Council for Geoscience

ANNUAL TECHNICAL REPORT of the Council for Geoscience 2009/10

Council for Geoscience

ANNUAL TECHNICAL REPORT

OF THE COUNCIL FOR GEOSCIENCE

2010

COUNCIL FOR GEOSCIENCE
SOUTH AFRICA

The Council for Geoscience is established in terms of the Geoscience Act (Act No. 100 of 1993), and is listed as a Schedule 3A Public Entity in terms of the Public Finance Management Act (Act No. 1 of 1999).

Compiled by
Information Management Unit

Private Bag X112
Pretoria 0001
280 Pretoria Street, Silverton, Pretoria, South Africa
Tel. +27 (0)12 841 1911
http://www.geoscience.org.za

Front cover
The type section of the Kirkwood Formation is exposed in a cliff above the Sundays River north of the town Kirkwood (S33°25'42" E25°26'18"). The buff sandstone in the middle is sandwiched between variegated shale horizons. Cenozoic alluvial gravel of the Kudusklоof Formation disconformably overlies the Kirkwood Formation at the top of the cliff.

Management
OF THE COUNCIL FOR GEOSCIENCE

CHIEF EXECUTIVE OFFICER

Thibedi Ramontja

BOARD ADMINISTRATOR

Nangamso Mbeki

EXECUTIVE MANAGER

APPLIED GEOSCIENCE

Fhatuwani Ramagwede

Engineering Geoscience	– *Stewart Foya (Acting)*
Environmental Geoscience	– *Tsholofelo Phajane*
Minerals Development	– *Stewart Foya*
Water Geoscience	– *Leslie Strachan*

in the office of the CEO

STRATEGIC SERVICES

Nico Keyser and Maleka Monyepao

- Annual Technical Programme Management
- Commercial Project Tender Management
- Strategy Planning Cycle
- Technology and Innovation Management

EXECUTIVE MANAGER

REGIONAL GEOSCIENCE AND MAPPING

Peter Zawada

Central Regions	– *Abraham Thomas*
Eastern Cape	– *Greg Botha*
KwaZulu-Natal	– *Greg Botha*
Limpopo	– *Nick Baglow*
Marine Geoscience	– *Rochelle Wigley (Acting)*
Northern Cape	– *Luc Chevallier*
Western Cape	– *Luc Chevallier*

CHIEF FINANCIAL OFFICER

CFO SERVICES

Leonard Matsepe

Finances and Procurement	– *Leonard Matsepe (CFO)*
Information and Communication Technology	– *Peter Motaung*
Technical Services and Logistics	– *De Clerq Botha*

EXECUTIVE MANAGER

SCIENTIFIC SERVICES

Gerhard Graham

Geophysics	– *Patrick Cole*
Information and Collections Management	– *Danie Barnardo*
Laboratory	– *Thinus Cloete*
Regional Geochemical Mapping	– *Thinus Cloete*
Seismology	– *Michelle Grobbelaar*
Spatial Data Management	– *Ken Wilkinson*

SENIOR MANAGER

CORPORATE SERVICES

Malefshane Kola

Human Resources	– *Malefshane Kola*
Marketing and Communications	– *Nthombi Mdluli Jacha*

CONTENTS

FOREWORD

The Board and Management are pleased to report that, despite the financial difficulties of the organisation, it reported a high level of completion of its statutory or public-good research, which testifies to the dedication of its staff and the sound management of the technical programme. The statutory or public-good programme of the Council for Geoscience forms a key component of the mandate of the organisation, providing the opportunity for young geoscientists to develop as researchers to MSc and PhD level, but also allowing the organisation to follow pre-competitive lines of investigation with potential innovative and commercial prospects.

A fundamental role of any national geoscience institution, such as the Council for Geoscience, is the acquisition of new geoscience data, be it in the form of geological mapping, geophysical surveys or national or regional geochemical sampling programmes. It is from this corpus of data that the country can adequately address geoscience concerns, be they mineral exploration, environmental, energy or water related. Furthermore, the increasing interest in and concern with dynamic systems, such as the environment and geohazards, means that geoscience data gathering is no longer a 'once-off' process, but one that is carried out increasingly on a continual, monitoring and real-time basis. It is therefore of concern to the Board and Management that, owing to the financial constraints imposed on the organisation, it was forced to suspend a number of mandated data-gathering programmes, such as the airborne geophysical and geological mapping programmes.

South Africa is currently facing a serious challenge with regard to attracting exploration and mining investment. It will have to prepare itself to be competitive in this area through urgent interventions, which should include reinvesting in the geoscientific mapping of the country. In this regard urgent funding is required to address the matter.

Further cost-cutting measures were implemented, which included a 72 per cent cut in the budget of the geoscience library, the provision of only minimal core-viewing services at our national borehole core library and the curtailment of attendance of workshops and conferences by geoscientists. These measures were regrettable, but were deemed necessary to ensure the sustainability of the organisation.

The Council for Geoscience entered into high-level discussions with the Department of Science and Technology (DST), which culminated in the submission of Research and Development projects, that were within the 'Grand Challenges' of the DST of energy security, space science and technology, global change, and human and social dynamics. The Department of Science and Technology has agreed to fund several of these projects, including a preliminary investigation of the geothermal potential of South Africa, a review of rare-earth element prospects in the country, and the development of a proposal or business plan for a systematic national geophysical sea-bed survey. Through this process, the Department of Science and Technology has also assisted the organisation in amending its research proposals such that they are more innovative (service driven) and embedded within the societal requirements and national imperatives of South Africa.

Excellent progress was made with the proposed amendments to the Geoscience Act (Act No. 100 of 1993), which is now at the stage where public inputs are being reviewed. The Act and the proposed amendments represent a crucial stage in improving the mandate of the organisation in order that it can play an increasingly important role in the economic and environmental welfare of South Africa and its people.

The Council for Geoscience acquired a state-of-the-art drilling rig and associated supply rig. This equipment represents an important scientific and commercial platform, with its ability to do multi-drilling up to 400–500 m in depth. It is expected that the rig will be used for projects related to small-scale mining, as part of scientific research programmes, and in ongoing groundwater resource assessments. The purchase of the drilling rig gives the organisation independence and allows a rapid response time in respect of its drilling needs.

Several planned activities for the year were terminated in order to reduce costs. These include the suspension of costs related to the Annual Technical Programme other than direct labour and personnel costs, and included, amongst others, new recruitments, new bursaries, training, incentive bonuses, etc. Overhead costs, such as travel expenses,

consulting fees, conference attendances, advertisement expenditure, etc. were also suspended. There were, however, costs that emanated from contracts that could not be suspended. These include costs pertaining to security services, cleaning services, maintenance services, etc. and had to be incurred in full.

The Board and Management of the Council for Geoscience are most appreciative of the dedication and loyalty shown by the staff in this difficult and unpredictable time for the organisation. We are certain that with this continued support the organisation will emerge from its financial difficulties stronger and reshaped for a future that looks bright for the geosciences.

The Board and Management of the Council for Geoscience would like to thank the Ministers and staff of the Departments of Mineral Resources and of Science and Technology for their valued support.

Dr T Ramontja
Chief Executive Officer

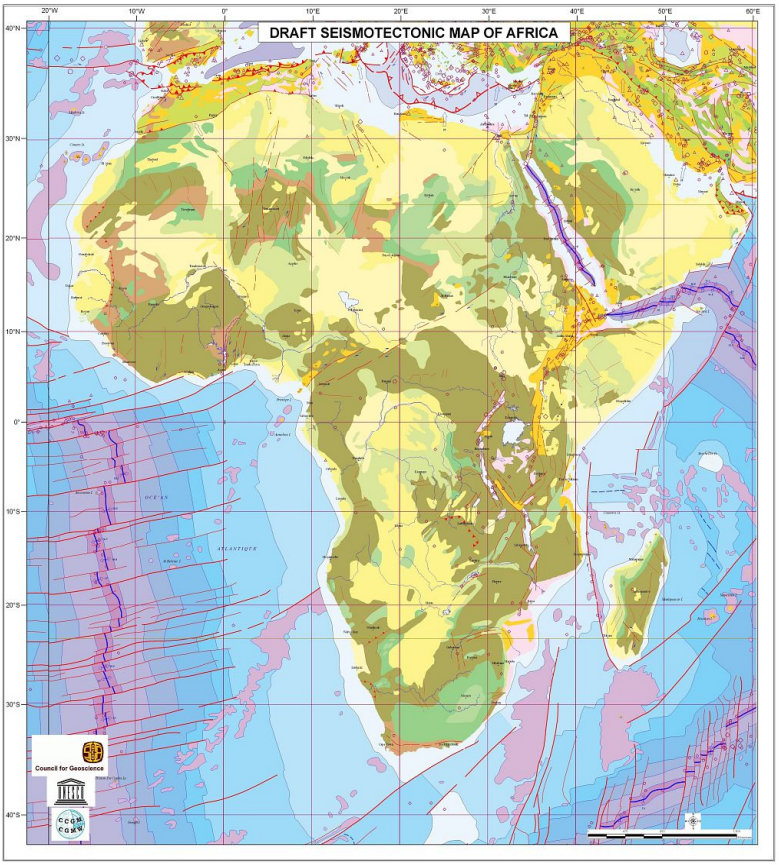
INTERNATIONAL COOPERATION

ST-2007-0944 **SEISMOTECTONIC MAP OF AFRICA**

Project leader: B.A. Ingram, M.Sc.
Project team: P.K. Zawada, Ph.D., M.R.G. Grobbelaar, B.Sc. Hons, V. Midzi, Ph.D., D. Delvaux, Ph.D. (Belgium), P. Rossi, Ph.D. (France), J.P. Cadet, Ph.D. (France), F. Toteu, Ph.D. (Cameroon)
Primary objective: To produce a seismotectonic map and database for Africa which will support a sustainable earthquake disaster mitigation strategy
Duration: 2008/09–2010/11
Budget: R185 389

Motivation
The Seismotectonic Map of Africa is an effort deployed by the Commission for the Geological Map of the World (CGMW) to obtain a better knowledge of the geology and geodynamics of Africa. This mapping project complements the 1:5 000 000-scale Geological Map of Africa, with a 1:5 000 000-scale Tectonic Map of Africa to be published soon. The map will assist in the mitigation of natural disasters in Africa. Whereas geological hazards are noteworthy in northern Africa, a limited impact is experienced in the sub-Saharan area, except in the East African Rift System and the Cameroon volcanic line, where earthquakes are associated either with active fault zones or with volcanic activity. Earthquake occurrences also are registered in the Cape Fold Belt and in deep mines in South Africa.

Progress
A draft Seismotectonic Map of Africa with a legend, showing tectonic provinces, seismological and fault data, was completed and an internal progress report was produced. The progress of the Seismotectonic Map of Africa project is profoundly dependent on the progress of the International Tectonic Map of Africa at a 1:5 million-scale, which was nearing completion in February 2010. The tectonic map, together with seismic activities, will be used to create updated seismotectonic provinces of Africa that will form the background of the map. At the CGMW General Assembly on 16 February 2010 the importance of the project was confirmed and the leadership of the CGS and its partners highlighted. In addition, the CGMW also obtained the full support of the IUGS, not counting the previous UNESCO support, and support from the IUGG will also be requested.



Draft Seismotectonic Map of Africa.

Since the CGMW General Assembly, the Geological Society of Africa have proposed candidates for the SeTMA project collaboration from the northern, southern, western, eastern and central regions of Africa.

Conclusions
With the completion of the draft copy, the first phase of the Seismotectonic Map of Africa project is complete.

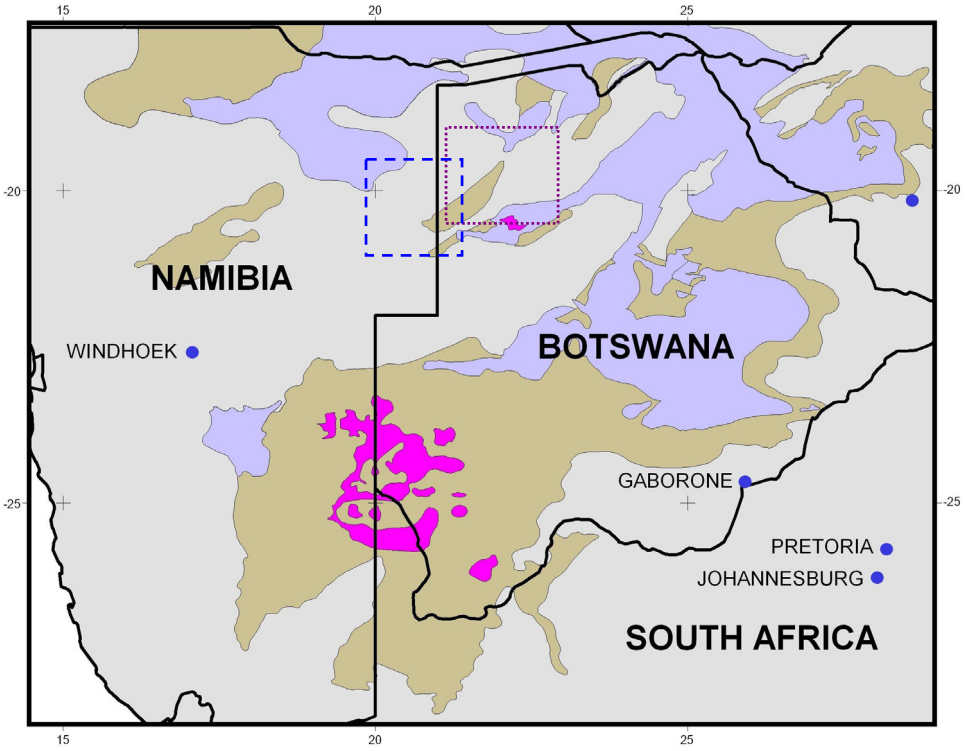
Future activities
A workshop will be organised with the nominated persons from the five African regions to discuss the project details, products, work plan and financial support. The CGMW proposed to aid in the contribution of the establishment of the legend and the inventory of the complementary relevant information to be provided on the map (i.e. GPS data, etc.). Hopefully a first draft could be presented in January 2011 at the Colloquium of African Geology in Johannesburg. To this extent the CGMW proposed to organise a session devoted to the global mapping projects in Africa, which would include, in particular, the presentation of the new tectonic map of the continent.

A simplified tectonic geology in faded colours, superimposed on a shaded Digital Elevation Model of Africa, will form the background of the map. In addition to recent active and neotectonic faults it is proposed that active volcanoes be indicated on the map. The establishment of a combined project with ICSU-ROA should be sought to produce one detailed Seismotectonic Map of Africa.

SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

CO-2007-5624 **TRI-NATIONS KAROO BASIN CORRELATION PROJECT**

Project leader: J. Neveling, Ph.D.
Project team: J. Neveling, Ph.D., V. Nxumalo, B.Sc. Hons, T. Segwabe, M.Sc. (Botswana Department of Geological Survey) and E.M. Bordy, Ph.D. (Rhodes University)
Primary objective: This project uses collaborative research to strengthen the ties between the scientific communities of South Africa, Botswana and Namibia. This project elicited participation or support from the geological surveys of all three countries, and focuses on the rocks and tectonic evolution of the Kalahari Karoo Basin, a structure centred in central Botswana.
Duration: 2006–2008
Budget: Total: R1 195 251



Study Area: Coal deposits of the Central Kalahari sub-basin (T. Segwabe).
Study Area: Stratigraphy of the Gemsbok sub-basin (V. Nxumalo).

Study area of the Tri-Nations Karoo Basin correlation project.

Motivation
This project supports the Department of Science and Technology's (DST) efforts to stimulate regional research collaboration in the SADC region. The project aims to correlate and analyse the sedimentary rocks found in the different Karoo-age basins of South Africa, Botswana and Namibia, with the primary research focusing on the rocks of the Kalahari Karoo Basin. Scientific capacity building also forms an important part of the project.

Progress
Mr T. Segwabe of the BDGS undertook a research project on the depositional environment of the coal deposits of the central Kalahari Karoo Basin. He completed his research in 2008 for which he was awarded an M.Sc. degree by Rhodes University. A manuscript by Mr Segwabe and his coworkers was also accepted for publication by the *Journal of African Earth Sciences*.

Ms V. Nxumalo of the Council for Geoscience leads an investigation on the geology of the Gemsbok Sub-basin, which forms the western extremity of the Kalahari Karoo Basin and extends into the Aranos Basin of Namibia. During the past year Ms Nxumalo completed all the laboratory analyses of samples collected from Botswana and Namibian drill core in 2008. The remainder of her time was devoted to writing up results and she submitted the first draft for her M.Sc. degree

in December 2009. She is currently busy making the necessary corrections and is expected to submit her paper by May 2010. Ms Nxumalo also presented her provisional research results as a poster at the South African Geoforum, held at Midrand in July 2009.

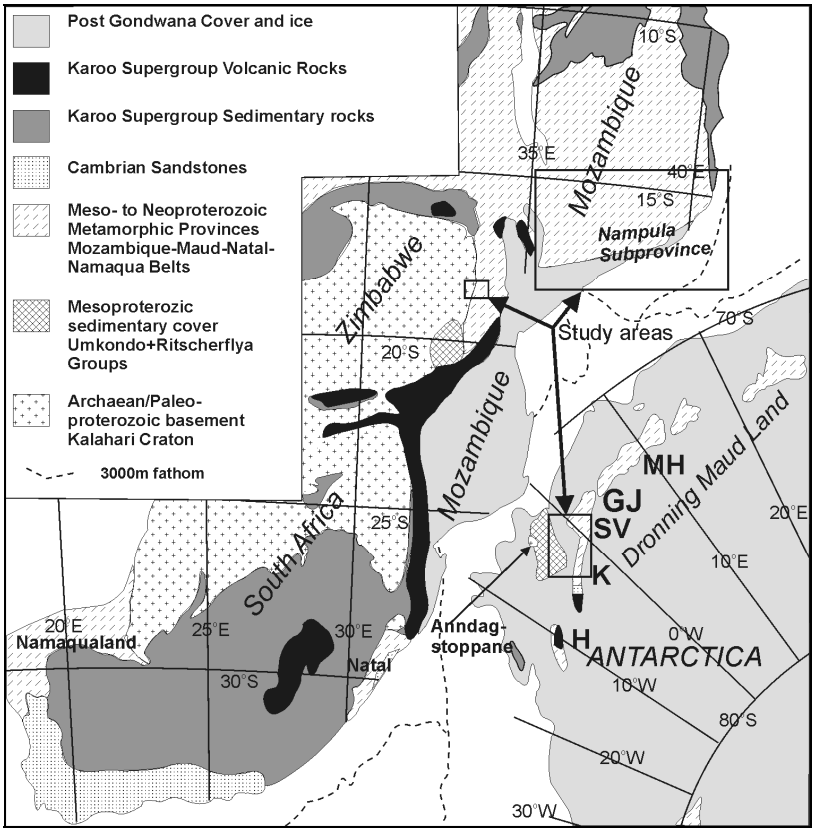
The Namibian Geological Survey (NGS) has been unable to assign a young geologist at any point from 2007 to 2010 as a result of personnel constraints.

Conclusions
Capacity (personnel) constraints had a negative impact on the project costs and also delayed the overall progress. Some amendments to the schedule and budget were previously proposed, but no resolution was reached. Nevertheless, work continued and the project is now nearing completion.

Future progress
The final draft for an M.Sc. degree (by V. Nxumalo) will be submitted by May 2010, followed by the submission of a final report to DST. Publication of research results in a scientific journal will follow thereafter.

ST-2007-0933 **MOZAMBIQUE PUBLICATIONS PROJECT**

Project leader: G.H. Grantham, Ph.D.
Project team: P.H. Macey, Ph.D., B. Ingram. M.Sc.
Primary objective: The Mozambique Publications Project is aimed at publishing some of the interesting research findings produced during the Mozambique Mapping Project conducted from 2000 to 2007 with the objective of makings these available to the international community by publishing in international scientific journals.
Duration: 2007–2012



Map of portion of Gondwana showing some of the localities. The abbreviations in the figure are geographic localities where H=Heimefrontfjella, K=Kirwanveggan, SV=Sverdrupfjella, GJ=Gelsvikfjella and MH=Muhlig-Hoffmanfjella.

Motivation
The Mozambique Mapping Project was conducted from 2000 to 2007. During this period, the Council for Geoscience produced eleven 1x1 degree map sheets on a 1:250 000 scale. In support of the mapping, comprehensive geochemical studies of their rock types, as well as their ages, were completed which facilitate a better understanding of the geology of Mozambique. This information is of economic and academic interest and publication of the data in international journals disseminates this information.

Progress and conclusions

A manuscript on the geology of the margin between the Kalahari Craton and the Mozambique Belt was submitted to the *Journal of African Earth Sciences* and was accepted for publication after major revision. These revisions are in the process of being completed. The paper describes a U/Pb zircon 1 000 Ma age from migmatitic veining developed parallel to strong shearing along the craton margin, as well as a U/Pb zircon age of ~2 600 Ma from a relatively undeformed granodiorite which forms part of the Kalahari Craton. Whole-rock major and trace element chemistry from granites from the Kalahari Craton and the Mozambique Belt are described, as well as Rb/Sr and Sm/Nd radiogenic isotope data. The latter radiogenic isotope data suggest that granitoids in the Mozambique Belt probably resulted from mixing of melts derived from the Archaean-age Kalahari Craton and the Mozambique Belt. In addition U/Pb zircon data and whole-rock geochemical data from from the Kalahari Craton–Maud Belt boundary, western Dronning Maud Land, Antarctica are also included. The data suggest that the Kalahari Craton has subsurface extensions below the Mozambique Belt, at least as far east as Chimoio, ~60 km from the Zimbabwe border and also underlies Sverdrupfjella in western Dronning Maud Land.

A manuscript entitled *Mesoproterozoic geology of the Nampula Subprovince, northern Mozambique* was submitted to *Precambrian Research* and is currently under review. The paper was prepared by CGS personnel, as well as personnel from the British, Norwegian and Mozambican Geological Surveys. The paper describes the geochronology and geochemistry of the Nampula Terrane in northern Mozambique.

A manuscript entitled *Post Pan-African thermo-tectonic evolution of the north Mozambican basement and its implication for the Gondwana rifting. Inferences from $^{40}Ar/^{39}Ar$ hornblende, biotite and titanite fission track dating* was published in a *Special Publications* volume of the Geological Society of London. The paper resulted from collaboration with personnel from the University of Bremen, Germany and the University of Bergen, Norway. The paper describes $^{40}Ar/^{39}Ar$ and fission track data, mostly from the Nampula terrane. The application of these techniques is aimed at understanding the uplift history of the area. The data show that between ~500 Ma and ~200 Ma ago, the Nampula Terrane underwent rapid erosion and uplift due to orogenic collapse and rifting related to the dispersal of Gondwana.

.

Future activities

Additional manuscripts are planned for publication until 2012.

Publications

G.H. Grantham, R.A. Armstrong, F.J. Kruger and A.S.D.T. Manhica (under review, Journal of African Earth Sciences). New SHRIMP data from central Mozambique and western Dronning Maud Land, Antarctica: implications for shearing along the eastern margin of the Zimbabwe Craton and the amalgamation of Gondwana.

P.H. Macey , R.J. Thomas, G.H. Grantham, B. Ingram, J. Jacobs, R.A. Armstrong, M.P. Roberts, L. Hollick, B. Bingen, G. de Kock, W. Bauer, E. Gonzales, T. Bjerkgård, I. Henderson, M. Cronwright, S. Harley, A. Solli, Ø. Nordgulen, G. Viola, G. Motuza, E. Daudi and V. Manhica (under review, Precambrian Research). Mesoproterozoic geology of the Nampula Subprovince, northern Mozambique.

Daszinnies, M.C., Jacobs, J., Wartho, J.-A. and Grantham, G.H. (2009). Post Pan-African thermo-tectonic evolution of the north Mozambican basement and its implication for the Gondwana rifting. Inferences from $^{40}Ar/^{39}Ar$ hornblende, biotite and titanite fission track dating. Special Publications, Geological Society, London, 324, pp. 261–286.

CENTRAL REGIONS

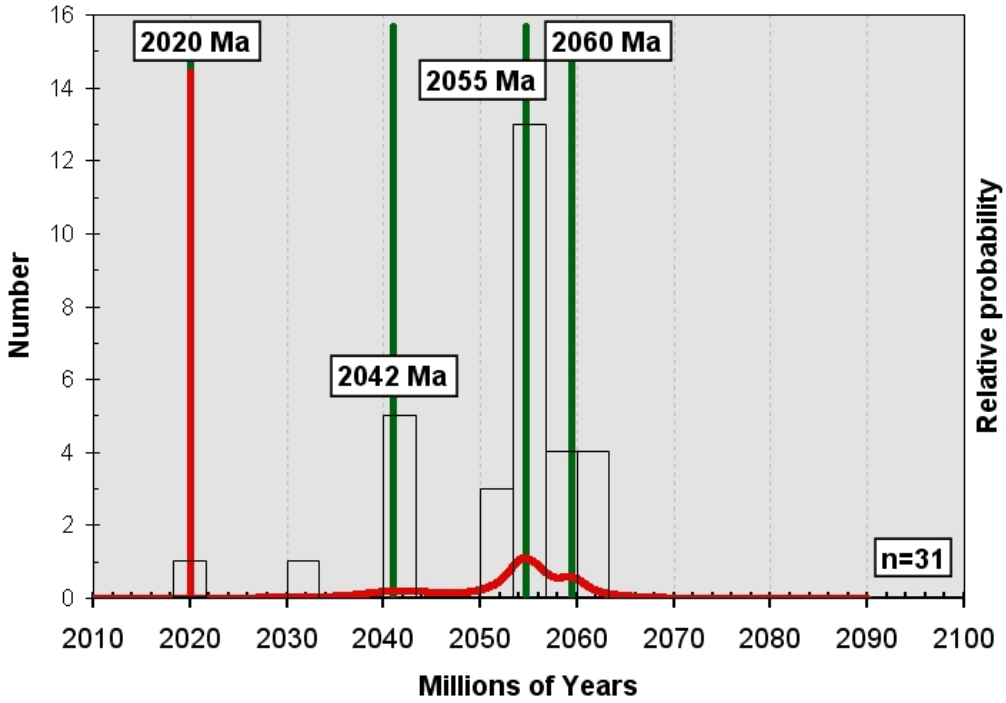
ST-2008-0998 **THE PALAEOPROTEROZOIC TRANSVAALIDE THRUST-AND-FOLD BELT IN THE PRETORIA AND CHUNIESPOORT GROUPS, TRANSVAAL SUPERGROUP**

Project leader: B.A. Ingram, M.Sc.
Project team: M.A.G. Andreoli, Ph.D. (supervisor), R.L. Gibson, Ph.D. (supervisor)
Primary objective: To study the tectonic history of the Pretoria and Chuniespoort Groups for the period between the Bushveld Complex intrusion and Vredefort meteorite impact event
Duration: 2009/10–2012/13
Budget: R296 095

Motivation
This project aims to study the deformation and metamorphism not previously recognised in the upper Transvaal Supergroup rocks situated between the Bushveld Complex and the Vredefort Impact Structure while unravelling the tectonic setting and framework of the central parts of the Kaapvaal Craton during the Palaeoproterozoic. The project will increase the scientific knowledge of this economic significant and unique period in South African geology. The future of several international tourism attractions (e.g. the Cradle of Humankind World Heritage Site, the Pilgrim's Rest area, the Pilanesberg Nature Reserve and Vredefort Dome) within the study area depends on the holistic management of the sites, i.e. the structural control of buildings, underground safety in caves, sinkhole hazards, water ingress hazards, underground water resource models, etc. An improved understanding of the Transvaal Basin, its structure, tectonic setting and geological history will help to generate future exploration targets that will create economic growth, employment and development of rural populations. The area is bordered by economically important deposits of platinum and gold, as well as several other economically important deposits hosted in structurally controlled features (e.g. bismuth, gold, copper, lead, silver and phosphate). Understanding the structural control of Karoo sedimentation on the palaeotopography of the Transvaal Supergroup will aid in exploration and target generation of coal deposits (sustainable electricity). The orogenic belt controls the distribution of brick-making material and dimension stone deposits needed by the government for housing development. Structural geology has a significant control on the distribution of underground water resources. The project will aid in understanding and creating structural models of water ingress in abandoned mines. An understanding of the geological structures will aid in predicting geological hazards (e.g. sinkholes, unstable ground and active faults). The information gathered from the project will aid in improving geological maps. The project will contribute towards the development of human capital, stimulation of innovation, develop skills and build capacity.

Progress
Progress was not as expected due to the cost-saving measures introduced by CGS Management. A digital bibliographic database with 146 references was created that will in future form part of a network-shared scientific reference database resource. A digital database with available geochronology from publications of the study area, as well as other related areas, was created. The database consists of 122 ages spanning the period *ca* 2 320–1 920 Ma, concentrating on the time span *ca* 2 060–2 020 Ma. Geochronology diagrams (histograms, cumulative Gaussian probability curves and weighted average diagrams) were compiled from the database, utilising Isoplot. An internal progress report was produced detailing the content of these databases. Satellite images (Landsat 7 ETM+) and SRTM (Shuttle Radar Topography Mission) data of the study area were acquired for structural studies in ArcGIS. Two abstracts were submitted and presentations given at the *Out of Africa: 140 years with Kevin Burke and Lew Ashwal Conference* (16–17 November 2010) at the School of Geosciences, University of Witwatersrand, Johannesburg and the *Stratigraphy Indaba Conference* (21 January 2010) at the Council for Geoscience, Pretoria.

Conclusion
Existing geochronology data for the Witwatersrand Supergroup, Transvaal Supergroup, Bushveld Complex, Barberton Supergroup and Archaean granitoids reveal two low-grade metamorphic-deformation events peaking at *ca* 2 150 Ma and *ca* 2 042 Ma. The latter event, the Transvaalide Orogeny, clearly is distinct from the Rooiberg Group (*ca* 2 060 Ma), Bushveld Complex emplacement (*ca* 2 055 Ma) and Vredefort Impact Event (*ca* 2 020 Ma) and might extend as far as the late D_{3-4} Limpopo Belt deformation.



Cumulative-histogram diagram summarising available geochronological data for the Rooiberg Group, Bushveld Complex, Transvaalide Orogeny and Vredefort impact event.

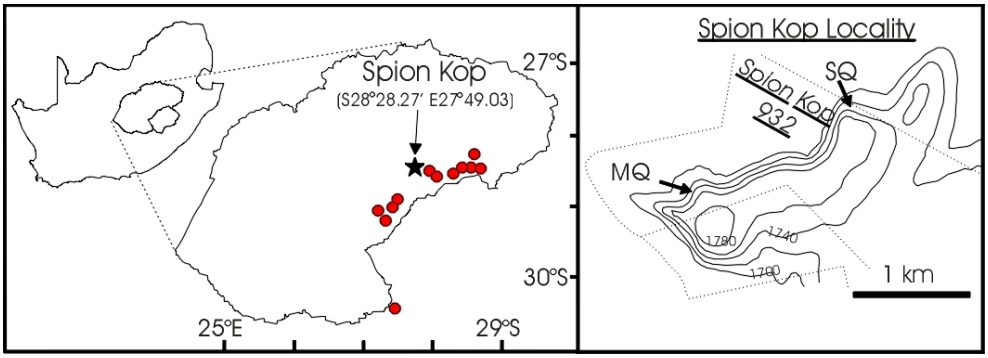
Future activities

The first period of the work will focus on the accumulation of data from available sources and the field. The initial focus of the work will be concentrated in a core area from Rustenburg in the west to Delmas in the east. Specific additional target areas around the Transvaal Basin will be identified where more detailed work can be done in especially the Pretoria Group to aid in identifying the extent of the fold belt. The field work will be focused on measurements of geological structures, descriptions of rocks and sampling of structural features at the target areas. Limited revision mapping might be required. Landsat images will be analysed for structures and the results added to a GIS-based database. Oriented and GPS-coordinated geological samples, along structural profiles, will be taken for petrographical and structural (and perhaps thermobarometry and fluid inclusion) analyses. White mica from especially thrust faults and cleavage planes will be dated to determine the age(s) of deformation.

The second period of the work will be focused on the processing and writing up of the data. This period will also be devoted to research where the structural history will be discussed and interpretations with regard to the tectonic environment be made. It will also include laboratory work and discussions with stakeholders. During this period a dolomite hazard model related to the structural features will be developed.

ST-2002-0781 **PALAEONTOLOGY AND PALAEO-ECOLOGY OF THE ELLIOT AND CLARENS FORMATIONS**

Project leader:	J. Neveling, Ph.D.
Project team:	J. Neveling, Ph.D., A.M. Yates, Ph.D. (University of the Witwatersrand), M.F. Bonnan, Ph.D. (Western Illinois University)
Primary objective:	To increase the scientific community's understanding of the palaeontology, palaeo-environment and stratigraphic relationships of the Elliot and Clarens Formations (Karoo Supergroup) that crop out in the Free State and Eastern Cape Provinces
Duration:	2005–2009
Budget:	R23 400



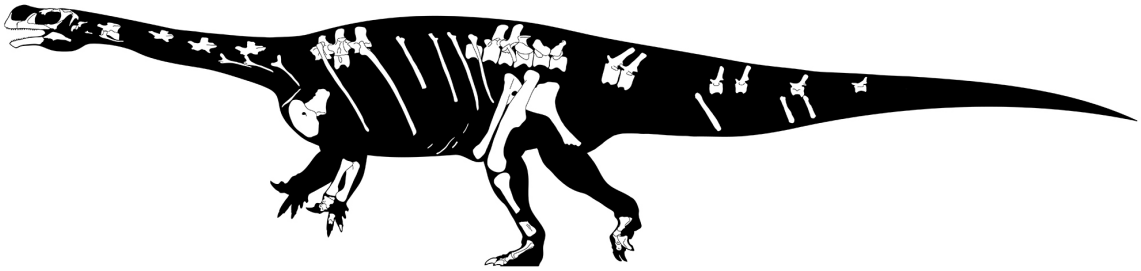
Location of the study area of the Elliot and Clarens Formations.

Motivation

The Elliot Formation crops out in the central part of South Africa, particularly in the Eastern Cape, Free State and Kwa-Zulu-Natal Provinces. It contains some of the world's earliest dinosaur and mammal fossils, although comparatively little research has been done on these and as a result this fauna is still comparatively poorly known. A review of established fossil collections by A. Yates (BPI, University of the Witwatersrand), a specialist in dinosaur taxonomy and one of the researchers for this project, revealed the presence of new dinosaur taxa in the Elliot Formation. A collaborative investigation was therefore launched to investigate the fossil fauna and local palaeo-environmental conditions of the Elliot Formation, with a special focus on the Heelbo locality in the northern Free State where new material was previously reported on.

Progress

It was not possible to complete any field-based studies during the financial year, but research continued in the laboratory; this primarily involved the continued preparation and analysis of the remaining fossil material. An earlier manuscript documenting the first findings of this research was rewritten and submitted to the journal *Proceedings of the Royal Society of London* (Volume 277, pp. 787–794) and was accepted for publication. This manuscript announced the discovery of a new dinosaur genus (*Aardonyx*) that is considered to be close to the common ancestor of all gigantic sauropod dinosaurs. The announcement of this discovery received considerable press coverage, while the manuscript was published on 7 March 2010.



Skeletal restoration of Aardonyx celestae (by A. Yates).

Conclusions

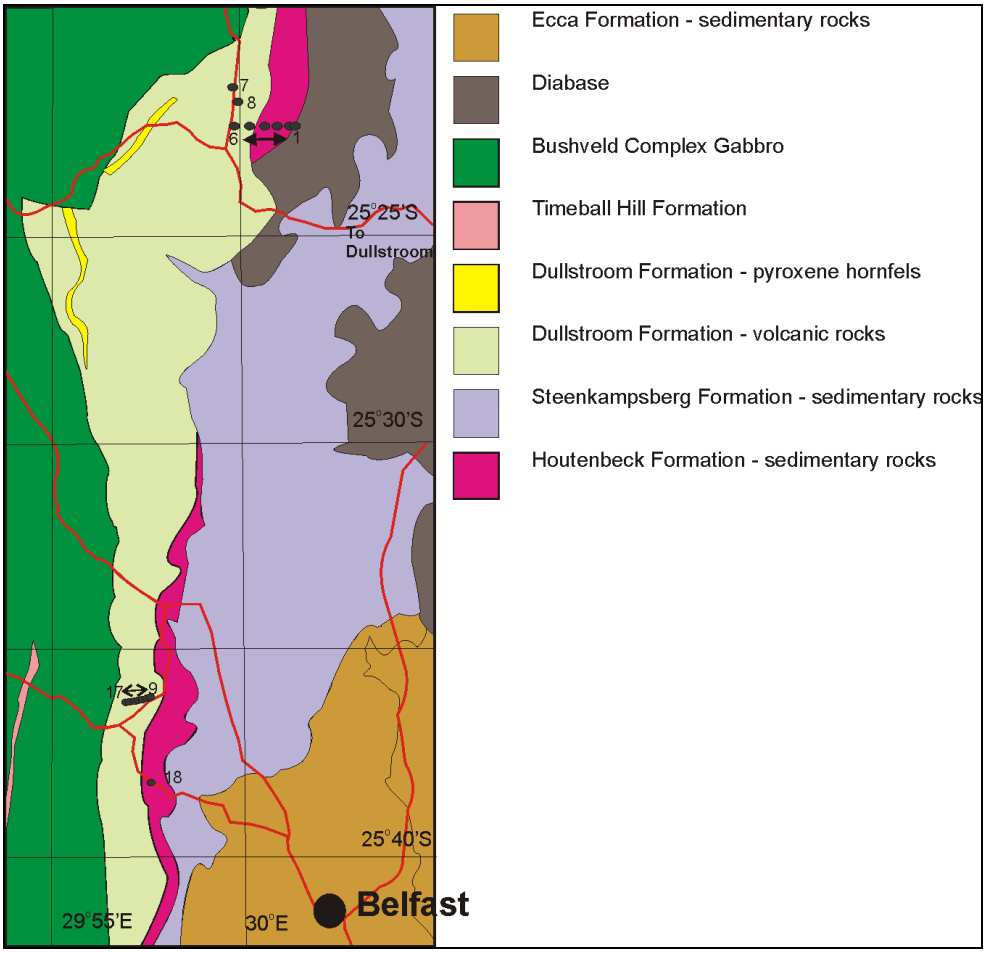
The Heelbo locality yielded several new forms of which one (*Aardonyx*) was announced to the scientific community. These findings indicate a much more diverse terrestrial fauna for the Early Jurassic (~200 Ma age) of South Africa than previously considered. The project team considers this to be indicative of ecological niche partitioning by the dinosaur fauna which may be related to a previously unrecognised local geological subenvironment.

Future activities

Fossil preparation will continue and at least two publications on new fossil taxa discovered at the Heelbo locality will follow. The manuscript on the local geological environment for the Heelbo locality still needs to be finalised.

ST-2009-1099 **METAMORPHISM OF THE ROOIBERG GROUP IN THE DULLSTROOM AND BELFAST AREAS**

Project leader:	G.H. Grantham, Ph.D.
Project team:	P. Buchanan (University of Texas, Kilgore, Texas)
Primary objective:	To examine the floor rocks of the Bushveld Complex in the Dullstroom and Belfast areas in order to understand the thermal conditions during its intrusion
Duration:	2009/2010
Budget:	Nil



Simplified geology of the study area and the locality of the samples collected.

Motivation

An understanding of the evolution of the wall rocks of Bushveld Complex in the Dullstroom area will improve the knowledge of the Barberton 1:250 000-scale sheet in Mpumalanga.

Progress

Eighteen samples were collected in 2008 from the Dullstroom Formation of the Rooiberg Group west of Dullstroom and Belfast. Polished sections from these were prepared and examined. Six samples showed textural evidence of metamorphic mineral growth involving clinopyroxene, biotite, plagioclase, scapolite and amphibole. In addition, unusual textures in some samples comprising spherical inclusions 1–2 cm in size with coarse (1.2 mm) quartz and feldspar can be interpreted to represent small melt globules. Limited microprobe data on some of the mineral phases was completed at the University of Pretoria; however, due to a lack of funding no further analyses were performed and completion of the project was not possible due to financial constraints.

Conclusions

No conclusions regarding the physical conditions of metamorphism could be reached due to the unavailability of sufficient mineral chemical analyses.

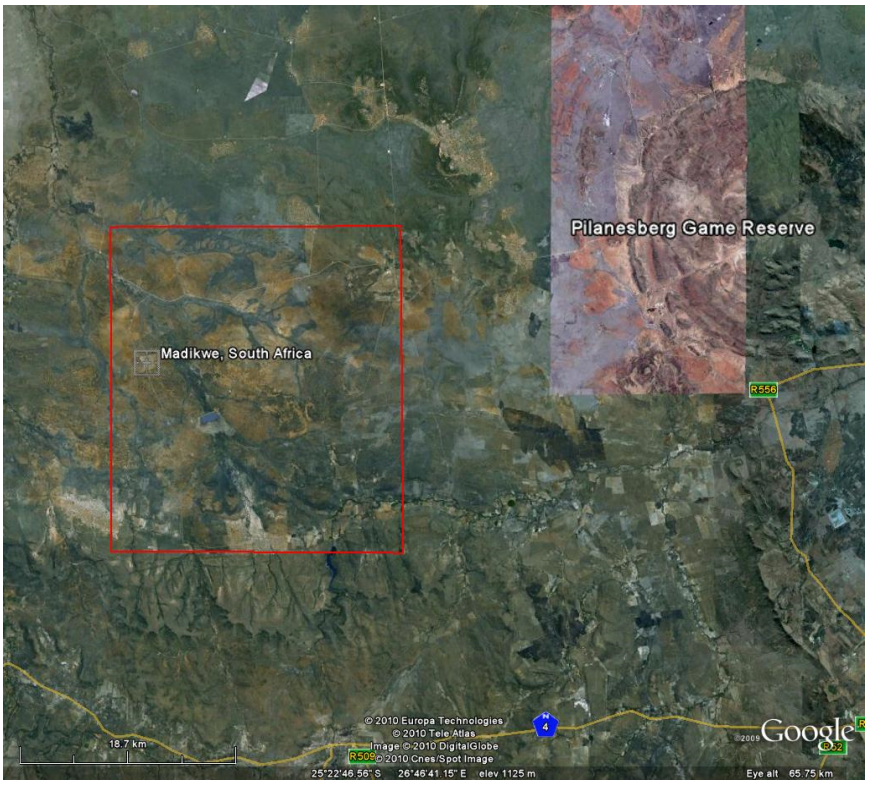
Future activities

It is planned to continue the investigation when additional funding can be secured.

ST-2009-1012 **1:50 000-SCALE GEOLOGICAL MAPPING OF 2526BC MADIKWE**

Project leader: R. Shelembe, M.Sc. (Geol.)
Project team: S. Molefe
Primary objectives:
- To produce an updated and accurate 1:50 000-scale map sheet and a map explanation of the Madikwe area
- To analyse the extent and intensity of the metamorphic aureole caused by the intrusion of the Bushveld intrusion
- To investigate the relationship between the sill intrusions that exist in the area and the Bushveld-type rocks
- To investigate the origin and relations of regional lineaments in the Madikwe area (are they related to the Thabazimbi–Murchison Lineament?)

Project duration: 36 months
Budget: R136 408



Aerial view of the Madikwe area.

Motivation
The mapping of the Madikwe area will close some of the gaps in terms of mapping in areas adjacent to those that have been mapped already in the North West Province for the purpose of systematic development of geoscientific knowledge. The formations of the Pretoria Group are composed of quartzite, hornfels and slate — lithologies that are evidence of metamorphism. The mineralogy of these rocks will indicate the extent to which the Bushveld Complex has affected the mineralogy of the area, since it is further away from the intrusion with respect to the Mabeskraal and the Mabaalstad map areas that have already been mapped.

Progress
- Field work with sample collection
- Preliminary petrographical studies on the collected samples
- Draft report on petrography
- Compilation of a preliminary map, legend and overlays of Madikwe (edited).

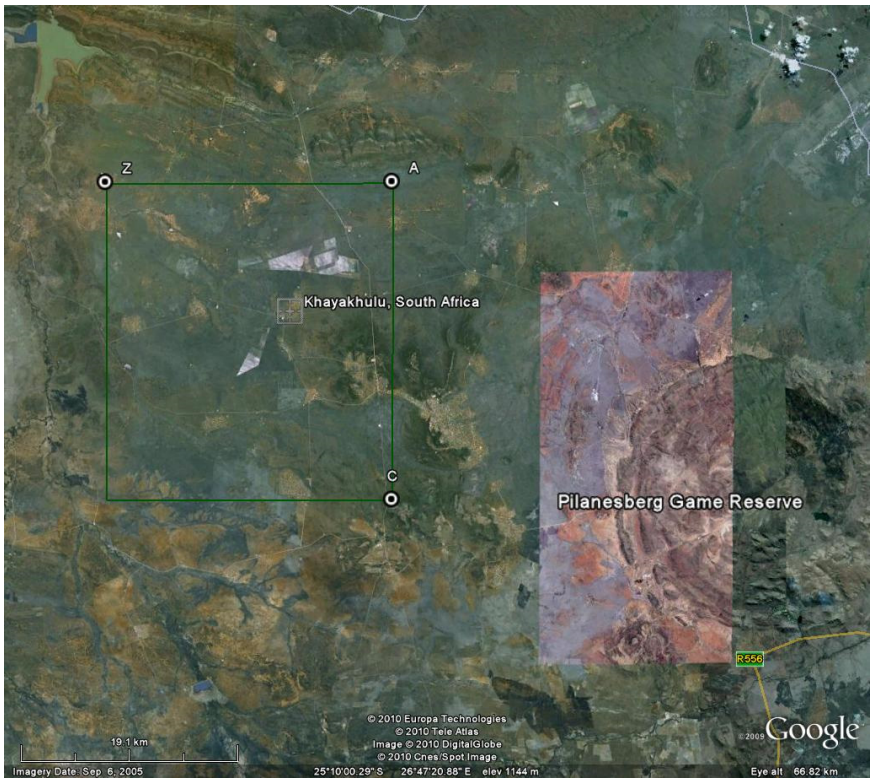
Conclusion
This project will assist in the understanding of the Bushveld metamorphic aureole. The groundwater studies will aid in the appropriate measures to be implemented for communities to avoid long-term illnesses due to unsuitable water.

Future activities
Writing up the remainder of the preliminary geological explanation.

ST-2010-1066 **KHAYAKHULU 2526BA 1:50 000-SCALE MAPPING**

Project leader: R. Shelembe, M.Sc. (Geol.)
Project team: S. Molefe, K. Majola, M.Sc. (Geohydro.), J. Leshomo, B.Sc. Hons (Geol.), N. Nefale, B.Sc. Hons (Geol.), E. Mulovhedzi, B.Sc. Hons (Geol.), R. Netshitungulwana, B.Sc. Hons (Geol.)
Primary objectives:
- To encourage interunit contributions towards geological mapping projects
- Produce an accurate 1:50 000-scale geological base map of the Khayakhulu area in the North West Province of South Africa
- Investigate the origin of lineaments in the map area
- Investigate the extent of the metamorphic aureole caused by the Bushveld Complex
- Investigate the quantity and quality of water in this semi-arid area close to the Kalahari Desert

Duration: 36 months
Budget: R369 430



Aerial view of the Khayakhulu area.

Motivation

The Khayakhulu 2526BA 1:50 000-scale mapping project will contribute significantly towards the understanding of the floor rocks of the Bushveld Complex and thereby also produce an up-to-date geological map of the area. Geophysics and regional geochemistry of the 23 major elements will be used to compile an up-to-date geological map. The geological study of the Khayakhulu map area in terms of metamorphic history will produce information which might be used for possible small-scale mining in the area.

Rural development will be accomplished by water quality assessment and characterisation. The communities have reported cancerous illnesses and water chemistry will assist in investigating whether these ailments are water related. Information gathered from this project will also help the Faculty of Agriculture of the university in the North West Province and other industries.

Progress

- Geological mapping covering 70 per cent of the Khayakhulu area
- Collection of rocks samples for petrographic and geochemical investigations
- Collection of water samples for chemical and quality assessments from existing boreholes in the communities
- Hydrocensus and hydrochemistry analyses of the water samples
- Storage capacities, coefficients and sustainability yield constraints will be determined using appropriate investigative techniques
- Desktop studies for geophysics and geochemistry

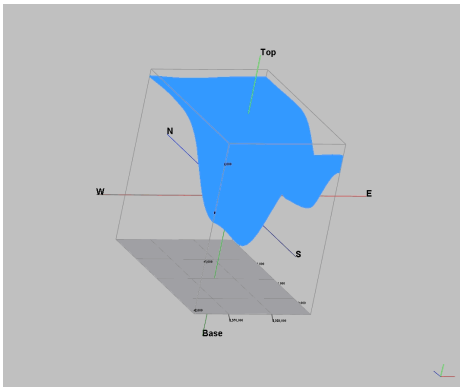
Conclusion
This project will assist in the understanding of the Bushveld metamorphic aureole. The groundwater studies will aid in the appropriate measures to be implemented for communities to avoid long-term illnesses due to unsuitable water.

Future activities
No activities are planned for the 2010/11 financial year. Completion of a preliminary geological, geophysical and geochemical map is envisaged. A geological explanation which will include a focus on water quality and recommendations will also be produced.

ST-2008-0994 **INTEGRATION OF 3D MODELLING INTO REGIONAL MAPPING**

Project leader: R. Shelembe, M.Sc. (Geol.)
Primary objectives: The main objective is to standardise 3D modelling for 1:50 000-scale geological mapping projects
Duration: 12 months
Budget: R169 360

Motivation
The 3D modelling programme has been used as an essential component for innovation and skills development. The evaluation of 3D GeoModeller software has shown the success of integrating 3D modelling into 1:50 000-scale geological mapping. 3D modelling can be used as a decision-making tool in various disciplines of the geosciences.



Progress
A strategy report was completed. GSI3D software was evaluated but the software evaluation was not completed. However, 3D modelling (in conjunction with groundwater levels) has been used for other commercial projects.

Conclusion
3D modelling has proved to be very useful in studying the morphology of the basins underlying the gold fields. In the models created, thickness variation of the dolomite units of the Transvaal Supergroup is observed. 3D modelling has shown to be an integral part of solution and decision making in geoscience research.

Future activities
3D modelling will be used in future statutory and commercial projects.

ST-2005-0864 **THE STRATIGRAPHIC AND TECTONIC HISTORY OF THE EO-PROTEROZOIC PERIOD BETWEEN THE LATE CHUNIESPOORT GROUP TO THE EARLY TIMEBALL HILL FORMATION, PRETORIA GROUP, SOUTH AFRICA**

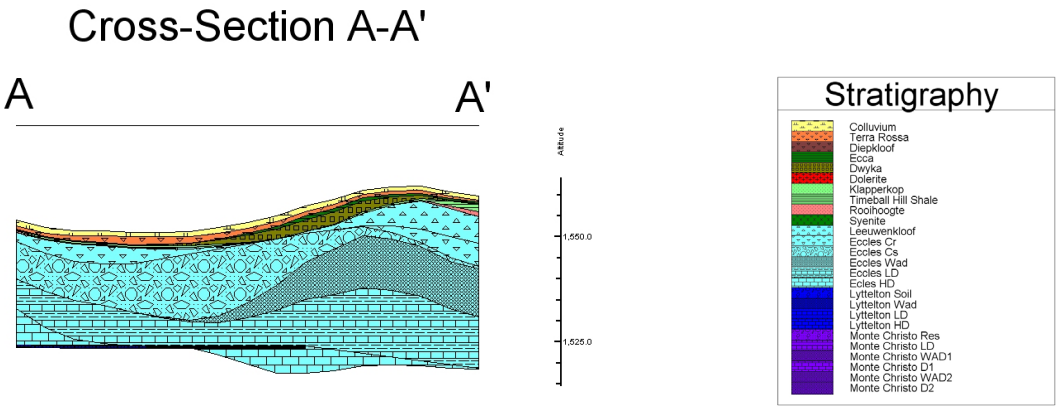
Project leader: P.J.A. Bosch, M.Sc. (Geol.)
Primary objective: To study the tectonostratigraphy and sedimentology of the late Chuniespoort Group to early Pretoria Group with special reference to the formation of karst on dolomitic land in Gauteng
Duration: 2005–2010
Budget: R439 785

Motivation
Development on hazardous dolomitic land is problematic due to the formation of sinkholes and/or subsidence along dolines. To understand dolomitic land earmarked for development a holistic approach is necessary. A holistic approach means that the three-dimensional framework of the geological environment, lithostratigraphy, weathered rocks, soils and structure of the area must be properly understood and characterised. It is also important to be able to delineate the boundaries of the area regarded as hazardous dolomitic land.

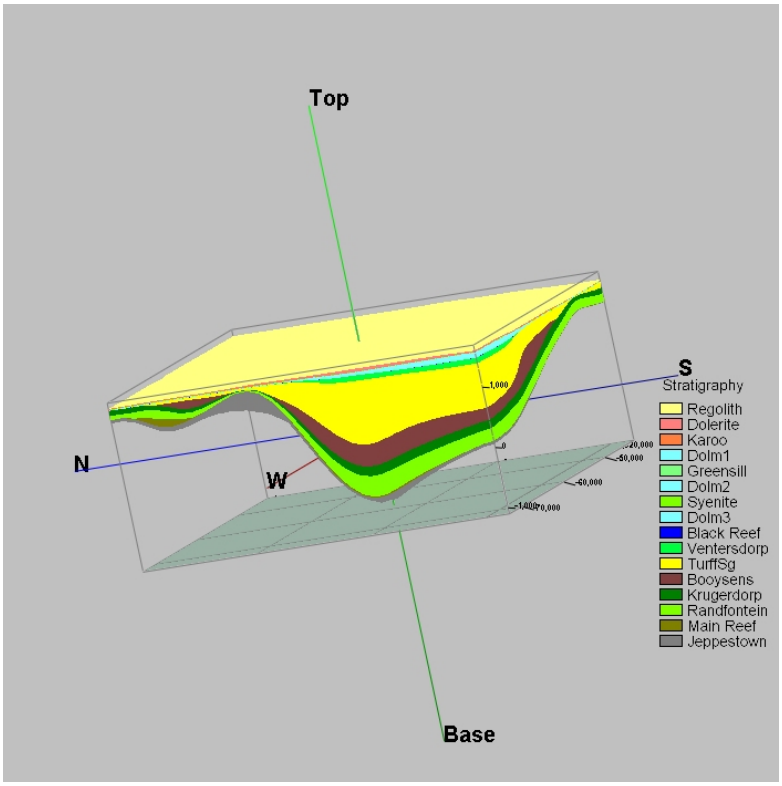
This study will also help to improve the understanding of the geological history and the timing of the formation of the various karst-weathering products. This study benefits the scientific community in that it will increase the scientific knowledge of this important period in the geological history with regard to geological maps, geological structures, lithologies and identification of geological hazards (sinkholes), problem soils and rocks.

Progress

It was not possible to do any field work during the 2009–2010 financial year, but research continued based on various commercial projects and information obtained from drill core. However, the project was advanced when two very large studies was undertaken whereby data from boreholes were analysed and used to compile isopach maps, cross-sections and 3D models of dolomitic terrains with the aid of the newly acquired RockWorks software.



Section AA' shows detailed dolomitic horizons and the variable thicknesses of material overlying the dolomite. The figure also shows the extent of weathered dolomite and the presence of geological folding. This information is valuable in aiding engineering geologists to make informed decisions, for example when zoning for future developments and for geological hazard determinations.



This 3D model shows the basin architecture of the East Rand Basin on a regional scale. From this scale the large-scale structures of the basin may be seen and their geometry might be studied.

Conclusions

It was found through the modelling of the geology on the various terrains that a better understanding of the weathering and behaviour in three dimensions of the dolomitic karst could be achieved. The basin architecture of the dolomite in the East Rand could also be better understood.

Future activities

Combining all the available information into a document.

SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY (SACS)

ST-2002-0449 **SACS PUBLICATIONS**

Project leader: C. Hatton, Ph.D.
Project team: A. van Heerden, B.A.
Primary objective: To provide definitive, standardised descriptions of all formally approved lithostratigraphic units recognised in South Africa
Duration: Ongoing
Budget: R630 740

Motivation
The published lithostratigraphic descriptions will constitute an essential source of information on the stratigraphy of southern Africa, thus enabling geologists to correctly identify and map all currently recognised stratigraphic units during field work, and provide basic data for use in reports and publications.

Progress
The status of the publications is as follows:

SACS Catalogue Volume 10 was printed. This volume contains descriptions of the Cullinan Kimberlite Suite, Dennilton Formation, Ecca Group, Hartenbos Formation, Kuils River Batholith units, Nelshoogte Trondhjemite, Saldanha Batholith units, Terra Nostra Formation and Vaalfontein Suite.
SACS Catalogue Volume 12. Final reviews of the following units have been received; Brulpan Group, Kalkwerf Gneiss, Koelmanskop Metamorphic Suite, Polisiehoek Gneiss, Schuitdrift Gneiss, Vaalkoppies Group, Yas Gneiss, Wilgenhoutsdrif Group.
SACS Catalogue Volume 14. Four contributions have been received for this volume (Emakwezini Formation, Maputuland Group, Mngazana Formation and Darling Batholith units): most of these are awaiting further inputs from the authors before they can be finalised.
SACS Catalogue Volume 15. Three contributions have been received for this volume (Enon Formation, Kirkwood Formation and Mbotyi Formation).
SACS Lithostratigraphic Series No. 50 (Lithostratigraphy of the Msikaba Formation) was printed.
SACS Lithostratigraphic Series No. 51 (Lithostratigraphy of the T'hammaberg Formation, Bushmanland Group) is ready for publication.

All SACS publications were scanned and are now available in electronic format. Beginning with SACS Catalogue Volume 15, future catalogues will be released in electronic format.

Future activities
More lithostratigraphic units will be formally described.

Conglomerate of the Enon Formation near Oudtshoorn.

ST-2002-0473 **SACS DATABASE**

Project leader: C. Hatton, Ph.D.
Project team: S. Tucker, Dip. S.B.M.
Primary objective: To store basic information on stratigraphic units recommended for use on maps, and in reports and publications of the CGS
Duration: Ongoing
Budget: R57 888

Motivation
It is necessary that standard names and map labels are used on geological maps, as well as in reports and publications by CGS geologists and, as far as possible, by the rest of the geological community.

Progress
During the year 15 lithostratigraphic units were added to the database. A total of 1 528 recommended names are now contained in the database. The polygons and points for the type localities were digitised and linked to the spatial database. These were printed in an atlas at a scale of 1:1 100 000 (Open File Report 2010-0119).

Future activities
This project is ongoing.

ST-1999-0519 **SACS SECRETARIAL FUNCTIONS, INCLUDING MEETINGS AND FIELD TRIPS**

Project leader: C. Hatton
Project team: P.K. Zawada, Ph.D., N. Keyser, M.Sc., G.A. Botha, Ph.D., J.S.V. Reddering, Ph.D., P.H. Macey, Ph.D., C.H. de Beer, M.Sc., H.P. Siegfried, Ph.D., L. Chevallier, Ph.D., D.I. Cole, Ph.D., D.L. Roberts, Ph.D., J.H.A. Viljoen, Ph.D., A.L.D. Agenbacht, M.Sc., G. Brandl, Ph.D., N. Baglow, M.Sc., P.J.A. Bosch, M.Sc., G.S. de Kock, Ph.D., J. Neveling, Ph.D., M.R. Johnson, Ph.D., R. Voordouw, Ph.D., N. Hicks, Ph.D.
Primary objective: To make recommendations concerning stratigraphic classification and nomenclature in South Africa and the formal approval of new units by organising and attending meetings and field trips, as well as refereeing and editing manuscripts submitted for publication
Duration: Ongoing
Budget: R542 615

Motivation
The Geological Survey of South Africa and its successor, the Council for Geoscience, have provided logistical and financial support for the activities of SACS, as all stratigraphic names used by the geoscience community (including CGS maps, reports and publications) should conform to the South African Code of Stratigraphic Terminology and Nomenclature.

As an organisational member of the ISSC (International Subcommission for Stratigraphic Classification), SACS also makes an input and receives feedback concerning stratigraphic terminology at an international level.

Progress
The ISSC solicited the opinions of the members on the issue of year as a date or a duration. The Secretary conveyed the opinion of SACS, that year as duration be designated 'yr' (year), and be distinguished from year as a date, designated 'a' (annum).

The 43rd Annual Meeting of the South African Committee for Stratigraphy was held in November 2009.

The Task Groups for the Karoo Supergroup (sedimentary rocks), Gariep-Cape, Cape Granite Suite and Pre-Gariep rocks in the northern and western Cape held meetings at Bellville in August 2009. It was resolved that the Gariep-Cape Task Group will henceforth deal only with the Cape Supergroup. The Task Group for the Cape Granite Suite was reconstituted as the Task Group for Pan-African units. The Task Group for the Bushveld Complex was re-assembled and held a field trip and meeting in April 2009. A meeting of the two Task Groups for the Transvaal Supergroup was held at the Council for Geoscience on 1 June 2009. At this meeting it was proposed that the two task groups be amalgamated. This decision was confirmed at the 43rd Annual Meeting of the South African Committee for Stratigraphy.

An Indaba dealing with the stratigraphy of South Africa to mark the retirement of Mike Johnson, the previous Secretary of SACS, was held at the Council for Geoscience. The 1:2 000 000-scale chronostratigraphic map of South Africa was presented to delegates at the Indaba.

The legends of all the 1:250 000- and 1:50 000-scale maps currently being produced by the Council for Geoscience, as well as some of the accompanying explanations, were edited and checked for stratigraphic correctness. In some cases errors and inconsistencies on the maps themselves were noted and brought to the attention of the cartographers.

Future activities
This project is ongoing.

ST-2002-0519 **CATALOGUE DESCRIPTIONS OF THE EARLY CRETACEOUS MBOTYI, ENON AND KIRKWOOD FORMATIONS (SACS JURASSIC AND CRETACEOUS WORKING GROUP)**

Project leader: J.S.V. Reddering, Ph.D.
Primary objective: Lithostratigraphic catalogue descriptions provide the basic description of unifying features used to classify lithostratigraphic units (formations, members, groups, etc.) and are essential in distinguishing rock units from one another during mapping or exploration projects
Duration: 2009–2010
Budget: R46 955

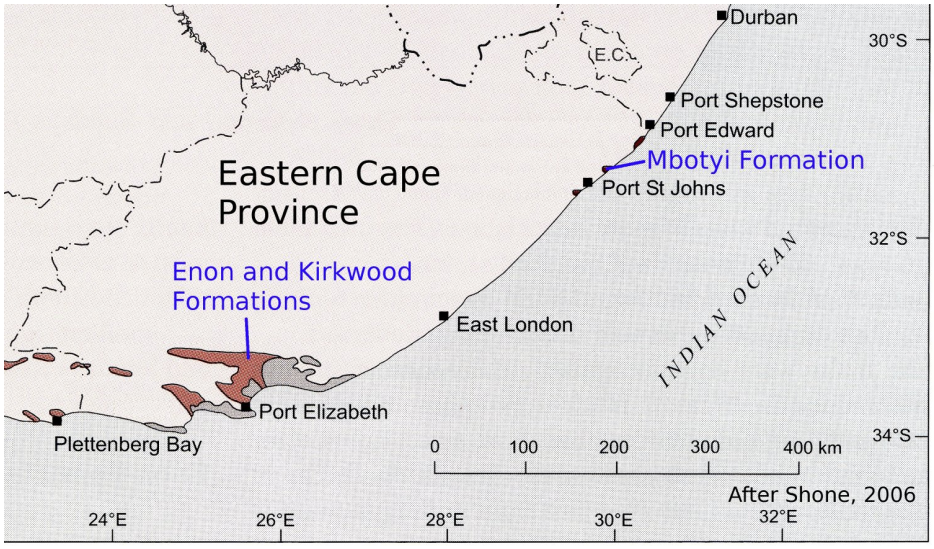
Motivation
These descriptions are necessary to ensure that cartographic databases assimilate formally described lithostratigraphic units compiled under the auspices of the South African Committee for Stratigraphy (SACS).

Progress
All three descriptions were completed, reviewed in-house and submitted to SACS.

1. **Mbotyi Formation;** occurs at Mbotyi, 25 km northeast of Port St Johns. The formation consists mostly of well-bedded conglomerate with subordinate sandstone and mudstone beds. The deposit occupies a half graben to the south of the Early Cretaceous Goso Fault which is a conjugate fault related to the Agulhas–Falkland Fracture Zone, a major translational fault that was active during the breakup of Gondwana. The formation originated largely by mass flow of rock debris across the Goso Fault scarp with local reworking by sheet flow deposits and rivers that flowed along the axis of the Mbotyi Basin. The age of the Mbotyi Formation is probably Early Cretaceous.
2. **Enon Formation;** is the oldest of three formations that constitute the Uitenhage Group. It lies predominantly along the northern and western fringes of the Mesozoic Algoa Basin north of Port Elizabeth, with a patchy distribution elsewhere in the basin. The formation consists predominantly of red-weathering, bedded conglomerate units with subordinate sandstone, deposited by rivers in an immature landscape. The Algoa Basin is the easternmost and largest of several extensional basins along the Cape Fold Belt along the southern coastal interior of South Africa, and several other basins contain conglomerate units equivalent to the Enon Formation. Being diachronous, the age of the Enon Formation extends from the Late Jurassic to the Early Cretaceous. The type area of the formation is at Enon, a village 10 km east of Kirkwood in the Eastern Cape Province.
3. **Kirkwood Formation;** the middle of three formations that constitute the Uitenhage Group, which occupies the extensional Algoa Basin north of Port Elizabeth. The formation overlies and laterally interfingers with the lowermost Enon Formation and is overlain by the Sundays River Formation. This upper contact is either transitional or unconformable. The Kirkwood Formation consists of fluvial mudstone and sandstone deposited in a meander-plain setting. It contains wood and other plant fossils, invertebrate fossils, and a number of vertebrate fossils have been recovered from the formation, notably the remains of dinosaurs. Two members, the Colchester Member comprising dark shale and the Swartkops Member, a prominent sandstone horizon, were described. These members have been encountered in boreholes drilled during oil exploration in the 1960s and 1970s. The age of the Kirkwood Formation is either Late Jurassic or Early Cretaceous.

Conclusions
The descriptions were completed and should be published in the next SACS catalogue of lithostratigraphic units.

Future activities
The lithostratigraphic descriptions are being reviewed by SACS.



Localities of the Early Cretaceous Mbotyi, Enon and Kirkwood Formations in the Eastern Cape Province.

Exposure of conglomerate of the Enon Formation at Roodekrans (S33°22'28" E25°02'04") near the northern margin of the Algoa Basin. The inclined bedding indicates basinward tilting of the unit.

ST-2010-1083 **LITHOSTRATIGRAPHIC CATALOGUE DESCRIPTIONS OF FORMATIONS COMPRISING THE MAPUTALAND GROUP**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Primary objective: Formal description of the formations comprising the Maputaland Group through preparation of lithostratigraphic descriptions in the South African Committee for Stratigraphy (SACS) Lithostratigraphic Catalogue format. These Cenozoic coastal deposits are highly weathered and the various stratigraphic units created to define these sediments have been used inconsistently on maps and in the literature.
Project duration: 2009–2010
Budget: Total: R97 212

Progress
The formations comprising the Maputaland Group were described.
Uloa Formation: this calcareous littoral marine deposit overlies bedrock of a variety of ages along the KwaZulu-Natal coast. These rocks are generally buried by younger sands and are highly weathered, forming a strong groundwater aquifer. The age of the deposit is post–mid Miocene to late Pliocene.

Umkwelane Formation: these aeolianites overlie the Uloa Formation and are almost completely weathered in pedogenic-weathering profiles to form the "Berea red sand". This unit replaces the Berea Formation which was used inconsistently.
Port Durnford Formation: late middle Pleistocene estuarine or coastal lagoon mud and silt deposits containing vertebrate fossil remains. Luminescence dating of the overlying sediments suggests an age of >355 ka.
Kosi Bay Formation: weathered aeolian sands that underlie large areas of the coastal plain north of Mtunzini. Recent discoveries under the coastal barrier dune north of St Lucia have extended the distribution. Truncated dune landscape underlies coastal Lake Sibayi and the Kosi lake system.
Isipingo Formation: coastal aeolianite and calcified beach deposits associated with late middle–late Pleistocene sea level fluctuations. Luminescence dating and correlation with sea level fluctuations has constrained a range of units of member status.
KwaMbonambi Formation: extensive surficial parabolic dune deposits that were derived by deflation of the underlying Kosi Bay Formation dunes. Includes interdune wetland peat and diatomite deposits. Luminescence dating has constrained the late Pleistocene to early Holocene period of accumulation.
Sibayi Formation: Holocene dunes forming the coastal barrier dune cordon and foredune complexes along much of the KwaZulu-Natal coastline.

Conclusions
The lithostratigraphic descriptions provide concise definitions of the lithological characteristics, age and bounding unconformities that characterise the unit.

Future progress
Descriptions will be finalised once critical field relationships and type sections can be measured. The catalogue descriptions will be sent for review prior to publication.

Boulder deposits forming a raised beach underlying the coastal red sand ridge north of the Mgeni River, Durban, correlated with the Pliocene Uloa Formation.

ENGINEERING GEOLOGY

ST-2009-1030 **DOLOMITE STABILITY INVESTIGATION IN AN EXTENDED AREA IN BAPSFONTEIN**

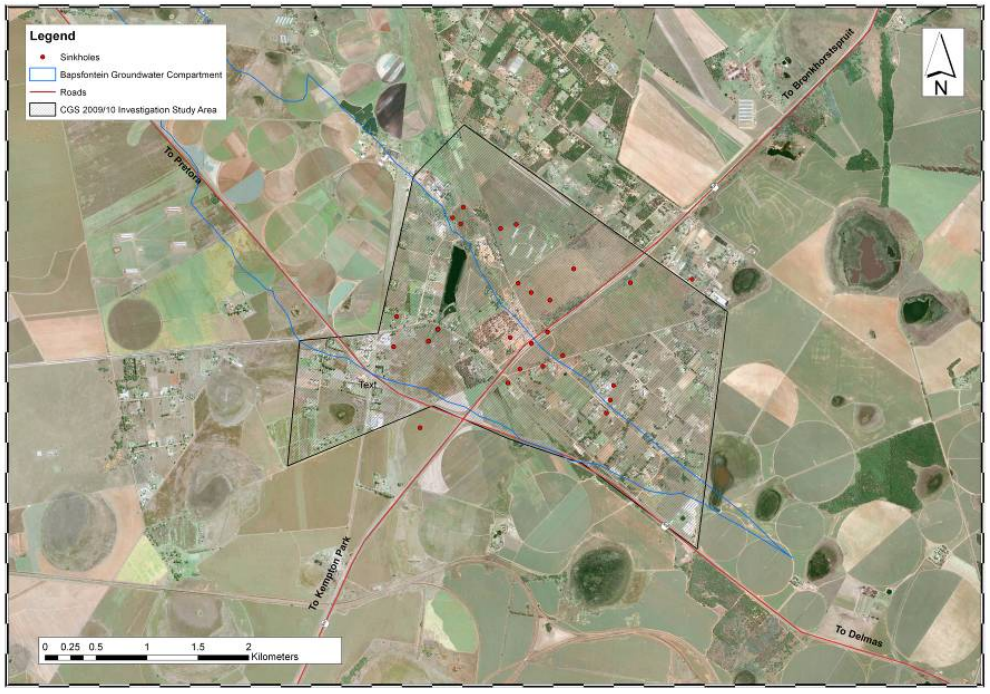
Project leader: G.J. Heath, M.Sc.
Project team: S. Richardson, B.Sc. Hons (Eng Geol.), S. Ngubelanga, B.Sc. Hons (Eng Geol.)
Primary objectives: To establish the risk conditions encountered in the Bapsfontein area where sinkholes have occurred and develop an understanding of the underlying geology
Duration: 2009/10
Budget: R200 000

Motivation
The town of Bapsfontein, situated approximately 30 km southeast of Pretoria in the Gauteng Province, has in recent years experienced a number of sinkholes. Considering that this town is at the intersection of two major regional roads (R51 and R50) and that there is also a large informal settlement in the town, this is cause for concern.

Progress
An approximately 900 ha study area was identified for a dolomite stability investigation which was to include a gravity survey on a 90 m grid and a rotary percussion drilling programme. The gravity survey commenced in August 2009, but was not completed. Due to budget limitations, the 2009/10 CGS investigation was cancelled. Using reports from the CGS dolomite databank for the Bapsfontein area a preliminary risk zonation was produced.

Conclusions
A preliminary risk zonation has been produced for an approximately 900 ha area surrounding Bapsfontein.

Future activities
The gravity survey for the 900 ha site in Bapsfontein is still to be completed followed by a rotary percussion drilling programme that will target gravity anomalies.



Bapsfontein Town is located at the intersection of the R51 and R50, 30 km southeast of Pretoria.

The largest sinkhole to form in Bapsfontein occurred on 28 January 2004.

ST-2002-0029 **CENTURION RISK MAP**

Project leader: A.C. Oosthuizen, B.Sc. Hons (Eng and Environ. Geol.)
Primary objective: To assist the Local Authority with safe development in the Centurion CBD area
Duration: Three years
Budget: None

Motivation
The Centurion CBD Sinkhole Risk Study was initiated during 2007 due to concerns regarding the Gautrain route and surrounding areas in the Centurion CBD area, which is believed to have relatively poor dolomite conditions. This need for infrastructure is likely to lead to a huge increase in demand for high-density developments in the Centurion CBD and surrounding areas.

Progress
The study area is bound by Trichardt Road in the north, Botha Avenue in the east, the N1 highway in the south and the N14 highway in the west in Centurion, Gauteng. The majority of the area has been developed, with commercial developments dominating the area around the Centurion Lake and residential development present towards the outskirts.

The Centurion CBD area is underlain by dolomite and chert of the Malmani Subgroup of the Transvaal Supergroup. Information for the study area is available through dolomite stability reports that have been submitted to the Council for Geoscience for peer review. A total of 435 dolomite stability investigations have been conducted within the CBD and surrounding areas in which a total of 2 894 percussion boreholes were drilled. Each borehole within the study area was assigned an inherent risk class. Eight inherent risk classes are present which classify an area into a low, medium or high risk of sinkhole formation.

After each of the boreholes was assigned an inherent risk class, a risk zonation map was compiled. This map was compiled using the spatial analyst extension of ArcGIS 9.3. This method interpolates between data points and if no data exist, nearby data are used to determine the risk in the area. The risk map generally indicates medium to high risk conditions in the study area with pockets of low risk.

The occurrence of 123 sinkholes in the study area caused the death of three people, four structures to be demolished and millions of Rands were spent to repair other structures, infrastructure and services. There is a relatively good correlation between the risk map and the past occurrence of sinkholes. Fifty one per cent sinkholes have occurred in areas classified as high risk, 42 per cent in areas classified as medium risk and 7 per cent in the low risk areas. The fact that a number of sinkholes occurred in areas classified as low to medium risk implies that sinkholes can occur anywhere in a dolomitic area if the necessary precautionary measures are not implemented.

The occurrence of sinkholes was compared to the annual and monthly rainfall data since 1980. No realistic comparison can be made between the occurrences of sinkholes against the annual rainfall. There is some correlation between the occurrences of sinkholes in the rainy season (September to March) as opposed to the dry winter months. Most of the sinkholes occur later in the rainy season than earlier, which could be because the soil profile is fully saturated later in the rainy season, facilitating soil profile erosion.

Conclusions
Based on limited information, the following conclusions could be made from the risk classification of the Centurion CBD and surrounding areas:

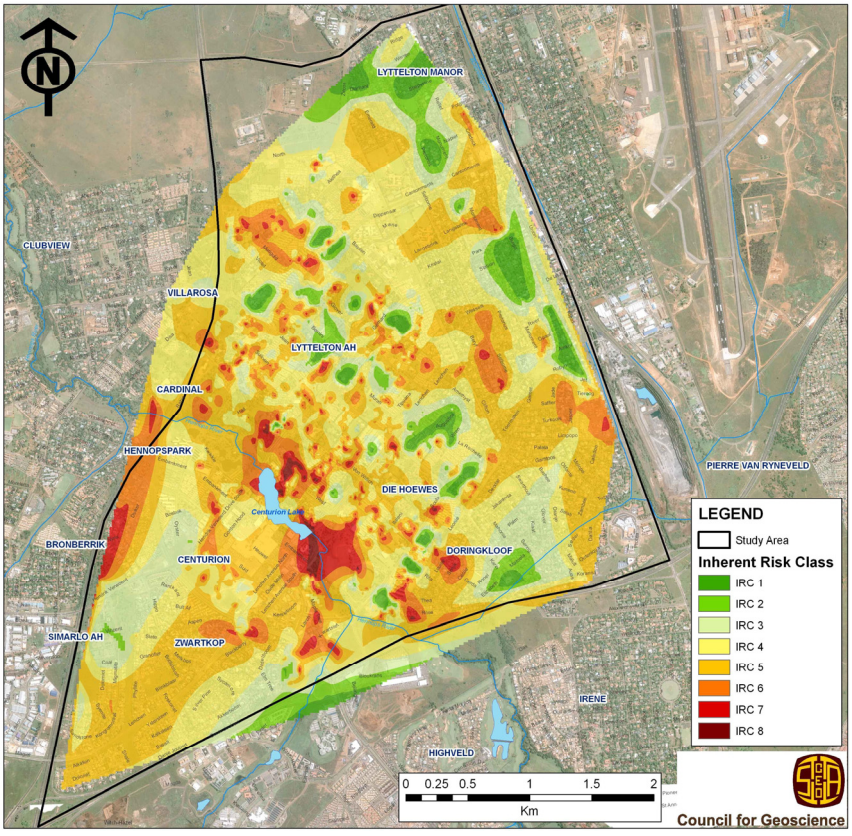
- The conditions are not as poor as were initially suspected
- The study area is mostly represented by medium risk conditions (Inherent Risk Classes 3 and 4)

- Only 3,99 per cent of the study area was classified as Inherent Risk Class 8 where no development types would be suitable.
- Poor conditions mostly prevail in the area immediately north of the Centurion Lake where this area has largely been developed.

Future activities

In order to produce a more reliable risk map, additional drilling would be required to ensure an even distribution of borehole positions within the CBD area. The outcome of this study will be used to evaluate the behaviour of dolomitic land in built-up areas, which has not been done before.

Location of the study area.



Risk of sinkhole formation in the study area.

ST-2008-0959 **LANDSLIDES IN THE SOUTPANSBERG, LIMPOPO PROVINCE, SOUTH AFRICA**

Project leader: S. Diop, Ph.D. (Eng Geol.)
Project team: S.G. Chiliza, B.Sc. Hons (Eng Geol.), S. Diop, Ph.D. (Eng Geol.)
Primary objective: To assess the landslide susceptibility of the Soutpansberg area in the Limpopo Province. The project has the potential to develop into an innovative project for the Department of Works, Disaster Management, Roads and Transport in Limpopo Province, given that some slope instabilities are evident along the National, Provincial and District roads of the province, of which many experienced cutting failure in the year 2000. The project will (i) directly improve the standard of living as it will mitigate development problems, (ii) reduce costs associated with public service delivery and (iii) improve public safety
Through collaboration with the local authorities the Council for Geoscience will be able to promote stakeholders awareness with regard to geohazards, safer land use and better implementation of disaster management responses
Duration: 2009/10
Budget: R73 500

Motivation
The occurrence of natural hazards such as landslides is a serious constraint on economic development, particularly in developing countries. The Engineering Geology Unit has in the financial years 2007/08–2008/09 compiled the first landslide inventory and susceptibility maps. This year's programme was intended to study landslides at a predominantly rural area of the Soutpansberg.

Progress
The regional investigation process identified over 700 recent and ancient landslide events. The methodology implemented in the study consisted of a desk study encompassing a literature review, stereoscopic examination and interpretation of aerial images. The desk study was followed by field work in the region to confirm landslide areas and get an insight into primary landslide casual factors. A geomechanical survey was also conducted. Six factors were identified as being contributors towards landslide occurrences in the province. These factors are slope angle, rainfall, geology, terrain morphology, lineaments and seismicity.

During the inventory a distinctive lake, namely Lake Fundudzi, was identified. Lake Fundudzi is and was formed by a landslide that blocked the course of the eastward-flowing Mutale River.

Conclusions
The Limpopo Province has a very low susceptibility area (80%), low susceptibility area (17%), moderate susceptibility area (2.5%) and high susceptibility area (<1%). The compiled map shows that the areas with moderate to high susceptibility (2.5% and <1% respectively) coincide with the three mountainous escarpments in the province.

Future activities
Further research is proposed to study the failure of a natural slope that blocked the Mutale River to form Lake Fundudzi.

ST-2010-1070 **ASSESSMENT OF SINKHOLE FORMATION MECHANISMS BY NUMERICAL ANALYSIS**

Project leader: S. Diop, Ph.D.
Project team: S. Diop, Ph.D., D. Mokhohlane, B.Sc. Hons (Eng Geol.)
Primary objectives: (1) To evaluate constitutive models and select a model to represent the progressive enlargement of the subsurface void, (2) to use the finite element method to investigate the influence of such cavities on the overall sinkhole development mechanism and (3) to add to the current body of knowledge of sinkholes with regard to site characterisation
Duration: 2009–2011
Budget: 2009/10: R76 540

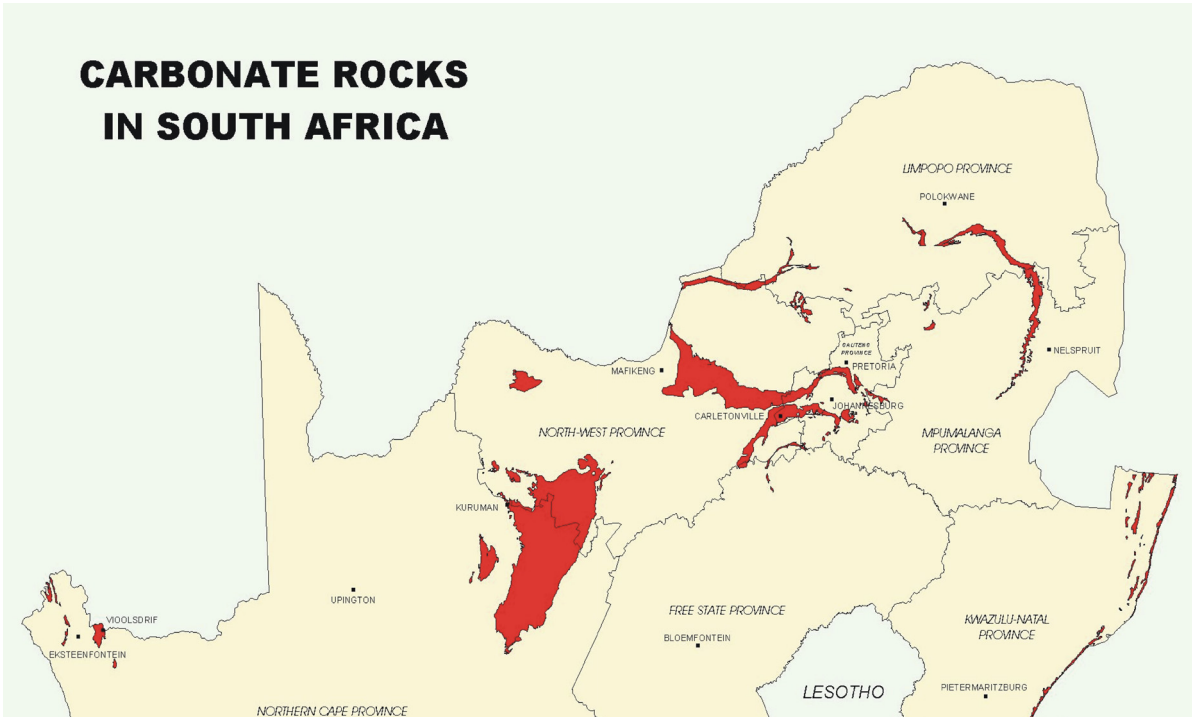
Motivation
Sinkholes in karst terrains are caused by natural or man-made cavities. They occur worldwide, with notable concentrations in South Africa, the eastern USA, southeast Asia and Canada. The very sudden nature of this phenomenon may be damaging to buildings and endangers lifes. In South Africa sinkholes and dolines are amongst the most serious geological hazards in karst terrains, particularly in the densely populated Gauteng Province and most of the Far West Rand and North West Province. Therefore assessing the mechanism by which sinkholes initiate and develop is of prime importance, particularly in terms of public awareness and potential land development.

Progress
Budgetary constraints prevented full implementation of these research aims. A literature review of a wide range of scientific studies and technical documents related to this topic has nevertheless been conducted to establish both current and past research approaches to this problem. It is hoped that the application of the methodology to a specific case study in the South African context will provide useful insight in understanding the mechanism of sinkhole formation and enable a design for effective sinkhole risk mitigation to be made on a more rational basis.

Conclusions
The numerical method addressing the mechanism of sinkhole formation in karst areas can be categorised into two basic steps. In order to achieve success in the pilot study, the Council for Geoscience has entered into a partnership with Dr Ming of the National Institute of Advanced Industrial Science and Technology (AIST), Japan, who agreed to provide the software, as well as technical assistance for a three-month period.

The proposed pilot study is intended to be used as a screening tool during the early stages of this project when only limited geomechanical parameters of the subsurface are available. It is hoped that the application of the methodology to a specific case study in South African context will provide useful insights in understanding the mechanism of sinkhole formation.

Future activities
The second phase of this project will only be undertaken if the first phase proves successful. Thereafter a more detailed programme comprising sampling, laboratory testing and analyses, as well as full-scale modelling and numerical analyses will be provided. This approach allows practical results to be produced concurrent with more scientific work aimed at increasing the fundamental understanding of the mechanisms of sinkhole development.



Distribution of major dolomitic groups in South Africa.

Sinkhole occurrence: (a) Venterspost tennis club, (b) along the N12, (c) Voortrekkerhoogte, Pretoria and (d) Laudium, Pretoria.

ST-2010-1069 **DETECTION OF SHALLOW UNDERMINING BY ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT)**

Project leader:	S. Diop, Ph.D.
Project team:	S. Diop, Ph.D., E. Chirenje, M.Sc. and D. Mokhohlane, B.Sc.
Primary objectives:	The focus of this survey is primarily to determine if the ERT technique could accurately image a trial survey over known abandoned shafts in the central Johannesburg area, and to determine to what extent the results could be extended to the whole study area
Duration:	2009–2011
Budget:	2009/10: R54 820

Motivation

Chief among the DMR's action plans is the implementation of a Sustainable Development through Mining programme, which aims to identify and prioritise abandoned mines for rehabilitation. Therefore, the activities associated with securing shafts and other facilities that pose hazards must receive the highest priority. The shallow old mine workings along the Main Reef road in Johannesburg pose a serious hazard to the growing squatter settlements in the area. Recently, loss of life and property through subsidence of the ground has been documented, particularly in the Primrose area. In the interest of ensuring public safety, the Council for Geoscience has decided to investigate the spatial and depth distribution of the old mine workings to the south of Main Reef road. A survey was proposed using the multi-electrode resistivity method at Maraisburg and Primrose along the Main Reef road where there are known vertical and south-dipping shafts.

Progress and future activities

Budgetary constraints prevented full implementation of the research aims. A literature review of a wide range of scientific studies and a preliminary reconnaissance survey have nevertheless been conducted to establish both current and past research approaches to this problem. Further field work, including areas in Limpopo, is scheduled for 2010–2011.

Conclusions

A literature review and a limited reconnaissance survey have been presented to assess the extent of hidden mine shafts and shallow undermining in the Central Witwatersrand Mining Basin south of Johannesburg where the potential exists for loss of life and property through subsidence of the ground. The following main conclusions and recommendations can be drawn:

1. The geometry and some physical properties of the mined-out material, as well as water-saturated zones, might be determined by resistivity imaging.
2. The detection of shallow undermining and mapping of the horizontal extent of shallow undermining is enabled with appropriate accuracy.
3. Ground truth data, including historic maps and a visual walkover survey, were shown to be essential for a robust interpretation of the surface ERT model.
4. The findings obtained from this review not only offer practical considerations in modelling the subsurface conditions, and enable the identification of areas of potential threat to human safety and health to be made on a rational basis, but they also come with potentially immediate implications for the location and management of water ingress to the mine void.
5. The survey covered a relatively small area. However, the method could reasonably be deployed in much larger areas, e.g. of the order of hundreds of thousands of square metres.
6. The major limitations of this application can arise from the fact that the resistivity method has proved to work only for shallow mine workings with depths less than 70 m. In addition, good data quality is largely dependent on a well designed survey which includes good coupling of the electrodes to the ground.

Site location map: Primrose–Boksburg in Gauteng.

Resistivity survey setup: (a) CGS team and contract workers, (b) dense vegetation and lack of access roads.

ST-2009-1009 **LANDSLIDE HAZARD AND SUSCEPTIBILITY MAPPING OF WORCESTER SHEETS 3319 AND 3419, WESTERN CAPE PROVINCE**

Project leader:	C. Forbes, B.Sc. Hons
Project team:	K. Tegegn, M.Sc., F. Azene, M.Sc., S. Richards, B.Sc. Hons, G. Chiliza, B.Sc. Hons, S. Ngubelanga, B.Sc. Hons
Primary objectives:	Characterisation of the geotechnical constraints affecting six villages in the Moretele LM, via desk studies and limited field work
Duration:	2009–2010
Budget:	Year 1: R153 750

Motivation
The Geoscience Act defines one of its functions as advising government institutions and the public on the safe and judicious use of land. It has also committed itself in its medium strategic plan to focus on contributing towards rural development and poverty eradication and monitors progress towards this end via its Balanced Scorecard system.

Moretele Local Municipality (LM) had informed the Council for Geoscience of serious house wall cracking prevalent at Makapanstad, in November 2007. A limited initial programme of power augering by the Council for Geoscience to assess founding soil conditions across the Moretele LM area followed in Febuary 2008. Subsequent efforts utilising the insights gained to obtain funding for a comprehensive geotechnical soils study via the Moretele Local Municipality and Bojanala District Municipality failed. CGS funding was approved by management for six selected villages and immediate environs to be investigated during the 2009–10 statutory programme. The villages are Lebotlwane, Tladistad, Ngobi, Kgomo-kgomo, Sutelong and Syferkraal. They range from 500–1 400 ha in extent and total almost 5 000 ha of rural village land.

Progress
Despite budget constraints in the financial year, the project team was able to conduct a limited reconnaissance of each village and desk studies culminating in six engineering-geological provisional development potential reports. Planned test pitting and soil testing at each village was not feasible. However, some prior augering data were available in a number of instances. This facilitated enhanced estimations of probable founding conditions and an understanding of local geotechnical constraints.

Each report considers, within the constraints of the investigations performed and use of available data sets (including topographic, geological, aerial imagery, pits, boreholes, reports, published literature), the following aspects: problem soils (expansive, collapsing, dispersive, etc.), excavatability, undermining, slope stability, shallow groundwater, flooding and inundation and local construction materials (aggregates). Preliminary development potential zoning was feasible for some villages.

Conclusions
Initial assessments show that extensive alluvial deposits adjacent to the Moretele River and deeply weathered shales and mudrocks of the Irrigasie Formation (Karoo age) are the likely contributors to the widespread house cracking present in this local municipality.

Relatively simple investigative tools and investigative methodologies can be employed to identify and delineate the geotechnical constraints and opportunities present at rural villages in South Africa. This can facilitate more optimal and economic use of land, if incorporated into local integrated development plans (IDPs).

A well funded, resourced and systematic programme could be applied in all provinces to elevate local awareness of problem soils and geohazards in general. It would also have the potential to reduce unnecessary expenditure of state subsidies by minimising the development of poor ground. The efforts of the Council for Geoscience to enhance rural development in this way depend on future funding support.

Future activities
No further investigative activities other than the delivery of current reports to local authorities and the relevant community leaders are planned for 2010–11. However, envisaged limited outreach at each village will entail layman presentations to convey the implications of the report findings by investigators. Topics from suitable soil-founding conditions for single storey house construction to site selection parameters for solid waste disposal and cemetery location will be covered. Issues such as sourcing local construction aggregates of acceptable standard and dealing with shallow groundwater would be included.

EASTERN CAPE

ST-2009-1056 **GEOLOGICAL MAPPING OF 1:50 000 SHEET 3327AD HAMBURG**

Project leader: J.S.V. Reddering, Ph.D.
Project team: D. Claassen, B.Sc. Hons, D. Black, B.Sc. Hons
Primary objective: Revised and updated geological map for the 1:50 000 sheet 3327AD Hamburg. The map explanation will be combined with that of the adjacent map to the west, 3327AC & CA Fish River Mouth, which was mapped in 2007. Mapping also focused on the occurrence of mineral deposits and their potential for future small-scale mining development within the Spatial Development Initiative (SDI) region
Duration: 2008–2010

Motivation
The 3327AC & CA Fish River Mouth and 3327AD Hamburg map areas fall within the Fish River Spatial Development Initiative (SDI) area. SDI areas identified by government are regions with high unemployment and poverty, but great inherent potential for economic and rural development through activities such as small-scale mining. To facilitate this economic and rural development the updating of geological maps of the area is essential to identify earth resources such as construction materials or potential mineral deposits capable of being developed by small-scale mining activities. These maps are the final gap in the revised geological maps between Port Elizabeth and East London, which, once completed, will cover the entire coastal area of the Fish River SDI.

Progress
Field work was completed at the end of February 2009. A large number of previously unmapped deposits of the Alexandria Formation were identified north of the Keiskamma River, near the villages of KwaVivi and Mazikhanye, south of the river near Hamburg and in the northwest near the village of Tuku. The mapped distribution of Nanaga Formation aeolian deposits is a considerable improvement on previous maps. Special attention was paid to Quaternary coastal deposits with coastal dunes and storm beach deposits mapped and the processes influencing their formation described. Occurrences of thick ferricrete and colluvium were also mapped.

The revised map has been compiled and draughted. The data collected for the 3327AD Hamburg area has been incorporated into the joint map explanation which highlights the limestone deposits that could support small-scale cement manufacture.

Conclusions
The Hamburg and Fish River Mouth maps and explanation have been edited and are currently being prepared for publication.

ST-2009-1041 **REGOLITH WEATHERING PROFILES IN THE INSIZWA AREA: IMPLICATIONS FOR THE IDENTIFICATION OF MINERAL DEPOSITS**

Project leader: V.R. Mitha, M.Sc.
Primary objective: For exploration purposes and prior to the commencement of costly drilling operations, context-specific regolith studies are undertaken to identify and roughly delineate the extent of any anomalies
Duration: 2009–2010
Budget: Total: R92 022

Motivation
Large mineral deposits are associated with mafic intrusions elsewhere in the country. Despite the occurrence of widespread dolerite intrusions in the Eastern Cape no significant mineral deposits have been identified. The Insizwa Complex, a thick dolerite sill near Mount Ayliff, has geochemical and mineralogical indicators of sulphide segregation and Cu-Ni-PGE mineralisation. The slopes around the high mountain are regolith covered and present an opportunity for the characterisation of regolith formation processes and the associated geochemical signatures that could assist exploration for platinum group minerals.

Progress
Regolith mapping shows that the area is characterised by erosional and depositional processes. Gully erosion is responsible for widespread truncation of regolith profiles. The depositional regime is characterised by colluvial and alluvial surface processes which transport and deposit sediments unrelated to the underlying regolith. This high-lying, immature landscape is characterised by thin soils and generally shallow regolith profiles. This is uncharacteristic of an

area with a humid climate such as that of the surrounding Mount Ayliff area. Regolith developed from *in situ* weathering of sedimentary rocks and dolerites were sampled and analysed for major and trace elements with the aim of defining typical weathering profile variations. The regolith profiles retain many mineralogical and geochemical characteristics of the parent rock. Weathering indices (WI) and ratios of incompatible elements were used to show relative enrichment or depletion patterns that represent geochemical signatures of the different rock types in the area.

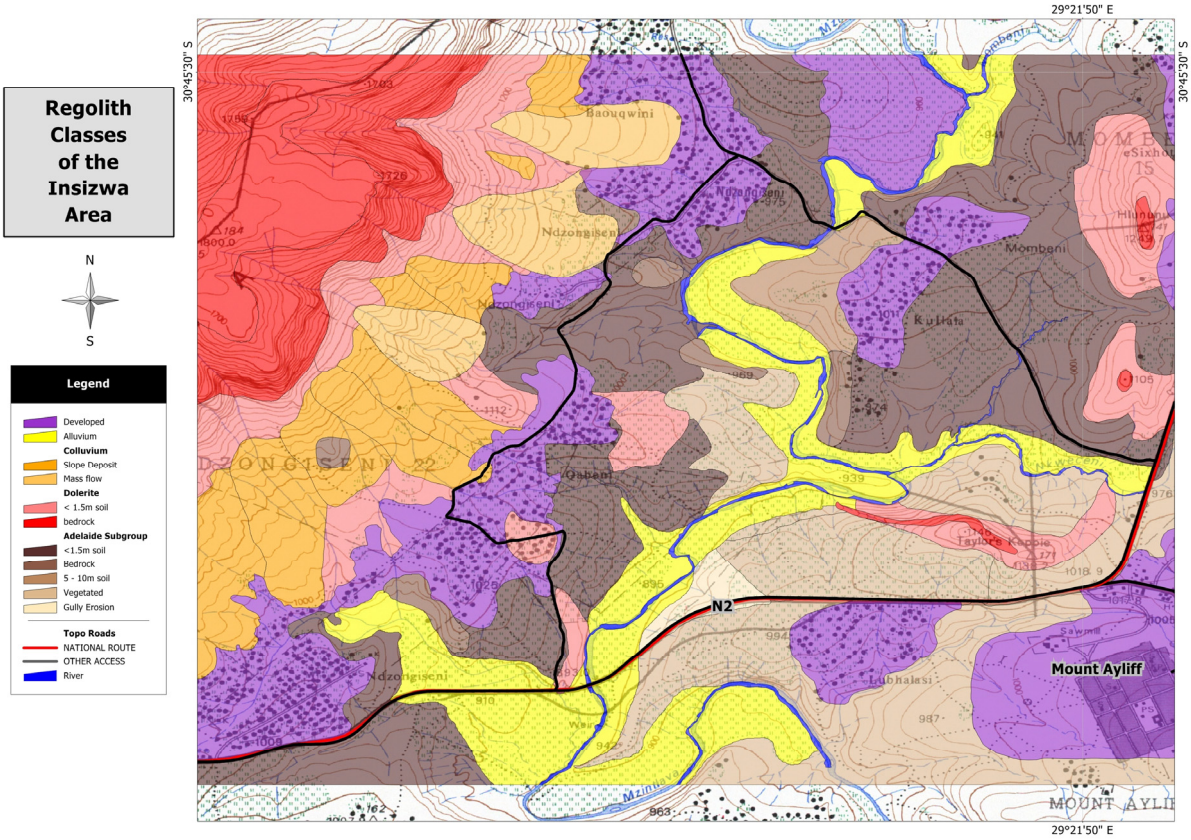
Geochemical profiles through dolerite are generally preferentially weathered near the surface where high WI values occur. In the upper soil horizons residual Ti-bearing minerals, haematite, goethite and gibbsite are most prevalent due to oxidation reactions in the aerated soil profile. Cr, Ni, Cu, Zr and V are concentrated lower down in the profile due to residual accumulation and adsorption onto clay minerals. Most of the ratios of incompatible elements are constant with depth, probably due to the advanced leaching of bases from the weathering profiles. Ratios of incompatible elements in regolith, developed from the weathering of sandstone and mudrock, are highly irregular due to lithological variations. Regolith developed over highly weathered sedimentary rocks contains an abundance of kaolin.

Conclusions

The platinum group ore zone is not exposed on the slopes around the base of Insizwa mountain. The regolith profiles are characterised by illuviation (accumulation) and eluviation (depletion) horizons. Residual Ti-bearing minerals which are highly resistant to pedogenic weathering show relative enrichment in the profile. Weathering indices vary with depth but have major accumulation and depletion patterns that coincide with in-profile fracture planes. Enrichment-depletion patterns develop through deposition of leached material in these zones, whereas depletion of the alkali and alkali-earth elements occurs due to concentrated surface water infiltration. Below the soil there is a prominent eluviation zone in which concentrations of Cr, Ni and Cu are relatively enriched.

Future activities

The project has achieved its goals.



Map showing the spatial variations in unconsolidated regolith at the base of Insizwa mountain, Eastern Cape.

ST-2002-0951 **LATE QUATERNARY REACTIVATION OF THE KANGO FAULT, SOUTH AFRICA: GEOPHYSICAL CHARACTER OF LATE QUATERNARY FAULT-RUPTURED ALLUVIUM**

Project leader: M.L. Goedhart, M.Sc.
Project team: C.J.S. Fourie (contract), M.Sc., C.J. de W. Raath (contract), B.Sc., L. Maré, M.Sc. and N.J. Cassidy (Potsdam University and Jena University, Germany)
Primary objective: Assess the suitability of a range of geophysical techniques for characterising regolith units across a fault zone that displaces Quaternary alluvium
Duration: 2009–2010
Budget: Total: R465 929

Motivation
During previous phases of this research programme a deep trench was excavated across the fault line to expose the fault scarp. The trench walls were logged in detail and displaced sedimentary strata and younger units that bury the fault scarp were identified and dated. Trenching across the fault line to identify displacement is a costly exercise. Suitable geophysical profiling techniques should provide a rapid means of identifying and correlating sedimentary units along the fault zone.

Progress
The magnetic susceptibility of several stratigraphic samples from the trench were analysed at the Council for Geoscience geophysical laboratory. This was done to determine which mapped horizons acted as main conductors for the induced electromagnetic fields. Results confirm that the main flood deposit (unit 2e), composed of coarse gravel and sand with some clay in the interstitial matrix, was the main horizontal conductor in the exposed trench stratigraphy. The magnetic results also confirm the location of a subsurface unconformity which was discovered while mapping the trench wall sediments. This unconformity was subsequently dated and found to correspond to the Last Glacial period, between 115 000 and 10 000 years ago, a period of increased aridity in the Little Karoo. The magnetic susceptibility results probably reflect the degree of weathering. Pre-Holocene strata below the unconformity have half the magnetic susceptibility of the younger Holocene units above it. This suggests the laboratory technique could be applied to samples of drill core from the area, to differentiate between older weathered deposits and younger cover sediments, and so map out the last glacial unconformity in the Little Karoo.

Following the presentation at the South African Geophysical Association and Inkaba ye Africa conference in Swaziland, 13–18 September 2009, a new research collaboration was initiated with Keele University, United Kingdom. This arose because several additional features in the ground-penetrating radar data collected at the trench were identified by Dr Cassidy when he reviewed the data during a short course at the conference. This independent review and assessment is expected to strengthen the current interpretation and provide guidance for improved geophysical data collection in future.

Findings from the research have been compiled into an internal report, which is currently undergoing review.

Conclusions
The electric and gravimetric methods were able to resolve most faults mapped in the trench wall, although to varying degrees of success, depending on instrument settings. While seismic refraction was able to detect the main stratigraphic and structural features, detail was not as easily resolved as with the other methods. Of all the methods, the ground-penetrating radar was least successful, due to high ground conductance. Of interest, using the same interpretive methodology, two additional structures were located in an unexcavated area to the south of the trench, suggesting there are additional fractures in this area that are not evident on the land surface.

Future activities
Research results have been compiled into an internal report, which is currently undergoing review. The findings will be published in a peer-reviewed journal.

ST-2010-1092 **GEOLOGICAL MAPPING OF 1:50 000 SHEET 3325DB COLCHESTER**

Project leader: J.S.V. Reddering, Ph.D.
Project team: D. Claassen, B.Sc. Hons, V. Mitha, M.Sc., D.E. Black, B.Sc. Hons
Primary objective: To revise the existing geological map and compile a more detailed and updated map explanation of the area covered by the 1:50 000-scale map 3325DB Colchester
Duration: 2009–2010
Budget: Total: R972 550

Motivation
South Africa remains committed to promoting sustainable economic and rural development in areas where poverty and unemployment are at their highest. Such areas are identified as Spatial Development Intiatives (SDI). The strategic geological mapping programme has focused on Eastern Cape coastal areas falling within the SDI. The 3325DB Colchester sheet was the only remaining 1:50 000-scale map still to be remapped with the intention to revise and update the geology and identify possible mineral deposits.

Progress
Relevant literature was sourced and reviewed. An aerial photograph interpretation was completed. Digital information was collected, collated and incorporated into 25 detailed 1:10 000 field base maps to be used in the Trimble Nomad GPS. The use of digital mapping techniques enables integration of field data with the GIS. Field observations are logged onto data templates that are downloaded to form a database.

Large sections of the Addo Elephant National Park are located within the boundaries of the Colchester map. Permission to work within the park boundary was granted by the park management. Field mapping was not undertaken due to financial restrictions.

Conclusions
The project was cancelled due to financial constraints. The preparatory process made a positive contribution towards the integration of GIS data with digital field-mapping techniques.

Future activities
No future developments are planned.

ENVIRONMENTAL GEOSCIENCE

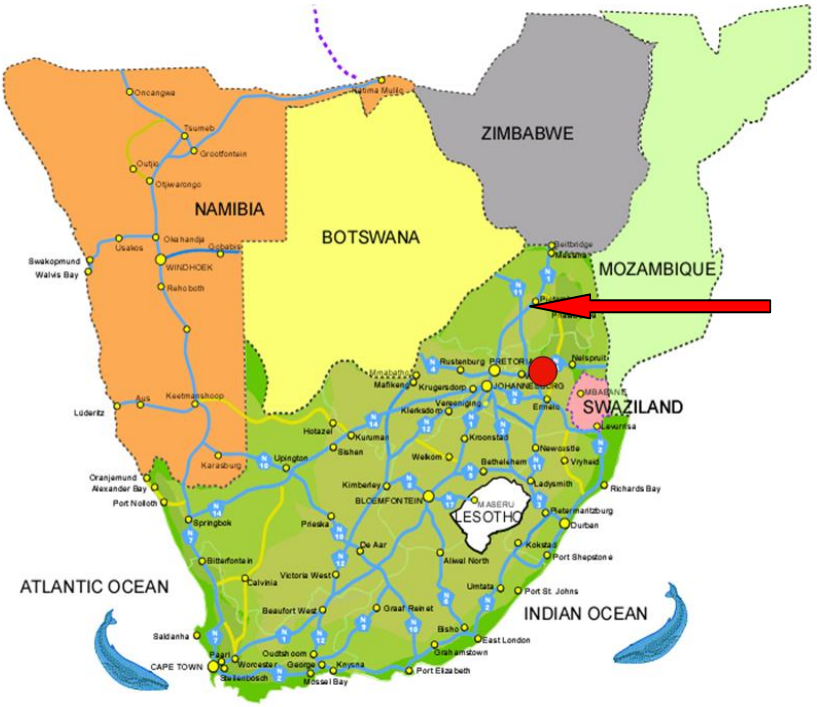
ST-2009-1032 **APPLICATION OF ECOTOXICOLOGY IN GEO-ENVIRONMENTAL MAPPING**

Project leader: D. van Tonder, B.Sc. Hons
Primary objective: To develop and adapt environmental methodologies for the investigation of mining legacies for use in producing geo-environmental risk maps. The mapping out of human health and environmental risks pertinent to proposed land use options will assist in future development and will enhance the quality of life of people living in and around areas affected by mining. With properly informed planning, the resulting economic restructuring would be maximised, generating jobs by most appropriately fitting land use plans to economic growth
Duration: 2008/9–2010/2011
Budget: Nil

Background
The traditional mining areas left a legacy of contaminated land and continuing impacts on the quality of water resources, land and air. The production of geo-environmental maps is seen as a vital step in making information available in an appropriate format for land-use assessors. The compilation of geo-environmental maps and risk maps requires both field work and laboratory research in order to understand the impacts of mining and other activities on soil, water, sediment and air. The resolution (scope and quantitative range) of the geo-environmental maps vary depending on the region and availability of information within the Council for Geoscience, such as water monitoring data, sediment contamination data and data from the regional soil-sampling programme.

The application of ecotoxicology and environmental geochemical mapping has never before been attempted in South Africa. The Council for Geoscience is developing in both these arenas and the combination of techniques will put it in the position as being the leader in Africa with regard to geo-environmental studies.

Motivation
The Council for Geoscience has very little background knowledge in the coal field and the impacts of coal mining on the environment. For this reason, the area selected for the first environmental risk assessment was the Mpumalanga coal field area.



Witbank local municipality.

The study area falls within the Mpumalanga coal field with coal mining impacting on the water resources in the area and affecting human health and the environment.

Progress
Field work and some environmental laboratory experiments on samples have been completed; no further progress was possible due to financial constraints. Alternative funding for the completion of the project are being sourced.

Future activities
It was requested that funds be made available for the continuation of the analysis of collected samples and interpretation of results.


Field sampling.

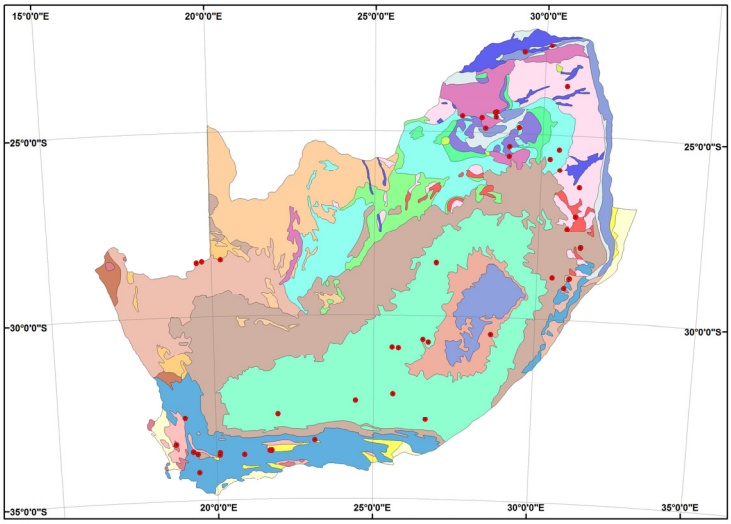
Community adjacent to collapsed underground coal mine.

Field placement of ecotoxicological microcosms.

ST-2009-1015 **HOT SPRINGS OF SOUTHERN AFRICA**

Project leader: J. Venter, B.Sc. Hons (Eng. Geol.)
Project team: T. Motlakeng, Nat. Dip. (Geol.), P. Nyabeze, M.Sc. (Explor. Geophys.), MBA, M. Sekiba, Nat. Dip. Tech., M. Kwata, B.Sc. Hons (Environ. Tech.)
Primary objective: To study the thermal springs of South Africa in terms of safety for use by humans (medical risk assessment) as part of the medical geology initiative. However, the scope was extended to specifically include the potential of these springs for alternative uses. These will include geothermal energy (power generation and direct heating), as well as agriculture (irrigation and aquaculture)
Duration: 2008/09–2009/10
Budget: R294 420

Background
South Africa has a number of thermal spring resources which could provide localised sources of energy, while the deeper seated thermal sources for these springs could also be exploited. These resources need to be studied to determine their potential in terms of power generation and/or other alternative uses. Many of these thermal springs are located in poverty-stricken rural areas. The identification of the optimal use of thermal springs, and subsequent development, could play a significant role in the social and economic uplift of these communities.



Simplified geology of South Africa with the thermal spring locations.

Motivation
Initially the project was proposed as a medical geology project, with the aim of assessing the safety of thermal spring water for various human uses. The project then expanded in scope to include alternative uses not being considered before. This could prove to be a project assisting in the uplift of rural communities, which forms part of the objective of the Council for Geoscience to alleviate poverty.

Progress
Two papers were submitted to the World Geothermal Congress in Bali in April 2010. The first paper covers the country update for South Africa regarding the use of geothermal energy, and the thermal springs of the Limpopo Province were discussed in the second paper.

The good working relationship between the Department of Environmental Sciences at UNISA and the Council for Geoscience also culminated into a successful project proposal with the Water Research Commission (WRC). The project will commence in April 2010.

The Environmental Geosciences Unit, together with the Geophysics Unit, continued research into selected thermal springs in the Limpopo Province. The Geophysics Unit was invited to assist in conducting research into the geological controls which lead to the formation of thermal springs. The Water Geosciences Unit was involved in describing the catchment of these springs through isotope studies.

Further collaboration between different business units lead to a joint field visit between the Environmental Geosciences Unit and the Mineral Resources Development Unit to investigate the presence of lithium in a selected thermal spring in the Northern Cape (Riemvasmaak).

Conclusions
This project has immense potential in exploring untapped resources for the development of South Africa.

Future activities
Funding to the value of R2.3 million has been awarded to the research team by the Water Research Commission (with UNISA as the leading agent) over the next three years. This will be used to further study the thermal springs of South Africa, with special focus towards alternative uses.

Research team visiting the thermal spring at Siloam, Limpopo.

Geophysical investigations at Siloam.

Water sampling for various chemical analyses, including stable isotopes.

Riemvasmaak thermal spring in the Northern Cape Province.

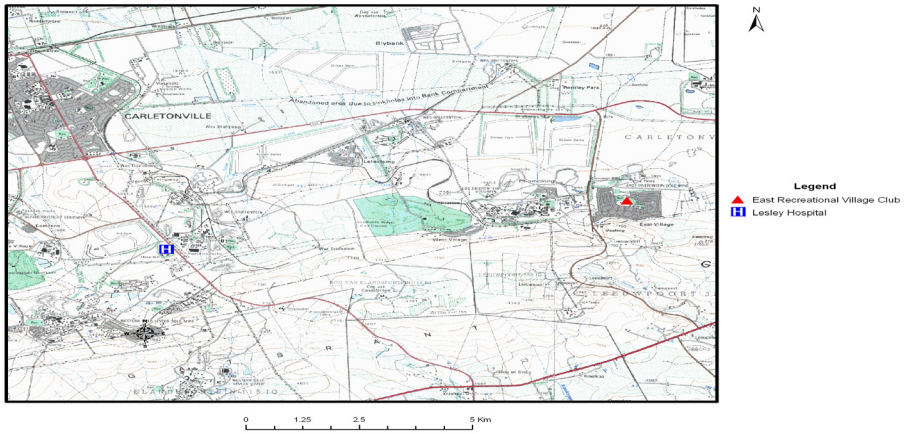
ST-2009-1062 **COMPARISON OF DUST METHODS FOR MEASUREMENT OF DUST DEPOSITION AND DUST FALL IN SOUTH AFRICA MINING SECTORS**

Project leader: M. Kwata, B.Sc. Hons
Project team: G. Kornelius, Ph.D., B. Yibas, Ph.D., S. Lekoadu, B.Sc. Hons
Primary objectives:
- To make use of dust sampling instruments which are capable of providing indications of the atmospheric dust fallout rate
- To see how the dust fallout rates compare to international and local standards
- To develop data systems for the methods of measurement of dust deposition for dust fallout

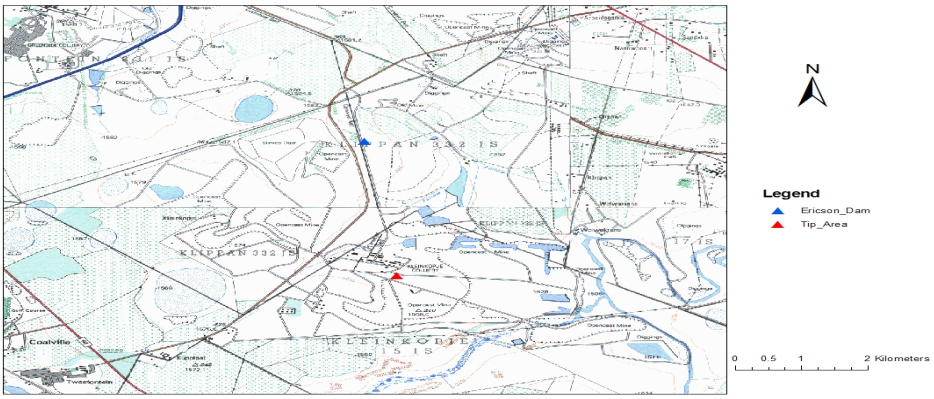
Duration: 2009/10–2010/11
Budget: Nil

Background

The study is about comparing two methods: (i) American Society Testing Material: 1739:82 (old) and (ii) American Society Testing Material: 1739:98 (new) for measuring dust deposition and dust fallouts in the Driefontein mine in Carletonville and Klein Kopje Colliery mine in eMalahleni.



The location of Driefontein Mine in Carletonville.



The location of Kleinkopje Colliery Mine in eMalahleni.

Motivation

To equip the Environmental Unit staff with skills and knowledge on air quality management in various industries such as mining and power stations.

Progress

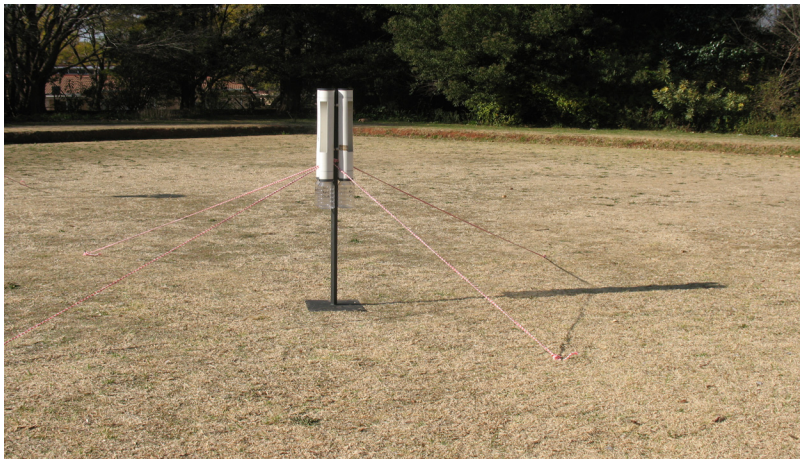
Dust monitoring instruments have been installed at the two mines (Driefontein mine and Klein Kopje Colliery mine). Four monthly reports were submitted to the Council for Geoscience as progress reports for the study. One quarterly report (Sept–Nov 2009) has been submitted to Klein Kopje Colliery mine and mine dust sample results were submitted to Driefontein. Field work is continuing for a period of 17 months (starting September 2009 to February 2011).

Future activities

Continue with dust monitoring for various industries.

American Society Testing Material: 1739:82

American Society Testing Material: 1739:98



Directional dust deposition gauge.

ST-2009-1093 **ARTISAN AND SMALL-SCALE MINING ENVIRONMENTAL IMPACT TOWARDS SUSTAINABLE DEVELOPMENT**

Project leader: B. Hanise, M.Phil.
Project team: D. Sebake, M.Sc., D. Katemaunzanga, B.Sc. Hons
Primary objectives:
- Explore gaps within legislation and policies regulating river systems in relation to surface water, river sand mining and environmental conservation. The legislative policies sited are as following: the South African Constitution, the National Water Act, the Mineral Resources Development Act and National Environmental Development Act
- Explore the challenges, experiences and regulatory tool used in other countries through case studies on small-scale and artisan mining
- Explore any future scenarios towards the use of technically (geological and GIS) informed holistic approaches for sustainability and conservation

Duration: 2009/10–2010/11
Budget: R246 353

Background

South Africa, like all other countries, has the constitutional obligation of meeting needs such as access to clean drinking water and decent housing for its citizenry. Added to this is the fact that the outcome of the growing economy has been the migration of people to urban centres. This continuous influx of economic migrants results in the ever-increasing urban population which places a heavy burden on the aging bulk infrastructure and the need for additional housing.

To meet these ever-increasing basic needs there should be an upgrade of the existing infrastructure through the building of more roads, bridges, residential buildings, office complexes, etc.
Two points to note are, firstly, that industrial minerals in the form of river sand and clay are the backbone in the refurbishment of old and building of new infrastructure by the construction industry. Secondly, South Africa is an arid

country and river systems are one of the major sources of surface water. Therefore, it is evident that the lack of a formal integrated technically informed and holistic framework to regulate river sand mining will in the long term expose South Africa to a possible collapse of river systems to irreversible extents.

Motivation
The Council for Geoscience is well equipped to handle this project as it has the expertise to explore a holistic approach that seeks to inform a policy/legislation process towards the establishment of a policy framework. There is a growing need for output-based research that answers to the challenges the country has towards a development that is sustainable and this project addresses such objectives.

Progress
Literature survey on artisan and small-scale mining; exploration of experiences through case studies; exploration of analysis tools and a data consolidation system thinking approach; the process of the creation of indicators (consultation with geological and GIS expertise before site selection and field-testing exercise).

Conclusions
The report highlights the fragmentation in the legislation and regulatory frameworks with relation to river systems, and because of such gaps, the tools' inability to address negative impacts caused by river sand mining. Case studies have been used and systems thinking analysis tools explored to strengthen the need for further empirical field work on selected study sites for analysis towards a scientifically informed regulatory and legislative tool for sustainable river sand mining exercises and the preservation of the natural ecosystems and water sources.

Future activities
Site selection; geological prospecting, resource estimation and short- to long-term monitoring; conducting community engagement studies; utilisation of remote sensing and GIS tool for monitoring and data collection.

ST-2009-0965 **DEVELOPMENT OF THE EGU LABORATORY IN TERMS OF ENVIRONMENTAL CHEMICAL SPECIATION (METAL AND ORGANIC) AND BIOGEOCHEMISTRY**

Project leader:	P. Wade, Ph.D. (Chem.)
Project team:	M. Kotoane, B. Tech. (in progress)
Primary objectives:	• To develop the Environmental Geoscience Unit's capacity with respect to the analysis of environmental samples and interpretation of data deriving from such analyses • Subsidiary aims are to ensure capacity development in laboratory personnel, to grow the laboratory both in technical and HR capacity and to increase the size of the target market
Duration:	2008/9–2009/10
Budget:	R133 000

Background
The EGU Laboratory has the function of providing environmental chemical information to support environmental risk assessments. The drive towards understanding the impacts on South Africa's water resources has brought the more integrated approach of Environmental Water Quality (EWQ) to the forefront. The EWQ approach is based on a combination of three main components, physico-chemical, biomonitoring and ecotoxicology, to assess the water quality and health of the ecosystem. The EGU Laboratory features three distinct components: (i) the Inorganic Lab, (ii) Biogeochemistry Lab and (iii) Ecotoxicology Lab. This section lists the actions performed in the Inorganic Laboratory and the Biogeochemistry Laboratory.

Motivation
- Alignment with CGS focus areas, these being:
  - *Growth*: The project will allow the Council for Geoscience to grow into a very profitable new area of business. The information products will be released on appropriate national and international platforms to assist in marketing the organisation in the ecotoxicological arena and to attract sponsors for future growth (as already planned)
  - *Regulatory, systems and stakeholder*: The project will assist regulatory bodies (DWAF and DMR) in monitoring and controlling aqueous environmental pollutants, and will assist in protecting citizens of South Africa from degradation of critical ecosystems upon which water quality depends
  - *Innovation*: Novel methods for rapidly determining the ecological status of river sediments will be developed at the organisation in collaboration with the University of Johannesburg and Rhodes University
  - *Africa development*: Capacity for assisting in crucial aspects of ecological reserve determination and in interbasin catchment management will be developed
  - *Skills development*: Skills in environmental chemistry and risk assessment will be grown in-house at the Council for Geoscience
  - *Transformation*: CGS employees benefiting mostly from skills development will be those who were previously disadvantaged.

The EGU Laboratory is at a fixed location, but laboratory personnel on occasion participate in sampling field excursions in order to ensure quality control with respect to sampling and sample preservation. Thus, the ambit of the EGU Laboratory extends to the geographical areas of interest to the EGU as a whole.

Progress
Data analysis and construction of a biogeochemical model with critical work that was done during this period under review. On the basis of the understanding gained in the modelling exercises, a new programme of experiments was designed for implementation in the next financial year.

Laboratory methods were updated to reflect changing technology in the EGU laboratories.

Strategic plans were developed for growth of people and laboratory capacity until 2015.

Conclusions
The 2009/10 financial year saw a refocusing of the efforts in the EGU Laboratory to prepare for an anticipated high volume of samples requiring chemical workup later in the 2010/2011 financial year. Also included in the refocusing was preparation for expansion into the national environmental risk market.

Future activities
There will be ongoing development and implementation of methods in the EGU Laboratory to reflect the changing demands of the mining and environmental market.

Columns with retort stands, connected to electrodes and pump and synthetic AMD.

ST-2009-1040 **DEVELOPMENT AND CONSTRUCTION OF A PILOT PERMEABLE REACTIVE BARRIER FOR REMEDIATION OF MINE WATER**

Project leader: P. Wade, Ph.D. (Chem.)
Project team: J. Glass, M.Sc.
Primary objectives:
- To characterise the current state and trends of the Olifants Water Management Area in terms of social, economic and ecological concerns
- To investigate the application potential of treatment methods for mine water pollution

Duration: 2008/9–2009/10
Budget: R263 220

Background
The Olifants River, in the Olifants catchment, is currently being polluted by mining activities, from both active and abandoned mines, and as such contains high concentrations of contaminates. The Olifants River flows into the Loskop Dam, which is situated in a conservation area and supports a vast variety of plant and animal species, including hippos, crocodiles, giraffes and a number of antelope. The area also supports recreational services, such as tourism and game fishing. The purpose of this project is to treat the mine water pollution before it enters the dam to allow the natural ecosystem to return to normal. It is critical to bring to an end the flow of contaminants into the Loskop Dam. The permeable reactive barrier technology was found to be the best for large-scale inexpensive and low-maintenance water treatment.

Motivation
The Olifants River, in the Olifants Water Management Area (WMA), is currently being polluted by human activities. Important sources of pollutants include discharge of water from treated and untreated sewage and from mining activities. Both active and abandoned mines are sources of contaminants from the mining sector.

The Loskop Dam is currently showing signs of stress from the highly contaminated inflow. Significant fish kills and deaths of other aquatic animals such as terrapins and crocodiles have been reported. The recreational services in the region are also being severely impacted by the toxic effects of the inflowing water. The effect of the pollution in the dam has received much media interest.

The South African National Water Act 36 of 1998 states that any person who has caused or is likely to cause pollution of water resources must take all reasonable measures to prevent such pollution from occurring. Derelict and ownerless (D&O) mines are the responsibility of the State. These mines are not generating economic value and all remediation of fugitive pollution from the mines represent an unmitigated cost. This cost will be borne by the taxpayer, and will necessarily divert funds from investments in the economy for growth.

A water quality management plan for the D&O mines thus needs to include water treatment technologies that are simple and inexpensive and require little or no skills to maintain.

This project seeks to determine the best technology to perform the above water treatment.

Progress
Data analysis and construction of a biogeochemical model, with critical work that was done during the period under review. Casuarina mulch was used to simulate biological organic material for a PRB to passively remediate AMD in the headwaters of the Olifants River.

The PRB was simulated in the laboratory by glass columns with contaminants upflow and pH and EC monitored continuously. Discrete samples of column effluent were taken from the last batch of columns tested. It was demonstrated that microbial activity is implicated during the conversion of sulphate to sulphide by casuarina mulch. Various mathematical methods of accurately determining the maximum lifespan of a column were tested.

The breakthrough curve at the end of column functionality is best characterised using the Monod function for biologically mediated growth and decay kinetics. The Eadie-Hofstee transformation of the Monod data is promising in contributing to the determination of the maximum lifespan of the column material.

Alternative mathematical methods for characterising the behaviour of the column effluent were investigated. For laboratory purposes the period to half breakthrough was used.

Functions found to best describe the breakthrough curves were the lorcum, the asymmetric sigmoid and the sigmoid functions. The sigmoid function was chosen to represent the column-monitoring data. Periods to mid-breakthrough were calculated from curve-fitting to the sigmoid function the column-monitoring data for all the column experiments to date.

The periods were compared between the experiments performed with the engineered microbe communities (EM) and without. Determinants for comparison were remediation effectiveness (pH, EC, iron and COD) and efficacy (lifetimes of columns).

The effects of EM on the chosen column parameters were found to be:

Effect of EM on column parameters

Column parameter	Effect of EM	Extent of effect
Effluent pH	Increased	52%*
Effluent Fe	Decreased	80%
Effluent EC	Decreased	9%
Effluent COD	Increased	+5 mg/ℓ O_2
Column longevity	Decreased	5%

* measured as decrease of titratable acidity

The influence of the EM on the effectiveness of AMD amelioration by the Casuarina mulch is as hypothesised.

Conclusions
EM facilitates more efficient breakdown of complex cellulosic components of the Casuarina mulch into smaller, water soluble organic molecules which are used as electron donors by the sulphate-reducing bacteria (SRB). The greater rate of production of more water soluble organic molecules likely increases the biomass of SRB, which, in turn, more efficiently reduces sulphate concentrations and acidity (thus increasing pH and decreasing EC) of effluent solution. Sulphate is converted to sulphide by the SRB, which, reacting with iron to form insoluble sulphides, would drastically reduce the iron concentrations in the effluents. The greater rate of consumption of labile cellulosic material decreases the longevity of the Casuarina mulch, which is the thermodynamic cost of increased efficiency of sulphate reduction. The consumption of the cellulosic material occurs at a higher rate than sulphate removal, hence the high levels of COD in the output solution.

Future activities
The project was suspended at this critical juncture in compliance with a CGS directive. Future work will focus on determining the parameters of effective materials for a PRB, with the emphasis on optimising the balance in microbial communities so as to effectively utilise organic matter for AMD remediation such that COD concentration in the processed solution be minimised.

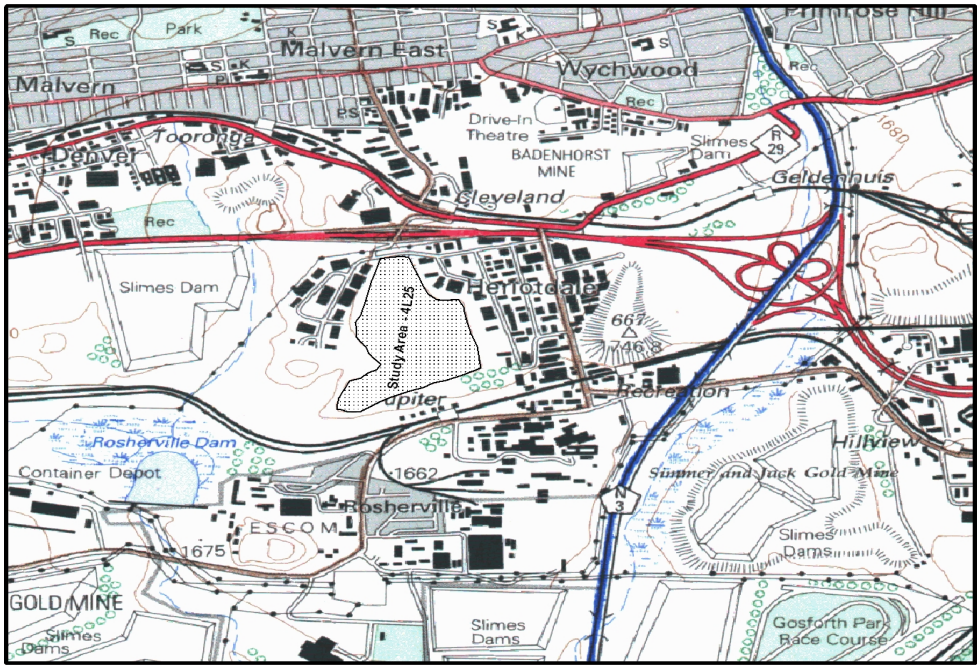
When the nature of biological material and microbial communities has been optimised, a pilot-scale project will be engaged to determine the modification of laboratory-determined parameters upon scale-up of the processes.

ADVANCED STUDY ON OXIDATION ZONE DEVELOPMENT PROCESSES ASSOCIATED WITH TAILINGS DAMS IN THE WITS BASIN: EMPHASIS ON ACID MINE DRAINAGE DEVELOPMENT

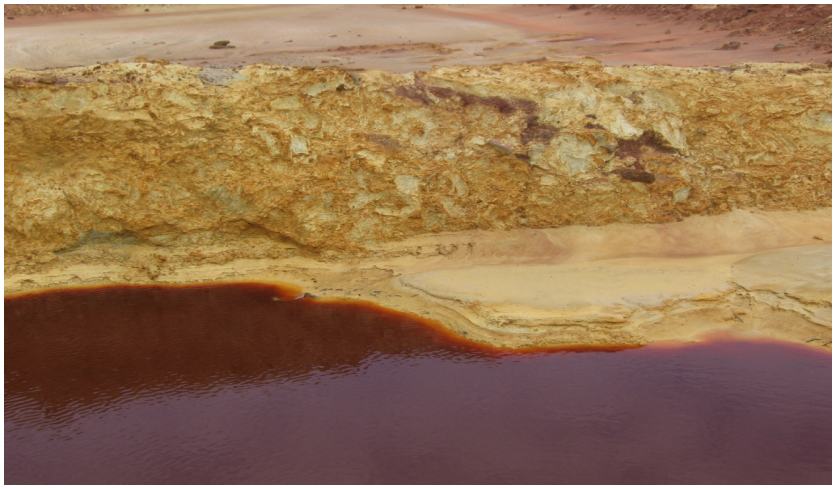
Project leader:	B. Yibas, Ph.D. (Geol.)
Project team:	S. Foya, Ph.D., S. Lekoadu, B.Sc. Hons, L. Molonyama, B.Sc.
Primary objectives:	• Understand the development and characteristics of oxidation zones in the gold tailings dams through field mapping, sampling, instrumental measurement and laboratory tests of different sites • Identify the key parameters and characteristics of oxidation zones, which can be applied for ARD prediction, prevention and remediation
Duation:	2006/07–2009/10
Budget:	Total: R846 000 2009/10: R300 000

Background
The understanding of oxidation zones and phreatic water surfaces plays a very important role in the prediction of acid rock drainage (ARD). Frequently, assumptions on the development of oxidation zones and phreatic surfaces are made based on rule-of-thumb experience and extrapolations from other sites/experiences. The uncertainty regarding the depth and progression of the oxidation zones is one of the major drawbacks in geochemical assessment and predictive modelling and the establishment of accurate oxidation profiles and determination of phreatic surface becomes an important issue for ARD prediction. Many gold mines from all the major gold-mining regions within South Africa are currently engaged in active reclamation of gold tailings dams. This large-scale reclamation of dams, ranging from 10 to 100 years in age, provides a perfect opportunity to study tailings dam profiles and characterise their oxidation profiles.

Motivation
The understanding of oxidation zones and phreatic water surfaces plays a very important role in the prediction of acid rock drainage (ARD). It has been the experience that the uncertainty regarding the depth and progression of the oxidation zones is one of the major drawbacks in geochemical assessment and predictive modelling, and that the establishment of accurate oxidation profiles and the determination of phreatic surface becomes an important issue for ARD prediction. Recent research findings have established the average oxidation zones associated with tailings dams in the Wits Basin. However, the role of mineralogical and geochemical variation with depth on migration of the phreatic surface and therefore oxidation progression with depth has not been quantitatively established.



The location of the TSF studied within the Central Rand gold field.



Acid mine drainage around 4L25 tailings dam.

Progress

Four of the six tasks planned for the project have been completed and documented into two project progress reports. Moreover, an honours dissertation entitled *Oxidation zone development processes associated with tailings dams in the Wits Basin: Emphasis on acid mine drainage* was submitted to the University of Pretoria by Mr S Lekoadu for an honours degree in geology.

Conclusions

Hydraulic characteristic measurements (*in situ* and in the laboratory) requires instruments such as a tension infiltrometer, double ring infiltrometer, instruments such as TDR to measure pore water content *in situ* and an experienced operator and supervising hydrogeologist. The remaining tasks planned (5th & 6th tasks) aimed to study the effect of variation in hydraulic properties (porosity, permeability, water content, preferential flow pathways such as cracks/fractures, megapores, etc.) with depth on oxidation processes and planned for the 2009/10 could not be implemented due to budgetary constraint.

Future activities

Complete project and prepare final report using available literature and previous work data.

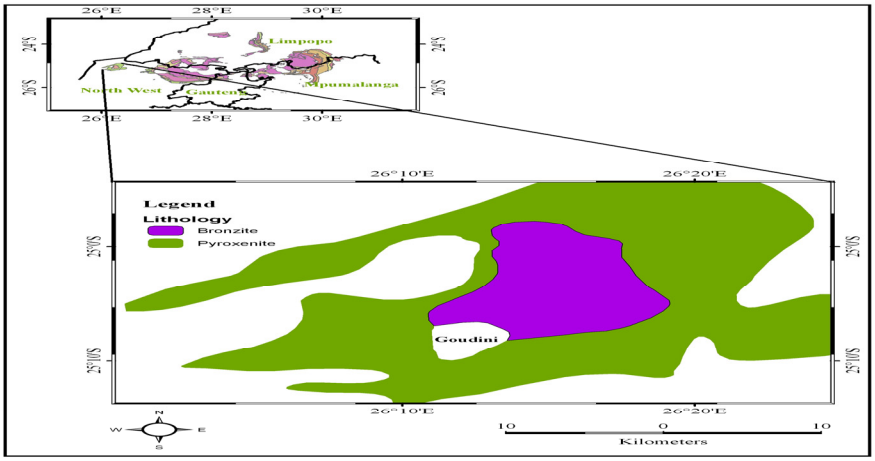
ST-2009-0996 **THE ECONOMIC GEOLOGY AND STRATIGRAPHY OF THE NIETVERDIEND (2526AA) AND SESOBE (2526AB) 1:50 000 MAP SHEETS**

Project leader: B. Yibas, Ph.D. (Geol.)
Project team: K. Prasad, Ph.D., A. Tessema, Ph.D., S. Molefe
Primary objective:
- To assess the mineral potential and stratigraphy of the Nietverdiend (2526AA) and Sesobo (2526AB) 1:50 000 map sheets with the aim of producing accurate geological base maps
- A special focus will include the identification of economic-grade mineralisation zones which may be found in the exposures of the Bushveld Complex or the carbonatites of the Ystervarkkop Complex. This, in turn, will encourage rural development and support poverty eradication

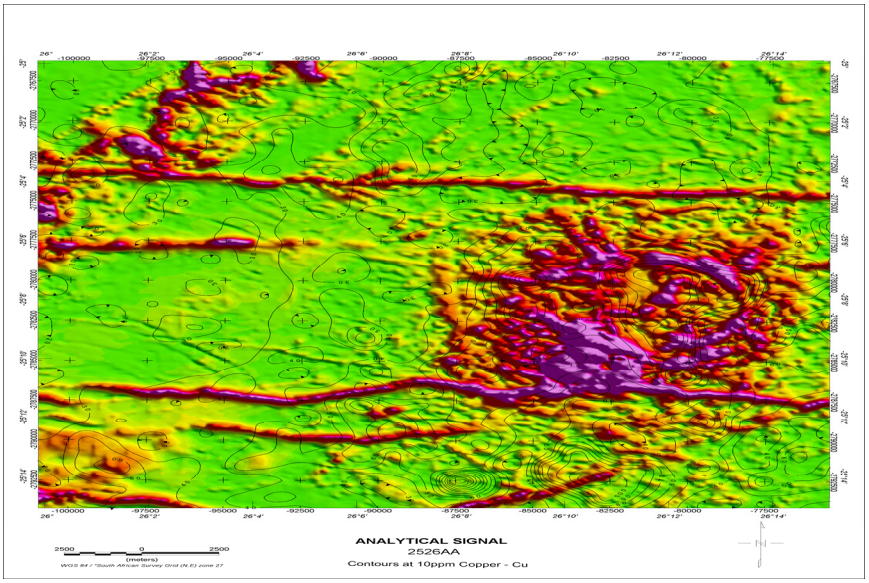
Duration: 2008/9–2010/2011
Budget: Total: R883 772
2009/10: R397 764

Background

At present the Council for Geoscience is carrying out a mapping programme in the North West Province. The focus of this programme has been the Mabaalstad (2526BD) and Mabeskraal (2526BB) 1:50 000-scale sheets northwest of Rustenburg. Even less is known of the region to the west of the above-mentioned study area, which forms the northwestern corner of the Rustenburg 1:250 000 geological sheet. The geological map of this area is based on mapping work done by students from the University of Pretoria more than 30 years ago. As a result the current map is lacking in detail and over the past decade staff members of the organisation became aware of several inaccuracies and unusual geological features found in this area.



Location map of the study area with respect to the geographical position of the Bushveld Complex.



Aeromagnetic map of the Nietverdiend 1:50 000 sheet: the high magnetic elliptical feature is the Goudini Carbonatite Complex.

Motivation
It is the mandate of the Council for Geoscience to produce and upgrade the geological maps of the country. Provincial and national government bodies will be the main beneficiaries, as well as the applied geology units of the organisation, e.g. to increase the understanding of groundwater flow.

Progress
Review of previous work: review of available information resident in old field reports and various remote-sensing data such as satellite imagery, regional geochemistry and geophysical data sets.

Field mapping: the project started with a reconnaissance field study and continued thereafter. A number of field visits have been carried out to map both the Nietverdiend and Sesobe sheets from April to October 2008. The field work was completed with all accessible areas of the sheets covered. Over 90 per cent of the area has been covered with over 544 observation points from which sufficient rock samples, structural data and photographs have been taken.

Geophysics and remote sensing: a CCI (colour composite image) (Band 742) for the area using Landsat TM7, aeromagnetic maps and radiometric maps were produced.

Petrography and geochemistry: over 142 thin sections and 90 samples for XRF and ICP-MS analyses have been submitted. XRD results of nine special samples from the Goudini Carbonatite Complex was obtained.

Preliminary geological description: the geology of the area consists of formations belonging to the Pretoria Group of the Transvaal Supergroup which forms the floor, intruded by the Rustenburg Layered Suite, of the far western limb of the Bushveld Complex (Johnson *et al*., 2006). The metasediments of the Transvaal Group are composed of quartzite, shale and garnet-bearing hornfels.

- Goudini Volcanic Complex: the Goudini Carbonatite Complex consists of a remarkable association of pyroclastic and tectonic breccia, tuff and carbonates (carbonate/dolomite) (carbonatite) rocks of probably volcanic origin in country rocks of the Bushveld Complex which are mainly norite and diabase.
- RSL Suite units
  - Pyroxenites and bronzitite units
  - Harzburgite/dunite mostly altered to birbirites
  - Norite
  - Diabase grading into gabbro and microgabbro
  - Lenses and bands of anorthosite
- Pretoria Group rocks
  - Quartzites
  - Argillaceous beds (mainly shale) and intrabedded diabase?

Conclusions
Currently the project is at the stage of map compilation (geology, remote sensing and geophysics) and draft map and report preparation.

Future activities
Map preparation and writing of report and explanation.

GEOCHEMISTRY

REGIONAL GEOCHEMICAL MAPPING: THE FOLLOWING 1:50 000 TOPOSHEETS WERE SAMPLED: 2430AA THE DOWNS (3OA), 2430AB OFCOLACO (3OB), 2430AD PENGE (3OF), 2431CA ACORNHOEK (3PI), 2431CC BOSBOKRAND (3PM), 2530BB SABIE (3UD), 2531AA KIEPERSOL (3VA), 2530BD NELSPRUIT (3UH) AND 2531AC WITRIVIER (3VA)

Project leader: M. Cloete, Ph.D.
Project team: S.W. Strauss, M.Sc., R. Netshitungulwana, B.Sc. Hons, E. Mulovhedzi, B.Sc. Hons, D. van der Walt, B.Sc. Hons, M. Bensid, B.Sc. Hons, S. Hlatshwayo, B.Sc. Hons, J.H. Elsenbroek, M.Sc. and M. Maya, B.Sc. Hons
Primary objective: To continue with the ongoing Regional Geochemical Mapping Programme as a core function of the Council for Geoscience

Motivation
The Regional Geochemistry Unit of the Council for Geoscience undertook the task of producing regional geochemical maps of South Africa to complement the existing geological information. The aim of the survey is to create a geochemical database. This information is useful to identify exploration targets for a wide range of commodities, to test exploration models and to initiate geological research.

Progress
The sampling was carried out on a sample density of one soil sample per km^2. A total of 6 353 samples were collected by means of helicopter-supported transport. Sample number barcodes were scanned for sample identification and quality assurance. Surface soil samples with an approximate mass of 5 kg were taken. The samples were sieved to extract the -75 micron size fraction, dried and pressed into a powder briquette for analysis.

Future work
The samples will be analysed for approximately 50 elements including SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, Ag, As, Ba, Ce, Co, Cr, Cu, Ga, Hf, Mo, Nb, Nd, Ni, Pb, Rb, S, Sb, Sc, Sn, Sr, Ta, Th, U, V, W, Y, Zn and Zr by simultaneous X-ray fluorescence, ICP-MS and DC-ARC (Pt, Pd and Au)

Geochemical analyses will be evaluated statistically and geochemical maps with a geological and topographic backdrop will be compiled. Anomalous chemical element combinations will be compiled on a synthesis geochemical map. Anomalies will then be verified by follow-up field work. Since project funds were cut during the year, the verification of the four anomalies could not be carried out.

Conclusions
As an ongoing statutory mapping core function, the service will continue to be rendered.

Sampler taking a soil sample during the Geochemical Mapping Programme with helicopter-supported transport.

Geochemical mapping team in the field.

GEOPHYSICS

1. DATA COLLECTION, PROCESSING AND CURATION

ST-2002-0174 **PHYSICAL PROPERTIES DATABASE: CONTINUE WITH THE COLLECTION OF SAMPLES AND THE EXPANSION OF THE WEB-BASED DATABASE. RESEARCH ON SELECTED PROPERTIES TO EXPAND THE DELIVERABLE PRODUCTS**

Project leader:	L.P. Maré, M.Sc.
Project team:	D. Kruger, K.R. Mantsha, L. Loots, B.Sc. Hons, F.M.A. Sekiba, B. Tech. and S. Tucker, Dip. SBM
Primary objective:	Continued collection of samples and the expansion of the ORACLE-based database. Time- and data-permitting selective research on acquired data and/or petrophysical methods to be conducted
Duration:	Ongoing
Budget:	2009/10: R260 218

Motivation
The South African Geophysical Atlas, Volume IV, Physical Properties of South African Rocks, represents a compilation of published and non-confidential physical properties of South African rocks. The aim of the atlas is to provide geoscientists with a quick reference to physical property information, as well as a comprehensive set of source references.

Progress
During 2009/10 petrophysical analyses including bulk density, magnetic susceptibility, intensity of magnetisation, magnetic remanence, electrical resistivity, induced polarisation and seismic velocity were performed on different stratigraphic units in South Africa.

Some of the stratigraphic units that have been covered during this period are the southeastern limb of the Bushveld Complex (BC), Vlakfontein Subsuite, Clarens Formation, Suurberg Group and Beaufort Group.

The ORACLE-based *Physical Properties Atlas of South African Rocks* has been updated and include data from publications, as well as outstanding data from previous years where stratigraphic information was lacking.

No new development has taken place with respect to the geophysics map on the GeoPortal.

Conclusions
The project is on track with its effort to cover as many stratigraphic units as possible.

Progress
During 2010/11 a trial set of soil samples collected from the geochemistry database and stored at the National Core Library will be analysed with regard to both their dry and saturated electrical properties. This will be used to produce a trial soil resistivity map and to test the viability of using these geochemistry samples for this purpose.

The results from magnetic polarity analysis on samples from the southeastern lobe of the BC will be compiled into a B. Tech. dissertation and possible publication (depending on outcome).

Research on the saturation of pores with time and the processes that occur within the pores is underway by making use of the IP electrical technique. This research forms part of an M.Sc. study by O.W. Dingoko entitled *Adaptation of the IP electrical technique to characterise groundwater-bearing layers and DNAPL pollution*. The dependence of the pore-size distribution and anisotropy on the temperature of the samples will be studied and the results will be related to current research. The degree of contamination affecting direct-current measurements will also be studied.

Research on induced polarisation (IP) and membrane constrictivity will be continued.

Once operational, tests on the new dielectric and seismic (s-wave) equipment will be conducted with the aim to expand the Petrophysical Laboratory's services.

The functionality of the Physical Properties database on the GeoPortal will be expanded to enable the production of online search reports.

ST-2002-0679 **UPKEEP AND DEVELOPMENT OF DATABASES**

Project leader: M. Havenga, B.Sc. Hons
Project team: P. Cole, M.Sc., J. Cole, M.Sc., O.W. Dingoko, B.Sc. Hons, R.L. Legotlo, Nat. Dip., R.H. Stettler, Nat. Higher Dip., N.N. Nefale, B.Sc.
Primary objective: To maintain and expand the geophysical databases, including GIS coverages
Duration: Ongoing
Budget: 2009/10: R463 101

Motivation
The vast amount of data of the Geophysics Unit had to be properly stored, backed up and catalogued. Data that are easily accessible result in better work efficiency and productivity.

Progress
The main objective for 2009/10 was to redesign, recreate and populate the entire database and front end. This was necessary as major shortcomings and flaws in the old database were becoming more apparent. The data structure was very rigid and it was difficult to add new type of data to the database. Adding data was a time-consuming task that could only be done by a qualified database administrator. The interface was slow and maintenance was tedious.

The old database server was replaced with a bigger machine equipped to handle large amounts of data. The physical directory structure on the server was simplified and all the data were regrouped to fit into this more flexible structure. A new database was created with fewer tables and only the most important metadata fields. This database was populated with the metadata of the data in the directory system. A new front end was created using the Content Management System (CMS) Joomla. The CMS makes the maintenance of the web-based front end and the database very easy and does not require the skills of a qualified database administrator or web designer.

The old database was stored in its entirety on an external hard drive as a backup. The airborne survey data were also written to DVDs and stored as an additional backup.

Conclusions
The new database is stable and very flexible. All the data have been added to the database and can easily be queried. Different types of data can slot with ease into the filing system.

Future progress
Future work will include rechecking old airborne data sets, fixing and re-processing data, where necessary, and adding the corrected data to the database. New data will be added to the database as it is collected and the interface will be continuously updated to suit the needs of users.

ST-2009-1003 **HIGH-DENSITY MAGNETIC AND RADIOMETRIC FLYING OF SELECTED PARTS OF SOUTH AFRICA (MTEF)**

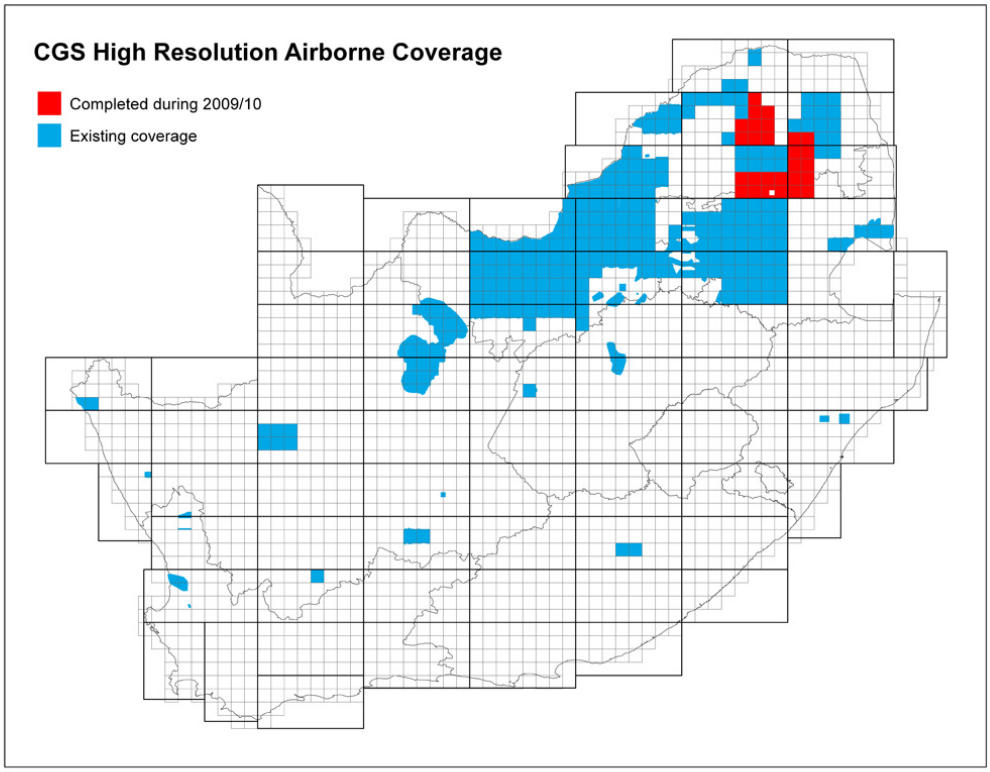
Project leaders: P. Cole, M.Sc., D.G. Eberle, Ph.D.
Project team: Southern Exploration Surveys, P.K. Nyabeze, M.Sc., J. Cole, M.Sc., M. Havenga, B.Sc. Hons, R.L. Legotlo, Nat. Dip., O.W. Dingoko, B.Sc. Hons, A. Graham, Nat. Cert., N.N. Nefale, B.Sc. Hons, F.M.A. Sekiba, Nat. Dip.
Primary objective: Geophysical mapping and identification of exploration target areas
Duration: 2007/8–2009/10
Budget: Total: R25m
2009/10: R10m

Motivation
This project has been part of a greater effort to cover the entire Republic of South Africa with airborne-geophysical high-resolution high-density total magnetic intensity and natural gamma radiation data, producing magnetic, digital terrain model, exposure rate (total count) and potassium, thorium and uranium surface concentration data sets. These data sets will become the national base for further geological mapping, mineral, groundwater and hydrocarbon exploration and environmental and land use projects all over South Africa. The data sets support other projects in the organisation, as well as vital sectors of the earth science industry.

Progress
Project activities follow a two-stage process: The initial stage consists of airborne geophysical data acquisition, processing and compilation; the subsequent ground-based geophysical stage involves screening the flown data for promising exploration targets and following up specific anomalies on the ground with a variety of ground-based techniques which are complementary to the airborne techniques to assess their mineral potential.

Two main areas were flown in the Limpopo and Mpumalanga Provinces; in total twenty seven 1:50 000-scale sheets were covered by the new high-resolution airborne geophysical data. Selection of these map sheets was done by considering previous geological and geochemical indications. The first survey block covers the eastern lobe of the Bushveld Complex and areas adjacent to the east and north that are prone to gold occurrences in the Black Reef Formation, Malmani Subgroup and Archaean greenschists. Ni-Cu-Co-PGE occurrences similar to that known from the Uitkomst Complex is also expected. The second survey block covers the area north of Polokwane which is underlain by Archaean greenschist and granite. Mineral exploration targets were Au, Fe and rare earth elements in this area. The map below depicts the present coverage of South Africa with high-resolution high-density airborne geophysical data. Coverage is still far from being complete as is in neighbouring countries such as Namibia and Botswana.

High-resolution airborne magnetic data acquired in 2008/09 over the Kraaipan Greenschist Belt of the North West Province were scrutinised for future mineral exploration target areas. Ground geophysical follow-up was carried out to examine specific airborne magnetic features presumably related to increased mineral potential. Ground follow-up results, in conjunction with the detailed assessment of the airborne geophysical data, provided the base to produce the Kraaipan mineral exploration target map. Mineral exploration will target minerals such as gold and platinum group elements.



Conclusions
The airborne surveying proved to be successful because it provided high-resolution data over areas that contain scarce geological outcrops. The data will be used in mineral exploration and groundwater-targeting projects, in support of geological mapping projects, as well as for small-scale mining projects. Geophysical ground follow-up is an integral part of the work flow to compile quality-assured mineral exploration target maps.

Future progress
The continuation of the project is currently highly doubtful due to the implications from budget constraints. South Africa, though, with its wealth of mineral commodities, is in urgent need of a countrywide and complete high-resolution airborne geophysical database to attract foreign mining investment. Namibia is a good example where mining investment is currently booming due to an exemplary geological/geophysical database in conjunction with investment-friendly mining legislation. It is recommended to approach international aid agencies for support to continue and accelerate the high-resolution airborne-geophysical data acquisition programme of South Africa. With its aircraft fleet and knowledge the Council for Geoscience provides a sound prerequisite for becoming a grant holder.

2. GEOPHYSICAL INTERPRETATION

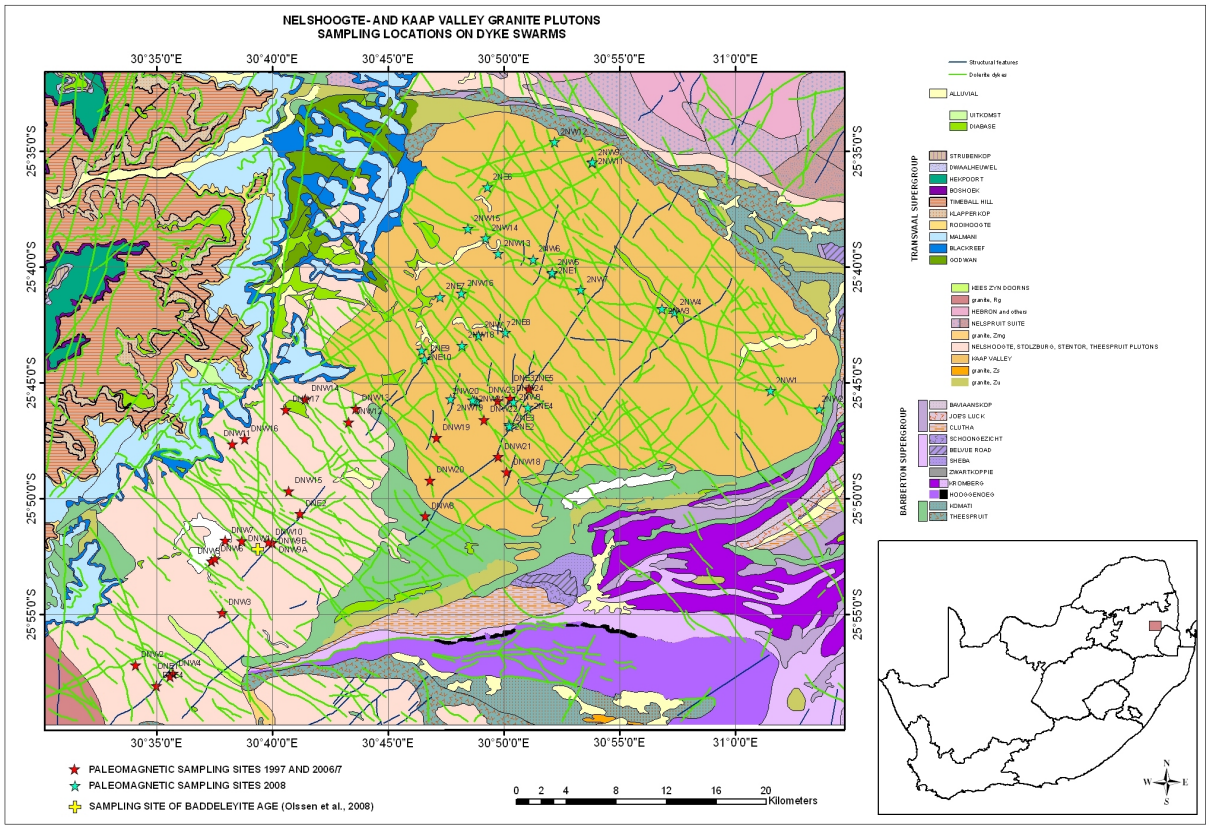
ST-2006-0897 **PALAEOMAGNETIC STUDY ON THE PRECAMBRIAN MAFIC DYKES OF MPUMALANGA**

Project leader: L.P. Maré, M.Sc.
Project team: L.R. Tabane, D. Kruger
Primary objective: Palaeomagnetic pole identification of different dyke swarms in the Badplaas–Barberton area
Duration: 2006/7–2009/10
Budget: Total: R198 881
2009/10: R146 558

Motivation
The aim of this study was to determine the palaeomagnetic pole positions for the different dyke trends in the Mpumalanga Province. The successful calculation of these pole positions might provide essential information regarding the mantle evolution during the Proterozoic and the possible source of the dyke swarm magma.

Progress
Two major dyke trends cut the Kaap Valley and Nelshoogte plutons. The most prominent direction of strike is 317° ± 19° west of north. Another trend is approximately normal to the above with variation from 46° ± 20° east of north.

Havenga and Armstrong produced a $^{207}Pb/^{206}Pb$ age of 2 972±11 Ma for two concordant points of the NW-trending dykes (pers. commun. Havenga, 1996). More recently Olsson *et al*. (2008) reported a U-Pb baddeleyite age of 2 965±0.74 Ma for the NW-trending dykes from the regression of four analyses. The sampling location for this date is indicated on the map below.



Both northwestern and southeastern magma flow directions were identified through AMS analysis, confirming that different intrusion events have re-utilised the same weak fractures of the Archaean continental crust.

Three poorly defined poles were identified and isolated from the NW–SE-trending dyke swarm. These poles correlate respectively with published poles for the *ca* 2 984±2.6 Ma Agatha basalt from the upper Pongola Supergroup, the 2 664–2 709 Ma Allanridge Formation of the Ventersdorp Supergroup, as well as the 2 050±12 Ma Bushveld Complex.

Conclusions
The AMS data were used successfully to identifying different magma flow directions. The palaeomagnetic data were statistically only weakly defined, but suggest at least three different intrusion events.

Future progress
The weak statistical results make the acceptance of a scientific paper into a pier-reviewed journal highly unlikely.

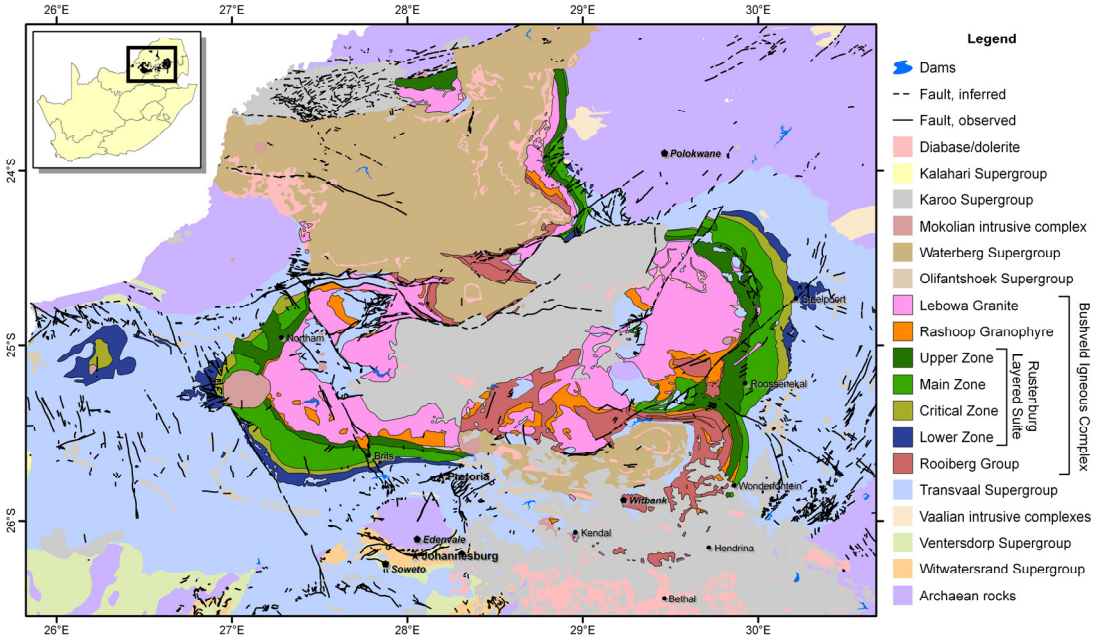
References

Havenga, A.T. (1996). Precambrian mafic dykes of Mpumalanga. Report number 1996-0309, Council for Geoscience, Pretoria (unpublished).

Olsson, J.R., Söderlund, U., Klausen, M.B. and Ernst, R.E. (2008). 2965 Ma and 2685 Ma U-Pb baddeleyite ages for two key dolerite dike swarms in the Kaapvaal Craton (South Africa); Plausible links to major volcanic rift forming events. 33rd International Geological Congress, Oslo, 6–14 August 2008, Sweden.

ST-2007-0937 **DEVELOPING A 3D POTENTIAL FIELD MODEL OF THE BUSHVELD COMPLEX**

Project leader: J. Cole, M.Sc.
Project team: L.P. Maré, M.Sc.
Primary objective: To create a three-dimensional model of the Bushveld Complex by using gravity and magnetic data with the aim of improving the understanding of the geometry of the complex
Duration: 2006/07–2011/12
Budget: Total: R863 858
2009/10: R281 007



Motivation
The Bushveld Complex is generally described as the largest known igneous layered intrusion in the world and is renowned for hosting large percentages of the world's chromite ore, vanadium and PGM reserves. Since its discovery late in the 19th century a vast amount of scientific literature has been published, but despite this volume of work there are still many unanswered questions, not the least of which is the three-dimensional geometry of the complex. Only a few conceptual models of the complex using geophysical data have appeared in the literature over a period of 40 years. Modelling of potential field data can provide valuable information on the subsurface geometry, which is of both academic and economic interest. If, for example, thorough and robust modelling confirms the presence of mafic rocks in the central part of the complex, the total economic resources of the complex will be hugely increased. In addition, possible configurations of the mafic rocks (e.g. flat/doming/sagging) deduced from the modelling process can contribute to the understanding of the emplacement and geological history of the Bushveld Complex.

Progress
Prior to creating a three-dimensional model, it is essential to understand the geophysical signatures of the different lithological units within the complex. It is also necessary to identify markers in the geophysical data sets that can be used during the modelling process. To facilitate this, an area in the eastern lobe of the complex was selected and interpreted in detail. The area was chosen based on the availability of detailed geological mapping and new high-resolution aeromagnetic data. Clear distinctions could be made between the Upper Zone and Main Zone rocks on the magnetic data. A high-amplitude reversely magnetised anomaly associated with a magnetite gabbro within the Main Zone is the most prominent geophysical marker that was identified.

The regional magnetic and gravity data sets were subjected to additional processing and filtering. The data were upward continued to see whether the prominent anomalies associated with the mafic rocks of the Bushveld Complex will still be visible if they were situated at greater depths. Very small anomalies are visible on the data that have been upward continued to 7 km, but the amplitudes of the anomalies are so small that they will be easily obscured by anomalies caused by other lithological units that are closer to the surface. A visibility filter was applied to the data in an attempt to enhance subtle anomalies that may be present in the central part of the complex if the mafic rocks were continuous between the western and eastern lobes. Before the filter could be applied, matched filtering was used to separate out the low frequency components of the gravity and magnetic data sets. This was done because the high-frequency, high-amplitude data associated with shallow bodies would dominate the results. The visibility filter highlighted anomalies that were already visible on the low-frequency data sets prior to the application of this filter, but did not enhance any previously undetected anomalies. The resulting data sets can be used in the interpretation process as it provides good edge detection possibilities.

The relation between magnetic lineaments and the Bushveld Complex was studied to see whether it is possible to use the lineaments to infer whether Bushveld rocks are present in the centre of the complex. However, the presence of the Transvaal Supergroup makes it impossible to contribute the presence/absence of a dyke in the central part of the complex to the presence/absence of the Bushveld Complex.

Conclusions
The work completed during the year resulted in a good understanding of the geophysical signature of the Bushveld Complex and provided a sound basis from which to proceed with the modelling process.

Future progress
During 2010/11 the bulk of the work will consist of analysing geophysical borehole logs and producing a density and magnetic stratigraphy to be used in the modelling. The modelling process itself will also commence.

ST-2009-1021 **REPROCESSING OF OLD AIRBORNE GEOPHYSICAL DATA SETS**

Project leader:	O.W. Dingoko, B.Sc. Hons
Project team:	P. Cole, M.Sc. and L.J. Ledwaba, B.Sc. Hons
Primary objective:	Review and reprocess any old airborne regional data sets that still show systematic levelling errors using the latest processing techniques
Duration:	Ongoing
Budget:	2009/10: R122 815

Motivation
The South African national airborne survey was flown between 1958 and 1997. A final processed version of the data was published in 1997 at a scale of 1:1 000 000. Two versions of the maps were produced. The first version displayed the standard total magnetic field intensity. The second version showed a magnetic fabric and was an enhanced version of the data showing shallow magnetic features. A process was started in 2005/06 to reprocess the data. This was in light of more advanced modern processing techniques that are available to improve the quality of the data. During the financial year 2009/10, the process of reprocessing the data continued and a number of blocks were reviewed for advanced processing.

Progress
During the year some 13 blocks were considered for reprocessing. These are 9/71, 10/71, 11/71, 12/71, 14/73, 15/73, 16/73, 1974, 24/77, 25/78, Karoo 1, Karoo 10 and Karoo 11. Some of the blocks required splitting into smaller manageable subsets to simplify the processing. The first step in processing was to import the data from an archive format into a workable ASCII format. This was done by studying the input archive format and writing a small script to perform the exporting process.

Once the data were in a suitable format they were gridded to identify any irregularities and after these irregularities were identified, tie-line levelling was performed to improve the data quality. Tie-line levelling does not always give the desired result and in such cases it is customary to apply microlevelling to further improve the quality of the data. In some cases, it has been observed that the raw data is of a higher quality than the levelled data. For such blocks, the raw data is

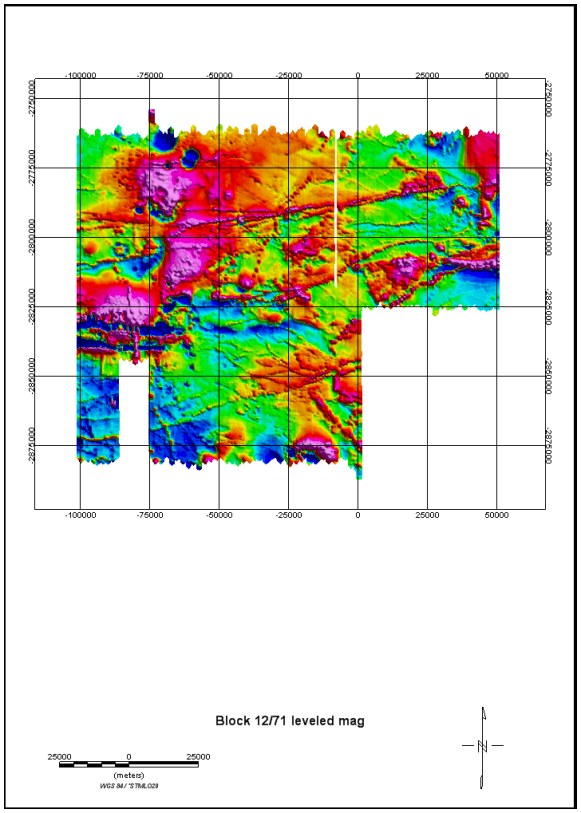
adopted as the final version. Examples of blocks devoid of any levelling errors include Karoo 1, Karoo 10 and Karoo 11. The fiigure below (left) shows the levelled total magnetic intensity map. In this image it can be observed that the tie-line levelling processing did not remove all the artefacts in the data. It was therefore necessary to apply microlevelling to improve the quality of this data set. The microlevelling results are shown in the figure to the right. This map shows that the microlevelling has removed the stripy features that were running north–south across the map.

Conclusions

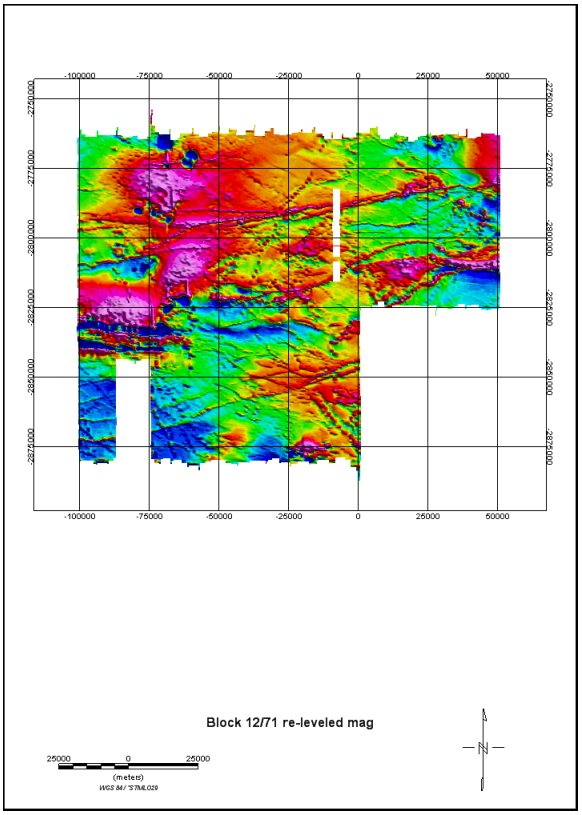
The project is on track with its effort to review and reprocess as many regional data sets as possible. During the 2009/10 year some 13 blocks were reviewed and levelling was applied to blocks that were affected by systematic errors.

Future progress

During 2010/11 a number of regional airborne data blocks will be selected for reviewing and, where necessary, further processing will be performed in order to improve the data quality.



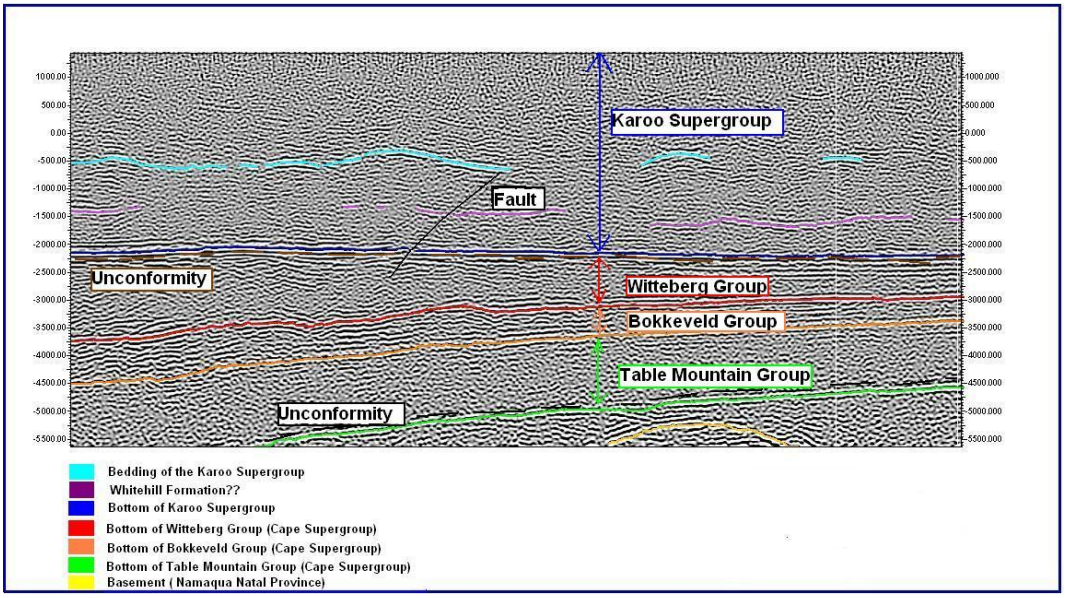
Levelled total magnetic intensity map for block 12/71.



Total magnetic intensity map after microlevelling.

ST-2009-1014 **INVESTIGATION OF THE CRUST IN THE SOUTHERN KAROO USING THE SEISMIC REFLECTION TECHNIQUE**

Project leader: L. Loots, B.Sc. Hons
Primary objective: Structural and stratigraphic interpretation of crustal features in aid of understanding how the geology formed
Duration: Ongoing
Budget: Total: R190 740
2009/10: R190 740



Motivation

The aim of this project is to process and interpret a seismic reflection line, which, until recently, has not been investigated. In 2009 a section of the line was interpreted by Tankard *et al*. (2009). The line is rather unique in the sense that it crosses over the Beattie magnetic anomaly and part of the southern Cape conductive belt. Because there are very limited publications available on the formation of the crust in this area, further interpretation will be of benefit to the earth science community.

The aim of this project is to:

- structurally and stratigraphically interpreted the data in detail
- find a possible source that might explain the occurrence of the Beattie magnetic anomaly
- find a possible depth for the crust-mantle boundary
- correlate data with other lines in similar-aged terrains
- fully interpret the data set.

Progress

During the year the processing of the data was finalised. Preliminary interpretation on paper was completed and areas where in-depth interpretation is necessary was chosen. Full interpretation commenced at the University of the Witwatersrand on the Kingdom Suite software (designed specifically for seismic reflection processing). Full interpretation will be completed and the findings will be correlated with boreholes and other geophysical data that were collected in the surrounding areas.

Conclusions

The project is on track with the effort to complete the interpretation as soon as possible for M.Sc. submission.

Future activities

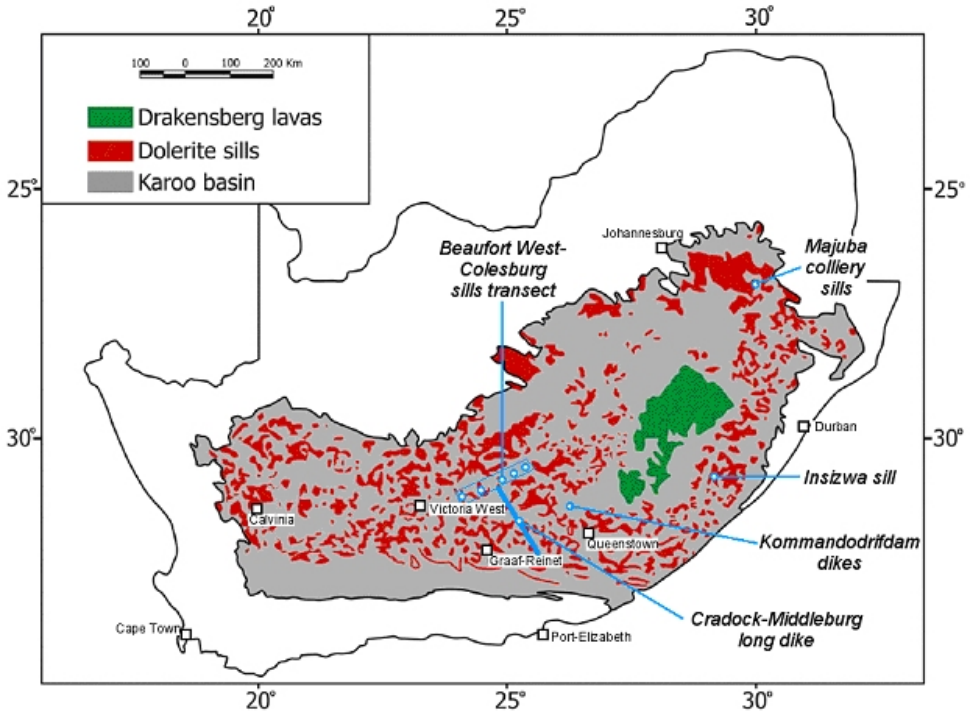
During 2010/11 the detailed interpretation will be completed, correlation with other work will be done and the results will be published.

Reference

Tankard, A., Welsink, H., Aukes, P., Newton, R. and Stettler, E., 2009. Tectonic evolution of the Cape and Karoo basins of South Africa. Marine and Petroleum Geology, doi:10.1016/j.marpetgeo.2009.01.022.

ST-2009-1004 **MAGMA DYNAMICS IN SILL AND DYKE SYSTEMS. CONSTRAINTS FROM MAGNETIC FABRICS AND PALAEOMAGNETISM IN THE KAROO LARGE IGNEOUS PROVINCE**

Project leader:	L.P. Maré, M.Sc.
Project team:	E.C. Ferré, Ph.D., C. Ranaweera, M.Sc. student and M. Marsh, M.Sc. student
Primary objective:	Conduct several magnetic fabric and palaeomagnetic experiments to evaluate the magma dynamics of a large igneous province
Duration:	2008/9–2009/10
Budget:	R270 300



Motivation

This is an NSF-funded international collaboration project. The goal of this project is to conduct several magnetic fabric and palaeomagnetic experiments to evaluate the magma dynamics of a large igneous province. The aim of the CGS involvement with this project is not only to gain valuable experience but also to build important relationships with leading scientists from America.

The determination of magma flow direction is a first order question in many igneous systems. This is particularly true for Large Igneous Provinces (LIPs) such as the Deccan, Ferrar or Karoo flood basalts, in which immense volumes of mafic magma have been transferred from the mantle towards the earth's surface over relatively short periods of time.

The goal of the proposed research is to provide new field- and laboratory-based observations to constrain magma dynamics in sill and dyke systems. A set of six controlled field experiments using magnetic fabrics and palaeomagnetism on selected exposures of rocks within the Karoo Province will test hypotheses related to magma transfer in such complex systems. For each of these experiments flow fabrics will be determined independently by direct field observations and image analysis on oriented thin sections. The proposed research will complement, but not duplicate, research efforts made by other groups using geochemical, petrological or geophysical approaches.

Progress

The second field season took place during November 2009. Samples were collected from one of the lowermost dolerite sills in the Karoo Basin which can be followed all along the edge of the basin. The aim of this part of the study is to try and constrain the source location of the dolerite magma.

As before, several students from Southern Illinois University and the University of New Mexico are involved with the aim of obtaining higher degrees. Several posters and one talk on preliminary results were presented at the 2009 AGU Fall Meeting in San Francisco.

L.P. Maré is studying the metamorphic effect of the emplacement of the Karoo Large Igneous Province (LIP) on the Karoo sediments. One of the main scientific questions related to the thermal history of the Karoo Basin is if the emplacement of large volumes of magma was preceded by a large-scale low-grade thermal doming similar to the one proposed in continental rift settings or, alternatively, if the Karoo thermal event was restricted to the contact aureole of intrusives.

Baked contact tests were conducted around specific intrusives of known sizes and geometries and preliminary data indicate a deflection of the magnetisation direction of the sediments within the contact aureole towards the magnetisation direction prevalent at the time of magma emplacement.

A preliminary peak palaeotemperature of the Karoo sediments within the contact aureole was determined from the variation of the magnetic susceptibility during repeated progressive heating and range from 200–300 °C. This correlates well with previously published fission track data.

Conclusions
Sample collection during the 2009/10 field season was successful and several new student projects were initiated.

Future progress
Although the NSF funding has come to an end, work will continue on the geothermal history of the Karoo Basin by L.P. Maré who has registered her research on the project for a Ph.D. degree.

ST-2010-1075 **THE RELATIONSHIP BETWEEN LINEAMENT DENSITY AND BOREHOLE YIELD IN THE NORTH WEST PROVINCE: RESULTS FROM GEOPHYSICAL STUDIES**

Project leader:	A. Tessema, Ph.D.
Project team:	E. Chirenje, M.Sc., F.M.A. Sekiba, Nat. Dip., R.M.S. Sethobya, B. Tech.
Primary objective:	Investigation of the groundwater resource potential of the area around Mafikeng town in the North West Province
Duration:	2009/10
Budget:	R621 025

Motivation
Water remains the most critical issue for social and economic development in semi-arid parts of South Africa and the North West Province in particular. In the longer dry seasons apart from fewer areas, water for domestic use in the North West Province is essentially supplied from groundwater stored in either carbonate rocks or fractured crystalline basement. In such geological terrain access to groundwater can only be achieved through well planned and integrated exploration techniques that involve geophysical and hydrogeological investigations. In the present study the area around Mafikeng Town in the North West Province was chosen, because it is located in a semi-arid climate where approximately three million people live without an adequate supply of water. The present study is therefore intended to assess the groundwater potential of the area in order to assist rural community development.

Progress
The project was subdivided into three different phases. During phase one (May to July 2009) the main task was the compilation of exiting geophysical and hydrogeological data which led to the selection of four follow-up targets. This was followed by phase two (August to October 2009) during which detailed field geophysical surveys were conducted. The third phase (October 2009 to March 2010) involved geophysical and hydrogeological data integration, interpretation and report write-up.

During the third phase the lineaments extracted from the interpreted geophysical data and Landsat imagery were superimposed on borehole yields. The resulting combined thematic map shows that zones of high borehole yield coincide with dense and cross-cutting lineaments. Six potential targets were identified that fall in two broad zones of NW–SE and NNW–SSE strike. The NW–SE-oriented target coincides with fractured crystalline basement, while the NNW–SSE-striking target corresponds to carbonate rocks that consist of dolomite and limestone of the Malmani Formation. The modelling of time-domain electromagnetic sounding conducted at selected areas indicates the presence of a fresh-water aquifer at a depth ranging from 15 to 35 m.

Conclusion
The groundwater distribution around Mafikeng in the North West Province is a relatively complex process that is controlled by geological variability in the subsurface. In the western and southwestern parts of Mafikeng groundwater is confined to fractured and intergranular aquifers. Potential fresh-water-bearing formations are located at a depth varying from 15 to 35 m.

Future progress
The future plan will be to extend the project to an area around Vryburg where many rural settlements occur under similar conditions without adequate supply of water.

3. NEW TECHNOLOGIES

ST-2008-0939 **DEVELOPING THE THEORY, INSTRUMENTATION AND INTERPRETATION OF THE IP METHOD APPLIED TO SURFACE MEASUREMENTS AND PHYSICAL MODELLING OF ROCK SAMPLES**

Project leader:	V.Y. Hallbauer-Zadorozhnaya, Ph.D.
Project team:	L.P. Maré, M.Sc., O.W. Dingoko, B.Sc. Hons
Primary objective:	Studying the membrane IP effect in order to gain a better understanding of the physical phenomenon and interpretation of surface and laboratory measures data
Duration:	2007/08–2009/10
Budget:	Total: R1 691 052 2009/10: R516 320

Motivation
Information about the physical parameters of investigated rocks is very important. Any mathematical and physical modelling requires a primary model, i.e. a model based on *a priopi* data about structures and reliable data of the physical properties of rocks. Another application of the properties of rock is the estimation of the permeability of rocks and parameters of transportation of water and contaminants. Physical parameters can be obtained by studying samples of excavated rocks. However, laboratory measurements show it is not possible to obtain 'true' resistivity and chargeability; membrane polarisation prevented current flow. Measurements disported by membrane polarisation (and other types of polarisation) show that resistivity and polarisability depend on a few parameters such as applied electrical current, frequency, porosity, salinity of electrolyte and size of pores. The motivation of this project is to study the physical phenomenon of the membrane IP effect, its mathematical consideration, analysis of parameters, the controlled IP effect, developing the algorithms and calculating programs for the interpretation of data obtained by the surface IP method and physical modelling of rocks.

Progress
During the project the theoretical basis of membrane polarisation continued to be developed. Several samples were measured and interpreted. The calibration of the algorithm for calculating membrane polarisation was performed using samples which had been investigated in the Lancaster Environmental Centre (mercury test). Calculating programs for interpretation of the time domain electromagnetic sounding were modified and compiled in the Matlab system. The calculating model consists of a set of polarising S-planes. The programs named as *tdem_cov.m* and *tdem_inloop.m* intend coaxial and loop-in-loop configurations accordingly. These programs were successfully used for the interpretation of the TDEM data collected in the field in commercial projects run by the the Council for Geoscience.

Conclusions
The algorithm for the calculation of membrane polarisation was developed. The following parameters influence the measured electrical signals, namely temperature and conductivity of the fluid that filled the pores. Increasing temperature increases mobility of ions in 2% per grade. The diffusion coefficient is a very important parameter that also depends on the temperature (linearly) and is inverse to the dynamic viscosity of the fluid. The diffusion coefficient also depends on the pore radii. Due to the double electrical layers existing in each pore the conductivity of pore fluid is different. All these phenomena were taken into account in the calculating program *Italian_kisses.m.* The next phenomenon decreasing the electrical current flowing in the sample is the electro-osmosis IP effect. Exchanging these parameters with temperature and DEL was taken into account for the created software.

Measurements in the Petrophysical Laboratory must be analysed further and improved. The measured porosity of samples does not agree with more reliable and accurate methods such as the vacuum method and mercury test. Testing the instrument RIP showed that at the higher applied current there is a linear dependence of the signal obtained when using the metal disks or perspex only. The membrane IP effect does not occur in these materials; the instrument RIP must be recalibrated and technologically improved.

It was shown that the calculated pore size distribution agreed with mercury test data. However, it must be confirmed that the range of pores used for mathematical modelling of the pore's space is quite limited. To improve this situation the higher electrical current must be applied. However, as mentioned above, it is not possible because the instrument RIP does not provide a reliable signal at high-applied currents.

Future progress
Developing the theory, instrumentation and interpretation of the IP method applied to flowing water and contaminants. More samples will be interpreted, measurements of samples in the instrument provided frequency domain source. Include effect of electro-osmosis polarisation into the mathematical description of polarisation effect. Compare data obtained using neutron tomography (NECSA) and mathematical modelling of pore space using CGS RIP instrument and calculating program for interpretation.

ST-2006-0896 **TIME DOMAIN AIRBORNE ELECTROMAGNETIC SYSTEM (TD-AEM)**

Project leader: D.G. Eberle, Ph.D.
Project team: V. Hallbauer-Zadorozhnaya, Ph.D., P. Cole, M.Sc., O.W. Dingoko, B.Sc. Hons
Primary objective: Installation, adaptation and testing of TD-AEM system
Duration: 2005/6–2009/10
Budget: Total: R1 497 926
2009/10: R1 112 114

Motivation
The new time-domain airborne electromagnetic (TD-AEM) system will be applied to geological mapping, mineral exploration, alluvial diamond exploration, groundwater resource management, mapping of underground seawater influx into coastal zones, mapping of mining legacies, such as contamination of soil and groundwater, monitoring of water/soil remediation, cavity detection and many other environment-related projects. Airborne Electromagnetic (AEM) exploration methods are a vast field with advances being made continuously by international researchers. The system is to expand the scope of airborne geophysical methods available from the Council for Geoscience and to increase market opportunities.

Progress
The Geophysics Unit has been in the process of implementing and testing the TD-AEM platform. Aero Services Ltd. has been in charge of designing modifications of the carrier aircraft, as well as the manufacture of ancillary parts required to mount the TD-AEM system aboard the CGS-owned Cessna Caravan 208B aircraft. Modifications of the wingtips for the transmitter loop to get mounted around the nose, wings and tail have been accomplished.

Unfortunately, due to a lack of funding, the project was suspended indefinitely at the end of August 2009.

Conclusions
As funding of the project does not appear secured in the new financial year, progress and completion of the project are highly uncertain. With all the financial, technology and man-power investments already done during past years and with the technically and commercially promising perspective inherent to the AEM system, completion of this project is highly recommended.

Future activities
In the light of absolutely avoiding technical and financial losses, technology development funds have to be identified and made available. If this is possible, the Council for Geoscience will continue with the installation and testing of the very first South African-owned and operated TD-AEM system. Once the Geophysics Unit runs the hardware, it will be mandatory to keep up to date with the latest theoretical advances. Processing and interpretation of the TD-AEM data have to be considered and a methodology for this must be developed, tested and implemented. Continuous improvement of AEM data acquisition, processing and interpretation will be essential to ensure that the best possible data are collected.

ST-2008-0962 **REDEVELOPMENT OF OLD DOS PROGRAMS INTO MODERN WINDOWS SOFTWARE**

Project leader: O.W. Dingoko, B.Sc. Hons
Project team: P. Cole, M.Sc., L.J. Ledwaba, B.Sc. Hons
Primary objective: Continued identification of old DOS programs authored using procedural languages such as FORTRAN and development of graphical user interfaces (GUIs) using object-oriented programming (OOP) languages
Duration: Ongoing
Budget: 2009/10: R178 640

Motivation
Some of the data-processing programs used in the Geophysics Unit were authored using procedural languages of the yesteryear. These programs are not easy to use because more often than not they are executed from the command line or, in exceptional cases, directly from the compiler. In order to make these programs accessible to everyone, it is desirable to have them reprogrammed into user-friendly GUIs. The new versions of the old DOS programs are easy to maintain and modify since they are authored using OOP techniques.

Progress
During 2009/10 a number of programs were developed to cover a wide range of functionalities and some previously developed programs were revised. The work done during the 2009/10 year covered different fields of geophysics. These include gravity, experimental geophysics, as well as earthquake seismology. The software deleveloped below represents highlights of the project.

The GravTool software was developed to rapidly process gravity data collected on the ground using a Scintrex CG5 gravimeter. This program applies different corrections to the raw gravity data including drift, latitude, free air and Bouguer slab corrections. The user has a choice as to which corrections are applied to the data. Apart from reducing the gravity measurements to anomaly formats, the program also allows for importing various spatial data formats including differential GPS and total station. Since these formats are generally Cartesian coordinates there is a need to convert these coordinates into geographic coordinates to allow for gravity corrections to be calculated. This was the reason for adding a coordinate transformation tool into the GravTool software. In cases where there are no height measurements the user can choose to use beacon heights if there are any. This can be achieved using either the single or double beacon configuration. The latest version of GravTool includes support for Google Earth geometry formats. This tool is used to export the gravity stations to Google Earth format which can be utilised in report authoring after the processing.

The RIPPER program was developed to handle electrical data measured with the RIP (resistivity and IP) instrument. This instrument measures voltages as a function of time for a given sample. Traditionally, the data were imported into a spreadsheet program for manipulation and this proved to be time consuming, especially in cases where there were lots of measurements. The program reads in raw data and converts these into voltage data which are plotted as a function of time. The resulting data are then exported into a format that is easily readable by any spreadsheet software.

Conclusions
The project is on track with its effort to identify and reprogram as many DOS programs as possible.

Future progress
During 2010/11 a number of DOS programs will be identified and reprogrammed using OOP techniques to produce user-friendly GUIs. New programs will also be developed wherever there is need to automate any redundant process.

INFORMATION AND COLLECTIONS MANAGEMENT

MUSEUM

Curator: L. Marais-Botes, B.A. Hons
Scientist: E. de Kock, M.Sc.
Graphic designers: A. Raath, Nat. Dip., A. Becker, Nat. Higher Dip.
Project team: S. Mahwayi
Duration: Ongoing

The Geoscience Museum of the Council for Geoscience houses a collection of more than 29 000 gemstone, meteorite, mineral and rock specimens, of which approximately 9 000 specimens are currently on display.

The meteorite and mineral collections, in particular, are amongst the most comprehensive in Africa and are internationally renowned, and a systematic minerals display provides an exciting introduction to minerals and mineralogy.

A new database for the minerals collection was established and editing of this database is progressing well. In the process all specimens are checked and photographs are taken for identification purposes. The database can be displayed on the Internet, showing the photographs and some additional information.

On International Museum Day, 18 May 2009, the Geoscience Museum opened a temporary exhibition of scientific fossil sketches by Pam Prowse. During the last week of June 2009 the museum presented the 2nd holiday programme for primary school learners. The goal of the holiday programme initiative is to teach primary school learners the history of the earth in a fun and entertaining way. Overwhelming positive feedback was received from attendees and parents regarding the holiday programme.

A total of over 53 800 visits were recorded at the museum during the year.

LIBRARY SERVICES

Chief librarian: L. Niebuhr , B.Bibl. B.Inf. Hons
Librarians: E. van Tonder, B.Sc., B.Bibl., L. Breytenbach, B. Tech. (Lib. & Inf. Sci.), S. Makhafola, B. Tech. (Lib. & Inf. Sci.), Z. Nondudule, B.Inf. (Lib. & Inf. Sci.), G. Makhubele, B. Tech. (Lib. & Inf. Sci.)

The functions of the Library and Information Centre (L&IC) of the Council for Geoscience include the collection, maintenance and dissemination of information in various formats to CGS employees and external clients, and the maintenance of the collections of reports, plans, unpublished geological maps and borehole logs.

The main function of the Publication Shop, as a division of the L&IC, is the selling of publications and reports of the organisation, as well as publications of the Geological Society of South Africa. Staff continue to maintain the exchange lists of both the Council for Geoscience and the Geological Society of South Africa. Furthermore, they provide copy services and base materials such as orthophoto maps, topographic maps and aerial photographs.

During the year the L&IC received 4 024 visitors and replied to 6 894 queries. There is an ever-growing demand for literature searches on a wide variety of topics using the various databases at the deposal of the library staff. An ever-increasing demand for maps and copies of maps of African countries in the Map Library collection is evident. During the year 589 requests were successfully handled by the Map Librarian.

The library currently houses approximately 17 000 book titles, and 3 846 journal titles of which 337 are current subscriptions and 908 are received on exchange. The library holds 2 601 journal titles that have been discontinued and has a collection of 15 000 other documents. Membership of Sabinet was continued during the year and the library remains an active member of the interlending scheme. During the year, the library handled 421 requests for interlibrary loans.

The extensive library catalogue, as well as catalogues of unpublished CGS, STK and Goldfields reports, can be accessed via a sophisticated computer-based search facility on the CGS website. Access to full-text electronic journals or e-journals has also been made possible through the library's subscription agent, a facility for the exclusive use of CGS staff.

To expand the library's electronic catalogue and automated loan system, the staff have embarked on an extensive retrospective serials cataloguing project. This applies to items such as the CGS bulletins and memoirs.

The unpublished map and report collections of the Council for Geoscience is an important source of valuable information, accumulated over nearly 100 years of the organisation's existence. This collection is currently being scanned and the growing volume of scanned images and PDF documents (in the case of reports) contributes to the service provided by the L&IC.

ST-2008-0374 BIBLIOGRAPHIC DATABASES

Project manager: R.R.M. Price, B.Sc. Hons
Project team: M.G.J. Janse van Rensburg, B.A.
Primary objective: To maintain the geological literature database
Duration: Ongoing

SAGEOLIT (South African Geological Literature Database) now contains more than 215 000 records, including published and unpublished material. SAGEOLIT increases the amount of information available to Southern African Development Community (SADC) member states by supplying CD-based SADC Bibliographic and Map databases to SADC member countries. SAGEOLIT also includes a registration system for the CGS internal reports, an innovation implemented during the current year. Records in the SACS database are linked to SAGEOLIT records. Searches by farm name are made possible by links from a table of farm information to SAGEOLIT records. A CD-ROM database of holdings of material in the SADC region in the SAGEOLIT system was created for distribution to the geological libraries of the SADC countries.

The Map Library database contains references to more than 48 000 maps, including unpublished maps of the Council for Geoscience. These items are spatially referenced to enable access by Geode/GIS.

ST-2008-0500 NATIONAL CORE LIBRARY

Core library manager: J. Mathebula, Nat. Dip. (Geol.)
Project team: R.R.M. Price, B.Sc. Hons (Database Manager)
Primary objective: To curate the borehole core collection and make it available to researchers
Duration: Ongoing

The National Core Library (NCL) is a repository of borehole core collected from exploration and mining activities of the past few decades. It is a national resource of considerable value to geological research, as it preserves material that has been obtained at great expense, sometimes from kilometres beneath the surface of the earth. The core library has now accessioned borehole core from more than 2 000 boreholes, representing over 600 km of drilling.

Renewed interest in the services offered by the core library was experienced during the reporting year and a total of 12 visitors were received. Towards the end of the year, the interest started to increase, as a result of the rising trend of investment in mining.

The core library is in the process of receiving core drilled in the Laingsburg area during a research project of the University of Liverpool. This core will be stored at the core library, but the cooperation also involves splitting and polishing the core, adding to the expertise of the core library.

PUBLICATIONS

Editors: S.J. van Eck, B.A. (HED), Z. Nel, M.A., J.A. van Heerden, B.A. (Lib.)
Graphic designer: A. Becker, Nat. Higher Dip.
Primary objective: To disseminate information in printed format
Duration: Ongoing

The following publications were released during the year:

Explanation: Sheet 3017 Garies (1:250 000). The geology of the Garies area by C.H. de Beer
Explanation: Sheet 2926BA (1:50 000). The geology of the Sannaspos area by I.G. Haddon, P.J.A. Bosch and D. van Niekerk
South African Committee for Stratigraphy (SACS). Lithostratigraphic Series No. 51. Lithostratigraphy of the T'hammaberg Formation (Bushmanland Group) by M.R. Johnson
Annual Report of the Council for Geoscience 2008/09
Catalogue of Publications of South African Geological Surveys and Government Publications on the Earth Sciences by R.R.M. Price

KWAZULU-NATAL

ST-2009-1017 **THE GEOLOGY OF 1:50 000 SHEET 3030CD MARGATE**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: R. Voordouw, Ph.D., N. Hicks, M.Sc.
Primary objective: This project involved the revision mapping of the 3030CD Margate 1:50 000 sheet. The lithostratigraphic mapping and associated research aimed at assessing the geology relative to the latest stratigraphic framework, compiling more structural detail and investigating possible industrial mineral resources
Duration: 2009–2010
Budget: 2009/10: R574 565

Motivation
The project is part of a long-term commitment to refine and update geological maps in KwaZulu-Natal. The enhanced level of detail is essential for the discovery of industrial minerals or construction materials that can support small-scale mining on the KwaZulu-Natal south coast.

Progress
Detailed field mapping at 1:10 000 scale was completed between May and August 2009. The project was a trial for a digital mapping procedure that uses aerial photo imagery with overlain geological, structural and other data loaded into a Trimble Nomad GPS/PDA. All observations were made directly onto data templates in the PDA and subsequently downloaded into the GPS database for map production. The small scale of mapping in well exposed stream and coastal zone outcrops allowed detailed analysis of lithological contact relationships, as well as structural analysis of the highly tectonised basement lithologies.

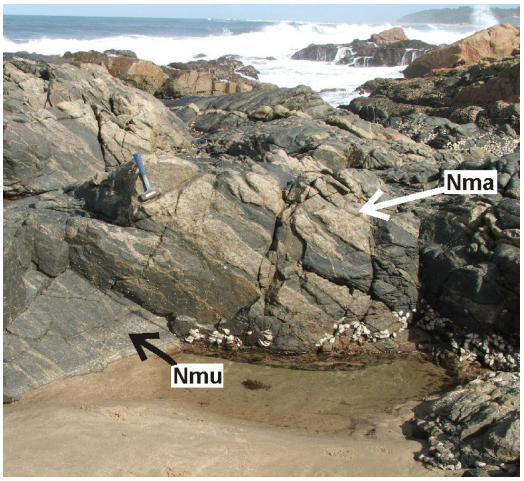
The principal bedrock elements consist of ~1 billion year old Natal Metamorphic Province (NMP) granitoids and sedimentary gneiss that are unconformably overlain by the ~500–180 million year old sedimentary successions of the Natal Group, Msikaba Formation and Karoo Supergroup. The coastal zone is dominated by the weathered dune deposits of the Maputaland Group.

Geochemical analysis of all igneous and sedimentary lithologies were assessed to identify the tectonic and depositional environments. Intensive structural mapping of the basement lithologies identified a ~10 km wide shear zone, named the Vungu Shear Zone, which is structurally similar to other ore-bearing shear zones within the NMP. Detailed sedimentological analysis of outcrops along the non-conformity between the NMP and overlying Msikaba Formation identified Natal Group argillaceous lithologies which have been preserved below the Msikaba Formation in several areas. Geochemical analysis revealed that, unlike the Natal Group to the north, these units were derived from a proximal source terrain. This hypothesis was substantiated by the 1 m thick monomict boulder conglomerate comprising clasts of weathered NMP granitoids, preserved along the contact between the Natal Group and Msikaba Formation.

Conclusions
The principal bedrock elements consist of ~1 billion year old NMP granitoids and sedimentary gneiss that are unconformably overlain by the ~150–500 million year old sedimentary successions of the Natal Group, Msikaba Formation and Dwyka Group. Key aspects of work on the NMP include detailed mapping of a ~10 km wide shear zone, similar examples of which host gold occurrences elsewhere in the Natal Metamorphic Province, and thorough petrographic and geochemical analysis of the granitoids in order to re-evaluate their origin. The mapping discovered several exposures of Natal Group which have never before been reported from the area.

Future progress
The project has been finalised and the research results compiled into a detailed map explanation. The geological map is currently being drafted and is targeted for submission by April 2011. The detailed mapping of the area has lead to three articles being prepared and submitted to peer-reviewed geological journals.

Boulder conglomerate comprising clasts of weathered granite separating maroon-coloured Natal Group siltstone from the trough cross-bedded quartz arenites of the overlying Msikaba Formation. An informal quarry has been cut into a hillside to the south of Margate Airport.



Outcrop photograph that shows typical massive, medium-grained Munster Suite diorite (Nmu) with sheets of Margate Granite Suite (Nma), along the shoreline near Trafalgar.

ST-2010-1082 **LANDSLIDE INVENTORY AND SUSCEPTIBILITY MAPPING OF THE NORTHEASTERN PART OF THE EASTERN CAPE PROVINCE**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: R.G. Singh, M.Sc.
Primary objective: The Council for Geoscience has identified geohazard mapping as one of its core functions. Although geohazards in the form of landslides remain difficult to predict, it is possible through a process of detailed landslide inventory mapping and statistical modelling techniques to identify areas that are at highest potential for slope failure. The main objectives of the landslide mapping project was to produce a comprehensive landslide inventory map and to create a regional susceptibility map covering four 1:250 000-scale map sheets (3028 Kokstad, 3026 Aliwal North, 3128 Mthatha, 3026 Queenstown)
Duration: 2009/2010
Budget: R380 161

Motivation

Geohazards often are sudden geological processes that threaten lives, property and strategic infrastructure. In southern Africa, mass movement can negatively impact urban areas with annual costs of landslide-associated expenses estimated to be about $20 million in 1989. Areas that are potentially unstable should therefore be one of the determining factors in land use management zonation for town planning and municipal spatial development strategies. Landslide deposits represent a significant hazard to strategic infrastructure and limit future development of these areas. Landslide susceptibility mapping can avoid development problems and promote formal housing developments in safer environments.

Progress

During the regional landslide mapping project numerous rockfalls and a range of landslide types were identified, mapped and classified across the mountainous study region. The very large size of some palaeolandslides mapped is a revelation in the context of eastern South Africa where few large landslides have been reported in modern times. Some of these very large geomorphic features such as Mqokweni landslide appear to have temporarily blocked large river valleys. A GIS spatial analysis of the landslides and a range of causal factors produced a regional landslide susceptibility map that differentiates the region into zones with varying degrees of slope instability and potential for landslides that could be triggered by heavy rainfall or seismic events.

Preliminary aerial-photograph interpretation was initiated in the mountainous Hogsback region, extending along the Great Escarpment through the Karoo.

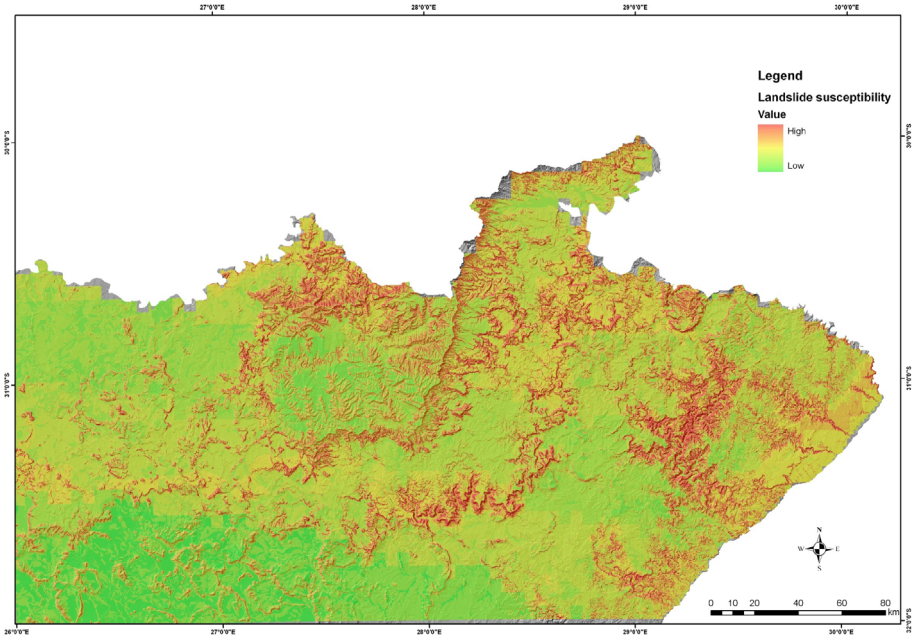
None of the landslides identified were visited for verification of data-gathering purposes due to the moratorium on expenditure.

Conclusions

The modified landslide classification system and susceptibility modelling technique, based on international best practice, was successfully applied in this project. The landslide susceptibility map of the northern part of the Eastern Cape will be marketed as a decision-making tool regarding regional urban expansions.

Future progress

The project has been completed and the research results compiled into a CGS report. After field verification of the landslides the map will be finalised and published.



The landslide susceptibility map of the northeastern region of the Eastern Cape.

LABORATORY

ONGOING LABORATORY ANALYSES AND SERVICES

ONGOING LABORATORY ANALYSES AND SERVICES: CERAMICS LABORATORY

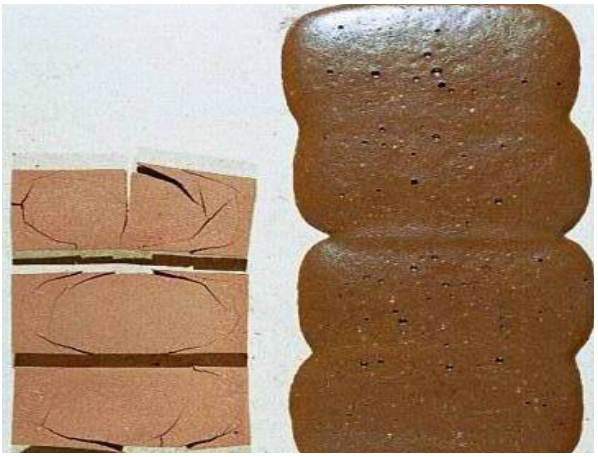
Project leader:	M. Atanasova, M.Sc.
Project team:	J. Friedland, B.Sc. Hons (Applied Mineral.), A.D. Mabela, Nat. Dip. (Ceramic Tech.), K.S. Khumalo, P.B. Mchunu
Primary objective:	Assistance to the ceramic industry in (i) the identification of suitable raw materials, (ii) optimising the use of raw materials by means of mix development, (iii) solving technical, ceramic or production problems and (iv) optimising process control. Small-scale entrepreneurs are also assisted in setting up factories for ceramic products
Year of reporting:	Ongoing

Motivation

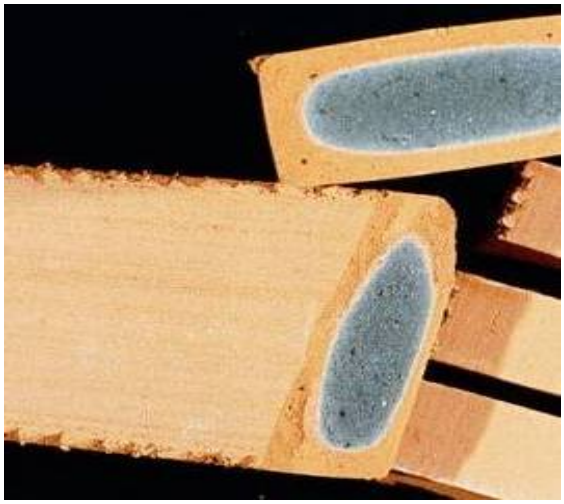
The CGS Ceramics Laboratory focuses on investigations involving clay, which, although not a very precious material, occurs abundantly and plays a vital role in the economy. Main activities include:

- evaluation of clays to determine suitability for possible uses
- site investigations of clay deposits
- mix development
- process control for existing manufacturers (e.g. tile and brick plants).

Analytical procedures such as dilatometry, full physical evaluations and flexural strength determinations are used in the described activities. Analytical services offered by other sections of the Laboratory Unit to determine mineralogical and chemical analyses are also used in the evaluation of the raw material.



Identification of problems in ceramic products – cracking and melting of mixtures.



Identification of problems in ceramic products – black core in clays.

Progress

Turnover for ceramic services during the 2009/10 financial year amounted to R414 795 of which R240 470 was generated by commercial activities and R174 325 by statutory work. Approximately 580 samples were submitted for XRD analysis contributing about R232 000 to the turnover of the XRD section, while 320 samples were submitted for XRF analysis contributing about R60 800 to the turnover of the XRF section.

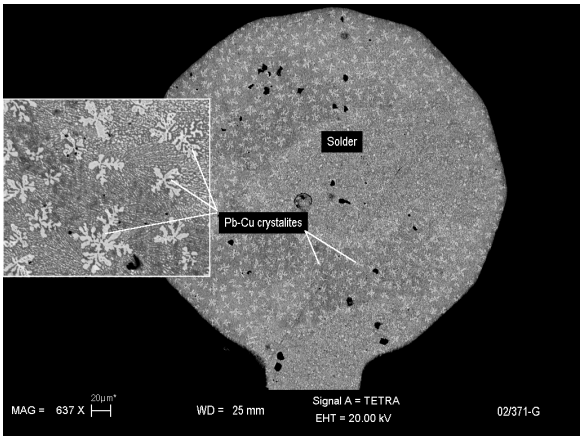
The key focus area was the brick and tile industry. Process control was performed for various companies by providing chemical, as well as mineralogical analyses on raw materials and mixes on a regular basis. Results were plotted and graphically represented to point out drifts or possible deviations from desired compositions. Occasional advice was given for small production problems experienced in the production plant.

Future activities
Maintaining high-quality service to the ceramics industry is a priority of the Ceramics Laboratory. As requests for dilatometry are still exceeding capacity, the purchase of a second dilatometer is strongly considered. Obtaining an autoclave designed specifically for the ceramics industry is also considered due to numerous requests for this service by various commercial clients.

ONGOING LABORATORY ANALYSES AND SERVICES: SCANNING ELECTRON MICROSCOPY (SEM)

Project leader: M. Atanasova, M.Sc.
Primary objective: To provide SEM/EDS services to the Council for Geoscience and industries
Year of reporting: Ongoing

Motivation
The SEM is utilised for imaging and X-ray analysis of rocks, minerals and industrial materials. It offers users the opportunity to do semiquantitative chemical analysis of microscopic particles. Researchers of the organisation and the academic and geological community at large are the main users of this facility. SEM is widely utilised in applied mineralogy investigations and increasingly more in environmental studies, especially for characterisation of microscopic particulate matter. In conjunction with other analytical techniques, SEM is a strong tool for solving various industrial application and scientific problems, as well as to enhance the quality of scientific observations.



Electron backscatter image of solder sample from an electronic circuit board with a zoomed insert, showing the dendritic crystallites (whitish grey) of Pb-Cu composition.

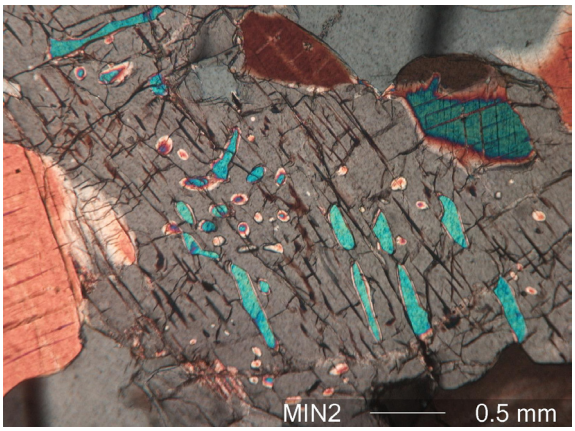
The CGS's Leica 440 Stereoscan scanning electron microscope (SEM) equipped with Oxford INCA energy dispersive system (EDS).

Progress
The total value of work for the 2009/10 financial year is estimated at R93 410 from which R38 860 is commercial income and R54 550 the value of statutory work provided for CGS projects. These include:
1) mineral identification and analysis for the secondary minerals of the Bushveld Complex project
2) investigation of dusts and residue samples as part of an environmental study on Pb contamination in urban areas
3) study of domestic dusts and soil samples from Witbank
4) mineralogical investigations for various small statutory projects of the CGS.

Future activities
Although the cut of funding for statutory work has negatively affected the utilisation of the SEM during the 2009/10 financial year, the high level of standards will be maintained in the next financial year. The Council for Geoscience should encourage its scientists to include SEM analysis to support other tests in extensive investigations and projects of commercial nature.

ONGOING LABORATORY ANALYSES AND SERVICES: PETROGRAPHIC AND THIN-SECTIONING SERVICES

Project leader: F. Roelofse, B.Sc. Hons (Geol.), B.Sc. Hons (Metal.), B. Tech. (Quality), Pr.Sci.Nat.
Project team: N. Nxokwana, B.Sc. Hons, S.D. Kgaditse, S.A. Dikgomo, T.S. Monyayi
Primary objective: To ensure that scientific staff have easy access to thin-sectioning services and related petrographic services for research purposes
Duration: Ongoing



Photomicrograph showing inverted pigeonite containing thick exsolution blebs of clinopyroxene.

Motivation
The microscopic study of rocks and minerals, either optically or with more advanced techniques such as electron microscopy, is one of the fundamental investigative procedures in geology and the petrographic study of rocks is frequently one of the first analytical methods employed in geological investigations. The availability of high-quality petrographic preparations (e.g. thin sections, polished stubs, etc.) is considered one of the fundamental components in the value chain of geological research.

Progress
During the 2009/10 financial year, the section delivered 1 195 products with a total commercial value of R135 291. This amount excludes work performed for external (i.e. commercial) clients. Scientific personnel of the section also contributed to other research projects within the organisation.

Conclusion
As an ongoing project, the service will continue to be rendered.

ONGOING LABORATORY ANALYSES AND SERVICES: XRF ANALYSES

Project leader: H.C.C. Cloete, B.Sc. Hons
Project team: D. Long, M.Sc., M.K.E. Ramela, Nat. Dip., K.I.G. Burger, M.E. Tsaagane, M.J. Matji
Primary objective: To provide chemical analyses by X-ray fluorescence spectrometry
Duration: Ongoing

Motivation
X-ray fluorescence spectrometry (XRF) is the emission of characteristic 'secondary' (or fluorescent) X-rays from a material that has been excited by bombarding it with high-energy X-rays. At the Council for Geoscience it is used for chemical characterisation of rocks, soils, ceramics and building materials and for research in geochemistry.

Progress
Two X-ray fluorescence (XRF) spectrometers are used for the analysis of a wide range of samples:

(a) PANalytical Axios, a wavelength sequential XRF spectrometer equipped with a 4 kW Rh-tube. It is mainly used for the analysis of major elements on fusion disks and trace elements on pressed powder wax pellets. Some 7 356 samples were analysed for major and/or trace elements during the financial year.

(b) PANalytical MagiX Fast, a wavelength simultaneous XRF spectrometer equipped with a 4 kW Rh-tube. The samples from helicopter-assisted stream sediment sampling projects, as well as the Lesotho project are analysed by the MagiX on pressed powder wax pellets. Some 8 635 samples were analysed during the financial year.

The main clients of the XRF section are in the quality control sector, where the chemical composition of raw material is determined before use in the manufacturing process, and governments such as the Government of Lesotho for whom about 2 500 samples were analysed for the production of geochemical maps. Services were also provided to universities. The total value of work performed by the XRF section during the 2009/10 financial year amounted to about R2.1 million.

Members of the Ministry of Natural Resources, Lesotho with Mrs C Cloete in front of the PANalytical MagiX Fast.

The implementation of ISO 17025 involves the description of the various test methods by XRF and implementation of quality control measures to validate the produced results. The methods have been written up while the quality control measures are being developed. The control measures depend on the availability of allocated funds and involve acquiring suitable reference materials such as a muffle furnace, temperature controls on the various ovens and temperature readers in the sample preparation and XRF rooms.

Future activities

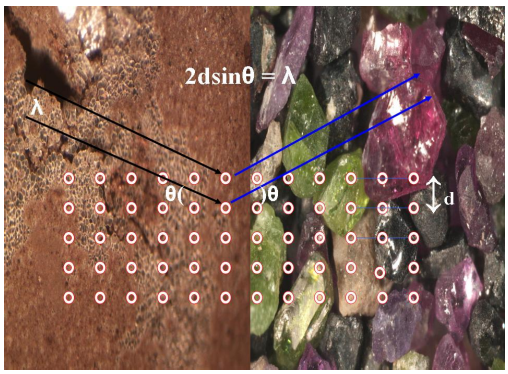
The finalisation of the ISO certification of the Laboratory Unit is one of the main priorities for the 2010/11 financial year while maintaining the high quality of service to the organisation, industry and academia.

ONGOING LABORATORY ANALYSES AND SERVICES: XRD SERVICES

Project leader: M. Atanasova, M.Sc.
Project team: I. Molebale, B.Sc. Hons, N. Dlamini, B.Sc. Hons, K. Mashishi, B.Sc.
Primary objective: To provide mineralogical analysis to the Council for Geoscience and general public
Duration: Ongoing

Motivation

Mineral identification and material characterisation are required for a broad range of applications, programmes and projects in which the Council for Geoscience is currently involved. Mineralogical evaluation is an essential service for the description and compilation of geological maps, mineral exploration, identification of environmental hazards, risk assessment and economic evaluation of mineral resources.



Bragg's Law which is used to identify the minerals.

Progress
The X-Ray diffraction facility at the laboratory of the Council for Geoscience offers researchers of the organisation, industry, academics, the geological community and the public quick, accurate analysis at competitive prices. It provides mineralogical evaluation and analytical results on the whole spectrum of geological material, as well as synthetic and man-made products. Routine phase analyses are performed on whole-rock powder and oriented clay preparations in reflection mode, while minute quantities of material are analysed in transmission mode using glass capillary. Typical applications include qualitative phase identification and quantitative evaluation of XRD traces. Geological and geotechnical interpretation of mineralogical data is provided to assist clients in the evaluation of data.

The total value of work is estimated to R1 506 486 from which R782 666 is commercial income and R723 820 the value of statutory work provided for the CGS projects. Statutory work provided for the organisation includes:
- Industrial Minerals Map of South Africa
- Developing of leaching processes of alkaline wastes
- Interaction between geological and aquatic environs
- Mineral carbonation
- Various method development projects of the analytical sections of the Laboratory.

Major projects and outside clients include:
- Industrial minerals sector - brickmaking and ceramics application
- Construction and road building
- Environmental sector – analyses of dusts, asbestos, water purification systems, etc.
- Mineral exploration
- Existing small mines.

Future activities
Prepare for ISO accreditation during the 2010/11 financial year. Carry on with in-house method development experiments and procedures to expand analytical applications and services to attract new market sectors. In adopting the latest developments in X-ray diffraction technology, instrumentation and software and mastering the vast range of additional applications they offer, new knowledge and skills will be acquired and developed.

ONGOING LABORATORY ANALYSES AND SERVICES: ICPMS AND WET CHEMISTRY

Project leader:	L.J. Jordaan, M.Sc.
Project team:	H. Maritz, B.Sc. Hons, A.N. Shabalala, B.Sc. Hons, M.T. Lehaha, B. Tech., L.M. Mokete, B. Tech., L.L. Sathekge, Nat. Dip., R.H. Sello, R.M. Papo, M. Vuma
Primary objective:	To provide competitive analytical services to the organisation and clients
Year of reporting:	Ongoing

Motivation
The Council for Geoscience requires chemical analyses of rocks, soils and water to interpret local and international resources, to verify geological mapping, to identify exploration targets and to quantify environmental hazards. This specialised service is also available to commercial clients.

Progress
The Analytical Chemistry Laboratory analysed 11 269 samples during the reporting period at a total income of R2 425 300. Twenty three per cent of this work was performed for commercial clients. Some 242 jobs were completed at an average income of R10 022 per job. An average of 47 samples were analysed per job. The average income per sample was R215.22.

Conclusion
It is essential that the Analytical Chemistry Laboratory caters for the needs of all its clients both within and outside of the organisation. This implies a stable and dedicated staff component, serviceable modern instruments and participation in commercial and research projects.

Future activities
The Analytical Chemistry Laboratory is presently preparing for SANAS 17025 accreditation which implies documentation of all procedures, as well as implementation of more ridged analytical and sample-handling protocols.

ONGOING LABORATORY ANALYSES AND SERVICES: SAMPLE PREPARATION SERVICES

Project leaders: H.C.C. Cloete, B.Sc. Hons and T.S. Motsiri, B.Sc. Hons
Project team: T.C. Khazamula, M.M. Mahlangu, T.J. Mbonane, S.M. Mgamlana, M.K. Mokoatedi, I.M. Phahlane, J.S. Radebe, M.M. Ramoshaba, L.L. Semelane, S.P. Zondi
Primary objective: To provide sample preparation services to the Laboratory Unit
Year of reporting: Ongoing

Motivation
Before any chemical and/or mineralogical characterisation of a material such as soil, ore, rocks and minerals, the sample is to be prepared in order for analytical methods to be applied. It is usually in the form of milled and homogeneous powder with a sample particle size less than 75 micron and is obtained either after crushing and milling of the sample or after sieving of the sample. Sample preparation services include the checking of sample lists, sorting, drying, sieving, crushing, milling, transporting, storing of samples and pressing of powder pellets for analysis by X-ray fluorescence spectrometry.

Progress
The relocation of the crusher and milling equipment from the damaged portion in the D-building to the palaeontology store area has been completed. An internet point in the reception area has been installed.

The entrance to the sample preparation area and the dust extraction system.

A total of 24 087 sample preparation services were provided with the total value of work to be R432 855, of which 40 per cent was for commercial clients and 60 per cent for the organisation.

Future activities
As the ISO certification of the Laboratory Unit is one of the main priorities for the 2010/11 financial year, quality control measures are to be developed while rendering services to the organisation, industry and academia.

ONGOING LABORATORY ANALYSES AND SERVICES: PARTICLE-SIZING SERVICES

Project leader: F.J. Doucet, Ph.D. (Chem. Eng)
Primary objective: To develop and optimise promising technological leaching approaches for the selective extraction of calcium from steel furnace slags under near-neutral and/or alkaline conditions for subsequent carbonation
Duration: 2009/10–2012/13
Primary objective: To ensure that scientific staff have easy access to particle size analysis services for research and quality control purposes

Motivation
The correct particle size distribution of crushed and milled rock/soil samples is critical to the meaningful quantification of results offered by XRD, XRF and other techniques. Particle sizing is therefore an essential quality control instrument for the validation of a number of services offered by the organisation, including crushing/milling, XRD, XRF, etc.

Conclusion
As an ongoing project, the service will continue to be rendered.

RESEARCH

ST-2007-0955 **THE CHEMICAL INTERACTIONS BETWEEN THE GEOLOGICAL ENVIRONMENT AND THE BIOLOGICAL COMPONENTS WITHIN LARGE DRAINAGE BASINS**

Project leader: L.J. Jordaan, M.Sc.
Project team: V. Wepener, Ph.D., M.C. Rademeyer, B.Sc., M.T.G. Anatasova, M.Sc., L.P.D. de Wet, Ph.D., D. Booyse, B. Venter, M. Cloete, Ph.D.
Primary objective: To chemically fingerprint sediments, water and fish within large drainage basins and to trace the path of chemical elements during weathering for the evaluation of environmental risk and the establishment of a forensic capability
Duration: 2007/8–2010/11

Field work at Sterkfontein Dam was extended to the deepest part of the dam where sediment samples were taken in approximately 85 m water depth.

Motivation
The Council for Geoscience has an extensive database on soil chemistry of South Africa that was collected during the National Geochemical Mapping programme. These data provide a phenomenal opportunity to chemically characterise large drainage basins and to evaluate sediments that wash down into rivers and dams and eventually influence the health of animals that depend on these dams. Natural weathering products may be distinguished from anthropogenic pollution and traced back to the source while the aquatic health of a drainage basin can be correlated with specific pollution sources or natural weathering upstream. The data further provide a forensic capability where a chemical fingerprint has been established for specific dams within drainage basins to trace illegal fishing activities.

Progress
In spite of the cancellation of the statutory programme the project showed satisfactory progress. All water, tissue and sediment sampling have been completed to a satisfactory level. Analyses of all these samples have also been completed to a satisfactory level. The collation and verification of the data that have been collected over the past three years, including data from the regional geochemical mapping programme, have progressed satisfactorily.

The major setbacks in the previous reporting period related to building maintenance have largely been overcome by laboratory staff themselves. The financial cutbacks at the organisation have eliminated the possibility of repeating any analyses that may have been subject to high blank levels. The only challenges still to overcome are the completion of Sr-isotope analyses that will now be funded by the University of Johannesburg and some outstanding X-ray diffraction analyses.

Future activities
Only data interpretation and report writing remains to be completed. The first task is to publish a report on the interpretation and forensic application of strontium isotope analyses that have been performed on water and fish bone samples.

ST-2007-0952 **XRF ANALYSIS OF PEATS AND SEDIMENTS OF LAKE ST LUCIA**

Project leader: H.C.C. Cloete, B.Sc. Hons.
Project team: P.-L. Grundling, M.Sc. (Peatlands for Wetlands Forever), M. Cloete, Ph.D.
Primary objective: To establish a standard analytical method of peat by X-ray fluorescence spectrometry at the Council for Geoscience and to determine the chemical composition of peat and sediments of St Lucia
Project duration: 2007/08–2010/11

Motivation
Peat is an accumulation of partially decayed vegetation matter and forms in wetlands or peat lands that are uninterrupted records of past environmental and climatic conditions. Standard XRF methods for analysing peat samples do not exist and therefore the normal geological XRF methods had to be adapted for the peat samples. This adaptation is not ideal due to the presence of very high (>90%) organic content. The standard preparation method for major elements on fusion disks requires the samples to be ashed at 1 000 °C. At this temperature peat bursts into flames and in this process some of the elements are lost due to vaporisation, which also leads to contamination of adjacent samples in the oven. Furthermore, due to the light mass of the peat, relatively large volumes of peat sample are required to fill the aluminium backings used for the pressed powder pellets necessary for trace element analysis.

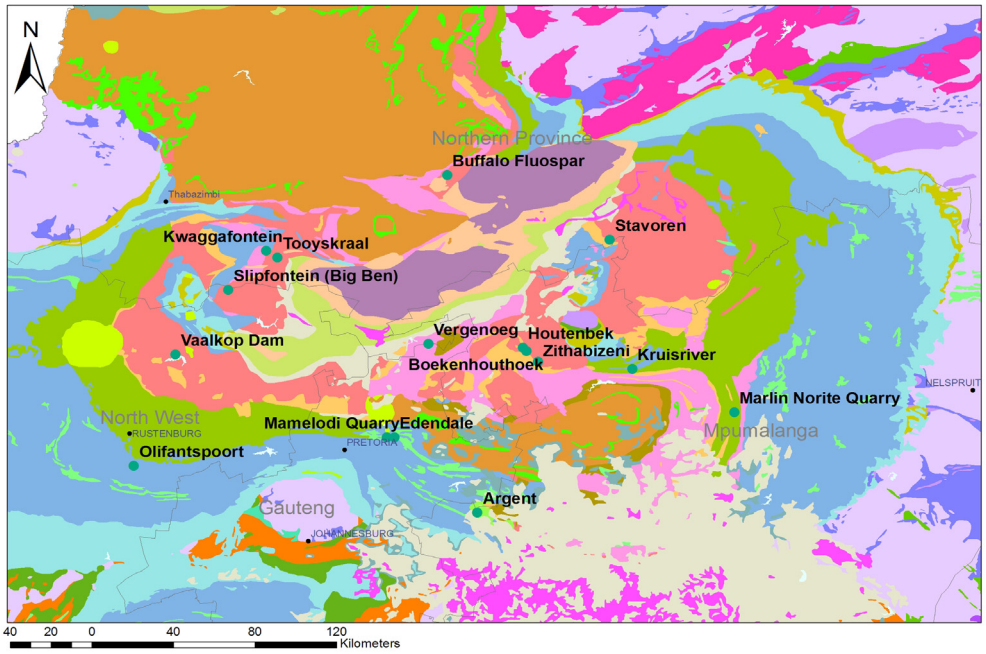
Progress
Different combinations of the oxygen flow rate and the electrical source (Watt) for the plasma were investigated for the optimal ashing of the peat samples. If the oxygen flow rate is too high, the ash tends to flow from the sample container to stick to the sample chamber, while a too high electrical source for the plasma could lead to the sample container being heated to unacceptable temperatures. Experiments and analytical work were suspended during the third quarter of the financial year and should resume during the 2010/11 financial year.

Future activities
Interpretation of the existing data and preparation of final report.

ST-2009-1038 **SECONDARY MINERALS OF THE BUSHVELD COMPLEX, SOUTH AFRICA**

Project leader: M. Atanasova, M.Sc.
Project team: B. Cairncross, Ph.D. (University of Johannesburg), Mr Windisch, retiree
Primary objective: To document and publish the occurrence of secondary mineralisation that appear as microminerals from selected localities in the Bushveld Complex
Project duration: 2008–2010

Motivation
The Bushveld Complex (BC) of South Africa is famous as the largest layered complex in the world and for its vast reserves of platinum, chromium and other economic deposits. Apart from these elements, the BC has also been a source of secondary mineralisation. A few of these occurrences have been published in the past, but most remain relatively unknown to the professional mineralogists and geologists and others interested in South Africa's rich geological and mineralogical heritage. The work will add to the database of knowledge on the mineralogy and genesis of the BC. The publication will complement existing literature on the BC and will be a useful reference to professional geologists and mineralogists. It will also appeal to the general public, inspire wider appreciation of our country's mineral heritage and promote the responsible collection of minerals.



Simplified geological map of the Bushveld Complex showing the site localities of this study.

Azurite with malachite from Vergenoeg, Bushveld Complex, South Africa (FOV3.10 mm).

Progress

During the financial year work continued with the identification of mineral specimens and species, site field visits, specimen collection and literature studies. In spite of the cancellation of the CGS statutory programme, the project has progressed as anticipated with some excellent findings. Field work proceeded as initially planned and is now funded by the University of Johannesburg. The progress report includes an introduction to the project, geological overview of the Bushveld Complex and brief notes on secondary mineralisation, microminerals, micromounting and the collection of minerals. Selected localities with secondary mineralisation, i.e. five of the seventeen site localities, are presented at this stage, namely Kruisrivier, Kwaggafontein, Marlin Norite Quarry, Tooyskraal and Vaalkop Dam. These are introduced by notes on the location, history of discovery and exploration and basic overview of the geology of the area, followed by a chapter on the site mineralogy, with mineral descriptions illustrated with color and SEM photographs.

Future activities

Continue with the identification of mineral species, field visits, literature surveys and site descriptions for the rest of the localities around the Bushveld Complex. It is, however, unclear at this stage if funds will be available for the publication of the manuscript at the end of the project next year.

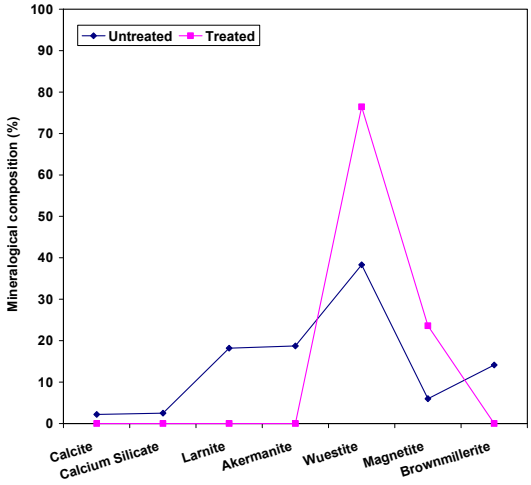
ST-2010-1084 **DEVELOPMENT AND OPTIMISATION OF STEEL SLAG REPROCESSING TECHNOLOGIES WITH IMPLICATIONS FOR THE STEEL AND CEMENT MANUFACTURING SECTORS AND FOR LONG-TERM CO_2 SEQUESTRATION**

Project leader: F.J. Doucet, Ph.D. (Chem. Eng)
Primary objective: To identify suitable industrial alkaline wastes for long-term CO_2 sequestration and to subsequently develop and test small-scale industrial dissolution and carbonation processes for the most promising wastes
Duration: 2009/10–2012/13

Motivation
The steel industry in South Africa generates over 1.1 million tonnes of steel furnace slag per annum, which is for the most part discarded into slag dumps. These slags contain significant amounts of valuable iron (16–30% FeO), which is the basic component of steel. Every year a staggering 240 000 tonnes of elemental Fe from iron ore are lost as steel furnace slags at landfill sites. The conservation and optimal use of natural resources such as iron ore are of primary importance for long-term sustainability, but currently there exists no economically viable process for the recovery of this iron. The Industrial Mineralogy Laboratory of the Council for Geoscience has conceptualised an integrated mineral carbonation process for the recovery of iron and the sequestration of CO_2.

Progress
The aforementioned integrated process is now able to generate iron concentrates of up to 100 per cent Fe minerals as demonstrated by XRD and to extract over 90 per cent calcium from steel-making slags. However, a number of difficulties must be overcome before the process can be tested at pilot scale and the process needs to be optimised for Fe-rich slags with varying physicochemical properties which originate from different industrial processes and from different plants.

Future activities
Optimisation of the current process is required, including the removal of identified impurities and testing of the physicochemical properties of the Fe concentrate. The lack of funding is, however, delaying the progress of this project and additional funding is sought.



Mineralogical composition of steel furnace slag before and after treatment. The treatment undergone by the slag gives rise to an iron concentration which contains approximately 80% wustite (FeO) and 20% magnetite (Fe_3O_4).

ST-2008-0987 **CARBON DIOXIDE SEQUESTRATION BY INDUSTRIAL MINERAL CARBONATION: EVALUATION OF INDUSTRIAL ALKALINE WASTES AND THEIR LEACHATES**

Project leader: F.J. Doucet, Ph.D. (Chem. Eng)
Primary objective: To identify suitable industrial alkaline wastes for long-term CO_2 sequestration, and to subsequently develop and test small-scale industrial dissolution and carbonation processes for the most promising wastes
Duration: 2007/8–2010/11

Motivation
The total CO_2 emissions in South Africa currently amount to over 440 million tonnes per annum. A combination of several climate change mitigation measures is required to effectively reduce atmospheric emissions of CO_2 from human activities. CO_2 sequestration by mineral carbonation of alkaline wastes is a recognised promising option for the permanent and safe storage of CO_2, although no economically viable processes have been successfully developed as yet.

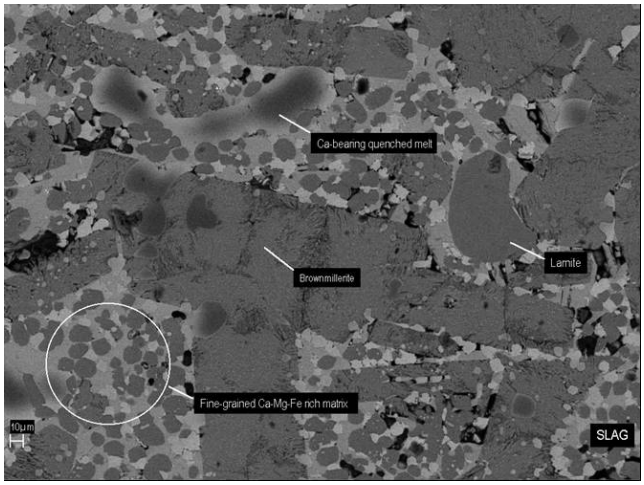
The overall objective of this project involves theoretical and experimental evaluation of a range of readily available alkaline wastes and early development of promising technological approaches and processes that can effectively dispose of CO_2 by chemically binding it with the wastes to form stable carbonates.

Progress
Eleven alkaline wastes with theoretically desirable properties for CO_2 sequestration were identified and acquired from three industrial sectors (paper recycling, steel making and platinum mining). Preliminary dissolution experiments were performed. Steel slags were originally shortlisted as they were found to be the most reactive material. The most promising leaching process developed to date at the Council for Geoscience allows rapid, near-complete leaching of calcium and magnesium from slags for subsequent carbonation and has the additional benefit of generating a non-dissolved residue with possible commercial value. This study recommended three basic oxygen furnace (BOF) slags and one electric arc furnace (EAF) slag generated at various steel mills in South Africa for further study on their potential for the combined sequestration of CO_2 and the recovery of valuable iron. This gave rise to project 2010-0037. It also recommended to widen the study and thereby investigate the selectivity of a broader range of calcium- and magnesium-specific leaching agents, which gave rise to project 2010-0036.

This study further identified fly ash and industrial brines as potentially suitable material for mineral carbonation. On the basis of this finding, two research proposals were submitted to funding bodies. The first one is entitled *Improving Geological Saline Reservoir Integrity through Applied Mineral Carbonation Engineering* and is now funded by the South African Centre for Carbon Capture and Storage. The M.Sc. bursary associated to this project amounts to R100 000 per year over a two-year period. The second proposal concerns the mineral carbonation of process brine streams with coal-combustion fly ash for the permanent and safe storage of CO_2. The outcome of these submissions are being awaited.

Another finding from this project is that mineral carbonation could remediate the hazardous nature of large asbestos dumps that occur at the proximity of varying settlements around the country. An expression of interest has been formulated and submitted to the DST for consideration.

Future activities
This project has been successfully completed, although desk study activities will be maintained to continually identify potentially suitable materials for mineral carbonation engineering.



Scanning electron micrograph of a steel slag showing the calcium-containing mineral phases suitable for mineral carbonation and CO_2 sequestration.

ST-2010-1085 **DEVELOPMENT AND OPTIMISATION OF SELECTIVE LEACHING PROCESSES FOR THE EXTRACTION OF CALCIUM FROM STEEL SLAGS IN VIEW OF SEQUESTERING CARBON DIOXIDE**

Project leader: F.J. Doucet, Ph.D. (Chem. Eng)
Project team: M. Kotoane, B. Tech.
Primary objective: To develop and optimise promising technological leaching approaches for the selective extraction of calcium from steel furnace slags under near-neutral and/or alkaline conditions for subsequent carbonation
Project duration: 2009/10–2012/13

Motivation
Industrial mineral carbonation is currently being researched at the Industrial Mineralogy Laboratory of the Council for Geoscience. It is a promising concept for the permanent long-term sequestration of CO_2 in solid form. It involves processing industrial alkaline wastes in a wet, aqueous process route that incorporates extraction of calcium from waste

materials, followed by carbonation with CO_2 to form stable mineral carbonates and recovery of the solvent chemicals. The rate-limiting step in this process is the extraction of calcium and no economically viable process is likely to be developed without the identification of a suitable calcium-specific leaching agent.

Progress
Several solvents have been identified and tested for calcium extraction. Extraction of 50 to 90 per cent has been achieved under mild experimental conditions, although the extraction efficiency was found to be slag-dependent.

Future activities
Optimisation of the extraction process will be pursued, along with the testing of additional leaching agents. Whilst progress on this project has been hampered by the withdrawing of funds, additional financial support is now provided by the Vaal University of Technology, which allows M. Kotoane to continue with her M. Tech. project.

LIMPOPO

The Limpopo Unit, centrally based in Polokwane, is responsible for the geological mapping of the province and is actively involved in providing geological input to allow prospectors to apply for initial DMR prospecting permits (for a variety of minerals) on available land. Enquiries from the public generally involve either mineral identification or the mineral/groundwater potential of specific farms or different areas within the province. Non-formalised, though structured, training this year focused on requirements for mapping and geological reports.

ST-2006-0899 **GEOLOGICAL FIELD MAPPING SCHOOL**

Project leader: N. Baglow, B.Sc. Hons
Project team: G. Brandl, Ph.D.
Primary objective: Skills development trough the training of junior geologists in practical field mapping
Duration: Ongoing
Budget: R317 400

Motivation
For some years now a need has been identified in terms of the practical mapping skills of new geologists joining the organisation, and in view of the statutory mapping mandate and the international mapping projects coming onstream in Africa, the field school was seen as one means of efficiently addressing this issue.

Progress
The project for this year was completed.

Conclusions
New scientific staff joining the Regional Mapping Division were targeted. Focusing on these geologists who are actually going to utilise the skills, the field school fitted into the overall CGS training strategy. The activities were coordinated through the Limpopo Unit; the province boasts varied and reasonably exposed geology, suitable climate and accessibility.

Though open to staff members from other units, new mapping geologists are now assigned to the Limpopo Unit for one year in the overall mapping programme which has a dominant training theme, this year being Musina. On completion of the evaluated training modules (which included a mapping module in the Richtersveld with young geologists from the Western and Northern Cape Units), the participants were each required to produce a report and make a presentation to their colleagues on an assigned aspect of the field work.

Future progress
The school is repeated on an annual basis to integrate new geologists into the overall CGS mapping programme. Though activities will be restricted for the 2010/11 year, it is intended to resume a full programme soon within the future.

Field School trainees at an iconic baobab near Musina.

ST-2008-0975	**2230AC MUSINA 1:50 000 GEOLOGICAL MAP** **2430BB MICA 1:50 000 GEOLOGICAL MAP**
Project leaders:	G. Brandl, Ph.D. N. Baglow, B.Sc. Hons
Project team:	T. Dhansay, B.Sc. Hons, N. Moabi, B.Sc. Hons, C. Mukhosi, B.Sc. Hons, P. Munyangane, B.Sc. Hons, K. Robey, B.Sc. Hons
Primary objective:	To understand the geology of the areas with particular emphasis on the structure, mineral potential where applicable, understanding the groundwater characteristics of the areas and maintaining organisational capacity in terms of understanding a variety of geological environments. Production of a 1:50 000-scale geological map and an accompanying explanation
Duration:	2007/8–2010/11
Budget:	R78 300

Motivation
The map areas were selected for the variety of geology that they cover and suitability to be used as the basis for the training of junior mapping geologists under the Field School programme.

Progress
The Musina field mapping was completed and the map compiled, together with an accompanying explanation. There was no progress on the Mica map due to the reduction in overall field work in the prevailing economic climate.

Conclusions
The geology encountered in the course of working in this area exposed the young geologists to enough variety to significantly broaden their experience within a strongly supervised project environment, while at the same time contributing to the overall mapping programme.

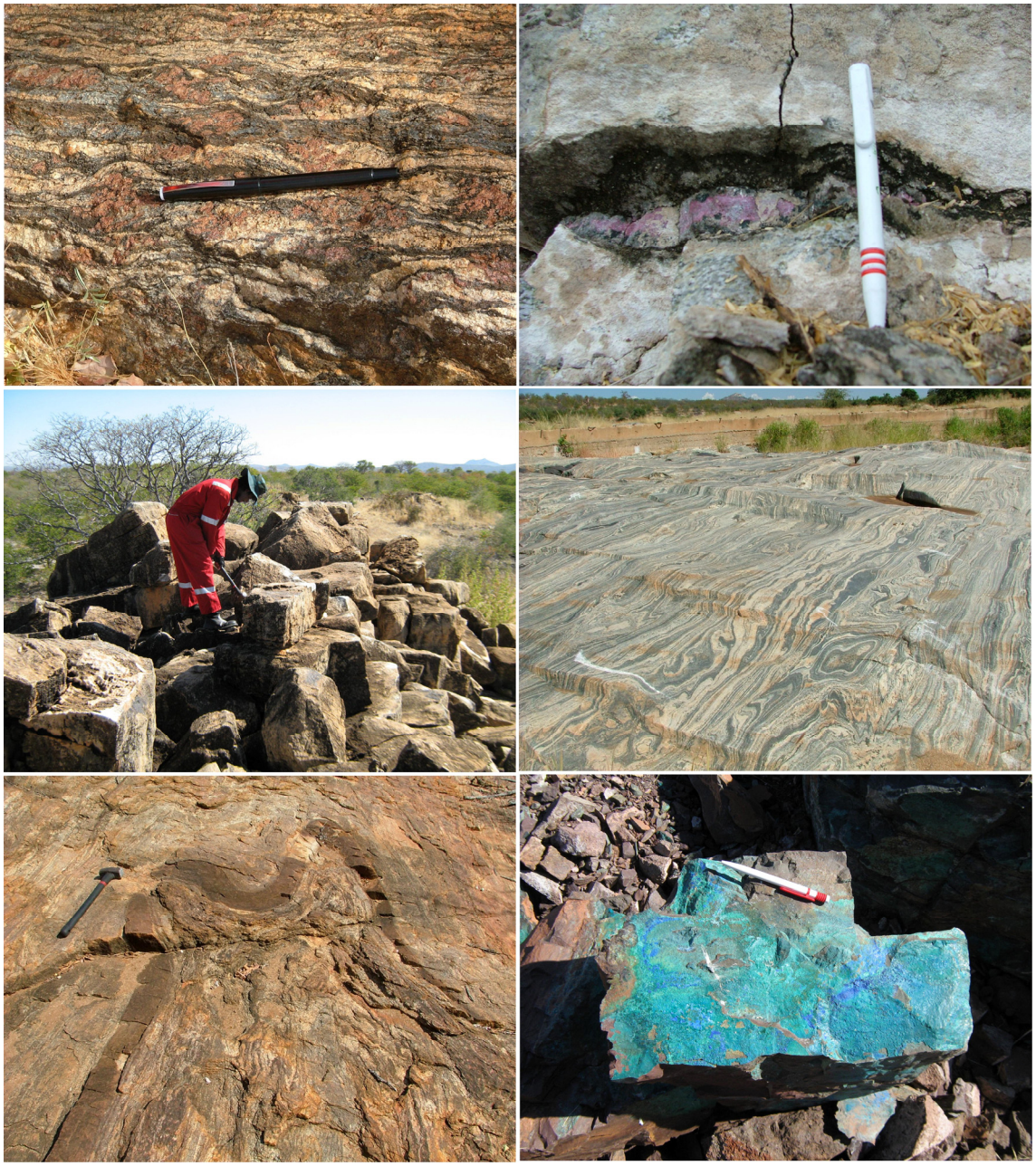
The Musina area falls within the Central Zone of the Limpopo Orogenic Belt formed as a consequence to the collision between the Zimbabwe and Kaapvaal Cratons. The geology around the Musina area predominantly encompasses early Archaean and Proterozoic lithologies, with minor Jurassic age lithologies towards the south.

The oldest units form part of the Beit Bridge Complex, which consists of supracrustal metaquartzites, magnetite quartzite, pelitic and calcic lithologies. These units were later deformed after being intruded by a series of anorthositic gneisses from the Musina Suite and TTG gneisses from the Sand River Gneiss Suite. Later intrusions included the Singelele, Bulai and Malala Drift Suite of gneisses.

The shifting of the Zimbabwe and Kaapvaal Cratons together resulted in further deformation and burial of the Central Zone and instigated the clockwise PT path towards granulite facies metamorphism. Following the peak metamorphic conditions that were reached exhumation began with associated rifting leading to the development of the depositional basin of the Soutpansberg Formation. Later the Clarens and Bosbokpoort Formations were deposited towards the south.

Future plans
While the final map and explanation sheet has been produced, this still remains one of the most complicated terrains in southern Africa, with an array of unanswered questions. Further research collaboration with relevant universities could possibly answer some of these questions and tighten the debate around the evolution of the Limpopo Belt.

The outstanding portions of the Mica map sheet will be covered within the next programme year with field training incorporated into the project mapping.



(Top left) Highly deformed metapelite of the Mt Dowe Group, (top right) Gumbu Group marble with piedmontite vein, (mid left) block-weathering characteristics of the Musina Suite anorthosites, (mid right) TTG sequence of highly migmitised Sand River Gneiss Suite, (bottom left) folded dyke in Mt Dowe Group, (bottom right) copper mineralisation along younger fracture zone.

ST-2008-0990 **LIMPOPO TAILINGS**

Project leader: O. Miyambu, BESMEG
Project supervisor: H. Coetzee, Ph.D.
Project objective: To investigate the environmental impacts of certain abandoned gold mines in the Giyani Greenstone Belt and recommend the best management and rehabilitation strategies
Duration: 2007/8–2009/10
Budget: R13 975

Motivation
The research is conducted in order to contribute towards the limited amount of available information about the environmental, social and economic issues/impacts. As such, the work can contribute towards the general debate on sustainable development in the mining industry, and highlight the need for rehabilitation of abandoned mines to be addressed, as it is for operating mines.

Progress
Data collection methods involved field observations (site visits, comparing and classifying current mine conditions compared with before-mining state), water and tailings dump sampling and community questionnaires. Water sampling was conducted from surrounding water bodies (streams, rivers and dams) adjacent to the mines of interest (Fumani, Osprey, Louis Moore, Birthday and Klein Letaba gold mines). The tailings, sediments, soils and plants sampling continues.

Conclusions
The tailings dumps have little vegetation cover and there are signs of the material being washed away alongside the tailings dam, plus a problem of dust blowing towards the community during winter. There are signs of runoff and erosion of dumps by water; the washed materials flow alongside the dumps and eventually lead to the water bodies/rivers. Water from shafts is being pumped for community use. Secure fencing off of shafts and derelict buildings needs to be implemented.

Future plans
This project was completed.

MARINE GEOSCIENCE

ST-2010-1095 **HOUT BAY GEOPHYSICS**

Project leader: M. MacHutchon, B.Sc.Hons, Pr.Sci.Nat.
Project team: Staff of MGU
Research supervisors: Prof. J. Compton (UCT), Dr J. Rogers (retired UCT)
Duration: 2009–2012
Primary objective: This project will comprise a detailed, multidisciplinary study of an area included within the Offshore Seabed Mapping Programme project, that of Hout Bay and its environs. It will also act as a project for the completion of a Masters degree. The first phase of the project in the 2009/10 and 2010/11 financial years involved geophysical and bathymetric mapping.
Budget: R219 113

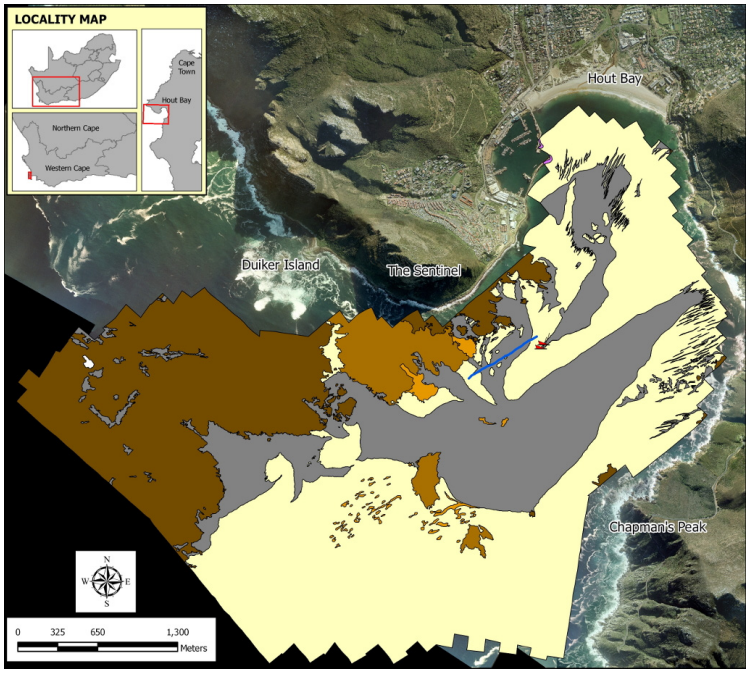
Motivation
The area is one of significant geological interest:

- the boundary between the Cape Granite and the Graafwater Formation of the Table Mountain Group has known exposures along Chapmans Peak drive, but not known offshore exposures.
- mineralisation of manganese lead to the temporary establishment of a mine on the eastern side of Hout Bay. Use of the magnetometer may lead to the offshore extension of this mineralised zone being able to be determined.

The first phase of the project for the 2009/10 and 2010/11 financial years will involve geophysical and bathymetric mapping, using the MGU's multibeam system from the vessel *GeoManzi*. This would result in high-resolution digital terrain models of the seabed and side-scan sonar mosaics for surficial seafloor geology. The use of reflection seismics will provide information on the depositional cycle and diver inspections will strengthen bottom-type classification and analysis.

This mapping project has potential commercial interest:
- I&J Fisheries operate out of Hout Bay and this is a large employer of previously disadvantaged communities.
- the surfing event *Red Bull Big Wave Africa* takes place just offshore of Hout Bay where waves are formed from the offshore reefs and provision of detailed offshore maps may assist in event planning.

Stakeholders that would also stand to benefit from such as programme include those for the Systematic Offshore Mapping programme, principally SAEON/SANBI – identification of marine habitats, and SAHRA – identification and delimitation of shipwrecks within the study area.



Progress
Collected side-scan sonar and single-beam data and compiled cruise report, surficial seafloor geology mosaic and interpretation and accompanying report.

Conclusions
First phase of data collection and interpretation completed successfully.

Future activities
Multi-beam bathymetric survey, seismic setting survey, sediment-sampling programme, diver observation programme.

ST-2009-1049 **OFFSHORE SURFICIAL SEDIMENT MAPPING PROGRAMME**

Project leader: R.A. Wigley, Ph.D.
Project researchers: R.A. Wigley, H. Cawthra, N. Sumner, W. van Zyl, M. MacHutchon, W. Hoosain, C. Botha
Primary objective: The primary aim of this project is to collate (and collect) data and compile a GIS map summarising surficial characteristics of the margins of southern Africa
Duration: Ongoing since 2008
Budget: R234 498

Motivation
This is a continuation of the project started in the third quarter of 2008/09, which aims to re-examine the map summarising features of the surface of the continental margin which was published as: *Deep-sea sedimentary environments around southern Africa (SE Atlantic & SW Indian Oceans) 1987. Dingle, R.V. et al. Annals South African Museum, 98: 1–27*. Despite the fact that these publications were produced more than twenty years ago at a very regional country-wide scale they are still used by organisations to plan government policy. This statutory programme would see these maps re-issued using additional survey data and by sourcing sample data from work undertaken in the last 20 years.

Progress
Identified relevant stakeholders and initiated meetings with a number of stakeholders. Outcomes of these meetings include:

- Sediment samples are to be collected by MCM divers, for processing at Marine Geoscience Unit
- Sediment samples to be collected by grab from MCM vessels whenever possible
- Number of samples collected and ready for processing (waiting funds for consumables)
- Collaborative MCM-Marine Geoscience Unit Masters degree project with UCT student
- Digitised all original Dingle charts as well as other Marine Geoscience Unit charts and academic records in order to be available electronically.

Research results
Very little progress has been made for a number of reasons. Preliminary data, however, from the Masters degree studies suggest that the Marine Geoscience Unit will have a much improved bathymetric model for the continental shelf of southern Africa to use as a base map for sediment data.

Future programme
Funding has been obtained from the Department of Science and Technology to put together a business proposal entitled: *Feasibility Study: Systematic Offshore Mapping of the South African Marine Environment*. The objective of this study is to put together all the supporting documentation required in order that this proposal can be placed before Government. This feasibility report will emphasise both the strategic importance and relevance of such a proposed systematic offshore mapping programme to Government.

ST-2007-0829 **DATA CURATION**

Project leader: W. van Zyl, B.Sc. Hons.
Project team: P. Young
Duration: Ongoing
Primary objective: To organise and store all digital data collected by the Marine Geoscience Unit in a uniform and coherent structure that is easily accessible to researchers and personnel. Compile a metadata database of all digital data.

Motivation
This is an ongoing project for the statutory year 2009/10. It is proposed that this project is expanded to provide additional inputs needed for inclusion in the data within the GeoPortal being developed in Pretoria.

Progress
A database and directory structure has been created into which all new projects and data must be entered upon completion. Systematic propagation of historic data is underway and data for the last decade have already been added to the structure. Some historical charts have been digitised and made available for background information in projects. These include Dingle's bathymetry and offshore geological maps of South Africa.

Conclusions
This project plays a very important roll in archiving and storing historical data to be used in future projects and research. With the high cost of collecting marine data it is of the utmost importance to preserve and archive all data in an easy to understand structure and to be readily available when needed.

Future activities
Data recently received from the Durban office must be incorporated into the database system. This will form part of the ongoing data curation project in 2010/11. Once all of the digital data have been incorporated work will commence on the more historic analogue data.

ST-2002-0462 **THE MARINE GEOLOGY OF BLOOD REEF (AN EXTENSION OF THE MARINE GEOLOGY OF THE DURBAN BIGHT)**

Project leader: H. Cawthra, B.Sc. Hons.
Project researchers: Staff of the Marine Geoscience Unit
Primary objectives: 1. The examination of the Quaternary evolution of the upper continental shelf in the vicinity of the Bluff Ridge by interpretation of boomer seismic data and analysis of sequence stratigraphic relationships between units. 2. Contribution to the knowledge of glacio-eustatic sea level changes on the east coast of South Africa by means of litho- and chronostratigraphic analysis of Late Pleistocene to Holocene submerged and raised deposits of beachrock and aeolianite. 3. The quantification of oceanographic processes operating on the shelf by the study of unconsolidated sediment bedforms.
Duration: 2003/04–2009/10
Budget: 2009/10: R105 677

Motivation
Prior to the initialisation of the Durban Bight project in 2003, little was known about the continental shelf offshore of Durban despite its importance as an outer anchorage for the harbour. In 2007, the southward extension of the Durban Bight research (the Marine Geology of Blood Reef) was initiated.

Progress
The project research and reporting has been completed and the dissertation for an M.Sc. degree at the University of KwaZulu-Natal was submitted in March 2010. The project leader attended and presented the project results at one National and one International conference (SASQUA 2009 and Hydro9) held in Knysna and Cape Town respectively. The project leader was presented with an award at SASQUA 2009 for the best student oral presentation.

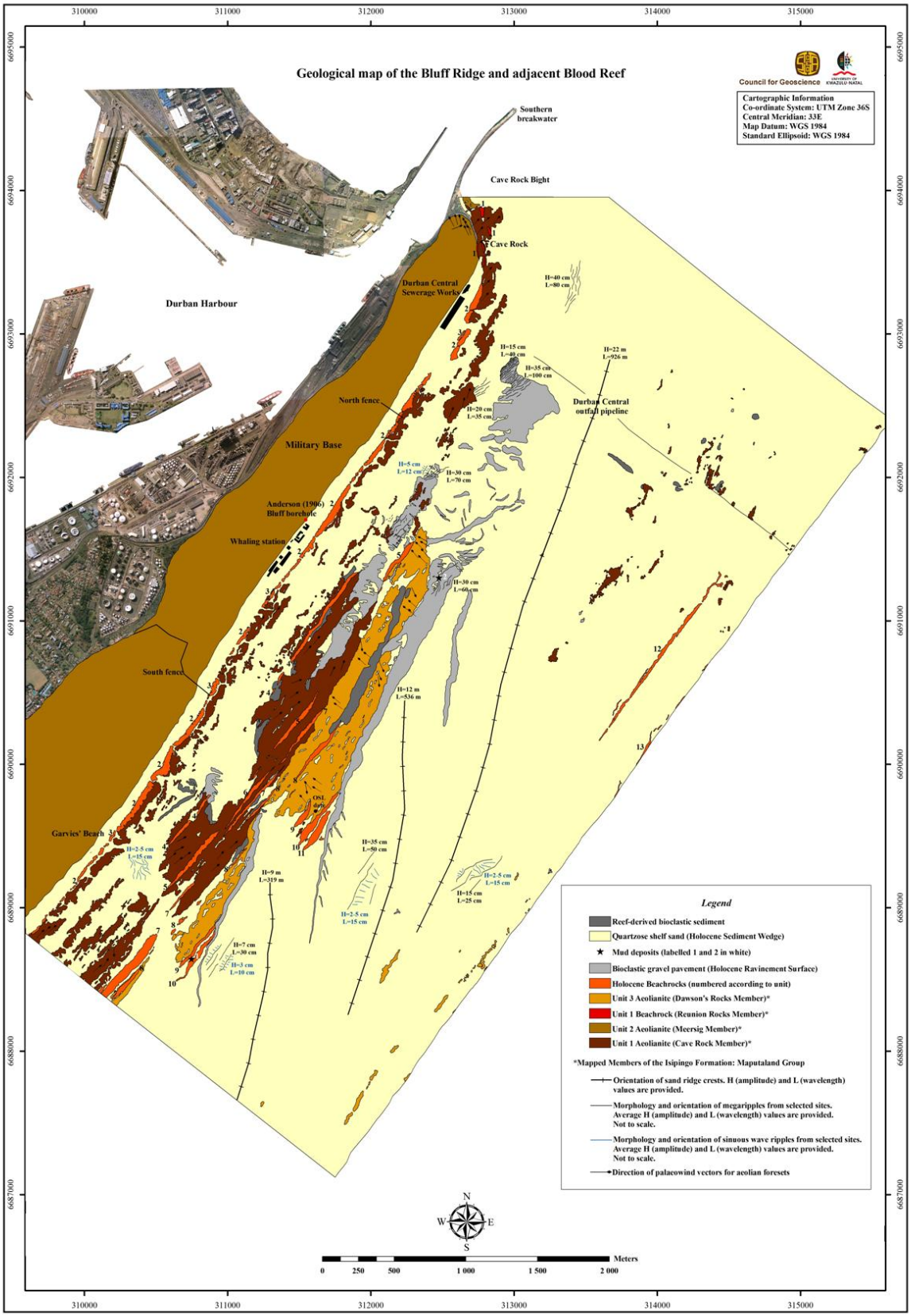
Research results
Boomer seismic interpretation revealed that the Bluff shelf was shaped by initial tectonic subsidence during Late Cretaceous drift sedimentation, followed by uplift during the Tertiary and eustatic sea level oscillations in the Quaternary. Eight seismic units are recognised, bounded by regional sequence boundaries, maximum flooding surfaces and wave ravinement surfaces. The basal units define the Late Cretaceous drift sequence. The shelf-edge wedge is interpreted as Pliocene in age with a basal facies indicative of basinward advance related to Early Pliocene regression, overlain by Late Pliocene deposits which were shaped by the transgression which marked the eventual onset of the Quaternary. The youngest units represent Quaternary deposits (cordons of aeolianite and interdune deposits of the Pleistocene) and the Holocene sediment wedge.

Mapping of Blood Reef by SCUBA and a multi-beam survey enabled subdivision of the Quaternary deposits into three aeolianite units and thirteen beachrock units. Calcareous nannofossils preserved in the aeolianites reveal a Late Pleistocene to Holocene (Zone NN21) age providing an upper age limit of ~290 000 years for the Bluff Ridge and Blood Reef. A new infared stimulated luminescence date on a cordon of aeolianite between 30 and 22 m below mean sea level provided an age of 60 000 to 70 000 years (Marine Isotope Stage 4). Dune-building events are inferred to have occurred on both sea level highstands and lowstands. Successive dunes accreted either vertically (Units 1 and 2 Aeolianite) or against the seaward margins of existing aeolianites (Unit 3 Aeolianite), younging in the offshore direction tracking sea level regression towards the glacial maxima.

Sea level stillstands associated with the Holocene Transgression manifest as wave-cut platforms and other erosional features incised into aeolianite at the same depths as the occurrence of beachrocks along strike. Notches occur at several distinct levels: 52, 49, 28, 26, 24, 19, 18, 17, 16, 12 and 9 metres below mean sea level and 0 and 1.5 metres above.

Geostrophic subaqueous dunes of quartzose shelf sand (shoreface-attached ridges) of the Holocene sediment wedge are shaped by a northward-flowing eddy of the Agulhas Current. Although interpreted to be mostly relict features associated with lowered sea levels, the northward growth of a ridge by entrained sediment has resulted in the burial of a 42 year old pipeline, indicating ongoing sedimentary activity.

Conclusion
The geology of the Bluff Ridge and adjoining Blood Reef is dominated by Mid- to Late Pleistocene aeolianites deposited on a marine Cretaceous sequence. Subsequent beachrocks deposited on and erosional features cut into the aeolianites track a series of palaeocoastlines extending semi-continuously from the supratidal zone to the outer continental shelf, recording sea level fluctuations from the Last Interglacial to the present.



Geological map of the Bluff Ridge and adjoining Blood Reef.

ST-2002-0460 **MARINE SURVEY TECHNOLOGIES**

Project leader: M. MacHutchon, B.Sc. Hons, Pr.Sci.Nat.
Duration: Ongoing
Primary objective: Enable the MGU to remain abreast of current survey technology and to facilitate technical improvements and innovations within the Unit
Motivation: This is an ongoing project to achieve the primary goal as stated above.
Beside the continual experience of using the MGU survey equipment, documents to be used to gain ISO9000 accreditation were compiled. These included HSE policies specifically tailored to the MGU and relevant risk assessment documents for diving and surveying operations.

Progress

- Completion of a MGU-specific HSE document
- Completion of risk assessment documents for surveying and diving operations of the MGU
- Ongoing equipment training and usage for the following geophysical surveys:

Survey	Personnel	Equipment used
Stat Project 1095 Hout Bay Survey	M. MacHutchon, H. Cawthra, W. Kupido, W. van Zyl, E. Wiles (CGS bursary student)	SSS, DGPS, Singlebeam, Hypack
J&G Survey (Simonstown Harbour)	H. Cawthra, W. van Zyl, W. Kupido, M. MacHutchon, P. Young, W. Kidwell	MBES, POS MV, Hypack and Hysweep
Martech Survey (Assegaai slip)	H. Cawthra, M. MacHutchon, P. Young, W. Kidwell	Pinger, SSS, Hypack
Martech Survey (Golf berth)	H. Cawthra, W. van Zyl, W. Kupido, M. MacHutchon, W. Hoosain	Pinger, Hypack

Conclusions
The MGU has very current equipment and software enabling it to be a worldwide leader in the marine geoscience industry. With continued training the unit can only go from strength to strength. Most members of the unit have improved their skills immensely by using these survey opportunities.

Future activities
Finalise ISO9000 accreditation.

MINERAL RESOURCES DEVELOPMENT

ST-2009-1013 **PRELIMINARY COAL RESOURCES OF SOUTH AFRICA**

Project leader: D. Katemaunzanga, B.Sc. Hons, Pr.Sci.Nat.
Project team: A.O. Kenan, M.Sc., Pr.Sci.Nat., T. Mudau, B.Sc. Hons., Cand.Sci.Nat., N. Mayekiso, B.Sc. Hons, M. Matshivha, B.Sc. Hons, Cand.Sci.Nat., M.M. Schalekamp
Primary objective: To collate coal resource/reserve information from coal-mining companies in mining-active coal fields and model coal resources from borehole core logs in the coal database
Duration: Two years
Budget: R22 609

Motivation
South Africa is by far the largest coal producer and holds the largest coal resource in Africa. About 77 per cent of all the energy used in South Africa is derived from coal. Consequently, such reliance on coal energy, along with the current energy crisis in southern Africa, prompted a review of the coal resources of South Africa. There is an uncertainty in the availability of coal resource/reserve data. A number of resource/reserve estimates have already been done. A project by Mining Tech, on behalf of the DME, in the late 1990 to 2007 proved to be not very successful because of non-participation of 50 per cent by the coal-mining fraternities. Therefore it is imperative to evaluate the national coal resources and reserves as these form the basis for governmental policies.

Progress
In the first year a pilot study was done in the Soutpansberg and Tuli coal fields because these coal fields are relatively small in size and have not been extensively mined. In the second year focus shifted to the other peripheral coal fields (Waterberg, Somkhele, Kangwane, Sasolburg-Vereeniging, Free State and Springbok Flats). A draft report of the gross *in situ* resources of these coal fields was submitted. Also included in the report are coal qualities information and coal tonnages with accompanying maps and plans.

The coal resources of coal fields such as the Molteno, where there is no active mining, and the central coal fields, where there is considerable information to model, will be modelled entirely based on information collected from mining companies or experts who have worked in the areas.

Conclusions
Coal resources of the Waterberg, Somkhele, Kangwane, Sasolburg-Vereeniging, Free State and Springbok Flats coal fields were estimated. The resource figures did not exclude mined-out areas and the information could not be categorised according to the SAMREC code. Information will need to be integrated with data from mining companies that are active in the areas to be able to present a clear picture of the coal resources of South Africa.

METALLURGICAL MAPPING (1:250 000 CALVANIA SHEET)

Project leader: D.I. Cole, Ph.D.
Project team: D.L. Ehlers, B.Sc., W.R. Oosterhuis, B.Sc. Hons, R. Malan, C. Vorster, M.Sc.
Primary objective: Editing and correcting the metallogenic map and explanation for publication
Duration: 2009–2010
Budget: None

Motivation
The 1:250 000-scale metallogenic maps provide a valuable visual display of the mineralisation over a large area, which is very important for land use planning, mineral exploration, future development and stimulating new mining activities. It also adds updated information to the South African Mineral Deposits Database (SAMINDABA).

The explanation accompanying the map primarily serves to document mining and mineral potential of the Calvinia (3118) map area with descriptions on the geology and the genesis of similar types of deposits and extensive references are provided for more in-depth information. A large variety of economic mineral deposits and occurrences are shown on the Calvinia map sheet, of which the most important are the limestone/dolomite, gypsum, heavy minerals, alluvial diamonds and dimension stone deposits.

Progress
The project is well advanced and ready for publication. To date the manuscript has been completed and scientifically edited and corrected.

Future activities
The manuscript and the map need to be finalised by the Publications Section.

Conclusion
The goal is to publish both the manuscript and map within the 2011/12 financial year.

Abandoned Widouw marble quarry near the foot of Gifberg Pass, SSE of Vanrhynsdorp.

ST-2005-0865 **MINERAL RESOURCES FOR SUSTAINABLE DEVELOPMENT IN THE SOUTHERN AFRICAN CONTEXT**

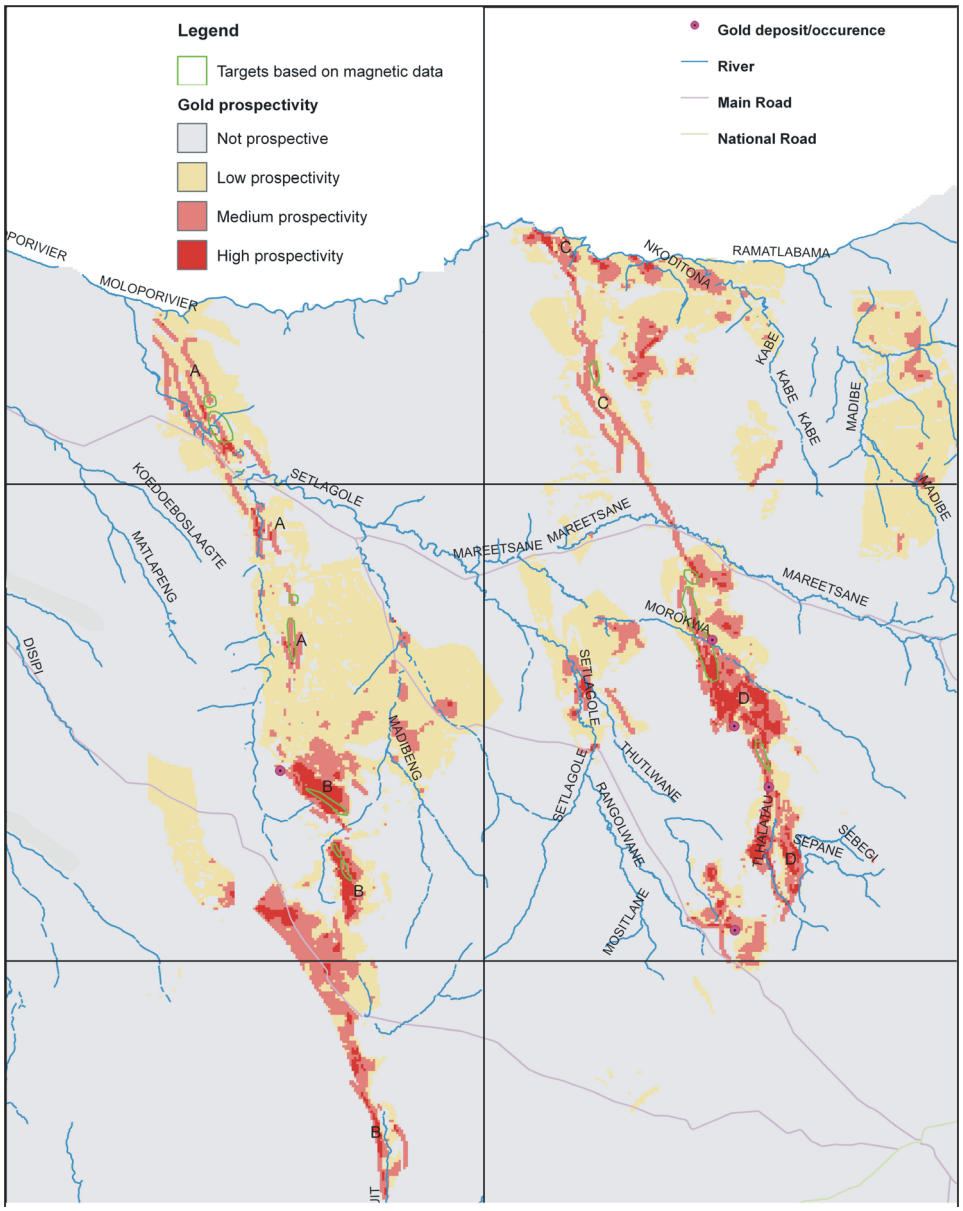
Project leader:	A.Y. Billay, Ph.D. (sub-programme 1), S. Frost-Killian, M.Sc. (sub-programme 2)
Project team:	L. Ngcofe (GIS/Remote Sensing, Bellville), M. Matshivha (B.Sc. Hons, Intern)
Primary objectives:	To generate mineral potential targets
Duration:	2006–2011
Budget:	2009/10: R39 585

Motivation
Modern mineral potential targeting by way of integrating multi-data sets of geophysics, geochemistry, satellite images, mineral occurrence/deposit data, structures and other relevant geological information using GIS has proved to be successful in generating mineral potential targets in known mineral provinces. This can aid in mineral resources development and stimulate exploration investment, by reducing the risk involved in exploration, as well as the public service organisations of a country to define prospective land and to weigh mineral potential against competing demands for land use. The CGS believes that additional discoveries will contribute to the economic growth of South Africa and the SADC region.

Progress
The project is currently subdivided into two sub-programmes.

Sub-programme 1:	Mineral prospectivity mapping (target generation) by integration of geology, geophysics, geochemistry, remote sensing and satellite imagery, etc. using GIS – Primary focus for 2009–2010.

The area of study for sub-programme 1 (for the fiscal year 2009/10) was the Kraaipan and Stella Greenstone Belts in the North West Province. The relevant data sets were collected, processed and integrated. A manuscript of the technical report together with a mineral potential map has been produced.



Gold prospectivity map of the Kraaipan and Stella Belts, North West Province. Note that the bright green polygons are targets based on magnetic data alone. They are characterised by low anomalies due to strong remnant magnetisation interpreted to be due to hydrothermal alteration of banded iron-formation during gold mineralisation.

Sub-programme 2: Mineral resources for sustainable development in the southern African context and the associated Global Mineral Resource Assesment Project (GMRAP), a cooperative programme between the USGS, CGS and other professionals throughout southern Africa

A member of the team attended an additional workshop to assess the undiscovered copper potential of the Central African Copperbelt (Zambia and the Democratic Republic of Congo). After receiving feedback from industry representatives on the initial results of the GMRAP assessment for undiscovered copper reserves within southern Africa, which were presented at the GSSA-SEG conference held in Johannesburg in July 2008, and the feedback from the assessment of the Zechstein Basin (2008), it was decided to hold a second assessment of the copperbelt. The workshop took place in Cape Town in January 2010. Revised rules for the assessment were implemented and new grade-tonnage models, specifically relevant to the copperbelt, were used.

It is hoped that the results from the assessment will better reflect the potential for undiscovered copper in the region. The preliminary results of the re-assessment should be available by September 2010.

Conclusions
For Sub-programme 1, the GIS-based data integration method applied has outlined several potential areas that require follow-up work by the Council for Geoscience to verify the gold potential of the targets generated. Follow-up work can also be done by the public (mining/exploration, and junior miners and state-mining companies) interested in gold.

For Sub-programme 2, preliminary results for the potential undiscovered copper resources within the southern African region have been discussed and analysed. As a result, the Central African Copperbelt has been re-assessed. Preliminary results from the re-assessment will be sent to the team for review before September 2010. The results of the 2006 assessments for PGEs are still being processed by the USGS.

Future activities
The project will continue in the 2010/11 financial year (Sabie-Pilgrim's Rest gold field for gold potential or Kakamas-Areachap-Kaaien terranes for uranium and various metals), but depends on the availability of funding. The CGS involvement in the USGS GMRAP will continue until all results are published. Continued involvement with the USGS on a similar South Africa specific project is envisaged for the future.

DATABASES

ST-2002-0166 SAMINDABA (SOUTH AFRICAN MINERAL DEPOSITS DATABASE)

Project leader:	C.J. Vorster, M.Sc.
Project team:	P.A. Endres, in collaboration with the Metallogenic Mapping Section and the Spatial Data Management Unit
Primary objective:	Capturing, storage and updating of mineral data on mines, mineral deposits and occurrences within the borders of South Africa. The fast and efficient provision of accurate mineral data to users all over South Africa and abroad
Duration:	Ongoing
Budget:	R127 000

Motivation
The numerous mineral resource appraisals, reports, maps and mineral data furnish the government and the mining industry, small, medium and large, with mineral resource information and advice for informed decision making, relating to mineral policy and development issues, and promote economic geological activities. The sterilisation of mineral deposits has been prevented during the planning of permanent surface structures such as townships, dams, roads, pipelines, railway lines, etc. SAMINDABA also plays a positive role in rural development and poverty eradication.

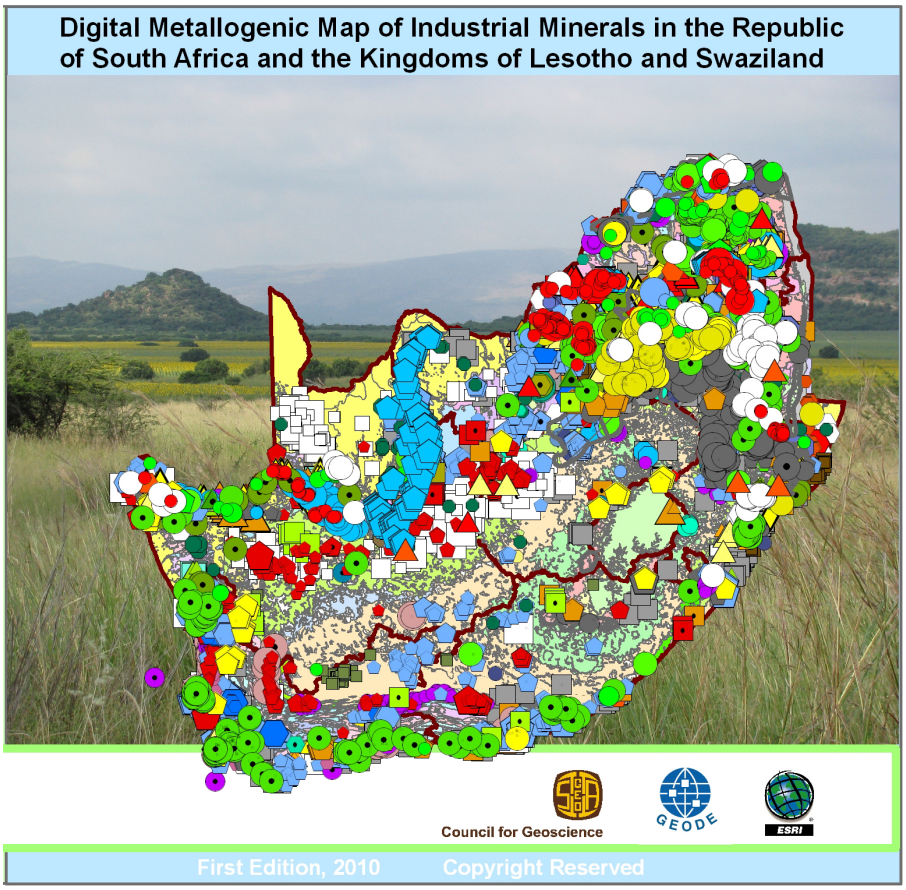
SAMINDABA is instrumental in the compilation of metallogenic maps and explanations that are designed to facilitate mineral reconnaissance exploration by way of ore deposit modelling and target identification, and to stimulate the mining industry in general.

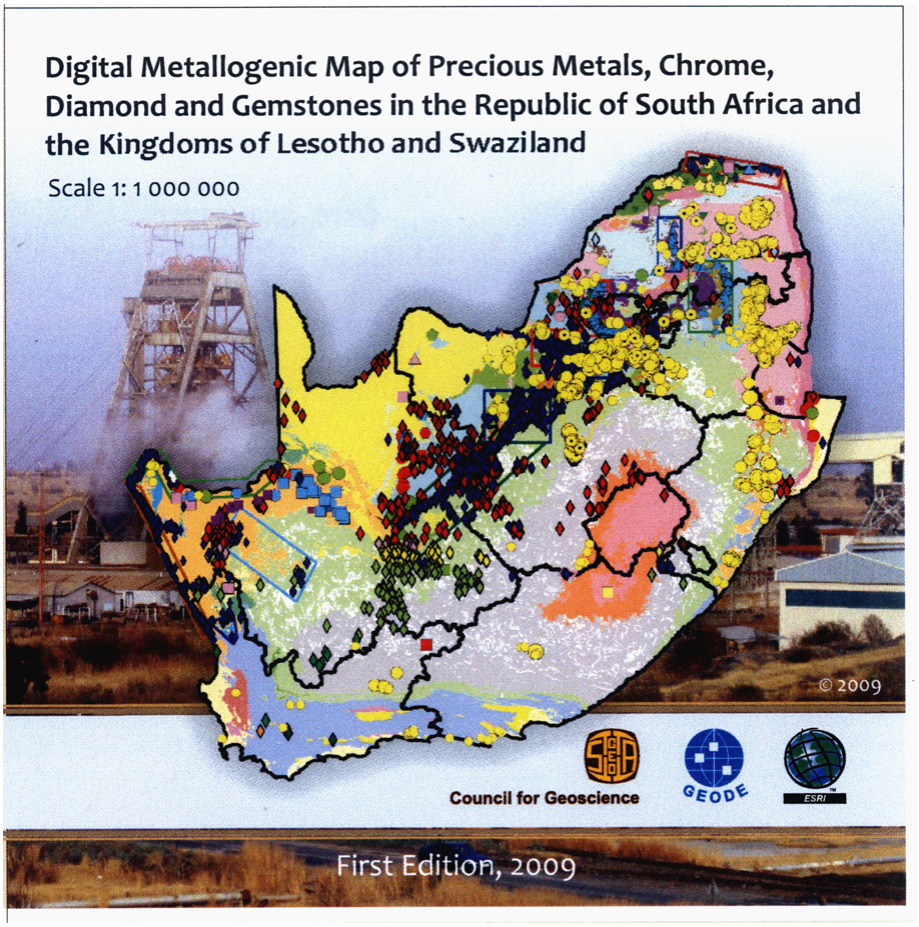
Progress
During the 2009/10 programme year, SAMINDABA was enlarged to 19 239 mineral records in total, providing information for both internal and external enquiries on South Africa's mineralisation, as well as for maps and other products. The Derelict and Ownerless Mines database now contains 6 345 mineral records.

A DVD entitled *Digital metallogenic map of industrial minerals in the Republic of South Africa and the Kingdoms of Lesotho and Swaziland* was also published.

Conclusions
SAMINDABA forms part of GEODE, the corporate modular database of the Council for Geoscience. The primary objective is to collect and electronically store and retrieve information concerning mineral deposits. It especially assists research and mineral exploration within the borders of the Republic of South Africa.

Future activities
Field work and research will be carried out to further enhance and update SAMINDABA, as well as the Derelict and Ownerless Mines database.


Digital Metallogenic Map of Industrial Minerals in the Republic of South Africa and the Kingdoms of Lesotho and Swaziland
Council for Geoscience
GEODE
ESRI
First Edition, 2010
Copyright Reserved


Digital Metallogenic Map of Precious Metals, Chrome, Diamond and Gemstones in the Republic of South Africa and the Kingdoms of Lesotho and Swaziland
Scale 1: 1 000 000
© 2009
Council for Geoscience
GEODE
ESRI
First Edition, 2009

ST-2002-0167 **SOUTH AFRICAN COAL DATABASE**

Project leader: M.M. Schalekamp
Project team: N. Mcilrae, M. Solomon, contract worker
Primary objective: To prepare, capture and manage information on coal deposits derived from borehole core logs, and to make this information accessible to a wide range of stakeholders
Duration: Ongoing
Budget: Included in unit overheads

Motivation
In terms of current legislation the Council for Geoscience maintains a coal database. The coal database is part of the corporate database GEODE and interfaces with other systems, allowing easy access to users.

This facility enables a centralised point of collection for most of the data available on the geology of coal deposits of South Africa. The availability of this information in electronic format makes it easy for the information to be disseminated in a user-friendly format, enabling further research work on the geology of the coal deposits, as well as facilitating planning of the optimal use of the country's coal resources and land management.

Progress
During the year 706 logs were prepared, 669 header details were coded and captured, 9 554 lithologies for 142 boreholes were captured, 446 logs were electronically converted and all the data have been loaded onto the database. The coal database now contains 111 705 boreholes with 2 824 139 lithologies and 1 588 959 analyses.

Conclusions
The coal database forms part of GEODE, the corporate database of the organisation. It is a database of strategic importance and enables comprehensive research work on the geology of coal deposits in South Africa.

Future activities
The coal database will form part of the CGS GeoPortal which provides the technology infrastructure required to make data contained in the organisation's various databases accessible to people outside the organisation.

ST-2002-0168 **COREDATA DATABASE**

Project leader: M.M. Schalekamp
Project team: M. Solomon, N. Mcilrae, contract worker
Primary objective: To prepare, capture and curate geological information from borehole core logs and to make this information accessible to a wide range of stakeholders
Duration: Ongoing
Budget: Included in unit overheads

Motivation
The Council for Geoscience has built up a large collection of borehole core logs of South African geological strata over a period of more than 25 years, and is continuing to increase this collection in order to ensure that the information is managed in such a manner that it is easily accessible. COREDATA provides easy access to this collection.

Progress
During the year 473 logs were prepared for capture into the database, while 296 headers were coded and captured. The borehole core log database now contains a total of some 86 000 entries.

Conclusions
The borehole core database is one of the modules of the corporate database GEODE. It is a database of strategic importance as it plays an important role in enabling research work on the geology of South Africa and facilitates proper planning of the optimal use of the country's mineral resources.

Future activities
Future ongoing work will increase the amount of information contained in this database.

ST-2002-0133 **INTERNATIONAL METALLOGENIC MAP OF AFRICA (1:5 000 000) – DATABASE MAINTENANCE**

Project leader: S. Frost-Killian, M.Sc.
Project team: W.R. Oosterhuis, B.Sc. Hons
Primary objectives: i) To improve existing knowledge on mineral deposits of the SADC and/or NEPAD region by continually adding and updating the database
ii) To improve the reliability of the data through verification and editing
iii) To possibly contribute towards capacity building and improved knowledge on deposit models in Africa
iv) To contribute information to other projects in line with the objectives of the Council for Geoscience
Duration: Ongoing
Budget: R6 368

Motivation
The Africa Minerals Database was designed as part of the compilation of the International Metallogenic Map of Africa (1:5 000 000). In view of the future direction of the Council for Geoscience and the use of the data for a variety of current and future statutory and commercial projects, it is important that the data be up to date and relevant.

This is particularly important for the innovative manipulation and interrogation of the data to produce a variety of products including prospectivity maps, as well as to advance knowledge of the origin and evolution of mineral deposits (deposit modelling). The maintenance of the database is a continuous process for as long as the Council for Geoscience sees working in Africa and being involved in NEPAD and SADC as key thrust directions.

Progress
The 1:5 000 000-scale International Metallogenic Map of Africa was published in June 2002 by the Council for Geoscience under the auspices of the Commission for the Geological Map of the World (CGMW), with support from UNESCO. The ß-version of the digital International Metallogenic Map of Africa was released in 2003. In 2009/10, a β1-version was released. Upgrades were made to keep up with the ESRI software upgrades.

Sales of the digital data continued through 2009/10 although they have been far less than in previous years. The map and associated digital data were used for the production of both country-specific and more regionally derived maps, reports and publications. Clients include the mining houses, mining juniors, consulting companies, other science councils, the Department of Mineral Resources, university libraries and departments, and companies working as suppliers to the mining industry in Africa. Many of the current clients are from South Africa, Australia and the USA.

The maintenance and updating of the database continued with the focus on southern Africa (Gabon, the Central African Copperbelt and Madagascar). Assistance was given to various units within the organisation for various projects for clients throughout Africa. The CGS participation in the collaborative USGS Global Mineral Assessment Project (GMRAP) for copper is ongoing. Following the release of preliminary results of the copper assessment of the southern African region, the Central Copperbelt was re-assessed in 2010.

Conclusions
The release of the digital data set generated interest within the mining community at large. It is hoped that the publication of the map and digital data set will serve to promote interest and investment in the mineral industries of Africa.

Future activities
The maintenance of the Africa Minerals Database is seen as an ongoing task. The database will be further improved upon, updated and expanded within the next project year**.**

ST-2005-0861 **INDUSTRIAL MINERALS MAP OF SOUTH AFRICA**

Project leader: G.F.J. Horn, M.Sc.
Project team: R. Opperman, B.Sc. Hons, A. Kenan, M.Sc., P. Kgwakgwe, B.Sc. Hons, U. Nondula, B.Sc. Hons, C.J. Vorster, M.Sc., R. Malan
Primary objective: To add information on industrial mineral deposits, mines and occurrences to the databases of the Council for Geoscience with the aim of producing industrial mineral maps, mineral exploration and target generation maps, resource estimations per commodity, and other products
Duration: 2004/5–2011/12

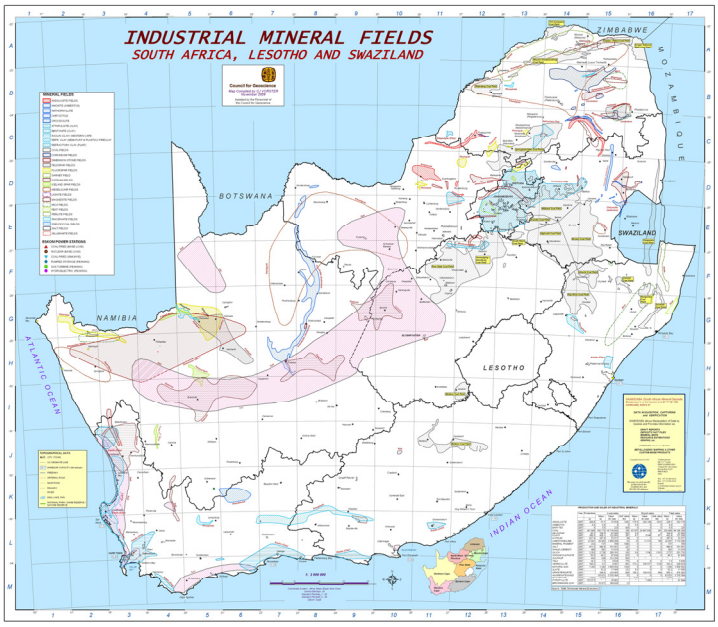
Motivation

This project aims to capture a strong, definitive set of scientific data on all known and many new industrial mineral deposits, mines and occurrences onto the mineral databases of the Council for Geoscience. This information is used to produce, amongst others, industrial mineral maps for South Africa, calculate mineral resources and determine mineral resource distribution patterns, do mineral characterisation projects that would highlight the value-added potential of different mineral commodities and for social, economic and environmental planning purposes on a national level. Furthermore, this information could be used to (i) support especially small- and medium-size mining companies with performing new exploration industrial mineral exploration ventures, (ii) contribute strongly to job creation and poverty alleviation initiatives of government, (iii) service and support the growing industrial sector of South Africa with beneficiated mineral and industrial products and (iv) provide information regarding decisions on land use issues such as the prevention of mineral sterilisation, environmental impact control and others.

Progress

Prior to the 2009/10 financial year, the project team completed all work covering the Free State, Eastern Cape, Gauteng and North West Provinces. Information on more than 2 000 industrial mineral deposits and occurrences have been compiled and the data from these occurrences were captured. However, during 2009/10 financial constraints impacted on the completion of industrial minerals mapping work in the Mpumalanga Province. A total of 300 deposits, or just more than 50 per cent of all deposits and potential deposits were visited by the mapping team. However, due to inaccessibility, the number of targets that could be sampled and studied were much less. One of the main reasons for inaccessibility of targets is ascribed to the fact that a much larger proportion of the Mpumalanga Province is included in nature conservation areas than in any of the other provinces where mapping has already been completed. The information on the geological aspects of the deposits that were accessible in the Mpumalanga Province were noted and captured into the electronic database of the organisation.

The most important mineral commodities that were investigated in the North West Province include dimension stone occurrences and deposits, andalusite, construction materials, talc, limestone, clays (kaolinitic) including brick clays, bauxite, dolomite, quartzite, verdite, asbestos (especially old asbestos dumps), magnesite, fluorite, syenite, pyrophyllite, barite and others.



Conclusion

In addition to the symbolised locality indication of mineral occurrences and deposits, information on infrastructure (water supply, electricity networks, roads) and simplified regional geology will be indicated on the map, as industrial minerals are dependent on these parameters.

The SAMINDABA module of the GEODE corporate database will provide 1:250 000-scale maps of the provinces, on which all known industrial mineral occurrences and deposits will be indicated. Client-specific maps and products, however, can be generated at any scale. Furthermore, important deposit characteristics, including deposit localities, exploration data, stratigraphy and ore body information (dimensions, ore body attitude, depth, overburden, structure and texture, mineralogy and host rock:ore body relations) that are part of the SAMINDABA data will be strictly adhered to during the capturing and accumulation of information from literature and field visits for each occurrence or deposit. The correlation of characteristics between deposits is important because this will allow identification and definition of mineral provinces.

Limited sampling was done at each deposit or occurrence, depending on the ore body accessibility and available analytical data. Analyses will be used to characterise the mineral commodities under investigation and will augment other databases, including the laboratory's geochemistry database.

Future activities
The project could deliver products that will contribute to the objectives of carrying out national resource estimations, publishing maps as contributions to commodity surveys and exploration programmes, assisting with the development of exploration models, contributing to due diligence reporting and optimising mine development. The project will contribute to successful strategic decisions of national and provincial government agencies and local authorities with regard to the development of infrastructure without sterilising mineral deposits of importance. Information could also contribute to the endeavours of small- and medium-size mining companies, and assist with transfer of technical and scientific information to the previously disadvantaged.

ST-2009-1054 **MINERAL COMMODITY UPDATE, A PUBLICATION ON PGM MINERALISATION IN SOUTH AFRICA**

Project leader: N.Q. Hammond, Ph.D.
Project team: U. Nondula, B.Sc. Hons, R. Malan
Primary objectives: To update the Mineral Resources Series for PGMs
Duration: Up to March 2011
Budget: 2010/11: R55 000

Motivation
In its quest to provide up-to-date information on the Mineral Resources of South Africa, the Council for Geoscience has traditionally produced the Mineral Resources Handbook that is aimed at stimulating interest, research and investment in South Africa's mineral deposits.

Considering that new information is available and that new developments are taking place in the platinum industry, it is imperative to update this information for public consumption.

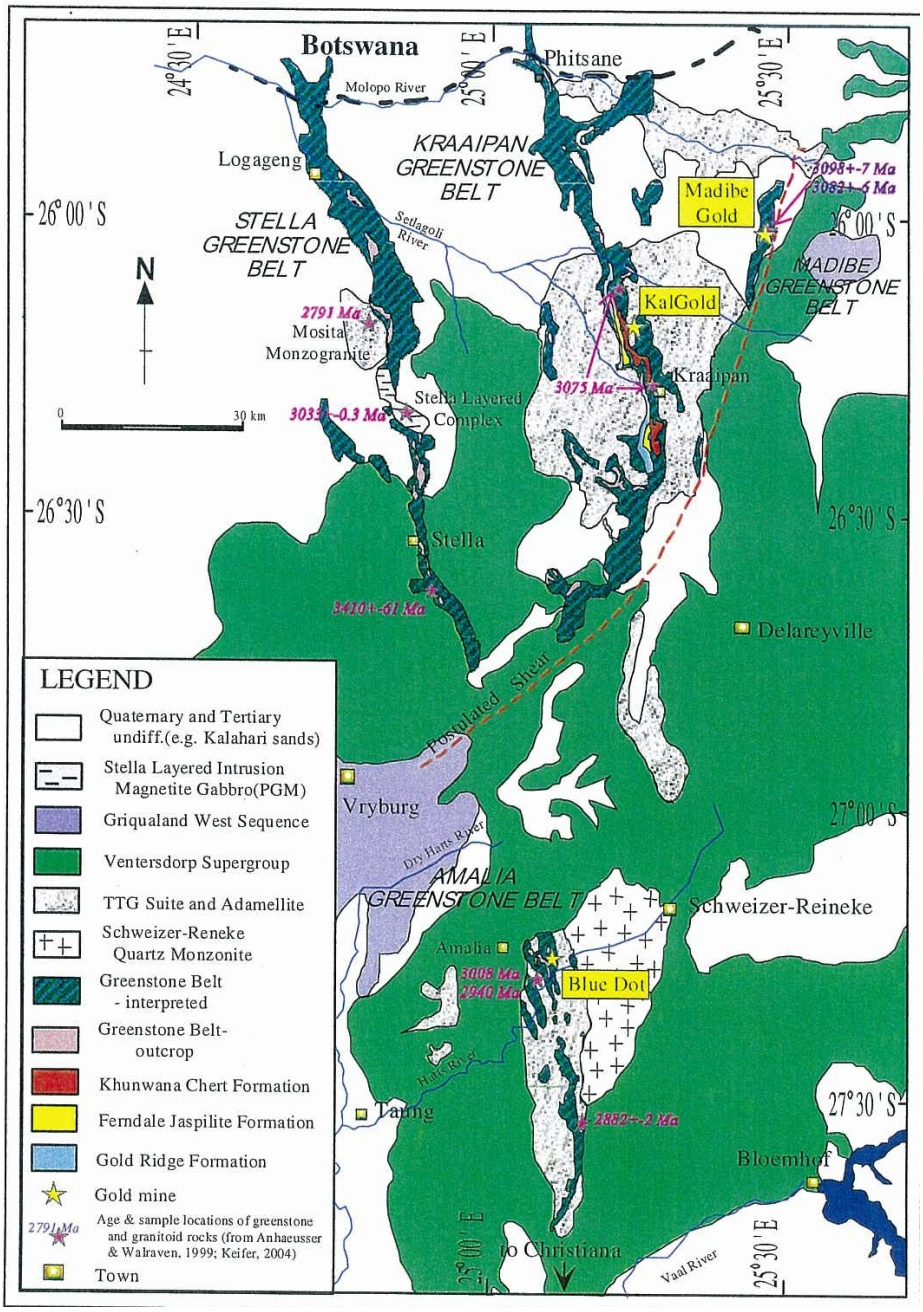
Progress
A number of people from both academia and industry have offered to contribute to various chapters of the PGM publication. Some contributions have been received and three contributions are still pending.

Future activities
A follow-up will be undertaken to receive all pending contributions. Also, a research component of this project which will apply secondary ion mass spectrometry (SIMS) to investigate the distribution of PGMs in sulphide ores in the Bushveld Complex will be undertaken in collaboration with the Geological Survey of Japan, AIST.

ST-2009-1057 **CONTROL OF MINERALISATION AT THE BLUEDOT MINING COMPANY, AMALIA GREENSTONE BELT, SOUTH AFRICA: PETROGRAPHIC, MINERAL-CHEMICAL AND FLUID ASPECTS**

Project leader: N.Q. Hammond, Ph.D.
Project team: T. Mizuta, D.Sc. (Akita University, Japan), D. Ishiyama, Ph.D. (Akita University, Japan), K. Adomako-Ansah, M.Sc. (Akita University, Japan)
Primary objectives: (i) To investigate the genesis of gold mineralisation in banded iron-formation at the Abelskop and Goudplaat deposits of the Bluedot mining company in the Amalia Greenstone Belt and (ii) to compare with similar studies previously conducted at the Kalahari Goldridge Mine in the Kraaipan Greenstone Belt to provide a comprehensive understanding of the mineralisation history of the Amalia-Kraaipan Greenstone Belts
Duration: Up to March 2011
Budget: 2010/11: R35 000

Motivation
The Kraaipan-Amalia Greenstone Belt in South Africa forms part of several greenstone belts on the Kaapvaal Craton. A number of gold and platinum deposits are hosted in these greenstone belts. There has been a general lack of knowledge concerning the mineralisation history in these greenstone terrains, which apparently is attributed to the general paucity of outcrops in a region entirely covered by calcretes and Kalahari sand. The advent of these mining operations has revealed the region as a potential metallogenic province in South Africa. However, realisation of the mineral potential of the Kraaipan-Amalia Greenstone Belt requires the development of effective mineralisation models and a thorough understanding of the belt.



Locality map of the Amalia Greenstone Belt, South Africa.

A number of studies have recently documented the genesis of gold mineralisation in BIF, the alteration pattern, fluid evolution and factors that controlled mineralisation in the Kraaipan Greenstone Belt.

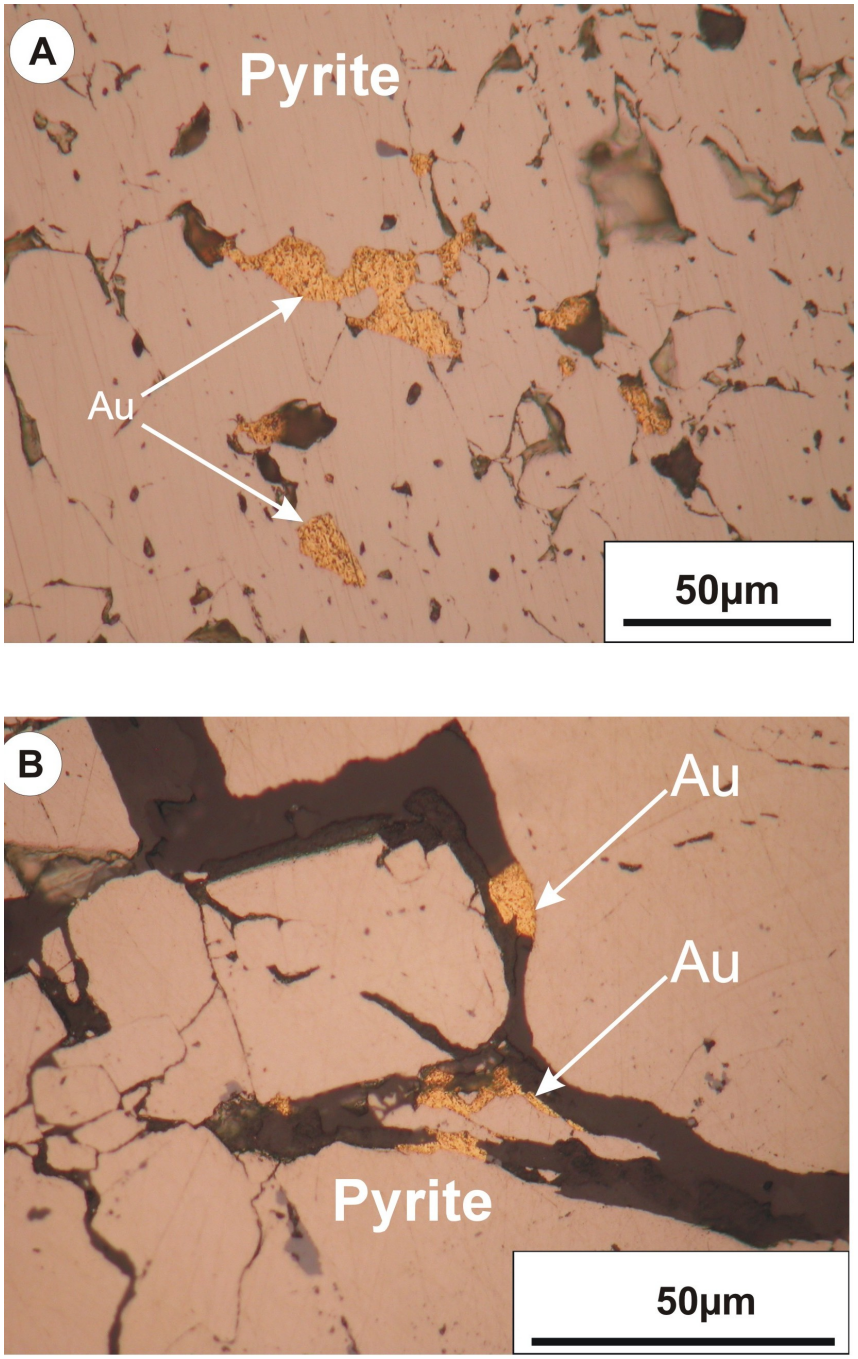
The current research at the Abelskop and Goudplaat deposits of Bluedot mining company in the Amalia Greenstone Belt will attempt to define the genesis of gold mineralisation from a geochemical-mineralogical perspective. In conjunction with earlier studies on the Kalahari Goldridge deposits in the Kraaipan Greenstone Belt, this study will also aim to provide a comprehensive understanding of the mineralisation history of the Amalia-Kraaipan Greenstone Belt.

Progress

Petrographic studies and analytical work including microthermometric and laser Raman spectroscopic analyses of fluid inclusions, geochemical studies of bulk rock samples and microprobe analyses of the alteration mineral assemblage and electrum were undertaken at Akita University.

Future activities

The remaining analytical, including C, O, S and Rb-Sr isotopic, studies, as well as write-up of the thesis to conclude this project will be undertaken this year.



Photomicrographs showing Au association with pyrite in BIF at the Blue Dot Mine, Amalia Greenstone Belt, South Africa.

COLLABORATIVE PROJECTS

ST-2008-1000	**CRITICAL METAL (E.G. REE, LITHIUM, INDIUM) RESOURCES POTENTIAL OF SOUTH AFRICA**
Project leader:	E. Long'a Tongu, Ph.D., Pr.Sci.Nat.
Project team:	N.S. Mayekiso, B.Sc. Hons, Other staff (Geological Survey of Japan/AIST) Y. Watanabe, Ph.D. (Team leader), K. Nishimura, Ph.D., T. Takagi, Ph.D., M. Kurihara and R. Yoshikawa (Japan Oil, Gas and Metals National Corporation — JOGMEC)
Primary objectives:	Research and discovery of critical metal resources in South Africa
Duration:	2007/8–20012/13
Budget:	R797 897

Motivation
This project is a five year collaborative project between the Council for Geoscience and the Japanese Geological Survey represented by AIST and JOGMEC. The project aims to identify the critical metal resources potential of South Africa. Critical metals such as rare earth metals, lithium and indium have important applications in industry. Discovering such metals will contribute to, amongst others, growth of the country's economy.

In order for South Africa to progress into a second tier economy, where the manufacture of finished goods and services constitute the dominant income generators, the nation must move away from a dependency on natural resources production and export, as well as an increasing dependency on foreign sources of strategic mineral commodities. In so doing, the local manufacturing industry will need to be supplied with raw materials. Strategic minerals are defined here as metals critical to industry and which have a ready market either within or without South Africa. Examples of strategic metals include indium, REE, uranium, lithium, etc. and their potential replacements.

There is a need to ascertain the strategic and critical minerals and metals need of the South African manufacturing industry with a view to ameliorating demand and supply. Justification for such involvement derives from the fact that at present, the USA and much of Europe are already alarmingly dependent on imports for many of their most critical industrial raw materials. For instance, it is estimated that 98 per cent of America's manganese, 97 per cent of its cobalt, 93 per cent of its aluminum and 91 per cent of its chromium come from foreign ores. More than 50 per cent of its tin, nickel, zinc and tungsten ores are also imported.

CGS and Japanese geologists at a mine site visit.

Progress
To date, a number of field sampling trips have been undertaken in South Africa, focusing mainly on the discovery of rare earth metal resources. Of the samples analysed, only samples from the Vergenoeg fluorite mine and the Phalaborwa carbonatite deposit showed significant rare earth element resource potential.

Conclusions
Project progress is proceeding well. Collaboration with the Japanese counterparts are amicable and positive.

Future activities
Future work will comprise sampling of outstanding targets for rare earth metals, as well as identifying and sampling targets for lithium and indium.

TARGET GENERATION AND GEO-ENVIRONMENTAL MODELLING IN THE GIYANI GREENSTONE BELT — SOUTH AFRICA

Project leader:	A.Y. Billay, Ph.D. (sub-programme 1) and J.S. Ogola (University of Venda)
Project team:	C. Muzerengi, B.Sc. Hons, K. Matshusa, B.Sc., M.B. Mametja, B.Sc. and M.J. Khorommbi, B.Sc.
Primary objectives:	Follow-up work on mineral potential targets and geo-environmental modelling of abandoned mines
Duration:	2009–2011
Budget:	2009/10: R500 000

Motivation
The Mineral Resources Development Unit generated gold potential targets in the Giyani Greenstone Belt using computer-based multi-data integration. The University of Venda and the Council for Geoscience established a collaborative project to undertake follow-up work on these targets in the form of projects for M.Sc. and Honours theses under the supervision of Prof. Ogola (University of Venda) and A.Y. Billay (CGS counterpart).

Progress
The first phase of the field work, as well as the laboratory analysis, has been completed. A second field session was carried out during the last half of the reporting year.

Conclusions
The M.Sc. and Honours theses will be completed within the interval of the duration of the project. However, preliminary results show As and Zn anomalies that are commonly associated with gold mineralisation in the region.

Future activities
The project will continue in 2010/11, however, Honours students are expected to complete the work in 2010.

NORTHERN CAPE

ST-2009-1025 **RESEARCH ON THE NAMAQUALAND METAMORPHIC PROVINCE**

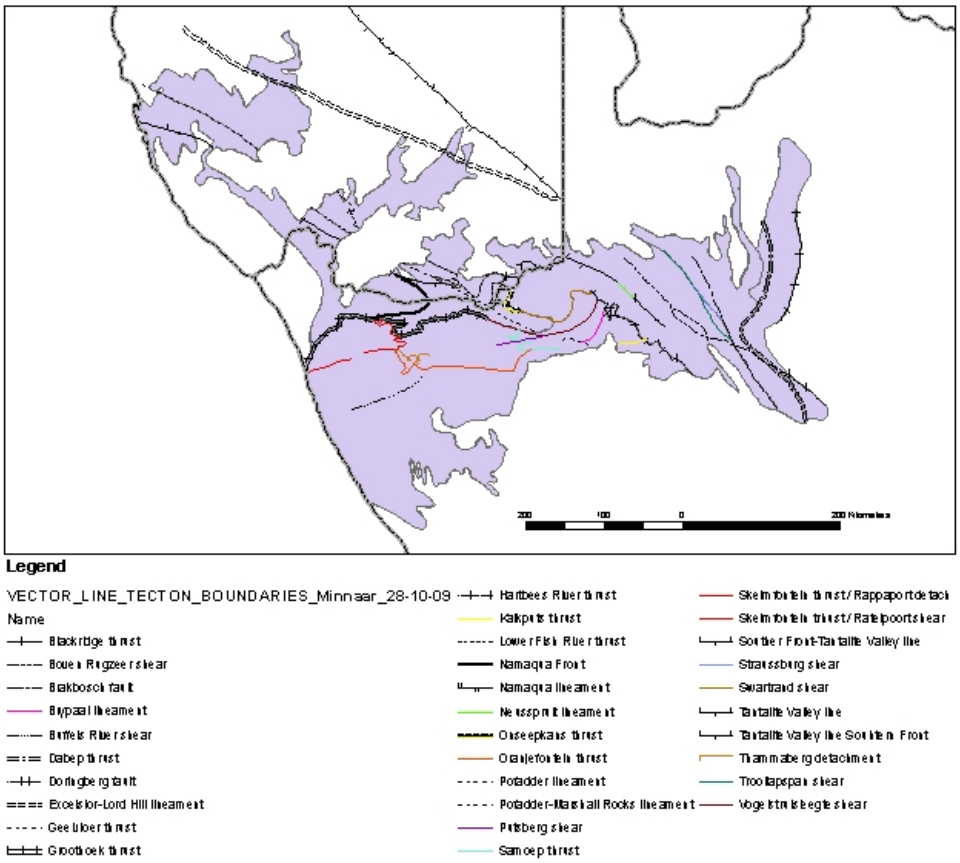
Project leader: H. Minnaar, M.Sc.
Researchers: P.M. Macey, Ph.D., C.H. de Beer, M.Sc.
Primary objective: To promote and assist in research on the Namaqualand Metamorphic Province (NMP)
Duration: April 2008–March 2019
Budget: Total: R5 000 000
2009/10: R528 920

Motivation
The Namaqualand Metamorphic Province (NMP) provides the opportunity to study geological processes of the Precambrian and specifically on crust formation, mineral deposit processes, tectonics, igneous processes and the evolution of the early earth. A large volume of information and data are currently available from previous studies and allow for the compilation of maps and explanations reflecting the current knowledge. The Council for Geoscience, through the nature of its statutory mapping programmes, may be regarded as the custodian of this information. This project is designed to promote and advance research on the NMP.

Project progress
A seamless map and explanation summarising the current status of research on the NMP have been compiled (2008–2009) and a digital database, designed to provide easy access to all currently available data, has been created (2009–2010) and will be continuously updated.

Conclusions
The NMP is defined to include all rock units in the western part of the Namaqua-Natal Metamorphic Belt (i.e. western South Africa and southern Namibia) on which the effects of the Namaqua orogeny (1 300–1 000 Ma) is imprinted. The oldest rock unit is the Orange River Group (2 000 Ma) and the youngest the Koras Group (>950 Ma). Current knowledge suggest that the NMP is the product of terrane accretion with various, previously separated, terranes juxtaposed to form one structural-metamorphic province. However, controversy rages on various issues including the position and nature of the currently identified terrane boundaries. Numerous units call for further investigation through various kinds of study including geochemical, metamorphic, structural, geophysical, seismic, remote sensing and others. Especially geochronology data are sparse.

Future progress
Publications from existing data, advancement of knowledge, the accumulation of data and the development of the mineral potential of the NMP is foreseen to emanate from the project.



Some of the lineaments on the NMP currently recognised as terrane boundaries.

ST-2009-1026 **COMPOSITION AND EVOLUTION OF THE VIOOLSDRIF BATHOLITH**

Researcher: H. Minnaar, M.Sc.
Primary objective: To investigate igneous and tectonic processes active during the evolution of the Vioolsdrif Batholith (2 000–1 700 Ma)
Duration: April 2009–March 2012
Budget: Total: R1 047 560
2009–2010: R315 520

Motivation
A number of previous studies dealt with certain parts of the batholith in isolation but no previous study has investigated the batholith as a whole. These dealt with the delineation and subdivision of the batholith, recognition of the tectonic environment and its relation to its surroundings, the igneous processes active during its evolution and the petrological aspects of its evolution. The current study is intended to focus on certain of these aspects, notably the tectonic environment and igneous processes in the light of modern study methods.

Progress
Initial stages of literature study, field work, sampling and analyses are largely completed and currently time is devoted to data processing and initial write-up.

Conclusions
The character of the Vioolsdrif Batholith, both in the field and geochemically, conforms to an Andean-type tectonic setting, offering a chance of comparison between a modern volcanic arc of known and well studied processes with that of a Precambrian environment. A number of issues complicate such a simple comparison, e.g. the intense deformational and metamorphic overprint on part of the batholith, the total destruction and re-orientation of the initial setting, and the fact that a large part of the batholith has been lost to erosion. These complications limit the conclusions that can be drawn from field observation and necessitate the inclusion of geochemical interpretation in all of the major, trace and rare-earth elements, as well as isotope composition.

Future plans
Data processing, initial write-up and presentation of the results in the form of publications and at congresses are planned.

SEISMOLOGY

ST-2002-0475 **THE COLLECTION OF SEISMOLOGICAL DATA AND MAINTENANCE OF THE SOUTH AFRICAN NATIONAL SEISMOGRAPH NETWORK**

Project leader: J. Steyn, M. Dip. Tech. (Elec. Eng)
Project team: F.A. Delport, B. Tech. (Elec. Eng), T.R. Kometsi, Nat. Dip. (Elec. Eng), G. van Aswegen, Nat. Dip. (Elec. Eng), P. Adamos, Nat. Dip. (Elec. Eng)
Primary objectives: Maintenance and operation of the South African National Seismograph Network (SANSN) to ensure high-quality seismic data to be received at the National Data Centre (NDC) at the Council for Geoscience for analysis and timely release of earthquake information to the public and media, or publication in quarterly seismograph bulletins
Duration: Ongoing

Motivation
To maintain the South African National Seismograph Network in order to produce high-quality seismic data from 21 remotely deployed seismograph stations throughout South Africa while ensuring high station availability. This data are used to produce seismic information for bulletins and seismic hazard maps.

Progress
Methods were implemented in order to enable the seismograph system to send real-time seismic data to a central facility for analysis. These methods utilise the General Packet Radio Switching (GPRS) data transmission protocol, as well as sophisticated data acquisition software at all the stations. The project researchers and maintenance team are in constant communication with the data acquisition software developers in order to implement new software releases for the South African National Seismograph Network. This technology enables data analysts to have access to seismic data immediately after a seismic event for the timely release of earthquake information. All operational stations have been equipped with GPRS communication equipment. All recording systems have been customised for optimal operation. Performance of the network is monitored through a internet-based interface which can monitor parameters such as up-times and data transmission latencies. The technical maintenance team also interacts proactively in the project by monitoring and controlling the hardware functions of the data acquisition systems. An in-house developed monitoring device was implemented at all stations which ensures proper operation of systems without undertaking unnecessary field trips.

Conclusions
Seismograph stations within the SANSN are capable of recording seismic occurrences throughout South Africa. The GPRS communications utilised within the network coupled to the SeisComp data acquisition software allow analysts to produce the bulletins in a timely fashion. As the cost, reliability and bandwidth capability of the GPRS network improves, the network offers the possibility to deploy more stations for more accurate earthquake locations without substantial cost implications to the data transmission. In addition, station performance can be monitored on a continuous basis and the performance of the network has proved to be better than ever before.

Future plans
Reduction of transmission costs coupled to improved methods will continue to be investigated by the technical team. Although mechanisms are implemented to recover station operation in the event of failure to a certain extent, additional electronic circuits will be developed to monitor detailed hardware operation of seismograph stations.

ST-2002-0184 **1) SEISMOLOGICAL MONITORING, ANALYSES AND BULLETIN COMPILATION**
2) COMPILATION AND MAINTENANCE OF CATALOGUE AND DATABASE OF SOUTH AFRICAN SEISMICITY

Project leader: I. Saunders, Nat. Dip. (Geotech.)
Project team: L. Akromah, Nat. Dip., B. Sutherland, T. Molea
Primary objectives: The continued operation of the SANSN is essential for providing daily reports on the seismic activity of the earth's crust in South Africa. The information obtained is distributed in the form of quarterly bulletins and catalogues. The seismological activity monitored by the SANSN provides the valuable data that are required for seismic hazard analysis and insurance claims. Seismological data from the SANSN are preserved for prosperity through a National Earthquake Database and are presented in earthquake catalogues of southern African seismicity
Duration: Ongoing
Budget: R1 278 895

Motivation
This project provides a continuous recorded of seismic activity within the borders of South Africa and southern Africa through the South African National Seismograph Network (SANSN). Analysis of the recorded waveforms presents static and dynamic parameters of the focus emitting the energy and additionally provides information on the medium transmitting the energy. These data also reveal the properties of materials through which the seismic waves propagated.

The SANSN is the only vehicle capable of accurately reporting the distribution of seismic foci in South Africa, the distribution of seismic activity in time and provide a calibrated uniform magnitude scale of recorded events. The information gathered through SANSN is banked in digital format, which affords future generations the ability to revisit seismic data if and when more advanced analysis tools and techniques become available.

The data obtained through the analysis of waveforms are shared with a varied audience both nationally and internationally and are distributed within the organisation, contributing to the Geoscience Mapping and Physical Geohazards thrusts.

Progress
Earthquakes in the Western Cape were used in a short study to determine whether the use of primary and secondary phase arrivals would assist in quantifying the depth of tectonic earthquakes in South Africa. The result of the investigation hinted at shallow depth (h <10 km), however, the solutions produced large errors which can be ascribed to the distance between stations being too great to accurately determine earthquake foci. It appears as if moment tensor solutions would be required to accurately determine earthquake depths.

Earthquake activity in South Africa for the period January to December 2009 was released through ad hoc reporting and quarterly seismological bulletins.

Large teleseismic earthquakes are routinely communicated to the International Seismological Centre in the United Kingdom and the National Earthquake Information Center of the United States.

Future plans
It is foreseen that the National Seismological Database of South Africa will be revisited to re-assess large earthquakes in South Africa to assist in evaluating the risk posed by earthquake activity to South Africa and neighbouring countries.

Table 1: List of tectonic earthquakes with M_L ≥3.0 recorded in South Africa during the period January to December 2009.

Date	Time	Latitude	Longitude	Region	Depth	Magnitude (M_L)
2009/01/08	05:04:41.9	-28.74	32.64	Offshore Cape St Lucia	5.0	3.2
2009/01/27	10:42:59.2	-30.22	29.28	Kokstad area	5.0	3.2
2009/03/08	21:10:17.3	-32.73	20.26	Sutherland area	5.0	3.0
2009/03/11	09:09:36.4	-25.21	29.42	Groblersdal area	5.0	3.3
2009/05/20	22:44:06.0	-29.65	27.69	Lesotho	5.0	3.3
2009/05/21	04:03:34.2	-28.63	28.99	Mkukwini area	5.0	3.4
2009/05/21	04:03:56.9	-28.63	28.98	Mkukwini area	5.0	3.6
2009/07/09	02:38:02.2	-28.84	20.22	Kakamas area	5.0	3.1
2009/07/13	12:53:00.7	-29.49	19.82	Pofadder area	5.0	3.7
2009/08/11	04:30:17.2	-32.79	22.05	Prince Albert area	5.0	3.3
2009/09/03	06:33:01.2	-32.85	22.05	Leeu-Gamka area	5.0	3.1
2009/10/16	18:32:27.7	-31.27	20.71	Williston area	5.0	3.2
2009/10/16	18:35:48.5	-31.29	20.67	Williston area	5.0	3.4
2009/11/04	22:14:11.2	-31.58	24.94	Middelburg area	5.0	3.0
2009/11/05	12:39:54.5	-32.85	22.15	Leeu-Gamka area	5.0	3.7
2009/12/02	17:09:23.7	-33.08	18.27	Hopefield area	5.0	3.0
2009/12/08	23:21:39.2	-32.79	22.13	Leeu-Gamka area	5.0	3.8

Table 2: List of tectonic earthquakes M ≥3.5 recorded in southern Africa during the period January to December 2009.

Date	Time	Location		Magnitude (M_b)	Magnitude (M_L)	Region
		Latitude	Longitude			
2009/01/15	09:04:37.9	-20.91	33.37		3.7	Mozambique
2009/01/19	15:20:17.0	-19.62	34.8		3.9	Mozambique
2009/01/27	17:6:34.9	-11.79	36.71		4.2	Tanzania
2009/01/28	04:27:15.1	-28.58	18.59		3.6	Southern Namibia
2009/02/15	06:35:23.5	-21.22	33.73		3.8	Mozambique
2009/03/04	22:28:48.3	-17.92	24.71		4	Namibia
2009/03/24	02:12:03.1	-11.52	34.62	4.2		Lake Nyasa
2009/04/02	04:24:22.4	-21.58	33.65		4.4	Mozambique
2009/04/18	01:04:06.7	-21.19	33.21		3.8	Mozambique
2009/04/24	17:10:32.6	-21.27	33.34		3.6	Mozambique
2009/04/26	11:01:32.6	-21.15	33.34		3.7	Mozambique
2009/05/01	18:23:06.4	-18.82	23.75		4.3	Botswana
2009/05/01	07:22:22.3	-21.35	33.61		3.5	Mozambique
2009/05/05	18:07:41.9	-20.95	33.31		4	Mozambique
2009/05/16	01:51:29.5	-15.22	31.03		4.5	Mozambique
2009/05/21	04:03:56.9	-28.63	28.98		3.6	Mkukwini area
2009/05/24	20:39:37.6	-17.36	27.52		4.1	Lake Kariba, Zimbabwe
2009/05/24	20:21:57.6	-17.35	27.61		3.8	Lake Kariba, Zimbabwe
2009/05/25	09:48:32.6	-17.4	27.6		3.5	Lake Kariba, Zimbabwe
2009/05/31	15:51:39.5	-21.13	33.24		3.8	Mozambique
2009/06/05	18:21:55.1	-21.31	33.44		3.5	Mozambique
2009/06/07	01:49:14.2	-25.72	15.88		3.8	Namibia
2009/07/07	06:28:47.4	-25.33	16.78		3.7	Namibia
2009/07/13	12:53:00.7	-29.49	19.82		3.7	Pofadder area
2009/07/14	15:19:24.7	-22.05	33.12		4.3	Mozambique
2009/07/31	08:14:38.4	-20.95	14.93		5	Namibia
2009/08/05	03:54:50.9	-16.33	35.42		4.3	Mozambique
2009/08/10	22:54:41.6	-10.65	34.41	4.6		Malawi
2009/08/15	00:02:37.1	-21.03	33.12		3.5	Mozambique
2009/08/28	12:07:52.6	-21	33.47		3.6	Mozambique
2009/09/06	13:41:44.7	-21.26	33.33		3.6	Mozambique
2009/09/06	21:38:41.9	-21.39	33.51		3.5	Mozambique
2009/10/08	14:29:03.7	-17.72	35.06		4.3	Mozambique
2009/10/19	18:51:49.1	-21.29	33.37		3.7	Mozambique
2009/10/19	12:06:12.9	-21.29	33.41		3.9	Mozambique
2009/11/05	12:39:54.5	-32.85	22.15		3.7	Leeu-Gamka area
2009/11/05	04:10:36.2	-10.17	34.03	4.3		Lake Nyasa
2009/12/01	13:44:42.4	-32.68	31.41		3.5	Offshore South Africa
2009/12/06	17:36:32.6	-10.16	33.82	5.3		Malawi
2009/12/06	17:58:13.0	-10.2	33.93	4.7		Malawi
2009/12/06	18:29:12.2	-10.25	33.93	4.9		Malawi
2009/12/06	17:59:53.0	-9.89	33.97	5		Malawi
2009/12/07	09:31:42.9	-10.2	33.81	4.7		Malawi
2009/12/07	03:35:36.1	-10.12	33.9	4.2		Malawi

Table 3: List of mining-related earthquakes larger than M_L=4 for the period January to December 2009.

Date	Time	Region	Magnitude (M_L)
2009/03/13	07:51:28.9	Klerksdorp gold mines	4.0
2009/03/16	14:05:42.1	Klerksdorp gold mines	4.4
2009/04/18	02:38:17.4	Klerksdorp gold mines	4.0
2009/11/29	01:04:46.8	Klerksdorp gold mines	4.0

CO-2006-5606 **OPERATION AND MAINTENANCE OF THE PRIMARY (PS39 – BOSHOF) AND AUXILIARY SEISMIC STATIONS AT SUTHERLAND AND THE ANTARCTIC (AS35)**

Project leader: J. Steyn, M. Dip. Tech. (Elec. Eng)
Project team: M.R.G. Grobbelaar, B.Sc. Hons, F.A. Delport, B. Tech. (Elec. Eng), R.T. Kommetsi, Nat. Dip. (Elec. Eng), G. van Aswegen, Nat. Dip. (Elec. Eng), P. Adamos, Nat. Dip. (Elec. Eng)
Primary objectives: The Council for Geoscience was designated by the Department of Foreign Affairs to act as the technical point of contact regarding Comprehensive Test-Ban Treaty (CTBT) matters. Due to South Africa's obligation to the Nuclear Test-Ban Treaty, the Council for Geoscience is committed to maintain the International Monitoring System (IMS) primary seismic stations at Boshof, Sutherland (auxiliary seismic station) and the auxiliary seismic station at the SANAE base in the Antarctic. The main objective of this project is to ensure a continuous flow of seismic data from the remote sites to the International Data Centre (IDC) based in Vienna, Austria. The objective of the National Data Centre (NDC) operations is to apply methods with respect to the operation and maintenance of the stations in order to meet the requirements of the protocol of the treaty.
Duration: Ongoing
Budget: ±R370 000

Motivation
Due to South Africa's commitment to the treaty, the Council for Geoscience is designated to act as a technical point of contact with respect to seismological and infrasound matters and also to operate a National Data Centre (NDC) which functions within the framework as required by the Comprehensive Test-Ban Treaty Organisation (CTBTO). The organisation's responsibility is to manage the various components within the project and to ensure continuous quality data flow and availability from the seismograph facilities. Apart from the Council for Geoscience's active participation in CTBT matters, the operation of such a NDC and analysis of seismic data, obtained from the local and neighbouring centres which all form part of the International Monitoring System, contribute towards International cooperation and enhance the corporate image of the organisation.

Progress
The station entered its fourth year of operation after certification in December 2004. The Station Operator (SO), who is to be considered as qualified technical staff from the Council for Geoscience, visited the station on a regular basis in order to ensure proper operation of the data communications and data acquisition equipment which are deployed at the borehole site at Boshof. Several configuration change notifications, outage requests and problem reports were generated and communicated with the International Monitoring System's Operational Center (IMS Ops). Monthly reports were also submitted to the IMS Ops as required.

Throughout the reporting period, the SO was in constant contact with experts at the Air Force Technical Application Centre (AFTAC) concerning discussions and resolutions in rectifying problems at the BOSA site. One main achievement regarding the operation of the station was a hardware upgrade which was performed during the beginning of the reporting period. The upgrade enables staff from AFTAC to remotely monitor and identify equipment failure. This enables the SO to react immediately and replace faulty equipment. The upgrade also included an advanced grounding scheme which minimises the effect of thunderstorm activity in the area.

In the past, most station outages were caused by AC power failure at the borehole site and the uninterrupted power supply unit could only supply power for approximately one hour after failure. This was often problematic as some AC load shed conditions often lasted for periods of up to three hours. The AFTAC delegation who visited the central facility from 7 to 14 April 2009 installed a power back-up system which will address the power outage issues at the site. The installation was thoroughly tested by the design team at AFTAC before it was deployed in South Africa.

Date	Time	Location		Magnitude (M_b)	Magnitude (M_L)	Region
		Latitude	Longitude			
2009/12/07	06:01:28.0	-10.14	34.01	3.8		Malawi
2009/12/08	23:21:39.2	-32.79	22.13		3.8	Leeu-Gamka area
2009/12/08	03:08:51.7	-9.95	33.84	5.7		Malawi
2009/12/11	04:49:04.9	-9.98	33.81	4.8		Malawi
2009/12/12	02:26:58.2	-9.96	33.88	5.3		Malawi
2009/12/19	23:19:14.5	-9.87	33.99	5.1		Malawi

Conclusions
On 24 December 2004 the station was certified and the Council for Geoscience has since then entered into a contractual agreement with the CTBTO. The SO has continually communicated operational matters between AFTAC and the IMS Operational Centre. After the upgrade of monitoring equipment, improvement of grounding and installation of the

power back-up system, the failure of equipment was limited and the SO was in a position to almost react immediately on outages in order to swap out defective components. The SO still needs to be informed by AFTAC on system failures. The advantage is that lesser skilled staff may respond and rectify station problems.

Future plans
Irrespective of the technical upgrades that were performed at the station, the SO wishes to gain access to the AFTAC system monitoring system to react immediately in the event of system failure issues. To further improve mission capable uptimes, the SO will suggest, and possibly design, the deployment of additional monitoring equipment at the station. The broadband sensor will need to be replaced during the beginning of the next reporting period.

CO-2006-5620 **INFRASOUND STATION IS47**

Project leader: J. Steyn, M. Dip. Tech. (Elec. Eng)
Project team: F.A. Delport, B. Tech. (Elec. Eng), D.L. Roblin, B.Sc. Hons, T.R. Kometsi, Nat. Dip. (Elec. Eng), G. van Aswegen, Nat. Dip. (Elec. Eng), P. Adamos, Nat. Dip. (Elec. Eng)
Primary objectives: The CGS has been appointed as the technical point of contact and was awarded the contract to operate and maintain the infrasound station (IS47) in Boshof as part of South Africa's commitment to contribute infrasound data to the International Data Centre (IDC) based in Vienna, Austria. The station forms part of one of the technologies that are used in the Global Monitoring System as part of the verification regime to detect atmospheric pressure changes which may occur after a large explosion. Atmospheric changes may also be caused by other sources than explosions such as objects entering the earth's atmosphere, supersonic aircraft or volcanic eruptions. Since research in this field is limited, studies and research in other fields will contribute towards defining signatures for explosions. The main objective of the project is to ensure that quality infrasound data are received in a timely fashion at the IDC for data analysis and to enable researchers to conduct further studies.
Duration: Ongoing
Budget: ±R370 000

Motivation
As in the case of the primary seismic station (PS39) the Council for Geoscience has been designated by the Department of Foreign Affairs as the technical point of contact for the operation and maintenance of the IS47 infrasound station. The infrasound station IS47 is one of the 60 infrasound stations of the International Monitoring System (IMS) of the Comprehensive Test Ban Treaty Organisation (CTBTO). The technology of infrasound (very low frequency sound waves) is important in the detection of atmospheric nuclear explosions and complements the other technologies chosen by the CTBTO, viz. seismic, hydro-acoustic and radionuclide, for monitoring adherence to CTBT. As mentioned, research in the field of infrasound data is limited and contributing quality data from this site may contribute towards studies in atmospheric wave behavior.

Progress
The infrasound station was certified on 12/12/2005 by the Preparatory Technical Secretariat. CGS technical personnel have operated and maintained the station during this reporting period. Routine maintenance and ad hoc repairs were performed from time to time. Due to the deployment of solar panels at each of the remote array sites, the array suffered from vandalism (removal of solar panels and batteries). The SO did a thorough investigation into deploying appropriate security equipment. Such equipment was deployed at selected array elements which resulted in the non-occurrence of vandalism. Security matters were also taken up with the local police who improved patrol and awareness matters. All related issues were communicated to the Department of Foreign Affairs.

The satellite communications equipment was also upgraded during the reporting period.

Conclusions
The CGS staff gained invaluable experience during the operation and maintenance of the station, especially in maintaining the assortment of data communications and acquisition equipment as used in the project. Station performance was good and no failures were experienced as a result of AC power outages. The equipment deployed at the central recording facility is backed up by a vast bank of batteries. Due to the age of the batteries, it was noted that the batteries of the various infrasound elements are due for replacement.

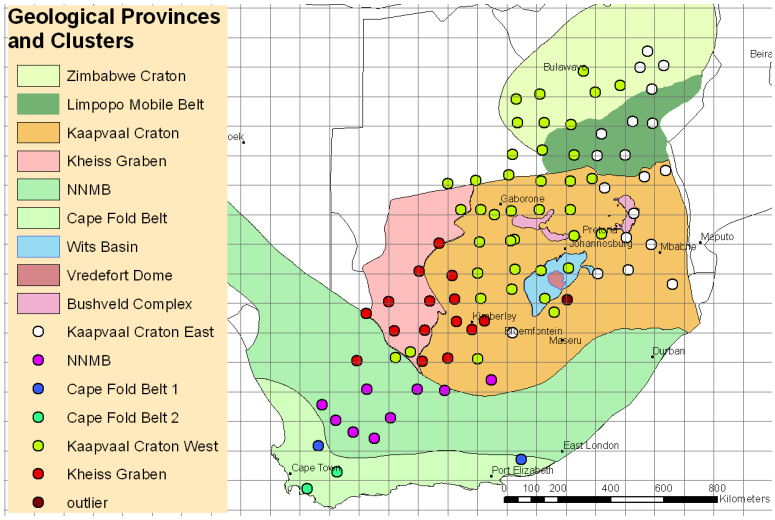
Future plans
As the radio telemetry and summing manifold vaults are located beneath the ground surface, water tends to infiltrate these facilities during the rainy season. To protect the delicate electronic equipment located in these vaults, the SO will suggest that the IMS Operational Centre deploys submersible water pumps in each of the vaults. It will also be suggested that dedicated hardware-monitoring modules be deployed to monitor hardware system performance and enable the local caretaker (on site) to perform swapouts of defective components. This will limit unnecessary field trips

by qualified electronic maintenance technicians. Alternative power sources, and their possible implementation at the sites, will be investigated.

ST-2010-1071 **CRUST AMPLIFICATION OF GROUND MOTION IN DIFFERENT REGIONS OF SOUTH AFRICA**

Project leader: A. Cichowicz, Ph.D.
Project team: E. Kgaswane, M.Sc., J. Ramperthap, B.Sc. Hons and M. Singh, B.Sc. Hons
Primary objectives: The objective is to determine the amplification factors of the seismic signal for different regions in South Africa
Duration: 2009/2010

Progress
The spectrum of ground motion at a site is controlled by seismic source, path and site parameters. The filter function of the site is distance independent. The term site generally refers to the ground level where hard rock occurs, hence the effect of the ground motion due to near-surface soil amplification is not analysed. The top 10 km of the crust has some influence on the seismic signal. Published results of shear wave velocity models for South Africa have been utilised in this paper. Exploratory data analysis was carried out by applying cluster analysis in order to determine groupings within the 89 velocity profiles. Cluster analysis objectively groups data, and the spatial distribution of clusters, in most cases, correlates well with the well known geological provinces. This is not surprising, since the geological provinces have distinct properties well beneath crustal level, as shown by independent evidence.



Map of South Africa with marked geological provinces. Dots represent the position of broad-band seismic stations; the colour of dots corresponds to the respective clusters. Note the close relation of geological provinces with clusters.

Conclusion
Results from the modelling of the transfer function of the upper crust indicate that crustal amplification factors for Fourier amplitude spectra above 0.4 (2.5 sec) vary from 1.1 to 1.4 from province to province. Site-specific investigation should include the detail structure obtained from the reflection-refraction profiles in the upper 2 km of the crust as that part of the velocity profile can cause some additional amplification. In the presented case study, an increase in ground motion amplification is from 1.15 to 1.5.

ST-2010-1072 **ATTENUATION MODEL FOR MINE DISTRICTS**

Project leader: A. Cichowicz, Ph.D.
Project team: D. Birch, B.Sc. Hons
Primary objectives: The objective is to determine the attenuation parameters that control ground motion in mining districts
Duration: 2009–2011

Progress
In seismology, the evaluation of the attenuation of ground motion amplitude is an essential problem for the seismological characterisation of a region. The attenuation of the P- and S-waves in the Kosh and Far West Rand mining districts is estimated by using the coda wave decay and coda normalisation methods. The coda quality factor Q_c^{-1} is computed from the slope of coda wave amplitude decay and body waves quality factors, Q_p^{-1} and Q_s^{-1} values are determined from the ratio of body wave picks to coda wave amplitude at a fixed lapse time. These analyses are done for the central frequencies 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 20 and 24 Hz using band-pass filters. The strong observed frequency dependency of the quality factors is modelled using the $Q^{-1}(f) = Q_o^{-1} f^n$ parametric model. The quality factor (Q_c^{-1}) was estimated in the Kosh mining area using local events (epicentre <30 km away) recorded by a single station. The results show that the Q_c^{-1} value varies from 0.0037 to 0.00033 (Q_c from 270 to 3 030). The frequency dependence was then modelled using a power-law function. The best fit model parameters for Q_c^{-1} (f) for the coda decay of the three components are:

$Q_{c\text{-}Z}^{-1}=0.0135\ f^{-1.14}$, $Q_{c\text{-}N}^{-1}=0.0141\ f^{-1.18}$, $Q_{c\text{-}E}^{-1}=0.0115\ f^{-1.14}$.

The coda normalisation method was used to obtain the quality factors for Q_p^{-1} and Q_s^{-1} for three-component data. The obtained values of Q_p^{-1} vary from 0.017 to 0.0031 (Q_p from 59 to 322) and of Q_s^{-1} from 0.012 to 0.0013 (Q_s from 83 to 769) in the frequencies ranging from 3 to 24 Hz. The frequency dependent relationships of Q_p^{-1} and Q_s^{-1} for the three components of P- and S-waves are expressed as:

$Q_{p\text{-}Z}^{-1}=0.046\ f^{-0.86}$, $Q_{p\text{-}N}^{-1}=0.0780\ f^{-1.1}$, $Q_{p\text{-}E}^{-1}=0.0318\ f^{-0.885}$,
$Q_{s\text{-}Z}^{-1}=0.026\ f^{-0.82}$, $Q_{s\text{-}N}^{-1}=0.0215\ f^{-0.86}$ and $Q_{s\text{-}E}^{-1}=0.023\ f^{-0.92}$.

The frequency dependence of parameters for the P- and S-waves are calculated for a set geometrical spreading constant, γ, which is fixed at unity for distances less than 60 km and at 0.75 for distances in the range between 60 to 120 km. The ratio Q_p^{-1}/Q_s^{-1} varies from 1.5 to 2.5.

Conclusion
The coda normalisation method provided the Q^{-1} models of the P- and S-waves propagating through the crust for a given geometrical spreading model. Quality factors for P- and S-waves were calculated as functions of frequency for a distance interval of 2–120 km. The coefficient 'n' ranges from 0.8 to 0.9 for the S-wave and from 0.9 to 1.1 for the P-wave. Strong frequency dependency of Q_p^{-1} (f) and Qs^{-1} (f) suggests heterogeneity of the medium. S- and P-wave frequency dependencies are similar and the ratio Q_p^{-1}/Q_s^{-1} varies from 1.5 to 2.5. The coda wave decay method based on the single backscattering model provided the quality factor Q_c^{-1} for the Kosh mining district using three-component waveforms from a single accelerometer station for a given geometrical spreading constant of 1. The events that were used were located at distances of 2–30 km from the station. The frequency dependence of the quality factor was described by the power-law function with the parameters 'n' and 'Q_o' which varied from 1.14–1.18 and 71–87 respectively.

ST-2010-1091 **EVALUATE AWARENESS OF EARTHQUAKE RESISTANT DESIGN IN SOUTH AFRICA**

Project leader: T. Pule, B. Tech. (Geol.)
Project team: M. Singh, B.Sc. Hons
Primary objectives: This work aims to gain information from the engineering community on their knowledge of earthquakes in South Africa and their thoughts for the design and construction of earthquake resistant infrastructure. This is done by means of evaluating results of a questionnaire distributed to industry.
Duration: Ongoing
Budget: ±R370 000
2009/10: R65 000

Motivation
The seismological monitoring network routinely records earthquake occurrences throughout South Africa. Extensive research is conducted annually by the Seismology Unit on earthquakes in South Africa, its frequency and probability of occurrence and wave propagation characteristics. However, this information may not be reaching the engineering community because there is an increase in the number of buildings that have been constructed with no consideration to the risk from earthquake ground shaking. This survey is aimed at understanding industry's perspective on earthquakes and earthquake resistant design.

Conclusions
The response from this survey was relatively poor with less than 10 per cent of the pool of candidates responding to the questionnaire. Only 19 per cent of the respondents take earthquake ground motion into account in their design/construction. Of this 19 per cent, many knew about the existence of seismic design codes for their project applications. They provided in detail their opinions on how they apply earthquake engineering techniques within their projects. Furthermore, most respondents knew that soft storey construction is not suitable for earthquake prone areas,

while others stated that pillars can be stiffened to adequately support the building above. Some respondents stated that one needs to incorporate a factor of safety into construction and many stated that design codes guide one to do this. Clearly, construction projects are unique and costs and losses vary, but respondents confirmed that one can expect large monetary losses, high numbers of fatalities and property loss if there were collapse of buildings, dams, bridges, etc.

Future activities
While earthquakes are infrequent in this country, they are a real threat to built-up metropolitan areas, hence all buildings need to be designed to be earthquake proof and the use of seismic design codes should be enforced. The research output from the Seismology Unit of the Council for Geoscience needs to be more readily available to people responsible for the planning, designing and construction of infrastructure.

This survey should be repeated and made more attractive by providing incentives in order to encourage participation.

ST-2007-0957 **HIGH-FREQUENCY RAYLEIGH WAVE TOMOGRAPHY OF THE BUSHVELD COMPLEX – 2ND PHASE**

Project leader: E. Kgaswane, M.Sc.
Research supervisors: A. Nyblade (Penn State University, USA), P. Dirks (James Cook University, Australia)
Primary objectives: The aim in the second phase of the research project is to investigate details of the upper and lower crust across the Bushveld Complex using new estimates of short-period Rayleigh wave group velocities and high-frequency receiver functions
Duration: 2005–2011

Motivation
Past geophysical studies of the Bushveld Complex (BC) indicate the presence of a subsurface continuous and connective mafic sheet connecting the discrete mafic bodies (limbs) of the BC exposed on the surface. However, these studies provide an ambiguous interpretation of this connectivity and continuity between the mafic exposures. Studies indicate the absence of this subsurface continuous layer in the upper crust and as such propose the western and eastern limbs of the BC to be inward-dipping sheets with a gap of 50–100 km towards each other. Recent gravity modelling is consistent with the presence of a mafic sheet in the upper crust that could possibly be a connective layer between the western and eastern limbs of the BC. This study intends to evaluate the merits of each of these models in terms of the findings.

Progress
For the first phase of the project, research findings entitled *Shear Wave Velocity Structure of the Lower Crust in southern Africa: Evidence for Compositional Heterogeneity within Archaean and Proterozoic Terrains* have been published by the *Journal of Geophysical Research*. A paper for the findings in the second phase is being drafted and there have already been initiatives kick-starting research activities for the third phase. The third phase involves characterising the tectonic architecture of basins and terrain boundaries in South Africa using the shear wave results obtained from the first phase of the research project.

Conclusions
The main finding in the second phase of the research project is that the upper crust in the centre of the BC shows a mixture of felsic and mafic compositions with a mean shear wave velocity of 3.5 km/s. This result implies that the mafic connectivity of the limbs in the centre of the BC which was probably part of the single magmatic unit during the initial phase of the mafic emplacement could have been either weathered or eroded by the updoming and/or upwarping of the crust that took place during or just after the emplacement of the mafic phase of the BC. The lower crust in most parts of the BC and vicinity shows a significant portion of the lower crust with shear wave velocities that are ≥4.0 km/s. This finding is consistent with the findings in the first phase and implies a crust that has been magmatically intruded and underplated.

Future plans
The aim is to have the research findings of the second phase published in an internationally peer-reviewed journal and to continue towards completion of the third phase of the research project by the end of 2010. A complete research thesis encompassing all the phases of this research project will be submitted to the Faculty of Science of the University of the Witwatersrand by mid-2011.

ST-2007-0956 **IMAGING THE AFRICAN SUPERPLUME**

Project leader:	M. Brandt, M.Sc.
Research supervisors:	G. Cooper (University of the Witwatersrand), S. Grand (University of Texas, Austin)
Primary objectives:	Research and training as part of AfricaArray through imaging the upper mantle beneath southern Africa with seismic waves, as well as imaging the deep mantle through seismic travel time tomography
Duration:	2005–2010

Motivation

This project forms part of the AfricaArray programme. AfricaArray is an initiative to promote, in the full spirit of the New Partnership for Africa's Development (NEPAD), coupled training and research programmes for building and maintaining a scientific workforce for Africa's natural resources sector. It is a joint effort between Penn State University, USA, the University of the Witwatersrand and the Council for Geoscience.

This project aims to increase the understanding of the African Superplume. The African Superplume is one of the most prominent and enigmatic features of the earth's mantle. Covering much of the southern African subcontinent it is characterised by seismic wave velocities that are lower than other structures in the earth's lower mantle. The superplume also lies beneath an area with an anomalously high topography, suggesting a geodynamic relationship between the superplume and the formation of plateaus and rift valleys in eastern and southern Africa.

A better understanding of the nature and origin of the African Superplume advances the understanding of regional seismotectonics. Using broadband seismic data the research aims to improve images of the African Superplume and investigates the geodynamic relationship with eastern and southern Africa.

Progress

A research paper was submitted for publication to the *Journal of Geophysical Research* and changes are currently being implemented. The project requires collaboration with African and international scientists as part of the AfricaArray programme. Research results have important industrial application for seismotectonics and long-term seismic hazard analysis.

Future plans

A second publication will be submitted to *Geophysical Research Letters* and the two publications, together with a summary/introduction, will be submitted as a Ph.D. thesis by December 2010.

SPATIAL DATA MANAGEMENT

Geodatabase — Development and Implementation (0856), System and Application Maintenance (0277), Maintain GIS Metadata (0276), Data Administration on the Spatial Data Engine (0277) and Database Administration (0793)

Project leader:	H.J. Brynard, Ph.D.
Project team:	K. Wilkinson, Nat. Higher Dip. Carto., D. Sebake, M.Sc. (Environ. and Dev.), D. Grobbelaar, Nat. Dip. Carto., S. Noruka, B.Sc. Hons
Budget:	R764 875

This project involves the planning, development and implementation of a Geographic Information System for input, storage and retrieval. Editing, modelling and cartographic presentation of geologically related data are the core functions of the unit.

Servers, workstations, operating system software, peripheral devices and applications in the SDM Unit must be continually maintained.

Metadata, information on the source and reliability of the data must be maintained for all the spatial data that the SDM Unit produces.

The spatial data that the SDM Unit captures and maintains need to be managed and correctly administered for the effective usage thereof.

The ArcSDE/SQL Server forms part of the CGS corporate database and these databases must be administered and maintained for the effective operation thereof.

Geode Systems — Data Administration GEODE (0785) and Database Administration (0473)

Project leader:	H.J. Brynard, Ph.D.
Project team:	K. Wilkinson, Nat. Higher Dip. Carto., S. Tucker, Dip. S.B.M., F. Nkosi, Nat. Dip. (IT)
Budget:	R173 101

The non-spatial data that the SDM unit captures and maintains need to be managed and correctly administered for the effective usage thereof.

The Oracle databases form part of the CGS corporate database and these databases must be administered and maintained for the effective operation thereof.

GeoPortal Maintenance/Applications (0856)

Project leader:	H.J. Brynard, Ph.D.
Project team:	S. Tucker, Dip. S.B.M., M. Roos, Nat. Higher Dip. Carto.
Budget:	R181 339

The GeoPortal is maintained by staff of the SDM unit who also develop new applications.

1:50 000 Geological Maps (GIS)/(Cartography)

Project No.	Title	Project Leader and Team	Costs
ST-0822	**2429AD Zebediela East (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., S. Noruka, B.Sc. Hons	R86 071
	2429AC Zebediela West (Cartography)	D. Grobbelaar, Nat. Dip. Carto., M. Sono, Nat. Dip. Carto.	
ST-0610	**2926AB Maselspoort (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., E. Magagane, Nat. Dip. Carto.	
ST-0590	**2926BB Thaba Nchu (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., E. Magagane, Nat. Dip. Carto.	R27 344
ST-0755	**2429AB Tshwene (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., S. Noruka, B.Sc. Hons, M. Sono, Nat. Dip. Carto.	R54 949
ST-0604	**2527DD Broederstroom (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., C. Thomas, Nat. Higher Dip. Carto.	R19 507
ST-0726	**2926BA Sannaspos (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., E. Magagane, Nat. Dip. Carto.	R46 833
ST-0911	**3318AD Darling (GIS 100% Cartography 80%) 3318AC Yzerfontein (GIS 100% Cartography 80%)**	K. Wilkinson, Nat. Higher Dip. Carto., H.J. Brynard, Ph.D., S. Noruka, B.Sc. Hons., H. Sello, M. Sono, Nat. Dip. Carto.	R48 397
ST-0346	**3217DB & DB Vredenburg (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., E. Dixon (contract worker), Nat. Dip. Carto., C. Thomas, Nat. Dip. Carto.	R65 250
	3218CA & CC Velddrif (Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., E. Dixon (contract worker), Nat. Dip. Carto.	R69 840

1:50 000 Geotechnical Map (Cartography)

ST-0762	**2930DD & 2931CC Durban (Cartography)**	K. Wilkinson, Nat. Higher Dip. Carto., E. Dixon (contract worker), Nat. Dip. Carto.	R37 050

1:250 000 Geological Maps (Cartography)

ST-2002-0036	**2816 Alexander Bay**	K. Wilkinson, Nat. Higher Dip. Carto., C. Thomas, Nat. Dip. Carto., M.P. Nkosi	R25 504
ST-2002-0014	**3017 Garies**	K. Wilkinson, Nat. Higher Dip. Carto., M.P. Nkosi, D. Grobbelaar, Nat. Dip. Carto.	R49 488

1:250 000 Gravity Maps (Cartography)

	2326 Lephalale		
	2522 Bray		
	2524 Mafikeng		
	2526 Rustenburg		
	2622 Morokweng		
	2624 Vryburg		
	2626 Wes-Rand		
	2720 Noenieput		
	2722 Kuruman		
	2724 Christiana		
	2726 Kroonstad		
	2818 Onseepkans		
	2820 Upington		
	2822 Postmasburg		
	2824 Kimberley	K. Wilkinson, Nat. Higher Dip. Carto., C. Thomas, Nat. Dip. Carto., A. Smith, Nat. Dip. (IT)	R25 504
	2918 Pofadder		
	2922 Prieska		
	2924 Koffiefontein		
	3018 Loeriesfontein		
	3020 Sakrivier		
	3022 Britstown		
	3024 Colesberg		
	3118 Calvinia		
	3120 Williston		
	3122 Victoria West		
	3124 Middelburg		
	3220 Sutherland		
	3222 Beaufort West		
	3224 Graaff-Reinet		
	3320 Ladismith		

WATER GEOSCIENCE

ST-2010-1090 **TOWARDS A CONCEPTUAL HYDROGEOLOGICAL MODEL OF THE SOUTPANSBERG GROUP AND THE BLOUBERG FORMATION**

Project leader: K.F. Netili, M.Sc. (Hydrogeol.)
Project team: T. Ntuli, H. Mengistu, G. Brandl and L.K.C. Strachan

Motivation
Although groundwater resources are available throughout the entire area, they vary in quantity depending on the hydrogeological characteristics of the underlying aquifer. Considering that the development of the area will put much more pressure on the existing or known resources, it means that more information will be needed to explore the hidden groundwater resources. Investigating groundwater availability and quality as an alternative source of water for emerging farmers and economic development is the main focus of this research project.

The most critical focus areas of research are to:

- Synthesise scattered existing information relating to the geology and hydrogeology of the area
- Understand the hydrogeology of the area
- Conceptualise groundwater flow regime dynamics and flow paths delineation
- Develop a conceptual hydrogeological model of the area.

Progress
Literature review and data collection commenced but the project was suspended due to budgetary constraints.

Conclusions
A small component of the first phase (literature review) of the project was undertaken. The project will continue as soon as funds become available.

ST-2010-1089 **MINE WATER QUALITY AND TREATMENT**

Project leader: K.A. Majola, M.Sc. (Hydrogeol.)
Project team: L.K.C. Strachan, Ph.D.
Project duration: April 2009–March 2010
Budget: R349 070
Primary objective: To compare processes, problems and remediation methods in two different contexts (upstream: hard rocks; downstream: karstic aquifers)

Motivation
South Africa's growing population has lead to an immense pressure on the country's limited water resources and research has shown that the country's water quality is declining. Mining and related industries are the major role players in metal pollution. Mine effluents are threatening streams and rivers. Acid mine drainage (AMD) has been studied extensively but there are still gaps in understanding it. Since water will always be linked to the mining process, this project attempts to understand this linkage in order to be able to manage and protect water resources for sustainability. Various treatment options will also be reviewed for reasons of mainly the post-closure period. In this case passive treatment options have to be explored.

Progress
A desktop study was done and a few possible study sites identified, including the East and West Rand basins of the Witwatersrand and some coal mines in the Mpumalanga Province.

Conclusion
It is essential that this project is resumed because the country is currently facing major mine water-related challenges and solutions are urgently required.

ST-2009-1006 **GROUNDWATER CHARACTERISATION OF SUITABLE SOURCES FOR SUSTAINABLE WATER RESOURCES IN THE NORTHERN CAPE**

Project leader:	K.A. Majola, M.Sc. (Hydrogeol.)
Project team:	K.F. Netili, M.Sc. (Hydrogeol.)
Research supervisor:	L.K.C. Strachan, Ph.D.
Project duration:	April 2009–March 2010
Budget:	R306 835
Primary objective:	To characterise the sustainability of groundwater resources in the province since it is a water-stressed region

Motivation

The Northern Cape Province is a typically dry, semi-arid region, dependent on both surface and groundwater resources. Due to the high evaporation potential and low, variable rainfall in the Northern Cape, groundwater resources are particularly important. The arid climate and limited potential of water resources that naturally occur in the water management area of the Northern Cape are a major constraint. For most people living in the Northern Cape Province, groundwater is their only potable water supply. Surface water resources are primarily associated with containment dams in the lower Orange River catchment. Water from these storage reservoirs is mainly used for irrigation purposes. Approximately 30 per cent of the Northern Cape population relies on groundwater resources of variable quality, with roughly 87 towns and settlements depending on groundwater resources, compared to 121 towns and settlements relying on surface water supplies. Water quality in many regions of the province is poor and high nutrient levels exist. Generally, the western areas of the province are characterised by deprived groundwater quality in the range of Class 2 to Class 3 according to DWAF standards. Management and protection of groundwater quality is of concern as the resource is vulnerable to salinisation (through seepage of seawater or irrigation water), seepage from agricultural run-off, industrial and domestic discharges and resultant high nitrate and phosphate levels. There is a need for increased groundwater monitoring, both for quantity (to determine safe sustainable levels of abstraction) and for quality (to determine fitness for use of the water, toxic and hazardous health effects) and the need for protection or remediation.

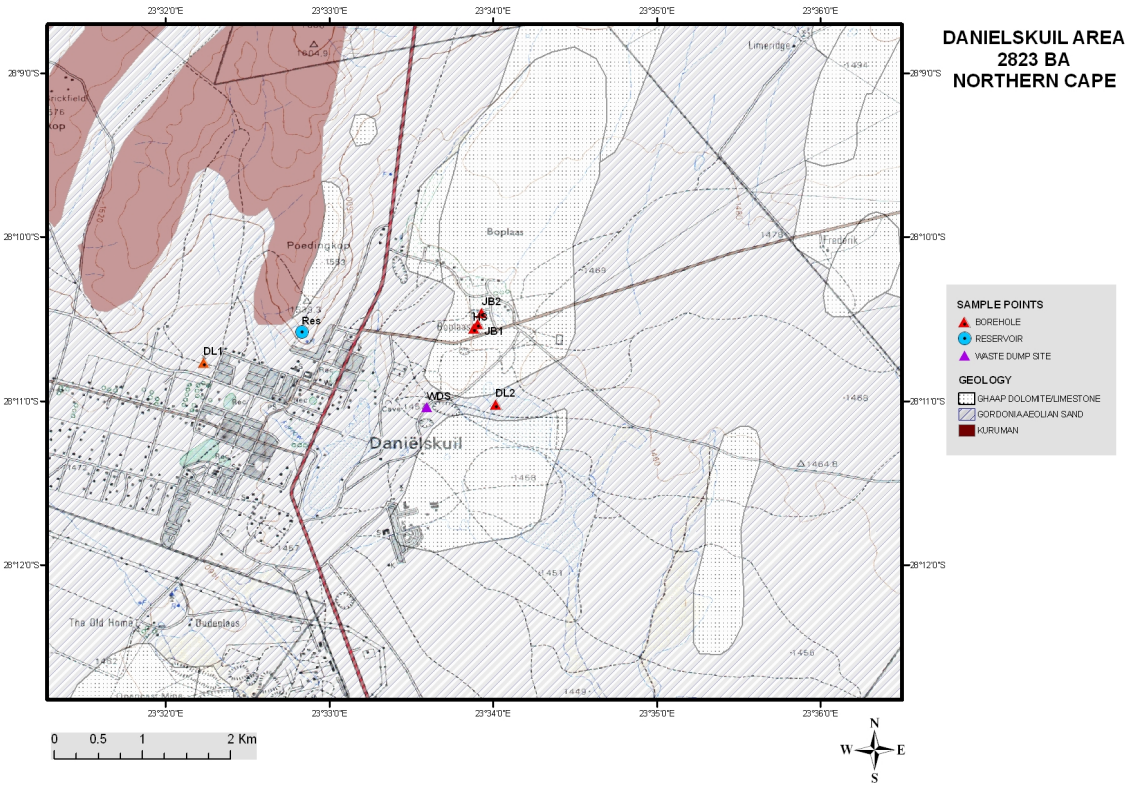
Progress

During Phase I of the project, which included a hydrocensus, a wealth of data for the Daniëlskuil study area was gathered. Information and data emanating from Phase I (2008/09) and previous studies of groundwater in the Northern Cape will be reviewed in order to ascertain the information that exists regarding groundwater characterisation. Sampling and analysis have already been conducted to identify water types in the area, and a preliminary vulnerability map was produced.

Conclusion

Both surface and groundwater sources are approaching complete development and utilisation in the Northern Cape Province. Almost all surface water in this province is of poor quality. Groundwater is thus a vital source of domestic water supply in this province and has to be sustained through appropriate management, monitoring and protection strategies. In order to attain a better perspective of water quality and supply in the area, a need exists for the enhancement of data sets and accessible databases of information for local government as the entity responsible for water services provision.

Unfortunately, this project was removed from the Annual Technical Programme due to a lack of funding.



Locality map of Daniëlskuil.

ST-2008-1007 **EXPLORING THE LINKS BETWEEN GROUNDWATER AND THE GROWTH AND DEVELOPMENT PARADIGM OF DWAF WITHIN AN IWRM AND SUSTAINABLE DEVELOPMENT FRAMEWORK**

Project leader: U. A. Rust, M.Phil. (Sustainable Development Planning and Management), B.Sc., B.A.
Primary objective: To delineate aspects related to groundwater management in South Africa from an IWRM and sustainable development perspective
Duration: 2007/08–2010/11

Motivation
Globally, there is recognition of the growing importance of groundwater in water security. Groundwater as a resource does, however, present unique challenges and is not being managed optimally. In South Africa, the situation is not much different. Groundwater has a pivotal role to play in water services provision in South Africa, particularly in the rural areas of the country where poverty is rife. However, studies show that there are challenges to overcome in South African groundwater management, for instance, a lack of valuing groundwater, expertise and coherent planning. It is believed that positioning groundwater within the current paradigms guiding water policy in South Africa, namely Integrated Water Resources Management (IWRM), sustainable development and Water for Growth and Development (WfGD), will assist in the management of this important and challenging resource.

Progress
This was the second year of the project. Unfortunately, funding was no longer available because of the suspension of the CGS Annual Technical Programme. However, the project continued with desk-top work on the use of sustainability indicators in the management of water. The project explored the need for indicators, as well as the fundamentals and caveats of indicator usage. In particular, some attention was devoted to the issue of scale, and the different sustainability horizons in sustainable development space-time. Other aspects that were considered are data availability, measurability and perspective.

Conclusions
Although the project was in effect halted due to a lack of funding, a set of strategic-level principles for the use of sustainability indicators in water management was derived from desk-top work. Depending on the availability of funding, the next phase of the project will be a desk-top study of the trans-disciplinary nature of performance management paradigms and indicators in the public water sector of South Africa as an enabler for sustainable development.

WESTERN CAPE

DEVELOPMENT OF HYPERSPECTRAL REMOTE-SENSING TECHNIQUES TOWARDS GEOLOGICAL MAPPING

Project leader: L. Ngcofe, M.Sc.
Project team: H. Minaar, M.Sc., L. Chevallier, Ph.D.
Primary objective: To investigate the potential of hyperspectral remote sensing towards geological mapping
Duration: 2008/9–2009/10

Motivation

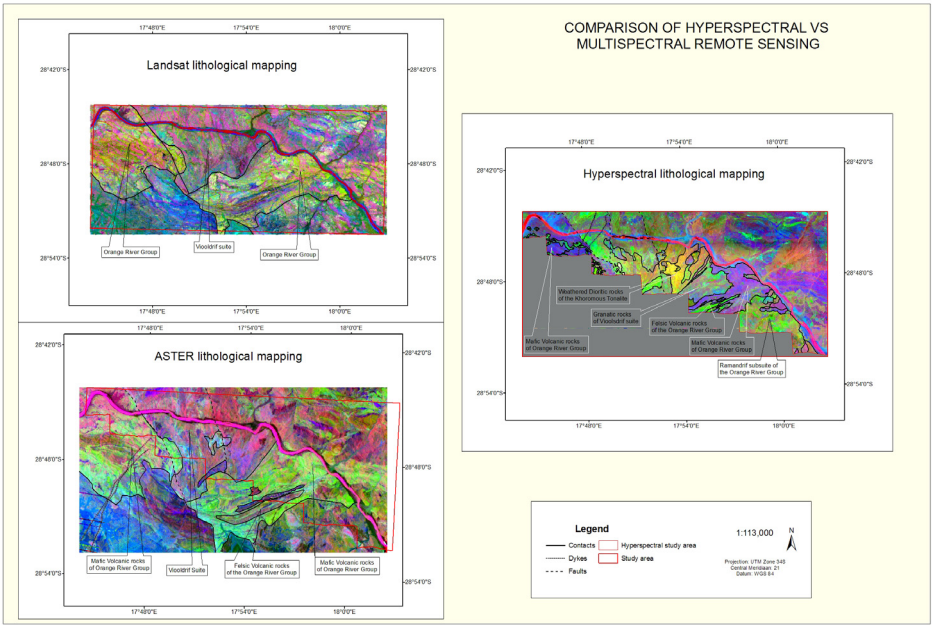
The application of remote sensing in geology plays an important role in geological mapping, especially in areas with limited infrastructural access and harsh environmental condition. It provides an opportunity to analyse and map surface geology in a relative short time and with lower costs.

Hyperspectral remote sensing is a relatively new technology that requires to be investigated for its full potential with regard to the identification of geological features. The research will therefore attain:

- to determine whether hyperspectral data could give a better identification of lithological units compared with available multispectral data
- to develop hyperspectral techniques towards geological mapping
- to establish new methodologies that will aid in the improvement of high-scale geological mapping.

Progress

The detailed report on the comparison of multispectral (Landsat and ASTER) images with hyperspectral images has been completed. The results revealed that more information can be retrieved when using hyperspectral data than multispectral data.



Conclusion

The hyperspectral investigation provides a new research method for mapping geological lithologies occurring in the 1:50 000 Nous sheet study area. This technique revealed new geological information not readily acquired from other traditional mapping techniques. The research has produced reliable and accurate results and is therefore recommended for further geological mapping investigations.

Future activities

The capturing of hyperspectral data to expand lithological mapping within the 1:50 000 Nous sheet is required. Other geological investigations such as mineral mapping need to be researched using this technique as it provides more geological information.

THE ARCHITECTURE OF A CRUSTAL-SCALE SHEAR ZONE: STRUCTURAL GEOLOGY, KINEMATICS, MECHANICS AND MINERALISATION OF THE POFADDER SHEAR ZONE, NORTHERN CAPE PROVINCE

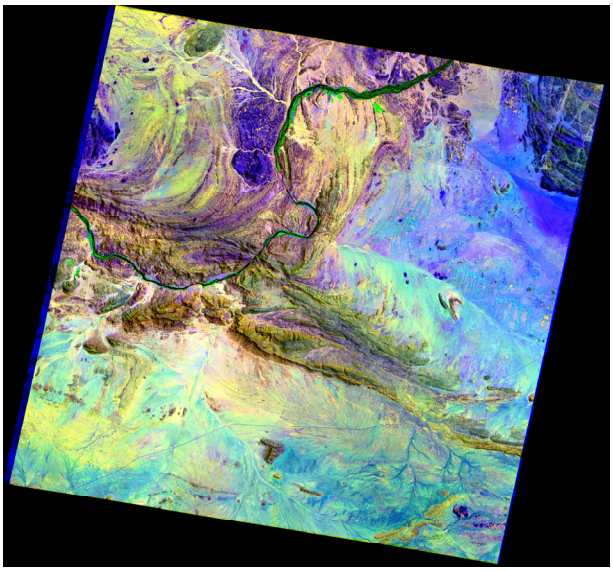
Project leaders: P.H. Macey, Ph.D.
Project team: C.W. Lambert, B.Sc. Hons, C.A. Groenewald, B.Sc. Hons and in collaboration with the University of Stellenbosch, A.F.M. Kisters, Ph.D.
Primary objectives: To study controls of shear zones for the migration and emplacement of granitic/pegmatitic melts in the continental crust by comparing mineral-enriched pegmatites with barren pegmatites and determining their spatial, temporal and geometric relation to the Pofadder Shear Zone (Northern Cape Province, RSA). To understand the changing geometry and kinematics of the shear zone during the progressive exhumation history concentrating on the characterisation of the different fault and shear zone rocks, the P-T conditions of formation, overprinting relationships and their timing. All data collected will be incorporated into a Namaqualand Database aimed at supplementing various sectors of geological data archived/held by the Council of Geoscience (e.g. mineral – SAMINDABA data, structural, field/geophysical/hydrogeology maps at various scales)
Duration: 2009–2012
Budget: R356 265

Motivation
Innovative research and staff development with implications for shear-hosted mineralisation. Project will lead to two M.Sc. degrees.

Progress
Remote sensing largely complete. One field season complete. Preliminary literature review complete. Field map and map database nearing completion. Structural database nearing completion. Mineralogical database being updated. Draft of scientific paper for M.Sc. nearing complete.

Conclusions
All desktop data collection and processing are complete. Primary data are still needed to complete many aspects of the database and therefore the data cannot be completed until more primary data are collected. Staff development in the form of degree qualification is under way but cannot be completed without primary data.

ASTER image of Pofadder Shear Zone, Northern Cape, South Africa. Band combinations RGB = 1 3 13.



Geologists and collaborative partners on an outcrop of melt-bearing biotite-hornblende gneiss in the Pofadder Shear Zone.

RADAR INTERFEROMETRY FOR GEOHAZARD ASSESSMENT IN SOUTH AFRICA

Project leader: J. Engelbrecht, M.Sc.
Primary objective: The project aims to employ differential radar interferometry techniques for the assessment of geohazards in South Africa. This will include the monitoring of surface subsidence due to mining activities in the Mpumalanga Province of South Africa, as well as monitoring movement along faults in the Eastern Cape Province. The detection of movement along faults will imply that seismic hazard assessment will be a possibility.
Duration: 3 years
Budget: Total: R99 480

Motivation
The Council for Geoscience has recently expressed interest in the formation of a Geohazards unit which will aim to address natural and anthropogenic hazards. Radar remote sensing can contribute to a programme dedicated to the assessment of risks and hazards and can be regarded as a unique tool to obtain deformation measurements over large areas. In this regard, radar interferometry can be used to monitor centimetre- to millimetre-scale deformations on the earth surface and has been applied successfully for the monitoring of several hazards including: 1) measurement of surface subsidence, 2) assessment of deformation following earthquake activity, 3) monitoring of landslides and volcanic activity and 4) measurement of movements along active faults. The interferometry technique therefore opens up many new potential application areas in disciplines such as volcanology, structural geology and geotechnics and for work relevant to a variety of geohazards. Radar remote sensing is an innovative technique to address the surface deformations associated with natural geological processes and human activities including mining. The project will build capacity in radar remote-sensing techniques which can then be used in various geological applications and geohazard assessments. The intended project will contribute towards innovation and development of human capital as radar remote sensing and radar interferometry, in particular, presently only have limited exposure in South Africa. Additionally, the contribution of this technique to programmes dedicated to hazard and risk management will be invaluable.

Progress
Project proposals were submitted to the European Space Agency (ESA), as well as the German Aeronautic and Space Agency (DLR) with the aim of using their radar remote-sensing data. The proposals have been accepted and granted access to archived and new acquisition data sets for use in this project. Numerous historical data sets spanning back to 1995 have been acquired for the study area in the Mpumalanga Province. Additionally, several new acquisition data sets have been captured and delivered. A field visit to the area influenced by mining subsidence has also been conducted. Initial data processing revealed several surface deformation features that may be an indication of surface subsidence. This includes features resembling subsidence basins, as well as linear deformation patterns, possibly indicative of longwall collapse. Field verification will be needed to verify the existence of these features on the ground. The historical data for the Mpumalanga Province have been pre-processed and master/slaves pairs have been identified for further processing. Initial results indicate that landcover changes between image acquisitions will cause difficulties in detecting deformation features using the technique.

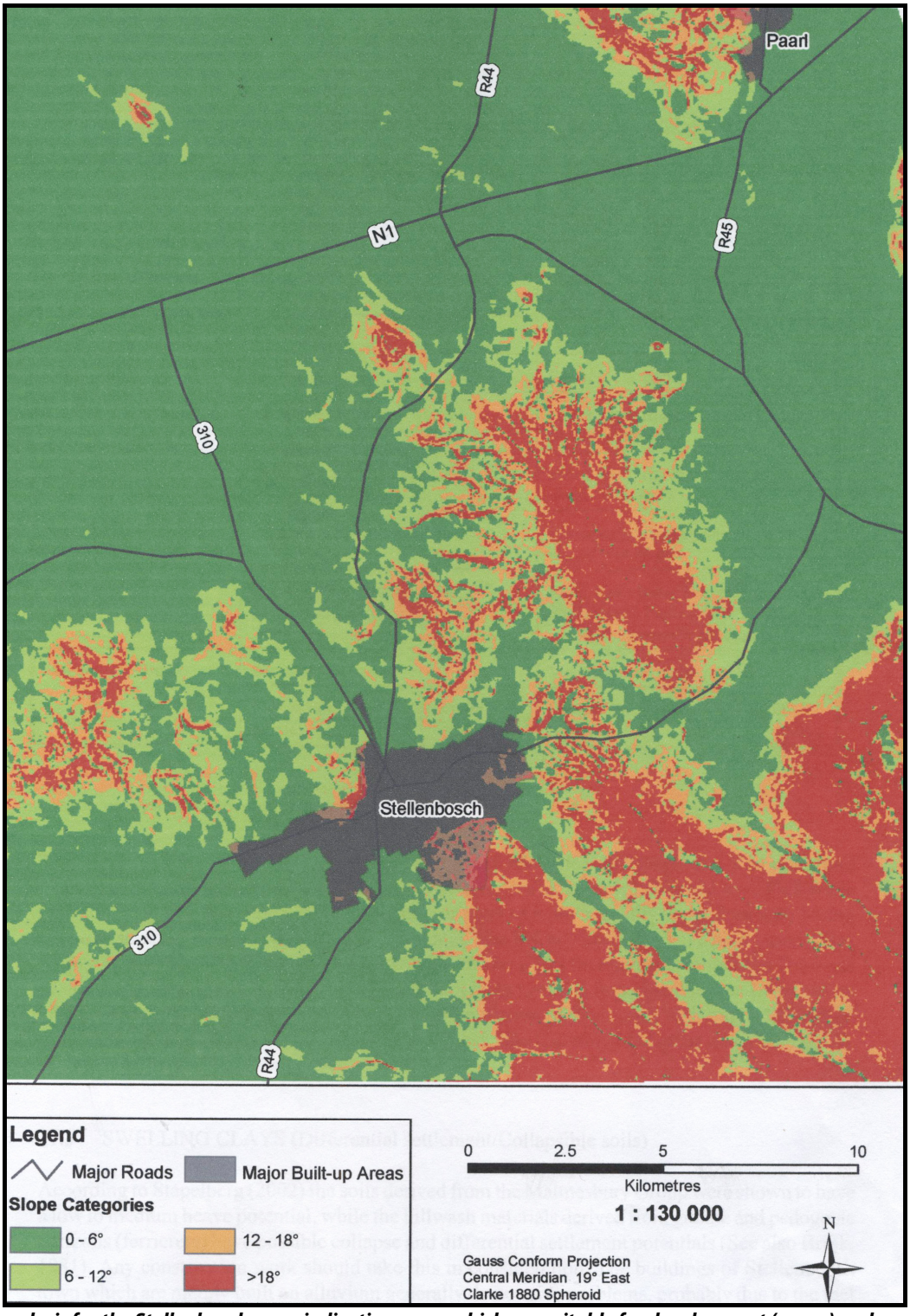
Conclusion
Radar interferometry techniques will be developed with the aim of measuring and monitoring surface deformation features related to geological and anthropogenic causes. The foundations for the project have been laid with the literature study and proposal-writing phases having been completed. The first of the image acquisition phases of the project have been completed and initial results on surface deformation quantification are limiting due to landcover changes between image acquisitions. It is expected that new acquisition data sets would be more suitable for the detection of surface deformation.

ST-2002-0027 **1:50 000 GEOLOGICAL MAPPING OF SHEET 3318DD STELLENBOSCH**

Project leader: J.H.A. Viljoen
Primary objectives: (i) To observe and record all geological/geotechnical data in the greater Cape Town urban environs which could assist urban planning and development. (ii) To identify areas where geological parameters pose a hazard to urban development. (iii) To provide information concerning the distribution and characteristics of minerals employed in construction (ferricrete, silcrete, calcrete, aggregate, sand and clay). (iv) To capture the above information onto a database to enable rapid access and manipulation of the data.

Due to unforeseen problems the final mapping and compilation of the sheet and explanation was only completed during the current year. Some stratigraphical problems could not be solved during the current study due to poor outcrops, intense deformation of the rocks and a lack of time to do more detailed research. Areas that need more research in future are the relationships between the different formations of the Malmesbury Group, the relationship between the Franschoek Formation and the Klipheuwel Group, the fault and shear zones and a detail geochemical

study of the granites, especially the Stellenbosch Batholith. More study could also be done on the geomorphology and river development of the area.



Slope analysis for the Stellenbosch area, indicating areas which are suitable for development (green) and areas that are less suitable (red – steep slopes).

ST-2001-0677 **3218 CLANWILLIAM 1:250 000-SCALE METALLOGENIC MAP**

Project leader: D.I. Cole
Project team: R. Oosterhuis, C. Vorster
Research supervisors: L. Ehlers
Duration: 6 years (1 year remains)
Budget: R193 475

Background
The Clanwilliam metallogenic map is part of the Council for Geoscience's programme to cover the entire country. It was started in 2001/02, but has been delayed due to information on the geological background only being available in 2009/10 when revision of the geological sheet is completed. The project is nevertheless 95 per cent complete.

Objectives
The project is in line with the thrusts of Geoscience Research and Mapping, and Mineral and Energy Resources Development and Poverty Alleviation. The objectives are: (i) to delineate metallogenic provinces (including industrial commodities such as limestone and phosphate), which will highlight the prospectiveness of certain areas and stimulate the discovery of new deposits, and (ii) to compile a database of all known mineral deposits concerning their locality, host rock, ore characteristics, exploration history, exploitation and literature references. This information is important for small-scale mining and provides a database for the targeting of new mines and prospects that will lead to rural development and poverty alleviation. There have already been several requests by potential small-scale miners for information on limestone, phosphate, dimension stone, salt and building sand, all which are present in the Clanwilliam map area. The information is useful for organisations interested in land use, such as rural planners and conservationists. The proposed West Coast Biosphere, for example, overlies large, subeconomic deposits of phosphate.

Methodology
In-house literature study of geology and commodity data. The 3218 geology map was published in 1973 and is out-dated. It is presently being revised and the new map scheduled for 2010 will form the template of the geological background map. Field investigations of new commodity occurrences and those having insufficient data. Sample collection and analyses plus thin section studies, where necessary. Capture commodity data on SAMINDABA. Compile a geological background map, mineral deposit overlay and mineral resource fields. Compile a metallogenic map explanation.

Progress
(a) Complete metallogenic map using data from the revised geology map to compile the geological background. Edit mineral deposit overlay and resource fields (DC; R. Oosterhuis).
(b) Edit explanation and compile a section on geological background (DC).

Future activities
Metallogenic map edited, map explanation edited and digital commodity database (SAMINDABA).

ST-2010-1079 **INDUSTRIAL MINERALS POTENTIAL IN THE WESTERN CAPE PROVINCE**

Project leader: D.I. Cole
Project team: C. Lambert, J. Horn and C. Vorster
Research supervisors: S. Foya
Duration: 2 years (1 year remains)
Budget: R715 476

Motivation
1) There is an ever-increasing demand for industrial minerals as the Western Cape provincial economy expands and there is a need for commodities such as fertiliser, cement and building sand.
2) Although the processes and applications regarding industrial minerals require a high level of technology and high capital costs, the commodities can be exploited easily by open-cast mining. This generates opportunities for labour-intensive small-scale mining.
3) The Western Cape contains at least 50 per cent of South Africa's phosphate deposits and with an increasing need for food and fertiliser these should be investigated.
4) Other potential commodities include limestone for cement, ground calcium carbonate, water purification and agricultural applications, silica sand for the glass industry, kaolin for the ceramics, paint and pharmaceutical industries, ball clay for the ceramics and brick-making industries, bentonite and sepiolite for absorbents, adsorbents, oil drilling and construction applications, granite and sandstone dimension stone for cladding and tiles in the construction industry, gypsum for cement, plaster board and agricultural applications, and salt for the food and chemical industries.
5) Construction materials are included in the project, since they form an integral part of the Western Cape provincial economy. Building sand is being rapidly depleted in the Greater Cape Town region and new sources of sand must be located. There is an urgent demand for gravel road material within the province and this commodity, together with

building sand, requires a low level of technology and low capital costs, thereby generating significant opportunities for labour-intensive small-scale mining.

Objectives
The project is in line with the thrusts of Geoscience Research and Mapping, and Mineral and Energy Resources Development and Poverty Alleviation. The objectives are: (i) to describe the industrial minerals of the Western Cape, including resources, existing applications and possible new applications; (ii) to compile and update a database of industrial and construction commodities, and (iii) to highlight mineral sites that are amenable to prospecting and mining. This information is important for small-scale mining and provides a database in the targeting of new mines and prospects that will lead to rural development and poverty alleviation. There have already been several requests by potential small-scale miners for information on limestone, phosphate, dimension stone, salt and bentonite in the Western Cape. The Western Cape Unit of the Council for Geoscience has comprehensive information and literature on industrial and construction commodities in the Western Cape Province, as well as unpublished 1:50 000-scale geological maps, which will be indispensible for the investigation.

Methodology
In-house literature study of existing commodity data. The latest SAMINDABA data will be checked and updated. Capture commodity data on SAMINDABA for new and missing deposits. Compile a commodity distribution and resource field map and a report.

Progress
(a) Field investigations and sample collection from sites lacking sufficient data (DC; JH, CL).
(b) Compile commodity data from these field investigations on SAMINDABA, update and complete commodity map and final report for Western Cape (DC; JH, CL).

Future activities
Industrial/Construction commodity map, digital commodity database (SAMINDABA) and report.

APPENDIX

PUBLICATIONS IN ACADEMIC JOURNALS AND BOOKS

Bessong, P.O., Odiyo, J.O., Tessema, A. and Muskene, J.N., 2009. Spatial distribution of diarrhea and microbial quality of domestic water during an outbreak of diarrhea in the Tshikuwi community in Venda, South Africa. Journal of Health, Population and Nutrition, 27, pp. 1–8.

Botha, G.A., Armitage, S.J. and Duller, G.A.T., 2008. Geological evolution and palaeoenvironments of the Bazaruto island archipelago, *In*: A Natural History of the Bazaruto Archipelago, Mozambique (B.I. Everett, R.P. van der Elst and M.H. Schleyer, Eds). Special Publication, Oceanographic Research Institute, South African Association for Marine Biological Research, 8, pp. 12–24.

Clarke, B., Uken, R. and Reinhardt, J., 2009. The geometry and emplacement mechanics of a Bushveld Complex peridotite body, South Africa. South African Journal of Geology, 112(2), pp. 141–162.

Daszinnies, M.C., Jacobs, J., Wartho, J.-A. and Grantham, G.H., 2009. Post Pan-African thermo-tectonic evolution of the north Mozambican basement and its implication for the Gondwana rifting. Inferences from $^{40}Ar/^{39}Ar$ hornblende, biotite and titanite fission tracking dating. Special Publication, Geological Society of London, 324, pp. 261–286.

Doucet, F.J., 2009. Effective CO_2-specific sequestration capacity of steel slags and variability in their leaching behaviour in view of industrial mineral carbonation. Minerals Engineering, 23, pp. 262–269.

Hammond, N.Q. and Morishita, Y., 2009. Source of ore fluids at the Kalahari Goldridge deposit, Kraaipan Greenstone Belt, South Africa: Evidence from Sr, C and O isotope signatures in carbonates. Geofluids, 9, pp. 356–364.

Jovanovic, N.Z., Majola, K.A., Ginster, M. and Adams, S., 2008. Preferential flow modelling in the vadose zone using MACRO 5.0: Cape Flats Porous Sands and Secunda Clays Case Studies (South Africa), *In*: Waste Management and the Environment IV (M. Zamorano, V. Popov, A. Kungolos, C.A. Brebbia and H. Itoh, Eds). WIT Transactions on Ecology and the Environment Series, 109, WIT Press, Southampton, ISBN 978-1-84564-113-9, pp. 373–382.

Katemaunzanga, D. and Gunter, C.J., 2009. Lithostratigraphy, sedimentology, and provenance of the Balfour Formation (Beaufort Group) in the Fort Beaufort-Alice area, Eastern Cape Province, South Africa. Acta Geologica Sinica, 83/5, pp. 902–916.

Paasche, H. and Eberle, D.G., 2009. Rapid integration of large airborne geophysical data suites using a fuzzy partitioning cluster algorithm: a tool for geological mapping and mineral exploration targeting. Exploration Geophysics, 40(3), pp. 277–287.

Pace, D.W., Gastaldo, R.A. and Neveling, J., 2009. Early Triassic aggradational and degradational landscapes of the Karoo Basin and evidence for climate oscillation following the P-Tr event. Journal of Sedimentary Research, 79(5), pp. 316–331.

Prevec, R., Labandeira, C.C., Neveling, J., Gastaldo, R.A., Looy, C.V. and Bamford, M., 2009. Portrait of a Gondwanan ecosystem: A new late Permian fossil locality from KwaZulu-Natal, South Africa. Review of Palaeobotany and Palynology, 156(3–4), pp. 454–493.

Roelofse, F., Ashwal, L.D., Pineda-Vargas, C.A. and Przybylowicz, W.J., 2009. Enigmatic textures developed along plagioclase-augite grain boundaries at the base of the Main Zone, Northern Limb, Bushveld Complex – evidence for late stage melt infiltration into a nearly solidified crystal mush. South African Journal of Geology, 112, pp. 39–46.

Singh, M. and Hattingh, E., 2009. Collection of isoseismal maps for South Africa. Natural Hazards, 50, pp. 403–408.

Titus, R., Beekman, H., Adams, S. and Strachan, L., Eds, 2009. The basement aquifers of southern Africa. Water Research Commission Report WRC TT 428, Water Research Commission, Pretoria, South Africa, ISBN 978-1-77005-898-9, 192 pp.

Vathiswa Papu-Zamxaka, V., Mathee, V., Harpham, T., Barnes, B., Röllin, H., Lyons, M., Jordaan, W. and Cloete, M., 2010. Elevated mercury exposure in communities living alongside the Inanda Dam, South Africa. Journal of Environmental Monitoring, 12, pp. 472–477.

Xu, Y., Lin, L. and Jia, H., 2009. Groundwater flow conceptualization and storage determination of the Table Mountain Group (TMG) aquifers. Water Research Commission Report No. 1419/1/09, ISBN 978-1-77005-840-8, 268 pp.

Yates, A.M., Bonnan, M.F., Neveling, J., Chinsamy, A. and Blackbeard, M.G., 2010. A new transitional sauropodomorph dinosaur from the Early Jurassic of South Africa and the evolution of sauropod feeding and quadrupaedalism. Proceedings, Royal Society of London, 277, pp. 787–794.

CONFERENCE ABSTRACTS AND POSTERS

Brown, K.S., Bernatchez, J., Marean, C.W., Herries, A.I.R., Jacobs, Z., Tribolo, C., Braun, D., Roberts, D.L., Meyer, M.C., Williams, H.M. and Bar-Matthews, M., 2009. An archaeological sequence from MIS 3 to 5: The Middle Stone Age deposits at Pinnacle Point site 5-6, Mossel Bay, South Africa. SASQUA 2009, Phantom View River Resort, Knysna, Western Cape, 6–10 September 2009, p. 15.

Carr, A.S., Boom, A., Chase, B.M. and Roberts, D.L., 2009. Palaeo-ecological reconstructions using pyrolysis gc/ms techniques: Rietvlei, southern Cape, South Africa. 24th International Meeting on Organic Geochemistry (IMOG), Bremen, Germany.

Carr, A.S., Roberts, D.L., Boom, A. and Lombino, A.G., 2009. Bivalve-derived records of sea surface temperature from the continental margin of southern Africa: preliminary data from the genus Donax. SASQUA 2009, Phantom View River Resort, Knysna, Western Cape, 6–10 September 2009, p. 17.

Chevallier, L., Dondo, C., Woodford, A., Murray, R., Nomnganga, A., Nhleko, L. and Gqiba, D., 2009. Groundwater exploration and development maps for the Mzimvubu-Keiskamma and Mvoti-Umzimkulu WMAs, the Eastern Cape and KwaZulu-Natal Provinces of South Africa. Proceedings, 2009 Biennial Groundwater Conference, Pushing the Limits, NH The Lord Charles, Somerset West, 16–18 November 2009.

Chingombe, W. and Thomas, A., 2009. Runoff, infiltration and non-point source pollution assessment of the Kuils-Eerste River Catchment, Western Cape Province, South Africa. Proceedings, Map Africa 2009, 4th Annual African Conference and Exhibition on Geospatial Information Technology and Applications, Birchwood Hotel and OR Tambo Conference Centre, Johannesburg, South Africa, 16–18 September 2009.

Chirenje, E. and Diop, S., 2009. The use of multi-electrode resistivity tomography to map shallow old gold mine workings in the Primrose area, East Rand, Gauteng. Poster, 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009.

Cichowicz, A., Kgaswane, E., Ramperthap, J. and Singh, M., 2009. Upper-crustal amplification in South Africa. TC4 Satellite Conference of Earthquake Geotechnical Engineering (TC4-SCEGE), Alexandria, Egypt, 2–3 October 2009.

Cloete, M., Elsenbroek, J.H. and Strauss, S.W., 2009. Regional geochemical mapping in South Africa and future planning. Abstact, Global Geochemical Mapping Symposium, Langfang, China, 10–12 October 2009, pp. 20–23.

Coetzee, H. and Van Tonder, D.M., 2009. Current and future challenges posed by abandoned mines, with examples from the South African coalfields. KZN Coal Indaba, Dundee, 25–26 June 2009.

Cole, J., Webb, S.J. and Finn, C.A., 2009. Developing a 3D potential field model of the Bushveld Complex. *AfricaArray* Workshop, University of the Witwatersrand, Johannesburg, 6–7 July 2009.

De Kock, G.S., 2009. Bedrock mapping and its significance on sustainable development in Africa, 2009. Abstract, Map Africa 2009, 4th Annual African Conference and Exhibition on Geospatial Information Technology and Applications, Birchwood Hotel and OR Tambo Conference Centre, Johannesburg, South Africa, 16–18 September 2009.

De Kock, G.S. and Armstrong, R., 2009. The significance of SHRIMP geochronology on establishing a stratigraphic succession in the Birim Supergroup/Complex in the Maluwe basin of Ghana. Abstract, Geoanalysis 2009, Champagne Sports Resort, Central Drakensberg, Winterton, KwaZulu-Natal, 7–11 September 2009.

Dondo, C., Chevallier, L., Potgieter, A. and Rivett, U., 2009. Bayesian networks for spatial groundwater resources assessment under uncertainty. Proceedings, 2009 Biennial Groundwater Conference, Pushing the Limits, NH The Lord Charles, Somerset West, 16–18 November 2009.

Doucet, F.J., 2009. Progress in industrial CO_2 sequestration technologies by mineral carbonation of industrial wastes with particular reference to climate change. Sustainability through Mineral Resource Conversation and Recycling '09 Conference, Cape Town, 4–5 April 2009.

Durrheim, R.J., Ogasawara, H., Nakatani, M., Yabe, Y., Milev, A., Cichowicz, A., Kawakata, H., Moriya, H. and the JST-JICA SA research group, 2009. Observational study to mitigate seismic risks in mines: a new Japanese-South African collaborative project. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 73–79.

Eberle, D., Cole, P. and Nyabezi, P., 2009. Acquiring high resolution airborne geophysical data and recognition of new mineral exploration potential as part of a development program launched by the South African government. Abstract, ASEG 09 Conference Handbook, 20th International Geophysical Conference and Exhibition, Adelaide Convention Centre, South Australia, 22–25 February 2009, p. 71.

Eberle, D.G., Tessema, A., Muiuane, E.A., Daudi, E.X. and Pontavida, M., 2009. Integration of geophysical and satellite imagery data from the Alto de Ligonha pegmatite fields, northern Mozambique: Implication for the control of mineralization. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 21–26.

Engelbrecht, J., 2009. Synthetic aperture radar data employed for soil moisture quantification in the Piketberg region in South Africa. Abstract, IGARSS 2009, Cape Town, 13–17 July 2009.

Fourie, C.J.S., Henry, G. and Maré, L.P., 2009. The structure of the Karoo-age Ellisras Basin in Limpopo Province, South Africa in the light of new airborne geophysical data: a preliminary report. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 27–32.

Gastaldo, R.A. and Neveling, J., 2009. The diastemic record of Early Triassic recovery environments in the Karoo Basin, South Africa. Abstracts with Program, Geological Society of America, 41(7), Portland, Oregon, 18–21 October 2009, p. 242.

Goedhart, M.L. and Booth, P.W.K., 2009. Early Holocene extensional tectonics in the south-eastern Cape Fold Belt, South Africa. Proceedings, 11th SAGA Biennial Technical Meeting and Exhibition and Inkaba yeAfrika Phase II Workshop, 13–18 September 2009, Swaziland, pp. 510–513.

Grantham, G.H. and Maier, W.D., 2009. Whole-rock and mineral chemistry of the Trompsburg Complex, Free State, South Africa and comparisons with the Bushveld Complex. Abstract, Geoanalysis 2009, Champagne Sports Resort, Central Drakensberg, Winterton, KwaZulu-Natal, 6–12 September 2009.

Hallbauer-Zadorozhnaya, V., 2009. Mathematical modeling of membrane polarization caused by constrictivity of pores. Poster, International Workshop on Induced Polarization in Near-Surface Geophysics, Bonn, Germany, 30 September–1 October 2009.

Hallbauer-Zadorozhnaya, V., Maré, L.P. and Dingoko, O.W., 2009. Application of membrane polarization for studying internal structure of samples. Poster, International Workshop on Induced Polarization in Near-Surface Geophysics, Bonn, Germany, 30 September–1 October 2009.

Hammond, N.Q., Robb, L.J. and Foya, S., 2009. Gold mineralization at the Morila Mine, Mali: Petrographic, mineral-chemical, and fluid aspects. Proceedings, 10th Biennial Meeting of the Society for Geology applied to Mineral Deposits (SGA), Townsville, Australia, 17–20 August 2009.

Hatton, C., 2009. Geotherms, lithosphere thickness and sedimentary basins. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 217–220.

Havenga, M., Barton, J.M. (Jr) and Webb, S., 2009. A structural analysis of the geophysical signature relationship between linear features and plug-like bodies of sheets 2229AB and 2229AD in the Limpopo Province, South Africa. *AfricaArray* Workshop, University of the Witwatersrand, Johannesburg, 6–7 July 2009.

Kemp, J., Villeneuve, N., Chevallier, L., Servadio, Z. and Jacquard, F., 2009. A study of riverbed dynamics using remote sensing: a 3D case study of Rivière des Galets, La Réunion Island. Abstract, IGARSS 2009, Cape Town, 13–17 July 2009.

Knight, C., Gastaldo, R.A. and Neveling, J., 2009. Late Permian palaeoenvironmental factors expounded through analysis of a forest-floor paleosol profile, Karoo Basin, South Africa. Abstracts with Program, Geological Society of America, 41(7), Portland, Oregon, 18–21 October 2009, p. 101.

Lehman, B.A., Ferré, E.C., Geissman, J.W., Marsh, J.S., Marsh, M.C., Maré, L.P., Ranaweera, C.K. and Maes, S.M., 2009. Magma flow pattern in a giant dolerite sill and implications for the Karoo mantle plume hypothesis. Abstract, Eos, Fall Meet. Suppl., 90(52), V23E-2155, 29 December 2009.

Lindeque, A.S. and De Wit, M.J., 2009. Revealing the Beattie Magnetic Anomaly and the anatomy of the crust of southernmost Africa: Geophysics and deep sub-surface geology where the Cape Fold Belt and Karoo Basin meet. 11th SAGA Biennial Technical Meeting and Exhibition and Inkaba yeAfrika Phase II Workshop, Swaziland, 13–18 September 2009, pp. 490–494.

Loots, L., Ryberg, T. and Durrheim, R.J., 2009. Investigation of the crust in the southern Karoo using the seismic reflection technique. *AfricaArray* Workshop, University of the Witwatersrand, Johannesburg, 6–7 July 2009.

Macey, P.H., Thomas, R.J., Grantham, G.H., Ingram, B.A., Jacobs, J., Armstrong, R.A., Roberts, M.P., Hollick, L., Bingen, B., De Kock, G.S., Bjerkgård, T., Henderson, I., Cronwright, M.S., Solli, A., Nordgulen, Ø., Viola, M.G., Daudi, G.E. and Manhica, V., 2009. Mesoproterozoic geology of the Nampula Sub-province, northern Mozambique. Abstract, Geological Society of London, Fermor Meeting 2009, Rodinia: Supercontinents, Superplumes and Scotland, Edinburgh, UK, 6–13 September 2009.

Mahed, G. and Xu, Y., 2009. Corporate governance of an institution managing charitable endowments. Proceedings, 9th Annual BEN-Africa Conference, Accra, Ghana, 3–5 August 2009, 23 pp.

Mahed, G. and Xu, Y., 2009. Charitable endowments as a tool for sustainable groundwater development and management. Proceedings, Groundwater 2009, Cape Town, 16–18 November 2009.

Maré, L.P., 2009. Palaeomagnetic results from a Neoarchaean dyke swarm in the Badplaas-Barberton area, South Africa. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 27–32.

Maré, L.P., Ferré, E.C., Ranaweera, C.K., Marsh, M.C. and Marsh, J.S., 2009. Magnetic evaluation of the thermal history of the Karoo Basin, South Africa.Abstract, Eos, Fall Meet. Suppl., 90(52), GP42A-03, 29 December 2009.

Maritz, H., Cloete, H.C.C. and Elsenbroek, J.H., 2009. Analysis of high density regional geochemical soil samples at the Council for Geoscience: The importance of quality control measures. Geoanalysis 2009 Conference, Champagne Castle Resort, Winterton, KwaZulu-Natal, 7–11 September 2009, p. 34.

Marsh, M.C., Ferré, E.C., Lehman, B.A., Ranaweera, C.K., Maré, L., Maes, S.M. and Geissman, J.W., 2009. Fabrics, internal zonation and magma flow in small gabbroic sills, Karoo, South Africa. Abstract, Eos, Fall Meet. Suppl., 90(52), V21A-1978, 29 December 2009.

Mengistu, H.A., 2009. Application of DGT samplers in monitoring of mine waters of the Witwatersrand goldfields, RSA. Proceedings, International Mine Water Conference, Pretoria, South Africa, 19–23 October 2009, 7 pp.

Mengistu, H.A., 2009. Passive samplers as long-term monitoring tools in Witwatersrand goldfields. Proceedings, Groundwater 2009, Cape Town, 16–18 November 2009.

Midzi, V., 2009. 1-D velocity model for use by the SANSN in earthquake location. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, p. 402.

Mokete, L.M., 2009. Validation of ICPMS methodology for analysis of heavy metals in water using the SABS water check proficiency testing scheme. Geoanalysis 2009 Conference, Champagne Castle Resort, Winterton, KwaZulu-Natal, 7–11 September 2009, p. 15.

Mukosi, N.C., 2009. Petrogenesis of the Ambohiby Complex, Madagascar. Poster, World Young Earth Scientists Symposium, Beijing, China, 24–29 October 2009.

Ngcofe, L., McGregor, G. and Chevallier, L., 2009. Can land degradation be predicted: a case study of Qoqodala in the Eastern Cape, South Africa. Extended Abstract, Water and Land Degradation Conference, Magdeburg, Germany, 6–13 September 2009, 9 pp.

Nhleko, L., 2009. Regional ground water resources for the area of Clanwilliam. Proceedings, 2009 Biennial Groundwater Conference, Pushing the Limits, NH The Lord Charles, Somerset West, 16–18 November 2009.

Nxumalo, V., 2009. Stratigraphic correlation and provenance studies in the Karoo Supergroup (Gemsbok Sub-basin) of the Kalahari Karoo Basin. Proceedings/Poster presentation, Student GeoCongress, Johannesburg, 9–10 July 2009.

Ogasawara, H., Durrheim, R.J., Nakatani, M., Yabe, Y., Milev, A., Cichowicz, A., Kawakata, H., Moriya, H. and the JST-JICA SA research group, 2009. A Japanese-South African collaboration to mitigate seismic risks in deep gold mines. Hard Rock Safety Conference 2009, Southern African Institute of Mining and Metallurgy, Sun City, Northern Province, 28–30 September 2009.

Paasche, H. and Eberle, D.G., 2009. Automated integration of large geophysical data sets using three partitioning cluster algorithms: a comparison. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 286–291.

Paasche, H. and Eberle, D., 2009. Integration and data-driven zonation of large geophysical maps using cluster analysis. Extended Abstract and Poster, 15th European Meeting of Environmental and Engineering Geophysics, Dublin, Ireland, 7–9 September 2009, 4 pp.

Paasche, H. and Eberle, D., 2009. Schnelle und objektive Integration großer airborne geophysikalischer Datensätze zur geologischen Kartierung. Poster, Conference Handbook, 69th Annual Meeting, DGG, Kiel, Germany, 23–26 March 2009.

Pludow, B.A., Gastaldo, R.A. and Neveling, J., 2009. Deciphering the Early Triassic recovery environment: The search for mud aggregates in the Karoo Basin, South Africa. Abstracts with Program, Geological Society of America, 41(7), Portland, Oregon, 18–21 October 2009, p. 101.

Pule, T. and Sauders, I., 2009. Recent seismicity in the Mozambique region and its impact/effects on South Africa. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 385–390.

Ramela, K. and Loubser, M., 2009. Chromite fussions: finally a conquest. Geoanalysis 2009 Conference, Champagne Castle Resort, Winterton, KwaZulu-Natal, 7–11 September 2009, p. 15.

Ranaweera, C.K., Ferré, E.C., Polteau, S., Marsh, M.C., Maré, L., Marsh, J.S., Maes, S.M. and Geissman, J.W., 2009. Magma flow pattern inferred from magnetic fabrics in a 100 km-long dolerite dike, Karoo LIP, South Africa. Abstract, Eos, Fall Meet. Suppl., 90(52), GP43A-0837, 29 December 2009.

Roberts, D.L., 2009. Twenty million years of environmental evolution: southern tip of Africa. Global Conference on Global Warming, Istanbul, Turkey, 5–9 July 2009.

Roberts, D.L., 2009. Evolution of the Benguela upwelling system and southern African west coast aridification. SASQUA 2009, Phantom View River Resort, Knysna, Western Cape, 6–10 September 2009, p. 43.

Roberts, D.L., 2009. Evolution of the Benguela Cold Upwelling System: Modulator of West African Climate. Sixth International Conference on the Geology of Africa, Assiut, Egypt, 24–29 October 2009.

Roelofse, C.J. and Van Tonder, D.M., 2009. A cost-effective geo-referenced thermal imaging survey technique developed to identify and characterize spontaneous combustion. KZN Coal Indaba, Dundee, 25–26 June 2009.

Scisio, L., Tsikos, H., Van Breugel, Y., Roberts, D.L. and Scott, L., 2009. Palaeobotany, biogeochemistry and sedimentology of Late Tertiary fluvial deposits, West Coast, South Africa. SASQUA 2009, Phantom View River Resort, Knysna, Western Cape, 6–10 September 2009, p. 46.

Tessema, A., 2009. Interpretation of aeromagnetic and ASTER images over the Kimberley and Boshof areas, Northern Cape Province, South Africa. Poster, 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009.

Van Schoor, M., Maré, L.P. and Fourie, C.J.S., 2009. Comparison between time- and frequency-domain induced polarisation parameters. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 259–263.

Van Tonder, D.M. and Coetzee, H., 2009. South Africa's challenges pertaining to mine closure – the problem of abandoned and derelict mines in the Mpumalanga coalfields. 4th International Mine Closure Conference, Perth, Western Australia, 9–11 September 2009, pp. 593–604.

Van Tonder, D.M. and Coetzee, H., 2009. Regional Mine Closure: Strategies to address the cumulative impacts from mines and the impacts of one mine on the other. 3rd Annual Mine Closure and Rehabilitation 2009, Sandton, Gauteng, 24–25 August 2009.

Van Tonder, D.M., Coetzee, H. and Cornelesin, H., 2009. Orphaned/abandoned mines on sustainable socio-economic development: What is South Africa's strategy for the management of ownerless/derelict mines? 3rd Annual Mine Closure and Rehabilitation 2009, Sandton, Gauteng, 24–25 August 2009.

Van Tonder, D.M., Coetzee, H., Esterhuyse, S., Strachan, L., Wade, P. and Mudau, S., 2009. South Africa's challenges pertaining to mine closure – development and implementation of regional mining and closure. 4th International Mine Closure Conference, Perth, Western Australia, 9–11 September 2009, pp. 79–92.

Van Tonder, D.M., Coetzee, H., Madau, S., Esterhuyse, S., Msezane, N., Strachan, L. and Wade, P., 2009. Regional mine closure: Strategies to address the cumulative impacts from mines and the impacts of one mine on the other. Mine Closure Symposium, Johannesburg, June 2009.

Wade, P. and Glass, J., 2009. Verification of a semi-passive microbially-assisted biotechnology for large-scale treatment of acid mine drainage. International Mine Water Conference, CSIR, Pretoria, 19–23 October 2009.

Wade, P.W., Glass, J.A. and Van Tonder, D.M., 2009. Ecosystem response to chronic cumulative impacts on Loskop Dam in Mpumalanga, South Africa and the effective use of chironomids as bioindicators in South African Rivers. Water management issues in South Africa and Saxony – Exchange of experiences – Freiberg, Germany, 3–4 April 2009.

Wade, P.W., Glass, J.A., Van Tonder, D.M. and Venter, J., 2009. Erosion of natural attenuation capacity in the Klip River catchment in Gauteng, South Africa. Water management issues in South Africa and Saxony – Exchange of experiences – Freiberg, Germany, 3–4 April 2009.

Yibas, B., 2009. Acid mine drainage from the mining industry of South Africa: towards a proper and holistic approach. Mining Technology World, Gallagher Estate, Midrand, September 2009.

Zadorozhnaya, V. and Maré, L.P., 2009. Application of membrane polarization for studying internal structure of rocks. IAGA, Sopron, Hungary, 23–30 August 2009.

Zadorozhnaya, V. and Maré, L.P., 2009. Further developing of the theory of membrane polarization for studying international structure of rocks. Book of Abstracts (in Russian), IV All-Russian Workshop on Electromagnetic Soundings in 2003, Moscow, Russia.

Zadorozhnaya, V. and Maré, L.P., 2009. Interpretation of laboratory measured data: New information on pore structure and anisotropy using IP effect. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16–18 September 2009, pp. 206–211.

Zadorozhnaya, V., Abu Zeid, N., Menghini, A., Santarato, G. and Dingoko, O.W., 2009. Developing the method of induced polarization (IP): theory and applications for groundwater characterisation: preliminary results; authors. Book of Abstracts, Geoitalia 2009, Rimini, 9–11 September 2009, pp. 41–42.

CGS STAFF

TITLE	SURNAME	INITIALS	POSITION	UNIT
DR	THOMAS	A	MANAGER CENTRAL REGIONS	CENTRAL REGIONS
MR	BOSCH	PJA	SCIENTIFIC OFFICER	CENTRAL REGIONS
DR	DE KOCK	GS	SCIENTIFIC OFFICER	CENTRAL REGIONS
MISS	ENGELBRECHT	CR	ADMINISTRATIVE OFFICER	CENTRAL REGIONS
DR	GRANTHAM	GH	SCIENTIFIC OFFICER	CENTRAL REGIONS
DR	HATTON	C	SPECIALIST SCIENTIST	CENTRAL REGIONS
MR	INGRAM	BA	SCIENTIFIC OFFICER	CENTRAL REGIONS
DR	IYENGAR	KP	SCIENTIFIC OFFICER	CENTRAL REGIONS
MR	MOABI	NG	SCIENTIFIC OFFICER	CENTRAL REGIONS
MR	MOLEFE	SM	TECHNICAL OFFICER	CENTRAL REGIONS
DR	NEVELING	J	SCIENTIFIC OFFICER	CENTRAL REGIONS
MISS	NXUMALO	V	SCIENTIFIC OFFICER	CENTRAL REGIONS
MRS	SHELEMBE	RP	SCIENTIFIC OFFICER	CENTRAL REGIONS
MRS	DE KOCK	FE	SCIENTIFIC OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	KGOALE	MO	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	LEKALAKALA	LR	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MADIBANE	MI	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	MAHWAYI	S	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MALOKELA	PS	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	MARAIS BOTES	L	MUSEUM CURATOR	INFORMATION & COLLECTIONS MANAGEMENT
MR	MATHEBULA	JS	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MATJEKE	KI	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MOJELA	TP	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MOSAKA	J	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	NKWINIKA	RD	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	RAATH	A	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	JACHA	N	MARKETING & COMMUNICATION SPECIALIST	CORPORATE SERVICES
MRS	KOLA	MEM	MANAGER CORPORATE SERVICES	CORPORATE SERVICES
MR	LEKOTOKO	MM	EVENTS COORDINATOR	CORPORATE SERVICES
MR	LESHOMO	JD	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
MISS	MAPARA	BM	EMPLOYEE RELATIONS SPECIALIST	CORPORATE SERVICES
MR	MAZIBUKO	DM	HUMANRESOURCES OFFICER	CORPORATE SERVICES
MISS	MKHIZE	ZJL	RECRUITMENT SPECIALIST	CORPORATE SERVICES
MR	MOTSATSING	KM	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
MISS	VAN WYK	J	EVENTS COORDINATOR	CORPORATE SERVICES
MISS	WILLIAMS	QD	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
MISS	BLACK	DE	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MR	GOEDHART	ML	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MISS	KILIAN	D	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MISS	MITHA	VR	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MR	MXATULE	BJ	ADMINISTRATIVE OFFICER	EASTERN CAPE UNIT
MISS	NONDUDULE	T	ADMINISTRATIVE OFFICER	EASTERN CAPE UNIT
DR	REDDERING	JSV	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MR	AZENE	FZ	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MR	CHILIZA	SG	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
DR	DIOP	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MR	FORBES	C	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MRS	GROBLER	JD	ADMINISTRATIVE OFFICER	ENGINEERING GEOSCIENCES
MR	HEATH	GJ	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES

TITLE	SURNAME	INITIALS	POSITION	UNIT
MR	MOKHOHLANE	DM	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MISS	MOOTE	GC	ADMINISTRATIVE OFFICER	ENGINEERING GEOSCIENCES
MR	MOTJALE	MI	TECHNICAL OFFICER	ENGINEERING GEOSCIENCES
MR	NGUBELANGA	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MRS	OOSTHUIZEN	AC	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MISS	RICHARDSON	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MR	TEGEGN	K	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
DR	COETZEE	H	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
MR	HANISE	BE	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
MISS	KOTOANE	AM	TECHNICAL OFFICER	ENVIRONMENTAL GEOSCIENCES
MISS	KWATA	MG	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
MR	LEKOADU	KS	JUNIOR SCIENTIST	ENVIRONMENTAL GEOSCIENCES
MISS	MASENYA	BP	ADMINISTRATIVE OFFICER	ENVIRONMENTAL GEOSCIENCES
MR	MOTLAKENG	RT	TECHNICAL OFFICER	ENVIRONMENTAL GEOSCIENCES
MRS	PHAJANE	TC	MANAGER ENVIRONMENTAL GEOSCIENCES	ENVIRONMENTAL GEOSCIENCES
MRS	VAN TONDER	DM	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
MR	VENTER	JS	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
DR	WADE	PW	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
DR	YIBAS BABSO	B	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
MR	BREYTENBACH	AF	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MRS	CHAGWIZA	V	ACCOUNTANT	FINANCIAL SERVICES
MR	DICHABE	SD	ADMINISTRATIVE OFFICER (S&T OFFICER)	FINANCIAL SERVICES
MRS	DINGOKO	MO	SENIOR CREDITORS CLERK	FINANCIAL SERVICES
MISS	GOUVERNEUR	M	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
MR	HUGO	JLM	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
MISS	LEKWARA	MG	PAYROLL ADMINISTRATOR	FINANCIAL SERVICES
MRS	LUBBE	CJ	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
MRS	MANDA	M	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MR	MATSEPE	LD	CHIEF FINANCIAL OFFICER	FINANCIAL SERVICES
MR	MOSTERT	JCN	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MR	MTEKI	AM	MANAGEMENT ACCOUNTANT	FINANCIAL SERVICES
MRS	PAWESKA	MD	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
MR	PEENS	WJF	CHIEF ACCOUNTANT	FINANCIAL SERVICES
MRS	POWER	S	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MRS	QAYISO	NA	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MRS	SNYMAN	SE	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MISS	STROH	C	PAYROLL SUPERVISOR	FINANCIAL SERVICES
MR	BENSID	ML	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	ELSENBROEK	JH	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	HLATSHWAYO	SM	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	MAHLANGU	MM	TECHNICAL OFFICER	GEOCHEMISTRY
MR	MAYA	M	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	MOKOATEDI	JK	TECHNICAL OFFICER	GEOCHEMISTRY
MR	MULOVHEDZI	AE	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	NETSHITUNGULWANA	R	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	RADEBE	JS	TECHNICAL OFFICER	GEOCHEMISTRY
MISS	SHABALALA	AN	JUNIOR SCIENTIST	GEOCHEMISTRY
MR	STRAUSS	SW	SCIENTIFIC OFFICER	GEOCHEMISTRY
MRS	VAN DER WALT	DM	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	VAN ROOYEN	RC	SCIENTIFIC OFFICER	GEOCHEMISTRY
MR	CHIRENJE	E	SCIENTIFIC OFFICER	GEOPHYSICS
MRS	COLE	J	SCIENTIFIC OFFICER	GEOPHYSICS
MR	COLE	P	MANAGER GEOPHYSICS	GEOPHYSICS

TITLE	SURNAME	INITIALS	POSITION	UNIT
MR	DINGOKO	OW	SCIENTIFIC OFFICER	GEOPHYSICS
DR	EBERLE	DG	SCIENTIFIC OFFICER	GEOPHYSICS
MRS	GRAHAM	A	ADMINISTRATIVE OFFICER	GEOPHYSICS
DR	HALLBAUER - ZADOROZHNAYA	VY	SCIENTIFIC OFFICER	GEOPHYSICS
MRS	HAVENGA	M	SCIENTIFIC OFFICER	GEOPHYSICS
MISS	KRUGER	D	TECHNICAL OFFICER	GEOPHYSICS
MR	LEDWABA	LJ	SCIENTIFIC OFFICER	GEOPHYSICS
MISS	LEGOTLO	RL	TECHNICAL OFFICER	GEOPHYSICS
MISS	LOOTS	L	SCIENTIFIC OFFICER	GEOPHYSICS
MR	MANTSHA	KR	TECHNICAL OFFICER	GEOPHYSICS
MRS	MARE	LP	SCIENTIFIC OFFICER	GEOPHYSICS
MISS	NEFALE	N	SCIENTIFIC OFFICER	GEOPHYSICS
MR	NYABEZE	PK	SCIENTIFIC OFFICER	GEOPHYSICS
MR	SEKIBA	FMA	TECHNICAL OFFICER	GEOPHYSICS
MR	SETHOBYA	MR	TECHNICAL OFFICER	GEOPHYSICS
MR	STETTLER	RH	TECHNICAL OFFICER	GEOPHYSICS
DR	TESSEMA	A	SCIENTIFIC OFFICER	GEOPHYSICS
MR	BARNARDO	DJ	MANAGER INFORMATION & COLLECTIONS MAN	INFORMATION & COLLECTIONS MANAGEMENT
MRS	BECKER	A	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	JANSE VAN RENSBURG	MG	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MISS	MAKHUBELE	GS	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	MALATSI	PM	GENERAL CLERK	INFORMATION & COLLECTIONS MANAGEMENT
MRS	MOKOENA	JM	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MISS	NEL	ZE	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MISS	NONDUDULE	Z	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	VAN ECK	SJ	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	VAN HEERDEN	JA	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	DOMINGO	EE	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MR	MOGARA	LM	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MR	MOTAUNG	PD	MANAGER INFORMATION TECHNOLOGY	INFORMATION TECHNOLOGY
MISS	MZIMBA	RJ	ADMINISTRATIVE OFFICER	INFORMATION TECHNOLOGY
MR	PHANGISA	TT	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MR	SMITH	P	BUSINESS TECHNOLOGY CONSULTANT	INFORMATION TECHNOLOGY
DR	BOTHA	GA	MANAGER KWAZULU NATAL & EASTERN CAPE	KWAZULU-NATAL
MRS	DLAMINI	P	ADMINISTRATIVE OFFICER	KWAZULU-NATAL
MR	HICKS	N	SCIENTIST	KWAZULU-NATAL
MR	MPOFANA	B	GENERAL CLERK	KWAZULU-NATAL
MRS	NGCOBO	LE	GENERAL CLERK	KWAZULU-NATAL
MRS	SINGH	RG	SCIENTIFIC OFFICER	KWAZULU-NATAL
DR	VOORDOUW	RJ	SENIOR SCIENTIST	KWAZULU-NATAL
MRS	ATANASOVA	MTG	SCIENTIFIC OFFICER	LABORATORY
MRS	BURGER	KIG	TECHNICAL OFFICER	LABORATORY
MRS	CLOETE	HCC	SCIENTIFIC OFFICER	LABORATORY
DR	CLOETE	M	MANAGER LABORATORY & GEOCHEMISTRY	LABORATORY
MR	DIKGOMO	SA	TECHNICAL OFFICER	LABORATORY
MISS	DLAMINI	NJ	TECHNICAL OFFICER	LABORATORY
DR	DOUCET	FJ	SCIENTIFIC OFFICER	LABORATORY
MISS	DUBE	KP	ADMINISTRATIVE OFFICER	LABORATORY
MR	FRIEDLAND	J	SCIENTIFIC OFFICER	LABORATORY
MR	JORDAAN	LJ	SCIENTIFIC OFFICER	LABORATORY
MR	KGADITSE	SD	TECHNICAL OFFICER	LABORATORY
MR	KHAZAMULA	TC	TECHNICAL OFFICER	LABORATORY
MR	KHUMALO	S	TECHNICAL OFFICER	LABORATORY

TITLE	SURNAME	INITIALS	POSITION	UNIT
MR	LEHAHA	MT	TECHNICAL OFFICER	LABORATORY
MR	LONG	DJ	SCIENTIST	LABORATORY
MR	MABELA	AD	TECHNICAL OFFICER	LABORATORY
MR	MAEMA	JJ	TECHNICAL OFFICER	LABORATORY
MISS	MARITZ	H	SCIENTIFIC OFFICER	LABORATORY
MISS	MASHISHI	KE	JUNIOR SCIENTIST	LABORATORY
MR	MATJI	JM	TECHNICAL OFFICER	LABORATORY
MR	MBONANE	TJ	TECHNICAL OFFICER	LABORATORY
MR	MCHUNU	PB	TECHNICAL OFFICER	LABORATORY
MISS	MOKETE	LM	TECHNICAL OFFICER	LABORATORY
MR	MOLEBALE	JI	JUNIOR SCIENTIST	LABORATORY
MR	MONYAYI	ST	TECHNICAL OFFICER	LABORATORY
MR	MOTSIRI	TS	TECHNICAL OFFICER	LABORATORY
MR	NGAMLANA	SM	TECHNICAL OFFICER	LABORATORY
MR	NKOSI	ME	TECHNICAL OFFICER	LABORATORY
MR	NXOKWANA	NS	JUNIOR SCIENTIST	LABORATORY
MRS	PAPO	RM	TECHNICAL OFFICER	LABORATORY
MR	PHAHLANE	I	TECHNICAL OFFICER	LABORATORY
MR	RAMELA	MKE	TECHNICAL OFFICER	LABORATORY
MR	RAMOSHABA	MM	TECHNICAL OFFICER	LABORATORY
MR	ROELOFSE	F	SCIENTIFIC OFFICER	LABORATORY
MISS	SATHEKGE	LL	TECHNICAL OFFICER	LABORATORY
MR	SELLO	RH	TECHNICAL OFFICER	LABORATORY
MR	SEMELANE	LL	TECHNICAL OFFICER	LABORATORY
MR	TSAAGANE	ME	TECHNICAL OFFICER	LABORATORY
MRS	VUMA	SM	TECHNICAL OFFICER	LABORATORY
MR	ZONDI	SP	TECHNICAL OFFICER	LABORATORY
MRS	BREYTENBACH	L	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	GROBLER	EE	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MAKHAFOLA	RS	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	MSIZA	A	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	SWART	TN	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MRS	VAN DER MERWE	L	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MR	BAGLOW	N	MANAGER LIMPOPO BUSINESS UNIT	LIMPOPO BUSINESS UNIT
MR	BARRY	IC	SCIENTIFIC OFFICER	LIMPOPO BUSINESS UNIT
MR	DHANSAY	TG	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MR	MASHAO	TP	GENERAL CLERK	LIMPOPO BUSINESS UNIT
MRS	MNISI	EH	ADMINISTRATIVE OFFICER	LIMPOPO BUSINESS UNIT
MR	MOTHETHA	MV	SCIENTIFIC OFFICER	LIMPOPO BUSINESS UNIT
MISS	MUKOSI	NC	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MISS	MUNYANGANE	LP	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MISS	ROBEY	K	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MR	BALOYI	IM	PROCUREMENT SPECIALIST	PROCUREMENT & LOGISTICS
MR	BOTHA	JD	SENIOR SPECIALIST, LOGISTICS	PROCUREMENT & LOGISTICS
MR	DIKETANE	MW	GENERAL CLERK	PROCUREMENT & LOGISTICS
MR	GUMEDE	VC	CONTRACT SPECIALIST	PROCUREMENT & LOGISTICS
MRS	JIJANA	CK	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
MR	KGOBANE	RJ	ADMINISTRATIVE OFFICER (DRIVER)	PROCUREMENT & LOGISTICS
MISS	KUNJU	N	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
MRS	MAMPURU	LM	SENIOR PROCUREMENT OFFICER	PROCUREMENT & LOGISTICS
MR	MASOGA	ME	GENERAL CLERK	PROCUREMENT & LOGISTICS
MR	PHUSHELA	PSH	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
MR	SNYMAN	J	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS

TITLE	SURNAME	INITIALS	POSITION	UNIT
MRS	TJIANE	LC	GENERAL CLERK	PROCUREMENT & LOGISTICS
MR	ZWANE	JJ	ADMINISTRATIVE OFFICER (DRIVER)	PROCUREMENT & LOGISTICS
MRS	ASHLEY	CCL	ADMINISTRATIVE OFFICER	MANAGEMENT
MISS	CELE	ND	PERSONAL ASSISTANT	MANAGEMENT
DR	GRAHAM	G	EXECUTIVE MANAGER SCIENTIFIC SERVICES	MANAGEMENT
MR	MATIMULANE	NW	SECURITY OFFICER	MANAGEMENT
MISS	MBEKI	N	BOARD ADMINISTRATOR	MANAGEMENT
MR	MNDAWONI	MJ	MANAGER BUSINESS DEVELOPMENT	MANAGEMENT
MR	MSIZA	JM	SECURITY OFFICER	MANAGEMENT
MRS	NKOE	JS	ADMINISTRATIVE OFFICER	MANAGEMENT
MISS	PILANE	ME	SECRETARY	MANAGEMENT
MR	RAMAGWEDE	FL	EXECUTIVE MANAGER APPLIED GEOSCIENCES	MANAGEMENT
DR	RAMONTJA	T	CHIEF EXECUTIVE OFFICER	MANAGEMENT
MISS	SKHOSANA	MN	ADMINISTRATIVE OFFICER	MANAGEMENT
DR	ZAWADA	PK	EXECUTIVE MANAGER REGIONAL MAPPING	MANAGEMENT
MR	BOTHA	CA	TECHNICAL OFFICER	MARINE GEOSCIENCE
MISS	CAWTHRA	HC	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
MISS	HOOSAIN	W	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
MR	KIDWELL	W	TECHNICAL OFFICER	MARINE GEOSCIENCE
MR	KUPIDO	W	TECHNICAL OFFICER	MARINE GEOSCIENCE
MR	MACHUTCHON	MR	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
MISS	SUMNER	NR	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
MR	VAN ZYL	WF	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
DR	WIGLEY	RA	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
MR	YOUNG	PM	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
DR	BILLAY	AY	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	EHLERS	DL	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	ENDRES	PA	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
DR	FOYA	S	MANAGER MINERAL RESOURCES DEVEOPMENT	MINERAL RESOURCES DEVELOPMENT
MRS	FROST- KILLIAN	S	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
DR	HAMMOND	NQ	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	HANSEN	RN	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	HORN	GFJ	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	KATEMAUNZANGA	D	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	KENAN	AO	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	KGWAKGWE	KP	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	KIRSTEIN	LS	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	MALAN	NP	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
MISS	MAYEKISO	NS	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	McILRAE	NM	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
MISS	MUDAU	T	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	OOSTERHUIS	WR	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	OPPERMAN	R	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	PUTTER	GV	ADMINISTRATIVE OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	SCHALEKAMP	MM	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	SENZANI	FED	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	SOLOMON	M	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
DR	TONGU	EL	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MRS	TSANWANI	M	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	VORSTER	CJ	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
DR	WALEMBA	KMA	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MR	AGENBACHT	ALDP	SCIENTIFIC OFFICER	NORTHERN CAPE UNIT
MR	GROENEWALD	CA	JUNIOR SCIENTIST	NORTHERN CAPE UNIT

TITLE	SURNAME	INITIALS	POSITION	UNIT
MR	MINNAAR	H	SCIENTIFIC OFFICER	NORTHERN CAPE UNIT
MRS	SKEFFERS	CJ	UNIT ADMINISTRATOR	NORTHERN CAPE UNIT
MR	ADAMOS	P	TECHNICAL OFFICER	SEISMOLOGY
MRS	AKROMAH	L	TECHNICAL OFFICER	SEISMOLOGY
MRS	BEJAICHUND	M	SCIENTIFIC OFFICER	SEISMOLOGY
MR	BIRCH	DJ	JUNIOR SCIENTIST	SEISMOLOGY
MR	BRANDT	MBC	SCIENTIFIC OFFICER	SEISMOLOGY
MRS	BRINK	L	TECHNICAL OFFICER	SEISMOLOGY
DR	CICHOWICZ	A	SCIENTIFIC OFFICER	SEISMOLOGY
MR	DELPORT	FA	TECHNICAL OFFICER	SEISMOLOGY
MISS	DUARTE	D	ADMINISTRATIVE OFFICER	SEISMOLOGY
MISS	FLINT	NS	PROJECT ADMINISTRATOR	SEISMOLOGY
MRS	GROBBELAAR	MRG	MANAGER SEISMOLOGY	SEISMOLOGY
MRS	HATTINGH	E	SCIENTIFIC OFFICER	SEISMOLOGY
MR	JELE	VM	TECHNICAL OFFICER	SEISMOLOGY
MR	KGASWANE	EM	SCIENTIFIC OFFICER	SEISMOLOGY
MR	KOMETSI	TR	TECHNICAL OFFICER	SEISMOLOGY
DR	MIDZI	V	SCIENTIFIC OFFICER	SEISMOLOGY
MR	MOLEA	TT	TECHNICAL OFFICER	SEISMOLOGY
MISS	PULE	TG	TECHNICAL OFFICER	SEISMOLOGY
MR	SAUNDERS	I	TECHNICAL OFFICER	SEISMOLOGY
MR	STEYN	J	TECHNICAL OFFICER	SEISMOLOGY
DR	STRASSER	FO	SENIOR SCIENTIST	SEISMOLOGY
MISS	SUTHERLAND	BE	TECHNICAL OFFICER	SEISMOLOGY
MR	TABANE	LR	TECHNICAL OFFICER	SEISMOLOGY
MR	VAN ASWEGEN	G	TECHNICAL OFFICER	SEISMOLOGY
MR	ZULU	BS	JUNIOR SCIENTIST	SEISMOLOGY
DR	BRYNARD	HJ	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
MR	GROBBELAAR	DA	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MR	KGARI	CS	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MR	LETSOALO	M	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MR	MAGAGANE	MEM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MISS	MOKONYAMA	ML	UNIT ADMINISTRATOR	SPATIAL DATA MANAGEMENT
MR	MSIZA	P	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MISS	NKOSI	FN	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MISS	NKOSI	MP	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MRS	NORUKA	S	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
MISS	OOSTHUIZEN	BC	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MRS	ROOS	HM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MR	SEBAKE	DM	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
MR	SELLO	MH	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MISS	SMITH	A	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MISS	SONO	MJ	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MISS	THOMAS	C	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MR	WILKINSON	KJ	MANAGER SPATIAL DATA MANAGEMENT	SPATIAL DATA MANAGEMENT
MR	KEYSER	N	SCIENTIFIC OFFICER	SPU
MRS	MAHLANGU	E	ADMINISTRATIVE OFFICER	PROCUREMENT AND LOGISTICS
MR	MAHLANGU	JZ	TECHNICAL OFFICER	PROCUREMENT AND LOGISTICS
MR	NDLELA	CT	TECHNICAL OFFICER	PROCUREMENT AND LOGISTICS
MR	NEMATANDANI	M	TECHNICAL OFFICER	PROCUREMENT AND LOGISTICS
MR	RANTJIE	JM	TECHNICAL OFFICER	PROCUREMENT AND LOGISTICS
MRS	SMYTHE	MM	ADMINISTRATIVE OFFICER	PROCUREMENT AND LOGISTICS
MR	STEVENS	R	TECHNICAL OFFICER	PROCUREMENT AND LOGISTICS

TITLE	SURNAME	INITIALS	POSITION	UNIT
DR	JIA	H	SENIOR SCIENTIST	WATER GEOSCIENCES
MR	LENONG	SE	SCIENTIST	WATER GEOSCIENCES
MRS	LESHOMO	JT	SCIENTIFIC OFFICER	WATER GEOSCIENCES
DR	LIN	L	CHIEF SCIENTIST	WATER GEOSCIENCES
MISS	MABILA	VM	ADMINISTRATIVE OFFICER	WATER GEOSCIENCES
MR	MAJOLA	KA	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MR	MAKGATE	DM	TECHNICAL OFFICER	WATER GEOSCIENCES
DR	MENGISTU	H	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MR	NETILI	KF	SENIOR SCIENTIST	WATER GEOSCIENCES
MRS	RUST	UA	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MR	SAEZE	HA	CHIEF SCIENTIST	WATER GEOSCIENCES
MR	STRACHAN	LKC	MANAGER WATER GEOSCIENCES	WATER GEOSCIENCES
MR	VAN WYK	Y	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MISS	BROWNING	C	SCIENTIST	WESTERN CAPE UNIT
DR	CHEVALLIER	LP	MANAGER WESTERN CAPE & NORTHERN CAPE	WESTERN CAPE UNIT
DR	COLE	DI	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MR	DAVIDS	I	TECHNICAL OFFICER	WESTERN CAPE UNIT
MR	DE BEER	CH	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MR	DE BRUIN	E	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MISS	DONDO	C	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MISS	ENGELBRECHT	J	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
DR	HARTZER	FJ	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MR	LAMBERT	CW	JUNIOR SCIENTIST	WESTERN CAPE UNIT
MR	MACEY	PH	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MRS	MALHERBE	JE	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MR	MOSES	D	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MISS	MTHEMBI	P	JUNIOR SCIENTIST	WESTERN CAPE UNIT
MR	NGCOFE	LDS	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MISS	PETERSEN	C	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
DR	ROBERTS	DL	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
MR	STAPELBERG	FDJ	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
DR	VILJOEN	JHA	SCIENTIFIC OFFICER	WESTERN CAPE UNIT