Council for Geoscience

ANNUAL TECHNICAL REPORT 2011

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Council for Geoscience

ANNUAL TECHNICAL REPORT
OF THE COUNCIL FOR GEOSCIENCE

2011

COUNCIL FOR GEOSCIENCE
SOUTH AFRICA

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

Compiled by
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Photograph
Kaolin quarry in Grahamstown.

Management

OF THE COUNCIL FOR GEOSCIENCE

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BOARD ADMINISTRATOR
Nangamso Mbeki

executive manager

CORPORATE SERVICES
vacant

Human Resources	- *vacant*
Marketing and Communications	- *Nthombi Mdluli Jacha*

in the office of the CEO

STRATEGIC SERVICES
Nico Keyser and Maleka Monyepao

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

Council for Geoscience

executive manager

APPLIED GEOSCIENCE

Fhatuwani Ramagwede

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Environmental Geoscience	- *Tsholofelo Phajane*
Minerals Development	- *Stewart Foya*
Water Geoscience	- *vacant*

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Seismology	- *Michelle Grobbelaar*
Spatial Data Management	- *Ken Wilkinson*

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Eastern Cape	- *Greg Botha*
KwaZulu-Natal	- *Greg Botha*
Limpopo	- *Nick Baglow*
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Northern Cape	- *Luc Chevallier*
Western Cape	- *Luc Chevallier*

chief financial officer

CFO SERVICES

Leonard Matsepe

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

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FOREWORD

The suspension of direct expenditure on statutory projects resulted in a reduced technical programme. However, Management is pleased to report that, despite the financial difficulties of the organisation, it reached a high level of completion of its public-good research. In this regard, the technical performance of the Council for Geoscience for the past year was good, which testifies to the dedication of its staff and the sound management of the organisation. The statutory programme of the organisation forms a key part of its mandate, and also provides an opportunity for young geoscientists to develop as researchers.

The Council for Geoscience has, since the end of 2010, noticed a marked improvement in the availability of geoscience-related projects, both nationally and internationally. Some positive outcomes so far include negotiations between the organisation and Eskom, culminating in the signing of a new contract, and the submission of several large tenders. It is hoped that this trend will intensify in the next financial year. To improve the competitiveness of the organisation, the Council for Geoscience has compiled the procedures necessary for the organisation to reach ISO 9001 certification and ISO 17025 accreditation for the laboratories. The forthcoming year will be devoted to the implementation of the ISO procedures in preparation for final ISO certification and accreditation.

The Geoscience Amendment Act (Act No. 16 of 2010) was signed into power by the President of South Africa in December 2010. This Act extends the functions of the organisation to include the rendering of advisory services in respect of geohazards and geo-environmental pollution, and of acting as custodian of all geoscience information. The process of preparing for the implementation of the Act has begun and will continue during the course of the next financial year.

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

- The compilation of the SADC geohydrological map
- The establishment of and involvement in various geoscience partnerships aimed at developing African infrastructural capacity and capabilities, for instance with the University of the Witwatersrand and Pennsylvania State University in *AfricaArray*
- The Council for Geoscience is a key role player within the Organisation of African Geological Surveys (OAGS), a NEPAD initiative, of which the mandate is to foster and sustain government-supported geoscience endeavours and excellence on the African continent
- The specific aims of the Council for Geoscience include creating regional and continent-wide promotional maps and documents to inform decision makers in government and industry on matters relating to the applied geosciences
- The provision of direct capacity-building support to African geological surveys through various programmes and interventions
- The Council for Geoscience, together with the Geological Society of South Africa, won the bid to host the 35th International Geological Congress (IGC) in 2016 in Cape Town. The IGC is one of the largest general geology congresses in the world. It is held every four years and attracts over 6 000 geoscientists. Holding this congress in South Africa, in collaboration with other southern African countries, will provide an excellent opportunity for capacity building and the development of the geosciences in the region. The organisation needs to secure considerable funding over the next four years for this event.

A fundamental role of any national geoscience institution such as the Council for Geoscience has historically always been the acquisition of new geoscience data. This usually took the form of geological mapping, geophysical surveys or national or regional geochemical sampling programmes. However, the increasing interest in and concern with dynamic systems, such as the environment and geohazards, is changing the traditional role of geological surveys worldwide. Extensive studies related to environmental and quality-of-life issues, land-use planning and development and the monitoring and mitigation of geohazards are required. This also implies that historical geoscience data gathering is no longer a 'once-off' process, but one that needs to be done increasingly on a continual, monitoring and real-time basis.

As an example of this type of investigation, the organisation has been involved in the Strategic Water Management Programme of South Africa for several years. The country's mining history has generated vast economic benefit for our country and still plays an important role in ensuring our position in the global market. Despite such benefit, large-scale closure of mining operations since the 1970s within the Witwatersrand mining regions and the subsequent termination of the extraction of underground water from mines has become an important national concern. The activities of the mining sector have resulted in serious environmental consequences and, in the case of the gold mines of the Witwatersrand, acid mine drainage.

Given the magnitude and dynamics of the South African mining industry, it must be accepted that the challenges of mine water management cannot be administered by either Government or the mining sector alone. The final report of a Team of Experts on acid mine drainage was submitted to Cabinet in February 2011.

In addition, the Council for Geoscience continued to curate the South African Minerals Database, a depository of data on mineral occurrences, mineral deposits and mines in South Africa. The objective of the South African Minerals Database project is to capture, store and continually update mineral data on mines, mineral deposits and mineral occurrences within the borders of South Africa and to provide data to users in South Africa and abroad. The database currently houses about 20 000 mineral records, as well as 6 500 records of derelict and ownerless mines in South Africa.

Although staffing issues and insufficient baseline funding represent key challenges to the organisation, it is gratifying to see the Council for Geoscience focusing on national strategic issues such as energy security and water. Management is certain that with the continued support of the staff, the organisation will strengthen its focus on similar national issues where geoscience has a role to play.

Dr T. Ramontja
Chief Executive Officer

INTERNATIONAL COOPERATION

ST-2011-1123	**TIMING THE STRUCTURAL EVENTS IN THE PALAEOPROTEROZOIC BOLE-NANGODI BELT AND ADJACENT MALUWE BASIN, WEST AFRICAN CRATON, IN CENTRAL-WEST GHANA**
Project leader:	G.S. de Kock, Ph.D.
Project team:	H. Théveniaut, P.M.W. Botha, B.Sc. Hons and W. Gyapong
Primary objective:	To describe the relationship between the granitic and sedimentary/volcanic deposition events of the rocks that were deposited over a period of 80 million years during the Palaeoproterozoic era. The rocks occurred in an intraoceanic environment and were generated during several cycles of subduction of oceanic crust with simultaneous development of basins caused by backarc spreading. The rocks were deformed during the closing stages of the basins and subsequent lateral movements caused by the accretion of disrupted volcano-magmatic arcs formed above the subducted oceanic crust. The geological history from area to area varies considerably and can only be compared with each other if the events present are of the same age
Duration:	12 months
Budget:	R6 000 (to print some figures in colour)

Motivation

The data were gathered during a mapping project funded by the European Union. The client, the Geological Department of Ghana, supports the distribution of the information to attract international investors in the mining industry.

Progress

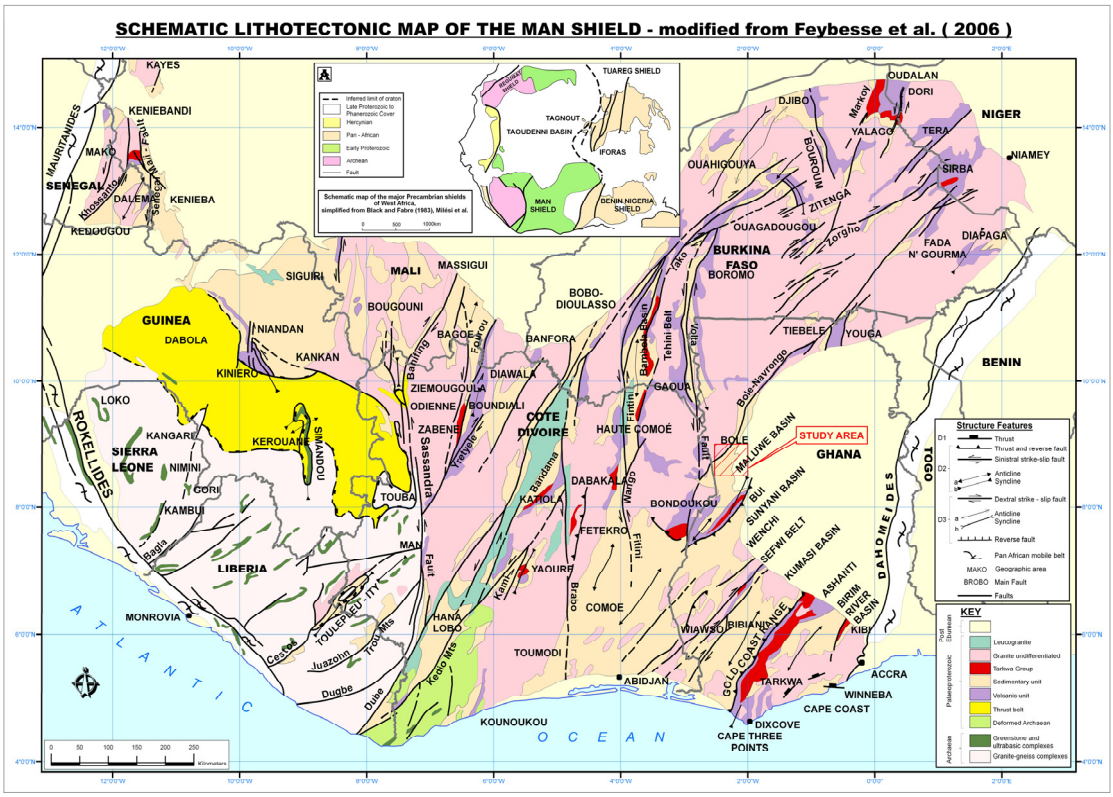
To execute the project, data had to be extracted from the mapping report and re-assembled in the correct format acceptable for publishing in the Journal of African Earth Sciences. A journal paper, entitled Timing the structural events in the Palaeoproterozoic Bolé-Navrongo belt and adjacent Maluwe basin, West African craton, in central-west Ghana, was finally submitted to the Publishing House of the journal in January 2011. This paper was accepted for publication (after making the corrections proposed by the reviewers). The abstract of this paper was as follows:

The Maluwe basin, north-adjacent to the Sunyani basin, is the northernmost of the northeast-trending Eburnean volcaniclastic depositories in Ghana. These basins are separated from each other by remnants of Eoeburnean crust formed during the evolution of arc-backarc basin complexes in a Palaeoproterozoic intraoceanic setting. The Bolé-Nangodi belt of mostly Eoeburnean crust, to the northwest, is fault-bounded with the Maluwe basin along the northeast-trending Bolé-Navrongo fault zone. Field relationships, aided with precise geochronology, decipher the stratigraphic succession of the rock units which was the basis for unravelling the structural evolution of the studied area. The quartzitic, pelitic, quartzofeldspathic and granitic gneisses of the Eoeburnean crust (>2 150 Ma) experienced complex metamorphic mineral growth and migmatitisation, mostly under static crustal conditions, and were subjected to several deformation episodes. Foliated mafic and metasedimentary enclaves within the Ifanteyire granite establish deformation prior to ~2 195 Ma, while the tectonically emplaced Kuri amphibolite within the 2 187 Ma gneissic Gondo granite indicates a stage of rifting, followed by closure and collision. Deformation of granite dykes intrusive into the Gondo granites of ~2 150 Ma concluded the development of the Eoeburnean orogenic cycle (D_{EE}). Fold axes with horizontal to moderate plunges are reflecting subhorizontal compression, while the steep ones indicate subsequent strike-slip conditions parallel to the fabric. The Sawla Suite, which is contemporaneous with the deposition of the Maluwe Group, intruded the tectonically exhumed Eoeburnean crust of the Bolé-Nangodi belt terrane between ~2 137 and 2 125 Ma and caused the separation of the Abulembre fragment. The Maluwe Group and synchronous Sawla granitoids were subjected to a compressive deformation D_{E1} event during which chlorite/sericite grew along the axial planes under greenschist grade conditions. The fold axes are NE trending with subhorizontal plunges and the phyllitic axial planar fabric subvertical. After cessation of the NW–SE-directed D_{E1} stress field, the early Tanina Suite intruded as batholiths, dykes and sheets and produced garnet, staurolite, sillimanite and kyanite in their thermal aureole. Shortly thereafter D_{E2} east-over-west thrusting occurred which caused elongation and foliation of the Tanina plutons, rotation and fracturing of the post-D_{E1} contact porphyroblasts of garnet, staurolite, kyanite and sillimanite to parallel the fronts and edges of the D_{E2} thrust sheets. The Maluwe basin, north-adjacent to the Sunyani basin, is the northernmost of the northeast-trending Eburnean volcaniclastic depositories in Ghana. These basins are separated from one another by remnants of Eoeburnean crust. Owing to the low-grade metamorphic conditions, the D_{E2} fabric within the Maluwe strata is limited to crenulation cleavages in the more psammitic and pelitic units. It was captured heterogeneously, however, as a planar fabric in the Tanina granitoids intruded between 2 122 and 2 120 Ma. The D_{E2} fold axes are double plunging (N and S) up to 60° with the axial planar fabric subvertical and N–S

trending. The D_{E2} thrust sheets were intruded by younger Tanina Suite bodies at about 2 119 Ma. D_{E1} occurred between 2 125 and 2 122 Ma and D_{E2} before 2 119 Ma. Around 2 118 Ma, the west-directed D_{E2} compression was replaced by a near N–S extension phase (D_{E3}) which caused fractures and fracture intersects to penetrate into the lower crust as these were filled by mafic and alkaline dykes and plugs. Around 2 103 Ma, strike-slip deformation (D_{E4}), evident along the basin-belt belt boundary as the Bolé-Navrongo shear zone, occurred. Along the boundary, the displacement was dextral along vertical faults but further to the south it became more east-over-west thrust related. Tension gashes, filled with vein quartz, associated with this event formed within the brittle sector of the crust. Tectonism in this part of the intraoceanic accretionary arc back-arc complex was concluded by limited, right-lateral strike-slip (D_{E5}) movement which formed some breccias.

Future activities

Corrections as proposed by the review panel have to be implemented during the 2011/12 year.



Distribution and subdivision of the Palaeoproterozoic Birim rocks in West Africa.

S_{E1}-foliated Sepi River granite crenulated into flat, open D_{E2} syn- and antiform pairs (Yakombo structure).

Disharmonic, irregular folding in thinly layered (S_0 and S_{E1}) garnet-bearing, manganiferous shale of the Maluwe Group, along a subsidiary fault of the Bolé-Navrongo shear zone.

ST-2009-1103 **JAPANESE ANTARCTIC RESEARCH EXPEDITION 51 (JARE51) PARTICIPATION**

Project leader: G.H. Grantham, Ph.D.
Primary objective: The objective of the study is to compare the geological evolution of the Sør Rondane of Dronning Maud Land, Antarctica with that of northern Mozambique recognising that the two areas were adjacent to one another prior to the dispersal of Gondwana approximately 180 Ma ago
Duration: 2010–2012

Motivation
Dr G.H. Grantham was invited to participate in the JARE51 expedition to the Sør Rondane Mountains in Central Dronning Maud Land, Antarctica. The duration of the involvement extended from 15 November 2009 to 15 March 2010 with three months being spent in active field work 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 will form the basis of continued research collaboration between and publications by the Council for Geoscience and the National Polar Research Institute of Japan in Tokyo.

Progress and conclusions
Work during the year focussed on samples and data collected during the field season. Study of the samples was limited due to the EMP Laboratory at the Council for Geoscience being closed and an absence of funding for access to external laboratories. Collaborative support from the University of Pretoria permitted a limited study of mineral chemistry, the results of which were presented at a workshop held at the National Institute for Polar Research in Tokyo, Japan in early December, 2010 and also at the 23rd Colloquium of African Geology at the University of Johannesburg held in January 2011. Zircon separates from rocks collected from Sør Rondane as well as Sverdrupfjella, western Dronning Maud Land were prepared for SHRIMP zircon analysis to determine their ages.

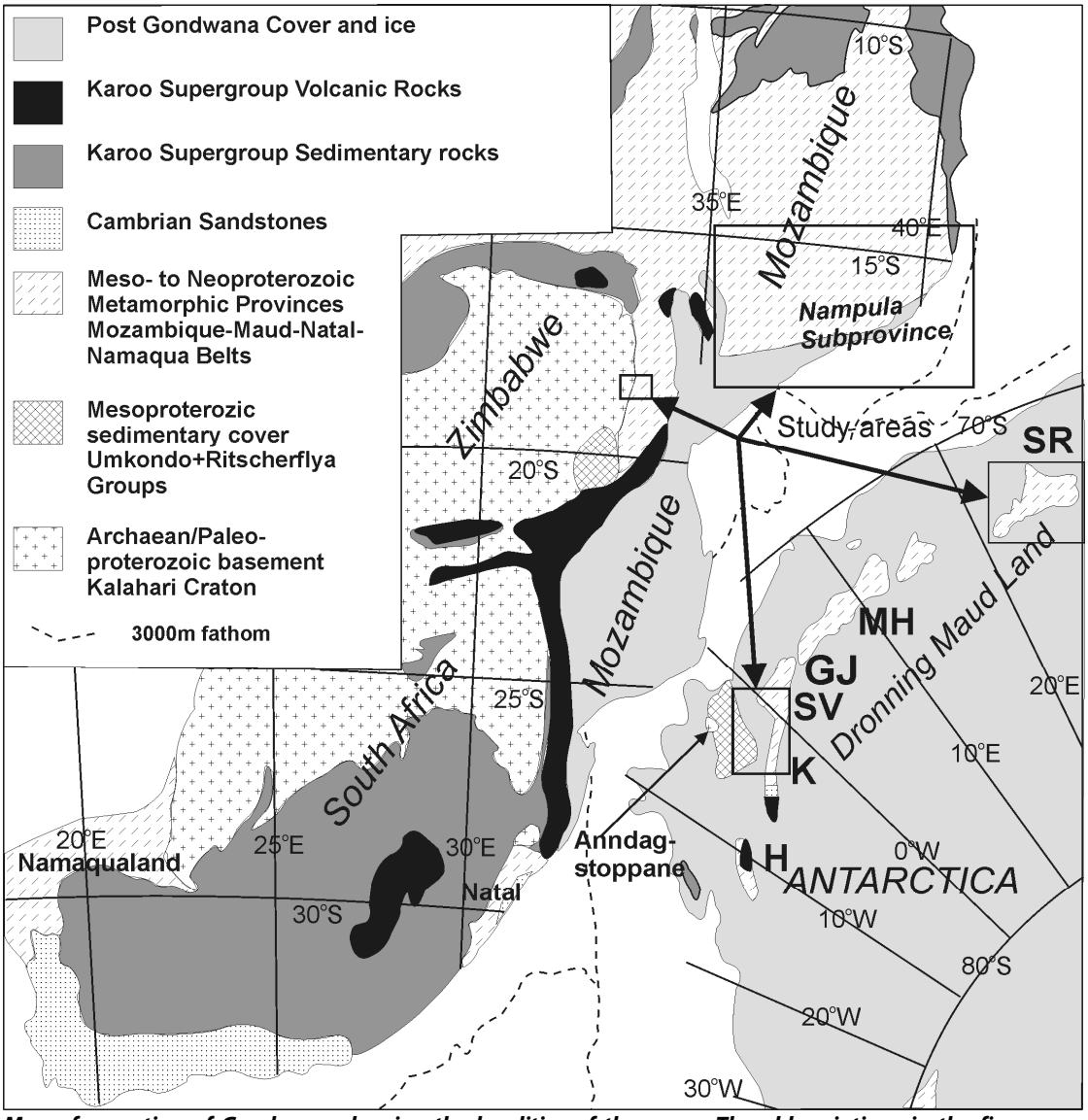
Preliminary results of the pressure-temperature (P-T) estimates from the mineral analyses indicate that they are virtually identical to mineral assemblages and P-T estimates from the Monapo Complex of northern Mozambique, thus supporting correlations between the two areas. Analyses of structural data collected during the field season show that the Sør Rondane area has lithologies and a deformation history similar to northern Mozambique.

Future activities
It is planned to prepare two manuscripts for publication from the Sør Rondane comparing the metamorphic and structural evolution of the area with that of northern Mozambique.

SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

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

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



Map of a portion of Gondwana showing the localities of the areas. The abbreviations in the figure are geographical localities where H=Heimefrontfjella, K=Kirwanveggan, SV=Sverdrupfjella, GJ=Gelsvikfjella, MH=Muhlig-Hoffmanfjella and SR=Sør Rondane.

Motivation

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

Progress and conclusions
Two manuscripts were published during the year; the first on the geology of the margin between the Kalahari Craton and the Mozambique Belt and the second on the Nampula area of northern Mozambique.

The first paper describes a U/Pb zircon age pf 1 000 Ma from migmatitic veining developed parallel to strong shearing along the craton margin, as well as an U/Pb zircon age of ~2 600 Ma from a relatively undeformed granodiorite which forms part of the Kalahari Craton. Whole-rock major- and trace-element chemistry from granites from the Kalahari Craton as well as the Mozambique Belt are described, as well as Rb/Sr and Sm/Nd radiogenic isotope data. The latter radiogenic isotope data suggest that granitoids in the Mozambique Belt probably resulted from the mixing of melts derived from the Archaean-age Kalahari Craton and the Mozambique Belt. In addition, U/Pb zircon data and whole-rock geochemical data from western Dronning Maud Land, Antarctica from the Kalahari Craton–Maud Belt boundary are also included. The data suggest that the Kalahari Craton has subsurface extensions below the Mozambique Belt at least as far east as Chimoio, ~60 km from the Zimbabwe border and also underlies Sverdrupfjella in western Dronning Maud Land.

The second paper was accepted for publication in Precambrian Research. The paper was prepared by CGS personnel as well as personnel from the British, Norwegian and Mozambican Geological Surveys. The paper provides extensive SHRIMP zircon age data from the area showing that the dominant age of the basement gneisses varies between ~1 000 Ma and ~1 140 Ma. In addition, the chemical variation of the various intrusive granitoid bodies and their host rocks is described. The broad tectonic setting of these rocks in a broader Gondwana and Rodinia evolution is provided.

Future activities
Additional manuscripts are planned for publication until 2012.

Publications
G.H. Grantham, A.D.S.T. Manhica, R.A. Armstrong, F.J. Kruger and M. Loubser, 2011. New SHRIMP, Rb/Sr and Sm/Nd isotope and whole-rock chemical data from central Mozambique and western Dronning Maud Land, Antarctica: Implications for the nature of the eastern margin of the Kalahari Craton and the amalgamation of Gondwana. Journal of African Earth Sciences, 59, pp. 74–100.

P.H. Macey, R.J. Thomas, G.H. Grantham, B.A. Ingram, J. Jacobs, R.A. Armstrong, M.P. Roberts, B. Bingen, L. Hollick, G.S. de Kock, G. Viola, W. Bauer, E. Gonzales, T. Bjerkgård, I.H.C. Henderson, J.S. Sandstad, M.S. Cronwright, S. Harley, A. Solli, Ø. Nordgulen, G. Motuza, E. Daudi and V. Manhica, 2010. Mesoproterozoic geology of the Nampula Block, northern Mozambique: Tracing fragments of Mesoproterozoic crust in the heart of Gondwana. Precambrian Research, 182, pp. 124–148.

CENTRAL REGIONS

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

Project leader: R. Shelembe, M.Sc.
Project team: A. Mofokeng, B.Sc. Hons
Primary objectives:
1. To produce an updated and accurate 1:50 000-scale map sheet and a map explanation of the Madikwe area
2. To analyse the extent and intensity of the metamorphic aureole caused by the Bushveld intrusion
3. To investigate the relationship between the sill intrusions that exist in the area and the Bushveld-type rocks
4. To investigate the origin and relations of regional lineaments in the Madikwe area

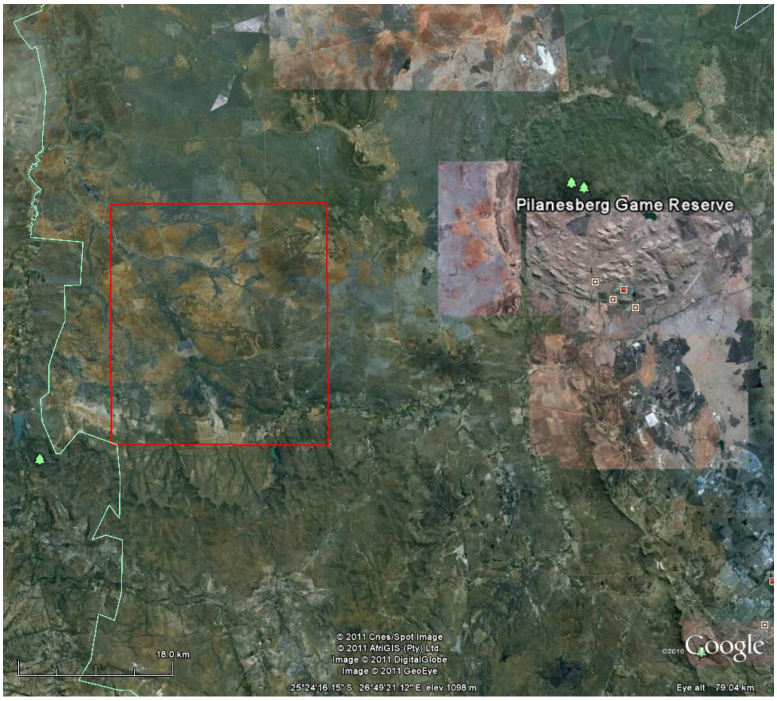
Duration: 2009–2012
Budget: R135 212,50

Motivation
Mapping of the Madikwe area will fill some of the gaps in terms of mapping in areas adjacent to those areas (Mabeskraal and Mabaalstad) already mapped in the North West Province for the purpose of the systematic development of geoscientific knowledge. The formations of the Pretoria Group are composed of quartzite, hornfels and slate (lithologies that are indicative of metamorphism). The mineralogy of these rocks will indicate the extent of the Bushveld Complex that 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 are already mapped.

Progress
1. Field work with sample collection is complete
2. Preliminary petrographical studies on the collected samples are complete
3. Report on petrography and geochemistry
4. Compile a preliminary map and legend (edited).

Conclusion
This project will assist in the understanding of the Bushveld metamorphic aureole and possibly its associated structures.

Future activities
Write-up of introductory chapters of the geological map explanation is currently underway. Future activities will include completing the rest of the geological map explanation.



Location of sheet 2526BC Madikwe.

ST-2005-0864 **THE STRATIGRAPHIC AND TECTONIC HISTORY OF THE EOPROTEROZOIC PERIOD BETWEEN THE LATE CHUNIESPOORT GROUP AND EARLY TIMEBALL HILL FORMATION, PRETORIA**

Project leader: P.J.A. Bosch, M.Sc.
Primary objectives: To study the tectonostratigraphy and sedimentology of the late Chuniespoort Group to early Pretoria Group with special reference to the formation of karst on dolomitic land in Gauteng to assist engineering-geological investigations
Duration: 2005–2009/11

Motivation
Development on dolomitic hazardous land has the potential for the development of sinkholes and dolines. To understand the hazards of dolomitic land, a holistic approach is necessary, requiring that the geological formations, karstic weathering, soils and geological structure of the area be understood and investigated. The boundaries of the dolomitic land need to be delineated to identify the part of the land which could be classified as dolomitic.

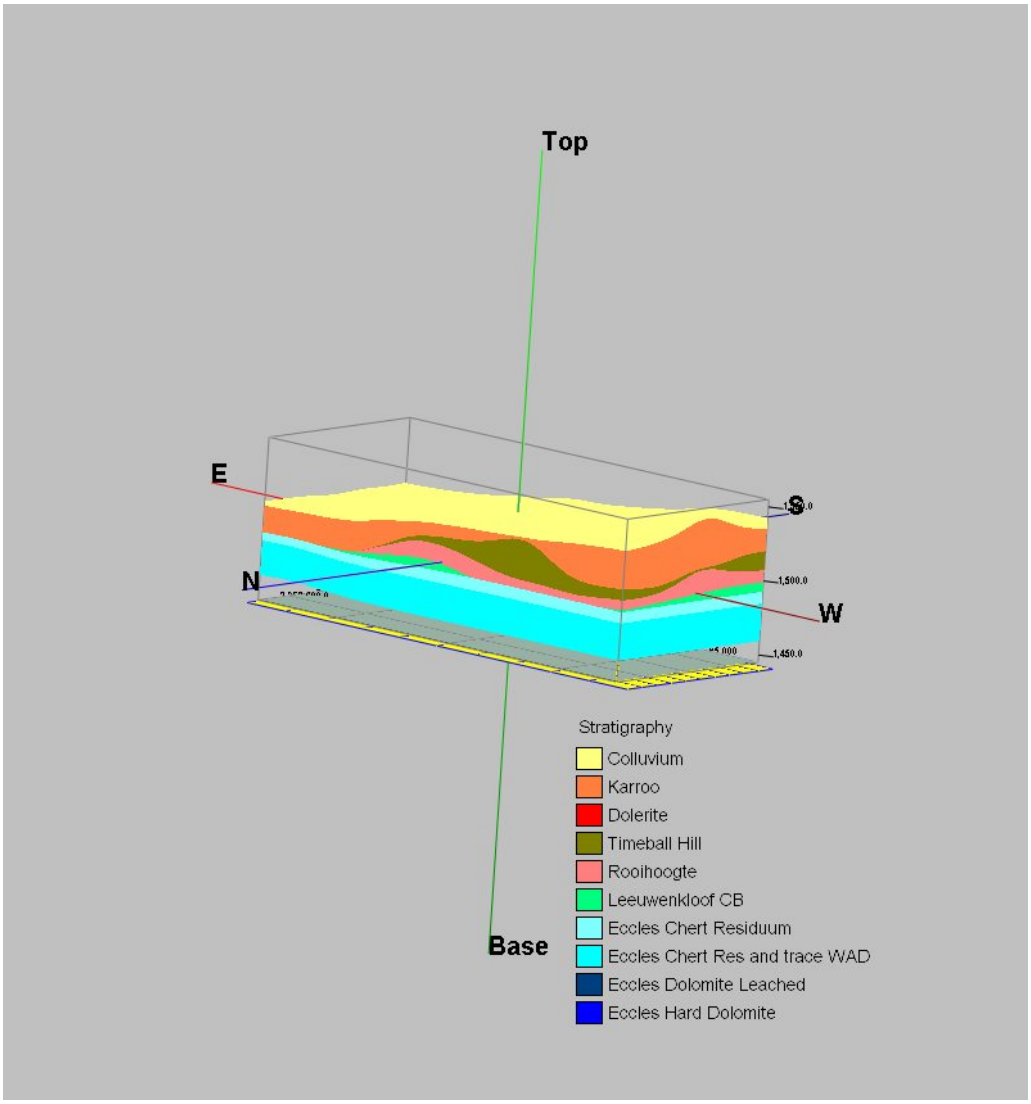
This study benefits the scientific community in the following ways:

- It increases the scientific knowledge of this important period in the geological history; it is also important internationally because it will record and report a period of earth history that is not well developed elsewhere in the world. Its international importance, for example, is highlighted by the discovery of halite imprints and salt blisters which contribute to the understanding of the sea and atmosphere during this period.
- Improves geological maps of the Transvaal Basin.
- Achieves a better understanding of the Transvaal Basin and its structure and history, which will help to generate future exploration targets, and hence economic growth, employment and rural development.
- Contributes to the understanding of geological structures, lithologies and their spatial distribution which will aid in the development of models, including 3D models used in the prediction of geological hazards, especially sinkholes. The characterisation of the structures and underlying lithologies aids engineering geologists and developers in recognising areas with problem rocks and soil.

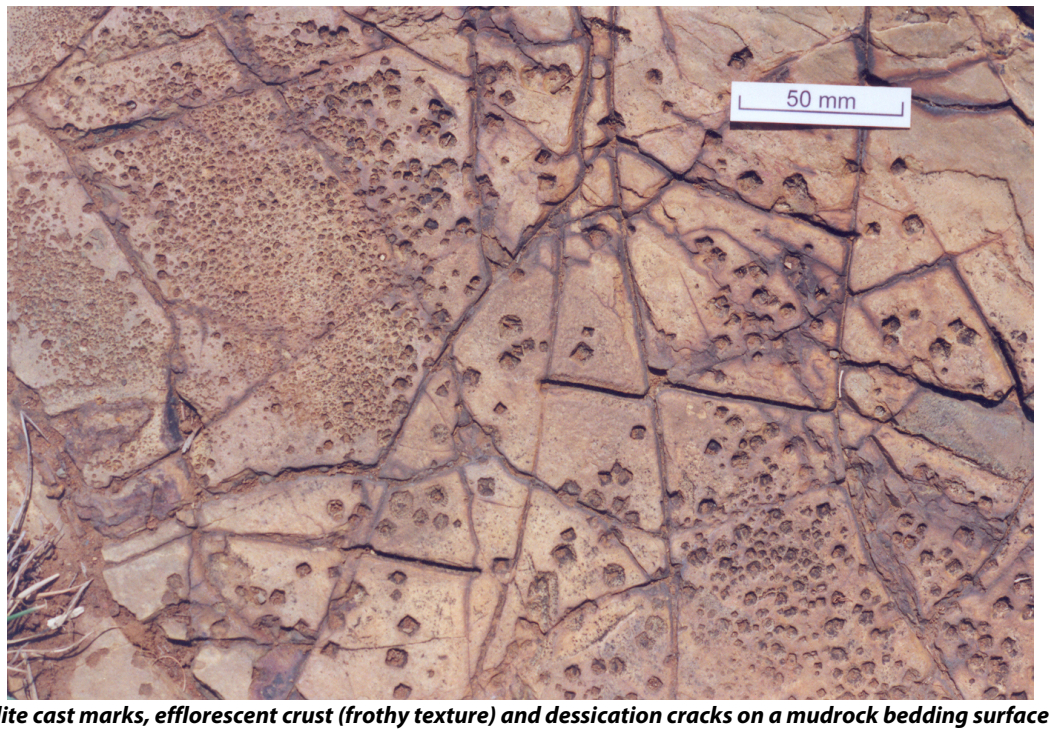
Progress
This project has now been terminated although work with regard to consultation and modelling of dolomitic land is still ongoing. The work done included profiles through portions of the Rooihoogte Formation south of Johannesburg; a short summary of periods of dolomite exhumation resulting in karst formation in Gauteng was written. A map depicting the dolomitic land in Gauteng, which includes areas where dolomite is present less than 100 m from surface, was also developed by the author in conjunction with the Engineering Geology Unit of the Council for Geoscience. Site-specific investigations were done along a portion of the Gautrain railway link, at Cornwall Hill, Heuweloord, the Manovani area near Olifantsfontein, Pierre van Ryneveld near Pretoria, Klipriviersval 371 north of Meyerton, Portion 24 of the farm Droogegrond 380-JR at Centurion, Pierre van Ryneveld Extension 3, the southern portion of Driefontein 146-IR, Zuikerboschfontein purification works near Vereeniging and Sterkfontein 401-JR for the proposed Junction 21. The geology and 3D geological modelling of the East Rand Basin dolomites and Witwatersrand Basin were also done.

Conclusions
The site-specific investigations following a new approach where formation tops are identified and isopach maps, as well as cross-sections and 3D block diagrams that were constructed with the aid of RockWorks15 show that a better understanding of the three-dimensional geological environment is feasible. This information may be used to make better-informed decisions when urban areas are zoned.

From literature research and work in the field it is deduced that the dolomite landscape is complex due to variable lithologies, geological structures and various cycles of erosion. Portions of the Chuniespoort Group were possibly exhumed and exposed to karstic weathering prior to the deposition of the Pretoria, Waterberg, Dwyka and Ecca Groups. Portions of the dolomite were also possibly exhumed and karstic weathering probably took place in response to the upliftment of southern Africa related to the African, post-African 1 and post-African 2 erosional land surfaces. These conclusions are supported by the presence of sinkholes filled with Rooihoogte Formation sediments, Karoo Supergroup sediments, Tertiary cave deposits and modern Terra Rossa soils. The identification of halite casts, efflorescent crust and dessication cracks in the Rooihoogte Formation provided important evidence for a dry cold climate during the deposition of the Rooihoogte Formation in what may be a marginal marine/lacustrine setting.



A 3D block diagram showing the dolomitic and related geology at Driefontein 146-IR.



Halite cast marks, efflorescent crust (frothy texture) and dessication cracks on a mudrock bedding surface of the Rooihoogte Formation.

SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY (SACS)

ST-2002-0449 **SACS PUBLICATIONS**

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

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

Progress
The status of the publications is as follows:

SACS Lithostratigraphic Series No. 51 (Lithostratigraphy of the T'hammaberg Formation, Bushmanland Group) is ready for publication.
SACS Catalogue Volume 11 was prepared for publication. This volume contains descriptions of the Goraap Suite, Hangfontein Granite, Kuboos Batholith units, Kuruman Kimberlite Suite, Stellenbosch Batholith, Vioolsdrif Suite and Wolkberg Group.
SACS Catalogue Volume 12. Final reviews of the following units have been received; Brulpan Group, Kalkwerf Gneiss, Koelmanskop Metamorphic Suite, Polisiehoek Gneiss, Schuitdrift Gneiss, Vaalkoppies Group, Yas Gneiss, Wilgenhoutsdrif Group.
SACS Catalogue Volume 14. Four contributions have been received for this volume (Emakwezini Formation, Maputuland Group, Mngazana Formation and Darling Batholith units). Most of these are awaiting further inputs from the authors before they can be finalised.
SACS Catalogue Volume 15. Three contributions for this volume are under review (Enon Formation, Kirkwood Formation and Mngazana Formation).
SACS Catalogue Volume 16. Five contributions have been received for this volume (George Pluton units, Sardinia Bay Formation, Goudplaats-Hout River Gneiss Suite, Messina Suite and Turfloop Batholith). The description of the George Pluton units has been accepted for publication. The extents of the Goudplaats-Hout River Gneiss Suite and the Turfloop Batholith need to be established with some mapping required.

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

Future activities
Further lithostratigraphic units will be formally described.

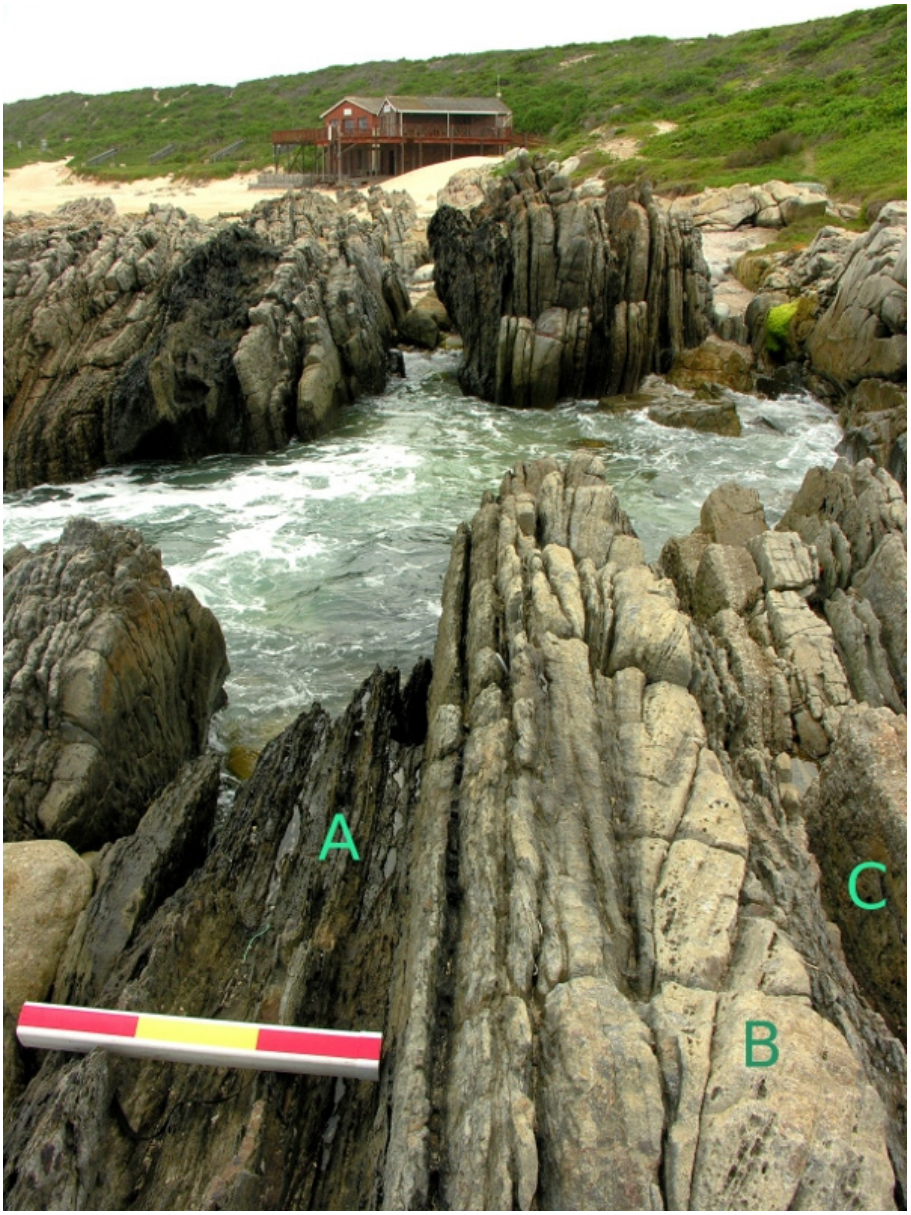
ST-2002-0473 **SACS DATABASE**

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

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

Progress
During the year no units were added to the database. Stratigraphic units associated with the Transvaal Supergroup were identified, pending possible restructuring. The database was supplied to the South African Institute for Aquatic Biodiversity in Grahamstown.

Future activities
This project is ongoing. A meeting is to be held at the University of Pretoria in June 2011 to decide the future of the term Transvaal Supergroup.



Metaquartzite-dominated unit of the lower Sardinia Bay Formation.

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

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

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

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

Progress
Discussions were held with the Chairman of the Subcommission for Precambrian Stratigraphy. Chronostratigraphic markers from the Kaapvaal were proposed for the Palaeoarchean-Mesoarchean and Eoproterozoic-Palaeoproterozoic boundaries.

Presentations based on the use of oxygen as an index of Precambrian stratigraphy were made at the 6th Quadrennial Conference of the International Geoscience Educators Organisation held at the University of the Witwatersrand in August and at CGS GeoIndaba meetings.

The ISSC solicited the opinions of the members on the issue of year as a date or a duration. The Secretary conveyed the opinion of SACS, that year as duration be designated yr (year), and be distinguished from year as a date, designated a (annum). However the ISSC decided that distinction was not essential.

An informal Task Group for the Rooiberg Group was established. Meetings of the formal Task Groups were curtailed due to a lack of funding. Informal discussions on the Transvaal Supergroup were held. It was resolved that the Loskop Group be removed from the Transvaal Supergroup and be placed in the post-Bushveld Waterberg Group. The Wolkberg Group should be included in the Ventersdorp Supergroup.

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

Future activities
This project is ongoing.

Red, oxidised sediments of the Mogalakwena Formation, Waterberg Group.

ST-2010-1106 **SACS (SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY) DESCRIPTIONS: MASHISHIMALE GRANITE, MICA PEGMATITE, ALLDAYS GNEISS**

Project leader: N. Baglow, B.Sc. Hons
Project team: T. Dhansay, B.Sc. Hons, N.C. Mukosi, B.Sc. Hons, L.P. Munyangane, B.Sc. Hons
Primary objective: To provide a concise comprehensive lithostratigraphic description and type area for the Mashishimale Granite, Mica Pegmatite and Alldays Gneiss
Duration: Annually

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

Progress
The Mashishimale Granite, Mica Pegmatite and the Alldays Gneiss descriptions were completed.

Conclusions
The Mashishimale Granite (2 698±21 Ma) is a stock-like body of fine- to coarse-grained hornblende-biotite granite in which four phases have been distinguished (Transport, Lillie, Hoed and Hope). Largely plotting within the monzogranite field, formal subdivision is not justified with the present state of knowledge.

Newly designated, the Mica Pegmatite is found as a belt that intrudes the Makhutswi Gneiss and an ultramafic complex which now exists as dismembered remnants largely defining the extent of the belt. In terms of age (2 912±3 Ma) the pegmatite is not related to any of the nearby granitoid intrusions. Individual pegmatite bodies are very irregular in shape, and are typically composed of the usual muscovite, quartz and feldspar (grading from pure albite to anorthite) with a variety of accessory minerals, including Li and Cu minerals and garnets. In the mined areas almost monomineralic zones occur.

The Alldays Gneiss is a suite of 2,72–2,61 Ga orthogneisses found in northern Limpopo. The most common variety is a leucocratic grey, often pink-grey augen gneiss in which the 1–3 cm augens display a preferred orientation and clear strain shadows associated with ductile shear zones into which it intruded. Other varieties of the gneiss include leucocratic and grey homogeneous gneiss and a darker variety, all displaying gradational boundaries.

ENGINEERING GEOLOGY

ST-2002-0006 **ENGEODE DATABANK**

Project leader: A.C. Oosthuizen, B.Sc. Hons (Eng. Geol.)
Project team: G.J. Heath, M.Sc., J.D. Grobler, L.G. Heath, B.Soc.Sc. Hons (Psychology)
Primary objective: To make engineering geology information available to the nation in assisting development
Duration: Ongoing

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

Progress
The bulk of the dolomite-related information has been submitted in the form of dolomite stability reports for peer-reviewing purposes by geotechnical consulting firms. An indexing system was compiled to easily access the data and a quality-control system was implemented to ensure that all the reports indicated on the index list are stored in the database. The total number of dolomite stability reports in the system is 4 596 of which a total of 259 reports were submitted during the period April 2010 to March 2011.

In the non-dolomitic databank the total number of reports submitted to date currently is 10 887.

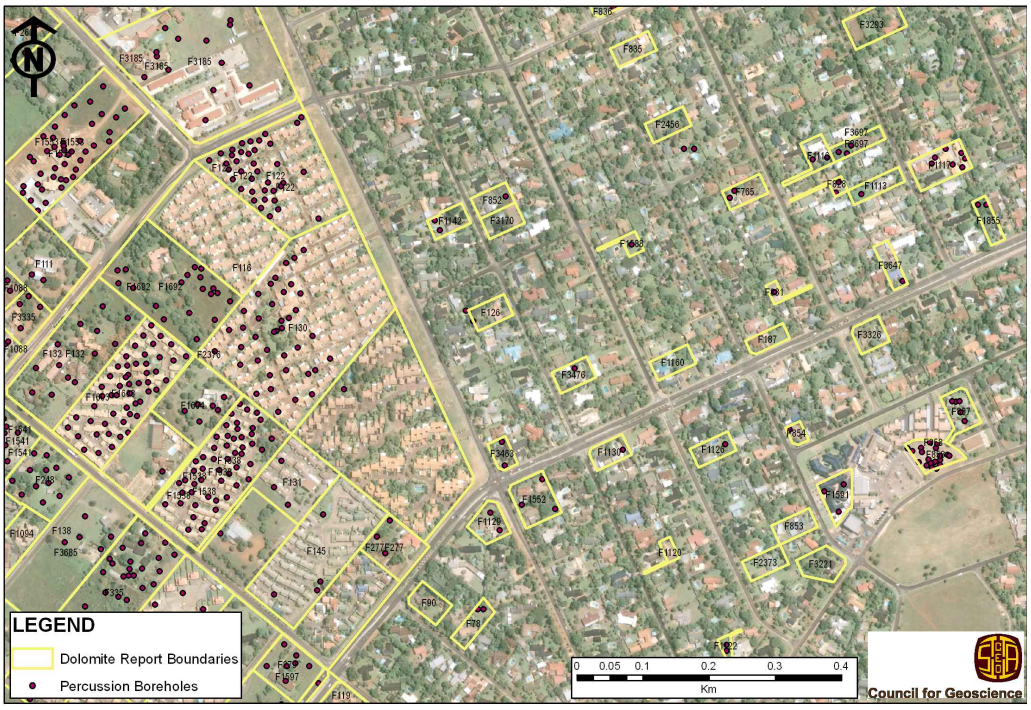
Capturing of report boundaries, dolomite boreholes and gravity maps into GIS commenced during 2007/08 and is continuing as new reports are submitted. The following data were captured during 2010/11:
- 259 dolomite stability report boundaries
- positions of 6 649 dolomite percussion boreholes
- 360 geotechnical report boundaries
- positions of 6 722 test pits
- digitising of gravity maps for the towns of Venterspost, Carletonville and Westonaria commenced
- sinkhole events were recorded in the municipal areas of Tshwane and Ekurhuleni and the provinces of Mpumalanga, Northern Cape and North West which brings the total number of sinkholes in the database to 3 307 events.

General telephonic and e-mail enquiries are received on a regular basis from the general public, stakeholders and developers. The digital accessibility of the information in the databank makes it possible to easily provide stakeholders with the necessary information, such as a small map showing the position of the site in relation to the presence of dolomite.

Conclusion
The importance of this databank is growing, as more consultants working in the industry require GIS data from the organisation. The Council for Geoscience has been involved in a number of large data-acquisition projects to date and this databank is becoming a very useful tool for industry. The ENGEODE databank was also used for the compilation of the 1:50 000 Geotechnical Map Series of the Council for Geoscience.

Future activities
Data capturing is an ongoing process, and will remain part of the unit's responsibilities in the years to come. The capturing of the dolomite- and non-dolomite-related data will continue in 2011/12 and work to produce a definitive sinkhole record for South Africa will continue.

Sinkhole in Valhalla, Pretoria during August 2010.



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

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

Project leader: A.C. Oosthuizen, B.Sc. Hons (Eng. Geol.)
Project team: G.J. Heath, M.Sc., L.G. Heath, B.Soc.Sc. Hons (Psychology), J.D. Grobler
Primary objective: To provide a map where the hazard of sinkhole formation is indicated in the Centurion CBD and surrounding areas which will assist the Local Authority with guiding safe development in the area. The map will also assist in making recommendations regarding the suitability of land usage based on the hazard of sinkhole formation
Duration: Three years

Motivation
Centurion has been rapidly densified over the last forty years and has become a major residential node midway between Johannesburg and Pretoria. The new Gautrain route will traverse across the Centurion CBD area which will encourage new high-rise developments (i.e. higher density of people per hectare) in the future. In order to guide this increased densification, a hazard map is required to ensure that these developments do not result in increased risk from sinkhole formation. The current classification system used on dolomitic land is also reviewed in order to make an assessment of the probability of sinkhole formation in the study area.

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

The Centurion CBD area is underlain by dolomite and chert of the Malmani Subgroup of the Transvaal Supergroup. Information for the study area is available through dolomite stability reports that have been submitted to the organisation for peer review. A total of 435 dolomite stability investigations have been conducted within the CBD and surrounding areas in which a total of 3 333 percussion boreholes were drilled. Each borehole within the study area was assigned an inherent hazard class. Eight inherent hazard classes are present which classify an area into a low, medium or high hazard, which is an indication of the probability of sinkhole formation.

Using the Spatial Analyst extension of ArcGIS 9.3, a map showing the hazard of sinkhole formation was compiled from the hazard class assigned from each borehole in the study area. This method interpolates between data points and if no data exist, nearby data are used to determine the hazard in the area. The hazard map of the area generally indicates a medium to high susceptibility to sinkhole formation with pockets of low hazard areas.

A total of 106 sinkholes have been recorded in the Centurion CBD area since the early 1970s. The average sinkhole depth is 3 m for the study area, whereas the average sinkhole size is 5 m in diameter. Three lives have been lost as a result of a sinkhole in the study area and a total of seven houses or units had to be demolished. Millions of rands have been spent to repair other structures, infrastructure and services. Ninety two of the events in the study area occurred as a result of man's disturbance of the natural ground conditions through increased water ingress.

The hazard map shows that no sinkholes occurred in the areas classified as having a 'low susceptibility to the formation of sinkholes', which suggest that the areas of low hazard were delineated well and that the classification system defines these areas well. A vast majority (67%) of the sinkholes in the study area occurred in areas classified as having a 'medium hazard for the formation of sinkholes', which suggests that medium hazard areas are as equally vulnerable to sinkhole formation than high hazard areas.

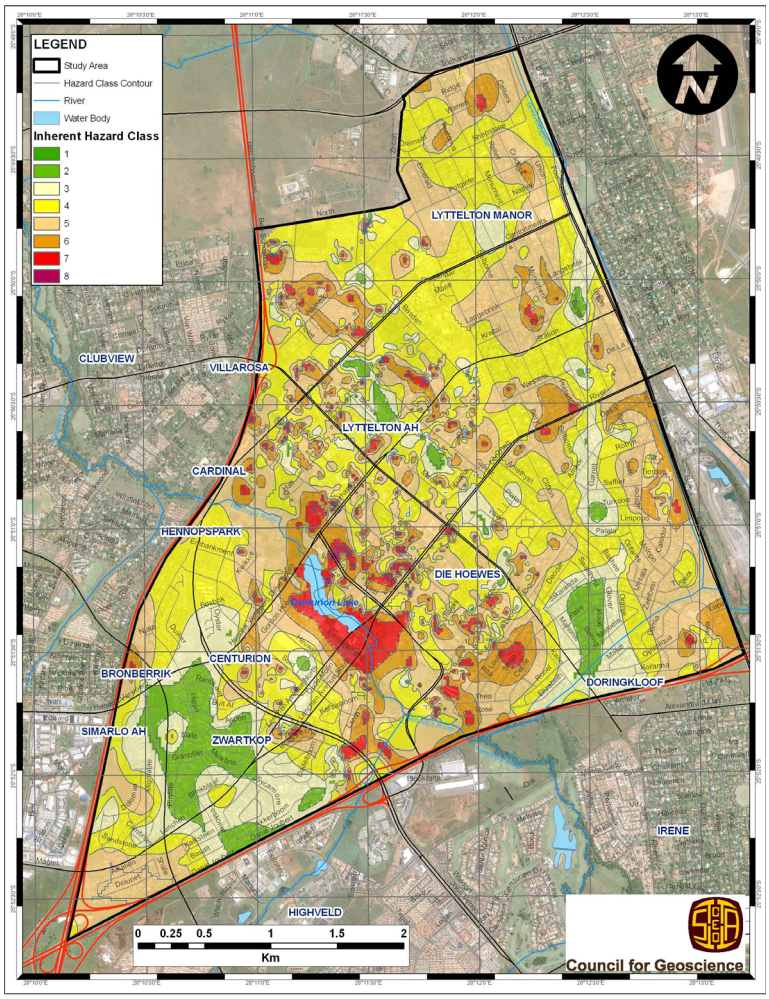
Almost two thirds of the study area represent a medium hazard for sinkhole formation, with almost a third of the area considered as having a high hazard for the formation of sinkholes and only a small portion of the area (5%) representing low hazard conditions.

Conclusion
The hazard map of the area generally indicates a medium to high susceptibility to sinkhole formation with pockets of low hazard areas.

Recommendations regarding the various types of land uses include 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 periphery.

Future activities
In order to produce a more reliable hazard map, additional drilling would be required to ensure an even distribution of borehole positions within the CBD area, especially in the area south of the Hennops River. The outcome of this study will be used to evaluate the behavior of dolomitic land in built-up areas, which has not been studied before.

Locality of the study area.



Hazard of sinkhole formation in the study area.

Sinkholes that occurred next to the N1 highway during 2010.

ST-2011-1137 **DEVELOP A DECISION-MAKING TOOL FOR URBAN DEVELOPMENT ON DOLOMITIC LAND (KARST SINKHOLE AND SUBSIDENCE RECORD FOR GAUTENG PROVINCE)**

Project leader: S. Richardson, B.Sc. Hons (Eng. and Env. Geol.)

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 statistical analyses of sinkhole and subsidence occurrences, and (3) to add to the current body of knowledge on sinkholes and subsidences with regard to the occurrence within the Gauteng Province

Duration: 2010–2013

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 Gauteng, Mpumalanga, Limpopo, North West and Northern Cape Provinces. The Gauteng Province is by far the worst affected; in excess of 2 400 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 subsidence database is crucial for future assessments of sinkhole hazards and decision making when it comes to development types and foundation designs.

Progress

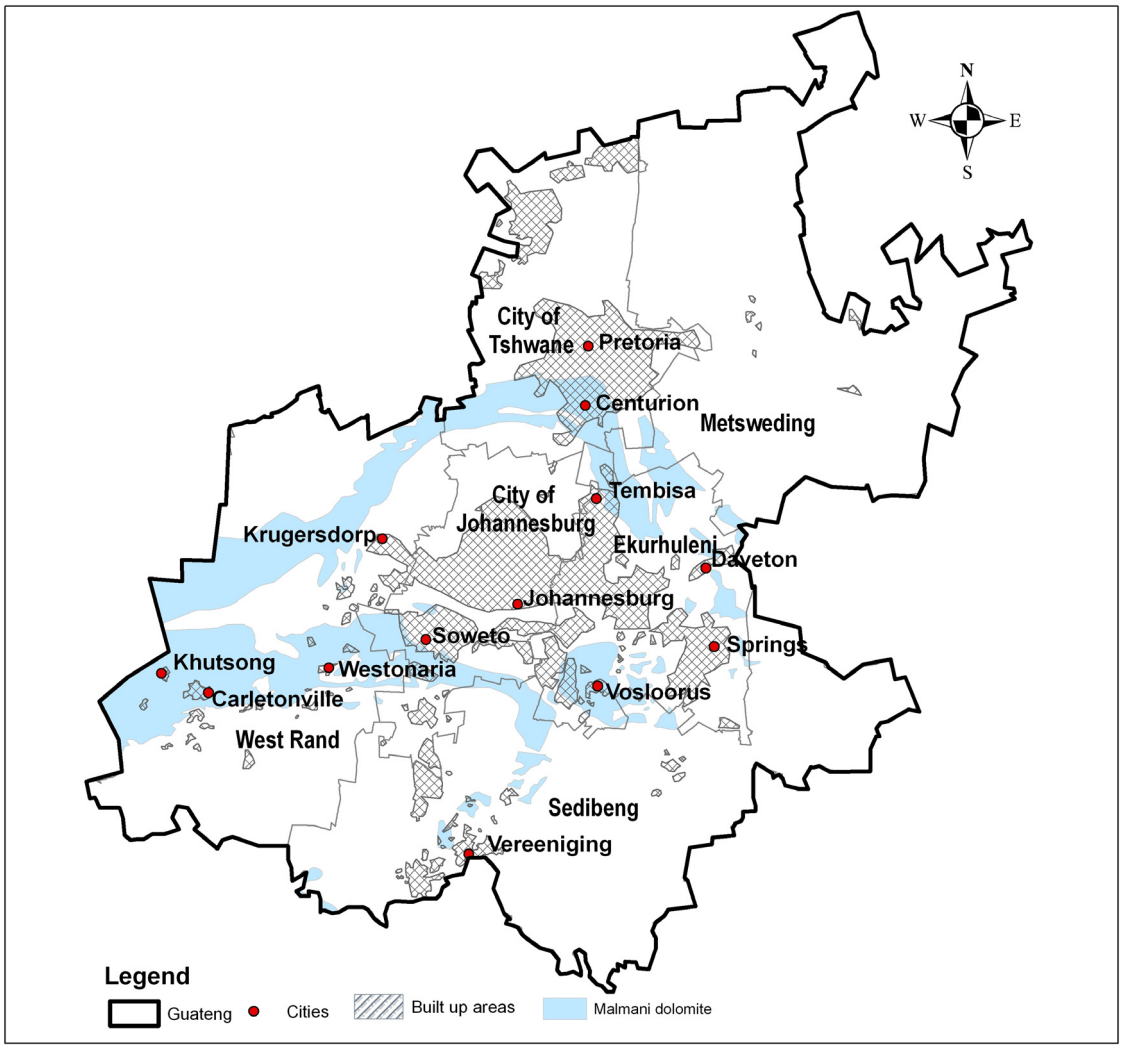
A desk study has been conducted incorporating all available sinkhole and subsidence information for three municipalities within the Gauteng Province; the City of Tshwane Metropolitan Municipality, West Rand District Municipality and Ekurhuleni Metropolitan Municipality. The information collected provides an indication of the number of sinkholes and subsidences that have occurred in the past, however, much data verification is still necessary. Preliminary analyses have been carried out on limited available data.

Conclusions

In excess of 2 400 sinkhole and subsidence events have occurred within the Tshwane, West Rand and Ekurhuleni Municipalities. Analyses show that all three municipalities have more sinkholes than subsidences or cracks, the dominant sizes of sinkholes differ across the three municipalities and the dolomite formation on which most instability events have occurred is the Monte Christo Formation, followed by the Eccles Formation.

Future activities

Much data verification and updating is still necessary. Data for the other three municipalities, Metsweding District Municipality, City of Johannesburg and Sedibeng District Municipality still need to be compiled. A comprehensive sinkhole and subsidence database is crucial for future assessment of the sinkhole hazard and decision making when it comes to the selection of appropriate development types and foundation designs.

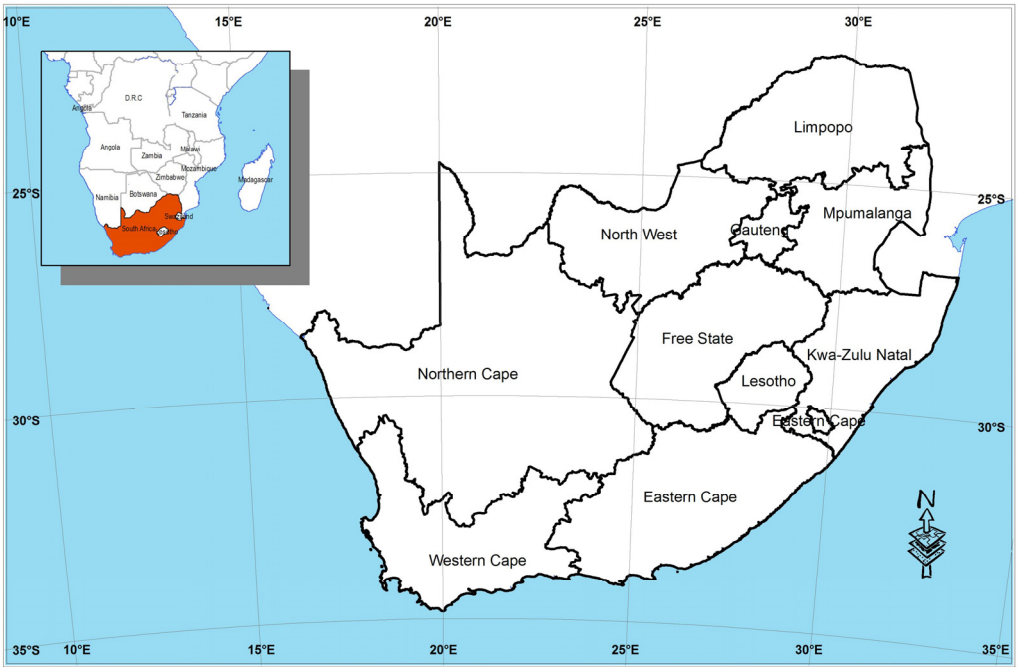


Distribution of dolomite within the Gauteng Province.

ENVIRONMENTAL GEOSCIENCE UNIT

ST-2011-1120 **GEOTHERMAL POTENTIAL OF SOUTH AFRICA – A DESKTOP SCOPING STUDY**

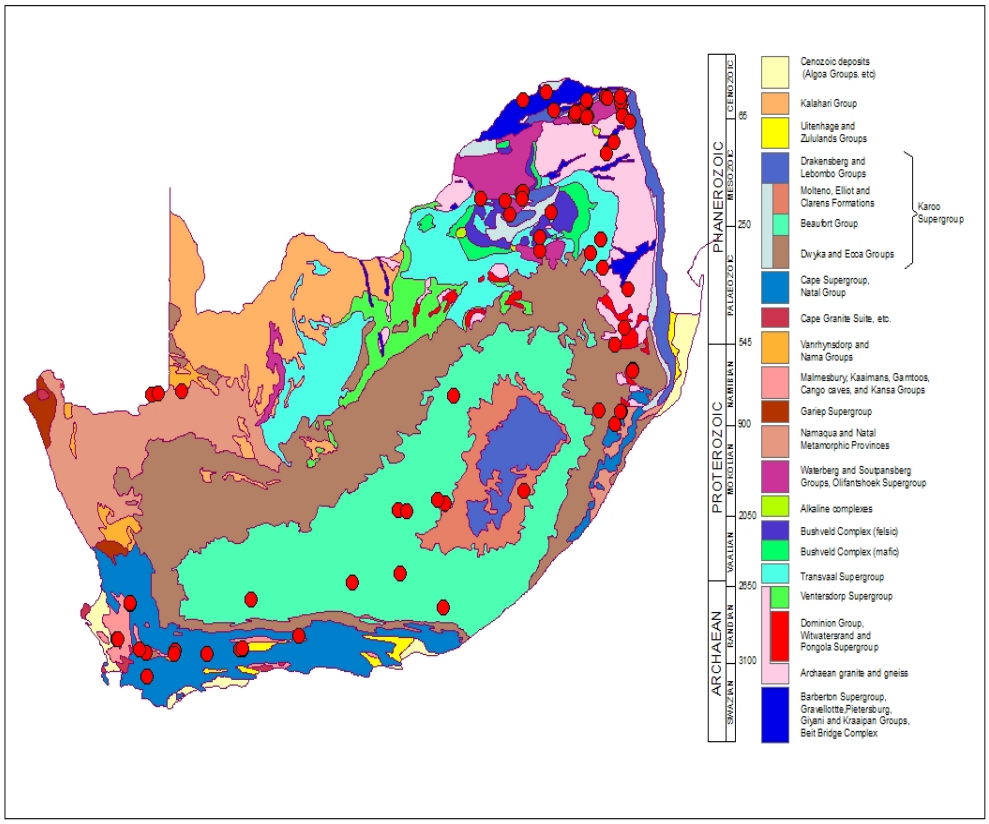
Project leader: J.S. Venter, B.Sc. Hons (Eng. Geol.)
Project team: P. Nybaze, M.Sc. (Geophys.), T. Motlakeng, Nat. Dip. Geol., D. Sebake, B.Sc. (Agriculture), M.Sc. (GIS), C. van der Merwe, M.Sc. (Hydrogeol.)
Primary objective: To determine the current status of geothermal research in South Africa and to determine the potential of geothermal energy that could be exploited
Duration: April 2010 to March 2011



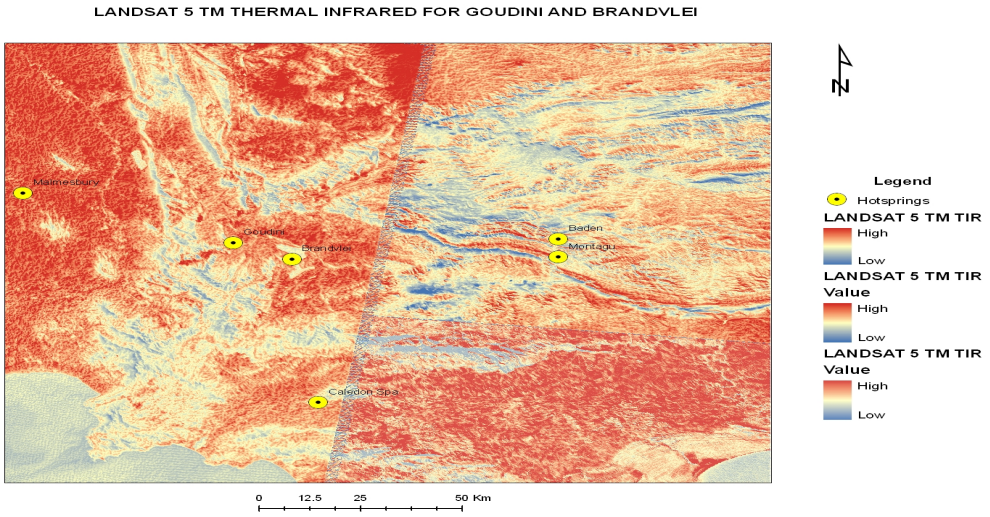
Location map of the study area.

Motivation
South Africa is an energy-stressed country and new or more renewable sources of energy need to be studied and implemented. Currently there are a number of alternatives to fossil fuels including nuclear power, solar energy, wind energy and electricity generated by hydro-electric power plants. Another option that has not been adequately explored in South Africa is geothermal energy. Two scales of energy generation are envisaged – a smaller-scale generation in hot spring areas and a larger-scale exploitation of areas of regionally elevated heat flow.

Progress
Literature studies regarding geology, geophysics, hydrogeology and remote sensing has been conducted. Interpretation of existing data was also performed on a limited scale. The study focused on regional scale data collection and interpretation. The GIS database includes information on existing heat flow measurements, regional geology, airborne geophysics as well as remote sensing (Landsat and ASTER images). A database of existing chemistry data for the hot springs of South Africa has also been compiled by UNISA.



Hot springs of South Africa (Simplified geology of SA supplied by SDM Unit).



Landsat 5 TM thermal infrared for Goudini and Brandvlei.

Conclusions

Even though South Africa does not have recent volcanic activity which is usually associated with high enthalpy geothermal resources, it is still believed that there is large scope for the exploitation of medium to low enthalpy resources. This desktop study is a first step to determine the geothermal potential of South Africa.

Future activities

The current research needs to be continued, with more detailed studies envisaged for the future. Detailed studies should include feasibility studies for local or district heating, aquaculture and greenhouse heating.

ST-2011-1122 **UTILISATION OF BIO-MONITORING TO ASSESS THE IMPACT OF CONTAMINATION CAUSED BY MINING IN SOCIAL-ECOLOGICAL SYSTEMS**

Project leader: B. Hanise, M.Phil.
Primary objective: Utilisation of the organism that included avifauna and arthropods in the ecosystem to monitor contamination caused by mining in social-ecological systems
Duration: Three years

Motivation
The decades of gold mining in the Witwatersrand has left a legacy of mixed fortunes and activities such as mineral prospecting, mineral extracting, mineral concentrating, refining and transportation has resulted in great disruption of the natural environment.

The externalities from the mining impacts and cumulative impact are often difficult to measure and manage because issues relating to contamination of the biodiversity might be cumulative with long-term disastrous consequences. Added to the tapestry are socio-economic issues such as human health, migration patterns and urban form that contribute towards socio-economic aspects of sustainability.

The eradication of bio-indicatory species such as amphibians, insects, birds, small mammals and plants are indicative of cumulative environmental degradation due to adverse contamination of the biodiversity. Terrestrial and aquatic birds of different species that have radii around water bodies in the form of wetlands, streams, lakes and dams are in this case the essential bio-indicators to be monitored for heavy-metal or trace-metal contamination.

A literature survey was done on avian biology, bird ringing, mining impacts and heavy-metal contamination. Methodologies and topics on the acquisition of data were also explored and these included bird feather collection exercises, bird trapping techniques, ethics during bird feather collection and the extraction techniques of heavy metals from the terrestrial bird feathers.

Progress
Aspects on the methodology, material and methods of data acquisition and analysis tools to be adopted for the study were explored.

The aim is to generate avian data that are to be used for profiling the aquatic areas for short-term analysis while building up a database that will be used for long-term monitoring. Both data profiles will assist in the assessment of the integrity and health of the water bodies where these birds reside.

A variety of concepts were explored to navigate the study on the kind of data anticipated and the available tools for analysis, namely the Zipf's Law, Power Law and the Pareto's principle. In addition to these, the systems thinking approach was explored, especially concepts such as resilience and panarchy. Exploration of the latter concepts is towards the development of an integrated approach to help understand the interplay between change and persistence within the embedded scales within which organisms exist and interact.

Future activities
Field data collection, laboratory analysis and database creation for long-term monitoring.

ST-2011-1110 **PHYTOREMEDIATION OF CONTAMINATED SOIL AND WATER**

Project leader: L. Sakiah, B.Sc. Hons (Eng. and Environ. Geol.)
Project team: Dr B. Yibas, Ph.D. (Geol., Geochem. and genesis and controls of gold mineralisation)
Motivation: The Environmental Protection Agency (2000) defines phytoremediation as an emerging technique in which different plants are used to degrade, extract, contain or immobilise contaminants from soil and water. The idea of phytoremediation is very old and it is extremely difficult to trace the original source. Current technologies that are usually used to remediate metal-contaminated sites include soil excavation and either land filling or soil washing followed by physical or chemical separation of contaminants. However these practices degrade soil properties, destroy biodiversity and render the soil useless for plant growth. As a result, phytoremediation has developed into a promising, cost effective and environmentally friendly technology
Primary objective: Determine the viability of using plants for remediating polluted sites
Duration: 2010/11–2011/12

Motivation
The project promotes the development of scientific knowledge that can assist the regulators, site managers and owners to evaluate the applicability of phytoremediation to their sites.

Progress
A progress report has being produced for the 2010/11 financial year. The report looked at the general aspects of the method, various categories and potential applications of phytoremediation, advantages and disadvantages of the technique, system selection and design considerations and the results from previous studies. Research has shown that the technique can be crucial for remediating heavy metals and metalloids from polluted soil and water.

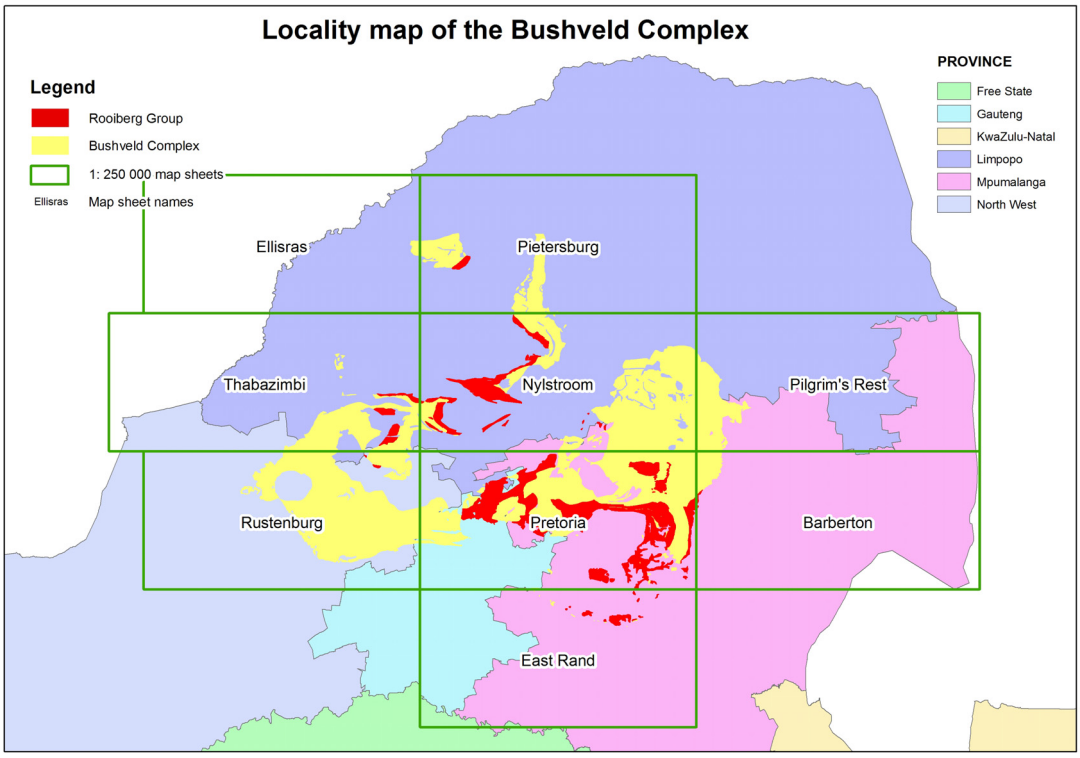
Future activities
Even though the results are promising, further research is needed to identify phytoremediating species.

GEOCHEMISTRY

ST-2011-1119 **REGIONAL GEOCHEMICAL MAPPING OF SOILS IN THE BUSHVELD COMPLEX**

Project leader: J.H. Elsenbroek, M.Sc.
Project team: S.W. Strauss, M.Sc., D. van der Walt, B.Sc. Hons, M.L. Bensid, B.Sc. Hons, R. Netshitungulwana, M.Sc., S. Hlatshwayo, B.Sc. Hons, E. Mulovhedzi, B.Sc. Hons, M. Maya, B.Sc. Hons
Primary objective: To provide a value-added product to the existing regional geochemical data in that it will highlight cryptic magmatic processes such as differentiation and fractionation of the igneous units which have previously not been seen on maps. It will also identify 'new' target areas for exploration for Pt, Pd, Au, Cr, Ni, Cu, Sn, W and F
Duration: 2010/11

Motivation
The Bushveld Complex is the largest intrusive complex in the world and therefore of enormous economic and scientific interest. The Council for Geoscience has recently completed the high density geochemical survey over the Bushveld Complex. The report will, for the first time, provide a value-added product to existing data in that it will highlight cryptic magmatic processes such as differentiation and fractionation of the igneous units which have previously not been seen on maps. It will identify 'new' target areas for exploration for Pt, Pd, Au, Cr, Ni, Cu, Sn, W and F and attempt to map post-emplacement structural adjustments to the host rocks of the Bushveld Complex as can be evidenced by cryptic geochemical contrasts related to the juxtaposition of variably jostled tectonic blocks now dissected by the current erosional surface. For the first time a holistic interpretation of the current regional geochemical data will be compiled to showcase the value of the data and showcase expertise for pre-competitive purposes.



Locality map of 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 compiled seven geochemical reports on seven different units of the Bushveld Complex:

- The Lebowa Granite Suite by J.H. Elsenbroek (M.Sc.)
- The Rooiberg Group by D. van der Walt (B.Sc. Hons)
- The Rashoop Granophyre Suite by M.L. Bensid (B.Sc. Hons)
- The Upper Zone by R. Netshitungulwana (M.Sc.)
- The Main Zone by S. Hlatshwayo (B.Sc. Hons)
- The Marginal Zone by E. Mulovhedzi (B.Sc. Hons)
- The Critical Zone by M. Maya (B.Sc. Hons).

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

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

Future activities
The seven geochemical reports on the different units of the Bushveld Complex will be compiled into one geochemical atlas. A standardised geochemical map will be compiled for all the different units of the Bushveld Complex. Field visits will be carried out to verify geochemical anomalies and to compare mineralisation and structure within the geological outcrops in the target area. The verification results will be incorporated in the final Bushveld Complex Geochemical Atlas.

GEOPHYSICS

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**

Poject leader:	L.P. Maré, M.Sc.
Project team:	D. Kruger, M.R. Mantsha, L. Loots, B.Sc. Hons, K.R. Sekiba, Dip. Tech. and S. Tucker, Dip. S.B.M.
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:	Reporting year: R356 002

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 2010/11 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.

Some of the stratigraphic units that have been covered during this period include samples from the Schiell Complex, Silverton Formation, Theespruit Formation, Ecca Group, Clarens Formation and Malmani Subgroup.

The ORACLE-based Physical Properties Atlas of South African Rocks has been updated, including outstanding data from previous years where stratigraphic information was lacking.

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

The results from a magnetic polarity analysis on samples from the southeastern lobe of the Bushveld Igneous Complex (BIC) have been compiled into a B. Tech dissertation which received a distinction.

The new dielectric probe test kit is operational and the first test samples were successfully measured.

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

Future progress
During 2011/12 the results from the magnetic polarity analysis on samples from the southeastern limb of the Bushveld Igneous Complex (BIC) will be converted into a scientific publication.

Research on induced polarization (IP) and membrane constrictivity will be continued by Dr V. Zadorozhnaya.

Problems delaying the implementation of new equipment will be looked into. Once operational, tests on the seismic (s-wave) equipment will be conducted with the aim to expand the services of the Petrophysical Laboratory.

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

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

Project leader:	M. Havenga, B.Sc. Hons
Project team:	P. Cole, M.Sc., J. Cole, M.Sc., L.R. Legotlo, B. Tech., R.H. Stettler, Nat. Higher Dip., L. Ledwaba, B.Sc.
Primary objective:	To maintain and expand geophysical databases, including GIS coverages
Duration:	Ongoing
Budget:	Total: R92 301

Motivation
The Geophysics Unit has vast amounts of data. This needs to be properly stored, backed up and catalogued. Data that are easily accessible result in greater work efficiency and better productivity. Data are valuable assets for a company and should be treated as such.

Progress
The financial year 2010/11 required mainly data quality control and formatting improvements of data and data structures, since very little new data were collected. Large amounts of storage space were freed with the reformatting of old gravity reports that were scanned to PDF using incorrect settings, resulting in enormous documents. The feasibility of using Google Earth and adding Google Earth coordinates to data sets to enable users to locate the position of the data sets using Google Earth was investigated and a workable solution was implemented. The administration database underwent a total makeover, which included the removal of reports and queries that have fallen into disuse over the years and adding functionality required by the new policies and procedures in the Council for Geoscience.

Conclusions
The database maintenance project is dependent on new data and the need for changes to the structure. Very little new data were collected in the 2010/11 financial year. The changes needed in the administration databases were made, new remote sensing data were captured and space was freed on the server by reformatting some extremely large reports.

Future progress
Future progress of the project includes creating a set of georeferenced images for each survey in the database, fixing and re-processing the data where necessary and adding the corrected data to the database. This will be no small task. New data will be added to the database as it is collected and the interface will be continuously updated to suit the needs of users.

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

Project leader:	L.J. Ledwaba, B.Sc. Hons
Project team:	P. Cole, M.Sc., O.W. Dingoko, B.Sc. Hons
Primary objective:	To review and reprocess any old airborne regional data sets that still show systematic levelling errors using the latest processing techniques
Duration:	Ongoing
Budget:	Reporting year: R144 130

Motivation
The South African National airborne survey was flown between 1958 and 1997. A final processed version of the data was published in 1997 at a scale of 1:1 000 000. Two versions of the maps were produced. The first version displayed the standard Total Magnetic Field Intensity. The second version showed a Magnetic Fabric and was an enhanced version of the data showing shallow magnetic features. A process was started in 2005/06 to reprocess the data. This was in light of more advanced modern processing techniques that were available to improve the quality of the data. During the financial year 2010/11, the process of reprocessing the data continued and a number of blocks were reviewed for advanced processing.

Progress
During 2009/10, some 30 blocks were considered for reprocessing. These are 1/66, 2/66, 3/66, 4/66, 5/69, 6/69, 7/69, 8/69, 17/73, 18/74, 20/74, 21/74, 22/75, 23/76, 27/81, Karoo 2 to Karoo 9 and Karoo 12 to Karoo 18. Some of the blocks required splitting into smaller manageable subsets to simplify the processing. The first step in processing is to import the data from an archive format into a workable ASCII format. This is done by studying the input archive format and writing a small script, usually in VB, to perform the exporting.

Once the data are in a suitable format, they are gridded to identify any irregularities and when these irregularities are identified, tie-line levelling is performed to improve the data quality. Tie-line levelling does not always give the desired result and in such cases it is customary to apply micro-levelling to further improve the quality of the data. In some cases, it has been observed that the raw data is of a higher quality than the levelled data. For such blocks, the raw data is adopted as the final version. Examples of blocks devoid of any levelling errors include 3/66, 1/66, 2/66 and most of the Karoo blocks.

A large portion of the data flagged for reprocessing was completed during the 2010/11 financial year.

Conclusions
As many regional data sets as possible were reprocessed and the process yielded satisfactory results. An effort will be made to try and recover the missing data so that all the remaining blocks can be processed.

Future progress
During 2011/12, a number of regional airborne data blocks will be selected for reviewing and, where necessary, further processing will be performed in order to improve the data quality.

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

Project leader: J. Cole, M.Sc.
Primary objective: Creation of a three-dimensional model of the Bushveld Complex using gravity and magnetic data with the aim of improving the understanding of the geometry of the complex
Duration: 2006/07–2011/12

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, but despite this volume of work there are still many unanswered questions, not the least of which is the three-dimensional geometry of the complex. Only a few conceptual models of the complex using geophysical data have appeared in the literature over a period of 40 years. Modelling of potential field data can provide valuable information about the subsurface geometry, which is of both academic and economic interest. If, for example, thorough and robust modelling confirms the presence of mafic rocks in the central part of the complex, the total economic resources of the complex will be hugely increased. In addition, possible configurations of the mafic rocks (e.g. flat/doming/sagging) deduced from the modelling process can contribute to the understanding of the emplacement and geological history of the Bushveld Complex.

Progress
Work this year focussed on determining physical properties of the units that will form part of the model, specifically densities that will be used in the gravity modelling. Density data are available from a variety of sources with the different types of measurements based on different principles. Before data sets from the various sources could be used to construct a density stratigraphy, they had to be related to one another.

The Moordkopje borehole, drilled in 1979 and 1980, was logged geophysically using wire-line logging techniques, and later physical properties of the core itself were measured in the laboratory. This provided the ideal opportunity to compare density measurements collected using fundamentally different methods. A sensitivity analysis was conducted to establish the minimum density contrast necessary to model the smallest anomalies observed in the Bushveld Complex.

Density measurements from nine boreholes located in the northern and western lobes of the Bushveld Complex were used to determine mean densities for the different lithologies encountered in the boreholes and to establish a density stratigraphy for the Rustenburg Layered Suite (RLS). Mean densities for the different zones of the RLS were also determined, and these amounted to 3,07 g/cm^3 for the Upper Zone, 2,92 g/cm^3 for the Main Zone, 3,09 g/cm^3 for the Critical Zone, 3,2 g/cm^3 for the Lower Zone and 3,05 g/cm^3 for the Marginal Zone. Densities for the Lower and Marginal Zones were taken from the physical properties atlas of the Council for Geoscience as none of the boreholes intersected these zones. The estimated densities were tested by creating a two-dimensional model along a gravity profile extracted across the western lobe of the Bushveld Complex. The profile coincided with a deep seismic reflection survey that was conducted in 1986 and this provided an excellent constraint for testing the geophysical stratigraphies. An interpretation of the seismic data was used as the starting model. A few changes had to be made to the model to obtain a reasonable fit between observed and calculated data. This is not necessarily in conflict with the seismic interpretation, since the seismic data in this part of the profile did not show very clear reflectors. Overall, the results suggested that the geophysical stratigraphy deduced from the available physical properties data was adequate.

Conclusions
The work completed during this year provided an important component of the parameters necessary to proceed with the modelling process.

Future progress
During 2011/12 the magnetic stratigraphy to be used in the modelling will be derived. The modelling process itself will continue.

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

Project leader:	L.P. Maré, M.Sc.
Project team:	E.C. Ferré, Ph.D., M.O. de Kock, Ph.D., H. Mouri, Ph.D., B. Cairncross, Ph.D., SIU students
Primary objective:	The goal of this project is to conduct several magnetic fabric and palaeomagnetic experiments to evaluate magma dynamics of a large igneous province. A Ph.D. study on the geothermal history of the Karoo Basin is in progress
Duration:	2008/9–2012/13
Budget:	Total: ~R1 770 180; Reporting year: R397 912,50

Motivation

The first three years of this international collaboration project was funded in part by the NSF. The aim of the Council for Geoscience getting involved with this project was not only to gain valuable experience, but also to build important relationships with leading scientists from America.

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

As a spin-off from the NSF-funded project, a Ph.D. was registered at the University of Johannesburg. The aim of the project was to determine the effect of the Karoo LIP on the geothermal history of the Karoo Basin by making use of existing magnetic and palaeomagnetic methods. One of the main scientific questions related to the thermal history of the Karoo Basin is if the emplacement of large volumes of magma was preceded by a large-scale low-grade thermal doming similar to the one proposed in continental rift settings or, alternatively, if the Karoo thermal event was restricted to the contact aureole of intrusives. These hypotheses will be tested with three experiments performed on Karoo sediments surrounding sill and dyke intrusions of know dimensions.

Progress

During 2010/11 samples were collected from stratigraphic borehole G39974 from the Kopoasfontein farm in the Calvinia District (western Karoo Basin).

Three dolerite sills of varying thicknesses have been intersected. Alteration index (A40) data from the three sedimentary formations of the Ecca Group separated by the sills indicate maximum acquired temperatures ranging between 200 °C and 650 °C, with the highest temperatures restricted to short distances within the contact aureoles. Both magnetostratigraphy and low field anisotropy of magnetic susceptibility (LFAMS) data confirm re-magnetisation of magnetic fabric to be restricted to short distances from the sill contacts.

The calculated geothermal temperatures of the whole stratigraphic section is elevated to above 150 °C which falls within the range where hydrocarbon is converted into gas. The question is whether the gas was re-absorbed and stored in the sediments or released into the atmosphere through breccia pipes as was suggested by Svensen *et al.* (2007). This knowledge could have major implications for the shale-gas industry of South Africa.

Conclusions

Results from the Kopoasfontein borehole indicated that the proposed experiments are successful in determining maximum acquired temperatures. This knowledge allows the project to be expanded to the rest of the Karoo Basin.

Future progress

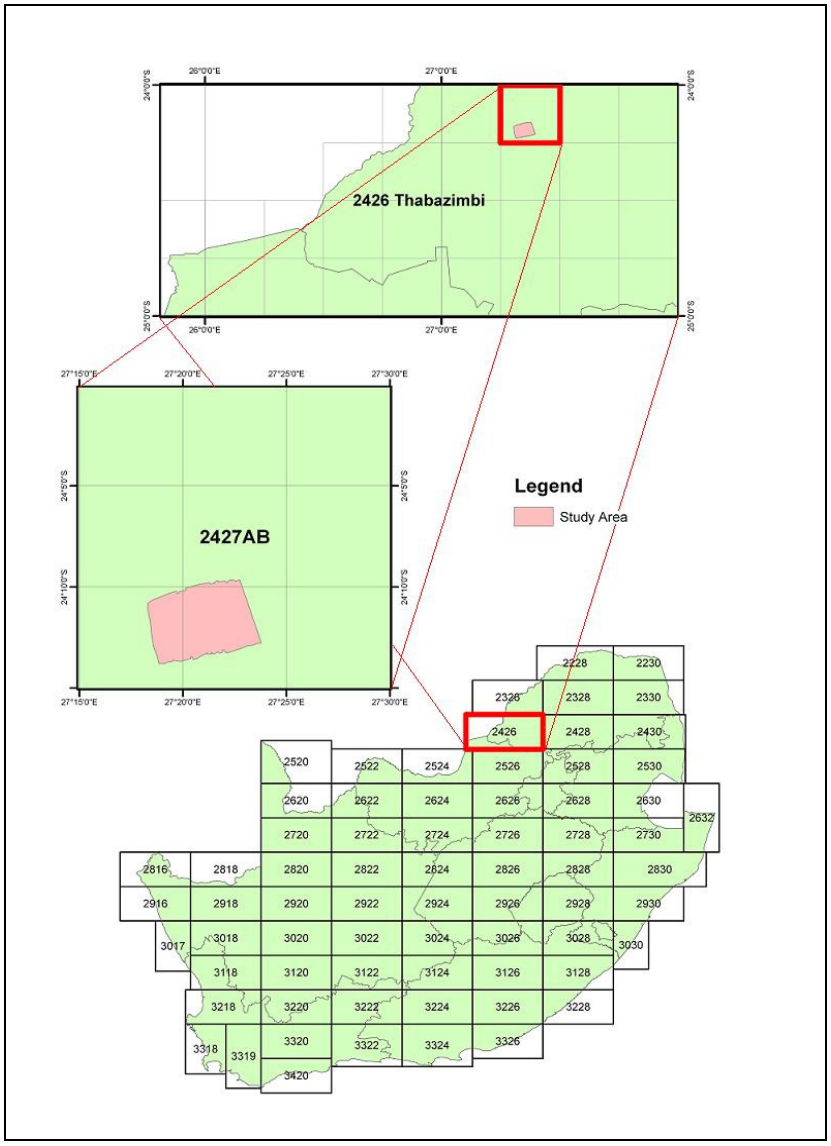
During 2011/12 the aim is to collect samples from different boreholes spread across the Karoo Basin. The aim will be to determine if the elevated temperatures vary from west to east as well as from south to north within the basin.

References

Svensen, H., Planke, S., Chevallier, L., Malthe-Sorenssen, A., Corfu, F. and Jamtveit, B., 2007. Hydrothermal venting of greenhouse gases triggering Early Jurassic global warming. Earth and Planetary Science Letters, 256, 554–566.

ST-2011-1107 **THE INTERPRETATION AND MODELLING OF AN ANOMALY ON THE 2427AB ROOIBOSBULT SHEET**

Project leader: M. Havenga, B.Sc. Hons
Project team: J. Cole, M.Sc., P. Nyabeze, B.Sc., M. Sethobya, N. Nefale, B.Sc.
Primary objective: Generating possible economic targets and groundwater targets to alleviate poverty in the region
Duration: Twelve months



Locality map.

Motivation
An airborne survey over a portion of the 2427AB Rooibosbult sheet revealed a large plug-like magnetic anomaly. This anomaly falls within the general strike direction of known carbonatite intrusions, such as Nooitgedacht and Ramakokskraal to the south of it. This area has geochemical data coverage and as such geochemistry can be incorporated into the project.

Progress
Airborne magnetic data were used in interpreting a dominant plug-like magnetic anomaly. Surrounding this magnetic anomaly are multiple diabase sills and a fault plane cutting through them. Modelling was used to delineate the body type and geophysical interpretation was used to further study the relationship to linear features found in the surrounding area. Modelling results suggest a slightly covered carbonatite complex as a possible source for the anomaly, as it produced the best fit for the anomaly. The radiometric data show an enrichment of the total radio-elements along the alluvium cover and individual channels indicate enrichment due to different remnants of erosion that act as sedimentary cover over the spread of the area. The potassium channel indicates a high percentage concentration over the northwestern part of the survey area, extending

southwesterly over the area covered with sandstones and siltstones of the Aasvoëlkop Formation. Due to the presence of different soils in the area the radioactivity variations seem to be higher.

Conclusions
The result of the magnetic models suggests that it could be a shallow carbonatite complex, which gave the best fit for the modelled profile over the anomaly. A diabase dyke swarm is noted trending east-northeast towards the northerly part of the area with a possible strike-slip fault plane identified cutting through the dykes to the southwestern end of the study area. The radiometric data show an enrichment of the total radio-elements along the alluvium cover and individual channels indicate enrichment due to different remnants of erosion that act as sedimentary cover over the spread of the area. A detailed gravity survey and ground magnetic surveys can be performed around the anomaly to further study the properties of the body.

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

Project leader: L.J. Ledwaba, B.Sc. Hons
Project team: P. Cole, M.Sc. and O.W. Dingoko, B.Sc. Hons
Primary objective: Continued identification of old DOS programs authored using procedural languages such as FORTRAN and development of graphical user interfaces (GUIs) using object-oriented programming (OOP) languages
Duration: Ongoing
Budget: Reporting year: R162 110

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

Progress
Commercial software packages that can perform clustering algorithms are very expensive and can be very restrictive. Similarly, programming languages that allow the writing of these clustering algorithms are extremely expensive and their interfaces are not user-friendly to a person who is not familiar to these languages. To deal with this, a user-friendly, easy to maintain and very cost effective interface to run clustering algorithms was developed using an open source scripting language, namely Python, and some of its libraries. This project was also part of an NRF project with collaboration from Germany.

The interface design is based on a spreadsheet where the columns allow for data set input and rows for the work flow or processing that will be applied to the data. This interface is described and demonstrated by using it to apply cluster algorithms to an example data set from the Limpopo Province, South Africa. The interface that was developed achieved all the goals set for it, including development on a platform that is freely available and that provides all the libraries to perform the mathematical functions required and has powerful GUI capabilities, especially in the plotting of data in different forms for analysis and interpretation.

Conclusions
The project is on track with its effort to identify and reprogram as many DOS programs as possible. The goal of developing easy to maintain user-friendly programs, using free software (Python) was also achieved. More time will be spent trying to learn the new programming language in order to develop useful software.

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

INFORMATION AND COLLECTIONS MANAGEMENT

MUSEUM

Scientist: E. de Kock, M.Sc.
Graphic designers: A. Raath, Nat. Dip., A. Becker, Nat. Higher Dip.
Project team: S. Mahwayi
Duration: Ongoing

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

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

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

A new temporary exhibition series termed 'Out of the Box' was started in the Museum. The idea behind this exhibition is to display ten or more favourite or unique specimens from the collections of individuals on a monthly basis in the Museum. This exhibition series started in December 2010 and ten specimens from the Museum's collection were displayed. During January 2011, specimens from the collection of Horst Windisch followed. In February 2011, ten specimens from Allan Fraser's collections were on display and in March 2011, Daphne Alp displayed 10 of her specimens. This series of temporary exhibitions will continue as long as willing participants can be found.

The Museum received loan requests from Prof. Faan Coetzee (Tshwane University of Technology) and James Tlhabane of SAASTA. 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.

The re-cataloguing of the fossil collections is progressing well and the services of a volunteer was utilised during the year.

Loans from the collections were made to Yale University, Field Museum, Chicago and the Bernard Price Institute at the University of the Witwatersrand.

A total of over 46 803 visitors were recorded at the Museum during the year.

LIBRARY SERVICES

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

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

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

During the year the L&IC received 5 137 visitors and replied to 8 686 queries. There is an ever-growing demand for literature searches on a wide variety of topics using the various databases at the deposal of the Library staff. An ever-increasing demand for maps and copies of maps from African countries in the Map Library collection is evident. During the year, 348 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 421 requests for interlibrary loans.

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

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

BIBLIOGRAPHIC DATABASES

Project team: M.G.J. Janse van Rensburg, B.Inf., E. van Tonder, B.Sc., B.Bibl., S. Tucker, Dip. S.B.M.
Primary objective: To maintain the geological literature database
Duration: Ongoing

SAGEOLIT (South African Geological Literature Database) now contains more than 276 755 records, including published and unpublished material. SAGEOLIT increases the amount of information available to SADC member states by supplying CD-based SADC Bibliographic and Map databases to SADC member countries. SAGEOLIT also includes a registration system for the CGS internal reports, an innovation implemented during the current year. Records in the SACS database are also linked to SAGEOLIT records. Searches by farm name are made possible by links from a table of farm information to SAGEOLIT records. An extract from the SAGEOLIT bibliographic database was made and distributed to the Geological Surveys of the countries in the Southern African Development Community (SADC) on CD. This product is used to great effect by these libraries.

The Map Library database contains references to more than 48 500 maps, including unpublished maps of the Council for Geoscience. These items are spatially referenced to enable access by Geode/GIS.

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

NATIONAL CORE LIBRARY

Core library manager: J. Mathebula, Nat. Dip. (Geol.)
Primary objective: To curate the borehole core collection and make it available to researchers
Duration: Ongoing

The National Core Library (NCL) is a repository of South African borehole core collected from exploration and mining activities of the past few decades. It is a national resource of considerable value to geological research as it preserves material that has been obtained at great expense, sometimes from kilometres beneath the surface of the earth. The Core Library has now 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 22 visitors were received from as far afield as Liverpool in the UK. A delegation from the Turkish General Directorate of Mineral Research and Exploration also visited the Core Library. Towards the end of the year, the interest started to increase, as a result of the rising trend of investment in mining. A number of organisations involved in the search for shale gas in the Karoo also made use of the collection.

Core from a Dwyka Formation sedimentology research project of the University of Liverpool were received at the Core Library. The core was split and semi-polished by the Core Library staff to assist the researchers to better view the fine structures in the core. This core is now stored at the Core Library. On 1 and 2 November 2010 a workshop of this project was held at the Core Library, which was attended by 35 delegates.

PUBLICATIONS

Editors: S.J. van Eck, B.A. (H.E.D.), Z. Nel, M.A., J.A. van Heerden, B.A. (Lib.)
Graphic designer: A. Becker, H. Nat. Dip.

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

Progress
The third edition of the Vredefort Structure popular geoscience publication was prepared by staff of the section. PDF files were submitted for printing in Germany. This popular publication was released by Springer in August 2010.

The first CO2 storage atlas of South Africa and an accompanying Technical Report was prepared and published during the year. This project involved collaboration with the CO2 Stakeholder Committee which consisted of staff from SANERI, PetroSA, Anglo Coal, Eskom, Sasol and the Petroleum Agency SA. The text was compiled, reviewed, edited, proofread and printed and the books were distributed to the various stakeholders and clients. The images were prepared and/or finalised by the SDM Unit staff and the layout of the text was done by the graphic artists of the Council for Geoscience.

Seven publications were prepared for printing in Morocco in collaboration with the Geochemistry Unit of the Council for Geoscience. This included editing and layout and the translation of the english text into french.

Five explanations that are part of the Map Series of the Council for Geoscience were completed during the year. Catalogue 11 of the SACS Series and the annual Catalogue of earthquakes in southern Africa were released in PDF format. All these publications are available at the Publications Bookshop. The Annual Report was printed and tabled in parliament.

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

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

Publications released during the year
- Meteorite Impact! The Danger from Space and South Africa's Mega-Impact, The Vredefort Structure, 3rd Edition by W.U. Reimold and R.L. Gibson
- Atlas on geological storage of carbon dioxide in South Africa by M. Cloete
- Technical report on the geological storage of carbon dioxide in South Africa by J.H.A. Viljoen, F.D.J. Stapelberg and M. Cloete
- Explanation: Sheet 2926AB (1:50 000). The geology of the Maselspoort area by P.J.A. Bosch
- Explanation: Sheet 2527DD (1:50 000). The geology of the Broederstroom area by B.A. Ingram and D.M. van Tonder
- Explanation: Sheet 2926BB (1:50 000). The geology of the Thaba Nchu area by P.J.A. Bosch
- Explanation: Sheet 3018 (1:250 000). The geology of the Loeriesfontein area by P.H. Macey, H.P. Siegfried, H. Minnaar, J. Almond and P.M.W. Botha
- Explanation Engineering Geology: Sheets 3418AB&AD: Soil profiles developed on the rocks of the Cape Peninsula, Western Cape, South Africa by F.D.J. Stapelberg
- Annual Report of the Council for Geoscience 2009/10
- Annual Technical Report of the Council for Geoscience 2008/9
- Seismological Series 42: Catalogue of earthquakes in southern Africa and surrounding oceans for 2006 by I. Saunders

KWAZULU-NATAL

ST-2011-1112 **SMALL-SCALE MINING POTENTIAL OF AU-BEARING QUARTZ VEINS FROM THE DUMISA GOLDFIELD, KZN**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: R.J. Voordouw, Ph.D.
Primary objective: This project reviewed the geological context of past gold mining from the Umzinto area and initiated the project that will assess the small-scale mining potential of the resources
Duration: 2010–2012

Motivation
The Umzinto gold field in the hinterland of the KwaZulu-Natal South Coast includes 20 gold showings, prospects, trenches and mines that were intensively worked until the turn of the 20th Century. The best-known occurrence that was mined until recently is the Dumisa gold mine. The project initiated the process of collating and digitising all available maps and data, reviewing the literature and devising a strategy to derive additional knowledge regarding the geological, structural and mineralogical context of Dumisa-type gold mineralisation.

Progress
Relevant literature was collated, including the STK and GFSA reports, and a list of references was compiled. Digital images of adit plan views, winzes, prospecting trenches, soil and stream sediment sampling points and rock assays from the Umzinto gold field were compiled in a comprehensive database. The maps and plans were scanned and raster and vector files produced in GIS. No funds were available to support data for the verification, field mapping and research aspects of the project.

Conclusions
The project has progressed to the point where detailed field mapping and the analysis of the structural and mineralogical context of mineralisation could lead to the development of an exploration strategy that could lead to new small-scale gold mining ventures.

Future progress
The principal researcher resigned and a new scientist must be appointed before the project can be continued during the 2011/12 programme year.

ST-2011-1113 **GEOLOGY AND STRUCTURE OF THE WHITE UMFOLOZI INLIER, PONGOLA SUPERGROUP**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: N. Hicks, M.Sc.
Primary objective: The aim of this project is to determine the lithostratigraphic, sedimentological and structural characteristics of the White Umfolozi Inlier within rural KwaZulu-Natal, with emphasis on possible Witwatersrand-style placer gold and uranium mineralisation in the Pongola Supergroup. A detailed study of this sequence will provide important constraints on the interplay between Pongola basin evolution and mineralisation and will allow the refinement of exisiting models on Archaean placer deposits. The project will benefit the rural community within the Ulundi/Vryheid District by identifying and delineating possible economic Au and U targets within the district
Duration: 2010–2013

Motivation
The project is part of a long-term commitment to refine and update geological maps in KwaZulu-Natal. The Archaean Pongola Supergroup is a volcano-sedimentary succession (*ca* 2,9 Ga old, 10 km thick) that is exposed in the southeastern part of the Kaapvaal Craton in Swaziland, Mpumalanga and northern KwaZulu-Natal. Although the stratigraphy and structure of the main Pongola Basin are broadly known, a detailed basin analysis has never been attempted. The stratigraphy and structure within the ~250 km^2 White Umfolozi Inlier has never been mapped in detail since the only published map of the inlier was produced in 1967.

Absolute age determinations indicate the broad contemporaneity of the Pongola Supergroup with the auriferous and uraniferous Witwatersrand Supergroup. The majority of the Au and U is associated with conglomerate horizons, interpreted as fluvial channel deposits. Conglomerates within the White Umfolozi Inlier of the Pongola Supergroup have a strong resemblance to the Witwatersrand conglomerates and locally contain placer gold and uranium. However, gold grades in the Pongola Basin are generally much lower and

there is currently no producing gold mine. The economic potential of the Pongola Supergroup has, however, not yet been fully explored.

The study will include sedimentological analysis applying sequence stratigraphic methods; geological-structural mapping defining the lateral extent and variation of key facies; structural analysis to investigate possible structural-hydrothermal control of mineralisation; petrographic-geochemical analysis of mineralised horizons, as well as basin analysis and inter-basin comparison with other areas of the Pongola Supergroup and correlative units within the Witwatersrand Supergroup.

The project will build on the M.Sc. research of Hicks that assessed the Au and U mineralisation and stratigraphy of the lower Mozaan Group within the White Umfolozi Inlier.

Progress
No field work could be conducted due to budgetary constraints and only the initial phases of the project, comprising an extensive literature review, were completed. Despite the geology of the inlier being well researched, no detailed structural analysis has been undertaken. The gold-bearing units of the Sinqeni Formation in the Mozaan Group have been studied by numerous authors, although the first major analysis was completed by Hicks in 2009. This report has lead to new definitions on the origin of the gold and uranium which need to be expanded. A detailed report has been compiled from published literature.

Conclusions
This study focused on the White Umfolozi Inlier and assessed the depositional environment, mode of formation and correlation between other basin remnants in KZN and with the Witwatersrand succession. Detailed structural investigations and petrographic-geochemical work will permit a better determination of the economic potential within the inlier. It is envisaged that this study will better constrain the origin of Witwatersrand-style gold and uranium placer deposits within rural KwaZulu-Natal.

Future activities
Detailed field mapping and additional research will be conducted during 2011/12.

ST-2011-1114 **THE GEOLOGY AND SMALL-SCALE MINING POTENTIAL OF THE PONGOLA SUPERGROUP IN THE NKANDLA REGION**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: N. Hicks, M.Sc.
Primary objective: This research project reviewed the Pongola Supergroup lithologies within the Nkandla area (portions of 1:50 000 sheets 2830BD, 2830DB, 2831CA) with the goal of detailed mapping in areas associated with gold mineralisation and previous mining. Revision mapping and lithostratigraphic description of the poorly defined rock units in the Nkandla area combined with detailed analysis of the gold-bearing conglomerates could facilitate stratigraphic correlation between the Nkandla Basin and the main Pongola Basin. This would assist in the formulation of an orebody model that could assist future small-scale mining development in the region
Duration: 2010–2013

Motivation
The project is part of a long-term commitment to refine and update geological maps in KwaZulu-Natal. The Archaean Pongola Supergroup is a volcano-sedimentary succession (*ca* 2,9 Ga old, 10 km thick) that is exposed in the southeastern part of the Kaapvaal Craton in Swaziland, Mpumalanga and northern KwaZulu-Natal. Although the stratigraphy and the structure of the main Pongola Basin are broadly known, the intensely deformed lithologies within the Nkandla Basin have only been subjected to relatively superficial studies.

Absolute age determinations indicate the broad contemporaneity of the Pongola Supergroup with the auriferous and uraniferous Witwatersrand Supergroup. The Nkandla project includes a detailed study on the geology and mineralisation of the Nkandla area in northern KwaZulu-Natal. Most of the mineral occurrences within the area are hosted in the Pongola Supergroup which crops out as an elongate east–west inlier. SACS (1980) stated that, unlike the northern inliers, only the Nsuze Group is evident in this structurally complex region. However, regional mapping identified a folded unconformity which was regarded as the contact between the Nsuze and Mozaan Groups, although this is not universally accepted. Rocks correlative with the Mozaan Group have also been identified within the Buffalo River gorge area to the west of the main Nkandla Inlier. The identification of Mozaan Group lithologies within the Nkandla Basin would assist in correlation with the auriferous units within both the main Pongola Basin and the Witwatersrand Basin.

No mineral occurrences within the region are being actively mined or prospected. However, with new technologies as well and the high gold commodity price some of these occurrences may become economically

viable on a small scale. The detailed reassessment of the geology within the Nkandla area and the associated local mineral occurrences could lead to the identification of new small-scale deposits which could be operated using new mining technologies.

Progress
The project comprised only an extensive literature review of all know literature published in the region. This detailed review allowed the delineation of possible correlative units throughout the Nkandla Basin. These correlations, if verified during future field mapping, could lead to a reorganisation and restructuring of the complex and confusing stratigraphic nomenclature that exist within the basin. The evidence of Archaean marker horizons could also help to define possible correlatives within the main Pongola Basin to the north and could assist in creating a simplified, better-structured lithostratigraphic subdivision based on the lithostratigraphy of the main basin.

The literature review has suggested that gold was prospected and won from numerous placer-type conglomeratic beds, as well as lode-type deposits in the Nkandla region between the turn of the century and 1936. The conglomeratic occurrences lie along parts of the Nsuze River west of Nkandla where the mineralisation is limited to pockets of payable gold mineralisation.

A number of uneconomic to subeconomic occurrences of copper are exposed in the Nkandla area. The only workings identified within the area are Goodrickes workings in the Buffalo River valley, west of Nkandla, that has been unfavourably reported. Cu-bearing syenite crops out intermittently along the Mhlatuze River northeast of Nkandla although no assay results appear to be available for this unit. Metamorphic kyanite occurrences have been identified to the south of Nkandla in the Nsuze Group lithologies along the contact with intrusive granite. Eleven orebodies were identified by the then Geological Survey of South Africa with an estimated reserve of 12 million tonnes @ 22–57 per cent kyanite, but there appears to be no record of this deposit ever being worked.

Conclusions
The complex structural geology, combined with the piece-meal manner in which the Nkandla area has been previously mapped has created a copious but confusing lithostratigraphic nomenclature for the different lithologies within the separate areas mapped by previous authors. The identification within the Nkandla Basin of marker beds and marker formations unique to the Nsuze and Mozaan Groups in the main Pongola Basin has allowed for possible lithostratigraphic correlation. If correct, this correlation will simplify the complex stratigraphy of the Nkandla Basin and help to identify possible areas for small-scale mining opportunities.

Future progress
The project will continue with field mapping to verify and describe the lithostratigraphic units in the Nkandla Basin and facilitate the correlation with the main Pongola Basin.

ST-2011-1115 **INDUSTRIAL MINERALS MAPPING OF THE KZN SOUTH COAST**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: R.J. Voordouw, Ph.D.
Primary objective: This project aimed to remap the industrial mineral occurrences on the 1:250 000-scale 3030 map sheet which includes the South Coast region of KwaZulu-Natal
Duration: 2010–2011

Motivation
The project reassessed the mining of industrial mineral commodities in the region to provide an updated map of these occurrences.

Progress
A literature study was undertaken to compile available data on industrial mineral resources in the region and examples of similar research and database projects elsewhere in the world were reviewed. The desk-based study identified over 650 industrial mineral quarries, prospects and commodity showings derived from SAMINDABA, the eKZNWildlife environmental database and remote sensing. The Google™earth online digital satellite imagery resource provided a convenient 'vehicle' that permitted a detailed assessment of recent industrial mineral mining of fine construction aggregate, river sand, bulk fill material and clay. The prospecting and mining right database of coordinates associated with applications was compiled for use in the GIS environment. Literature relevant to conducting a market analysis was compiled from online resources.

The project revealed that the vast majority of sites where fine aggregates have been extracted do not correspond with areas regulated by the authorities. The distribution of unconsolidated deposits is not well represented on the published geological map and extensive additional river channel and terrace sand deposits occur in the region. The lithological association of hard-rock quarries in the region and the clustering of the sites relative to developing centres need to be quantified.

Conclusions
The project has established a comprehensive database that could support a detailed review of the geological context and distribution of the most important soft aggregate deposits close to the rapidly developing KZN South Coast.

Future activities
The project achieved its goals for the 2010/11 year and has identified scope for additional detailed research and mapping that could quantify the fine-aggregate resource, market potential and environmental impacts in the region.

ST-2011-1116 **DEVELOP A NATIONAL DATABASE TO SUPPORT A GEOHAZARD DECISION SUPPORT SYSTEM**

Project leader: G.A. Botha, Ph.D., Pr.Sci.Nat.
Project team: R.G. Singh, M.Sc., Pr.Sci.Nat.
Primary objective: Identification and mapping of areas where a broad range of geohazards exist with the aim of planned mitigation of geohazards using a national-scale, internet-based, digital enquiry system in the form of a Decision Support System
Duration: 2010/2011

Motivation
Geohazards are responsible for large socio-economic impacts which can be mitigated or reduced through adequate development planning or disaster response strategies. The Geoscience Amendment Bill mandates the Council for Geoscience to be a national advisory authority in respect of geohazards related to infrastructure development. The worldwide web-based geohazard decisions support system envisaged is a digital enquiry system that provides an alternative method of placing the CGS geological data in public domain. Geohazards often present civil emergencies that require rapid response. An internet-based digital database is the preferred medium for the dissemination of information.

Progress
The KwaZulu-Natal Unit was tasked with the creation of a geohazard decision support system for South Africa that could be access through a commercial data portal. The national-scale geotechnical data layers were based on the 1:250 000 geological data as well as other geohazard proxy data. The national geohazard system was derived from a range of geotechnical layers (e.g. slope instability, inundation, shallow water table, excavatability, etc.) that were amalgamated to create new geohazard layers. The internet application uses map services generated through the ESRI ArcGIS Server software version 9.3.1. It is based on the ArcGIS/Google API which offers fast and up-to-date locational data incorporating recent South African name changes.

Conclusions
The Geohazard Decision Support System is an effective, user-friendly digital enquiry system that will aid decision making during spatial development and promote public awareness.

Future activities
The project goals have been met although the products will be absorbed into the DST-funded Earth Observation and Geohazards project.

LABORATORY

ST-0332 **ONGOING ANALYSES: CHEMISTRY SECTION**

Project leader: L.J. Jordaan, M.Sc.
Project team: H. Maritz, B.Sc. Hons, M.T. Lehaha, B. Tech., L.L. Sathekge, Nat. Dip., R.H. Sello, R.M. Papo, M. Vuma
Primary objective: To provide specialised analytical services
Duration: Ongoing

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

Progress
The Chemistry Section analysed 6 140 samples during the reporting period at a total income of R1 208 256. Seventy-four per cent of this work was performed for commercial clients. Two hundred and nineteen jobs were completed at an average income of R5 517,15 per job. An average of 28 samples was analysed per job. The average income per sample was R196,78.

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

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

The CGS Laboratory, established in 1897, has grown to a modern well-equipped analytical facility, capable of competing at an international level.

ONGOING LABORATORY ANALYSES AND SERVICES: XRF ANALYSES

Project leader: H.C.C. Cloete, B.Sc. Hons, Pr.Sci.Nat
Project team: D. Long, M.Sc., K.I.G. Burger, M.E. Tsaagane, M.J. 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 bombarding with high-energy X-rays. At the Council for Geoscience it is used for the chemical characterisation of rocks, soils, ceramics and building materials and for geological research.

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

(a) PANalytical Axios, a wavelength sequential XRF spectrometer equipped with a 4 kW Rh tube. It is mainly used for the analysis of major elements on fusion disks and trace elements on pressed powder wax pellets. About 6 700 samples were analysed for major and/or trace elements during the period under review.

(b) PANalytical MagiX Fast, a wavelength simultaneous XRF spectrometer equipped with a 4 kW Rh tube. The samples from the Uganda project are analysed by the MagiX on pressed powder wax pellets. Two thousand four hundred samples were analysed during the year.

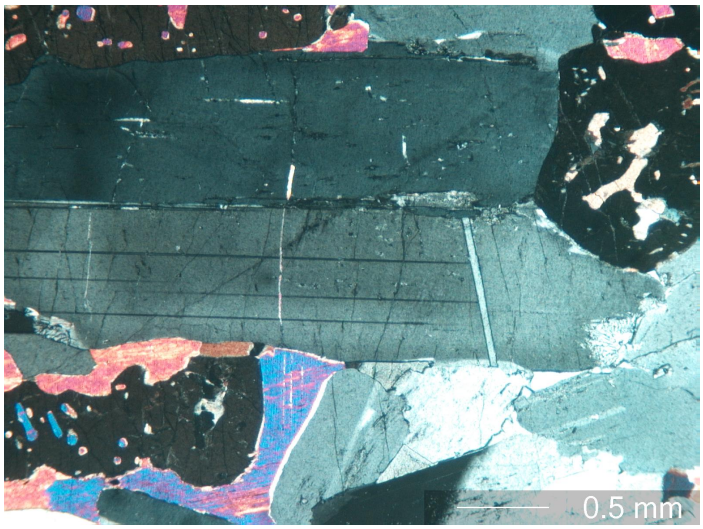
The main clients of the XRF section are in the process/quality control sector, where the chemical composition of raw material is determined before use in manufacturing, and participate in large tenders, such as the Uganda tender, where both rock and soil samples were analysed for major and trace elements. During the 2010/11 financial year, the ratio of work for commercial and statutory clients was about 67:33 due to the downscaling of statutory services in the difficult financial climate. About 9 500 samples were analysed for commercial clients and the value of the services amounted to about R1,4 million, while 195 samples were analysed for internal clients.

Two staff members of the XRF section are also involved with the ISO19725 accreditation process, implementing quality control measures of the Laboratory instrumentation, as well as setting up traceability measures of the results by reorganising and verifying certified materials and their associated information such as suppliers, manufacturers, etc.

Future activities
Finalisation of the ISO19725 for the XRF Section by auditing at least three test methods in preparation for inspection by SANAS.

ONGOING PETROGRAPHIC SERVICES

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



Photomicrograph of a rock containing plagioclase, clinopyroxene and inverted pigeonite with thick exsolution blebs under cross-polarised light.

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, etc.) is considered one of the fundamental components in the value chain of geological research.

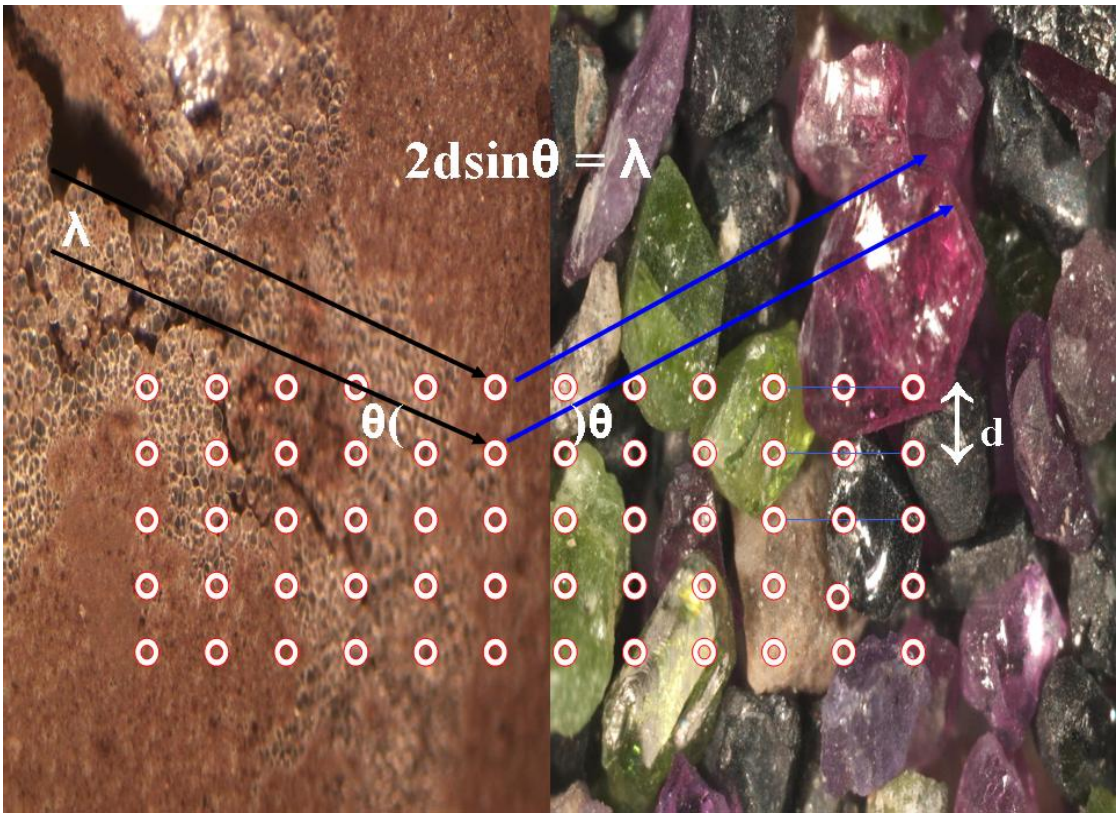
Progress
The section has delivered 183 and 2 075 analytical units for statutory and commercial services respectively, with a total statutory value of R36 619,75 and commercial value of R415 064,15. Mr Nxokwana also contributed to the Shale Gas project with Sasol and Chesapeake Energy during the financial year under review.

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

ST-5036 **ONGOING MINERALOGICAL ANALYSES: X-RAY DIFFRACTION**

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

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



Bragg's Law.

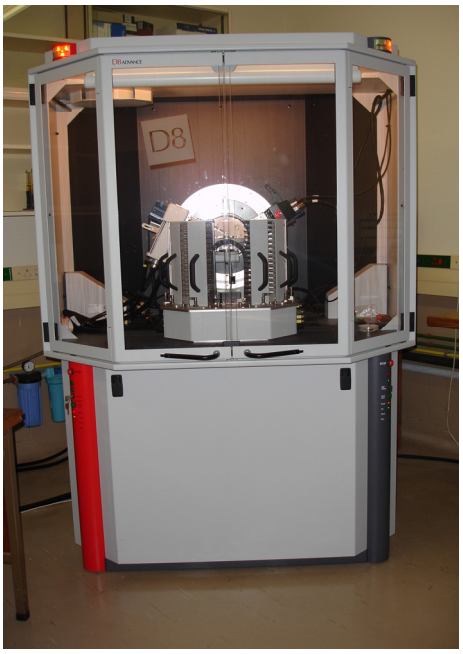
Progress
The X-ray diffraction facility at the Laboratory of the Council for Geoscience offers researchers of the organisation, industry, academics, the geological community and the public quick, accurate analyses at competitive prices. It provides mineralogical evaluation and analytical results on the whole 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 capillary. Typical applications include qualitative phase identification and quantitative evaluation of XRD traces. Geological and geotechnical interpretation of mineralogical data is provided to assist clients in the evaluation of data.

The total value of work is estimated at R795 284 of which R782 666 is commercial income and R123 540 for statutory work. The drastic decline in the statutory income for the section is directly related to the temporary hold of the organisation's statutory programme since 2009. Statutory work was provided for the following projects carried over from previous years: developing of leaching processes of alkaline wastes (PN 1085); Interaction between geological and aquatic environs (PN 0955); Mineral carbonation (PN 0987) and various method development projects of the analytical sections of the Laboratory. Major projects and outside clients include the industrial minerals sector — brick making and ceramics application — Ceramic industries; SAMCA Tiles; Corobrick; Construction and road building — CSIR Transportek, Concor Constructions; Engineering and Geotechnical Consulting; Environmental sector — analyses of dusts, asbestos, water purification systems, etc. — WaleRock; Biograde; Geostrada; Animal nutrition; Minerals development; Mineral carbonation; High temperature engineering; Mineral exploration; Existing small mines.

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

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



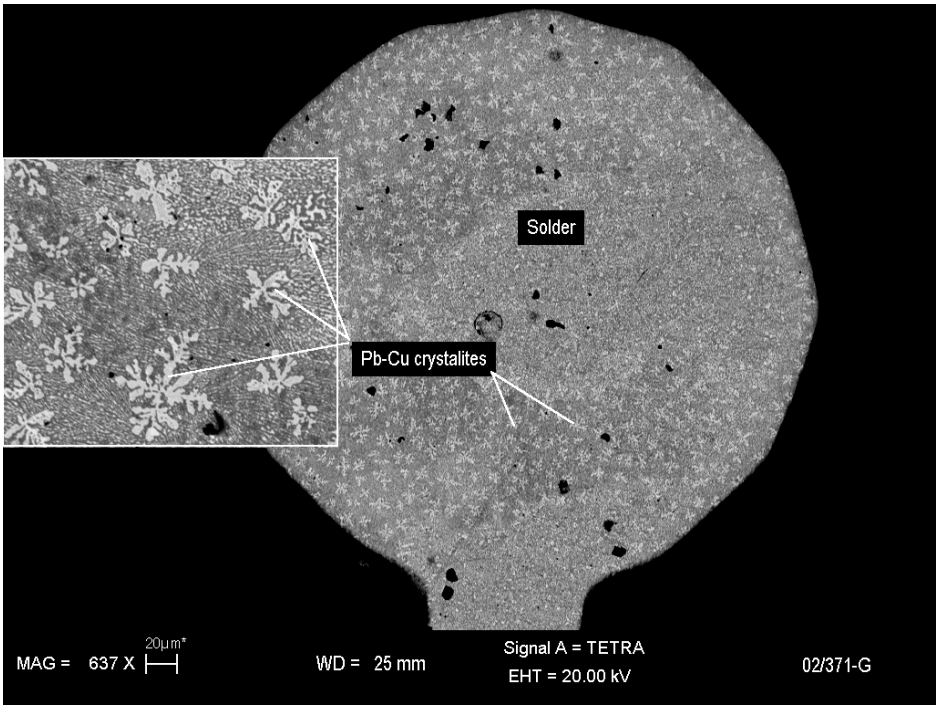
BRUKER D8 Advance.

ST-5032 **ONGOING MINERALOGICAL ANALYSES DURING 2010–2011: SCANNING ELECTRON MICROSCOPY (SEM)**

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

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

Progress
The total value of work for 2010–2011 is estimated to R125 083 of which R85 433 is for commercial income and R39 650 for statutory work provided for the CGS projects, which include mineral identifications and analyses for the secondary minerals of the Bushveld Complex project; investigation of residue samples as part of a mineral carbonation research project and mineralogical investigations for various small statutory projects of the organisation. Amongst the external customers are Rare Earth International; Environmental Science Associates; CSIR; Microsearch; Walerock and Exxaro.



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

SEM — Leica 440 Stereoscan with INCA (OXFORD) EDS.

Instrumentation

The Council for Geoscience Laboratory runs a Leica 440 Stereoscan SEM equipped with an INCA (OXFORD) EDS (energy dispersive system) which controls the analytical capacity of the instrument. In May 2009, a new-generation LN-free SDD detector from Oxford — a X-max SDD detector with 20 mm^2 active area and a resolution of *ca* 128 eV for Mn K-a (5 895 eV) was installed. This setup gives a wide range of analytical capability — secondary, backscattered and cathodoluminescence electron imaging, X-ray EDS microanalysis and X-ray element mapping.

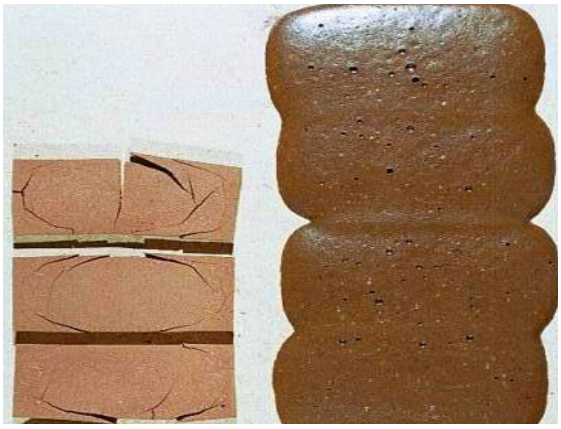
ST-5182 **ONGOING CERAMIC INVESTIGATIONS**

Project leader: M. Atanasova, M.Sc.
Project team: J. Friedland, B.Sc. Hons (Appl. Mineral.), K.S. Khumalo, P.B. Mchunu
Primary objective: Identification of suitable raw materials for use in the heavy-ceramic industry, optimising the use of raw materials by means of mix development, assisting the heavy-ceramic industry in process control or in solving technical, ceramic or production problems and assisting small-scale entrepreneurs in setting up factories for heavy-ceramic products
Duration: Ongoing

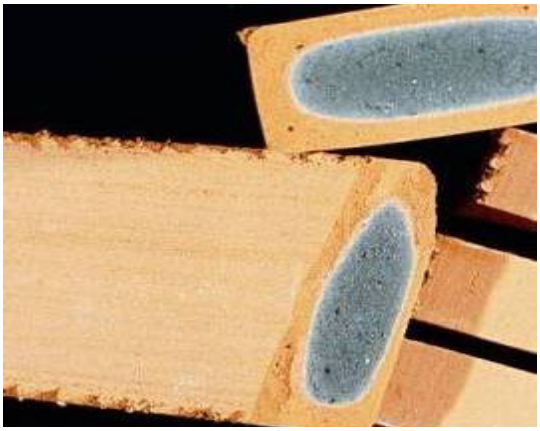
Motivation

The CGS Ceramics Laboratory focuses on investigations involving clay, which, although not a very precious material, occurs abundantly and plays a vital role in the economy. The main activities of the CGS Ceramics Laboratory include the evaluation of clays to determine suitability for possible uses; site investigations of clay deposits and mix development and process control for existing manufacturers (e.g. for tile and brick plants). These activities involve analysis procedures such as full clay evaluations, flexural strength determinations and dilatometry (all performed in the CGS Ceramics Laboratory). Furthermore, the Ceramics Section makes use of analytical services offered by other sections of the organisation; these include mineralogical analyses by X-ray diffraction and analyses of the bulk chemistry. Dilatometry involves the measurement of thermal expansion over a given temperature profile; this is important for the ceramics industry in that it can help to determine efficient firing curves. Furthermore, the compatibility between a glaze and the clay body it is applied to is also largely determined by thermal expansion behaviour of the two materials.

The full clay evaluation mentioned above entails a small-scale laboratory simulation of a manufacturing process to test the suitability of a material or the manufacturing process itself. The steps for the full clay evaluation are the same than those of the envisaged production process, but include measurements such as flexural strength, water absorption, shrinkage (drying and firing) and the identification of problems such as lamination, cracking, black coring or melting. The full clay investigation usually starts off with the shaping units that are laboratory-scale equivalents of a ceramic product (e.g. small tiles by dry pressing, small bricks by extrusion or hand shaping) from fine ground clay combined with water. These are dried (with flexural strength determination of the undried and dried sample) and subsequently fired at various temperatures to determine the optimum firing temperature (the fired samples are also tested for flexural strength).



Cracking and melting.

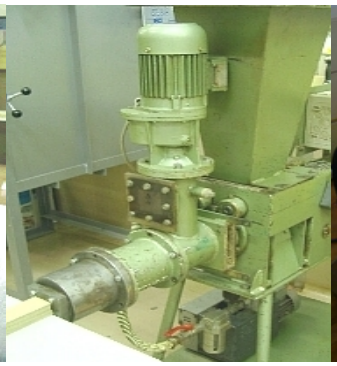


Black coring.

Mix development is frequently requested by a client, as the full clay investigation described above often shows that a given material is not suitable for ceramic production. In many cases, a naturally occurring clay is unsuitable for manufacturing, and mixing of different materials, such as the addition of sand or feldspars or other clay materials, is required. Mix development strives to find the proportions in which the available materials can be combined to yield a clay mix with optimum properties.

Usually the available raw materials are first investigated individually; this investigation also includes mineralogical and chemical analyses as well as full clay investigations. Subsequently recipes are developed for mixtures with optimised properties, which can be used for manufacturing ceramic products such as sanitary ware, bricks, tiles and many other products.

For a manufacturing plant it is vital that the compositions of the raw materials as well as the process materials are consistent over time. The CGS Ceramics Laboratory offers process control to a variety of production plants; this involves sampling, mineralogical/chemical analysis and plotting of the analysis results to show trends.


Hydraulic laboratory press. ***Germatec extruder.*** ***LINSEIS L75 Platinum Series dilatometer.***

Progress

Turnover for ceramic services during 2010/11 amounted to R198 140; from this R191 390 was generated by commercial activities and R6 750 by statutory work. As statutory projects were generally placed on hold during the past financial year, no statutory projects were received from other sections of the organisation. Therefore, compared to previous financial years, the amount of statutory work performed in the Ceramics section decreased drastically. Statutory work was limited to occasional promotional work performed for potential clients (e.g. Bravo Projects) and minor internal studies. Approximately 530 samples were submitted for XRD analysis contributing about R212 000 to the turnover of the XRD section. Approximately 370 samples were submitted for XRF analysis contributing about R74 000 to the turnover of the XRF section.

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

A statutory investigation on kaolinite samples taken from Vereeniging Refractories is in progress.

Future activities

Requests for dilatometry are still exceeding capacity, therefore motivating to purchase a second dilatometer is strongly considered. Further, the motivation for obtaining an autoclave designed specifically for the ceramics industry is considered due to numerous requests for this service by various commercial clients.

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

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

Motivation

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

Progress

Two draft reports have been submitted:

Jordaan, L.J., Rademeyer, M.C., De Wet, L.P.D., Booyse, D., Venter, B. and Wepener, V., 2011. The strontium isotope distribution in water and fish within major South African catchments.

Jordaan, L.J., 2011. The carbon, sulfur and anion distribution in water and sediments within major South African drainage basins.

Future activities

Production of reports will continue, starting with the following:

Jordaan, L.J. and Wepener, V., 2011. The mercury distribution in fish and sediments within major South African catchments.

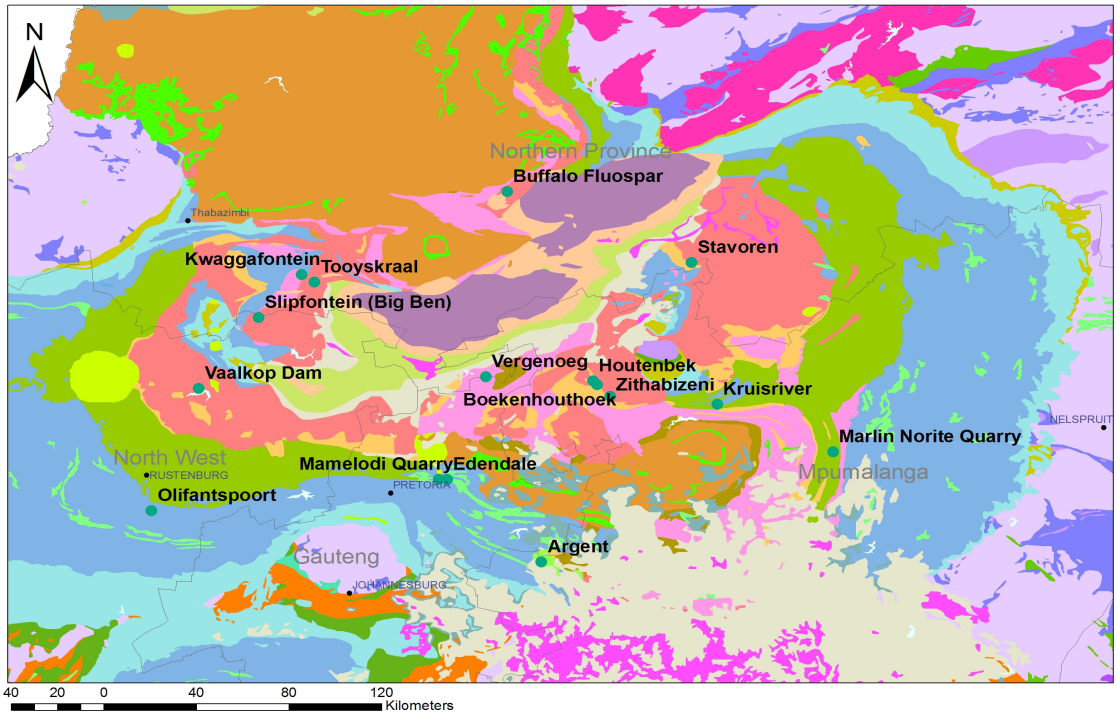
Forensic capabilities are regularly used to validate winning entries at major South African fishing tournaments.

ST-2009-1038 **SECONDARY MINERALS OF THE BUSHVELD COMPLEX, SOUTH AFRICA — 2010–2011**

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

Motivation

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



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

Progress and comments

The work continued with the identification of mineral specimens and species, site visits, specimen collection and literature studies. In spite of the cancellation of the CGS statutory programme, the project has progressed as anticipated with some excellent findings. Field work proceeded as initially planned and is now funded by the University of Johannesburg. The final report includes an introduction to the project, geological overview of the Bushveld Complex and brief notes on secondary mineralisation, microminerals, micromounting and mineral collecting. The localities are introduced with notes on the location, history of discovery and exploration and basic overview of the geology of the area, followed by chapters on the site mineralogy with mineral descriptions illustrated by color and SEM photographs. All information and analytical mineralogical data for the total of seventeen site localities with secondary mineralisation are compiled in a concise document in preparation for publication. The book will be in full colour, illustrating the magnificence of the microscopic world of minerals that the Bushveld Complex has to offer. Other important aspects of the work are that the documentation and publishing of these minerals give an insight into the diversified mineralogy of the complex other than the well-known platinum and chrome deposits.

Future activities

Final editing and compilation of data. The Council for Geoscience has committed itself to prepare the layout and design of the publication. However, additional outside sponsorship is required for the printing of the book. It is envisaged to run approximately 250 pages with full colour throughout. A flyer has been prepared and distributed to industries through the GSSA.

Gypsum from Vergenoeg, Bushveld Complex, South Africa. Sample WOF 3,1 mm.

ST-2011-1136	**IMPROVING GEOLOGICAL SALINE RESERVOIR INTEGRITY THROUGH APPLIED MINERAL CARBONATION ENGINEERING**
Project leader:	F.J. Doucet, Ph.D. (Chem. Eng.), Pr.Sci.Nat., IUPAC Fellow
Project team:	E.M. van der Merwe, Ph.D., W. Altermann, Ph.D., T.K. Mlambo, B.Sc. Hons (Geol.)
Primary objective:	The overall objective of this project is to test the hypothesis whereby accelerated mineral carbonation can be induced in South African geological sandstone cores sampled from saline reservoirs by co-injection of CO_2 with coal-combustion fly ash
Duration:	January 2010–December 2011
Budget:	R200 000 (R100 000 per year) – externally funded by the South African Centre for Carbon Capture and Storage

Motivation

The most widely advocated method of carbon capture and storage (CCS) technology in South Africa involves the injection of CO_2 into underground geological formations. High-integrity geological sites are key to the development of this technology for the long-term storage of CO_2. It was found that 98 per cent of the geological storage opportunities in South Africa are in the form of saline reservoirs located offshore. However, unlike depleted oil and gas reservoirs which are historically proven to be well confined, saline reservoirs may not have a similar proven sealing capacity, and increases in porosity and permeability due to aggressive supercritical CO_2/brine mixtures have been reported, which could cause increased risk of leakage beyond the confining layers. The co-injection of coal-combustion fly ash (to be used as a reactive matrix for accelerated carbonation) along with CO_2 in deep saline formations may help improve the integrity of saline formations for the safe, long-term sequestration of CO_2.

Progress

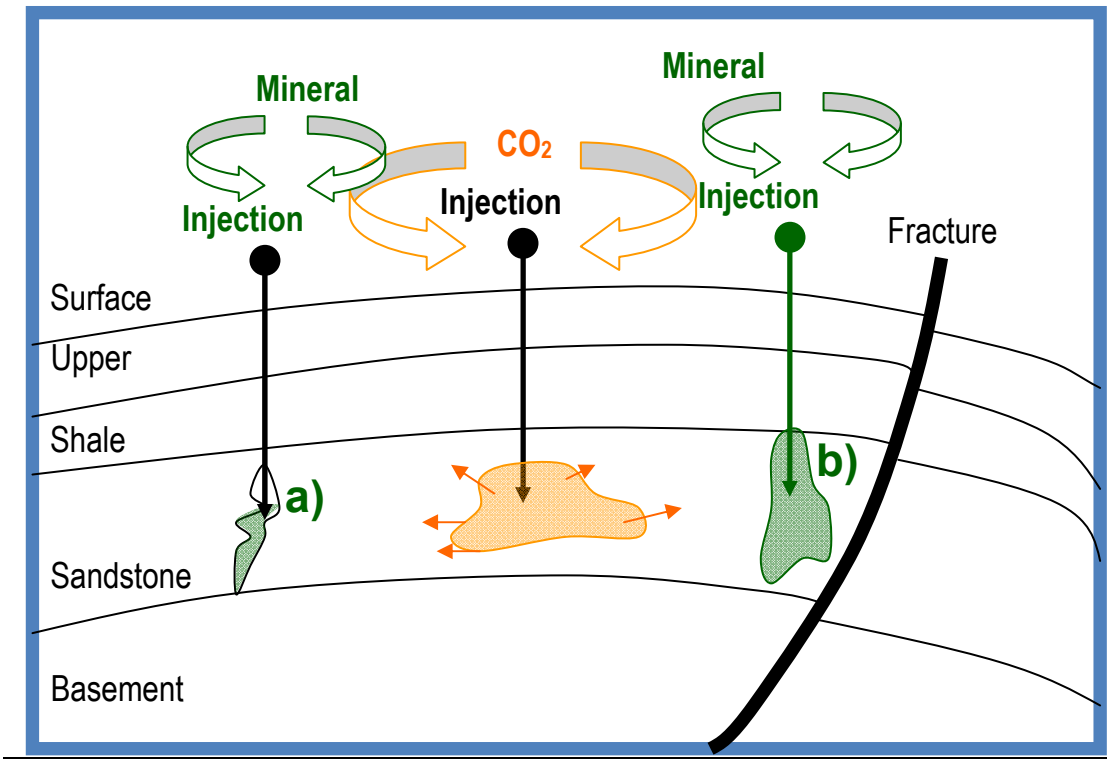
1. A theoretical concept for various co-injection strategies of fly ash and CO_2 for the improvement of geological saline reservoir integrity was developed.
2. Eight fly ash samples with varying particle sizes from three South African power stations were collected and thoroughly characterised.
3. The reaction of fly ash with CO_2 under supercritical conditions was demonstrated for the first time. Both aragonite and calcite formed as sheets at the bottom of the reactor and on the walls.

Future activities

Further leaching and carbonation experiments are planned to better understand the formation of carbonates in brines under conditions relevant to deep saline formations.

The two most conceivable scenarios involve

a) Fracture filling to inhibit excessive porosity/permeability
b) Emplacement of a slurry wall or grout curtain between the CO_2 flood and known faulty zones or facies changes.



Hypothetical geological cross-section.

ST-2012-1152 **PHYSICOCHEMICAL PROPERTIES OF SOUTH AFRICAN SHALES IN THE CONTEXT OF GEOLOGICAL CO_2 STORAGE**

Project leader: F.J. Doucet, Ph.D. (Chem. Eng.), Pr.Sci.Nat., IUPAC Fellow
Project team: M. Cloete, Ph.D., Pr.Sci.Nat., D. Cloete, M.Sc., Pr.Sci.Nat., E.M. van der Merwe, Ph.D., W. Altermann, Ph.D., N.S Nxokwana, B.Sc. Hons (Geol.), Cand.Sci.Nat.
Primary objective: To identify, classify and characterise South African shales in the context of carbon capture and geological storage (CCS). To determine diffusion rates and sorption behaviour of CO_2 in South African shales
Duration: January 2011–December 2012
Budget: R200 000 (R100 000 per year) – externally funded by the South African Centre for Carbon Capture and Storage

Motivation

Shale is generally known as an impermeable rock with low porosity and for this reason it was not examined by the project on geological storage of CO_2 in South Africa as a potential storage reservoir. However, the latest developments in the exploration for shale gas in this country and the recent findings on the successful trapping of significant amounts of CO_2 in adsorbed state within its organic matter forces the South African community to reconsider its position on the storage potential of shale. Indeed, bulk volumes of CO_2 concentrations can be greater for shale (222–389 mol/m^3) than for coal (3–4 mol/m^3) and cemented sandstone (8–10 mol/m^3). This can be explained in terms of the structure of kerogen, which is a nanoporous material with micropores (<2 nm) and mesopores (20–50 nm) with molecular sieving properties allowing CO_2, a molecule with linear molecular geometry, to reside in small pores which cannot be accessed by other naturally occurring gases. This has brought about a need to develop a database on shales in South Africa to inform scientists and decision makers about the potential role these shales can play in CCS in South Africa.

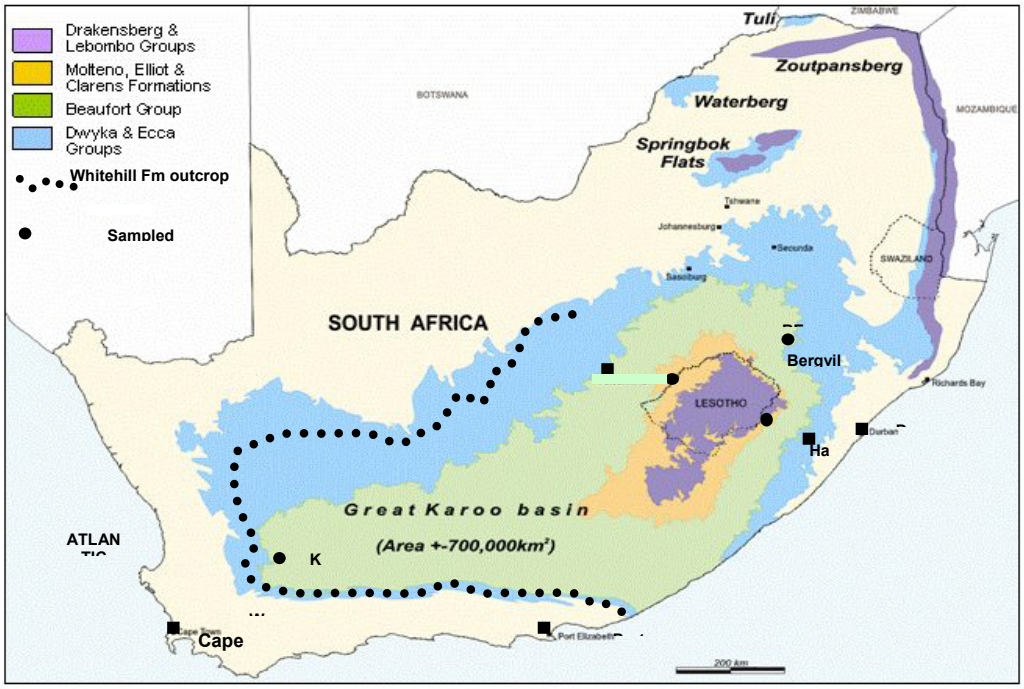
Progress

Four boreholes from the Karoo, namely KL 1/65, BE 1/67, SW 1/67 and La 1/68 were identified and sampled. A total of 64 samples were obtained. The boreholes are part of the Soekor deep boreholes archived at the National Core Library at Donkerhoek. More sampling is still to be done targeting dark carbonaceous shales of the Whitehill Formation in the southwestern Cape from borehole KL 1/65 and a few dolerite samples from a borehole also from the southwestern Cape, SW 1/67.

A map showing the distribution of shales and mudstone in South Africa was produced for the study. GPS locations of the sampled boreholes will also be shown on the map.

Future activities

Diffusion and sorption experiments on collected shale samples will begin shortly.



Map showing the location of the sampled boreholes and the outcrop area of the Whitehill Formation.

LIMPOPO UNIT

The Limpopo Unit, centrally based in Polokwane, is responsible for the geological mapping of the Limpopo Province. Details of the current projects 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, though there was a reduction in activity due to a 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 this year has focussed on requirements for compiling maps and geological reports.

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

Project leader: N. Baglow, B.Sc. Hons
Project team: T. Dhansay, B.Sc. Hons
Primary objective: Skills development trough the training of junior geologists in practical field mapping
Duration: Annually from 2005

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

Progress
The project for this year was completed. In addition, 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 graduate geologists this year, and thus this group was not available for participation. However, a curtailed field mapping school (Introductory Module) was held for a total of six trainees, comprising MQA interns with the organisation and a couple of young geologists from the Mineral Resources Development and Geophysics Units.

Subject matter covered included the location of the geologist in the field, collecting appropriate geological data and plotting these data. Individual reports with maps were produced and evaluated.

Future activities
The school will be repeated on an annual basis to integrate new geologists into the overall CGS mapping programme. Though activities were restricted in the past year, it is intended to resume a full programme as normality returns to the general economic situation and the organisation's activities.

During the Field School held at Legalameetse (Limpopo Province), trainees learn what features can be expected in a geological environment and are shown what to look for. They are then encouraged to make their own independent observations and interpretations.

ST-2008-0975 **2430BB MICA 1:50 000 GEOLOGICAL MAP**

Project leader: N. Baglow, B.Sc. Hons
Project team: T. Dhansay, B.Sc. Hons, N.C. Mukhosi, B.Sc. Hons, L.P. Munyangane, B.Sc. Hons
Primary objective: To understand the geology of the area with particular emphasis on the emplacement history and mineral potential where applicable, understanding the groundwater characteristics of the areas and maintaining organisational capacity in terms of understanding a variety of geological environments. Production of a 1:50 000-scale geological map and an accompanying explanation
Duration: From 2009

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

Progress
The revised project for this year was completed with a preliminary map (and report) being compiled and captured digitally; existing data with interpretation were utilised. Budget constraints precluded additional field work.

Conclusions
The area is notable for the variety (both in type and age) of granitoid intrusions in relatively close proximity to one another; these are the Mashishimale, Lekkersmaak and Harmony Granites intruding the deformed Makhutswi Gneiss basement. The pegmatite field that extends through the small centre of Mica has been designated the Mica Pegmatite and is of economic interest, already being exploited for mica and feldspar industrial minerals.

Future activities
It is anticipated that the outstanding portions of the Mica map sheet will be covered within the next programme year with field training incorporated into the project mapping.

Good exposure of the Mica pegmatite with well-developed books of mica, a high proportion of feldspar (which can also be recovered in mining operations) and lesser quartz. Scale of photo: 1,8 m across.

MARINE GEOSCIENCE

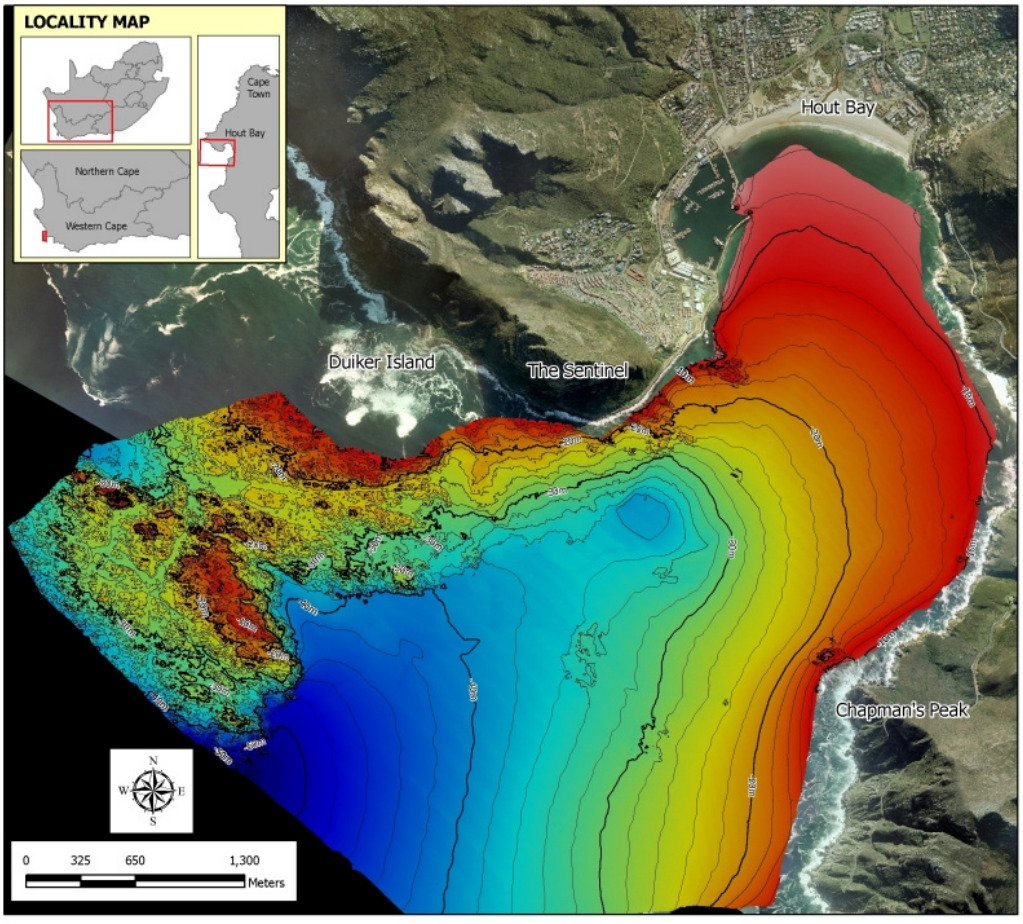
ST-2010-1095 **HOUT BAY GEOPHYSICS**

Project leader: M. MacHutchon, B.Sc. Hons, Pr.Sci.Nat.
Project team: Prof. J. Compton, UCT, Dr J. Rogers, retired UCT
Duration: 2009–2012
Primary objective: This project will comprise a detailed, multidisciplinary study of an area included within the Offshore Seabed Mapping Programme project, that of Hout Bay and its environs. It will also act as a project for the completion of a Masters degree for the project leader. The area is one of significant geological interest
The first phase of the project in the 2009/10 and 2010/11 financial years would involve geophysical and bathymetric mapping
Budget: R55 000 (from R500 000 of DST systematic offshore mapping feasibility study)

Motivation
The area is one of significant geological interest;

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

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



Multibeam image of Hout Bay.

Such a mapping project has potential commercial interest;

- I&J fisheries operate out of Hout Bay and this is a large employer of previously disadvantaged communities.
- The surfing event "Red Bull Big Wave Africa" takes place just offshore of Hout Bay where waves are formed from the offshore reefs and provision of detailed offshore maps may assist in event planning.
- Stakeholders that would also stand to benefit from such a programme include those for the Systematic Offshore Mapping Programme, principally SAEON/SANBI – identification of marine habitats and SAHRA – identification and delimitation of shipwrecks within the study area.

Progress

- Collected multibeam bathymetric data
- Collected magnetic data
- Collected medium- and shallow-penetration seismic data
- Collected beach profiling data
- Ground truthed geophysical data using SCUBA
- Collected 57 sediment samples for sedimentological analysis.

Processed, interpreted and synthesised all of the above data sets into a technical report.

Conclusions

All data acquisition completed.

Future activities

Compile technical bulletin.

MINERAL RESOURCES DEVELOPMENT

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

Project leader: C.J. Vorster , M.Sc.
Project team: Data capturer (vacant), in collaboration with Metallogenic Mapping and the Spatial Data Management Unit
Primary objective: The capturing, storage and updating of mineral data on mines, mineral deposits and occurrences within the borders of South Africa. The fast and efficient provision of accurate mineral data and maps to users all over South Africa and abroad
Duration: Ongoing
Budget: R150 000

Motivation
Building the economy requires access to information to identify opportunities. This database already provided information for numerous mineral resource appraisals, reports, maps and mineral data. These activities furnish the government and the mining industry – small, medium and large – with mineral resources information and advice for informed decision-making, relating to mineral policy and development issues, and to promote economic-geological activity. The sterilisation of mineral deposits has also been prevented during the planning of permanent surface structures such as townships, dams, roads, pipelines, railwaylines, etc. SAMINDABA plays a positive role in rural development and poverty eradication and is also instrumental in the compilation of metallogenic maps and explanations, which are designed to facilitate mineral reconnaissance exploration by way of ore deposit modelling and target identification, and to stimulate the mining industry in general.

Progress
During the 2010/2011 programme year, SAMINDABA was enlarged to 19 260 mineral records in total, providing information for both internal and external enquiries on South Africa's mineralisation, as well as for maps and other products. The Derelict and Ownerless Mines Database now contains 6 383 mineral records.

Also published is a DVD entitled 'Digital Metallogenic Map of Base Metallic Minerals in the Republic of South Africa and the Kingdoms of Lesotho and Swaziland'.

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

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

Field work (currently suspended) and research will be carried out to further enhance and update SAMINDABA as well as the Derelict and Ownerless Mines Database.

ST-2008-1000 **CRITICAL METALS RESEARCH AND EXPLORATION**

Project leader: E. Long'a Tongu, Ph.D.
Project team: D.N. Mayekiso, B.Sc. Hons (Geol.)
Primary objectives: This research topic is proposed with the following main objectives: (1) Discovery of rare-earth resources in South Africa; (2) Understanding discovered resources to aid future discovery
Duration: 2010–2013
Budget: 2010/13: R1 798 370

Motivation
Rare-earth oxides constitute an important group of natural resources with a wide range of applications in modern high technology, such as permanent magnets, magnetic disks, batteries, lasers, etc.

The current leading producer of rare-earth metals is China, which accounts for >95 per cent of world production. Recognising this, the Council for Geoscience has partnered with the Geological Survey of Japan to research for rare-earth mineral resources in South Africa. The discovery of minable resources will be beneficial to the sustainable development of the country.

Progress
Significant progress has been made by the team, having identified several potential key deposits for in-depth research. Metallurgical tests on a few identified sites are currently in progress.

Conclusions
Continued participation in researching rare-earth metals in South Africa is essential as discovery will contribute to production, thereby leading to job creation and socio-economic development.

Future activities
Key activities include desktop studies and reconnaissance sampling, followed by sample analysis and report writing.

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

Project leader: M.M. 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 organisation's corporate database GEODE and interfaces with other systems, allowing easy access to users.

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

Progress
During the year 266 logs were prepared, 569 header details were coded and captured, 3 686 lithologies for 95 boreholes were captured and 287 logs are in the electronic conversion process and will be loaded onto the database during the year. The coal database now contains 112 265 boreholes with 2 826 784 lithologies and 1 590 637 analyses. Three hundred and forty-six queries for outside clients were done with an income of more than R215 000.

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

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

ST-2002-0168 **COREDATA DATABASE**

Project leader: M.M. 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 to users. COREDATA provides easy access to this collection.

Progress
During the year 319 logs were prepared for capturing into the database, while 400 headers were coded and captured. The borehole core log database now contains a total of some 86 000 entries.

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

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

ST-2011–1118 **NATIONAL MINERAL RESOURCES ASSESSMENT**

Project leaders: A.O. Kenan, M.Sc., A.Y. Billay, Ph.D.
Project team: S. Frost-Killian, D. Katemaunzanga, S. Naicker, G.F.J. Horn
Duration: 2010–2011
Primary objective: Outline existing problems and suggest recommendations for future studies in mineral resources assessment

Introduction
The scoping study for a National Minerals Assessment was conducted during the 2010/11 financial year. The project included studies of mineral energy complexes and material flow analysis. The mineral energy complex encompasses the linkages of mining industries with manufacturing industries and their contributions to the economy. Material flow analysis is defined as systematic accounting of the flows and stocks of materials within a system which connects the sources, the pathways and the final sinks of a material. A case study of manganese was studied as part of the material flow analysis.

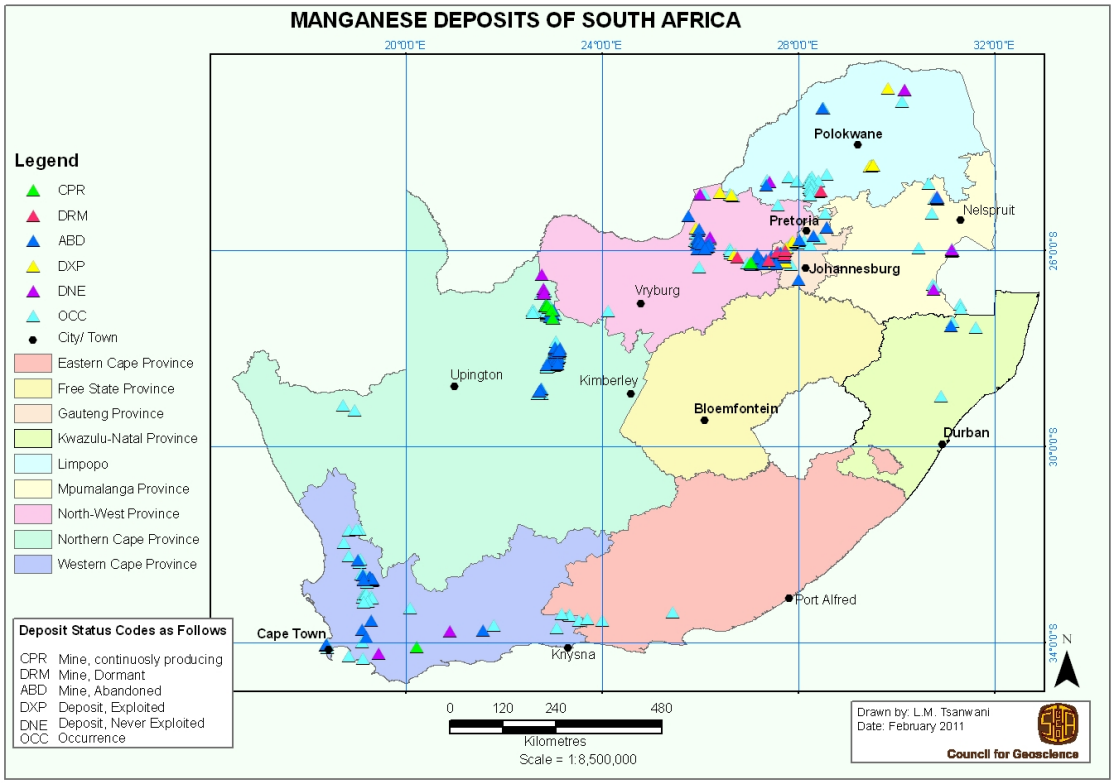
Findings
The mining sector's contribution to gross value added is more significant through its linkages with the rest of the economy. The mining industries have important linkages with manufacturing industries such as basic iron and steel, electricity, motor vehicles and parts, petroleum products, non-ferrous metals, basic chemicals, construction and other industries. These industries, combined with mining, make up the so-called minerals and energy complex (MEC). The contribution of the mining sector, when considering the broader mineral and energy complex, is much larger. The MEC contributes 21,1 per cent to gross value added (at constant prices), 66,56 per cent to exports (at current prices) and 13,1 per cent to formal employment. Growth in value added of the MEC was also significantly larger compared with growth in mining and non-MEC manufacturing goods. The MEC manufacturing industries such as motor vehicles and parts, metal products and machinery have large backward linkages in the economy (when weighted by exports). Iron and steel, basic chemicals, motor vehicles and parts and petroleum products and coal, in turn, have relative large forward linkages in the economy (when weighted by exports). Most of these industries also transact with a large number of industries across the economy. The importance of the mining sector should not be measured in isolation without the so-called MEC industries. The mining sector plays an important role in facilitating growth in these industries. These industries, in turn, have significant forward and backward linkages with the rest of the economy. Further linkages between the mining sector and the rest of the economy should be developed, but the most benefit for the economy would be through linkages with those industries, which in turn, have significant linkages throughout the economy. The MEC clearly indicates the value and importance of the mining sector and therefore a thorough understanding of the mineral resources must become a state imperative to continue to leverage the mineral wealth.

Manganese flow analysis indicated that the overwhelming majority of manganese ore from South Arica is currently exported to China, and hence depends on the performance and demands of China's steel industries. This contributes to the high volatility of manganese markets. It should be noted that about 94 per cent of all manganese produced is used in the steel industries. South Africa hosts about 75 per cent of the world's manganese resources but the country's production in 2008 represented only about 15 per cent of the total world production. On the other hand, China's manganese production amounted to about 42 per cent of the world's manganese production, having a mere 2 per cent of the world's manganese resources. It is critical that local beneficiation is encouraged, with more incentives, which will help to increase the demand for manganese within the country and hence encourages more production of manganese ore. Manganese ore exported in

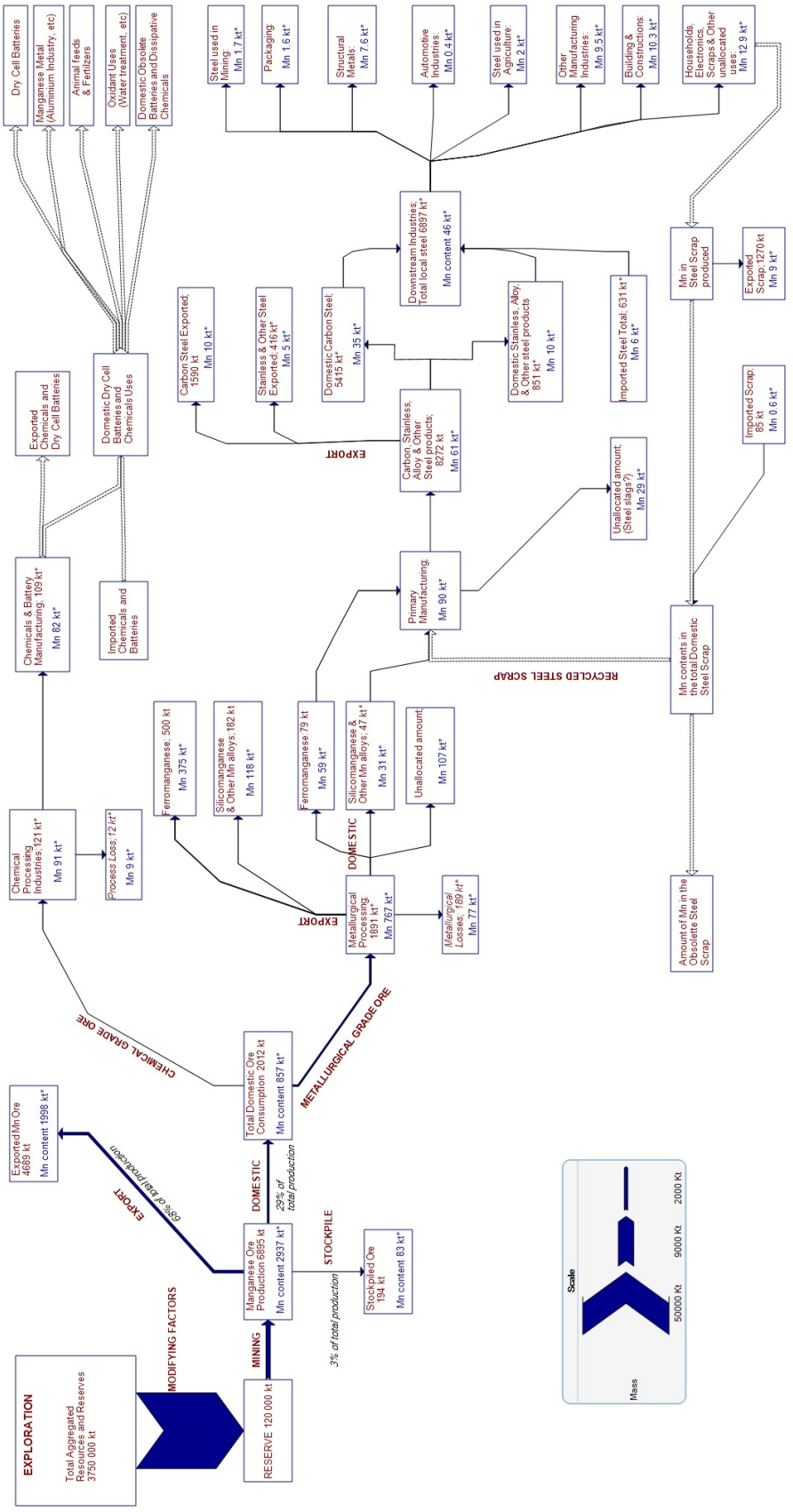
2008 was about 68 per cent, compared with 32 per cent of the manganese ore used in the domestic industries and stockpiles. This indicates that there are insufficient beneficiation industries in South Africa. The need for an increase of beneficiation in order to leverage the inherent competitive advantage cannot be over-emphasised. Beneficiation will enhance the diversification of the economy from a resource-based economy to a sustainable knowledge-based economy, hence reducing the dependency on mineral resources and its associated price volatility. About 5 per cent of all manganese available for domestic industry use in the country ends up in the steel used in the downstream industries for mining, automobiles, building and construction, and other end-use applications. Approximately about 25 per cent of all manganese, available for domestic industry use in the country is lost through processing and other losses. Research may be required for new technological innovations to reduce the loss of manganese during processing, primary steel manufacturing and downstream industries. The majority of manganese in the domestic downstream industries is consumed in the building and construction industries. Currently, there is no substitute for manganese in the steel industry. This, coupled with the fact that China's steel industry is still growing, means that the manganese future is still bright. The manganese flow analysis study was not thoroughly carried out because of the lack of sufficient information, especially the chemical, dry cell batteries and steel scrap industries. It is important that this information be made available, either from the individual companies or from government, to ensure that future studies of material flow analyses are based on a complete set of data. There were discrepancies and inconsistencies in the manganese information collated from different governmental departments. It is important for reconciliation to be done across departments before the publication and dissemination of information. The government's reporting on minerals resources and reserves do not conform to the SAMREC requirements, compared with the original reports from the exploration and mining companies. It is important to align governmental reporting to companies' reports in order to avoid distortion of information. The manganese market is almost entirely hinged on steel demands. There is little use of manganese outside the steel industry.

Future activities

Future work will be based on material flow analysis of commodities to establish the mineral resource assessment of South Africa. However, the stumbling block will be the accessibility of data to conduct such studies. It is recommended that data should be readily accessible for successful studies of the mineral industries within the country as stipulated by the Promotion of Access to Information Act No. 2 of 2000. The main data sources are the Department of Mineral Resources, South African Revenue Authority, mining and exploration companies and the Johannesburg Stock Exchange, among others.



The manganese deposits of South Africa.



The manganese process flow for the year 2008. The values shown in blue are manganese values. All the values are in kilotonnes (kt). The dotted lines indicate that data could not be found or estimated.
**** = estimated values.***

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

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

Motivation
There is a strong perception that South Africa is over-explored with regard to metalliferous ores and under-explored with regard to industrial minerals. It is therefore not surprising that exploration for new base-metal deposits in South Africa by large corporations has declined over the past 10 years. On the other hand, most industrial-minerals mining companies are small- to medium-size enterprises with limited venture capital available. If the large value-added potential of industrial minerals, from crude-mined products through to beneficiated mineral products and finished industrial products is considered, it is evident that beneficiation will be directly transferred to the industrial sector of the South African economy where most of the products find their markets. It is in the industrial sector of the economy that industrial minerals contribute most to job creation and poverty alleviation through their large value-addition potential.

It is the objective of this project that the entrance risk for existing and new small- and medium-sized companies will be lowered by identifying and, within limits, characterising existing and new industrial-minerals mining opportunities. It is believed that the project will:
(i) contribute to the understanding of the geology of industrial-mineral deposits and occurrences,
(ii) pro-actively provide information to avoid sterilisation of mineral resources, in that information can be accessed by, or compiled for, local and national development agencies,
(iii) assist in mineral-resource and ore characterisation and thus contribute to more optimised mineral-resource utilisation in deposits,
(iv) train geoscientists in mineral-resource assessment and use the acquired technical and scientific knowledge in projects where knowledge transfer can assist in the establishment of a sound and viable small-scale mining sector,
(v) participate in research programmes in NEPAD/SADC-related projects and participate in knowledge transfer with SADC countries, and
(vi) create geological products that will lower the risk of prospective local or international investors in South Africa's minerals industry.

Progress
The research and inventory of industrial minerals were undertaken in the Eastern Cape Province, which consists of the following 1:250 000-scale geological maps:
3024 Colesberg, 3026 Aliwal North, 3028 Kokstad, 3030 Port Shepstone, 3124 Middelburg, 3126 Queenstown, 3128 Umtata, 3222 Beaufort West, 3224 Graaff-Reinet, 3226 King William's Town, 3228 Kei Mouth, 3322 Oudtshoorn, 3324 Port Elizabeth and 3326 Grahamstown.

The minerals covered are:
Salt, gypsum, phosphate, coal, clay (brick clay, interstratified illite-montmorillonite clay, bentonite, hormites: palygorskite and sepiolite), rutile, aggregate, gravel and sand, silica, agrominerals, dimension stone, dolerite, sandstone, travertine, quartzite, pigments, lithium, shale gas and kieselguhr.

Conclusion
In addition to the symbolised locality indication of mineral occurrences and deposits, information on infrastructure and simplified regional geology will be indicated on the map, as industrial minerals are dependent on these parameters.

The SAMINDABA module of the GEODE corporate database will provide 1:250 000-scale maps of the provinces, on which all known industrial-mineral occurrences and deposits will be indicated. Client-specific maps and products, however, can be generated at any scale.

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

Small clay workings east of Indwe.

NORTHERN CAPE

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

Project leader: H. Minnaar, M.Sc.
Project team: P.M. Macey, Ph.D., C.H. de Beer, M.Sc.
Primary objective: To promote and assist in research on the Namaqualand Metamorphic Province (NMP)
Duration: April 2008–March 2019
Budget: Total: R5 000 000; 2010–2011: R15 000

Motivation
The NMP represents the equivalent of Kibaran and Grenville mobile belts in Africa and North America. It therefore provides an opportunity for studying crust formation and deformation processes during the Proterozoic. This includes the formation of many of the earth's mineral deposits and energy sources. A large volume of information and data is currently available from previous studies and allows for the compilation of maps and explanations reflecting the current knowledge. It also provides a basis for future studies. The Council for Geoscience, through the nature of its statutory mapping programmes, may be regarded as the cunstodian of this information. This project is designed to promote and advance research on the NMP.

Progress
A digital seamless map and explanation summarising the current status of research on the NMP has been compiled (2008–2009). A digital database has been constructed (2009–2010) and contains some initial data. The database is yet to be fully populated. Two studies are currently being executed on the NMP and have produced some initial results, including new isotope data.

Conclusions
Studies on the NMP are continuing and data are becoming available on a continuous basis, including stratigraphic, structural and geochronological data. Knowledge on the evolutionary history of th NMP is advancing. Studies on the NMP in the southern part of Namibia are progressing slowly and include mostly isotope studies. Mapping projects in Namibia aiming at integrating South African and Namibian data on the NMP should be promoted.

Future activities
Publications from existing data, advancement of knowledge, the accumulation of data and the development of the mineral potential of the NMP are suspected among the results eminating from the project.

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

Project leader: H. Minnaar, M.Sc.
Primary objective: To investigate igneous and tectonic processes active during the evolution of the Vioolsdrif Batholith (2 000–1 700 Ma)
Duration: April 2009–March 2012
Budget: Total: R1 047 560; 2010–2011: R10 000

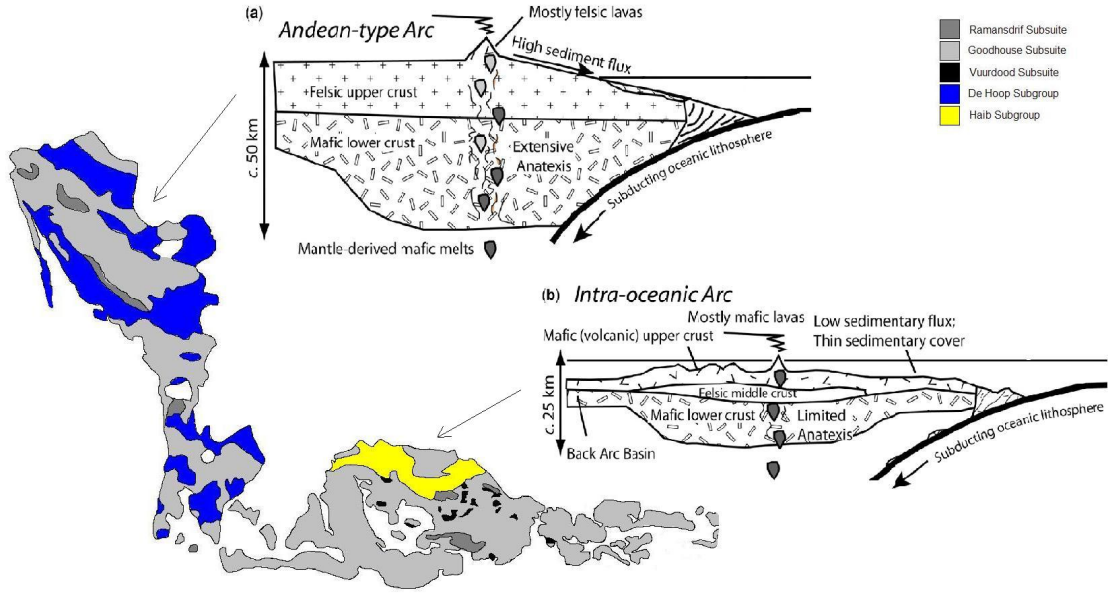
Motivation
A number of previous studies dealt with certain parts of the batholith in isolation, but no study has investigated the batholith as a whole. Previous studies also provided the framework for the current subdivision and identified the original tectonic environment in which the batholith formed. The current study aims to produce a generally accepted subdivision of the batholith and to investigate the tectono-magmatic processes during the development of the batholith.

Progress
The study has been submitted for a Ph.D. degree and has been reviewed. It is currently being edited.

Conclusions
The Vioolsdrif batholith has developed in a time during which the tectono-magmatic crust-forming processes on the earth apparently changed dramatically. During the Archaean, these processes produced vast volumes of crust which were of TTG composition. During the Late Archaean-Early Proterozoic, they changed to producing less crust in volume, and with calc-alkaline composition. The Vioolsdrif batholith was formed in this period of change (2,0–1,7 Ga). Classification and discrimination diagrams indicate that the Vioolsdrif batholith is comparable to modern crust-forming processes (subduction-related volcanic arc similar to the Andes). Geochemical variation diagrams distinguish two different types of settings for the Vioolsdrif batholith. The

Haib Subgroup represents an intra-ocean volcanic arc setting, while the De Hoop Subgroup represents a continental arc setting.

Future activities
Final submission for degree purposes is planned for 2012.



The Vioolsdrif batholith with the Haib Subgroup representing an intra-ocean, and the De Hoop Subgroup a continental volcanic arc setting.

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: T.R. Kometsi, Nat. Dip. Elec. Eng., P. Adamos, Nat. Dip. Elec. Eng., V. Jele, Nat. Dip. Elec. Eng., L. Tabane
Primary objectives: Maintenance and operation of the South African National Seismograph Network (SANSN) to ensure high-quality seismic data to be received at the National Data Centre (NDC) at the Council for Geoscience for analysis
Duration: 1 April 2010–31 March 2011

Motivation
To maintain the South African National Seismograph Network in order to produce high-quality seismic data from 28 remotely deployed seismograph stations throughout South Africa while ensuring 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 quick response to any failures. The data are used to produce seismic information for bulletins and seismic hazard maps.

Progress
Methods have been implemented in order to enable 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 a internet-based interface which can monitor parameters such as uptimes and data transmission latencies. The technical maintenance team also interacts pro-actively in the project by monitoring and controlling the hardware functions of the data acquisition systems. An in-house-developed monitoring device was implemented at all stations which ensures the proper operation of systems without undertaking unnecessary field trips. New hardware for the data acquisition software has been introduced to help improve reliability.

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 continual basis and the performance of the network has proven to be better than ever before.

Future activities
The reduction of transmission costs coupled to improved methods and new technologies will continue to be investigated by the technical team and implemented if and when possible.

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

Project leader: I. Saunders, Nat. Dip. Geol.
Project team: L. Akromah, Nat. Dip., M.B.C. Brandt, M.Sc., B. Sutherland, T. Molea
Primary objectives: The continued operation of the SANSN is essential for providing daily reports on the seismic activity of the earth's crust in South Africa. The information obtained is distributed in the form of quarterly bulletins and catalogues. The seismological activity monitored by the SANSN provides the valuable data that are required for seismic hazard analysis and insurance claims. Seismological data from the SANSN are preserved for prosperity through a National Earthquake Database and are presented in earthquake catalogues of southern African seismicity
Duration: 1 April 2010–31 March 2011

Motivation
The 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 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 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 is shared with a varied audience both nationally and internationally and is distributed within the Council for Geoscience contributing to the Geoscience Mapping and Physical Geohazards Thrusts.

Progress
An earthquake swarm manifested in the towns of Augrabies and Keimoes in the Northern Cape Province and commenced in February 2010 with over 380 earthquakes recorded in the period February 2010 to March 2011. The largest earthquake occurred on 25 January 2011 and measured 4,9 on the Richter scale with slight damage reported from the area. Several fault plane solutions were calculated for the area which indicate strike-slip movement that is supported by geological evidence. Earthquake depth was determined by measuring the time difference between direct arriving body waves as opposed to body waves selected from the Moho interface. It would appear that the earthquake foci is shallow (<20 km).

Earthquake activity in South Africa for the period January to December 2010 was released through ad hoc reporting and quarterly seismological bulletins.

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

Future 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 ML = 3,0 in South Africa for the period January to December 2009

Date	Time	Region	Magnitude (ML)
2010/03/11	17:06:37.4	Springfontein area	3,6
2010/03/29	10:54:39.1	Cape of Good Hope area	3,1
2010/04/08	08:39:40.3	Pofadder area	3,3
2010/06/05	19:47:01.9	Atlantic Ocean	4,4
2010/06/18	17:26:10.8	Indian Ocean	4,8
2010/06/19	20:59:48.7	Welbedagt Dam area	3,0
2010/06/24	12:06:26.7	Augrabies area	4,0
2010/06/24	18:39:37.3	Augarbies area	3,2
2010/06/29	04:07:00.4	Augrabies area	3,7
2010/07/26	16:24:19.2	Augrabies area	4,1
2010/07/26	16:27:05.4	Augrabies area	3,8
2010/08/05	11:03:54.2	Augrabies area	3,6
2010/10/03	09:28:23.4	Piet Retief area	3,4
2010/10/07	02:52:08.4	Augrabies area	3,5
2010/10/07	02:52:08.9	Augrabies area	3,6
2010/11/01	17:19:58.5	Van Wyksvlei area	3,6
2010/11/01	17:19:58.5	Van Wyksvlei area	3,6
2010/11/15	09:22:50.6	Blyvooruitsig area	3,0
2010/11/17	13:53:36.8	Lesotho	3,0
2010/11/17	13:53:36.7	Lesotho	3,0
2010/11/17	16:09:12.6	Augrabies area	3,5
2010/11/17	16:09:13.2	Augrabies area	3,5

2010/11/18	04:50:40.6	Augrabies area	3,9
2010/11/18	12:00:16.7	Louis Trichardt area	3,2
2010/11/21	04:28:52.4	Augrabies area	4,5
2010/12/05	22:49:43.2	Augrabies area	3,0
2010/12/09	10:51:55.2	Augrabies area	3,3
2010/12/16	06:00:50.0	Augrabies area	4,4
2010/12/25	20:29:10.4	Augrabies area	3,8
2010/12/26	01:28:22.2	Augrabies area	4,3
2010/12/28	02:38:41.2	Augrabies area	4,2

Table 2: List of tectonic earthquakes larger than ML = 3,5 in southern Africa for the period January to December 2009

Date	Time	Region	Magnitude (ML)
2010/03/11	17:06:37.4	Springfontein area	3,6
2010/06/05	19:47:01.9	Atlantic Ocean	4,4
2010/06/18	17:26:10.8	Indian Ocean	4,8
2010/06/24	12:06:26.7	Augrabies area	4,0
2010/06/29	04:07:00.4	Augrabies area	3,7
2010/07/26	16:24:19.2	Augrabies area	4,1
2010/07/26	16:27:05.4	Augrabies area	3,8
2010/08/05	11:03:54.2	Augrabies area	3,6
2010/10/07	02:52:08.4	Augrabies area	3,5
2010/10/07	02:52:08.9	Augrabies area	3,6
2010/11/01	17:19:58.5	Van Wyksvlei area	3,6
2010/11/01	17:19:58.5	Van Wyksvlei area	3,6
2010/11/17	16:09:12.6	Augrabies area	3,5
2010/11/17	16:09:13.2	Augrabies area	3,5
2010/11/18	04:50:40.6	Augrabies area	3,9
2010/11/21	04:28:52.4	Augrabies area	4,5
2010/12/16	06:00:50.0	Augrabies area	4,4
2010/12/25	20:29:10.4	Augrabies area	3,8
2010/12/26	01:28:22.2	Augrabies area	4,3
2010/12/28	02:38:41.2	Augrabies area	4,2

Table 3: List of mining-related earthquakes larger than ML = 4,0 for the period January to December 2010

Date	Time	Region	Magnitude (ML)
2010/02/15	23:09:16.8	Klerksdorp gold mines	4,2
2010/06/07	15:21:40.7	Klerksdorp gold mines	4,1
2010/06/14	13:51:56.4	Far West Rand gold mines	4,2
2010/11/13	00:53:45.2	Far West Rand gold mines	4,1
2010/12/31	18:00:11.6	Far West Rand gold mines	4,2

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

Project leader: F.A. Delport, B. Tech., Elec. Eng.
Project team: M.R.G. Grobbelaar, B.Sc. Hons, V. Jele, Nat. Dip., Elec. Eng.
Primary objectives: The Council for Geoscience has been designated by the Department of Foreign Affairs to act as the technical point of contact regarding Comprehensive Test Ban Treaty (CTBT) matters. Due to South Africa's obligation to the Nuclear Test-Ban Treaty, the Council for Geoscience is committed to maintain the International Monitoring System (IMS) primary seismic stations at Boshof, 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: 1 January 2010–31 December 2010

Budget: ±R370 000.

Motivation

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

Progress

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

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

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

Conclusions

On 24 December 2004, the station was certified and the Council for Geoscience has since then entered into a contractual agreement with the CTBTO. The SO continually communicates operational matters between AFTAC and the IMS Operational Centre. After the upgrade of the monitoring equipment, improvement of the grounding and the installation of the power backup system, the failure of equipment was limited and the SO was in a position to almost react immediately on outages in order to swap out defective components. The SO still needs to be informed by AFTAC on system failures. The advantage is that lesser skilled staff may respond to and rectify station problems.

Future activities

Irrespective of the technical upgrades which 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 uptimes, the SO will suggest and possibly design the deployment of additional monitoring equipment at the station. The broadband sensor will need to be replaced during the beginning of the next reporting period.

CO-2006-5620 INFRASOUND STATION IS47

Project leader: F.A. Delport, B. Tech., Elec. Eng.

Project team: M.R.G. Grobbelaar, B.Sc. Hons, V. Jele, Nat. Dip. Elec. Eng.

Primary objectives: The Council for Geoscience has been appointed as the technical point of contact and awarded the contract to operate and maintain the infrasound station (IS47) in Boshof as part of South Africa's commitment to contribute infrasound data to the International Data Centre (IDC) based in Vienna, Austria. The station forms part of one of the technologies which is used in the Global Monitoring System as part of the verification regime to detect atmospheric pressure changes which may occur after a large explosion. Atmospheric changes may also be caused by other sources

than explosions, such as objects entering the earth's atmosphere, supersonic aircraft, volcanic eruptions, etc. As research in this field is limited, studies and research in other fields will contribute towards defining signatures for explosions. The main objective of the project is to ensure that quality infrasound data are received in a timely fashion at the IDC for data analysis and to enable researchers to conduct further studies

Duration: 1 January 2010–31 December 2010

Budget: ±R370 000

Motivation

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

Progress

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

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

Conclusions

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

Future activities

As the radio telemetry and summing manifold vaults are located beneath the ground surface, water tends to infiltrate these facilities during the rainy season. To protect the delicate electronic equipment located in these vaults, the SO will suggest that the IMS Operational Centre deploy submersible water pumps in each of the vaults. It will also be suggested that dedicated hardware monitoring modules be deployed to monitor hardware system performance and enable the local Caretaker (on site) to perform swapouts of defective components. This will limit unnecessary field trips by qualified electronic maintenance technicians. Alternative power sources, and their possible implementation at the sites, will be investigated.

ST-2011-0020 ATTENUATION MODEL FOR MINE DISTRICTS (CONTINUATION)

Project leader: A. Cichowicz, Ph.D.

Project team: D. Birch, B.Sc. Hons

Primary objectives: To validate a parametric model for groundmotion prediction obtained by determining the relevant attenuation parameters that control groundmotion in mining districts and further software development improvement of the Seismology Unit services required that a theoretical model of groundmotion should be verified with real data in order to estimate the accuracy of the methodology developed for seismic hazard assessments

Duration: 1 April 2010–31 March 2011

Motivation

One of the focuses of the Council for Geoscience is to promote a better understanding of the tectonic activity in the country. This project provides useful insight into the attenuation of seismic waves in South Africa. A study of regional attenuation contributes to the seismological and geological characterisation of the region. The only place in South Africa which guarantees excellent recordings of groundmotion caused by seismic events are mining districts.

An important element of seismic hazard assessment is the selection of the seismic wave attenuation equation. All currently run seismic hazard assessment projects in South Africa are utilising the attenuation equations mostly from the central and eastern US (CEUS). This is done on the assumption that both areas are intraplate regions characterised by low seismic activity. The quantification of similarities and differences between the South African and other crustal models is vital for assessing the sensitivity of the hazard assessment.

Progress
The coda normalisation method is used to obtain a quality factor as a function of frequency with an assumed model of geometrical spreading. A power law Q-1(f) = Qo-1f-n for the frequency relationships with the body wave quality factors is assumed. The coda normalisation method was extended to include optimal parameters of the geometrical spreading used to obtain the quality factors. A detailed derivation of methodology is presented together with its application to real data.

The Q-coda method is also presented in this report. The objective was to investigate the variation in the attenuation of various mining districts. Five mining districts supplied a wealth of data, which was processed to obtain the quality factor attenuation factor, Qc, and model the frequency dependence using the power law relationship. The five districts included the Rustenburg platinum mining district, KOSH mining district, Far West Rand mining district and the Central Rand mining district.

Conclusions
The new method of coda normalisation technology provides parameters of attenuation 'Qo' and 'n' with systematically smaller standard deviations. Additionally, differences in the 'n' parameters of the S-wave components are smaller than is determined with the method of fixed geometrical spreading. This indicates that optimisation of the geometrical parameters represents an important improvement to the coda normalisation methods.

An accurate estimation of the attenuation parameters is important in magnitude determination. The average over all the areas was Qc(f) =173 f 1,04 with strong differences in attenuation between the platinum mining areas surrounding Rustenburg and the gold mining areas of the Witwatersrand Basin.

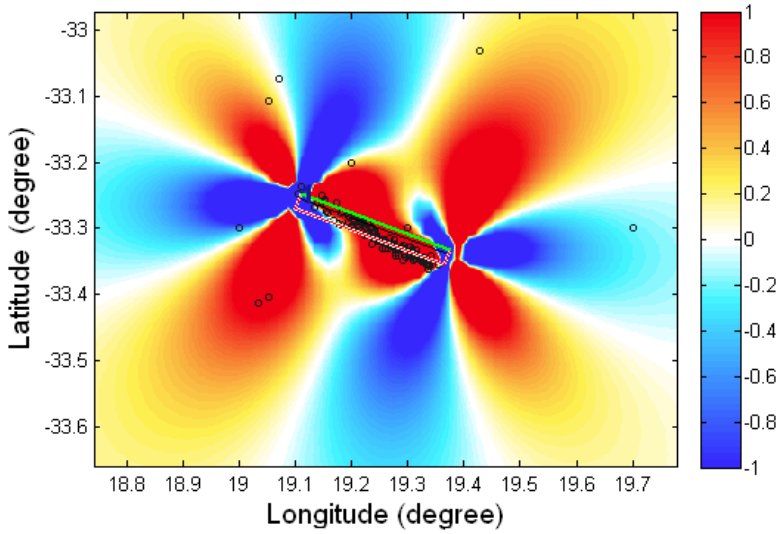
Future activities
The parametric model for the prediction of ground motion will have two major applications: one for hazard assessment and the second one for rapid groundmotion estimation.

ST-2011-0075 **STRESS CHANGE DUE TO THE 1969 MW = 6,3 CERES, SOUTH AFRICA EARTHQUAKE AND ITS EFFECT ON AFTERSHOCKS AND FUTURE EARTHQUAKE PROBABILITIES**

Project leader: V. Midzi, Ph.D.
Primary objectives: To investigate active faults in the Ceres region from published material
To investigate the stress changes caused by the September 1969 earthquake using the USGS software Coulomb3.1
To evaluate the effect of stress change on seismicity of the area
Duration: 1 April 2010–31 March 2011

Motivation
Understanding the transfer of stress between faults in the region will help to evaluate earthquake potential more effectively, thus improving seismic hazard assessments. Several large earthquakes around the world, such as the 1992 Loma Prieta and the 1995 Kobe shocks reveal a good correlation between the calculated Coulomb stress change and the distribution of aftershocks. Stress triggering was also observed to cause sequences of moderate to large earthquakes.

Progress
Having collected data on active faults, seismicity, focal mechanisms and regional tectonic stress of the area, Coulomb stress changes were calculated from the M = 6,3 earthquake that shook and caused the deaths of 12 people and destroyed property in the Ceres/Tulbagh area on 29 September 1969. Using the USGS software Coulomb32 version 2010, the stress changes on fault planes adjacent to the source fault (assumed to be the Groenhof fault) were mapped. The stress was also mapped on optimally oriented planes that were determined by assuming a regional stress field. The results showed that Coulomb stress increases in regions near the source fault where aftershocks were located. Although actual stress change values were small (0,2–0,7 bars), relatively large and shallow aftershocks were triggered including a magnitude 5,7 earthquake. This has significant implications for seismic hazard assessment and earthquake forecasting, as the static stress interactions result in significant spatio–temporal variations in seismicity patterns.



Location of the 1969 M = 6,3 Ceres earthquake aftershocks (black open circles) in the Coulomb stress change field (in bars).

Conclusion

Important facts that were observed in this study include the fact that the static stress changes promote the occurrence of shallow focus aftershocks. Coulomb stress increases are highest along fractures/faults oriented in direction similar to source faults. Thus aftershock activity is enhanced along strike-slip faults of similar characteristics in the Ceres region. It is also clear that stress changes modify the occurrence of earthquakes following a main shock and thus static stress interactions should be considered in seismic hazard analysis.

Future activities

The writing-up of an article using material in this report for submission to a peer-reviewed journal. It is also hoped that if there are large earthquakes in South Africa in future, this technique can be implemented to predict the location of aftershocks.

ST-2010-1104 **IMPLEMENTATION OF COMPUTATIONAL CAPACITY AND RIVATION OF A REFERENCE MODEL FOR SEISMIC HAZARD IN SOUTH AFRICA, CONSISTENT WITH THE SSHAC GUIDELINES**

Project leader:	F. Strasser, Ph.D.
Project team:	V. Midzi, Ph.D., E. Hattingh, M.Sc., M. Brandt, M.Sc., M. Singh, M.Sc., S. Zulu, B.Sc. Hons
Primary objectives:	The objectives of the proposed work are to develop the Council for Geoscience's computational and personnel capacity in the field of seismic hazard analysis to bring it on par with other national geological surveys active in this field
Duration:	1 April 2010–31 March 2011

Motivation

Although South Africa is located in a region of low natural seismicity, an assessment of the hazard related to groundmotions caused by earthquakes still needs to be carried out to determine appropriate design parameters for a number of special structures such as dams, storage tanks, essential lifelines or tall buildings.

In the absence of specific provisions for such studies in the relevant South African building codes, design regulations from other countries (most frequently the United States) are adopted. These design regulations generally assume the existence of either a national seismic zoning map or a national seismic hazard map based on the results of probabilistic seismic hazard calculations that are consistent with the guidelines defined by the Senior Seismic Hazard Assessment Committee.

The seismic hazard calculation procedures implemented to date at the Council for Geoscience have been found to fall short of these guidelines due to the omission of consideration of uncertainties, particularly with respect to the groundmotion model. Therefore, alternative software solutions need to be implemented at the organisation.

In relation with the ESKOM project, the Seismology Unit has acquired a licence for the commercial seismic hazard software FRISK88M, developed by Risk Engineering Inc. The current licence is valid until 2011 and limited to applications within the territory of South Africa. While the use of this software is necessary for nuclear applications in view of the quality assurance requirements of the regulatory framework, which are not

met by other software packages, the limitations of the current licence in both space and time make it desirable to implement alternative software packages that could be used by the organisation for seismic hazard analyses beyond nuclear applications, and outside South Africa.

Progress
Two software packages (both of which can be used free of charge) were identified as suitable alternatives to FRISK88M for applications where the quality assurance requirements are less strict than in the nuclear context:

CRISIS: The CRISIS software package has been developed by Dr Mario Ordaz and co-workers at the National Autonomous University of Mexico (UNAM). As well as being used in commercial projects by other geological surveys such as the BRGM, this software has also been extensively tested within the context of research into the methodology of seismic hazard analysis and can therefore be considered as thoroughly vetted by the international seismological community. This software includes a windows-based graphical user interface providing extensive guidance on the inputs, which are more limited than in FRISK88M, but still adequate for training purposes and smaller commercial projects.

HAZ: The HAZ software is being developed by Dr Norman Abrahamson of Pacific Gas & Electric Co., who uses it for seismic hazard analyses in his projects, most recently the SSHAC Level 3 study for hydro-electric dams carried out in British Columbia on behalf of BC Hydro. This software possesses much the same functionalities as FRISK88M, and similarly relies on scripted files, rather than a graphical user interface, for data input.

Conclusions
The implementation of the software included testing of all functionalities of CRISIS 2007 on CGS computers using a simple model case in South Africa, as well as the writing of a set of user manuals to guide future applications.

Additionally, material was prepared for a training course covering the fundamental notions of seismic hazard assessment and guidance on the use of seismic hazard analysis software. This training course was designed to be given both internally for capacity building and as a service to external clients.

Future activities
The following objectives should be further investigated:

- Develop a national generic framework to serve as a basis for seismic hazard analyses for specific projects/applications
- Address the specificity of South African conditions.

ST-2011-0021 **GEOTECHNICAL INVESTIGATIONS — CHARACTERISATION OF NEAR SURFACE GROUND USING RESONANCE AND SHEAR-WAVE VELOCITY**

Project leader: A. Cichowicz, Ph.D.
Project team: D. Birch, B.Sc. Hons
Primary objectives: The objective of this evaluation is to develop efficient methods of service to determine the site effects. A soil characterisation in terms of the vertical shear-wave velocity profile of the soil column is crucial for the estimation of dynamic soil response. Shear-wave velocities can be obtained by inverting the dispersive phase velocity of the surface Rayleigh waves using a process called the multichannel analysis of surface waves (MASW)
Duration: 1 April 2010—31 March 2011

Motivation
South Africa's infrastructure is undergoing rapid development. As a result, there is a need for the development of nuclear power stations, more coal-fired power stations and alternative sources of energy such as liquid gas. With this large infrastructure comes the contractors' responsibility for environmental and public safety. The Council for Geoscience currently does not provide a service of site evaluations to determine site effects. The geological conditions at a site govern its response to seismic activity. Large amplification factors can result in unforeseen damage and destruction. The shear-wave velocity model is a key parameter in building code regulations, as well as for the microzonation of urban areas and the assessment of ground improvement measures during the construction process. It is thus vital to understand and develop methods to quantify this response.

Progress
The MASW process includes data acquisition, extraction of experimental dispersion curves from Rayleigh waves and performing inversion algorithms to obtain the near-surface S-wave velocities. It is well known that dispersion of the phase velocity of Rayleigh waves is mainly controlled by thicknesses and S-wave velocities of shallow deposits. The effect of geophone configuration on the dispersion image for linear spreads in the MASW

methods is evaluated. To reveal the spectral resolution of dispersion images, MASW records were collected using nine different types of linear spread configurations, and a dispersion image for each record was calculated using the phase velocity analysis technique. Two types of inversions are used: one involves using a dispersion image and the second one uses dispersion curves. The dispersion curve is used as an input to a gradient-based iterative method and Monte-Carlo search for dispersion images. In order to overcome the problem of obtaining different inversion solutions, an inversion strategy with a high level of confidence was proposed to evaluate dominant trends in the vertical shear-wave velocity profile.

Surface wave testing was conducted at a roadside in Pretoria, South Africa. The MASW method provides a shear-wave velocity model with good resolution down to 30 m. Site resonance defines the thickness of a low velocity layer in the top 20 m of soil. This agrees with the MASW results.

Conclusions
MASW is a non-invasive seismic survey method that has been found by the geotechnical community to be an efficient method for the measurement of the vertical S-wave velocity profile.

Future activities
The Council for Geoscience currently does not provide any service to determine site effects. The developed methodology will be used to provide services. The method is cost effective and involves 3h field work and 6h data processing per site.

ST-2007-0957 **TECTONIC INTERPRETATION OF THE BASINS AND TERRAIN BOUNDARIES WITHIN THE KAAPVAAL CRATON USING JOINT INVERSION AND GEOPHYSICAL RESULTS**

Project leader: E. Kgaswane, M.Sc.
Project team: Prof. R. Durrheim, Wits University, South Africa
Primary objectives: This study constitutes the third phase of a research project. The first aim of this study is to characterise the different tectonic basins within the Kaapvaal Craton using existing shear-wave velocity (Vs) at least up to 30 km depths and to verify if this characterisation matches with what is already known geologically. The second aim is to seismically characterise anomalies in southern Africa with the main focus on the Beattie Magnetic Anomaly (BMA) in the Namaqua-Natal Belt
Duration: September 2005–December 2011

Motivation
The Archaean Kaapvaal Craton constitutes a complete record of the evolution of a portion of the Kalahari Craton spanning a period of one thousand million years. The Kaapvaal Craton is subdivided into four major tectonostratigraphic terrains, the Kimberley (3,0–2,8 Ga), Pietersburg (3,0–2,8 Ga), Witwatersrand and Swaziland terrains (3,6–3,1 Ga), separated by the Thabazimbi-Murchison and Colesberg lineaments and the Inyoka Fault.

The architecture of the basins, e.g. the Ventersdorp Supergroup (~2,7 Ga), within each of the terrains of the Kaapvaal Craton as indicated by an abundance of geological literature is lithostratigraphically distinct across the terrains and this, together with tectonic features such as faulting and folding, imparts a unique geotectonic signature to each terrain. However, the differences in the lithostratigraphic settings of the basins as shown by geological studies are mostly limited to supracrustal depths (≤10 km). Much of the evidence of crustal variability up to Moho depth within the Kaapvaal Craton has been revealed by seismic studies. This study aims to use the available Vs data to characterise the lithological composition of the Kaapvaal Craton up to 30 km depths and as such uses these results to reconcile with what is already understood geologically.

Progress
Geological and geophysical maps of 1:1 000 000-scale size which will help in the seismic interpretation of the different features of the crust have been organised. A clustering algorithm (in Matlab) to be used to assist with the stratigraphic interpretation of the different basins within the Kaapvaal Craton has already been compiled and preliminary results from the code have been obtained using joint inversion data from the first phase of the research project. With regard to the second aim of this project, a computer code is currently been used to yield synthetic receiver functions for a few seismic stations on or in the vicinity of the BMA. These synthetic receiver functions will be used in the interpretation of the BMA within 10–15 km of the upper crust.

Conclusions
As preliminary results of this study, lithological columns based on the existing Vs data were constructed. However, lithological layering resulting from these columns does not conform with what is already known geologically. The principal reason for this lack of agreement is that the level of vertical resolution in the Vs profiles yields uncertainties that are higher than the resolution size required in delineating subsurface crustal layering which is mostly sensitive to seismic wavelengths less than 1 km. It will therefore be difficult to use this

approach independently to differentiate the lithostratigraphic setting between the tectonic terrains within the Kaapvaal Craton. A statistical approach is currently been deployed to assist in the seismic interpretation of the lithostratigraphy of the crust (up to 30 km depths) within the Kaapvaal Craton.

Future activities
The research findings of this study should be submitted and reviewed in a local journal, e.g. South African Journal of Geology. A complete research thesis encompassing all the phases of this research project will be submitted to the Faculty of Science of the University of the Witwatersrand by early 2012.

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

Project leader:	M. Brandt, M.Sc.
Project team:	Dr R. Durrheim, University of the Witwatersrand, Prof. S. Grand, University of Texas (Austin)
Primary objectives:	Research and training as part of *AfricaArray* through imaging the upper mantle beneath southern Africa with seismic waves, imaging the deep mantle through seismic travel time tomography and calculating regional moment tensors and crustal stresses
Duration:	September 2005–March 2011

Motivation
This project forms part of the *AfricaArray* programme. *AfricaArray* is an initiative to promote, in the full spirit of the New Partnership for Africa's Development (NEPAD), coupled training and research programmes for building and maintaining a scientific workforce for Africa's natural resource sector. It is a joint effort between Penn State University, USA, the University of the Witwatersrand (WITS) and the Council for Geoscience (CGS). More information may be obtained at: http://africaarray.psu.edu/.

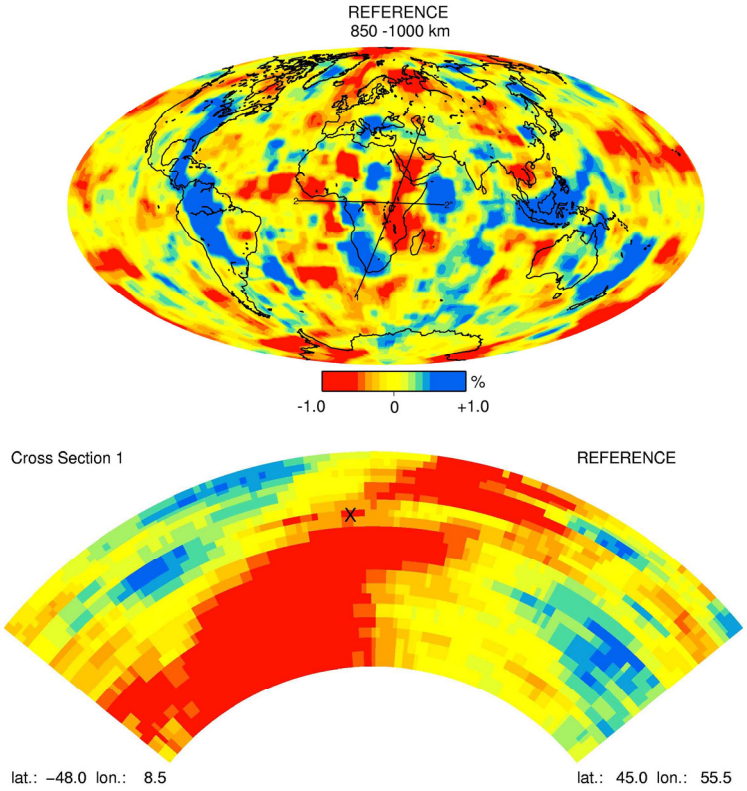
The research consisted of a sandwich programme; for the forth year in a row four months, from February to May, were spent at the University of Texas in Austin, USA where research was done with a world-class seismologist. For the other eight months each year about 30 per cent work time is made available for research. Visits to the USA are now complete and the writing up and implementation of the reviewer's suggestions are in progress.

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

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

Progress
A research paper, New regional moment tensors in South Africa, by Brandt and Saunders, has been published in the January/February 2011 issue of Seismological Research Letters. A third manuscript, Upper Mantle Seismic Structure beneath Southern Africa – Constraints on the Buoyancy Supporting the African Superswell, by Brandt *et al.*, has been accepted by Pure and Applied Geophysics conditional on minor review. The reviewer's suggested changes are currently being implemented. The project requires collaboration with African and international scientists as part of the *AfricaArray* Programme. Research results have important industrial application for seismotectonics and long-term seismic hazard analysis.

Future activities
A second chapter, Middle mantle seismic structure of the African Superplume, is currently being edited by Prof. S. Grand and will be submitted, together with the above publications, and an introductory summary as a Ph.D. thesis by December 2011.



Spherical profile at 850 to 1 000 km depth from Grand's global tomography model labeled with REFERENCE (top). The "x" on cross-section one (bottom) indicates the complex link between the slow velocity in the deep mantle (i.e. the African Superplume) and the upper mantle velocity anomaly beneath eastern Africa.

SPATIAL DATA MANAGEMENT

GEODATABASE — DEVELOPMENT AND IMPLEMENTATION (0856), SYSTEM AND APPLICATION MAINTENANCE (0277), MAINTAIN GIS METADATA (0276), DATA ADMINISTRATION ON THE SPATIAL DATA ENGINE (0277) AND DATABASE ADMINISTRATION (0793)

Project leader: H.J. Brynard, Ph.D.
Project team: K. Wilkinson, Nat. Higher Dip. Carto., D. Sebake, M.Sc. (Environ. and Dev.), D. Grobbelaar, Nat. Dip. Carto., S. Noruka, B.Sc. Hons
Budget: R654 892

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

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

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

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

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

GEODE SYSTEMS — DATA ADMINISTRATION GEODE (0785) AND DATABASE ADMINISTRATION (0473)

Project leader: H.J. Brynard, Ph.D.
Project team: K. Wilkinson, Nat. Higher Dip. Carto., S. Tucker, Dip. S.B.M., F. Nkosi, Nat. Dip. (IT)
Budget: R188 094

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

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

GEOPORTAL MAINTENANCE/APPLICATIONS (0856)

Project leader: H.J. Brynard, Ph.D.
Project team: S. Tucker, Dip. S.B.M., M. Roos, Nat. Higher Dip. Carto.
Budget: R163 922

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

1:50 000 GEOLOGICAL MAPS (GIS)/(CARTOGRAPHY)

Project No.	Title	Project Leader and Team	Costs
ST-0871	2429BC Lebowakgomo (GIS & Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, E. Magagane, Nat. Dip. Carto., M. Roos, Nat. Higher Dip. Carto.	R66 279
ST-0610	2930DD&2931CC Durban (GIS & Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, M. Roos, Nat. Higher Dip. Carto., M. Nkosi, Learner Technician, H. Sello, Matric	R34 988
ST-0711 & 0564	3317BB&3318AA Saldanha (Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., M. Roos, Nat. Higher Dip. Carto., C. Thomas, Nat. Higher Dip. Carto.	R81 504
ST-0768	3418BB Somerset West & 3418BD Hangklip (Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., M. Roos, Nat. Higher Dip. Carto., M. Nkosi, Learner Technician, B. Oosthuizen, Matric	R39 070
ST-0701	2429AA Mokopane (Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., M. Roos, Nat. Higher Dip. Carto., C. Thomas, Nat. Higher Dip. Carto.	R72 333
ST-0742	3227CD King William's Town (GIS & Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, M. Roos, Nat. Higher Dip. Carto., E. Magagane, Nat. Dip. Carto., P. Msiza, Matric	R104 566
ST-0468	2528CC Centurion (GIS & Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, M. Roos, Nat. Higher Dip. Carto., D. Grobbelaar, Nat. Dip. Carto., C. Kgari, Matric, P. Msiza, Matric	R98 548
ST-0346	2627BC Westonaria (GIS & Cartography)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, M. Roos, Nat. Higher Dip. Carto., D. Grobbelaar, Nat. Dip. Carto., H. Sello, Matric	R92 015
ST-0920	3327AC&CA Fish River Mouth (GIS)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, P. Msiza, Matric, H. Sello, Matric	R32 269
ST-0980	3129BD&3130AC Mkambati (GIS)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, P. Msiza, Matric	R32 516
ST-0644	2528CD Rietvlei Dam (GIS)	K. Wilkinson, Nat. Higher Dip. Carto., H. Brynard, Ph.D., S. Noruka, B.Sc. Hons, H. Sello, Matric	R32 516

1:50 000 GEOTECHNICAL MAP (CARTOGRAPHY)

ST-0762	2528BC Silverton (GIS)	K. Wilkinson, Nat. Higher Dip. Carto., M. Brynard, Ph.D., P. Msiza, Matric	R37 888

1:250 000 GRAVITY MAPS (CARTOGRAPHY)

2620 Twee Rivieren		
2230 Musina		
2328 Polokwane		
2330 Tzaneen		
2428 Modimolle		
2528 Pretoria		
2628 East Rand		
2630 Mbabane		
2728 Frankfort		
2730 Vryheid	K. Wilkinson, Nat. Higher Dip. Carto., C. Thomas, Nat. Dip. Carto., A. Smith, Nat. Dip. (IT)	R24 490
2816 Alexander Bay		
2826 Winburg		
2828 Phuthaditjhaba		
2916 Springbok		
2926 Bloemfontein		
2928 Drakensberg		
3026 Aliwal North		
3028 Kokstad		
3126 Queenstown		
3128 Umtata		

WATER GEOSCIENCE

ST-2011-0121 **EXPLORING THE LINKS BETWEEN GROUNDWATER AND THE DWA *WATER FOR GROWTH AND DEVELOPMENT* PARADIGM WITHIN AN IWRM AND SUSTAINABLE DEVELOPMENT FRAMEWORK: A TRANSDISCIPLINARY PERSPECTIVE**

Project leader: U. Rust, M.Phil. (Sustainable Development Planning and Management)
Primary objective: To explore a complexity-based approach for the use of sustainability indicators to facilitate groundwater management
Duration: 2009/10–2010/11

Motivation
An analysis of existing research and policy discourse shows that groundwater is not only important in the future South African water mix, but the management thereof is complex for a number of reasons. Furthermore, groundwater has in recent times been subjected to increased abstraction. However, groundwater management has lagged the importance and complexity of the resource. The current public management paradigm often relies on the use of metrics to measure progress towards strategic objectives, and therefore the issues surrounding sustainability indicators in groundwater management are important.

Progress
Because of funding restrictions, no field work could be undertaken. A desktop study of projects evaluating the status of global, SADC and South African groundwater management was conducted. Relevant policy documents, legislation and guidelines were also analysed. In January 2011, a five-day seminar on new directions in transdisciplinary research was attended. This seminar was offered by the Stellenbosch University School of Public Management and Planning, the Sustainability Institute, ETH Zürich Institute for Environmental Decisions, Natural and Social Science Interface, TD-net and the Swiss Academy of Sciences. The information obtained in this seminar was used to classify water management in general as a transdisciplinary issue, and therefore the transdisciplinary research approach could be used to develop the indicator set.

Conclusions
The desktop work done thus far has indicated that a transdisciplinary research approach would be needed to address the groundwater issue optimally. Therefore the original project planning would have to be modified in line with the transdisciplinary methodology. The transdisciplinary approach is inclusive, and therefore relies on funding for workshops, interviews and focus group discussions, as well as feedback sessions.

Future activities
As this is the second year without funding, no future activities are planned until funding becomes available.

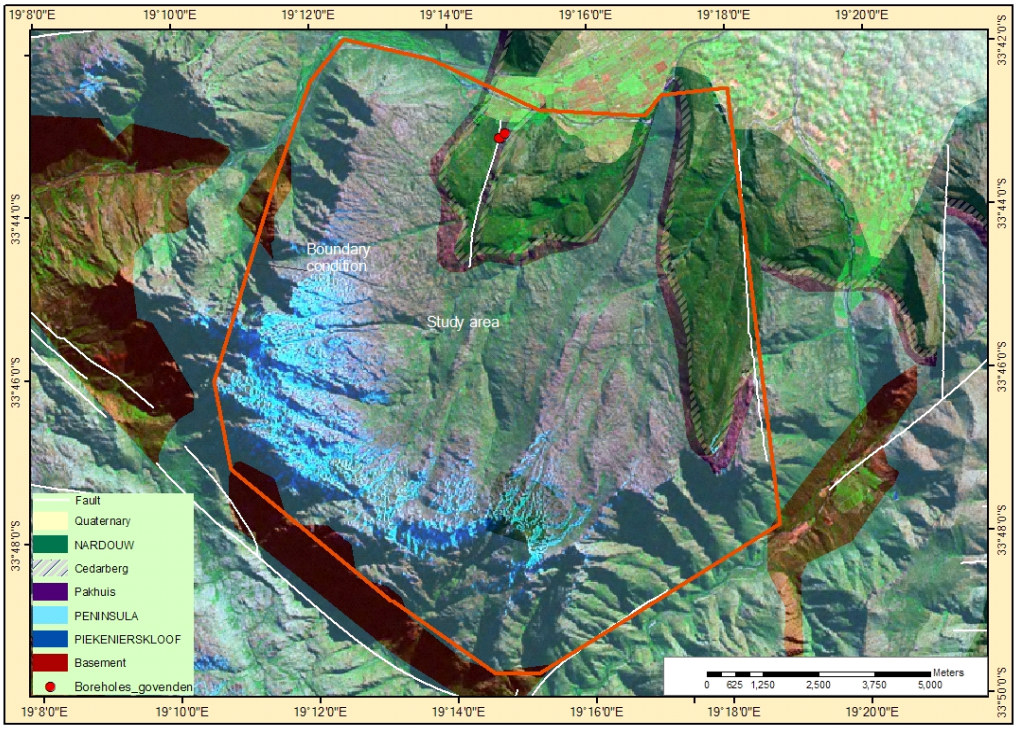
A transdisciplinary approach to water management draws extensively from the input of society by way of community groups such as this women's group from rural South Africa. (Photograph courtesy of African Pictures)

ST-2011-1132 **CHARACTERISATION OF FAULT-CONTROLLED AQUIFERS FOR GROUND-WATER DEVELOPMENT IN WATER-SCARCE AREAS IN SOUTH AFRICA**

Project leader: L. Lin, Ph.D.
Primary objective: To develop conceptual models and ultimately 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: 2010–2013

Motivation

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



Study area with a normal fault in the Rawsonville site.

Progress

This research is a desktop-based study. Firstly, a comprehensive literature review was done. Secondly, to study the fault-controlled aquifer, a case study with a groundwater research and monitoring site with a five-borehole network near Rawsonville, Western Cape was established; this site was established in the vicinity of the normal fault. Based on the data derived from previous field work, research in this phase is 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 on the aquifer's conceptual model and associated hydraulic properties, which was done in this phase.

Conclusions
In order to obtain a better understanding of the fault-controlled aquifer type, the fault-bounded aquifer in the TMG area, together with the study of aquifer properties, and a site with a five-borehole network was established. Multiple approaches to the field observations were employed, including borehole coring and logging, field geophysical surveys, field fracture measurement, 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. Large variation of the aquifer responses to hydraulic tests shows difficulty to determine the aquifer's hydraulic properties represented by the T and K values. In other words, it is extremely difficult, through hydraulic tests, to give a sound estimate of the aquifer's transmissivity and hydraulic conductivity. This is due to the anisotropic features embedded in the fractured rocks and perhaps can be summarised by the conclusion of scale-dependent aquifer properties which actually implies the uncertainty of the problem studied.

Future activities
Considering the fractured rock aquifer in Karoo and dolomite aquifers, more case studies via field work need to be conducted for the development of more robust conceptual models for the quantification of groundwater resources that are controlled by fault structures.

ST-2011-1133 **THE DEVELOPMENT OF AN ARCGIS EXTENSION AS A PRE-PROCESSOR FOR GROUNDWATER FLOW MODELLING**

Project leader: H. Jla, Ph.D.
Primary objective: To develop an ArcGIS extension as a bridge between GIS and MODFLOW for the preprocessing of groundwater flow modelling
Duration: 2010–2011

Motivation
ArcGIS and MODFLOW are of the most commonly used software packages among the hydrogeologists in South Africa. However, GIS data cannot be readily used in MODFLOW, which makes the preprocessing of groundwater flow modelling very difficult, especially for complicated models. Therefore a proper link between this software will make the process more accurate. The GIS-MODFLOW extension developed in this project can do most of the preprocessing and the data files in compatible format can be created and exported from ArcGIS, which can be directly used in MODFLOW. This extension can be made available for all hydrogeologists in South Africa.

Progress
The interface of this extension is a customised docking toolbar added to the existing ArcMap toolbars. All the functions are grouped into menus or commands which can be found on that toolbar. The following five main function modules are involved in GIS-MODFLOW: model dimension, specifying the boundary condition, setting top and bottom elevation of layers, assigning parameter values and preparing data for MODFLOW packages. The first three modules have been done.

Conclusions
The major part of the extension has been done and can already be used for simple groundflow models or at least can help to do some preprocessing for more complicated flow models. With the VBA programming, the extension 'GIS-MODFLOW' can successfully act as the bridge between GIS and MODFLOW. The powerful spatial selection function and topology control in GIS is utilised for more accurate and easier preprocessing of groundwater flow models.

Future activities
Some parts (parameters and MODFLOW packages) of the current extension are still under development. Two other functions are considered to be added to this extension, i.e. rotation and refinement of the model. A case study will be carried out for this project. After the programming part of the extension is completed, a proper user manual will be provided and a short course will possibly be organised for the purpose of technology transfer.

WESTERN CAPE UNIT

ST-2005-0882 **COASTAL CENOZOIC DEPOSITS — IMPLICATIONS FOR GLOBAL CHANGE AND HUMAN ORIGINS**

Project leader: D.L. Roberts, Ph.D.
Project team: C. Dondo, Ph.D.
Primary objectives: To identify patterns of global change through geochronological, sedimentological, palaeontological and archaeological studies of coastal Cenozoic deposits, as well as via evidence of sea level fluctuations. Predictions of future trends in global change and enquiry as to how these predictions may impinge on present day communities, especially historically disadvantaged groups, are important aspects
Duration: April 2006 to March 2010
Budget: Total: R195 000

Progress
Field work was carried out in December 2010 at Noorhoek and Rondeberg (Malmesbury) under the auspices of the African Origins Platform project (AOP). This project is based at the West Coast Fossil Park, which forms one of the cornerstones of Project 0882. Biogeochemical analyses were applied to fluviolacustrine deposits to determine actual depositional temperatures. This represents a major breakthrough in understanding Miocene palaeoenvironments and sea level changes.

Drilling at Noorhoek for Miocene organic deposits for palynology and biogeochemical studies.

The second cornerstone of Project 0882 is the internationally funded (R400 000, LeverHulme Trust) project entitled 'Impacts of fluctuating margins of the southern coastline of South Africa and the emergence of modern humans'. Under this project results from OSL dating of aeolianites from False Bay and a paper on sea levels was produced; Andrew S. Carr, Mark D. Bateman, David L. Roberts, Colin V. Murray-Wallace, Zenobia Jacobs and Peter J. Holmes, 2010. The last interglacial sea-level high stand on the southern Cape coastline of South Africa. Quaternary Research, 73, 351–363.

ST-2010-1078 **THE ARCHITECTURE OF A CRUSTAL-SCALE SHEAR ZONE: STRUCTURAL GEOLOGY, KINEMATICS, MECHANICS, FLUID DYNAMICS AND MINERALISATION OF THE POFADDER SHEAR ZONE, NORTHERN CAPE PROVINCE AND SOUTHERN NAMIBIA**

Project leaders: P.H. Macey, Ph.D.

Project team: C.W. Lambert, B.Sc. Hons, P.H. Macey, Ph.D., C.A. Groenewald, B.Sc. Hons and in collaboration with Prof. A.F.M. Kisters and Prof. D. Frei of the University of Stellenbosch. In addition, there are other collaborative projects with UCT (Prof. C. Harris and M. Nelufule), Mainz University (Dr T. Zack and students) and McGill University (Dr C. Rowe and students)

Primary objectives:
1. To understand the changing geometry and kinematics of the shear zone during the progressive exhumation history concentrating on the characterisation of the different fault and shear zone rocks through geological mapping and allied research
2. To study controls of shear zones for the migration and emplacement of granitic/pegmatitic melts in the continental crust by comparing mineral-enriched pegmatites to barren pegmatites and determining their spatial, temporal and geometric relation to the Pofadder Shear Zone
3. To understand the flow of hydrothermal fluids through mega-shear zones
4. To understand the orthomagmatic and hydrothermal mineralisation potential of the Pofadder Shear Zone
5. All data collected will be incorporated into a Namaqualand database aimed at supplementing various sectors of geological data archived/held by the Council of Geoscience (e.g. mineral –SAMINDABA data, structural, field/geophysical/ hydrogeology maps at various scales)

Duration: 2009–2012, depending on the frequency of field time as well as M.Sc. requisites for universities

Budget: Personnel costs: R416 000

Motivation

Innovative research and staff development with implications for shear-hosted mineralisation. The project will lead to two M.Sc. degrees. It is a collaborative project between the Western Cape and Northern Cape units and the Universities of Stellenbosch, Cape Town, Maintz (Germany) and McGill (Canada).

Progress

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

Conclusions

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

Outcrop in the Pofadder Shear Zone. The isotope systematics of the rocks are investigated in order to determine the origins and characteristics of hydrothermal fluids associated with the shear zone.

Discrete ultramylonites developed during the D_{4c} phase of the shear.

ST-0925 **RADAR INTERFEROMETRY FOR GEOHAZARD ASSESSMENT IN SOUTH AFRICA**

Project leader: J. Engelbrecht, M.Sc.
Primary objective: The project aims to employ differential radar interferometry techniques for the assessment of geohazards in South Africa. This will include the monitoring of surface subsidence due to mining activities in the Mpumalanga Province of South Africa, as well as monitoring movement along faults in the Eastern Cape Province. The detection of movement along faults will imply that seismic hazard assessment will be a possibility
Duration: Three years
Budget: Total: R99 480

Motivation

The Council for Geoscience has recently expressed interest in the formation of a Geohazards Unit which will aim to address natural and anthropogenic hazards. Radar remote sensing can contribute to a programme dedicated to the assessment of risks and hazards and can be regarded as a unique tool to obtain deformation measurements over large areas. In this regard, radar interferometry can be used to monitor centimetre to millimetre scale deformations on the earth surface and has been successfully applied for the monitoring of several hazards including: 1) measuring of surface subsidence, 2) assessment of deformation following earthquake activity, 3) monitoring landslides and volcanic activity and 4) measuring movements along active faults. The interferometry technique therefore opens up many new potential application areas in disciplines such as volcanology, structural geology and geotechnics and for work relevant to a variety of geohazards. Radar remote sensing is an innovative technique to address the surface deformations associated with natural geological processes and human activities, including mining. The project will build capacity in radar remote sensing techniques which can then be used in various geological applications and geohazards assessment. The intended project will act as a stimulation of innovation and development of human capital as radar remote sensing and radar interferometry, in particular, presently only has a limited exposure in South Africa. Additionally, the contribution of this technique to programmes dedicated to hazard and risk management will be invaluable.

Progress

A major advance was the acquisition of RADARSAT-2 data that are currently being collected on a monthly basis. To date seven scenes have been received and processed and image acquisition will continue until January 2012. The results of the image analysis revealed that several stages of subsidence basin evolution could be detected and measured. Ground truth data confirmed the presence of a subsidence basin detected using differential interferometry techniques during the 24-day period between 2011/01/26 and 20114/02/19 with a maximum vertical deformation of 9 cm being recorded (at a spatial resolution of 10 m). Interferometric monitoring revealed an eastward migration of the subsidence basin during successive time periods with deformation between 6 and 9,8 centimetres being recorded. This migration coincides with the advance of the

working face of the mine during this period. The results obtained from the SAR interferograms demonstrate clearly the ability of these techniques to measure surface subsidence as well as the monitoring of the evolution of subsidence basins over time. This implies that the technique could be included, together with traditional field-based surveying techniques, in an operational monitoring system. With knowledge on deformation rates and subsidence basin evolution, informed decisions on current and future infrastructure development can be made and remedial actions and prevention strategies can be formulated for the problems associated with environmental degradation.

Conclusion
Radar interferometry techniques are being developed with the aim of measuring and monitoring surface deformation features related to geological and anthropogenic causes. The foundations for the project have been laid with the literature study and proposal writing phases having been completed. The first of the image acquisition phases of the project have been completed and initial results on surface deformation are promising. It is expected that the processing of the new data and advanced algorithms will assist with designing the optimal sensor configuration for the implementation of a long-term monitoring system. Such a monitoring system will assist with mitigation of the impacts of surface deformation associated with mining activities in South Africa.

ST-2010-1079 **MINERAL COMMODITIES IN THE WESTERN CAPE PROVINCE**

Project leaders: D.I. Cole, Ph.D.
Project team: C.W. Lambert, BSc. Hons, J.H.A. Viljoen, Ph.D., C. Vorster, B.Sc. Hons
Primary objectives: To document all mineral commodities in the Western Cape in the form of a database and digital incorporation onto ARC-GIS. To assess the resources of economically viable mineral commodities and the economic potential of other unexploited commodities. To highlight mineral sites that are amenable to prospecting and mining. This information is important for small-scale mining and provides a database in the targeting of new mines and prospects that will lead to rural development and poverty alleviation. To focus on: 1) industrial minerals, which are prevalent in the Western Cape. These minerals include phosphate, which is required for fertiliser, limestone, which is important for cement and ground calcium carbonate applications, and silica sand, which is necessary for the glass industry; and 2) energy minerals. The latter include uranium and gas-from-shale in the southwestern part of the Karoo Basin between Laingsburg, Beaufort West and Murraysburg
Duration: 2009–2013
Budget: Personnel costs: R715 476

Motivation
There is an ever-increasing demand for industrial and construction materials as the Western Cape provincial economy expands, for example fertiliser, cement and building sand. Secondly, the relatively large uranium and gas-from-shale deposits in the Laingsburg–Beaufort West–Murraysburg region will probably be developed when market conditions improve. Thirdly, it is important that local and provincial planning authorities have an in-depth knowledge of the mineral commodities in the Western Cape, in order to prevent sterilisation of deposits by other land-use activities, e.g. nature areas, and to monitor mine and future mine developments.

Progress
A minerals database has been completed for the 1:250 000-scale Calvinia, Clanwilliam, Cape Town and Worcester topocadastral sheets. These data were mostly derived from the SAMINDABA database, but numerous errors were discovered, resulting in an update of SAMINDABA. A report entitled "Specialist Report on the Remaining Extent and Status of Mineral Resources in the City of Cape Town" was completed for the Cape Town City Council.

Conclusions
The importance of the project was shown by both the Cape Town City Council and the Planning Division of the Western Province Government requesting mineral resources data, as well as small-scale miners requiring data for potential mines.

APPENDIX

Maps released during the year

1:50 000 Geological Maps

2429BC Lebowakgomo
2930DD & 2931CC Durban
3317BB & 3318AA Saldanha
3418BB Somerset West
3418BD Hangklip
2429AA Mokopane
3227CD King William's Town
2528CC Centurion
2627BC Westonaria

1:250 000 Gravity Maps

2230 Musina
2328 Polokwane
2330 Tzaneen
2428 Modimolle
2528 Pretoria
2620 Twee Rivieren
2628 East Rand
2630 Mbabane
2728 Frankfort
2730 Vryheid
2816 Alexander Bay
2826 Winburg
2828 Phuthaditjhaba
2916 Springbok
2926 Bloemfontein
2928 Drakensberg
3026 Aliwal North
3028 Kokstad
3126 Queenstown
3128 Umtata

1:250 000 Metallogenic Maps

2628 East Rand.

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CGS STAFF

Surname	Initials	Position	Business Unit
BOSCH	PJA	SCIENTIFIC OFFICER	CENTRAL REGIONS
DE KOCK	GS	SCIENTIFIC OFFICER	CENTRAL REGIONS
ENGELBRECHT	CR	ADMINISTRATIVE OFFICER	CENTRAL REGIONS
GRANTHAM	GH	SCIENTIFIC OFFICER	CENTRAL REGIONS
HATTON	C	SPECIALIST SCIENTIST	CENTRAL REGIONS
IYENGAR	KP	SCIENTIFIC OFFICER	CENTRAL REGIONS
MOABI	NG	SCIENTIFIC OFFICER	CENTRAL REGIONS
NEVELING	J	SCIENTIFIC OFFICER	CENTRAL REGIONS
NXUMALO	V	SCIENTIFIC OFFICER	CENTRAL REGIONS
SHELEMBE	RP	SCIENTIFIC OFFICER	CENTRAL REGIONS
THOMAS	A	MANAGER CENTRAL REGIONS	CENTRAL REGIONS
JACHA	N	MARKETING & COMMUNICATION SPECIALIST	CORPORATE SERVICES
LEKOTOKO	MM	EVENTS COORDINATOR	CORPORATE SERVICES
LESHOMO	JD	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
MAZIBUKO	DM	HUMAN RESOURCES OFFICER	CORPORATE SERVICES
MKHIZE	ZJL	RECRUITMENT SPECIALIST	CORPORATE SERVICES
MOTSATSING	KM	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
VAN WYK	J	EVENTS COORDINATOR	CORPORATE SERVICES
WILLIAMS	QD	ADMINISTRATIVE OFFICER	CORPORATE SERVICES
BLACK	DE	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
CLAASSEN	D	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MITHA	VR	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
MXATULE	BJ	ADMINISTRATIVE OFFICER	EASTERN CAPE UNIT
REDDERING	JSV	SCIENTIFIC OFFICER	EASTERN CAPE UNIT
AZENE	FZ	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
CHILIZA	SG	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
DIOP	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
FORBES	C	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
GROBLER	JD	ADMINISTRATIVE OFFICER	ENGINEERING GEOSCIENCES
HEATH	GJ	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
MOOTE	GC	ADMINISTRATIVE OFFICER	ENGINEERING GEOSCIENCES
MOTJALE	MI	TECHNICAL OFFICER	ENGINEERING GEOSCIENCES
NGUBELANGA	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
OOSTHUIZEN	AC	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
RICHARDSON	S	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
TEGEGN	K	SCIENTIFIC OFFICER	ENGINEERING GEOSCIENCES
COETZEE	H	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
HANISE	BE	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
KOTOANE	AM	TECHNICAL OFFICER	ENVIRONMENTAL GEOSCIENCES
KWATA	MG	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
LEKOADU	KS	JUNIOR SCIENTIST	ENVIRONMENTAL GEOSCIENCES
MASENYA	BP	ADMINISTRATIVE OFFICER	ENVIRONMENTAL GEOSCIENCES
MOTLAKENG	RT	TECHNICAL OFFICER	ENVIRONMENTAL GEOSCIENCES
PHAJANE	TC	MANAGER ENVIRONMENTAL GEOSCIENCES	ENVIRONMENTAL GEOSCIENCES
VAN TONDER	DM	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
VENTER	JS	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
YIBAS BABSO	B	SCIENTIFIC OFFICER	ENVIRONMENTAL GEOSCIENCES
BREYTENBACH	AF	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
CHAGWIZA	V	ACCOUNTANT	FINANCIAL SERVICES

Surname	Initials	Position	Business Unit
DICHABE	SD	ADMINISTRATIVE OFFICER (S&T OFFICER)	FINANCIAL SERVICES
DINGOKO	MO	SENIOR CREDITORS CLERK	FINANCIAL SERVICES
GOUVERNEUR	M	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
HUGO	JLM	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
LEKWARA	MG	PAYROLL ADMINISTRATOR	FINANCIAL SERVICES
LUBBE	CJ	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
MANDA	M	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MATSEPE	LD	CHIEF FINANCIAL OFFICER	FINANCIAL SERVICES
MOSTERT	JCN	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
MTEKI	AM	MANAGEMENT ACCOUNTANT	FINANCIAL SERVICES
PAWESKA	MD	PROJECT ADMINISTRATOR	FINANCIAL SERVICES
PEENS	WJF	CHIEF ACCOUNTANT	FINANCIAL SERVICES
POWER	S	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
QAYISO	NA	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
SNYMAN	SE	ADMINISTRATIVE OFFICER	FINANCIAL SERVICES
BENSID	ML	SCIENTIFIC OFFICER	GEOCHEMISTRY
ELSENBROEK	JH	SCIENTIFIC OFFICER	GEOCHEMISTRY
HLATSHWAYO	SM	SCIENTIFIC OFFICER	GEOCHEMISTRY
MAHLANGU	MM	TECHNICAL OFFICER	GEOCHEMISTRY
MAYA	M	SCIENTIFIC OFFICER	GEOCHEMISTRY
MOKOATEDI	JK	TECHNICAL OFFICER	GEOCHEMISTRY
MULOVHEDZI	AE	SCIENTIFIC OFFICER	GEOCHEMISTRY
NETSHITUNGULWANA	R	SCIENTIFIC OFFICER	GEOCHEMISTRY
RADEBE	JS	TECHNICAL OFFICER	GEOCHEMISTRY
STRAUSS	SW	SCIENTIFIC OFFICER	GEOCHEMISTRY
VAN DER WALT	DM	SCIENTIFIC OFFICER	GEOCHEMISTRY
CHIRENJE	E	SCIENTIFIC OFFICER	GEOPHYSICS
COLE	P	MANAGER GEOPHYSICS	GEOPHYSICS
COLE	J	SCIENTIFIC OFFICER	GEOPHYSICS
DINGOKO	OW	SCIENTIFIC OFFICER	GEOPHYSICS
EBERLE	DG	SCIENTIFIC OFFICER	GEOPHYSICS
GRAHAM	A	ADMINISTRATIVE OFFICER	GEOPHYSICS
HALLBAUER - ZADOROZHNAYA	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	SCIENTIFIC OFFICER	GEOPHYSICS
MANTSHA	KR	TECHNICAL OFFICER	GEOPHYSICS
MARE	LP	SCIENTIFIC OFFICER	GEOPHYSICS
NEFALE	N	SCIENTIFIC OFFICER	GEOPHYSICS
NYABEZE	PK	SCIENTIFIC OFFICER	GEOPHYSICS
SEKIBA	FMA	TECHNICAL OFFICER	GEOPHYSICS
SETHOBYA	MR	TECHNICAL OFFICER	GEOPHYSICS
STETTLER	RH	TECHNICAL OFFICER	GEOPHYSICS
TESSEMA	A	SCIENTIFIC OFFICER	GEOPHYSICS
BARNARDO	DJ	MANAGER INFORMATION & COLLECTIONS MANAGEMENT	INFORMATION & COLLECTIONS MANAGEMENT
BECKER	A	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
JANSE VAN RENSBURG	MG	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MAKHUBELE	GS	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT

Surname	Initials	Position	Business Unit
MALATSI	PM	GENERAL CLERK	INFORMATION & COLLECTIONS MANAGEMENT
NEL	ZE	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
NONDUDULE	Z	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
VAN ECK	SJ	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
VAN HEERDEN	JA	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
BREYTENBACH	L	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
DE KOCK	EC	SCIENTIFIC OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
KGOALE	MO	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
LEKALAKALA	LR	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MADIBANE	MI	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MAHWAYI	S	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MALOKELA	PS	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MATHEBULA	JS	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MATJEKE	KI	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MOJELA	TP	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
MSIZA	A	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
NKWINIKA	RD	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
RAATH	A	TECHNICAL OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
SWART	TN	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
VAN DER MERWE	L	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
VAN TONDER	EE	ADMINISTRATIVE OFFICER	INFORMATION & COLLECTIONS MANAGEMENT
DOMINGO	EE	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MOGARA	LM	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
MOTAUNG	PD	MANAGER INFORMATION TECHNOLOGY	INFORMATION TECHNOLOGY
MZIMBA	RJ	ADMINISTRATIVE OFFICER	INFORMATION TECHNOLOGY
PHANGISA	TT	TECHNICAL OFFICER	INFORMATION TECHNOLOGY
SMITH	P	BUSINESS TECHNOLOGY CONSULTANT	INFORMATION TECHNOLOGY
BOTHA	GA	MANAGER KWAZULU-NATAL & EASTERN CAPE	KWA-ZULU NATAL UNIT
DLAMINI	P	ADMINISTRATIVE OFFICER	KWA-ZULU NATAL UNIT
HICKS	N	SCIENTIST	KWA-ZULU NATAL UNIT
MPOFANA	B	GENERAL CLERK	KWA-ZULU NATAL UNIT
NGCOBO	LE	GENERAL CLERK	KWA-ZULU NATAL UNIT
SINGH	RG	SCIENTIFIC OFFICER	KWA-ZULU NATAL UNIT
ATANASOVA	MTG	SCIENTIFIC OFFICER	LABORATORY
BURGER	KIG	TECHNICAL OFFICER	LABORATORY
CLOETE	M	MANAGER LABORATORY & GEOCHEMISTRY	LABORATORY
CLOETE	HCC	SCIENTIFIC OFFICER	LABORATORY
CRONWRIGHT	H	SCIENTIFIC OFFICER	LABORATORY
DIKGOMO	SA	TECHNICAL OFFICER	LABORATORY
DLAMINI	NJ	TECHNICAL OFFICER	LABORATORY
DOUCET	FJ	SCIENTIFIC OFFICER	LABORATORY

Surname	Initials	Position	Business Unit
DUBE	KP	ADMINISTRATIVE OFFICER	LABORATORY
FRIEDLAND	J	SCIENTIFIC OFFICER	LABORATORY
JORDAAN	LJ	SCIENTIFIC OFFICER	LABORATORY
KGADITSE	SD	TECHNICAL OFFICER	LABORATORY
KHAZAMULA	TC	TECHNICAL OFFICER	LABORATORY
KHUMALO	S	TECHNICAL OFFICER	LABORATORY
LEHAHA	MT	TECHNICAL OFFICER	LABORATORY
LONG	DJ	SCIENTIST	LABORATORY
MABELA	AD	TECHNICAL OFFICER	LABORATORY
MAEMA	JJ	TECHNICAL OFFICER	LABORATORY
MASHISHI	KE	JUNIOR SCIENTIST	LABORATORY
MATJI	JM	TECHNICAL OFFICER	LABORATORY
MBONANE	TJ	TECHNICAL OFFICER	LABORATORY
MCHUNU	PB	TECHNICAL OFFICER	LABORATORY
MONYAYI	ST	TECHNICAL OFFICER	LABORATORY
MOTSIRI	TS	TECHNICAL OFFICER	LABORATORY
NGAMLANA	SM	TECHNICAL OFFICER	LABORATORY
NKOSI	ME	TECHNICAL OFFICER	LABORATORY
NXOKWANA	NS	JUNIOR SCIENTIST	LABORATORY
PAPO	RM	TECHNICAL OFFICER	LABORATORY
PHAHLANE	I	TECHNICAL OFFICER	LABORATORY
RAMOSHABA	MM	TECHNICAL OFFICER	LABORATORY
SATHEKGE	LL	TECHNICAL OFFICER	LABORATORY
SELLO	RH	TECHNICAL OFFICER	LABORATORY
SEMELANE	LL	TECHNICAL OFFICER	LABORATORY
TSAAGANE	ME	TECHNICAL OFFICER	LABORATORY
VUMA	SM	TECHNICAL OFFICER	LABORATORY
ZONDI	SP	TECHNICAL OFFICER	LABORATORY
BAGLOW	N	MANAGER LIMPOPO BUSINESS UNIT	LIMPOPO BUSINESS UNIT
DHANSAY	TG	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MASHAO	TP	GENERAL CLERK	LIMPOPO BUSINESS UNIT
MNISI	EH	ADMINISTRATIVE OFFICER	LIMPOPO BUSINESS UNIT
MOTHETHA	MV	SCIENTIFIC OFFICER	LIMPOPO BUSINESS UNIT
MUKOSI	NC	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
MUNYANGANE	LP	JUNIOR SCIENTIST	LIMPOPO BUSINESS UNIT
ASHLEY	CCL	ADMINISTRATIVE OFFICER	MANAGEMENT
CELE	ND	PERSONAL ASSISTANT	MANAGEMENT
GRAHAM	G	EXECUTIVE MANAGER SCIENTIFIC SERVICES	MANAGEMENT
MATIMULANE	NW	SECURITY OFFICER	MANAGEMENT
MBEKI	N	BOAD ADMINISTRATOR	MANAGEMENT
MNDAWONI	MJ	MANAGER BUSINESS DEVELOPMENT	MANAGEMENT
MSIZA	JM	SECURITY OFFICER	MANAGEMENT
NKOE	JS	ADMINISTRATIVE OFFICER	MANAGEMENT
PILANE	ME	SECRETARY	MANAGEMENT
RAMAGWEDE	FL	EXECUTIVE MANAGER APPLIED GEOSCIENCES	MANAGEMENT
RAMONTJA	T	CHIEF EXECUTIVE OFFICER	MANAGEMENT
SKHOSANA	MN	ADMINISTRATIVE OFFICER	MANAGEMENT
ZAWADA	PK	EXECUTIVE MANAGER REGIONAL MAPPING	MANAGEMENT
BOTHA	CA	TECHNICAL OFFICER	MARINE GEOSCIENCE
CAWTHRA	HC	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
HOOSAIN	W	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
KUPIDO	W	TECHNICAL OFFICER	MARINE GEOSCIENCE

Surname	Initials	Position	Business Unit
MACHUTCHON	MR	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
VAN ZYL	WF	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
WIGLEY	RA	SCIENTIFIC OFFICER	MARINE GEOSCIENCE
BILLAY	AY	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
EHLERS	DL	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
FOYA	S	MANAGER MINERAL RESOURCES DEVEOPMENT	MINERAL RESOURCES DEVELOPMENT
HAMMOND	NQ	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
KENAN	AO	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
KGWAKGWE	KP	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
KIRSTEIN	LS	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MALAN	NP	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
MAYEKISO	NS	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
MUDAU	T	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
OOSTERHUIS	WR	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
OPPERMAN	R	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
PUTTER	GV	ADMINISTRATIVE OFFICER	MINERAL RESOURCES DEVELOPMENT
SCHALEKAMP	MM	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
SOLOMON	M	TECHNICAL OFFICER	MINERAL RESOURCES DEVELOPMENT
TONGU	EL	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
TSANWANI	M	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
WALEMBA	KMA	SCIENTIFIC OFFICER	MINERAL RESOURCES DEVELOPMENT
GROENEWALD	CA	JUNIOR SCIENTIST	NORTHERN CAPE UNIT
MINNAAR	H	SCIENTIFIC OFFICER	NORTHERN CAPE UNIT
SKEFFERS	CJ	UNIT ADMINISTRATOR	NORTHERN CAPE UNIT
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	ADMINISTRATIVE OFFICER (DRIVER)	PROCUREMENT & LOGISTICS
KUNJU	N	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
MAHLANGU	E	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
MAHLANGU	JZ	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
MAMPURU	LM	SENIOR PROCUREMENT OFFICER	PROCUREMENT & LOGISTICS
MASOGA	ME	GENERAL CLERK	PROCUREMENT & LOGISTICS
NDLELA	CT	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
NEMATANDANI	M	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
PHUSHELA	PSH	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
SMYTHE	MM	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
SNYMAN	J	ADMINISTRATIVE OFFICER	PROCUREMENT & LOGISTICS
STEVENS	R	TECHNICAL OFFICER	PROCUREMENT & LOGISTICS
TJIANE	LC	GENERAL CLERK	PROCUREMENT & LOGISTICS
ZWANE	JJ	ADMINISTRATIVE OFFICER (DRIVER)	PROCUREMENT & LOGISTICS
ADAMOS	P	TECHNICAL OFFICER	SEISMOLOGY
AKROMAH	L	TECHNICAL OFFICER	SEISMOLOGY
BIRCH	DJ	JUNIOR SCIENTIST	SEISMOLOGY
BRANDT	MBC	SCIENTIFIC OFFICER	SEISMOLOGY
BRINK	L	TECHNICAL OFFICER	SEISMOLOGY
CICHOWICZ	A	SCIENTIFIC OFFICER	SEISMOLOGY
DELPORT	FA	TECHNICAL OFFICER	SEISMOLOGY
DUARTE	D	ADMINISTRATIVE OFFICER	SEISMOLOGY
FLINT	NS	PROJECT ADMINISTRATOR	SEISMOLOGY
GROBBELAAR	MRG	MANAGER SEISMOLOGY	SEISMOLOGY
HATTINGH	E	SCIENTIFIC OFFICER	SEISMOLOGY

Surname	Initials	Position	Business Unit
JELE	VM	TECHNICAL OFFICER	SEISMOLOGY
KGASWANE	EM	SCIENTIFIC OFFICER	SEISMOLOGY
KOMETSI	TR	TECHNICAL OFFICER	SEISMOLOGY
MANGONGOLO	TA	SENIOR SCIENTIST	SEISMOLOGY
MIDZI	V	SCIENTIFIC OFFICER	SEISMOLOGY
MOLEA	TT	TECHNICAL OFFICER	SEISMOLOGY
PULE	TG	TECHNICAL OFFICER	SEISMOLOGY
SAUNDERS	I	TECHNICAL OFFICER	SEISMOLOGY
STRASSER	FO	SENIOR SCIENTIST	SEISMOLOGY
TABANE	LR	TECHNICAL OFFICER	SEISMOLOGY
VAN ASWEGEN	G	TECHNICAL OFFICER	SEISMOLOGY
ZULU	BS	JUNIOR SCIENTIST	SEISMOLOGY
BRYNARD	HJ	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
GROBBELAAR	DA	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
KGARI	CS	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
LETSOALO	M	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MAGAGANE	MEM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MAGAGULA	FN	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
MOKONYAMA	ML	UNIT ADMINISTRATOR	SPATIAL DATA MANAGEMENT
MSIZA	P	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
NKOSI	MP	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
NORUKA	S	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
OOSTHUIZEN	BC	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
ROOS	HM	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
SEBAKE	DM	SCIENTIFIC OFFICER	SPATIAL DATA MANAGEMENT
SELLO	MH	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
SMITH	A	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
THOMAS	C	TECHNICAL OFFICER	SPATIAL DATA MANAGEMENT
WILKINSON	KJ	MANAGER SPATIAL DATA MANAGEMENT	SPATIAL DATA MANAGEMENT
KEYSER	N	SCIENTIFIC OFFICER	STRATEGIC PLANNING UNIT
HOGAN	C	JUNIOR SCIENTIST	WATER GEOSCIENCES
JIA	H	SENIOR SCIENTIST	WATER GEOSCIENCES
LENONG	SE	SCIENTIST	WATER GEOSCIENCES
LESHOMO	JT	SCIENTIFIC OFFICER	WATER GEOSCIENCES
LIN	L	CHIEF SCIENTIST	WATER GEOSCIENCES
MAJOLA	KA	SCIENTIFIC OFFICER	WATER GEOSCIENCES
MAKGATE	DM	TECHNICAL OFFICER	WATER GEOSCIENCES
MENGISTU	H	SCIENTIFIC OFFICER	WATER GEOSCIENCES
NETILI	KF	SENIOR SCIENTIST	WATER GEOSCIENCES
RUST	UA	SCIENTIFIC OFFICER	WATER GEOSCIENCES
SAEZE	HA	CHIEF SCIENTIST	WATER GEOSCIENCES
SHABALALA	AN	JUNIOR SCIENTIST	WATER GEOSCIENCES
BROWNING	C	SCIENTIST	WESTERN CAPE UNIT
CHEVALLIER	LP	MANAGER WESTERN CAPE & NORTHERN CAPE	WESTERN CAPE UNIT
COLE	DI	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
DAVIDS	I	TECHNICAL OFFICER	WESTERN CAPE UNIT
DE BEER	CH	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
DE BRUIN	E	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
ENGELBRECHT	J	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
HARTZER	FJ	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
LAMBERT	CW	JUNIOR SCIENTIST	WESTERN CAPE UNIT
MACEY	PH	SCIENTIFIC OFFICER	WESTERN CAPE UNIT

Surname	Initials	Position	Business Unit
MALHERBE	JE	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MOSES	D	ADMINISTRATIVE OFFICER	WESTERN CAPE UNIT
MTHEMBI	P	JUNIOR SCIENTIST	WESTERN CAPE UNIT
MUSEKIWA	C	SCIENTIFIC OFFICER	WESTERN CAPE UNIT
NGCOFE	LDS	SCIENTIFIC 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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