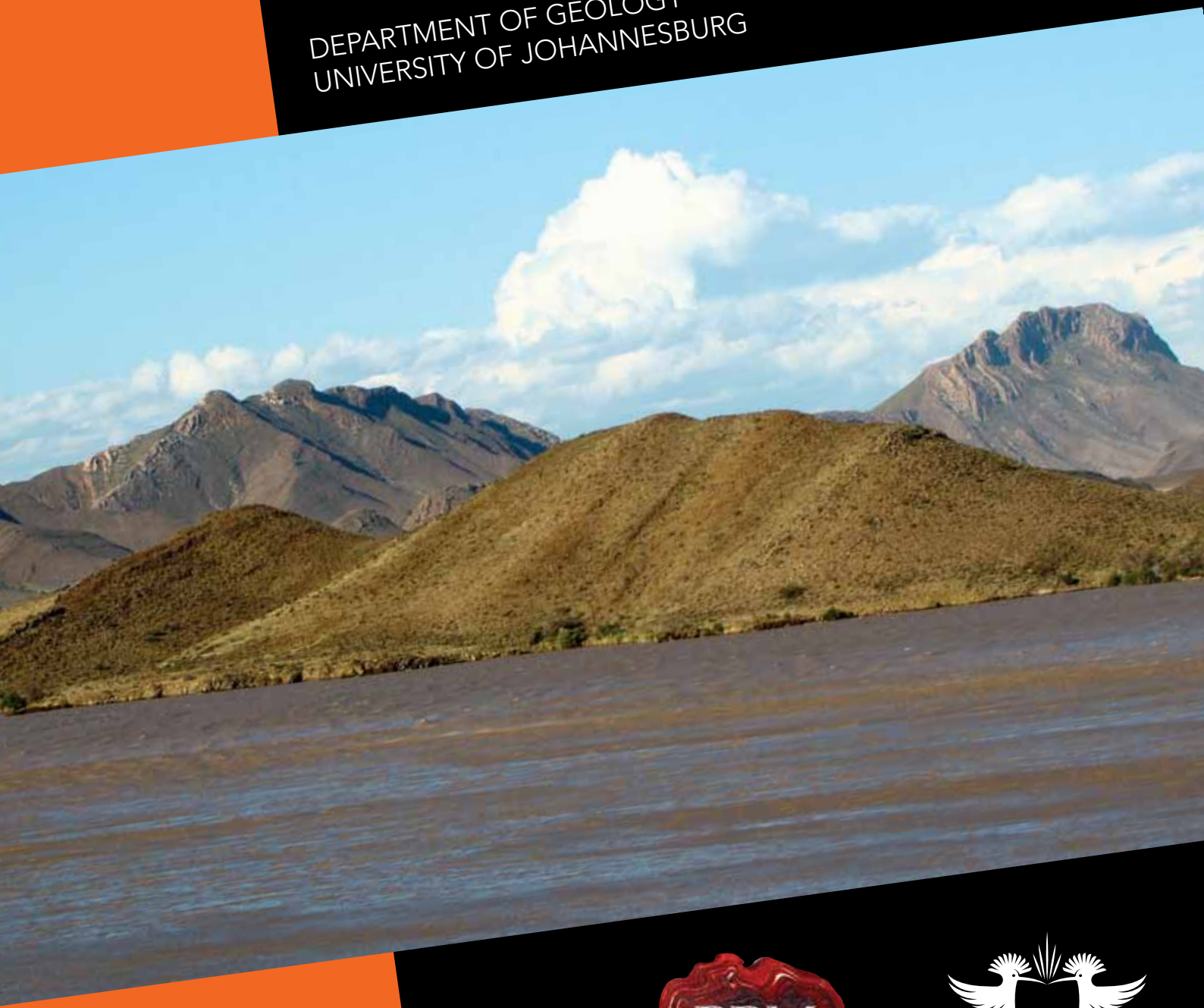
PPM Annual Report 2010

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 HM Rajesh and Nic Beukes. Layout and design by HM Rajesh and the UJ Graphic Studio.

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Please direct all enquiries and applications for research to:
Prof. Nic Beukes or Prof. Fanus Viljoen
PPM, Department of Geology
University of Johannesburg
Auckland Park Kingsway Campus
PO Box 524, Auckland Park 2006
Johannesburg, South Africa
E-mail: nbeukes@uj.ac.za or fanusv@uj.ac.za
Tel: +27 (0) 11 559 4712/4710/4711
Fax: +27 (0) 11 559 4702
http://www.uj.ac.za/geology

Cover photo: View of the Bokkeveld (in foreground) and Witteberg strata of the Cape Supergroup at Gamkapoort Dam, Western Cape Province

INTRODUCTION

The PPM Research Group, formed in 1997 as an informal research group in the Department of Geology, has for the past four years been officially recognized by Management of the University of Johannesburg as one of the Research Centres of Excellence at the University. This meant that PPM received an annual research grant from the University Research Committee to strengthen the group especially with respect to funding salaries of support staff and providing additional bursary support to postgraduates and postdoctoral associates. A review of the research centres took place during 2010 and PPM was in the fortunate position to be awarded support funding for another three-years from 2011 to 2013, after which outputs shall again be reviewed. As part of the additional support from UJ we were able to appoint several new postdoctoral fellows in PPM. The funds also made provision for appointment of Profs Jan Kramers and Nic Beukes (who officially retired at end of 2010) on contract basis for another three years.

Axel Hoffman joined the Department of Geology and PPM during August 2010. With this appointment the PPM Research Group further strengthened the research niche into the field of early Precambrian environments, especially origin of early life. Geometallurgy figured prominently in the research topics initiated by new students. New research projects were launched on the characterization of strategic minerals – PGE- and REE-bearing minerals. Prof. Nic Beukes again received an A1 rating from NRF for another five year cycle that started in January 2010.

During 2010, 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). In addition Prof Bruce Cairncross continued work on geoheritage research.

PPM Research Group (2010) 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. Axel Hoffmann, 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
Ms. G Mishra
Ms. S Mkhatshwa
Ms. L Mngoma
Dr. C McClung
Mr. D Pretorius
Dr. B Richards
Mr. D Rose
Mr. F van der Merwe

Metalliferous Mineral Deposits

Team Members
Mr. B Chisonga
Mr. F Kruger
Mr. T Mabundza
Mr. B Nel
Mr. K Osburn
Mr. JC Beyeme-Zogo

Paleomagnetism, Provenance Studies

Team Members
Mr. R da Silva
Ms. D Dreyer
Mr. P Fourie
Ms. M Peche
Ms. C Vorster
Mr. H Wabo

Coal Geology

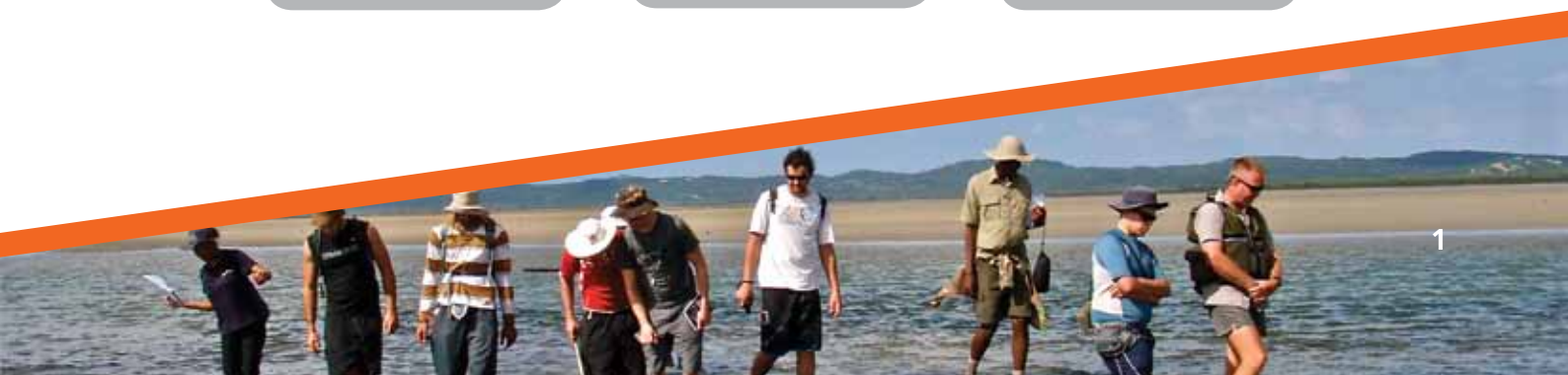
Team Members
Dr. H Tsikos (Rhodes)
Mr. P Meyer
Mr. B van der Walt

Early Precambrian Environments

Team Members
Mr. GA Belyanin
Mr. A Gumsley
Mr. B Guy
Mr. M Watts

Technical Support Staff

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



PPM group members in the meeting room of the Geology Department

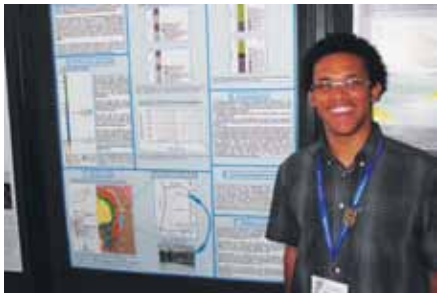
RESEARCH PROGRESS AND HIGHLIGHTS

Growth in geometallurgical research at the University of Johannesburg

As the world demand for metals increases, the focus changes to lower-grade or problematic deposits that would not have been mined in the past. Without a thorough understanding of the mineralogical constraints (i.e. variations in mineral compositions, size, morphology, mineralogical associations, impact of grind size on liberation and the reason for deportment of minerals in certain streams) interpretation of metallurgical test work could be flawed. This highlights the necessity for conducting in-depth mineralogical, petrographical and mineral chemical investigations in order to obtain a better understanding of the metallurgical behaviour imparted by these ores.

The primary thrust of the geometallurgy group 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. Research is focused on the characterisation of platinum-group element mineralisation within the Merensky Reef and the Plat Reef of the Bushveld complex, utilising mineralogical and geochemical techniques such as X-ray diffraction analysis, scanning electron microscope-based automated mineralogy, and electron microprobe analysis. Research into automated mineralogy as applied to the characterisation of ores and ore bodies is conducted on a 'state-of-the-art' FEI 600F Mineral Liberation Analyser at UJ. An example is the determination of the mineralogy of various ores of the platinum-group elements, along with associated silicate, oxide and sulphide minerals, in relation to metallurgical issues during the recovery of platinum-group elements. Research is also focussed on geometallurgical aspects of gold, diamond, nickel, the base metals (copper-lead-zinc), coal and lime, with a view on the optimisation of treatment plants and optimised metal recovery.

During 2010 papers were presented by Geometallurgy students and staff at the Geological Society of America Meeting in Denver, Colorado, the Society of Economic Geologists Conference in Keystone, USA, the International Mineralogical Association Conference in Budapest, Hungary, and the Process Mineralogy 2010 Conference in Cape Town. Five MSc projects, six PhD projects, and one post-doctoral project is currently in progress.



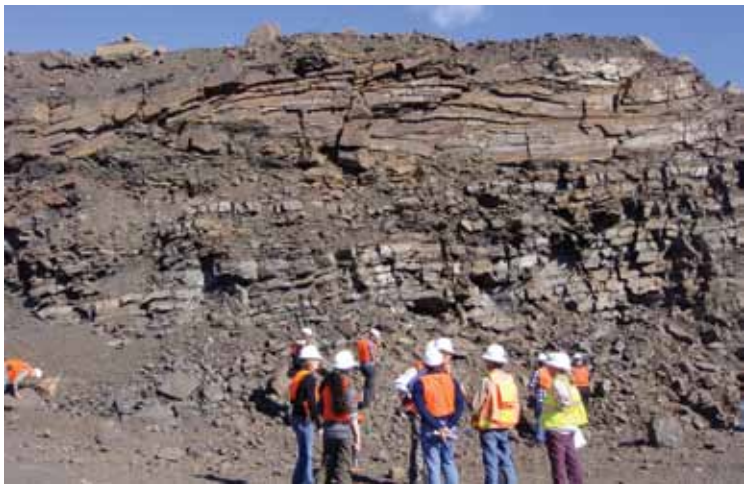
Some of the geometallurgy group members at the IMA meeting in Budapest, Hungary

Metalliferous mineral deposits

Research on the iron ore potential of the Asbestos Hills region in Griqualand West continued during 2010. The main aim of this project is to establish the high-grade iron ore potential of the region outside of the area of the known high-grade BIF-hosted hematite iron ore deposits of the Sishen-type on the Maremane Dome. In addition research is also undertaken on low-grade iron ores and banded iron formation of the region to establish their potential for beneficiation to saleable iron ore products. Another project aims at characterizing high-grade small magnetite ore bodies and associated supergene-modified hematite ore bodies in the Mesoproterozoic Gams Formation of the Bushmanland succession in the Namaqua Metamorphic Belt.

During 2010 we took part in presentation of three workshops on banded iron formation and associated iron ores. The first was at PDAC in Toronto, Canada during March 2010 where Jens Gutzmer, Joydip Mukhopadhyay and Nic Beukes presented talks on the iron ores of southern Africa and India as well as models for the origin of high-grade BIF-hosted iron ores in general worldwide. The second workshop took place at the University of Minnesota in Duluth during October 2010. It was the Fourth Professional Workshop organized by Precambrian Research Center of the University of Minnesoata in Duluth and focused on BIF and associated ore deposits. As one of the invited lecturers Nic Beukes presented a seminar on BIF-hosted manganese and high-grade iron ores deposits. The third workshop, co-organized by the Universities of Brasilia and the Federal University of Ceara, was held in Fortaleza, Brazil towards the end of November 2010. The main presenters at the workshop were Michael Bau from Jacobs University in Germany and Nic Beukes. Michael Bau was responsible for presenting geochemical aspects of iron formations while Nic presented two afternoon lecture series on the sedimentology of iron formations, high-grade iron ore deposits and the classification, nature, origin and paleoenvironmental significance of Precambrian manganese deposits. The workshop was followed by a weeklong field trip to Archean and Proterozoic iron formations and associated rocks to the southeast of Fortaleza.

Nic Beukes with students and staff of the Universities of Brasilia and Ceara that attended a field excursion to iron formations southeast of Fortaleza in Brazil. Co-presenter of the workshop, Michael Bau, is in the back row second from right



Delegates of the Duluth BIF Workshop workshop looking at what appears to be a channel-fill of granular iron formation in banded lutitic iron formation at one of the iron ore mines in the Mesabi Range, Minnesota

Developments in Geoheritage

Recent developments in geoheritage research can be summarized by the question - why publicize South Africa's mineral heritage? It is non-renewable, it has scientific value (type-locality species, parageneses, geometallurgical value), it has beauty and diversity and mineral collections can be draw-cards at museums. Bruce Cairncross points out that rare geological specimens, considered as portable geoheritage specimens, are neither defined nor described in the National Heritage Resource Act (1999), making their geoheritage status questionable. He further points out that geological specimens (resources) are complex objects when defining their rarity status and multiple rarity factors can apply to single specimens. A lack of clear criteria for defining rare geological specimens appears to place the National Heritage Resource Act (1999) in direct conflict with the more recent Mineral and Petroleum Resources Development Act (2002) which legitimizes the legal exploitation of any mineral resource.

Bruce Cairncross underground in the N'Chwaning II manganese mine, Kalahari manganese field (left). Rhodochrosite specimens from the Kalahari manganese field - the front left stone is 17.5 carats (photograph by Bruce Cairncross)

Contribution to SEG Student Chapter

Ashley Gumsley, a Masters student in PPM was voted Chairman of the SASC-SEG (South African Student Chapter for the Society of Economic Geologists) for 2010. The membership consists mainly of geology students from the University of Johannesburg and the University of the Witwatersrand. During his tenure as Chairman, Ashley was selected by the Society of Economic Geologists (SEG) to participate in the annual SEG Foundation Student-Dedicated Field Trip Course across the western United States, entitled: 'Ore Deposits of Utah and Colorado'. The field course emphasized the geology and ore deposits of the Tintic Mining District in the basin-and-range of Utah and included the Bingham Canyon copper-molybdenum-gold porphyry mine. The uranium-vanadium-copper roll-front deposits of the San Rafaél Swell district were also viewed together with the stratigraphy of the Colorado Plateau.

Bingham Canyon Cu-Mo-Au porphyry mine, the world's largest man-made excavation (left). Ashley on the Colorado plateau with the San Rafaél reef in the background (right)

Developments in the noble gas laboratory at UJ

Jan Kramers

The MAP 215 noble gas mass spectrometer and extraction line with 1064 nm continuous Nd-YAG laser became operational in July 2010 following minor repairs and alignment of the laser. George Belyanin has joined this laboratory as a postdoc following submission of his PhD thesis. The first batch of samples for Ar/Ar dating, comprising amphibole and stilpnomelane separates mainly from the western Transvaal Supergroup and the Central Zone of the Limpopo Belt, is about to be dispatched to Pelindaba for irradiation. We have carried out degassing experiments on unirradiated grains of these minerals to evaluate whether they would be datable, to chart step-heating degassing behavior and plan optimal analytical protocols for when the irradiated samples are returned for dating.

In addition to preparation for the Ar/Ar dating application, the unit has been further developed to enable U-Th-He dating. This method is normally applied to low-temperature thermo chronology using apatite, but our intention is to use it for dating of soil authigenic minerals such as components of ferricrete, and speleothems. This is a pioneering approach, and will be applied in geomorphological studies as well as in the dating of hominin fossil-bearing cave deposits. The extreme sensitivity of the instrument and low blank of the line allows very small quantities of radiogenic He to be accurately measured. This will enable dating of relatively young (a few Ma) mineral grains containing moderate amounts (around 1 ppm) of U and/or Th. Following published reports that aragonite, hematite and goethite are retentive for He at ambient temperatures, experiments were carried out which demonstrated that samples of these minerals would most probably be datable down to a few hundreds of thousands years – thus bridging the gap between geochronometers of the geological time scale such as Ar/Ar and U-Pb, and the ones applicable to the archaeological time scale, such as U/Th, OSL, and 14C dating. Two projects, one in cave dating and one in landscape evolution, are currently being initiated.

The extension to U-Th-He dating has entailed developments on the extraction line. Of the twin, originally identical laser ports, one was equipped with a sapphire window (impermeable to He) and a liquid nitrogen cold trap containing activated charcoal granules, to be dedicated to He extraction, whereas the second remained unmodified, with a quartz window, and dedicated to Ar extraction. Further, a 3He spike reservoir is being added. The 3He tracer and a calibrated volume vacuum pipette were donated by the noble gas laboratory of the University of Heidelberg, Germany.

Further, a completely new software suite is being written to operate the mass spectrometer and reduce the data. This was necessary because the existing software was unable to stabilize the magnetic field at low masses such as required for helium, and desirable from the point of view of having a more interactive and experiment-oriented environment.

Jan Kramers, Mike Knoper and post-graduate students at the Ar-Ar facility

Field excursion through southwestern US examining different extensional geologic features

Mike Knoper

Mineralization is often associated with crustal extension. A very well exposed region to study features associated with crustal extension is the Basin and Range Province, a broad continental rift that has stretched the crust to twice its original width, in southwestern North America. There extension began after the Laramide Orogeny during the Tertiary and as the San Andreas Fault (in California) developed, with extension continuing up to the present day. Associated with extension of the Basin and Range Province is the Rio Grande Rift, numerous core complexes, sedimentation, and bi-modal volcanism.

With this background in mind, four members of the PPM Research Group arrived in the United States to attend the annual Geological Society of America (GSA) meeting held in Denver. Before commencement of the GSA annual meeting, the four PPM members met in Socorro, New Mexico. Starting there, Mike Knoper, Craig McClung, Bryony Richards, and Ashley Gumsley spent five days on a field excursion through the southwestern United States. The purpose of the excursion was to examine features associated with extension in New Mexico and Arizona; specifically the Rio Grande Rift (located in New Mexico), the Rincon Core Complex (outside Tucson, Arizona), and the Buckskin-Rawhide detachment fault (located in western Arizona).

One of the first stops was to examine the Carrizozo basalt flow near Carrizozo, New Mexico. This is one of the youngest basalt flows in the Basin and Range Province, and erupted from numerous vents during the Holocene at different times between 5,000 and 1,500 years ago. The basalt flow examined during the field excursion was a well preserved example of pahoehoe lava (see figure). The next stop was White Sands National Monument in New Mexico. Here gypsum that has precipitated in the many salt pans found in half grabens is accumulating as wind-blown sand dunes. Shortly before the visit, precipitation associated with cold front had ponded in many areas in the Monument, which provided a spectacular backdrop of distinct white dunes (see figure).

White sand gypsum dunes at the White Sands National Monument in New Mexico

The group then carried on to Tucson where they arrived in the late evening. On the following day, the Rincon Core Complex was next on the itinerary. The purpose of visiting this locality was to gain a clear understanding of the fundamental components of metamorphic core complexes. From bottom to top, first seen was mylonite and ultramylonite derived from quartz monzonite, chloritically altered microbrecciated mylonite gneiss, fine-grained microbreccia, and then the detachment fault itself, and finally the overlying non-mylonitic and non-cataclastic rocks. Continuing with the core complex theme, the group travelled to Swansea, an old ghost town located in the western Arizona desert. Here, copper mineralization is thought to be associated with fluid activity on the Buckskin-Rawhide detachment fault, which is associated with a number of metamorphic core complexes just west of the Colorado River. Many of the features found in the Rincon Core Complex were also identified in the footwall of the Buckskin-Rawhide detachment fault, except the latter feature includes copper mineralization and abundant specular hematite. After spending a day in Swansea, the group continued to the GSA annual meeting in Denver, with stops along the way at the Grand Canyon and at the Black Canyon of the Gunnis.

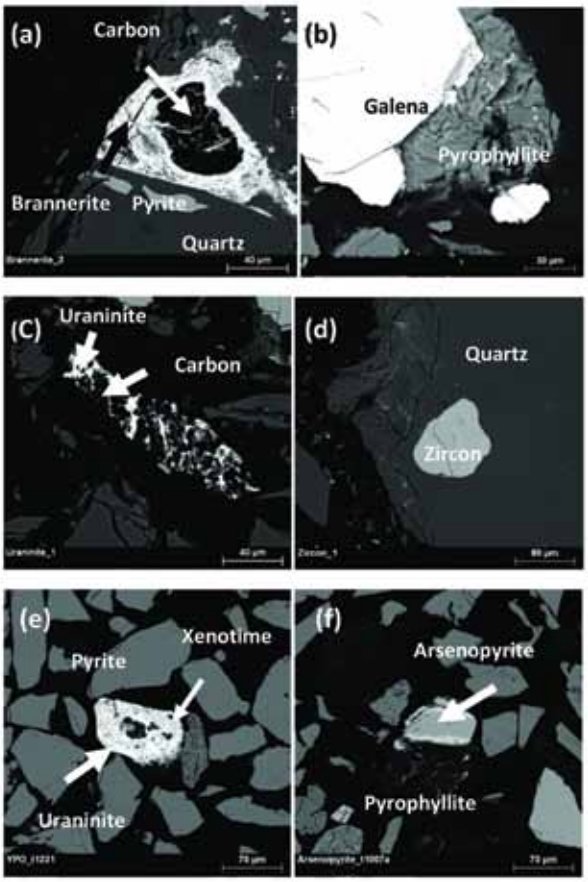
HIGHLIGHTS OF RESEARCH FOCUS AREAS

MLA based assessment of mineralogical variability of the UE1A, A1 and A5 reefs at Cooke Section, Rand Uranium properties

Sindile Mkhatshwa

One of the challenges faced by Rand Uranium Gold Mines in the Cooke section area, is the difficulty in differentiating between the various reef types by means of their macroscopic characteristics. It is virtually impossible to differentiate between the various reefs visually; hence a study based on the use of mineral liberation analyser (MLA)-based automated mineralogy was carried out to distinguish between the various reefs and to assess the mineralogical variation within the reefs and within the region. A total of 133 reef samples, consisting of the Elsburg UE1A, A1 and A5 reefs have been obtained from Cooke 2 and 3 (two of the three Rand Uranium Mines) using the conventional chip sampling method.

The mineralization in this area is hosted by the upper (dominantly alluvial quartzite-rich) Central Rand Group of the Witwatersrand Supergroup. The main orebodies that are exploited at the mines occur within the Gemsbokfontein Member of the Elsburg Formation. These orebodies have been deformed into an east-west trending anticline at Cooke 3. The present study also attempts to prove or disprove the equivalence of the UE1A reef on the western limb of the anticline to the A1 or A5 reefs on the eastern limb of the anticline using mineralogy.

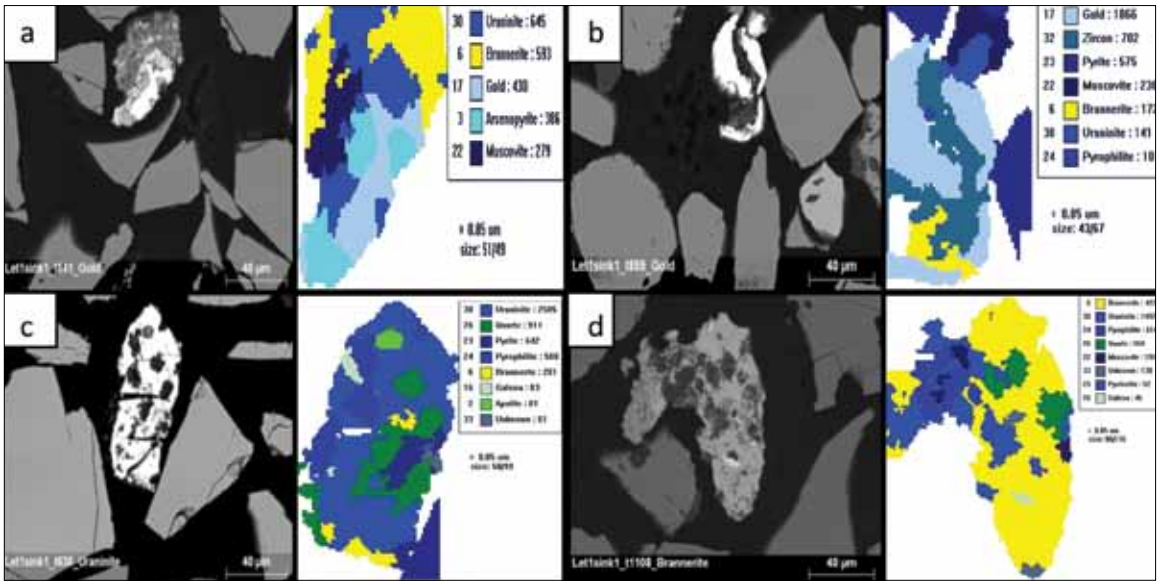


Backscatter electron images of (a) flyspeck-carbon enclosed by brannerite, (b) galena associated with pyrophyllite, (c) uraninite occurring with carbon, (d) zircon associated with quartz, (e) uraninite in association with xenotime and pyrite and (f) pyrophyllite associated with arsenopyrite and brannerite

Representative splits of the samples were subjected to mineralogical abundance quantification as possible through quantitative MLA-based modal abundance protocols such as XMOD. A standard file on the various mineralogical phases encountered, was created on the 600F MLA and complemented by quantitative XRD data. Mineral abundances were quantified by MLA, which works by backscatter electron (BSE) images and energy dispersive spectrometry (EDS) analysis, using sophisticated automated image analysis techniques. The various phases are distinguished from each other through their grey-level variations within BSE images (as grey-level is a reflection of the mean atomic number of the respective phase). Thirty two minerals have been detected using the MLA and they include phases such as quartz, pyrophyllite, chlorite, brannerite and pyrite.

MLA based mineralogical assessment of gold and uranium mineralization at Cooke Section, Rand Uranium properties

Lethuxolo Mngoma



Backscatter electron image and segmented particle image from the MLA indicating mineral associations for the phases of interest gold (a, and b), uraninite (c) and brannerite (d)

The use of automated quantitative mineralogical (MLA) techniques has become increasingly important for minerals processing, recovery and geometallurgy as a whole. The speed and accuracy with which these SEM-based automated technologies perform, has meant that the time and costs of analysis are greatly minimised. An MLA-based study has been employed for the assessment of gold and uranium mineralisation on the gold-and uranium-bearing reefs of the upper Witwatersrand Supergroup in a deportment study.

In the sampling phase, the UE1a, A5 and A1 reefs were sampled from Rand Uranium's Cooke 3 Shaft. From the twelve sampled panels, four were chosen for the deportment study. The four chosen panels were deemed to be representative of the mined reefs. These samples were milled and crushed down to 80% passing 75 µm. Some of the samples were taken in for grade analysis in the various size fractions and some were taken in for heavy liquid separation, in which the slimes, sinks and floats were analysed. From the information gained from the assaying, 30mm flat resin mounts (polished blocks) were made. These blocks were of the sinks and from the pulp or feed material.

Two types of searches were conducted, a sparse phase liberation (SPL) search on the gold and uranium species, and given the abundance of the uranium species, it was advisable to run the XBSE mode which is ideal for investigating the pulp feed. The blocks were run at a 350 x magnification on both the SPL_lite and XBSE modes. The following was observed: As expected gold was present along with two uranium species, brannerite and uraninite (see figure). From the modal abundance one was able to gather that these minerals are associated with pyrite (which accounts for more 75% of the mineralogy in the sinks for all four samples), arsenopyrite, heavy minerals, quartz, and other silicates. Other data gained from the analyses were, for example, information on the size frequency distributions and mineral grade recovery. Grading analysis indicate that gold is mainly coarse (>+75 µm) in all the samples. The inverse was noted for uranium minerals, these were found mainly in the finer fractions (<+53 µm). Mineral liberation data indicates that only 17% of the brannerite, 27% of the uraninite and 50% of the gold is liberated. This implies that the majority of the mineral grains are locked in the sulphides which account for a large fraction of the observed mineralogy.

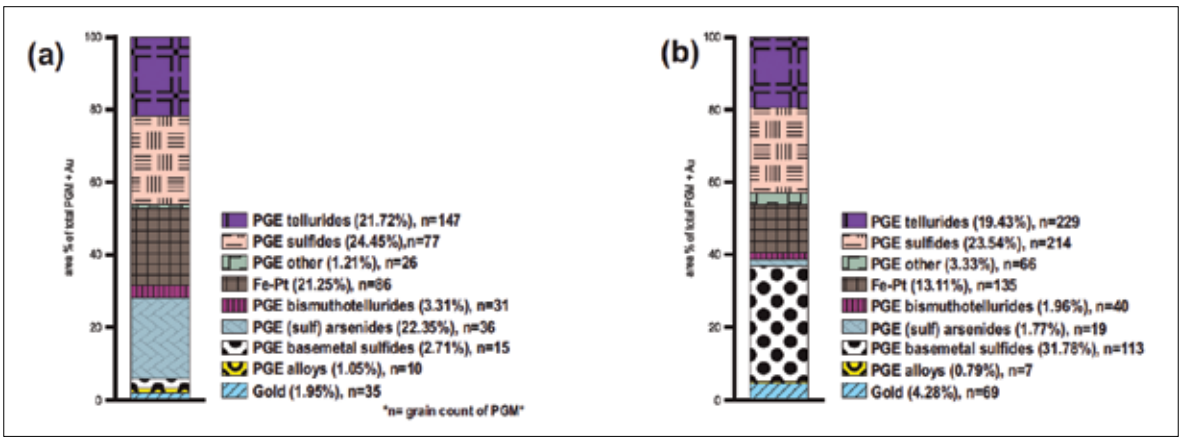
Silicate and platinum group mineral characterization of chromitite stringers from the Merensky Reef, Two Rivers Platinum Mine

Derek Rose

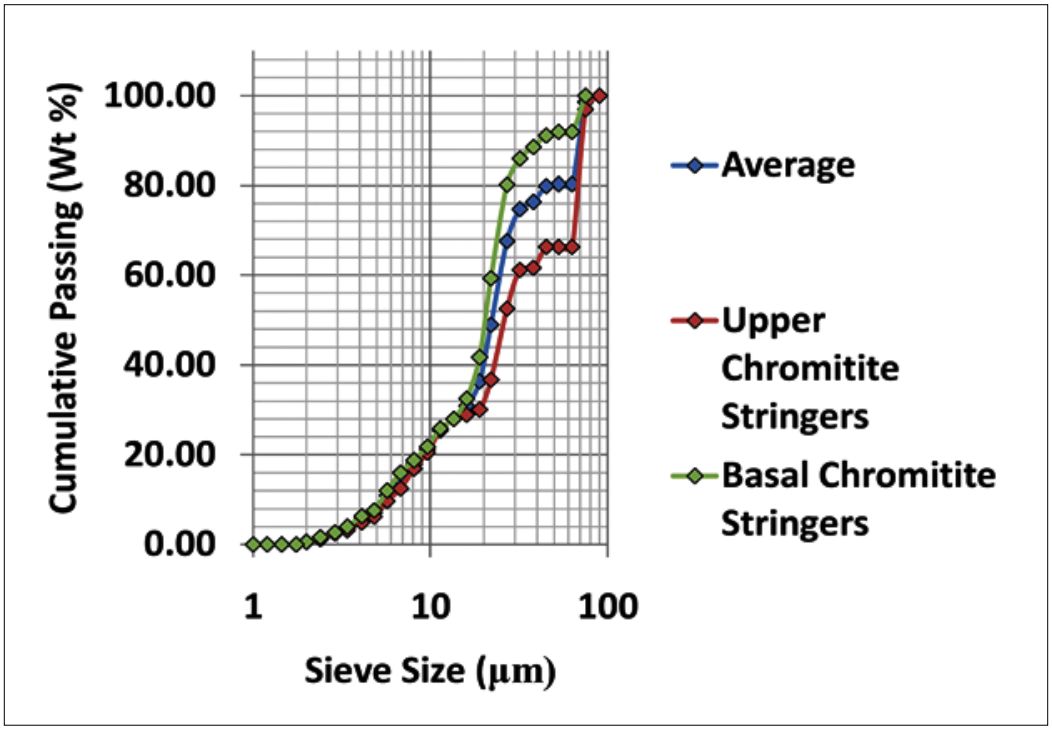
This study focuses on the Merensky Reef (MR) at the Two Rivers Platinum Mine property on the farm Dwarsriver 372 KT, in the southern sector of the Eastern limb of the Bushveld Complex. The cryptic variation of orthopyroxene, plagioclase and chromite, from five exploratory drill core intersections through the Merensky Reef at Dwarsriver are described in this study. Locally the vertical cryptic variation of these minerals is broadly consistent with regional trends of the Rustenburg Layered Suite (RLS).

The lateral variation along strike is less pronounced than the vertical cryptic variation. However, locally these minerals appear to be chemically evolving moving from north to south on the property. Footwall orthopyroxene compositions vary from a minimum of En66 and reach a maximum of En84. Those of the Merensky Reef range from En71 to En85. Hanging wall orthopyroxene compositions range from En60 to a maximum of En80. Plagioclase compositions in the footwall units range from a minimum of An69 and reach a maximum of An85. Those of the Merensky Reef range from a minimum of An35 to a maximum of An84. This wide range in plagioclase compositions is believed to be as a result of the increased presence of fluids within the Merensky Reef interval. The hanging wall plagioclase compositions range from An64 to An84.

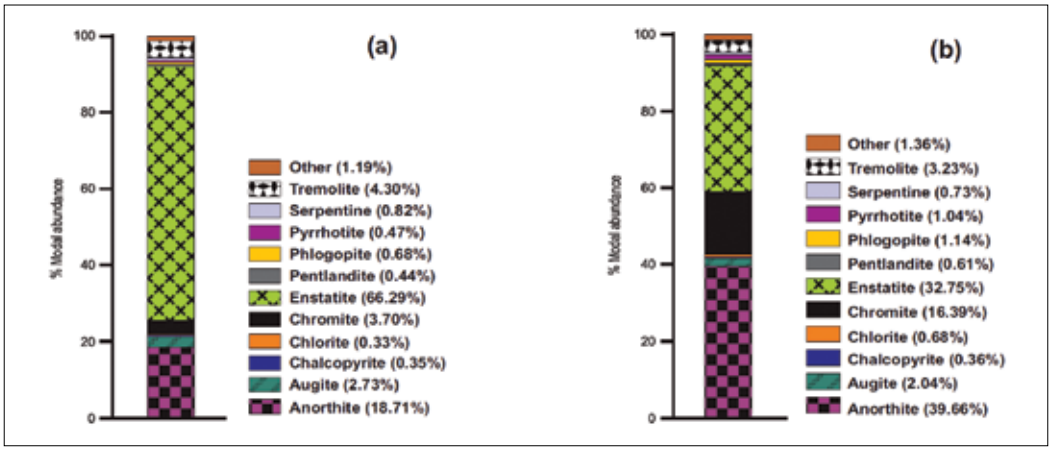
In situ platinum-group mineral (PGM) assemblages associated with and adjacent to the Merensky Reef chromitite stringers were evaluated using an MLA. Data obtained from this technique is in broad agreement with regional studies of the Merensky Reef. With the aid of whole rock platinum-group element (PGE) assays the MLA technique has proven to be a powerful tool in evaluating PGM assemblages relatively quickly, from a few carefully selected samples. The mineralogical associations of PGM with the gangue and host minerals have shown three main associations, namely with chromite, base metal sulfide (BMS) and silicates. Finding of the BMS association is remarkable given that the sulfide have a relatively low modal abundance. The relatively high mineralogical association of the BMS with PGM has been explained by a model involving a base metal sulfide liquid which possibly scavenged chalcophile and siderophile elements. Chromite chemistry and modal analyses of Merensky Reef secondary silicate phases, which peak adjacent to the chromitite stringers, suggests elevated fluid overprinting within and adjacent to the chromitite stringers. However, the upper chromitite stringers have higher abundances of PGM phases that are believed to be secondary in origin (see figure) relative to the basal chromitite stringers. Generally the PGM associated with the upper chromitite stringers are also larger in size (see figure) averaging 70 µm as opposed to 27 µm for those associated with the basal chromitite stringers. The increase in grain size of the PGM along with the higher modal abundance of secondary PGM phases associated with the upper stringers (see figure) is believed to be as a result of fluids. These fluids, although affecting both the upper and basal chromitite stringers, appear to have had a relatively higher influence on the upper chromitite stringers. The most common PGMs encountered in this study are isoferroplatinum, sperrylite, michenerite, maslovite, cooperate, laurite and braggite.



Stacked 100% histograms showing the dominant and subordinate PGM + Au assemblages associated with (a) the upper – and (b) basal chromitite stringers as a function of the total area of the upper and basal chromitite stringer populations respectively. n = grain count



Grain size distribution of the PGM + Au for the upper (red curve) and basal (green curve) chromitite stringer populations, also shown is the average grain size distribution for the entire PGM + Au (blue curve) population



Stacked 100% histograms showing the modal proportions of the pooled populations for (a) the upper – and (b) basal chromitite stringers respectively. The data was acquired using the XMOD procedure on the MLA

Geometallurgical characterization of the Main Mineralized Zone at the Nkomati Nickel Mine, Mpumalanga

Gargi Mishra

This study aims to carry out a geometallurgical characterization of the different ore types at the Nkomati Ni-Cu-Co-PGE deposit located within the Uitkomst Complex. Based on core logging and petrographic study of selected boreholes from Pit 3, the textural variation of the sulfide ore in the main mineralized zone can be summarized as:

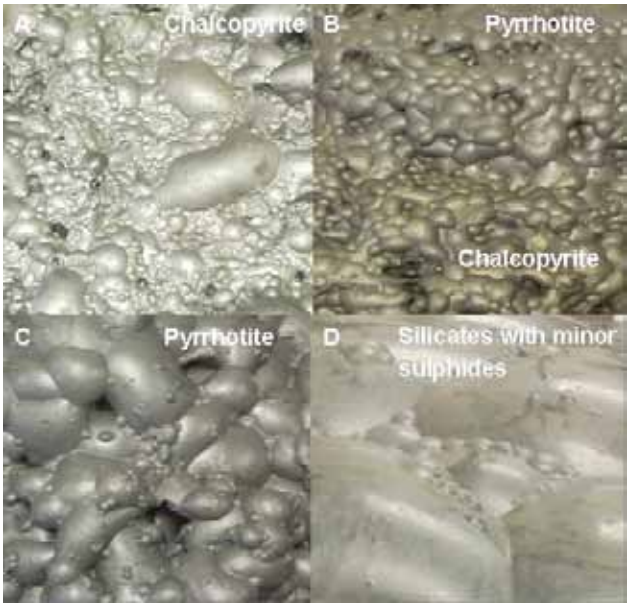
- Net texture - this includes both fine and coarse net texture associated with the lower pyroxenite (fine-medium grained).
- Bleb and Net texture - associated with coarse-grained pyroxenite
- Bleb-disseminated-semi net texture - associated with pyroxenite.
- Massive to Semi-massive texture - observed occasionally associated with pyroxenite.
- Hybrid-mix of calcsilicate and pyroxenite with and without sulfide mineralization.

These textural variants are largely controlled by the nature (mineralogical composition) of the host rock, as well as grain size and the total amount of sulfide mineral present. The dominant sulfide minerals are pyrrhotite, pentlandite, chalcopyrite and pyrite, while the host rock mineralogy comprises of olivine, pyroxene, serpentine, calcite and plagioclase.

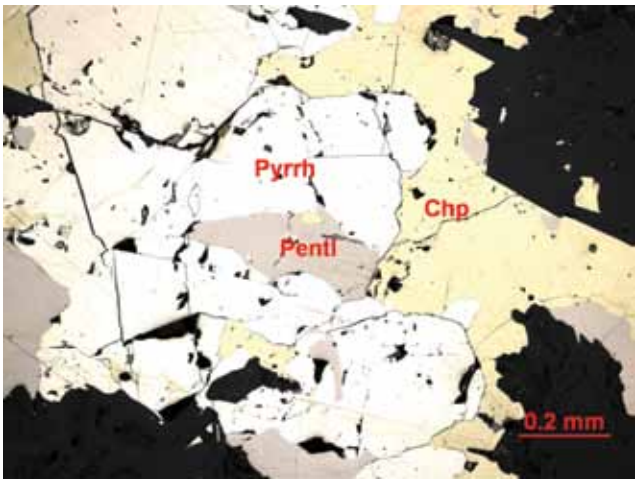
Core samples illustrating the main sulfide textures

Based on the textural classification, a number of samples were selected on which to conduct bench-top rougher flotation tests. From these, the concentrates and tailings were analyzed for Ni, Cu, MgO and SiO_2, Fe, AL_2O_3, S and Cr_2O_3, in order to generate total recovery curves which can be interpreted in terms of ore mineralogy.

It is observed that in a typical rock with pyrrhotite-pentlandite-chalcopyrite composition (see figure), chalcopyrite is the first mineral to float, followed by pyrrhotite and then other ore minerals and silicates with minor sulfides and oxides i.e. magnetite (see figure). It is also observed that when talc (a naturally flotable mineral) is presents in the rock it dilutes the concentrate, and may even depress the flotation of other minerals. However, chalcopyrite appears to be unaffected due to its strongly hydrophobic nature and rapid flotation kinetics. Detailed mineralogical study is in progress to understand the flotation behavior of each of these minerals, as well as their liberation.



Example of a series of flotation froths obtained from a typical rock with pyrrhotite-pentlandite-chalcopyrite Nkomati ore. Chalcopyrite (1) is the first mineral to float, followed by pyrrhotite+chalcopyrite (2), then mainly pyrrhotite (3) and finally other ore minerals and silicates with minor sulphides and oxides (4)

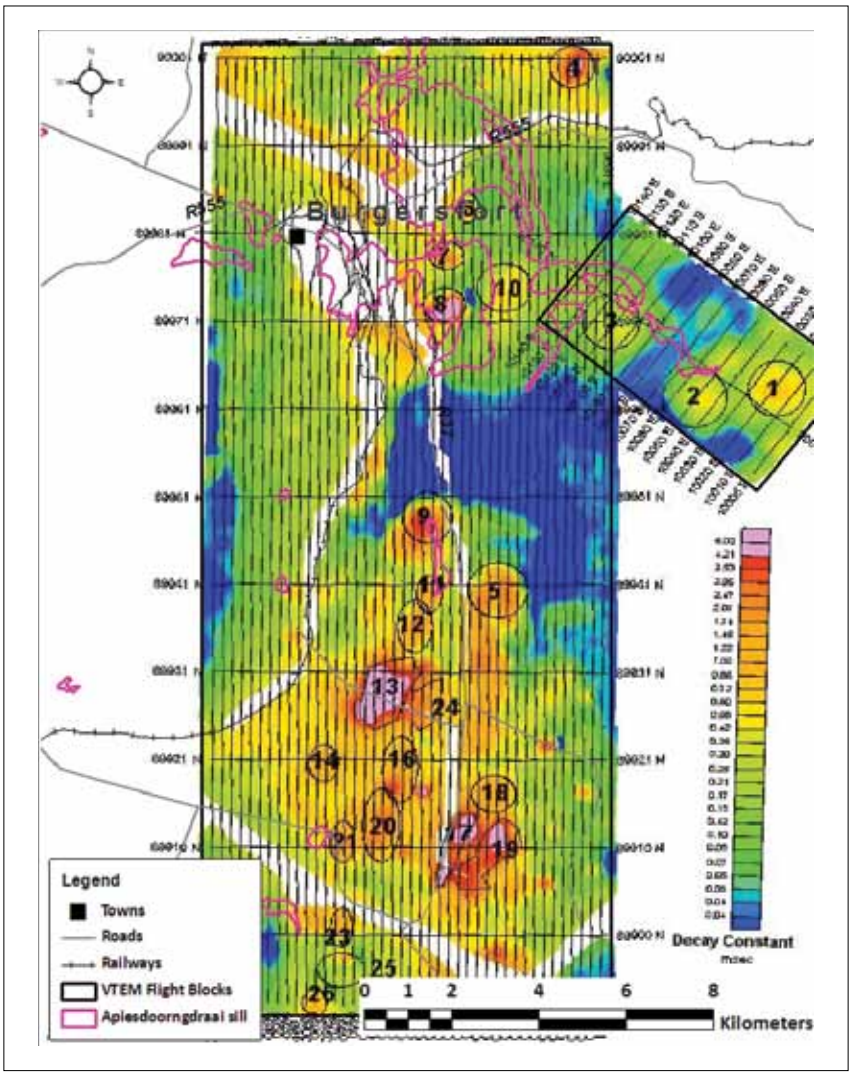


Photomicrograph of pyrrhotite, pentlandite and chalcopyrite in ore from Nkomati

Preliminary exploration results from the Apiesdooringdraai ultramafic sill east of the Burgersfort bulge: Is it an economically viable Ni-Sulphide deposit?

Themba Mabundza

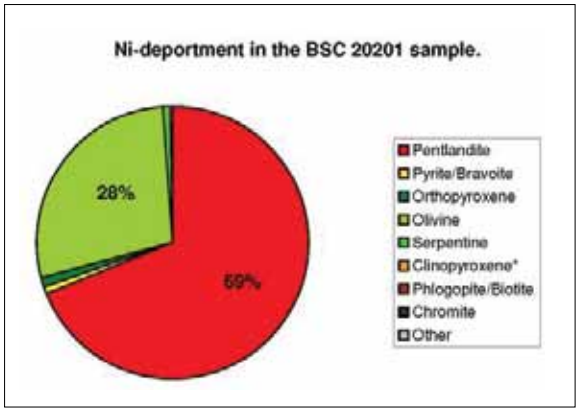
The Apiesdooringdraai sill east of Burgersfort bulge is a syn-Bushveld intrusion, that is dominantly composed of harzburgite. The sill outcrops where Burgersfort town is situated and was historically mined for magnesite. Exploration through diamond drilling was carried out intermittently in the early 1970's by Goldfield Mining Development in the hope of finding a nickel sulphide deposit. Some of the boreholes intersected disseminated sulphide mineralization. Follow up work is being conducted currently by BSC Resources. Airborne geophysics (VTEM) was conducted recently over the project area and a number of anomalies were identified and are currently being drilled. A nickel deportment study was carried out recently on a mineralised sample (~5% disseminated sulphides) from one of the earlier boreholes with the aim to determine how much nickel is potentially extractable from the ultramafic sill. QEMSCAN was used for bulk modal analyses to identify and quantify all minerals phases present on the sample. Selected mineral phases were further analysed by EPMA for their nickel content.



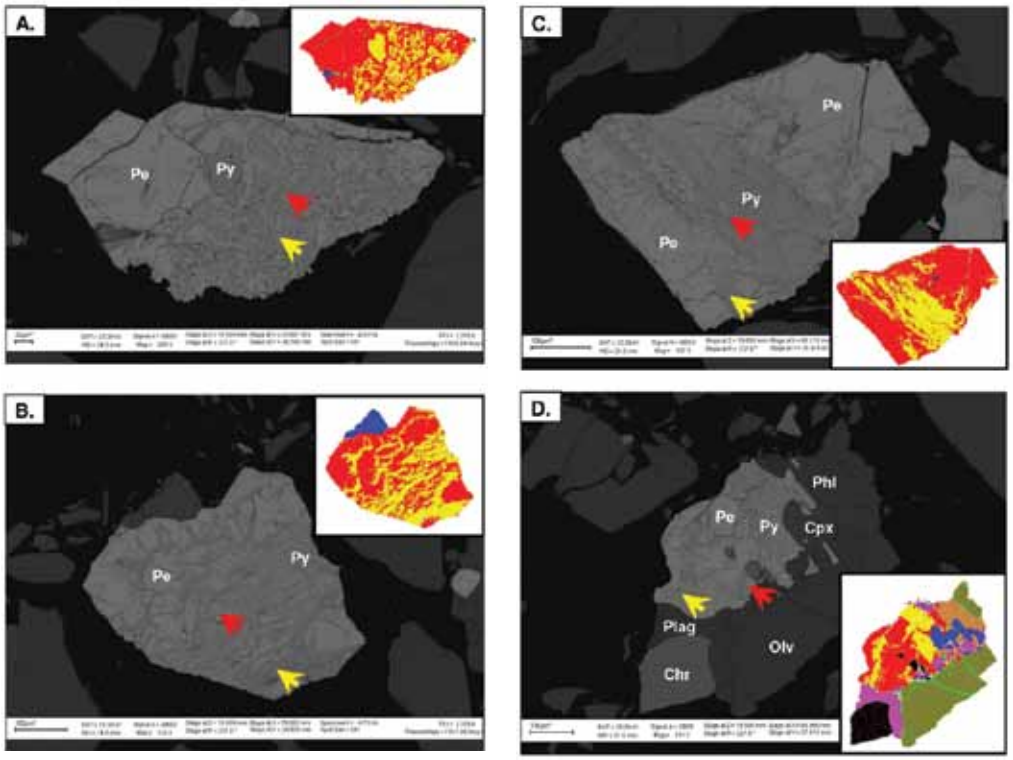
VTEM survey over the project area. The pink outline represents the extent of the Apiesdooringdraai ultramafic sill

The bulk of the Ni (69%) is contained by pentlandite, with another ~1% by pyrite/bravoite. The pentlandite and pyrite/bravoite are closely associated with each other and often intensely intergrown. This indicates that most of the pyrite is most probably not pyrite (see figure), but bravoite, which occurs as an alteration phase of pentlandite. Only ~0.7% of the 1.0% contained nickel is extractable as the remaining 0.3% is hosted by gangue, mostly olivine and orthopyroxene. The project is ongoing and more data is being acquired with the current drilling programme. The boreholes drilled so far indicate that the sill is differentiated and this will require more studies on petrography and geochemistry.

Minerals	% Ni
Pentlandite	69.02
Pyrite/Bravoite	0.74
Total Sulphides	**69.76**
Orthopyroxene	1.11
Olivine	28.12
Serpentine	0.80
Clinopyroxene*	0.08
Phlogopite/Biotite	0.06
Total Silicates	**30.17**
Chromite	0.07
Other	0.00
Total:	**100.00**



Pentlandite is the main Ni host (~69%), with olivine containing the bulk of the remainder (~28%). The Ni content of olivine is low (0.50 mass% NiO), but it makes up nearly 80 mass% of the sample, while only approximately 2.0 mass% of pentlandite contains nearly 70% of the Ni, due to its high Ni content of nearly 36 mass%



Backscatter electron images (main) and QEMSCAN images (inset) of pentlandite (Pe & red) intensely intergrown with pyrite/bravoite (Py & yellow). The bravoite is most probably an alteration product of the pentlandite. Note the olivine (Olv), plagioclase (Plag), chromite (Chr), phlogopite (Phl) and clinopyroxene (Cpx) proximal to sulphides

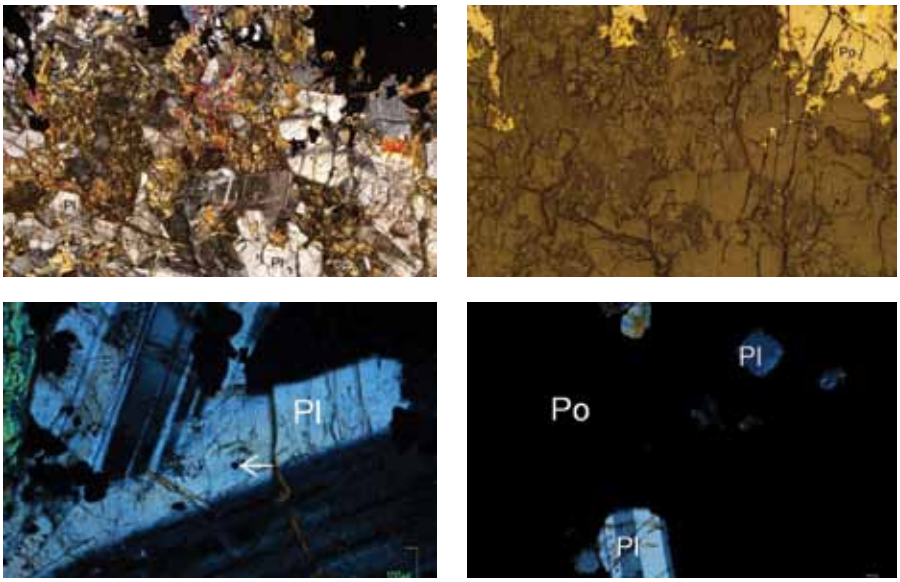
Ni-Cu sulphide mineralization associated with gabbroic rocks from northern Japan

Kazuyasu Shindo

There are few known Ni-Cu-(PGE) deposits in northern Japan, of which some were mined in the past. Although none of the mines are currently operating, research on Ni-Cu mineralization in mafic rocks is very useful for not only elucidating formation of these mineralization but also for future Ni-Cu-PGE exploration. The Oshirabetsu deposit, situated at the southeastern part of Hokkaido (northern Japan), is adjacent to the Main Zone of the Hidaka metamorphic belt. Metamorphism in the Main Zone corresponds to peak conditions of ~850°C at ~7.5 kbar related to gabbro intrusion around ~56-51 Ma, followed by reheating by an younger gabbro-granite intrusion around ~23-18 Ma and subsequent cooling to lower temperature and pressure conditions.

Rocks hosting Ni-Cu mineralization include coarse-grained gabbro, olivine gabbro and norite. The gabbroic rocks are considered products of differentiation. K-Ar age of the gabbroic complex is 35.3±1.1 Ma obtained from biotite in norite. Ni-Cu sulphide ores are classified into disseminated and semi-massive based on their mode of occurrence. Ore samples are composed mainly of plagioclase, with lesser amount of pyroxene, amphibole, biotite, ilmenite, alteration minerals and sulphides.

Sulphide minerals comprise mainly pyrrhotite with minor chalcopyrite and pentlandite and traces of secondary unidentified sulphides. Sulphide minerals have two modes of occurrence – as interstitial sulphides and as sulphide inclusions in plagioclase. The former has its grain boundaries in contact with silicates and appear to surround these crystals in some cases. The latter, which is relatively rare, is semi-rounded and occurs in plagioclase, indicating that sulphide was a liquid phase at the stage of plagioclase crystallization. Chemical composition of pyrrhotite is almost hexagonal (Fe7S8) with minor amount of Ni. The pentlandite compositions have relatively higher Ni content than Fe and contain several wt.% of Co. Considering the occurrence of sulphides with plagioclase, the gabbroic magma was saturated in sulphur at a relatively early stage of crystallization. Sulphide liquids first formed monosulfide solid solution (mss) in the magma (briefly ~1100°C). With decreasing temperature, mss and residual sulphide liquid came to be sulphide minerals seen in the rocks (i.e., pyrrhotite, pentlandite, and chalcopyrite).



Photomicrographs illustrating the different modes of occurrence of sulphides in mineralized gabbroic rocks from northern Japan. Top images illustrate interstitial sulphides and bottom images illustrate sulphide inclusion in plagioclase (shown by arrow) and silicate inclusion in sulphide. All the images except the top right image is in crossed polars. The top right image was taken under reflected light. Pl – plagioclase; Opx – orthopyroxene; Po – pyrrhotite; Cp – chalcopyrite

Oxidation of magmatic sulfides as explanation for elevated Cu/Fe in the Platinova Reef of the Skaergaard Intrusion (East Greenland)

Cora Wohlgemuth-Ueberwasser

The Skaergaard Intrusion (East Greenland) differs from other layered intrusions in that it contains disseminated, stratiform Pd-Au mineralizations with up to 5 ppm Pd and 9 ppm Au. In comparison to classic disseminated sulfide-PGE horizons like the Merensky reef in the Bushveld Complex or the JM reef at Stillwater, the Platinova reef occurs at a much higher, chemically more evolved stratigraphic level in the cumulate pile in magnetite-quartz-rich assemblages.

Sulfide mineralogy is dominated by metal-rich Cu sulfides (bornite and chalcopyrite), and the noble metals associated with the sulfide are Pd and Au, mostly as alloys with (Cu,Fe)(Au,Pd,Pt). Typical Fe-Ni-dominated sulfides like pyrrhotite or pentlandite are absent. Two processes have been suggested to explain Cu-enriched, Fe-depleted Pd-Au-enriched sulfide horizons: 1) fractional crystallization of $(Fe,Ni)1_{-x}S$ monosulfide leading to Cu enrichment in the derivative sulfide melt, and 2) modification of Fe-Ni-sulfides by infiltration of Cu-enriched postmagmatic fluids. A further possible explanation is sulfide oxidation during fractional crystallization. To simulate this third process, we equilibrated a $(Fe,Ni,Cu)1_{-x}S$ sulfide melt with oxidants like hematite and chromium (VI) oxide in welded evacuated SiO_2 glass capsules at temperatures ranging from 1050 (superliquidus) to 700°C (subsolidus). Hematite reacts with the FeS component of the sulfides according to $2\ FeS + 2\ Fe_2O_3 = 6\ FeO + S_2$, raising fS_2 and sequestering FeO to the sulfide melt. In the subsolidus region, the reaction is $6\ FeS + 24\ Fe_2O_3 = 18\ Fe_3O_4 + 3\ S_2$, raising fS_2 and stabilizing magnetite. The sequence of oxidation of sulfide species follows broadly the electromotive series, first FeS, then NiS, and finally Cu_2S and CuS, eventually producing Cu-rich sulfides like bornite that coexist with metallic Cu, as observed in the Platinova reef.

Microprobe analyses of the first experiments at 1050°C revealed a successive increase in oxygen (O_2) content in the sulfur melt at the expense of S_2, from < 0.5 wt.% (detection limit) to 7 ± 1 wt.% O_2 in charges with > 30 wt% hematite. Iron also increases with increasing O_2 content in the melt, suggesting that oxygen dissolves in the sulfide melt principally as FeO and/or $FeO_{1.5}$ complexes. Oxidation with hematite is buffered by the fayalite-magnetite-quartz (FMQ) equilibrium. Equilibration with CrO_3 does not lead to a reaction with the glass capsule. The Fe1-xS component of the sulfide phase becomes oxidized by CrO_3 under crystallization of magnetite respectively chromite and Cu/Fe ratios of the residual sulfide phase increases significantly above 1. Oxidation of sulfide is limited by the transition of S^{2-} to S^{6+}, the sulfide-transition, respectively. Equilibration of a $(Fe,Ni,Cu)_{1-x}S$ sulfide melt with natural anhydrite at elevated pressure of 10 kbar using a piston-cylinder-apparatus (picture below) changed the sulfide composition dramatically. All Fe and Ni was oxidized to magnetite in equilibrium with Cu-sulfides and anhydrite. Any sulfide coexisting in equilibrium with sulfate should be Cu-sulfide like bornite or chalcocite. Our experiments show that the Cu-rich sulfide assemblages as described above for the Skaergaard type PGE deposits may be generated by a combination of fractional crystallization and magmatic oxidation.

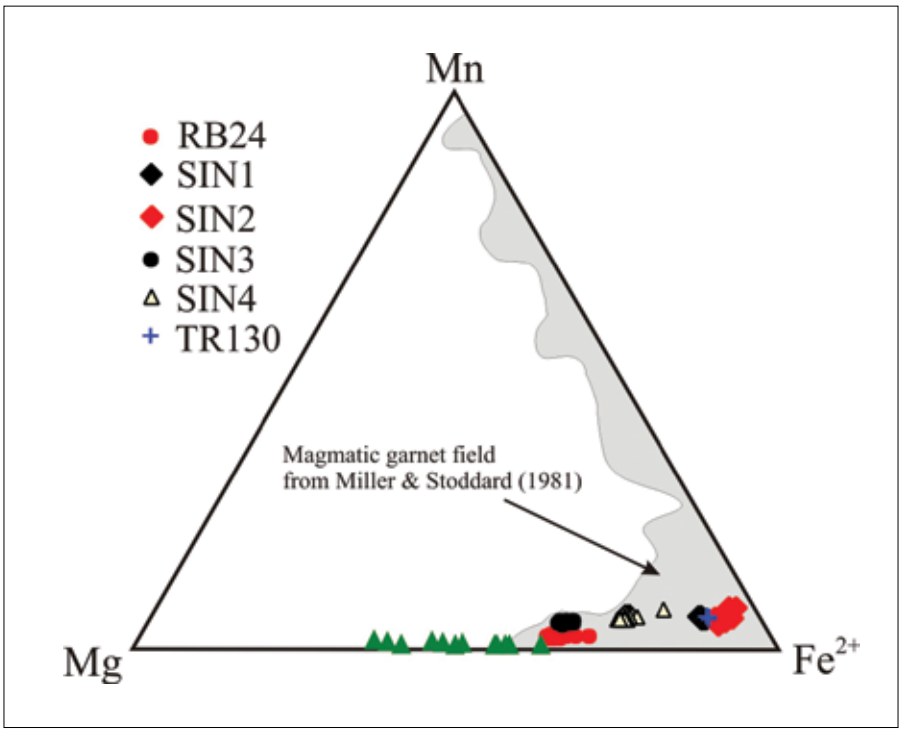
Piston-cylinder-press at the University of Muenster used for the anhydrite experiment. Charges can be equilibrated up to 2000°C

Different types of Mn-rich garnets from Singelele-type gneisses in and around Musina, Central Zone of the Limpopo Complex

George A Belyanin

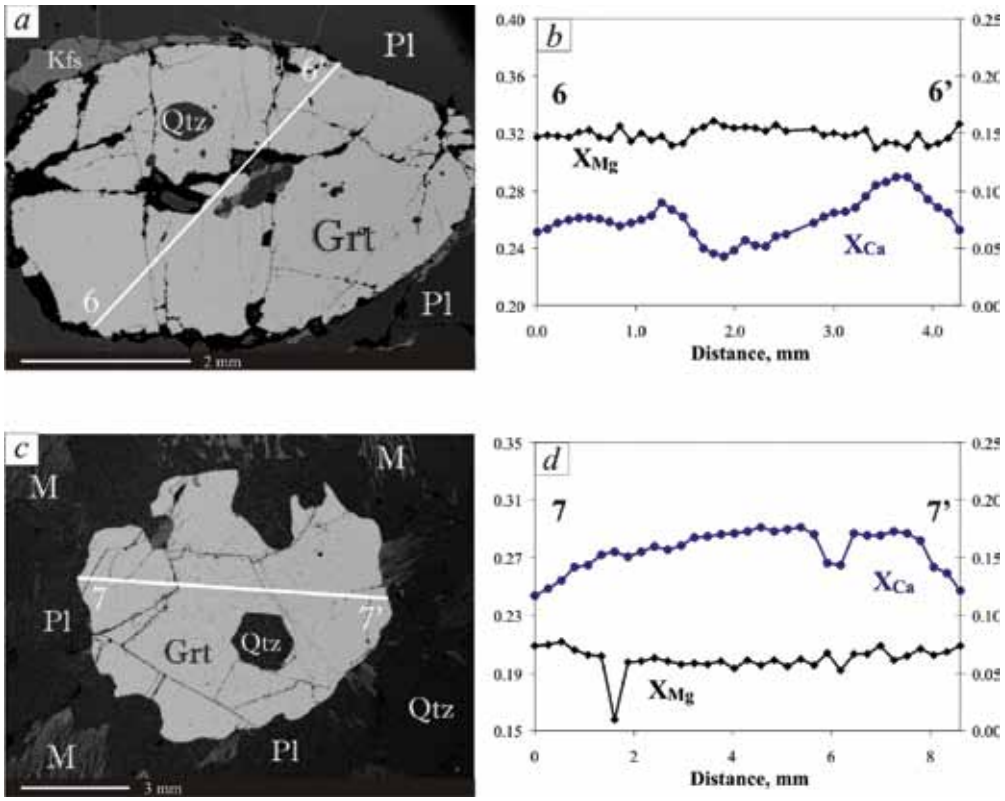
The pink to orange colored garnetiferous Singelele-type gneisses constitute a long lived Neoarchean magmatic event (~2.72 – 2.56 Ga) that affected the Central Zone of the Limpopo Complex. This study presents petrographic and mineral chemical characteristics of garnet-bearing Singelele-type gneisses occurring in and around Musina. These include Singelele-type gneiss samples collected from a road cut along the Doreen-Musina road on the farm Ostend, east of Musina (represented by TR130), garnet-bearing leucocratic gneisses (represented by SIN1 and SIN2) from the type locality at Singelele Hill near Musina, the Singelele-type gneiss (represented by RB24) that intrudes the main gneissic fabric of the Beit Bridge Complex rocks near the type outcrop locality of the Bulai pluton on the farm Macuville ~12 km northwest of Three Sisters, and Singelele-type gneisses representing both Paleoproterozoic event overprinted (represented by SIN4) and non-overprinted (represented by SIN3) rocks at the Causeway locality southeast of Musina, where meter-sized bodies of Singelele-type gneisses occur interlayered and interfolded with rocks of the Beit Bridge Complex.

In addition to the common minerals (quartz, K-feldspar, plagioclase and garnet), biotite and amphibole occurs in the Singelele-type gneisses collected from the type-locality at Singelele Hill. In the Mg-Mn-Fe^{2+} ternary diagram (see figure), garnets from the different Singelele-type gneisses fall in the field for magmatic garnets. In terms of garnet chemistry, three groups can be distinguished. Garnets from Singelele-type granitic gneisses SIN1 and SIN2 (~2.64 Ga) are characterized by similar position on the diagram, very close to the Fe2+ corner, and contribute to the first group. Garnets from TR130 (~2.68 Ga) have similar composition as this group. The second group consists of the more Mg-rich varieties SIN3 and RB24, whereas the overprinted gneiss SIN4 forms the third group (see figure). Metamorphic garnets from metapelites from different parts of the Central Zone (green triangles in figure) are characterized by significantly higher Mg/(Mg+Fe) and lower Mn content.



Mg-Mn-Fe2+ ternary diagram for garnets from the studied Singelele-type gneisses as well garnets from true metamorphic rocks in the Central Zone

Electron microprobe profiling of garnet grains display constant X_{Mg}^{Grt} (= Mg/(Mg+Fe+Mn)) ~0.07 as well as slight decrease of X_{Ca}^{Grt} (= Ca/(Ca+Mg+Fe+Mn)) from core (0.11) to rim (0.10) for Singelele-type gneiss TR130. X_{Mg}^{Grt} is either constant (0.07), or increases slightly from the core (0.03) to rim (0.05), while X_{Ca}^{Grt} = 0.15-0.16 for Singelele-type gneisses SIN1 and SIN2. The latter value is one of the highest in the Singele-type gneisses studied here, comparable only with X_{Ca}^{Grt} in the Paleoproterozoic overprinted gneiss SIN4. In terms of X_{Mg}^{Grt}, Singelele-type gneiss RB24 is most similar to SIN3. Ca zonation in garnet is complex. Moving from the core towards the rim a slight decrease of X_{Ca}^{Grt} is first observed, followed by an increase and, finally again a decrease of X_{Ca}^{Grt}. This zonation pattern is characteristic of all garnet porphyroblasts from RB24. X_{Mg}^{Grt} in SIN3 is the highest (0.32) in the studied Singelele-type gneisses, while SIN4 is characterized by significantly lower (0.21) values. Garnet grains from both gneisses do not display any zoning of Mg. At the same time, the zoning of Ca is more complex and differs in SIN3 and SIN4. In the latter case, X_{Ca}^{Grt} decreases from 0.18 (the value is the highest in the Singelele gneisses studied together with SIN1 and SIN2) in center of porphyroblasts to 0.12 at their rim, whereas in SIN3, X_{Ca}^{Grt} increases from 0.05 to 0.12, and then decreases to 0.07 at the rim



BSE images (a) and (c) and corresponding zoning profiles (5-5′ in b and 6-6′ in d) of garnet porphyroblasts in Singelele-type gneiss SIN-3 (a) and its Paleoproterozoic analog SIN-4 (c). In the zoning profile plots, left y-axis corresponds to X_{Mg}^{Grt} and right y-axis to X_{Ca}^{Grt}

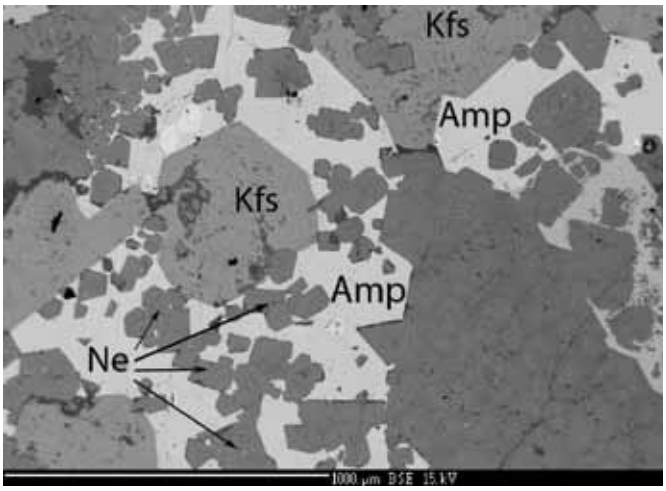
Fluorite mineralization associated with lujavrite from the Mesoproterozoic Pilanesberg Alkaline Complex

Sara Turnbull

The wide spectrum of minerals seen in peralkaline igneous rocks like agpaitic nepheline syenites are important repositories of large ion lithophile elements such as Na, K and Li, as well as the rare earth elements and high field strength elements such as Zr, Hf, Nb, Ta, U and Th. Magmatic or late magmatic to hydrothermal processes, or a combination of both have been invoked to account for the range of minerals seen in these agpaitic rocks. The Mesoproterozoic Pilanesberg agpaitic alkaline complex, emplaced into the older Bushveld Complex, has reported occurrence of fluorite mineralization.

Lurie reported fluorite as an accessory mineral in all the major rock types occurring within the complex. The present project aims to characterize the fluorite mineralization associated with lujavrites from the Pilanebesberg alkaline complex. The lujavrite studied here occurs as an arcuate ring-dike unit in the southern part of the complex. Samples were collected from a series of hillocks (outside the perimeters of the national park) covered with dense vegetation. Metre scale mapping of the lujavrite exposures indicate a very wide range of textures and modes as a result of flow differentiation, crystal sorting and accumulation. Trachytic texture due to flow alignment of felsic and mafic phenocrysts are obvious in most of the exposures examined.

Preliminary electron microprobe analyses (carried out at SPECTRAU, UJ) indicate the presence of alkali feldspar, nepheline, aegirine and amphibole as the dominant minerals in the lujavrite. Albite- and sodalite-rich regions occur in certain exposures. Other prominent minerals, identified so far, which occurs as large crystals in hand specimens include eudialyte, astrophyllite and fluorite.



Representative backscatter electron image from the lujavrite of the Pilanesberg Complex

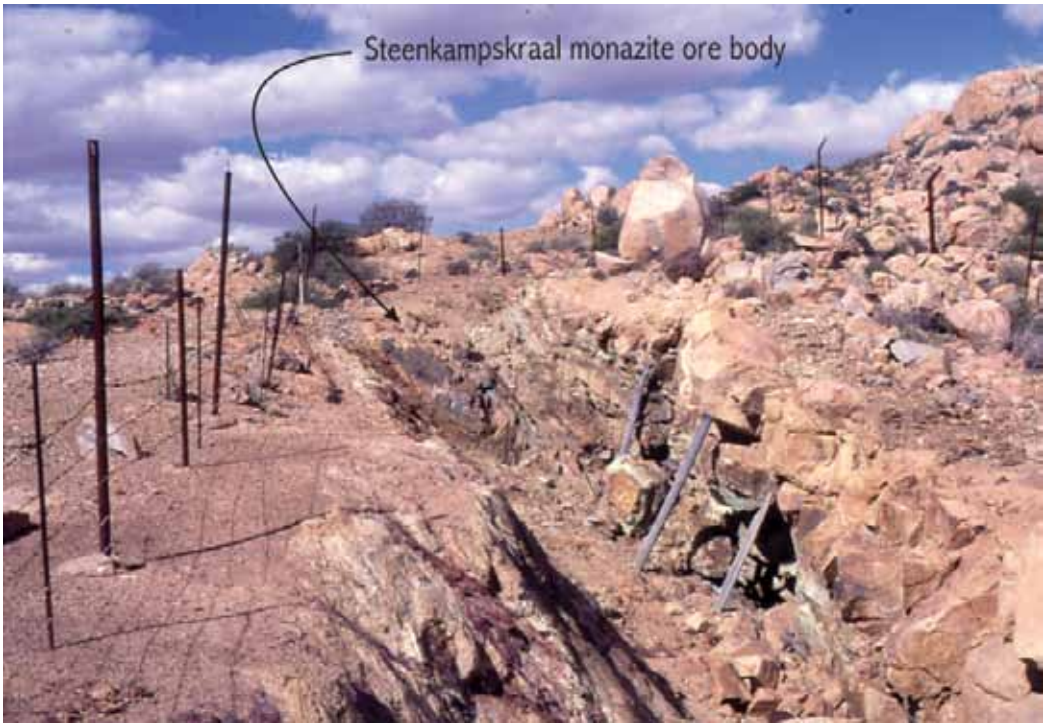
Fluorite-rich vein in lujavrite from the Pilanesberg Complex

Deep purple fluorite-rich veins cut across the general flow fabric of the host rock (see figure). Such veins occur in different scales – from centimetre to meter-scale. Unlike the fluorite occurrence reported by Lurie, where it is mostly intergrown with other minerals, these veins are dominantly made up of fluorite. The important role that volatiles play during the generation, emplacement and crystallization of alkaline rocks has been emphasized by many authors. With the aim of documenting the evolving composition of magmatic-hydrothermal fluids in the lujavrites, a fluid inclusion study is currently carried out in various minerals representing different stages in the paragenesis.

Structural setting of the Steenkampskraal monazite REE ore body

Mike Knoper

The origin of the Steenkampskraal monazite orebody within Mesoproterozoic Namaquan gneiss located near Kliprand in the northern part of the Western Cape Province (South Africa) has been attributed to magmatic emplacement under granulite-grade metamorphic conditions. This model explains the association of the monazite orebody with Qtz-Kfs-Pl-Grt-Bt-Opx dykes that intrude megacrystic granite-gneiss at Steenkampskraal.



A cross-sectional view, towards the east, of the Steenkampskraal monazite ore body. The trench in this part of the ore body is about 2.5 m deep, and a stope developed on the ore body occurs below the support timbers

To explain the structural setting into which the dykes was emplaced, structural measurements were obtained from the monazite ore body and the surrounding Namaquan gneiss. The structural data reveal the presence of three F3 folds; from north to south: (a) an open synformal flexure north of the monazite ore body, (b) a cuspate antiform located immediately north of the ore body's surface expression, and (c) an open synformal flexural south of the ore body. All folds rework and fold the gneissic banding (S2). However, it is notable that the monazite ore body is not folded similarly to the reworked gneissic banding (S2), implying that the ore body intruded after formation of the gneissic banding but before F3 fold development. First the ore body was emplaced obliquely to the gneissic banding, and then upright F3 folds developed by flexural-slip deformation of the gneissic banding. Two open synformal flexures formed north and south of the ore body, and buckling instability nucleated along the obliquely inclined ore body. This resulted in the formation of the cuspate antiform (i.e., the Steenkampskraal steep structure) found immediately north of the ore body. The implication of this data is that the monazite ore body intruded before F3 deformation, and that there is potential for an extension of the ore body at depth.

Origin and emplacement of manganese with conglomeratic iron ore at the Beeshoek Iron Ore Mine, Northern Cape Province

J-C Beyeme Zogo

Beeshoek Iron Ore Mine, located 7 km west of Postmaburg in the Northern Cape Province, has two sections referred to as North and South open pit mines. Both mines produce high-grade hematite iron ore. Two main ore types are present, namely laminated and conglomeratic ore. The laminated ore was derived from supergene enrichment of Kuruman iron formation in ancient (~ 2,1 billion year old) sinkhole structures in underlying dolomite of the Campbellrand carbonate platform succession. In contrast the conglomeratic ores represent ancient alluvium, derived from the earlier supergene laminated ores, that accumulated in conglomerates at the base of the overlying Gamagara succession some 2 billion years ago. Both ore types are typically of very high grade, containing between 62 and 66 weight persent iron metal, with very low silica contents and only traces of other elements. However, some of the conglomeratic ore from the north pit mine is enriched in manganese up to a few percent Mn(II) oxide. The present study investigates the emplacement of manganese within the conglomeratic iron ore in the North pit mine.

Hand sample of conglomeratic iron ore showing manganese oxyhydroxide infiltration (black) in porous laminae of large laminated iron ore pebble

Fresh samples of conglomeratic ore are composed of laminated iron ore pebbles in a matrix of hematite (see figure). Results of this study indicated that the manganiferous conglomeratic ores are always represented by ore material that has been subjected to weathering and supergene alteration below the modern land surface. The manganese occurs in the form of Mn(IV) oxyhydroxides that infiltrated into porous laminae in laminated ore pebbles in the conglomeratic ore and into parts of partly leached surrounding hematite matrix (see figure). The manganese enrichment is thus related to recent supergene mobilization of manganese and emplacement into conglomeratic ores. The manganese is most probably derived from dissolution of underlying manganiferous dolomite of the Campbellrand carbonate succession. Dissolution and karstification of dolomite are thus ongoing processes as manifested by the highly disturbed and slumped character of the ancient iron ores below the modern or post-Gondwana African land surface.

Mineralogical assessment of spatially associated iron formations in the Mesoproterozoic Gams Formation, Bushmanland Group, Aggeneys Area

Fanie Kruger

Metamorphosed iron formations are hosted in the Gams Formation of the Mesoproterozoic Bushmanland Group. In the Aggeneys-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. The iron-rich rocks of the Gams Formation display macroscopic features that are very similar to banded iron formations (BIF's) in general. This was also observed in the iron formation that occurs at Gamsberg (see figure).

Investigations of the petrography and mineralogy of the Fe-oxide minerals and the associated amphibolite-facies metasediments indicate that they are characterized by a predominance of magnetite and quartz. Garnets are present in distinct bands and some of these are conspicuously manganese bearing. Lesser quantities of amphiboles were identified as well as occasional occurrences of pyroxenes, pyroxenoids, and olivine.

Within these iron formations there are locally developed distinct ore bodies of magnetite that are replaced by hematite close to the present day land surface. The hematite is associated with a soft saprolitic highly chloritic alteration zone. Microchemical investigations by means of the electron microprobe of magnetite from different intersections of the Gamsberg Formation at Gamsberg indicate that magnetite grains from certain samples are chemically zoned with respect to Fe, Mn, and Zn content.

Example of metamorphosed banded iron formation of the Gams Formation at Gamsberg

Laser ablation ICP-MS dating of zircon populations from the Cape and lower Karoo Supergroups

Clarisa Vorster

The development of efficient methods for the collection of U-Pb data for detrital zircon populations, as well as the meaningful interpretation of results, has been the basis of many sedimentological studies worldwide in recent years. Age determination of c. 30 µm regions of zircon grains was first made possible by secondary ion mass spectrometry (SIMS) in the 1980's, and then made more accessible by the cheaper, more widely available method of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). The proposed detrital zircon study has two objectives: Firstly, the technique of U-Pb zircon geochronology by LA-ICPMS is to be developed and optimized on the instrumentation currently existing at UJ (A New-Wave UP 213 Nd:YAG laser coupled to a ThermoFisher X-SeriesII quadrupole ICP-MS). Secondly, dating of detrital zircons from the sedimentary sequences of the Cape and lower part of the Karoo Supergroups are to be undertaken in an effort to determine the source areas for these sediments. This has the potential to be an ideal study area for the determination of U-Pb ages of detrital zircons, as these sequences represent a gap in the global database, and filling this gap will allow the reconstruction of tectonic events and drainage patterns of the Gondwana continent in the early Phanerozoic.

With regards to the method development side of the project the aspects involved in the establishment of a reliable analytical protocol, capable of producing U/Pb data that are both accurate and precise have been thoroughly investigated. The careful optimization of both Laser- and ICP-MS operating conditions for the spot ablation of detrital zircons using a typical 30-60 µm spot size has been a main point of focus. Essential fractionation corrections required for the meaningful interpretation of LA-ICP-MS data are conducted using the data processing software 'GLITTER', while common lead corrections are made following the model Pb compositions proposed by Stacey and Kramers. The U/Pb isotopic ratios obtained during the ablation of the greatly homogenous 91500 zircon standard are used as means of monitoring the short term precision and accuracy attainable during analytical procedures. Secondary zircon standards including GJ1 and Temora-II, among others are also incorporated during analysis. Currently, the internal structure of detrital zircon populations obtained from sediments of the Natal Group is being investigated in preparation for detrital zircon age dating. By establishing the U-Pb age of detrital zircons within the sediments of the Cape Supergroup and related Natal Group, a correlation between the sequences could be confirmed. Various tectono-sedimentary models regarding the source of sediments in the Cape – Karoo Supergroups, which have been suggested in the past, could be re-evaluated and tested in the light of newly gathered U-Pb detrital zircon age data. The study will further be extended to the sedimentary basins in South America that are similar in age to the Southern African Cape and Karoo basins, in order to test proposed correlations and constrain models of sediment provenance on a broader Gondwana-wide scale.

View of the Dwyka Diamictite at the base of the Karoo Supergroup (in foreground) overlying strata of the Witteberg Group of the Cape Supergroup in the background near Matjiesfontein, Western Cape Province

Geochronology and correlation of Paleoproterozoic red beds of the Elim Group in Griqualand West, Northern Cape Province

Daphne Dreyer

This study was designed to assist in the re-evaluation and/or confirmation of the possible correlation of the Mapedi/ Gamagara and Lucknow Formations in the Griqualand West basin to the Transvaal basin geology, and to compare the composition of the Mapedi/Gamagara Formation above and below the Black Ridge thrust fault system. This is done in order to obtain better constraints on the maximum possible ages of the various quartzite units in the succession from detrital zircon age populations and in turn give a minimum age for the conglomerates associated with the red beds of the Olifantshoek and Elim Groups, with specific focus on the Doornfontein Conglomerate Member or pre-Gamagara unconformity. These results are important for constraining 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 of the Transvaal Supergroup in Griqualand West.

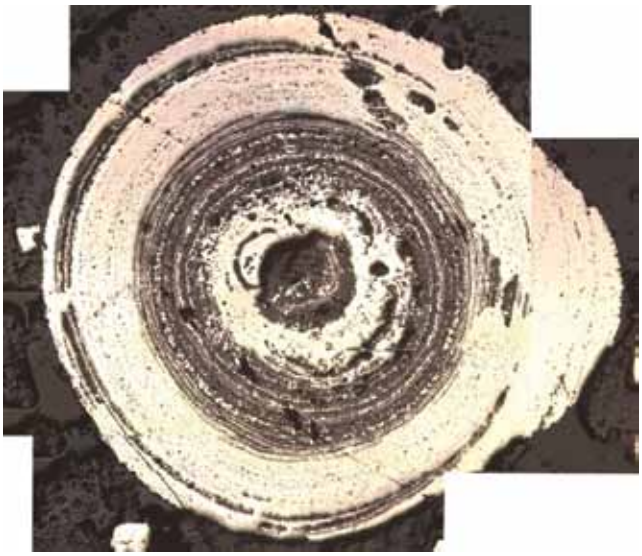
Doornfontein Conglomerate Bed, with boulders of iron formation and iron ore, at base of Gamagara/Mapedi succession, Rooinekke Iron Ore Mine

Multiple sulfur isotope signatures of diagenetic pyrite nodules in quartz pebble conglomerates of the Witwatersrand Supergroup and Ventersdorp Contact Reef

Bradley M Guy

The occurrence of sedimentary pyrite (or buckshot pyrite) as reworked and rounded fragments in quartzites and conglomerates of the upper Witwatersrand Supergroup has been well documented, although the focus has justifiably been centered on detrital and epigenetic pyrite. Consequently, very little attention has been given to reworked (endoclastic) pyrite nodules, despite the fact that it comprises a large percentage of total pyrite in several Witwatersrand quartz pebble conglomerates (QPCs) and that it contains elevated contents of Au and Ag. Historically, the confined range of conventional sulfur isotope data (δ34S) from Witwatersrand pyrite has lead authors to suggest a magmatic source of the pyrite sulfur. However, recent laser ablation study has found larger fractionations in δ34S (-5.3 to +6.7 ‰) and small-scale isotopic gradients in sedimentary pyrite (see figure) – suggestive of bacterial sulfate reduction. The discovery of mass-independent fractionation of sulfur isotopes (MIF-S) has provided geoscientists with new opportunities to obtain further insights into the pre 2.4 Ga sulfur cycle. In this regard, a recent multiple sulfur isotope study has shown that pyrite in the Witwatersrand QPCs was probably derived from both sedimentary and hydrothermal/igneous sources.

This investigation primarily focuses on sedimentary pyrite, i.e., syngenetic and diagenetic pyrite nodules in auriferous conglomerate beds. These specific paragenetic pyrite associations act as geological black boxes and record biogeochemical changes in atmosphere, hydrosphere and subsurface environment. A total of 47 individual pyrite grains were analyzed from six different gold-bearing QPCs or reefs (the Middelvlei, Basal, Vaal, Kalkoenkrans, Beatrix and Ventersdorp Contact Reef). δ34S, Δ33S and Δ36S values range from -6.8 to +8.3 ‰, -1.7 to +1.7 ‰ and -3.9 to +0.1 ‰, respectively. We found that multiple sulfur isotope compositions vary as a function of paragenetic pyrite association, pyrite type and depositional environment. Syngenetic and early diagenetic pyrite nodules display the largest variations in δ34S, Δ33S, and Δ36S, and most examples display negative Δ33S values, suggestive of microbial sulfate reduction. Epigenetic pyrite grains (in-situ and reworked fragments), however, are characterized by attenuated δ34S, Δ33S, and Δ36S values, which are distinctly different from sedimentary pyrite sulfur isotope signatures. Concentrically coated pyrite grain (CIS) or oolitic pyrite grains (see figure) exhibit the largest negative δ34S excursions. A depositional control on multiple sulfur isotope compositions is also apparent. Sedimentary pyrite grains from fluvial braidplain settings are characterized by near-zero Δ33S values, which may indicate terrigenous dilution. Pyrite grains obtained from transgressive marine conglomerates (that have reworked underlying fluvial deposits) display both fluvial and marine signatures (i.e., a trend towards enriched δ34S values). These results suggest that low atmospheric oxygen concentrations prevailed during the deposition of the Witwatersrand QPCs, but that local influxes of sulfur into the riverine environment attenuated Δ33S anomalies and contributed to the abundance of sedimentary pyrite in the conglomerates that we observe today.



Example of an oolitic pyrite grain from the Ventersdorp Contact Reef

Petrographic and geochemical characterization of modern sedimentary environments and geological units of the KaNyaka Island System, Mozambique

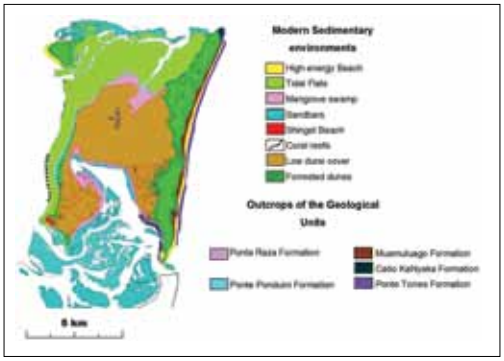
Marieke Peché and Herman van Niekerk

The KaNyaka (previously known as Inhaca) island system forms a barrier island along the southeast coast of Mozambique. It is an extension of the large dune cordon that separates the coastal plain of Mozambique with the Indian Ocean. The aim of this study is to identify and describe the lithological and geochemical characteristics of modern and ancient sedimentary units present on the island and to obtain age dates on some of the lithological units. Age dating was performed on shell fossils and calcareous root marks by means of the ^{14}C method.

Main outcrop of the Cabo KaNyaka Formation on the northeast point of KaNyaka Island

Lithological studies suggest that the geological units of KaNyaka Island should be regrouped and classified into five major formations, namely the Ponte Torres, Ponte Ponduini, Cabo KaNyaka, Ponta Raza and Muamuluago Formations. The Ponte Torres Formation, which consists of massive and flat bedded calcarenites, most likely forms the eastern basement of the island and stretches from the west of Saco KaNyaka, along the eastern coast of KaNyaka Island. The Ponte Ponduini Formation is the oldest dated formation (42130±860 before present; ^{14}C age obtained from a fresh water shell fossil) on the island and appears to overlie the Ponte Torres Formation. It is composed of calcrete with steep crossbedding and is exposed all along the west coast of KaNyaka Island. The Cabo KaNyaka Formation is made up of various ancient dune systems that formed around 24 940 years ago (age obtained from a fresh water shell fossil) and may be a lateral equivalent of the upper part of the Ponte Ponduini Formation. It is mainly exposed on the most northern tip of KaNyaka Island. The Muamuluago Formation is an eroded dune system (with ages ranging between 3363±20 to 1802±20 before present; ages obtained from fresh water shell fossils and calcified root marks respectively) exposed on the eastern side of the island, and may be a lateral equivalent of the Ponta Raza Formation (3293±20 BP; ^{14}Cage obtained dated from a sea shell) – that is exposed on the western side of the island.

The KaNyaka island system also contains several modern sedimentary environments, which can be roughly classified into three groups. The sedimentary environments on the western shore of KaNyaka Island are dominated by the tides and biogenic sedimentation, while those on the eastern shore are dominated by wave action, the northwards flowing off-shore current and the strong winds.

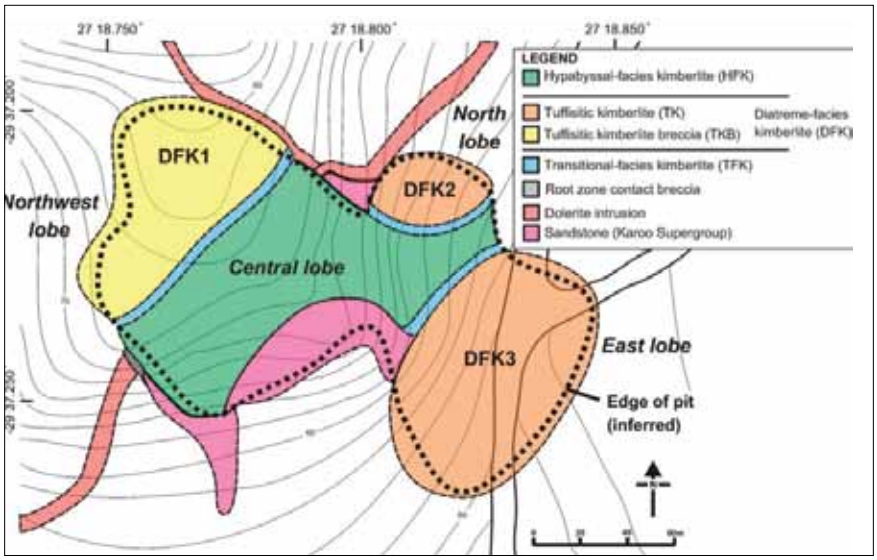


Map showing the modern depositional environments of KaNyaka Island, and distribution of the five geological formations identified

Preliminary geology of the Kolo kimberlite pipe, Lesotho

Bryony Richards

The Kolo kimberlite pipe is located in the western lowlands of Lesotho at approximately S 29° 37′ and E 27° 19′, roughly 38 km southwest of the nation's capital, Maseru (within the Mafeteng administrative district), along the international border with South Africa. The pipe itself is located on the flank of a ridge at an elevation of approximately 1575 metres at the base of the Kolo Mountain (2103 metres in elevation). The Kolo pipe is a basaltic-type (Group 1) kimberlite, consisting of four lobes: central, east, north and northwest (see figure). The pipe forms part of the much larger Sekameng-Kolo Kimberlite Group, a group of five pipes and eight southeast-trending dykes close to the margin of the Kaapvaal Craton in the southwestern Lesotho lowlands. The Kolo kimberlite intruded along the contact between the Upper Beaufort and lower Stormberg Groups of the Karoo Supergroup and a late Jurassic (Karoo) dolerite dyke. The pipe is small, approximately 1.2 ha and of low grade ranging between 1.2-13.6 cpht.



Schematic map of the Kolo kimberlite pipe

The main kimberlite lithologies within the pipe (see figure) are defined as hypabyssal-facies kimberlite (HFK), dominated by carbonated ilmenite-phlogopite-bearing kimberlite and diatreme-facies kimberlite (DFK), consisting of tuffisitic kimberlite breccia (TKB) and tuffisitic kimberlite (TK). In-situ transitional zones (TKt, TKtB and HKt) between the hypabyssal and diatreme-facies are consistent with other reports of transitional-facies kimberlite (TFK) and occur in several areas of HFK-DFK transition in the pipe.

Recalculated diamond grades are highest in the hypabyssal-facies kimberlite (13.6 cpht) and transitional facies kimberlite (10.8 cpht) and comparatively low (1.2-5.8 cpht) within the diatreme-facies (DFK). Low grades in the DFK are primarily due to internal dilution by abundant country rock xenoliths/inclusions (i.e. sandstone, shale, dolerite, basalt and granitic gneiss). Diamond grades are noted to differ between the different diatreme-facies lobes (DFK1; 5.8 cpht, DFK2; 1.2 cpht, DFK3; 2.2 cpht) indicating that grade is not based on internal dilution alone. The fact that the pipe crosscuts a Karoo dolerite dyke, indicates that it was emplaced after the Early Jurassic between 87-95 Ma, coinciding with ages of other kimberlite pipes and dykes in Lesotho.

New data from probe analyses (see figure) has indicated that although hypabyssal and diatreme units were emplaced in a single, discrete episode, differing thermal regimes has allowed for chemical differentiation and morphological evolution of minerals. The aims of this study is to provide the first published, petrological and chemical analyses of the different units of the Kolo kimberlite, to reclassify and expand on previous mapping work and to do a detailed interpretation of the genesis and emplacement of different kimberlite units.

Possible post-Permian diatreme activity in the northeastern Karoo basin

Byron van der Walt

Four anomalous borehole core sequences from the northeastern Karoo Basin are examined for this study. The boreholes are located up to 30km from each other and are litohostratigraphically completely atypical for coal bearing strata of the Permian Vryheid Formation of the Ecca Group, Karoo Supergroup. The lithologies of the four boreholes are intensely brecciated for the most part, while all of the surrounding boreholes reveal normal stratigraphy; their sedimentary strata are normally horizontal with no faulting present. The only known disturbances to the Vryheid Formation in the study area are the occurrence of intrusive mafic dolerite sills and dykes, which are known to have been contemporaneous with and immediately following the eruption of the Jurassic Drakensburg flood basalts.

The borehole core lithologies have been described in detail with reference to their textural, mineralogical and petrographic characteristics. Preliminary mineral and chemical data requisitions are completed and geochemical investigations are in progress. Several modes of origin of the breccias are considered, with the primary hypothesis that the brecciation is due to diatreme activity. A review of diatremes and their mode of emplacement is proposed with reference to their occurrence within the Karoo Igneous Province, as some diatremes in the Karoo are associated with dolerite sill emplacement. The isolated occurrences, lithologies, petrography, alteration and geochemistry of the sequences will be used to argue that the Vryheid Formation, intersected in the form of the four anomalous boreholes, was disturbed by diatreme activity, which are genetically related to the late dolerite sill emplacement into the Karoo strata.

Examples of core from the brecciated borehole intersections in strata of the Vryheid Formation of the Karoo Supergroup

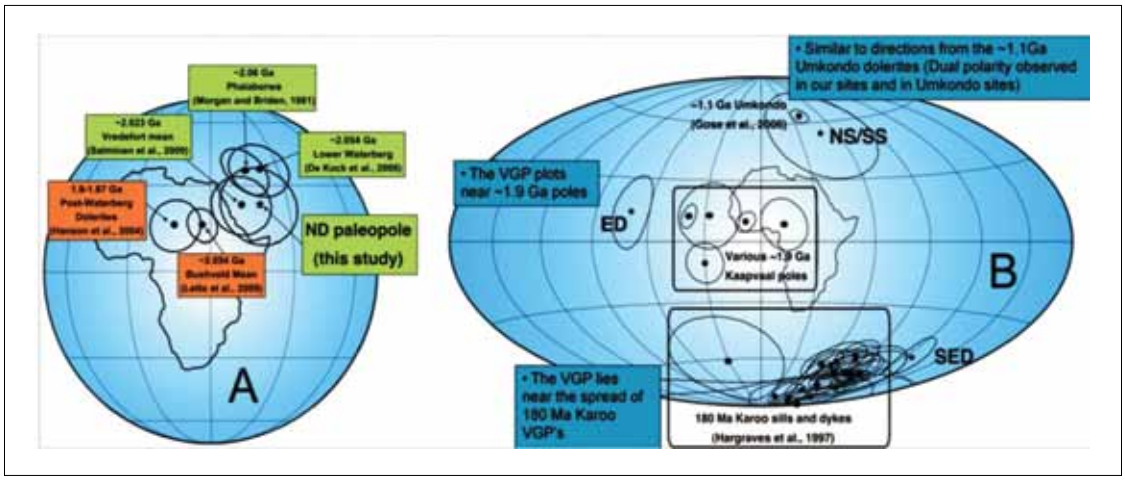
Paleomagnetic study of post-Transvaal sills and dykes in the eastern Kaapvaal Craton

Herve Wabo

In the Kaapvaal Craton, disagreement between paleomagnetic poles obtained from the Bushveld rocks and those from units of Bushveld-age has long presented a problem. In addition rapid polarity reversals reported from the Bushveld Complex by Letts et al. (2009; Palaeomagnetism of the 2054 Ma Bushveld Complex (South Africa): implications for emplacement and cooling; Geophysical Journal International, vol. 179, pp. 850-872) also remains to be explained. To investigate these problems, we sampled post-Transvaal sills and dykes in the eastern half of the Kaapvaal Craton (see figure). These intrusions are believed to be genetically associated with the ca 2.05 Ga BIC and represent rapid cooling as opposed to the main complex (i.e., simpler magnetic history). For our study, about 122 oriented cores were obtained from six sills (pyroxenite, norite, dolerite, and diorite rocks types), one east-trending pyroxenite dyke, and eight NNE-trending dolerite dykes near Belfast and Lydenburg (see locality figure). In addition, 5 oriented cores were also taken from one site of country rocks for conducting a baked contact test.

The paleomagnetic measurements were achieved using the new superconducting rock magnetometer housed at UJ. Specimens were treated using both low-fieldstrength AF (up to 10mT) and thermal demagnetization (from 100°C to above 580°C). Paleomagnetic analysis reveals the existence of four high-stability remanent magnetic components that unblock above 500°C.

The first one is oriented north down (ND component) and is identified in many of the sills as well as the dykes from the Belfast and Lydenburg areas. This ND component is believed to be primary, based on a positive baked contact test. The ND paleopole overlaps with the 2.06 to 2.054 Ga poles (see paleomagnetic results figure A), suggesting that many of the post-Transvaal intrusions are related to a magmatic event of this age interval (i.e., the Bushveld Complex). Importantly, however, our pole doesn't overlap with Letts' Bushveld mean pole (see paleomagnetic results figure A). In addition, the absence of reversals in our ND directions may suggest that Letts' pole might be representative of a longer time period (i.e., protracted cooling).



Paleomagnetic poles and VGP obtained from sills and dykes in this study compared to existing data from the Kaapvaal craton

The second high stability component is shallow dual- polarity directions (North and South) and is obtained from the NNE-trending dykes from Lydenburg. These NS/SS directions are similar to the directions from the ~1.1Ga Umkondo dolerites (see paleomagnetic results figure B).

The third high stability direction, oriented east-down (ED component), is identified in one NNE-trending dyke from Lydenburg. The VGP, recalculated from this ED component, plots near existing ~1.9 Ga poles (see paleomagnetic results figure B), indicating that the NNE-trending dyke swarm hosts dykes of at least three discrete magmatic events.

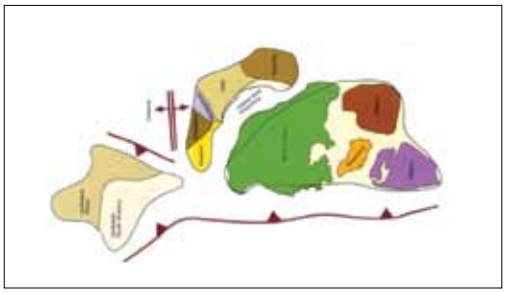
The fourth high stable magnetic direction, identified in one sill from Belfast, gives a 180 Ma-like direction (see paleomagnetic results figure B), thus some post-Transvaal intrusions are probably related to the Karoo Large Igneous Province.

The paleogeographic position of India during the break-up of the Mesoproterozoic supercontinent Nuna

Michiel de Kock

The configuration of continents in Earth history is becoming increasingly important for our understanding of the changing Earth system through time. Since paleomagnetism coupled with precise isotope age data is the only method by which to gain direct information on ancient continental configurations, insufficient paleomagnetic and geochronological data is the most significant problem facing paleogeographic reconstructions. The exact configuration of Rodinia, for example, remains highly debatable, but has generally matured over two decades of scientific effort aimed at filling gaps in the paleomagnetic and geochronological database. Compared to this, ideas on the configuration of the earlier Mesoproterozoic Nuna supercontinent are in their infancy.

Nuna is usually represented around the 'Hudsonland' juxtaposition of Laurentia and Baltica. Siberia can be fitted along the eastern margin of Laurentia and the Uralian margin of Baltica to complete the acronym NENA (Northern Europe and North America) within Nuna. Other blocks (e.g., Proto-Australia, North China, Amazonia, India, etc.) are usually tentatively positioned around the NENA-fit based mostly upon geological correlation and limited paleomagnetic consideration. Geological similarities between eastern India and the Columbia region of North America promoted usage of the name Columbia for this Mesoproterozoic supercontinent. In addition India was made part of the larger crustal block (i.e., Ur), which sees it essentially in a Pangean arrangement with respects to Proto-Australia, Madagascar, coastal East Antarctica and Kalahari. India's position, however, has subsequently been significantly modified by other authors, which is why the name Nuna is given preference instead of Columbia.



Proposed reconstruction of the supercontinent Nuna, which places India near the Columbia region of North America. This reconstruction is not geometrically accurate, and has been modified by various authors

India's position within Nuna has only been tested paleomagnetically at ~1770 Ma, and then via the "closest approach" method which allows considerable leeway in relative paleolongitude between India and other continental blocks. Since then new paleomagnetic data has become available. Combined with the recent acquisition of reliable paleomagnetic data and 1405 ± 9 Ma to 974 ± 8 Ma ages from carbonate sequences from the Penganga and the Chandarpur-Raipur groups, India's position within Nuna can now be constrained more reliably via arc-length comparisons between similarly-aged poles from India and other continental blocks of interest.

Finely-bedded grey limestone of the Bhima basin, Karnataka, India

The new paleomagnetic data consists of six sampling sites and is supported by various field tests of paleomagnetic stability, which attests its primary nature. To enhance the quality of paleomagnetic poles obtained from India during the break-up of phase of Nuna, additional sites are to be sampled in early 2011 from the Kaladgi and Bhima basins of Karnataka in India.

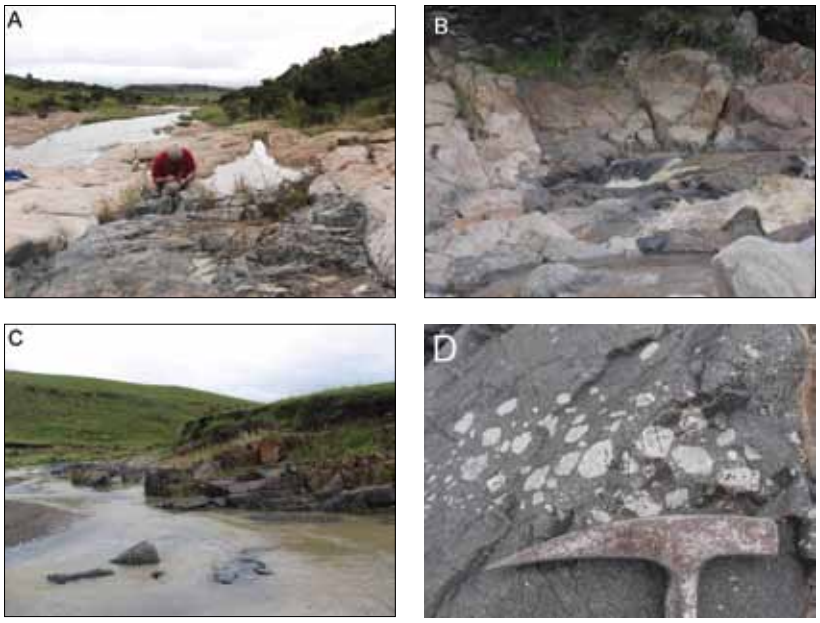
Mafic- to ultramafic intrusions along the southeastern margin of the Kaapvaal Craton

Ashley Gumsley

The southeastern margin of the Kaapvaal Craton in northern KwaZulu-Natal hosts numerous inliers of Archean crust. It is preserved in the Mesoarchean to Neoarchean granite-greenstone basement and the supracrustal volcano-sedimentary Pongola Supergroup which lies unconformably over it. These inliers of Archean crust host at least four distinct generations of mafic to ultramafic dykes and sills. The dykes are subvertical, and typically less than 100 m in width. Three of these generations cut the Archean crust and are absent from the surrounding areas of Karoo Supergroup sedimentary and volcanic rocks, and therefore must pre-date this succession. These dykes include ENE-, NW-, NE- and N-tending dykes in addition to the Hlagothi Complex.

The ENE-trending dykes are massive, fine- to medium-grained and are extensively altered to upper greenschist facies metamorphism and appear restricted to the undifferentiated basement granitoids. These dykes are believed to be ca. 2.95 Ga and associated with the extension-related volcanic and sedimentary rocks of the ca. 3.07 Ga Dominion and ca. 2.98 Ga Nsuze events.

The NW-trending dykes are massive and medium- to coarse-grained. These dykes are associated with the 2.85 Ga Usushwana event in Swaziland, and includes the Hlagothi Complex sills further south, which intrudes into the basal quartzite of the Nsuze Group. These sills were believed to be contemporaneous with the ca. 2985 Ma Nsuze Group. However, recent age dating suggests a link with the Usushwana Complex further north in Swaziland. It is possible that the Usushwana Complex was the product of several magmatic pulses over an extended period of time, and that the Hlagothi Complex followed the magmatic pathways of the Usushwana Complex. This signifies a possible large igneous province in the region, and a re-emergence of mafic magmatism following the Nsuze event. These sills are less than 200 m width and trend east-west along a major lineament in the area, dipping gently to the south. The lower sills comprise meta-peridotite and meta-pyroxenite, whereas the upper sills comprise meta-gabbro.



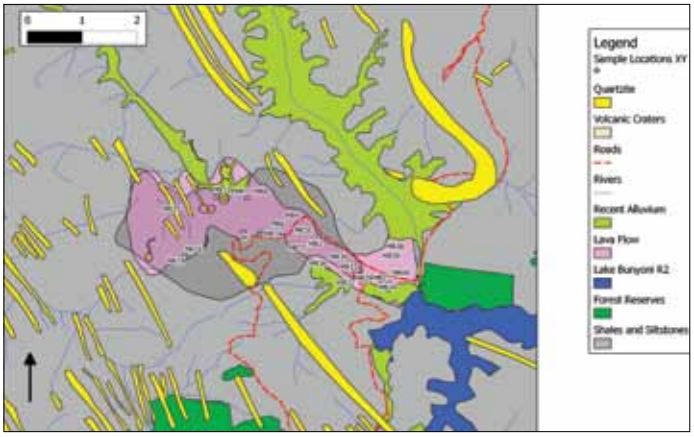
Photos illustrating a NE-trending dyke in the Mvunyana granitic inlier (A), a ENE-trending dyke in the White Mfolozi inlier (B), the ultramafic section of the Hlagothi Complex with a shallow dip to the south (C), and plagioclase phenocrysts within a NE-trending dyke from the Ilangwe inlier (D)

The NE-trending dykes are porphyritic and fine- to medium-grained, many of which include phenocrysts of plagioclase feldspar (see figure). These dykes are thought to be associated with the ca. 2.65 Ga rifting related to the Ventersdorp volcano-sedimentary event and cross-cut the Pongola Supergroup. Finally, the N-trending dykes are fresh, unaltered massive and medium- to coarse-grained. These dykes are associated with the ca. 0.18 Ga Karoo magmatic event, and also cross-cut sedimentary strata of the Karoo Supergroup.

Preliminary geophysics and geochemistry of Muko volcano, Uganda

Michael de Villers

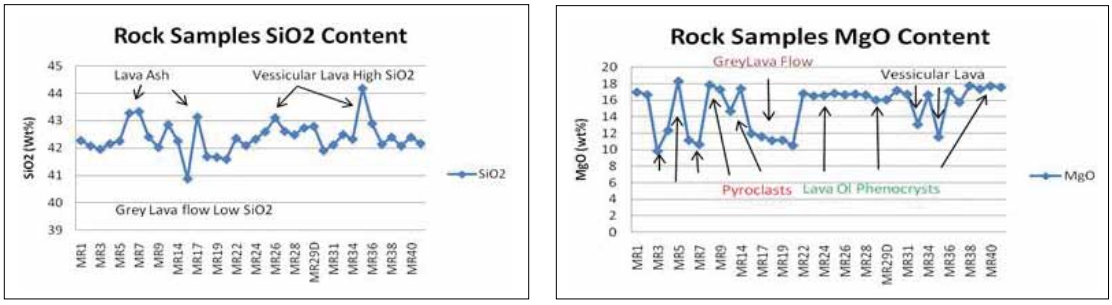
The Muko volcanic field lies at the northwestern end of Lake Bunyonyi, with the lava flow emanating from Muko volcano leading to the damming of the valley and the subsequent formation of the lake (see figure). The volcano is intruded into Karagwe Ankolean successions consisting of northwesterly trending phyllite and quartzite. The volcano itself consists of a series of vents from which magma erupted as gases, lava, and ejecta. The volcanic area is covered by pyroclastic rocks of varying size from fine ash < 1mm to lava bombs of size up to 600mm. A prominent lava flow in the centre of the valley was mapped. The lava is a fine-grained very dark grey rock having a greasy appearance with abundant olivine and pyroxene discernable in the groundmass.



Geologic map of the study area

Ground geomagnetic surveys were completed on the Muko Volcano. The objective of the survey was to investigate the possible diamond economic potential of the area. It was hoped that the location of the diatremes could be accurately pinpointed using ground geomagnetic survey methodology. Diamond bearing kimberlite and lamproite pipes containing diamonds usually contain magnetite and/or ilmenite. A magnetic anomaly was identified by preliminary interpretation of the total field aeromagnetic map and the volcano was identified as a possible target for further investigation. From the geomagnetic survey two possible diatremes were identified. The survey was complicated by the overlying pyroclastic rocks which masked the analytic signal of the magnetic survey. Processing of the geomagnetic field data delineated two locations that may represent diatremes below pyroclastics.

The lava exhibits a porphyritic texture with olivine phenocrysts indicating that olivine formed slowly and remained as fairly large crystals; the sudden cooling caused the rapid crystallization of the remainder of the melt into a fine grained matrix surrounding the olivine phenocrysts. The light green olivine crystals are up to 6 mm long with an average size of approximately 3 mm. Pyroxene phenocrysts are present in the lava. Petrographic and geochemical investigations identified the rocks from Muko as belonging to the Kamafugite group. The rocks were classified as Ugandite.



Geochemical variation of MgO and SiO_2 observed among the samples studied

STAFF NEWS

Axel Hofmann

Axel Hofmann joined the Geology Department and PPM to take up position as an Associate Professor. His main interests revolve around the geology of the Archaean era, the most ancient part of Earth history for which rocks as old as 4 billion years are preserved. Under the umbrella of the PPM group he is in the process of establishing a research project entitled Early Earth Life and Mineral Systems Science.

Freeman Senzani

Freeman, an exploration geologist involved in investigations in coal, petroleum, base and precious metals, joined the Geology department and PPM. His current research interest is on how lime and cement production plants can be customised for use by small-scale operators in South Africa, where large-scale operations are the norm, and in Malawi, where, although there has been a long history of such small scale operations, they have been inefficient and environmentally unfriendly, especially with regard to deforestation.




POST-DOCTORAL RESEARCH ASSOCIATES

From left to right, Barbara Cavalazzi, Cora Wohlgemuth-Ueberwasser, George Belyanin and Kazuyasu Shindo joined the department to further the research activities of PPM. Barbara, who received PhD from the Universitá di Modena e Reggio Emilia, Italy, has research interests primarily in the field of geomicrobiology of Precambrian hydrothermal systems and their implications for the origin of life. Cora, who received PhD from the University of Münster, Germany, has research interests on the analysis of platinum group elements (PGEs) and other trace metals in sulfides using LA-ICP-MS facilities. George, who received PhD from the University of Johannesburg, has research interests in the field of ultrahigh-temperature metamorphism and Ar-Ar geochronology. Kazuyasu, who received PhD from the University of Tsukuba, Japan, has research interests in sulphide mineralization in mafic-ultramafic rocks, with focus on PGEs.

SUPPORT STAFF

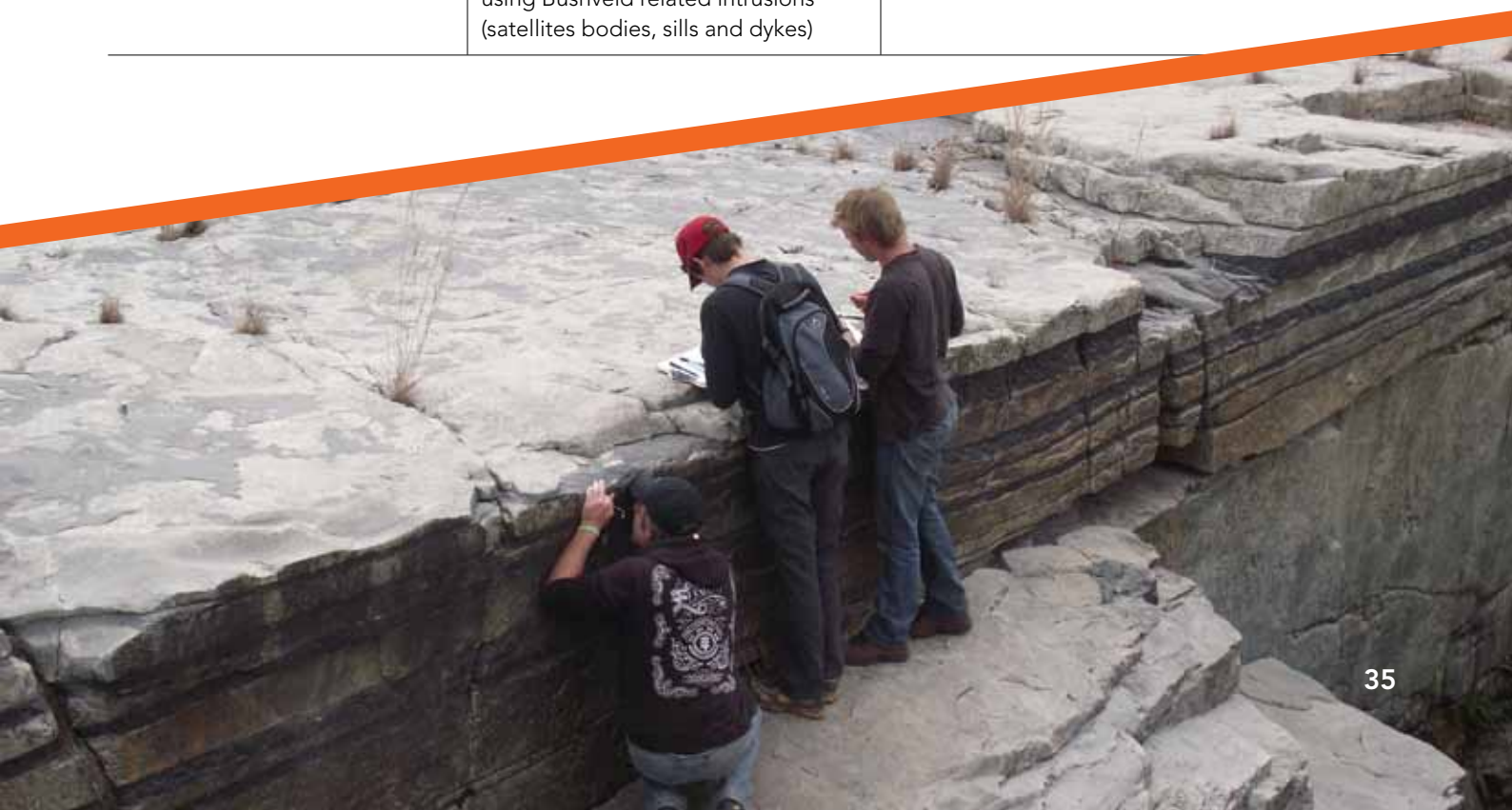
From left to right, Lisborn Mangwane (technical assistant for thin section preparation), B.T. Tshivhiahuvhi (technical assistant for rock crushing and sample preparation), and Michael Chakuparira (PPM secretary).



STUDENTS IN PPM – 2010

STUDENT	THESIS TOPIC	ADVISORS
Cloete, Louis (MSc)	Geochemistry of a gold-bearing alteration zone in the Witwatersrand succession.	K.S Viljoen, J.M. Huizenga
Crossingham, Alexandra (MSc)	Modelling of diamond precipitation from fluids in the Earth's mantle.	J.M. Huizenga, K.S. Viljoen
Da Silva, Richard (MSc)	Characterisation of the Lucknow, Neylan and Matsap quartzites in the Koegas-Postmasburg area.	N.J. Beukes
Dreyer, Daphne (MSc)	Geochronology and correlation of red beds of the Paleoproterozoic Elim Group, Griqualand West.	H. van Niekerk, N.J. Beukes
Greeff, Christiaan (MSc)	Modal and cryptic variation of the Merensky Reef, Western Bushveld Complex.	M. Knoper, K.S. Viljoen, H.M. Rajesh
Gumsley, Ashley (MSc)	Towards establishing a 'bar code' for the south-eastern terrane of the Kaapvaal Craton in northern KwaZulu-Natal,South Africa.	M. Knoper, H.M. Rajesh, and M.O. de Kock
Mabundza, Themba (MSc)	Characterization of syn-Bushveld sills from the Uitkomst Complex.	H.M. Rajesh, M. Knoper
Mkhatshwa, Sindile (MSc)	Assessment of the mineralogical variability of the UE1A and A5 reefs at Rand Uranium properties, Cooke Section, using MLA-based automated mineralogy.	K.S. Viljoen, H. Mouri
Mngoma, Lethuxolo (MSc)	MLA-based mineralogical assessment of gold and uranium mineralization at Cooke Section, Rand Uranium, Randfontein.	K.S. Viljoen, H.M. Rajesh
Nel, Brian (MSc)	Stratigraphy, petrography and geochemistry of iron formations of the Koegas Subgroup of the Transvaal Supergroup	J. Gutzmer, N.J .Beukes
Osburn, Keith (MSc)	The nature and origin of the polymetallic Salt River massive sulphide deposit, Northern Cape Province, South Africa.	J. Gutzmer, J.M. Huizenga, C.R. McClung
Peche, Marieke (MSc)	The sedimentary characteristics and origin of Inhaca Island.	N.J. Beukes, H. v Niekerk
Pretorius, Donavan (MSc)	Mineralogical assessment of coal from New Vaal Colliery through the application of automated mineralogy with a view on possible beneficiation	K.S. Viljoen, B. Cairncross

Rose, Derek (MSc)	The Merensky Reef at Dwarsriver 372 KT with reference to the mineral chemistry and the platinum-group minerals in the Merensky Reef chromitite stringers.	M. Knoper, H.M. Rajesh , K.S. Viljoen
Van der Merwe, Frits (MSc)	A mineralogical investigation of Lonmin's Akanani platinum group metal project.	K.S. Viljoen, M. Knoper
Van der Walt, Byron (MSc)	Petrography, geochemistry and origin of anomalous boreholes intersections in the Northern Karoo Basin.	B. Cairncross, H.M. Rajesh
Belyanin, George (PhD)	Magmatic and metamorphic characteristics from the Limpopo Belt.	D. van Reenen, H.M. Rajesh
Beyeme-Zogo, Jean-Clement (PhD)	Low grade iron ore potential of iron formation of the Transvaal Supergroup in the Griqualand West region of the Northern Cape Province, South Africa.	N.J. Beukes
Chisonga, Benny (PhD)	Relation of mafic dykes and sills to genesis of high-grade iron ore.	N.J. Beukes, H.M. Rajesh
Guy, Bradley (PhD)	Massindependent sulphur isotope fractionation in the Witwatersrand succession.	N.J. Beukes, J. Gutzmer
Mishra, Gargi (PhD)	A geometallurgical assessment of the geological and mineralogical influences on plant performance at the Nkomati Nickel Mine, Mpumalanga.	K.S. Viljoen , H. Mouri
Smith, Bertus (PhD)	Geometallurgical characterisation of the Merensky Reef facies at Bafokeng Rasimone Platinum Mine, South Africa.	K.S. Viljoen
Vorster, Clarisa (PhD.)	Developing ICP-MS laser ablation zircon dating at Spectrau with application in the Cape Supergroup.	J. Kramers, N.J. Beukes, H. v. Niekerk
Wabo, Herve (PhD)	Paleomagnetism and high precision chronology of the Bushveld complex, using Bushveld related intrusions (satellites bodies, sills and dykes)	M.O. de Kock



POST–DOCTORAL ASSOCIATES

McClung, Craig Dr.	Geometallurgical assessment of the massive sulfide deposits in the Aggeneys - Gamsberg District in the Namaqua Metamorphic Province, with an emphasis on mineralogy and location of deleterious elements.	K.S. Viljoen
Richards, Bryony Dr.	Characterization of the Kolo kimberlite pipe: Constraints on the composition and genesis of the diamondiferous lithospheric mantle below the eastern margin of the Kaapvaal Craton.	K.S. Viljoen

THESES COMPLETED - 2010

LOUIS MICHIEL CLOETE (MSc)
Characterization of a recently discovered zone of intense hydrothermal alteration, deformation and unusual Au mineralization at AnglogoldAshanti's Kopanang gold mine.
Supervisor: F. Viljoen

PIETER HUGO FOURIE (MSc)
Provenance and paleotectonic setting of the Devonian Bokkeveld Group, Cape Supergroup, South Africa.
Supervisors: N.J. Beukes and U. Zimmerman

S.D. OPOUBOU-LANDO (MSc)
Mineralogical characterization of chromite in the UG2 Reef from Waterval Mine, Western Bushveld: Implications for minerals processing.
Supervisors: J. Miller, M. Becker, F. Viljoen

DANEL VAN TONDER (MSc)
Petrology and geochemistry of the granitoids of the Halfway House Dome.
Supervisor: H. Mouri

PUBLISHED PAPERS

AUTHORS	TITLE AND JOURNAL DETAILS
Abre P, Cingolani C, Zimmermann U, Cairncross B, Chemale F.	Provenance of Ordovician clastic sequences of the San Rafael Block (central Argentina), with emphasis on the Ponon Trehue Formation. Gondwana Research, V. 19, pp. 275 – 290.
Bailie R, Gutzmer J, Rajesh HM	Lithogeochemistry as a tracer of the tectonic setting, lateral integrity and mineralization of a highly metamorphosed Mesoproterozoic volcanic arc sequence on the eastern margin of the Namaqua Province, South Africa. Lithos, V. 119, pp. 345 - 362.
Bailie R, Gutzmer J, Strauss H, Stüeken E, McClung CR	Sulfur isotope characteristics of metamorphosed Zn–Cu volcanogenic massive sulfides in the Areachap Group, Northern Cape Province, South Africa. Mineralium Deposita. V. 45, pp. 481- 496.

Belyanin GA , Rajesh HM	Corundum + orthopyroxene ± spinel intergrowths in an ultrahigh-temperature Al-Mg granulite from the Southern Marginal Zone, Limpopo Belt, South Africa. American Mineralogist, V. 95, pp. 196 -199.
Blanco G, Rajesh HM, Gaucher C, Germs GJB, Chemale F	Reply to the comment by Sánchez Bettucci et al. on: "Provenance of the Arroyo del Soldado Group (Ediacaran to Cambrian, Uruguay): Implications for the paleogeographic evolution of southwestern Gondwana" , V. 171, pp. 57 – 73.
Cairncross B	The first book on minerals of South Africa. South African Lapidary Magazine, V. 42(1), pp. 31 - 35.
Cairncross B	Gothic goethite. South African Lapidary Magazine, pp. 6 – 9.
Cairncross B, Van Niekerk H, Reinke C, Bahmann U.	Raspite from the Erongo Mountains, Namibia. Rocks & Minerals, V. 85, pp. 272 - 274.
Dirks PHGM, Kibii JM, Kuhn BF, Steininger C, Churchill SE, Kramers JD, Pickering R, Farber DL, Mériaux AS, Herries AIR, King GCP, Berger LR	Geological Setting and Age of Australopithecus sediba from southern Africa. Science, V. 328, pp. 205 - 208.
Ghavami-Riabi, Mouri H, Graser	Applying the box plot to the recognition of footwall alteration zones related to VMS deposits in a high-grade metamorphic terrain, South Africa: a lithogeochemical exploration application. Chemie der Erde, V. 71, pp. 143 -154.
Guy B, Beukes NJ , Gutzmer J	Palaoenvironmental controls on the texture and chemical composition of pyrite from non-conglomeratic sedimentary rocks of the Mesoarchean Witwatersrand Supergroup, South Africa. South African Journal of Geology, V. 113, pp. 195 – 228.
Master S, Bekker A, Hofmann A	A review of the stratigraphy and geological setting of the Palaeoproterozoic Magondi Supergroup, Zimbabwe - type locality for the "Lomagundi" carbon isotope excursion. Precambrian Research, V. 182, pp. 254 - 273.
McClung CR, Gutzmer J Beukes NJ	A new chronostratigraphic paradigm for the age and tectonic history of the Mesoproterozoic Bushmanland ore district, South Africa - A discussion. Economic Geology, Vol. 8, pp. 1277-1281.
Nishimiya Y, Tsunogae T, Santosh M	Sapphirine corona around magnesian (XMg ~0.58) staurolite from the Palghat-Cauvery Suture Zone, southern India: Evidence for high-pressure and ultrahigh-temperature metamorphism within the Gondwana suture. Lithos, V. 114, pp. 490 - 502.
Perchuk LL, Moiseeva EI, Belyanin GA, Van Reenen DD	High temperature polymetamorphism in the Central Zone of the Limpopo granulite complex (South Africa): Structural and petrologic evidence. Doklady of the Russian Academy of Science, V. 431, pp. 523 - 527.
Pickering R, Kramers J	Re-appraisal of the stratigraphy and determination of new U-Pb dates for the Sterkfontein hominin site. South African.Journal of Human Evolution, V. 59, pp. 70 - 86.
Pickering R, Kramers J, Partridge T, Kodolanyi J, Pettke Th	U–Pb dating of calcite–aragonite layers in speleothems from hominin sites in South Africa by MC-ICP-MS. Quaternary Geochronology, V. 5, pp. 544 - 558.

Praekelt HE, Germs GJB, Kennedy JH	Late Ediacaran glaciation in southern Africa and its glacioeustatic record: a reply to Zimmerman's comments on Praekelt, Germs and Kennedy (2008). South African Journal of Geology, V. 113, pp. 135 – 139.
Steinhoefe, G, Von Blanckenburg F, Horn I, Konhauser KO, Beukes NJ, Gutzmer J	Deciphering formation processes of banded iron formation from the Transvaal and Hamersley successions by combined Si and Fe isotope analyses using UV femtosecond laser ablation. Geochimica et Cosmochimica Acta, V. 74, pp. 2677 - 2696.
Tolstikhin I, Kamensky I, Tarakanov S, Kramers J, Pekala MV, Skiba V, Gannibal M, Novikov D	Noble gas isotope sites and mobility in mafic rocks and olivine. Geochimica et Cosmochimica Acta, V. 74, pp. 1436 - 1447.
Tsunogae T, Santosh M	Sapphirine + quartz assemblage from the Southern Granulite Terrane, India: diagnostic evidence for ultrahigh-temperature metamorphism of sapphirine granulites from within the Gondwana collisional orogen. Geological Journal, V. 46, pp. 183 - 197.
Tsunogae T, Santosh M	Ultrahigh-temperature metamorphism and decompression history of sapphirine granulites from Rajapalaiyam, southern India: implications for the formation of hot orogens during Gondwana assembly. Geological Magazine, V. 147, pp. 42 - 58.
Van Tonder DM, Mouri H	Petrology and geochemistry of the granitoid rocks of the Johannesburg Dome, Central Kaapvaal Craton, South Africa. South African Journal of Geology, V. 113, pp. 257 - 286.
Viljoen KS , Dobbe R, Harris JW, Smit B	Trace element chemistry of mineral inclusions in eclogitic diamonds from the Premier (Cullinan) and Finsch kimberlites, South Africa: Implications for the evolution of their mantle source. Lithos, V. 118, pp. 156-168.
Voegelin A, Nägler TF, Beukes N, Lacassie JP	Molybdenum isotopes in late Archean carbonate rocks: Implications for early Earth oxygenation. Precambrian Research, V. 182, 70-82.

PRINTED CONFERENCE ABSTRACTS

AUTHORS	TITLE AND CONFERENCE INFORMATION
Beukes NJ, Gutzmer J	Oxygenated oceanic environments and Mn(IV) respiration prior to the rise of atmospheric oxygen at ~2.32 Ga: Evidence from iron and manganese formations. EOS (AGU Meeting of the Americas, Iguazu, Brazil, pp.231.
Beukes NJ, Gutzmer J , Nel B	Ce anomalies in ~2.4 Ga iron and manganese formations as proxy for early oxygenation of oceanic environments. Geochemica et Cosmochimica Acta, Goldschmidt Conference Abstracts, A85.
Beukes NJ	Origin of iron formation-hosted high-grade iron and manganese deposits and their paleoenvironmental significance. Abstract Volume, Iron Formation Workshop, Univ. Minnesota, Duluth . pp.45 - 51.
Cairncross B	"Minerals maketh man ...." so where is South Africa's mineral heritage? South African Lapidary Magazine, pp.12.
Chisonga C, Rajesh HM, Beukes NJ, Gutzmer J, Armstrong RA	New precise SHRIMP U-Pb titanite ages from the Thabazimbi sills and from dolerites at the Sishen mine. Abstract Volume, PPM Annual Colloquium, UJ Hotel School, Auckland Park, pp. 6.

Crossingham A, Huizenga J-M, Viljoen KS	A theoretical examination of diamond precipitation from fluids in the Earth's mantle. IMA2010, 21-27 August, Budapest, Hungary. Acta Mineralogica-Petrographica Abstract Series, vol 6, p. 184.
Da Silva R, Dreyer D, Vorster C	Detrital zircon age populations in Gamagara/Mapedi, Lucknow and Olifantshoek red beds: implications for the timing of development of high-grade Sishen-type iron ore in Griqualand West. Abstract Volume, PPM Annual Colloquium, UJ Hotel School, Auckland Park, pp. 4 - 5.
GuyB	A multiple-sulfur and organic carbon isotope record from the Mesoarchean Witwatersrand Supergroup, South Africa. Abstract Volume, PPM Annual Colloquium, UJ Hotel School, Auckland Park, pp.15 -16.
Heimann H, Johnson CM, Beard BL, Valley JW, Roden EE, Spicussa MJ, Beukes NJ	Fe, C and O isotope composition of banded iron formation carbonates demonstrate a major role for dissimilatory iron reduction in ~2, 5 Ga marine environments. Earth and Planetary Science Letters, V. 294, pp. 8 -18.
Johnson CM, Heimann A , Beard BL, Valley JW, Roden EE, Spicuzza MJ, Beukes NJ	Fe, C and O isotope compositions of banded iron formation carbonates demonstrate the role of bacterial dissimilatory iron reduction in ~2.5 B.Y. old marine environments. Abstracts, NE-SE GSA Regional Meeting, pp. 56.
Kruger F, Beukes NJ	Iron formations and magnetite ore bodies of the Aggeneys area. Abstract Volume, PPM Annual Colloquium, UJ Hotel School, Auckland Park. pp. 3 - 4.
McClung CR, Viljoen F	Mineralogical Investigation of the Aggeneys-Gamsberg BHT District, South Africa: Implications for Classification of a Classical Broken Hill-type District: SEG 2010 Conference, 2-5 October 2010, Keystone, USA, D-11, 3 pp.
McClung CR, Viljoen KS	Ore mineralogy of the world-class Gamsberg zinc sulfide deposit, South Africa: Geological Society of America Meeting 31 October-3 November 2010, Denver, Colorado, USA. Geological Society of America Abstracts with Programs, vol 42, No. 5, p. 535.
McClung CR, Viljoen F	Mineralogical assessment of sphalerites from the Gamsberg deposit, South Africa: the manganses conundrum. Proceedings of Processing of Zinc Ores and Concentrates 2010, Cape Town, South Africa, 13 November 2010, p. 1-3
Nel , Beukes NJ	Geochemistry of ~2.4 Ga Koegas and Duitschland iron formations and implications for oceanic environments at the time. Abstract Volume, PPM Annual Colloquium, UJ Hotel School, Auckland Park. pp. 3.
Moore M, Shaikhaidarov R, Petrashov V, Viljoen F	Probing inclusions in diamonds with fine beams of synchrotron X rays. 26th European Crystallographic Meeting, ECM 26, Darmstadt, Germany. Acta Cryst. A66, s303.

Richards BG, McClung CR, Viljoen KS	Characterization of the Kolo Kimberlite Pipe: Constraints on the composition and genesis of the diamondiferous lithospheric mantle below the eastern margin of the Kaapvaal Craton. Geological Society of America Meeting 31 October-3 November 2010, Denver, Colorado, USA. Geological Society of America Abstracts with Programs, vol 42, No. 5, p. 579.
Rose DH, Knoper MK, Rajesh HM, Viljoen KS	In-situ, MLA-based examination of Platinum Group Minerals associated with chromitite stringers in the Merensky Reef of the Eastern Bushveld Complex, South Africa. IMA2010, 21-27 August, Budapest, Hungary. Acta Mineralogica-Petrographica Abstract Series, vol 6, p. 272.
Smith AJB, Beukes NJ, Gutzmer J, Cochrane JM	Evidence for dissimilatory manganese reduction and availability of free molecular oxygen during deposition of Mesoarchean Witwatersrand-Mozaan strata. Geochemica et Cosmochimica Acta, Goldschmidt Conference Abstracts, pp. A973.
Smith AJB, Viljoen KS, Schouwstra R, Roberts J, Schalkwyk C, Gutzmer J	The geometallurgical characterisation of different Merensky Reef facies in the western limb of the Bushveld Complex, South Africa. IMA2010, 21-27 August, Budapest, Hungary. Acta Mineralogica-Petrographica Abstract Series, vol 6, p. 278.
Smith AJB, Viljoen KS, Schouwstra R, Roberts J, Schalkwyk C, Gutzmer J	Geological variations in the Merensky Reef at Bafokeng Rasimone platinum mine and it's influence on milling and flotation performance. Proceedings of Process Mineralogy '10, Cape Town, South Africa, November 10-12, 2010. www.min-eng.com. Unpaginated.
Van der Merwe F, Viljoen KS, Knoper MW	An in-situ, MLA-based mineralogical examination of the Akanani Platinum Group Metal Project, Bushveld Complex, South Africa. IMA2010, 21-27 August, Budapest, Hungary. Acta Mineralogica-Petrographica Abstract Series, vol 6, p. 273
Viljoen KS, Harris JW, Ivanic T, Richardson SH, Whitehead K	Trace element geochemistry and Ni thermometry of garnet inclusions in peridotitic diamonds from Premier and Finsch, South Africa: implications for diamond formation. IMA2010, 21-27 August, Budapest, Hungary. Acta Mineralogica-Petrographica Abstract Series, vol 6, p. 187.

CONFERENCE PRESENTATIONS

NAME	TITLE OF PAPER	CONFERENCE/PLACE OF MEETING
Beukes NJ	The origin of high-grade BIF-hosted iron ore.	Geology Seminar Series University of Manitoba, Canada, 12 March.
Beukes NJ	Classification and geology of iron ore deposits of South Africa.	Mike Porter Iron Ore Workshop, Sandton, South Africa, 19 April.
Beukes NJ	Origin of iron formation-hosted high-grade iron and manganese deposits and their paleoenvironmental significance.	Iron Formation Workshop, University of Minnesota, Duluth, 12 October.
Beukes NJ	Nature and paleoenvironmental significance of Precambrian manganese deposits.	Workshop on iron and manganese formations. Federal University of Ceara (UFC), Fortaleza, Brazil, 23 November.
Beukes NJ	Iron formation depositional systems and their paleoenvironmental significance.	Workshop on iron and manganese formations. Federal University of Ceara (UFC), Fortaleza, Brazil, 24 November.

Beukes NJ	Origin of high-grade iron ore deposits with special reference to Bif-hosted deposits.	Workshop on iron and manganese formations. Federal University of Ceara (UFC), Fortaleza, Brazil, 24 November.
Beukes NJ, Gutzmer J, Nel BP	Ce anomalies in ~2.4 Ga iron and manganese formations as proxy for early oxygenation of oceanic environments.	Goldschmidt Conference, Knoxville, USA, 17 June.
Beukes NJ, Gutzmer J	Oxygenated oceanic environments and Mn(IV) respiration prior to the rise of atmospheric oxygen at ~2.32 Ga: Evidence from Iron and manganese formations.	AGU Meeting of the Americas, Iguazu, Brazil, 12 August.
Cairncross B	Can legislation protect rare geological specimens - a case study from South Africa	6th International Geoscience Education Conference, University of the Witwatersrand, 29 August 3 September.
Cairncross B	The Johannesburg Geological Museum - an earth science education extravaganza	6th International Geoscience Education Conference, University of the Witwatersrand, 29 August - 3 September.
Cairncross B	Exotic micro-minerals from Aris, Namibia.	3rd Southern African Mineral Symposium, Council for Geoscience, Pretoria, 20 November.
Cairncross B	Micro-minerals from the Bushveld Complex, South Africa.	3rd Southern African Mineral Symposium, Council for Geoscience, Pretoria, 20 November.
Cairncross B	The mineral collection of Bruce Cairncross.	3rd Southern African Mineral Symposium, Council for Geoscience, Pretoria, 20 November.
Cairncross B	Should legislation protect South Africa's rare geological specimens?	PPM Annual Colloquium, UJ Hotel School, 18 November.
Cairncross B	The National Heritage Resource Act and rare geological specimens.	PPM Annual Colloquium, UJ Hotel School, 18 November.
Cairncross B	World famous South African mineral localities.	MINSA (Mineralogical Society of South Africa), AGM, UJ, 5 August.
Cairncross B	The Tucson Gem and Mineral Show - a 12-year retrospective.	Witwatersrand Gem & Mineral Club monthly meeting, UJ, 27 January.
Cairncross B	Photographing minerals	Witwatersrand Gem & Mineral Club monthly meeting, UJ, 21 March.

Cairncross B	The Messina copper mines: before, during and after.	Witwatersrand Gem & Mineral Club monthly meeting, UJ, 26 May.
Cairncross B	Who is responsible for South Africa's mineral heritage?	Witwatersrand Gem & Mineral Club monthly meeting, UJ, 28 July.
Chisonga B, Rajesh HM	New precise SHRIMP U-Pb titanite ages from the Thabazimbi sills and from dolerites at the Sishen mine.	PPM Annual Colloquium, UJ Hotel School, Bunting Road Campus, 18 November.
Crossingham A, Huizenga JM, Viljoen KS	A theoretical examination of diamond precipitation from fluids in the Earth's mantle.	20th General Meeting of the International Mineralogical Association, Budapest, Hungary, 21-27 August.
Da Silva R, Dreyer D, Vorster C	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.	PPM Annual Colloquium, UJ Hotel School, Bunting Road Campus, 18 November.
Rose D, Knoper MW, Rajesh HM, Viljoen KS	In-situ, MLA-based examination of platinum group minerals associated with chromitite stringers in the Merensky Reef of the eastern Bushveld Complex, South Africa.	20th General Meeting of the International Mineralogical Association, Budapest, Hungary, 21-27 August.
Guy B	Mass-independent sulfer isotope fractionation in the Witwatersrand succession	PPM Annual Colloquium, UJ Hotel School, Bunting Road Campus, 18 November.
Gutzmer J, Beukes NJ	Iron ore resources of South Africa.	PDAC Conference, Toronto, Canada, 5-11 March.
Knoper MW	Re-evaluating the provenance of gold in the Witwatersrand basin, South Africa using shale geochemistry.	Society of Economic Geologists SEG Conference, Keystone, USA, 2 - 5 October.
Knoper MW	The Mesoproterozoic Steenkampskraal rare-earth element deposit in Namaqualand, South Africa	Geological Society of America Annual Meeting, Denver, USA, 31 October - 3 November.
Knoper MW	Episodic mafic magmatism during the Mesoarchean to Paleoproterozoic on the Kaapvaal Craton: implications for cratonic reconstructions.	Geological Society of America Annual Meeting, Denver, USA, 31 October - 3 November.
Kramers JD	The ancient gneiss terrain in the context of global crustal evolution models.	Field workshop on early crustal evolution of the southeastern Kaapvaal craton in South Africa and Swaziland, Manzini, Swaziland, 17-23 May.
Kramers JD	An update on the Limpopo Belt.	Centennial Conference, Geological Survey of Zimbabwe, Harare, Zimbabwe, 21 October.
Kramers JD	Constraints on models for the formation of the Limpopo Belt, from Nd and Hf isotope systematics.	Centennial Conference Geological Survey of Zimbabwe, Harare, Zimbabwe, 21 October.

McClung C, Viljoen F	A detailed mineralogical investigation of the of the Aggeneys-Gamsberg BHT District, South Africa: Implications for classification of a classical Broken Hill-type district	SEG conference, 2-5 October, Keystone, USA.
McClung C, Viljoen KS	Ore mineralogy of the world-class Gumbserg zinc sulfide deposit, South Africa	Geological Society of America Meeting, 31 October - 3 November 2010, Denver, Colorado, USA.
Moore M, Shaikhaidarov K, Petrashow V, Viljoen F	Probing inclusions in diamonds with fine beams of synchrotron X rays.	26th European Crystallographic Meeting, Darmstadt, Germany, 29 August - 2 September.
Nel B, Beukes NJ	Geochemistry of ~2.4 Ga Koegas iron formation and implications for oceanic environments at the time.	PPM Annual Colloquium, UJ Hotel School, Bunting Road Campus, 18 November.
Richards BG, McClung CR, Viljoen KS	Characterization of the Kolo Kimberlite Pipe: Constraints on the composition and genesis of the diamondiferous lithospheric mantle below the eastern margin of the Kaapvaal Craton.	Geological Society of America Annual conference, Denver, Colorado, 31 October - 11 November.
Smith AJB, Viljoen KS, Schouwstra R, Roberts J, Schalkwyk C, Gutzmer J	Geological variations in the Merensky Reef at Bafokeng Rasimone Platinum Mine (BRPM) and its influence on milling and flotation performance.	Process Mineralogy, Cape Town, 10 -12 November.
Smith AJB, Viljoen KS, Schouwstra R, Roberts J, Schalkwyk C, Gutzmer J	The geometallurgical characterization of different Merensky Reef facies in the western limb of the Bushveld Complex, South Africa.	20th General Meeting of the International Mineralogical Association, Budapest, Hungary, 21 - 27 August.
Smith AJB, Beukes NJ, Gutzmer J, Cochrane JM	Evidence for dissimilatory manganese reduction and availability of free molecular oxygen during deposition of Mesoarchean Witwatersrand-Mozaan strata.	Goldschmidt Conference, Knoxville, USA, 18 June.
Van der Merwe F, Viljoen KS, Knoper MW	An in-situ, MLA-based mineralogical examination of the Akanani platinum group metal project, Bushveld Complex, South Africa.	20th General Meeting of the International Mineralogical Association, Budapest, Hungary, 21-27 August.
Viljoen KS, Harris JW, Ivanic T, Richardson SH, Whitehead K	Trace element geochemistry and Ni thermometry of garnet inclusions in peridotitic diamonds from Premier and Finsch, South Africa: implications for diamond formation.	20th General Meeting of the International Mineralogical Association, Budapest, Hungary, 21 -27 August.

ANNUAL RESEARCH COLLOQUIUM

University of Johannesburg
Department of Geology
PALEOPROTEROZOIC MINERALIZATION RESEARCH GROUP

Venue The University of Johannesburg, Auckland Park Kingsway Campus, Main Building, B Les 103, Kingsway, Auckland Park

Date Thursday, 3 November 2011

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 (2011), research involves thirteen academic staff members, four post-doctoral researchers, eight PhD and seventeen 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: Thursday, 3 November 2011
Place: University of Johannesburg, Kingsway Campus, Building B Les 103
Time: 13h00-20h00

13.00 - 13.30	Registration, Tea & Coffee	
13.30 - 13.35	Opening Remarks	Fanus Viljoen
13.35 - 13.55	Geometallurgical characteristics of the Merensky Reef, Bushveld Complex	Bertus Smith
13.55 - 14.15	Post-Permian diatreme activity in the northeastern Karoo basin	Byron van der Walt
14.15 - 14.35	Assessment of the mineralogy and Au deportment of reefs at Cooke Section, Rand Uranium properties	Sindile Mkhatshwa, Lethuxlo Mngoma
14.35 - 14.55	Geochronology and correlation of Paleoproterozoic red beds of the Elim Group in Griqualand West, Northern Cape Province	Daphne Dryer, Clarisa Vorster
14.55 - 15.15	Fluorite mineralization associated with lujavrite from the Mesoproterozoic Pilanesberg Alkaline Complex	Sara Turnbull
15.15 - 15.35	Structural setting of the Steenkampskraal monazite REE ore body	Mike Knoper
15.35 - 15.55	Tea	
15.55 - 16.15	Multiple sulfur isotope signatures of diagenetic pyrite nodules in quartz pebble conglomerates of the Witwatersrand Supergroup and Ventersdorp Contact Reef	Bradley Guy
16.15 - 16.35	Nontraditional stable isotope in Archean geology	Axel Hofmann
16.35 - 16.55	The Noble gas lab: Developments and projects	Jan Kramers
16.55 - 17.15	Spodumene-bearing pegmatites from the Greenlands Formation, Vredefort Impact Structure	Brandon Zacharopoulos
17.15 - 17.35	Paleomagnetic and geochemical characterization of post-Transvaal sills and dykes in the eastern Kaapvaal Craton	Herve Wabo
17.35 - 17.55	Paleogeographic position of India during the break-up of the Mesoproterozoic supercontinent Nuna	Michiel de Kock
17.55 - 18.05	Concluding Remarks	Nic Beukes
18.05 -	Wine and Snacks	

SPECTRAU

MLA Lab

EPMA Lab

Ar/Ar Lab

ICP-MS Laser Ablation Lab

Paleomag Lab

SPECTRAU, the Central Analyrtical Facility of the Faculty of Science at UJ, was established in 1999 as a one-stop state-of-the-art analytical 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:
Dr Willie Oldewage, Tel: 011 559 2274, Fax: 011 559 3361
Email: willieho@uj.ac.za