2012

ANNUAL TECHNICAL REPORT OF THE COUNCIL FOR GEOSCIENCE

Council for Geoscience

Leading earth-science solutions

Council for Geoscience

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2012

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 the
Information Management Unit
Council for Geoscience

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

Photograph
An impressive book of mica in pegmatite mine workings near Mica, Limpopo Province

Management of the COUNCIL FOR GEOSCIENCE

Chief Executive Officer

Gerhard Graham *(Acting)*

Board Administrator

Nomkhosi Cele *(Acting)*

Strategic Services

(in the office of the CEO)

Nico Keyser *and* ***Maleka Monyepao***

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- Commercial Project Tender Management
- Strategy Planning Cycle

Applied Geoscience

Executive Manager

Fhatuwani Ramagwede

- Engineering Geoscience – *Stewart Foya (Acting)*
- Environmental Geoscience – *Mosidi Makgae*
- Minerals Development – *Stewart Foya*
- Water Geoscience – *Fortress Netili*

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Executive Manager

***Luc Chevallier** (Acting)*

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- Eastern Cape – *Greg Botha*
- KwaZulu-Natal – *Greg Botha*
- Limpopo – *Nick Baglow*
- Marine Geoscience – *Luc Chevallier (Acting)*
- Northern Cape – *Luc Chevallier*
- Western Cape – *Luc Chevallier*

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Executive Manager

***Ken Wilkinson** (Acting)*

- 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*

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Chief Financial Officer

Leonard Matsepe

- Information and Communication Technology – *Peter Motaung*
- Procurement and Logistics – *Michael Nkuna*
- Finances and Legal Services – *Leonard Matsepe*

Corporate Services

Executive Manager

Monica Mabuza

Contents

Foreword

The statutory programme of the organisation forms a key component of its mandate, and also provides an opportunity for young geoscientists to develop as researchers. While the temporary suspension of parts of the Annual Technical Programme resulted in a reduced statutory programme, the Board and Management are pleased to report that, despite the financial difficulties of the organisation, the technical performance of the Council for Geoscience for the past year was 95,4%, which testifies to the dedication of its staff and the sound management of the organisation.

During 2008/09, the Council for Geoscience embarked on developing and implementing ISO 17025 for the Analytical Laboratory and ISO 9001 for the remainder of the organisation. Good progress has been made in the Analytical Laboratory. It is anticipated that final accreditation, with the completion of both ISO 9001 and 17025, will be achieved during the forthcoming year.

The Geoscience Amendment Act (Act No. 16 of 2010) was signed into law by the President of South Africa in December 2010. This Act extends the functions of the organisation to include the rendering of advisory services in respect of geohazards and geo-environmental pollution. The organisation will also act as custodian for all geoscience information. As the Council for Geoscience has not received the required funding for the implementation of the Act, only sections of the Act entailing no financial implications have been submitted to the Department of Mineral Resources for proclamation.

The Council for Geoscience continued with its African agenda during the period under review. Geoscience information and expertise are critical for the sustainable development of Africa, when considering the mineral wealth of the continent, in particular, but are also necessary to address other important challenges such as water shortages, pollution and geohazards. In this regard, the organisation has been involved in a number of key projects for several years and it is envisaged that this involvement will remain and may be extended over time. Some examples of this involvement are:

- The compilation of the SADC hydrogeological map was a European-funded project that addressed the need to standardise the groundwater systems in the SADC region for further development and to create new fields for investigation, especially for transfrontier aquifer development.

- The Council for Geoscience is one of the partners in the AEGOS (African European Georesources Observation System) project that aims to develop a Pan-African spatial system capable of hosting and providing access to geological information, including groundwater, energy, raw materials and mineral resources.

- *AfricaArray*, which is an innovative programme, aims to promote, strengthen and maintain a workforce of highly trained geoscientists and researchers for Africa. Well-trained geoscience professionals are key to sustainable development as the demand for Africa's natural resources is ever increasing and Africa's environment is impacted by global change.

- The continuing provision of direct capacity building support to African Geological Surveys through various programmes and interventions such as seismology training and the provision of technical support. Countries that have received technical or training support include Namibia, Botswana, Zimbabwe, Mozambique, Swaziland, Rwanda, the Democratic Republic of the Congo and Sudan.

- The Council for Geoscience, together with the Geological Society of South Africa, has won the bid to host the 35th International Geological Congress in 2016 in Cape Town. Good progress has been made with the preparations relating to this prestigious event.

A fundamental role of any national geoscience institution such as the Council for Geoscience has historically been the acquisition of new geoscience data. Traditionally this has taken the form of geological mapping, geophysical surveys and national or regional geochemical sampling programmes. The geological mapping of the country at a scale of 1:250 000 was completed recently after fifty years of systematic reconnaissance and surveys which included field and laboratory work supported by airborne geophysics. However, the increasing interest in and concern with dynamic systems, such as the environment and geohazards, are changing the traditional role of Geological Surveys worldwide. Extensive studies related to environmental and quality-of-life issues, land-use planning and development, and the monitoring and mitigation of geohazards are required. This implies that

historical geoscience data gathering is no longer a "once-off" process, but one that needs to be done increasingly on a continual, monitoring and real-time basis.

As an example of this type of investigation, the Council for Geoscience is developing remote-sensing techniques to better understand and predict the occurrence and impact of a wide range of geohazards. This information will be directly applicable to the planning and development options facing the country. Some of the geohazards to be investigated will include, for example, surface deformation associated with mining activities and water abstraction, sinkholes, earthquakes, geochemical hazards, groundwater vulnerability, problem soils, terrestrial erosion, coastal and beach erosion and landslides. The programme calls for capacity building initiatives, which will include graduate, MSc and PhD candidates.

Another example of this type of investigation is the involvement of the Council for Geoscience in the Strategic Water Management Programme. The activities of the mining sector have resulted in serious environmental consequences and, in the case of the gold mines of the Witwatersrand, acid mine drainage. Given the magnitude and dynamics of the South African mining industry, it must be accepted that the challenges of mine water management cannot be administered by either Government or the mining sector alone.

The Inter-Ministerial Committee (IMC) on Acid Mine Drainage (AMD) appointed a Team of Experts which reported on the assessment and reappraisal of the situation with respect to acid mine drainage, focusing on the Witwatersrand goldfields. The Council for Geoscience took cognisance of the recommendations of the IMC Report that had been made public in 2010/11 and implemented various programmes to address the problems identified. Furthermore, staff of the Council for Geoscience continued to participate in activities coordinated by the Inter-Governmental Task Team which reports to the Inter-Ministerial Committee. This ensures alignment of the related programmes and prevents the duplication of efforts by State Institutions.

The Council for Geoscience, together with Eskom and the Department of Mineral Resources, has completed a project to identify and provide technical and financial support to junior/BEE miners. The objective of the project is to assist junior/BEE participation in the mainstream coal industry.

The Council for Geoscience, together with the South African Centre for Carbon Capture and Storage (SACCCS), has been investigating the financial and geological feasibility, legal requirements and a geographical information management system for carbon capture and storage in South Africa. The Council for Geoscience is in charge of assessing the effective storage capacity of the Zululand and Algoa Basins. These investigations form a critical requirement for the South African Roadmap for Carbon Capture and Storage with the aim of performing CO_2 test injections in South Africa by 2016.

The Mineral Resources of South Africa Handbook is in the process of being updated with the assistance of specialist scientists from academia and industry.

The Council for Geoscience has recently received an allocation of R200 million as part of an economic competitiveness support package that will be appropriated over a period of three years and that will allow the organisation to make a significant contribution through the identification of new target areas with mineral potential, hence promoting the mining industry in South Africa and ultimately attracting investment into the industry. Part of this allocation will be applied to maintain the buildings and facilities of the Council for Geoscience.

As of 1 November 2011, Dr Thibedi Ramontja, the CEO of the Council for Geoscience, was appointed as the Director-General for the Department of Mineral Resources. Dr Gerhard Graham was appointed as the acting CEO for the interim period.

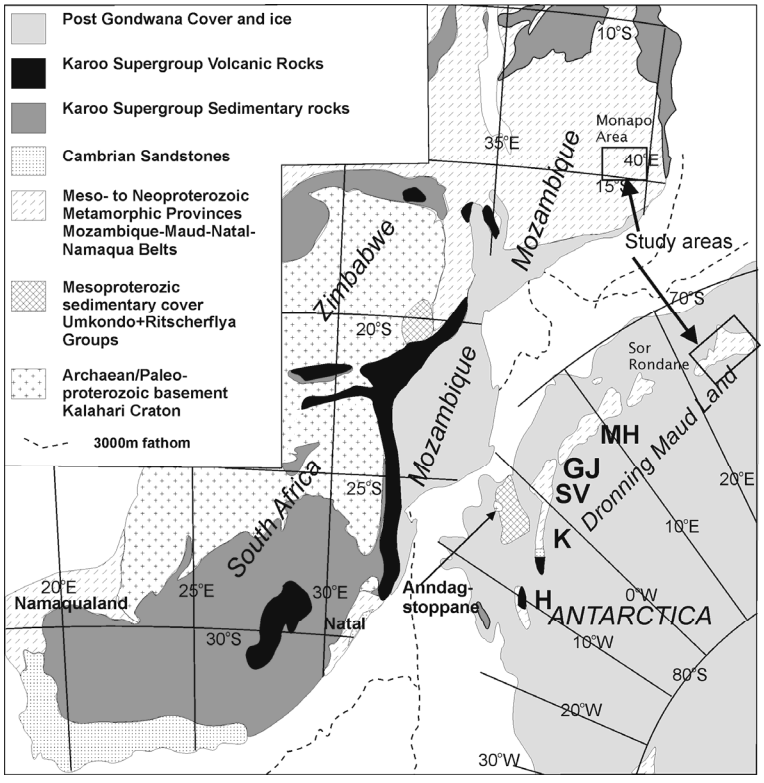
Dr Gerhard Graham
Acting Chief Executive Officer

INTERNATIONAL COLLABORATION

ST-2007-0933

Mozambique publications project

Project leader GH Grantham, PhD
Project team PH Macey, PhD
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 making these available to the international community by publishing in international scientific journals
Duration 2007–2012



Locality map of a portion of the Gondwana area. H=Heimefrontfjella, K=Kirwanveggan, SV=Sverdrupfjella, GJ=Gelsvikfjella, 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 the rock types as well as the ages were completed which facilitate a better understanding of the geology of Mozambique. This information is of economic as well as academic interest and publication of the data in international journals will disseminate this information.

Progress and conclusions

One manuscript was submitted to *Precambrian Research* for publication during the year. The manuscript compares mineral assemblages from the Monapo Complex with similar assemblages from the eastern Sor Rondane as well as reports new U/Pb zircon SHRIMP data from Sor Rondane. Both areas are characterised by isothermal decompression paths from >10 kb and ~850 °C to ~6 kb and 700 °C with the geochronology indicating crystallisation ages of between ~635 Ma and ~530 Ma. Recognising the similar mineral assemblages, P-T-t paths and age data from these areas, it is concluded that these similarities support the mega nappe model proposed by the project leader in 2008.

Future plans

The project has been terminated.

ST-2009-1103

Japanese Antarctic Research Expedition 51 (JARE51) participation

Project leader	GH Grantham, PhD
Primary objective	The objective of the study is to compare the geological evolution of the Sor Rondane of Dronning Maud Land, Antarctica with that of northern Mozambique recognising that the two areas were adjacent to one another prior to the dispersal of Gondwana approximately 180 Ma ago
Duration	2010–2013
Budget	R15 000

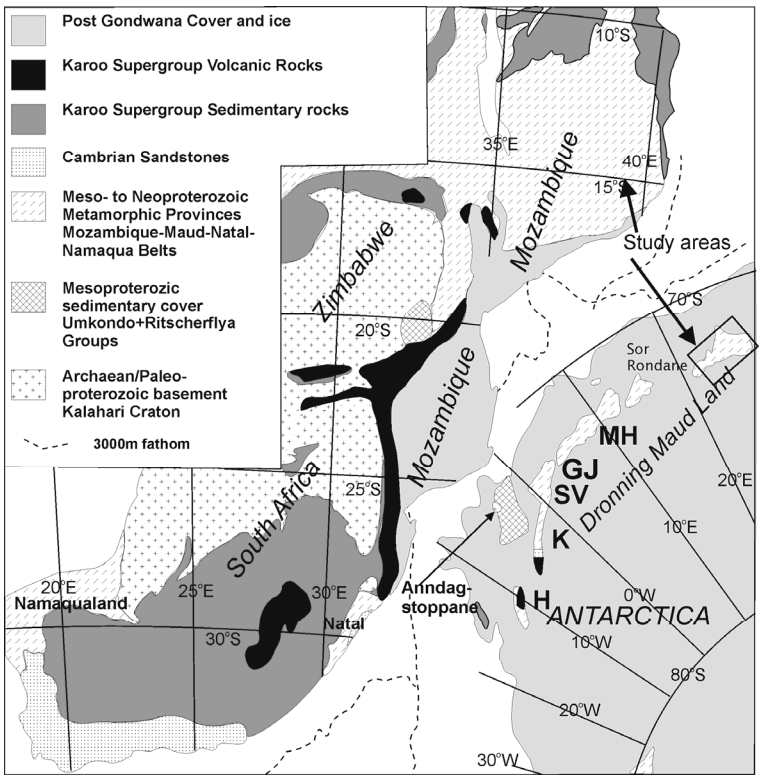


Diagram showing a reconstruction of Gondwana and the areas of comparison

Motivation

The project leader was invited to the Sor Rondane Mountains in Central Dronning Maud Land, Antarctica to participate in JARE51. The duration of the involvement extended from 15 November 2009 to 15 March 2010 with three months being spent in active fieldwork in western and eastern Sor Rondane. The Sor Rondane area of Central Dronning Maud Land is thought to have been situated immediately south of northern Mozambique prior to the fragmentation of Gondwana 180 Ma ago. Involvement in JARE51 has facilitated comparison of the geology of that area with the geology of northern Mozambique. Samples and data collected during the field season will form the basis of continued research collaboration and publications between the Council for Geoscience and the National Institute of Polar Research in Tokyo, Japan.

Progress and conclusions

To date, data from six samples have been analysed for the mineral assemblages from which P-T estimates have been completed. The data, along with samples from six zircon separates, provide ages of metamorphism in the area and have been incorporated into a manuscript submitted to *Precambrian Research* for publication. In addition, three other collaborative manuscripts have been submitted to *Precambrian Research* by team members of JARE51.

During the current year, funding has been provided for the analysis of seven samples for the Rb/Sr and Sm/Nd isotopic data to facilitate a deeper understanding of the source from which some of the samples dated by SHRIMP were derived. The data will be reported on during the next financial year.

Future plans

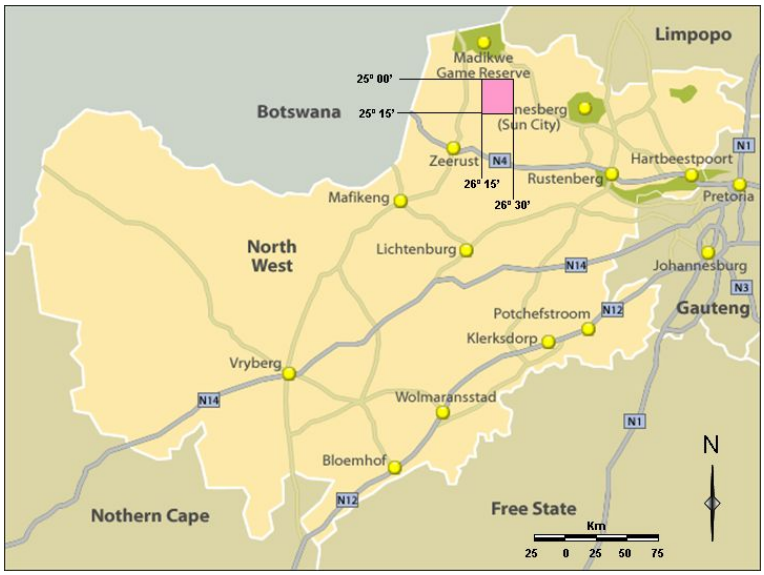
It is planned to prepare more manuscripts for publication on the Sor Rondane comparing the metamorphic and structural evolution of the area with that of northern Mozambique utilising SHRIMP data from samples which have been analysed by the National Institute of Polar Research in Tokyo.

CENTRAL REGIONS

ST-2008-1002

Economic geology and stratigraphy of the Sesobe (2526AB) 1:50 000 sheet

Project leader	AV Keshava Prasad, PhD
Project team	B Yibas, A Tessema, S Molefe
Primary objective	The primary objective of this project is to assess the mineral potential and stratigraphy of the Sesobe 2526AB 1:50 000 map sheet with the aim of producing an accurate geological base map. A special focus will include the identification of economic-grade mineralisation zones which may be found in exposures of the Bushveld Complex
Duration	August 2011 to March 2012
Budget	R7 423.00



Location map of sheet 2526AB Sesobe in the North West Province

Motivation

Mapping of the Nietverdiend (2526AA) and Sesobe (2526AB) 1:50 000 sheets has been envisaged to be part of a project started in 2008/09 (ST-2008-1002) which has been formulated as part of the ongoing mapping programme in the North West Province.

Progress

The geological mapping of sheet 2526AB Sesobe was carried out between 2008 and 2009 and petrographic and chemical analyses of selected samples were undertaken to understand the relationship between different lithology types and the mineral potential of the area. The existing geological map for the Sesobe area, which was more of an outcrop map, was modified to produce an interpreted geological map based on the data collected from this project. The geological map, along with its explanation, was submitted for publication.

ST-2009-1012

The 1:50 000 geological mapping of Madikwe

Project leader	R Shelembe, MSc (Geol)
Primary objective	The Madikwe area is defined by the geology of the metamorphosed Pretoria Group rocks, as affected by the intrusion of the Bushveld Complex in the area west of the Pilanesberg Complex. Since this area is adjacent to the already-mapped Mabeskraal and Mabaalstad areas, it is beneficial to investigate the extent and grade of metamorphism in the Madikwe area. The distribution and grade of the metamorphic assemblages will also provide an insight into the character of the Bushveld Complex intrusion and heat distribution. A number of lineaments were depicted on the magnetic intensity geophysical maps of the study area. One objective is to investigate the origin of these lineaments that appear on magnetic intensity geophysical maps but that are not expressed on the surface
Duration	2009/10 to 2012/13

Motivation

The information generated in this project will add to the wealth of data in the Council for Geoscience repository. The aim of the project is to gain understanding and insight of the Bushveld Complex intrusion and its effects on the Pretoria Group rocks. The geophysical properties of the crust in this area will indicate the tectonic history and the response of the crust at the intrusion of the Bushveld Complex.

Progress

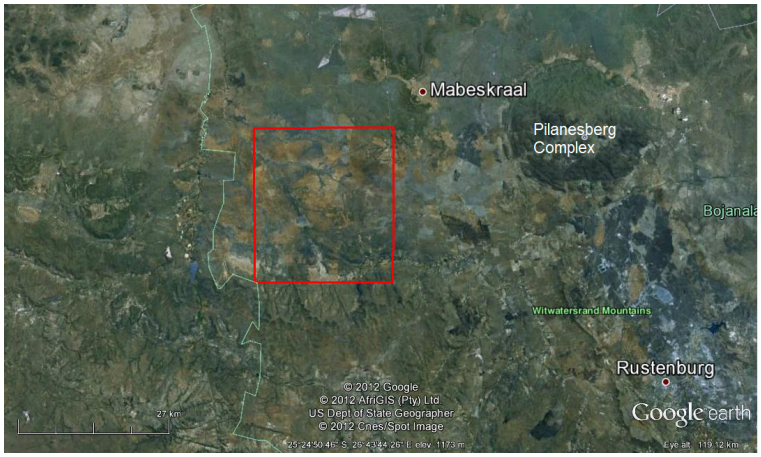
The compilation of the preliminary geological map and its overlays is complete. The petrography, geology and geochemistry sections of the report are also being finalised.

Conclusions

A knowledge gap between the Mabeskraal/Mabaalstad and Madikwe areas will be closed and a better understanding of the geology, extent of metamorphism and geophysical properties will be gained.

Future activities

The write-up of a geological explanation for the Madikwe area is still in progress and will continue.



Location of sheet 2526BC Madikwe

ST-2010-1066

The 1:50 000 geological mapping of Khayakhulu

Project leader	R Shelembe, MSc
Project team	A Ndhukwani, BSc Hons
Primary objective	The Khayakhulu area, adjacent to the Mabeskraal map area, is characterised by the geology of the metamorphic rocks of the Pretoria Group and sills related to the Bushveld Complex. The objective of this project is to investigate how the geology of this area has affected the chemistry of the groundwater. Because of the semi-arid nature of this area, the communities in this region heavily rely on groundwater for domestic use. According to the State of Environment Report 2009 of the North West Province, the groundwater is rich in total dissolved solids, fluoride, calcium and sodium. These elements were contributed to the groundwater by rocks of the Pilanesberg and Bushveld Complexes. The elements also proved to cause human health issues. Therefore, investigations are necessary in the Khayakhulu area to determine how the geology of the area affects the health of communities
Duration	2009/10–2012/13
Budget	R45 746.00

Motivation

The health of communities in peri-urban areas is affected by the surrounding geology through the use of groundwater. Data collected during this project will help in assessing the water chemistry and the investigation of suspect elements or nanoparticles that are likely to be found in the groundwater. This will contribute towards sustainable solutions or techniques to alleviate this potential problem.

Progress

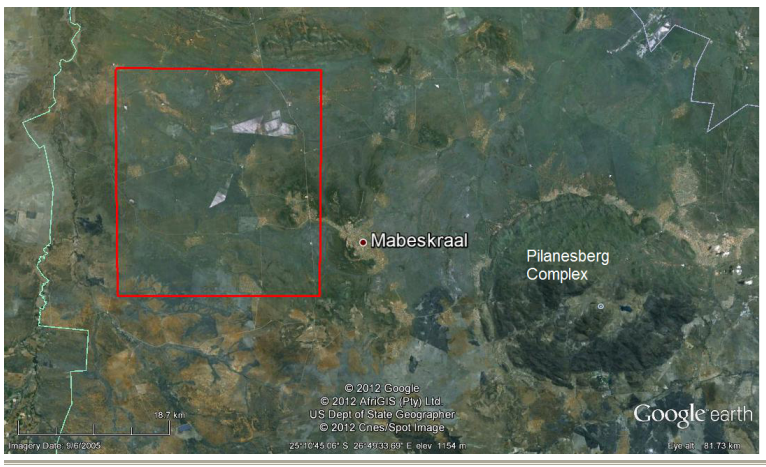
The field geological mapping has been covered for 85% of the area. The collected samples have been analysed for geochemistry and petrography. Water samples have also been analysed.

Conclusions

A knowledge creation of how geology can affect the health of people will be achieved. Techniques and solutions will be formulated to alleviate the already-affected areas.

Future activities

Field data collection will be completed. The write-up of a geological explanation for the Khayakhulu area will commence in the next financial year.



Location of sheet 2526BC Khayakhulu

EASTERN CAPE

ST-2011-1135

A 3D geological subsurface model of the Thyspunt nuclear site

Project leader	D Claassen, BSc Hons
Primary objective	To produce a robust and interactive three-dimensional geological subsurface model of the Thyspunt area, Eastern Cape, South Africa and to explore and compare current software programs. The focus is on open/freeware software packages and their capabilities, extensions and possible scripts to identify a preferred software program for the processing and visually display of subsurface data. The project will also derive a best-practice approach for conducting 3D subsurface modelling. Geological implications will be derived from the final model once it is completed
Duration	2012–2013
Budget	Manpower R141 000.00; Overheads R21 000.00

Motivation

Skills development within the geological community is important and will influence future scientific success. Knowledge and experience in advanced geographical information systems (GIS) and their powerful analytical capabilities is a requirement that needs to be nurtured in an increasingly technology- based geoscience environment. GIS is more than a graphic software package although most applications simply use the low-level map-making capability. The real value of GIS is advanced statistical analysis of multiple datasets.

The need for advanced ArcMap GIS skills as well as Spatial Analyst and 3D modelling skills arose from the intensive geological mapping and structural geological interpretation required for recent statutory and commercial projects within the Council for Geoscience.

A large amount of surface and subsurface data, including groundwater, exploration/geology borehole logs, geological cross-sections and geophysical seismic reflection data exists for the Thyspunt and surrounding areas. Staff of the Eastern Cape Unit have already collated a substantial amount of the available data. Thyspunt is a particularly good region for applying 3D modelling as this will assist associated scientific investigation relating to future groundwater/engineering/- pollution and security studies. This three-dimensional model will set a benchmark upon which future research can be based.

Progress

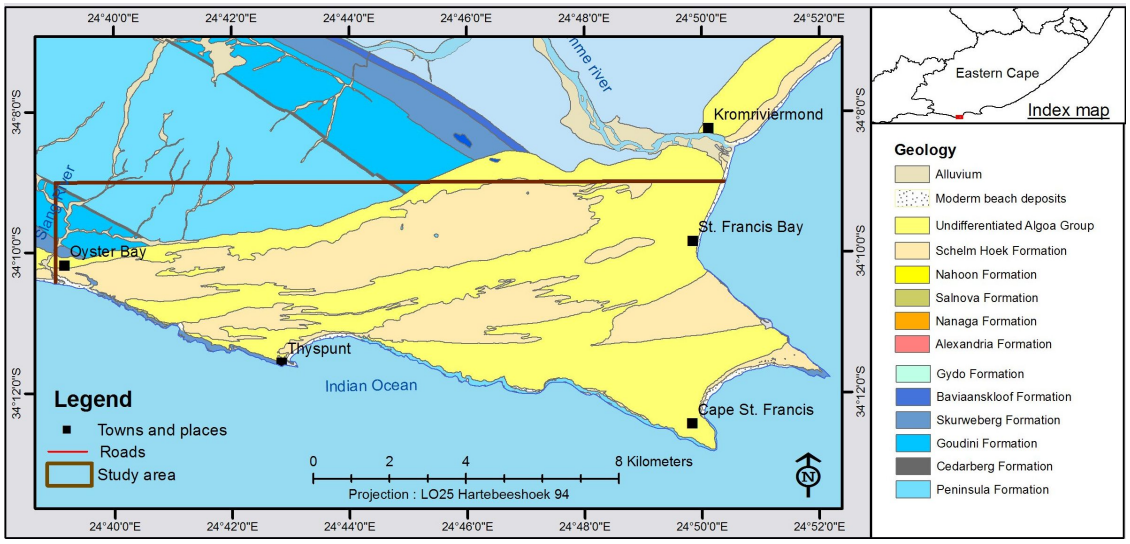
The sourcing of relevant data (surface/subsurface data such as topocadastral, geological, geotechnical, groundwater, engineering and geophysical data) from internal and external sources have been completed and digitally captured in a main database. A review of software capabilities, extensions and scripts has been undertaken and the three main software packages to be used will be ArcGIS, Google Earth and Google Sketchup.

During the period May 2011 and February 2012, drilling in the project area provided an additional subsurface dataset; creation of the model was thus postponed until drilling had been completed. Data from the drilling programme have been captured but not included in the main database until all newly drilled boreholes are surveyed at the end of March 2012, at which point the building of the 3D model will commence.

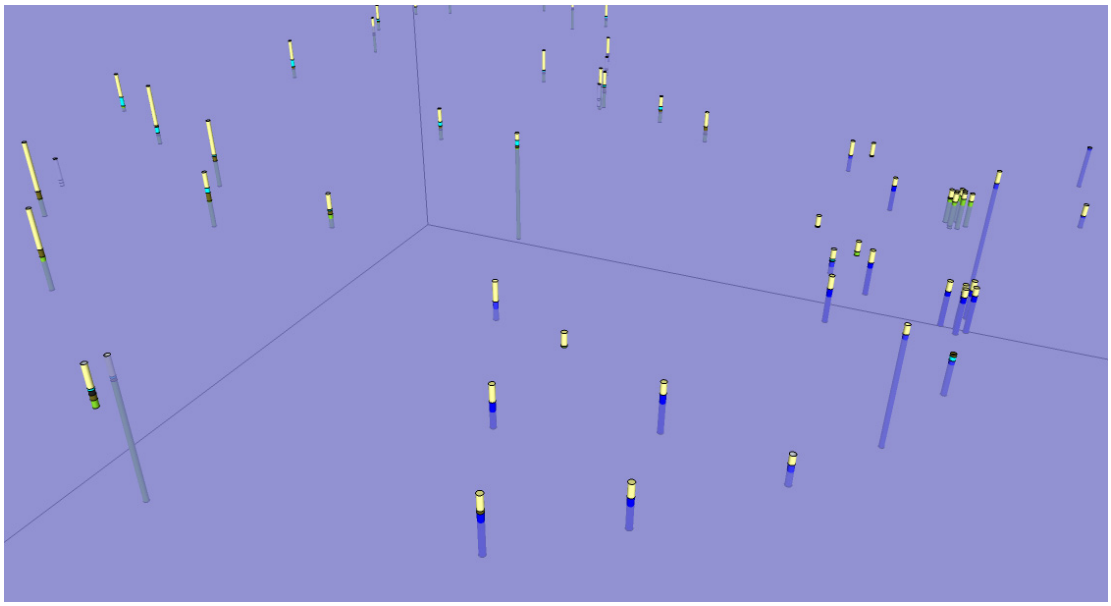
A draft report has been written which includes the interpretation of geological, structural, geohydrological and neotectonic data for the area. The report also documents data collection, collation, the database format, compilation and detailed methodology of the data manipulation and modelling process. In addition, the report contains detailed maps and subsurface cross-sections drawn from data collected to date. Chapters are, however, not yet complete.

Conclusions

During the last phase of the project, the 3D model will be constructed and the report will be completed at the end of March 2013.



Map showing the regional geology of the study area between the two coastal towns of St Francis Bay and Oyster Bay



A 3D view of boreholes within the study area. Borehole elevations are plotted as metres above mean sea level, which is indicated by the light-blue transparency

ENGINEERING GEOSCIENCE

ST-1161

Nquthu Local Municipality: GFSH-2 Phase 1 geotechnical investigations

Project leader	SG Chiliza, BSc Hons
Project team	K Tegegn, MSc, ML Sebesho, Nat Dip, SBM Nkosi, BSc Hons, NP Mkhize, BSc Hons, BC Msane, BSc Hons, SV Nyathi, BSc Hons, PP Msomi, BSc Hons
Primary objective	To conduct Phase 1 geotechnical investigations for township development in the Nquthu area. All geotechnical constraints and guidance to sustainable development are to be encompassed
Duration	2011/12–2012/13
Budget	R75 000.00

Motivation

Nquthu Local Municipality is in the northeastern part of KwaZulu-Natal, under the UMzinyathi District Municipality. Several RDP housing and related infrastructure developments are planned by the Municipality to provide decent housing and alleviate poverty in the community.

The development of infrastructure has specialised requirements with regard to the founding material and design. GFSH-2 Phase 1 geotechnical investigations are conducted to indicate and broadly classify the potential land use, particularly taking into consideration critical geotechnical factors such as excavatibility, problem soils, etc. Hence, the Engineering Geoscience Unit has embarked on conducting a Phase 1 geotechnical investigation as per the Department of Housing Project Linked Greenfield Subsidy Project Developments Generic Specification GFSH-2.

This forms part of ensuring that the Council of Geoscience is an active partner for the Government in rural community development initiatives by providing scientific solutions to earth-related problems.

Progress

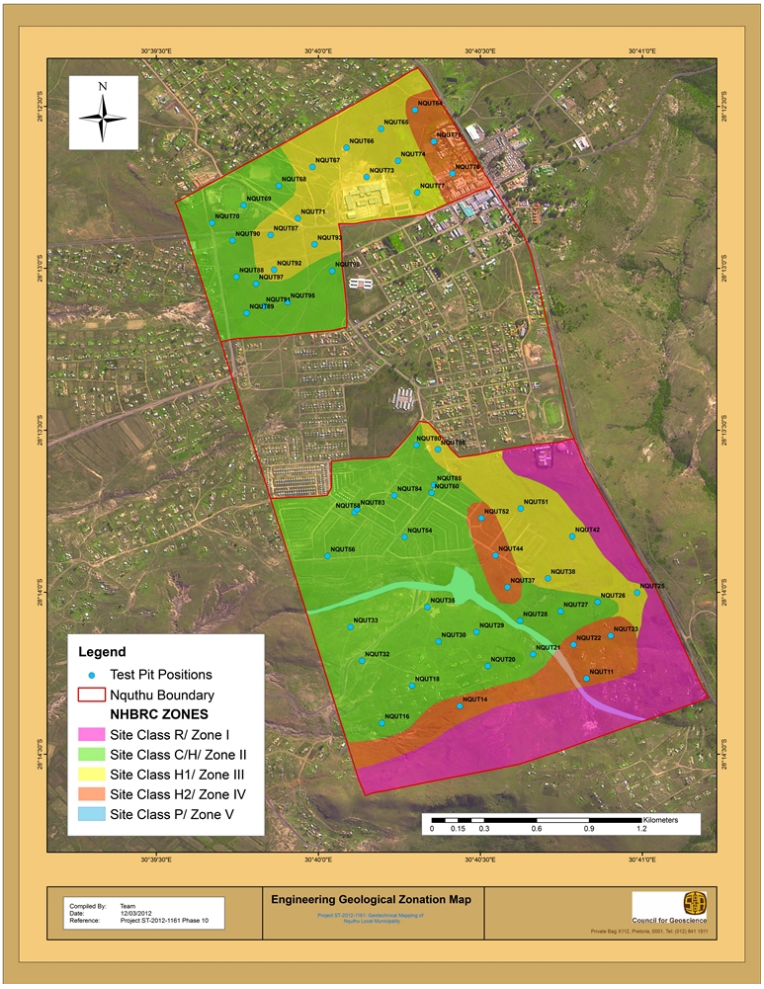
The investigation has been conducted and included pit trenching using TLB, DCP (Dynamic Cone Penetrometer), laboratory testing and analyses for several soil engineering properties. The report was compiled and two copies were submitted to the Municipal Manager.

Conclusions

A geotechnical zonation map was produced to delineate the investigated area into five NHBRC site classes and recommendations with regard to suitable foundation designs were given for the respective geotechnical site classes. This investigation has provided the municipality with a significant product which is a prerequisite for the development and formalisation of the remainder of portion F100 of the Nquthu area.

Future activities

The final step which will be conducted in the 2012/13 financial year will be to embark on a geotechnical study that will identify suitable land for cemetery and waste disposal sites as per municipality request and needs.



Geotechnical zonation map delineating the site into five NHBRC site classes

ST-1137

Develop a decision making tool for developments on dolomite (karst sinkhole and subsidence record for Gauteng Province)

Project leader S Richardson, BSc Hons (Eng Geol)
Project team GJ Heath, MSc
Primary objective This research topic was proposed with the following main objectives: (1) to develop a comprehensive sinkhole and subsidence database for the Gauteng Province; (2) to use the database information in the statistical analyses of sinkhole and subsidence occurrences, and (3) to add to the current body of knowledge on sinkholes and subsidences with regard to occurrences within the Gauteng Province
Duration 2010–2013

Motivation

Sinkholes and subsidences occur in areas underlain by dolomitic rocks. These instability events are a serious problem and can result in loss of life and/or damage to property when they coincide with human development. Dolomitic land occurs in several South African provinces including Gauteng, Mpumalanga, Limpopo, North West and the Northern Cape. Gauteng is by far the worst affected; in excess of 3 000 events have occurred in the past 60 years. Damage to buildings and other infrastructure has been more severe than on any other geological formation in South Africa. A sinkhole and subsidence database is crucial for future assessments of sinkhole hazard and decision making when it comes to development on dolomite.

Progress

A desk study has been conducted incorporating all available sinkhole and subsidence information for four municipalities in the Gauteng Province, the City of Tshwane Metropolitan Municipality, West Rand District Municipality, Ekurhuleni Metropolitan Municipality and City of Johannesburg Metropolitan Municipality. The information collected provides an indication of the number of sinkholes and subsidences that have occurred in the past 60 years.

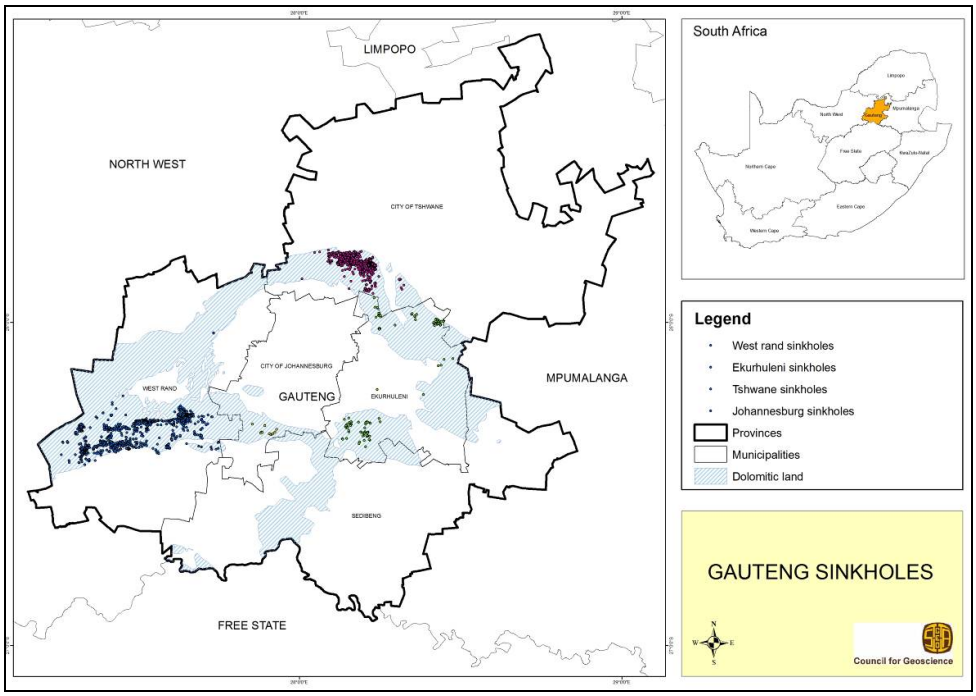
- Data verification (as far as possible), updating and amalgamation of all databases within Gauteng up to 31 December 2011 have been undertaken.
- The bulk of the data comes from external sources such as departments, municipalities and consultants.
- Data have been captured on a GIS system (ESRI ArcView 9.3) in the form of point shape files with an associated attribute table where details such as the location, coordinates, dimensions, geological formation, triggering mechanism, source data and date of occurrence are stored. Each instability event is also given a unique event number. The record is incomplete in many instances, i.e. size, date of occurrence and cause of events were often not recorded.
- A preliminary analysis has been carried out.

Conclusion

In excess of 3 000 sinkhole, subsidences and crack events have occurred within the City of Tshwane, West Rand, Ekurhuleni and City of Johannesburg Municipalities. Analyses show that all four municipalities have more sinkholes than subsidences or cracks and that the dominant sizes of sinkholes differ across the three municipalities, however, across Gauteng, more large size events (5–15 m diameter) than small, medium or very large events have occurred. The dolomite formation on which most instability events have occurred is the Monte Christo Formation, followed by the Eccles Formation of the Malmani Subgroup, Chuniespoort Group and the Transvaal Supergroup.

Future activities

Some data verification and updating is still necessary; this progress report only provides an indication of the numbers of sinkholes and subsidences that have occurred in the four municipalities of the City of Tshwane, West Rand, Ekurhuleni and City of Johannesburg. Data for the outstanding Sedibeng District Municipality still need to be compiled. All analyses need to be updated for all events occurring within Gauteng up to end of 2012, which may change the results obtained so far. A sinkhole database is ongoing and constantly updating, therefore results of the analyses may change fairly rapidly depending on available sinkhole database information. Statistical methods need to be researched further.



Distribution of dolomite and sinkhole/subsidence/crack events within the Gauteng Province.

ST-0060

ENGEODE databank

Project leader	AC Oosthuizen, BSc Hons (Eng Geol)
Project team	GJ Heath, MSc (Eng Geol), JD Grobler, LG Heath, BSocSc Hons (Psych)
Primary objective	To make engineering geology information available to the nation in assisting development
Duration	Ongoing

Motivation

Access to geotechnical information assists in guiding development and provides the foundation for research into geotechnical-related issues. The CGS geotechnical databank (ENGEODE) incorporates all geotechnical data submitted over the last 50 years and consists of two sets of information, namely the dolomitic and the non-dolomitic databanks. Owing to the growing demand from developers, consultants and the general public for this information, it is being made more easily accessible and available via digital means.

Progress

The bulk of the dolomite-related information has been submitted in the form of dolomite stability reports for peer reviewing purposes by geotechnical consulting firms. An indexing system was compiled to easily access the data and a quality-control system was implemented to ensure that all the reports indicated on the index list are stored in the database. The total number of dolomite stability reports in the system is 4 810 of which a total of 214 reports were submitted during the period April 2011 to March 2012.

In the past, the Council for Geoscience received township applications from local authorities and town planners, which contained the geotechnical reports on which the Council for Geoscience had to comment. Although no comments are currently provided on the geotechnical reports, the Council for Geoscience still receives a couple of new reports each year from consultants, for record purposes. In the non-dolomitic databank, the total number of reports submitted to date currently is 10 972.

Capturing of report boundaries, dolomite boreholes and gravity maps into GIS commenced during 2007/08 and is continuing as new reports are submitted. The following data were captured during 2011/12:

- 214 dolomite stability report boundaries,
- Positions of 2 304 dolomite percussion boreholes,
- 525 geotechnical report boundaries,
- Positions of 10 298 test pits,
- sinkhole events were recorded in the municipal areas of Tshwane and Ekurhuleni and the provinces of Mpumalanga, Northern Cape and North West which brings the total number of sinkholes in the database to 3 048 events.

Telephonic and e-mail enquiries are received on a regular basis from the general public, stakeholders and developers. The digital accessibility of the information in the databank makes it possible to easily provide stakeholders with the necessary information, such as a small map showing the position of the site in relation to the presence of dolomite. For the financial year ending March 2012, a total of 580 small geology maps have been created for clients, whereas a total of 235 telephonic/e-mail enquiries have been received in order to obtain or request available dolomite data.

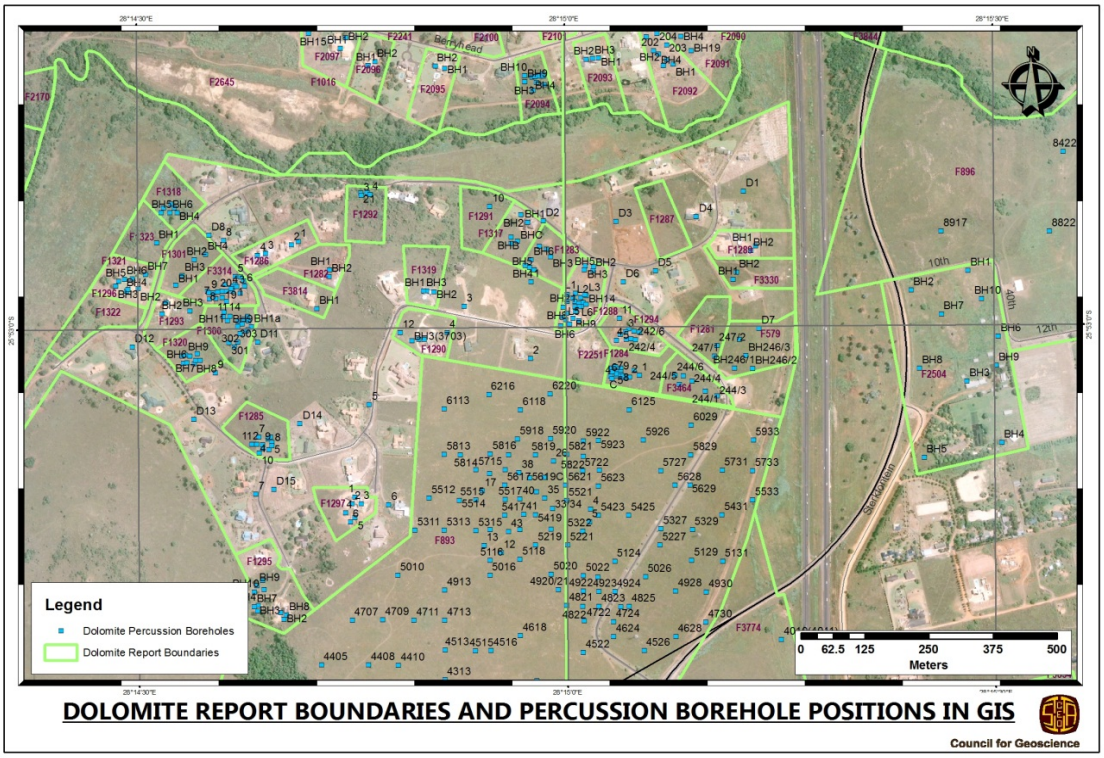
Conclusion

The importance of this databank is growing, as more consultants working in the industry require GIS data from the Council for Geoscience. The organisation has been involved in a number of large data-acquisition projects to date and this databank is becoming a very useful tool for industry. The aim is to make the data in the ENGEODE database easily accessible through the planned Web-portal of the Council for Geoscience. This will allow a broader field of users that will be able to utilise the information stored in the database from the convenience of their offices or work sites.

Future activities

Data capture is an ongoing process and will remain part of the unit's responsibilities in the years to come. The capturing of the dolomite- and non-dolomite-related data will continue in 2012/13 and work to produce a definitive sinkhole record for South Africa will continue.

Sinkhole in Khutsong that occurred during 2011



The Dolomite GIS System: Map showing report boundaries and the positions of percussion boreholes in GIS

ST-0029

Centurion hazard map

Project leader	AC Oosthuizen, BSc Hons (Eng Geol)
Project team	GJ Heath, MSc (Eng Geol), LG Heath, BSocSc Hons (Psych)
Primary objective	To provide a map where the hazard of sinkhole formation is indicated in the Centurion CBD and surrounding areas which will assist the Local Authority with guiding safe development in the area. The map will also assist in making recommendations regarding the suitability of land usage based on the hazard of sinkhole formation
Duration	Three years

Motivation

In South Africa, dolomite rock has a notorious reputation for forming sinkholes and subsidences. Thousands of people reside and work in the Centurion area, where numerous sinkholes have occurred, causing damage and in some instances loss of property. This area has been rapidly densified over the last forty years, and has become a major residential node midway between Johannesburg and Pretoria. The Gautrain route now traverses across the Centurion CBD area and the Centurion Station being situated in West Street is attracting high-rise developments to this area. This will lead to an increase in the population which results in an increase in road traffic and density of people per hectare in this area. The Council for Geoscience currently has had to support numerous developments in the Centurion CBD and surrounding areas. The large amount of information available on the CBD area, particularly in digital format, meant that a first-order sinkhole hazard analysis could be attempted.

Progress

The Centurion study area is bounded by Trichardt Road in the north, Botha Avenue in the east, the N1 highway in the south and the N14 highway in the west. 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 on the study area is available through dolomite stability reports that have been submitted to the Council for Geoscience for peer review. A total of 555 dolomite stability investigations have been conducted within the study area and a total of 3 587 percussion boreholes were drilled. Each borehole within the study area was assigned an inherent hazard class. Eight inherent hazard classes are present that classify an area into a low, medium or high hazard, which is an indication of the probability of sinkhole formation.

A total of 119 sinkholes have been recorded in the Centurion CBD area since the early 1970s. The average sinkhole depth is 3 m whereas the average sinkhole size is 5 m in diameter. Three lives have been lost as a result of sinkholes in the study area and a total of seven residential structures had to be demolished. Millions of rands have been spent to repair structures, infrastructures and services. A recent sinkhole in Jean Avenue estimated a total remediation cost of almost R5 million.

Using the Spatial Analyst extension of ArcGIS 9.3, a map showing the hazard of sinkhole formation was compiled from the hazard class assigned for each borehole in the study area. The hazard map of the area generally indicates a medium to high susceptibility to sinkhole formation with pockets of low hazard areas. The map shows that no sinkholes occurred in the areas classified as having a low hazard to the formation of sinkholes, which suggest that the areas of low hazard were delineated well and that the classification system defines this well. A vast majority (70%) of the sinkholes in the study area occurred in areas classified as having a medium hazard for the formation of sinkholes, which could suggest that medium hazard areas are equally vulnerable to sinkhole formation as high hazard areas, although it must also be borne in mind that two thirds of the study area is considered to have a medium susceptibility to the formation of sinkholes.

A back analysis is made using the existing sinkhole occurrence database against the method used to classify dolomite land in South Africa, the Method of Scenario Supposition. The Method of Scenario Supposition is based on an abused land use situation, where the study area is situated in a densely developed, well-managed area in terms of precautionary measures. The back analysis broadly indicates that fewer sinkholes occur in areas where appropriate precautionary measures including the adequate foundation design and well-

managed services are installed, such as the Centurion CBD and surrounding areas, compared to the abused land situation.

Recommendations regarding the various types of land uses are made. The conclusion can be made that the majority of the Centurion CBD and surrounding areas would be suitable for most types of residential and commercial type developments, with commercial type developments being more suitable in the CBD area surrounded by the Centurion Lake and residential type developments being more suitable towards the outskirts.

Conclusion

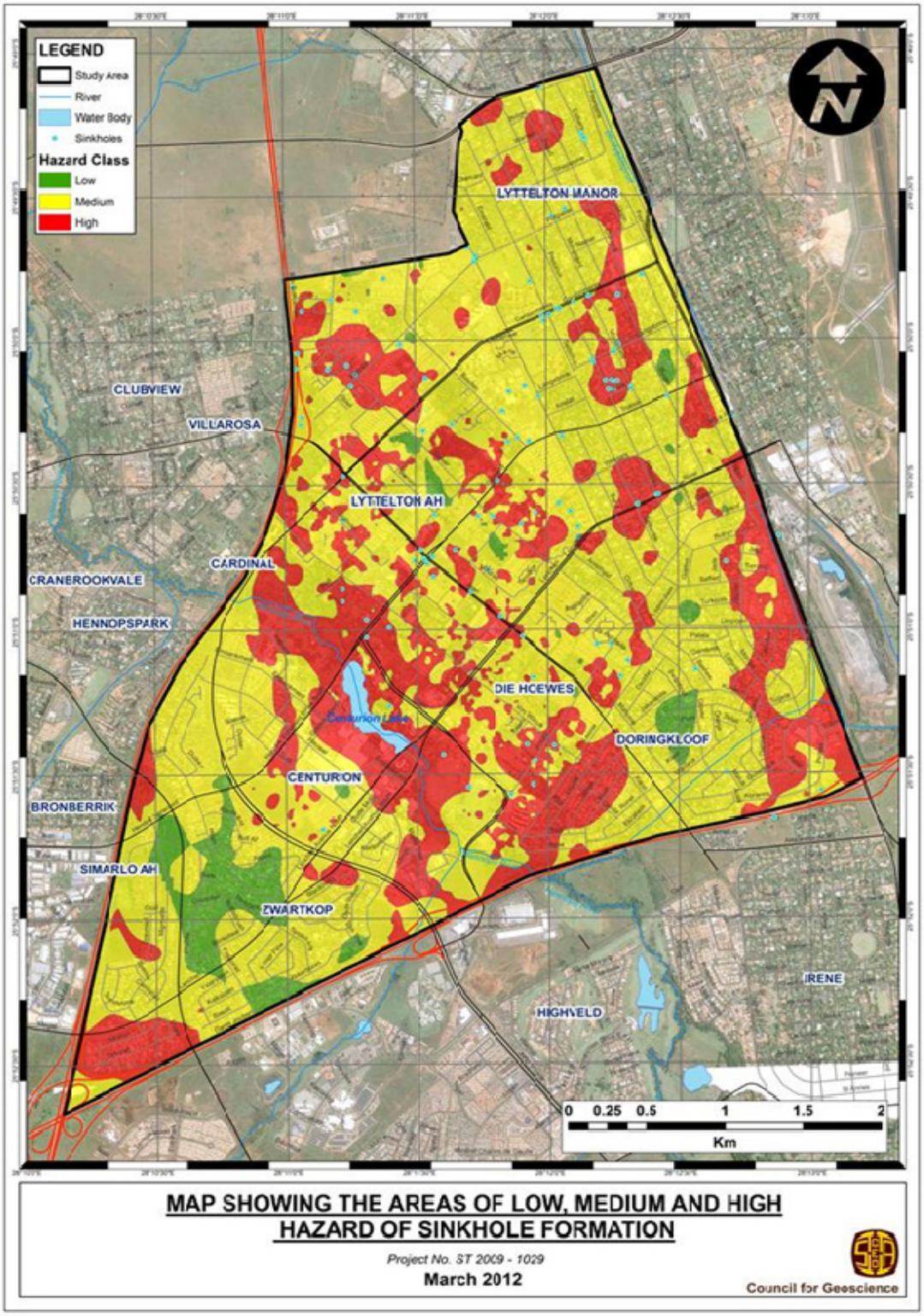
The hazard classification map shows that the study area can mainly be classified as having a medium to high hazard for sinkhole formation, although calculations using the actual sinkhole events show that the area can be classified as having a low to medium hazard for sinkhole formation. The reasoning behind this could be explained as follows:

- The method used to classify the boreholes is too conservative, and the actual hazard for sinkhole formation is actually much lower.
- Not all the sinkhole events were recorded in the study area which causes the calculations to show a much lower probability of sinkhole occurrence.

Future activities

Should the outcome of this study show reliable results, it could be used as a new tool to classify dolomite land in developed areas. The results of this study need to be tested against actual data which were obtained during sinkhole remediation.

A sinkhole that occurred in Jean Avenue during 2011



Hazard of sinkhole formation in the study area

ENVIRONMENTAL GEOSCIENCE

ST-2012-1150

A holistic approach towards best management practices of mining impacts on the environment with emphasis on water resources

Project leader	B Yibas
Project team	O Novhe, R Netshitungulwana, P Nyabeze and T Motlakeng
Primary objective	Assessment and management of mining impacts on the environment, particularly on the water resources
Duration	Three years
Budget	R9 million

In South Africa, mining pollution has historically been a major source of degradation of the natural resource systems such as water resources (surface and ground), land use and land degradation, air, etc. Unfortunately, the current information on mining externalities is insufficient to be useful for policy setting. Extensive but systematic studies need to be undertaken to fill this information gap, particularly in the development of policy instruments which require information on the social costs of mining, and partly to assist in the formulation of guidelines on damage assessment and compensation for the mining sector.

The major concerns in this regard are the lack of national coordination in the research, development and application of remediation techniques. The Environmental Geosciences Unit (EGU) of the Council for Geoscience positions itself to play a leading role in developing a national holistic strategy for rehabilitation and remediation of environmental impacts and critical pollution problems affecting the environment and ecosystem with a particular focus on the scarce water resources of the nation from the mining industry.

With this overall objective, the project is started in 2011 with impact and pollution assessments. The sources and impacted areas of the country are classified into 13 major geo-environmental provinces in South Africa.

Geo-environmental provinces of South Africa for the assessment and management of the impact on water resources

The impact assessment component of the project began with a catchment area-based approach. In 2011/12, the Olifants and the Komati–Crocodile catchment areas have been targeted. The project has a multidisciplinary task team of remote sensing and GIS, hydrology and water quality, hydrogeology, geochemistry and acid mine drainage, ecotoxicology, physical hazard assessment, geophysics and air quality.

Acid mine drainage in the Komati–Crocodile catchment (upper photos) and fieldwork for the assessment of acid mine drainage (lower photos)

GEOPHYSICS

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	LP Maré, MSc
Project team	D Kruger, MR Mantsha, M Brynard 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	R604 205.75

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 2011/12, petrophysical analyses including bulk density, magnetic susceptibility, intensity of magnetisation, magnetic remanence, electrical resistivity, induced polarisation, seismic velocity as well as dielectric parameters that were performed on different stratigraphic units in South Africa.

Some of the stratigraphic units that have been covered during this period include samples from the Karoo Supergroup, Keimoes Suite and a Bushveld-related dolerite sill.

Due to staff shortages, not all the data have been captured into the ORACLE-based Physical Properties Atlas of South African Rocks.

An interactive map application for the geophysics atlas was developed using the Google Maps application programming interface (API). This allows the user to zoom into the 1:100 000 geology map of South Africa and to query specific stratigraphic formations for available petrophysical data in the database.

The design and building of a new time-domain resistivity-induced polarisation instrument for the laboratory was planned, but the designated person unfortunately passed away and the project was put on hold. Several contamination experiments were conducted using the induced polarisation (IP) method.

Conclusions

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

Future progress

During 2012/13, research on IP and membrane constrictivity will be continued. Owing to a lack of resources, the s-wave function of the Portable Ultrasonic Non-destructive Digital Indicator Tester (PUNDIT) is not yet operational. An advert has been sent out to employ an extra scientist in the lab.

ST-2009-1004

Magma dynamics in sill and dyke systems. Constraints from magnetic fabrics and palaeomagnetism in the Karoo Large Igneous Province

Project leader	LP Maré, MSc
Project team	EC Ferré, PhD, MO de Kock, PhD, H Mouri, PhD, B Cairncross, PhD, SIU students
Primary objective	The goal of this project is to conduct several magnetic fabric and palaeomagnetic experiments to evaluate the magma dynamics of a large igneous province. A PhD study on the geothermal history of the Karoo Basin is in progress
Duration	2008/9–2013/14
Budget	In total: ~R2 316 617.50; Report year: R546 437.50

Motivation

The first three years of this international collaboration project was funded in part by the NSF. The aim of the Council for Geoscience getting involved with this project was 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.

As a spin-off from the NSF-funded project, a PhD was registered at the University of Johannesburg. The aim of the project is to determine the effect of the Karoo LIP on the geothermal history of the Karoo Basin by making use of existing magnetic and palaeomagnetic methods. 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. These hypotheses will be tested with three experiments performed on Karoo sediments surrounding sill and dyke intrusions of know dimensions.

Progress

During 2011/12, samples were collected from another three boreholes in the Karoo Basin that intersect dolerite sills as well as from three boreholes that do not intersect any dolerites.

A total of 1 547 samples from different stratigraphic units were collected. The sampling process was severely hampered by the breakdown of the forklift of the National Core Library.

Preliminary magnetic susceptibility, anisotropy of magnetic susceptibility as well as intensity of magnetisation of the collected samples have been measured.

Conclusions

A comprehensive collection of samples from across the whole Karoo Basin has been acquired. Owing to unforeseen delays, only preliminary measurements were possible on these samples.

Comparing the preliminary mean susceptibility and magnetic intensity variations for different stratigraphic units across the Karoo Basin from southwest to northeast does not at this stage reveal any distinct pattern that can be associated with a depositional environment or depth of burial. No specific differences in mean values between boreholes with or without dolerite were observed.

Future progress

During 2012/13, the aim will be to perform all three magnetic experiments on samples from those boreholes that intersected dolerite sills. The aim will be to determine if the observed elevated temperatures from the western Karoo Basin is also prevalent in the rest of the basin, or whether there is any variation from west to east as well as from south to north within the basin.

During 2013/2014, the same experiments will be performed on samples from dolerite-free boreholes.

GEOPHYSICAL INTERPRETATION

ST-2002-0679

Upkeep and development of geophysical databases

Project leader	M Havenga, BSc Hons
Project team	L Ledwaba
Primary objective	Maintain and expand geophysical databases, including GIS coverages
Duration	2002/03–2012/13

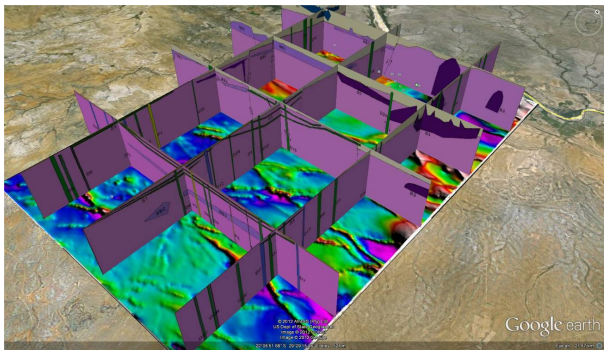
Motivation

The Geophysics Unit has vast amounts of data. This needs to be properly stored, backed up and catalogued. Data that are easily accessible result in greater work efficiency and better productivity.

Progress

The maintenance and development of the geophysical databases is an ongoing project, largely dependent on the commercial climate for the collection of new data and the changes in requirements from users for the structure of the data. Since 2011/2012 was a quiet year on both the commercial and statutory front, very little new data were collected and added to the database. The work done on the database project consisted mainly of data quality control and general maintenance, since only a few surveys, mostly commercial, were conducted and data captured. The reprocessing of two surveys that contained levelling errors was completed. Landsat images downloaded for commercial and statutory projects were added to the database.

The possibility to store models and modelled profiles in the compressed Google Earth Keyhole Markup Language (KMZ) format was investigated and implemented. In future, the geophysical models will be stored in this format in the database to ensure ease of use and availability of such models and profiles to users without the requiring special software.



Example of modelled profiles in Google Earth

Conclusions

The database was maintained and the quality of the data improved during the year. The KMZ format will improve product delivery to clients.

Future progress

During 2012/13, the process to capture commercial ground survey data will be continued, along with general maintenance and quality control.

ST-2012-1146

A review of the gravity processing procedures and data

Project leader	RH Stettler
Project team	J Cole, MSc
Primary objective	To update the routines used for gravity processing to the latest standards and to start a gravity calibration line
Duration	2011/12
Budget	R30 000.00

Motivation

The processing of gravity data is based on a number of standard formulas that have been developed over the years. Many of these formulas have been adapted as more accurate data became available. In some cases, new formulas better representing the shape of the earth have been proposed. The Geological Surveys (or equivalent organisations) in many countries have adopted these improved processing techniques and it was decided to apply these to the regional gravity data for South Africa.

As there has never been a calibration line in South Africa (previously calibration was only done between two points), it was deemed necessary to establish a South African National Gravity Calibration Line (SANGCAL).

Progress

Up to now, the procedure for obtaining a Bouguer anomaly map started with determining the theoretical value of the earth's gravity at a specific point using the International Gravity Formula (IGF) of 1971, based on the GRS67 reference ellipsoid. A newer formula which was put forward in 1984, based on the more recent GRS80 ellipsoid, which is almost identical to the WGS84 ellipsoid, was applied to the observed data. This formula includes an atmospheric component for which a correction has to be applied. The difference between the IGF84 and IGF67 for South Africa ranged between -0.031 and 0.297 mgal.

The second step in processing gravity data is to calculate the height correction. Traditionally, a very simple linear formula was used, namely multiplying the height above a datum (normally sea level) by 0.3086. This is a first-order approximation of the vertical gradient of gravity. However, more powerful computers allow for the use of more complete approximations and the new formula used a Taylor series expansion to the third order. It incorporates not only the height above a reference level, but also the latitude. Another big difference is the use of ellipsoidal height (height above the reference ellipsoid) instead of orthometric height (height above a datum such a sea level). Height corrections applied to the South African data set using the new equation differed by between 2 and 11 mgal from the traditional height correction.

The final step in deriving the Bouguer anomaly map is to calculate the Bouguer correction. This correction accounts for the material between the observation point and the reference datum. This is normally approximated by a horizontal slab with a specific density (normally 2.67 g/cm^3) and a thickness equal to the height above the reference plane, traditionally sea level. This formula was replaced by the spherical Bouguer correction that better approximates the shape of the earth than a horizontal slab. Once again, the ellipsoidal height was used instead of the orthometric height. The new formula differed from the old formula by 0.5 to 1.37 mgal for South African data.

The final Bouguer anomaly dataset that was calculated using the new techniques differed by up to 9 mgal from the previous Bouguer anomaly dataset calculated using the traditional methods.

Calibration line

As a starting point, it was decided to try and do a calibration point roughly every one hundred kilometres in a town along the N1 from Mussina to Cape Town. Maps were obtained and points were chosen depending on locality, durability, geology and safety. Points are mostly close to 100 km from each other with the closest 80 km and the furthest 136 km.

Only the stretch between Pretoria and Paarl had been completed. It took four days and some 450 measurements were taken.

The data were processed using standard software, after which calibration constants were calculated for each instrument.

Conclusions

The new processing algorithms used to calculate the Bouguer anomaly map follow a geodetic approach, in other words the reference plane to which all measurements refer is the WGS84 ellipsoid. Previously, the free air correction and Bouguer slab correction was used for the orthometric height. Since the theoretical gravity formula is based on the reference ellipsoid, the geoid height (height between the geoid and the ellipsoid) introduced an indirect effect on the final results.

The calibration line has been successfully established and the gravimeters were calibrated.

Future progress

The calibration line will be extended from Mussina to Pretoria.

ST-2012-1148

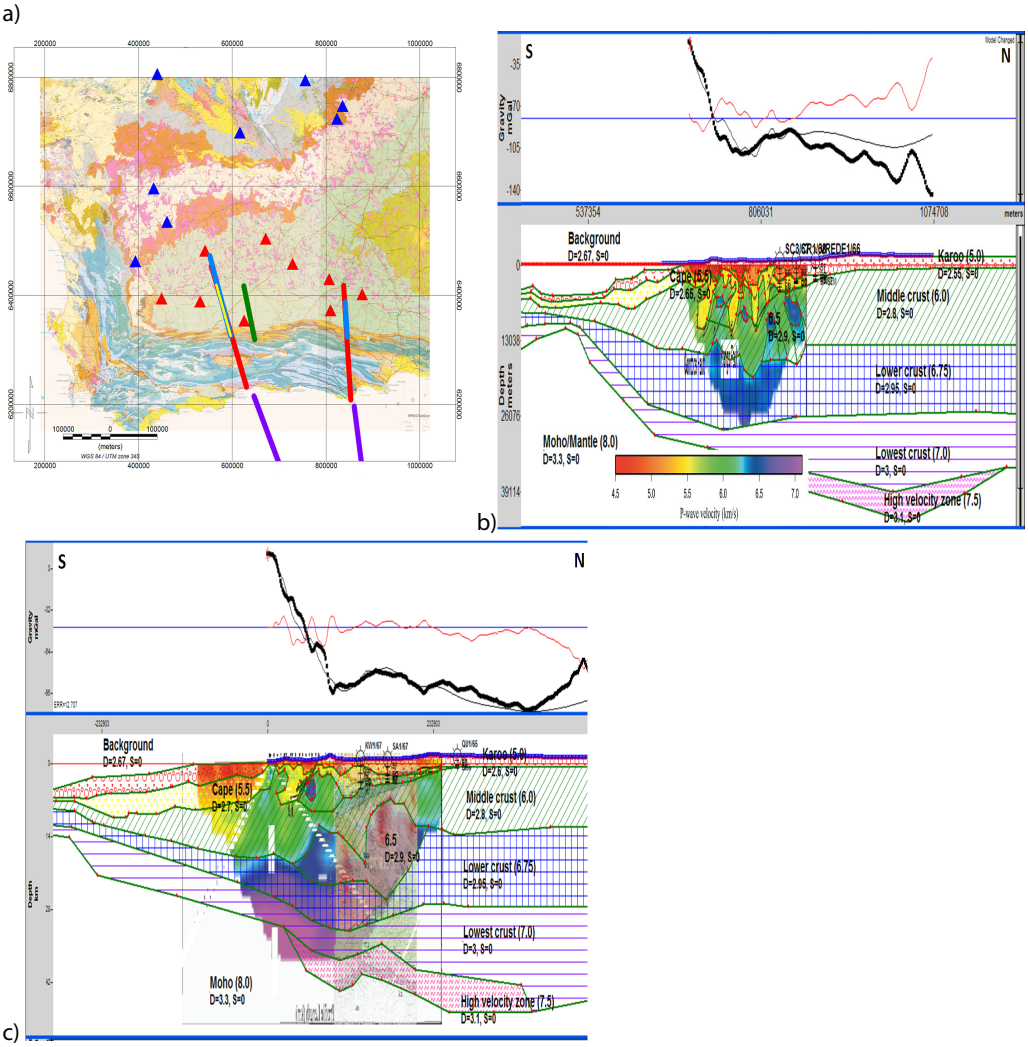
Geophysical 3D modelling of the Karoo Basin

Project leader	S Scheiber
Project team	D Eberle, S Webb (Wits University), J Ebbing (Norwegian Geological Survey)
Primary objective	The aim of this study is to develop a 3D model of the southwestern Karoo Basin based on seismic and potential field data and constrained using surface geological and structural information, deep boreholes and Moho structures from teleseismic data. This model will be used to carry out isostasy and flexure studies on the lithosphere in this region in an attempt to gain new insight into the possible evolution of the Karoo Basin on and off craton
Duration	3 years
Budget	R70 000

Declining natural gas production worldwide has caused a shift in focus to unconventional sources such as the Karoo Basin, the broad arid plateau that covers much of the interior of South Africa. The plateau, which is supported by the stable Archean Kaapvaal Craton in the north and several surrounding Proterozoic basement blocks in the south, formed within the continental interior of Gondwana between the Late Carboniferous to Middle Jurassic (125 Ma). No clear tectonic model exists for the Karoo Basin, with several hypotheses regarding the nature of the subsidence resulting in basin formation, which, in turn, has implications for shale gas formation within the basin.

The aim of this study is to develop a 3D model of the southwestern Karoo Basin based on seismic and potential field data, and constrained using surface geological and structural information, deep boreholes and Moho structures from teleseismic data. This model will be used to carry out isostasy and flexure studies on the lithosphere in this region in an attempt to gain new insight into the possible evolution of the Karoo Basin on and off craton.

The project "Geophysical 3D modelling of the Karoo basin" between April 2011 and March 2012 presented two 2D profiles across the region that are currently being combined to produce a preliminary 3D model of the basin as well details about the collection of data used to constrain these models. Two side projects have been developed which involve modelling along shorter profiles.



a) Geological map of the western Karoo showing datasets used, including Council for Geoscience (red triangles) and SOEKOR (blue triangles) boreholes, and several seismic lines; b) 2D gravity model extended north along the eastern profile shown in (a). Upper panel shows the observed gravity field (thick black line), modelled gravity (thin black line) and error (red line). Lower panel shows 2D gravity model with density values in g.cm^{-3}, with seismic image and SOEKOR borehole logs (circular wells) overlain; c) 2D gravity model extended north along western profile shown in (a) with details same as (b).

Conclusions

Several tectonic models exist for the Karoo Basin, but only recent models are starting to draw on knowledge gained from geophysical datasets collected in the area and there is still disagreement as to the tectonic environment of the Karoo. This provides an opportunity through the project to contribute to the current understanding of basin formation. Existing borehole data investigated during this first part of the project show that the Karoo basement depth increases towards the coast. This deepening to the south is also seen in processed seismic data (the regional extent of which will hopefully be better understood when the SOEKOR seismic data is interpreted) and the 2D potential field models. This increase in depth is a combined result of the mode of basin formation as well as the change in rheology of the underlying basement (i.e. from the inland stronger, older Kaapvaal Craton to the younger, weaker coastal mobile belts). Thus, by creating a 3D model of the basin and carrying out flexure studies in the next stage of the project, the formation of the basin will be better investigated.

ST-2007-0937

Developing a 3D potential field model of the Bushveld Complex

Project leader J Cole, MSc
Primary objective To create a three-dimensional model of the Bushveld Complex using gravity and magnetic data with the aim of improving the understanding of the geometry of the complex
Duration 2006/07–2012/13

Motivation

The Bushveld Igneous 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 on it, 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 about 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

Work this year focused on determining physical properties of the units that will form part of the model, specifically magnetic properties that will be used in the magnetic modelling. Magnetic susceptibility data were available from a variety of sources, namely laboratory measurements of rock samples collected in the field, laboratory measurements of borehole core and downhole wire-line logging. Before datasets from the various sources could be used to construct a magnetic susceptibility stratigraphy, they had to be related to each other. In addition to the susceptibilities, magnetic properties can also include remanent magnetisation parameters. These were obtained from published data. As can be expected, the magnetites in the Upper Zone have very high susceptibilities, resulting in an average susceptibility of 0.1184 SI for the zone. Average susceptibilities for the Main, Critical and Lower Zones are very low, although it was found that some of the anorthosites and pyroxenites within the Critical Zone had higher susceptibilities. The Main Zone is characterised by very strong remanent magnetisation.

The magnetic stratigraphy was used in conjunction with the density stratigraphy determined during an earlier phase of the project to model magnetic and gravity data along a seismic reflection line north of Pretoria. The magnetic data along this profile contain two prominent negative anomalies that could only be modelled by remanently magnetised bodies. The southernmost anomaly correspondes to the Middelwater Layered Sill that intruded into the Transvaal Supergroup and palaeomagnetic analyses on samples obtained from the sill revealed a strong, reversely polarised remanent magnetisation component. The second negative anomaly coincided with the Rustenburg Layered Suite on the geological map, but could not be successfully modelled using the established average susceptibilities and palaeomagnetic parameters determined for the Main and Upper Zones. Including a layer with a high susceptibility (0.012 SI) and strong reversely polarised remanent magnetisation between these two zones, resulted in a good fit between the observed and calculated values. This layer may be similar to the magnetite gabbro that is located near the top of the Main Zone in the eastern lobe of the Bushveld Complex. Overall, it was possible to model the potential field data along the profile using the physical properties determined for the Bushveld Complex rocks while still adhering to the seismic reflection data.

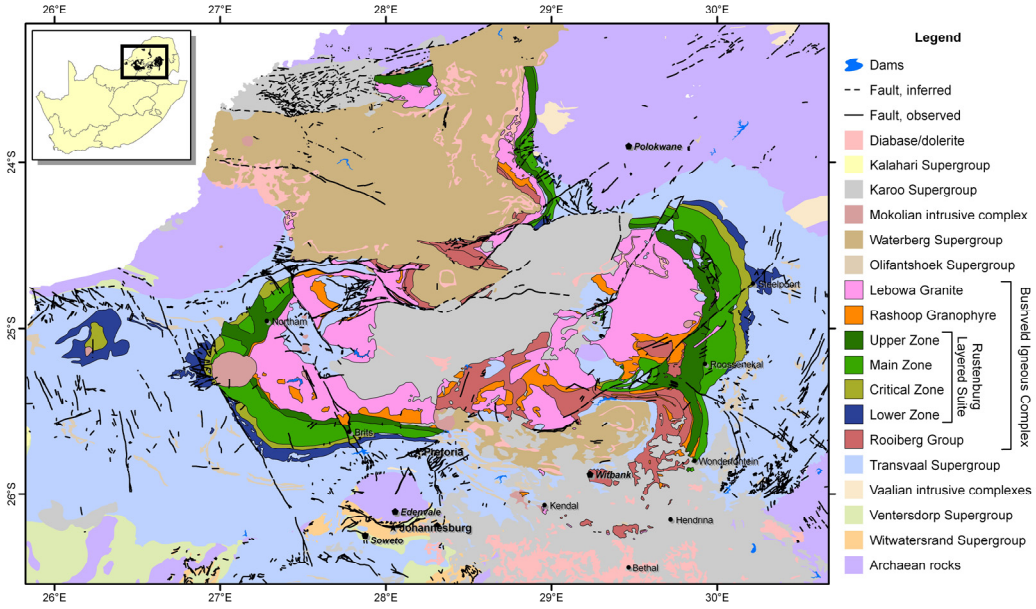
Finally, basic models were created along a set of north–south- and east–west-striking profiles to test the effect of variations in crustal thickness and mantle density on the gravity field. The gravity data over the Bushveld Complex display a long wavelength anomaly that has in the past mostly been modelled by density variations in the upper crust. The simple models created in this study showed that for a model on the scale of the Bushveld Complex, variations in physical properties even as deep as the mantle can influence the modelling results.

Conclusions

The work completed during this year provided an important basis necessary to proceed with the modelling process.

Future progress

During 2012/13, the three-dimensional model will be created.



Map of the Bushveld Complex

ST-2012-1147

Further interpretation and ground follow-up of high-resolution airborne geophysical data collected in the central part of the Capricorn District, Limpopo Province

Project leader	E Sakala, MSc
Project team	A Tessema, E Havenga, BSc Hons, E Chirenje, D van der Walt, BSc Hons and C Mukosi, BSc Hons
Primary objective	Follow-up geophysical surveys over selected mineral and groundwater target zone using remote sensing data and ground geophysical methods
Duration	2011/12–2012/13

Motivation

The main objective of the study will be to follow up on recommendations of the recent geophysical interpretation work done on the project area in the previous financial year.

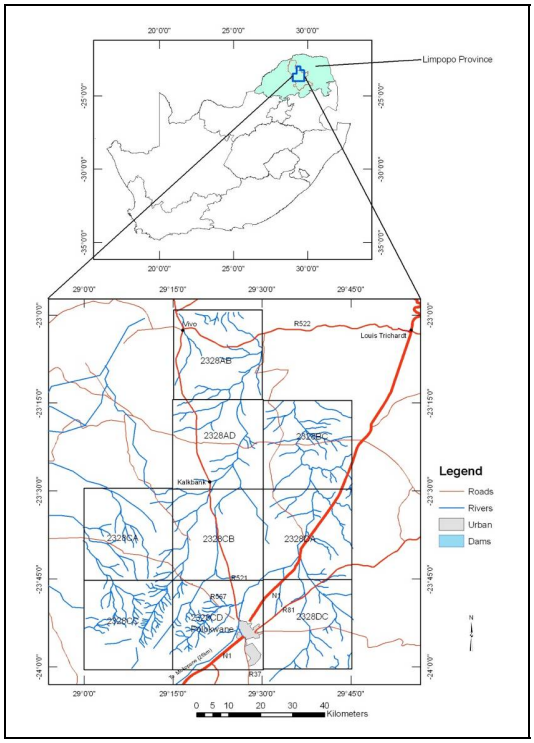
The groundwater study will aim to identify targets that can assist in improving the quality of life of local communities. It can also contribute to sustaining the agricultural sector in periods of drought.

Progress

High-resolution airborne magnetic and radiometric data which were collected over an area covered by nine 1:50 000 sheets in the central part of the Capricorn District in the Limpopo Province were interpreted for groundwater and mineral potential.

Interpretation work identified a number of mineral exploration targets (gold, copper, nickel, corundum, uranium and rare-earth elements). Currently, a review to link ore genesis processes to the interpreted high-resolution geophysical structures is being done. Target zones will be classified based on the findings of the review process. Detailed ground geophysical surveys will be done over the priority target zones.

Groundwater studies showed that the northern and central eastern parts of the study area are potentially feasible for groundwater occurrence, while the southern and southwestern parts of the project area are dry with bare soil and no surface manifestation of the availability of groundwater. Regional groundwater surveys will be done over the groundwater target zones and groundwater drilling targets identified.



Location map of project area

Future activities

Drilling targets identified will be shown to the relevant authorities. Drilling of the target will then follow for groundwater. A localised exploration programme for mineral targets will be drafted and relevant authorities advised.

INFORMATION AND COLLECTIONS MANAGEMENT

Museum

Curator K Nzolo, Museum Diploma
Project team E de Kock, MSc, 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. It also curates a major fossil collection containing, amongst others, a collection of unique synapsida fossils from the Karoo and a significant collection of ammonite fossils.

The meteorite and mineral collections, in particular, are amongst the most comprehensive in Africa and are internationally renowned. A systematic minerals display provides an exciting introduction to minerals and mineralogy. The fossil collection is amongst the most important in South Africa and is increasingly being utilised by national and international scientists for research purposes.

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 photographed for identification purposes. The database will eventually be displayed on the Internet, showing the photographs and some additional information. The fossil collection is also being re-catalogued; unknown fossils are identified and important fossils prepared to increase their research potential.

The exhibition series termed "Out of the Box" was continued. The idea behind this exhibition is to display ten or more favourite or unique specimens from the collections of individuals in the Museum on a monthly basis. This exhibition series started in December 2010 and ten specimens from the Museum's collection were displayed. The latest display, introduced on 1 March 2012, included 13 specimens from the collection of Prof Bruce Cairncross. New monthly exhibitions have been scheduled up to August 2012.

The Museum received loan requests from the Tshwane University of Technology and the South African Agency for Science and Technology Advancement. Baddeleyite samples from the Museum collection were donated to the Geology Department of the University of Arizona to assist in the development of a standard for U-Pb dating.

A total of 51 288 visitors were recorded at the Museum during the year.

Library services

Chief librarian L Niebuhr, BBibl, BInf Hons
Librarians E van Tonder, BSc, BBibl, L Breytenbach, BTech (Lib & Inf Sci), Z Nondudule, BInf (Lib & Inf Sci), G Makhubele, BTech (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 employees of the Council for Geoscience 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 sale of publications and reports of the Council for Geoscience, 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 2 346 visitors and replied to 2 134 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 and during the year, a total of 1 420 searches were conducted by the staff. An ever-increasing demand for maps and copies of maps from African countries in the Map Library collection is evident. During the year, 560 requests were successfully handled by the Map Librarian.

The Library currently houses approximately 17 500 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 302 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 fulltext electronic journals or e-journals has also been made possible through the Library's subscription agent, a facility for the exclusive use by CGS staff.

The unpublished map and report collections of the Council for Geoscience are 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.

Bibliographic databases

Project team MGJ Janse van Rensburg, BInf, E van Tonder, BSc, BBibl, S Tucker, Dip SBM
Primary objective To maintain the geological literature database
Duration Ongoing

SAGEOLIT (the South African Geological Literature Database) now contains more than 535 824 records, which includes published and unpublished material, borehole logs and maps. Records in the SACS and SAMINDABA databases are also linked to the SAGEOLIT records. Searches by farm name are made possible by links from a table of farm information to the SAGEOLIT records. An extract from the SAGEOLIT bibliographic database was made and distributed to the Geological Surveys of the countries in the Southern African Development Community (SADC) on CD. This product is used to great effect by these libraries.

The Map Library database contains references to more than 67 741 maps, including unpublished maps of the Council for Geoscience. These items are spatially referenced to enable access by GEODE/GIS.

Maps and unpublished reports in the L&IC collections are scanned on a continuous basis to provide easier access to these documents and also to provide a back-up of this irreplaceable material. Scanned documents are stored on a LAN server of the Council for Geoscience.

National Core Library

Core library manager J Mathebula, Nat Dip (Geol)
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 South African 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 now has accessioned borehole core from more than 2 000 boreholes, representing nearly 2 000 km of core.

Renewed interest in the services offered by the Core Library was experienced during the reporting year and a total of 21 visitors were received from as far afield as Liverpool in the UK. The interest in old SOEKOR boreholes, drilled during the 1960s and 1970s increased as the interest in possible shale gas deposits in the Karoo intensified.

On 3 March 2012, a group of more than 30 delegates to a Geological Society workshop spent a day at the Core Library doing practical borehole logging using some of the core housed at the Core Library. This activity is bound to increase since the organisers expressed an interest to host more of these training sessions at the Core Library.

Publications

Editors SJ van Eck, BA (HED), Z Nel, MA

Motivation

The Publications Section is responsible for disseminating the geoscience information of the Council for Geoscience in a printed format by means of several series of publications. The most important series that were released during the period under review included the Popular Geoscience Series and the Explanations accompanying geoscience maps.

Progress

A geological explanation to accompany the Mozambique 1:1 000 000 geological map was published during the year, completing the project to produce a geological map of the whole of Mozambique.

A number of publications were prepared in pdf format and are available at the CGS Bookshop. The Annual Report was printed and tabled in parliament.

One of the main functions of the section is the translation of the increasing number of texts from english into french and vica versa. Staff are also actively involved in the editing and proofreading of reports from various business units within the organisation and for the editing of French reports and publications for various CGS projects in Francophone countries.

Future activities

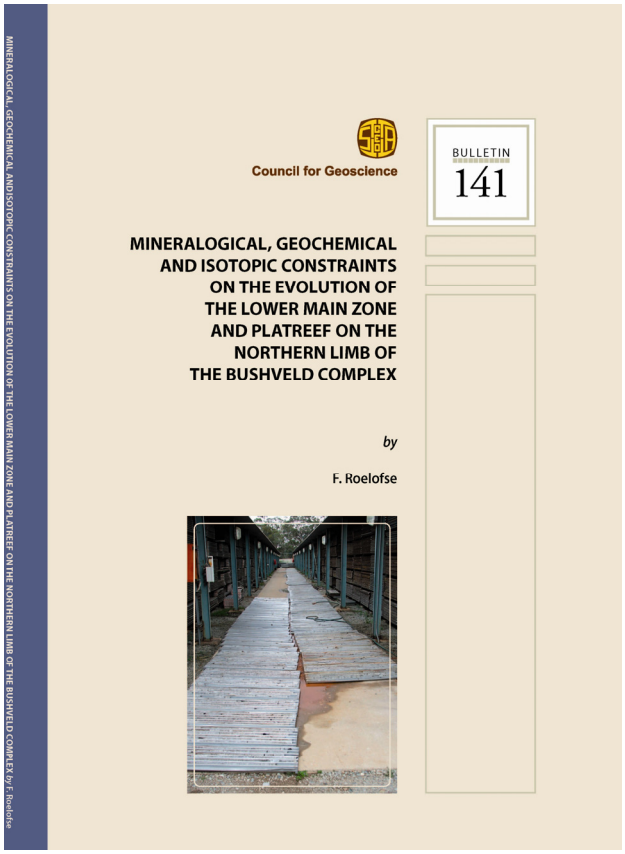
The publishing and release of manuscripts will continue. The translation of a large number of text into french is in progress, and the linguistic editing of reports should increase during the next financial year.

Publications released during the year

Bulletin 141:

> Mineralogical, geochemical and isotopic constraints on the evolution of the Lower Main Zone and Platreef on the Northern Limb of the Bushveld Complex by F. Roelofse.

Annual Report of the Council for Geoscience 2011.


MINERALOGICAL, GEOCHEMICAL AND ISOTOPIC CONSTRAINTS ON THE EVOLUTION OF THE LOWER MAIN ZONE AND PLATREEF ON THE NORTHERN LIMB OF THE BUSHVELD COMPLEX by F. Roelofse
Council for Geoscience
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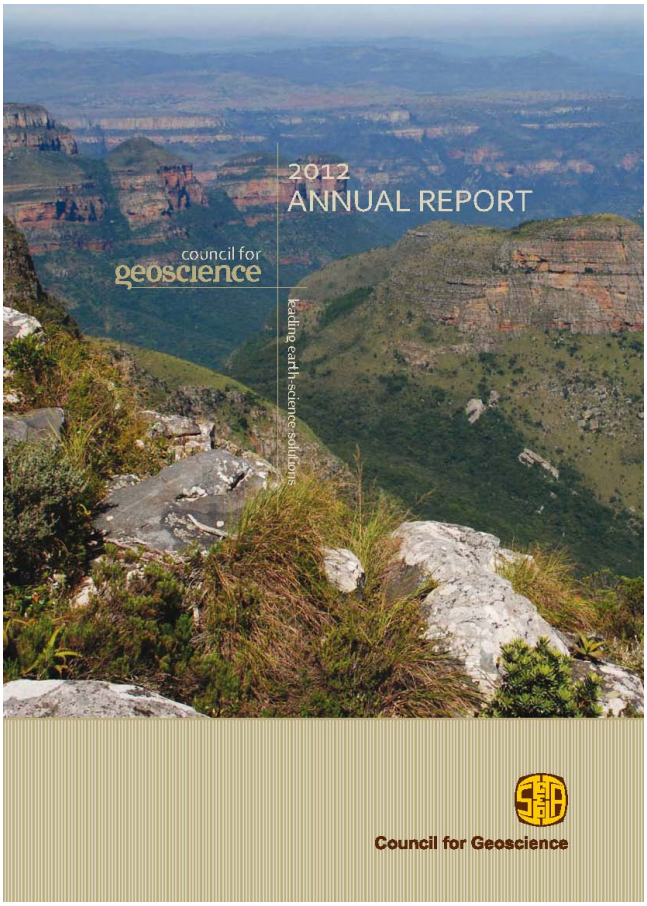
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KWAZULU-NATAL

ST-2011-1114

The geology and small-scale mining potential of the Pongola Supergroup in the Nkandla region

Project leader N Hicks, MSc
Primary objective This research project comprised the geological mapping of the Pongola Supergroup within the Nkandla area (portions of 1:50 000 sheets 2830BD, 2830DB and 2831CA) with special emphasis on mapping in areas associated with gold mineralisation and previous mining. The Pongola Supergroup within the Nkandla region is highly dissected and tectonised with lithologies being ill defined, thus hampering stratigraphic correlation between outcrop areas. Mapping during this project could help to reinforce stratigraphic correlation between the Nkandla Basin and the main Pongola Basin, thereby assisting in the formulation of a orebody model that may be used in future small-scale mining attempts in the region
Duration 2010–2013
Budget R22 650.00

Motivation

The project is part of a long-term commitment to refine and update geological maps in KwaZulu-Natal. The Archaean Pongola Supergroup forms a large volcanosedimentary succession (ca 2.9 Ga old, 10 km thick) that is exposed in the southeastern part of the Kaapvaal Craton in Swaziland, Mpumalanga and northern KwaZulu-Natal. Within northern KwaZulu-Natal, the southernmost units of the Pongola Supergroup occur as a number of tectonically dissected areas that need to be reassessed as, to date, the lithostratigraphy of the units does not conform to that of the main Pongola basin to the north.

It is suggested that the Mozaan Group of the Pongola Supergroup forms the lithostratigraphic equivalent of the West Rand Group of the Witwatersrand Supergroup. Absolute age determinations suggest a broad contemporaneity of the Pongola Supergroup with the auriferous and uraniferous Witwatersrand Supergroup. The Nkandla region hosts five small-scale (uneconomic to subeconomic) gold deposits within conglomerates of the Pongola Supergroup. The project includes a detailed study of the geology and mineralisation in selected outcrop areas within the Nkandla District in northern KwaZulu-Natal. Gold mineralisation is hosted predominantly within conglomerates of the Pongola Supergroup which are exposed in a number of tectonically juxtaposed inliers within the region. It is currently suggested that, unlike within the main Pongola Basin, only the Nsuze Group is preserved within the structurally complex Nkandla region. This suggestion is, however, under scrutiny as a folded unconformity which was suggested to separate the Nsuze and Mozaan Groups in the Nkandla region was identified. Throughout the main Pongola Basin, gold-bearing conglomerates are hosted within the Sinqeni Formation of the Mozaan Group. However, it is only within the ill-defined Nkandla region that gold-bearing conglomerates have been associated with the Nsuze Group. The identification and correlation of the gold-bearing units in the Nkandla region with Mozaan Group equivalent lithologies would assist in the correlation with the auriferous units within both the main Pongola Basin and the Witwatersrand Basin.

No mineral occurrences within the region are being actively mined or prospected, however, with newer technologies as well as increased commodity prices, some of these occurrences may become economically viable on a small scale. The detailed reassessment of the geology within the Nkandla area and the associated local mineral occurrences could lead to the identification of new small-scale deposits which could be operated using new mining technologies.

Progress

The project has been completed with an extensive literature review having been undertaken in 2011 due to the moratorium placed on statutory projects by the Council for Geoscience. This detailed review allowed for the delineation of possible correlative units throughout the Nkandla Basin. These correlations were verified by site-specific fieldwork undertaken in 2011. The fieldwork focused primarily on strike-perpendicular traverses across the contacts of the gold-bearing lithologies and the underlying units. A detailed stratigraphic profile was measured in the Mhlatuze Inlier along the Mhlatuze River, where the most complete Pongola Supergroup succession is preserved. Traverses through selected portions of the Central and Northern Synclines, exposed to the west of Nkandla town, were undertaken to verify the contact relationship between the Vutshini Formation (a proposed Mozaan-equivalent formation) and the underlying units. These profiles were used to assess the lithostratigraphic variations between the Nkandla outcrops and those of the main basin. A number of selected traverses were undertaken in the Southern Syncline; however, owing to the lack of access in this region and limited field time, no detailed traverses were performed.

Gold was previously prospected and won from five placer-type conglomeratic deposits within the Pongola Supergroup whilst a number of small lode-gold deposits are associated with greenstone successions in the Melmoth area. As per the currently accepted stratigraphic nomenclature and published maps, placer deposits are primarily associated with conglomerates within the basal and central portions of the Vutshini Formation in the Central and Northern Synclines whilst the occurrences in the Mhlatuze Inlier and Southern Syncline occur within the Mabaleni and Dlabe Formations respectively. The mineralisation in these conglomerates is generally subeconomic with ore limited to pockets of payable gold mineralisation.

Outside of the Pongola Supergroup lithologies, a number of uneconomic to subeconomic occurrences of copper, iron and kyanite are exposed in the Nkandla area, associated with greenstone successions that unconformably underlie the Pongola Supergroup. A Cu-bearing syenite body crops out intermittently for 7.5 km along the Mhlatuze River intruding the Mhlatuze Greenstone Belt. Although no assay results appear to be available for this unit, geochemical analyses during this study returned concentrations of 322 ppm Cu for one sample taken from the unit at Gassets Claims. Iron ore is associated with banded iron-formations which form a large portion of the Mhlatuze Greenstone Belt. The BIF has previously been worked on a small scale with a number of trenches and pits evident on surface. The grades are, however, generally poor with surface enrichment being the main target. Geochemical analysis during this study returned concentrations of 11.99% and 55.76% Fe_2O_3(t) for two samples taken from the occurrence. Metamorphic kyanite occurrences have been identified to the south of Nkandla in the Nsuze Group lithologies along the contact with intrusive granite. Eleven orebodies were identified by the then Geological Survey with an estimated reserve of 12 million tonnes @ 22–57% kyanite but there appears to be no record of this deposit ever being worked.

Conclusions

The complex structural geology, combined with the piece-meal manner in which the Nkandla area has been previously mapped has created a confusing and lengthy lithostratigraphic nomenclature for the different lithologies within the separate mapping areas of previous authors. The identification of marker beds and marker formations unique to the Nsuze and Mozaan Groups within the main Pongola Basin within the Nkandla Basin has allowed for verifiable correlation between units in the Mhlatuze Inlier and the Central and Northern Synclines. Within the Mhlatuze Inlier, detailed mapping has revealed that the entire Nsuze Group succession identified in the White Umfolozi Inlier in the main Pongola Basin is represented in this area. This proposal is aligned with other views that also suggested that the lithologies can easily be lithostratigraphically correlated with the units identified in the main Pongloa Basin. The identification of gold-bearing conglomerate horizons directly overlying either volcanics or carbonate sandstones and phyllites of the Nsuze Group is in accordance with the well-defined lithostratigraphy of the main Pongola Basin, suggesting that the conglomerates, quartz arenites and iron-rich shales which are exposed in the northern portion of the Mhlatuze Inlier represent the lateral equivalent of the gold-bearing Sinqeni Formation in the main Pongola Basin. Detailed mapping within the Central and Northern Synclines has identified an identical lithostratigraphic subdivision, with stromatolite-bearing carbonate sandstones overlain by amygdaloidal volcanics which are subsequently overlain along a sheared contact by gold-bearing conglomerate. This stratigraphy is identical to that identified in the White Umfolozi Inlier, suggesting that the Vutshini Formation preserved in the Central and Northern Synclines represents folded Mozaan Group lithologies preserved in the Nkandla region.

The stratigraphy of the Southern Syncline, however, does not conform to the easily correlatable lithostratigraphy of the Central and Northern Synclines and the Mhlatuze Inlier. The Southern Syncline therefore needs a full re-evaluation which was not possible during this project due to the moratorium placed on fieldwork. A re-evaluation of historic maps shows that each authors' interpretation of the Pongola Supergroup in the Southern Syncline differed vastly. Mapping during the current project has cast doubts as to

the position of the Southern Synclines in the stratigraphy of the Nkandla area, however, a more detailed evaluation of this was outside the scope of this project.

Gold-bearing conglomerates within the Nkandla region occur along the base of the Mozaan-equivalent Vutshini Formation overlying volcanics and carbonate sandstones of the Nsuze Group. The Central Nsuze reef, however, occurs near the top of the Vutshini Formation representing a separate auriferous conglomerate within the newly defined Mozaan Group strata. Although no gold grades were determined during this study, microscopy analyses suggest that the gold is likely to be associated with detrital pyrite as well as having been re-distributed by later hydrothermal fluids. A detailed review of previous exploration projects showed that grades are generally poor with the Dickson Mine being the only prospect which returned sporadic grades in the region of 4–6 g/t over ~20 cm.

Geochemical analyses of the samples of the copper occurrences within the greenstone assemblages in the Nkandla region suggest that the ore within the Cu-bearing syenite is too disseminated to allow for economic extraction. The iron ores analysed from the Mhaltuze Greenstone Belt show that although some iron ore occurs at surface it is interbedded with highly siliceous bands that host little iron. The identification of surface enrichment in these units suggests that although iron does occur in appreciable amounts, the tonnage may be limited.

Future progress

Although the project has ended, it is proposed that the project be linked with the next MTEF-funded project which is due to start in the region. A detailed review of the Southern Syncline is also necessary to redefine the stratigraphy of this tectonic feature to fully understand the complex nature of this region. A detailed section through the Vutshini Formation in the Central Syncline would be a valuable asset to the organisation as it would help to re-define the newly discovered Mozaan Group lithologies and allow for direct lithostratigraphic correlation with the Mozaan Group in the main basin.

ST-2011-1113

Geology and structure of the White Umfolozi Inlier, Pongola Supergroup

Project leader	N Hicks, MSc
Primary objective	The aim of this project is to determine the lithostratigraphic, sedimentological and structural characteristics of the auriferous and uraniferous White Umfolozi Inlier within rural KwaZulu-Natal. The study will include sedimentological analyses applying sequence stratigraphic methods, geological-structural mapping defining the lateral extent and variation of key facies, as well as basin analysis and inter-basin comparison with other areas of the Pongola Supergroup and correlative units within the Witwatersrand Supergroup. The basal Sinqeni Formation of the Mozaan Group hosts Witwatersrand-style placer gold and uranium mineralisation. A review of the gold mineralisation at the Denny Dalton Mine will be undertaken to provide important constraints on the interplay between Pongola basin evolution and mineralisation, and will allow the refinement of exisiting models on Archaean placer deposits. A review of the small-scale copper and talc mineralisation in the region will also be undertaken. The proposed study will be beneficial to the rural community within the Ulundi/Vryheid District by identifying and delineating possible economic Au and U targets
Duration	2010–2013
Budget	R22 650.00

Motivation

The project is part of a long-term commitment to refine and update the geological maps of KwaZulu-Natal. The Mesoarchaean Pongola Supergroup was deposited in an elongate intracratonic basin on the southeastern margin of the Kaapvaal Craton between ~2.98 Ga and ~2.87 Ga. The rocks are preserved in southern Swaziland as well as in numerous isolated inliers in Mpumalanga and northern KwaZulu-Natal, South Africa. The White Umfolozi Inlier forms the largest of the southern erosional inliers cropping out over an area of ~300 km^2 in the

Denny Dalton area in northern KwaZulu-Natal where the White Umfolozi River has incised a large valley into the pre-Karoo rocks, exposing the Pongola Supergroup and basement granites and gneisses. Rocks of both the Nsuze and Mozaan Groups are exposed in the northwest–southeast-trending inlier. Although the stratigraphy of the White Umfolozi Inlier has been well documented, the structure of the inlier has never been assessed. The stratigraphy of the inlier has not been mapped in detail since the only published map of the inlier was produced in 1967.

It is suggested that the Mozaan Group of the Pongola Supergroup forms the lithostratigraphic equivalent of the West Rand Group of the Witwatersrand Supergroup. Absolute age determinations suggest a broad contemporaneity of the predominantly volcanic Nsuze Group with the Dominion Group and the sedimentary Mozaan Group with the auriferous and uraniferous Witwatersrand Supergroup. Within the Witwatersrand, the majority of the Au and U is associated with conglomerate horizons, interpreted as fluvial channel deposits. Conglomerates within the Sinqeni Formation in the White Umfolozi Inlier are mineralogically similar to the Witwatersrand conglomerates and locally contain placer gold and uranium. However, gold grades in the Pongola basin are generally much lower and there is currently no producing gold mine. The economic potential of the Pongola Supergroup has, however, not yet been fully explored.

The project will build on the MSc thesis produced on part of the area. This research assessed the Au and U mineralisation and stratigraphy of the lower Mozaan Group within the White Umfolozi Inlier.

Progress

Owing to the moratorium placed on statutory projects by the organisation, the project comprised an initial extensive literature review of all know papers published in the region. The gold-bearing units of the Sinqeni Formation in the Mozaan Group have been studied by numerous authors; however, the first major analysis was completed only recently. This report led to new definitions on the origin of the gold and uranium. A detailed discussion on the structure of the Nsuze and Mozaan Groups within the inlier was undertaken with a number of alterations having been made to the current geological map to account for previously unmapped faulting. Although the stratigraphy of the inlier is well defined, the Nsuze and Mozaan successions have been redefined to correlate with equivalent units in the main basin to the north in accordance with the lithostratigraphic subdivisions done in 1998.

Conclusions

This study focuses on the White Umfolozi Inlier and attempts to define the depositional environment, mode of formation and correlation between other basin remnants in KwaZulu-Natal and with the Witwatersrand succession. Within the White Umfolozi Inlier, two major extensional events have been identified. The analysis of the White Umfolozi Inlier has identified two pre-Mozaan deformational events that have affected the Nsuze Group. These include an initial extension in the half-graben rift system with faulting orientated ~320° causing repetition of units between discrete fault blocks. It is likely that this faulting is related to the syndepositional growth faulting within the northeast-trending Mahamba fault belt which forms the eastern margin of a large half-graben structure in the main Pongola Basin. The faulted strata were later subjected to extensional horst and graben style normal faulting orientated ~060°/240°. Throw on these faults ranges from tens of metres to hundreds of metres with the tilted strata on the downthrown fault block appearing to have been offset laterally towards the southwest. On surface, the lithological offsets along these northeast-trending faults suggest, on initial observation, that the faulting is strike-slip, with either a sinistral or dextral sense of movement. However, this is not the case as both sinistral and dextral movement has been identified along parallel, adjacent faults which often give a pattern of sinistral-dextral-sinistral-dextral. The distinct angular unconformity between the Nsuze and Mozaan Groups within the White Umfolozi Inlier suggests that uplift and erosion of the Nsuze Group occurred prior to deposition of the Mozaan Group. Post-Mozaan deformation within the inlier is represented by two episodes of deformation. The first appears to be associated with reactivation of older ~320°-oriented Nsuze-age faults. The final post-Mozaan deformation event resulted in a number of ~100°-trending normal faults associated with horst and graben structures. Later tectonic events that have affected the inlier include minor compressional tectonics possibly associated with the ~1 000 Ma Namaqua-Natal Orogeny and extensional brittle faulting associated with the breakup of Gondwana.

The White Umfolozi Inlier and surrounding lithologies host a multitude of small subeconomic to uneconomic mineral occurrences in a variety of lithologies. Basement granitoids host minor occurrences of copper and are associated with quartz veins that are exposed and have been previously worked at the Magdalene Mine on the farm Schoonuitzicht 385 on the northwestern boundary of the inlier. Pongola Supergroup lithologies host two occurrences of uneconomic to subeconomic mineralisation, a small uneconomic talc occurrence and the sub-economic Denny Dalton Gold Mine. The Denny Dalton Gold Mine occurs as a conglomerate-hosted, placer gold occurrence on the farm Tusschenby 411. This gold occurrence was previously worked where gold- and uranium-bearing conglomerates have been identified at the base of the Mozaan Group. These conglomerate

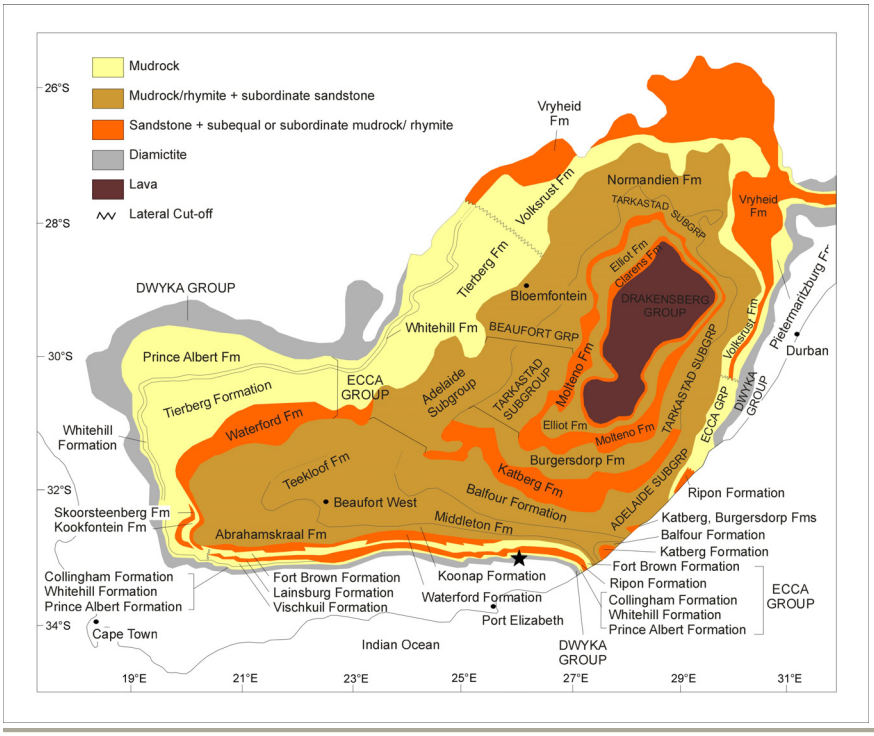
horizons can be traced laterally along strike for ~9 km to the east and ~ 7 km to the northwest, however, only the zone around the old Denny Dalton Gold Mine has yielded promising results.

ST-2011-1134

Shale gas potential and stratigraphy of the lower and middle Karoo Supergroup north of Patterson, eastern Cape, South Africa

Project leader DE Black, BSc Hons
Project team Prof PWK Booth, Department of Geosciences, NMMU, Prof M de Wit, Department of Geosciences, NMMU

Primary objective Strata of the Karoo Supergroup (Karoo Basin) in an area north of Paterson, Eastern Cape, South Africa, are being mapped in order to better define the litho- and chronostratigraphy of the Ecca Group (with particular reference to the Ripon, Collingham, Whitehill and Prince Albert Formations) in an attempt to better understand the shale gas potential of the units

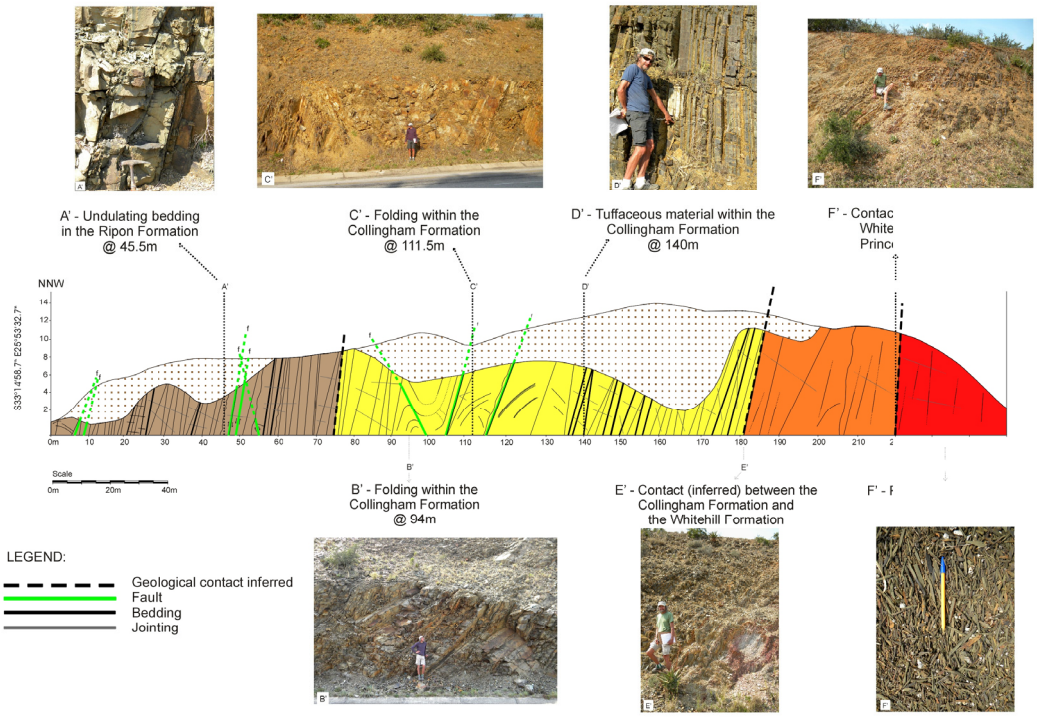


Areal distribution of lithostratigraphic units in the main Karoo Basin. The star highlights the study area traverses.

Progress

Fieldwork to date has shown that mainly thinly bedded deltaic deposits (Prince Albert, Whitehill and Collingham Formations) are overlain by thick deltaic units of sandstone and mudrock (Ripon, Fort Brown and Waterford Formations). Stratigraphically upwards, the deltaic deposits of the Ecca Group give way to mudrock and lesser sandstones of the Beaufort Group that represent fluvial sedimentation in an inland sea.

Once fieldwork is complete, detailed lithostratigraphic columns will be constructed and geological sections drawn for the study area. Features such as sedimentary structures, unit thicknesses and mineralogy will provide the basis for the reconstruction of the palaeoenvironment which is key in identifying the shale gas potential throughout the stratigraphic section. The sections produced will form the basis for correlating Karoo strata with the western part of the basin where such studies have been done, albeit that such long range correlation may not be accurate.

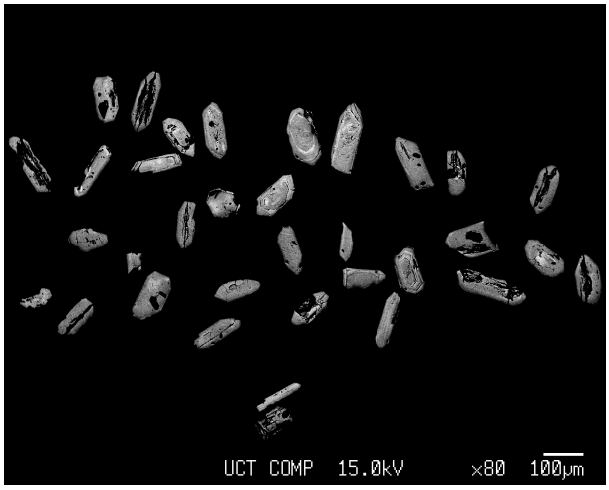


An example of a section that has been constructed to allow for correlation

Radiometric age dating, especially of zircon in tuffaceous beds which occur throughout the Ecca and Beaufort Groups will be determined by mass spectrometry (U/Pb isotropic method). Samples collected and analysed should provide improved time constraints of the Permian–Triassic boundary in the southeastern Karoo Basin and will add to the existing chronostratigraphic database for the Karoo Basin. This approach should make for improved interpretations of palaeoenvironments which previously relied on lithostratigraphy but can now be modified or redefined through chronostratigraphy. By doing this dating, it is hoped that units with shale gas potential can be constrained and identified by both stratigraphy and chronostratigraphy.

Summary:

- Two field trips have been made.
- Samples for zircon extraction have been collected from the area north of Paterson, the Ecca Pass and a borehole drilled near Jansenville in the Eastern Cape. These will be submitted for zircon age dating.
- Samples have been collected in order to do SEM and thin-section descriptions.
- The total length of traverses mapped is 1.3 km (5 traverses to date).
- Two sections have been produced for a 250 m traverse.
- Four samples have been submitted for zircon extraction (results pending).
- Reference material has been sourced.
- Contact has been made in order to obtain information from the PetroSA database.



Zircons collected and submitted for age dating

Progress since 2011

PHASES	CATEGORY	ACTIVITY	TIME ALLOCATION
1	Desk study	Review of existing information	2 months (material has been reviewed)
2	Fieldwork	Mapping, sample collection, etc.	3 months (some fieldwork has been undertaken and a borehole has been sampled)
3	Compilation	Database compilation	3 months (samples have been submitted and database is up to date for work completed)
		Sample submission	
		Petrography	
		Petrographic reports	
		Age dating	
4	Interpretation	Of all relevant information	3 months
5	Write-up	In form of a thesis, CGS Bulletin and paper in peer-reviewed journal	3 months

*Approximate completion time of three years part time

LABORATORY

ONGOING SERVICES

ST-0999

Sample preparation

Project leader	TS Motsiri, BSc (Chem)
Project team	TC Rantsane, KJ Mokoatedi, MM Ramoshaba, SP Zondi, SM Ngamlana, JS Radebe, IM Phahlane, LL Semelane, MM Mahlangu
Primary objective	To provide primary sample preparation services
Duration	Ongoing

Motivation

The CGS Laboratory analyses rock and soil samples for external and internal customers for research and commercial purposes. About 90% of the analytical methods require the particle size to be reduced to less than 75 microns prior to analysis. The Sample Preparation Section is equipped with crushers and mills which are utilised to obtain the required particle size for the analyses of rock and soil samples.

The Sample Preparation Section is at times involved in large regional geochemistry mapping projects during which the section's technical officers collect large numbers of samples either by foot or helicopter. The samples are then verified and transported to the Laboratory Unit for further processing, e.g. drying, sieving, weighing, pellet pressing and registration and finally submitted for analyses.

Progress

The Sample Preparation Section processed 9 089 samples during the period under review with a total value of R197 121.00; about 20% of this work was performed for statutory clients. This amount shows a significant increase in services rendered to external clients of the Laboratory Unit considering that there were no significant external projects during the reporting period.

Sample preparator loading a milling vessel with samples into a carbon-steel swing mill

Conclusion

It is crucial that the Sample Preparation Section continuously provides in the needs of the Laboratory Unit for both internal and external clients as very few analyses can be done without the reduction of rocks and soils to powder form.

ST-0332

Chemistry

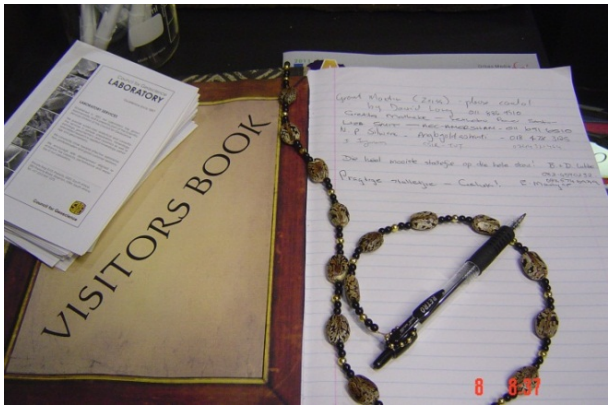
Project leader	LJ Jordaan, MSc
Project team	H Maritz, BSc Hons, MT Lehaha, B Tech, LL Sathekge, Nat Dip, RH Sello, RM Papo, M Vuma
Primary objective	To provide excellent analytical services in South Africa
Duration	Ongoing

Motivation

The Council for Geoscience requires chemical analyses of rocks, soils and water to make interpretations about 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 Chemistry Section was influenced significantly by the global financial recession as many clients reduced their activities. Expanding existing analytical services towards water and wastewater analyses provided welcome relief.



The CGS Laboratory showcased its capabilities at the 2011 LabAfrica Exhibition in Johannesburg. The theme was "Excellence since 1897"

Conclusion

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

Future activities

The Chemistry Section is actively involved in preparing for SANAS 17025 accreditation, which implies the documentation of all procedures as well as the implementation of more rigid analytical and sample handling protocols.

Particle size analyses

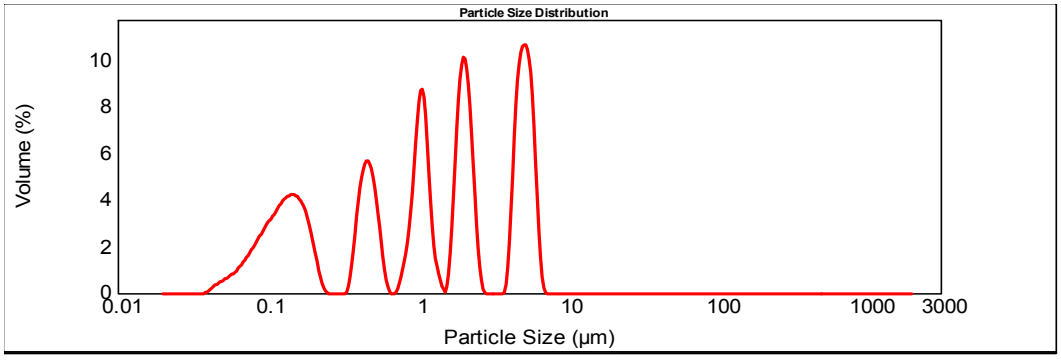
Project leader FJ Doucet, PhD (Chem Eng)
Primary objective To provide particle size evaluation of geological and manufactured materials as a service to the business units of the Council for Geoscience and to commercial clients
Duration Ongoing

Motivation

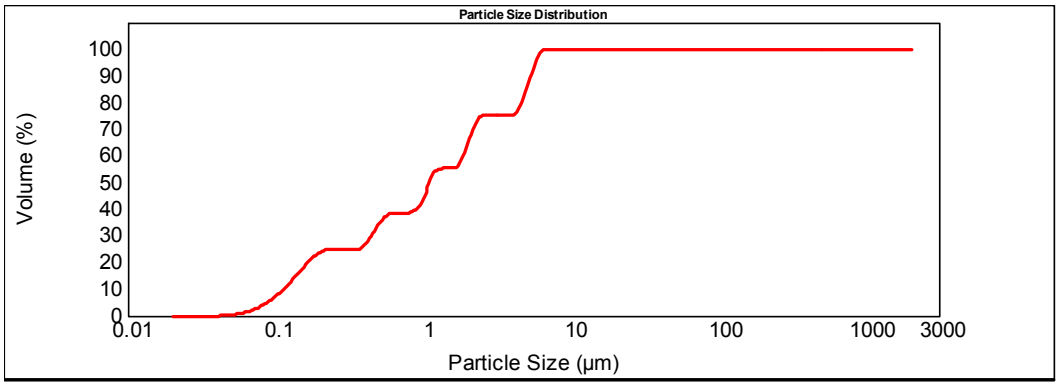
The Industrial Mineralogy Laboratory of the Council for Geoscience provided particle size analyses to internal and external clients. All analyses were carried out using the Malvern Mastersizer 2000 laser light scattering particle size analyser. The instrument is equipped with a Hydro 2000G wet dispersion unit and a Scirocco dry dispersion unit, which permit the measurement of both dry loose powders and liquid dispersions. It is also fitted with an internal ultrasound bath to improve the dispersion of challenging samples. The measuring range covered by the instrument is 0.02 to 2 000 µm.

Progress

The total value of the particle size analyses performed during this period under review amounted to R103 550.00, including R36 400.00 raised from statutory work and R67 150.00 from external clients.



Particle size distribution results expressed as frequency curve



Particle size distribution results expressed as cumulative undersize

Future activities

This service will continue in the next financial year.

Petrographic services

Project leader	NS Nxokwana, BSc Hons (Geol), CandSciNat
Project team	SD Kgaditse, SA Dikgomo, TS Monyayi
Primary objective	To ensure that scientific staff have easy access to thin-sectioning services and related petrographic services for research purposes
Duration	Ongoing

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

The Petrographic Services Section has delivered 582 and 2 666 analytical units for statutory and commercial services respectively, with a total statutory value of R74 560.00 and commercial value of R319 975.00. A staff member also contributed to the Shale Gas project that the Laboratory Unit was involved in during the period under review.

Six-micron polisher used for preparing polished petrographic thin-section slides

Conclusions

As an ongoing project, the service will continue to be rendered. However, the section is faced with a problem of old equipment which is difficult to maintain. This has a limiting effect on the production levels and turnaround time.

ST-5032

Scanning Electron Microscopy

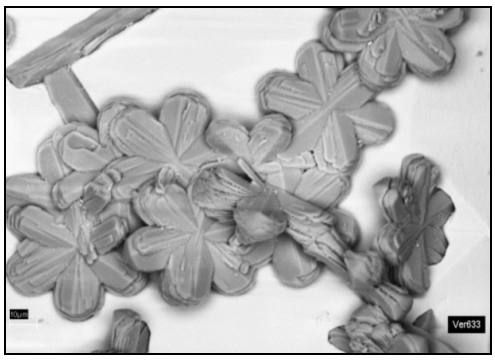
Project leader M Atanasova, MSc
Primary objective To provide SEM/EDS services to the organisation and industries
Duration Ongoing

Motivation

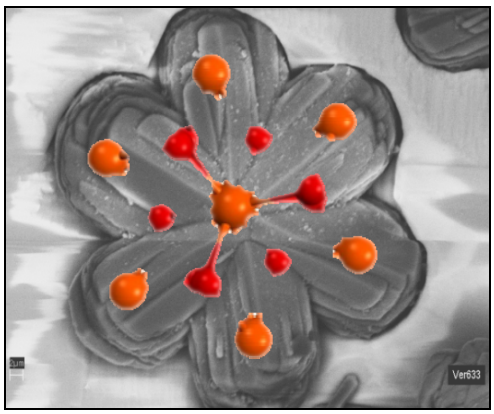
Scanning Electron Microscopy (SEM) is utilised for imaging and X-ray analyses of rocks, minerals and industrial materials. It offers users the opportunity to do semiquantitative chemical analyses of microscopic particles. Researchers of the Council for Geoscience and the academic and geological community 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 the 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.

Progress

The total value of work for the period under review is estimated to R362 820.00 of which R322 880.00 is commercial income and R11 700.00 the value of statutory work. Statutory income is a figure based on the value of the service provided for statutory projects of the Council for Geoscience or what such a service would have cost if obtained from an outside provider. It is determent by the number of statutory projects in the organisation that need mineral identifications. The drastic decline in the statutory income for the section in the last three years is directly related to the temporary hold of the organisation's statutory programme since 2009.



SEM images of haematite of unusual "flower-like" morphology. Field of view 175 µm



SEM images of haematite of unusual "flower-like" morphology with analogy to the atomic arrangement of Fe^{3+} (orange) and O^{2-} (red) atoms in its structure. Field of view 70 µm

Instrumentation

The Council for Geoscience Laboratory runs a Leica 440 Stereoscan SEM equipped with an INCA (OXFORD) EDS (energy dispersive system) which controls the analytical capacity of the instrument. In May 2009, a new-generation LN-free SDD detector from Oxford, a X-max SDD detector with 20 mm^2 active area and resolution of ca 128 eV for Mn K-a (5895 eV) was installed. This set-up gives a wide range of analytical capability — secondary, backscattered and cathodoluminescence electron imaging, X-ray EDS microanalysis and X-ray element mapping.

Leica 440 Stereoscan SEM

ST-5036

X-ray Diffraction

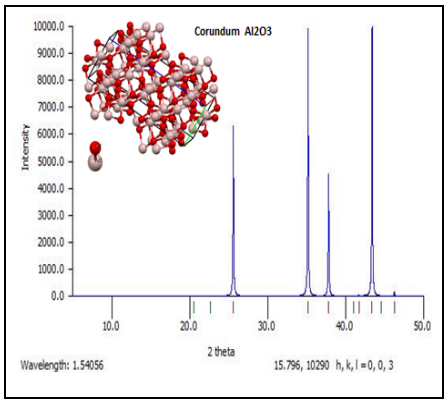
Project leader	M Atanasova, MSc
Project team	K Mashishi, BSc Hons, N Dlamini, BSc Hons
Primary objective	To provide mineralogical analysis to the organisation and general public
Duration	Ongoing

Motivation

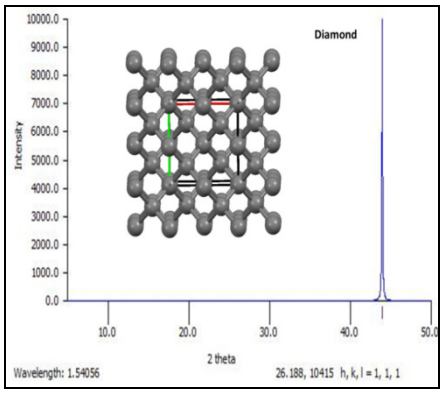
Mineral identification and material characterisation are required for a broad range of applications, programmes and projects in which the Council for Geoscience is currently involved. Mineralogical evaluation is an essential service for the description and compilation of geological maps, mineral exploration, economic evaluation of mineral resources, the identification of environmental hazards and risk assessments. 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 analyses at competitive prices. It provides mineralogical evaluation and analytical results on a wide spectrum of geological material as well as synthetic and man-made products. Routine phase analyses are performed on whole-rock powder and oriented clay preparation in reflection mode, while minute quantities of material are analysed in transmission mode using glass capillary. Typical applications include qualitative phase identification and the quantitative evaluation of XRD traces. Geological and geotechnical interpretation of mineralogical data is provided to assist clients in the evaluation of data.

Progress

The total value of work is estimated at R1 084 948.00 of which R1 003 108.00 is commercial income and R81 840.00 the value of statutory work. Statutory income is a figure based on the value of the service produced for statutory projects of the CGS or what such a service would have cost if obtained from an outside provider. It is determent by the number of statutory projects in the CGS that need mineral identifications. The drastic decline in the statutory income for the section in the last three years is directly related to the temporary hold of the statutory programme of the Council for Geoscience since 2009.



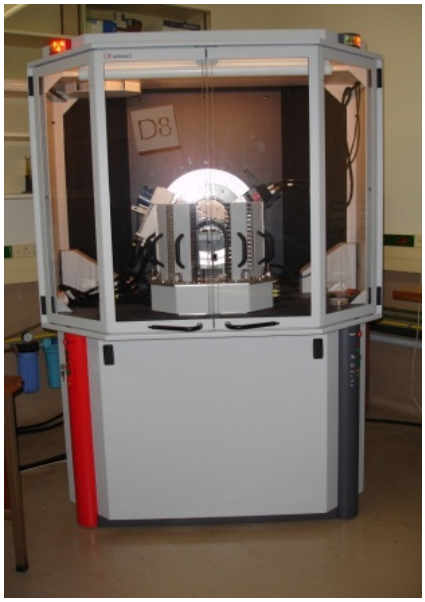
X-ray diffraction data and crystal structure of corundum (Al_2O_3)



X-ray diffraction data and crystal structure of diamond (C)

Instrumentation

The work was performed on a BRUKER D8 Advance diffractometer purchased in 2007. The system produces high-resolution X-ray powder diffraction data as well as fast and reliable results. The advanced hardware technology combined with Rietveld Refinement-based interpretation present new opportunities for more detailed and advanced research in the field of crystallography and applied mineralogy.



BRUKER D8 XRD Advance diffractometer

Future activities

Prepare for ISO 17025 accreditation during the financial year. Carry on with in-house experiments for method development and operating 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.

X-ray Fluorescence

Project leader	HCC Cloete, BSc Hons, PrSciNat
Project team	D Long, MSc, KIG Burger, ME Tsaagane, MJ Matji, J Mbonane
Primary objective	To provide chemical analyses through 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 the chemical characterisation of rocks, soils, ceramics and building material and for research in geochemistry.

Progress

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

- 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. About 7 000 samples were analysed for major and/or trace elements during the period under review.
- PANalytical MagiX Fast, a wavelength simultaneous XRF spectrometer equipped with a 4 kW Rh-tube. About 1 500 samples were analysed for various clients.

The main clients of the XRF Section are in the quality control sector where the chemical composition of raw materials is determined before use in the manufacturing process. During the 2011/12 financial year, the ratio of work for commercial and statutory clients was about 90:10 due to the downscaling of statutory services in the difficult financial climate.

Two of the staff members are involved with the ISO 17025 accreditation process, implementing quality control measures of the Laboratory instrumentation as well as setting up traceability measures of the results by reorganising and verifying certified materials and their associated information such as suppliers, manufacturers, etc. One staff member attended a Method Validation Course of the National Laboratory Association.

Future activities

Finalisation of ISO 17025 for the XRF Section by auditing at least three test methods in preparation for inspection by SANAS.

RESEARCH PROJECTS

ST-2007-0955

The chemical interactions between the geological environment and the biological components within large drainage basins

Project leader	LJ Jordaan, MSc
Project team	V Wepener, PhD, JM Huizenga, PhD, MC Rademeyer, BSc, MTG Anatasova, MSc, LPD de Wet, PhD, D Booyse, B Venter, M Cloete, PhD
Primary objective	To chemically fingerprint sediment, 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	2007/8–2012/13

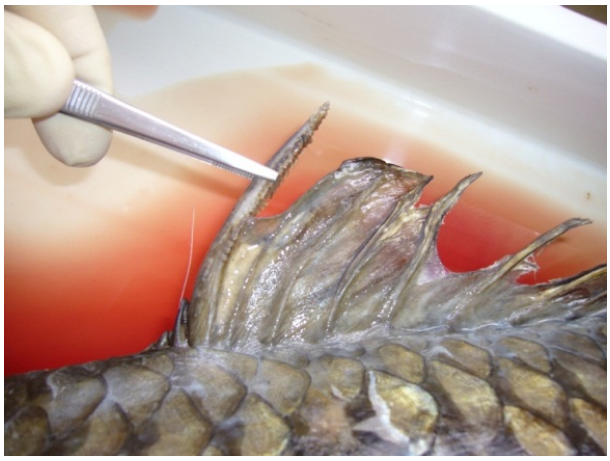
Motivation

The Council for Geoscience has an extensive database of the soil chemistry of South Africa that was collected during the National Geochemical Mapping Programme. These data provide an 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 living in 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. It will further provide a forensic capability where a chemical fingerprint has been established for specific dams within drainage basins to trace illegal fishing activities.

Progress

Three additional draft reports have been submitted:

- Jordaan, LJ, Shabalala, AN and Wepener, V (2011). The mercury distribution in fish and sediments within major South African catchments.
- Jordaan, LJ, Atanasova, MTG and Wepener, V (2011). The mineralogy of soil and lake sediments within major South African catchments.
- Jordaan, LJ and Wepener, V (2012). The lead isotope distribution in fish, soil, lake water and lake sediments within major South African catchments.



Forensic capabilities are regularly used to validate winning entries at major South African fishing tournaments. Bone from the dorsal fin is used for chemical validation tests

Future activities
Production of reports will continue, starting with the following:

- Jordaan, LJ and Wepener, V (2012). The major and trace element chemistry of fish, lake water and lake sediments within major South African catchments.
- Jordaan, LJ and Wepener, V (2013). The major and trace element chemistry of soil and lake sediments within major South African catchments.

ST-2012-1152

Physiochemical properties of South African shales in the context of geological CO_2 storage

Project leader	NS Nxokwana, BSc Hons (Geol), CandSciNat
Project team	F Doucet, PhD, M Cloete, PhD, DI Cole, PhD (CGS supervisors), W Altermann, PhD, L van de Merwe, PhD (academic supervisors, University of Pretoria)
Duration	2010/11–2011/12
Budget	R200 000.00 — bursary from the South African Centre for Carbon Capture and Storage (SACCCS)

Core sampling at the CGS National Core Library at Donkerhoek

Motivation
Geological storage of anthropogenic CO_2 has been accepted as a viable option in the mitigation of the high concentrations of CO_2 in the atmosphere. The Council for Geoscience undertook a study to assess South Africa's geological storage capacity and published an atlas to this effect. The Atlas study found that 98% of South Africa's geological storage capacity is in offshore Mesozoic basins and only 2% is onshore. This study investigates the storage potential of shales which occupy a large part of the South African interior. Studies in other countries have found that shales trap significant amounts of CO_2 in an adsorbed state in their organic matter.

Progress
A detailed literature review of South African shales in the context of geological CO_2 storage has been completed. Four old SOEKOR boreholes from the National Core Library were used and 64 samples have been retrieved. Analytical techniques such as XRD, XRF and C & S analysis have been used to characterise these samples. The findings were presented at two conferences in 2011.

Conclusions
The work is still in progress; experimental work on adsorption and diffusion of CO_2 in shale samples is being planned.

CO-2012-5731

Detection of expansive soils using remote sensing in the northwest of Pretoria

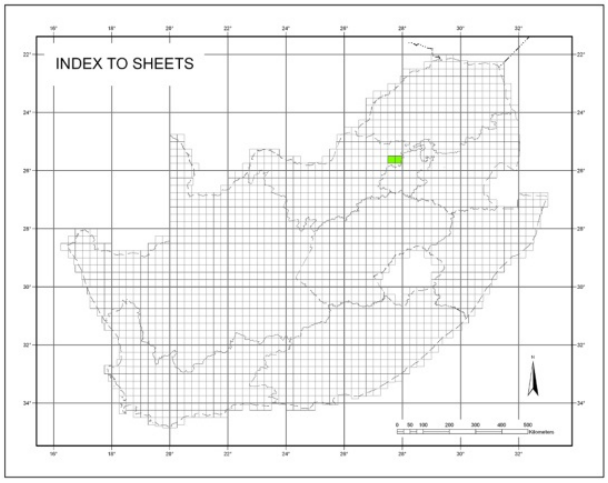
Project leader	J Botai, PhD
Project team	M Cloete, PhD, J Engelbrecht, MSc, M Atanasova, MSc
Primary objective	To detect and analyse spectral properties of swelling soils by using spectroscopic techniques and multispectral imagery and then correlate the data to the published mineralogical map of the area
Duration	2011/12–2012/13
Budget	R43 055.00

Motivation

Expansive soils pose a significant geological hazard worldwide; it causes civil infrastructure damage that amounts to losses of billions of rand every year. In the event that the swelling clay minerals can be confidently matched to specific spectroscopic and multispectral data, it will establish an efficient method to screen geotechnical hazardous soil conditions for future planning and building developments.

Progress

Mineral maps of quartz, plagioclase, K-feldspar, pyroxene, haematite, kaolinite, smectite and interstratification were compiled from the XRD results of previous work. Soil samples and spectral signatures collected are currently being analysed.



Locality map of the study area

Conclusions

The project is progressing slowly owing to the unavailability of a handheld spectroradiometer and satellite imagery.

Future activities

More spectral signatures will be obtained along the same traverse and ASTER imagery processing of the study area will take place. The correlation of ASTER imagery to XRD mineral maps and ASD results as well as report writing will be done.

ST-2012-1151

CO_2 sequestration by mineral carbonation and production of value-added products

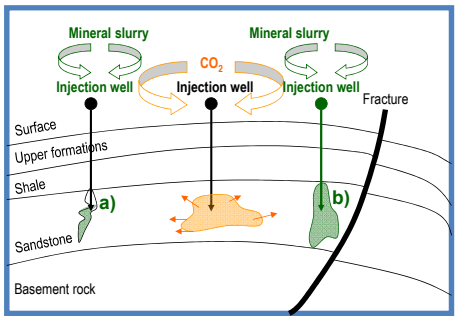
Project leader FJ Doucet, PhD (Chem Eng)
Primary objective To develop small-scale carbonation processes for the conversion of industrial solid wastes into carbonated products and for long-term CO_2 sequestration
Duration 20011/12
Budget R20 000.00

Motivation

The total CO_2 emissions in South Africa currently account 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 the theoretical and experimental evaluation of a range of readily available alkaline wastes and the 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

This project has focused on (1) the production of calcium carbonate ($CaCO_3$) from phosphogypsum waste (in collaboration with the Department of Chemistry, University of Pretoria), (2) the mineral carbonation of fly ash under supercritical CO_2 conditions found in deep geological reservoirs (in collaboration with the Departments of Chemistry and Geology, University of Pretoria), and (3) the CO_2 capture in fresh coal fly ash by *ex situ*-accelerated carbonation and in naturally-weathered fly ash (in collaboration with Department of Chemistry, University of the Western Cape). For (1), the conversion of phosphogypsum wastes into useful calcium carbonate was investigated following two process routes, i.e. the NaOH route and the Merserburg process. Conversion of over 90% has been achieved using the former route, but the latter yielded a maximum conversion of about 63%. For (2), the experiments demonstrated for the first time that fly ash can react with supercritical CO_2 under varying pressure and temperature conditions. This work also introduced a theoretical concept whereby fly ash in a slurry form could be injected at strategic sites of deep saline formations in order to prevent the migration of injected CO_2 plumes beyond the confining layers of the formations, via induced, *in situ*-localised, accelerated mineral carbonation. Such an injection strategy could also be combined with the recently proposed Active CO_2 Reservoir Management strategy. For (3), natural carbonation was found to occur in coal-combustion fly ash disposal sites, with up to 6.8 wt % CO_2 having been identified. The morphology of the ash changed from sphero-particles in fresh ash to needle-like particles in carbonated ash and to irregularly shaped particles in weathered ash. It was also investigated whether carbonation can act as a stabilisation reaction for stock piles.



Conceptual schematic representation of emplacement of a mineral slurry wall or curtain between underground CO_2 plumes and known fault zones or facies changes

Future activities

This project is extending its focus to the study of mine tailings.

LIMPOPO

ST-2006-0899

Geological Field Mapping School

Project leader	N Baglow, BSc Hons
Project team	T Dhansay, BSc Hons
Primary objective	Skills development through the training of junior geologists in practical field mapping
Duration	Ongoing since 2005
Budget	R300 000

Motivation

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

Progress

The project for this year was completed. In addition, further progress was made in the development of written unit standards for various levels of training subject matter, a precursor to working towards formal accreditation.

Conclusions

The prevailing economic situation did not allow for the intake of a new batch of permanent graduate geologists this year, and thus this group was not available for participation. However, a curtailed field mapping school (Introductory Module) was held for a total of six trainees, comprising MQA interns and young scientists with the organisation, plus a couple of young geologists from the Geological Survey of Namibia. With a variety of different geoscience backgrounds being represented, there was scope for fruitful and robust interaction between all involved.

Subject matter covered included locating yourself in the field, collecting appropriate geological data and plotting this data. Individual reports with maps were produced and evaluated.

Future progress

The school will be repeated on an annual basis to integrate new geologists into the overall CGS mapping and other compatible programmes. Though activities were again restricted in the past year, it is intended to increase the level of programme activity as normality returns to the general economic situation.

Field school held at Legalameetse (Limpopo). Trainees came from a variety of different geoscience backgrounds and were required to make their own independent observations and interpretations

ST-2008-0975

2430BB Mica 1:50 000 geological map

Project leader	N Baglow, BSc Hons
Project team	T Dhansay, BSc Hons, NC Mukhosi, BSc Hons, LP Munyangane, BSc Hons
Primary objective	To understand the geology of the area with particular emphasis on the emplacement history, mineral potential where applicable, understanding the groundwater characteristics of the area and maintaining organisational capacity in terms of understanding a variety of geological environments. Production of a 1:50 000 geological map and an accompanying explanation
Duration	Ongoing from 2009
Budget	R100 000

Motivation

The map area has received little attention in the past, but is situated within the development corridor from Bushbuckridge to Phalaborwa. Geologically diverse, it can provide mapping experience to junior geologists in a variety of disciplines. Besides their mineral potential, the pegmatites are of interest as a groundwater source.

Progress

The project for this year was completed with a map and report being compiled and captured digitally; interpreted existing data and supplementary fieldwork were utilised.

Conclusions

The area covered by the 1:50 000 2430BB Mica map sheet embraces a segment of the Archaean granite-gneiss terrane south of the Murchison Greenstone Belt. The oldest rocks comprise ~3.11 Ga Makhutswi gneiss folded in with fragmented greenstones of the Shobi Ultramafic Complex. A number of granitoid units which, though in close proximity to one another, are probably not related have intruded into this basement.

Earliest amongst these is the Harmony Granite, a large batholith of homogeneous light-grey, locally porphyritic biotite muscovite granite which is generally weakly foliated and at 3.09 Ga not much younger than the gneisses. Only the northeastern portion of the intrusion is represented on the map sheet and the extremities are marked by zones of gneissic inclusions and pegmatites. However, the main development of the Mica Pegmatite is to the north, where the unit is developed as an east–west-trending belt through the gneisses and fragmented ultramafic rocks. The pegmatite hosts the mica deposits which have been mined for over 100 years, and from which the area takes its name.

Two contrasting granites of comparable ages complete the overall granitoid assemblage. A medium-grained biotite granite exists as the southern limit of the Lekkersmaak Granite, whereas the ~2.7 Ga Mashishimale Granite development is almost totally contained within the confines of the map area. This intrusion follows the regional roughly east–west trend, with linear lines of hills standing out in contrast to the generally subdued surrounding country. At least four granite phases (Transport, Lillie, Hoed and Hope) have been recognised, though the relationships between them are not unequivocal, and the lithology varies from coarse-grained porphyritic biotite granite to medium-grained hornblende-biotite granites to fine-grained leucogranites.

Scattered through the south-central portions of the area are a number of small syenitic plugs, related to the 2.05 Ga Phalaborwa Complex and prominent as steep, almost conical koppies within the flat to gently undulating landscape. Mafic dykes are developed right across the map area, generally trending northeasterly, though ages are variable from Archaean diabases through to Jurassic (Karoo) dolerites that have followed the same fracture trends.

The picture of the geological history of the area is completed by remnants of Tertiary river gravels near the Olifants River and widespread Quaternary river alluvium and residual soil development.

In terms of economic minerals, interest has largely focused on the pegmatites, with mica and feldspar being the most important commodities, though at various times beryllium, columbite/tantalite and corundum have been recovered with quartz as a by-product. The mica resources were the target of the first mining activity and spectacular books of muscovite have been exploited over the years.

Future progress

This map project is now complete.

Typical ridge outcrop of Lillie phase of the Mashishimale Granite; here porphyritic with mafic inclusions (a). Pegmatite intrusion at an old quarry face at Union Mine. Books of mica are strongly developed near the top margin of the body (b)

MARINE GEOSCIENCE

ST-2011-1139

The marine environment of Mossel Bay: geological facies and palaeoenvironmental modelling

Project leader	HC Cawthra, MSc
Project team	MR MacHutchon, BSc Hons, W Kupido
Primary objective	The data collected for this study will be used to obtain a clearer understanding of the geological evolution, marine sedimentary processes and seismic stratigraphy of the Mossel Bay shelf to model Quaternary palaeoenvironments associated with sea level fluctuations. The objective is to conduct marine geophysical and sampling surveys using the most advanced current technologies available and develop a high-resolution geomorphic/palaeoenvironmental database for a sector of the shelf off the South Coast of South Africa
Duration	2011–2015
Budget	R1 500 000 (partially funded through the National Geographic Society)

Motivation

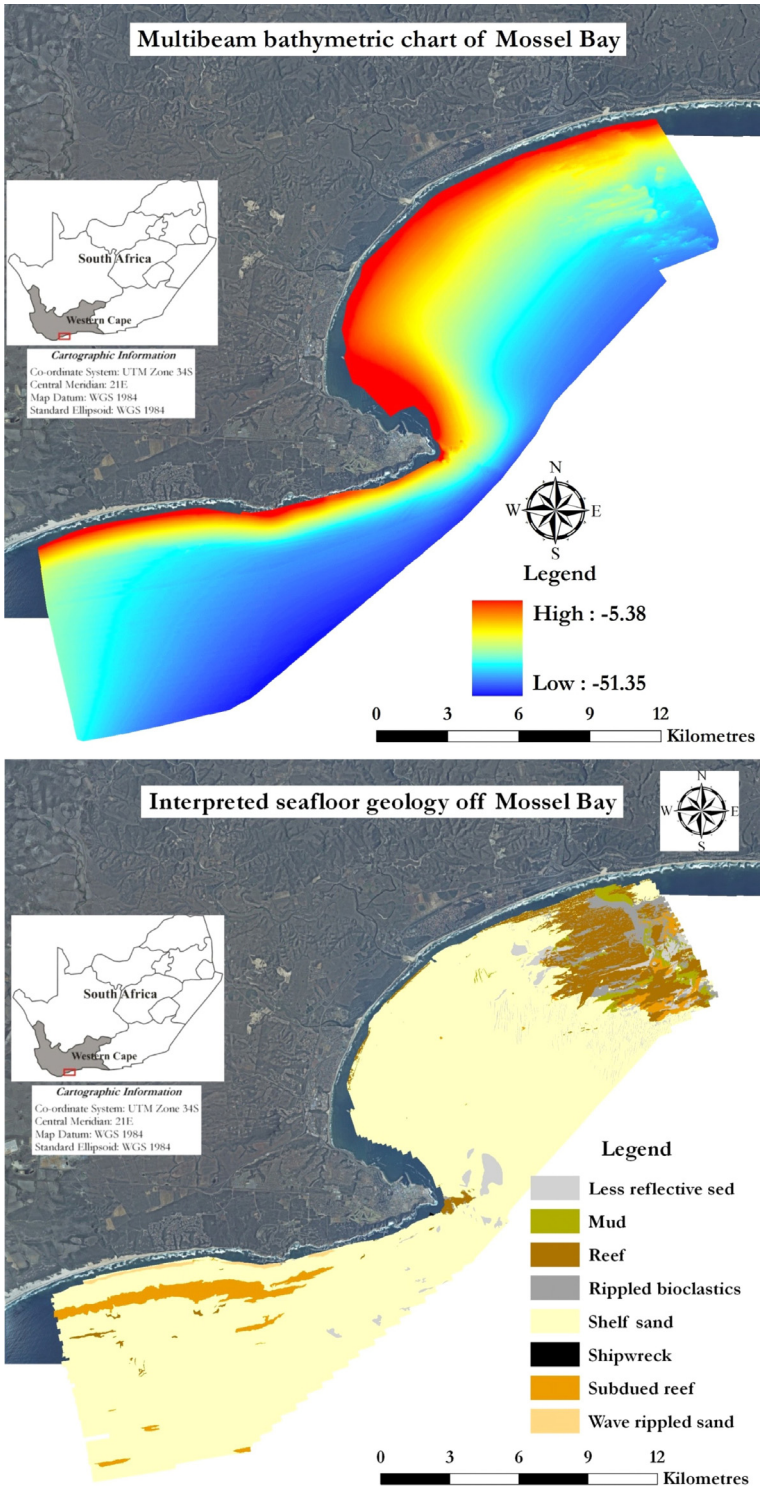
The southern African Middle Stone Age archaeological record is one of the richest worldwide, with many crucial sites situated along the southern coastline of South Africa. During much of this period, earth's climate was colder than present with sea levels lowered by as much as 130 m below the present level. In order to understand the evolution of humans who occupied the glacial expanded coastal plain, it is critical to establish the nature of the landscape, its topography and underlying geology which, in turn, can shed light on the soils, vegetation and climate.

Progress

All marine geophysical data have been acquired and processed. Interpretations on the surficial acoustic data are complete and seismic stratigraphic reconstructions are in progress.

Conclusions

The results obtained so far are generating initial geological models. The high-resolution marine geophysical data are of excellent quality.



Top: Multibeam bathymetric chart of the mapped area in Mossel Bay. Below: Interpreted surficial units from multibeam bathymetry and side-scan sonar data

ST-2012-1155

Offshore mineral mapping in the Western Cape

Project leader	HC Cawthra, MSc
Project team	MR MacHutchon, BSc Hons, FW van Zyl, BSc Hons, W Kupido
Primary objective	This project has been initiated to collect regional high-resolution geophysical data (specifically shallow-penetration seismics) on the continental shelf of the Western Cape Province. Prominent horizons in the stratigraphy of the upper continental shelf which truncate against the seafloor can be correlated to existing samples and geological modelling applied to the prediction of the occurrence of similar deposits at other localities
Duration	2011–2015
Budget	R3 000 000

Motivation

No high-resolution continental shelf studies have been conducted in the Western Cape Province to quantify the distribution of seafloor minerals. Although exploration has traditionally focused on seismic stratigraphy in oil and gas and exploration for diamondiferous units on the South African West Coast, these data are protected by proprietary interests.

Progress

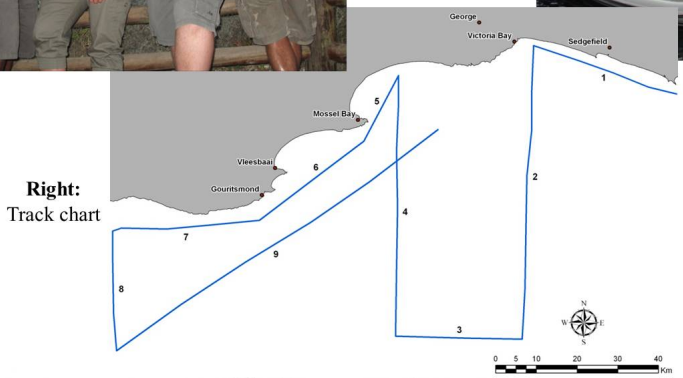
The Marine Geoscience Unit collected nine profiles between Knysna and Stilbaai using a vessel rated to work on the Agulhas Bank. The orientation of the profiles was mostly coast-perpendicular and the depth ranged from -20 m to -110 m below mean sea level.

Conclusions

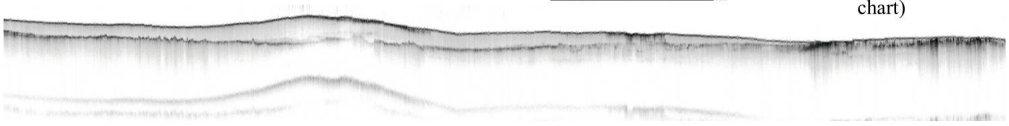
The horizons identified with shallow penetration seismic data gathered for this study which truncate the seafloor will be correlated to existing surficial samples.

Left: Staff of the MGU (Willem Kupido, Hayley Cawthra, Michael MacHutchon, Wilhelm van Zyl)

Above: Survey vessel in Knysna Marina with the pinger seismic system on the back deck



Right: Track chart



Below: Seismic profile 6 (see track chart)

ST-2012-1159

Sediment budget and dynamics of the Western Cape, with implications for the mining of building sand and integrated coastal management for provincial expansion

Project leader	M MacHutchon, BSc Hons, PrSciNat
Project team	W van Zyl, BSc Hons, H Cawthra, MSc, PrSciNat, W Daniëls, BSc Hons, Prof J Compton, University of Cape Town
Primary objective	This project aims to fulfil the national imperatives of the Council for Geoscience as well as address the growth strategy of DMR through a study on coastal sediment dynamics - Knowledge of the dynamics behind sediment movements in the Western Cape has implications for offshore and nearshore engineering installations and coastal urbanisation - The study areas are envisaged to assist the understanding of global climate change, with past climatic peturbances being analysed. From these data, prediction models can be made - Movement of sediment is a very important aspect of the City of Cape Town's Integrated Coastal Management Plan. Issues such as beach nourishment and erosion, especially along the high-density urbanised coastline and popular tourist beaches, are of vital importance to the province
Duration	2010–2015
Budget	R2 800 000.00 over 5 years

Progress

- Work is currently being carried out along the Atlantic coast between Duiker Point (near Hout Bay) and Mouille Point (at the entrance to Table Bay). Historical side-scan sonar and bathymetric data have been compiled and interpreted to map the distribution of sediment along the coast.
- Multibeam bathymetry data were collected between the 30 m and 15 m isobaths. The data have been processed.
- From the multibeam and side-scan sonar data and sediment distribution maps, a sediment sampling campaign has been planned. Samples have been collected offshore of the Camps Bay and Clifton beaches, which contain a large proportion of the sediment found along this stretch of coast.

Future activities

Continued multibeam bathymetric surveys to expand the area covered are planned towards the end of 2012. Selected areas will also be picked to do regular repeat surveys to look at the rate of change and sediment movement along the coast. More sediment samples are also planned. The samples will be used to study the grain size distribution and composition of the sediment found in the coastal environment.

The project is also expected to expand into Table Bay early next year. This will result in a clearer understanding of the sediment distribution and movement along the Atlantic coast of the Cape Peninsula.

MINERALS DEVELOPMENT

ST-0167

South African Coal Database

Project leader MM Schalekamp
Project team M Solomon
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

Motivation

In terms of current legislation, the Council for Geoscience maintains a coal database. The coal database is part of the organisation's 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 the 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, 103 logs were prepared, 402 header details were coded and captured, 1 983 lithologies for 88 boreholes were captured and 406 logs were electronically converted and loaded onto the database. The coal database now contains 112 977 boreholes with 2 843 611 lithologies and 1 597 153 analyses. 257 queries for outside clients were done with an income of R900 000.00.

Conclusions

The coal database forms part of GEODE, the corporate database of the Council for Geoscience. It is a database of strategic importance as it plays an important role in enabling further research work on the geology of the coal deposits in South Africa and facilitates proper planning of the optimal use of the country's mineral resources and better land management.

Future activities

The coal database will form part of the planned GEODATA portal which will provide the technology infrastructure required to make data contained in the Council for Geoscience's various databases accessible to persons outside the organisation.

ST-0168

COREDATA database

Project leader MM Schalekamp
Project team M Solomon
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

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 access to this collection.

Progress
During the year, 218 logs were prepared for capturing into the database, while 242 headers were coded and captured. The borehole core log database now contains a total of some 86 500 entries.

Conclusions
The borehole core database is one of the modules of GEODE, the corporate database of the Council for Geoscience. It is a database that plays an important role in enabling research work on the geology of South Africa and to facilitate 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-1118

A review of the thorium resources of South Africa

Project leader AO Kenan, MSc
Project team I Mutele
Primary objective To estimate the thorium resources of South Africa
Duration 2011/12

Introduction
Thorium occurs in several geological settings in South Africa, such as in vein and placer deposits as well as in alkaline and carbonatite complexes. The most significant vein-hosted thorium deposit is the Steenkampskraal monazite deposit which is considered to be one of the largest vein-hosted monazite deposits in the world. The main placer-hosted thorium deposits include Richards Bay, Namakwa Sands, Dominion Reef and Karoo-hosted (Bothaville–Wolmaransstad, Carolina) deposits. The Pilanesberg Complex is the only alkaline complex in South Africa and hosts substantial amounts of thorium. Carbonatite complexes which have considerable thorium resources include the Phalaborwa, Zandkopsdrift, Salpeterkop, Glenover, Tweerivier and Bulhoek Carbonatite Complexes.

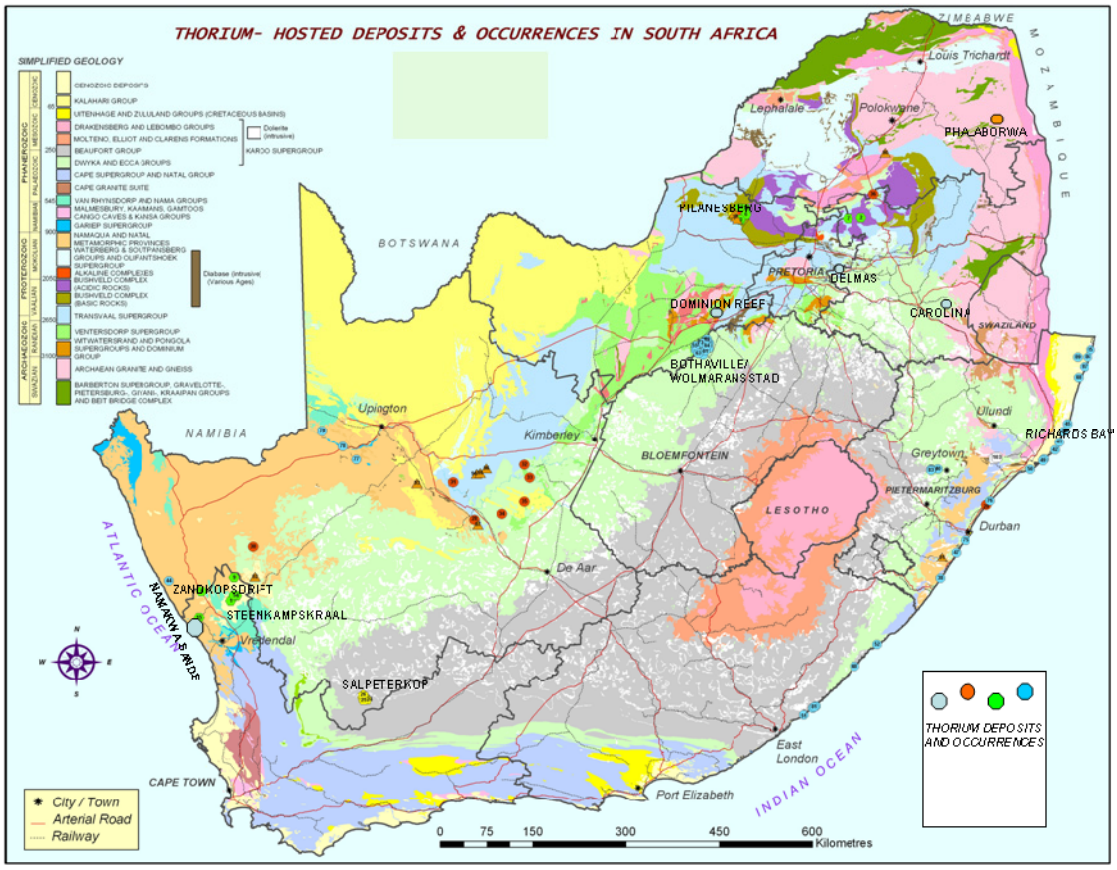
Motivation
The ever-increasing global energy demand, caused by an increasing population, can be addressed through other energy alternatives (other than the traditional fossil fuels) such as nuclear energy. Nuclear energy has the potential to eliminate the impending energy shortages, if a breakthrough is achieved in the ongoing research to utilise thorium as a fuel for nuclear reactors. Currently, uranium-fuelled nuclear reactors produce about 5.7% of the total primary energy used worldwide.

The thorium fuel cycle offers several potential advantages over the uranium fuel cycle, including superior physical and nuclear properties of fuel which makes thorium a safer fuel than uranium, enhanced proliferation resistance hence very little risk of nuclear weapon proliferation, and reduced plutonium and actinide production. Therefore, it is imperative that the thorium resource available in South Africa is known.

Resources
The Steenkampskraal, Richards Bay, Namakwa Sands and Zandkopsdrift deposits are currently mined or soon to be mined operational mines for other commodities such as rare earths and heavy-mineral sands (i.e. titanium, rutile and zircon). The total thorium resource in these deposits is about 41 413 tonnes (contained thorium oxide) and can be classified in the reasonably assured resource category. Other deposits such as the Dominion Reef, Bothaville–Wolmaransstad, Carolina, Pilanesberg, Phalaborwa, Salpeterkop and Glenover deposits host about 163 100 tonnes of thorium resources (contained thorium oxide) which are classified as estimated additional resources. Therefore, the total thorium resource in South Africa is approximately 204 513 tonnes (contained thorium oxide).

Conclusion

There are several challenges that need to be addressed to realise thorium as a fuel for nuclear reactors, which include the significant radiation dosage of uranium-232 because of the re-use of spent thorium fuel and the fact that the database and experience of thorium fuel cycles are currently very limited. Furthermore, South Africa needs to establish a national radioactive stockpile to safeguard thorium produced in the operational mines for future use in case thorium-fuelled reactors become commercialised.



Thorium-hosted deposits and occurrences in South Africa

ST-1054

Mineral resource assessment: Platinum-group elements (PGEs)

Project leader	AO Kenan, MSc
Project team	T Mudau
Primary objective	To (i) estimate the current PGE resources and reserves of South Africa as well as the remaining extent of the PGE mineralisation that has not yet delineated as resources and reserves; (ii) to estimate the PGE depletion rates, and (iii) to provide a basic PGE flow analysis of South Africa
Duration	2011/12

Introduction

Platinum-group elements (PGE) in South Africa occur mainly in the Bushveld Complex. Other occurrences include the Uitkomst Complex and Phalaborwa Carbonatite Complex, amongst others. All the economic PGEs in the Bushveld Complex are found in the Merensky Reef and the Upper Group 2 chromitite layer (UG 2) located in both the western and eastern limbs, as well as in the Platreef in the northern limb.

Motivation

South Africa hosts more than 88% of the global PGE resources and produced more than 60% of the global PGE primary production in 2010. However, there are limited SAMREC-compliant reports on national aggregated PGE resources and reserves and there is a misunderstanding amongst what constitutes a reserve and a resource base. In addition to PGE resources and reserves, it is important to understand the PGE annual depletion rates in order to assist the Government in its long-term policy planning. A basic PGE material flow analysis is also provided to establish the amounts of PGE used in the South African downstream industries, as well as the amounts of energy and water consumed in the PGE primary production.

PGE resources, reserves and depletion rates

The total PGE resource (exclusive of reserves) available in South Africa is about 59 085 tonnes of contained PGE. The total PGE reserve is about 11 508 tonnes PGE. Therefore, the total resource, inclusive of reserves, is about 70 592 tonnes PGE. The PGEs reported are mainly platinum, palladium, rhodium and minor amounts of gold. A further 18 561 tonnes of PGE was calculated as extended PGE mineralisation that has not been classified as resources and reserves yet. It will take about 143 years to deplete the current reserves, resources and the remaining extent of PGE mineralisation in South Africa at current production rates (the 2010 PGE production rates of 287.3 tonnes refined PGE).

PGE material flow analysis

The PGE material flow analysis shows that about 210 million tonnes of rock were mined in 2010, of which 95 million tonnes were sent to the beneficiation plants and 115 million tonnes were sent to the low-grade stockpiles and rock waste dumps. About 91 million tonnes tailings material were produced from the beneficiation plants and sent to the tailings dams in 2010. About 9 007 tonnes of slag from smelting processes were discarded to the slag dumps. Sulphur dioxide produced in the PGE beneficiation plants amounted to about 105 600 tonnes, of which 36 500 tonnes of sulphur dioxide were emitted into the atmosphere and the other 69 100 tonnes were converted to sulphuric acid. About 287.3 tonnes of refined PGE were produced in South Africa in 2010, of which 244.4 tonnes was exported and 42.9 tonnes was used for domestic downstream industries. The material flow analysis indicates that 40.9 tonnes of refined PGE were used for the production of catalytic converters, while 2.03 tonnes were for other industrial uses. About 36.8 tonnes of PGE in the catalytic converters were exported, and about 4.1 tonnes of PGE in the catalytic converters were used for domestic vehicle production. An estimated amount of 69 418 megalitres of water were used, of which 6 830 megalitres were discharged as effluents to the surface water. About 49 586 terrajoules of energy were consumed in the production of PGE in 2010, of which 11.52 million tonnes (carbon dioxide equivalent) of greenhouse gas were emitted.

Conclusion

The future of PGE is looking good due to the projected economic growth in China, India and other emerging economies. This expected growth will be contributed by increased environmental focus such as cleaner standard emissions and energy requirements, plus exciting new applications (fuel cell technology) and an increased jewellery demand forecast in Asia.

Expansion of production from the Bushveld Complex has been hampered in the past few years by many issues, including safety, power, labour, smelter problems and development difficulties with irregular ore bodies. In 2010, the platinum-group metal prices rose by 18% to 43% compared to 2009, while the strong rand-dollar exchange rates offset the extra revenues that would have been accrued by local producers. Therefore, in 2010, local producers did not enjoy the full benefits of metal price surges. There is still a huge PGE resource in South Africa that may last for more than 143 years, under current production rates. Ensuring water and electrical supply capacities is vital in the PGE production and requires continuous monitoring and planning.

Table 1

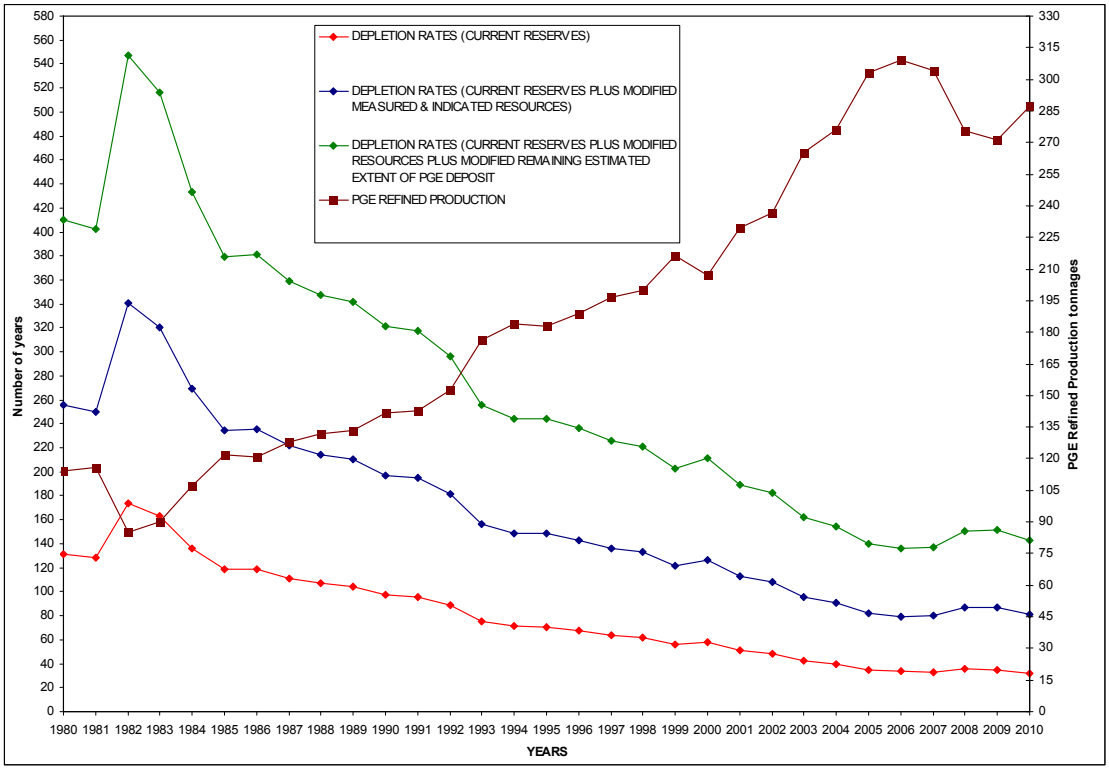
PGE reserves in South Africa (Data obtained from mining company annual reports)

OCCURRENCE	RESERVES CATEGORY		PROVED	PROBABLE	TOTAL
MERENSKY	RESERVES	(Mt)	213.92	305.97	519.88
	GRADE	(g/t)	4.45	4.47	4.46
	CONTAINED PGE	PGE (Moz)	30.59	43.98	74.57
		PGE (t)	951.41	1368.07	2319.47
UG2	RESERVES	(Mt)	711.31	705.25	1416.57
	GRADE	(g/t)	4.00	4.34	4.17
	CONTAINED PGE	PGE (Moz)	91.45	98.36	189.81
		PGE (t)	2844.32	3059.44	5903.77
PLATREEF	RESERVES	(Mt)	393.00	216.30	609.30
	GRADE	(g/t)	2.90	2.68	2.82
	CONTAINED PGE	PGE (Moz)	36.64	18.64	55.28
		PGE (t)	1139.70	579.68	1719.38
TOTAL (BUSHVELD INSITU)	RESERVES	(Mt)	1318.23	1227.52	2545.75
	GRADE	(g/t)	3.74	4.08	3.91
	CONTAINED PGE	PGE (Moz)	158.68	160.99	319.66
		PGE (t)	4935.43	5007.19	9942.63
OTHERS	RESERVES	(Mt)	0.00	129.51	129.51
	GRADE	(g/t)	0.00	0.87	0.87
	CONTAINED PGE	PGE (Moz)	0.00	3.62	3.62
		PGE (t)	0.00	112.67	112.67
TAILINGS	RESERVES	(Mt)	0.00	372.60	372.60
	GRADE	(g/t)	0.00	3.90	3.90
	CONTAINED PGE	PGE (Moz)	0.00	46.70	46.70
		PGE (t)	0.00	1452.39	1452.39
TOTAL RESERVES	RESERVES	(Mt)	1318.23	1729.63	3047.86
	GRADE	(g/t)	3.74	3.80	3.78
	CONTAINED PGE	PGE (Moz)	158.68	211.30	369.98
		PGE (t)	4935.43	6572.26	11507.69

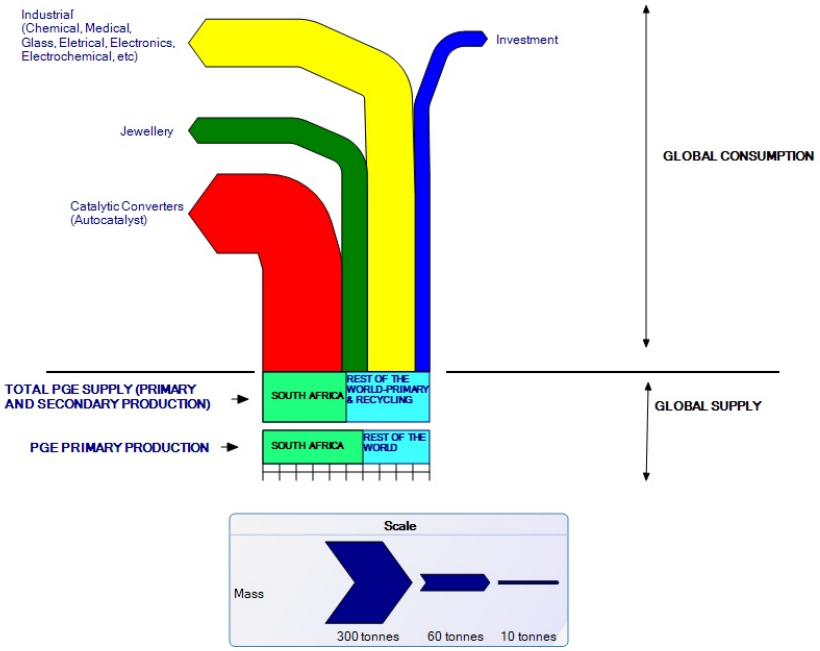
Table 2

PGE resources (inclusive of reserves) in South Africa (Data obtained from mining company annual reports)

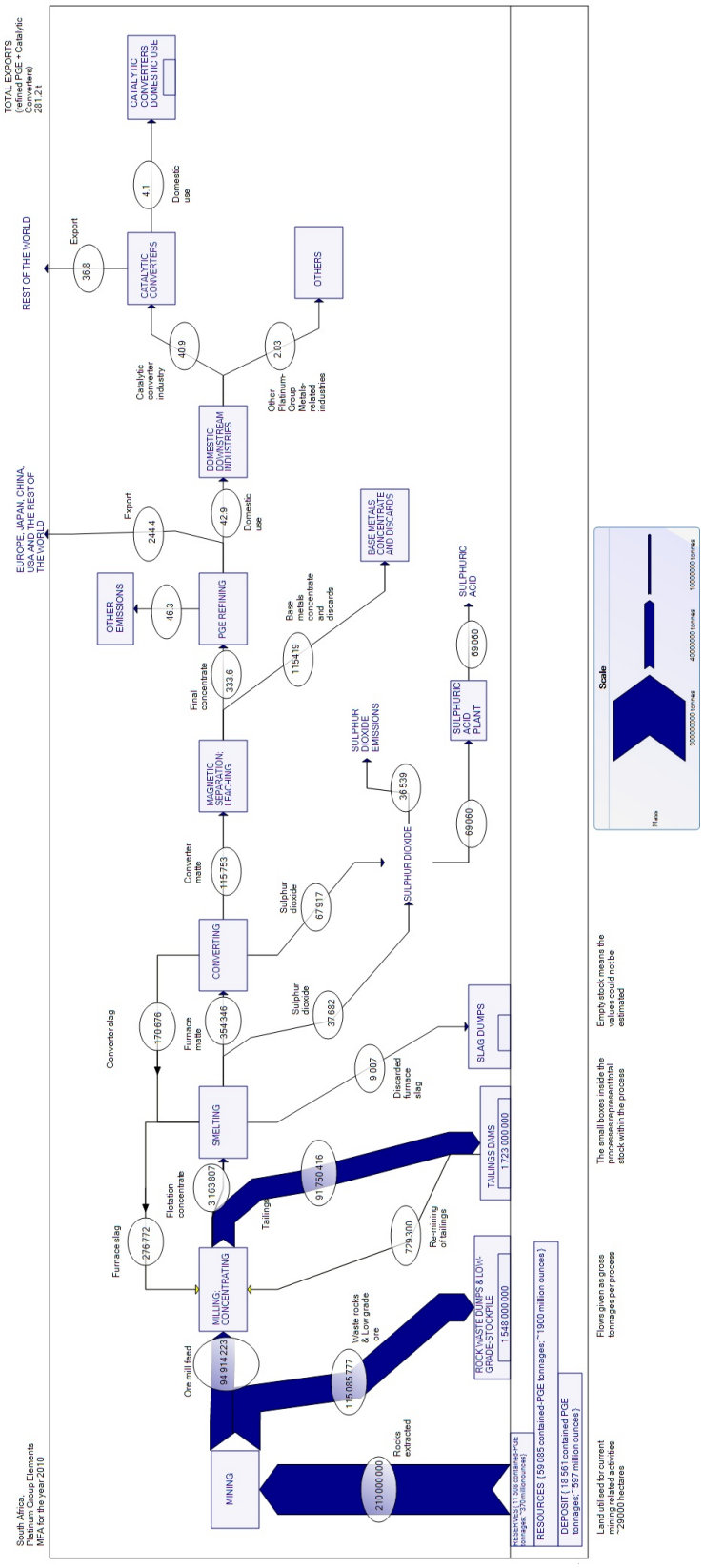
OCCURRENCE	RESOURCES CATEGORY		MEASURED	INDICATED	INFERRED	TOTAL
MERENSKY	RESOURCES	(Mt)	1148.09	1096.38	2443.33	4687.80
	GRADE	(g/t)	4.47	4.67	4.82	4.70
	CONTAINED PGE	PGE (Moz)	165.06	164.77	378.34	708.16
		PGE (t)	5133.84	5124.79	11767.68	22026.31
UG2	RESOURCES	(Mt)	1842.06	1963.49	3557.18	7362.72
	GRADE	(g/t)	5.30	5.12	5.26	5.23
	CONTAINED PGE	PGE (Moz)	313.61	323.24	601.18	1238.02
		PGE (t)	9754.20	10053.77	18698.81	38506.78
PLATREEF	RESOURCES	(Mt)	503.30	1252.80	1455.66	3211.76
	GRADE	(g/t)	2.79	2.17	1.79	2.10
	CONTAINED PGE	PGE (Moz)	45.08	87.51	83.87	216.46
		PGE (t)	1402.21	2721.88	2608.65	6732.74
TOTAL (In-situ Bushveld)	RESOURCES	(Mt)	3493.45	4312.66	7456.17	15262.28
	GRADE	(g/t)	4.66	4.15	4.44	4.41
	CONTAINED PGE	PGE (Moz)	523.75	575.51	1063.39	2162.65
		PGE (t)	16290.26	17900.43	33075.14	67265.83
OTHERS	RESOURCES	(Mt)	615.34	868.98	83.09	1567.41
	GRADE	(g/t)	0.90	0.93	1.54	0.95
	CONTAINED PGE	PGE (Moz)	17.71	25.89	4.11	47.71
		PGE (t)	550.90	805.36	127.74	1484.00
TAILINGS	RESOURCES	(Mt)	89.25	415.20	216.30	720.75
	GRADE	(g/t)	1.10	2.81	2.68	2.56
	CONTAINED PGE	PGE (Moz)	3.16	37.45	18.64	59.24
		PGE (t)	98.18	1164.69	579.68	1842.55
TOTAL GRAND RESOURCES (INCLUSIVE OF RESERVES)	RESOURCES	(Mt)	4198.04	5596.85	7755.56	17550.44
	GRADE	(g/t)	4.04	3.55	4.36	4.02
	CONTAINED PGE	PGE (Moz)	544.61	638.85	1086.14	2269.60
		PGE (t)	16939.33	19870.48	33782.56	70592.37



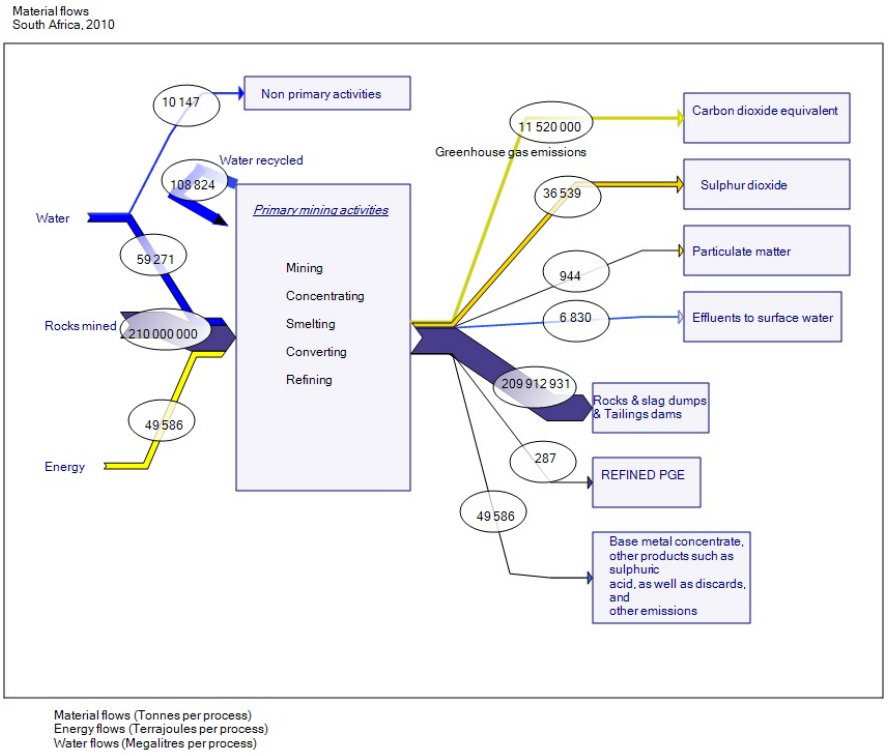
Depletion rates graph showing depletion trends from 1980 to 2010 in South Africa as well as refined PGE production



Arrow diagram showing global supply and consumptions of PGE and the role of South Africa in the global supply



PGE material flow analysis diagram for the year 2010



Water and energy consumption in South Africa's PGE production in 2010

ST-0166

SAMINDABA (South African Mineral Deposits Database)

Project leader CJ Vorster, MSc
Project team R Malan, in collaboration with Metallogenic Mapping and the Spatial Data Management Unit
Primary objective The capturing, storage and updating of mineral data on mines and mineral deposits and occurrences within the borders of South Africa. The fast and efficient provision of accurate mineral data and maps to users all over South Africa and abroad
Duration Ongoing
Budget R185 000

Motivation

Building the economy requires access to information to identify opportunities. From this database flowed numerous mineral resource appraisals, reports, maps and mineral data — these activities 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 to promote economic geological activity. The sterilisation of mineral deposits has also been prevented during the planning of permanent surface structures such as townships, dams, roads, pipelines, railway lines, etc. SAMINDABA plays a positive role in rural development and poverty eradication.

Progress

During the 2011/2012 reporting year, SAMINDABA was enlarged to 19 340 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 6 485 mineral records.

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

SAMINDABA is involved in the GEODATA portal. This portal will provide the technology infrastructure required to make data in the organisation's various databases accessible to organisations and persons outside the organisation.

Fieldwork and research will be carried out to further enhance and update SAMINDABA as well as the Derelict and Ownerless Mines Database.

ST-0133

International Metallogenic Map of Africa 1:5 000 000 — database maintenance

Project leader	WR Oosterhuis, BSc Hons
Primary objective	To i) improve the existing knowledge of mineral deposits of the SADC and NEPAD regions by updating the database; ii) to improve the reliability of the data by verification and editing; iii) to contribute towards capacity building and improving knowledge of genetic models of mineralisation in Africa, and iv) to contribute information to other projects in line with the objectives of the organisation
Duration	Ongoing

Motivation

The African Mineral Deposits Database was designed as part of the compilation of the International Metallogenic Map of Africa on a scale of 1:5 000 000. It is important to continuously update and improve the data, which are particularly important for the innovative manipulation and interrogation of the data in the production of a variety of products, including regional exploration target maps as well as the advancement of knowledge of the genesis of mineral deposits (deposit modelling). The maintenance of the database is a continuous process for as long as the organisation sees working in Africa and being involved in NEPAD and SADC as key thrust directions.

Progress

The 1:5 000 000 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 B-version of the digital International Metallogenic Map of Africa was released in 2003. The Africa Metallogenic DVD was upgraded in 2009 to include projects in ArcMap 9.2 and 9.3 formats, with all shape file projects in WGS84.

Sales of the digital data have been continuous throughout the year. The digital data have been used for the production of both country-specific and more regionally derived maps and reports. Currently, the Africa Mineral Deposits Database has 12 728 mineral deposit records in .db format.

Conclusions

The release of the digital data has generated interest within the mining community at large and it is hoped that the data will serve to promote interest and new investments in the mineral industries of Africa.

Future activities

The maintenance of the Africa Minerals Database is an ongoing task and will be further improved, updated and expanded during the next financial year.

NORTHERN CAPE

ST-2010-1078

The architecture of a crustal-scale shear zone: structural geology, kinematics, mechanics fluid dynamics and mineralisation of the Pofadder Shear Zone, Northern Cape Province and southern Namibia

Project leader	PH Macey, PhD
Project team	CW Lambert, BSc Hons, CA Groenewald, BSc Hons, Prof AFM Kisters and Prof D Frei (University of Stellenbosch). In addition, there are other collaborative projects with UCT (Prof C Harris and M Nelufule), Mainz University (Dr T Zack and students) and McGill University (Dr C Rowe and students)
Primary objective	1. 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 through geological mapping and allied research 2. To study controls of shear zones for the migration and emplacement of granitic/pegmatitic melts in the continental crust by comparing mineral-enriched pegmatites to barren pegmatites and determining their spatial, temporal and geometric relation to the Pofadder Shear Zone 3. To understand the flow of hydrothermal fluids through mega shear zones 4. To understand the orthomagmatic and hydrothermal mineralisation potential of the Pofadder Shear Zone 5. All data collected will be incorporated into a Namaqualand Database aimed at supplementing various sectors of geological data archived/held by the Council for Geoscience (e.g. mineral–SAMINDABA data, structural, field/geophysical/ hydrogeology maps at various scales)
Duration	2009–2012
Budget	R416 000

Motivation

Innovative research and staff development with implications for shear-hosted mineralisation. Project will lead to two MSc degrees. Collaborative project between the Western Cape and Northern Cape Units and the Universities of Stellenbosch, Cape Town, Maintz (Germany) and McGill (Canada).

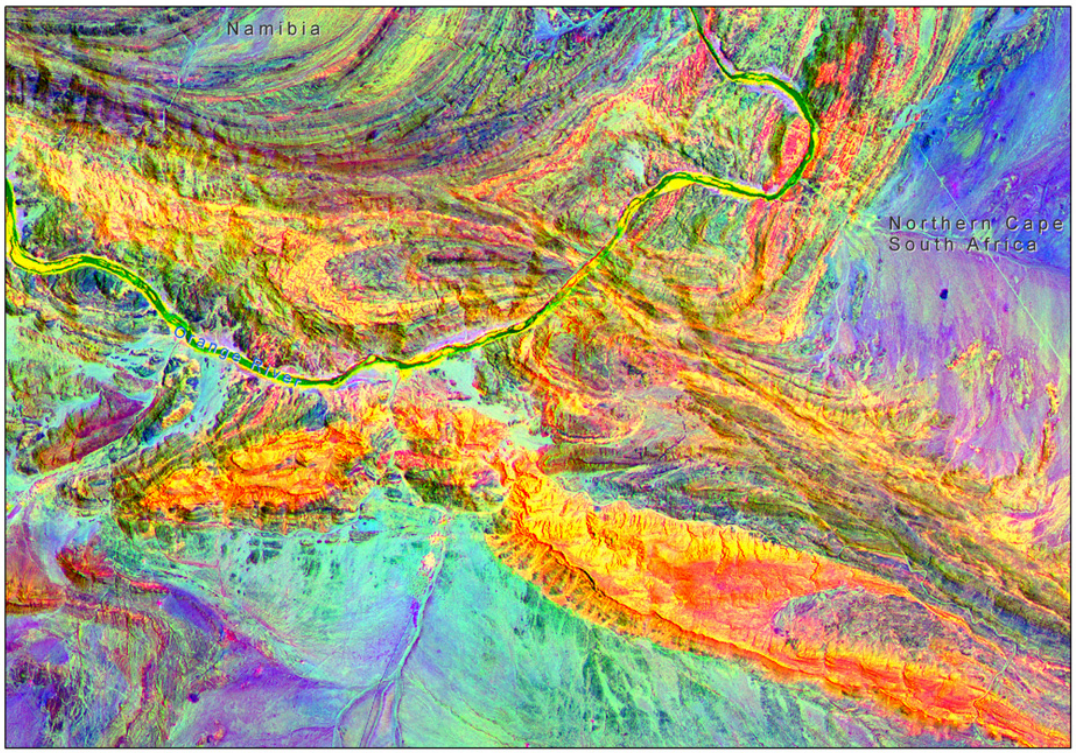
Progress

1. Preliminary literature review and construction of spatial database (structure, mineral data, vector map data and raster image and map data) completed
2. Spatial analysis, preliminary remote sensing completed
3. Preliminary maps compiled
4. Four mapping and sampling field seasons have been completed during which the main lithological units have been mapped and the geometry and kinematics of the various structural elements have been measured and recorded
5. Petrographic sections prepared
6. Zircons and monazites separated for isotopic dating
7. Zircons and monazites imaged on SEM for isotopic dating
8. Monazite analysis has been completed
9. Stable isotope analyses completed

10. South Africa–Namibia transborder maps are in preparation
11.Two MSc compilations in preparation.

Conclusions

1. As a result of the mapping, the team has been able to determine the modified lithostratigraphy along the shear zone and in surrounding areas and to constrain the structural evolution to five major deformation episodes with six separate, yet temporally overlapping phases of deformation within the shear zone.
2. Geometric relationships indicate that many of the melts (especially the pegmatite magmas) and hydrothermal fluids are directly related to the six-phase structural evolution of the shear zone.
3. This 6th phase can be dated through the monazite analysis that is completed.



Aster band combination RGB = (4/7), (PCA 5), (Aster 13) used for remote sensing and field map compilation

REGIONAL GEOCHEMISTRY

ISO 9001 status

The following documents were compiled for the ISO accreditation process of the Regional Geochemical Mapping Unit:

1. Regional geochemical mapping
1.1 Preparations for mapping
1.2 Fieldwork — helicopter and/or foot sampling
1.3 Sample transportation
1.4 Sample submission for laboratory analysis
1.5 Orientation study
1.6 Receipt of analytical data
1.7 Data cleansing: Data merging, Basic statistics, Preliminary digital geochemical map
1.8 Compilation of database
1.9 Compilation of geochemical maps: Bubble plot, Contour plot, Composite grid image, Ternary plot, Synthesis maps, Multiple function map
1.10 Geochemical report/Exploration report/Geochemical atlas
2. Verification and classification of geochemical anomalies
3. Geochemical map and data sales.

Documents submitted for ATP evaluation

1. The Regional Geochemistry Unit of the Council for Geoscience has started compiling the layout for the Geochemical Atlas of the Bushveld Complex and surrounding rocks based on the geochemical reports of seven different units of the Bushveld Complex.
   - The Regional Geochemical Maps of the Bushveld Complex and surrounding rocks
   - The Lebowa Granite Suite – in progress
   - The Rooiberg Group – in progress
   - The Rashoop Granophyre Suite – in progress
   - The Upper Zone – in progress
   - The Main Zone – in progress
   - The Marginal Zone – in progress
   - The Critical Zone – in progress
   - Literature study – in progress.

2. High-density soil geochemical data of the Bushveld Complex, South Africa – geochemical baselines and vectors. Report ST-2012-0033. By: Elsenbroek JH, Strauss SW, Bensid ML, Van der Walt, DM.
3. Multivariate statistical evaluation of heavy metals in soils around Tzaneen, South Africa. By: Maya, M.
4. Regional geochemical data interpretation in the central part of the Capricorn District, Limpopo Province. Report ST-2012-0010. By: Van der Walt, DM, Elsenbroek, JH.
5. Applied ArcGIS training manual; Regional geochemical data; Uganda training workshop and Kingdom of Lesotho project — Geochemical maps. Report ST-2012-0028. By: Van der Walt, DM.

RESEARCH PROJECTS

ST-2011-1119

High-density geochemical mapping of the Bushveld Complex and surrounding rocks

Project leader JH Elsenbroek, MSc
Project team SW Strauss, MSc, DM van der Walt, BSc Hons, ML Bensid, BSc Hons, S Hlatshwayo, BSc Hons, E Mulovhedzi, BSc Hons, M Maya, BSc Hons
Primary objective To provide a value-added product — Geochemical Atlas — for the existing regional geochemical data in that it will highlight cryptic magmatic processes such as differentiation of the igneous units, which have previously not been seen on maps. It will also identify "new" target areas for exploration for Pt, Pd, Au, Cr, Ni, Cu, Sn, W and F.

Motivation

The Bushveld Complex is the largest intrusive complex in the world and therefore of enormous economic and scientific interest. The Council for Geoscience completed the high-density geochemical survey over the Bushveld Complex recently. The report will, for the first time, provide a value-added product for existing data in that it will highlight cryptic magmatic processes such as differentiation of the igneous units, which have previously not been seen on maps. It will identify "new" target areas for exploration for Pt, Pd, Au, Cr, Ni, Cu, Sn, W and F. For the first time, a holistic interpretation of the current regional geochemical data will be compiled to showcase the value of the data and showcase expertise for pre-competitive purposes.

Progress

The Bushveld Complex is considered to be a unique geological formation as it is the biggest mafic layered intrusion on earth and hosts the richest reserves of platinum, chromium and vanadium. The Bushveld Complex is formed by four principal units, i.e. the Rooiberg Group, the Lebowa Granite Suite, the Rashoop Granophyre Suite and the Rustenburg Layered Suite. The Rustenburg Layered Suite is subdivided into an Upper Zone, a Main Zone, a Critical Zone and a Marginal Zone.

The Regional Geochemistry Unit of the Council for Geoscience compiled geochemical reports on seven different units of the Bushveld Complex:

- The Lebowa Granite Suite by JH Elsenbroek (MSc)
- The Rooiberg Group by D van der Walt (BSc Hons)
- The Rashoop Granophyre Suite by ML Bensid (BSc Hons)
- The Upper Zone by R Netshitungulwana (MSc)
- The Main Zone by S Hlatshwayo (BSc Hons)
- The Marginal Zone by E Mulovhedzi (BSc Hons)
- The Critical Zone by M Maya (BSc Hons).

Regional geochemical maps were compiled by clipping the data on the different geological units for the following elements: TiO_2, MnO, Fe_2O_3T, Sc, V, Cr, Co, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Sn, Sb, Ba, W, Pb, Th and U. Histograms and statistical tables were produced for each element and the data were interpreted.

Conclusions

The geochemical baselines of the different units in the Bushveld Complex were determined. The geochemical anomalies were compared with the known mineral occurrences and new exploration targets were identified.

Future activities

A Geochemical Atlas of the Bushveld Complex and surrounding rocks has been laid out in A3 format. The seven geochemical reports on the different units of the Bushveld Complex will be compiled into one geochemical atlas in A3 format and is still in progress. Field visits will be carried out to verify geochemical anomalies and to compare the mineralisation and structure within the geological outcrops in the target area. The verification results will be incorporated in the final Bushveld Complex Geochemical Atlas. Pt, Pd and Au analyses still have to be carried out to complete the samples on the rocks of the Rustenburg Layered Suite.

SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY (SACS)

ST-1999-0519

SACS secretarial functions, including meetings and field trips

Project leader	C Hatton
Project team	N Keyser, MSc, GA Botha, PhD, JSV Reddering, PhD, PH Macey, PhD, CH de Beer, MSc, HP Siegfried, PhD, L Chevallier, PhD, DI Cole, PhD, DL Roberts, PhD, JHA Viljoen, PhD, G Brandl, PhD, N Baglow, MSc, PJA Bosch, MSc, GS de Kock, PhD, J Neveling, PhD, N Hicks, MSc
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

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

Discussions were held with geologists from the University of Pretoria and Rhodes University on the proposal that the Postmasburg Group and Pretoria Group are not lateral equivalents. Field trips were undertaken to examine the evidence. It was concluded that the argument that the Postmasburg Group is older than the Pretoria Group is valid. The revised stratigraphy will be implemented on the next edition of the 1:1 000 000 geology map of South Africa.

Presentations based on biostratigraphy and lithostratigraphy were delivered at the Pretoria Branch of the Astronomical Society, at Geosynthesis 2011 and at the annual meeting of the Igneous and Metamorphic Study Group. A talk on the origin of early life is to be delivered at the International Geological Congress in Brisbane, Australia.

The legends of all the 1:250 000 and 1:50 000 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 CGS cartographers.

Future activities

This project is ongoing.

ST-2002-0449

SACS publications

Project leader	C Hatton, PhD
Project team	A van Heerden, BA
Primary objective	To provide definitive, standardised descriptions of all formally approved lithostratigraphic units recognised in South Africa
Duration	Ongoing

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 fieldwork and provide basic data for use in reports and publications.

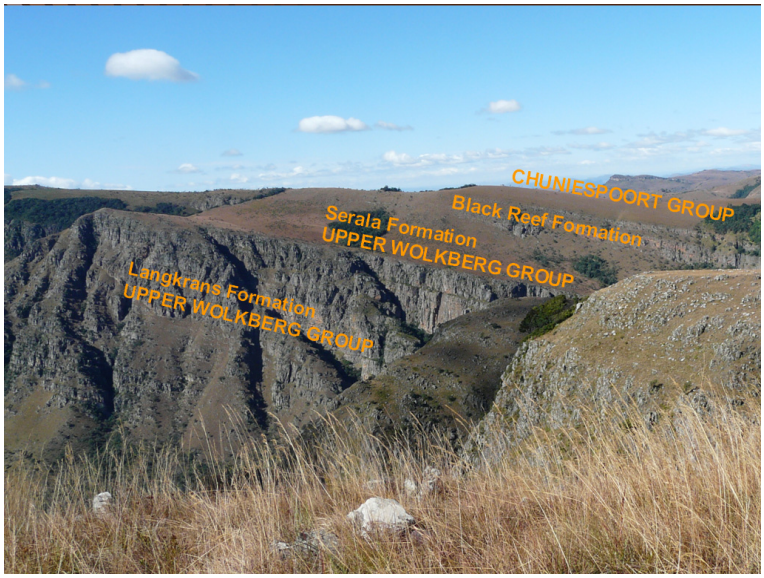
Progress

The status of the publications is as follows:

SACS Catalogue Volume 17: Five contributions have been received for this volume (Serala Formation, Dullstroom Formation, Damwal Formation, Kwaggasnek Formation and Schrikkloof Formation).

Future activities

Further lithostratigraphic units will be formally described.



Field stratigraphy of the Serala Formation in cliffs south of the lookout beacon on The Downs

ST-2002-0473

SACS database

Project leader	C Hatton, PhD
Project team	S Tucker, Dip SBM
Primary objective	To store basic information on stratigraphic units recommended for use on maps and in reports and publications of the Council for Geoscience
Duration	Ongoing

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
No units were added to the database.

Future activities
This project is ongoing.

ST-2010-1106

SACS descriptions: Harmony Granite, Makhutswi Gneiss, Timbavati Gabbro

Project leader	N Baglow, BSc Hons
Project team	T Dhansay, BSc Hons, NC Mukosi, BSc Hons, LP Munyangane, BSc Hons
Primary objective	To provide a concise comprehensive lithostratigraphic description and type area of the following stratigraphic units: Harmony Granite, Makhutswi Gneiss and the Timbavati Gabbro
Duration	2011/12

Motivation
The description of the units and stratotypes partially fulfil the requirements for the South African Committee for Stratigraphy in cataloguing the lithostratigraphy, chronostratigraphy and biostratigraphy in South Africa.

Progress
The SACS descriptions for the Harmony Granite, Makhutswi Gneiss and Timbavati Gabbro were completed.

Conclusions
The Harmony Granite, existing as a batholith-like intrusion situated northwest of Hoedspruit, is a medium-grained locally porphyritic biotite-muscovite granitoid of tonalitic composition. With an age of 3.09 Ga ±5 Ma, it is believed to be possibly equivalent to the volcanic Weigel Formation of the Murchison Greenstone Belt to the north.

Forming an extensive area (± 1 000 km^2) of basement south of the Murchison Greenstone Belt, the Makhutswi Gneiss, with an age of emplacement of 3.064 Ga ±21 Ma, is close in age to the homogeneous Harmony Granite. Typical of many older gneisses, it has a bulk tonalitic to granodioritic composition, with the lithology including leucocratic grey, banded and migmatitic gneisses, with a mineralogy of quartz, plagioclase and biotite and lesser microcline and accessory sphene. In the central development of the unit, greenstone inclusions/remnants are widespread, as are intrusions of the younger Mica Pegmatite.

The Timbavati Gabbro intrudes as a number of mafic to ultramafic sill-like bodies into granitic, gneissic and migmatitic basement of the Limpopo and Mpumalanga lowveld. Age is somewhat problematic, but the oldest date is 1 454 Ma, with other much younger results indicative of overprinting. Three distinct rock types have been recognised on the basis of petrography and chemistry: olivine-rich gabbro, olivine-poor gabbro and quartz-bearing gabbro. Compositional gaps between these gabbros suggest that they were formed by more than one magma intrusion, possibly the event was marked by three distinct magmatic pulses.

SEISMOLOGY

ST-2002-0184

1) Seismological monitoring, analyses and bulletin compilation
2) Compilation and maintenance of database of South African seismicity

Project leader	I Saunders, Nat Dip (Geol)
Project team	L Akromah, Nat Dip, MBC Brandt, MSc, T Molea, P Msiza
Primary objective	The continued operation of the South African National Seismograph Network (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. The seismological activity monitored by the SANSN provides valuable data that are required for seismic hazard analyses and insurance claims. Seismological data from the SANSN are preserved for prosperity through a National Earthquake Database
Duration	1 April 2011 to 31 March 2012

Motivation

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

The SANSN is the only vehicle capable of reporting the distribution of seismic foci in South Africa, the distribution of seismic activity in time and of providing a calibrated uniform magnitude scale of recorded events. The information gathered through the SANSN is banked in a 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 is shared with a varied audience both nationally and internationally and is distributed within the Council for Geoscience, contributing to the Geoscience Mapping and Physical Geohazards thrusts.

Progress

An earthquake swarm manifested in the towns of Augrabies and Keimoes in the Northern Cape Province during February 2010 and continued throughout the period of reporting with more than 824 earthquakes being recorded. The largest earthquake occurred on 18 December 2011 and measured 5.0 on the Richter scale, with slight damage reported from the area.

Earthquake activity in South Africa for the period January to December 2011 was released through ad hoc reporting and quarterly seismological bulletins.

Future activities

Waveform data from the Incorporated Research Institutions for Seismology (IRIS) will be requested to assist with re-evaluating earthquake epicentre locations of interest in South Africa.

Table 1

List of tectonic earthquakes with $M_L \geq 3.0$ in South Africa for the period January to December 2011

Date	Time	Region	Magnitude (M_L)
2011/01/01	11:15:33.4	Augrabies area	3.5
2011/01/02	14:52:54.8	Augrabies area	3.5
2011/01/04	13:41:26.5	Augrabies area	4.3
2011/01/07	14:56:41.3	Augrabies area	4.7
2011/01/07	23:00:19.0	Augrabies area	3.6
2011/01/08	21:57:19.0	Augrabies area	3.0
2011/01/11	07:31:53.6	Augrabies area	3.7
2011/01/12	02:09:50.2	Augrabies area	3.8
2011/01/12	08:14:21.0	Augrabies area	4.9
2011/01/13	19:36:56.3	Augrabies area	4.7
2011/01/14	22:56:50.9	Augrabies area	3.1
2011/01/15	11:12:42.9	Augrabies area	3.0
2011/01/16	05:07:36.9	Augrabies area	3.3
2011/01/16	22:02:21.7	Augrabies area	3.1
2011/01/18	13:37:36.6	Standerton area	3.9
2011/01/18	19:33:32.2	Augrabies area	3.1
2011/01/19	05:49:08.8	Augrabies area	4.4
2011/01/21	11:02:24.8	Tholeni area	3.4
2011/01/22	04:34:39.7	Augrabies area	3.1
2011/01/22	04:35:53.4	Augrabies area	3.4
2011/01/23	22:44:02.3	Augrabies area	3.8
2011/01/25	04:39:52.4	Augrabies area	4.9
2011/01/28	03:29:06.6	Augrabies area	4.1
2011/01/30	06:26:27.8	Augrabies area	3.0
2011/01/30	07:18:34.0	Augrabies area	3.5
2011/02/01	08:58:10.8	Augrabies area	3.0
2011/02/01	19:19:57.5	Augrabies area	3.0
2011/02/03	08:32:01.1	Augrabies area	3.4
2011/02/03	19:57:13.5	Augrabies area	3.0
2011/02/05	07:47:39.5	Augrabies area	3.5
2011/02/05	10:22:37.7	Augrabies area	4.3
2011/02/09	15:22:25.4	Augrabies area	4.1
2011/02/11	09:52:35.8	Augrabies area	4.0
2011/02/11	09:58:52.7	Augrabies area	3.6
2011/02/21	23:19:11.8	Augrabies area	4.7
2011/02/25	14:40:13.1	Leeu-Gamka area	3.2
2011/03/01	05:23:28.2	Augrabies area	3.5
2011/03/06	12:51:35.9	Augrabies area	3.0
2011/03/09	10:52:44.6	Augrabies area	3.9
2011/03/12	01:58:51.3	Augrabies area	4.3
2011/03/18	22:42:58.4	Graaff-Reinet area	3.3
2011/03/22	04:59:30.9	Augrabies area	3.2
2011/04/07	01:34:52.8	Augrabies area	4.8

Date	Time	Region	Magnitude (M_L)
2011/04/21	15:20:21.1	Augrabies area	3.0
2011/04/28	08:41:37.8	Scottburgh area	3.0
2011/05/04	09:59:01.2	Augrabies area	3.6
2011/05/05	12:06:27.2	Augrabies area	3.0
2011/05/05	12:11:42.4	Augrabies area	4.2
2011/05/05	12:38:20.9	Augrabies area	3.2
2011/05/05	13:45:27.8	Augrabies area	3.0
2011/05/07	11:53:19.8	Augrabies area	3.5
2011/05/14	16:10:41.7	Leeu-Gamka area	4.8
2011/05/14	18:26:12.7	Augrabies area	4.3
2011/05/23	04:33:14.9	Leeu-Gamka area	3.2
2011/05/27	06:25:35.8	Augrabies area	3.3
2011/06/12	04:06:29.2	Augrabies area	3.4
2011/06/12	10:28:49.1	Augrabies area	3.0
2011/06/13	12:09:57.8	Augrabies area	3.2
2011/06/22	23:02:50.6	Augrabies area	3.5
2011/06/22	23:10:03.8	Augrabies area	3.7
2011/06/22	23:10:04.4	Augrabies area	3.8
2011/06/22	23:04:05.6	Prieska area	3.4
2011/06/22	23:11:19.7	Prieska area	3.7
2011/06/25	13:38:22.7	Namaqualand	4.0
2011/07/16	10:27:16.7	Augrabies area	3.1
2011/08/09	12:57:04.6	Masinyusane area	3.0
2011/08/12	15:45:07.2	Bethlehem area	3.2
2011/08/13	20:51:21.8	Bitterfontein area	3.3
2011/08/13	21:33:28.7	Augrabies area	3.3
2011/08/27	03:00:11.3	Augrabies area	3.4
2011/10/09	11:40:30.4	Atlantic ocean	3.0
2011/11/13	03:33:04.5	Augrabies area	3.2
2011/11/16	13:34:59.6	Lesotho	3.1
2011/11/29	07:41:42.5	Namaqualand	3.4
2011/12/08	21:28:46.2	Paternoster area	3.5
2011/12/09	16:06:21.3	Paulpietersburg area	3.5
2011/12/18	16:23:25.3	Augrabies area	3.0
2011/12/18	20:07:05.7	Augrabies area	5.0
2011/12/22	17:12:46.3	Dullstroom area	3.0
2011/12/23	09:51:08.1	Namaqualand	3.5
2011/12/23	10:07:02.5	Namaqualand	3.1
2011/12/27	05:55:56.2	Augrabies area	3.4
2011/12/27	05:56:52.5	Augrabies area	3.2

Table 2
List of mining-related earthquakes with $M_L \geq 4.0$ for the period January to December 2011

Date	Time	Region	Magnitude (M_L)
2011/03/09	23:35:43.4	Klerksdorp gold mines	4.3
2011/10/05	22:48:57.4	Free State gold mines	4.2
2011/11/17	08:00:11.4	Far West Rand gold mines	4.0
2011/12/27	12:25:16.9	Klerksdorp gold mines	4.0
2011/12/28	05:22:04.3	Klerksdorp gold mines	4.3

ST-2002-0475

Collection of seismological data and maintenance of the South African national seismograph network

Project leader G van Aswegen, Nat Dip Elec Eng (Comp Systems)
Project team TR Kometsi, Nat Dip (Elec Eng), P Adamos, Nat Dip (Elec Eng), V Jele, Nat Dip (Elec Eng), L Tabane, L Fisha
Primary objective Maintenance and operation of the South African National Seismograph Network (SANSN) to ensure high-quality seismic data to be received by the National Data Centre (NDC) at the Council for Geoscience for analysis
Duration 1 April 2011 to 31 March 2012

Motivation

(i) To maintain the South African National Seismograph Network in order to produce high-quality seismic data from 28 remotely deployed seismograph stations throughout South Africa while ensuring high-percentage data availability in as near real time as possible. (ii) To monitor the state of health of seismic stations on a daily basis and to ensure a quick response to any failures. The data are used to produce seismic information for bulletins and seismic hazard maps.

Progress

Methods have been implemented in order to enable seismograph systems 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 in 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 and all recording systems have been customised for optimal operation. Performance of the network is monitored through an 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 and ensures proper operation of systems without undertaking unnecessary field trips. New hardware for the data acquisition software was introduced to help improve reliability. A new safe door was installed at Mussina to prevent harm to the equipment.

Conclusions

Seismograph stations within the South African National Seismograph Network 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 seismological 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 proven to be better than ever before. Vandalism and theft are increasingly affecting the seismograph stations.

Future activities

Reduction of transmission costs coupled to improved methods and new technologies will continue to be investigated by the technical team and implemented if and when possible. Ways will be investigated to better secure stations or find possible alternative sites which offer increased security in the areas of vandalised stations.

CO-2006-5606

Operation and maintenance of the primary (PS39 — Boshof) and auxiliary seismic stations in the Antarctic (AS35)

Project manager	FA Delport, B Tech (Elec Eng)
Project team	V Jele, Nat Dip (Elec Eng), G van Aswegen, Nat Dip (Elec Eng)
Primary objective	The Council for Geoscience has been designated by the Department of International Relations and Cooperation to act as the technical point of contact regarding Comprehensive Test Ban Treaty matters. Owing to South Africa's obligation to the Nuclear Test Ban Treaty, the Council for Geoscience is committed to maintain the primary seismic stations of the International Monitoring System at Boshof 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 based in Vienna, Austria. The objective of the operations of the National Data Centre 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	1 April 2012 to 28 March 2015
Budget	R345 211.58

Motivation

Owing 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 to operate a National Data Centre which functions within the framework required by the Comprehensive Test Ban Treaty Organisation (CTBTO). The responsibility of the Council for Geoscience 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 organisation's active participation in CTBT matters, the operation of such a National Data Centre 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 eighth year of operation after certification in December 2004. Staff of the Council for Geoscience visited the station on a quarterly basis in order to ensure proper operation of the data communication 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 Centre (IMS Ops). Monthly reports were also submitted to IMS Ops.

Throughout the reporting period, the Council for Geoscience was in constant contact with experts at the US Air Force Technical Application Centre (AFTAC) concerning discussions and resolutions in rectifying problems at the BOSA site. Hardware upgrades were performed on an ad hoc basis to ensure data availability is at a level as prescribed by the Provisional Technical Secretariat (98% constant data availability at all times). The upgrades enable staff from AFTAC to remotely monitor and identify equipment failures through a Supervisory Control and Data Acquisition System. The upgrades also included an advanced grounding scheme which minimises the effect of thunderstorm activity in the area.

The power configuration at the site has been upgraded to a new system which now integrates the local AC supply, solar panel system and a battery backup system to ensure that the site has power from whichever source may be available.

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 organisation has continually communicated operational matters between AFTAC and IMS Ops and managed to react almost immediately on outages in order to swap out defective components. The Council for Geoscience and the local operator have been able to solve the problems at the site, including issues with the Satellite Communication System.

Future activities

Irrespective of the technical upgrades which were performed at the station, the Council for Geoscience plans to be able to access the AFTAC monitoring system in order to react immediately in the event of system failure issues. To further improve mission-capable up-times, the organisation will suggest and possibly design the deployment of additional monitoring equipment at the station.

CO-2006-5620

Infrasound station IS47

Project manager	FA Delport, B Tech (Elec Eng)
Project team	V Jele, Nat Dip (Elec Eng), G van Aswegen, Nat Dip (Elec Eng)
Primary objective	The Council for Geoscience has been appointed as the technical point of contact and awarded the contract to operate and maintain the infrasound station (IS47) at 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 which is 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 an object entering the earth's atmosphere, supersonic aircraft or volcanic eruptions. As 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	1 January 2009 to 31 December 2012
Budget	R422 828.48

Motivation

As in the case with the primary seismic station (PS39), the Council for Geoscience was also designated by the Department of International Relations and Cooperation (DIRCO) as the technical point of contact for the operation and maintenance of the IS47 infrasound station. Infrasound station IS47 is one of 60 infrasound stations of the International Monitoring System 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 the Treaty.

Progress

The infrasound station was certified on 12 December 2005 by the Preparatory Technical Secretariat. The CGS technical staff have operated and maintained the station during the reporting period. Routine maintenance and ad hoc repairs were performed from time to time. Owing 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 Council for Geoscience did a thorough investigation into deploying appropriate security equipment at selected array elements. Security matters were also taken up with the local police station who improved patrols and awareness. All related issues were communicated to DIRCO. Currently, a security monitoring system is being deployed at the site and will be maintained on a monthly basis. The local operator also replaced all commercial solar brackets with dedicated brackets and strengthened some with expanded metal.

The satellite communications equipment was upgraded during the reporting period and the Council for Geoscience has been involved with AIS Eng (an AFTAC subcontractor) for the benefit of ensuring that the data are transferred to the United States Defence Corps and Comprehensive Test Ban Treaty Organisation within the requirements as mandated by the agreement between the Council for Geoscience and the CTBTO.

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 outages were experienced as a result of AC power outages. The power for the equipment deployed at the Central Recording Facility is backed up by a vast bank of batteries. Owing to the age of the batteries, the batteries of the various infrasound elements were replaced.

Future activities

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 Council for Geoscience suggested that the IMS Operational Centre deploy submersible water pumps in each of the vaults. However, the problem was escalated to the CTBTO's Engineering and Development Department who decided to replace the vaults with pre-fabricated vaults which will be imported from Vienna, Austria.

It was also suggested that dedicated hardware monitoring modules be deployed to monitor hardware system performance and enable the local operator 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, such as ethanol power generators, will be investigated.

ST-2012-1154

Tectonic interpretation of the basins and terrain boundaries within the Kaapvaal Craton using joint inversion and geophysical results

Project leader	E Kgaswane, MSc
Project team	A Nyblade (Penn State University, USA), R Durrheim (University of the Witwatersrand), P Dirks (James Cook University, Australia)
Primary objective	The project is divided into two sections, i.e. the "Tectonic history of the Kaapvaal Craton recorded by the Vs-Z soundings" and "Upper crustal variability across the Beattie Magnetic Anomaly". The aim in the first section is to use a clustering algorithm to delineate spatial variations of the different sequences within the Kaapvaal Craton with depth. The aim in the second section is to use the joint inversion of high-frequency receiver functions and Rayleigh wave group velocities (periods of 10–60 s) to examine variability within the upper crust across the Beattie Magnetic Anomaly
Duration	September 2005 to December 2011

Motivation

Section 1: Tectonic history of the Kaapvaal Craton recorded by the Vs-Z soundings

The tectonic history of the Kaapvaal Craton in southern Africa is synchronous with the formation of basins or sequences within it. These basins were deposited from early Archaean, e.g. Barberton Supergroup (>3.1 Ga) and mid- to late Archaean, e.g. Dominion Group (~3.1–3.0 Ga) and Witwatersrand (~3.0–2.8 Ga), Pongola (~3.2–2.8 Ga) and Ventersdorp (~2.7 Ga) Supergroups. Some of the Proterozoic and Neoproterozoic overprinting of the Kaapvaal Craton is characterised by supergroups, e.g. Transvaal (~2.6–2.2 Ga), Olifantshoek (2.0–1.8 Ga), Karoo (280–180 Ma); groups, e.g. Waterberg (2.0–1.7), Soutpansberg (2.0–1.7 Ga), Kalahari (65–0 Ma) and the Bushveld Complex (~2.06 Ga).

The description of the sequences within the Kaapvaal Craton as indicated by geological studies is mostly limited to shallow to mid-crustal depths (≤20 km). Much of the evidence of crustal variability up to Moho depth has been revealed by seismic studies, however at a limited resolution. In this study, the spatial variation will be described of the different sequences within the Kaapvaal Craton, from surface to Moho, using the joint inversion results from

Kgaswane *et al.* of 2009 for which the crust is better constrained than previous seismic studies. A hierarchical clustering algorithm is used to sort the inversion results based on shear wave velocity.

Section 2: Upper crustal variability across the Beattie Magnetic Anomaly

The Beattie Magnetic Anomaly (BMA) and the Southern Cape Conductive Belt (SCCB) are two of the most prominent geophysical anomalies occupying parts of the NNB (Namaqua-Natal Belt) and CFB (Cape Fold Belt) in South Africa. The BMA spatially coincides with the SCCB and they both extend across South Africa in an east–west direction for distances of ~1 000 km. Previous studies show diverse interpretations as to the nature of the BMA. Most of these studies focused on a north–south transect across the BMA. In this study, the variability across the upper crustal structure of the BMA in a relatively east–west direction will be modelled and compared with modelling results with past studies.

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*. Currently, suggestions from the review process of the second paper and a revised manuscript will be submitted to *Tectonophysics* for a second round of reviews. A parallel activity to the one indicated above is that a draft manuscript based on the research findings of the Beattie Magnetic Anomaly (third phase of the research) will be submitted to an internationally peer-reviewed journal for review.

Conclusions

Section 1: Tectonic history of the Kaapvaal Craton recorded by the Vs-Z soundings

In this study, the spatial variation of the sequences with depth within the Kaapvaal Craton (KC) is investigated. A clustering approach involving the average linkage or group average method was used to determine the clustering of the 63 broadband stations distributed across the Kaapvaal Craton. The clustering algorithm used the joint inversion results from a previous study as an input. The clustering results suggest that the Kaapvaal Craton can geodynamically be divided into two sectors: 1) the eastern shield which has experienced less deformation and this can be supported by the observation of Archaean age rocks, such as the granites, gneisses and the Witwatersrand being predominantly exposed on the eastern parts of the Kaapvaal Craton, and 2) the western, central and northern parts of the Kaapvaal Craton which have experienced a series of magmatic and deformational events that have holistically resulted in the surface exposure of a number of sequences or formations such as the Ventersdorp, the Transvaal and post-2.0 Ga basins.

Section 2: Upper crustal variability across the Beattie Magnetic Anomaly

In this study, a joint inversion approach is used to examine the upper crustal variability across the Beattie Magnetic Anomaly (BMA) within the Namaqua-Natal Belt (NNB). The joint inversion results show upper crustal velocities between 3.3 and 3.5 km/s for crustal depths of 1–5 km and ≥3.6 km/s for crustal depths of 6–10 km along the Beattie Magnetic Anomaly. The depths of 1–5 km could be indicative of the presence of Karoo sediments mixed with alluvium whereas depths of 6–10 km could be defining the locus of the magnetic anomaly of which its depth extent is most probably more than 10 km. Further modelling results suggest that the anomaly probably comprises a mafic component (Vs ≤ 4.0 km/s) and an ultramafic component (Vs≥4.0 km/s).

Future activities

The research findings will be published in an internationally peer-reviewed journal. 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.

ST-2007-0956

Imaging the African Superplume

Project leader	M Brandt, MSc
Project team	R Durrheim (University of the Witwatersrand), S Grand (University of Texas, Austin)
Primary objective	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	September 2005 to March 2012

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 resource 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 better understand the African Superplume. The African Superplume is both one of the most prominent and one of the most 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 understanding of the 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 has been submitted for publication to *Pure and Applied Geophysics*. 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 analyses.

Future activities

The thesis has been submitted to the University of the Witwatersrand for a PhD degree.

ST-2012-1142

Geotechnical investigations — characterisation of near-surface ground

Project leader	A Cichowicz, PhD
Project team	R Kometsi, Nat Dip (Elec Eng), D Birch, BSc Hons, G van Aswegen, Nat Dip (Elec Eng) (Comp Systems), E Kgaswane, MSc, I Saunders, Nat Dip (Geol), V Jele, Nat Dip (Elec Eng), L Fisha, P Adamos, Nat Dip (Elec Eng), L Tabane
Primary objective	Installation of ten seismic stations in the Far West Rand (FWR) and developing a parametric model for predicting strong ground motion
Duration	1 April 2011 to 31 March 2012

Motivation

The five-year Japanese-South African collaborative project entitled "Observational Studies to Mitigate Seismic Risks in Mines" commenced officially on 6 August 2010. The project is jointly implemented by South African and Japanese participating research institutions, namely the Council for Scientific and Industrial Research, Council for Geoscience, School of Geosciences at Witwatersrand University, Ritsumeikan University, Tokyo University and Tohoku University. The Council for Geoscience is responsible for (1) installing the seismic stations in the Far West Rand mining district (Carletonville area) on the surface to monitor surface ground motion caused by mine tremors; (2) upgrading the data centre in the Silverton offices of the Council for Geoscience, and (3) developing and validating a parametric model that will be capable of predicting strong ground motion.

Progress

A series of site surveys were conducted in and around the FWR mining region (Carletonville) with the aim of establishing ten seismograph stations. The pattern of seismicity obtained by the South African National Seismograph Network was used as a guideline for selecting sites and at least three candidate locations were considered per site.

To avoid vandalisation, all stations are located about 50 m from existing infrastructure. Noise tests for the sites generally show average noise amplitudes varying from -125 to -132 dB. Near-surface shear-wave velocities were also calculated for each of the sites. The shear-wave velocity is a direct indicator of the stiffness of material and is a key parameter used to estimate site amplification effect. The process includes the extraction of experimental dispersion curves from surface waves and the running of inversion algorithms to obtain the near-surface shear-wave velocities.

Conclusions

After following a careful selection process, ten sites were chosen in the Far West Rand. The surface geology of the Carletonville region and the average noise amplitude show that the Carletonville area can reasonably host seismograph stations. These ten new JICA stations will make an excellent cluster for seismic recording.

Future activities

Monitor the seismicity in the FWR mining district.

ST-2012-1143

Plate tectonics movement in the EARS: the MW 7.0 Mozambique earthquake of 2006 and its effects in South Africa (phase 1)

Project leader	T Pule, BTech (Geol)
Project team	V Midzi, PhD
Primary objective	The main objectives are to provide an overview of the tectonics and geology of the affected cities in South Africa and the East African Rift System (EARS) and to study the activities on the tectonic plates and its movement
Duration	1 April 2011 to 31 March 2013

Motivation

By doing this research on the East African Rift System (EARS), the society as well engineers who are responsible for building infrastructure can be informed and prepared to take tectonic movement into consideration. It is actually the first step in informing the community and engineers of the risks and hazards that can affect the society through EARS earthquakes.

The seismological monitoring network routinely records earthquake occurrences throughout South Africa, thus the data will be used to determine the most vulnerable regions by (a) examining the highest recorded earthquakes, (b) determining the active faults from geological maps and seismological data of the region, and (c) providing an estimation of ground motions by using different attenuation models.

Conclusions

Based on the observations presented in this study, earthquakes occurring in the southwestern part of Mozambique can potentially have a devastating effect owing to poorly attenuated and amplified ground motion on South African structures. The project is ongoing, and more investigations will be done in Phase 2 of this project.

Future activities

Continue investigations on the East African Rift System and estimate the ground motions using different attenuation equations.

SPATIAL DATA MANAGEMENT

Geodatabase — Development and implementation (0856), System and application maintenance (0277), Maintain GIS metadata (0276), Data administration on the spatial (Geoportal) data engine (0277) and Database administration (0793)

Project leader HJ Brynard, PhD
Project team K Wilkinson, Nat Higher Dip (Carto), D Sebake, MSc (Environ and Dev), D Grobbelaar, Nat Dip (Carto), S Noruka, BSc Hons
Budget R825 848.00

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.

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

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

Project leader HJ Brynard, PhD
Project team K Wilkinson, Nat Higher Dip (Carto), S Tucker, Dip SBM, F Nkosi, Nat Dip (IT)
Budget R284 346.00

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.

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

Project no.	Title	Project leader and team	Costs
ST-0901	2526BB Mabeskraal GIS Data Capture	K Wilkinson, Nat Higher Dip (Carto), S Sogayise, BSc Hons	R109 838
ST-0901	2526BD Mabaalstad GIS Data Capture	K Wilkinson, Nat Higher Dip (Carto), S Sogayise, BSc Hons	R109 838
ST-1056	3327AD Hamburg GIS Data Capture & Cartography	K Wilkinson, Nat Higher Dip (Carto), D Grobbelaar, Nat Dip (Carto), C Kgari	R81 954
ST-0920	3327AC & CA Fish River Mouth GIS Data Capture & Cartography	K Wilkinson, Nat Higher Dip (Carto), D Grobbelaar, Nat Dip (Carto), H Sello	R81 954
ST-0594	3129BD & 3130AC Mkambati GIS Data Capture & Cartography	K Wilkinson, Nat Higher Dip (Carto), E Magagane, Nat Dip (Carto), P Msiza	R81 954
ST-0605	2528CD Rietvlei Dam GIS Data Capture & Cartography	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip Carto, C Kgari	R71 079

1:50 000 Geotechnical Map (Cartography)

ST-0821	2528BC Silverton GIS & Cartography	K Wilkinson, Nat Higher Dip (Carto), P Nkosi, Nat Dip (Carto), H Sello	R46 001

1:250 000 Gravity Maps (Cartography)

2228 Alldays Cartographic preparation	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
2426 Thabazimbi Cartographic preparation		
2430 Pilgrim's Rest Cartographic preparation		
2520 Nossob Cartographic preparation		
2530 Nelspruit Cartographic preparation		
2632 Mkuze Cartographic preparation		
2830 Richards Bay Cartographic preparation		
2930 Durban Cartographic preparation		
3017 Garies Cartographic preparation		
3030 Port Shepstone Cartographic preparation		

WATER GEOSCIENCE

ST-2011-1132

Characterisation of fault-controlled aquifers for groundwater development in water-scarce areas in South Africa

Project leader	L Lin, PhD (Hydrogeol)
Primary objective	To develop the conceptual models and ultimately to assess the impact of different types of fault structures on groundwater resources in highly anisotropic fractured-rock aquifers
Duration	2010–2013
Budget	R50 000.00

Motivation

Faults are of the most important geological structures that control the occurrence of groundwater in fractured rock aquifers. Fault-controlled aquifers have been one of the most important wellfield development target zones for water supply, especially for water-scarce areas in South Africa. However, much research is still needed as detailed information on faults that control the occurrence of groundwater and are responsible for exerting impacts on aquifer properties at various scales is necessary. This has resulted in very few researches investigating the characteristics and patterns of these geological structures at various scales. Therefore, the mechanism of fault structures and its impact on groundwater occurrence are not yet fully understood. Key issues needed to study the spatial occurrence of groundwater for sustainable groundwater development in fault-controlled aquifers are the classification of faults based on the perspective of hydrogeology, identification of representative faults via data collection and collation, delineation of faults functioning on the occurrence of groundwater, conceptualisation of fault-controlled aquifer systems on both regional and local scales and numerical modelling for the assessment of sustainable groundwater development. To achieve these, a comprehensive approach will be adopted in this research.

Progress

This research is a desktop-based study. Firstly, a comprehensive literature review was done, based on the research work of the previous financial year. Secondly, to study the fault-controlled aquifer, a case study with a groundwater research and monitoring site with a five-borehole network near Rawsonville, Western Cape was established. This site was established in the vicinity of the normal fault. With the data derived from previous fieldwork, a conceptual model for a fault-related aquifer and associated numerical model for the evaluation of the fracture network were established.

Conclusions

In order to obtain a better understanding of the fault-controlled aquifer type, the fault-bounded aquifer in the area, together with the study of aquifer properties, and a site with a five-borehole network was established. Multiple approaches to the field observations were employed, including borehole coring and logging, field geophysical surveys, field fracture measurements, groundwater monitoring, and pumping and packer tests. Associated results from these methods were comparatively analysed, from which a conceptual model dedicated for fault-related fractured rock aquifers was proposed. As more understanding is gained from the analytical results, it is realised that the groundwater in the fractured aquifer is actually not flowing through a geological continuum. Large variation of the aquifer responses to hydraulic tests shows difficulty to determine the aquifer's hydraulic properties represented by the T and K values. In other words, it is extremely difficult, through hydraulic tests, to give a sound estimate of the aquifer's transmissivity and hydraulic conductivity. This is because of the anisotropic features inherited from rock formation and perhaps can be summarised by the conclusion of scale-dependent aquifer properties which actually implies the uncertainty of the problem studied.

Future activities

(1) Considering the fractured rock aquifer in Karoo and dolomite aquifers; more case studies via fieldwork need to be done if financially permitting for the development of more robust conceptual models for the quantification of groundwater resources that are controlled by fault structures.

(2) Groundwater modelling by using discrete fracture network and numerical models (Such as 3D-Frac and Feflow).

ST-2011-1133

The development of an ArcGIS extension as a pre-processor for groundwater flow modelling

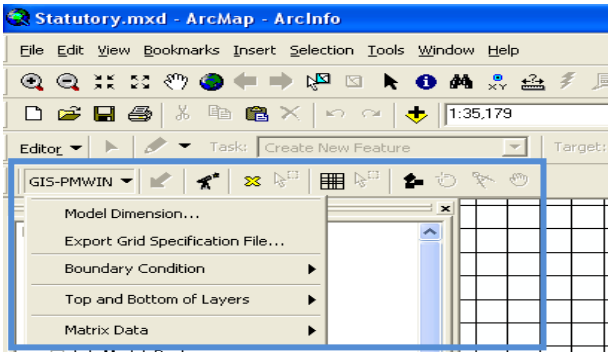
Project leader H Jla, PhD
Primary objective To develop an ArcGIS extension as a bridge between GIS and MODFLOW for the preprocessing of groundwater flow modelling
Duration 2011–2012

Motivation

PMWIN 5.3 has been one of the most commonly used software packages for groundwater modelling because of its free source and the adoption of the popular core program MODFLOW. However, the fixed formats required for data input and lack of GIS data support have posted major challenges for modellers who are dealing with large areas with complicated hydrogeological conditions. In South Africa, most geological and hydrogeological data have been captured and stored in GIS format through various national research projects. Therefore, a proper linkage between PMWIN and ArcGIS is necessary to do the preprocessing for modelling in PMWIN.

Progress

The interface of this extension is a customised docking toolbar added to the existing ArcMap toolbars. All the functions are grouped into menus or commands that can be found on the toolbar. Based on the conceptualisation of the study area, the model dimension, discretisation and many value setting processes can be easily carried out in ArcGIS. The grid specification file and other input files can be exported as PMWIN-compatible files. The functions of movement, rotation, refinement, submodelling, deleting and inserting row(s) or column(s) of the model have also been developed to avoid the inconvenience aroused from model modification. The linkage can be used with a higher version of PMWIN or ArcGIS. The programming part of the extension has been completed.



The interface of GIS-PMWIN

Conclusions

The extension has been completed and can already be used for groundwater flow models. With the VBA programming, the extension "GIS-PMWIN" can successfully act as the bridge between GIS and PMWIN. It has been applied to different goldfields in the Witwatersrand gold basin to simulate groundwater flow and mass transportation for different conditions and scenarios. It has been proved that the linkage is efficient and easy to use.

Future activities
A proper user manual will be provided and possibly a short course will be organised for the purpose of technology transfer. A final report will also be submitted.

ST- 2012-1162

Assessment of locally available reactive materials for use in Permeable Reactive Barriers (PRBs) in remediating acid mine drainage

Project leader	A Shabalala, MSc
Primary objective	To find a reactive material and/or reactive material mixture for permeable reactive barriers that can neutralise acidity, remove metal ions and are locally abundant
Duration	2011–2012

Motivation
Contaminated water flowing from abandoned mines is one of the most significant contributors to water pollution. Permeable reactive barriers (PRBs) are passive, in situ remediation systems which have seen increased application as a means of treating contaminants in groundwater as a result of bacterial sulphate reduction and the subsequent precipitation of sparingly soluble sulphide solids. The ability of PRBs to remediate contaminants is dependent on the type of reactive material used. Therefore, more research is needed to find a suitable material that can increase the pH of mine water to a level that causes metals to precipitate out of solution, provide reactive sites for the precipitation to take place, have a permeability and effective porosity that allows groundwater to pass freely through the barrier and not release toxins into the environment.

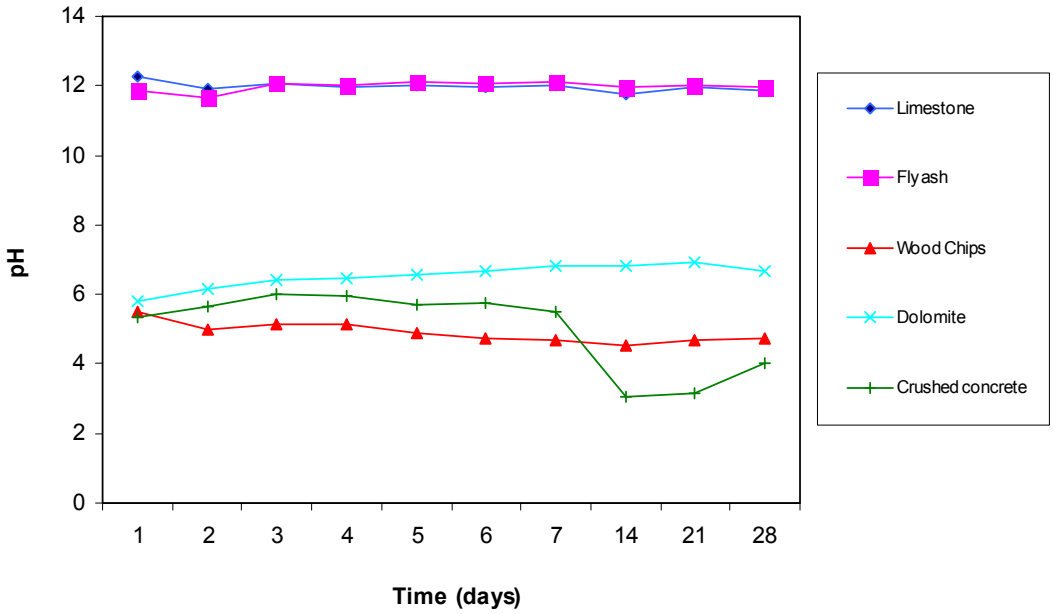
Progress
In this study, individual solid reactive materials as well as mixtures of the reactive materials were tested as filling material for biological permeable reactive barriers (PRBs) that can be used in the treatment of heavy-metal contamination. The results of the analysis of the mine water collected from the Black Reef Incline (BRI) shaft near Krugersdorp in South Africa showed that the water had a pH of 5.54 and contained very high concentrations of magnesium, calcium, iron, manganese and sulphate. The performance of the reactive materials was determined based on their ability to neutralise acidity and remove metals and sulphate found in the mine water. The batch tests performed on limestone, concrete, fly ash, dolomite and wood chips showed that in terms of the ability to increase the pH, the top performing reactive materials were limestone and fly ash as they both achieved a pH above 11. The mineralogy of both materials is dominated by calcite and calcium hydroxide which are known to be effective in raising the pH. Limestone, concrete, fly ash and dolomite successfully removed at least 99% of the Fe from the mine water. Limestone and fly ash removed at least 99% of Mn and Mg from the mine water. While the other reactive materials were ineffective in removing sulphate, limestone and fly ash removed 72% and 99.9% of sulphate from the mine water respectively. Some of the elements were elevated in the batch tests, for example Ca and Sr, because of calcium carbonate and calcium hydroxides abundantly available in limestone and fly ash, Mg from dolomite, potassium was possibly leached from K-feldspars and allunite found in concrete and fly ash and Na, Ba and Rb from mica which is a constituent of dolomite and concrete.

Three reactive material mixtures were studied; (1) limestone-wood chips-concrete, (2) limestone-fly ash, and (3) fly ash-concrete. The results from the study showed that all three systems were effective in removing heavy metals that were present in the mine water. All the mixtures increased the ph to above 11 and decreased Fe, Mn and Mg to below the South African discharge criteria. The sulphate concentration was decreased from 3 569 mg/ℓ to 2 mg/ℓ in mixtures 2 and 3 within 14 days. Both mixtures contained fly ash which is assumed to be responsible for the rapid removal of the sulphate. The decrease in concentrations of some of the elements was accompanied by an increase in the concentrations of Na, K, Ca, Sr and Ba and Al. The mineral composition of the reactive materials contributed to an increase of the concentration of the above-mentioned metals. Most of the elements were measured at concentrations below the limits applicable to the discharge of waste water into a water resource. The worst-performing reactive material was determined to be the material comprising wood chips as it achieved insufficient removal of Fe, Mn and sulphate and released many toxins in the water, which led to an increase in the concentration of elements such as B, Mg, K, Ca and Sr. Dolomite achieved varying success. It significantly reduced some of the contaminants such as Fe and Mn but the concentration of

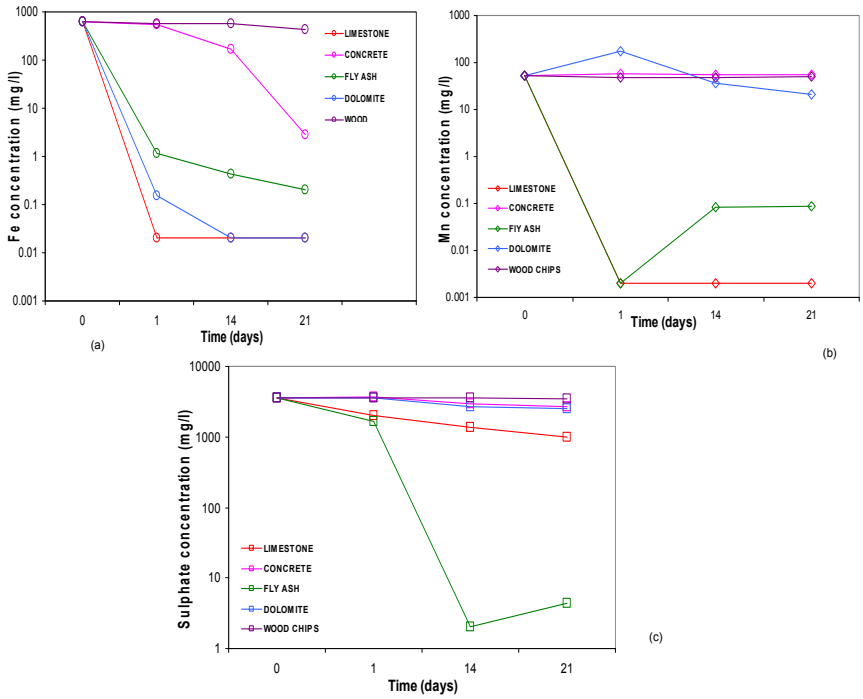
SO_4 still remained high and did not meet the water quality requirements. Concrete was ineffective in remediating the acidic water with Fe, Mn and SO_4 still remaining significantly high.

Conclusions

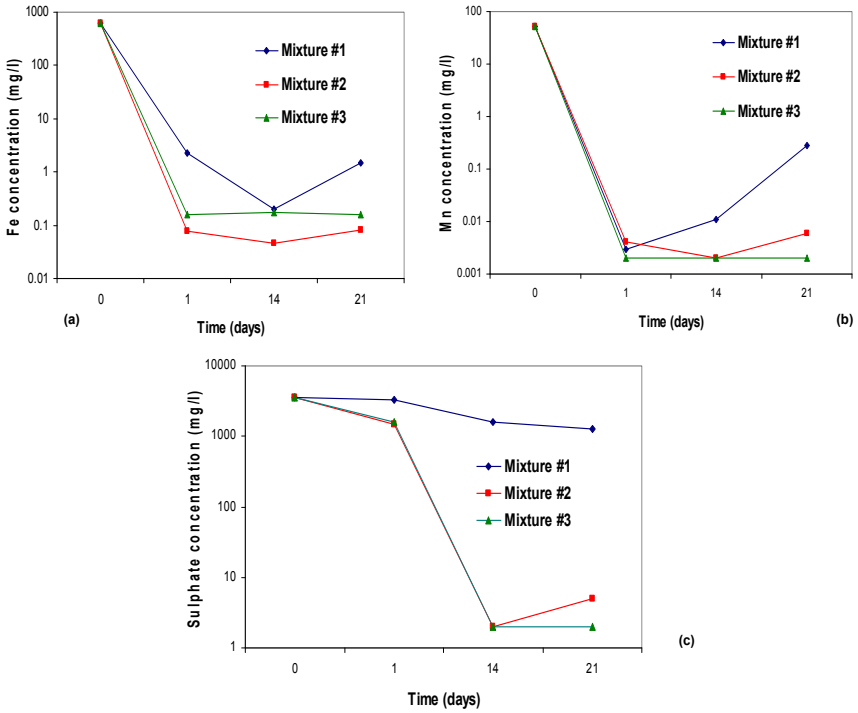
This study found that the most suitable reactive material for remediating mine water was fly ash because it is locally abundant, it neutralises acidity and removes sulphates and heavy metals such as iron and manganese from the mine water. More laboratory work is required to determine the performances of the reactive materials over longer periods of time and to monitor the risks associated with leachable toxic substances from the materials which could be released into the environment. After the batch tests are completed, column tests should be conducted, which will simulate the natural flow conditions through the PRB. The result of these tests will assist in the design of the PRBs.



Change in pH with time of the five reactive materials in the mine water for a total of 28 days



Concentration of selected metals in the supernatant of five reactive materials after 21 days in batch tests using mine water — (a) Iron, (b) Manganese and (c) Sulphate



Concentrations of Fe, Mn and SO_4 for three batch mixtures in mine water for a total of 21 days

WESTERN CAPE

ST-2011-1129

Cenozoic dune gastropods of the southern and western Cape coastlines of South African: Implications for climate change

Project leader C Browning, MSc, PrSciNat

Primary objective Fossilised dune snails are abundant in the South African Cenozoic geological record. They have been used to delineate stratigraphic units in the past but their potential to contribute to the understanding of both local and global climate shifts has been largely overlooked. Some species, for example *Trigonephrus globulus*, are temporally distributed from the Miocene to the present and are found today on the West Coast of South Africa, within a winter rainfall regime. Individuals of this species vary greatly in size over time, with fossil examples from certain horizons being markedly larger (~20%) than present-day specimens. Preliminary stable isotope (oxygen and carbon) studies of *Trigonephrus globulus* shells from the Langebaan area have shown that there is a complex interaction between the biosphere and the geosphere which needs further study. The analysis of growth lines of individual shells in particular may provide very high resolution climatic information. Genetic, morphometric, ecological and life-history studies of the modern population will be key to future interpretations of fossil evidence for climate shifts

Duration 2010–2015

Budget R450 000

Motivation

There is an ever-increasing need for research into past climate change as an analogue for modelling and predicting present-day climatic fluctuations. Coastal areas are at the interface of land and ocean and thus play a major role in recording interactions between these over time. These areas also record the changes in sea level that affect industry, infrastructure and low-lying coastal settlements.

Progress

Mapping and the description of sedimentary columns have been done at a number of locations. A stable isotope analysis has been performed on a number of gastropod species from different stratigraphic horizons. A comparison has been made between the techniques of whole shell *vs* inter-shell isotope records. This analysis implies that whole-shell isotope patterns may not be as effective and is thus relevant and novel research in the field of palaeoclimatic reconstruction.

Conclusions

The reconstruction of palaeoclimates, especially from the Cenozoic, is paramount to the understanding and future modelling of the earth's climate. This research is therefore both relevant in a South African and global context.

Fossil dune snail shells of an extant species, Trigonephrus globulus, being prepared out of a block of Cenozoic dune sediments from a quarry near Saldanha Bay

Detailed sedimentary mapping of the Prospect Hill Quarry near Saldanha Bay

ST-2011-1130

Palaeoclimates and ecosystems of the Pleistocene, as archived in the Kalkkop Crater Lake deposits, South Africa

Project leader	P Mthembi, BSc Hons
Project team	Dr D Roberts, Prof C Harris, Dr R Smith
Primary objective	The aim of this project is to study the single core of the Kalkkop Crater Lake deposits mainly to reconstruct the palaeo-environmental conditions and sedimentary processes that existed during its accumulation. The core is studied in detail with the aim of extracting palaeodata, with emphasis on critical time intervals such as past warm periods as an analogue for present and future regional/global climate change to inform policy-makers in terms of adaptation and developing the site to enhance its value for ecotourism and education. Geological mapping of the area, sedimentological (core analysis), palaeontological, biogeochemical and stable isotope studies are the main areas of study in this project
Duration	2010–2013
Budget	R390 000

Motivation

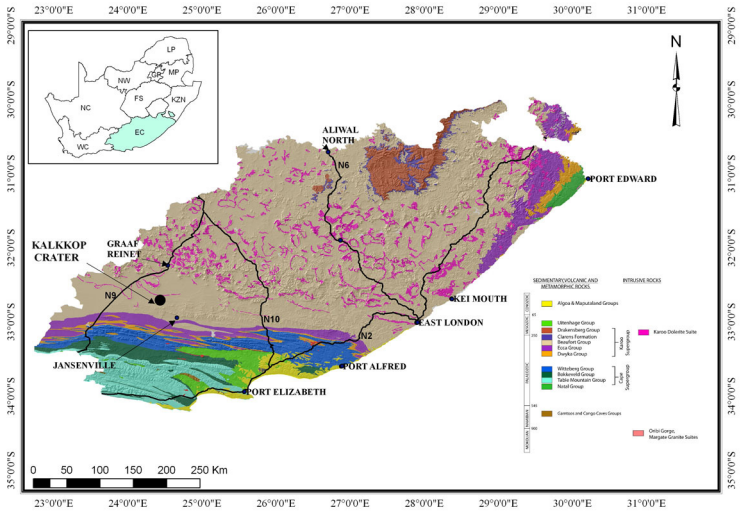
Impact cratering is one of the fundamental surface forming and modifying processes on all solid bodies in the solar system. Since the accretion stage of planets, impact cratering has played a major role in the geological and biological evolution of our planet. In South Africa, both cosmic impact and endogenic crater lake deposits of various ages occur and these craters include the Palaeoproterozoic Vredefort, Early Cretaceous Morokweng, Middle Pleistocene Tswaing and Kalkkop craters. Studies show that only a few craters in South Africa have been identified as impact craters and Kalkkop crater has been found to be of impact origin. Drill core show that the Kalkkop crater mainly comprises finely laminated carbonate underlain by a breccia succession formed during the impact.

Progress

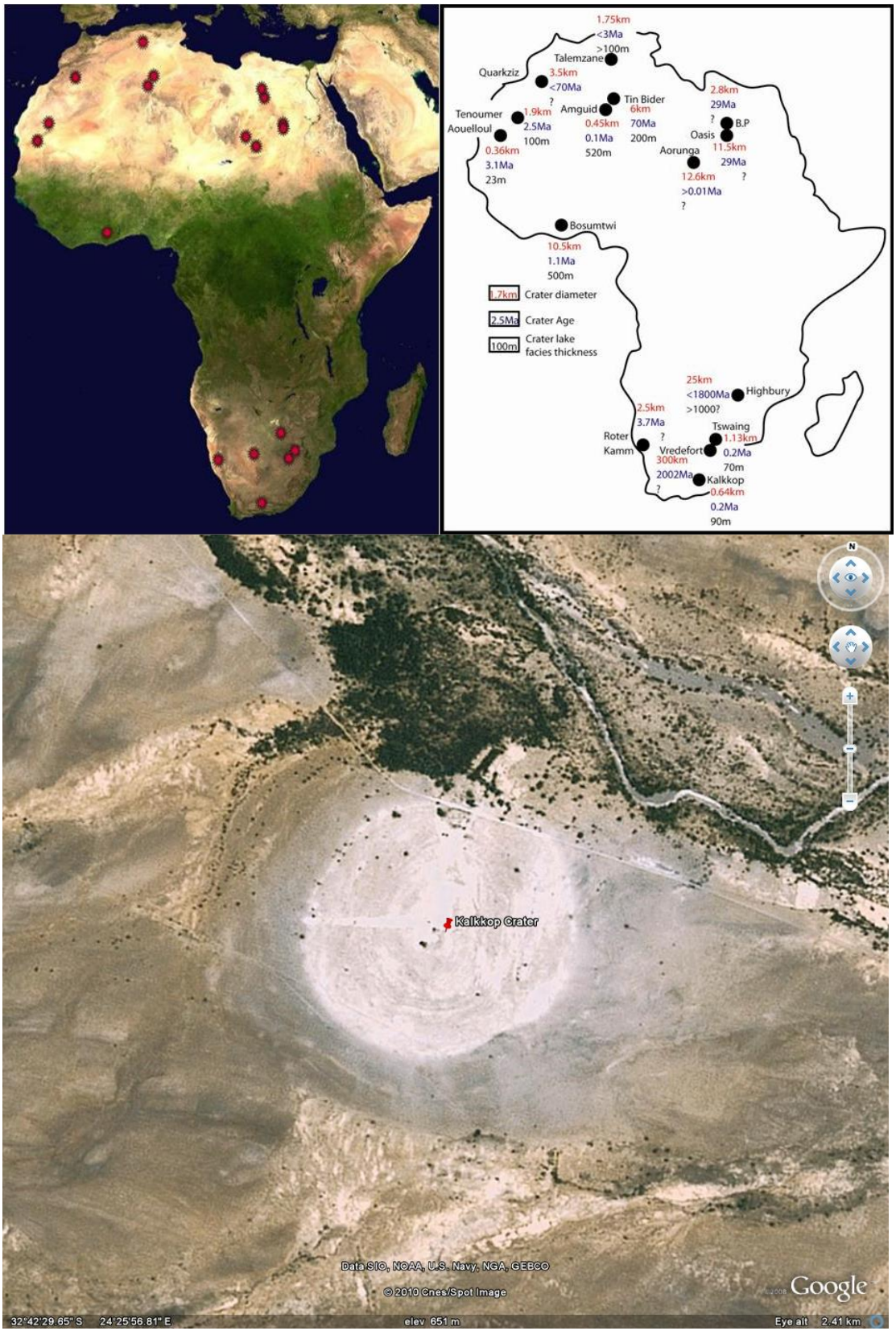
Almost all isotope analyses and fieldwork are completed. Core logging is almost complete with log analyses in progress. Thin sections were analysed and some pollen samples were sent to Free State University for analysis.

Conclusions

The method used for isotope analysis can be used as proxy for climate change since the correlation of the results was very good. The Kalkkop crater has been dated before by using the U-series date of ~250 Ka, but comparing the Kalkkop with other craters, the Kalkkop seems to be much older than the estimated date. The conclusion that Kalkkop crater is much older was reached by estimating the rim height, which was done by using the morphometry of fresh lunar simple craters and other well-known craters such as the Tswaing crater.



Locality map of Kalkkop crater



Google_earth image of Kalkkop crater

ST-2006-0926

Radar interferometry for geohazard assessment in South Africa

Project leader	J Engelbrecht, MSc
Primary objective	The project aims to employ differential radar interferometry techniques for the assessment of geohazards in South Africa. The focus will be placed on the monitoring of surface deformation owing to mining activities in the Mpumalanga Province
Duration	Three years
Budget	R9 9480.00

Motivation

The Council for Geoscience has recently expressed interest in the formation of a Geohazards Unit which aims 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 successfully applied for the monitoring of several hazards including: 1) the measuring of surface subsidence, 2) assessment of deformation following earthquake activity, 3) monitoring landslides and volcanic activity and 4) measuring movements along active faults. The interferometry technique therefore opens up many new potential application areas in disciplines such as volcanology and structural geology 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 that can then be used in various geological applications and geohazard assessments. The intended project will act as a stimulation of innovation and development of human capital as radar remote sensing and radar interferometry, in particular, have presently only got limited exposure in South Africa. Additionally, the contribution of this technique to programmes dedicated to hazard and risk management will be invaluable.

Progress

All the Synthetic Aperture Radar (SAR) data have been received and processed. These include data from the Canadian RADARSAT-2 sensor, the Japanese ALOS PALSAR sensor, the German TerraSAR-X sensor and the European ERS-2 sensor. The results suggest that both C-band and L-band data can be employed for the monitoring of surface subsidence owing to mining. Changing landcover conditions at the time of image capturing remains problematic and limits the time frame between image acquisitions. For C-band, the required time frame between image acquisitions is longer when compared to L-band data. Ground truth data confirmed the presence of a subsidence basin detected using differential interferometry techniques during the 24-day period between 2011/01/26 and 2011/02/19 with a maximum vertical deformation of 9 cm being recorded (at a spatial resolution of 10 m). Interferometric monitoring revealed an eastward migration of the subsidence basin during successive time periods with deformation between 6 and 9.8 cm being recorded. This migration coincides with the advance of the working face of the mine during this period. The results obtained from the SAR interferograms demonstrate clearly the ability of these techniques to measure surface subsidence as well as the monitoring of the evolution of subsidence basins over time. This implies that the technique could be included, together with traditional field-based surveying techniques, in an operational monitoring system. With knowledge on deformation rates and subsidence basin evolution, informed decisions on current and future infrastructure development can be made and remedial actions and prevention strategies can be formulated for the problems associated with environmental degradation.

Conclusion

Radar interferometry techniques are being 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 image acquisition phases of the project have been completed and the results on surface deformation are promising. It is expected that the processing of the new data and advanced algorithms will assist with designing the optimal sensor configuration for the implementation of a long-term monitoring system. Such a monitoring system will assist with the mitigation of the impacts of surface deformation associated with mining activities in South Africa.

APPENDIX

Publications in Academic Journals and Books

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COUNCIL FOR GEOSCIENCE STAFF

Surname	Initials	Position	Business Unit
BOSCH	PJA	SCIENTIFIC OFFICER	CENTRAL REGIONS
DE KOCK	GS	SCIENTIFIC OFFICER	CENTRAL REGIONS
ENGELBRECHT	CR	ADMINISTRATIVE OFFICER	CENTRAL REGIONS
GRANTHAM	GH	SCIENTIFIC OFFICER	CENTRAL REGIONS
HATTON	C	SPECIALIST SCIENTIST	CENTRAL REGIONS
IYENGAR	KP	SCIENTIFIC OFFICER	CENTRAL REGIONS
MOABI	NG	SCIENTIFIC OFFICER	CENTRAL REGIONS
NEVELING	J	SCIENTIFIC OFFICER	CENTRAL REGIONS
NXUMALO	V	SCIENTIST	CENTRAL REGIONS
SHELEMBE	RP	SENIOR SCIENTIST	CENTRAL REGIONS
THOMAS	A	MANAGER CENTRAL REGIONS	CENTRAL REGIONS
DE KOCK	EC	SCIENTIFIC OFFICER	COLLECTIONS MANAGEMENT
KGOALE	MO	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
LEKALAKALA	LR	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
MADIBANE	MI	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
MAHWAYI	S	ADMINISTRATIVE OFFICER	COLLECTIONS MANAGEMENT
MALOKELA	PS	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
MATHEBULA	JS	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
MATJEKE	KI	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
MOJELA	TP	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
NKWINIKA	RD	TECHNICAL OFFICER	COLLECTIONS MANAGEMENT
JACHA	N	MARKETING & COMMUNICATION SPECIALIST	CORPORATE SERVICES
KHOSA	ED	EMPLOYEE RELATIONS SPECIALIST	CORPORATE SERVICES
KOTA	ZJ	RECRUITMENT SPECIALIST	CORPORATE SERVICES
LEKOTOKO	MM	EVENTS COORDINATOR	CORPORATE SERVICES
LESHOMO	JD	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
MABUZA	JM	EXCECUTIVE MANAGER CORPORATE SERVICES	CORPORATE SERVICES
MAZIBUKO	DM	HUMAN RESOURCES OFFICER	CORPORATE SERVICES
MOTSATSING	KM	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
VAN WYK	J	ADMINISTRATIVE OFFICER	STRATEGIC PLANNING UNIT
WILLIAMS	QD	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
BLACK	DE	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
CLAASSEN	D	SCIENTIST	EASTERN CAPE UNIT
MITHA	VR	SENIOR SCIENTIST	EASTERN CAPE UNIT
MXATULE	BJ	ADMINISTRATIVE OFFICER	EASTERN CAPE UNIT
REDDERING	JSV	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
AZENE	FZ	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
CHILIZA	SG	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
DIOP	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
FORBES	C	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
GROBLER	JD	ADMINISTRATIVE OFFICER	ENGINEERING GEOSCIENCES
HEATH	GJ	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES

Surname	Initials	Position	Business Unit
MOLAPO	TD	TECHNICAL OFFICER	ENGINEERING GEOSCIENCES
MOOTE	GC	ADMINISTRATIVE OFFICER	ENGINEERING GEOSCIENCES
MOTJALE	MI	TECHNICAL OFFICER	ENGINEERING GEOSCIENCES
OOSTHUIZEN	AC	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
RICHARDSON	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
TEGEGN	K	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
COETZEE	H	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
HANISE	BE	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
KOTOANE	AM	TECHNICAL OFFICER	ENVIRONMENTAL GEOSCIENCES
KWATA	MG	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
LEKOADU	KS	JUNIOR SCIENTIST	ENVIRONMENTAL GEOSCIENCES
MAKGAE	ME	MANAGER ENVIRONMENTAL GEOSCIENCES	ENVIRONMENTAL GEOSCIENCES
MASENYA	BP	ADMINISTRATIVE OFFICER	ENVIRONMENTAL GEOSCIENCES
MOTLAKENG	RT	TECHNICAL OFFICER	ENVIRONMENTAL GEOSCIENCES
NOVHE	NO	SCIENTIST	ENVIRONMENTAL GEOSCIENCES
YIBAS BABSO	B	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
BREYTENBACH	AF	ACCOUNTANT	FINANCIAL SERVICES
CHAGWIZA	V	ACCOUNTANT	FINANCIAL SERVICES
CHIBASA	TE	JUNIOR ACCOUNTANT	FINANCIAL SERVICES
DICHABE	SD	ADMINISTRATIVE OFFICER (S&T OFFICER)	FINANCIAL SERVICES
DINGOKO	MO	SENIOR CREDITORS CLERK	FINANCIAL SERVICES
GOUVERNEUR	M	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
HUGO	JLM	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
LEKWARA	MG	PAYROLL ADMINISTRATOR	FINANCIAL SERVICES
MANDA	M	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MATSEPE	LD	CHIEF FINANCIAL OFFICER	FINANCIAL SERVICES
MOSTERT	JCN	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MTEKI	AM	MANAGEMENT ACCOUNTANT	FINANCIAL SERVICES
PAWESKA	MD	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
PEENS	WJF	CHIEF ACCOUNTANT	FINANCIAL SERVICES
POWER	S	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
QAYISO	NA	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
SNYMAN	SE	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
BENSID	ML	SCIENTIFIC OFFICER	GEOCHEMISTRY
ELSENBROEK	JH	SCIENTIFIC OFFICER	GEOCHEMISTRY
HLATSHWAYO	SM	SCIENTIFIC OFFICER	GEOCHEMISTRY
MAYA	M	SCIENTIFIC OFFICER	GEOCHEMISTRY
MOKOATEDI	JK	TECHNICAL OFFICER	GEOCHEMISTRY
MULOVHEDZI	AE	SCIENTIST	GEOCHEMISTRY
NETSHITUNGULWANA	R	SENIOR SCIENTIST	GEOCHEMISTRY
RADEBE	JS	TECHNICAL OFFICER	GEOCHEMISTRY
STRAUSS	SW	SCIENTIFIC OFFICER	GEOCHEMISTRY
VAN DER WALT	DM	SENIOR SCIENTIST	GEOCHEMISTRY
CHIRENJE	E	SCIENTIFIC OFFICER	GEOPHYSICS
COLE	P	MANAGER GEOPHYSICS	GEOPHYSICS
COLE	J	SCIENTIFIC OFFICER	GEOPHYSICS
EBERLE	DG	SCIENTIFIC OFFICER	GEOPHYSICS
GRAHAM	A	ADMINISTRATIVE OFFICER	GEOPHYSICS
HALLBAUER	VY	SCIENTIFIC OFFICER	GEOPHYSICS

Surname	Initials	Position	Business Unit
HAVENGA	M	SCIENTIFIC OFFICER	GEOPHYSICS
KRUGER	D	TECHNICAL OFFICER	GEOPHYSICS
LEDWABA	LJ	SCIENTIFIC OFFICER	GEOPHYSICS
LEGOTLO	RL	TECHNICAL OFFICER	GEOPHYSICS
LOOTS	L	SCIENTIST	GEOPHYSICS
MANTSHA	KR	TECHNICAL OFFICER	GEOPHYSICS
MARE	LP	SCIENTIFIC OFFICER	GEOPHYSICS
NYABEZE	PK	SCIENTIFIC OFFICER	GEOPHYSICS
SAKALA	E	SCIENTIST	GEOPHYSICS
SEKIBA	FMA	TECHNICAL OFFICER	GEOPHYSICS
SETHOBYA	MR	TECHNICAL OFFICER	GEOPHYSICS
STETTLER	RH	TECHNICAL OFFICER	GEOPHYSICS
TESSEMA	A	SCIENTIFIC OFFICER	GEOPHYSICS
BARNARDO	DJ	MANAGER INFORMATION & COLLECTIONS MANAGEMENT	INFORMATION MANAGEMENT
JANSE VAN RENSBURG	MG	TECHNICAL OFFICER	INFORMATION MANAGEMENT
MALATSI	PM	GENERAL CLERK	INFORMATION MANAGEMENT
NEL	ZE	ADMINISTRATIVE OFFICER	INFORMATION MANAGEMENT
NONDUDULE	Z	ADMINISTRATIVE OFFICER	INFORMATION MANAGEMENT
NZOLO	KA	MUSEUM CURATOR	INFORMATION MANAGEMENT
VAN ECK	SJ	ADMINISTRATIVE OFFICER	INFORMATION MANAGEMENT
DOMINGO	EE	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MOGARA	LM	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MOTAUNG	PD	MANAGER INFORMATION COMMUNICATION TECHNOLOGY	INFORMATION TECHNOLOGY
MZIMBA	RJ	ADMINISTRATIVE OFFICER	INFORMATION TECHNOLOGY
PHANGISA	TT	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
SMITH	P	BUSINESS TECHNOLOGY CONSULTANT	INFORMATION TECHNOLOGY
BOTHA	GA	SENIOR MANAGER KWAZULU-NATAL & EASTERN CAPE	KWAZULU-NATAL UNIT
DLAMINI	P	ADMINISTRATIVE OFFICER	KWAZULU-NATAL UNIT
HICKS	N	SCIENTIST	KWAZULU-NATAL UNIT
MPOFANA	B	GENERAL CLERK	KWAZULU-NATAL UNIT
NGCOBO	LE	GENERAL CLERK	KWAZULU-NATAL UNIT
SINGH	RG	SCIENTIFIC OFFICER	KWAZULU-NATAL UNIT
ATANASOVA	MTG	SCIENTIFIC OFFICER	LABORATORY
BURGER	KIG	TECHNICAL OFFICER	LABORATORY
CLOETE	M	SENIOR MANAGER LABORATORY & GEOCHEMISTRY	LABORATORY
CLOETE	HCC	SCIENTIFIC OFFICER	LABORATORY
CRONWRIGHT	H	SCIENTIFIC OFFICER	LABORATORY
DLAMINI	NJ	JUNIOR SCIENTIST	LABORATORY
DOUCET	FJ	SCIENTIFIC OFFICER	LABORATORY
DUBE	KP	ADMINISTRATIVE OFFICER	LABORATORY
FRIEDLAND	J	SENIOR SCIENTIST	LABORATORY
JORDAAN	LJ	SCIENTIFIC OFFICER	LABORATORY
KGADITSE	SD	TECHNICAL OFFICER	LABORATORY
KHUMALO	KS	TECHNICAL OFFICER	LABORATORY
LEHAHA	MT	TECHNICAL OFFICER	LABORATORY
MAEMA	JJ	TECHNICAL OFFICER	LABORATORY
MASHISHI	KE	JUNIOR SCIENTIST	LABORATORY
MATJI	JM	TECHNICAL OFFICER	LABORATORY

Surname	Initials	Position	Business Unit
MBONANE	TJ	TECHNICAL OFFICER	LABORATORY
MBOYI	A	TECHNICAL OFFICER	LABORATORY
MCHUNU	PB	TECHNICAL OFFICER	LABORATORY
MONYAYI	ST	TECHNICAL OFFICER	LABORATORY
MOTSIRI	TS	TECHNICAL OFFICER	LABORATORY
NGAMLANA	SM	TECHNICAL OFFICER	LABORATORY
NKOSI	ME	TECHNICAL OFFICER	LABORATORY
NXOKWANA	NS	JUNIOR SCIENTIST	LABORATORY
PAPO	RM	TECHNICAL OFFICER	LABORATORY
PHAHLANE	I	TECHNICAL OFFICER	LABORATORY
RAMOSHABA	MM	TECHNICAL OFFICER	LABORATORY
RANTSANE	TC	TECHNICAL OFFICER	LABORATORY
SATHEKGE	LL	TECHNICAL OFFICER	LABORATORY
SELLO	RH	TECHNICAL OFFICER	LABORATORY
TSAAGANE	ME	TECHNICAL OFFICER	LABORATORY
VUMA	SM	TECHNICAL OFFICER	LABORATORY
ZONDI	SP	TECHNICAL OFFICER	LABORATORY
BREYTENBACH	L	ADMINISTRATIVE OFFICER	LIBRARY
MSIZA	A	ADMINISTRATIVE OFFICER	LIBRARY
SWART	TN	ADMINISTRATIVE OFFICER	LIBRARY
VAN DER MERWE	L	ADMINISTRATIVE OFFICER	LIBRARY
VAN TONDER	EE	ADMINISTRATIVE OFFICER	LIBRARY
BAGLOW	N	MANAGER LIMPOPO BUSINESS UNIT	LIMPOPO BUSINESS UNIT
DHANSAY	TG	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MASHAO	TP	GENERAL CLERK	LIMPOPO BUSINESS UNIT
MNISI	EH	ADMINISTRATIVE OFFICER	LIMPOPO BUSINESS UNIT
MOTHETHA	MV	SENIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MUKOSI	NC	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MUNYANGANE	LP	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
BOTHA	JD	SENIOR SPECIALIST, LOGISTICS	LOGISTICAL SERVICES
DIKETANE	MW	GENERAL CLERK	LOGISTICAL SERVICES
GUMEDE	VC	CONTRACT SPECIALIST	LOGISTICAL SERVICES
JIJANA	CK	ADMINISTRATIVE OFFICER	LOGISTICAL SERVICES
KGOBANE	RJ	ADMINISTRATIVE OFFICER (DRIVER)	LOGISTICAL SERVICES
KUNJU	N	ADMINISTRATIVE OFFICER	LOGISTICAL SERVICES
MAMPURU	LM	SENIOR PROCUREMENT OFFICER	LOGISTICAL SERVICES
MASOGA	ME	GENERAL CLERK	LOGISTICAL SERVICES
NKUNA	MM	MANAGER PROCUREMENT, LOGISTICS & FACILITIES	LOGISTICAL SERVICES
PHUSHELA	PSH	ADMINISTRATIVE OFFICER	LOGISTICAL SERVICES
SNYMAN	J	ADMINISTRATIVE OFFICER	LOGISTICAL SERVICES
TJIANE	LC	GENERAL CLERK	LOGISTICAL SERVICES
ZWANE	JJ	ADMINISTRATIVE OFFICER (DRIVER)	LOGISTICAL SERVICES
ASHLEY	CCL	ADMINISTRATIVE OFFICER	MANAGEMENT
CELE	ND	PERSONAL ASSISTANT	MANAGEMENT
GRAHAM	G	EXECUTIVE MANAGER SCIENTIFIC SERVICES	MANAGEMENT
MATIMULANE	NW	SECURITY OFFICER	MANAGEMENT
MOTHABI	EPM	PERSONAL ASSISTANT	MANAGEMENT
MSIZA	JM	SECURITY OFFICER	MANAGEMENT
NKE	CN	QUALITY SPECIALIST	MANAGEMENT

Surname	Initials	Position	Business Unit
NKOE	JS	ADMINISTRATIVE OFFICER	MANAGEMENT
RAMAGWEDE	FL	EXECUTIVE MANAGER APPLIED GEOSCIENCES	MANAGEMENT
BOTHA	CA	TECHNICAL OFFICER	MARINE GEOSCIENCE
CAWTHRA	HC	SCIENTIST	MARINE GEOSCIENCE
HOOSAIN	W	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
KUPIDO	W	TECHNICAL OFFICER	MARINE GEOSCIENCE
MACHUTCHON	MR	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
VAN ZYL	WF	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
WIGLEY	RA	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
BILLAY	AY	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
EHLERS	DL	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
FOYA	S	MANAGER MINERAL RESOURCES DEVEOPMENT	MINERAL RESOURCES DEVELOPMENT
HAMMOND	NQ	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
KENAN	AO	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
KGWAKGWE	KP	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
KIRSTEIN	LS	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MALAN	NP	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
MUDAU	T	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
OOSTERHUIS	WR	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
OPPERMAN	R	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
PUTTER	GV	ADMINISTRATIVE OFFICER	MINERAL RESOURCES DEVELOPMENT
SCHALEKAMP	MM	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
SOLOMON	M	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
TONGU	EL	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
TSANWANI	M	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
WALEMBA	KMA	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
GROENEWALD	CA	JUNIOR SCIENTIST	NORTHERN CAPE UNIT
MINNAAR	H	SCIENTIFIC OFFICER	NORTHERN CAPE UNIT
SKEFFERS	CJ	UNIT ADMINISTRATOR	NORTHERN CAPE UNIT
ADAMOS	P	TECHNICAL OFFICER	SEISMOLOGY
AKROMAH	L	TECHNICAL OFFICER	SEISMOLOGY
BIRCH	DJ	JUNIOR SCIENTIST	SEISMOLOGY
BRANDT	MBC	SCIENTIFIC OFFICER	SEISMOLOGY
CICHOWICZ	A	SCIENTIFIC OFFICER	SEISMOLOGY
DELPORT	FA	TECHNICAL OFFICER	SEISMOLOGY
DUARTE	D	ADMINISTRATIVE OFFICER	SEISMOLOGY
FLINT	NS	PROJECT ADMINISTRATOR	SEISMOLOGY
GROBBELAAR	MRG	MANAGER SEISMOLOGY	SEISMOLOGY
HATTINGH	E	SCIENTIFIC OFFICER	SEISMOLOGY
JELE	VM	TECHNICAL OFFICER	SEISMOLOGY
KGASWANE	EM	SENIOR SCIENTIST	SEISMOLOGY
KOMETSI	TR	TECHNICAL OFFICER	SEISMOLOGY
LABUSCHAGNE	L	TECHNICAL OFFICER	SEISMOLOGY
MANGONGOLO	TA	SENIOR SCIENTIST	SEISMOLOGY
MIDZI	V	SCIENTIFIC OFFICER	SEISMOLOGY
MOLEA	TT	TECHNICAL OFFICER	SEISMOLOGY
PULE	TG	TECHNICAL OFFICER	SEISMOLOGY
SAUNDERS	I	TECHNICAL OFFICER	SEISMOLOGY
SEMELANE	LL	TECHNICAL OFFICER	SEISMOLOGY

Surname	Initials	Position	Business Unit
SONGWANE	TR	SENIOR ANALYST PROGRAMMER	SEISMOLOGY
STRASSER	FO	SENIOR SCIENTIST	SEISMOLOGY
TABANE	LR	TECHNICAL OFFICER	SEISMOLOGY
VAN ASWEGEN	G	TECHNICAL OFFICER	SEISMOLOGY
ZULU	BS	JUNIOR SCIENTIST	SEISMOLOGY
BRYNARD	HJ	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
GROBBELAAR	DA	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
KGARI	CS	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
LETSOALO	M	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MAGAGANE	MEM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MAGAGULA	FN	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MSIZA	P	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
NEMAKHAVHANI	M	ADMINISTRATIVE OFFICER	SPATIAL DATA MANAGEMENT
NKOSI	MP	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
NORUKA	S	SCIENTIST	SPATIAL DATA MANAGEMENT
OOSTHUIZEN	BC	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
ROOS	HM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
SEBAKE	DM	SENIOR SCIENTIST	SPATIAL DATA MANAGEMENT
SMITH	A	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
THOMAS	C	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
WILKINSON	KJ	MANAGER SPATIAL DATA MANAGEMENT	SPATIAL DATA MANAGEMENT
KEYSER	N	SCIENTIFIC OFFICER	STRATEGIC PLANNING UNIT
MNDAWONI	MJ	MANAGER BUSINESS DEVELOPMENT	STRATEGIC PLANNING UNIT
PILANE	ME	SECRETARY	STRATEGIC PLANNING UNIT
SKHOSANA	MN	ADMINISTRATIVE OFFICER	STRATEGIC PLANNING UNIT
MAHLANGU	E	ADMINISTRATIVE OFFICER	TECHNICAL SERVICES
NDLELA	CT	TECHNICAL OFFICER	TECHNICAL SERVICES
NEMATANDANI	M	TECHNICAL OFFICER	TECHNICAL SERVICES
SMYTHE	MM	ADMINISTRATIVE OFFICER	TECHNICAL SERVICES
STEVENS	R	TECHNICAL OFFICER	TECHNICAL SERVICES
LENONG	SE	SCIENTIST	WATER GEOSCIENCES
LESHOMO	JT	SENIOR SCIENTIST	WATER GEOSCIENCES
LIN	H	SENIOR SCIENTIST	WATER GEOSCIENCES
LIN	L	SPECIALIST SCIENTIST	WATER GEOSCIENCES
MAKGATE	DM	TECHNICAL OFFICER	WATER GEOSCIENCES
MARUBINI	SJ	JUNIOR SCIENTIST	WATER GEOSCIENCES
MENGISTU	H	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MOKONYAMA	ML	UNIT ADMINISTRATOR	WATER GEOSCIENCES
NEMAXWI	P	JUNIOR SCIENTIST	WATER GEOSCIENCES
NETILI	KF	MANAGER WATER GEOSCIENCES	WATER GEOSCIENCES
NZOTTA	UO	SENIOR SCIENTIST	WATER GEOSCIENCES
SAEZE	HA	CHIEF SCIENTIST	WATER GEOSCIENCES
SHABALALA	AN	JUNIOR SCIENTIST	WATER GEOSCIENCES
STRACHAN	LKC	SENIOR SCIENTIST	WATER GEOSCIENCES
BROWNING	C	SCIENTIST	WESTERN CAPE UNIT
CHEVALLIER	LP	SENIOR MANAGER WESTERN CAPE & NORTHERN CAPE	WESTERN CAPE UNIT
COLE	DI	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
DAVIDS	I	TECHNICAL OFFICER	WESTERN CAPE UNIT
DE BEER	CH	SCIENTIFIC OFFICER	WESTERN CAPE UNIT

Surname	Initials	Position	Business Unit
DE BRUIN	E	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
ENGELBRECHT	J	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
LAMBERT	CW	JUNIOR SCIENTIST	WESTERN CAPE UNIT
MACEY	PH	SPECIALIST SCIENTIST	WESTERN CAPE UNIT
MALHERBE	JE	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MOSES	D	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MTHEMBI	P	JUNIOR SCIENTIST	WESTERN CAPE UNIT
MUSEKIWA	C	SENIOR SCIENTIST	WESTERN CAPE UNIT
NGCOFE	LDS	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
NGWENYA	K	ADMINISTRATIVE OFFICER - RECEPTIONIST	WESTERN CAPE UNIT
PETERSEN	C	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
ROBERTS	DL	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
ROBEY	K	JUNIOR SCIENTIST	WESTERN CAPE UNIT
STAPELBERG	FDJ	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
VILJOEN	JHA	SCIENTIFIC OFFICER	WESTERN CAPE UNIT