Council for Geoscience

ANNUAL TECHNICAL REPORT of the Council for Geoscience 2013

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2013

COUNCIL FOR GEOSCIENCE
SOUTH AFRICA

The Council for Geoscience was established in terms of the Geoscience Act (Act No. 100 of 1993). This Act also established the mandate and national responsibilities of the organisation. The Council for Geoscience was listed as a schedule 3A Public Entity in terms of the Public Finance Management Act (Act No. 1 of 1999), as amended by the Public Finance Management Amendment Act (Act No. 29 of 1999). The Geoscience Amendment Act (Act No. 16 of 2010) was signed into power in December 2010 and came into operation on 1 July 2012, with the exception of sections 4(c), (eA) and (f), section 5(b) and section (8).

Compiled by the
Information Management Unit
Council for Geoscience

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Classification of founding material at the Dorper Wind farm near Molteno in the Eastern Cape Province

MANAGEMENT OF THE COUNCIL FOR GEOSCIENCE

Chief Executive Officer

Mxolisi Kota

Board Administrator

Nomkhosi Cele *(Acting)*

Strategic Services
(in the office of the CEO)

Nico Keyser *and* **Maleka Monyepao**

- Annual Technical Programme Management
- Commercial Project Tender Management
- Strategy Planning Cycle

Scientific Services

Executive Manager
Gerhard Graham

- Geophysics – *Peter Nyabeze (Acting)*
- Information and Collections Management – *Danie Barnardo*
- Laboratory – *Thinus Cloete*
- Regional Geochemical Mapping – *Thinus Cloete*
- Seismology – *Michelle Grobbelaar*
- Spatial Data Management – *Ken Wilkinson*

Regional Geoscience and Mapping

Executive Manager
Gerhard Graham *(Acting)*

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

Applied Geoscience

Executive Manager
Fhatuwani Ramagwede

- Engineering Geoscience – *Stewart Foya*
- Environmental Geoscience – *Mosidi Makgae*
- Mineral Resources Development – *Stewart Foya*
- Water Geoscience – *Fortress Netili*

Corporate Services

Executive Manager
Fhatuwani Ramagwede *(Acting)*

- Human Resources – *Vacant*
- Marketing and Communications – *Nthombi Mdluli Jacha*

Financial Services

Chief Financial Officer
Leonard Matsepe

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

Contents

Foreword

The financial position of the Council for Geoscience has improved to an appreciable degree, leading, inter alia, to the Annual Technical Programme being restarted, albeit to a limited extent. In addition, the moratorium on new appointments has been lifted in some measure and the number of bursaries awarded has been increased. Moreover, the number of staff members studying towards higher degrees has increased. The culmination, and certainly the most memorable and enjoyable aspect of the past year, was celebrating the first century of existence of the Council for Geoscience and its predecessor organisations.

The restrictive financial measures that had, of necessity, been in place since 2009/10 are slowly being relaxed to facilitate a new phase of generative growth for the organisation. The financial position of the organisation was reversed, mainly due to augmented funding received from National Treasury for a substantial increase in the scope of the entity's support for mineral exploration.

The organisation is in the fortunate position to report a surplus of R18,4 million for the 2012/2013 financial year. The statutory programme of the organisation, which is a key component of its mandate, also provides the opportunity for young geoscientists to develop as researchers. The improved financial position enabled the organisation to partly reinstate the statutory programme and the Board and Management of the Council for Geoscience are pleased to report that the audited technical performance of the organisation for the past financial year was 92 %. This is a clear testament to the dedication of the staff and the sound management of the organisation.

After a year under the guidance of an Acting Chief Executive Officer, Dr Gerhard Graham, the Council for Geoscience welcomed a new leader, Mr Mxolisi Kota, on 1 December 2012. Under the leadership of Mr Kota the Council for Geoscience will embark on the development and implementation of a strategy to place the organisation in an optimal position to fulfil its role in South Africa, Africa and the broader society.

Specific sections of the Geoscience Amendment Act (Act No. 16 of 2010) were intended to extend the functions of the Council for Geoscience. Apart from acting as the custodian of all geoscience information, the organisation is now also tasked with becoming the national advisory authority on geohazards. The additional funding required for the implementation of these amendments was discussed with the Department of Mineral Resources and a formal request was submitted to National Treasury. However, as the required funding could unfortunately not be made available, the Act came into operation on 1 July 2012 subject to the exclusion of some of the more significant amendments.

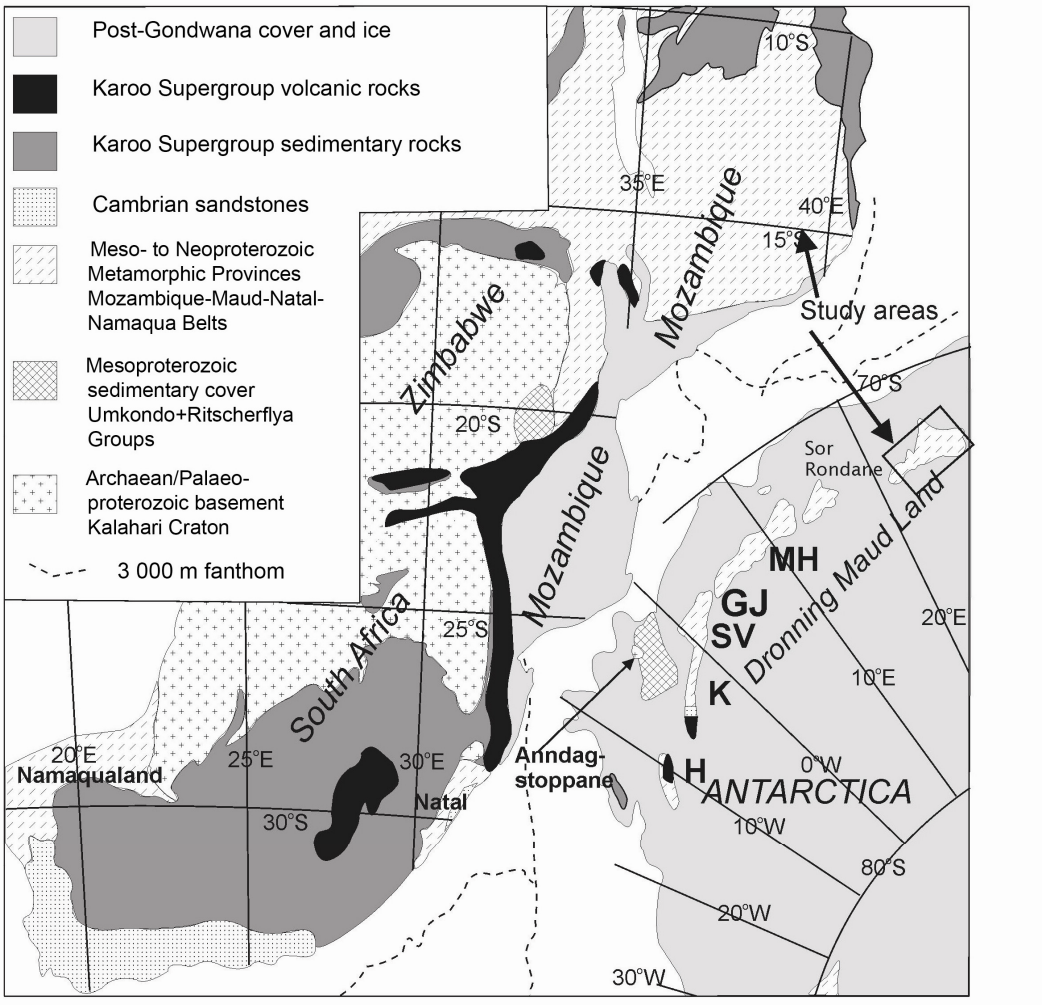
The Council for Geoscience hosted a two-day conference on 8 and 9 November 2012, to celebrate its first century of existence. The event was attended by some 2 000 guests including representatives from Government, the international geoscience community, universities and the industry, as well as former staff members, well-wishers and friends. The Minister of Mineral Resources, as the guest of honour, opened the proceedings, congratulating the organisation on past successes, but also cautioning that its future relevance would depend on how successfully the Council for Geoscience would provide solutions to the changing needs of the community it serves.

INTERNATIONAL COLLABORATION

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 Sør Rondane Mountains of Dronning Maud Land, Antarctica with that of northern Mozambique, recognising that the two areas were adjacent to each another prior to the dispersal of Gondwana approximately 180 Ma ago
Duration	2010 to 2014
Budget	R5 000.00



A reconstruction of Gondwana and the areas of comparison

Motivation

The project leader was invited to the Sør Rondane Mountains in Central Dronning Maud Land, Antarctica, to participate in JARE51. The duration of his involvement extended from 15 November 2009 to 15 March 2010, with three months being spent in active fieldwork in western and eastern Sør Rondane. The Sør 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 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 mineral assemblages from which P-T estimates have been completed. These data, along with samples from six zircon separates providing ages of metamorphism in the area, have been accepted for publication in the journal *Precambrian Research*. In addition, two other collaborative manuscripts have been accepted for publication in *Precambrian Research*. Additional Rb/Sr and Sm/Nd radiogenic data have been received and will be described in the future.

Future activities

It is planned to prepare more manuscripts for publication on the Sør 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. A paper comparing the evolution and chemistry of Neoproterozoic to Cambrian granites of northern Mozambique and western Dronning Maud Land is in the process of being prepared, as well as a paper describing and interpreting new Rb/Sr and Sm/Nd data from Sør Rondane.

ST-2011-1126

Geochemistry of volcanomagmatic rocks from the western Bolé–Nangodi terrane in Ghana: geotectonic evolution of a Palaeoproterozoic intra-oceanic back-arc basin system

Project leader	GS Kock, PhD
Project team	H Théveniaut, PhD, PMW Botha, MSc, W Gyapong, BSc Hons, HP Siegfried, PhD and E Thomas, PhD
Primary objective	The objective of the project is to present and discuss the geochemical results obtained during a mapping project executed in Ghana during 2006
Duration	2011 to 2014
Budget	R5 000.00

Motivation

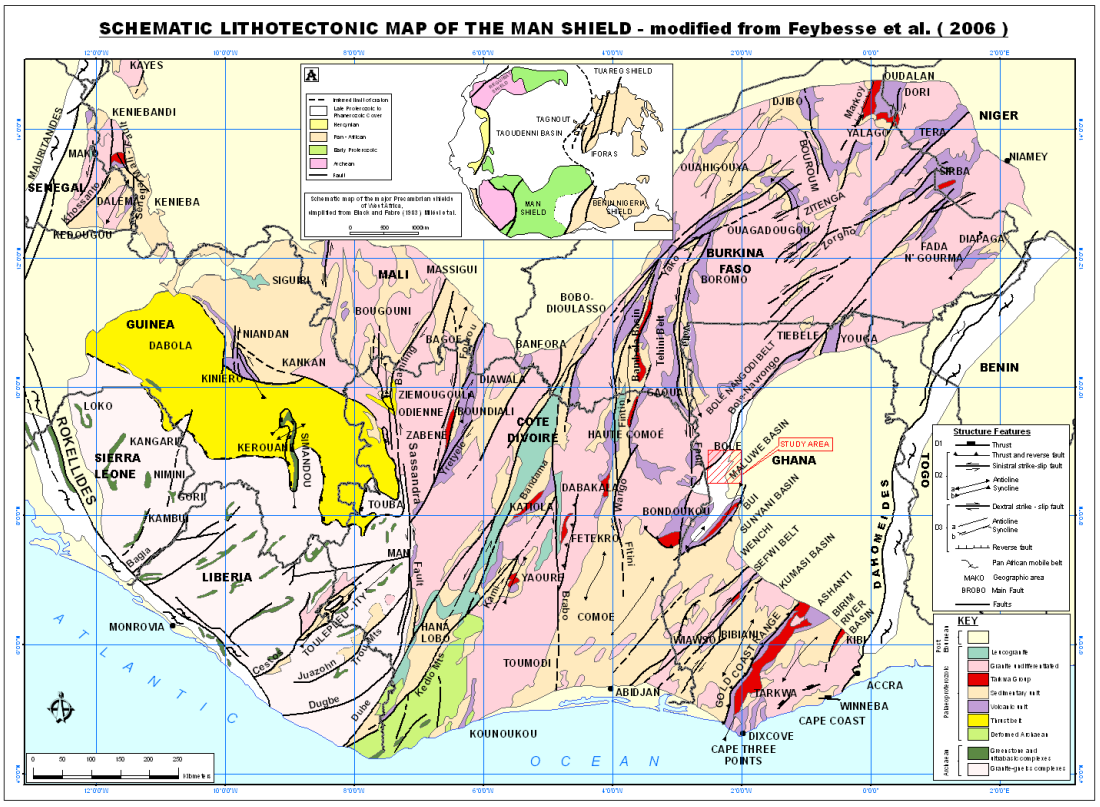
Numerous projects and publications have dealt with the chemistry of rocks from the West African craton in which the study area occurs. Since the first major reports on mostly the mafic rocks and subsequently the granitic rocks were released, a geotectonic environment was established for describing the origin and processes that were active some two billion years ago. In only a few studies, the evolution of both the mafic and granitic magmas were evaluated, irrespective of their age. In the last two decades, the developments in technology to obtain accurate age dating results have improved dramatically. In modern environments, similar to those for the West African craton, cycles and processes have a life-cycle of less than 30 million years. The lack of structural studies and the limited ages obtained for small regions have restricted the previous researchers to identified individual cycles and they have treated all rocks as a single continuous event active for more than 200 million years. In this study area, structural studies, supported by geochronology, have been able to define shorter cycles which comprise crustal divergence as well as convergence. The ages and crustal processes have allowed the linking of igneous and volcanosedimentary units to individual, short-lived crustal processes, something which, until now, has been problematic.

Progress

For this project, an overview of the related research, including a description of the field appearance of the analysed units. was given. The rocks were grouped according to composition and age before their chemistry was discussed. The analytical results of previous researchers were summarised and major characteristics of the modern intra-oceanic back-arc systems were outlined. Currently, the results and development stages within a back-arc basin environment are discussed and compared with those of other researchers.

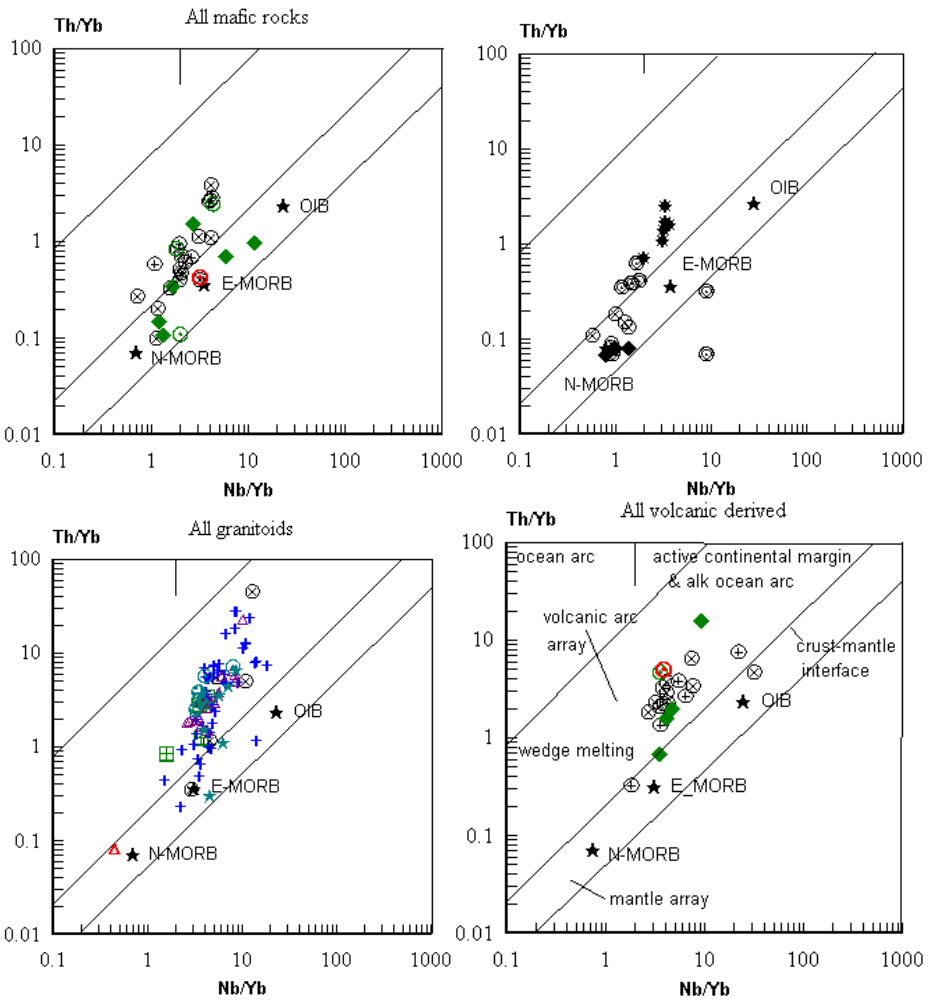
Future activities

Future activities will include a chapter on the results and conclusions and the updating of the reference list before submitting a report for publishing.



Visual representation of the location of the study area in the West African craton

Gondo granite (~2 187 Ma) with gneissic texture and enclaves of older finer-grained dioritic granite. Note the younger granite dyke (~2 122 Ma) cutting all older phases and textures



Diagrams illustrating the compositon of the source rocks and subsequent contamination of the magmas present in the study area

ST 2010-1127

Testing the terrestrial Guadalupian (Middle Permian) extinction in the Karoo Basin, South Africa

Project leader	J Neveling, PhD
Project team	R Gastaldo (Colby College, Waterville, USA), R Prevec (Albany Museum, Grahamstown), C Looy (University of California, Berkeley, USA), S Kamo (Jack Satterly Geochronology Laboratory, Toronto), J Geissman (University of Texas, Dallas)
Primary objective	The project aims to test the proposed ecosystem instability during the Middle to Late Permian, especially its implications for the end-Permian mass extinction, by investigating the rocks of the Karoo Basin
Duration	2010 to 2014

Motivation

Over the past two decades, much international research attention and activity have focused on the end-Permian mass extinction, which has been reported from the Karoo Basin of South Africa. The Council for Geoscience also participated in this research and the results of this work have been published in several papers and numerous conference abstracts. More recently some of this research focus has shifted to the identification of other mass-extinction events in the geological record of the Karoo and a worker proposed that the faunal changes reported from the top of the thickest vertebrate biozone in the Beaufort Group, the *Tapinocephalus* Assemblage Zone, correlate with the end of the Guadalupian extinction in the marine record. However, this correlation is poorly supported by data while the palaeobotanical record of the lower Beaufort Group in the southern parts of the basin is poorly known. The project therefore aims to expand the known plant record of the Middle to Late Permian and to test the proposed ecosystem instability in South Africa during this period. This research will contribute to the ongoing body of research on prehistoric biotic perturbation which may help to better understand the link between changes in global temperature and atmospheric chemistry and biodiversity loss in the oceans and terrestrial ecosystems.

Progress

As a result of the involvement of the relevant CGS staff in commercial work, very little fieldwork was undertaken during the course of the past financial year. One field trip was undertaken in the Graaff-Reinet District in March 2013 to prepare for a much more extensive field trip that would be undertaken in May 2013. The preliminary results of fieldwork carried out in the previous financial year were presented as an oral paper at the annual meeting of the American Geophysical Union. In addition, some of the members of this research group submitted a paper entitled *Mud aggregates from the Katberg Formation, South Africa: additional evidence for Early Triassic degradational landscapes* to the *Journal of Sedimentary Research*. This paper reports on the first documentation of mud aggregates from the channel systems of the Karoo fluvial deposits and was accepted for publication in March 2013.

Conclusions

Work to date suggests that the environmental aspects of the sedimentary and extinction models proposed for the Permian and Triassic rocks of the Karoo Basin may be oversimplified and that it requires careful review.

Future activities

Fieldwork by almost all the researchers was scheduled for the winter of 2013. It is expected that one to two manuscripts will result from this work.

CENTRAL REGIONS

ST-2009-1012

The 1:50 000-scale geological mapping of Madikwe

Project leader	R Shelembe, MSc (Geol)
Primary objective	The main objective of this project is to produce an updated and accurate 1:50 000-scale map sheet and a map explanation of the Madikwe area according to the mandate of the Council for Geoscience. A secondary objective is to compare the mineralogy, through the petrographic study of the geology of the Madikwe area, with that of the Mabaalstad and Mabeskraal map areas. This will assist in analysing the extent and intensity of the metamorphic aureole caused by the Bushveld intrusion. Rocks analyses will assist in investigating the relationship between the pyroxenite sills in the area and the Bushveld-type rocks. East–west-trending lineaments are present in the Madikwe map area. This project will attempt to investigate the origin and relations of these lineaments and to determine whether there are outcrops related to these lineaments
Duration	20010 to 2013

Motivation

The Madikwe map sheet area in the North West Province is situated southwest of the Pilanesberg Complex. The mapping of the Madikwe area will close some of the 'gaps' in areas adjacent to those that have already been mapped, i.e. 2526BB Mabeskraal and 2526BD Mabaalstad.

The Magaliesberg, Silverton, Daspoort and Strubenkop Formations of the Pretoria Group comprise the greater part of the map area. These formations curve roughly around the far Western Limb of the Bushveld Complex and are composed of quartzite, hornfels and slate; lithologies that are evidence of metamorphism. It would be interesting to analyse to what extent the Bushveld Complex has affected the mineralogy of the area, since it is further away from the intrusion with respect to the Mabeskraal and the Mabaalstad map areas that have already been mapped.

With urbanisation and crop farm developments, areas are quickly being changed and geological outcrops are being removed, thus limiting the amount of information geoscientists can extract in the field. In this regard, it is therefore critical for geoscientists to acquire geological information (which may aid in interpreting subsurface geological information) before such areas are totally modified by anthropogenic activities.

Progress

Work completed

Fieldwork and geological sample collection.
Compilation of 1:50 000-scale preliminary map.
Samples submitted for XRF analyses.
Progress report.

Work in progress

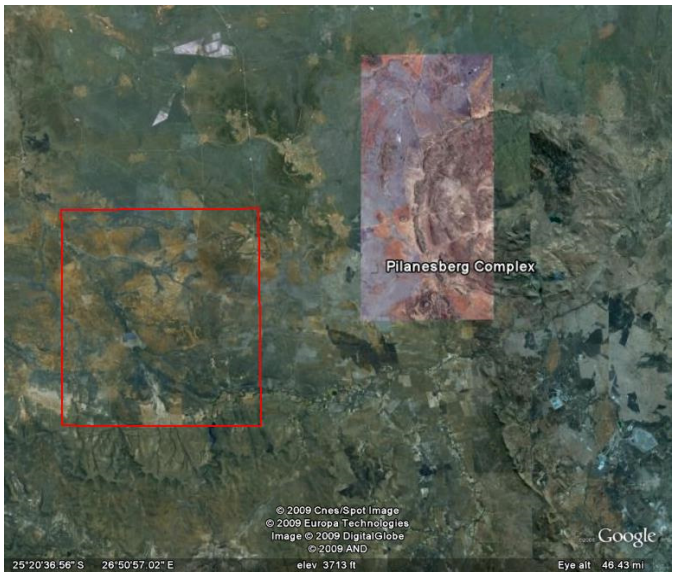
Preliminary petrographic work (95 % complete).

Conclusions

The Madikwe area is studied additionally to aid in investigating the extent of the metamorphic aureole and heat distribution owing to the intrusion of the Bushveld Complex. The structural lineaments in the area will give an insight into the tectonic influence in the vicinity.

Future activities

Compilation of a detailed geological explanation and refinement of the preliminary geological base map are the key future activities.



Location of the Madikwe area southwest of the Pilanesberg Complex

Layered garnet hornfelses of the Silverton Formation in the Madikwe area indicating probable higher-temperature metamorphic conditions

ST-2010-1066

The 1:50 000-scale geological mapping of the 2526BA Khayakhulu area

Project leader	R Shelembe, MSc
Project team	J Leshomo, MSc, A Ndhukwani, BSc Hons
Primary objective	Since this area is semi-arid, the communities in this region rely heavily 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 added to the groundwater by rocks of the Pilanesberg and the Bushveld Complex. The elements were also proven 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. The primary objective of this project is to investigate how the geology of this area has affected the chemistry of the groundwater. The major objectives of this mapping project are the following: - Update and produce an accurate 1:50 000-scale geological base map of the Khayakhulu area in the North West Province of South Africa - Investigate the extent of the metamorphic aureole caused by the Bushveld Complex - Investigate the quantity and quality of the water in this semi-arid area close to the Kalahari Desert - To encourage interunit contributions to geological mapping projects
Duration	2010 to 2013
Budget	R270 884.00

Motivation

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 2526BA Khayakhulu 1:50 000-scale mapping project will contribute significantly to the understanding of the floor rocks of the Bushveld Complex and thereby the extent of the metamorphic aureole. The geological study of the Khayakhulu map area in terms of metamorphic history will produce information which might be used for possible small-scale mining in the area.

The health of communities in peri-urban areas is also affected by the surrounding geology through the use of groundwater. The communities of this area have reported various illnesses. Water chemistry will assist in investigating whether these ailments are water related. Data collected during this project will be used to assess the water chemistry and to investigate suspect elements or nanoparticles that are likely to be found in the groundwater. This will aid in determining sustainable solutions or techniques to alleviate this potential problem. Information gathered from this project will also be used to assist government departments in the North West Province and other industries. Rural development will be enhanced by water quality assessments and characterisation.

Progress

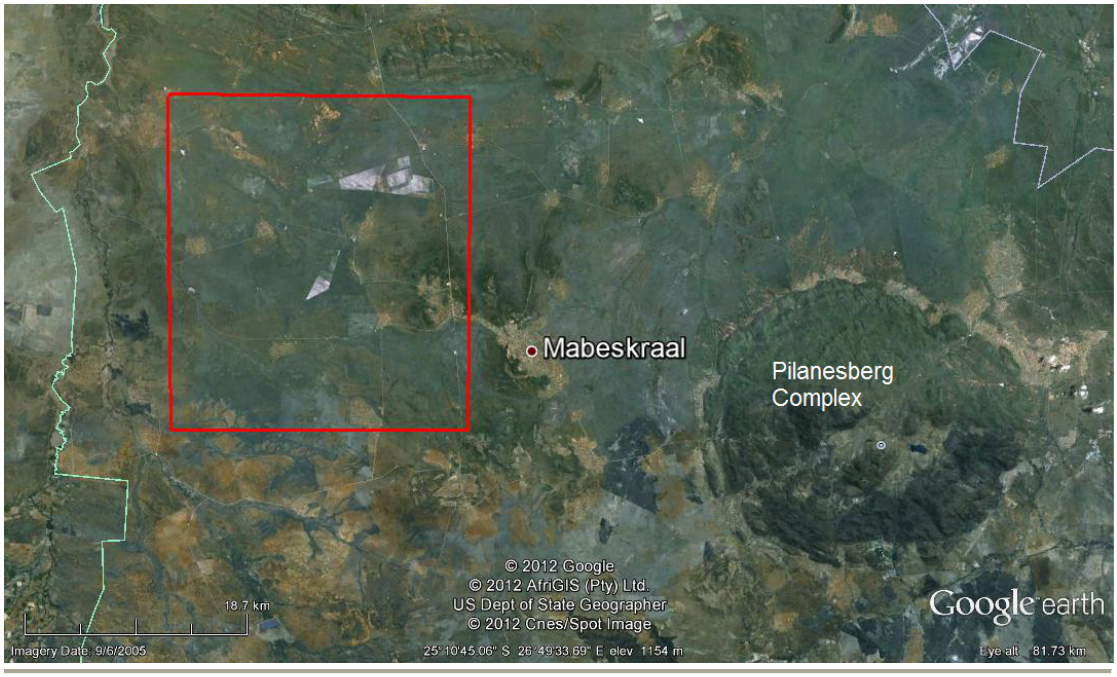
Geological mapping covering 98 % of the Khayakhulu area has been completed.
Collection of rocks samples for petrographic and geochemical investigations completed.
Draft petrographic report (15 % completion).
Completed collection of water samples for chemical and quality assessments from existing boreholes in the communities.
Completed hydrocensus and hydrochemistry analyses of water samples.
Desktop studies for geophysics and geochemistry.

Conclusions

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

Future activities

The geochemical data will be analysed and the completion of a preliminary geological, geophysical and geochemical map is envisaged. A geological explanation including a focus on the water quality and relevant recommendations will also be produced. The assessment of hydrogeological parameters such as storage capacities, coefficients and sustainability yield constraints will be completed using appropriate investigative techniques.



Location of sheet 2526BA Khayakhulu

EASTERN CAPE

ST-2011-1135

A three-dimensional surface and subsurface GIS-based model of the greater Thyspunt area, Eastern Cape, South Africa: Data requirements, model development, structure and design with associated scientific implications

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. Explore the use of Google SketchUp as a dynamic 3D geomodelling software tool by describing a methodology for its use with a variety of geological data sources such as borehole, geophysical, cross-sectional and geological map data with associated geological implications
Duration	2012 to 2014
Budget	R15 650.00

Motivation

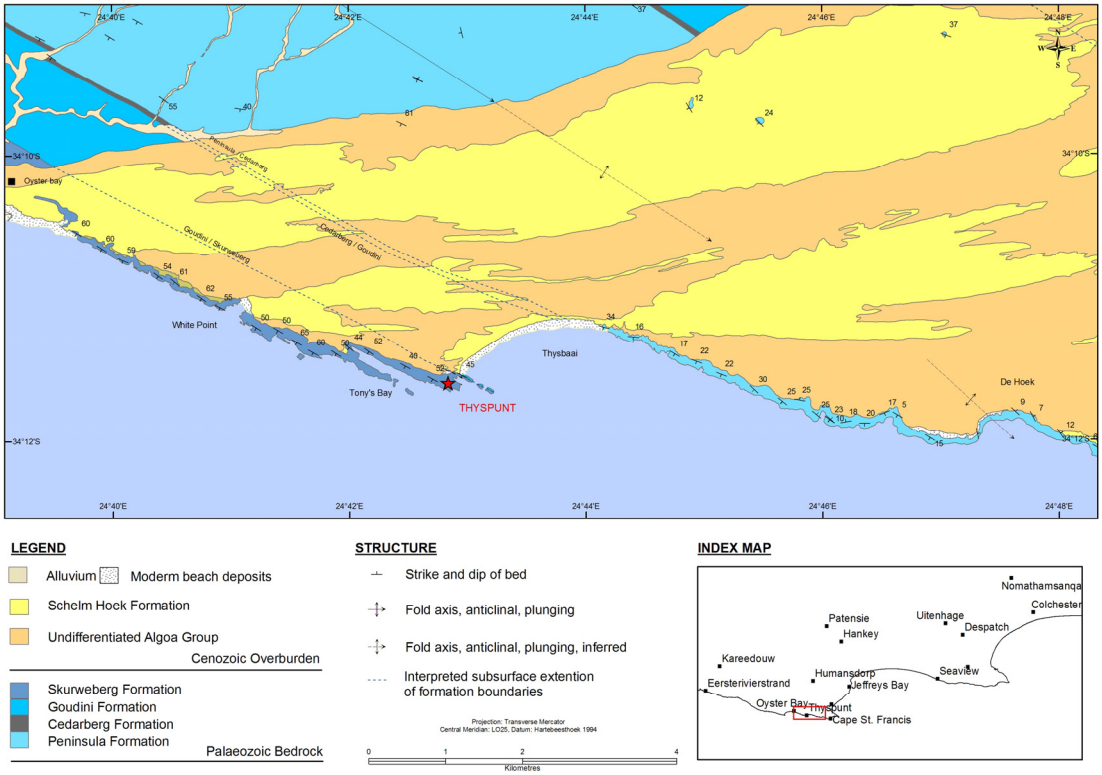
The area between Oyster Bay and St Francis is earmarked for substantial development in the future. A large amount of surface and subsurface data, including numerous geological maps, borehole logs, geological cross-sections and geophysical data exist for Thyspunt and the surrounding areas. The model will succeed in integrating a large amount of data scatted in reports, documents, logs and photos into a single location with a three-dimensional perspective upon which future investigations can be based. In addition, the project explores the capabilities of Google SketchUp software in three-dimensional modelling.

Progress

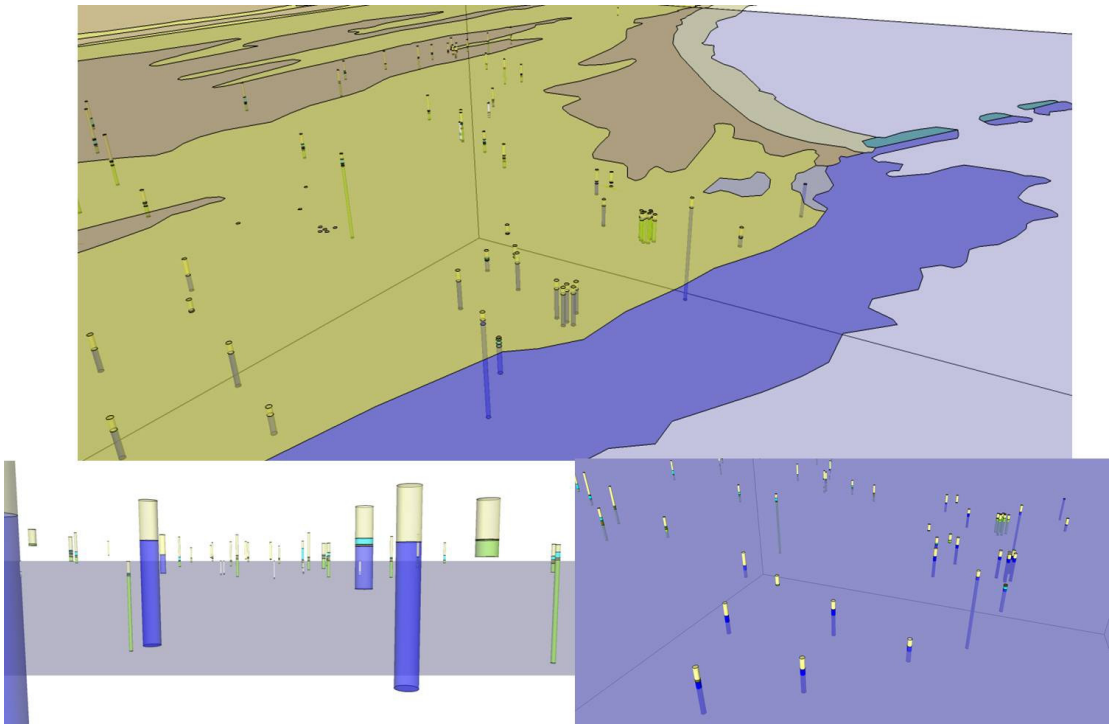
Data acquisition and collation into a main digital database is complete including recent 2011/12 drilling results from near Thyspunt and Cape St Francis with preliminary modelling and methodology in progress. A draft report has been written with numerous chapters of an MSc thesis currently being reviewed by the Nelson Mandela Metropolitan University in Port Elizabeth.

Conclusions and future activities

During the last phase of the project the 3D model construction will be completed and the report will be scientifically reviewed by the Nelson Mandela Metropolitan University at the end of March 2014.



The regional geology of the study area between the two coastal towns of St Francis 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 purple overlay. Modelling is done with the aid of Google SketchUp software

ST-2011-1134

Shale gas potential of the lower Karoo rocks, north of Paterson, Eastern Cape, South Africa

Project leader	D Black, BSc Hons
Primary objective	To analyse samples of the lower Ecca Group in the Karoo Basin, South Africa. The focus will be on the Collingham Formation as a caprock to shale gas as well as the potential of the formation as a gas conduit or gas-bearing horizon. Methodologies include scanning electron microscopy, thin sections, XRF, XRD and possibly total organic carbon (TOC) and mercury porosimetry. In addition, zircon will be utilised in radiometric age dating
Duration	2012 to 2014
Budget	R24 150.00

Motivation

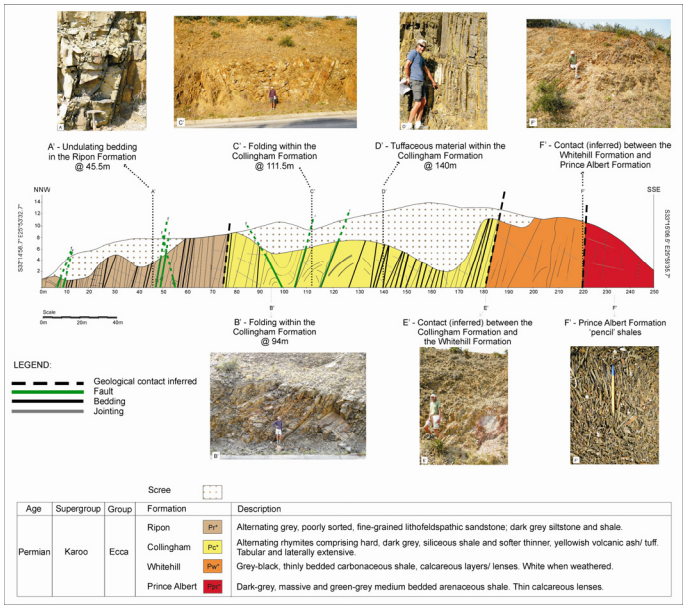
The scientific undertaking of this project will solve a regional geological problem that has not been undertaken in the Eastern Cape to date. Shale gas is becoming increasingly important as an alternative source of energy. The latest studies are focusing on the Karoo Basin as an ideal geological host for these resources. There is a potential economic spinoff, as currently there are proposed investigations of the lower Karoo rocks for shale gas in order to define targets.

Progress

Field mapping is nearing completion and a log has been constructed for borehole SFT 2. Samples from field mapping and a boreholes have been submitted for XRD and XRF analyses. Samples have also been studied by thin section and under SEM. Additional samples may be submitted for total organic carbon and mercury porosimetry in due course. Work on the final write-up has begun.

Future activities

All analyses will be interpreted. Additional samples will be analysed and the write-up of an MSc thesis will continue.



Dating of zircons from the Collingham Formation

ENGINEERING GEOSCIENCE

ST-2011-1137

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

Project leader	S Richardson, BSc Hons (Eng Geol)
Project team	G J Heath (MSc)
Primary objective	This research topic is 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 analysis 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 to 2013

Motivation

Sinkholes and subsidences occur on 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 the provinces of Gauteng, Mpumalanga, Limpopo, North West and the Northern Cape. The Gauteng Province is by far the worst affected, with more than 3 000 events having 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 subsidences database is crucial for the future assessment of sinkhole hazards 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 within the Gauteng Province, the City of Tshwane Metropolitan Municipality, the West Rand District Municipality, the Ekurhuleni Metropolitan Municipality and the City of Johannesburg Metropolitan Municipality. The information collected provides an estimation of the number of sinkholes and subsidences that have occurred in the past 60 years. 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 location, coordinates, dimensions, geological formations, triggering mechanisms, source data and dates of occurrences are stored. Each instability event is also given a unique event number. A large percentage of data have not been recorded for certain attributes. Statistical analyses have been carried out using the available data.

Conclusion

In excess of 3 000 sinkhole, subsidence and crack events have occurred within the study area. Results indicate that sinkholes and subsidences are still regularly occurring in areas underlain by dolomite in Gauteng; however, based on available data, events in the West Rand and Tshwane Municipalities appear to be decreasing in number annually.

More events occur in high-rainfall months or years owing to increased ingress water entering the ground profile.

The most dominant type of event recorded is attributed to sinkholes.

Overall, the largest percentage of events has occurred on the chert-rich Monte Christo Formation and Eccles Formation.

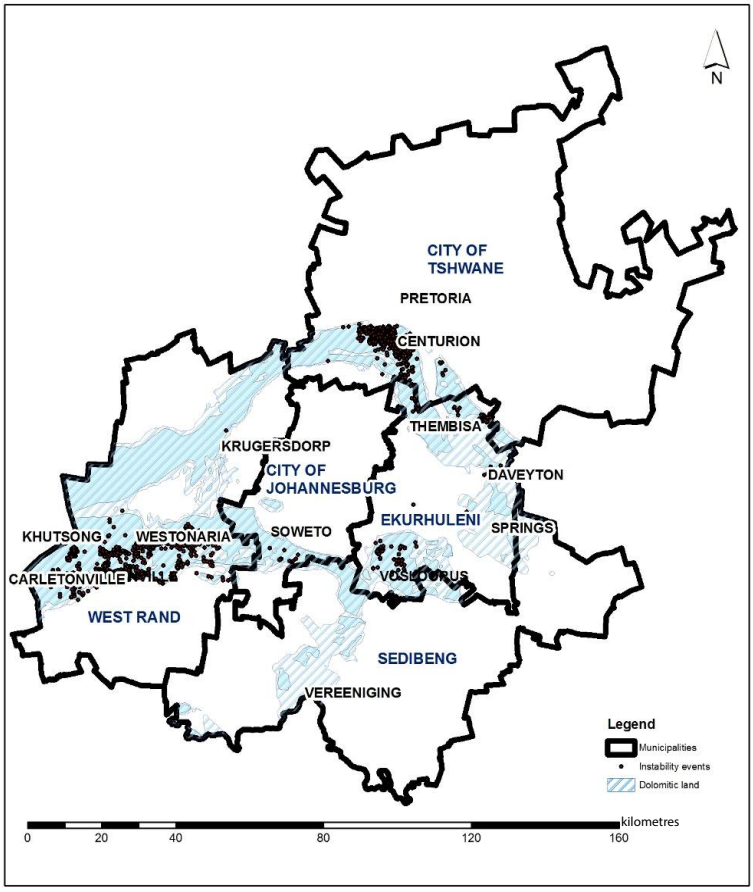
Triggering mechanisms were considered for the different areas. On the West Rand, most occurrences prior to 1984 were due to dewatering while post-1984, most are attributed to ingress. Most of the events on the West Rand have occurred in the Oberholzer Groundwater Compartment. In Tshwane, almost all occurrences can be attributed to ingress while, in Ekurhuleni, just under a quarter of events were identified as owing to dewatering.

When considering sinkhole and subsidence sizes and depth distributions, the largest percentage of sinkholes in the West Rand (>60 %) are large to very large (i.e. greater than 5 to 15 m diameter), the largest percentage of sinkholes in Tshwane (>60 %) are medium to large (i.e. greater than 2 m to less than or equal to 15 m diameter) and the largest percentage of events in Ekurhuleni (>70 %) are small to medium (i.e. less than 2 m to less than or equal to 5 m diameter).

When considering size distribution on the different formations, it is difficult to assess size and depth inclinations. It was not possible to determine whether certain sizes were dominant for specific formations.

Future activities

The sinkhole database is ongoing and is constantly updated; therefore results of analyses may change fairly rapidly depending on available sinkhole database information.



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

Sinkhole in Lyttelton, Centurion, that occurred in November 2012

ST-2012-1178

The role of the State Coordinating Technical Committee (SCTC) on sinkholes and subsidences

Project leader	AC Oosthuizen, MSc (Eng Geol)
Project team	S Richardson, BSc (Eng Geol), L Heath, BSoc Sci Hons, T Sebyi, BA (Geogr.)
Primary objective	To give an overview of the responsibilities and decisions taken by the State Co-ordinating Technical Committee (SCTC) on sinkholes and subsidences that operated in the Far West Rand from January 1964 to October 2003
Duration	2012 to 2013

Background

During the 1930s to 1970s gold mines on the Far West Rand (Westonaria to Carletonville) experienced higher working costs owing to the rising pumping of underground water seeping into the mine workings and permission was requested in approximately 1955 to dispose of the pumped water beyond the confines of the mines to counter recharging of the dolomite aquifer. This resulted in an inadequate recharge of the dolomite compartments and the water table consequently started to recede, leading to accelerated sinkhole and subsidence formation. The State Coordinating Technical Committee (SCTC) was established to deal with the technical issues and to advise on matters related to the accelerated sinkhole and subsidence formation occurring at the time.

Progress and conclusions

Members representing the various bodies of the SCTC, mainly from the mining sector and the Department of Water Affairs, changed over the years. The SCTC was approached regarding the suitability of land and to give advice to the responsible body as to the cause of sinkholes and subsidences resulting in damage. Research and investigations were also commissioned.

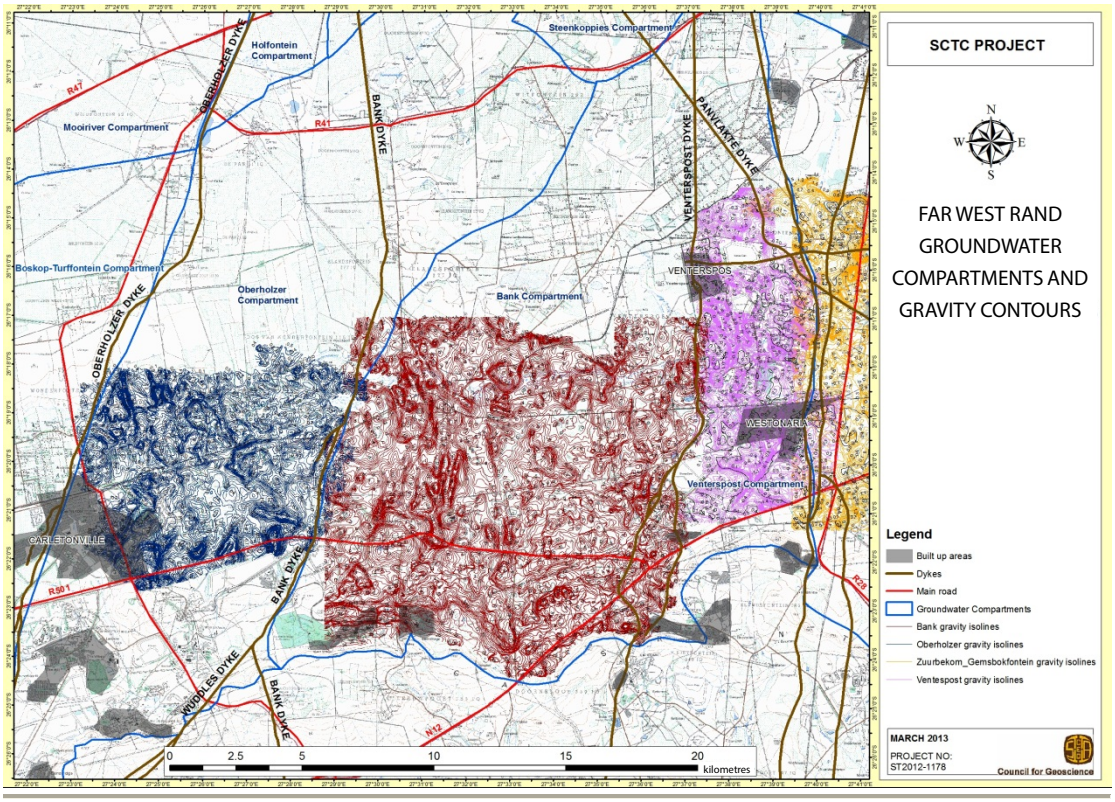
As part of the research, the dykes dividing the groundwater compartments were delineated using geophysical methods. Gravity surveys were undertaken in the various compartments (100 m grid) during the late 1950s and 1960s. Approximately 2 400 boreholes were drilled within the Far West Rand by the former Geological Survey, mainly to determine the safety of properties and to investigate certain occurrences (sinkholes or subsidences) or priority infrastructure, i.e. roads.

The SCTC undertook to continuously observe and inspect areas that did not belong to mines. Requests, cases or issues/queries were detailed in writing and submitted to the committee for consideration/action/advice. The committee carried out inspections of properties and sinkhole and subsidence occurrences.

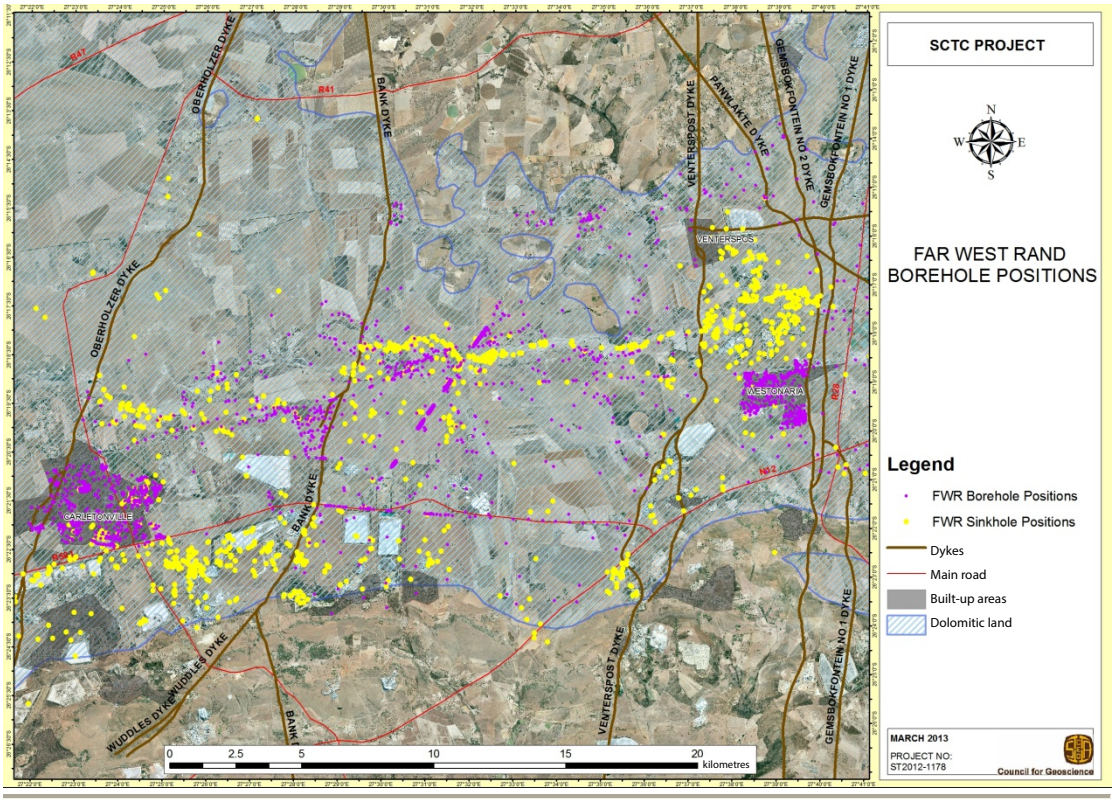
In areas not owned by the mines, the SCTC commented on the safety of stands or properties specifically. A total of 1 646 comments were made for Carletonville, 1 155 for Westonaria and 1 767 for Venterspost.

Future activities

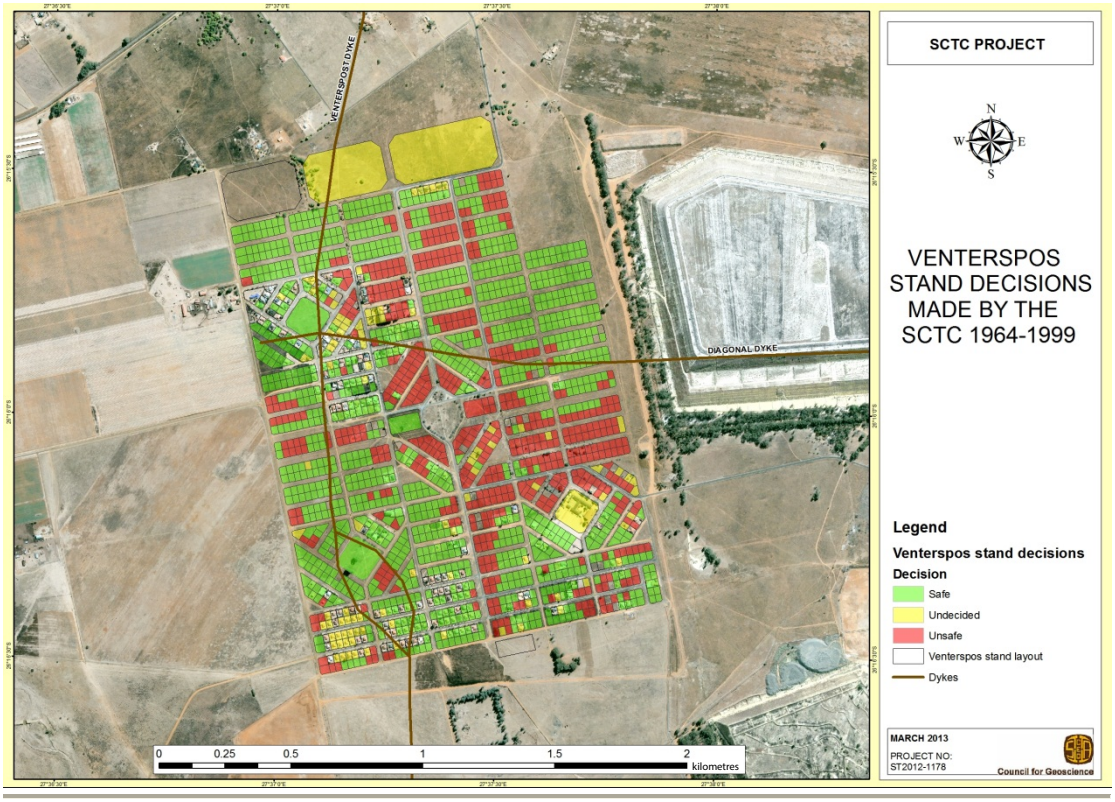
The next concern is that some mines are approaching closure, which will bring up issues of rehabilitation and rewatering, which may cause further sinkhole and subsidence problems.



Gravity surveys conducted in each of the groundwater compartments on the West Rand during the 1950s and 1960s



Boreholes drilled by the former Geological Survey in the Far West Rand and sinkholes that have occurred to date



A graphic representation of a SCTC Stand Specific Classification for the town of Venterspost

ST-2013-1180

National report reviews

Project leader	AC Oosthuizen, MSc (Eng Geol)
Project team	S Richardson, BSc Hons (Eng Geol)
Primary objective	An estimated 2.5 million people live on dolomite and in excess of 1.2 billion rands of property damage have been observed to date owing to instabilities on dolomite ground. Safe development on dolomite land is therefore crucial for the sustainability of areas underlain by dolomite. As part of the mandatory role of the Council for Geoscience to assist government authorities, the Engineering Geoscience Unit has been involved in sinkhole hazard evaluations since the early 1970s by assisting local authorities, to ensure safe development on dolomite
Duration	Ongoing

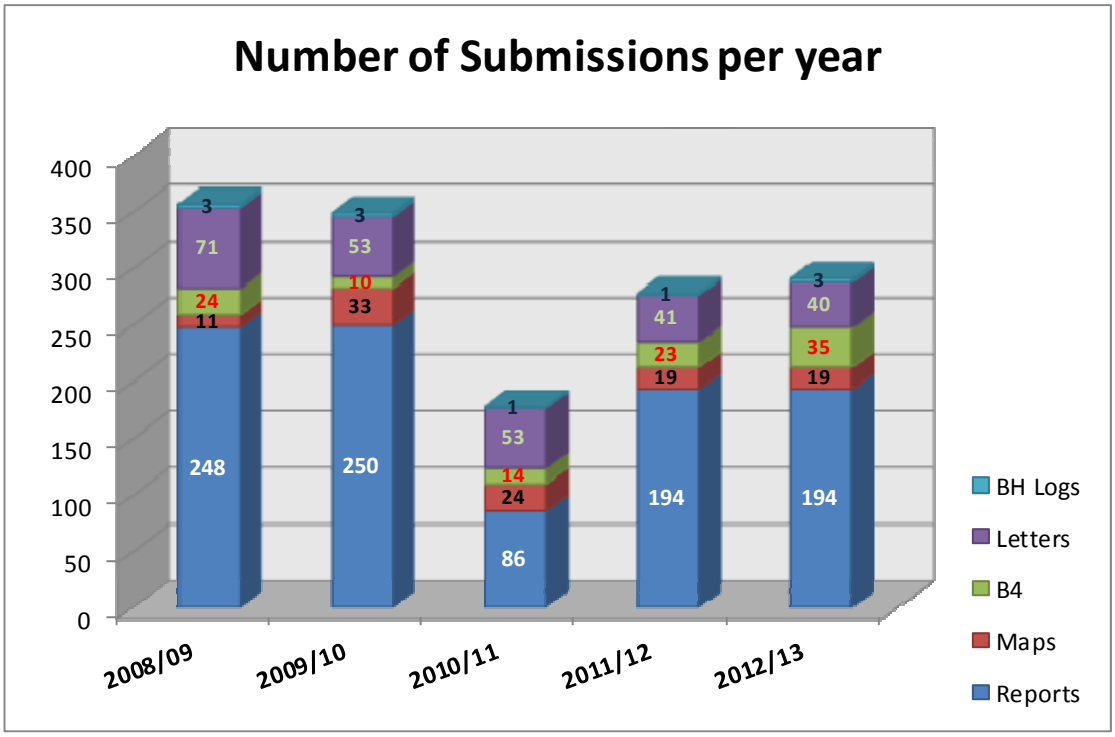
Motivation

The formation of sinkholes and subsidences in South Africa is largely related to the presence of carbonate rocks. In particular, the dolomite-bearing formations of the Chuniespoort Group in the northern part of the country (North West, Gauteng, Limpopo and Mpumalanga Provinces) and the Campbell Group in the Northern Cape Province collectively occupy an area of approximately 15 500 km^2. Current standard practice is to execute a geotechnical investigation on all dolomitic land earmarked for development, whether residential or commercial. Dolomite stability reports that are produced by an engineering geologist for residential or commercial development are submitted to the Council for Geoscience where they are stored in the National Dolomite Databank. Currently, not all the dolomite stability reports are submitted to the Council for Geoscience for review, and it mainly depends on the specific local authority who decides whether comments by the Council for Geoscience are required.

Progress

The dolomite stability reports are submitted on a weekly basis for review and comment. These reports are reviewed based on the SANS 1936 documents. The Council for Geoscience aligns itself with the SANS 1936-1:2012 document which indicates permissible land usage that is suitable for the eight inherent hazard classes.

Since 2005 more reports and requests have been received by the Council for Geoscience as a result of an increase in development on dolomite land. The graph on the next page shows the number of submissions to the Council for Geoscience per year since 2008. Most of the requests that have been submitted for review are for reports (dolomite stability reports) but many requests for letters, B4 applications (for NHBRC enrolment purposes) and co-signing of site development plans are received every year.



Submission of dolomite stability reports to the Council for Geoscience

The average turnaround time from when a report is submitted to when the comment is completed and made available to the client was seven consecutive days for the 2012/13 financial year.

Letters of comment were provided to the following municipalities during 2012/13: Tshwane Metropolitan Municipality, Ekurhuleni Metropolitan Municipality, Tlokwe Local Municipality, Merafong Local Municipality, Westonaria Local Municipality, West Rand District Municipality, Delmas Local Municipality, Thaba Chweu Municipality (Sabie), Mogale Local Municipality, Midvaal Local Municipality, Randfontein Local Municipality and Moshaweng Municipality (Kuruman). Other government departments or bodies that sought the advice of the Council for Geoscience during 2012/13 were the NHBRC, North West Province, Johannesburg Department of Housing, Far West Rand Dolomitic Association (FWRDA) and the Bombela Operating Company.

In the Geoscience Amendment Act (Act No. 16 of 2010) it is indicated that the Council for Geoscience is allowed to charge for the services rendered. The costs involved in reviewing a report are invoiced for the account of the engineering geologist that submits the report to the Council for Geoscience.

In order to assist staff with the dolomite report review process, construction sites are visited from time to time in order to observe the onsite geology, lay of the land, size, etc.

Conclusions

The Engineering Geoscience Unit provides an expert opinion mainly on the safe use of land in dolomitic areas. This unit has been called upon by national, provincial and local authorities for decades to provide an independent view on the suitability of dolomitic land for development.

Future activities

The Engineering Geoscience Unit will continue to provide recommendations and comments on the safe and judicious use of dolomite land when requested.

Engineering geologist going down an auger hole during a site visit

ST-2009-0029

Centurion hazard map

Project leader	AC Oosthuizen, MSc (Eng Geol)
Project team	LG Heath, BSoc Sc Hons
Primary objective	To provide a hazard map of sinkhole formation for the densely developed Centurion CBD and surrounding areas. Such a map will enable the City of Tshwane Metropolitan Municipality (CTMM) to guide safe development in Centurion, to identify areas where a high hazard of sinkhole formation exists and to manage the risk appropriately. The map will also assist in making recommendations regarding the suitability of land usage based on the hazard of sinkhole formation
Duration	Three years
Budget	R267 074.00

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. As part of the mandatory role of the Council for Geoscience to assist government authorities, the Engineering Geoscience Unit has been involved in the field of sinkhole risk evaluation since the early 1970s by assisting local authorities such as the CTMM to ensure safe development on dolomite. The Gautrain route now traverses the Centurion CBD area and the Centurion station, situated in West Street, has attracted high-rise developments to this area. The Council for Geoscience currently supports numerous developments in the Centurion CBD and surrounding areas. The large amount of information available in the CBD area, particularly in digital format, means that a first-order sinkhole hazard analysis could be achieved.

Progress

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

The Centurion CBD area is underlain by dolomite and chert of the Malmani Subgroup of the Transvaal Supergroup. Dolomite stability reports that have been submitted to the Council for Geoscience for peer review contain information of the study area. A total of 555 dolomite stability investigations were conducted within the study area and a total of 3 587 percussion boreholes were drilled. These boreholes were each classified in eight different Inherent Hazard Classes using the "Modified Method of Scenario Supposition" as proposed in this study. The eight Inherent Hazard Classes 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 for the study area is 3 m, whereas the average sinkhole size is 5 m in diameter. Three lives have been lost as a result of sinkholes and a total of seven residential structures had to be demolished. Millions of rands have been spent to repair other structures, infrastructure and services. The remediation of a sinkhole in Jean Avenue which occurred during 2011 amounted to an estimated total cost of R6,3 million.

Using the Spatial Analyst extension of ArcGIS 9.3, a map showing the hazard of sinkhole formation was compiled from the hazard classes 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 for the formation of sinkholes, which suggests that the areas of low hazard were delineated well and that the classification system defines this properly. 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 for the formation of sinkholes. It appears the hazard for sinkhole formation in medium and high hazard areas is generally the same (0,07 events per hectare in a 20-year period).

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. This method 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 such as 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 is 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.

Conclusions

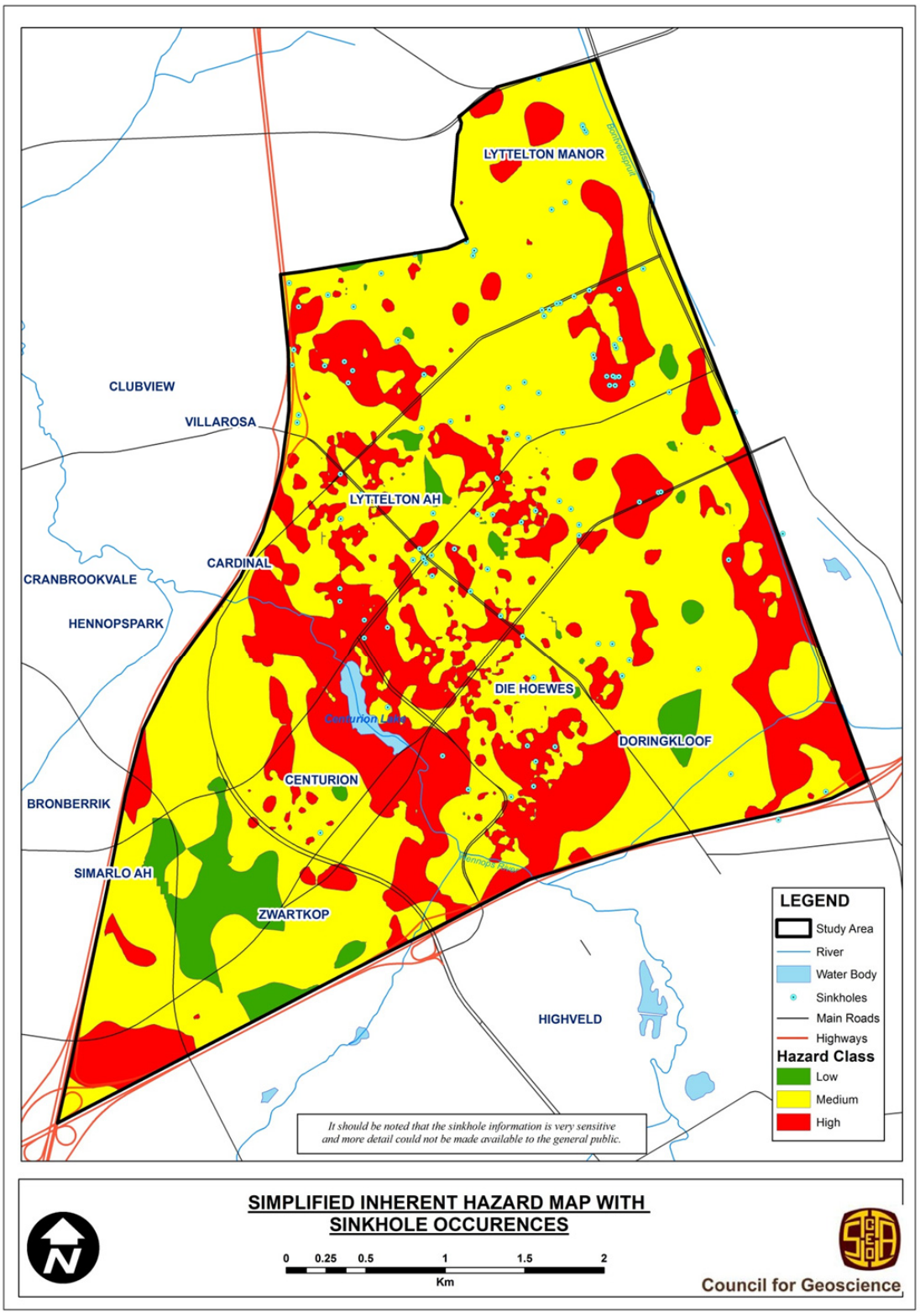
The hazard classification map shows that the study area can mainly be classified as having a medium to high hazard for sinkhole formation, although calculations by using the actual sinkhole events show that the area can be classified as a low to medium hazard for sinkhole formation. The reasoning behind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

- The method used to classify the boreholes is too conservative and the 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

The classification of percussion boreholes in the Centurion area will continue and a hazard map of the Tshwane municipal area will be compiled.

A large sinkhole occurred in Jean Avenue during 2011



Hazard of sinkhole formation in the Centurion CBD and surrounding areas

ST-1161

Geotechnical investigations in the Nquthu local municipality area

Project leader	SG Chiliza, BSc Hons
Project team	ML Sebesho, Nat Dip; SBM Nkosi, BSc Hons; BC Msane, BSc Hons; SV Nyathi, BSc Hons
Primary objective	To undertake geotechnical investigations in order to determine the suitability of identified parcels of land for low-cost housing developments, waste disposal and cemetery sites
Duration	2012 to 2013
Budget	R80 000.00

Motivation

The Nqutu Local Municipality is predominantly a rural area in the northeastern part of KwaZulu-Natal and is part of the UMzinyathi District Municipality. Several low-cost housing and related infrastructure developments are planned by the municipality to provide decent housing for the poor communities.

Development of infrastructure requires specialised assessments with regard to the physical condition and behaviour of founding materials and the determination of critical geotechnical factors such as excavatability, flood lines, problem soils, etc. As part of an effort to ensure that the Council for Geoscience is an active partner of the government in rural community development initiatives and spatial plans, four sites have been investigated, i.e. the remainder of eastern portion F100, Nquthu Cemetery, Nondweni Cemetery and Nondweni landfill sites.

Progress

The project was completed successfully. The findings of the investigation revealed that excavatability was a major geotechnical problem in the four sites investigated.

Conclusions

Geotechnical reports, including maps and recommendations with regard to the suitability of land for development, were compiled and handed over to the municipality.

Future activities

A similar project will be undertaken in the next financial year in the Mpumalanga Province for another predominantly rural municipality.

An unsuitable Nondweni waste dump site because of the close proximity to dwellings and distance to water channels

Abandoned graves because of ground excavatability problems

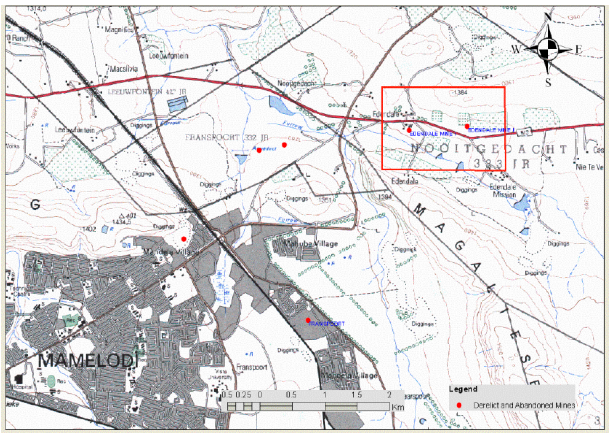
Graves at Nquthu Cemetery which have been backfilled with limited available soil material

ENVIRONMENTAL GEOSCIENCE

ST-2011-1110

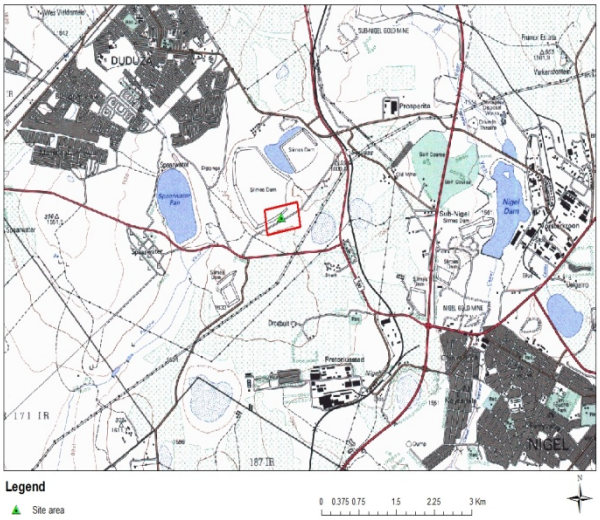
Phytoremediation of contaminated soil and water

Project leader	L Sakiah, BSc Hons (Engng and Environ Geol)
Project team	S Tlowana, MSc (Chem), L Lekgothwane, BSc Hons (Min and Environ Geol)
Primary objective	- To identify the metals that can be extracted from polluted media using particular plants - To determine how the plants perform in terms of extracting heavy metals from the polluted soil or water
Duration	2011 to 2013
Budget	R369 906.00



Topographic map for the Edendale lead mine

The Edendale study site



Topographic map for the Nigel site

Study site in the Nigel area

Motivation

The project will aid in developing scientific knowledge to assist regulators, site managers and owners to evaluate the applicability of phytoremediation to their sites.

Progress

A pot trial is being undertaken to test two different types of grasses for phytoremediation purposes.

Conclusions

Phytoremediation is a low-cost environmentally friendly technique that requires multidisciplinary inputs.

Future activities

The future activities will focus mainly on the results/observations of the grasses tested. The strongest grass can be studied further in polluted water and may be applied to clean up the polluted sites on a field scale.

ST-2012-1150

A holistic approach towards best management of mine pollution impacts using river catchment strategy

Project leader	B Yibas, PhD
Project team	R Netshitungulwana, MSc, O Novhe, MSc, H Mengistu, PhD, E Sakala, MSc, A Thomas, PhD, R Lusunzi, BSc Hons, G Sandane, BSc Hons, A van Averbeke, BSc Hons, P Mchunu, BSc Hons, T Kgari, BSc Hons, VF Mahlangu, BSc Hons, C Rikohotso, BSc Hons, O Makonto, MSc, E Sakala, MSc, E Chirenje, MSc, PK Nyabeze, MSc
Primary objective	The primary objective of the project is the mine pollution assessment and management (remediation and rehabilitation) of identified mine pollution hotspots
Duration	2012 to 2015
Budget	R8 000 000.00

Motivation

The Council for Geoscience has been working on projects and research related to environmental issues with various major stakeholders including the Department of Mineral Resources, Department of Science and Technology, mining houses and affected communities.

Progress

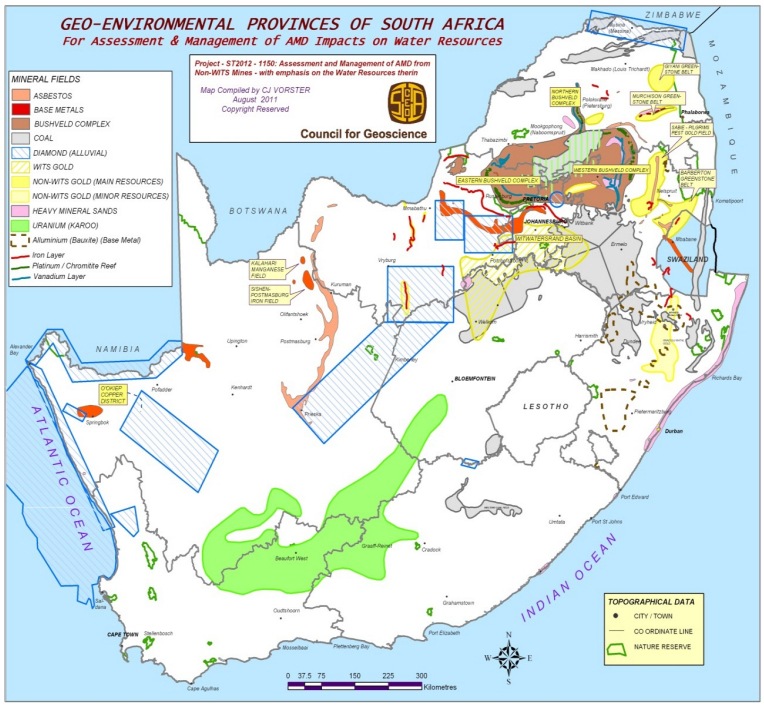
A mine pollution atlas map is being prepared for the Olifants catchment area after integrating the findings of a) catchment-scale stream sediment and water geochemistry; b) a hydrological study for runoff and infiltration estimation; c) mine area scale hydrogeology; d) AMD assessments from mining facilities such as MRDs, and e) ground geophysical detection of shallow subsurface plumes. Nineteen pollution influence areas have been delineated. Eight of the nineteen pollution influence areas are within the Witbank Coalfield, confirming the severity of mining pollution in the coalfield.

Conclusions

The study shows that catchment-scale mine pollution assesments using a multidisciplinary approach with an understanding of geoenvironmental provinces are powerful and more meaningful than focusing on a number of separate localised and mine-scale studies. Such catchment-scale investigations provide a holistic understanding of mine-related pollution and an integrated perspective on source to pathways and receiving environments. The mine pollution atlas provides a powerful management tool for the remediation and rehabilitation of the pollution influence area which encompasses the pollution source, pathways and the receiving areas.

Future activities

- To continue catchment-scale pollution assessments to delineate mine pollution hotspots for all South African primary catchments and to generate catchment-scale mine pollution hotspot atlases
- To produce a national mine pollution atlas for the country from the catchments-scale pollution atlases
- Concurrent and subsequent pollution hotspot management (remediation/rehabilitation) planning and implementation.



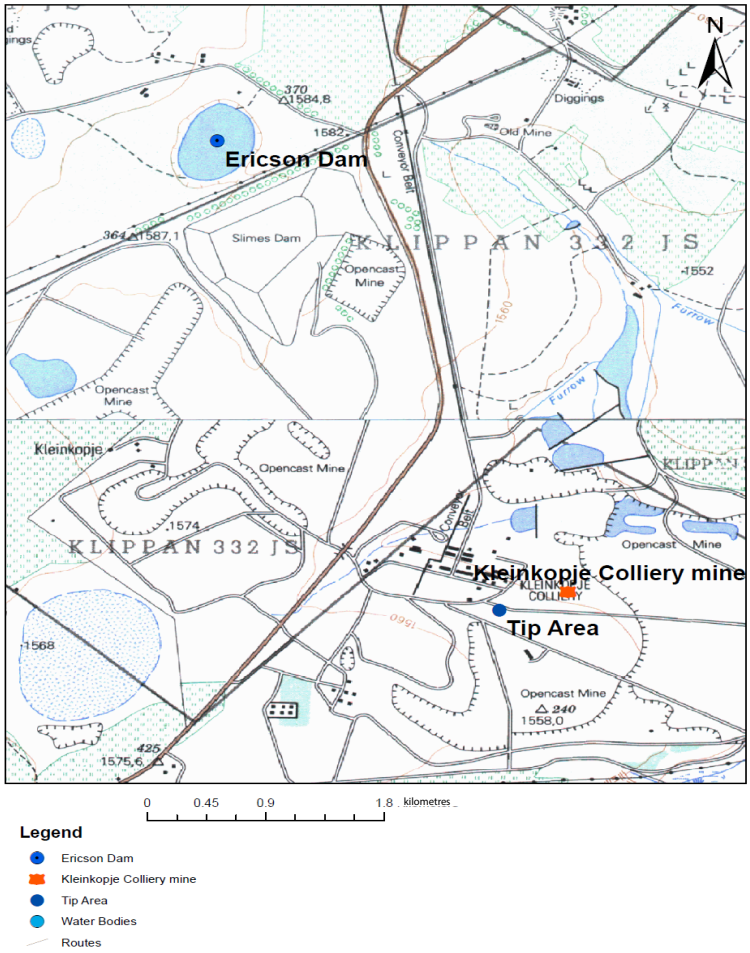
Map summarising the assessment and management of acid mine drainage in South Africa

ST-2013-1176

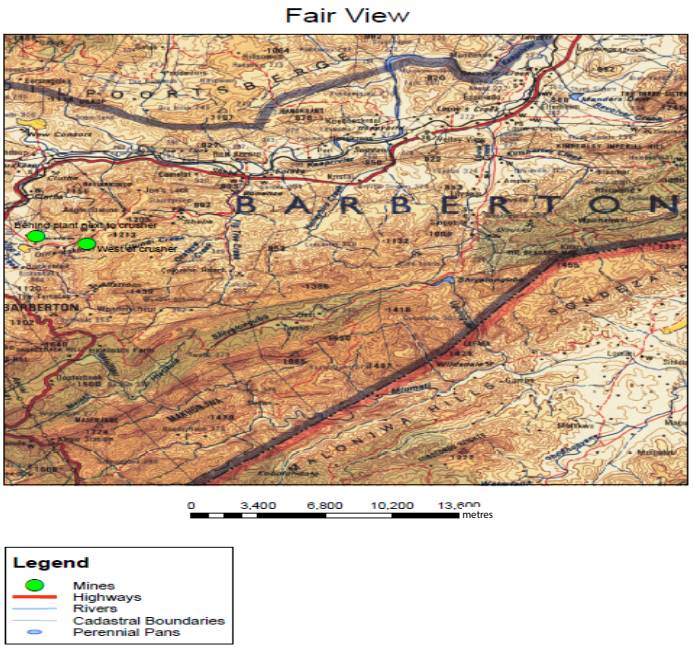
Air quality monitoring and dust deposition in coal mines and gold mines

Project leader	M Kwata, BSc Hons
Project team	A van Averbeke, BTech, M Modiba, BSc Hons (Geol)
Primary objective	To do air quality monitoring, to identify and quantify the pollutants and to develop a dispersion model of these air pollutants
Duration	2013 to 2014
Budget	R435 740.00

ASTM 1739:98 with wind shield



Map showing dust sampling points for Kleinkopje colliery mine: a) Ericson Dam; b) Tip area



Fairview gold mine: a) Fairview adit; b) Fairview biox plant

Motivation

To develop capabilities in air quality techniques and to gain skills and knowledge in the air quality field.

Conclusions

Dust deposition rates for coal mines are higher than dust deposition rates for gold mines. The direction of the wind is mostly from the south and the most dominant minerals are quartz, kaolinite and plagioclase which contribute to dust-generating activities in coal and gold mines.

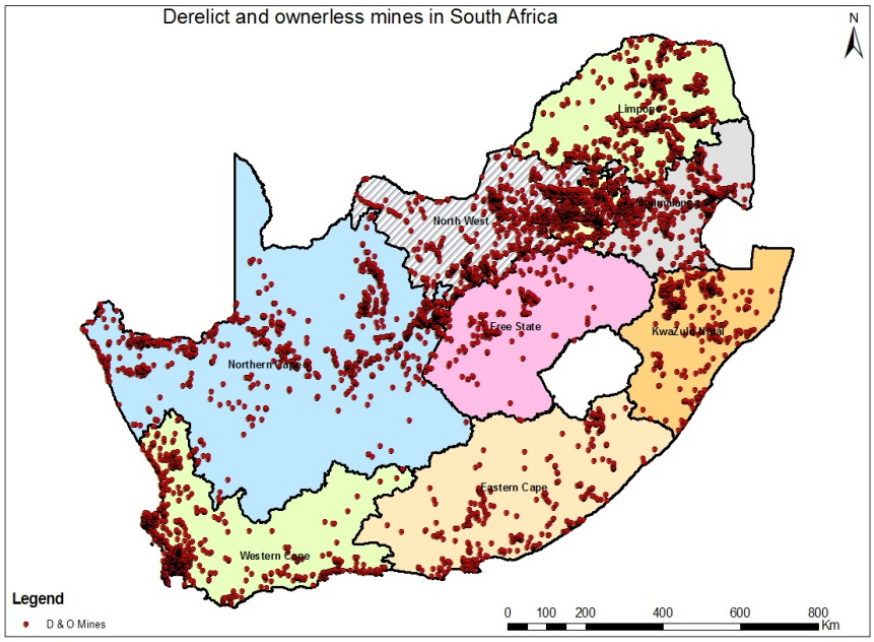
Future activities

Fieldwork to sample street dust will be completed in the Barberton area, the results will be interpreted and a final report will be submitted.

ST-2013-1165

Management of state contingent liabilities with respect to derelict and ownerless mines in South Africa

Project leader	M Makgae, PhD
Project team	H Coetzee, PhD, G Dube, BSc Hons, D Molapo, BSc Hons, D Sebake, MSc, SK Lekoadu, BSc Hons, S Tlowana, MSc Three year D&O contract employees: SP Gcasamba, BSc Hons, T Kgari, BSc Hons, K Madikizela, BSc Hons, B Mahlase, BSc Hons, K Matshusa, MSc, B Monchusi, BA Hons, T Ramukumba, BSc Hons, B Sibiya, BSc Hons, S Sogayise, BSc Hons, N Smit (IT database) D&O interns: N Kanedi, BSc Hons, LN Lekgothoane, BSc Hons, U Mahlati, B Tech, L Mashamba, BSc Hons, K Masindi, BSc Hons, T Motsoenyane, BSc, O Mtyelwa, BSc Hons, O Musi, BSc Hons, N Ndou, BSc Hons
Primary objectives	- To update, maintain and rank the database and to improve its integration into the licensing system of the Department of Minerals and Energy - The database should facilitate the estimation of the contingent liability of the Department of Minerals and Energy with respect to derelict and ownerless mines - Rehabilitation plans must be developed and bills of quantities on identified mine sites must be developed - A field investigation and database ranking will be undertaken to identify priorities on an ongoing basis - Dangerous openings will be closed where these pose an immediate threat to human safety
Duration	2013 to 2015
Budget	R60 000 000.00, with R20 000 000 transferred annually.



Map indicating the derelict and ownerless mines in South Africa

Motivation

Between 2005 and 2008, the Council for Geoscience (CGS) developed and populated a national database of derelict and ownerless (D&O) mines on behalf of the Department of Minerals and Energy (DME) as part of the Sustainable Development through Mining (SDM) project. This database, currently containing over 6 000 records, is the most comprehensive database of its kind currently available in South Africa, although it does have certain inherent shortcomings in terms of requirements which were beyond the scope of the original project. In addition to the identification of sites, the SDM deliverables included a ranking system, which was intended to rank sites in terms of their priority for rehabilitation. A desktop system was developed, but it was concluded that this could provide no more than a screening of sites and that field investigations would be required to adequately assess sites. The scope of work of the Council for Geoscience is mainly to quantify and characterise the State's potential liability by:

1. compiling and maintaining a database of derelict and ownerless mine sites,
2. investigating these sites to determine what work is needed to reduce potential public health and safety and environmental risks to acceptable levels and to estimate costs for the required interventions, and
3. annually updating an estimate of the potential liability of the State by using the generated information.

Progress

- Completed the asbestos field investigation of about 246 sites and ranked them; the report was submitted to the DMR
- Completed the annual assessment of the state potential liability; the report was submitted to the DMR
- Closed mine holes in Gauteng, with temporary jobs being created to the local communities; closure certificate was submitted to DMR.

Conclusion

The work has progressed well and other commodities such as gold, coal, copper and sand from other provinces are also being considered. The database is improving each day as more data are accumulated and uploaded. The Council for Geoscience is now in the process of linking the minehole database to the D&O database. The merging of the two databases is progressing well. The DMR regional office has also provided the Council for Geoscience with information with regard to the D&O sites that now have either prospecting or mining rights. This is also going to be an ongoing task to keep the database up to date and optimally refined.

Future activities

- Detailed field investigation is ongoing for Gauteng, Limpopo, Mpumalanga and KwaZulu-Natal
- Civil engineering services
- Closure of holes in the Gauteng Province
- Closure of holes in the Mpumalanga Province
- Closure of holes in the Limpopo Province
- Rehabilitation of gold mines in Gauteng
- Designs and Bills of Quantities for rehabilitation of Stella 1 & 2 and Kaapsehoop
- Rehabilitation of D&O coal mines in eMalahleni (Witbank).

ST-2013-1177

Environmental impacts of South African mines — a holistic approach towards best management practices on impact prevention and remediation

Experiment 1. Realistic simulation of acid mine drainage generation in the gold mines of the Witwatersrand, South Africa

Experiment 2. Laboratory simulation of the effects of influent acid mine drainage on dolomitic aquifers

Project leaders	SI Tlowana, MSc (Chem), H Coetzee, PhD, M Makgae, PhD, M Kotoane, BTech (Chem)
Primary objective	The production of a publication or thesis is not a primary objective. The primary objective may be an intangible which can be communicated through a document
Duration	2012 to 2015
Budget	R335 640.00

Motivation

Experiment 1 — Rationale

Since the underground mine voids in the Witwatersrand gold mining basins are rapidly flooding with water, there are concerns expressed regarding the fate of the mine water that is being generated. Two opinions regarding the management of this problem have been expressed:

- The mine water should be pumped out and treated for discharge purposes, in which case the walls of the mine voids that contain pyritic rock will be further exposed to oxygen.
- The mine voids should be allowed to flood with water which will devoid the oxygen and oxidation of the pyritic rock will be limited.

This experiment therefore aims to simulate these scenarios and to understand which of the two options generate better-quality mine water. It was decided to carry out column leach experiments simulating the two conditions.

Experiment 2 — Rationale

The research will specifically investigate the dissolution of dolomite in acid mine water generated from the mining activities in the western basin of the Witwatersrand. Chemical and mineralogical data will be used to assess the occurrence and effect of various reactions, while petrographic and scanning electron microscopic investigations will be used to identify the effects of the dissolution reactions and the precipitates that form.

A two-column experiment was set up so as to resemble an aerated mine area generating acid mine drainage (AMD) and the subsequent reaction of acid mine water with underground dolomite under saturated conditions.

The Council for Geoscience, as a scientific advisory body for the Department of Mineral Resources, was tasked to conduct research to address the issues related to the prevention of water ingress into the underground workings of the Witwatersrand mining basins. In particular, the research is aimed at identifying sustainable management options to:

- prevent ingress of surface and groundwater into the underground workings
- manage decant of mine polluted water
- predict and prevent harm to the environment
- apportion pollution sources and liabilities
- develop a mine water management strategy.

Progress

Experiment 1

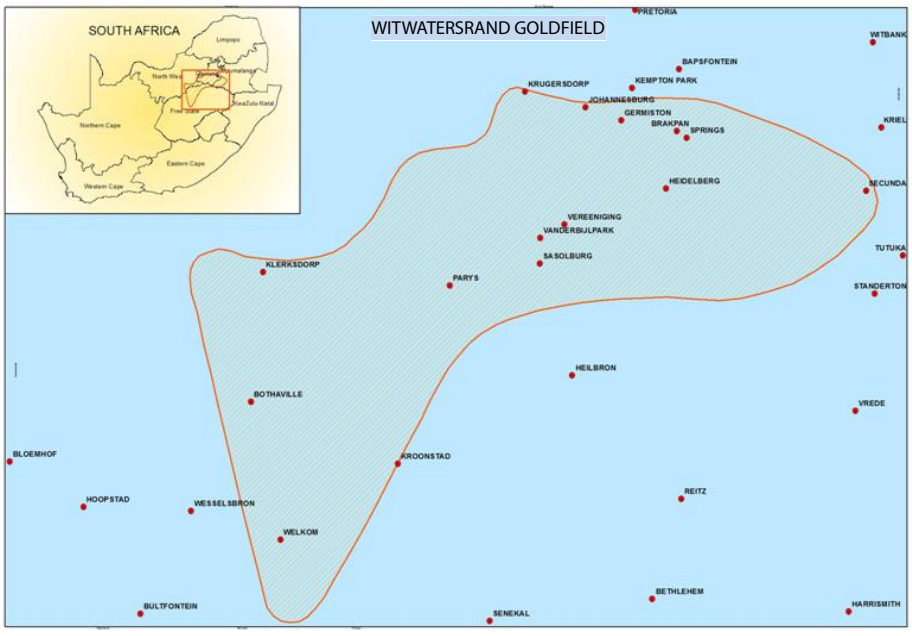
The rock and AMD samples that were used for the project were characterised by XRD, XRF, C and S analyses, ICP-MS and IC spectrometry. The experiment was set up and run for more than a year and all the data generated were published in Volume 1 of *Reliable Mine Water Technology*. The data were also presented as a poster at the IMWA2013 Conference in Colorado, USA.

Experiment 2

The rocks and AMD samples used for this experiment were characterised by XRD, XRF, C and S analyses, ICP-MS and IC spectrometry. The experiment was set up and has been running for nine months. The data generated from the experiment were submitted as a quarterly report for the financial year 2013/14 and an updated report will be submitted later.

Future activities

The experiment will be run until all the reactive constituents are depleted. A kinetic model will be generated from the data generated by the two experiments.



Location map showing the Witwatersrand goldfields

GEOPHYSICS

GEOPHYSICAL INTERPRETATION

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	2007 to 2014

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 on the subsurface geometry, which is of both academic and economic interest. If, for example, thorough and robust modelling confirms the presence of mafic rocks in the central part of the complex, the total economic resources of the complex will be hugely increased. In addition, possible configurations of the mafic rocks (e.g. flat/doming/sagging) deduced from the modelling process can contribute to the understanding of the emplacement and geological history of the Bushveld Complex.

Progress

Work this year focused on studying various emplacement models that have been proposed for the Bushveld Complex over the years. These include, amongst others, a lopolith originating from vents located at the intersection of the Thabazimbi Murchison Lineament (TML) and the Great Dyke, magma feeders located throughout the complex, a mantle plume and finally emplacement of a sill-like body via the TML. This knowledge will be very important during the creation of the final 3D model as the geometry and emplacement mechanisms are linked. Once the 3D potential field model is at a point where the present-day geometry of the complex is better understood, the model that best explains how the geometry could be achieved can be identified.

In addition to the emplacement models, the three published conceptual geophysical models of the Bushveld Complex were re-examined in light of new crustal thickness data and the availability of fully three-dimensional modelling software. New information about the crustal thickness has only become available in the last decade and could therefore not be considered in the earlier models. Also, all of the models published up to now have been done in 2 or 2.5 dimensions, which is not well suited to modelling the complex geometry of the Bushveld intrusion. Three-dimensional modelling takes into account the effects of variation in geometry and geophysical properties of lithologies in a full three-dimensional sense and therefore affects the shape and amplitude of the calculated fields. The three published geophysical models were remodelled using full three-dimensional potential field modelling software and including crustal thicknesses obtained from the Southern African

Seismic Experiment (SASE). The aim was not to construct very detailed models, but to test the existing conceptual models in an equally conceptual way. Including the thicker crust underneath the Bushveld Complex necessitates the presence of dense material in the central area between the eastern and western lobes. The simplest way to achieve this is to model the Rustenburg Layered Suite as a single intrusion. This is similar to the suggestion of the first students of the Bushveld Complex. In addition to these findings, variations in the mantle density also appear to contribute to models of this scale and have to be considered. Conceptual models are, by definition, simplified versions of the real situation and the geometry of the Bushveld Complex is expected to be much more intricate.

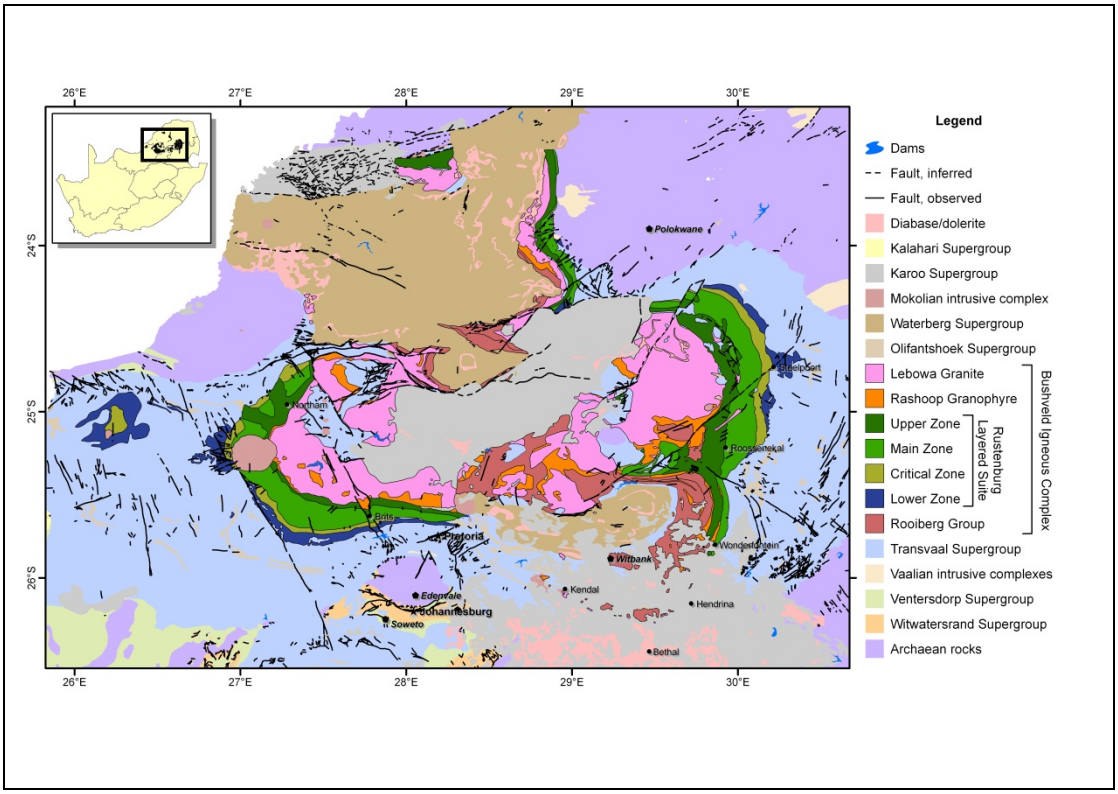
Finally, a number of different modelling packages that are available at the Council for Geoscience were compared. One is a commercial package (Modelvision Pro), the second is freeware (Geomodel) and the third is an in house-developed 3D package (PyGMI). The main reason for comparing these was to illustrate that PyGMI provided acceptable results since it will be the 3D modelling used to create the Bushveld 3D model. The results calculated by the three packages were the same.

Conclusions

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

Future activities

The three-dimensional model will be created in the forthcoming year.



Geological map of the Bushveld Complex

ST-2012-1148

Geophysical 3D modelling of the Karoo Basin

Project leader	SE Scheiber-Enslin, MSc
Primary objective	To create a three-dimensional model of the Karoo Basin using gravity and magnetic as well as seismic and borehole data with the aim of improving the understanding of the geometry and tectonic formation of the basin
Duration	20012 to 2014
Budget	R210 000.00

Motivation

No clear tectonic model exists for the Karoo sedimentary basin in South Africa, which is a possible host for Permian shale gas. The main aim of this proposed project is to create a 3D geological model of the Karoo Basin using geological information, magnetic and gravity data, and supplementary borehole and seismic data. This model will be used to investigate the tectonic environment of the Karoo and the dynamic formation of the basin in terms of the flexural response on- and off-craton, as well as the possible formation of natural gas deposits.

Progress

2D potential field models that were created in 2011 and early 2012 were combined into a 3D model using IGMAS+ software during a research visit to the Norwegian Geological Survey in April/May 2012. This basic model will be refined as new data sets become available. One such data set is the SOEKOR seismic data that was shot in the southern Karoo during the 1960/1970s. Using a free education licence for Kingdom Suite software, the seismic data were interpreted in late 2012/early 2013. Seismic horizons were constrained using deep SOEKOR boreholes drilled in the Karoo and velocity estimates from previous seismic surveys in the area. The data will now be used to refine and extend the 3D model to include a larger part of the Karoo. Additional boreholes that were recently obtained will be included in the model.

Further investigation into the source of the Beattie Magnetic Anomaly in the basement rock below the southern portion of the Karoo Basin revealed the need for a more comprehensive investigation of the geology and geophysical data collected over the anomaly to better understand the source. Several possible explanations have been proposed for the source anomaly, such as serpentinised oceanic crust, mineralised shear or thrust zones, or a disseminated magnetic-sulphide body within the middle crust. The anomaly is shallowest on the east coast, which led to an investigation into the basement rocks that are exposed further north of the anomaly (the anomaly itself is covered by younger Karoo and Natal rocks) which, in turn, revealed a correlation with similar magnetic anomalies. These similar magnetic anomalies north and south of the Beattie may also be correlated with anomalies on seismic and magnetotelluric profiles collected over the area. A field trip to the area in 2012 confirmed that rock magnetic susceptibilities were highest within zones of shear, as well as measured ground magnetic data. Thin sections cut from collected rock samples revealed primary magnetite mineralisation. The results of these investigations suggest that these magnetic anomalies could be linked to mineralised shear zones. The link between the Beattie in South Africa and other similar anomalies in the Antarctic was also studied.

Conclusions

Karoo Basin

- The first comprehensive depth map of the Karoo using borehole (Council for Geoscience, SOEKOR and private) and seismic (SOEKOR and Inkaba) data.
- A gravity high in the central-south Karoo appears to be correlated with a reduction in basement depth.
- More dolerite dykes are visible in the SOEKOR seismic data in the north and east.
- Basin depths are shallowest over the Kaapvaal Craton, deepen to the south over the Namaqua-Natal mobile

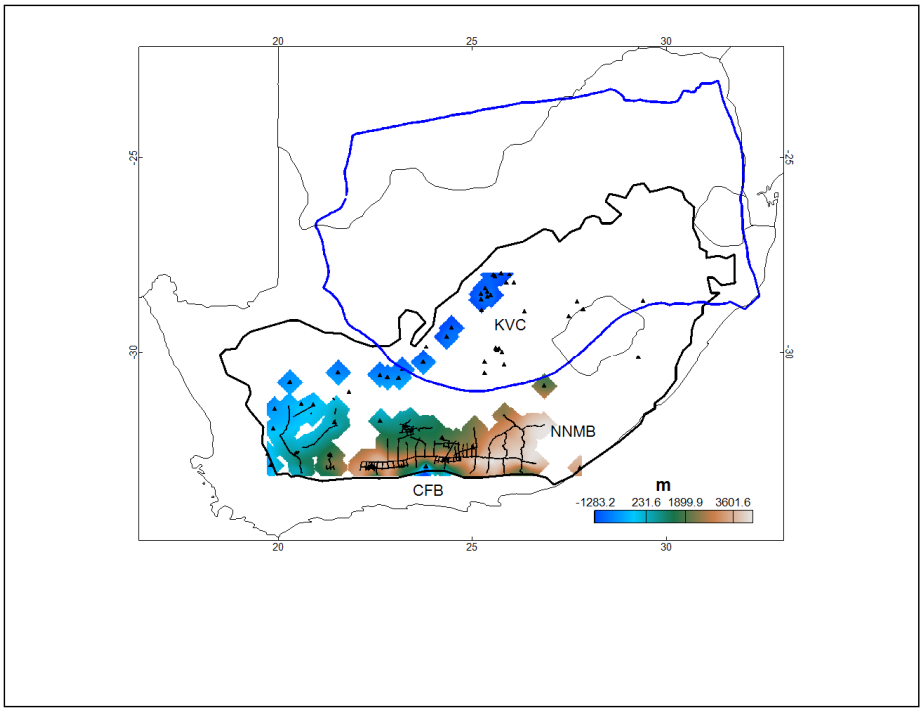
belt and are deepest in front of the Cape Fold Belt. This preliminary result shows how the rheology of the different basement blocks has affected the formation of the basin.

Beattie Magnetic Anomaly

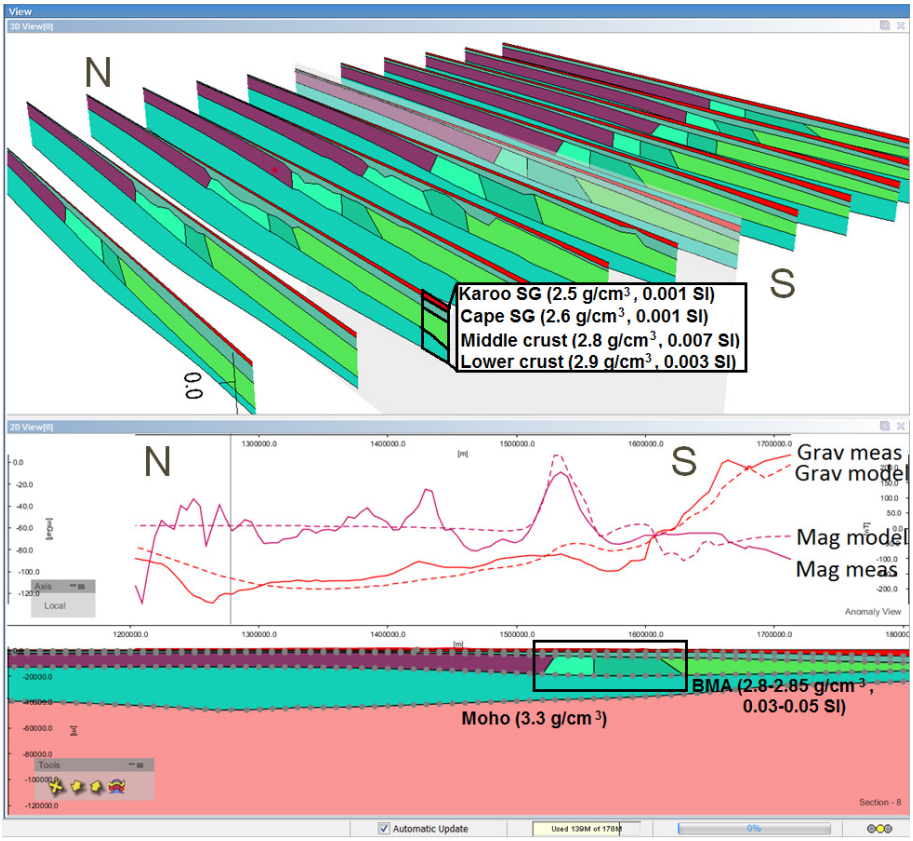
- On the east coast of South Africa, the BMA appears to be correlated with magnetic bands to the north (Williston anomaly) and south (Mbashe anomaly), although the BMA has the highest amplitude. These magnetic bands were correlated with similar high-velocity anomalies on seismic profiles and zones of high conductivity on magnetotelluric data.
- The BMA is covered by younger rocks across its entire profile, though basement rocks are exposed to the north around Amanzimtoti that are correlated with the Williston anomaly. These basement rocks have been strongly sheared in places which appear to be attributable to the strong magnetic anomalies.
- Ground magnetic profiles collected over these shear zones show magnetic highs over regions of maximum shear, which are also correlated with high magnetic susceptibility readings.
- Thin sections from rocks collected within shear zones show primary magnetite mineralisation.
- These ~1.1 Ga orogenic basement rocks appear to be correlated with similar-age western Dronning Maud Land orogenic belts with recorded high magnetic susceptibilities and similar magnetic anomalies, which were linked during Gondwana times. The BMA is therefore a result of mineralised shear zones.
- The models will now be used to consider how the Beattie anomaly formed in the context of the broader South African tectonic history, as well as how the source affected the flexural response of the southwestern South African lithosphere, namely during the formation of the Karoo.

Future activities

During 2013/14, the preliminary potential field models will be combined into a final 3D model on which flexure studies can be conducted in order to investigate the formation of the Karoo Basin.



Elevation map of the Ecca shales within the Karoo Basin



IGMAS model of the southwestern Karoo Basin

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, PhD 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	Report year: R412 070.00

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 2012/13, petrophysical analyses, including bulk density, magnetic susceptibility, intensity of magnetisation, magnetic remanence, electrical resistivity, induced polarisation as well as seismic velocity, were performed on different stratigraphic units in South Africa. However, due to staff shortages, not all the data have been captured into the Oracle-based Physical Properties Atlas of South African Rocks.

Mainly three study areas were covered, which include a general petrophysical analysis of sediments in the Karoo Basin, an electrical property analysis in the Sadini hot springs area as well as mineral exploration in the Bronkhorstspruit area.

A research report on the seismic characteristics of coal from the eMalahleni area and a detailed petrophysical characterisation of sediments from several deep boreholes in the Karoo Basin were produced.

The petrophysical database can be queried via an open-source Google maps application that allows the user to zoom into the 1:100 000 geology map of South Africa and query specific stratigraphic formations for available petrophysical data in the database.

Research on the influence of super-paramagnetic minerals on measured electrical properties were conducted by Dr V Zadoroshnaya using the IP method.

Conclusions

The project is on track with its research efforts using different physical properties, but owing to a lack of resources is lagging behind in its efforts to create a complete petrophysical atlas for all the stratigraphic units in South Africa.

Future activities

A new sample core IP tester was purchased to perform resistivity and IP tests in the laboratory. Comparative tests will be performed on the new and old instruments before implementation will take place.

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	To study the geothermal history of the Karoo Basin for a PhD degree
Duration	2009 to 2014
Budget	In total: ~R2 316 617.50; Report year: R631 539.32

Motivation

The first three years of this international collaboration project were funded in part by the National Science Foundation. The aim of the project was to gain valuable experience and to build important relationships with leading scientists from America.

As a spinoff from the NSF-funded project, a PhD was registered by the project leader at the University of Johannesburg with the aim 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 whether the emplacement of large volumes of magma was preceded by a large-scale, low-grade thermal doming similar to that 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 known dimensions.

Progress

During 2012/13, rock magnetic data from four stratigraphic boreholes that intersect dolerite sills at different depths were studied. Magnetic susceptibility, normal remanent magnetisation (NRM), anisotropy of magnetic susceptibility (AMS), thermal demagnetisation for magnetostratigraphic analysis as well as the variation in Alteration Index (A_{40}) were measured on samples collected from these cores at different depths.

Results indicated that re-magnetisation because of the heating effect of the dolerite intrusions is limited to short distances within the contact aureole. For the four boreholes studied, this heating effect was never wider than half of the sill thickness. However, a general increase in the thermal effect of the intrusions on the Karoo sediments was observed from southwest to northeast across the Karoo Basin.

The influence of the Cape Fold Belt on the Karoo sediments was investigated. For this purpose, a classic fold test was performed on samples collected from three folds from the Ecca Group sediments situated near the town of Laingsburg, Western Cape Province.

Results indicated that in the lower Ecca Group, a significant fold test could be achieved at 30 % unfolding, while for the upper Ecca Group this was achieved at 100 % unfolding. This would suggest that the thermal effect was only significant in the lower part of the Ecca and did not extent far from the Cape Fold Belt itself.

Conclusions

Results indicated that re-magnetisation owing to the heating effect of the dolerite intrusions are limited to short distances within the contact aureole. A general increase in the thermal effect of the intrusions on the Karoo sediments was, however, observed from southwest to northeast across the Karoo Basin.

The geothermal effect of the Cape Fold Belt was found not to extend far into the Karoo Basin.

Future activities

During 2013/2014, the aim will be to repeat the three magnetic experiments on samples from boreholes that do not intersect any dolerite sills. This will be done to determine the background temperature of the Karoo Basin before the intrusion of any magma.

The amount of different magnetic carriers as well as their grain size will also be determined during 2013/14 at the Institute for Rock Magnetism (IRM) using specialised instruments that are not currently available in South Africa. As the magnetic minerals are temperature dependent, the knowledge of their existence and proportions can be used as geothermometers.

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, PhD, E Havenga, BSc Hons, E Chirenje, MSc, D van der Walt, BSc Hons and C Mukosi, BSc Hons
Primary objective	Follow-up geophysical surveys over selected mineral and groundwater target zones using remote sensing data and ground geophysical methods
Duration	2012 to 2013

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. The study may also contribute to sustaining the agricultural sector in periods of drought.

Progress

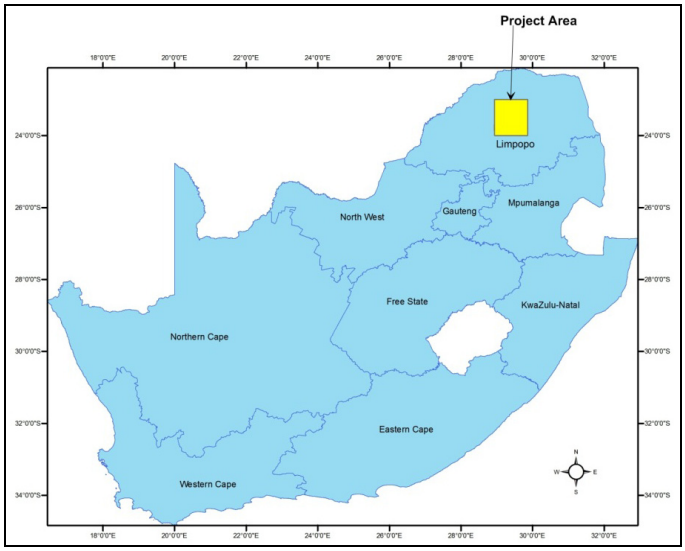
High-resolution airborne magnetic and radiometric data which were collected over an area covered by nine 1:50 000 sheets in the central part of the Capricorn District in the Limpopo Province were interpreted for groundwater and mineral potential.

Interpretation work identified a number of mineral exploration targets (gold, copper, nickel, corundum, uranium and rare-earth elements). Currently, a review to link the ore gneiss to the structures identified by high-resolution airborne interpretation 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.

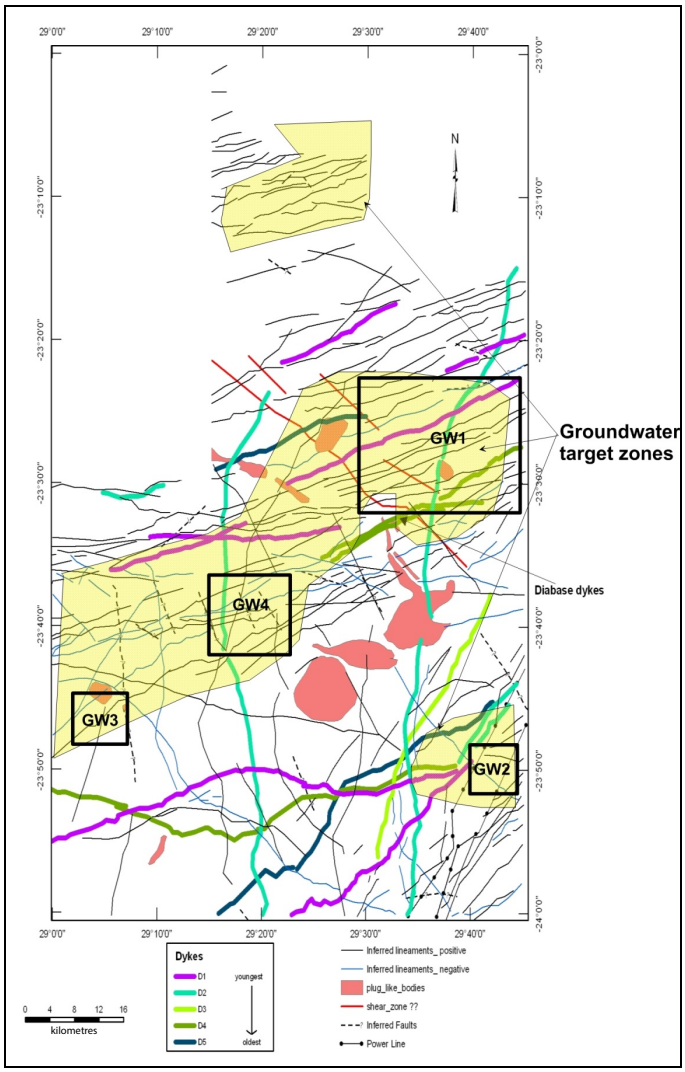
Groundwater studies showed that the northern and central-eastern parts of the study area are potentially feasible for groundwater occurrences, while the southern and southwestern parts of the project area are dry with bare soil and no surface manifestation of the availability of groundwater. Regional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

Future activities

Drilling targets identified will be revealed 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.



Location map of project area



Combined airborne magnetic data, geological drainage lines and satellite imagery interpretation (yellow polygons) showing groundwater target areas

ST-2013-1172

The development of a modelling system in 2D and 3D

Project leader	P Cole, PhD
Project team	G Cooper (Supervisor), J Cole, MSc
Primary objective	To create 3D modelling software
Duration	2013 to 2017

Motivation

The collection of potential field data has long been a standard part of geophysical exploration. The interpretation of such data can be a daunting task, especially since 3D models are becoming more necessary. The current trend in modelling software is to follow either the modelling of individual profiles, which are then "joined" up into 3D sections, or to model in full 3D using polygonal-based models. Unfortunately, both techniques have disadvantages. When modelling in 2.5D, the impact of other profiles is not truly available on the profile being modelled, and vice versa. Although the problem is not present when full 3D algorithms are used, 3D polygonal models have other shortcomings. While it is easy to construct the initial model, it is not as easy to edit this model in a short time span. In some cases, the entire model must be recreated from scratch. The ability to easily change a model is the very basis of forward modelling. This project seeks to find ways to greatly accelerate 3D modelling.

Progress

The software adopts a voxel-based approach, rather than a polygonal approach. The solution for a cube is used to calculate the potential field for each voxel and the voxels are then summed over the entire volume. The language used is Python, because of the large number of scientific and graphical display libraries available.

The interface to the program is similar to a paint program. The model is simply drawn into the side views or top views of the volume of interest. Relevant voxels are either activated or deactivated in this way.

The software has enabled faster modelling of anomalies in a non-complex manner, implying little or no training of prospective users.

The software in its basic forward modelling form is complete. The resulting code has been extensively tested in-house and has since been launched as an open-source package on the website https://code.google.com/p/pygmi/.

Conclusions

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

Future activities

Future work will examine newer techniques to incorporate to further enhance the interpretation process and automate the modelling.

ST-2002-0679

Upkeep and development of geophysical databases

Project leader	M Havenga, BSc Hons
Project team	L Ledwaba, BSc Hons (Geophys.)
Primary objective	To maintain and expand geophysical databases, including GIS coverages
Duration	Ongoing

Motivation

The Geophysics Unit has vast amounts of data. The data need 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 and 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 and interfaces. The current financial year has mainly required data quality control and general maintenance since only a few surveys, mostly commercial, were conducted and little data captured. A high- resolution airborne survey specification report was completed for the current data coverage.

General maintenance and upkeep of the administration database was done, which included changing the format of reports to fit in with changes in Council for Geoscience policies.

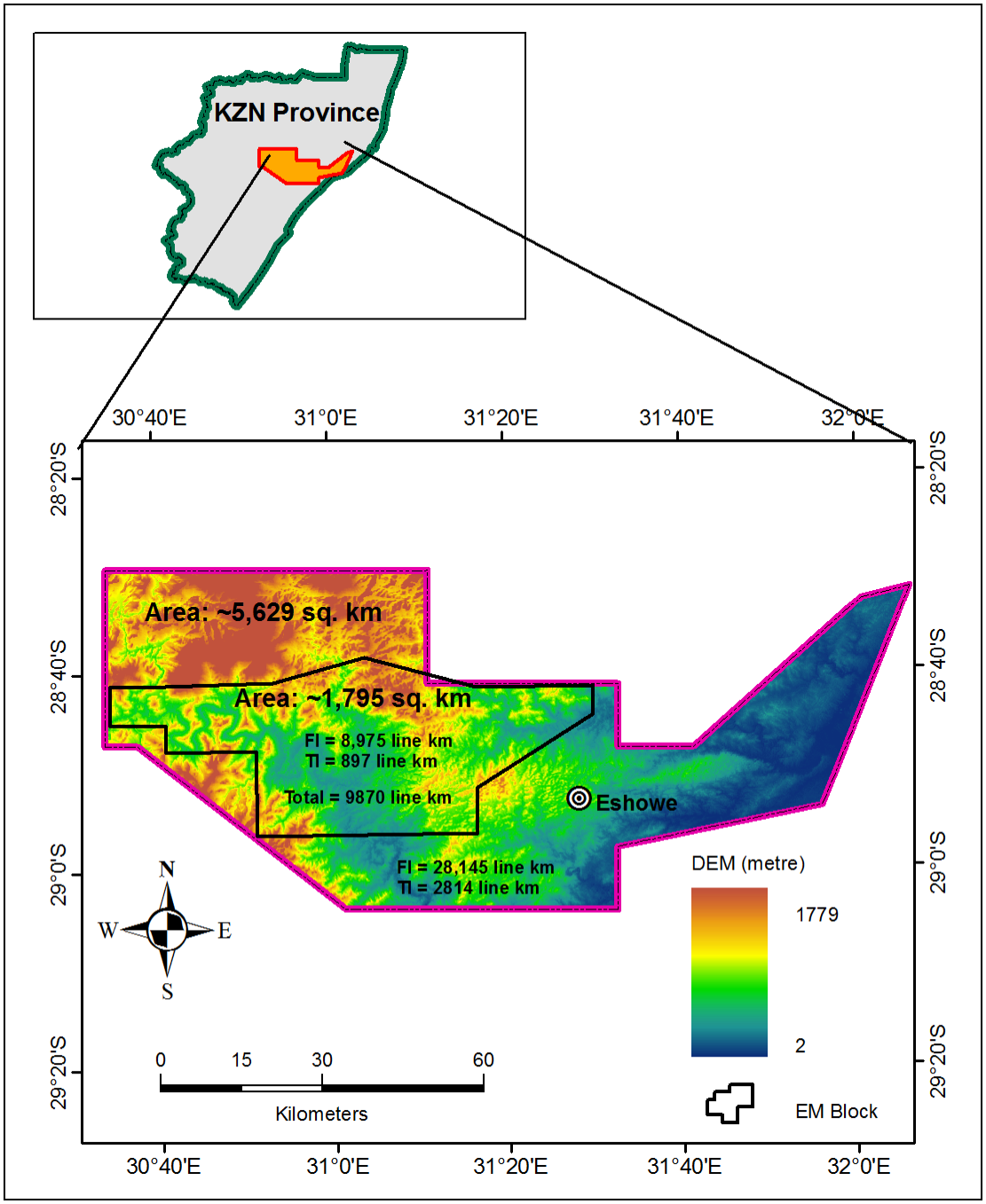
A high-resolution airborne survey collecting magnetic and radiometric data in the Eshowe area to aid in potential mineral target generation is currently underway in the Tugela Terrane of the KwaZulu-Natal Province. A time-domain airborne electromagnetic (VTEM) survey is also underway over a selected subsection of the area.

Conclusions

The database was maintained and the quality of the data improved during the year. New airborne geophysical data are captured as they are collected.

Future activities

The process to capture commercial ground survey data will be continued in the next financial year along with general maintenance and quality control.



Locality map of the Tugela survey

ST-2012-1149

Joint elastic and electrical properties based on laboratory measurements and mathematical modelling

Project leader	V Hallbauer-Zadorozhnaya, PhD
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	2013 to 2014

Motivation

Geophysical parameters such as acoustic velocity, resistivity and density are very important physical properties of rocks. For several decades many researchers tried to determine the properties using statistical approaches. Analytically, resistivity is estimated using Archie's Law, while velocity is estimated using the simplest formulae for minerals, but not sedimentary rocks. In contrast, statistical approaches can be done for any kind of rock, but the results are always very approximate and different. It is very important to "look into the rocks" using the petrophysical characteristics of the rock, as well as strong mathematical equations describing the petrophysical structure, and to calibrate these with laboratory measurements.

There are many equations describing the resistivity and velocity based on real physical parameters such as acoustic modules, pressure, water and gas saturation and clay content. For resistivity, the parameters include clay content, water saturation and salinity and the amount of double electric layers. Using Semenov's approach, the project leader developed the fractal model which is useful for calculating the following parameters: resistivity, permeability and hydraulic conductivity. The Council for Geoscience has instruments for measuring the velocity and resistivity of rocks.

For the first year of this project the equations for seismic velocity propagation and resistivity in the different kinds of rocks were collected and calculating programs were written in Matlab. Some measurements of resistivity and seismic velocity of selected samples are currently being done in the laboratory.

The aim of the new project is to join or combine geophysical parameters (resistivity, velocity and density) by the mathematical modelling of these parameters to characterise different types of rocks. For this project, the laboratory measurements must be done using different types of rock for the calibration of the theoretical considerations.

Progress

During the second year of the project different rock samples were collected, which included 37 samples of fresh rocks such as laterites, volcanic rocks, phyllites, pegmatites, ores containing haematite, quartzite, andalusite, dolerite, schist, etc. The rock samples were collected along several profiles in Rwanda where the Council for Geoscience carried out a geophysical survey. The samples were collected by Dr Claus Legler of BEAKS, Germany. Each sample was cut into two samples (A and B0 with standard size: cubic 2.5 cm of length). Measurements were carried out in the physical properties laboratory of the Council for Geoscience. The measured parameters were acoustic velocity, electrical resistivity and chargeability. Density of samples was calculated using gravity methods. Each sample was measured twice to achieve better accuracy. Average data will be used for the final calculation of the joint petrophysical parameter formulas. Each sample was measured using all three directions (X, Y and Z) to find the asymmetry of samples.

The resistivity and chargeability data were measured by using the amplitude of at least three currents. A picometer was used for the measurements. On the one hand, this method provides a better resolution and on the other hand each file with only one reading contains enormous masses of data (20 000 values). A code lab_data.m was written in Matlab which allows the calculation of the resistivity and chargeability for each reading.

Conclusions

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

Future activities

During 2013/14, the project will focus on determining the axe of asymmetry and commence the mathematical modelling of join petrophysical parameters characterising different types of rocks.

INFORMATION AND COLLECTIONS MANAGEMENT

Museum

Curator	K Nzolo, Museum Diploma
Project team	E de Kock, MSc, S Mahwayi
Duration	Ongoing

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

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 being identified and important fossils are being prepared to increase their research potential.

The exhibition series termed "Out of the Box" was continued. The exhibition displays ten or more favourite or unique specimens from the collections of individuals in the museum on a monthly basis. The 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.

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.

The museum participated in the National Science Week hosted at the University of Johannesburg campus in Soweto from 27 July until 2 August 2012. Some 55 schools and 5 000 learners attended this event and it provided an ideal platform to advertise the museum.

The Geoscience Museum participated in the Heritage Month Celebration hosted by the Ekurhuleni Metropolitan Municipality from 28 to 30 September 2012 by distributing promotional material.

The Think Pink exhibition was launched on 1 October 2012 for the duration of one month with the aim of creating a comparison between minerals and breast cancer awareness and of showing the role of pink minerals. Furthermore, on 1 December 2012, the Geoscience Museum, as a public institution, created awareness by putting up a banner to remind visitors of the dangers of AIDS.

During the Africa Cup of Nations, held in South Africa from 19 January to 10 February 2013, the Geoscience Museum put together a display of minerals found in the 16 countries that participated in the tournament.

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 material 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 disposal 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 full-text 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 services 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, including 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 on CD to the Geological Surveys of the countries in the Southern African Development Community (SADC). 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 backup 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 a 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 year under review included the Bulletin Series and the Explanations Series that accompany geoscience maps. Five bulletins were edited, prepared for publication and printed.

Progress

A number of publications were prepared in a digital format and are available at the CGS Bookshop. Many of the digital publications were printed and distributed to various institutions during the year. 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 vice versa. The translator is actively involved in editing and proofreading reports from various business units within the organisation and in editing French reports for various CGS projects in Francophone countries.

Future activities

The publishing and release of manuscripts will continue, as well as the translation of French texts.

Publications released during the year

Bulletin 142: Cretaceous to Recent evolution of the Durban Bluff and adjacent continental shelf by H.C. Cawthra

Bulletin 143: A preliminary understanding of deep groundwater flow in the Table Mountain Group (TMG) aquifer system by K.F. Netili

Bulletin 144: Landslide classification, characterisation and susceptibility modelling in KwaZulu-Natal by R.G. Singh

Bulletin 145: Acquisition, processing and enhancement of multi-channel radiometric data collected with ultralight aircraft-mounted detectors by H. Coetzee

Bulletin 146: Stratigraphy and sedimentology of the Karoo Supergroup in the Gemsbok Sub-basin (Botswana and Namibia) by V. Nxumalo

Explanation: Metallogenic Map Sheet 2628 East Rand (1:250 000). The metallogeny of the East Rand area by G. Henry and W.R. Oosterhuis

Explanation: Metallogenic Map Sheet 2918 Pofadder (1:250 000). The metallogeny of the Pofadder area by A.L.D. Agenbacht and W.R. Oosterhuis

Explanation: Metallogenic Map Sheet 3118 Calvinia (1:250 000). The metallogeny of the Calvinia area by D.I. Cole

Explanation: Sheet 2528CC: The geology of the Centurion area (Scale: 1:50 000) by S.A.B. Laubscher, M. van der Neut, D. van Tonder and D. Gqiba

Explanation: Sheet 2429BC: Geology of the Lebowakgomo area (Scale: 1:50 000) by R.W. Belcher

Explanation: Sheet 2627BC: Geology of the Westonaria area (Scale 1:50 000) by M. van der Neut, G.J. Davids, H. Coetzee and M. Cronwright

Explanation: Sheet 2528CD: Geology of the Rietvlei Dam area (Scale 1:50 000) by B.A. Ingram, H. Minnaar and M. Britz

Explanation: Explanation of the engineering and geotechnical conditions for the Silverton 2528CB 1:50 000-scale map sheet by S. Ngubelanga

Seismological Series 43: Catalogue of earthquakes in southern Africa and surrounding oceans for 2007

Annual Report of the Council for Geoscience 2012

Annual Technical Report of the Council for Geoscience 2012

Popular publications

GEOclips Volume 30. September 2012, 8 pp.

GEOclips Centennial Volume 31. November 2012, 24 pp.

GEOclips Volume 32. February 2013, 12 pp.

KWAZULU-NATAL

ST-2013-1170

A study of the Phanerozoic Natal mineralising event: Special reference to the Au-bearing quartz veins from the Chakaskraal goldfield, KwaZulu-Natal

Project leader	N Hicks, MSc
Primary objective	This research project comprised the geological mapping of the Natal Group within the Chakaskraal and Glendale regions of KwaZulu-Natal (1:50 000 sheet 2931AC Glendale), with special emphasis on mapping areas associated with gold mineralisation and previous mining and exploration. The Chakaskraal goldfield is the only known gold occurrence within the Natal Group and only saw limited exploration in the late 1980s. Detailed mapping, combined with mineralogical and geochemical analysis of the rocks within the goldfield, could assist in defining the genesis and timing of mineralisation which may be used in the formulation of an orebody model for future small-scale mining projects in the region
Duration	2013 to 2014
Budget	R16 100.00

Motivation

The project is part of a long-term commitment to refine and update the geological maps of KwaZulu-Natal. The Palaeozoic Natal Group crops out within the KwaZulu-Natal Province from Margate in the south to Hlabisa in the north. The group has been the subject of many literature studies, although none have dealt specifically with the gold mineralisation identified within quartz veins at Chakaskraal.

Gold was previously prospected and won from a small adit at the Linton Mine on the farm Chakaskraal in the early 1900s. This sparked a brief gold rush in the area with numerous gold occurrences being identified, associated with a large east–west-trending quartz breccia shear zone. Gold was also identified at a depth of ~60 feet below surface, associated with thin conglomerate beds and narrow clay seams intersected by the quartz veining.

No mineral occurrences within the region are being actively mined or prospected. However, new mineral-prospecting technologies and increased commodity prices may result in some of these occurrences becoming economically viable on a small scale. The detailed analysis of the geological structures within the Chakaskraal area with which gold mineralisation is associated could lead to the identification of new small-scale deposits that could be operated using new mining technologies.

Progress

The project has been completed with an extensive literature review having been undertaken, supported by field mapping and geochemical and petrographic analyses of samples from both the former mining area and surrounding Natal Group exposures. Detailed stratigraphic profiles were measured ~10 km to the north of the Chakaskraal goldfield in the vicinity of St Martins and Glendale. This area, due to the dissected nature of the terrain, exposes the most complete successions of Natal Group rocks, although the upper units are not exposed. Stratigraphic correlation was used to define the specific member in which the mineralisation at Chakaskraal was hosted. The Chakaskraal goldfield occurs within the Tulini and Newspaper Members of the

Mariannhill Formation of the Natal Group. Within the goldfield, outcrop is limited to small informal borrow pits and quarries and limited surface exposure within the highly cultivated sugar cane plantations of the north coast. Mineralisation is, however, subeconomic with ore limited to pockets of gold mineralisation associated with authigenic pyrite precipitated along fracture planes in the shear zone and in the surrounding sandstones and conglomerates.

A second, smaller gold-bearing area, Fawsley Park near Glendale, was also investigated as early mining reports from 1905 indicate that two boreholes were sunk in this region. Owing to a lack of mining activity in this region, no prospecting data were available and field mapping proved fruitless because of the highly cultivated nature of the land. No further exploration can be undertaken in this region without drilling.

Conclusions

The Chakaskraal goldfield represents one of the only known gold occurrences in the sedimentary rocks of the Natal Group. Gold is associated with authigenic pyrite mineralisation which is related to fluid movement and precipitation along brecciated fault zones within competent sedimentary lithologies of the Natal Group. Gold is of epithermal origin, having been precipitated at a depth of ~1.5 km in upper Natal Group lithologies beneath Karoo Supergroup lithologies. Mineralisation is associated with a large ~5 m wide shear zone consisting of brecciated sandstone and quartz veins at the Linton Mine in the Chakaskraal goldfield. It was initially presumed by early prospectors that the gold was also detrital in nature, being a placer deposit similar to that of the Witwatersrand goldfields. However, the association of gold and pyrite with conglomerate, sandstone and clay in the Chakaskraal goldfield is due to either localised fracturing, or increased pore space in which authigenic pyrite could be precipitated. Mineralisation is associated with extensively altered and silicified sandstones which form the wall rock to the Chakaskraal shear zone. Relatively high porosity within the sandstone and conglomerate wall rocks, as well as open channel permeability associated with fracture arrays, allow disseminated and fracture-associated precipitation of sulphides within the wall rocks. The identification of gold occurrences associated with faults in adjacent Karoo Supergroup lithologies by Goldfields Mining and Development as well as lode gold occurrences in the Chakaskraal goldfield therefore indicate that the goldfields represent an anomalous gold occurrence associated with Gondwana breakup faulting and late-stage Karoo volcanism.

Future progress

Although the project goals were achieved, the investigation has highlighted potential for further research which must include the following:

- Shallow exploration drilling should be undertaken along the structure at the Linton Mine at Chakaskraal to properly define the mineralisation at depth and to provide fresh samples to be used for petrographic studies and assayed for gold content.
- The old mine adit should be dewatered to gain access to the mine and, if safe, underground channel samples retrieved for gold assaying.
- A detailed study of the late-stage faulting and late-stage intrusion of Effingham-type dolerites and their possible association needs to be undertaken as these dolerites could have provided the heat and mineralising fluid source for the Chakaskraal mineralisation. The identification of authigenic sulphides within the Effingham dolerite suite also needs to be investigated. The timing of intrusion and late-stage faulting within KwaZulu-Natal has been assessed in this report but needs to be studied in detail as the correlation of the Chakaskraal shear zone to the Type II faulting along the northern coastline of KwaZulu-Natal opens up the possibility for further exploration for possible epithermal fault/shear zone hosted gold in KwaZulu-Natal.

ST-2013-1173

Remote sensing analysis of regolith susceptibility to erosion on the Eastern Cape Wild Coast

Project leader	RG Singh, MSc
Primary objective	This research project aims to develop a local-scale monitoring practice to predict soil erosion susceptibility and impacts along the Eastern Cape Wild Coast. The soil erosion study will combine remote sensing techniques and Geographic Information System (GIS) methods which will facilitate the mapping and classification of eroded areas and spread patterns using historical time-slice imagery to evaluate both water and wind erosion models. Historical time-slice imagery will also be utilised to assess biophysical and socio-economic conditions preceeding and following erosion development. Spatial analysis will aid the identification of relationships and thresholds of causal factors. The project has been registered for a PhD at the University of Stellenbosch
Duration	2013 to 2017
Budget	R26 100.00

Motivation

This capacity building, remote sensing geohazard project forms part of the Department of Science and Technology (DST) funded umbrella project entitled *Earth Observation and Geological Hazard Assessment: Towards the creation of the Geological Hazard Atlas of South Africa.* Soil erosion is a global geohazard resulting in land degradation which may lead to desertification. According to the website of the International Union of Geological Sciences, soil erosion rates in Africa are double those of the United State of America. In South Africa, many areas in the Eastern Cape Province are affected by soil erosion, which poses both onsite and offsite threats. Alfred Nzo District Municipality within the Eastern Cape identified soil erosion and land degradation as environmental challenges in its 2012–2017 Integrated Development Plan. Within the Alfred Nzo District Municipality, widespread soil erosion is associated with communal croplands around Xolobeni on the Eastern Cape Wild Coast, designated by the World Wildlife Fund as an International Global Ecoregion of Global Significance. Despite the risk to an area with high environmental status, there is currently no local-scale soil erosion monitoring protocol that can highlight areas at highest risk. The development of a decision support tool that could predict local-scale erosion susceptibility and assess critical impact areas is therefore crucial.

Progress

The initial phase of the project comprised a literature review, the collation of available historical aerial photographs and preliminary erosion mapping, confined to the Xolobeni pilot study area which has several generations of wind and water erosion related to development and rural agricultural practices. Mapping involved visual interpretation and digitisation of eroded areas and patterns based on multitemporal imagery (1937–2012). Initial erosion mapping indicates that anthropogenic activity accelerates erosional processes, which is evident in the increased introduction of bare patches in the communal croplands and along access tracks. Some of these bare patches have occurred on low-gradient slopes with sandy soil substrate that is particularly susceptible to wind erosion. Water erosion is conspicuous along the steeper slopes where agricultural activity has historically been conducted on the coastal dune ridge and areas where remobilisation of dune sand has created bare surfaces. The pilot study area has revealed that the transverse dunes within the wind remobilised dunefield reverse their direction of movement in response to seasonal wind patterns and that some dunefields have expanded laterally through time whereas others have recovered and/or stabilised.

Conclusions

Preliminary mapping has revealed a complex erosional history with an overall increase in erosional activity over the past 75 years along the Xolobeni coastal region.

Future progress

After a full spectrum of historical Landsat imagery has been obtained for the end of the wet and dry seasons, further investigations will be conducted in the pilot study area to test proposed remote sensing, spatial

analysis and susceptibility evaluation methodologies. The temporal mapping of erosion and causal factors will make use of the Brilliant Index, Normalised Difference Vegetation Index, image classification (Maximum likelihood classification or iterative self-organising data analysis) and post classification. Soil erosion susceptibility will be evaluated using the Universal Soil Loss Equation and Wind Erosion Susceptibility model. Only successful methodologies will be extended to the broader Wild Coast study region.

LABORATORY

Ongoing services — XRF analyses

Project leader	HCC Cloete, BSc Hons, PrSciNat
Project team	M Crowley, BSc Hons, KIG Burger, ME Tsaagane, MJ Matji, J Mbonane
Primary objective	To provide chemical analyses by X-ray fluorescence spectrometry

Motivation

X-Ray Fluorescence Spectrometry (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by having been bombarded with high-energy X-rays. At the Council for Geoscience, the method is used for the chemical characterisation of rocks, soils, ceramics and building materials and for research in geochemistry.

Progress

Two X-Ray Fluorescence (XRF) spectrometers are used for the analysis of a wide range of samples:
PANalytical Axios, a wavelength sequential XRF spectrometer equipped with a 4 kW Rh-tube. The instrument is mainly used for the analysis of major elements on fusion disks and trace elements on pressed powder wax pellets. About 7 200 samples were analysed for major and/or trace elements during the financial year.
PANalytical MagiX Fast, a wavelength simultaneous XRF spectrometer equipped with a 4 kW Rh-tube. The samples from the helicopter-assisted sampling projects were analysed by the MagiX on pressed powder wax pellets. Four thousand five hundred (4 500) samples were analysed in the financial year.
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. About 6 850 samples were analysed for commercial clients to the value of about R1.2 million.

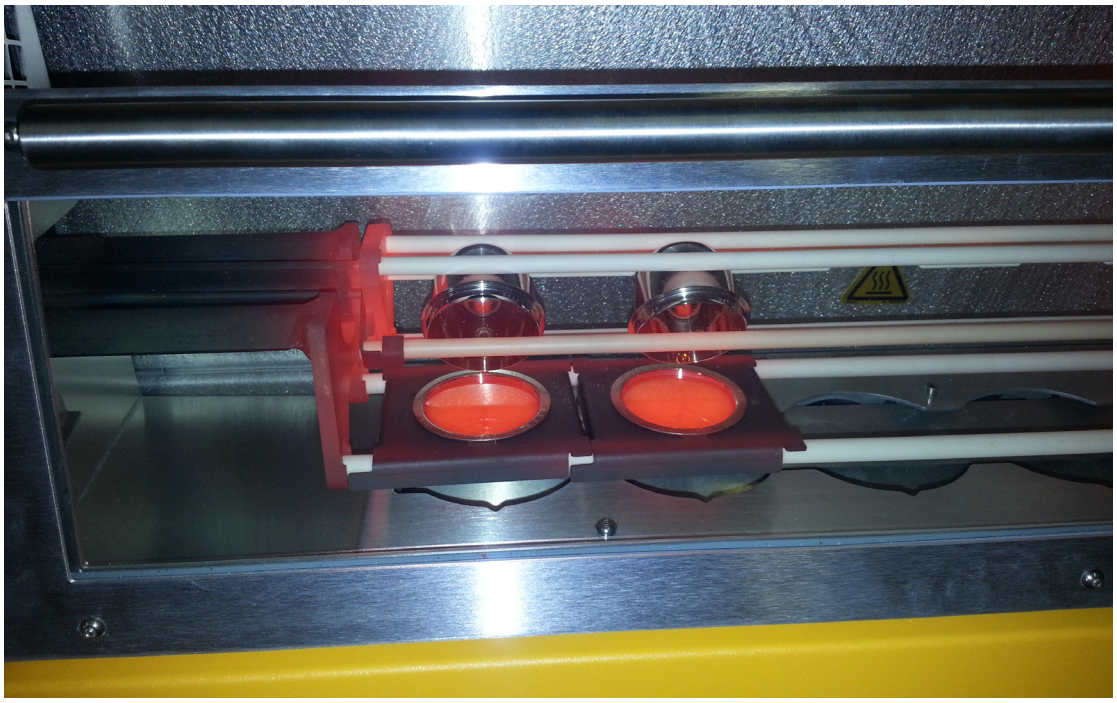
A new fluxer system for the preparation of glass disks which are used in the analysis of major elements by XRF has been purchased.

Two staff members of the XRF Section are also involved in the ISO 19725 accreditation process, implementing quality control measures for the laboratory instrumentation as well as setting up traceability measures for the results by reorganising and verifying certified materials and their associated information, such as suppliers, manufacturers, etc.

Future activities

Finalisation of ISO 19725 for the XRF Section by auditing at least three test methods in preparation for inspection by SANAS (South African National Accreditation System) and implementing a new Laboratory Information Management System (LIMS).

Mr Johannes Matji with the Claisse theOX — the new electric furnace for the preparation of glass disks



Two glass disks being prepared for the analysis of major elements by XRF

Ongoing services — Particle size analysis

Project leader	FJ Doucet, PhD (Chem Eng)
Primary objective	To provide particle size evaluation of geological and manufactured materials as a service to the units of the Council for Geoscience and commercial clients
Duration	20012/13
Budget	R85 800.00

Motivation

The Industrial Mineralogy Laboratory of the Council for Geoscience provides particle size analyses to internal and external clients. All analyses are carried out with 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. The instrument 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.

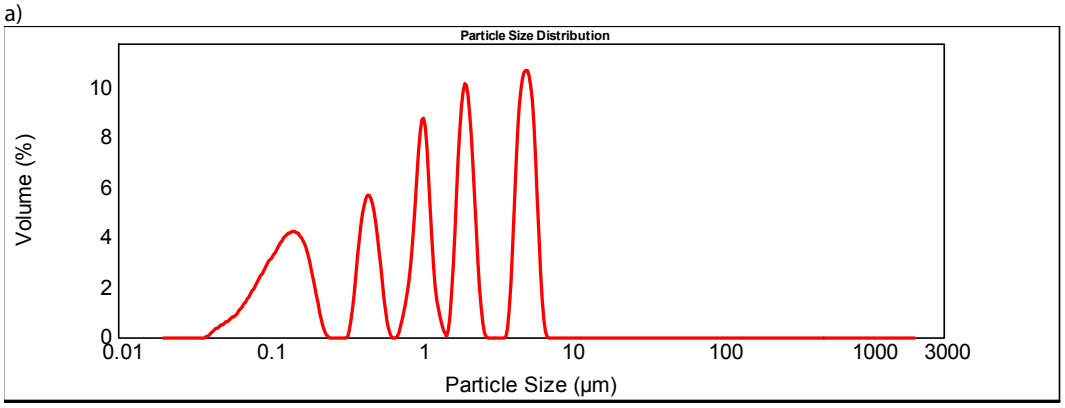
Progress

The total value of particle size analyses performed during the financial year amounted to R85 800, with R61 250 raised from statutory work and R24 550 from external clients.

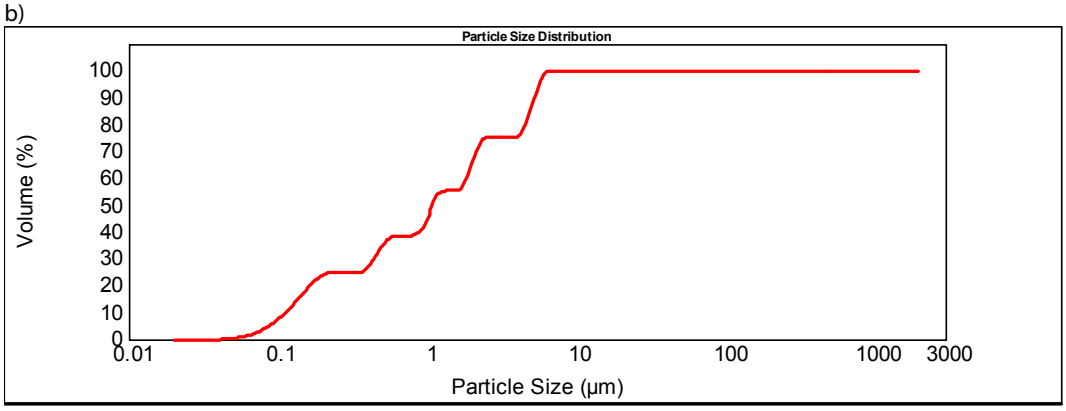
Future activities

This service will continue in the next financial year.

a)



b)



Particle size distribution results expressed as a) frequency curve and b) cumulative undersize

Ongoing services — Chemistry

Project leader	LJ Jordaan, MSc
Project team	H Maritz, BSc Hons, MT Lehaha, BTech, LL Sathekge, Nat Dip, RH Sello, RM Papo, M Vuma
Primary objective	To provide analytical services to the CGS Units and clients
Duration	Ongoing

Motivation

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

Progress

The Chemistry Section still felt the influence of the global financial recession during the reporting period, while maintenance and procurement issues limited the capabilities of the section to perform analyses.

Dust pollution generated during the renovation of the laboratory building, which started in December 2012, limited the ability of the Chemistry Section to perform analyses at low concentration levels.

Conclusion

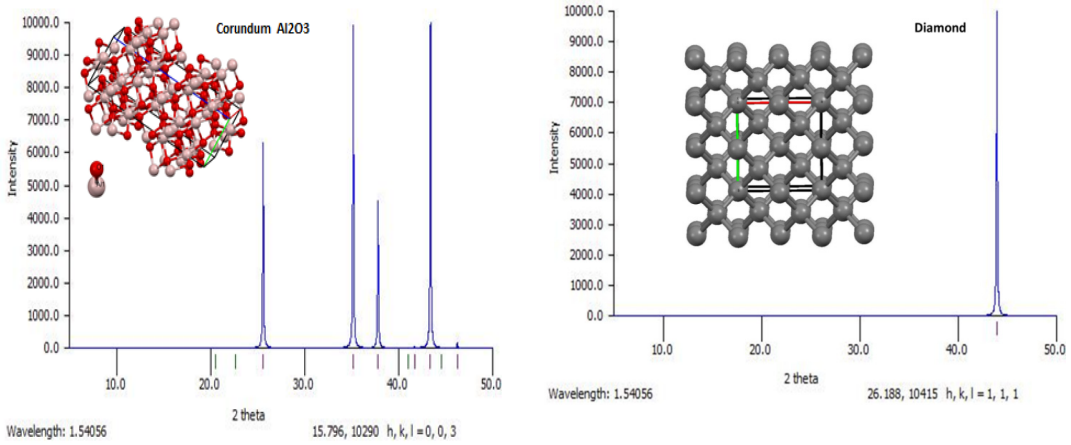
It is essential that the Chemistry Section caters for the needs of all its clients both within and outside the organisation. This implies a stable and dedicated staff component, serviceable modern instruments and participation in commercial and research projects.

Future activities

The Chemistry Section is heavily involved in preparing for SANAS 17025 accreditation, which implies documenting all procedures as well as implementing more rigid analytical and sample handling protocols.

Ongoing services — Mineralogy by X-Ray Diffraction

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



The crystal structure model and XRD pattern of corundum and diamond

Motivation

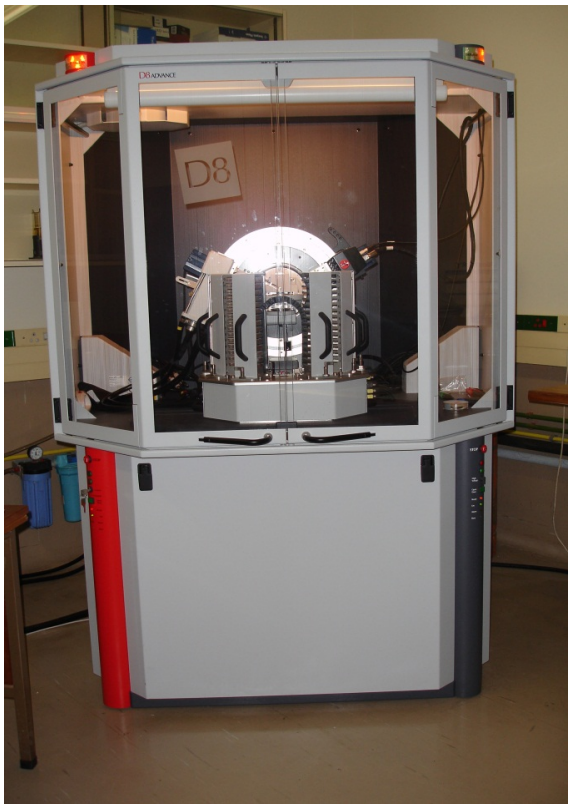
Mineral identification and material characterisation are required for a broad range of applications, programmes and projects of the Council for Geoscience. Mineralogical evaluation is an essential service for the description and compilation of geological maps, mineral exploration, economic evaluation 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, industry, academics, the geological community and the public quick accurate analyses at competitive prices. The section provides mineralogical evaluations and analytical results on a wide spectrum of geological materials 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 capillaries. Typical applications include qualitative phase identification and quantitative (including the Rietveld method) evaluation of XRD traces. Geological and geotechnical interpretation of mineralogical data is provided to assist clients with their assessments.

Progress

The total value of the services provided for the year is estimated at R897 355, of which R409 675 was commercial income and R487 680 the value of the statutory work. The drastic uprise in statutory income for the section during the reporting period was directly related to the increase in internal research and statutory work after the temporary hold on the statutory programme since 2009. This trend has negatively affected the commercial work as reflected by the statistics.

The work was performed on a BRUKER D8 Advance diffractometer purchased during 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 presents new opportunities for more detailed and advanced research in the field of crystallography and applied mineralogy.



The BRUKER D8 Advance diffractometer

Future activities

Prepare for ISO accreditation during the financial year. Continue with in-house experiments for method development and operating procedures to expand analytical applications and services to attract new market sectors. Adopt the latest developments in XRD technology, instrumentation and software and master the vast range of additional applications on offer. Acquire and develop new knowledge and skills.

Ongoing services — Mineralogy by Scanning Electron Microscopy (SEM)

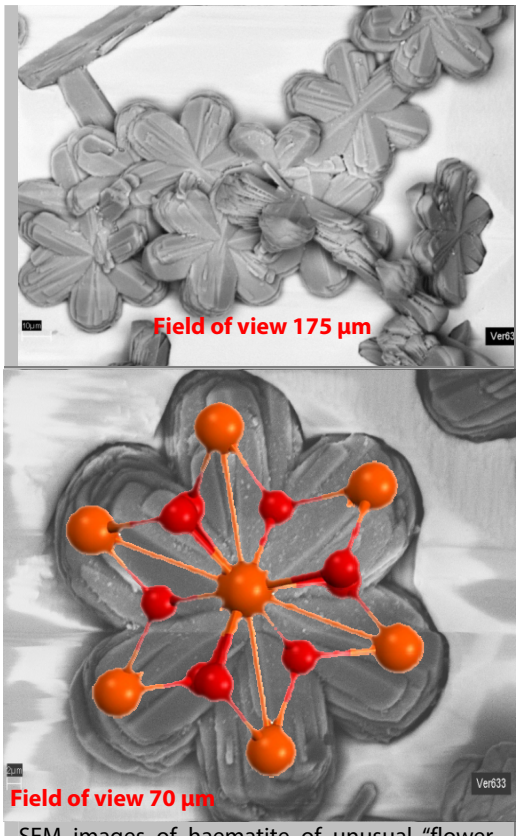
Project leader	M Atanasova, MSc
Primary objective	To provide SEM/EDS services to the Council for Geoscience and industries
Duration	Ongoing

Motivation

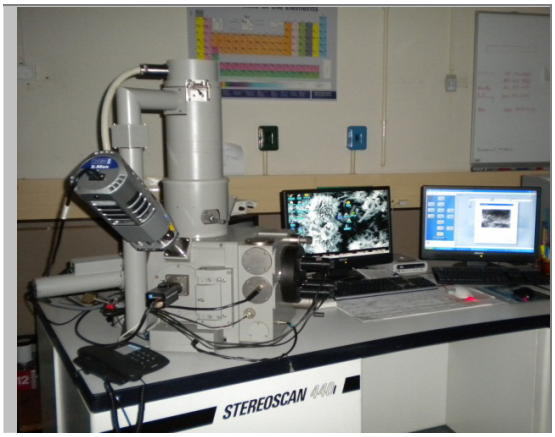
The Scanning Electron Microscope (SEM) is utilised for imaging and the X-ray analysis of rocks, minerals and industrial materials. It offers users the opportunity to do semiquantitative chemical analyses of microscopic particles. Researchers of the Council for Geoscience and the academic and geological community at large are the main users of this facility. SEM is widely utilised in applied mineralogy investigations and increasingly more frequently 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 for enhancing the quality of scientific observations.

Progress

The total value of work for the year is estimated at R118 045 of which R81 445 is commercial income and R37 900 income from statutory work. The 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. The figure is determined by the number of statutory projects in the organisation that need mineral identification.



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



Leica 440 Stereoscan scanning electron microscope

The laboratory runs a Leica 440 Stereoscan scanning electron microscope 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 a 20 mm^2 active area and a resolution of *ca.* 128 eV for Mn K-a (5 895 eV), was installed. This setup gives a wide range of analytical capabilities, including secondary, backscattered and cathodoluminescence electron imaging, X-ray EDS microanalysis and X-ray element mapping.

Sample Preparation Section

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

Motivation

The laboratory analyses rocks and soils samples for external and internal customers for research and commercial purposes. About 90 per cent 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 by foot and helicopter. The samples are verified and transported to the Laboratory Unit for further processing, e.g. drying, sieving, weighing, pellet pressing and registration before being submitted for analysis.

Progress

The Sample Preparation Section processed 11 631 samples during the year under review at a total value of R256 187.00; about 40 per cent of this work was performed for statutory clients. The amount shows a significant increase in services rendered to external clients of the Laboratory Unit.

Conclusion

It is crucial for the Sample Preparation Section to continuously provide for 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.

Sample preparator splitting samples using a rotary splitter

Ongoing petrographic services

Project leader	NS Nxokwana, BSc Hons (Geol), PrSciNat
Project team	SD Kgaditse, SA Dikgomo, L Mabena and M Raleaka
Primary objective	To ensure that the scientific staff as well as private entities have easy access to high-quality thin sectioning and related petrographic services for research and commercial purposes

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 often one of the first analytical methods employed in geological investigations. The availability of high-quality petrographic preparations (e.g. thin sections, polished stubs, polished rock specimens, etc.) is considered one of the fundamental components in the value chain of geological research.

Progress

The section delivered 390 and 620 analytical units for statutory and commercial services, respectively, at a total statutory value of R50 995.00 and commercial value of R79 595.00. Two new technical assistants were appointed on 1 February 2013.

Conclusions

As an ongoing project, the service will continue to be rendered. However, the section is faced with the challenge of old equipment which is difficult to maintain. This has a limiting effect on the production levels and turnaround time. The old equipment also makes it difficult to train new staff or staff from other organisations.

ST 2012 – 1152

Physicochemical 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 (Council for Geoscience), W Altermann, PhD, L van de Merwe, PhD (University of Pretoria)
Duration	2011 to 2013

Budget	R200 000.00 — bursary from the South African Centre for Carbon Capture and Storage (SACCCS)

Motivation

The 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 per cent of South Africa's geological storage capacity in is offshore Mesozoic basins and only 2 per cent is onshore. This study investigates the storage potential of shales which occupy a large part of the South African interior. Studies in other parts of the world have found that shales trap significant amounts of CO_2 in an adsorbed state in their organic matter.

Progress

A detailed literature review on South African shales in the context of geological CO_2 storage has been completed. Four old Soekor boreholes from the National Core Library have been sampled and 64 samples retrieved. Analytical techniques such as XRD, XRF, TOC and C & S analysis have been used to characterise these samples. Petrographic studies on the samples still need to be done to characterise the shales. Preliminary adsorption studies were done at the Tshwane University of Technology but the process was halted because of the unavailability of the high-pressure adsorption system. Plans are being made to have the analysis done elsewhere. The preliminary findings were presented at two conferences in the previous financial year.

Conclusions

The physicochemical properties and preliminary adsorption results compare favourably with those of shales from other parts of the world (e.g. the United States) which have been found to store significant quantities of CO_2 in the adsorbed state. However, further work still needs to be done in this study to corroborate these findings.

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 sediments, water and fish within large drainage basins and to trace the path of chemical elements during weathering for the evaluation of environmental risk and the establishment of a forensic capability
Duration	2008 to 2014

Motivation

The Council for Geoscience has an extensive database of the soil chemistry of South Africa with data having been 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 that 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. The study 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 were submitted:
Jordaan, LJ and Wepener, V (2012). The major and trace element chemistry of fish and lake water within major South African catchments.
Jordaan, LJ and Wepener, V (2012). The major and trace element chemistry of soil, lake sediments and lake water within major South African catchments.
Jordaan, LJ and Wepener, V (2012). The rare earth element chemistry of lake water and sediments within major South African catchments.

Future activities

Three reports will be submitted for publication in scientific journals.

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

CO-2012-5731

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

Project leader	N Dlamini, BSc Hons
Project team	J Botai, PhD, M Cloete, PhD, M Cho, PhD, J Engelbrecht, MSc, M Atanasova, MSc
Primary objective	To correlate the known mineralogical distribution of swelling soils northwest of Pretoria with their spectroscopic and multispectral image responses
Duration	2012 to 2014
Budget	R43 055.00

Motivation

Expansive soils pose a significant geological hazard worldwide by causing civil infrastructure damage amounting to billions of rand every year. In the event that the swelling clay minerals can be confidently matched to specific spectroscopic and multispectral responses, the matching will establish an efficient method to map geotechnical hazardous soil conditions for future planning and building developments. The Council for Geoscience has suitable data for this kind of study.

Progress

Samples collected in the study area were analysed for their mineral composition using X-Ray Diffraction (XRD). These samples were classified into highly expansive clays and low expansive soils based on XRD results. Statistical methods were also used to classify the results. Spectral signatures of the samples were measured in controlled laboratory conditions and were classified using the same statistical operations.

Conclusions

The project will progress markedly when ENVI software is made available.

Future activities

Correlation of XRD results to spectral signatures, processing of ASTER images, re-sampling of spectra to ASTER images, correlation of XRD results, spectra and ASTER images and report writing.

ST-2012-1151

Mineral carbonation and 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 the long-term CO_2 sequestration
Duration	20012/13
Budget	R20 000.00

Motivation

The total CO_2 emissions in South Africa currently account for 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 the 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. In addition to being significant contributors to South Africa's CO_2 emissions, the mining industry and Eskom also generate large volumes of potentially valuable industrial wastes, such as coal-combustion fly ash and mine tailings.

The project entitled *Mineral carbonation and value-added products* is a large project aimed at investigating the recycling opportunities offered by industrial wastes concentrated in calcium (Ca) and/or magnesium (Mg), which also contain valuable elements such as iron (Fe), silicon (Si) and/or aluminium (Al).

Progress

This project focused on (1) the production of calcium carbonate ($CaCO_3$) from phosphogypsum waste (collaboration with the Department of Chemistry, University of Pretoria), (2) the beneficiation of diamond and platinum tailings (collaboration with the Department 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 (collaboration with the 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: the NaOH route and the Merserburg process. Conversion of over 90 per cent was achieved using the former route, but the latter yielded a maximum conversion of about 63 per cent. For (2), preliminary experiments showed that up to 40 per cent of the Fe, Al and Mg contained in tailings can be extracted from the tested tailings. 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 spheroparticles 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 stockpiles.

Future activities

This project will continue on phosphogypsum wastes and tailings, with the focus being on optimising the processes in terms of extent and rate of conversion, and economics.

LIMPOPO

The Limpopo Unit, centrally based in Polokwane, is responsible for the geological mapping of the province; details of the projects for the year are outlined below. In addition, the Unit is actively involved in providing geological input to allow prospectors to apply for initial DMR prospecting permits (for a variety of minerals) and mining permits over available ground; there was an increase in activity after lifting the temporary moratorium. Enquiries from the public generally involve either mineral identification or the mineral/groundwater potential of specific farms or different areas within the province. Non-formalised, though structured, training of interns and young geologists this year again focused on requirements for compiling maps and geological reports.

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 from 2005
Budget	R284 250.00

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 coming onstream in Africa, the field school was seen as one means of efficiently addressing this issue.

Progress

The project for this year was completed. 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 the group was not available for participation. However, a curtailed field mapping school was held for a total of six trainees, comprising MQA/NRF interns/young scientists from five different units at the organisation. With a variety of geoscience backgrounds being represented, there was scope for mutually beneficial interaction between all involved.

An introductory course on GIS and the preparation of a base map preceded fieldwork which was this year undertaken in the Richtersveld area of the Northern Cape Province. Subject matters covered included orientation in the field, the collection of appropriate geological data and plotting of the data. Individual reports with maps were produced and evaluated. A combined map/data table was compiled and added to the regional database.

Future activities

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

The 2012 field school participants on gneisses within the Pofadder Shear Zone at the Orange River

ST-2008-0975

2330BB Shangoni 1:50 000 geological map

Project leader	N Baglow, BSc Hons
Project team	LP Munyangane, BSc Hons, T Maja, BTech (intern), B Leta (intern), T Ramashala (intern)
Primary objective	To understand the geology of the area with particular emphasis on the emplacement history and mineral potential, where applicable, to understand the groundwater characteristics of the areas and to maintain organisational capacity in terms of understanding a variety of geological environments. To produce a 1:50 000-scale geological map and an accompanying explanation
Duration	2012 to 2014
Budget	R57 000.00

Motivation

Sheet 2330BB is part of the 1:250 000 Tzaneen map area which has received little attention over the last decade. The Shangoni area is economically impoverished and was the focus of an earlier Presidential Keynote Address on rural development. The sheet will form the focus of the Limpopo Units skills development and training programme and scientific research output for the year ahead.

Progress

The project objectives for this year were achieved with a number of training reports and BTech thesis proposals completed.

Conclusions

The Giyani Greenstone Belt (GGB) is situated in the northeastern edge of the Kaapvaal Craton in the Limpopo Province of South Africa. The GGB is 15 km wide and 70 km long, trending in a northeasterly direction. Towards

the southwest, the belt bifurcates into two arms, namely the northern Khavagari and the southern Lwaji arm. The northern portion of the GGB is dominated by ultramafic and mafic sequences while the southern part comprises mafic and subordinated felsic units. This metamorphosed volcanosedimentary succession, termed the Giyani Group, has been intruded by mafic and ultramafic rocks.

Initial training mapping carried out in the Muyexe area in the southeast of the map area allowed for the collection of samples which, on chemical and petrographic analysis, confirmed the dominant ultramafic nature of the greenstone lithologies. The satellite imagery analysis of the area delineated the broad lithological distribution which will be groundtruthed during mapping.

Future activities

This map project now moves into a more intensive mapping and data collection phase with an integrated geological map and explanation to be completed.

Sampling typical ultramafic talc-tremolite schists of the Giyani Greenstone Belt near Muyexe

ST-2013-1166

Heat-flow modelling and geothermal potential of South Africa

Project leader	N Baglow, BSc Hons, Prof. MJ de Wit (AEON)
Project team	T Dhansay, BSc Hons
Primary objective	The objective of this study is to examine and model the heat-flow signatures of the mobile belts located within the Kaapvaal Craton to better ascertain their viability towards geothermal energy
Duration	2012 to 2014
Budget	R19 400.00

Motivation

This project could have further implications for the South African Energy Sector regarding the future of South African energy security and major implications for climate change.

Progress

The initial report was completed, and an MSc thesis submitted ahead of schedule.

Conclusions

South Africa generates more than 90 per cent of its total energy capacity through non-renewable sources. With coal forming the predominant energy source, South Africa has become the leading carbon emissive nation in Africa, emitting 450 million tonnes of CO_2 in 2011. In an international effort to restrict global average temperature rise to 2 °C above the average prior to the industrial revolution, the Kyoto Protocol has been extended for another eight-year commitment period. This is complementary to an expected resolution of a new legally binding climate change policy in 2015. This policy will aim to introduce financial penalties for nations failing to meet prescribed greenhouse gas emission targets by 2020. In an attempt to meet these climate change resolutions, South Africa will research and develop cleaner, alternative forms of energy, including hydro, wind and biomass forms of renewable energy, in addition to designating stringent building regulations for the incorporation of solar energy. These measures form part of an Integrated Development Plan that aims to generate a target of 10 000 GWh of renewable energy in 2013. South Africa is also investigating the possibilities of extracting its shale gas reserves and implementing these as a major energy source. This energy mix has given little attention to geothermal energy. The reasons for this omission appears to be the lack of active volcanism and previous research, suggesting South Africa, largely underlain by the Kaapvaal Craton, has a relatively low heat flow profile, deemed insufficient for harnessing geothermal energy.

Despite the available knowledge illustrating South Africa's poor potential for geothermal energy, anomalously higher heat flow regions could potentially be successful in harnessing low-enthalpy geothermal energy. This study investigates the possibility of harnessing low-enthalpy geothermal energy from one of these anomalous areas, namely the Limpopo Mobile Belt, in the northeast of South Africa. This is accomplished by considering a 75 MW hypothetical Enhanced Geothermal System (EGS) plant, sustainable over a 30-year period. The plant would theoretically yield energy from a minimum of three producing wells, from a reservoir with a minimum volume of 1 000 m^3.

All parameters associated with the total cost and total potential energy yield of this hypothetical plant are inculcated within a Levelised Cost of Electricity (LCOE) model. These parameters include: 1. The available heat flow data, which estimate the basal reservoir temperature at a specific depth. 2. Engineering and geological parameters, which calculate the potential energy yield and sustainability of the plant. 3. Hydrogeological parameters, which ascertain the impact on the regional water supply. 4. Economic and business development factors, which estimate the economic viability of the plant. 5. Financial factors associated with construction, operation and maintenance. The aforementioned parameters function towards the calculation of a single unit cost of electricity generated from low-enthalpy EGS at this site in South Africa. These factors aim to better ascertain its viability and potential impact towards South Africa's mitigation of climate change and future energy security.

The LCOE model for a hypothetical EGS plant within the Limpopo Mobile Belt estimates the unit cost of electricity as 14 $c/KWh. This generation avoids adverse effects on the groundwater quality and supply, and has the potential of mitigating CO_2 emissions by 1.5 gCO_2/KWh. The model also estimates a maximum basal reservoir temperature drawdown of 10–15 °C over the 30-year period, which could potentially result in an overall capacity decrease of 1 MWh.

The results of this study indicate that EGS in South Africa would be at least 7 $c/KWh more expensive than the current coal-generated forms of energy in addition to having a much lower energy capacity. However, with an added, globally comparable, $25/MWh renewable energy production incentive, the LCOE decreases to 12 $c/KWh, making it comparable with other forms of renewable energy, including concentrated solar power. With the deadline for the climate change resolution of the 2015 Conference of the Parties 18th meeting looming, further research and development towards cleaner and alternative forms of energy are important features for South Africa's greenhouse gas emissions reduction and energy development. Low-enthalpy geothermal energy development could potentially form another alternative energy option in South African climate change adaption and broad energy security.

Future activities

A scientific paper will be written and a draft bulletin prepared.

ST-2013-1167

The geochemical circulation of some potential harmful elements (PHEs) in groundwater and soil of Giyani, Limpopo Province; implications for human health

Project leader	N Baglow, BSc Hons, Prof. H Mouri (University of Johannesburg)
Project team	LP Munyangane, BSc Hons
Primary objective	Unquestionably there is a pressing need to safeguard the environment against exposure to harmful trace elements by providing relevant information and knowledge of their behaviour in the environment compartment. Thus, this study is proposed as a first phase of a project aimed at acquiring relevant information and knowledge of the behaviour of PHEs in the soil and groundwater across Giyani, Limpopo Province and their impact on the health of the population
Duration	2012 to 2014
Budget	R32 000.00

Motivation

Giyani, the selected area for the research study, typifies rural South Africa. For most of the people in rural Giyani, groundwater is often the only available supply of water. But the quality of the water, including the concentration levels of both nutritional and toxic trace elements, is still unknown.

Progress

The literature review, field reconnaissance study and the sampling of identified water boreholes were completed.

Conclusions

Twenty-nine borehole water samples, including 15 community boreholes and 14 primary school boreholes, were collected from this area. Initial sampling was done before the onset of the rainy season, and re-sampling took place towards the end of the season for comparative purposes.

The samples were analysed for trace elements such as arsenic (As), cadmium (Cd), chromium (Cr), selenium (Se), lead (Pb) and uranium (U) using the inductively coupled plasma mass-spectrometry (ICPMS) technique. The concentrations of some of these elements exceeded South African National Standard (SANS) permissible limits for drinking water in more than one borehole. Preliminary results suggest that water quality problems do exist and justify investigation into whether they constitute a health risk in the area.

Future progress

The work continues with the evaluation of sampling results that will form the basis of an MSc thesis and a presentation at an international conference.

Borehole water storage reservoirs supplying communal taps at Ha-Nkomo village

Taking water sample pH, temperature and Eh on site using a portable WTW multimeter

MARINE GEOSCIENCE

ST-2012-1155

Offshore mineral mapping in the Western Cape

Project leader	HC Cawthra, MSc
Project team	MR MacHutchon, MSc, FW van Zyl, BSc Hons, W Kupido
Primary objective	This project was 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 with existing samples and geological modelling applied for the prediction of the occurrence of similar deposits at other localities
Duration	2011 to 2015
Budget	R3 000 000.00

Motivation

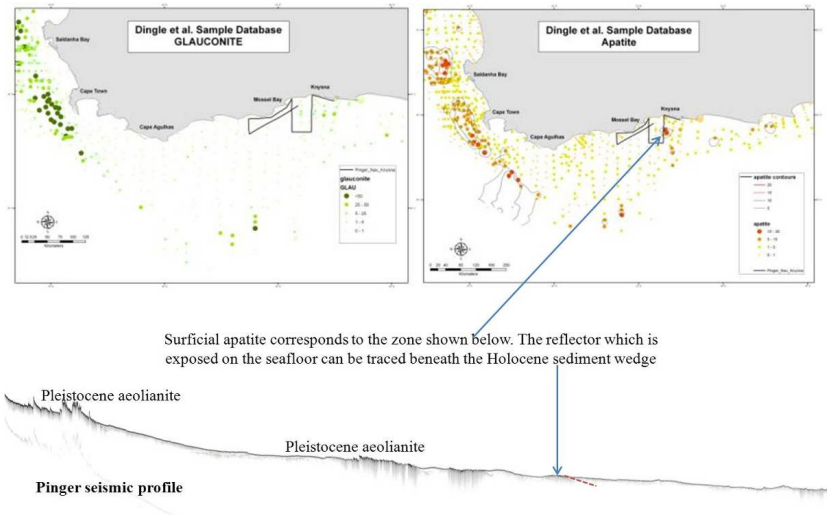
No recent high-resolution continental-shelf studies have been conducted in the Western Cape to quantify the distribution of seafloor minerals. Although exploration has traditionally focused on seismic stratigraphy in oil and gas and exploration for diamondiferous units on the South African West Coast, 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. The data have been processed and integrated into the existing database.

Conclusions

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



Example of the integration of newly acquired seismic profiles into existing data sets

ST-2011-1139

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

Project leader	HC Cawthra, MSc
Project team	MR MacHutchon, MSc, W van Zyl, BSc Hons, W Kupido
Primary objective	- To conduct marine geophysical and sampling surveys using the most advanced current technologies available and to develop a high-resolution geophysical/ geomorphic/palaeo-environmental database for a selected sector of the shelf off Mossel Bay - To integrate the geophysical data with geological modelling to reconstruct past ecosystems with a focus on critical climate/sea level intervals associated with events in human evolution such as the earliest as yet recorded use of marine resources ca 164 ka at Pinnacle Point Utilise the products of the study as an analogue for present and future climatic trends with special emphasis on sea level response to global climate change.
Duration	2011 to 2015
Budget	R1 500 000.00, partially funded through the National Geographic Society.

Motivation

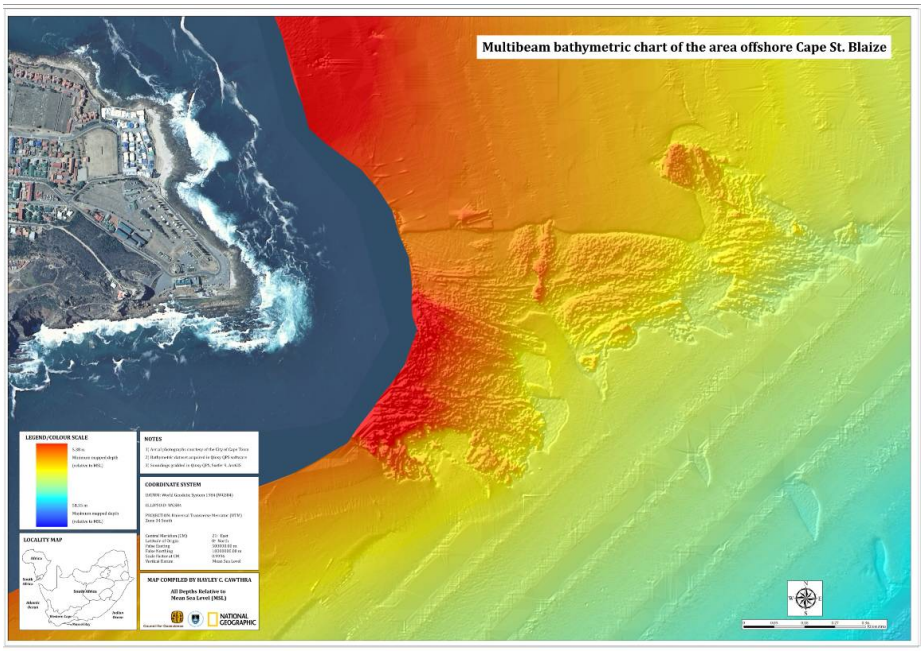
The southern African Middle Stone Age archaeological record is one of the richest worldwide, with many crucial sites situated along the southern coastline of South Africa. During much of this period, the earth's climate was colder than present with sea levels lowered by as much as 130 m below the present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

Progress

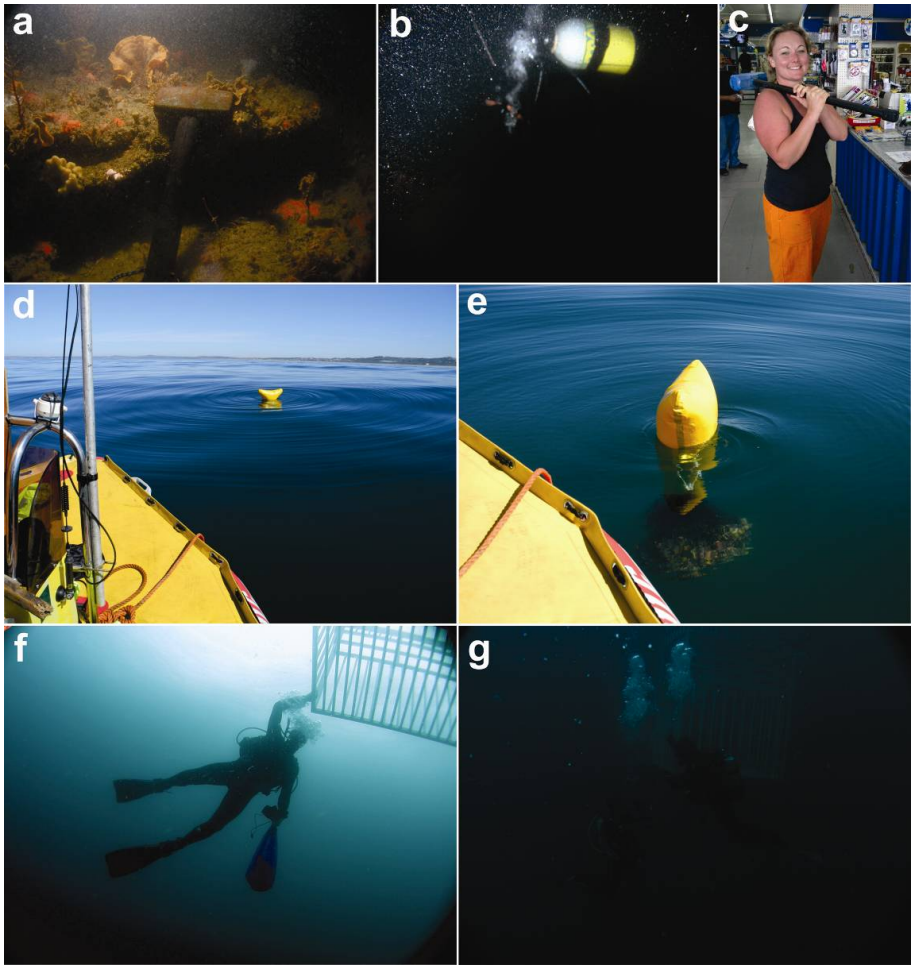
All marine geophysical data have been acquired and processed. Interpretations on the surficial acoustic data are complete. Scuba diving mapping and sampling surveys are complete.

Conclusions

The Mossel Bay seafloor has been found to consist of limited outcrops of numerous consolidated geological facies within an area dominated by mobile shelf sediments. Competent Palaeozoic strata forming an offshore promontory of the coastal cliffs from Cape St Blaize, extending east, terminates approximately 2 km offshore. Incised coastal caves exist within a submerged embayment. In the eastern section of the surveyed area, shore-parallel trending Quaternary palaeocoastlines offshore of the Groot Brak River crop out semicontinuously from the coastline to a depth of at least 52 m below mean sea level. These deposits have been incised by the palaeoflow of the Groot Brak River during periods of lowered sea level. The surficial geology of the Mossel Bay continental shelf is dominated by shelf sediments subdivided into numerous facies. These sediments constitute the dynamic Holocene sediment wedge.



Multibeam bathymetric chart of the area offshore of Cape St Blaize



Methods applied in scuba-dive sampling offshore of Mossel Bay

MINERAL RESOURCES DEVELOPMENT

ST-2005-0861

Industrial minerals map of South Africa (Investor's Manual)

Project leader	R Opperman, BSc Hons (Geol, Geogr)
Project team	E Tongu, PhD, PrSciNat, NQ Hammond, PhD, A Billay, PhD, K Kgwakgwe, BSc, UNondula, BSc Hons, R Oosterhuis, BSc Hons, M Matshivha, MSc, T Mudau, BSc Hons, A Kenan, MSc
Primary objective	To support and assist scientists from the German Natural Resources Agency (DERA) at the Federal Institute for Geosciences and Natural Resources (BGR) with visits to selected deposits in South Africa to identify new potential for German investors and natural resource purchasers. DERA intends to technically back up and assist German companies interested in becoming involved in the South African mining sector
Duration	2013 to 2014
Budget	R1 020 328.00

Motivation

The project is part of a cooperation venture between the Council for Geoscience and DERA that began at the end of 2011 and that is conducted by experts from the German Natural Resources Agency (DERA) at the Federal Institute for Geosciences and Natural Resources (BGR) together with experts from the Council for Geoscience. Separate studies on the different natural resources will be compiled in a manual on new occurrences and deposits with investment and supply options for German investors and purchasers in South Africa.

Progress

The first field trip for the year took place from 1–8 May 2012 when data were collected on zircons, rutiles and ilmenites. Heavy-mineral sand deposits near Vredendal on the west coast as well as deposits north of Durban on the east coast were visited.

During the second trip, from 14–21 September 2012, the team visited potential deposits of rare-earth elements and antimony in various regions of the central and northeastern part of South Africa. These included the Pilanesberg Complex, Glenover Complex (an abandoned phosphate mine with potential REE mineralisation), the Schiel Complex, the Phalaborwa phosphate mine of Foskor, a few fluorspar mines that might have REE potential as well as South Africa's only antimony producer, namely the Murchison antimony mine near Gravelotte.

Extensive use was made of the SAMINDABA database, the library and especially the old, unpublished reports of the Council for Geoscience during the desktop study for this project.

Conclusion

The project is ongoing and a draft report is being compiled on the rare-earth elements, antimony and heavy-mineral deposits that were visited. The manual on the new deposits of natural resources and supply options will successively be prepared for each specific natural resource.

Future activities

The study will continue in the forthcoming year with the following commodities to be investigated: chrome, platinum, graphite and possibly vanadium.

The studies will also flag new potential for German investors and natural resource purchasers. DERA intends to technically back up and assist German companies interested in becoming involved in the South African mining sector. The demand for German technologies and services for the South African natural resources industry, as an opportunity for German companies, will also be analysed.

Soil sampling in the centre of the eastern part of the Schiel Complex by scientists of the Council for Geoscience and DERA. The Schiel Complex is located approximately 40 km southeast of Makhado (Louis Trichardt) and has previously been investigated for phosphate-bearing apatite. The apatite may also contain REE. The apatite mineralisation does not outcrop at all

Field visit to the pit of the abandoned Ruigtepoort fluorspar mine, 60 km southeast of Thabazimbi. The fluorspar orebody was also investigated for possible REE mineralisation

ST-2005-0861

South African Mineral Deposits Database (SAMINDABA)

Project leader	M Matshivha, MSc
Project team	R Malan
Duration	Ongoing
Primary objective	The primary objective for SAMINDABA (South African Mineral Deposits Database) is to capture, store and update mineral data on mines, mineral deposits and occurrences within the borders of South Africa. SAMINDABA provides accurate mineral data and maps to users in South Africa and abroad. This database is designed to allow manipulation of data by means of intelligent queries and to provide information in different ways, e.g. draft reports, deposit profiles, graphs, resource estimations, mineral maps, DVDs, etc. In addition, the database serves as a tool for metallogenic map making and research

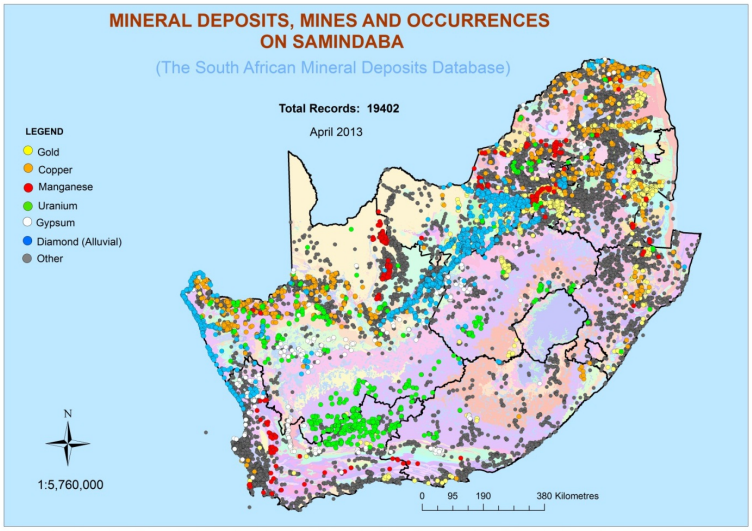
Motivation

SAMINDABA makes it possible for the Council for Geoscience to provide accurate mineral deposit data and maps to users both nationally and internationally. It also enables the Council for Geoscience to advise the government and state departments on the optimal use of mineral resources/reserves and realistic long-term mineral resource planning. When consulted by regional and town planners, the use of SAMINDABA prevents mineral deposits from being sterilised during the planning of permanent surface structures such as townships, dams, roads and pipelines.

Results

During the year, new database records were captured and a number of old database records were updated and checked, providing information for both internal and external enquiries on South Africa's mineralisation, as well as for maps (e.g. mineral maps) and other products (e.g. DVDs).

The total mineral records contained in the database has now grown to 19 402 (2 738 confidential, 16 664 non-confidential). More than 400 mineral enquiries were handled, both for internal clients (CGS geologists) as well as for external clients (private sector, small-scale miners, government, etc.). Geological and mineralogical explanations were also given to clients.



Total mineral records contained in the SAMINDABA database

ST-2002-0459

Lephalale/Ellisras Metallogenic Map (1:250 000)

Project leader	WR Oosterhuis, BSc Hons
Project team	L Mutele, BSc Hons, R Malan
Primary objective	Editing and correcting the metallogenic map and explanation for publication
Duration	2012 to 2014

Motivation

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

The manuscript accompanying a metallogenic map primarily serves to document the mining and mineral potential of the map area, in this case Ellisras 2326, with descriptions on the geology and genesis of similar types of deposits. Extensive references are provided for more in-depth information. A large variety of economic mineral deposits and occurrences are shown on the map sheet, of which the most important probably are the coal deposits.

Progress

The project is in an advanced stage of completion. To date, the manuscript has been completed and scientifically edited and corrected.

Future activities

Map compilation and finalisation of the manuscript for publishing.

Conclusion

The aim is to publish both the manuscript and map within the forthcoming financial year.

ST-2002-0133

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 Africa, SADC and NEPAD regions by updating and growing 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 Council for Geoscience
Duration	Ongoing

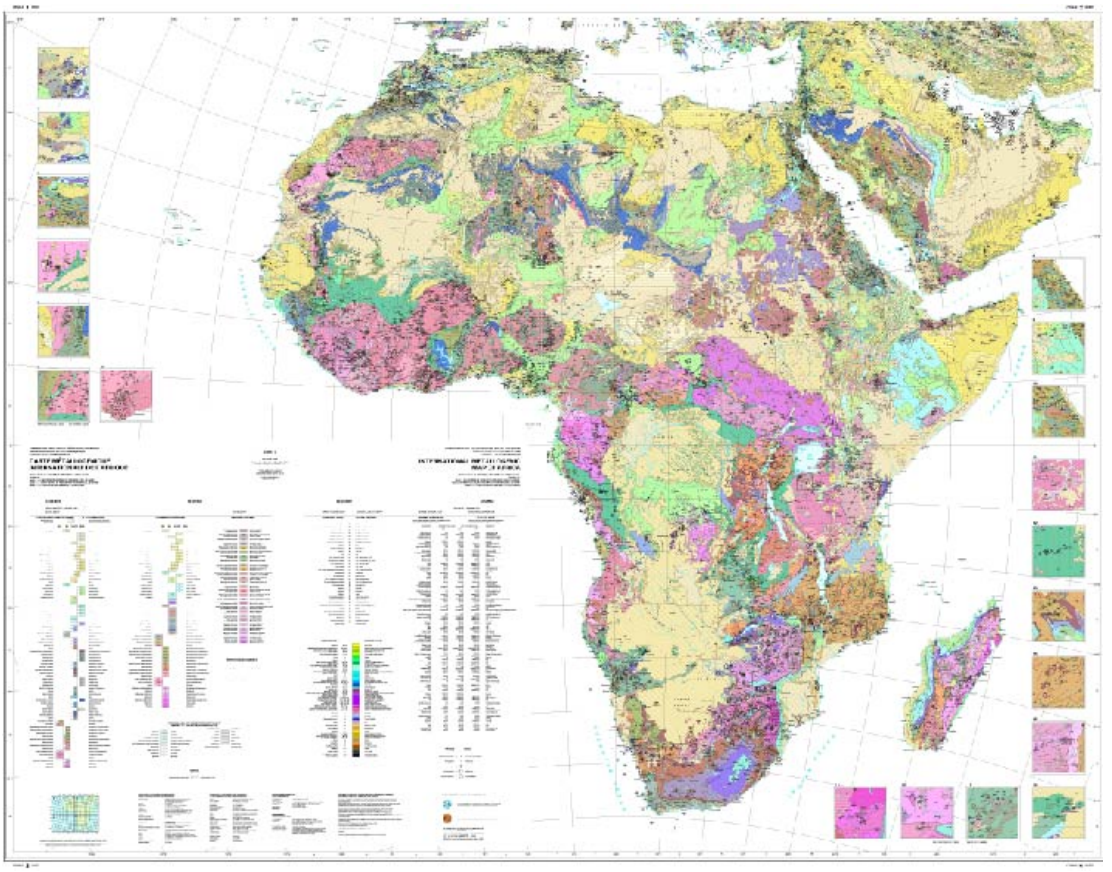
Motivation

The African Mineral Deposits Database was designed as part of the compilation of the International Metallogenic Map of Africa at a scale of 1:5 000 000. It is important to continually update and improve the data, which is of particular importance to 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 Council for Geoscience sees working in Africa and being involved in NEPAD and SADC as key thrust directions.

Progress

The 1:5 000 000-scale International Metallogenic Map of Africa was published on four A0 sheets 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 Metallogenic Map of Africa DVD was upgraded in 2009 to include projects in ArcMap 9.2 and 9.3 formats with all shape files projects in WGS84.



Visual representation of the International Metallogenic Map of Africa

Sales of the digital data have been steady throughout the year. The digital data have been used for the production of both country-specific and more regionally derived maps and reports.

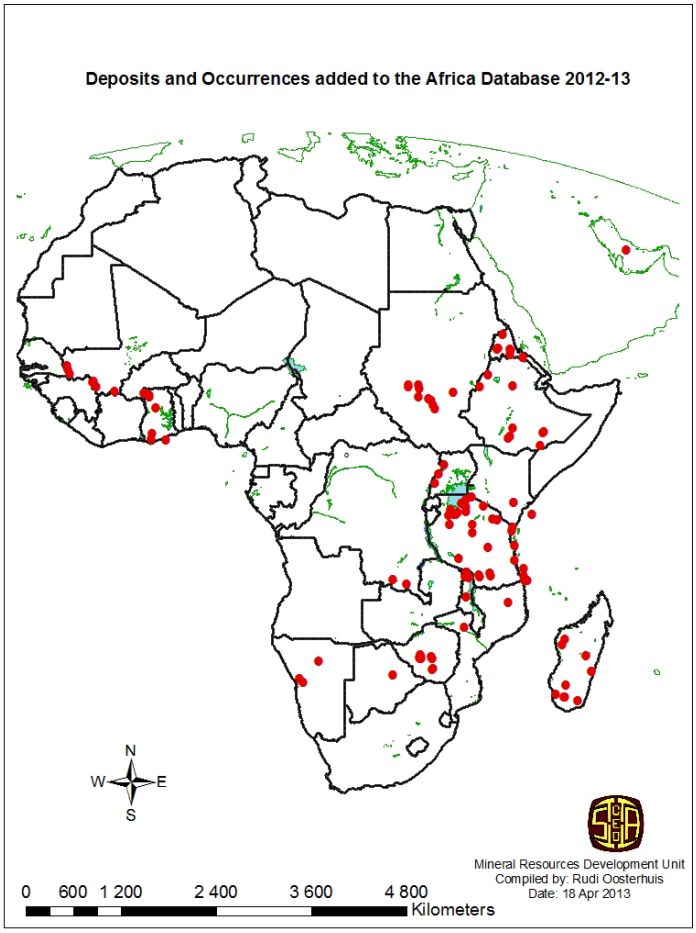
Currently, the Africa Mineral Deposits Database has 12 828 mineral deposit records in Paradox.db format.

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 new investment 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.



Deposits and occurrences added to the Africa Minerals Database in 2012/13

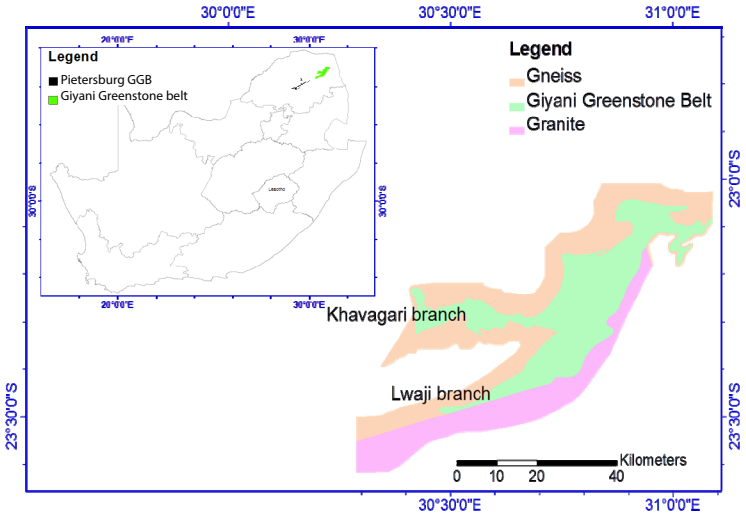
ST-2005-0865

Predictive bedrock and gold prospectivity mapping of the Giyani Greenstone Belt (South Africa)

Project leader	AY Billay, PhD
Project team	M Sadeghi, PhD (Swedish Geological Survey), M Matshivha, MSc
Primary objective	The objective of the project is to carry out predictive bedrock and gold prospectivity mapping in the Giyani Greenstone Belt using and analysing multiple geoscience data sets and eventually integrating the relevant derived (manipulated) maps. The bedrock and gold prospectivity maps will support the exploration/mining industry as well as the junior and small-scale miners to focus on the delineated gold potential targets, thereby reducing the risk and the cost involved in blindly exploring large tracts of land. The results of this study will also impact on job creation and poverty alleviation and will provide support in land-use planning
Duration	2012 to 2013

Motivation

The Giyani Greenstone Belt is known for its gold potential. There are about 44 gold occurrences, prospects and deposits in this greenstone belt. Gold mining in the belt started in the 1870s and ended in the late 1990s owing to low gold prices. A recent increase in the gold price has stimulated a renewed interest in this greenstone belt and currently several parts of the greenstone belt have been leased to exploration companies. The majority of the previous gold exploration campaigns used traditional methods and were unsystematic, in part exacerbated by the scarcity of rock outcrops. Previous geological mapping attempts to map the greenstone belt also could not produce an accurate geological map owing to the paucity of rock outcrops. Exploration in covered regions requires multiple geoscience data including geology, geophysics, geochemistry, remote sensing and appropriate data manipulation to establish gold predictor maps and to eventually integrate the relevant data sets to generate potential target areas. The Council for Geoscience has conducted soil sampling (1 sample per square kilometre) and high-resolution magnetic and radiometric surveys in the Giyani Greenstone Belt in the late 1990s. This project is thus aimed at using these and additional data sets (remote sensing, structural, etc.) as well as processes using modern software technology to look deeper below the regolith cover that conceals most of the underlying bedrock and gold mineralisation. To achieve this, a collaborative research programme between the Council for Geoscience and the Swedish Geological Survey was established. This collaborative research programme will significantly contribute to skills training in modern methods of multiple data analysis and integration for mineral prospectivity and bedrock mapping.



Location and general geology of the Giyani Greenstone Belt and the surrounding granite-gneiss terrane

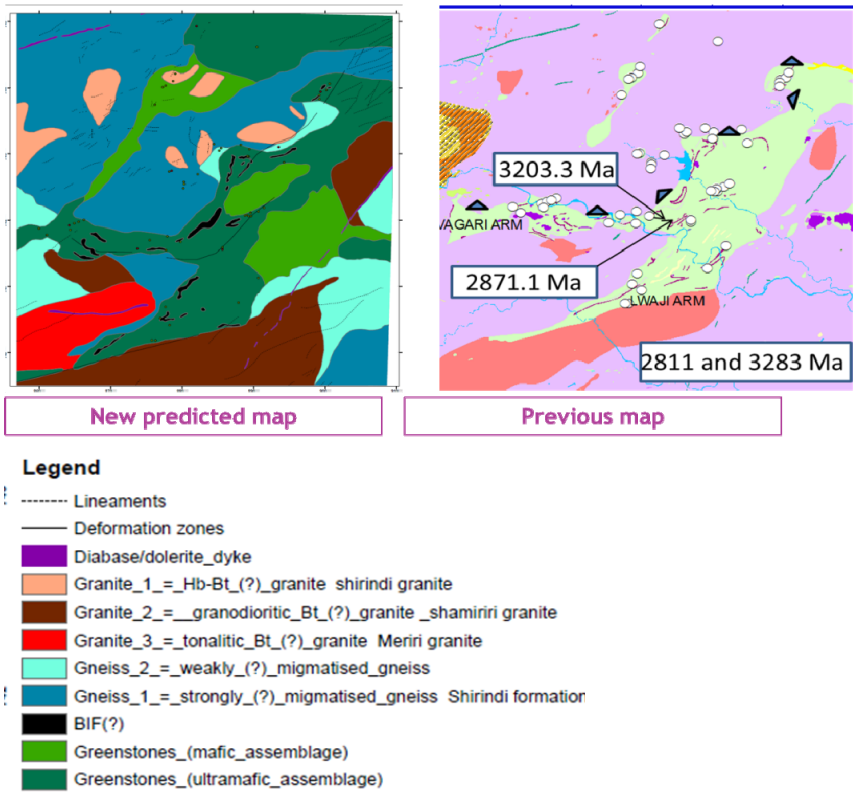
Old gold processing plants, Klein Letaba gold mine

Old mine damp, Klein Letaba gold mine

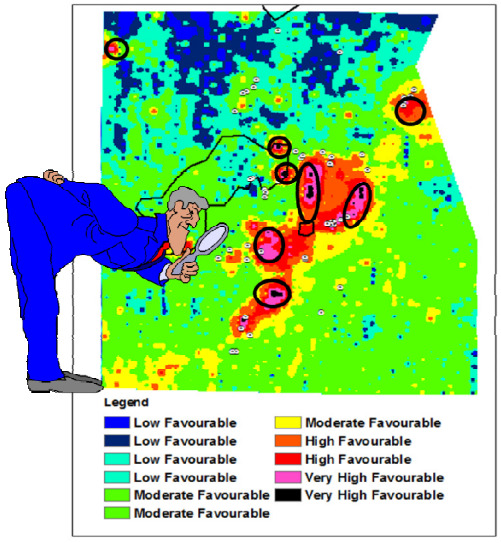
Defunct Klein Letaba mine relicts in the Giyani Greenstone Belt

Results

Data processing and analysis have been completed. Predictive bedrock mapping has been completed and has shown a significant improvement compared to the original geological map. Preliminary results of the gold prospectivity mapping have successfully delineated gold potential zones. To reduce the cost and the risk involved in exploration, the exploration/mining companies as well as junior and small-scale miners should focus their exploration activities in the outlined potential areas.



Predictive bedrock map (left) and original geological map (right)



Gold prospectivity map of the Giyani Greenstone Belt

Conclusions

The preliminary results of the project have shown that the project was successful in terms of its aims. The bedrock and gold prospectivity maps were successfully produced. The gold potential targets delineated will support the exploration and mining industry in concentrating their exploration activities in these zones, instead of blindly exploring the entire greenstone belt with less success and at high cost.

Future activities

Future activities for this project included synthesising the preliminary results and finalising the project between August and September 2013 by producing a comprehensive report on predictive bedrock and gold prospectivity mapping in the Giyani Greenstone Belt.

ST-2012-1163

Predictive bedrock and gold prospectivity mapping of the Giyani Greenstone Belt (South Africa)

Project leader	AY Billay, PhD
Project team	A Tessema, PhD, P Cole, MSc, L Ledwaba, BSc Hons (Geophys), E Mulovhedzi, BSc Hons, S Hlatshwayi, MSc, M Bensid, BSc Hons, M Maya, BSc Hons, M Bala, BSc Hons, T Ntikang, BSc Hons, N Mashale, BSc Hons, P Munyangane, BSc Hons, N Mukosi, MSc, M Tsanwani, MSc, T Mudau, BSc Hons, C de Beer, MSc, P Macey, PhD, C Musekiwa, PhD, J Engelbrecht, MSc, C Lambert, BSc Hons, A Tshimane, BSc Hons, C Groenewald, BSc Hons, H Minnaar, PhD, D Cole, PhD
Primary objective	The main aim of the project is to stimulate mining/exploration and to create wealth and jobs in South Africa by providing the public and the mining industry with new and updated geoscience data and by generating mineral targets using the modern methods of mineral prospectivity mapping. The end product of this project is the production of mineral prospectivity maps (showing potential target areas) accompanied by a comprehensive report
Duration	2012 to 2015

Motivation

New developments including a better understanding of ore-forming processes, advanced exploration techniques (geophysics and geochemistry), advanced analytical techniques, remote sensing and other spectral technologies, advances in database and data capturing techniques, data processing software technologies as well as data integration, visualisation and interrogation technologies such as GIS help predict mineral potential targets more efficiently than the traditional approaches to mineral exploration.

Realising:
(1) The decreasing trend in exploration expenditure in South Africa during the last decade
(2) The need to promote investment in the exploration and opening of new mines in South Africa in order to reverse the diminishing reserves
(3) The fact that many known and/or exposed mineral resources of South Africa are currently being exploited and the discovery of new hidden (either covered by overburden or sited at depth) deposits requires the acquisition of high-quality and high-resolution data and modern methods of data processing and integration
(4) The significance of the mineral industry in the economy of South Africa.

Motivation

The Council for Geoscience has embarked on an ambitious programme to re-investigate selected mineral belts and districts by acquiring high-resolution geophysical and geochemical data that will be integrated with existing additional data such as remote sensing data, geological and structural maps and mineral deposit/occurrence data to delineate mineral potential targets in the various mineral belts and districts. This

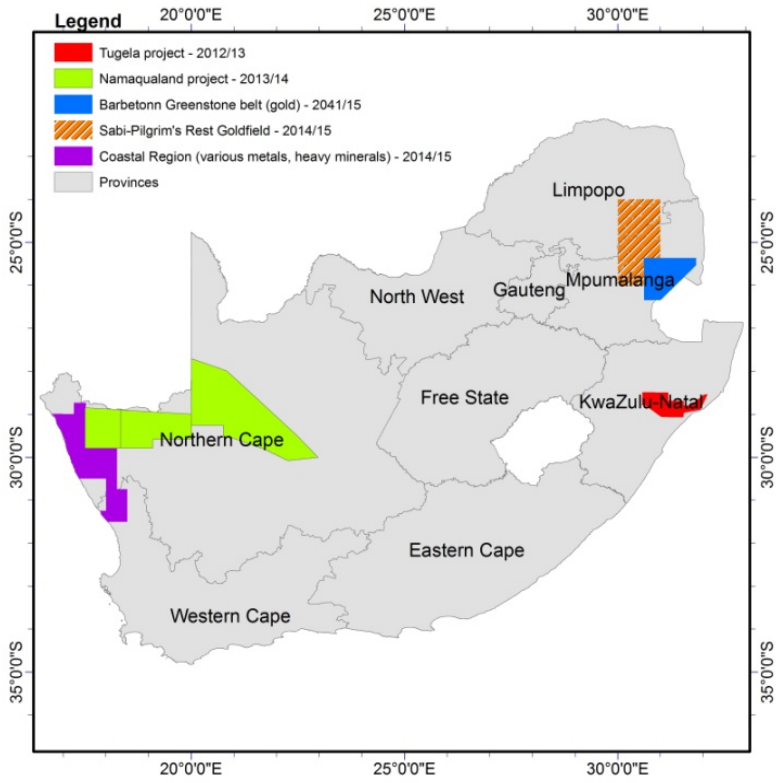
project aims to produce mineral prospectivity maps and an accompanying comprehensive report that will be disseminated to the public and the government.

Progress

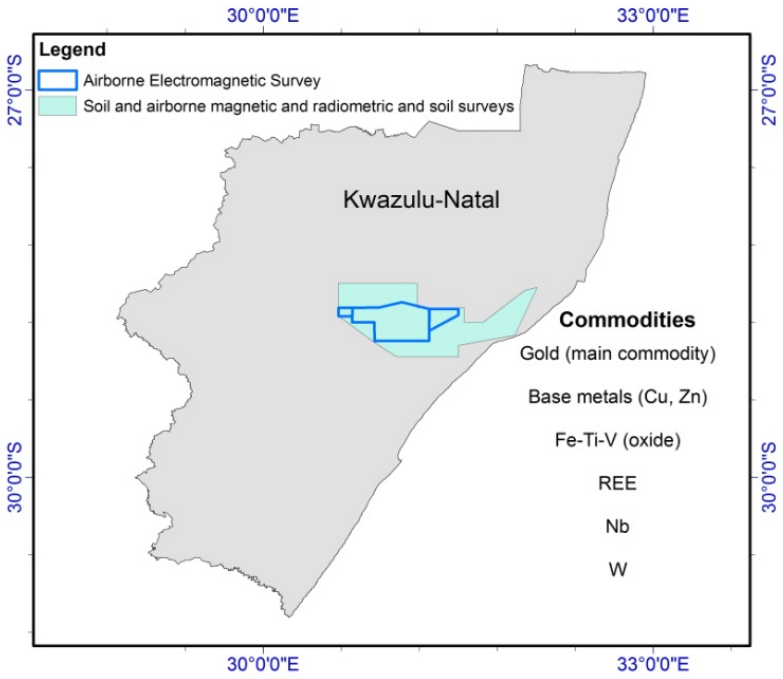
The MTEF project *Exploration and mining stimulation in the minerals and energy sectors* is a three-year programme. Geochemical and geophysical surveys will be conducted in several areas and eventually mineral prospectivity maps and reports will be produced. The Tugela region is characterised by a rough relief and swamps and frequent rains hamper the airborne electromagnetic and soil sampling work.

During the first year (2012/13) airborne magnetics and radiometrics, airborne Time Domain Electromagnetic (TEM) and airborne soil sampling were conducted in the Tugela region of the KwaZulu-Natal Province. To date, the airborne magnetics and radiometrics survey has been completed. The airborne TEM survey was completed for about 50 per cent of the proposed area. The total cost of the airborne geophysical surveys amounted to R15 815 258 for the Tugela region.

Airborne soil sampling started late in March 2013. It would be completed in September 2013. Completion of the analysis of the collected samples was planned for December 2013. Data processing, integration and report writing accompanied by mineral prospectivity maps of the Tugela region are expected to be completed in December 2014.



Location of project areas for the three-year MTEF project



Location of the Tugela project for 2012/13

Rugged relief of the Tugela region

Reconnaissance field visit, Tugela region

Rugged relief (left) and marshy valleys (right) of the Tugela region

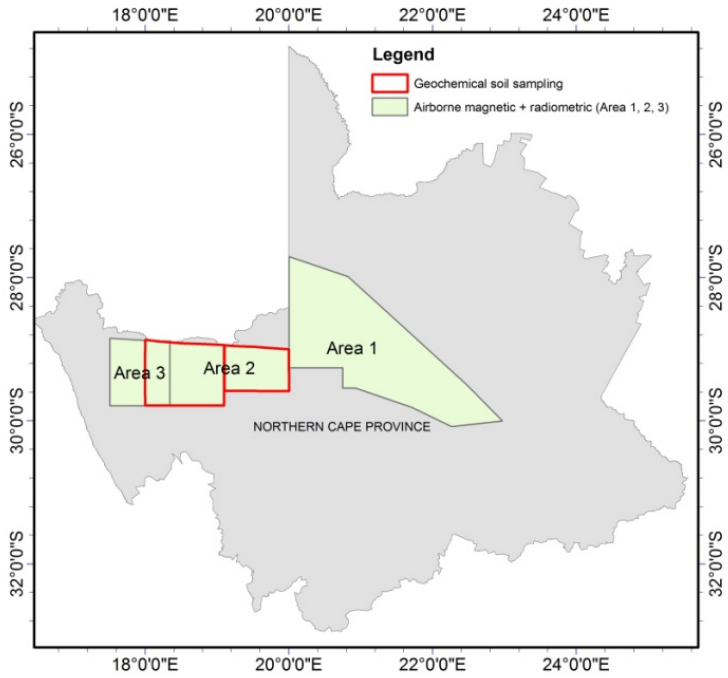
Future activities

The survey areas selected for the 2012/13 year are in the Namaqualand region of the Northern Cape Province and the activities to be conducted in this region include:

- A desktop study of the selected areas in the Namaqualand region
- Airborne magnetic and radiometric surveys
- Soil sampling
- Sample preparation and analysis of the collected soil samples.

Activities from the 2012/13 budget year that need to be completed in the 2013/14 year for the Tugela project in KwaZulu-Natal include:

- Continuation of the soil sampling in the Tugela region in KwaZulu-Natal
- Continuation of the airborne electromagnetic surveys
- Sample preparation and analysis of the collected soil samples
- Data processing and report writing (expected to be completed by March 2014).



Location of airborne magnetic and radiometric surveys and geochemical soil sampling areas for 2013/14

ST-2008-1000

Evaluation of the rare-earth resource potential of the carbonatite and alkaline complexes of South Africa

Project leader	EL Tongu, PhD, PrSciNat
Project team	L Muteleo, BSc Hons, PM Manhlwa, BTech, Staff from the Geological Survey of Japan: Y Watanabe, PhD (Team leader), M Hoshino, PhD, K Sanematsu, PhD, T Ohno, PhD
Primary objective	Research and the discovery of rare-earth mineral resources

Motivation

Growth: The project aims to discover rare-earth element resources in South Africa. This will enable the country to be catapulted into the role of a producer of rare-earth oxides, thereby aiding the growth of the country's economy.

Regulatory and Stakeholder: The project will assist the South African mining and exploration industry to focus on a potentially profitable new arena, through the hitherto poorly understood range of mineral commodities.

Rural Development and Poverty Eradication: By highlighting the economic potential of rare-earth metals, rural and previously disadvantaged communities stand to benefit directly or indirectly through participation in mining and exploration of a relatively new range of resources.

Innovation and Skills Development: The project will develop local skills for the exploration and mining of rare-earth element resources. It must be remembered that South Africa at present is not a player in the production of rare-earth oxides. It is therefore imperative that the Council for Geoscience continues its participation in the project.

Progress

To date, the research team has discovered an amphibolite-hosted rare-earth deposit in the North West Province. In November and December 2012, five holes were drilled and samples were taken.

Amphibolite specimen

Drill rig used for drilling five holes

Future activities

Future work will include additional drilling, core cutting, sampling and chemical analysis in addition to ground geophysics to delineate extensions of the orebody to the north and south.

Conclusions

The project will lead to the discovery of minable rare-earth resources, which, in turn, will lead to the generation of jobs and poverty alleviation, in addition to catapulting South Africa to becoming the leading producer of rare-earth metals.

ST-2009-1054

Precious metals deportment studies in ore deposits in South Africa: A mineralogical study of platinum-group element (PGE) mineralisation in the Merensky Reef, Two Rivers Platinum Mine, Eastern Bushveld Complex

Project leader	NQ Hammond, PhD
Project team	T Mudau, BSc Hons, P Manhlwa, BTech, M Valdah, P Tjale
Duration	Two years

Motivation

The Critical Zone of the Bushveld Complex, which hosts the Merensky and UG2 Reefs, carries the world's largest platinum-group element (PGE)-bearing orebodies. Most studies of the Merensky Reef have concentrated primarily on the Western Limb of the intrusion, where mining operations yield exposures over many tens of kilometres of strike. Information on the reef from the Eastern Limb is sparse, apparently owing to the fact that platinum exploration and mining only commenced in the region in recent years.

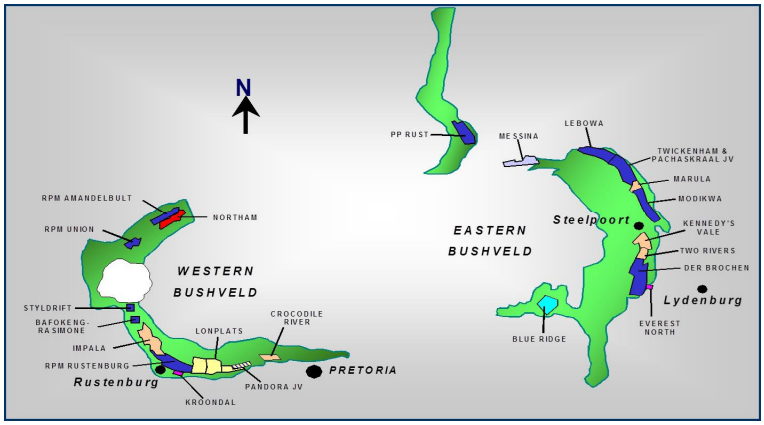
Merensky Reef samples from Two Rivers Platinum Mine in the eastern Bushveld Complex were studied under the standard reflected microscope and secondary electron microscope (SEM) to determine the sulphide mineral assemblage and characteristics of the platinum-group minerals associated with the ore.

Progress

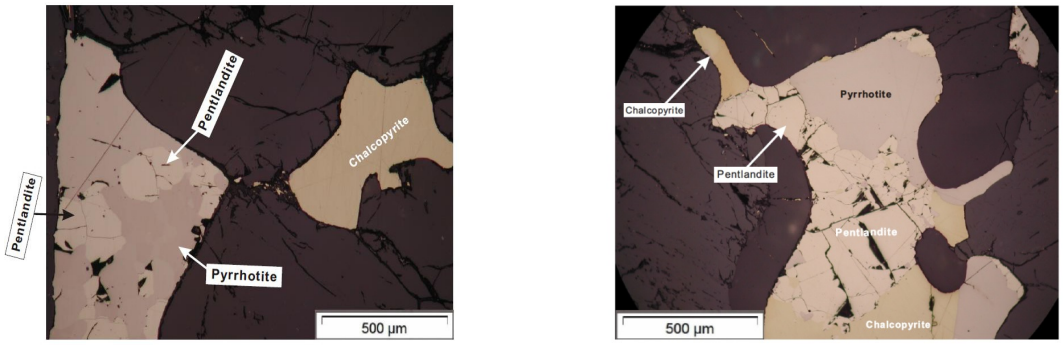
The current result indicates base-metal sulphides, pyrrhotite, pentlandite and chalcopyrite as the principal sulphide phases in the Merensky Reef at Two Rivers Platinum Mine. Varieties of platinum-group minerals were identified and these are grouped into three main populations; PtTeBi alloys, PGE sulphides and PGE arsenides. The PtTeBi alloys form the dominant population of the PGMs (55 %), followed by PGE sulphides (33 %), PGE arsenides (10 %) and other PGE metal alloys (2 %). The grain sizes range from less than 5 to 142 µm (average 30 µm). There is a strong association of most PGMs with the sulphides, typically chalcopyrite. The close association of the PGMs within the sulphides and at the margins of the sulphides indicates that the PGMs were derived from the sulphide melt.

Future activities

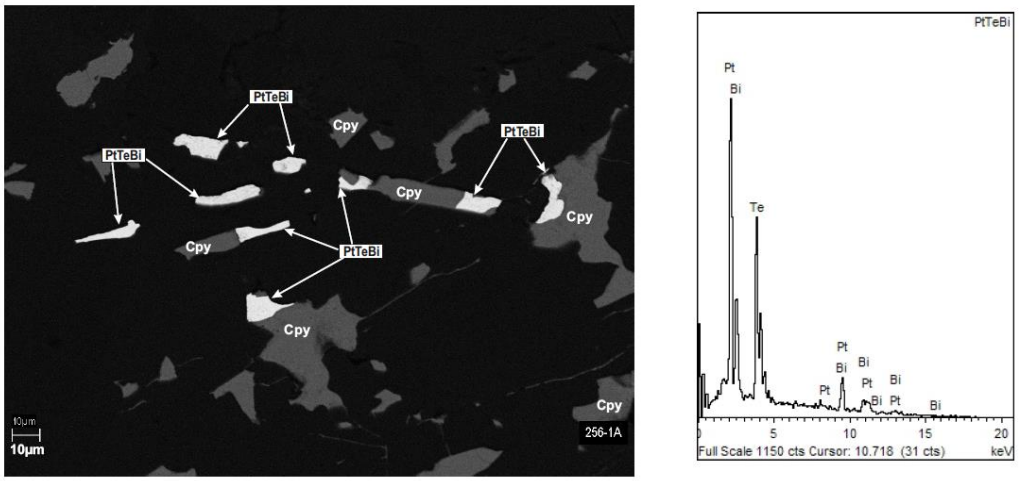
Future activities will include the application of high-precision analytical facilities such as the electron microprobe, secondary ion mass spectrometry (SIMS) and laser ablation inductively coupled plasma mass spectrometry (LA ICP-MS) to quantify and determine the distribution of PGEs in the sulphide ores.



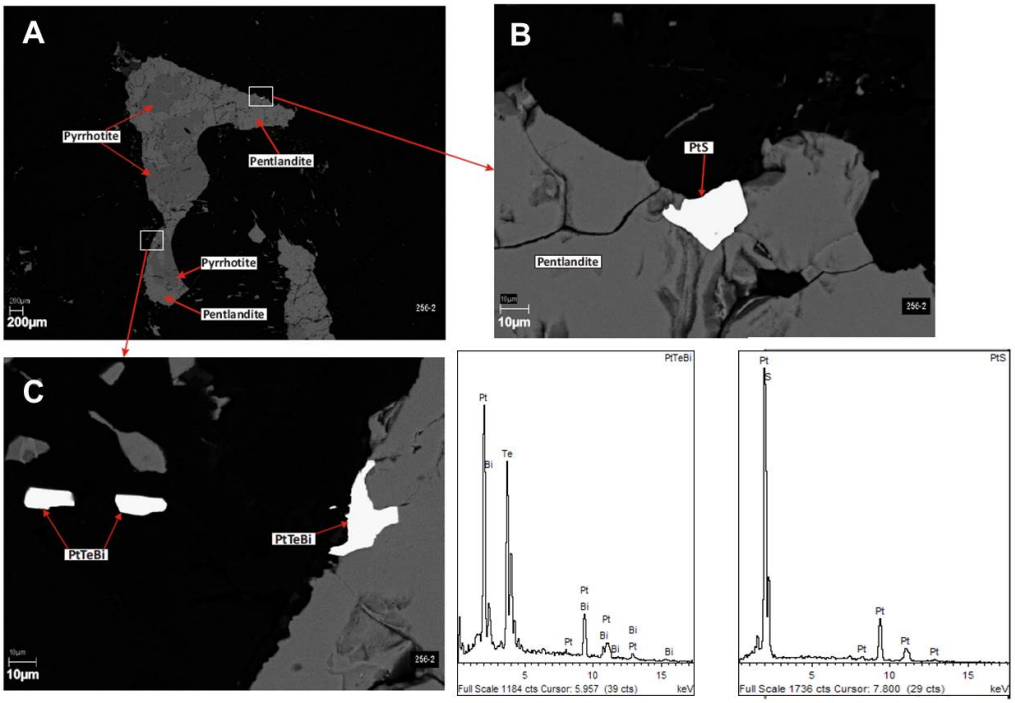
Outline of the Bushveld Complex and location of Two Rivers Platinum Mine in the eastern Bushveld Complex



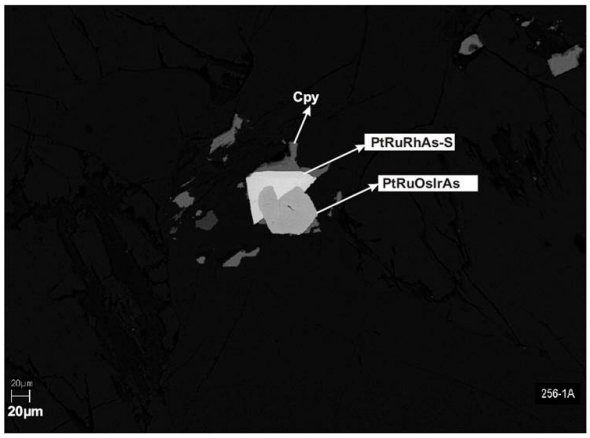
Photomicrographs showing principal sulphides in the Merensky Reef at Two Rivers Platinum Mine



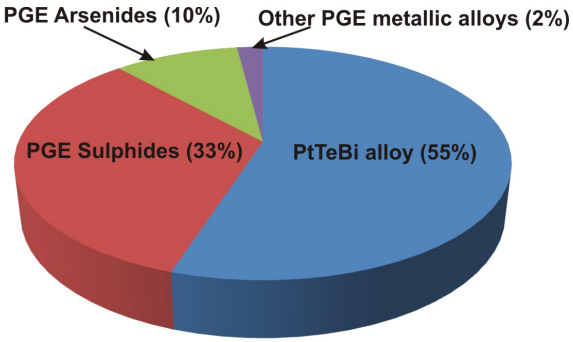
PtTeBi alloy in close association with chalcopyrite



Pt-Ru-Rh-As-S and Pt-Ru-Os-Ir-S-As in close association with chalcopyrite (cpy)



PtTeBi alloy and PtS association with sulphides



Platinum-group minerals distribution in the Merensky Reef, Two Rivers Platinum Mine

ST-2002-0167

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
Budget	Included in unit overheads

Motivation

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

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

Progress

During the year 454 logs were prepared, 681 header details were coded and captured, 1 946 lithologies for 86 boreholes were captured and 1 328 logs were electronically converted and will be loaded onto the database by the end of this month. The coal database now contains 113 970 boreholes with 2 844 200 lithologies and 1 597 500 analyses. More than 300 queries for outside clients were done with an income of R963000.00.

Conclusions

The coal database forms part of GEODE, the corporate database of the Council for Geoscience. This database of strategic importance as it plays an important role in enabling further research work on the geology of coal deposits in South Africa.

Future activities

The coal database will form part of the planned GEODATA portal that will provide the technology infrastructure required to make data contained in the various databases accessible to persons outside the organisation.

ST-2002-0168

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
Budget	Included in unit overheads

Motivation

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

Progress

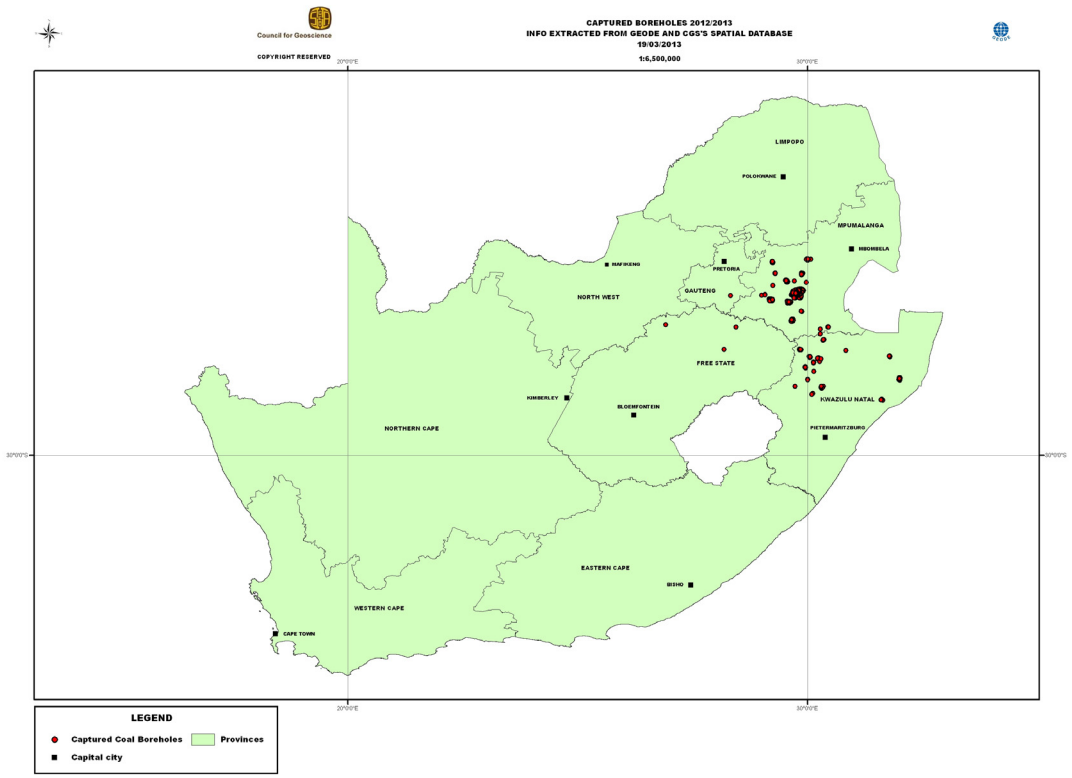
During the year no logs were prepared for capturing into the database since no new data were received for capturing. The borehole core log database now contains a total of some 86 500 entries.

Conclusions

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

Future activities

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



Boreholes captured in the current financial year

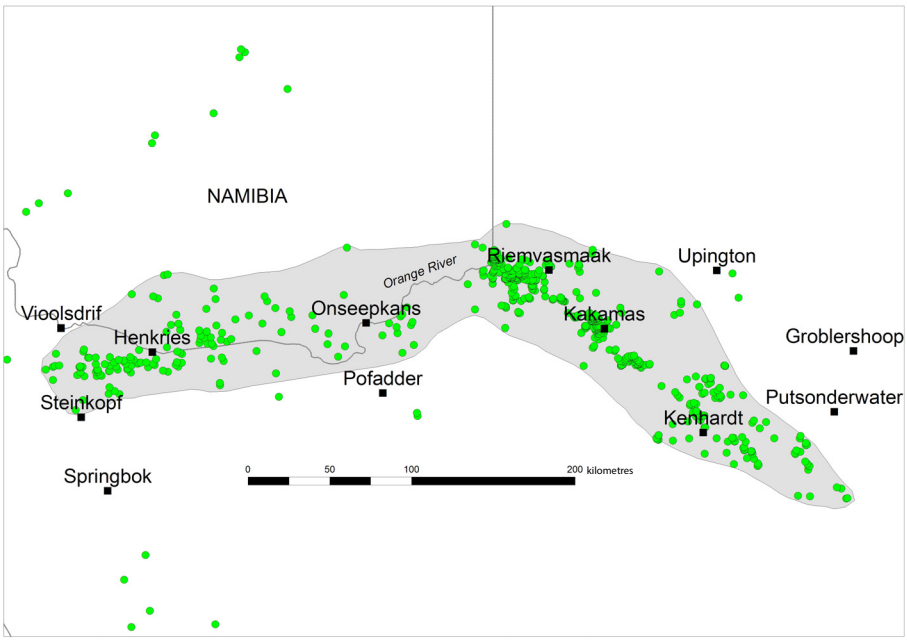
NORTHERN CAPE

ST-2013-1163

Investigation of the economic potential of the pegmatite deposits in the Northern Cape Pegmatite Belt

Project leader	H Minnaar, PhD
Project team	L Chevallier, PhD
Duration	One year

The Northern Cape Pegmatite Belt strikes over a total distance of about 510 km from Vioolsdrif in the west to Putsonderwater in the east and is on average about 50 km wide, partly extending into Namibia.



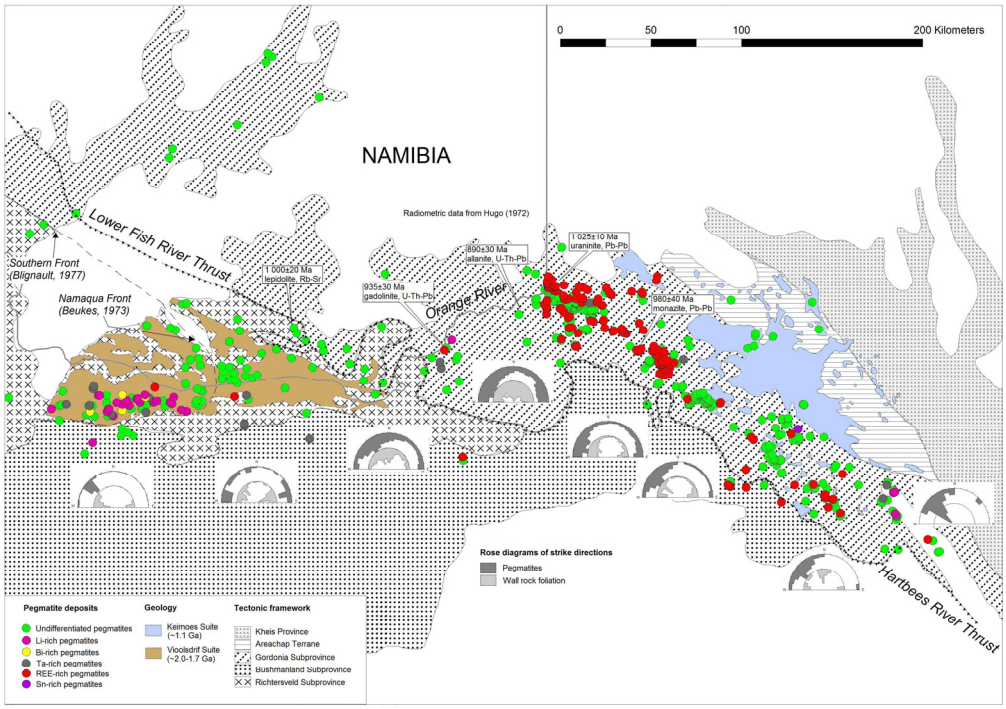
Distribution of pegmatite bodies in the Northern Cape Pegmatite Belt

The sizes of individual pegmatite bodies within the belt vary from a few centimetres to about 5 km. Two types are recognised, namely homogeneous and zoned types and their shapes vary from that of rounded bodies to dykes. Only the zoned bodies have historically been economic. Commodities which have previously been mined from the pegmatites include rose quartz, feldspar, mica, beryl, tantalite, rare earths, Li-minerals and crystals (for ornamental, jewelry and collector purposes).

According to current ore deposit models, the zoned pegmatites represent late-stage crystallisation products after fractional crystallisation. The zoned character is explained by sequential crystallisation from the wall inwards. The identification of the source to the pegmatite fluids is problematic since they are usually not situated within the source pluton.

The first pegmatite to be mined in the Northern Cape pegmatite belt was Blesberg, in 1925, for bismuth and mica. Throughout the years, as the value of commodities varied, the bodies were mined for different commodities. Beryl was a high-priced commodity during the 1930s and 1950s. Mica was important during the early days of electronics. Tantalite became prominent when communication systems started utilising rechargeable batteries. During recent years, feldspar has become the only commodity which offers the opportunity for pegmatite mining operations as a stand-alone commodity. The local glass industry currently presents the only sustainable market while the local ceramics industry provides sporadic opportunities.

Blesberg pegmatite



Regional geological framework of the Northern Cape Pegmatite Belt

In the regional geological framework, the Northern Cape Pegmatite Belt is associated with two distinct calc-alkaline granitic suites, namely the 1.9 Ga Vioolsdrif and the 1.1 Ga Keimoes Suites. The belt is also associated with two distinct tectonic terranes, namely the Richtersveld and Gordonia Subprovinces, occurring near the bounding structures represented by the Southern Front–Namaqua Front and the Lower Fish River–Hartbees River thrusts. Radiometric data fall into two groups, namely 1 000 and 950 Ma. The strike of individual bodies mostly parallels that of the country rock which is predominantly northwest. However, the strike also cuts across the country rock foliation, especially in the west.

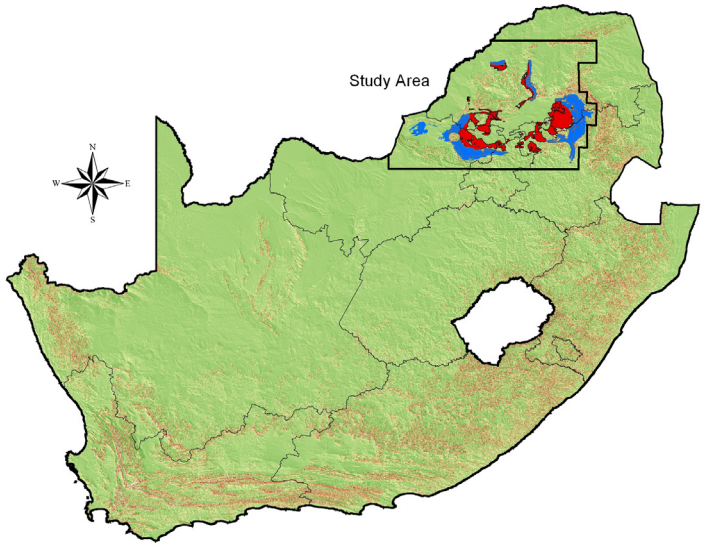
There are still vast resources of pegmatite within the Northern Cape Pegmatite Belt; however, they are not all economic and need to be evaluated individually. Market opportunities for pegmatite minerals are numerous, but the industry is deterred by replacement of traditional pegmatite resources by alternative sources and commodities. The main limiting factors for the development of the Northern Cape Pegmatite Belt are poor infrastructure and distance to the markets with associated transport costs, limited domestic industries and markets, poor demand and low prices. Recommendations for the future development of the pegmatite mining industry in the Northern Cape include the replacement of traditional selective mining by a bulk mining method, value addition operations such as crushing and milling and the purification of materials to industry-specific specifications and extension to the international market. The development of the local markets and industries should also receive attention.

REGIONAL GEOCHEMISTRY

ST-2011-1119

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

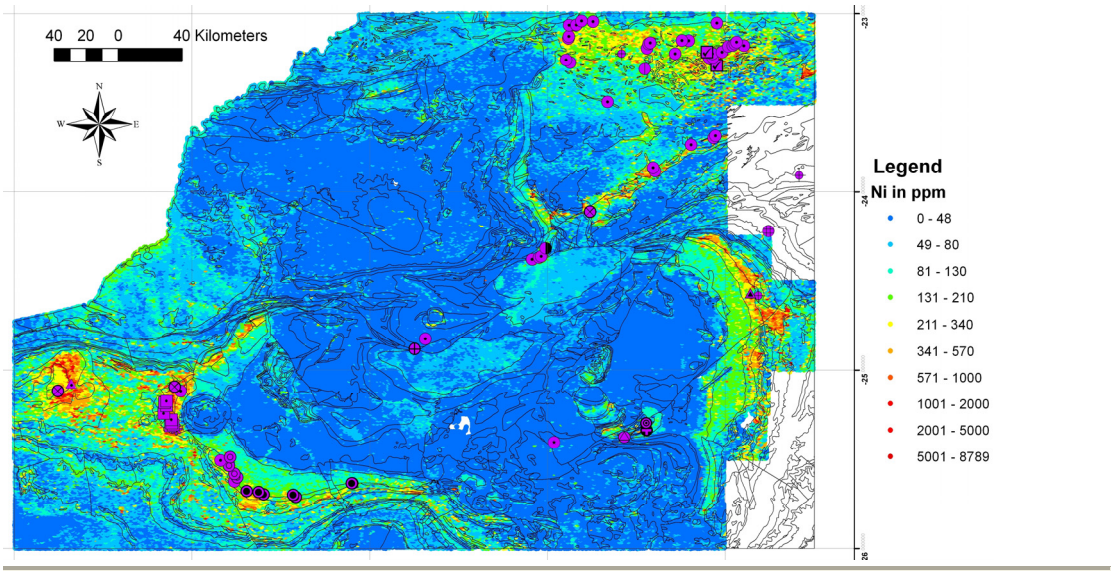
Project leader	JH Elsenbroek, MSc
Project team	SW Strauss, MSc, D van der Walt, BSc Hons, ML Bensid, BSc Hons, S Hlatshwayo, BSc Hons, E Mulovhedzi, BSc Hons, M Maya, BSc Hons
Primary objective	To provide a value-added product, a geochemical atlas, to the existing regional geochemical data in order to highlight cryptic magmatic processes such as differentiation of the igneous units which have previously not been seen on maps. The atlas will also identify 'new' target areas for exploration for Pt, Pd, Au, Cr, Ni, Cu, Sn, W and F
Duration	2011 to 2013
Budget	R60 000.00



Locality of the study area

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. The Regional Geochemical Mapping Atlas of the Bushveld Complex will, for the first time, provide a value-added product to 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. The atlas will identify 'new' target areas for exploration for Pt, Pd, Au, Cr, Ni, Cu, Sn and W. For the first time a holistic interpretation of the current regional geochemical data will be compiled to showcase the value of the data and expertise for pre-competitive purposes.



Geochemical map indicating the occurrence of Ni in the Bushveld Complex

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: 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 has started compiling the layout for the Geochemical Atlas of the Bushveld Complex and surrounding rocks based on the seven geochemical reports on seven different units of the Bushveld Complex:

The Regional Geochemical Maps of the Bushveld Complex and surrounding rocks – previously submitted
The Lebowa Granite Suite – submitted
The Rooiberg Group – submitted
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.

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 on the Bushveld Complex were determined. The geochemical anomalies were compared with the known mineral occurrences. The geochemical data interpretation was described in relationship to the underlying geology.

Future activities

A Geochemical Atlas of the Bushveld Complex and surrounding rocks has been laid out in an A3 format. The seven geochemical reports on the different units of the Bushveld Complex will be compiled into one geochemical atlas in an A3 format which is still in progress. Field visits will be carried out to verify geochemical anomalies and to compare mineralisation and structures 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 of the rocks of the Rustenburg Layered Suite.

CO-2011-5731

Application of hyperspectral remote sensing to assess contamination associated with gold mining in the Witwatersrand Gold Basin, South Africa

Project leader	M Maya, BSc Hons
Project team	H Tutu, PhD, I Weiersbye, MSc, J Engelbrecht, MSc, A Rameolo, PhD
Primary objective	To assess contamination using hyperspectral remote sensing data and efflorescent mineral salts as surrogates in gold mining
Duration	2012 to 2014
Budget	R50 000.00

Motivation

The extent of contamination from mining activities is unknown. Hyperspectral remote sensing can provide quick and effective methods that will detect, monitor and characterise environmental changes in mining areas that are needed to ensure sound environmental practices.

Progress

Sampling and reflectance spectra acquisition by handheld ASD spectrometer were completed in December 2012. Spectral identification of mineral end-members and physical mineralogical characterisation by XRD were also completed. The last part of the chemical analysis was finished in June 2013.

Conclusion

Efflorescence salt crusts are characterised by colourful precipitates. Geochemical evaluation revealed higher concentrations of trace elements in efflorescent salts than in tailings, seepage and groundwater. Higher reflectance was recorded in samples with lighter colours. Spectrally identified mineral end-members include copiapite, geothite, haematite, gypsum and a mixture of clay minerals. X-ray diffraction results confirmed the existence of clays and mica minerals. Correlation between geochemical variables and reflectance parameters show that the SWIR region is sensitive to the pollutants associated with these salt crusts.

Future activities

Current work involves statistical modelling using partial least regression squares (PLSR) to confirm the relationship between geochemical and spectral variables and to establish spectral parameters that can directly predict contamination variables. Geochemical modelling to explain mineralogical sequences will also be carried out.

SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY (SACS)

ST-2002-0449

SACS publications

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

Motivation

The published lithostratigraphic descriptions 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.

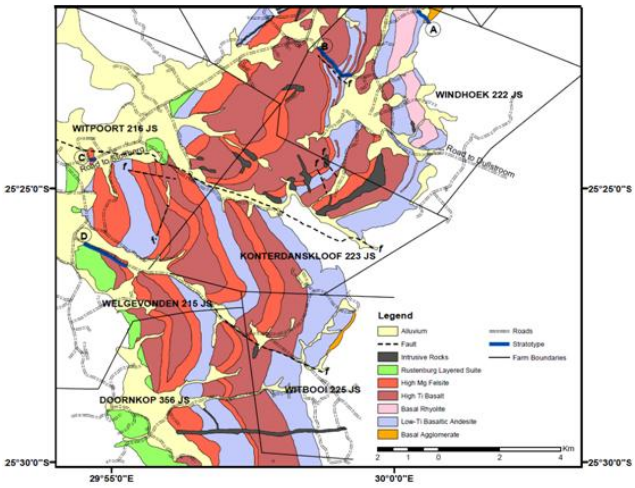
Progress

The status of the publications is as follows:

SACS Catalogue Volume 17. Five contributions were received for this volume (Serala Formation, Dullstroom Formation, Damwal Formation, Kwaggasnek Formation and Schrikkloof Formation). The stratigraphic description of the Dullstroom Formation was revised to include the detailed mapping of individual lava types.

Future activities

Further lithostratigraphic units will be formally described.



Stratigraphic units in the lower Dullstroom Formation

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

Information on stratigraphic units is currently stored in an Oracle database, maintained by an expert database administrator. To facilitate access by SACS Task Group members to the database, migration to a web-based system has begun. The web-based database provides the following information for each entry: (1) unique map label, (2) SACS approval status (approved or not yet approved), (3) name of "parent" unit (next higher in the hierarchy), (4) age, (5) publication status, (6) relevant task group. Additional information, including (7) proposer of name, (8) basic lithology, (9) thickness (where applicable), (10) geographic distribution, and (11) literature references will be extracted from the GEODE database and incorporated into the web-based database. SACS Task Groups will examine existing shape files which are linked to the stratigraphic units and will advise on appropriate modifications before the shape files are fully integrated into the spatial database. New stratigraphic units will be created where appropriate.

Future activities

This project is ongoing.

ST-1999-0519

SACS secretarial functions, including meetings and field trips

Project leader	C Hatton, PhD
Project team	N Keyser, MSc, GA Botha, PhD, JSV Reddering, PhD, PH Macey, PhD, CH de Beer, MSc, L Chevallier, PhD, DI Cole, PhD, DL Roberts, PhD, JHA Viljoen, PhD, G Brandl, PhD, N Baglow, BSc Hons, 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

A report on the Cenozoic Graauw Duinen Formation was received and accepted for publication as a catalogue description.

A 1:500 000 map of western Namaqualand was prepared for presentation at the Centennial Celebration of the Council for Geoscience.

A field trip to examine detailed mapping of the lower Dullstroom Formation was undertaken. Lavas within this formation are of particular significance in determining the tectonic setting of the Bushveld Complex and as records of atmospheric evolution. A presentation based on ancient biostratigraphy was delivered at the International Geological Congress in Brisbane. Preparations for field trips during the International Geological Congress to be held in Cape Town in 2016 were continued.

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

Future activities

This project is ongoing.

ST-2010-1106

Meinhardskraal Granite, Singelele Gneiss and Schiel Alkaline Complex

Project leader	N Baglow, BSc Hons
Project team	NC Mukosi, BSc Hons, LP Munyangane, BSc Hons
Primary objective	To provide a concise comprehensive lithostratigraphic description and type area for the following stratigraphic units: Meinhardskraal Granite, Singelele Gneiss and the Schiel Alkaline Complex
Duration	Ongoing
Budget	R7 870.00

Motivation

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

Progress

The descriptions for the Meinhardskraal Granite, Singelele Gneiss and the Schiel Alkaline Complex were completed.

Conclusions

The Meinhardskraal Granite is intrusive into the Turfloop Granite and is unconformably overlain by the late (<2.65 Ga) Archaean to early Proterozoic Transvaal Supergroup strata, ranging in composition from alkali granite to syenogranite. Located southwest of Polokwane, the intrusion comprises a generally homogeneous, leucocratic medium- to coarse-grained rock which varies from pale pink to light grey in colour.

The Singelele Gneiss occurs in the Central Zone of the Limpopo Belt where the stratigraphic succession consists of a granitic basement complex (Sand River Gneiss) that is infolded and possibly inthrust with a suite of supracrustal gneisses. The Singelele Gneiss yields Rb-Sr whole rock isochron ages of approximately 2 650 to 2 600 Ma and these ages have been largely confirmed by a number of zircon U-Pb dates. Recently, a hafnium model age of 2 647 ± 12 Ma has been put forward.

In the Singelele Kop type area immediately to the west of Musina, the Singelele Gneiss is exposed as a dome that has extended for not more than 200 m. The gneiss usually exhibits a patchy distribution and hosts fold closures, minor folds and minor interference structures. The Singelele Gneiss represents groups of quartz-feldspathic lithologies that can be subdivided into banded and felsic types. Various suggestions have been put forward as to the origin of the gneisses, including partial melting of tonalitic gneisses which form the basement of the Musina Group rocks, though other workers have argued that the Singelele could not have been derived from the rocks known in the area. Yet others have presented evidenced that the Singelele Gneiss represents highly metamorphosed sedimentary or volcanosedimentary rocks that were part of the supracrustal succession.

Intruding into the granitic and migmatitic Goudplaats–Hout River Gneiss in which slivers of metapelitic and ultramafic gneisses of the Bandelierkop Complex occur, the Schiel Alkaline Complex has yielded a Pb isotopic age of 2 059 + 34/-36 Ma. The complex can be subdivided into eastern and western components. In the eastern part, the complex consists of a small, elliptical syenogabbro body that is partially surrounded by a larger V-shaped pyroxenite-syenite-quartz syenite-granite body with two limbs extending west–northwestwards and southwestwards for about 15 and 20 km. The latter is partly controlled by the northeast-striking Kudus River Lineament. The most prominent rock type is the quartz syenite that forms an arcuate range of hills approximately 5 km in diameter, adjoining an amphitheatre of deeply weathered ground.

SEISMOLOGY

ST-2002-0475

The 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
Primary objective	Maintenance and operation of the South African National Seismograph Network (SANSN) in order to ensure that high-quality seismic data are received at the National Data Centre (NDC) at the Council for Geoscience for analysis and timely release of earthquake information to the public and media and publication in quarterly seismological bulletins
Duration	2012/13

Motivation

To maintain the South African National Seismograph Network in order to produce high-quality seismic data from 33 remotely deployed seismograph stations throughout South Africa while ensuring a high-percentage data availability in as near real time as possible. To monitor the state-of-health of seismic stations on a daily basis to ensure a quick response to any failures. The data are used to produce the relevant information required for bulletins and seismic hazard maps.

Progress

Methods have been implemented in order to enable a seismograph system to send real-time seismic data to a central facility for analysis. These methods utilise the General Packet Radio Switching (GPRS) data transmission protocol as well as sophisticated data acquisition software at all the stations. The project researchers and maintenance team are in constant communication with the data acquisition software developers in order to implement new software releases 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. 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 to insure proper operation of systems without undertaking unnecessary field trips. New hardware for the data acquisition software has been introduced to help improve reliability. A new seismic station was installed near Beaufort West during the financial year.

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 bulletins in a timely fashion. As the cost, reliability and bandwidth capability of the GPRS network improve, 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 better than ever before.

Future plans

By reducing communication costs, it may be an option to move over to continuous high sample data streams. This option will eventually enable the Council for Geoscience to have less hardware in the field and thus higher reliability.

ST-2002-0184

1) Seismological monitoring, analyses and bulletin compilation

2) Compilation and maintenance of database of South African seismicity

3) THRIP — Seismological Database for Nuclear Power Plants

Project leader	I Saunders, BTech (Geol)
Project team	MBC Brandt, PhD, 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 SANSN provides the valuable data that are required for seismic hazard analysis and insurance claims. Seismological data from the SANSN are preserved for prosperity through a National Earthquake Database
Duration	2012/13

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). Analysis of the recorded waveforms presents static and dynamic parameters of the focus emitting the energy and additionally provides information on the medium transmitting the energy. The data also reveal the properties of materials through which the seismic waves were propagated.

The SANSN is the only vehicle capable of accurately reporting the distribution of seismic foci in South Africa, the distribution of seismic activity in time and provides a calibrated uniform magnitude scale of recorded events. The information gathered through the SANSN is banked in digital format, which affords future generations the ability to revisit seismic data if and when more advanced analysis tools and techniques become available. The data obtained through the analysis of waveforms are shared with a varied audience both nationally and internationally and are distributed within the Council for Geoscience through the Geoscience Mapping and Physical Geohazards thrusts.

Progress

The earthquake swarm in the towns of Augrabies and Keimoes in the Northern Cape Province continued during the year, but with less intensity and 113 earthquakes were recorded.

Earthquake activity in South Africa for the period January to December 2012 was released through *ad hoc* reporting and quarterly seismological bulletins.

Two scientific papers were published in international journals. These were:

- Brandt, MBC and Saunders, I (2011). New regional moment tensors in South Africa. Seismological Research Letters, 82(1), pp. 69–80.
- Saunders, I, Ottemöller, L, Brandt, MBC and Fourie, CJS (2013). Calibration of an M_L scale for South Africa using tectonic earthquake data recorded by the South African National Seismograph Network: 2006 to 2009. Journal of Seismology, 17(2), pp. 437–451.

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 larger than $M_L \geq 3.0$ in South Africa for the period January to December 2012

Date	Time	Region	Magnitude (M_L)
2012/01/13	12:17:00.9	Namaqualand	3.1
2012/01/25	25:38:56.6	Namaqualand	3.7
2012/01/27	02:42:53.4	Roggeveldberge area	3.1
2012/01/28	23:45:19.8	Augrabies area	3.2
2012/01/31	06:27:12.1	Augrabies area	4.1
2012/02/28	12:40:44.2	Kokstad area	3.4
2012/03/09	09:18:18.9	Augrabies area	3.3
2012/03/27	17:50:19.2	Groblersdal area	3.0
2012/03/30	22:06:43.7	Prince Albert area	4.1
2012/03/31	05:13:51.7	Namaqualand	4.4
2012/04/02	04:36:04.2	Augrabies area	3.7
2012/05/13	15:58:11.2	Augrabies area	3.0
2012/05/26	08:36:28.3	Namaqualand	3.4
2012/05/27	20:56:33.7	Piet Retief area	5.0
2012/06/10	15:03:21.3	Namakwaland	3.3
2012/07/30	22:28:23.2	Edenburg area	3.7
2012/11/01	16:18:01.5	Klerksdorp gold mines	3.3
2012/12/01	11:20:18.8	Namibia	3.1

Table 2: List of mining related earthquakes larger than $M_L \geq 4.0$ for the period January to December 2012

Date	Time	Region	Magnitude (M_L)
2012/03/08	15:40:56.2	Klerksdorp gold mines	4.1
2012/05/24	00:37:21.2	Klerksdorp gold mines	4.1
2012/12/01	11:20:18.8	Namibia	3.1

CO-2006-5606

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

Project leader: FA Delport, BTech Elec Eng

Project team: L Tabane, Nat Dip Elec Eng

Primary objective: The Council for Geoscience (CGS) has been designated by the Department of International Relations and Cooperation (DIRCO) to act as the technical point of contact regarding Comprehensive Nuclear-Test-Ban Treaty (CTBT) matters. Owing to South Africa's obligation to the Nuclear-Test-Ban Treaty, the Council for Geoscience is committed to maintaining the International Monitoring System (IMS) primary seismic station 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 (IDC) based in Vienna, Austria. The objective of the National Data Centre (NDC) operations is to apply methods with respect to the operation and maintenance of the stations in order to meet the requirements of the protocol of the Treaty

Duration 2013 to 2015

Motivation

Because of South Africa's commitment to the treaty, the Council for Geoscience (CGS) has been designated to act as the technical point of contact with respect to seismological and infrasound matters and also to operate a National Data Centre (NDC) which functions within the framework as required by the Comprehensive Nuclear-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 active participation of the Council for Geoscience in CTBT matters, the operation of such a National Data Centre and analysis of seismic data, obtained from the local and neighbouring NDCs which all form part of the International Monitoring System (IMS), contribute towards international cooperation and enhance the corporate image of the Council for Geoscience.

Progress

The station entered its eighth year of operation after certification in December 2004. The Station Operator (SO), who is to be considered a qualified technical staff member of the Council for Geoscience, visited the station on a quarterly basis in order to ensure proper operation of the data communications and data acquisition equipment which are deployed at the borehole site at Boshof. These visits are mandated in terms of the approved budget for the project and are agreed upon by both parties. Several configuration change notifications, outage requests and problem reports were generated and communicated with the Operational Centre of the International Monitoring System. Monthly reports were also submitted to the operational centre as required. The Provisional Technical Secretariat (PTS) considers the monthly reports as a payment validation for each quarter. Invoices are submitted to the PTS.

Throughout the reporting period, the Station Operator was in constant contact with experts at the Air Force Technical Application Centre (AFTAC) concerning discussions and resolutions in rectifying problems at the BOSA site. Hardware upgrades which are performed on an ad hoc basis to ensure data availability is at a level as prescribed by the PTS (98 % constant data availability at all times). The upgrades enable staff from AFTAC to monitor and identify equipment failure remotely through a Supervisory Control and Data Acquisition system (SCADA). This enables the Station Officer to react immediately and replace faulty and/or dysfunctional equipment. The upgrade also included an advanced grounding scheme which minimises the effect of thunderstorm activity in the area.

In the past, most station outages were caused by AC power failures at the borehole site and the Uninterrupted Power Supply unit (UPS) could only supply power for approximately one hour after failure. This was often problematic as some AC load shed conditions often lasted for periods of up to three hours. The installation was thoroughly tested by the design team at AFTAC before it was deployed in South Africa. This system 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

Since the station was certified, the Council for Geoscience has entered into a contractual agreement with the CTBTO. The Station Officer (SO) (of the CGS) has continually communicated operational matters between AFTAC and the IMS Operational Centre. The SO was in a position to react almost immediately on outages in order to swap out defective components. The SO still needs to be informed by AFTAC on system failures. The SO and the LO (Local Operator) have always been able to solve problems at the site. These include issues with the Satellite Communication System.

Future activities

Irrespective of the technical upgrades that were performed at the station, the SO wishes to gain access to the AFTAC monitoring system to react immediately in the event of system failure issues. To further improve mission capable up-times, the SO will suggest and possibly design the deployment of additional monitoring equipment at the station. The broadband sensor was replaced in 2010. This was done by installing the new seismometer above the old since the older seismometer could not be recovered from the borehole after so many years of operation.

CO-2006-5620

Infrasound station IS47

Project leader	FA Delport, BTech Elec Eng
Project team	L Tabane, Nat Dip Elec Eng
Primary objective	The Council for Geoscience has been appointed as the technical point of contact and has been 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 that 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 and 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	2012/13

Motivation

As in the case of the primary seismic station (PS39), the Council for Geoscience has also been 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 the 60 infrasound stations of the International Monitoring System (IMS) of the Comprehensive Nuclear-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, namely seismic, hydro-acoustic and radionuclide, for monitoring adherence to the CTBT. Research in the field of infrasound data is limited and contributing quality data from this site may contribute towards studies in atmospheric wave behaviour.

Progress

The infrasound station was certified on 12/12/2005 by the Preparatory Technical Secretariat. The technical staff of the Council for Geoscience 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 Station Officer (SO) did a thorough investigation into deploying appropriate security equipment. Such equipment was deployed at selected array elements which resulted in the non-occurrence of vandalism. Security matters were also taken up with the local police station who improved patrol and awareness matters. All related issues were communicated to the DIRCO. Currently an ADT monitoring system is deployed at the site and is maintained by ADT on a monthly basis. The Local Operator (LO) has also replaced all commercial solar brackets with dedicated brackets and has strengthened some with expanded metal.

The satellite communications equipment was also upgraded during the reporting period and the SO has been involved with AIS Eng (an AFTAC subcontractor) to ensure that the data are transferred to the United States National Defence Corps (USNDC) and CTBTO within the requirements as mandated by the agreement between the Council for Geoscience and the CTBTO.

Conclusions

The 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 this project. Station performance was good and no outages were experienced as a result of AC power failures. The equipment deployed at the Central Recording Facility (CRF) 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 radiotelemetry and summing manifold vaults are located beneath the ground surface, water tends to infiltrate these facilities during the rainy season. To protect the delicate electronic equipment located in these vaults, the SO suggested that the IMS Operational Centre deploy submersible water pumps in each of the vaults. This problem was escalated to the Engineering and Development Department of the CTBTO who decided to replace the vaults with new constructed items imported from Vienna, Austria.

It will also be suggested that dedicated hardware monitoring modules be deployed to monitor hardware system performance and enable the LO (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 also be investigated.

ST-2012-1157

Seismic analysis and updating database of cluster networks in South Africa

Project leader	L Labuschagne
Project team	TT Molea, A Mangongolo, D van Zyl, Analysts
Primary objective	The project objectives are to add to the record of seismic activity in southern Africa, to disseminate earthquake information to stakeholders, the banking and safe keeping of recorded data and to provide training to seismic analysts to assist with commercial projects
Duration	2012/13

Motivation

The Seismology Unit has and will be installing a number of small cluster networks in areas of high seismicity. The data generated by these stations will be sent in real time to the CGS offices. These data fall outside the SANSN and thus are saved and analysed separately from those under the responsibility of SANSN.

This project therefore aims to provide an "umbrella" project under which all of these smaller cluster networks will be analysed.

Ultimately, the data will contribute to the knowledge base of the unit, especially the Seismic Hazard Section.

Progress

Data were analysed and updated on SEISAN. In June/July 2012 the Seismology Unit upgraded their system to Antelope. Data were checked by individual analysts and events were located and checked back in for revision for the time period April 2012 to March 2013. A report was compiled for these data.

A test was conducted to determine the residual improvements between locating events using all the stations from all the cluster networks which were available and locating events using only the close stations (i.e. stations located closest to the epicentre). These test results were compiled into a report.

Conclusions

The stations that are closer seem to be more reliable in terms of a good location with fewer residual values compared to those far from the epicentre. Thus, the best results appear to be achieved by only using cluster network stations for more correct residuals as well as a better location of events.

Future activities

Improvement of the analysis of data by adding more different phases to data.

ST-2012-1143

Plate tectonics movement in the EARS: the M_w 7.0 Mozambique earthquake of 2006 and its effects in South Africa

Project leader	T Pule, BTech (Geol)
Project team	V Midzi, PhD
Primary objective	The main objectives of the project 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 their movement. The seismological monitoring network routinely records earthquake occurrences throughout South Africa. The data will be used to determine the most vulnerable regions by studying the highest recorded earthquakes and to determine the active faults by investigating the geological maps and seismological activity of the region. Different attenuation models will be used to provide an estimation of the ground motions
Duration	2012/13

Motivation

Research in the East African Rift System can have various indirect benefits to society. The society as well engineers who are responsible for the building of infrastructure may be advised to always take tectonic movement into consideration. This is actually the first step in preparing the community and engineers of the risk and hazard that can affect society.

Conclusions

There is a potential for large earthquakes occurring at the southern extent of the East African Rift System in Mozambique. Based on the observations presented in this study, the earthquakes occurring in the southwestern part of Mozambique can potentially have a devastating effect on South African structures through poorly attenuated and amplified ground motion.

Future plans

The future activities include continued investigations on the East African Rift System and estimating the ground motions using different attenuation equations in an effort to understand how the earthquakes occurring in the East African Rift System can affect South Africa.

ST-2013-1210

Earthquake relocation using the double difference method in the Augrabies area

Project leader	L Akromah, BSc Hons (Phys), Nat Dip (Analytical Chem)
Project team	A Mangongolo, MSc (Geophys)
Primary objective	Investigation of active faults that could be responsible for the swarm that began in 2010 in the Augrabies area using the data acquired from the National Seismograph Network of the Council for Geoscience. This will benefit the public and scientists interested in the seismicity of the area
Duration	2012/13

Motivation

To investigate and locate the active faults responsible for the seismicity in the Augrabies area, with the data obtained mostly from the nearby stations to ensure accuracy of the results. The use of the HypoDD algorithm was necessary to make sure that accurate results are obtained despite errors that could be found in the data acquired. The information obtained from this project could also be utilised for seismic hazards. While most earthquakes are caused by movement of the earth's tectonic plates, human activity can also produce earthquakes. Four main activities contribute to this phenomenon: storing large amounts of water behind a dam (and possibly constructing an extremely heavy building), drilling and injecting liquid into wells, and by coal mining and oil drilling.

Progress

In this research, the HypoDD method was used to relocate the events that were initially located by SEISAN with the aim of eventually comparing the resulting seismicity with the structural maps provided by geologists at the Council for Geoscience. HypoDD is a Fortran computer program developed by Waldhauser and Ellsworth in 2000 and has been packaged to relocate earthquakes with the double difference algorithm. Geiger's method is usually used in earthquake location algorithms. Here, the travel time equation is linearised in first order Taylor series. This is done so that the equation will relate the difference between the observed and predicted travel times to the unknown adjustments by finding the partial derivatives of travel times with respect to the unknown.

The instruments communicate via GPRS using IP addresses. In this research, one out of two types of instruments was chosen for each station, since seismometers could be either broadband or short period. Each seismometer has three channels, two vertical components (east–west and north–south) and one horizontal (Z-component).

Conclusions

The results show an extension along the vertical axis, and shortening along the horizontal axis, with a northeast–southwest orientation. Conclusions could not be made as to whether the seismicity was associated with the geological structures in the area since the orientation was not aligned to any of them.

Future activities

Deriving focal mechanisms from a solution of the moment tensor for the earthquakes, which itself is estimated by an analysis of observed seismic waveforms and finding depths of earthquakes using waveform modelling.

ST-2013-1171

Comparison and quantitative study of vulnerability/damage curves in South Africa

Project leader	T Pule, BTech (Geol)
Project team	V Midzi, PhD
Primary objective	The aim of this study is to assess the seismic risk for South Africa by examining the expected losses owing to damage to residential buildings. Vulnerability/damage curves of different building classes for South Africa will be determined. Technical input will be obtained from several sources which are actively involved in construction within South Africa and other countries. The main objectives of the study are (1) the collection of all available information about damage curves available in literature; (2) extensive study and comparison, and (3) choice of the most adequate curves for South Africa
Duration	2012/13

Motivation

This study will provide vulnerability and damage curves of different building classes for South Africa, the extensive study and comparison of the existing literature and the selection of the most adequate damage curves. It is necessary for scientists, planners, engineers and decision makers to be aware and consider the probabilities of structural damage which might result from the occurrence of an earthquake.

Conclusions

The study is intended for policy makers, practitioners and researchers in the public and private sectors who have roles in assessing risk, developing strategies for managing risk and formulating plans for responding to and recovering from natural disasters. It is also necessary for scientists, planners, engineers and decision makers to be aware and consider the probabilities of structural damage which may result from an earthquake. Moreover, the study informs and prepares the society as well engineers who are responsible for building infrastructure to always take damage curves into consideration.

Future activities

The second step will include the identification of suitable Ground Motion Prediction Equations (GMPEs) for South Africa, calculating damage curves from each selected GMPE and comparing the effect of damage curves on predicted damage in South Africa and other countries.

ST-2013-1181

Compilation of an inventory of historical and macroseismic data for South African earthquakes

Project leader	N Flint, MSc
Project team	F Strasser, PhD, V Midzi, PhD, B Zulu, BSc Hons, Dr Albini (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Primary objective	The objective of this project is to establish an inventory of original records, macroseismic observations and other records used to assess the intensities of historical earthquakes, and, in some cases, to allow for additional information on the historical sources and localities (e.g. the historical context, population structure and nature of buildings or building methods) in order to support and expand the CGS earthquake catalogue. This information will be used by the

Seismology Unit and may eventually be made available to other members of the scientific community

Duration 2012 to 2016

Motivation

The study of historical events attempts to reliably reconstruct the events of the past with the aim of creating a survey of earthquakes in history in order to determine the risks and hazards of a particular area or country. As reliable instrumental data have only been available for a few decades, it is internationally accepted that research on historical earthquakes plays an important role in the compilation and development of an earthquake catalogue. Although major earthquakes (M>5) are rare in South Africa, there have been at least two earthquakes of M_L 6.3 in the last 80 years, resulting in widespread damage to buildings and property and, in the case of the Ceres earthquake of 29 September 1969, the loss of 12 lives.

In order to comply with evolving requirements for seismic hazard assessments and nuclear safety, the Council for Geoscience has begun a revision of the existing CGS earthquake catalogue, including the incorporation of historical records and the evaluation of historical sources in order to supplement the instrumental record and identify previously unknown or spurious earthquakes.

Since the use of the historical approach is still relatively new in the Council for Geoscience, the supporting information is either distributed between various persons within the organisation, has not been retained or has not been found or consulted yet. Therefore, there is currently no simple way for assessing what data are available for which earthquake. This makes it difficult to identify "data gaps" that need to be addressed. A more organised approach will add value to the existing CGS earthquake catalogue and will inform the way forward in building a more complete historical catalogue.

Progress

There has been much discussion about how best to organise the data and the output of the assessment of intensity data points to maximise their usefulness to those who will be required to use the data in seismic hazard assessments but, to date, no consensus has been reached as there has been little opportunity for in-depth discussion.

Since October 2012, the currently available sources of data that were accessible are being collected and reviewed to refine the representation of events and are being incorporated into a simple structure to determine completeness for each event. Where applicable and, as required, the information gathered was used to identify actions and searches that could increase the number and/or quality of the observations of the effects of the earthquake. In the light of forthcoming projects, the area of interest predominantly has been the Western and Northern Cape, but this has not precluded searches for information on other events that are already included in the catalogue.

In addition, and simultaneously, some new sources that could be found in national libraries and archives have been consulted, and, where applicable, used to supplement existing earthquake accounts or initiate the investigation of 'new' events. As mentioned previously, care should be taken to distinguish between real and 'spurious' earthquakes, and as more information is collected on these 'new' events, the validity thereof will become more apparent.

Conclusion

To date, the use of this approach has resulted in the addition of approximately 70 new events that were not previously included in the CGS earthquake catalogue. Many of these were found in the annual reports of the Meteorological Commission to the Parliament of the Cape of Good Hope. The Meteorological Commission, initiated by Sir Thomas Maclear (1794–1879), the Royal Astronomer at the Cape of Good Hope, had an extensive network of various kinds of meteorological stations all over the Cape Colony and surrounds and was responsible for collecting daily meteorological observations. As these were educated men with a scientific interest, there is often mention of other items of interest, such as earthquakes, meteors, diseases, locusts, etc.

Negative information, i.e. about the lack of earthquakes, can also be useful in that it places constraints on the time periods to be searched for events. In fact, according to current knowledge, the first recorded genuine earthquake at the Cape only occurred in 1690, although there are reports of possible earthquakes in 1620 and 1635, respectively.

Future activities

An inventory of all supporting information and the associated IDPs may, in future, be used as follows:
i) Isoseismal contours may be plotted and the epicentral coordinates may be computed using the barycentre of the isoseismals of maximal intensities.
ii) Source parameters, such as magnitude and depth, may be calculated from intensity data.
iii) Intensity data points and derived data may be used in seismic hazard assessments for critical structures, e.g. dams, high-rise buildings, etc.

It is planned that historical work done by the author and co-workers arising from previous projects will be published in due course and this has also played a role in the events that have been investigated at in more detail.

ST-2007-0944

Seismotectonic Map of Africa

Project leader	V Midzi, Dr Sci (Seismology), Dip (Meteorology)
Project team	B Manzunzu, BSc Hons, BS Zulu, BSc Hons, T Mulabisana, BSc Hons, T Pule, BTech
Primary objective	The main objective is to prepare a seismotectonic map for Africa that can be used easily in seismic hazard investigations on the continent. A database of relevant information will be created by means of an ArcGIS subproject. A leaflet that supplements the map will include a detailed legend with explanations of the seismotectonics of each province
Duration	2012/13

Motivation

The African continent forms a tectonic plate with diverse geological domains that include seismically active zones. Although some regions of the plate are presumably qualified as stable, several moderate to large earthquakes (with M≥6) have occurred in the past. Active zones with significant late Pleistocene and Holocene tectonics (last 100 ka) characterise the continental deformation near the plate boundary and its permanent background seismicity. The presence of major active faults that generate destructive earthquakes is among the most important geological and geophysical hazards for the continent. The Seismotectonic Map of Africa at 1:10 000 000 is an effort deployed by the Organisation of African Geological Surveys (OAGS) to obtain a better knowledge of the geology and geodynamics of Africa. The map will assist in mitigating earthquake-related disasters in Africa.

Progress

A seismic catalogue for the period 1620 to 2011 was compiled and was homogenised to moment magnitude (Mw). The current catalogue covers South Africa, Lesotho, Swaziland, Botswana and Namibia. Several maps of faults in southern Africa have been compiled with the assistance of colleagues from Namibia, Botswana and Zimbabwe. At this first stage, no effort was made to identify the active faults. The next step is to characterise the faults including associating the seismicity with major faults in the region. An effort was also made to compile available information on earthquake fault plane solutions for earthquakes in southern Africa. Most of the available solutions were obtained from publications, whilst some were determined by staff members of the Council for Geoscience and are yet to be published. In general, the style of faulting in the region is dominated by normal and strike-slip faulting. Information on the African intraplate stress regime was obtained from the World Stress Map.

Conclusions

To prepare a map that will reliably be used in seismic hazard assessments. It is necessary that more data are collected in order to characterise earthquake sources in the region and on the continent, such as geophysical and geodetic data. Such data and interpretations are available in collected publications, which will be extracted and added to the database.

Future activities

The activities of the project in the forthcoming year will be dedicated to: 1) the preparation of the draft map of seismotectonic provinces of Africa, 2) the development of the exchange of data and software, and to increase the contact between scientists in Africa. Specifically, to achieve these goals, there will be a need to obtain published fault plane solutions in Mozambique, Zimbabwe, Botswana, Namibia and Angola, to identify active faults by associating seismicity with faults and to characterise active faults using fault plane solutions, and for published geophysical and geological information.

SPATIAL DATA MANAGEMENT

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

Project leader	HJ Brynard, PhD (till end July 2012)
Project team	K Wilkinson, Nat Higher Dip (Carto), D Sebake, MSc (Environ and Dev), S Noruka, BSc Hons
Budget	R448 811.25

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

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

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

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

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

Geode Systems — Data administration (0785) and Database administration (0473)

Project leader	HJ Brynard, PhD (till end July 2012)
Project team	K Wilkinson, Nat Higher Dip (Carto), S Tucker, Dip SBM, F Nkosi, Nat Dip (IT)
Budget	R211 266.00

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.

GeoPortal maintenance/applications (0856)

Project leader HJ Brynard, PhD (till end July 2012)
Project team S Tucker Dip SBM, M Roos, Nat Higher Dip (Carto)
Budget R52 526.26

The geoportal forms part of the stakeholder function of the Council for Geoscience and must therefore be properly maintained to operate on a full-time basis. To ensure this, certain maintenance and back-up procedures need to be performed.

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

Project number	Project title/map sheet	Project leader and team	Costs
ST-2006-0901	2526BB Mabeskraal	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, E Magagane, Nat Dip (Carto)	
ST-2006-0901	2526BD Mabaalstad	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, E Magagane, Nat Dip (Carto)	
ST-2001-0697	3129BC Lusikisiki	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, M Roos, Nat Higher Dip, C Thomas, Nat Dip (Carto)	
ST-2000-0594	3129CB Tombo	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, M Roos, Nat Higher Dip, C Thomas, Nat Dip (Carto)	
ST-2000-0594	3129CC & CD Coffee Bay	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, M Roos, Nat Higher Dip, C Thomas, Nat Dip (Carto)	
ST-2000-0594	3129DA Port St Johns	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, M Roos, Nat Higher Dip, C Thomas, Nat Dip (Carto)	
ST-2007-0901	3129BD & 3130AC Mkambati	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, E Magagane, Nat Dip (Carto)	

1:250 000 Metallogenic Maps

ST-2002-0748	2918 Pofadder	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, M Roos, Nat Higher Dip (Carto), M Nkosi, Nat Dip (Carto)	
ST-2003-0797	3118 Calvinia	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, S Noruka, BSc Hons, E Magagane, Nat Dip (Carto)	
ST-2002-0459	3324 Port Elizabeth	K Wilkinson, Nat Higher Dip (Carto), H Brynard, PhD, M Roos, Nat Higher Dip (Carto), M Nkosi, Nat Dip (Carto)	

1: 250 000 Gravity Maps

0279-Small Cartographic Projects	3218 Clanwilliam	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3226 King William's Town	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3228 Kei Mouth	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3318 Cape Town	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3319 Worcester	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3322 Oudtshoorn	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3324 Port Elizabeth	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3326 Grahamstown	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	
0279-Small Cartographic Projects	3420 Riversdale	K Wilkinson, Nat Higher Dip (Carto), C Thomas, Nat Dip (Carto)	

WATER GEOSCIENCE

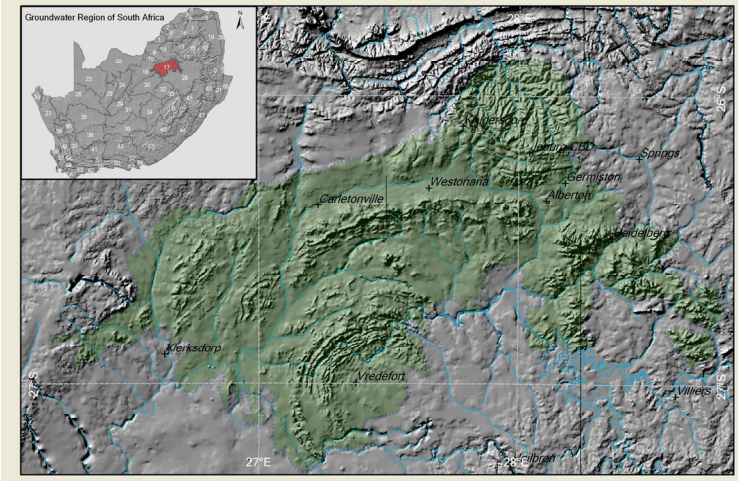
CO-2012-5743

The hydrogeology of Groundwater Region 17: Central Highveld (K5/2049/1)

Project leader	L Lin, PhD
Primary objective	The major objective of the project is to delineate the occurrence of groundwater in Groundwater Region 17 by using existing data/information obtained from different data sources and subsequently prepare a guideline document for the exploration and further development of groundwater resources in the region
Duration	2011 to 2013
Budget	R700 000.00

Motivation

The project *K5/2049: Hydrogeology of Groundwater Region 17: Central Highveld* was commissioned by the Water Research Commission (WRC) in 2011 with a contract between the WRC and the Council for Geoscience (CGS) in May 2011. The project is prioritised because (1) the region covers the majority of Witwatersrand Basin goldfields from KOSH through the Far West Rand to the Western and Central Basins and part of the Eastern Basin, where the operation in three gold basins have been ceased, resulting in the increasing threat of mine water level rebounds; (2) the region covers South Africa's most urbanised area — one of high population and lower abundance of natural water resources. The vulnerability of the groundwater resources to contamination may worsen as a result of a wide range of human, industrial and land use activities; (3) the Central Highveld region is increasingly under threat because of anthropogenic activities of the past and present. The area includes arguably not only the most impacted natural environment in the already water-stressed Upper Vaal Water Management Area, but also the Vredefort Impact Structure World Heritage Site, which elevates interest in this groundwater region to an international level. Therefore, there is a need to collate in a single reference a synthesis of the current knowledge and understanding of the hydrogeological system in the region.



Location of Groundwater Region 17

Progress

This project mainly concentrates on two aspects in the description of the Groundwater Region by using existing data sourced from databases and previous reports. One aspect is the occurrence of groundwater controlled by natural factors and the other the impact of anthropogenic activities on groundwater physical and chemical environments. So far, most of the data collection has been completed, except for some geophysical data that need to be captured from previous reports hosted by DWA GH Report, CGS archive, and data from the mines in the area; this part of data capturing will be completed at the final report (draft) stage. So far, two inception reports have been submitted to the client (the WRC), with the other two deliverables still to be submitted. This project would be completed by September 2013 and we now approaching to the final (draft) stage in terms of technical work and final report preparation.

Conclusions

This research is a desktop-based study, based on existing data which include physiography, geology, aquifer property and borehole groundwater data. First, a comprehensive literature view and acquisition of relevant data/information were undertaken, resulting in a better understanding of the aquifer systems in the region. Second, this study will lead to a number of products which are a series of maps for the delineation of the groundwater occurrence, a guideline for groundwater development study and a guideline to indicate the need of further groundwater research in the region.

Future activities

1) Integrate groundwater data from various sources into a database with consistent format that can be directly used by other mapping software; perform relevant data analysis and associated diagram process; 2) a more detailed subdivision of the region will be done; 3) revise and prepare datasets for archive purposes, review additional reports to extract additional data, and 4) compile final report draft.

CO-2012-5742

Impact of fault structures on the occurrence of groundwater in fractured rock aquifers (K5/2053)

Project leader	L Lin, PhD
Primary objective	To develop conceptual models and to assess the impact of different types of fault structures on groundwater resources in highly anisotropic fractured-rock aquifers for water-scare areas in South Africa
Duration	2011 to 2013
Budget	R700 000.00

Motivation

Faults are one of the most important geological structures that control the occurrence of groundwater in fractured-rock aquifers. Fault-controlled aquifers have been an important well-field development target zone for water supply, especially for water-scarce areas in South Africa. However, much research is still needed as detailed information on faults, which control the occurrence of groundwater and are responsible for exerting impacts on aquifer properties at various scales, is scarce. This has resulted in very few researchers investigating the characteristics and patterns of these geological structures at various scales. Therefore, the constituents and mechanisms of fault structures and their impact on groundwater occurrences 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 comprehensive, incorporating desktop studies, field measurements and testing. There are six deliverables that need to be completed. In 2011/12, a comprehensive literature review was done, with an inception report submitted to the client and a presentation given to the Reference Group Meeting in February 2012. Thereafter, the project concentrated on data collection and site selection to meet the requirements of Deliverable 2.

After examining previous studies/reports from the 1980s to 2000s in South Africa, it became evident that the site selected for the case study of the project would include the lithology of granitic gneiss or basalt lava, or sandstones or mudstones, but not dolomitic aquifers which hold complex cavity systems, because this research would focus on the properties of fracture networks that control both groundwater flow and storage. As a result, the sites such as Alldays with the Taaibos fault in Limpopo, Ottosdal with the Kareekuil fault in North West, Oudtshoorn with the Cango fault, and Rawsonville with the Waterkloof fault were taken into account for further research purposes.

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 in the vicinity of a normal fault. Based on the data derived from previous fieldwork, research in this phase would be dedicated to the analyses of the field observations through borehole core logging, groundwater observations, hydraulic tests and the examination of fracture characteristics, with the objective of establishing a site-specific study of the conceptual model and associated hydraulic properties of the aquifer.

Conclusions

In order to gain a better understanding of the fault-controlled aquifer, together with the study of aquifer properties, 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, in-situ identification and examination of groundwater behaviour and hydraulic tests. Associated results from these methods were comparatively analysed, from which a conceptual model was proposed and presented on a plan view.

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. A large variation of the aquifer responses to hydraulic tests highlights the difficulty in determining the hydraulic properties of the aquifer represented by the T and K values. To solve this problem that has arisen from previous research, more candidate sites must be selected for further research, with the intention of meeting the requirements of the project objectives and coming up with more representative results.

Future activities

Considering the fractured rock aquifer in the Karoo and other rock formations, more case studies via fieldwork need to be conducted for the development of more robust conceptual models for the quantification of groundwater resources that are controlled by fault structures.

WESTERN CAPE

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 attributable to mining activities in the Mpumalanga Province
Duration	Three years
Budget	R99 480.00

Motivation

Radar remote sensing (SAR) 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 surface of the earth and has been successfully applied to the monitoring of several hazards including: 1) the measurement of surface subsidence, 2) the assessment of deformation following earthquake activity, 3) monitoring of landslides and volcanic activity and 4) the measurement of movements along active faults. The interferometry technique therefore opens up many new potential application areas in disciplines such as volcanology, structural geology and geotechnics and for work relevant to a variety of geohazards. Radar remote sensing is an innovative technique to address the surface deformations associated with natural geological processes and human activities, including mining. The project will build capacity in radar remote sensing techniques which may be used in various geological applications and geohazard assessments. The intended project will act as a stimulator of innovation and for the development of human capital as radar remote sensing and radar interferometry, in particular, have presently only a limited exposure in South Africa. Additionally, the contribution of this technique to programmes dedicated to hazard and risk management will be invaluable.

Progress

The project has been finalised and has focused on the development of differential radar interferometry techniques for the long-term monitoring of surface deformation attributable to mining activities. The emphasis was placed on analysing and identifying the major obstacles associated with radar interferometry for operational monitoring. The project involved the analysis of ERS-2, RADARSAT-2, ALOS PALSAR and TerraSAR-X data. These data sets, providing information at three different wavelengths, provided the opportunity to investigate the operational limitations of this technology in the presence of disturbances to reflected signals owing to the agricultural use of the area under investigation. This enabled the identification of various signal decorrelation effects from standard SAR imaging platforms using the real-world deformation phenomenon as a test case.

The results have revealed that, despite limitations because of land cover changes between image acquisitions, surface subsidence basins and the surface deformation measured using differential interferometry techniques could be detected. Additionally, the evolution of subsidence basins as the working face of the mine progresses could be monitored. The results coincided well with ground truth data available for the region of interest. Successful long-term monitoring, however, would be dependent on the availability of satellite images captured on at least a monthly basis. Furthermore, differential interferometry can overcome some of the limitations associated with traditional field-based measurements. This includes the ability to monitor large areas remotely and that the full extent of subsiding areas can be monitored as opposed to point-based measurements

obtained through field-based techniques. Consequently, it was concluded that differential interferometry techniques would be a complementary source of information to deformation measurement obtained through traditional field-based monitoring techniques.

Conclusion

Radar interferometry techniques were developed with the aim of measuring and monitoring surface deformation features related to geological and anthropogenic causes. The results include the recommendations of the optimal sensor configuration and image acquisition strategy for the long-term operational monitoring of mining-induced deformation. The monitoring system will assist with the mitigation of the impacts of surface deformation associated with mining activities in South Africa. The work was also the topic of a PhD thesis that was completed through the University of Cape Town.

ST-2013-1184

Groundwater monitoring in the Western and Northern Cape to attend to rural community development and climate change. A case study in the Suid-Bokkeveld, Northern Cape Province

Project leaders	K Robey, BSc Hons, J Engelbrecht, MSc
Project team	L Chevallier, PhD
Duration	2012 to 2016
Budget	R280 031.00

Motivation

Global climate change is known to have a significant effect on the human and natural environment. In South Africa, the effects of climate change are expected to be manifested by an increase in the exposure to water shortages owing to suggested temperatures increases by 3 per cent with a concurrent decrease in rainfall by as much as 10 per cent, leading to a decrease in the yield of agriculture. One of the most vulnerable regions identified is the rooibos tea growing Suid-Bokkeveld region within the Northern Cape Province of South Africa. The sustainable development of agricultural activities in the Suid-Bokkeveld region is an important tool for poverty alleviation. Consequently, water resource availability will be a critical factor for the long-term sustainability of the rooibos industry. However, since surface water sources are continuously threatened by periods of drought and the high potential for global climate change, the long-term feasibility of agricultural development is uncertain. Consequently, the development of groundwater resources will be critical to augment the water supply from surface water sources during periods of drought. However, the exploitation of groundwater resources poses unique problems. These include the risk of abstracting groundwater resources at a rate exceeding the rate of natural recharge that would result in a lowering of the water table and eventual depletion of the resource. The sustainable development of groundwater resources necessitates information on the volume, reliability, quality and vulnerability of the resource.

Primary objectives

The Council for Geoscience has embarked on a scientific research programme with a non-governmental organisation, Indigo Development & Change, to assess the current status of groundwater reserves in the Suid-Bokkeveld area. The project aims to generate information that will result in a better understanding of the extent of the groundwater resources in the region and to devise a monitoring system to assess the groundwater quality and quantity on an annual and seasonal basis. This knowledge generated aids the Suid-Bokkeveld rooibos tea farmers to make informed adaptations to their farming practices for the sustainable use of their water resources and agricultural development.

Progress

A Memorandum of Understanding between the Council for Geoscience and Indigo, Development & Change was signed on 12 February 2013, whereby both parties agree to facilitate and generate scientific knowledge in the participation of rural development and poverty alleviation activities within the Suid-Bokkeveld region.

Furthermore, a data logger has been installed at one of the monitoring boreholes to gather long-term groundwater level and temperature data. Additionally, climatic trends identified from long-term weather station data will be used together with the data logger information to identify the aquifer's response to seasonal fluctuations in rainfall and temperature. This information will allow the assessment of aquifer recharge potential. In collaboration with Indigo, Development & Change, the local rooibos tea farmers are actively involved in this project which includes education on the geology of the area and its effects on the groundwater supply. Furthermore, the Council for Geoscience has provided assistance by making recommendations on the siting of new boreholes and supervision and maintenance of the new and existing boreholes on the relevant farms.

Kate Robey showing Dobbelaarskop farmers how to measure the groundwater level using a dipmeter before installing the data logger

Conclusions

The information derived from the first year of research aims to yield some idea of the current state of the groundwater resources in the Suid-Bokkeveld region, so that in the future it will be possible to predict variations in groundwater availability and make adequate adaptations to the farming practices for sustainable use and to ensure the protection of the groundwater resources.

APPENDIX

Publications in academic journals and books

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RAMUKUMBA	T	JUNIOR SCIENTIST	ENVIRONMENTAL GEOSCIENCES
SIBIYA	BK	JUNIOR SCIENTIST	ENVIRONMENTAL GEOSCIENCES
SOGAYISE	SL	JUNIOR SCIENTIST	ENVIRONMENTAL GEOSCIENCES
TLOWANA	SI	SCIENTIST	ENVIRONMENTAL GEOSCIENCES
VADAPALLI	VRK	CHIEF SCIENTIST	ENVIRONMENTAL GEOSCIENCES
YIBAS BABSO	B	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
BEKKER-BONNET	A	MANAGER - FINANCIAL SERVICES	FINANCIAL SERVICES
BREYTENBACH	AF	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
CHAGWIZA	V	ACCOUNTANT	FINANCIAL SERVICES
DICHABE	SD	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
DINGOKO	MO	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
ENGELBRECHT	AJ	ADMINISTRATIVE OFFICER (DEBTORS)	FINANCIAL SERVICES
ENGELBRECHT	CR	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
GOUVERNEUR	M	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
HUGO	JLM	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
KALAZANA	LB	JUNIOR ACCOUNTANT	FINANCIAL SERVICES
LEKWARA	MG	PAYROLL OFFICER	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	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
PHUSHELA	PSH	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
POWER	S	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
QAYISO	NA	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
STROH	C	PAYROLL SUPERVISOR	FINANCIAL SERVICES
BALA	NM	SCIENTIST	GEOCHEMISTRY
BENSID	ML	SCIENTIFIC OFFICER	GEOCHEMISTRY
ELSENBROEK	JH	SCIENTIFIC OFFICER	GEOCHEMISTRY
HLATSHWAYO	SM	SCIENTIFIC OFFICER	GEOCHEMISTRY
MAYA	M	SCIENTIFIC OFFICER	GEOCHEMISTRY
MOKOATEDI	KJ	TECHNICAL OFFICER	GEOCHEMISTRY
MULOVHEDZI	AE	SCIENTIST	GEOCHEMISTRY
NTIKANG	TJ	JUNIOR 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	J	SCIENTIFIC OFFICER	GEOPHYSICS
COLE	P	SPECIALIST SCIENTIST	GEOPHYSICS
EBERLE	DG	SCIENTIFIC OFFICER	GEOPHYSICS
GRAHAM	A	ADMINISTRATIVE OFFICER	GEOPHYSICS
HALLBAUER	VY	SCIENTIFIC OFFICER	GEOPHYSICS
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	RM	TECHNICAL OFFICER	GEOPHYSICS
STETTLER	RH	TECHNICAL OFFICER	GEOPHYSICS
TESSEMA	A	CHIEF SCIENTIST	GEOPHYSICS
KHOSA	ED	EMPLOYEE RELATIONS SPECIALIST	HUMAN RESOURCES
KOTA	JZ	RECRUITMENT SPECIALIST	HUMAN RESOURCES
LESHOMO	JD	ADMINISTRATIVE OFFICER	HUMAN RESOURCES
MAZIBUKO	DM	HR OFFICER	HUMAN RESOURCES
MOTSATSING	KM	ADMINISTRATIVE OFFICER	HUMAN RESOURCES
WILLIAMS	Q	ADMINISTRATIVE OFFICER	HUMAN RESOURCES
MAHLANGU	RB	GENERAL CLERK - PHOTOCOPIER	INFORMATION & COLLECTIONS MANAGEMENT
BARNARDO	DJ	MANAGER - INFORMATION & COLLECTIONS MANAGEMENT	INFORMATION MANAGEMENT
CHACKO	JEJ	TECHNICAL OFFICER (GRAPHIC DESIGNER/LAYOUT ARTIST)	INFORMATION MANAGEMENT
JANSE VAN RENSBURG	MG	TECHNICAL OFFICER	INFORMATION MANAGEMENT
MANGANYI	BN	ADMINISTRATIVE OFFICER	INFORMATION MANAGEMENT
NEL	ZE	ADMINISTRATIVE OFFICER (TRANSLATOR)	INFORMATION MANAGEMENT
VAN ECK	SJ	ADMINISTRATIVE OFFICER	INFORMATION MANAGEMENT
DOMINGO	EE	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MAEMA	BJ	SUPPORT TECHNICIAN	INFORMATION TECHNOLOGY
MOGARA	LM	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MOTAUNG	PD	MANAGER - INFORMATION TECHNOLOGY	INFORMATION TECHNOLOGY
MUGWENA	NA	SUPPORT TECHNICIAN	INFORMATION TECHNOLOGY
PHANGISA	TT	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
SMITH	P	BUSINESS TECHNOLOGY CONSULTANT	INFORMATION TECHNOLOGY
BOTHA	GA	MANAGER – KWAZULU-NATAL AND EASTERN CAPE	KWAZULU-NATAL UNIT
DLAMINI	P	ADMINISTRATIVE OFFICER	KWAZULU-NATAL
HICKS	N	SENIOR SCIENTIST	KWAZULU-NATAL
MPOFANA	B	GENERAL CLERK	KWAZULU-NATAL
NGCOBO	LE	GENERAL CLERK	KWAZULU-NATAL
SINGH	RG	SCIENTIFIC OFFICER	KWAZULU-NATAL
ATANASOVA	MT	SCIENTIFIC OFFICER	LABORATORY
BURGER	KIG	TECHNICAL OFFICER	LABORATORY
CLOETE	M	MANAGER - LABORATORY	LABORATORY
CLOETE	HCC	SCIENTIFIC OFFICER	LABORATORY
CRONWRIGHT	H	SCIENTIFIC OFFICER	LABORATORY
CROWLEY	MH	SCIENTIST	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
MABENA	LM	TECHNICAL OFFICER	LABORATORY
MAEMA	JJ	ADMINISTRATIVE OFFICER	LABORATORY
MASHALE	HN	JUNIOR SCIENTIST	LABORATORY
MASHISHI	KE	JUNIOR SCIENTIST	LABORATORY
MATJI	MJ	TECHNICAL OFFICER	LABORATORY
MBONANE	TJ	TECHNICAL OFFICER	LABORATORY
MBOYI	A	TECHNICAL OFFICER	LABORATORY
MCHUNU	PB	TECHNICAL OFFICER	LABORATORY
MORAKE	AO	ADMINISTRATIVE OFFICER	LABORATORY
MOTSIRI	TS	TECHNICAL OFFICER	LABORATORY
NGAMLANA	SM	TECHNICAL OFFICER (SAMPLE PREPARATOR: SUPERVISOR)	LABORATORY
NKOSI	ME	TECHNICAL OFFICER	LABORATORY
NXOKWANA	NS	JUNIOR SCIENTIST	LABORATORY
PAPO	RM	TECHNICAL OFFICER	LABORATORY
PHAHLANE	I	TECHNICAL OFFICER	LABORATORY
RALEAKA	MW	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
MALATSI	PM	GENERAL CLERK	LIBRARY
MSIZA	A	ADMINISTRATIVE OFFICER	LIBRARY
MZAMANE	CB	ADMINISTRATIVE OFFICER	LIBRARY
NONDUDULE	Z	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	LIMPOPO
DHANSAY	TG	JUNIOR SCIENTIST	LIMPOPO
MASHAO	TP	GENERAL CLERK	LIMPOPO
MNISI	EH	ADMINISTRATIVE OFFICER	LIMPOPO
MOTHETHA	VM	SENIOR SCIENTIST	LIMPOPO
MUKOSI	NC	JUNIOR SCIENTIST	LIMPOPO
MUNYANGANE	LP	SCIENTIFIC OFFICER	LIMPOPO
CELE	ND	PERSONAL ASSISTANT	MANAGEMENT
GRAHAM	G	EXECUTIVE MANAGER - SCIENTIFIC SERVICES	MANAGEMENT
KOTA	MW	CHIEF EXECUTIVE OFFICER	MANAGEMENT
MATIMULANE	NW	SECURITY OFFICER	MANAGEMENT
MOTHABI	EPM	PERSONAL ASSISTANT	MANAGEMENT
MSIZA	JM	SECURITY SPECIALIST	MANAGEMENT
NKOE	JS	PERSONAL ASSISTANT	MANAGEMENT
RAMAGWEDE	FL	EXECUTIVE MANAGER - APPLIED GEOSCIENCES	MANAGEMENT
BOTHA	CA	TECHNICAL OFFICER	MARINE GEOSCIENCE
CAWTHRA	HC	SENIOR SCIENTIST	MARINE GEOSCIENCE

HOOSAIN	W	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
KUPIDO	W	TECHNICAL OFFICER	MARINE GEOSCIENCE
MACHUTCHON	MR	SENIOR SCIENTIST	MARINE GEOSCIENCE
VAN ZYL	FW	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
BILLAY	AY	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
FOYA	S	SENIOR MANAGER - MRD & ENGINEERING GEOSCIENCES	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
MALUMBAZO	N	SENIOR SCIENTIST	MINERAL RESOURCES DEVELOPMENT
MATSHIVHA	MR	JUNIOR SCIENTIST	MINERAL RESOURCES DEVELOPMENT
MUDAU	T	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
NONDULA	UU	JUNIOR SCIENTIST	MINERAL RESOURCES DEVELOPMENT
NXUMALO	V	SCIENTIST	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	CHIEF SCIENTIST	MINERAL RESOURCES DEVELOPMENT
TSANWANI	M	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
WALEMBA	KMA	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
GROENEWALD	CA	SCIENTIFIC OFFICER	NORTHERN CAPE UNIT
MINNAAR	H	SCIENTIFIC OFFICER	NORTHERN CAPE UNIT
MOFOKENG	AS	SENIOR SCIENTIST	NORTHERN CAPE UNIT
SKEFFERS	CJ	TECHNICAL OFFICER	NORTHERN CAPE UNIT
BOTHA	JD	SENIOR SPECIALIST LOGISTICS	PROCUREMENT & LOGISTICS
DIKETANE	MW	GENERAL CLERK	PROCUREMENT & LOGISTICS
GUMEDE	VC	CONTRACT SPECIALIST	PROCUREMENT & LOGISTICS
JIJANA	CK	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
KGOBANE	RJ	DRIVER	PROCUREMENT & LOGISTICS
KUNJU	N	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
LEGWABE	HT	MAINTENANCE ASSISTANT	PROCUREMENT & LOGISTICS

MAHLANGU	E	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
MAMPURU	LM	SPECIALIST PROCUREMENT OFFICER	PROCUREMENT & LOGISTICS
MKHONZA	TT	SENIOR PROCUREMENT OFFICER	PROCUREMENT & LOGISTICS
MPOFANA	WN	MAINTENANCE ASSISTANT	PROCUREMENT & LOGISTICS
NASE	AL	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
NDLELA	CT	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
NEMATANDANI	M	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
NKUNA	MM	MANAGER - PROCUREMENT AND LOGISTICS	PROCUREMENT & LOGISTICS
SATHEKGE	MJ	GENERAL CLERK - MESSENGER	PROCUREMENT & LOGISTICS
SNYMAN	J	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
STEVENS	R	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
VELE	I	SENIOR PROCUREMENT OFFICER	PROCUREMENT & LOGISTICS
ZWANE	JJ	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
ZWANE	VS	RECEPTIONIST/ADMINISTRATOR	PROCUREMENT & LOGISTICS
ADAMOS	P	TECHNICAL OFFICER	SEISMOLOGY
AKROMAH	L	TECHNICAL OFFICER	SEISMOLOGY
BIRCH	DJ	SCIENTIFIC OFFICER	SEISMOLOGY
BRANDT	MBC	SCIENTIFIC OFFICER	SEISMOLOGY
CICHOWICZ	A	SCIENTIFIC OFFICER	SEISMOLOGY
DELPORT	FA	TECHNICAL OFFICER	SEISMOLOGY
FLINT	NS	SCIENTIST	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
MANZUNZU	B	JUNIOR SCIENTIST	SEISMOLOGY
MIDZI	V	SCIENTIFIC OFFICER	SEISMOLOGY
MOLEA	TT	TECHNICAL OFFICER	SEISMOLOGY
MPHAHLELE	LK	TECHNICAL OFFICER	SEISMOLOGY
MSIZA	P	TECHNICAL OFFICER	SEISMOLOGY
MULABISANA	TF	JUNIOR SCIENTIST	SEISMOLOGY
NGOBENI	DD	JUNIOR SCIENTIST	SEISMOLOGY
NTSUKU	MH	TECHNICAL OFFICER	SEISMOLOGY
PULE	TG	TECHNICAL OFFICER	SEISMOLOGY
RATHOD	GW	SENIOR SCIENTIST	SEISMOLOGY
SAUNDERS	I	TECHNICAL OFFICER	SEISMOLOGY
SEMELANE	LL	TECHNICAL OFFICER	SEISMOLOGY
SONGWANE	TR	SENIOR ANALYST PROGRAMMER	SEISMOLOGY
STRASSER	FO	SENIOR SCIENTIST	SEISMOLOGY
TABANE	LR	TECHNICAL OFFICER	SEISMOLOGY
VAN ASWEGEN	G	TECHNICAL OFFICER	SEISMOLOGY
VAN ZYL	D	ADMINISTRATIVE OFFICER	SEISMOLOGY
ZULU	BS	SCIENTIFIC OFFICER	SEISMOLOGY
ZULU	TP	TECHNICAL OFFICER	SEISMOLOGY
FOURIE	BC	TECHNICAL 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	ME	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
NEMUDZIVHADI	M	ADMINISTRATIVE OFFICER	SPATIAL DATA MANAGEMENT

NKOSI	MP	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
NORUKA	S	SCIENTIST	SPATIAL DATA MANAGEMENT
ROOS	HM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
SEBAKE	MD	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	SPU
MNDAWONI	MJ	BUSINESS DEVELOPMENT MANAGER	SPU
MZIMBA	RJ	ADMINISTRATIVE OFFICER - SECRETARY	SPU
SKHOSANA	MN	ADMINISTRATIVE OFFICER - TENDERS	SPU
VAN WYK	J	SENIOR ADMINISTRATIVE OFFICER	SPU
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
MAKONTO	OT	JUNIOR SCIENTIST	WATER GEOSCIENCES
MARUBINI	SJ	JUNIOR SCIENTIST	WATER GEOSCIENCES
MENGISTU	H	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MOKONYAMA	ML	ADMINISTRATIVE OFFICER	WATER GEOSCIENCES
MUSETSHO	M	SCIENTIST	WATER GEOSCIENCES
NEMAXWI	P	JUNIOR SCIENTIST	WATER GEOSCIENCES
NETILI	KF	MANAGER - WATER GEOSCIENCES	WATER GEOSCIENCES
NTULI	TW	SENIOR SCIENTIST	WATER GEOSCIENCES
NZOTTA	UO	SENIOR SCIENTIST	WATER GEOSCIENCES
RIKHOTSO	C	JUNIOR SCIENTIST	WATER GEOSCIENCES
SAEZE	HA	CHIEF SCIENTIST	WATER GEOSCIENCES
SHABALALA	AN	SCIENTIFIC OFFICER	WATER GEOSCIENCES
STRACHAN	LKC	SENIOR SCIENTIST	WATER GEOSCIENCES
BROWNING	C	SCIENTIST	WESTERN CAPE UNIT
CHEVALLIER	LP	MANAGER - WESTERN AND 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
DE BRUIN	E	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
ENGELBRECHT	J	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
LAMBERT	CW	SCIENTIFIC OFFICER	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	N	ADMINISTRATIVE OFFICER	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

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