Africa's mineral heritage.
- Bertus Smith received the Corstorphine Medal and John Handley Prize for his MSc on "Iron-rich rocks of the Witwatersrand-Mozaan basin" from the Geological Society of South Africa.
- After long delays permission was finally given in July 2009 to advertise a position on permanent basis under the Quick-Win URC Allocation to the Geology Department to replace Prof Beukes after retirement end 2010. Dr Axel Hoffman was the successful candidate and shall assume duties middle 2010.
- Prof Jan Kramers from the University of Bern, Switzerland was appointed as part-time professor in the Geology Department and PPM after his move to South Africa following his retirement from Bern University. He is a major asset to the Department specifically because of his experience managing a facility similar to Spectrau for many years in Bern.
- PPM held a very successful Annual Colloquium on November 4, 2009 at the Hotel School of the UJ Bunting Road Campus. It was attended by 100 delegates of which about half was from industry and other geological institutes and departments in South Africa.
- Dr Hassina Mouri is the Chairperson for organization of the 23rd Colloquium of African Geology to be held at the University of Johannesburg early 2011 (see copy of flyer)

The paleomagnetic laboratory at UJ: A unique African facility

Michiel O. de Kock

Paleomagnetic studies are used to trace the "paths of drift of continents" through time. Magnetism gets recorded in rocks when they form – like many tiny compass needles pointing north being "frozen" into the rock. Measurement of the magnetic directions in rocks enables us to determine the orientation and latitude of the rock mass at the time of its formation. It allows the reconstruction of the components of ancient continents, now fragmented by plate tectonics. Paleomagnetic data can also be used for correlation and indirect dating of rock successions and ore deposits.

The year 2009 ended on a very exiting note with the long-expected arrival of our superconducting rock magnetometer in November. Installation took place during the first week of January 2010. The superconducting rock magnetometer or SQUID as commonly known was purchased on a "50:50" basis from in-house PPM funds and Central Research Funds of the University of Johannesburg. It is the first vertical new generation enclosed liquid helium free rock magnetometer system to be installed in the world.

The measurement capabilities of the UJ paleomagnetic laboratory are unique on the African continent and in the southern hemisphere. Our magnetometer is named for Dr. Alex du Toit, prominent South African geologist and supporter of Alfred Wegener's hypothesis of continental drift. It is connected to an automatic sample changer system that allows for automated measurement, alternating-field demagnetization and rockmagnetic experiments of up to 180 samples in a run. The magnetometer will send an e-mail to the user once a sample run is complete or if it needs assistance.

The laboratory forms part of the internet-linked Rapid Consortium of Paleomag Labs comprised of similar automated labs designed by Prof Joe Kirschvink at Caltech, MIT, Yale, Univ of Texas in Austin, US Geological Survey and Occidental College.

We aim to operate the unit as a "National and Africa Facility" and would like to invite researchers and postgraduate students of other institutes and universities to contact Michiel de Kock (mdekock@uj.ac.za) if they see possibilities of incorporating paleomagnetic analyses in their research projects.

Dr. de Kock in front of "Du Toit", a vertical 2G Enterprises DC-4K (liquid helium free) superconducting rock magnetometer, and automatic sample changer (designed by Prof Joe Kirschvink of Caltech, USA)

Fellowship in Japan and Manganese Workshop in Hungary

Nic Beukes

Nic Beukes spend March 2009 in Japan with a fellowship of the Japan Society for the Promotion of Science (JSPS). His host researcher in Japan was Dr Shoichi Kiyokawa at the Kyushu University in Fukuoka. One of the main focus areas of the visit was to participate in the International Geoscience Symposium on the "Precambrian World" with the topic "Bridging Precambrian and Modern Geoscience Studies" organized by Dr Kiyokawa and co-workers. Nic delivered a keynote address on the "Origin and paleoenvironmental significance of major iron formations at the Archean-Paleoproterozoic boundary".

During field trips linked to the symposium, visits were made to several outcrops of young rock successions and modern hydrothermal depositional systems that may have had analogs in the Archean. These included pelagic banded jaspers with bedding very reminiscent of Archean jaspilitic iron formation, and hydrothermal vent systems depositing ferric-oxyhydroxides in very shallow water along parts of the shoreline of the volcanic island of Satsumo Iwo-Jima (see photos). Another interesting visit was the one to the approximately one million-year old epithermal gold deposits of Hishikari mine. It is considered the richest known gold mine in the world with ore grades up to several thousand grams per ton (see photo). The mine is situated in an active plate margin and one wonders if similar very rich epithermal gold deposits in an orogenic belt could have sourced the detrital gold of the Witwatersrand succession. Towards the end of the fellowship period a visit was also made to the Institute for the Study of Earth's Interior (ISEI) of Okayama University in Misasa. It must be one of the best-equipped isotope and geochemical laboratories in the world. During the visit zircons from the Gua granite-greenstone terrane were dated on the Cameca SIMS.

PPM was also very actively involved, through contributions by Nic Beukes and Jens Gutzmer, in the short course on "Manganese in the Twenty-first Century" that was held in Veszpren, Hungary early September 2009. Nic presented a morning session on "Precambrian Manganese Depostis" and Jens an afternoon session dedicated to the giant Kalahari Manganese Field. Excursions took delegates to the Jurassic Urkut manganese and karst-hosted bauxite deposits in the Veszpren area. The sedimentary manganese carbonate ore of Urkut (see photo) displays remarkable bedding similarities to that of sedimentary Mamatwan-type ore of the Kalahari manganese field.

Cretaceous bedded pelagic radiolarian jasper along the southern coast of Japan

Nic Beukes on the rim of an active volcanic vent in the caldera of Aso volcano

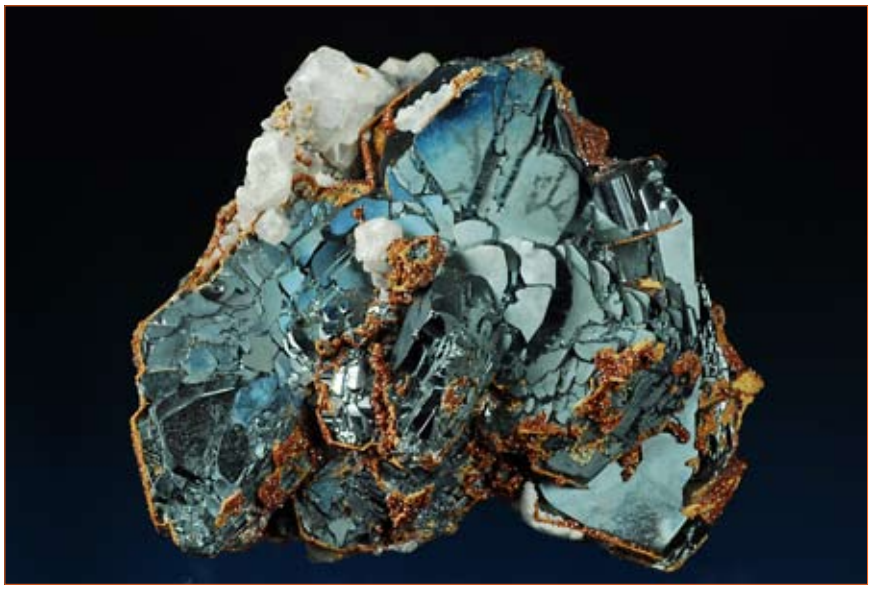
Red ferric-oxyhydroxides precipitating from shallow water hydrothermal vents along the shoreline of Satsumo Iwo-Jima Island

Adularia-rich gold-bearing epithermal veins in host rock of lava at the Hishikari Mine

Bedding in Jurassic Urkut manganese carbonate ore that is very reminiscent of that in early Paleoproterozoic Mamatwan-type braunite-carbonate ore of the Kalahari manganese field

Developments in Geoheritage/ Mineral Research

This is ongoing research undertaken by Prof Bruce Cairncross in addition to his coal research. During the year, Bruce was invited to present a paper at the World Heritage and Geotourism held in Pretoria in June 2009. In addition, an article was published in the American journal "The Mineralogical Record" on the fluorite deposits at Riemvasmaak in the Northern cape Province. During late-2009, the work for a new book for Random House-Struik Publishers was completed, at their request. This is part of the publisher's series that deals with natural history in South Africa and is titled "A Pocket Guide to Rocks and Minerals of Southern Africa". The book will be launched mid-2010. Finally, two public lectures were delivered at the monthly meetings of the Witwatersrand Gem and Mineral Society in Johannesburg. The collaborative project with the Council for Geoscience in Pretoria on the microminerals of the Bushveld Complex is ongoing.



Hematite and andradite garnet. N'Channing II mine, Kalahari manganese field.

Hausmannite on andradite garnet. N'Chwaning II mine, Kalahari manganese field.

HIGHLIGHTS OF RESEARCH FOCUS AREAS

An in-situ MLA-based mineralogical investigation of the Akanani Platinum Group Metal Project, northern Bushveld Complex

Frits van der Merwe

Modern mineral processing operations require detailed characterization of the ore for beneficiation purposes. In the past, mineralogical aspects of ore characterization (e.g. mineral liberation, particle size distributions, and mineral associations), critical to recovery grade, were typically performed utilizing optical microscopy. With the more recent introduction of automated electron microscope-based instruments such as the Mineral Liberation Analyser (MLA), the speed and accuracy of these measurements have advanced to such a degree, that fully quantitative and statistically relevant data can now be acquired with ease.

The metallurgical extraction of platinum group elements (PGE) from the Platreef on the Northern Limb of the Bushveld Complex is complicated by the mineralogical variability of the ore. In spite of this, and, in comparison to the more established PGE sources of the Bushveld Complex (Merensky and UG2), the Platreef has recently experienced a phase of increased expansion of exploration and mining activity e.g. the establishment of a mining operation by Anglo Platinum.

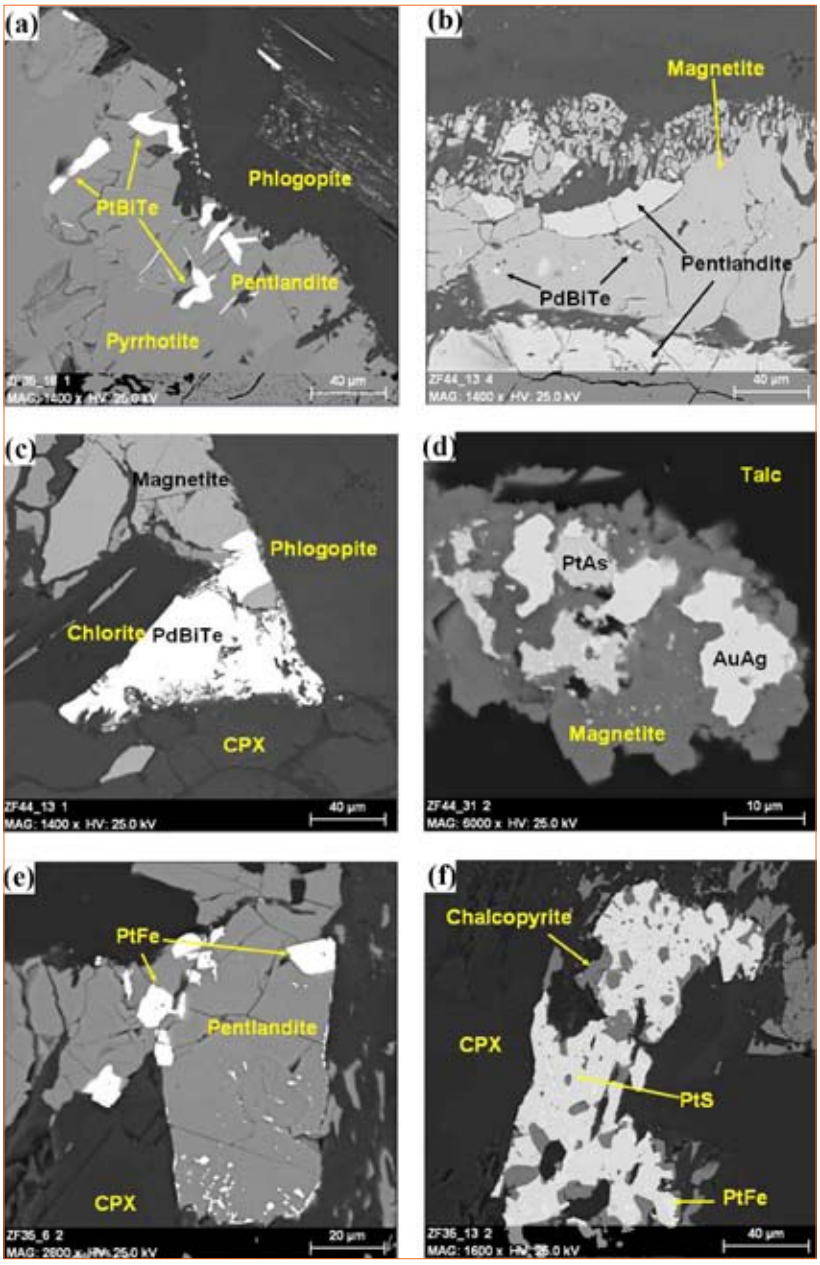
To date, very little data on platinum group mineral (PGM) assemblages, size frequency distributions and associated mineral phases are available for the Platreef. Drill core through the main mineralized zone of the Platreef at Lonmin's Akanani project (adjacent to, and down-dip from, Anglo Platinum's Sandsloot and Zwartfontein mines) were selected for detailed mineralogical study of PGM's, utilising a FEI 600F Mineral Liberation Analyser at the University of Johannesburg. A variety of PGM's were encountered, of which the most abundant are Pt-Pd compounds such as maslovite, michenerite and ferroplatinum (see table).

List of major PGM's present

Mineral Name	General Formula	Area%
Maslovite	PtBiTe	27.63
Michenerite, Kotulskite	PdBiTe	14.17
Isoferroplatinum	PtFe	10.84
Hessite, Empressite	Ag2Te, AgTe	8.23
Sperrylite	PtAs	7.99
Altaite	PbTe	6.27
Cooperite	PtS	5.28
Plumbopalladinite	Pd3Pb2	4.6
Electrum	AuAg	4.26
Platarsite	(Pt,Rh,Ru)AsS	2.71
Maslovite	(Pt,Pd)(Bi,Te)	1.49
Hollingworhtite	(Rh,Pt)AsS	1.11
Other	-	5.38

Mineral phases co-existing with these PGM's comprise predominantly of pentlandite, chalcopyrite, pyrrhotite, magnetite, and pyroxene (see figure). Mineral association data obtained prove the existence of both primary and secondary PGE mineralization within the Platreef. Hydrous silicate phases and their association with PGM's correspond to the degree of alteration present.

As the sample material cannot be considered fully representative of the entire Akanani Mineral Resource, the results are considered semi-quantitative at best. However the data may be used to derive some preliminary qualitative conclusions.



MLA images of (a) Maslovite (PtBiTe) associated with pentlandite, adjacent to pyrrhotite and phlogopite. (b) Michenerite (PdBiTe) hosted in magnetite, suggesting exsolution of PdBiTe during replacement of pentlandite by magnetite. (c) Michenerite associated with magnetite, chlorite, clino-pyroxene and phlogopite. (d) Sperrylite (PtAs) and Electrum (AuAg-alloy) enclosed in magnetite, and which is surrounded by talc. (e) Ferroplatinum (PtFe) associated with pentlandite

A geometallurgical assessment of the geological and mineralogical influences on plant performance at the Nkomati Mine, Mpumalanga

Gargi Mishra

Nkomati is South Afica's only primary nickel mine, in addition to which it also produces chrome, copper, palladium and platinum as by-products. Located approximately 300km east of Johannesburg, the mine is a joint venture between African Rainbow Minerals and Norilsk Nickel Africa (Pty) Ltd. The deposit is located within the Uitkomst Complex, an 8x1 km and up to 650 m thick, NW-SE trending, flat lying, poorly layered, sill like, 2025 Ma mafic body of harzburgite, gabbro, pyroxenite and gabbro-norite. It is believed to be genetically associated with the Bushveld Complex, and is intruded into rocks of the Transvaal Supergroup (including quartzite, shales, dolomite) and also Archaean granitoids.

The Uitkomst Complex comprises: i) a basal gabbro (6-30 m thick, possibly an earlier sill), overlain by ii) a sulphide bearing lower harzburgite (50-90 m) containing sedimentary xenoliths, iii) chromitiferous harzburgite (±60 m), iv) main harzburgite (±300 m), v) upper pyroxenite (60 m) and vi) upper gabbro-norite (±250 m). The Complex contains three disseminated, sulphide mineralised zones hosted by the basal gabbro and lower harzburgite, namely the Basal Mineralised Zone, Main Mineralised Zone and the Chromititic Pyroxenite Mineralised Zone.

The focus of the current project is to investigate the mineralogy of the main mineralized zone with a view on geometallurgy (e.g. the relationship between spatial variations in ore mineralogy and associated plant performance issues). The study is based on mine mapping, bench sampling and logging of diamond drill cores intersections with the aim of developing a three-dimensional geometallurgical model, taking into account selected mineralogical, textural and geochemical parameters. The model will provide substantive and quantitative foundations for (a) an understanding of the influence of primary ore mineralogy, as well as later modification through alteration, on plant performance, and (b) developing strategies for the effective exploitation and processing of the future mineral resource. Quantitative mineralogical and textural information is obtained through the 600F field emission Mineral Liberation Analyzer at the University of Johannesburg, along with flotation tests to be conducted on carefully selected samples, at the Nkomati flotation test facility.

Nkomati Mine, Mpumalanga, South Africa (photograph courtesy of Jonathan Woolfe, African Rainbow Minerals)

The Merensky Reef at the Two Rivers Platinum Mine, Eastern Limb, Bushveld Complex

Derek Hugh Rose

Most of our existing knowledge of the Merensky Reef and associated platinum group minerals come from the Western limb of the Bushveld Complex, enabled by large-scale mining exploration. In contrast the dearth of mines on the Eastern limb targeting the Merensky Reef has resulted in only a rudimentary understanding of the platiniferous horizon in that part of the Bushveld Complex. In particular lacking is an understanding of the *in-situ* distribution and association of platinum group minerals.

This study is aimed at contributing to the database of the Merensky Reef in the Eastern limb. It aims at determining what PGMs occur within the Merensky Reef and to systematically collect mineral chemistry of the major platinum group mineral phases throughout the mine lease area from representative samples. At the Two Rivers platinum mine, four facies types are present in the Merensky Reef. For this study drill core samples were taken of the four Merensky reef facies over the entire mine lease area.

Sampling drill core at the Two Rivers Platinum mine (left) and surface exposure of the Merensky Reef in the the Eastern limb of the Bushveld Complex (right)

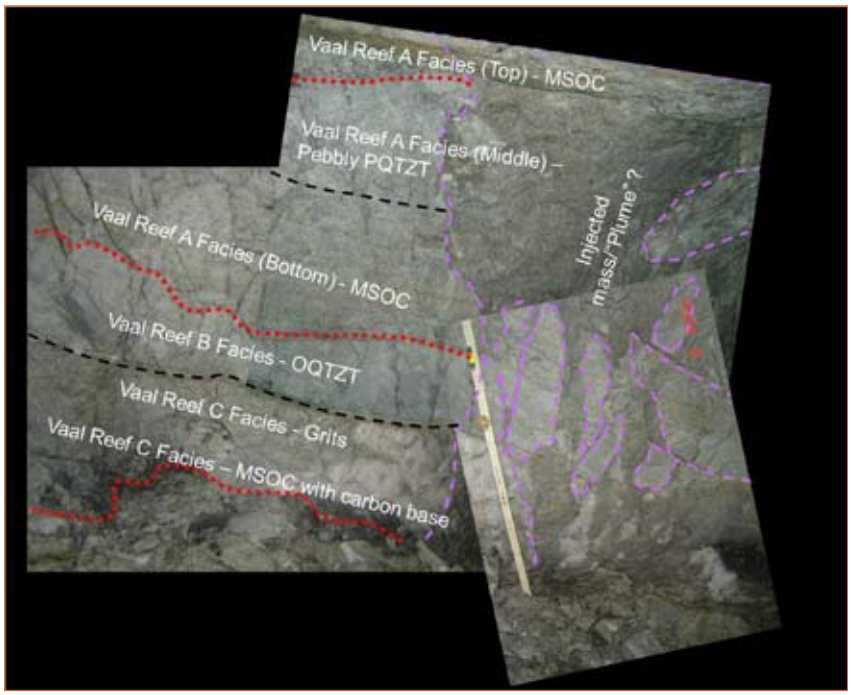
The interval covering the Merensky Reef was logged and samples taken at 30 cm intervals. The mineral chemistry of the major minerals such as orthopyroxene, anorthite, chromite and clinopyroxene was determined using a Cameca SX 100 electron microprobe analyzer housed in Spectrau at the University of Johannesburg. The PGMs within the Merensky Reef were assessed using a FEI 600F Mineral Liberation Analyzer at Spectrau.

Characterization of a recently discovered zone of intense hydrothermal alteration, deformation and unusual Au mineralization at Anglogold-Ashanti's Kopanang mine

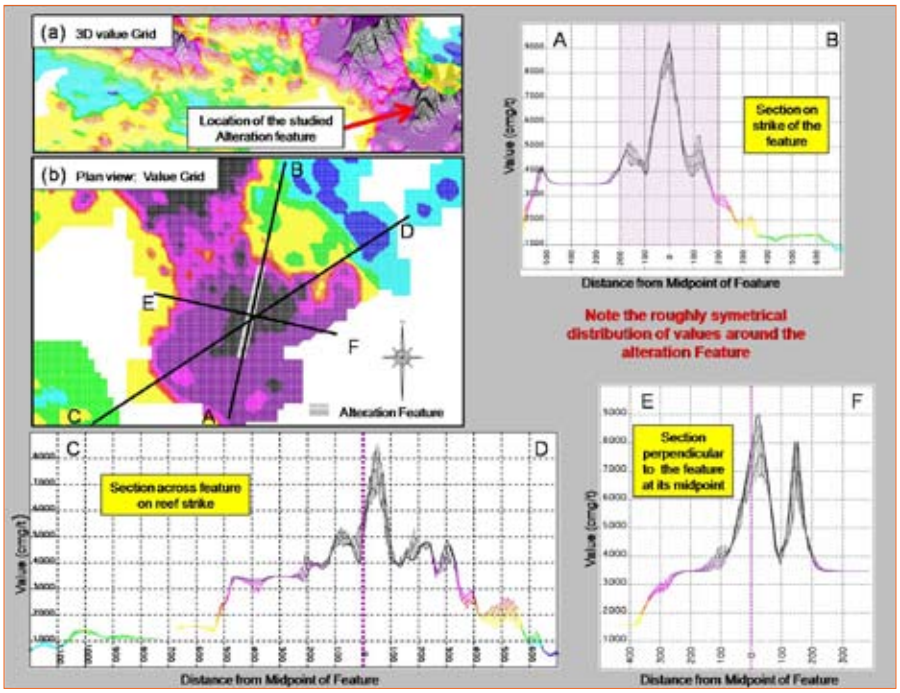
Louis Cloete

A prominent zone of deformation, identified as a possible hydrothermal fluid pathway, has recently been discovered in the 64 SW4 21Line workings at the Kopanang Mine. The zone is between 3m and 16m wide, has a NE-SW trend and dips steeply (65-70°) towards the SE. Very little to no displacement seems to occur along this zone of alteration that is marked by intensive albite veining. The surrounding host rocks are also intensively altered (albitized; see first figure). A marked increase of Au grades is observed where the Vaal Reef, the most important economical reef horizon exploited at the mine, is affected by deformation, veining, and associated alteration (see figure).

In light of the above observations it appears only reasonable to expect that this zone of deformation and hydrothermal alteration could either be the direct cause of, or at least have a prominent influence on the high gold values occurring in the area. A causal link between high Au grades, deformation and hydrothermal fluid flow would have obvious economic implications. The study therefore strives to characterise the extent and style of deformation, constrain the effects of hydrothermal alteration and nature of hydrothermal fluids associated with the structure, and assess its importance for Au mineralization.



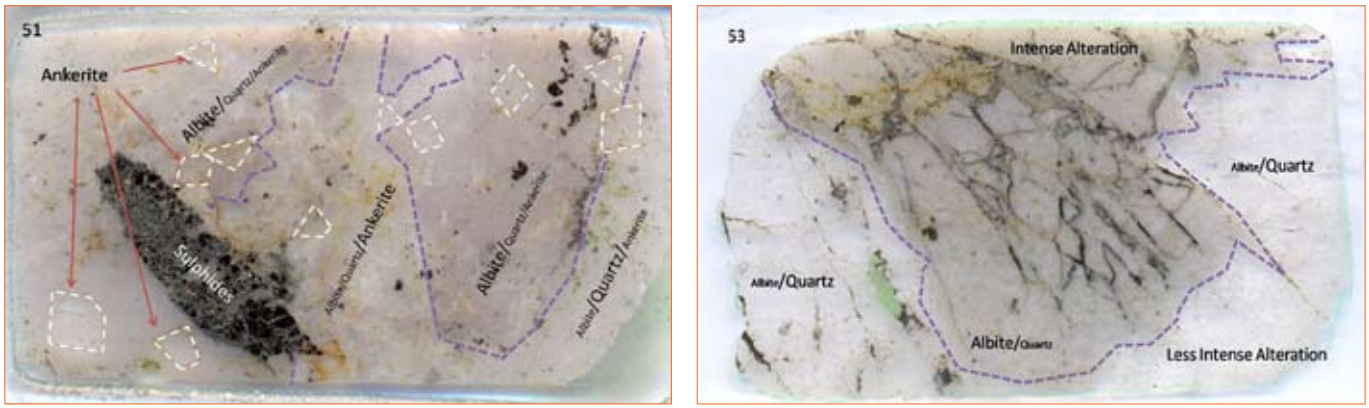
Annotated composite of photographs taken in the vicinity of the alteration feature in Panel 12 (note the bleached appearance of the host lithologies – despite severe alteration all stratigraphic units are discernable). PQTZT: Proto quartzite; MSOC: Matrix supported oligomitic conglomerate; OQTZT: Ortho quartzite



Directional sections, along and across the alteration feature, illustrating a good relationship between estimated gold grades, on reef horizon, and the alteration feature

The following techniques were applied to characterize the alteration feature and assess any possible influence on gold mineralisation:

- Detailed underground observations and mapping (focussing on the geometry and structural relationships of the feature)
- Petrography and mineralogical assessment (by means of conventional light microscopy, scanning electron microscopy, and XRD analysis)
- Fluid inclusion studies
- Geochemical assessment (including whole rock analysis and microprobe analysis of selected minerals)
- Hyperspectral core imaging of affected diamond drill core.



Annotated polished thin sections of two samples. This figure illustrates the "porosity dependence" of alteration; brecciation and veining creates porosity and delivers fluids to the host rock, thus controlling alteration

One deposit, four sphalerites: A mineralogical assessment of the Gamsberg Zn deposit

Craig R. McClung

The Gamsberg deposit is the largest deposit of the world-class Aggeneys-Gamsberg district, located in the Northern Cape Province of South Africa. Since its discovery in 1974, the Gamsberg deposit has and continues to be one of the country's largest (~265 Mt at 6% Zn and 0.3% Pb) and most important unexploited base metal resources. The deposit consists of disseminated to massive bodies of Fe-Zn sulfides and oxides hosted by calc-silicate-rich pelitic schists, which collectively experienced intense deformation and metamorphism during the Namaquan Orogeny (1000-1200 Ma).

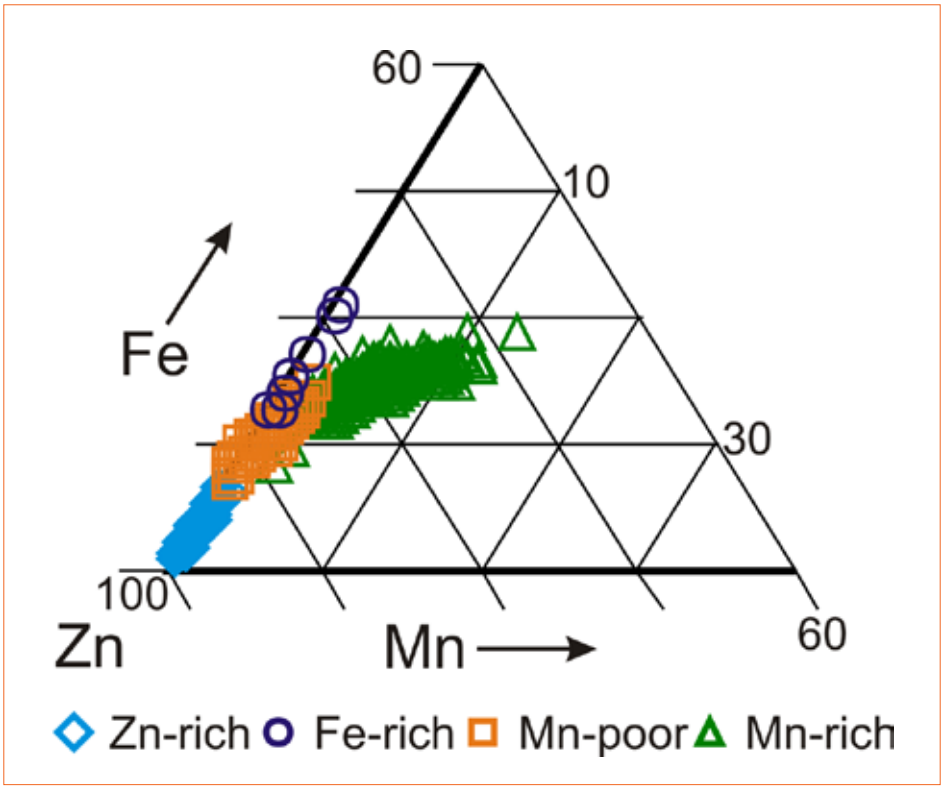
While numerous investigations of the deposit have been conducted, very few published investigations have focused on the mineralogy of the ore minerals. Therefore, the aim of this investigation is to provide a detailed mineralogical and mineral chemical assessment of the Gamsberg deposit. This has resulted in the definition of four different sphalerite populations, namely Mn-poor, Mn-rich, Fe-rich and Zn-rich (see figure).

Compilation of geochemical attributes for all sphalerite populations defined

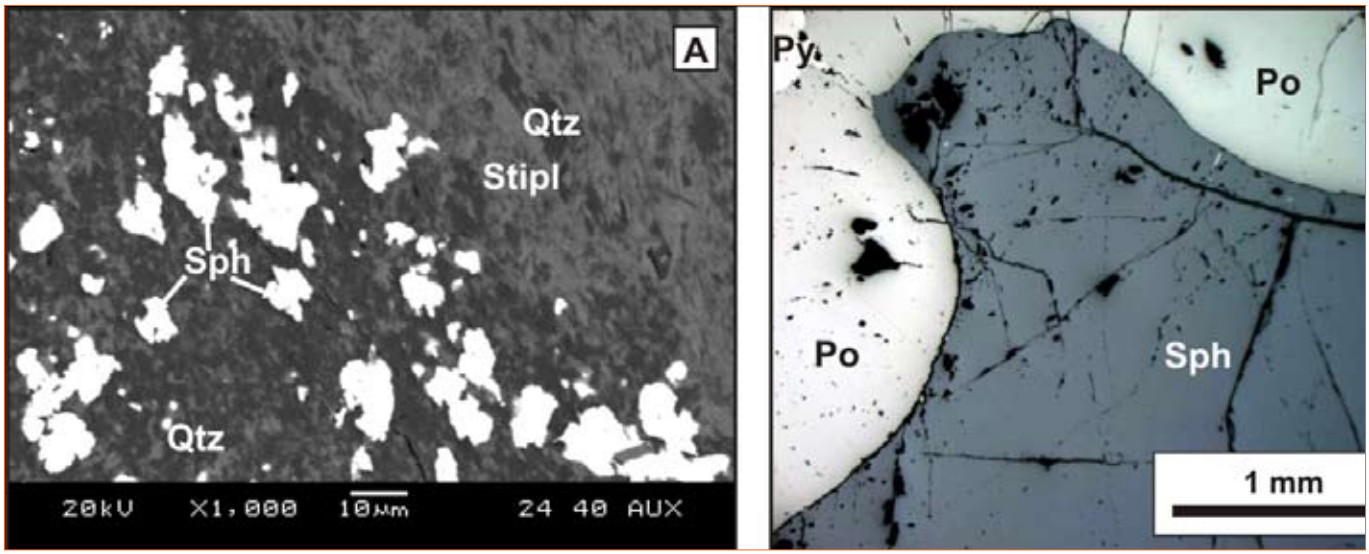
Sphalerite Populations	Zn (wt%)	Fe (wt%)	Mn (wt%)
Zn-rich	64 ± 1.3	2.2 ± 1.2	0.1 ± 0.2
Fe-rich	55 ± 2.3	10 ± 1.9	0.3 ± 0.1
Mn-poor	58 ± 1.5	6.9 ± 1.1	0.8 ± 0.4
Mn-rich	52 ± 2.9	9.6 ± 0.8	3.9 ± 1.4

Petrographic and statistical analyses indicate that the Mn-poor and -rich (i.e. Mn-enriched) populations comprise massive, coarsely crystalline, overgrowths and annealed crystals that predominate the samples analyzed. Combined, these attributes suggest that the Mn-enriched populations represent the composition of the primary sulfide mass succeeding modification and secondary growth during peak metamorphism. By comparison, the Zn- and Fe-rich populations form minor constitutes. Morphologically, the Zn-rich population is characterized by anhedral to subhedral, fine- to coarse-grained, porous to void-filling crystals commonly intergrown with microscopic phyllosilicates (i.e. stiplnomelane), suggesting growth under retrograde metamorphic conditions.

Unfortunately, the scarcity of the Fe-rich population precludes analysis at this time. In spite of this, the apparent mixing line observed between the Mn- and Zn-rich populations, indicates the introduction of a secondary fluid that interacted with the pre-existing Mn-rich population, resulting in the precipitation of the secondary Zn-rich population. A similar interpretation might apply to the Fe-rich population, which displays a high degree of scatter on a bivariant plot of Fe versus Mn, a feature common to hydrothermally altered minerals. In conclusion, the results of this investigation suggest that after milling and concentration, the coarser size fractions will be Mn-enriched (i.e. concentration of Mn-enriched populations), while the finer size fractions should contain a higher Zn content (i.e. Zn-rich population).



Spot analyses of the Gamsberg sphalerites plotted on a ternary plot of Fe-Mn-Zn illustrating the clustering of the four sphalerite populations

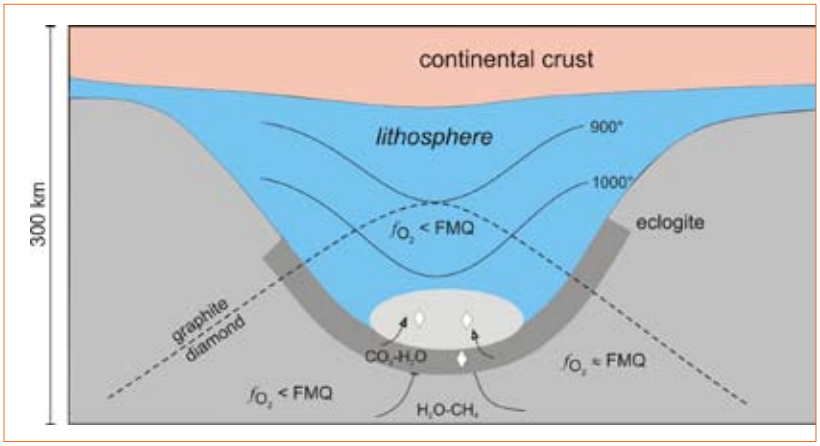


(a) Backscatter electron (BSE) image of fine-grained, Zn-rich sphalerite crystals from the bedded sulfide ore. (b) Photomicrograph of coarse-grained, Mn-rich sphalerite crystal from the massive sulfide ore. Abbreviations: Qtz – quartz; Po – Pyrrhotite; Py – Pyrite; Sph – sphalerite; Stipl – stiplnomelane

A theoretical examination of diamond precipitation from fluids in the Earth's mantle

Alexandra Crossingham

It has been suggested that diamond precipitation may occur as a result of the infiltration and mixing of oxidised and/or reduced mantle fluids with the surrounding mantle peridotite. If this model is correct, important aspects that should be considered include the fluid speciation in the mantle, and the oxidation state of the surrounding lithosphere. According to Haggerty (1999): "The preferred distribution of diamonds, although related to the minimum pressures required to form diamond, must also be related to carbon speciation (CH_4, CO_2, or carbonate) and oxidation state".



Theoretical section of the continental crust and a part of the upper mantle. Diamonds are typically formed in a relatively cold, deeper part of the mantle (shaded area) along the contact of oxidized and reduced material (modified after Haggerty, 1999)

Mantle xenoliths from the Kaapvaal Craton have been widely used for petrological studies in the past, in order to determine the relationship between pressure, temperature, and oxygen fugacity in the Earth's mantle. These studies have shown that: (1) the sub-lithospheric mantle beneath the Kaapvaal Craton is reduced, i.e. the oxygen fugacity varies between 1 and 3 log units below the FMQ buffer, and (2) oxygen fugacity shows a strong correlation with depth, i.e. the mantle becomes more reducing with increasing depth. The correlation between pressure, temperature and the oxygen fugacity allows the calculation of the fluid composition of the mantle within the C-O-H system. Aspects of the study include the theoretical analysis of possible fluids in the Kaapvaal Craton, as a large xenolith dataset is available for the Kaapvaal lithosphere in the published scientific literature. This involves the quantification, using thermodynamic data and related calculations, of variations in oxygen fugacity of the host mantle to diamonds, mantle fluid compositions, and the effect of mixing of a 'mantle' fluid and various introduced fluids (methane, CO_2) on the degree of carbon oversaturation in the mantle, and consequent diamond crystallization. These calculations suggest that the most ideal conditions for diamond precipitation are low fluid-rock ratio systems of which the oxygen fugacity is controlled by the rock system.

Reference: Haggerty, S.E., 1999. A diamond trilogy: Superplumes, supercontinents, and supernovae. Science, v. 285, pp. 851-860.

Evaluating the upgrade potential of low-grade partly mineralized banded iron formation to iron ore in Griqualand West

Jean-Clement Byeme Zogo

This project is aimed at evaluating the iron ore potential of some of the partly mineralized banded iron formation (BIF) units of the Transvaal Supergroup in Griqualand West. It has three target iron formations namely the Kuruman-Manganore BIF, the Rooinekke BIF of the Koegas Subgroup and the Hotazel iron formation that hosts the Kalahari manganese deposits. The study involves characterization of some of the hematite-bearing units in the iron formations to establish textural parameters that may assist in developing processes through which the BIFs could possibly be upgraded to iron ore quality. Up to the present most attention was given to a study of the sideritic Rooinekke BIF that is known to be transformed to a goethite-hematite banded iron formation by supergene processes to depths of several tenths of meters below surface. Work has also started on partly mineralized Manganore iron formation (a correlative of the Kuruman iron formation) in the Beeshoek and Khumani mining areas.

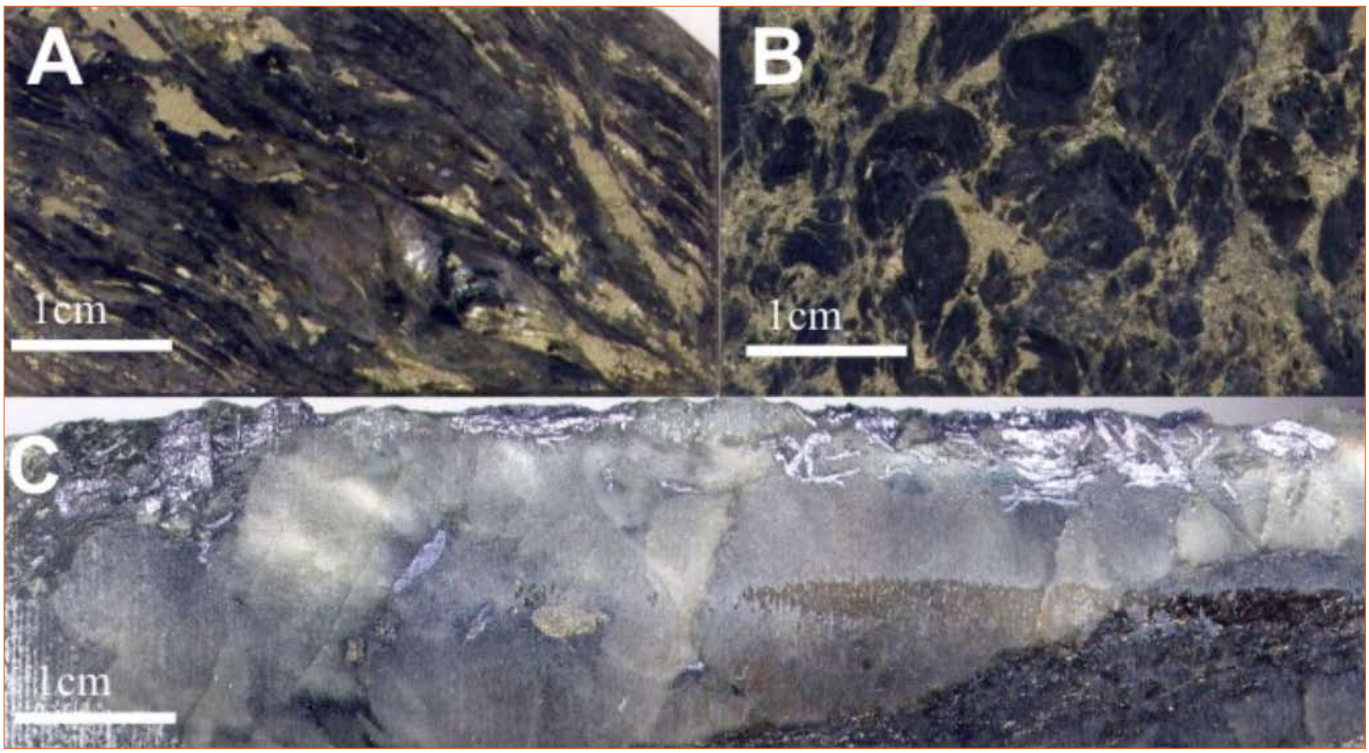
View of the defunct Rooinekke iron ore mine

Boulder conglomerate with clasts of iron ore at base of the Paleoproterozoic Mapedi/ Gamagara succession at Rooinekke mine

Re-Os systematics of the Salt River VMS Deposit, Northern Cape Province

Keith Osburn

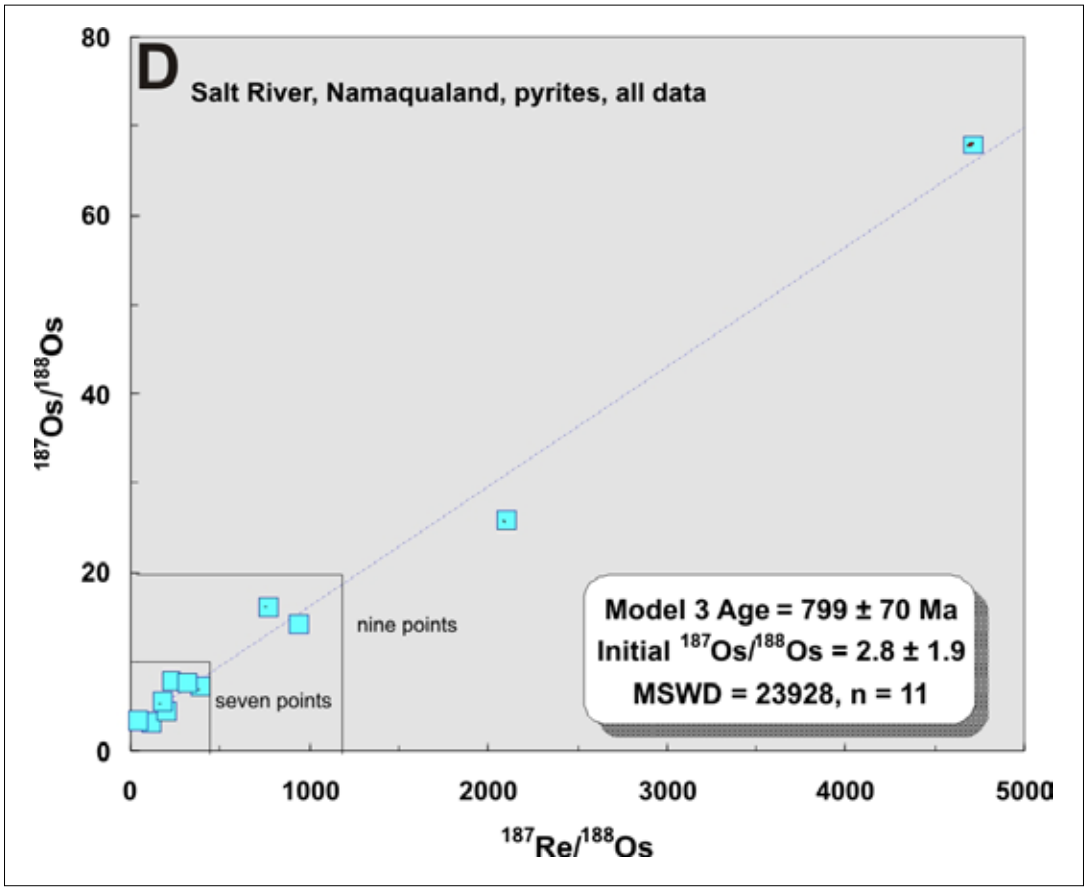
The Salt River VMS deposit occurs within the poly-metamorphosed and highly deformed Namaqua Metamorphic Province (NMP), Northern Cape Province. Forming part of a larger investigation focussed on the architecture of the Salt River deposit, a reconnaissance geochronological investigation of the Salt River deposit was undertaken. The aim of this study was to precisely date the age of mineralization as the Re-Os method of dating allows for the direct dating of the sulphide mineralization. These results further enable discussion of the Re-Os isotopic disturbance in a deformed and metamorphosed massive sulphide.



(a) Characteristic example of streaky sulphide mineralization as commonly observed below massive sulphide mineralization. (b) Example of netlike-textured mineralization - typically containing the best grades of mineralization. (c) Whispy tabular molybdenite crystals hosted by pegmatite

The mineralized horizons of the Salt River deposit consist of pyritic massive, streaky and disseminated sulphide mineralization. Pyrite samples selected for dating occur as elongate, foliation-parallel (streaky) laths, while the molybdenite samples occur as elongate tabular crystals hosted by pegmatites. Contrary to similar deposits, the pyrite samples display low concentrations of Re and Os, while the molybdenite samples display characteristic concentrations of Re and Os. Age determinations for the molybdenites conform to a well-constrained age of 933 ± 2.1 Ma, which is similar to the ages of molybdenites from elsewhere in the NMP. In contrast, the pyrite

samples display significant disturbance to the Re-Os system, as demonstrated by the wide scatter of the data around a 799 ± 70 Ma isochron. Several pyrite samples were identified as Low Level, Highly Radiogenic (LLHR) pyrite, which are characterised by those samples where ^{187}Os composes more than half of the total Os concentration. Irrespective of these, all pyrite samples display mantle separation model ages (T_{MA}) between 733-2105 Ma. Lastly, all molybdentite and pyrite samples analyzed display positive γOs values.



Age data obtained on Salt River pyrite samples yielding an 'isochron' of 799 ± 70 Ma

While the age determinations of molybdenite suggest that crystallization occurred during retrograde metamorphism, the wide-scatter and positive γOs values of the pyrites suggest a prolonged history of isotopic disturbance (i.e. metamorphism and deformation), as well as derivation from a heterogeneous crustal source. Hence, the scattering of ages observed in the pyrites could be related to 1) a single period of ore formation subsequently modified by single or repeated periods of deformation or metamorphism, 2) a second ore forming event during emplacement of the molybdenite-bearing pegmatites or 3) a combination of both processes.

Mineralogical characterization and genesis of iron formation spatially associated with stratabound sulfide deposits of the Aggenys-Gamsberg area in Bushmanland

S. J. Kruger

Metamorphosed iron formations are hosted in the amphibolite-facies of the multiply deformed metasedimentary rocks that belong to the Karas Member of the Gams Formation of the Mesoproterozoic Bushmanland Group. In the Aggenys-area these formations share a close spatial and stratigraphic association with the stratabound, polymetallic massive sulfide deposits of the Aggenys-Gamsberg district of the Northern Cape Province. This district consists of five major sulfide deposits. From three of the five, namely Broken Hill, Big Syncline, and Gamsberg, bore-hole samples were obtained for a more detailed petrographical and mineralogical investigation of the iron formations and their associated silicate assemblages to obtain information that could shed more light on their mode of origin.

Broken Hill Deeps shaft with the Aggenys Mountains in the background

Detailed investigation of the petrography and mineralogy of the Fe-oxides minerals and the associated amphibolite-facies metasediments indicate that they are characterized by a predominance of magnetite and quartz. Lesser garnet species form distinct layers, and some of these are conspicuously manganese bearing. Lesser quantities of amphiboles (i.e. grunerite, cummingtonite, riebeckite) were identified as well as occasional occurrences of pyroxenes, pyroxenoids, and olivine. Other minor and trace minerals have been identified, however, their petrological and genetic relationship to Fe-oxide minerals and pyroboles remains under investigation.

Core sample showing the garnetiferous zone; part of the Gams iron formation

Paleomagnetism of Bushveld-related intrusions

H. Wabo

Reliable and well-dated Paleoproterozoic paleopoles from the Kaapvaal Craton are both important for constructing an apparent polar wander path for the craton with which to test Precambrian paleogeographic reconstructions, and for the identification of new prospective areas for mineral deposits.

The present project aims to evaluate the position of the Kaapvaal Craton at 2.0 Ga. To achieve this goal, reliable new paleopoles and ages are needed to use in conjunction with existing paleopoles. Bushveld-related intrusions (i.e., satellites intrusions, sills and dykes) are targeted specifically in this study. The Bushveld-related intrusions have never been investigated paleomagnetically, this despite being excellent targets for such studies. Sampling them has the following advantages:

- Geochronology data is already available for many of these intrusions,
- The units are relatively small in size (i.e. they presumably cooled quickly). This increases the chances to isolate primary magnetic components,
- The Bushveld-related intrusions are abundant on the Kaapvaal Craton and there is a high likelihood of being able to conduct field tests for paleomagnetic stability.
- Analyses are undertaken in the paleomagnetic laboratory of the PPM in Spectrau with the new "AL du Toit "SQUID attached to an automated sample changer system.

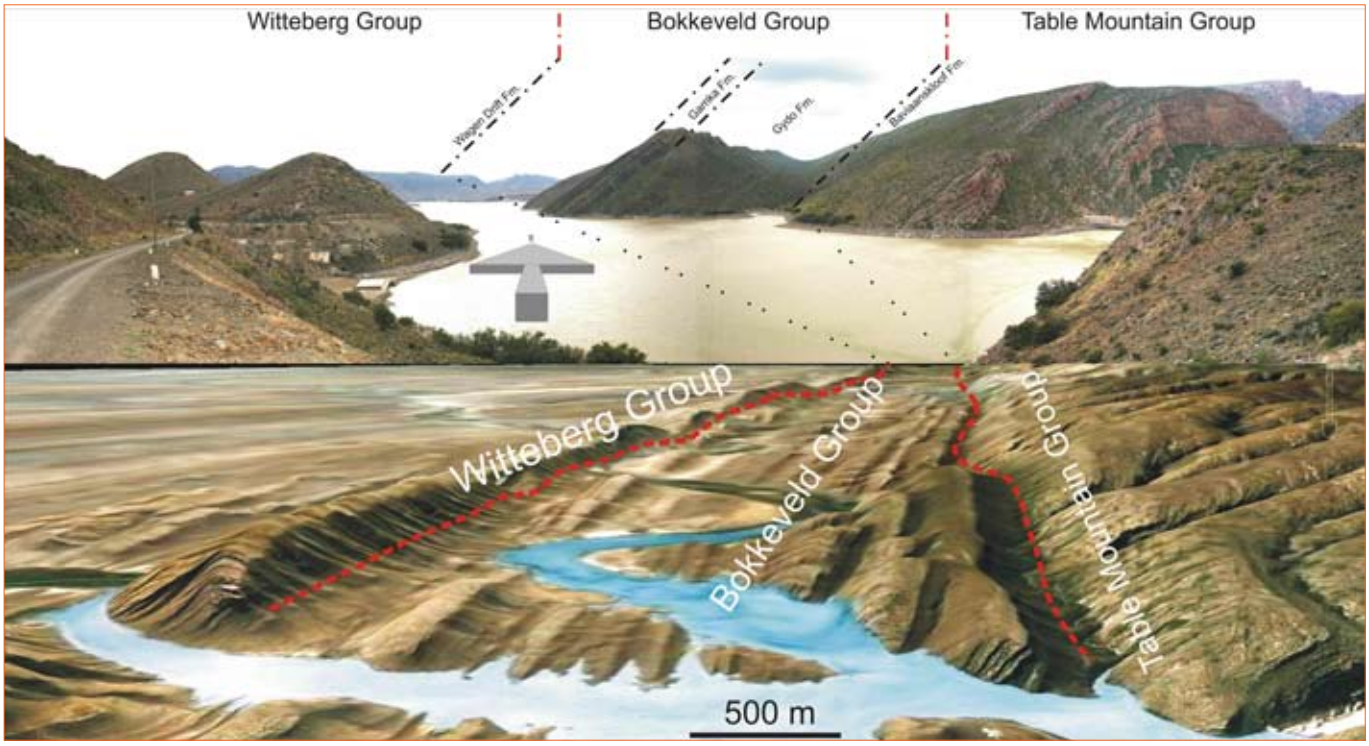
From left to right: Mafic sills intruding the Transvaal Supergroup, drilling paleomagnetic samples and orientation of samples after drilling

Development of a Laser Ablation ICP-MS zircon dating facility at UJ combined with a study of detrital zircon age populations in the Cape and lower part of the Karoo Supergroups

Clarisa Vorster

Laser ablation ICP-MS has long been considered an extremely versatile technique for the conductance of geochronological dating of not only zircons, but also other minerals such as monazite, baddeleyite and titanite. The process involves the ablation of zircons, collection of U and Pb signal intensity data, calculation of relevant isotope ratios and the correction of ratios by calibration against a zircon standard. Laser ablation ICP-MS may not match the precision or spatial resolution of techniques such as Thermal Ionization Mass Spectrometry (TIMS) or Ion Microprobe Analysis but has the advantage of rapid, low cost analysis.

Development of the LA ICP-MS zircon dating facility at UJ is to be followed up by a detrital zircon age study on arenaceous rocks of the Cape Supergroup (Table Mountain, Bokkeveld and Witteberg Groups) and lower Dwyka and Ecca Groups of the overlying Karoo Supergroup. Various depositional models have been proposed for the history and formation of the Cape Supergroup and overlying lower part of the Karoo Suprgroup in the southern Cape area. By evaluating the age populations of detrital zircons in the units, valuable information about the age and provenance of the sediments would be obtained. The data will in turn aid in critical evaluation of the validity of the various tectono-sedimentary models that have been put forward for the origin of the successions.



View of the Table Mountain, Bokkeveld and Witteberg Groups (Cape Supergroup) at Gamkapoort (top), accompanied by the corresponding Google image of the area (below)

Detrital zircon age populations of the Paleoproterozoic Gamagara-Mapedi succession, Northern Cape Province

Daphne Dreyer

This project involves the study of stratigraphically controlled quartzite samples from drill cores through the Gamagara Formation from the Hotazel and Beeshoek regions, as well as from exposures of the Mapedi Formation on the farms Voëlwater 480 and Venn 665 near the town of Olifantshoek. Petrographic and heavy mineral studies are undertaken in combination with U-Pb age dating of detrital zircons from the quartzites by means of Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA ICP-MS).

The main aim of the study is to compare the composition of the Gamagara and Mapedi Formations below and above the Black Ridge thrust and to obtain better constraints on the maximum possible ages of the various quartzite units in the succession from detrital zircon age populations. The results are important to constrain the age of ancient lateritic weathering profiles and timing of formation of the supergene Sishen-type high-grade BIF-hosted iron ore deposits developed along the pre-Gamagara unconformity on the Maremane dome.

Cathodoluminescence SEM image of a zircon grain from the Lucknow Formation

View of the Lucknow Quartzite Formation on Voëlwater 480

An integrated genetic, stratigraphic, petrographic, mineral chemistry and multiple sulfur isotope study of Mesoarchean Witwatersrand pyrites

B. Guy, N. J. Beukes, J. Gutzmer, S. Ono, A.J. Kaufman

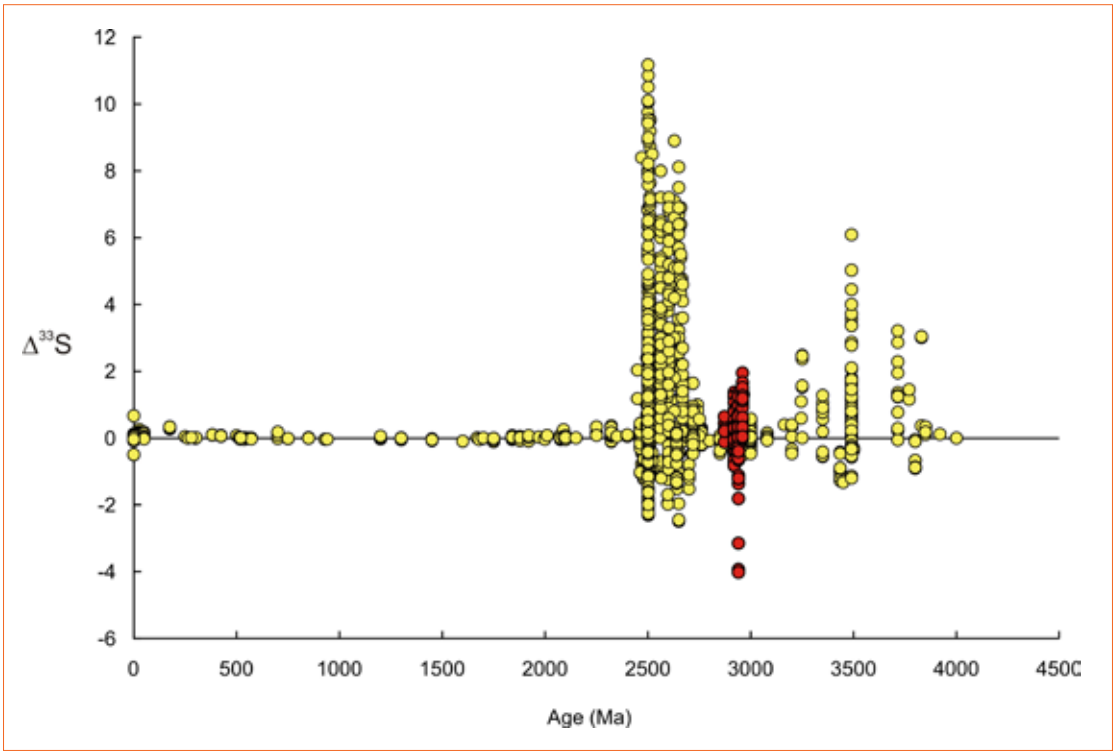
Isotopic, chemical and petrographic studies were conducted on pyrite in sedimentary rocks of the Mesoarchean Witwatersrand Supergroup to try and establish controls on the nature and composition of pyrites in the succession focusing mainly on argillaceous units. Unlike other studies, where rock samples are crushed, analyzed and interpreted, we chose to categorize the different types of pyrite based on textural information and mineral chemistry, prior to interpretation. By examining the mineral chemistry of the different types of pyrite, we were able to independently verify our petrographic assessments and isolate diagenetic pyrite from epigenetic pyrite for further investigation.

Outcrops of the Mozaan Group that are correlative to the lower part of the Witwatersrand succession

Sulfur mass-independent fractionation (S-MIF) is an indirect proxy for the composition of the ancient atmosphere and is thought to occur via photolysis of volcanic SO_2. Generally, this anomaly ($\Delta^{33}S \neq 0$) can only be preserved in an atmosphere devoid of oxygen (<10-5 present atmospheric levels) and an ozone shield. The occurrence of this anomaly and redox-sensitive minerals (e.g. detrital pyrite and uraninite) in Archean and early Proterozoic rocks have led many researchers to suggest that the ancient atmosphere was anoxic. The disappearance of the anomaly (i.e.$\Delta^{33}S=0$) at around 2.3 to 2.4 Ga is commonly interpreted to reflect increasing proportions of oxygen due to the emergence of cyanobacteria and oxygenic photosynthesis.

However, some Mesoarchean rocks, including the Mozaan succession (see photo), display only very small to no $\Delta^{33}S$ anomalies and could suggest ephemeral increase in the oxidation state of the atmosphere at this time interval. This study focuses on rocks of this age in the Witwatersrand succession. Results display definite $\Delta^{33}S$ anomalies, ranging from -4 to +2‰, which is much larger than those obtained from earlier studies (± ~0.5‰) and supports the concept of a largely anoxic Archean atmosphere. In addition, the bulk of early diagenetic pyrite in proximal carbonaceous rocks is characterized by negative $\Delta^{33}S$ anomalies, while pyrite in distal ferruginous environments contains positive $\Delta^{33}S$ anomalies. These results, along with other lines of evidence obtained during this study, provide strong evidence for bacterial sulfate reduction in the proximal parts of the basin possibly in association with the anaerobic oxidation of methane.

Furthermore, the virtual absence of pyrite in carbonaceous mudrocks in marine depositional settings and the abundance of pyrite in carbonaceous mudrocks in fluvio-deltaic depositional settings is consistent with the notion of low sulfate concentrations in the Archean ocean and possibly a minor terrigenous supply of sulfate, respectively. The latter could imply a flux of at least some free oxygen in the Mesoarchean hydrosphere – concomitant with foreland basin development.



$\Delta^{33}S$ through time with the results of this study highlighted in red

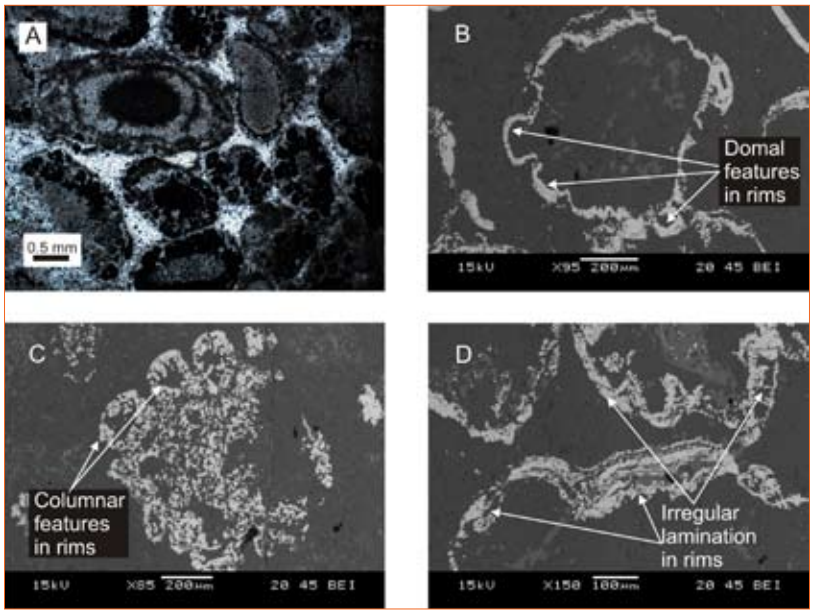
First discovery of biogenic oncoids in Archean granular iron-formation, Mozaan Group, Pongola Supergroup

Albertus Smith, Noah Nhleko, Nicolas Beukes and Jens Gutzmer

The involvement of biological activity in the deposition of iron-formations has long been debated due to a lack of microfossils or biological textures, especially in Archean iron formations. In the Mesoarchean Nconga Formation of the Mozaan Group, an oncoidal granular iron-formation interbedded with banded iron formation and iron-rich mudstone occurs that shows strong textural and geochemical evidence for biological activity during Archean iron formation deposition. Oncoids are coated grains that show irregular rims due to the involvement of bacterial or microbial films during the precipitation of the grains. Oncoids have been documented in numerous carbonate successions as well as iron formation of early Proterozoic age. However, the depositional age of the Nconga Formation is ~2914 Ma, making this the oldest known occurrence of oncoids in a granular iron formation.

The oncoids occur in a quartz matrix and have irregular rims consisting of euhedral magnetite and calcite. The rims are not smoothly concentric laminated like more commonly occurring coated grains, but show irregular domal and columnar features that are very similar in appearance to micro-stromatolites. Cross-stratification in oncoid beds suggests deposition in a shallow water wave-dominated environment. The iron was probably deposited by iron-oxidizing bacteria that had to form stronger microbial films or mats around nuclei of chert peloids to survive in the wave-dominated environment. Such microbial films can trap detrital particles, but in the case of the Mozaan oncoids the films acted as chemical traps for iron due to a lack of detrital material. The geochemistry of the iron formation also supports biological activity, since the stable carbon isotopes of calcite are depleted in ^{13}C, which is characteristic of organically derived carbon.

This oncoidal granular iron-formation of the Nconga Formation signifies the oldest textural evidence linking biological activity to the deposition of iron-formation in the Archean. The close stratigraphic association of this granular iron formation as well as its similar geochemistry to the surrounding deeper water banded iron formation, suggest that biological activity could have played a part in the deposition of Archean banded iron formations.



Photomicrograph (a) and scanning electron microscope backscatter images (b – d) of the oncoidal granular iron formation of the Nconga Formation, Mozaan Group

Archean cratonic reconstructions for the southeastern Kaapvaal Craton

Ashley Paul Gumsley

Northern KwaZulu-Natal hosts several Archean inliers of the Kaapvaal Craton which are composed of granite-greenstone terrane overlain by the Pongola Supergroup. The granites are comparable to both the Archean tonalite-trondhjemite-granodiorite and granodiorite-granite suites of the Barberton area. These inliers will allow us to further refine existing terrane boundaries proposed for the Kaapvaal Craton by comparison with other Archean terranes. Palaeomagnetic sampling of the mafic dykes and sills that have intruded into the granites may also provide age and palaeopole constraints for the Kaapvaal Craton back into the Archean. This will enable further resolution into the possible cratonic reconstruction between the Kaapvaal Craton and the Grunehogna Craton of East Antarctica. Of particular interest is the Hlagothi Complex, which is a sill with a poorly constrained age of ca. 3000 Ma. Baddeleyite age dating and palaeomagnetic sampling of the sill will provide a better constrained age and position of the Kaapvaal Craton during the Mesoarchaean.

Mafic dyke in Archaean granite (left) and migmatitic tonalite near the southern margin of the Kaapvaal Craton (right)

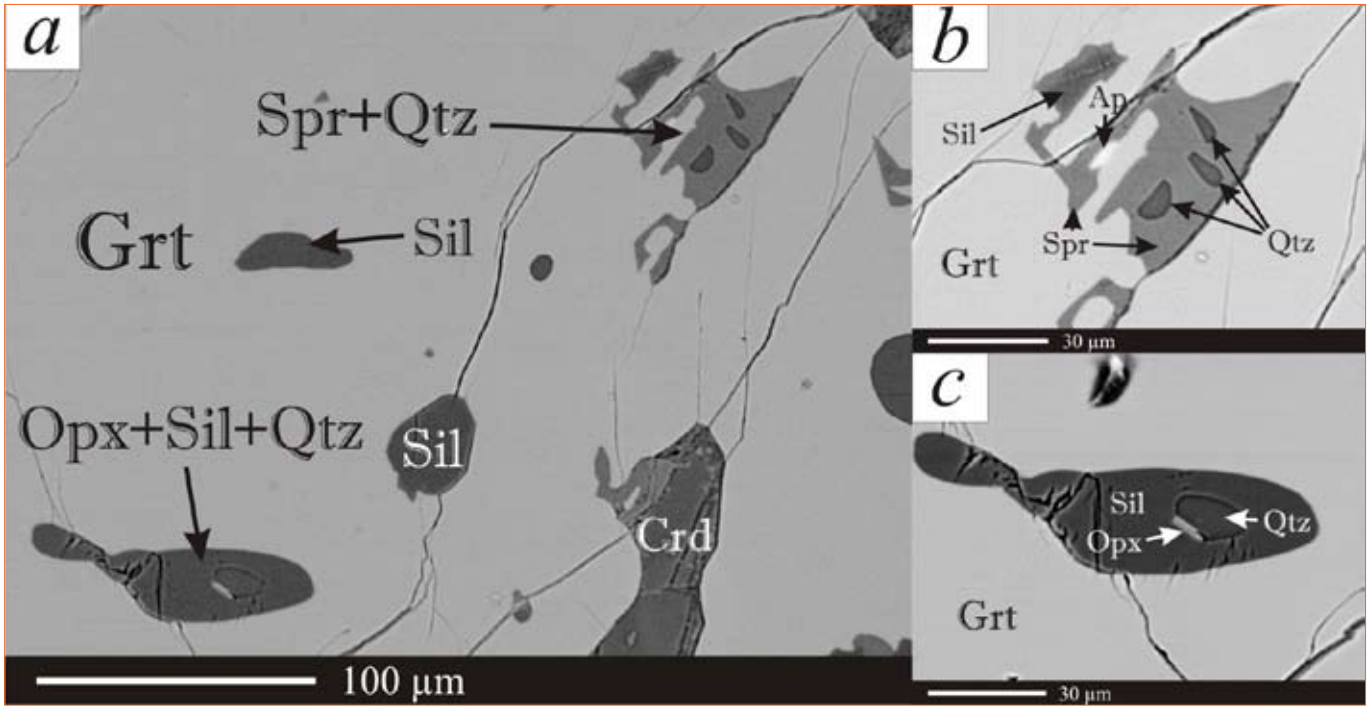
Samples were obtained from the granites and mafic dykes and sills. Foliation intensity increases toward the margin of the craton. Samples have undergone petrographic descriptions and major element geochemical analyses are under way using XRF. Baddeleyites for age dating on the mafic dykes and sills have already been separated, and are in the process of being analyzed.

Sapphirine + quartz and orthopyroxene + sillimanite ± quartz in garnet from an Mg-Al granulite from the Central Zone, Limpopo Belt, South Africa

George A. Belyanin, H. M. Rajesh, Dirk. D. Van Reenen

Although less common, documented from only approximately 30% of all ultrahigh temperature localities, sapphirine + quartz is the most unequivocal and orthopyroxene + sillimanite ± quartz is the most common ultrahigh temperature metamorphic assemblage reported in the literature.

We report on the occurrence of both sapphirine + quartz and orthopyroxene + sillimanite ± quartz as inclusions within garnet from an Mg-Al granulite from the Central Zone of the Limpopo Belt. Textural evidence argues for the formation of sapphirine + quartz after orthopyroxene + sillimanite ± quartz. In addition, numerous inclusions of sapphirine + quartz and orthopyroxene + sillimanite (± quartz) occur in separate garnet grains. Application of Al-in-opx thermobarometry and comparison with P-T pesudosections indicate ultrahigh temperature conditions for the sapphirine + quartz assemblage, slightly higher than those for the orthopyroxene + sillimanite ± quartz assemblage. Given the less common occurrence of sapphirine + quartz post dating orthopyroxene + sillimanite ± quartz in granulites, our report of both these diagnostic ultrahigh temperature mineral assemblages as inclusions in garnet from an Mg-Al granulite is unique.



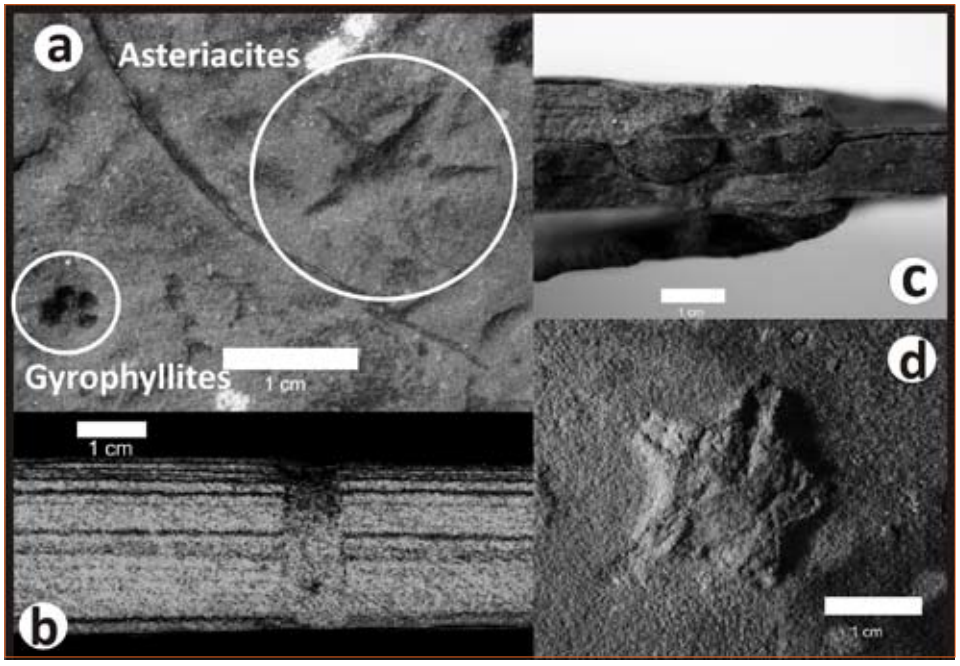
Representative back-scattered electron images illustrating (a) both sapphirine + quartz and orthopyroxene + sillimanite + quartz inclusions in the same garnet, (b) enlargement of sapphirine + quartz inclusion in (a), (c) enlargement of orthopyroxene + sillimanite + quartz inclusion in (a)

Unique *Asterozoan* trace fossils of the Gydo Formation (Bokkeveld Group, Cape Supergroup) near Nieuwoudtville, Northern Cape Province

Pieter Hugo Fourie

The northernmost exposures of the Bokkeveld Group, in the Nieuwoudtville area of the Northern Cape Province, display a great variety of Malvinokaffric ichnofauna of Lower Devonian age. This area's uniquely high variety (over 50 recorded ichnogenera) and concentration of ichnospecies is most likely due to it being the most proximal exposed parts of the Bokkeveld basin fill, deposited in a variety of shallow marine environments. The Gydo Formation, the lowermost unit of the Bokkeveld Group, has yielded quite unique asterozoan trace fossils that shed light on asterozoan behaviour and the morphology of the associated traces. *Asteriacites Lumbricalis* occur together with what most closely resembles *Gyrophyllites* in thinly-bedded heterolithic successions of the contact between the Gydo and overlying Gamka Formations of the Bokkeveld Group.

Cross-cuts through slabs collected of both these ichnospecies revealed clear preservation of full-relief between positive hyporeliefs and negative epireliefs for both *Asteriacites* and *Gyrophyllites* (refer to figure). The five-fold symmetry of both ichnospecies, as well as the close association, suggests that they may be the result of a single producer, most likely an ophiuroid. The ichnofossil described here as *Gyrophyllites* may be a new ichnospecies belonging to *Asteriacites*, and as such may be a cubichnium or fugichnium instead of a fodichnium as is the case for *Gyrophyllites*. It is believed that the *Gyrophyllites* burrows are the result of the ophiuroid animal burrowing its body into sediment to avoid predators or energy fluctuations within its environment.



(a) Negative epireliefs of *Asteriacites Lumbricalis* and *Gyrophyllites*, (b) digitally enhanced photograph of a cross-cut through an *Asteriacites Lumbricalis* trace that displays as both a negative epirelief and positive hyporelief, thus revealing full relief, (c) side view photograph of *Gyrophyllites* as full relief and (d) positive hyporelief of *Asteriacites Lumbricalis*

Kamafugites from the Muko volcano along the western branch of the East African Rift system, Uganda

Michael de Villers

Kamafugites are a group of rare silica-under saturated volcanic rocks originally named after three petrographically-defined rock types, namely katungite, mafurite and ugandite, and correspond to strongly potassic types of olivine melilitite to nephelinite in modern classifications. The rocks were originally investigated in the western branch of the rift valley in Uganda, East Africa.

The unusual kamafugites volcanics are strongly enriched in K, Ca, CO_2, Sr and other trace elements. Besides this, they are also characterized by very primitive geochemical signatures that express themselves in high Mg concentrations, high Cr and Ni as well as low Al, Si, Pb and low $^{87}Sr/^{86}Sr$ which do not vary with Mg concentration. Altogether, isotopes and trace elements of the volcanics show that more than one mineral assemblage must have been involved as sources and that major crustal assimilation processes did not occur. In terms of Nd, Hf and Os isotopes the volcanics indicate a mixing trend between metasomatised peridotite and possibly picritic pyroxenite.

This study concentrates on kamafugites of the Muko volcano. Eruption of the volcano resulted in the formation of Lake Bunyoni in Uganda. Lava flowed down a tributary of a major river and blocked the river valley forming a natural dam wall. Lake Bunyoni is a drowned river valley. Fertile soils around Lake Bunyoni and Muko ensure good agricultural yields from the area. This is achieved by terracing the highly incised topography surrounding the lake (see photo).

Lake Bunyoni viewed from Muko (left) and outcrop of fertile soil profile overlying inclined dark fresh volcanic ash bed and weathered basement phyllite (right)

Initial investigations of the Muko volcano indicate that the dominant lava consists of ugandite. At least two distinct lava flows were mapped. The samples are currently subjected to detailed mineralogic and petrolographic examinations, including mineral chemical analysis using EPMA at Spectrau. Powdered rock samples will be subjected to geochemical and isotope chemical studies to characterize the individual flows that were identified during detailed field mapping.

STAFF NEWS

JAN KRAMERS

Jan Kramers joined the Geology Department and PPM in September 2009 on part-time basis following his retirement from the University of Bern in Switzerland. He is to motivate and supervise projects using the analytical facilities at Spectrau, in particular laser ablation ICP-MS zircon dating and Ar/Ar dating

HERMAN VAN NIEKERK

Herman van Niekerk, a former Ph.D student at the University of Johannesburg, joined the Geology Department and the PPM group in June 2009 as a permanent academic staff member after being employed a number of years as a senior research scientist at Spectrau.

MIKE DE VILLIERS

Mike joined the staff of UJ in 2009 and is employed as a lecturer on the Doornfontein Campus. He lectures geology and petrography to Metallurgical and Civil Engineering students. Mike was previously employed as Regional Geologist of Namakwa Diamonds and has extensive exploration experience in various countries.

SUPPORT STAFF

Photo below: From left to right Lisborn Mangwane (technical assistant for rock crushing and sample preparation), Diana Khoza (administrative assistant) and, Michael Chakuparira (GIS-digitizing technician). Photo on left: Sacky Maluleke (technician thin section preparation).

STUDENTS IN PPM – 2009

Student	Thesis topic	Advisors
Blane, Craig (M.Sc.)	Provenance of the West Rand Group	N.J. Beukes, J. Gutzmer and U. Zimmerman
Cloete, Louis (M.Sc.)	Geochemistry of a gold-bearing alteration zone in the Witwatersrand succession	K.S. Viljoen and J-M. Huizenga
Crossingham, Alexandra (M.Sc.)	Modelling of diamond precipitation from fluids in the Earth's mantle	J-M. Huizenga and K.S. Viljoen
Da Silva, Richard (M.Sc.)	Provenance of red beds in Paleoproterozoic, Northern Cape Province	N.J. Beukes and J. Gutzmer
Dreyer, Daphne (M.Sc.)	Detrital zircon age populations in the Gamagara-Mapedi succession, Griqualand West	H.S. Van Niekerk and N.J.Beukes
Fourie, Pieter (M.Sc.)	Provenance of the Palaeozoic Bokkeveld Group	U. Zimmermann and N.J. Beukes
Greeff, Christiaan (M.Sc.)	Modal and cryptic variation of the Merensky Reef, Western Bushveld Complex	M.Knoper, K.S. Viljoen and H.M. Rajesh
Gumsley, Ashley (M.Sc.)	Archean cratonic reconstructions for the southeastern Kaapvaal Craton	M. Knoper, H.M. Rajesh, and De Kock, M.O
Lamprecht, Alet (M.Sc.)	Genetic stratigraphy of the Gamagara Formation	N.J. Beukes, J. Gutzmer and U. Zimmermann
Mabundza, Themba (M.Sc.)	Characterization of syn-Bushveld sills from the Uitkomst Complex	H.M. Rajesh and M. Knoper
Nel, Brian (M.Sc.)	Iron formations of the Koegas Subgroup, Transvaal Supergroup	N.J. Beukes and J. Gutzmer
Osburn, Keith (M.Sc.)	Origin of the Salt River massive sulfide deposit, Namaqualand	J. Gutzmer, J.M. Huizenga and C.R. McClung
Rose, Derek (M.Sc.)	Modal and Cryptic Variation of the Merensky Reef, Eastern Bushveld Complex	M.Knoper, K.S. Viljoen and H.M. Rajesh
Van der Merwe, Frits (M.Sc.)	A mineralogical investigation of Lonmin's Akanani platinum group metal project	KS Viljoen and M. Klopper
Watts, Mark (M.Sc.)	Spectral mapping of phyllosilicate assemblages, Witwatersrand succession	J. Gutzmer and J. Genis
Belyanin, George (PhD)	Magmatic and metamorphic characteristics from the Limpopo Belt	D. van Reenen and H.M. Rajesh
Chisonga, Benny (Ph.D)	Relation of mafic dykes and sills to genesis of high-grade iron ore	J. Gutzmer, N.J. Beukes and H.M. Rajesh
Guy, Bradley (PhD)	Mass-independent sulpher isotope fractionation in the Witwatersrand succession	N.J. Beukes and J. Gutzmer

Student	Thesis topic	Advisors
Mishra, Gargi (PhD)	A geometallurgical assessment of the geological and mineralogical influences on plant performance at the Nkomati Nickel mine, Mpumalanga	K.S. Viljoen and H. Mouri
Smith, Bertus (PhD)	Geometallurgical characterisation of the Merensky Reef Facies at Bafokeng Rasimone Platinum Mine, South Africa	K.S. Viljoen, J. Gutzmer and R. Schouwstra
Van Staden, Anelda (PhD)	Provenance of glacial deposits, southwestern Gondwana	U.Zimmermann and J. Gutzmer
Wabo, Herve (PhD)	Paleomagnetic analyses of intrusive rocks associated with the Bushveld Complex	M.O. De Kock and N.J. Beukes
Vorster, Clarisa (PhD.)	Developing ICP-MS laser ablation zircon dating at Spectrau with application in the Cape Supergroup.	J.D. Kramers, H.S. van Niekerk and N. J. Beukes
George Tetteh	Mineralogy and geochemistry of the Nsuta manganese deposit (University of Ghana)	F. Nyame (Ghana), N.J. Beukes
Voordouw, Ron (Postdoc)	Genesis of the UG2 chromitite, Eastern Bushveld Complex	N.J. Beukes and J. Gutzmer
McClung, Craig R. (Postdoc)	Geometallurgy and Metallogenesis in the Bushmanland succession	KS Viljoen

THESES COMPLETED - 2009

JEAN-CLEMENT BEYEME ZOGO (MSc cum laude)

Beneficiation potential of low-grade iron ore from a discarded lumpy stockpile and fines tailings dam at Beeshoek Iron Mine, Northern Cape Province, South Africa.

Supervisors: J Gutzmer & NJ Beukes

JUSTIN MICHAEL COCHRANE (MSc)

Diagenetic carbonates and biogeochemical cycling of organic matter in selected Archean-Paleoproterozoic sedimentary successions of the Kaapvaal craton, South Africa.

Supervisors: NJ Beukes & J Gutzmer

WIKUS FREDERICK VAN DEVENTER (MSc)

Textural and geochemical evidence for a supergene origin of the Paleoproterozoic high-grade BIF-hosted iron ores of the Maremane dome, Northern Cape Province, South Africa.

Supervisors: NJ Beukes & J Gutzmer

RUSSELL HOPE BAILIE (PhD)

Mesoproterozoic volcanism, metallogenesis and tectonic evolution along the western margin of the Kaapvaal Craton.

Supervisors: J Gutzmer, HM Rajesh & H van Niekerk

GONZALO HOMERO BLANCO GAUCHER (PhD)

Provenance and tectonic setting of the Neoproterozoic to Lower Palaeozoic deposits of the Nama Group (Namibia) and equivalents on the Rio de la Plata Craton, the Arroyo del Soldado Group (Uruguay): Palaeogeographic implication for terrane boundaries in central Gondwana.

Supervisors: HM Rajesh, U Zimmermann & GJB Germs

PUBLISHED PAPERS

Authors	Title and Journal Details
Banas, A., Stachel, T., Phillips, D., Viljoen, K.S., Harris, J.W.,	Ancient metasomatism recorded by ultra-depleted garnet inclusions in diamonds from De Beers Pool, South Africa: Lithos, vol. 112(s2). pp. 736 – 746.
Blanco, G. Rajesh, H.M. Gaucher, C. Germs, G.J.B. Chemale Jr, F.	Provenance of the Arroyo del Soldado Group (Ediacaran to Cambrian, Uruguay): for the paleogeographic evolution of southwestern Gondwana: Precambrian Research, vol. 171, pp. 57-73.
Blanco, G, Rajesh, H.M., Germs, G.J.B., Zimmermann, U.	Chemical Composition and Tectonic Setting of Chromian Spinels from the Ediacaran–Early Paleozoic Nama Group, Namibia: The Journal of Geology, vol. 117, pp. 325-341.
Bumby, Mouri, Alterman	Introduction to the Special Edition in celebration of the 100th Anniversary of the Geology Department at the University of Pretoria (2008): South African Journal of Geology, vol. 111. pp. 141-142.
Cairncross, B.	Fluorite from Riemvasmaak, Northern Cape Province, South Africa. Mineralogical Record, vol. 40, pp. 307-324.
De Kock, M.O., Evans, D.A.D., Beukes, N.J.	Validating the existence of Vaalbara in the Neoarchean: Precambrian Research, vol. 174. pp. 145-154.
De Kock, M.O., Evans, D.A.D., Kirschvink, J.L., Beukes, N.J., Rose, E. Hilburn, I.	Paleomagnetism of a Neoarchean-Paleoproterozoic carbonate ramp and carbonate platform succession (Transvaal Supergroup) from surface outcrop and drill core, Griqualand West region, South Africa.: Precambrian Research, vol. 169. pp. 80-90.
Fischer, W.W., Schroede,r S., Lacassie, J.P., Beukes, N.J., Goldberg, T., Strauss, H., Horstman, U.E., Schrag, D.P., Knoll. H.	Isotopic constraints on the Late Archean carbon cycle from the Transvaal Supergroupo along the western margin of the Kaapvaal Craton, South Africa: Precambrian Research, vol. 169, pp. 15-27.
Frauenstein, F., Veizer, J., Beukes, N.J., Van Niekerk, H.S., Coetzee, L.L.	Transvaal Supergroup carbonates: Implications for Paleoproterozoic $\gamma\sigma^{18}O$ and $\sigma^{13}C$ records: Precambrian Research, vol. 175, pp. 149-160.
Gröcke, D.R., Rimmer, S., Yoksoulian, L., Cairncross, B., and Tsikos, H.	No evidence for thermogenic methane release in coal from the Karoo-Ferrar large igneous province. Earth and Planetary Science Letters.
Guo, Q., Strauss, H., Kaufman, A.J., Schroeder, S., Gutzmer, J., Wing, B., Baker, M.A., Bekker, A., Jin, Q., Kim, S-T., Farquhar, J.	Reconstructing Earth's surface oxidation across the Archean-Proterozoic transition: Geology, vol. 37. pp. 399-402.
Hossain, I., Tsunogae, T., Rajesh, H.M.	Geothermobarometry and fluid inclusions of dioritic rocks in Bangladesh:Implications for emplacement depth and exhumation rate: Journal of Asian Earth Scienes, vol. 34. pp. 731-739.

Authors	Title and Journal Details
Jacob, D.E., Viljoen, K.S., Grassineau, N.V.	Eclogite xenoliths from Kimberley, South Africa - a case study of mantle metasomatism in eclogites: Lithos, vol. 112(s2). pp. 1002 - 1003
Knoll, A.H., Beukes, N.J.	Introduction: Initial investigations of a Neoarchean shelf margin-basin transition(Transvaal Supergroup, South Africa) : Precambrian Research, vol. 169. pp. 1-14.
McClung, C.R., Gutzmer, J., Beukes, N.J.,	A new chronostratigraphic paradigm for the age and tectonic history of the Mesoproterozoic Bushmanland ore district, South Africa - A discussion: Economic Geology, vol. 105, pp. 1277-1285.
Mouri, H., Whitehouse, M.J., Brandl, G., Rajesh, H.M.	A magmatic age and four successive metamorphic events recorded in zircons from a single metaanorthosite sample in the Central Zone of the Limpopo Belt, South Africa: Journal of the Geological Society of London, vol. 166. pp. 827-830
Nielsen, S.G., Williams, H.M., Griffin, W.L., O'Reilly, S.Y., Pearson, N., Viljoen, F.	Thallium isotopes as a potential tracer for the origin of cratonic eclogites: Geochimica et Cosmochimica Acta, vol. 73. pp. 7387 – 7398.
Ono, S., Beukes, N.J., Rumble, D.	Origin of two distinct multiple-sulfur isotope compositions of pyrite in the 2.5 Ga Klein Naute Formation, Griqualand West basin, South Africa: Precambrian Research, vol. 169. pp. 48-57.
Ono, S., Kaufman, J., Farquha, J., Sumner ,D.Y., Beukes, N.J.	Lithofacies control on multiple-sulfur isotope records and Neoarchean sulfur cycles: Precambrian Research, vol. 169. pp. 58-67.
Palot, M., Cartigny, P., Viljoen, F.	Diamond origin and genesis: A C and N stable isotope study on diamonds from a single eclogitic xenolith (Kaalvallei, South Africa): Lithos, vol. 112(s2). pp. 758 - 766
Perchuk, L.L., Moiseeva, E.L., Belyanin, G.A., Van Reenen, D.D.	High temerature polymetamorphism in the Central Zone of the Limpopo granulite complex (South Africa): structural and petrographic evidence: Doklady of Russian Academy of Science.
Rajesh, H.M., Mukhopadhyay, J., Beukes, N.J., Gutzmer, J., Belyanin, G.A., Armstrong, R.A.	Evidence for an early Archaean granite from Bastar craton, India: Journal of the Geological Society of London, vol. 166. pp. 109 - 196
Rigby, Mouri, Brandl	P-T conditions and the origin of quartzo-feldspathic veins in metasyenites from the Central Zone of the Limpopo Belt, South Africa: South African Journal of Geology, vol. 111. pp. 313-332.
Schroeder, S., Beukes, N.J., Sumner, D.Y.,	Microbialite-sediment interactions on the slope of the Campbellrand carbonate platform (Neoarchean, South Africa): Precambrian Research, vol. 169. pp. 68-79.

Authors	Title and Journal Details
Shimizu, H., Tsunogae, T., Santosh, M.	Spinel + quartz assemblage in granulites from the Achankovil shear zone, southern India: implications for ultrahigh temperature metamorphism: Journal of Asian Earth Science, vol. 36. pp. 209-222.
Simonson, B., Sumner, D.Y., Beukes, N.J., Johnson, S., Gutzmer, J.	Correlating multiple Neoarchean-Paleoproterozoic impact spherule layers between South Africa and Western Australia: Precambrian Research, vol. 169. pp. 100-111.
Voordouw, R.J., Beukes, N.J.	Alteration and metasomatism of the UG2 melanorite and its stratiform pegmatoids, Bushveld Complex, South Africa - Characteristics, timing and origins: South African Journal of Geology, vol. 112. pp. 47-64
Voordouw, R.J., Gutzmer, J., Beukes, N.J.	Intrusive origin for Upper Group (UG1,UG2) stratiform chromitite seams in the Dwars River are, Bushveld Complex, South Africa: Mineralogy and Petrology, vol. 97, pp.75-94.
Voordouw, R.J., Gutzmer, J., Beukes, N.J.,	Zoning of platinum group mineral assemblages in the UG2 chromitite determined through in situ SEM-EDS-based image analyses: Mineralium Deposita, vol. 45, pp. 147-159
Viljoen, F., Dobbe, R., Smit, B.	Geochemical processes in peridotite xenoliths from the Premier diamond mine, South Africa: Evidence for the depletion and refertilisation of subcratonic lithosphere: Lithos, vol. 112(s2). pp. 1133 – 1142.
Williams, H.M., Nielsen, S.G., Renac, C., Griffin, W.L., O'Reilly, S.Y., McCammon, C.A., Pearson, N., Viljoen, F., Alt, J.C., Halliday, A.N.	Fractionation of oxygen and iron isotopes by partial melting processes: Implications for the interpretation of stable isotope signatures in mafic rocks: Earth and Planetary Science Letters, vol. 283. pp. 156 – 166.

PRINTED CONFERENCE ABSTRACTS

Authors	Title and Conference Information
Beukes, N.J., Gutzmer, J.	Origin and paleoenvironmental significance of major iron formations at the Archean-Paleoproterozoic boundary: *International Geoscience Sympposium: Precambrian World 2009, Geological Society of Japan, Kyushu University, Fukuoka, Japan,*
Beukes, N.J., Gutzmer, J.	Precambrian manganese deposits: Geological setting, metallogenesis and paleoenvironmental implications: Manganese in the Twenty First Century, Short Course Abstract *Volume, Institute for Geochemical Research, Hungarian Academy of Sciences, Veszprem, Hungary, pp.7-18.*
Gröcke, D.R., Rimmer, S.M., Yoksoulian, L.E., Cairncross, B., Tsikos, H., Van Hunen, J.	No evidence for thermogenic methane release in coal from the Karoo-Ferrar large igneous province: *Abstract EGU (European Geosciences Union) General Assembly, Vienna, Austria, vol. 11, pp. 1965*
Gröcke, D.R., Rimmer, S.M., Yoksoulian, L.E., Cairncross, B., Tsikos, H., and van Hunen, J	No evidence for thermogenic methane release in coal from the Karoo-Ferrar large igneous province. Abstract EGU (European Geosciences Union) General Assembly, Vienna, Austria, 2009, Vol. 11, EGU2009-1965.
Gumsley, A., Knoper, M.W., Rajesh, H.M., De Kock, M.O.	Towards establishing a 'bar code' for the southeastern terrane of the Kaapvaal Craton in northern KwaZulu-Natal, South Africa: *Out of Africa: 140 years with Kevin Burke and Lew Ashwal,The University of the Witwatersrand , Johannesburg.*
Gutzmer, J., Beukes, N.J.	The giant Kalahari Manganese Field, South Africa: *Manganese in the Twenty First Century, Short Course Abstract Volume, Institute for Geochemical Research, Hungarian Academy of Sciences, Veszprem, Hungary, pp. 19-28*
McCarthy, T.S., Cawthorn, R.G., Corner, B., Shaw, M., Koll, G., Cooper, G., Lombard, H., Beukes, N.J., Armstrong, R.A., De Waal, L., Comline, S.	The pre-Karoo geology of the southern portion of the Kaapvaal Craton: *Out of Africa: 140 years with Kevin Burke and Lew Ashwal,The University of the Witwatersrand , Johannesburg, pp. 47*
Mouri, H., Rajesh, H.M.	One rock, five events: An example from the Limpopo Belt, South Africa: *PPM Annual Report 2008, pp. 19*
Rajesh, H.M., Gutzmer, J., Bailie, R.	Characterization of altered and unaltered volcanic rocks along the collision zone between a mobile belt and a craton: A southern African scenario: *Proceedings of Precambrian World Symposium.*
Steinhoefel, G., Horn, I., Von Blanckenberg, F., Konhauser, K.O., Beukes, N.J., Gutzmer, J.	Precambrian seawater Fe and Si stable isotope signatures in BIFs revealed by UV femtosecond laser ablation: *Goldschmidt Conference Abstracts 2009, Geochim. Cosmochim. Acta, pp. A1269*
Tripke, C., Strauss, H., Mezger, K., Gutzmer, J., Beukes, N.J.	Spatial and temporal variability of $\gamma^{13}C_{carb}$ and $\gamma^{18}O_{carb}$ of the Voëlwater Subgroup, South Africa: *Goldschmidt Conference Abstracts 2009, Geochim. Cosmochim. Acta, pp. A1347*
Voegelin, A.R., Nagler, T.F., Beukes, N.J.	Mo isotopes in Archean carbonates: Ocean water evolution, atmospheric oxygen and sulfidity levels: *Goldschmidt Conference Abstracts 2009, Geochim. Cosmochim. Acta, pp. A1390*
Zimmermann, U.	Unroofing the Kalahari craton: Provenance data: *Goldschmidt Conference Abstracts 2009, Geochim. Acta, pp. A1536*

CONFERENCE PRESENTATIONS

Name	Title	Conference/Meeting
Beukes, N.J.	Origin and paleoenvironmental significance of major iron formations at the Archean-Paleoproterozoic boundary	Precambrian World 2009, Fukuoka, Japan
Beukes, N.J.	Paleoenvironmental and tectonic controls on formation of giant early Paleoproterozoic BIF and associated iron and manganese deposits in southern Africa	Kyushu University Geology Seminar Series, Fukuoka, Japan
Beukes, N.J.	Origin of sediment-hosted high-grade hematite iron ore deposits	Kyushu University Geology Seminar Series, Fukuoka, Japan
Beukes, N.J.	The nature and origin of major manganese deposits of the world	Kyushu University Geology Seminar Series, Fukuoka, Japan
Beukes, N.J.	Aerobic to anaerobic depositional systems tracts in Archean-Early Paleoproterozoic sediments: Implications for the composition of the early hydrosphere and biosphere	Okayama University Geology Seminar Series, Okayama, Japan
Beukes, N.J.	A critical evaluation of the meaning of the so-called "2,2 Ga Great Oxygenation Event" in Earth history	Institute for the Study of Earth's Interior (ISEI) Research Seminar Series, Misasa, Japan
Beukes, N.J.	Precambrian manganese deposits: Geological setting, metallogenesis and paleoenvironmental significance	International Workshop on "Manganese in the 21st Century", Veszprem, Hungary
Beukes, N.J.	Mn-carbonate concretions in Wiwatersrand-Mozaan strata and implications for the history of oxygenic photosynthesis	PM Annual Research Colloquium, Johannesburg
Beukes, N.J.	Ancient supergene versus hydrothermal origin for the Sishen-type high-grade iron ore deposits	PPM Annual Research Colloquium, Johannesburg
Byeme-Zogo, J.C., Beukes, N.J.	Upgrading potential of discard low-grade hematite iron ore: A case study from the Northern Cape	PPM Annual Research Colloquium, Johannesburg
Cairncross, B.	No evidence for thermogenic methane release in coal from the Karoo-Ferrar igneous province.	Abstract EGU (European Geosciences Union) General Assembly, Vienna, Austria
Cairncross, B.	Who is responsible for South Africa's mineral heritage?	World Heritage and Geotourism Conference, Pretoria
Fourie, P., Beukes, N.J.	Source of Bokkeveld zircons and their paleogeographic implications	PPM Annual Research Colloquium, Johannesburg
Greeff, C., Knoper, M.W.	MLA study of PGM in the Merensky Reef, Marikana (Lonmin)	Lonmin Collaborators Workshop, Marikana

Name	Title	Conference/Meeting
Gumsley, A.P., Knoper, M.W.	Towards establishing a 'bar code' for the southeastern terrane of the Kaapvaal Craton in northern KwaZulu-Natal, South Africa	Out of Africa Conference, University of Witwatersrand, Johannesburg
Gutzmer, J., Beukes, N.J.	The giant Kalahari Manganese Field	International Workshop on "Manganese in the 21st Century", Veszprem, Hungary
Guy, B., Beukes, N.J.	Mineral chemistry and genesis of Witwatersrand pyrites	PPM Annual Research Colloquium, Johannesburg
Knoper, M.W.	Geology of the Steenkampskraal ore body	PPM Annual Research Colloquium, Johannesburg
Knoper, M.W.	Monazite as a natural waste form: a natural example from Steenkampskraal	MINSA Symposium (Exxaro), Pretoria
Knoper, M.W.	Monazite as a natural waste form: a natural example from Steenkampskraal	PPM Annual Research Colloquium, Johannesburg
Knoper, M.W.	Namaqualand (South Africa): a Mesoproterozoic core complex?	Univ of Arizona Geology Seminar, Tucson
Kramers, J.D.	Lessons from failed experiments on the U-Pb dating of fossils	Goldschmidt Conference on Geochemistry, Davos, Switzerland
Kramers, J.D.	Is the D" layer a very early sunken mafic crust? problems solved and new ones created.	"Out of Africa" Symposium in honour of Profs.Kevin Burke and Lew Ashwal. University of Witwatersrand, Johannesburg
McClung, C., Beukes, N.J.	A unified stratigraphy for the Bushmanland succession, Northern Cape	PPM Annual Research Colloquium, Johannesburg
Smith, A.J.B.	In-situ experiences on a Field Emission Mineral Liberation Analyser.	Mineral Liberation Analyser User Group Meeting, Toronto, Canada
Smith, A.J.B.	Ysterryke sedimentêre gesteentes in die 2.9 biljoen jaar oue Witwatersrand-Mozaan opeenvolging: Implikasies vir vroeë afsettingsomgewings op Aarde	Suid-Afrikaanse Akademie vir Wetenskap en Kuns Studentesimposium 2009, Bloemfontein

Name	Title	Conference/Meeting
Smith, A.J.B.	Iron-rich sedimentary rocks in the Mesoarchean Witwatersrand-Mozaan succession: Implications for paleodepositional conditions on Earth	PPM Annual Research Colloquium, Johannesburg
Viljoen, K.S.	In-situ experiences on a field-emission Mineral Liberation Analyser	Auto-SEM Users Meeting, Mintek, Johannesburg
Viljoen, K.S.	An introduction to kimberlites and diamonds	Anglo Research staff training, Anglo Research Labs
Viljoen, K.S.	Application of the Mineral Liberation Analyser to Geometallurgy	Lonmin Collaborators Workshop, Marikana
Viljoen, K.S.	Trace element chemistry of mineral inclusions in eclogitic diamonds from the Premier and Finsch kimberlites, South Africa	Mineralogical Society of South Africa Symposium, Exxaro Head Office Pretoria
Viljoen, K.S.	Automated mineralogy as applied to geometallurgy	PPM Annual Research Colloquium, Johannesburg
Voordouw, R., Beukes, N.J.	The intrusive nature of UG1 and UG2 chromitites and economic implications	PPM Annual Research Colloquium, Johannesburg

ANNUAL RESEARCH COLLOQUIUM

University of Johannesburg
Department of Geology
PALEOPROTEROZOIC MINERALIZATION RESEARCH GROUP

Venue The University of Johannesburg Hotel School, Kerzner Building, Bunting Road Campus, Auckland Park

Date Wednesday 3rd November 2010

Time 13h00 – 20h00

The Paleoproterozoic Mineralization Research Group (PPM) in the Department of Geology at the University of Johannesburg, Department of Geology was formed in 1997. At present (2010), research involves twelve academic staff members, two post-doctoral researchers, nine PhD and 18 MSc students.

The PPM research group receives funding from South Africa's mineral industry, the National Research Foundation and Research Grants provided by the University of Johannesburg.

THE OBJECTIVES OF PPM INCLUDE:

- To study and model the relationship between environmental change and styles of mineralization in the Precambrian, with a specific focus on the Paleoproterozoic Era.
- To apply the knowledge for evaluating the mineral exploration and beneficiation potential of that era (1.6 - 2.5 billion years ago) on a global scale.
- To ensure a competitive edge for industrial partners in global mineral exploration and acquisition markets by studying the temporal and spatial distribution, composition, and origin of mineral deposits, on local and regional scale.
- To train postgraduate students in the fields of especially, but not exclusively, Economic Geology and Geometallurgy.

PURPOSE OF THE COLLOQUIUM

The research colloquium is aimed to present major findings of different research focus areas of PPM to professionals from the industrial and academic environment as well as current and prospective post-graduate students. Attendance is free of charge but booking is essential. More information can be obtained from **Michael Chakuparira (email: michaelc@uj.ac.za; tel 011-559-4715)**

PPM ANNUAL RESEARCH COLLOQUIUM PROVISIONAL PROGRAMME

Date: Wednesday, 3rd November 2010
Place: Hotel School, University of Johannesburg
Time: 13h00-20h00

13.00 - 13.30	Registration, Tea & Coffee	
13.30 - 13.35	Opening Remarks	Fanus Viljoen
13.35 - 13.55	Geochemistry of ~2.4 Ga Koegas iron formation and implications for oceanic environments at the time	Brian Nel and Nic Beukes
13.55 - 14.15	Iron formations and magnetite ore bodies of the Aggeneys area	Fanie Kruger and Nic Beukes
14.15 - 14.35	Detrital zircon age populations in Gamagara/Mapedi, Lucknow and Volop red beds: implications for the timing of development of high-grade Sishen-type iron ore in Griqualand West	Richard da Silva, Daphne Dreyer and Clarissa Vorster
14.35 - 14.55	New SHRIMP titanite ages for mafic intrusives at the Sishen and Thabazimbi iron ore mines	Benny Chisonga and HM Rajesh
14.55 - 15.15	Cryptic and modal variation of the Merensky Reef, Bushveld Complex	Derek Rose and Mike Knoper
15.15 - 15.35	A mineralogical investigation of Lonmin's Akanani platinum group metal project	Frits van der Merwe and Fanus Viljoen
15.35 - 15.55	Tea	
15.55 - 16.15	Modelling of diamond precipitation from fluids in the Earth's mantle	Alexandra Crossingham and Fanus Viljoen
16.15 - 16.35	Geochemistry of a gold-bearing alteration zone in the Witwatersrand succession	Louis Cloete
16.35 - 16.55	A mineralogical assessment of the Gamsberg zinc deposit	Craig McClung
16.55 - 17.15	Kamafugites of the Muko volcanoe, Uganda	Mike de Villiers and HM Rajesh
17.15 - 17.35	A geometallurgical assessment of the geological and mineralogical influences on plant performance at the Nkomati Nickel mine, Mpumalanga	Gargi Mishra and Fanus Viljoen
17.35 - 17.55	Mass-independent sulpher isotope fractionation in the Witwatersrand succession	Bradley Guy
17.55 - 18.05	Closing remarks	Axel Hoffman
18.05 -	Wine and Snacks	

SPECTRAU

MLA

Cameca Microprobe

Ar/Ar Lab

Paleomaglab

SPECTRAU, the Central Analyrtical Facility of the Faculty of Science at UJ, was established in 1999 as a one-stop state-of-the-art facility that is managed and staffed to ensure an accessible analytical service not only for UJ staff and students but also for outside clients.

SPECTRAU operates 24hrs per day and offers wide and comprehensive solutions for a broad range of applications utilizing modern high-tech equipment that include a PANalytical X'Pert Pro XRD, PANalytical Magix Pro XRF, a Jeol 733 microprobe, a Jeol 5600 SEM, two ThermoFisher X-SeriesII ICP-MS's, a Spectro ARCOS ICP-OES, a SHIMADZU QP2010 GC-MS, a Metter Toledo DSC 822e DSC, a Varian Unity Inova NMR system, a ThermoFisher DFS (High resolution GC-MS), a ABI 3130xl genetic znalyser, a BD FACSAria flow cytometer as well as Zeiss Axioplan 2 compound and Zeiss Discovery stereo microscopes.

SPECIALIZED GEOSCIENCE APPLICATIONS AT SPECTRAU

Apart from the more general instrumentation at Spectrau mentioned above, it also houses five facilities geared rather specifically to Geoscience applications and the needs of PPM. **Two of these represent unique African facilities with another a unique African university-housed facility. They are:**

- A MAP-215 noble gas mass spectrometer with both infrared and ultraviolet lasers. This instrument will be utilized for Ar-Ar geochronology as well as research into other isotopic systems. It is a unique African facility.
- A fully functional paleomagnetic laboratory, unique in Africa, which has recently been upgraded with a fully automated snake chain sample changing system and a state of the art SQUID magnetometer. This will allow for rapid and much more efficient measurement of samples for paleomagnetic studies.
- Two MLA's (Mineral Liberation Analysers), the one being an older generation FEI XL-40 and the other a state of the art FEI 600F field emission system. These instruments are extensively used in research in the field of geometallurgy and are the only ones housed at a University in Africa.
- A New-Wave UP-213 Nd:YAG laser permanently connected to the one ThermoFisher X-SeriesII ICP-MS which is dedicated for laser ablation studies, especially for the age determination of detrital zircons.
- A new Cameca SX-100 electron microprobe equipped with 3 wavelength dispersive detectors and one energy dispersive detector making it ideal for in-situ chemical analysis of minerals.

For further information and cost of services please contact:
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