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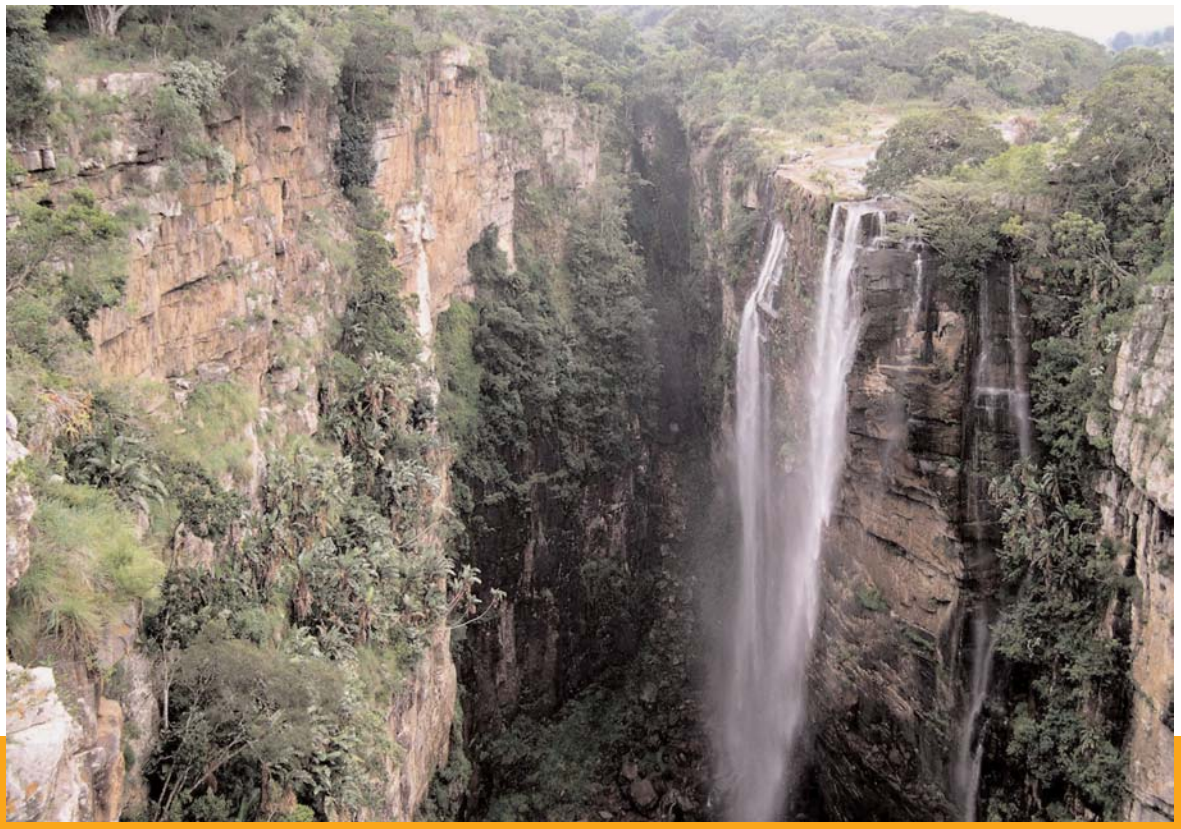

COUNCIL FOR GEOSCIENCE

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The Council for Geoscience is a statutory body established in terms of the Geoscience Act (Act no. 100 of 1993).

Cover: *Msikaba Formation quartzite is exposed in a vertical section at the Magwa Falls, southeast of Lusikisiki. These falls are 154 m high and the second highest in South Africa. The Devonian Msikaba Formation was deposited in the tidal nearshore environment. The vertically sided valley into which the falls discharge may be a gap dyke. Scenic geological features such as these form the basis of the geotourism industry. (Photograph by Koos Reddering.)*

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1. FOREWORD

The Annual Technical Report of the Council for Geoscience (CGS) informs the Council's stakeholders of the research undertaken by the CGS' staff during the past year using the funds apportioned to the CGS by Parliament. Most of the research results reported in this volume result from projects and programmes which have not yet been completed, and the reports essentially reflect work in progress.

It has been the policy of the CGS, as well as of its predecessor the Geological Survey of South Africa, over the past 108 years, to publish all the research and mapping results obtained by the use of State funding. As indicated in this report, all the maps, journals, articles and official publications which have been completed during the past year have been published and made available for public use. Since the basic geoscientific knowledge of a country forms the basis for informed and wise use of mineral, energy and water resources, as well as for the optimal use of the surface space on a fair and equitable basis, it is essential that geoscience information be accessible to all residents of the country. In this volume an overview is given of the diverse geoscientific work in which the CGS is engaged in order to satisfy this basic demand for geoscientific knowledge.

Over the years both the scope and extent of geoscientific research within the CGS have increased considerably to take into consideration the changing needs and concerns of our evolving society, particularly with regard to water supply and public safety. This diversification is more or less in accordance with international trends.

T. Ramontja
Director

2. POVERTY-ALLEVIATION PROGRAMME

Project 0664

WESTERN CAPE MINERAL SECTOR

(D.I. Cole, D.L. Roberts, C.H. de Beer, J.H.A. Viljoen, S. Coles)

Objective:

to produce an inventory of mineral-development opportunities for small-scale mining and poverty alleviation for the Western Cape, including deposits amenable to large-scale mining, by established mining companies, as these operations also provide employment opportunities. Reports on diamonds, glass sand, plastic clay and marble will be compiled. The diamond deposits in the Western Cape have not been completely exploited and those in the surf zone are renewable. Proposed exploration programmes, with costings, for the delineation of economically-viable deposits of onshore diamonds near Doring Bay will be compiled.

Four mineral deposits were identified as having a potential for small-scale mining, and both the geology and an exploration programme, with estimated costs, were compiled for each deposit. The first three deposits are marble on the farm Widouw 309 near Van Rhynsdorp, glass sand on the farm Elandsfontein 349 near Hopefield, and plastic clay on the farms Zouterivier 22 and Klipvlei 28 near Atlantis.

Marble was quarried for dimension stone in the Van Rhynsdorp District for over 70 years until 1996. The main constraints on delineating a viable deposit are the nature and depth of overburden and density of fractures. An exploration programme costing approximately R7,5 million was proposed and, unlike previous operations, future exploitation would include beneficiation of the raw marble blocks into finished products such as polished tiles and kitchen working surfaces.

Glass sand in the Western Cape is currently exploited at Philippi on the Cape Flats but, as the workings are threatened with closure by urban expansion, it is important to locate alternative sources. High-grade quartzose sand was discovered in the Pliocene Varswater Formation on the farm Elandsfontein 349, west of Hopefield, in 1991, but a detailed drilling and sampling programme would be required to determine the quality and reserves of the deposit, and preliminary exploration costs were calculated at R1 million.

Plastic clay has been exploited in the Western Cape for use in the whiteware ceramic industry and as a plasticiser to improve the brick-making qualities of residual clay from the Malmesbury Group shales. Resources are limited, and the demand for plastic clay is high. Preliminary studies indicate the presence of two deposits, on the farms Zouterivier 22 and Klipvlei 28, east of Atlantis, and an exploration programme costing approximately R 0,75 million has been proposed.

The fourth deposit comprises diamondiferous gravel placers in the "A" concession, from the shoreline to 1 km offshore, along a 75-km stretch from Donkin's Bay to Voëlklip. A marine geophysical survey, costing approximately R2 million, is proposed for selected areas in order to delimit reserves of potentially diamondiferous gravels. Subsequently, financial and technical feasibility studies for labour-intensive, small-scale diamond mining in the surf zone can be undertaken. Several potential small-scale miners, including the South African Women's League of Small-Scale Miners, have expressed interest in these projects.

During the year, information in the form of locality, geological and geochemical data was given to MINTEK, in order to assist them with their West Coast Phosphate Project for small-scale mining.

Pit, approximately 5 m deep, exposing light- and dark-coloured plastic clay of Miocene age, east of Atlantis, Western Cape Province. The clay is a lacustrine deposit and is used as a plasticiser for brick making.

Project 0783

ALLUVIAL DIAMOND GRAVELS OF THE NORTH WEST PROVINCE

(M.G.C. Wilson, G. Henry)

Objective:
to assess all available information and produce a research proposal which will lead to small-scale mining opportunities.

This study will form a significant contribution by the CGS toward poverty alleviation and Black Empowerment Enterprises (BEE) in the North West Province, which has significant alluvial diamond deposits. A study of past production by Marshall (1986) estimated that these fields had produced some 14,4 million carats of diamonds between 1904 and 1984, with an estimated value of R 141 600 000 in 1986. For the sake of simplicity, there are four specific fields, namely the Mafikeng–Molopo or northwestern field, the Lichtenburg–Bakerville or northern field, the Ventersdorp–Potchefstroom–Klerksdorp or eastern field and the Christiana–Schweizer-Reneke–Wolmaransstad–Bloemhof or southern field.

Because diamonds are a high-value commodity, they lend themselves to all scales of exploitation and offer the most potential in the province for successful small-scale mining. Freeing of the diamond marketing system has enhanced the potential for successful small- to medium-scale alluvial diamond mining. Over the last five years there has been a noticeable increase in alluvial diamond-mining activities in the province. The new Minerals Act will free additional ground for new entrants over the next few years, so the timing is perfect for the proposed study to be undertaken. It will contribute significantly to the development of additional alluvial diamond mines, by indicating new target areas and assisting current operators by offering a better understanding of the geology and distribution of these deposits. It will also provide a strategic advantage for the CGS by improving its level of knowledge and expertise in this field, which will lead to additional consulting possibilities and make the organisation more relevant to our society and its needs.

The discovery of the Lichtenburg alluvial diamond field in 1926 was the most significant in terms of alluvial diamond production in South Africa, and it dramatically increased the country's and the world's diamond production between 1926 and 1930. The rapid decrease of production from 1930 was largely the result of a dramatic decline in demand caused by the Great Depression. Many viable diggings were forced to close at that time, even though they still had good reserves, and some of these operations may not have been exploited since. Those that did re-open were often forced to cease operations when they reached the water table because of the lack of powerful pumping equipment. There is undoubtedly potential for further production in some of the abandoned operations, especially where they have not reached their most productive gravel horizons which are often the lowest, rest directly on bedrock, are difficult to access, and may require powerful and expensive equipment to reach. In general the diggers exploited the richer, more easily accessible deposits close to surface, leaving the marginal ones.

There is no doubt that there are some deposits in the area still to be discovered. Apart from those along the more obvious palaeoriver channel "runs", many of which form positive topographic features, by far the richest deposits in the Lichtenburg and Ventersdorp fields have been found in potholes or sinkholes within the Transvaal dolomite country rock. These features are not usually on the palaeochannel trends, but offset from them. Limited geophysical test work carried out during the 1970s by the Geological Survey of South Africa revealed that gravity methods were ideally suited to the exploration and location of gravel-filled palaeosinkholes. No doubt further application of this method could locate additional gravel-filled sinkholes. The deposits in the southern fields are of a different nature, as they are underlain by Ventersdorp lavas in which karstic sinkholes do not form.

This assessment revealed that there is a lot of information about these fields within the CGS databases that needs to be compiled into easily accessible and understandable maps, with an explanation. It also revealed that there is much about these deposits and their geological controls that is not yet understood, including the origin of the diamonds and gravels, the sedimentology of the gravels and the structural controls which have affected the distribution of the palaeosinkholes.

3. INTERNATIONAL COLLABORATION

INDIA:

Project 0487

STRATIGRAPHIC CORRELATION BETWEEN THE KAROO SUPERGROUP OF SOUTHERN AFRICA AND THE GONDWANA SUPERGROUP OF INDIA

(D.I. Cole)

Objective:

to produce a detailed correlation on a formation level between the Karoo Supergroup in southern Africa and the Gondwana Sequence in India for the period from the Carboniferous until the Jurassic, and evaluate potential economic deposits, particularly coal.

Six long profiles through the Karoo Supergroup were completed, and 11 composite sections were compiled digitally on Autocad®. Seven of these sections relate to the main Karoo basin and one to each of the Springbok Flats, Ellisras, Tshipise and Tuli basins. The digital profiles were assembled into a fence diagram across the deepest southern portion of the foreland of the main Karoo basin and into a north–south cross-section through the main Karoo, Springbok Flats, Ellisras and Tshipise basins. These diagrams display both lithology and stratigraphy of the Karoo Supergroup.

The oldest sediments are glacial and are Late Carboniferous — about 310 million years old. The main Karoo basin is a retroarc foreland basin that developed by subduction of the Panthalassan (palaeo-Pacific) plate beneath the Gondwana plate. The smaller basins to the north have been interpreted as rift basins, intracratonic thermal sag basins or flexural tectonic basins in the back-bulge setting of the Karoo foreland system. The Ellisras basin is in fact the proximal portion of the extensive Kalahari basin. All the basins are characterised by a mid-Triassic lacuna, which is longer in the northern basins. Renewed sedimentation occurred during Late Triassic–Early Jurassic times as a result of basin subsidence, probably associated with mantle plumes, that signalled the break-up of Gondwana. India has a similar geological history, although a foreland basin is absent. The sedimentary sequence is almost identical, as both regions in Gondwana lay at the same palaeolatitude between Late Carboniferous and Early Jurassic times. The palaeoclimate changed from cold wet conditions to warm arid conditions as Gondwana moved away from the palaeo-South Pole. The sedimentary succession begins with the Late Carboniferous to Early Permian glacial Dwyka Group in South Africa and the Talchir Formation in India. This is followed by the Permian Ecca Group in South Africa which comprises mostly deep-water mudrock in the main Karoo basin, and fluvial-deltaic sandstone and mudrock and lacustrine mudrock in the northern part of the main Karoo basin, Springbok Flats, Ellisras, Tuli and Tshipise basins. The latter successions contain most of South Africa's coalfields and correlate with similar successions in the Indian basins.

As a result of increasing aridity and a shallowing of the basins during the Late Permian, sediment progradation was predominant, accompanied by a change from subaqueous to subaerial deposition and the formation of red-coloured mudrock. This latter lithology is characteristic of the Beaufort Group in South Africa which normally starts with a thin succession of deltaic sediments above the Ecca Group mudrock before becoming dominated by terrestrial sediments. These strata are equivalent to the Raniganj Formation of India.

The Permian–Triassic boundary is marked by the appearance of the fossil reptile *Lystrosaurus* and the deposition of coarse-grained fluvial sediments, the Katberg Formation in the southern Karoo and the Verkykerskop Formation in the northern Karoo basin. In India, similar coarse-grained fluvial sediments containing *Lystrosaurus* form the Panchet Formation. The Beaufort Group is very thin in the northern basins of South Africa and is represented by the Lehau Member in the Springbok Flats basin, the Eendragtpan Formation in the Ellisras basin and the Fripp and Solitude Formations in the Tshipise basin. *Lystrosaurus* has not been found in these basins and the Early Triassic coarse fluvial sediments are missing, the succession being disconformably overlain by Late Triassic, coarse fluvial sediments of the Molteno Formation equivalents.

A Middle Triassic lacuna separates the Beaufort and Stormberg Groups in the main Karoo basin, but in the northern basins this lacuna commences in the Early Triassic. The lacuna represents complete infilling of the basins and was followed by downwarping and deposition of coarse fluvial sediments during the Late Triassic. A similar lacuna is present in India. The coarse-grained fluvial sediments are assigned to the Molteno Formation in the main Karoo basin, the Ntabene Formation in the northeastern part of the main Karoo basin, the Codrington Member in the Springbok Flats basin, the Greenwich Formation in the Ellisras basin, the Klopperfontein Formation in the Tshipise basin and the Mahadeva Formation in India.

Erosion of elevated source areas resulted in less-vigorous sedimentation and the accumulation of flood-plain muds. These are invariably red in colour and form the Elliot Formation in the main Karoo basin, the Nyoka Formation in the northeastern part of the main Karoo basin, the Worthing Member in the Springbok Flats basin, the Lisbon Formation in the Ellisras basin, the Bosbokpoort Formation in the Tshipise basin and the Maleri Formation in India. Increasing aridity led to the widespread deposition of aeolian sediments, which are assigned to the Early Jurassic Clarens Formation in all the South African basins. Sedimentation was terminated by the outpouring of basaltic lavas of the Drakensberg Group and the Letaba Formation. Conversely, for India sedimentation continued in places until the end of the Cretaceous when the Deccan Traps were extruded.

Project 0499

INDO-SOUTH AFRICAN BILATERAL PROJECT NO. 3: "PRECAMBRIAN CRUSTAL EVOLUTION AND METALLOGENY OF PENINSULAR INDIA AND EASTERN SOUTHERN AFRICA"

(S. Frost-Killian, G.S. de Kock, L.G. Wolmarans, W.A. Voors, D. van der Walt, W.R. Oosterhuis)

Objective:

to produce a Precambrian metallogenic and tectonic map of India and eastern Africa.

The project schedule has been revised, with a completion date set for 2005. The project team from South Africa (S. Frost-Killian, G. de Kock and L.G. Wolmarans) visited Hyderabad in India in March 2004 and met with the team members from the GSI (N. Rajendran — GIS and Archaean Geology, S.K. Biswas — Economic Geology and Archaean Crustal Evolution, D. Ganguly — Metallogeny and Tectonics, and M.W. Haque — Economic Geology and Geochemistry). While in Hyderabad, the team met to finalise and sort out technical information for the production of the map. Prior to the visit, revised and updated tectonic information was received from the Geological Survey of India. During the visit, certain discrepancies between the adopted CGMW (Commission for the Geological Map of the World) and existing Indian legends (metallogenic and tectonic) were resolved, including some simplification of the current CGMW Tectonic Map of Africa legend for the purposes of this particular project. All details concerning the GIS (Geographic Information System) (including database structure and methodology for the GIS integration) were discussed and finalised, and a provisional timetable for the six months from March to September 2004 was proposed.

Two field trips to areas of specific metallogenic and tectonic importance in India were undertaken during the visit. The first visit was planned with a view to study some of the known mineralisation in the Dharwar craton and to study the Proterozoic platform rocks of the Cuddapah Supergroup and Kurnool Group. Visits were made to various kimberlite outcrop areas, a couple of exploration camps run by the GSI (Geological Survey of India) and the Hutti Gold Mine in the Hutti greenstone belt.

The second field visit consisted of a field trip across the Eastern Ghat mobile belt. Two cross-sections were studied — the first from Visakhapatnam to Jaypur and the second from Jaypur to Bhubaneswar. Rock types included the Khondalite group of metasupracrustals, the variants of charnockites, mafic granulites, garnetiferous granitic gneisses, nepheline syenite and associated rocks of the of Koraput alkaline complex, and the anorthosite body near Balugaon. The traverses facilitated study of the four tectonic zones of the belt — Western Charnockite, Western Khondalite, Central Migmatite and the Eastern Khondalite Zones, apart from the Baster craton–mobile belt transition zone near Jaypur. To conclude the visit, the team visited the historic Charnock tombstone in Calcutta.

The project is proceeding on schedule, with the Indian team members due to visit the CGS in Pretoria in September–October 2004.

Left: Discussions at the INDIGEO (GSI) offices in Hyderabad.

Left bottom: Tombstone of Job Charnock, the founder of Calcutta, after whom Charnockite is named.

Bottom: The team at Hutti Gold Mine

FRANCE:

Project 5506

SIXTH EUROPEAN FRAMEWORK PROGRAMME
(L. Chevallier)

Objective:
(i) to build partnerships and to participate in European research within the thematic subpriority: Global Change and Ecosystems and (ii) to submit a research proposal on desertification and land use.

A research proposal called DEWAMOS (**D**esertification **E**arly **WA**rning **MO**nitoring **S**ystem) was submitted to FP6 (European Framework programme 6) in December 2003. DEWAMOS is a project dealing with desertification problems, whether caused by climate change or by social and human pressure. The CGS has proposed the Eastern Cape as a study area. The research consortium consists of European partners (France, United Kingdom, Czech Republic) and one African partner (the Council for Geoscience).

NORWAY:

Project 5519

DOLERITE AQUIFER TESTING
(W. Wheeler, L. Chevallier, L. Nhleko, L. Gibson)

Objective:
to compare the fluid transmissivity across dolerite intrusions in the Karoo and dolerite intrusions off Norway.

Norsk Hydro is working in collaboration with the CGS in the Eastern Cape. Field pump tests and injection tests down the exploration holes were organised during September, and a flow-dynamic model has been proposed.

4. INTERNATIONAL METALLOGENIC MAPPING PROGRAMME

Project 0133

INTERNATIONAL METALLOGENIC MAP OF AFRICA

(S. Frost-Killian, W.R. Oosterhuis, R. Smith, W.A. Voors)

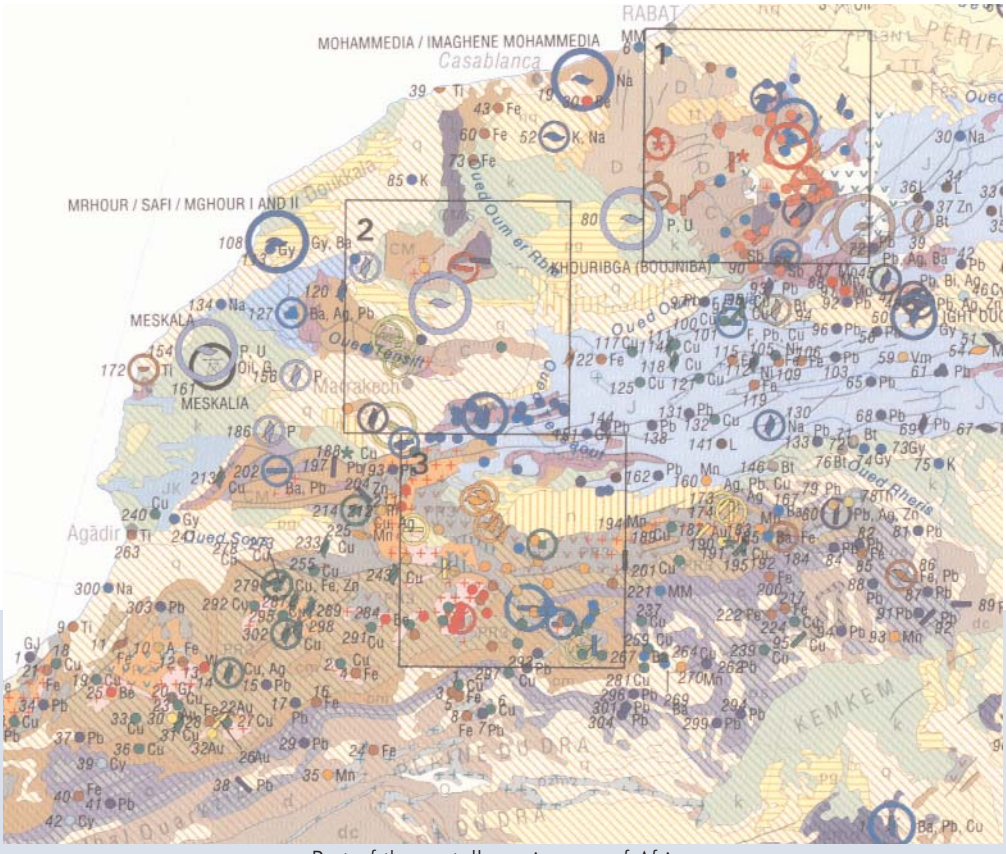
Objective:
(i) to compile a 1:5 000 000-scale Metallogenic Map of Africa, with explanation, and (ii) capture and maintain mineral-deposit data on a "Minerals Map of Africa" database.

The 1:5 000 000-scale International Metallogenic Map of Africa was published in June 2002. Interest in the digital data has been continuous, several $-version CD-ROMS of the Digital Map of Africa having been sold. The $-version was revised throughout the year as feedback was obtained from users. The map has been used as a base for SADC and World Bank projects, by mining houses and consulting companies looking for detailed country-based mineral-deposit and geological information, by import-export companies looking for information on the ownership of current mining operations throughout Africa, and by scholars seeking information for school projects. All the map errors have been identified and the explanatory notes will be published on CD-ROM.

Assistance was given to the OBRGM (L'Office Béninois des Recherches Géologiques et Minières) in the compilation of a Metallogenic Map of Bénin. A copy of the International Metallogenic Map of Africa and the digital data for Bénin have been presented to the director of the OBRGM.

The mineral-deposit data and geology compiled for the International Metallogenic Map of Africa have been integrated to a minor extent, with papers on the map and digital data, as well as on aspects of African mineralisation, presented at conferences in Ghana, Nigeria and Yemen. An article publicising the map was published in Episodes (an IUGS publication) in June 2003.

Maintenance and updating of the Africa mineral database have continued, with various sources of additional data identified for integration during 2004.



Part of the metallogenic map of Africa

5. COLLABORATION WITH SADC COUNTRIES

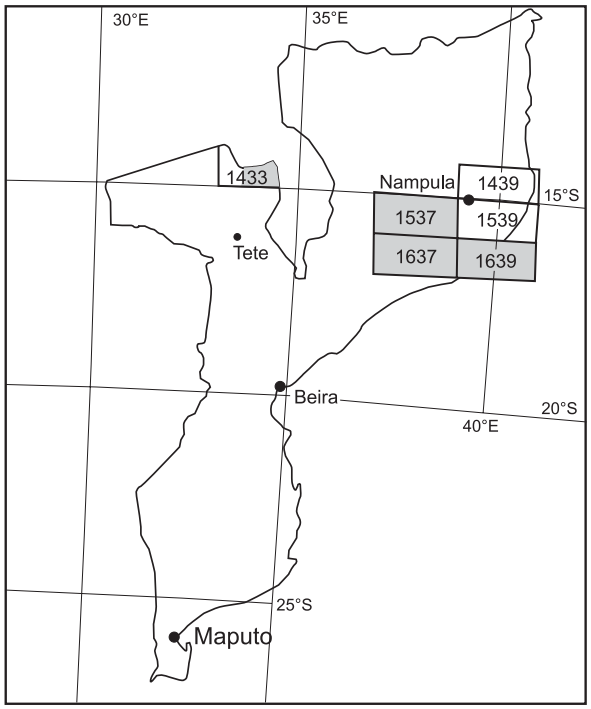
Project 5111

WORLD BANK-FUNDED GEOLOGICAL MAPPING PROJECT IN MOZAMBIQUE

(G.H. Grantham, M.C. Cronwright, B.M. Ingram, P. Macey, R. Opperman, I. Haddon, P.M.W. Botha, G.S. de Kock, L. Gibson, J. Cole)

Objective:
to produce reconnaissance geological maps of thirteen 1x1 1:250 000-scale geological sheets in northern Mozambique, using remote-sensing and geophysical techniques, with field checks.

As part of a World Bank-funded geological mapping project in Mozambique, the CGS has been providing geological mapping services and hands-on training of personnel to the National Geology Directorate of Mozambique. The first phase, now completed, includes data gathering in Maputo and remote-sensing interpretation. Field mapping has been completed for two sheets, and map compilation has started.



The Mozambique mapping project and the areas in which field mapping has been completed (shaded).

Sheet name	Coordinates
1433 Furancongu/Ulongue	14–15°S and 33–35°E
1439 Meconta/Monape	14–15°S and 39–41°E
1537 Alto Molocue/Murrupula	15–16°S and 37–39°E
1539 Nampula/Ilha de Mocambique	15–16°S and 39–41°E
1639 Angoche	16–17°S and 39–41°E
1637 Mulevale/Gile	16-17°S and 37-39°E

Mapping commenced in 2002/2003 when the field work for sheets 1639 Angoche and 1637 Mulevale/Gile was completed. During the current year field work for sheet 1537 Alto Molecue/Murrupula and approximately 50 per cent of sheet 1433 Furancongu/Ulongue were completed. Approximately 200 samples have been analysed for major- and trace-element contents, and approximately 400 samples have been examined in thin section. The data will augment the classification of the lithological units identified and will be supplemented by SHRIMP zircon analysis to determine the ages of the rocks. A number of samples will be analysed for their Rb/Sr and Sm/Nd radiogenic isotope characteristics to gain an understanding of their sources. Researchers from the National Institute of Polar Research in Tokyo, Japan, The University of Bremen, Germany, the Australian National University in Canberra, Australia and the University of Saskatchewan in Saskatoon, Canada, are collaborating in this venture.

Project 5111

WORLD BANK-FUNDED GEOLOGICAL MAPPING PROJECT IN MOZAMBIQUE – ALTO MOLOCUE AREA

(Project leader: G. Grantham, Scientific officer: P.M.W. Botha)

Objective:
to map and report on areas in Mozambique.

Introduction

The lithology consists of equigranular granites, some medium-grained porphyritic granite, pegmatitic dykes and veins, augen-gneiss, quartz-feldspar-biotite gneiss, grey migmatitic biotite gneiss, and schist. Pegmatites were found as dyke-like bodies or as veins in the various lithologies encountered. The pegmatite in the dyke-like bodies consists of quartz and euhedral feldspar, with lesser amounts of muscovite and biotite. Quartz veins were seldom seen, but vein quartz was often seen as float or in pits. Ferricrete was encountered along most traverses.

Posttectonic granitoid rocks

The homogeneous, grey, equigranular granite crops out as small scattered exposures, or large inselbergs, and has a biotite content varying from 5 to as much as 15 per cent; foliation is non-existent or extremely weak. The granite is widespread and intrudes most of the other lithologies.

The medium-grained, pink-grey megacrystic granite has subhedral twinned feldspar phenocrysts, up to 15 mm long, which are generally unaligned, but crystals in the matrix occur sometimes with a slight alignment, accentuated by the alignment of the biotite. The foliation can also be considered to be a magmatic crystallisation fabric which developed in the regional stress field as the magma cooled. The matrix of this megacrystic granite consists of feldspar, quartz and biotite (<10%). This granite could be classified as late syn- to posttectonic.

Pretectonic gneiss

The equigranular feldspar-biotite-quartz gneiss is fine- to medium-grained rock, with a biotite content varying from 5 to 35 per cent and colour varying from light grey to almost melanocratic as a result. The gneisses are texturally and compositionally banded, and are more often than not migmatised; small pegmatitic veins are common.

The banded grey biotite gneiss has a migmatitic character. The leucosomes consist of quartz and feldspar with minute amounts of biotite. The melanosomes comprise biotite with a little quartz and feldspar. Pegmatite veins cut these outcrops in various directions, and at some localities the grey biotite gneiss is intruded by equigranular granite-gneiss, which is in turn intruded by equigranular granite. These intrusions result in the apparent formation of injection migmatites.

Pretectonic granite/gneiss

The equigranular feldspar-quartz-biotite granite-gneiss is homogeneous, light grey, and comprises varying amounts of quartz, feldspar and biotite up to a maximum of 15 per cent. A small number of megacrysts are found in some outcrops. This gneiss shows some areas of migmatisation, which may result from the intrusion of equigranular granite.

The augen gneiss is usually greyish brown to cream and comprises a variable amount of feldspar augen, up to 40 mm long, which vary in their degree of deformation. Some are deformed to almost streaky gneisses with augens stretched into boudins. In some of these gneisses a second generation of megacrysts exhibiting clear twinning can be seen, which could be the result of an intrusion of younger megacrystic granite.

Migmatites are commonly found with the gneissic rocks, some possibly formed by the injection of granitic magma into the gneisses.

Structure

The fabric in the late-tectonic intrusive rocks is a result of the cooling of the magma in a regional stress field. Locally developed ductile deformation is commonly observed in the earlier rocks and can be seen as boudins and pinch-and-swell structures. Disharmonic folding is commonly found in most of the migmatitic rocks in the area. The long axes of the boudins and pinch-and-swell structures are parallel to the dip of the regional fabric. The original fabric is not visible in the deformed and metamorphosed rocks.

Late, small-scale faulting is observed in many of the rocks. The small shear zones are accentuated by leucocratic minerals, including small-scale quartz veining. The faulting is usually dextral. These shears are possibly of Pan-African age.

As far as the progress of the project is concerned, all the map descriptions for the Alto Molocue area have been completed.

Project 0413

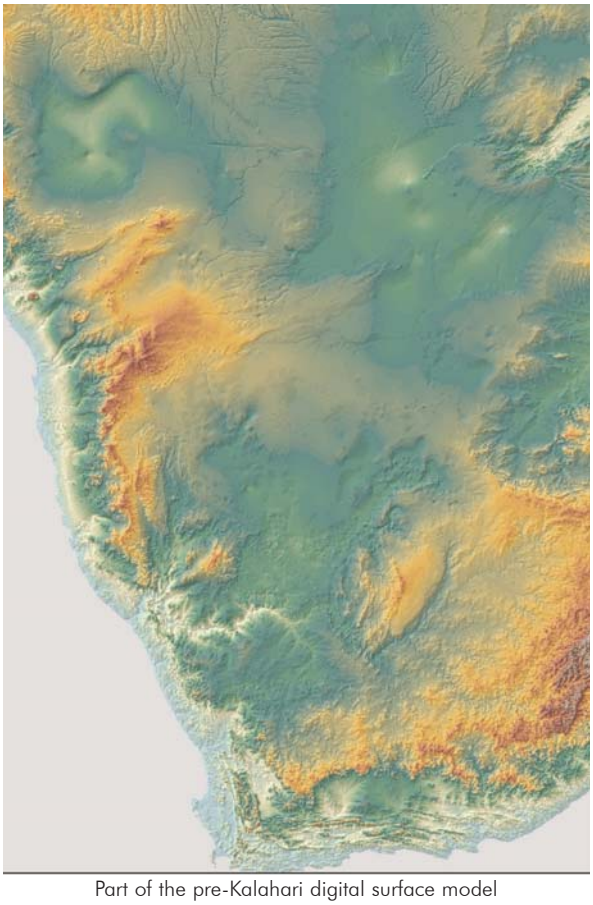
THE STRATIGRAPHY, PALAEOCLIMATE, DRAINAGE AND TECTONIC DEVELOPMENT OF THE KALAHARI BASIN

(I.G. Haddon)

Objective:
to synthesise available information on Kalahari basin evolution and publish the findings and ideas.

While much research has been done on the Kalahari Group in the last one hundred years, insufficient attention has been paid to understanding the tectonic evolution of the region in general and the development of the Kalahari basin in particular. An understanding of the geology of the Kalahari basin, as well as the sub-Kalahari geology and structure, is vital to the understanding of the geology and geomorphology of southern Africa, as Kalahari Group sedimentary rocks cover large portions of seven southern African countries, stretching from South Africa in the south, northward through Botswana, and up into Angola.

The Southern African Development Community (SADC) Kalahari Working Group decided in 1995 that, as a matter of priority, maps showing the thickness of Kalahari



Part of the pre-Kalahari digital surface model

Group sedimentary rocks, as well as the distribution and nature of the geological units beneath the Kalahari Group rocks, be produced for the SADC region. Following the preparation of these two maps, it was decided that further research should be conducted on the Kalahari Group and its depositional basin in order to identify the sequence of tectonic and climatic events that influenced its formation and evolution. The production of a map showing the thicknesses of the basal gravels of the Kalahari Group in South Africa was attempted in order to delimit the main palaeochannels, as these are not only important in understanding basin evolution but also have economic significance in exploration for diamonds and water.

The large size of the area covered and the complexity of the geology are not conducive to all aspects of the Kalahari basin being covered in equal detail, but an attempt has been made to describe the sub-Kalahari geology, as well as the Kalahari Group stratigraphy, and to identify those factors which played an important part in basin evolution. A brief chapter on the mineral potential of the area is included in order to illustrate the potential of the region for mineral exploration.

Scientific editing of the manuscript was undertaken by M.R. Johnson, G.S. de Kock and Professor T.S. McCarthy (EGRI, University of the Witwatersrand), and several changes have been made. The development of a sub-Kalahari topographical surface has been an important addition to the project. This has involved subtracting the Kalahari Group thickness from the Digital Elevation Model (DEM) of southern Africa in order to see the topographical surface underlying the Kalahari Group rocks. Apart from some minor additions to the discussion, this manuscript is complete.

Project 0380

1:2 500 000-SCALE GEOLOGICAL MAP OF THE SADC REGION

(F.J. Hartzer, P.J.A. Bosch, Representatives of geological surveys of SADC countries)

Objective:
to improve collaboration between workers in the geological sciences and mining across political borders by the production of a 1:2 500 000-scale geological map of the region.

A 1:2 500 000-scale geological map of the SADC countries was compiled from existing 1:1 000 000-scale geological maps to improve collaboration of geological sciences and mining across political borders. The most recent geological map of Tanzania, on a scale of 1:1 200 000, was published in 1959, so an updated 1:1 000 000-scale map of the country was compiled from published and unpublished maps with the aid of the GIS. The legend will be finalised in consultation with the Geological Survey of Tanzania and personnel of the University of Dar-es-Salaam.

The 1:1 000 000-scale geological map shows the various metamorphic terranes of the Mozambique, Ubendian and Usugaran belts. It also shows subdivisions of the Bukoban, Karagwe-Ankolean and Karoo Supergroups, and the lithologies of the Tanzania shield, the Dodoman Supergroup, Nyanzian greenstones, Cretaceous and Jurassic deposits, and the Konse Supergroup. The lithologies and relative ages of the Neogene volcanism (associated with the Great African Rift valley) and the various Quaternary deposits are also differentiated.

Geological mapping has been completed and the Spatial Data Management unit has commenced processing the maps.

6. COLLABORATION WITH GOVERNMENT DEPARTMENTS, RESEARCH INSTITUTES AND OTHER ORGANISATIONS

The CGS cooperated with other science councils and the Department of Minerals and Energy (DME) on two minerals projects in the Eastern Cape, initially identified in 2002 for inclusion in the poverty-alleviation programme. These projects, under the auspices of the National Steering Committee of Service Providers to the Small-Scale Mining Sector (NSC), involved a coal-extraction and brick-making initiative in the Indwe–Dordrecht area and an investigation into the viability of mining the travertine deposit in the Port St Johns area.

Having expert local knowledge of the kaolin deposits and industry in the Grahamstown region, a CGS representative serves on the Makana Council Housing and Industrial Development Working Group. The intention is to develop the Makana Ceramic Park, with products unique to the Grahamstown region, and to avoid sterilisation of the clay reserves by housing developments.

Review of a waste-site investigation for Humansdorp was conducted for the Department of Water Affairs and Forestry (DWAF). Advice on the geology of the areas around the Port Elizabeth and Grahamstown waste sites was also given. Ad hoc advice to DWAF on geological conditions for borehole-drilling purposes was also provided. Advice on groundwater and location of potential high-yielding boreholes, based on a sound understanding of local geology, was given to various emerging farming groups under guidance from the Department of Agriculture. Similar advice was also provided in answer to public enquiries from the area between George–Fort Beaufort–East London and toward Port St Johns. An investigation of the groundwater potential of the Table Mountain Group was undertaken with the Western Cape Unit and the University of the Western Cape. The Eastern and Western Cape Units also collaborated in preparing International Best Practice and Quality Assurance Manuals for geological research in the region, a first step towards ISO grading.

7. REGIONAL MAPPING

7.1 GEOLOGICAL MAPPING AND RESEARCH PROGRAMME

Objective:
The objective of the geological mapping programme is to produce a series of geological maps of the country, on suitable scales, together with a series of explanations.

7.1.1 1:250 000-SCALE MAPS

Objective:
to produce a series of detailed 1:250 000-scale lithostratigraphic maps covering the whole of South Africa, together with a set of accompanying explanations. In general, each sheet covers an area of 2 by 1.

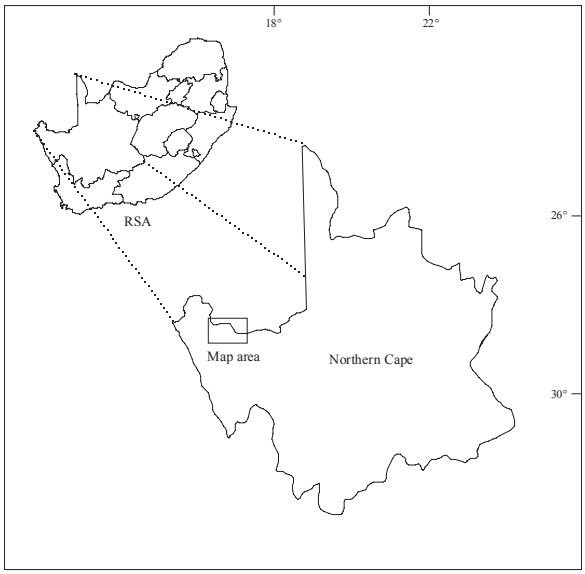
Project 0378

2816 ALEXANDER BAY
(H. Minnaar (Vioolsdrif area), P.M.W. Botha (Kuboos Pluton))

Mapping of the 1:50 000-scale sheets 2817DA (Noordoewer), 2817DC (Vioolsdrif) and 2817DD (Nous) is complete and a report is in progress. The mapping and reports for portions of sheets 2816DB Rooibank, 2816BD Khubus, 2817AC Vandersterrberg and 2817CA Sabiesies (the Kuboos pluton area) are complete, but some geochemical and petrological analysis, as well as the compilation, is still outstanding.

Introduction

The Proterozoic Orange River Group and Vioolsdrif Suite have been investigated in areas adjacent to the current study area by De Villiers and Söhnge (1959), Beukes (1973), Blignault (1977) and Ritter (1980). Reid (1977) concentrated on geochemistry and isotope dating, and the Neoproterozoic Nama Group was described by Germs (1972).



Location of map area

Lithology

The area is dominated by three major rock units:

1. The Orange River Group (2 Ga), metavolcanics of andesitic to rhyolitic composition.
2. The Vioolsdrif Suite (2–1,8 Ga), a granitic batholith which intrudes the Orange River Group.
3. The Nama Group (600–530 Ma), which rests unconformably on the older units and consists of sedimentary rocks deposited in a peripheral foreland basin between the Kalahari craton and the Damara and Gariep orogenic belts during the Neoproterozoic (Germs and Gresse, 1991).

The northeast-striking Gannakouriep dyke swarm, which intrudes the Orange River Group and the Vioolsdrif Suite, but is overlain by the Nama Group, is also prominent in the area.

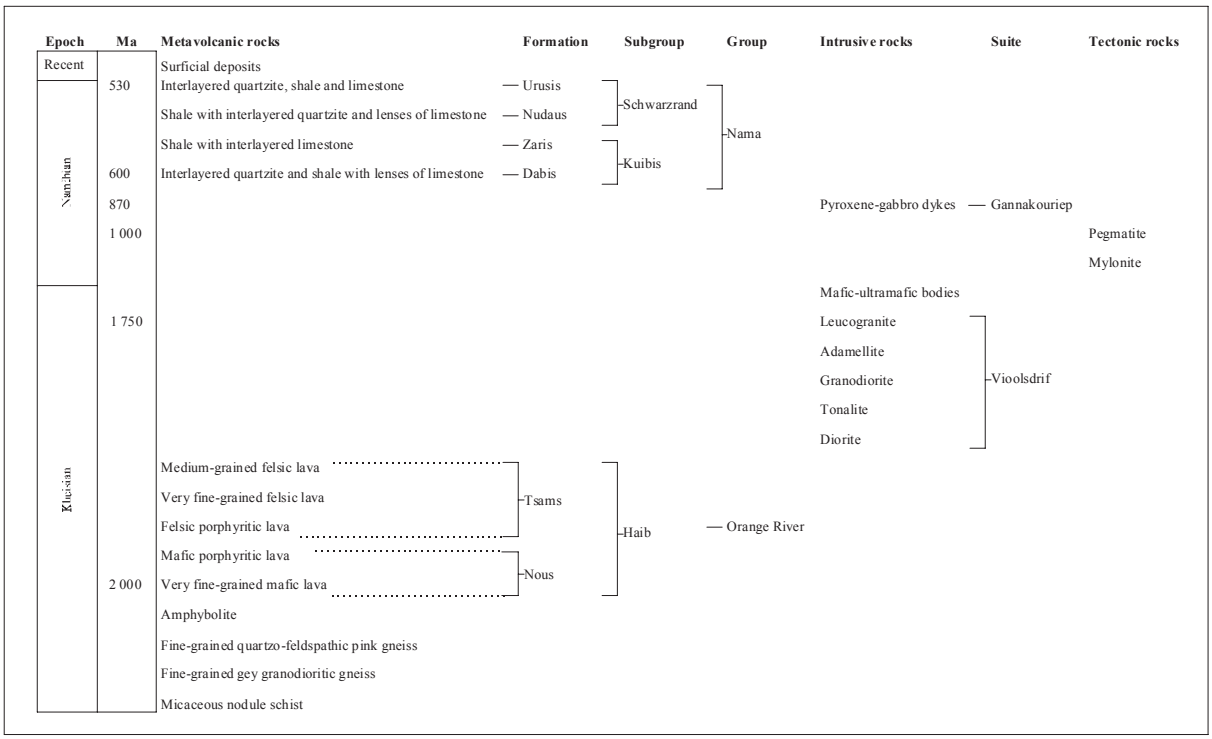
Metavolcanic and metasedimentary rocks

Micaceous-nodule schist occurs in the extreme southeast where the Namaqualand Metamorphic Complex disappears under the Nama Group. A transitional relationship between this schist and the granodiorites of the Vioolsdrif Suite is apparent in some places where the granodiorites sometimes display a nodular character, and inclusions have also been observed in the nodular gneiss. These observations suggest a possible origin for the nodular gneiss unit where the Vioolsdrif magma was not able to fully assimilate the rock unit into which it intruded.

To the South, a grey-weathering, fine-grained (1–2 mm) granodioritic grey gneiss is intruded by the Vioolsdrif granitoids, and frequently occurs as inclusions in the granodiorite of the Vioolsdrif Suite. Sharp, cross-cutting contacts between the two rock types are numerous. The grey gneiss has a granodioritic composition, but is distinguishable from the Vioolsdrif granodiorite by its fine grain size and grey-weathering colour, in contrast to the course grain and brown colour of the Vioolsdrif Suite.

Fine-grained, pink-weathering gneiss occurs interlayered in the grey gneiss unit in the southwest. The contact between the two is largely obscured by regionally developed intense foliation, but generally appears to be gradational over narrow widths (less than a metre). In areas where the pink gneiss is associated with large-scale pegmatite development, it has an unusually high muscovite content. Lenses of amphibolite, up to 50 by 10 m, occur in the extreme southeast within the nodule schist unit. Contacts between the two rock units are concordant.

The Haib Subgroup of the Orange River Group is divided into the mafic Nous Formation and the felsic Tsams Formation. Two rock types can be distinguished in the Nous Formation, a mafic lava and a mafic schist, which



The stratigraphy of the map area

represents the highly foliated equivalent of the lava. The lava is very fine to fine grained (<0,1–1 mm). The fresh rock is green grey and weathers to a rust brown, dark grey or black, often with a glossy black desert varnish. The unit often contains lenses of felsic lava. A characteristic of the mafic lava unit is the occasional occurrence of vesicular quartz, interpreted as amygdales. Parallel layering, 5 mm thick, can be observed in places. Close to the contact with the granitoids of the Vioolsdrif batholith, the mafic lava unit has been deformed into schist, ascribed to the intrusion of the Vioolsdrif batholith.

The felsic lava of the Tsams Formation weathers to a creamy colour. The fresh rock is grey and grain size varies from very fine to medium, but it can also be porphyritic. Volcanic breccia is locally developed in the felsic lava sequence.

The sporadically developed Uilkraal Member and overlying Nigramoep Member of the Dabis Formation form the base of the Nama Group in the area. The Uilkraal Member is a conglomerate of well- to poorly rounded clasts, up to 60 cm in diameter, and is succeeded by the Nigramoep Member (predominantly quartzite with interlayered shale) and Plaatjiesfontein Member (predominantly shale with interlayered quartzite). The overlying Zaris Formation is divided into the Mooifontein* and Urikos Members, and comprises shale with a layer of limestone.

The Nudaus Formation comprises the Niederhagen Quartzite and Vingerbreek* Members, and consists of shale with interlayered quartzite and lenses of limestone near the base. The Nasep Quartzite Member (interlayered shale, quartzite and limestone) forms the base of the Urusis Formation, while the prominent Huns Limestone Member terminates the Nama Group in the area.

Intrusive rocks

The Vioolsdrif batholith consists of five plutons which follow a calc-alkaline trend from diorite through tonalite, granodiorite and adamellite to leucogranite (Reid, 1977). The diorite is the oldest intrusive, and is intruded by irregular dykes and veins of tonalite, granodiorite and leucogranite. The tonalite and granodiorite are difficult to distinguish in the field as they have similar weathering colours and patterns. Inclusions of country rock characterise both rock types, suggesting that intrusion of these magmas was achieved, at least in part, by stoping. In contrast, the adamellite and leucogranite contain almost no inclusions. The adamellite plutons are irregular bodies from which apophyses typically protrude into the country rock. The pink-weathering leucogranite cuts across the older members of the Vioolsdrif Suite and the Haib Subgroup, as well as across contacts between these rock types.

Localised mafic-ultramafic sheets of gabbro, peridotite, pyroxenite and troctolite occur throughout the Vioolsdrif Suite. Gabbro is the most abundant, and most of its original clinopyroxene has been replaced by actinolite, which is especially abundant, and chlorite and epidote. Peridotite occurs as massive, serpentinised brown-weathering bodies, and pyroxenite commonly grades into gabbro. Troctolite was encountered only at Swartkop, 20 km south of Vioolsdrif.

* not yet approved by SACS

The Gannakouriep Suite

The Gannakouriep Suite is a swarm of dark-brown or deep red-brown-weathering metagabbro dykes striking north-northeast. The fresh rock is dark grey, generally medium grained (1–3 mm), massive and exhibits an onion-skin weathering pattern with boulders up to 50 cm in diameter.

Structure

In the south the influence of the Namaqua orogeny is evident in a regionally developed intense foliation affecting all rock types. Mylonite is developed in zones of intense shearing, and generally occurs as lenses up to 50 m in length. The Pegmatite belt of the Northern Cape transects the map area in the southern parts; pegmatites also occur in the rest of the area and are especially associated with the mafic-ultramafic bodies. The size and shape of individual pegmatites vary, dimensions ranging from a few centimetres to 3 km in length.

In the north, most of the area is unaffected by the Namaqua orogeny and only rocks of the Orange River Group display intense foliation, which is attributed to the intrusion of the Vioolsdrif Suite. The granitoids of the Vioolsdrif Suite itself are either unfoliated or weakly foliated, except in locally developed shear zones.

The boundary between the two structurally contrasting areas is transitional, but in the southeastern and southwestern parts of the map area the two structurally contrasting regions are brought into sharp juxtaposition by displacement along shear zones.

Kuboos pluton

A geophysical investigation of the Kuboos pluton is complete, and economic deposits associated with the pluton are being investigated for the possibility of development of small-scale mining operations. The Kuboos pluton was described as a batholith by Van Biljon (1939), and more detailed mapping was done by Söhnge *et al.* (1948) and Middlemost (1964 and 1965). Most of the work done on the Bremen Line of intrusive rocks was carried out in Namibia (Frimmel *et al.*, 1996a; Killick *et al.*, 1980; Reid, 1991; Smithies, 1992 and Smithies *et al.*, 1996).

Granite and silica-oversaturated syenite dominate the pluton, which intrudes low-grade metamorphic and highly tectonised metasedimentary rocks of the Pan-African Gariep Belt. The bulk of the pluton comprises porphyritic granite surrounding a core of syenite, and medium-grained granite. U-Pb age determinations by Frimmel (2000) put the age of the youngest intrusive phase at 507±6 Ma.

The sequence of emplacement of the Kuboos pluton, according to Söhnge and De Villiers (1948), is as follows.

(1) Elliptical stock of medium- to fine-grained granite; probably accompanied by aplite dykes.
(2) Smaller body (stock) of coarse syenite centrally intruded into (1)
(3) Shell of granite-porphyry and aplogranite as a chilled marginal/roof facies of (4)
(4) Discordant, funnel-shaped intrusion of coarse porphyritic granite
(5) Bostonite, granite-porphyry, aplite and two varieties of lamprophyre dykes.

Medium-grained granite

The equigranular, reddish medium-grained granite forms a stock in the southeastern sector of the Kuboos pluton with a central core of syenite. Green to olive-brown biotite is found as scattered flakes throughout the body, and is often accompanied by black ore minerals. A striking feature of the granite is the abundance of partly-digested xenoliths in most of the outcrops, ranging from schist, limestone and quartz diorite to arenaceous beds of the surrounding strata.

Syenite

Syenite forms the crest of the Goariep mountain block, and pegmatitic varieties form rims around xenolithic masses of mafic rocks, fine-grained quartz syenite and granite, or occupy joints in the latter. Evidence suggests that portions of the syenite formed as metasomatic replacement of the medium-grained granite and not by bodily injections. Supporting this is the fact that xenoliths found in the granite are also found in the syenite.

Granite-porphyry and aplogranite

The granite-porphyry and aplogranite are poorly exposed. The pale pinkish-grey granite-porphyry displays 1–3-cm-long phenocrysts of microcline in an even-grained groundmass of quartz, microcline-microperthite, zoned oligoclase and biotite, and grades into a fine-grained aplogranite.

Coarse porphyritic granite

The coarse porphyritic granite is by far the largest unit of the Kuboos pluton. The phenocryst size varies throughout the pluton and can be a result of depth of emplacement, as well as distance from the various contacts, and ranges between very coarse (~ 5 cm) to medium (~1,5 cm). All the porphyritic granites are grouped together, regardless of the size of the phenocrysts.

Dyke rocks

The Kuboos pluton is intruded by a dyke swarm striking N60°W which includes biotite-free and biotite-bearing lamprophyre, bostonite, granite-porphyry and aplite dykes, and fills strongly developed vertical joints in the pluton. Flat or moderately-inclined joints are less regular and are difficult to distinguish from fractures formed by exfoliation. According to Söhnge and De Villiers several major faults are cut off by the younger Kuboos pluton. These faults trend on average N10°W.

Geophysical investigation of the Kuboos pluton

A coarse 3-D model of the Kuboos pluton was constructed using software developed by the USGS. The

model consists of four bodies, the first two bordering the northern side of the third somewhat less-magnetic body. A fault separates bodies one and two. Body three represents the fine- to medium-grained granites. Bodies one and two correlate with the porphyritic granite, which forms a shell around roughly three-quarters of the pluton. The fourth can be explained as a second intrusion into the pluton.

Economic deposits

Small-scale mining activities are relatively common in the area. Some pegmatites offer economic mining opportunities and of these some are currently being exploited, mainly for feldspar and mica which are currently mined at Swartkop and Kokerboomrand.

The Nous Formation hosts a number of scheelite deposits that were mined from the 1930s to the 1960s, when this mineral was a valuable source of tungsten, but these workings have been abandoned. The mineralisation occurs in quartz-tourmaline veins occupying shear-propagated tension fractures.

Dimension stone is mined at two localities, at Boesmanskop close to Vioolsdrif, where "picture stone" is mined from a siltstone horizon in the Nama Group, and approximately 30 km south of Vioolsdrif, where a serpentinite (bowenite) is mined as "greenstone" and exported, mainly to Italy.

Project 0023

3017 GARIES
(C.H. de Beer)

Mapping on a scale of 1:50 000 has been completed, and the 1:250 000-scale map has been compiled and submitted to the Spatial Data Management Unit for processing. A contribution was made to a chapter on Tertiary igneous activity in a textbook on South African geology (W.J. Verwoerd co-author).

Project 0257

3218 CLANWILLIAM
(J.H.A. Viljoen, C.H. de Beer, D.L. Roberts, P.H. Macey)

A literature study has been conducted, and the revision of the Witteberg Group on the 1:50 000-scale sheets 3219AD Grootberg, 3219BC Elandsvlei, 3219DA Tulpfontein and 3219DC Groenfontein was completed, as well as sheets 3217DB/DD Vredenburg and 3218CA/CC Velddrif. The 1:50 000-scale maps 3219DC and 3219DA, which formed part of a groundwater research project of the Department of Water Affairs and Forestry, were completed. Boreholes drilled by the Department of Water Affairs and Forestry were logged as part of the project. Reports on the mapping of all the sheets were completed.

7.1.2 1:50 000-SCALE MAP SERIES

Objective:
This series of projects is aimed at producing a series of detailed 1:50 000-scale geological maps with accompanying explanations to provide a base for the 1:50 000-scale geotechnical map series. Priority is generally given to areas of rapid urban development in order to assist in the planning and development of townships.

Project 0371

ALEXANDRIA–GRAHAMSTOWN–BATHURST–PORT ALFRED REGION OF THE FISH RIVER SPATIAL DEVELOPMENT INITIATIVE

(M.L. Goedhart, M.H. Rohwer, L.B. Majokweni)

The region from Springmount, on the eastern margin of the Algoa basin, to the Fish River in the Ciskei, and inland to Grahamstown has been mapped on a scale of 1:50 000. The six map sheets are: 3326CA Springmount, 3326CB and CD Alexandria, 3326DA and DC Boesmansriviermond, 3326DB Port Alfred, 3326BC Grahamstown and 3326BD Trappes Valley. Additional mapping has been completed on five surrounding sheets, to match up the geology along sheet edges. These are 3327CA Great Fish Point, 3327AC Prudhoe, 3326AD Salem, 3326BA Fort Brown and 3326BB Breakfast Vlei. All of the towns in the map area were mapped on a scale of 1:10 000 (22 sheets).

The mapping was conducted to clarify the structure and stratigraphy of the Palaeozoic rocks, map the margin of the Cretaceous basin, and define the extensive coastal Cenozoic cover. The intention was to stimulate interest in the mineral potential of the southern end of the Fish River SDI region (for example, the kaolin at Grahamstown), provide a basis for geotechnical investigations at development nodes, and to assist in meeting groundwater requirements for agriculture and local communities. The project complements the geological mapping of the Buffalo City area to the northeast of the Fish River SDI.

Important findings are: (a) field evidence for neotectonics in the Cretaceous Algoa basin, (b) delineation of the buried eastern margin to the Algoa basin which improves the tectonic understanding of the region for oil exploration, as well as providing potential groundwater targets for the town of Alexandria and the Greater Addo National Park, (c) updated distribution of Cenozoic sediments in the Alexandria area, (d) new correlations between the Alexandria, Martindale and Bathurst Formations, and (e) identification of several new structures in the underlying Palaeozoic rocks, including possible wedging in the Bushmans River, and backthrusting in the Karoo foreland basin. The mapping is almost complete, and the reports are in progress.

Project 0605

2528CD RIETVLEI DAM

(B.A. Ingram, M. Britz, H. Minnaar)

The area covered by Sheet 2528CD Rietvlei Dam is mainly underlain by sedimentary rocks of the Transvaal Supergroup, intruded by diabase sills and outliers of the Karoo Supergroup deposits. Displacement and duplication of the Transvaal strata by faults are greatest to the east and southeast of Pretoria, where the regional strike parallels the edge of the Johannesburg dome. Small-scale, symmetrical and gentle to open folding is largely restricted to the Timeball Hill Formation. A southwesterly verging thrust fault duplicated most of the upper Malmani Subgroup and lower Pretoria Group rocks in the southwestern portion of the map.

Four dolomite compartments, delineated by intrusive dykes, occur in the study area. Increased groundwater exploitation has resulted in a considerable lowering of the water table of the Rietvlei compartment which will ultimately lead to accelerated karst formation in the dolomite beds. This is already apparent as 27 new sinkholes have been identified in the Rietvlei and Witkoppies compartments. The map and explanation have been technically edited.

Project 0608

2627BD LENASIA AND 2628AC ALBERTON

(G.S. de Kock, P.J. Bosch, M.J. Cronwright)

A literature study of the Lenasia and Alberton areas revealed interesting ideas on the tectonic evolution of the terrane. Published data on the lavas of the Klipriviersberg Group and the thesis of Wyatt (1976) were examined to obtain a more comprehensive lithological description of the textures and volcanic features, this being the type area of the Klipriviersberg Group. Much attention was given to the geochemical data provided in the thesis and to those available in international publications on the lavas.

Lithostratigraphic descriptions by staff of the University of the Free State, the Secretary of SACS and the team members resulted in a formal three-fold classification for the five-unit Alberton Formation. The Glen Vista* Member includes the upper Porphyritic Basalt and underlying Porphyritic Basalt Marker, the middle Amygdaloidal Basalt will be named the Bassonia* Member, and the underlying Massive Basalt and lowermost Porphyritic Basalt will define the Glenanda* Member.

The green phyllitic unit at the base of the Rooihoogte Formation was analysed and consists mainly of sericite (99%). Chemically it contains SiO_2 (45%), Al_2O_3 (36%) and K_2O (10%). This is similar to units occurring between the Ventersdorp Supergroup and the base of the Black Reef Formation of the Transvaal Supergroup, and may represent a palaeosol.

* not yet approved by SACS

Project 0702

2628AA JOHANNESBURG
(R. Opperman)

The draft Johannesburg geological map had some serious defects relating to the geology and the legend. It was found that the northernmost granite on the Johannesburg geological map area, although fitting perfectly, was not the same granite as that on the area of the adjoining geological map to the north. Comparing the 1:50 000-scale map with the 1:250 000-scale geological map, it was found that one variant of the granites was not shown on either of the maps. In liaison with C.R. Anhaeusser it was agreed that the missing granite could be considered to be a transitional zone and the contact was redrawn to comply with the legends of both maps. Differing levels of mapping detail resulted in problems in matching the geology of the Johannesburg sheet with that of the adjoining map to the east. Alterations are reflected on the new version and the legend was corrected.

Problems with the coding and with the different geological units were also encountered. Some polygons on the Johannesburg geological map were found to be incorrectly coded. The name Halfway House Granite was discarded, as new isotope dates for the granites which had become available shortly after the Johannesburg map was completed showed too large a range for the granites to be included in the same lithostratigraphic unit. Some of the outcrops were also found to be wrongly positioned, and older field maps were used to correct these positions. Additional data which had not previously been used, including borehole data and index map, were included. The map is being redrawn.

A bibliography which summarises geological articles, as well as geotechnical reports that were found on the SAGEOLIT and ENGEODE databases of the CGS, was prepared to accompany the map. A map showing the locations of the ENGEODE engineering reports was also created. The format of the bibliography has been changed to improve the layout and to avoid potential copyright problems. The bibliography was completed in May.

Project 0726

2926BA SANNASPOS
(I.G. Haddon)

This project forms part of the mapping of metropolitan areas surrounding Bloemfontein, undertaken in response to a need for higher-resolution maps of the area to obviate the sterilisation of deposits by urban development The maps and explanations are used by provincial and national government bodies for decision making and planning, the mining industry, town and regional planners, developers seeking to avoid risk areas and by the applied-geology units of the CGS. Mapping was undertaken on a 1:10 000 scale, to be compiled and published as 1:50 000-scale sheets, indicating outcrop and suboutcrop regions, accompanied by an explanation.

Sedimentary rocks of the Late Permian Adelaide Subgroup of the Karoo Supergroup underlie the sheet area. These rocks have been intruded by dykes and sills of Jurassic dolerite. Most of the rocks in the area are covered by soil, colluvium and to a small extent alluvium. Economically the area is unimportant from a mining viewpoint, as no significant mineral deposits have been found in the area.

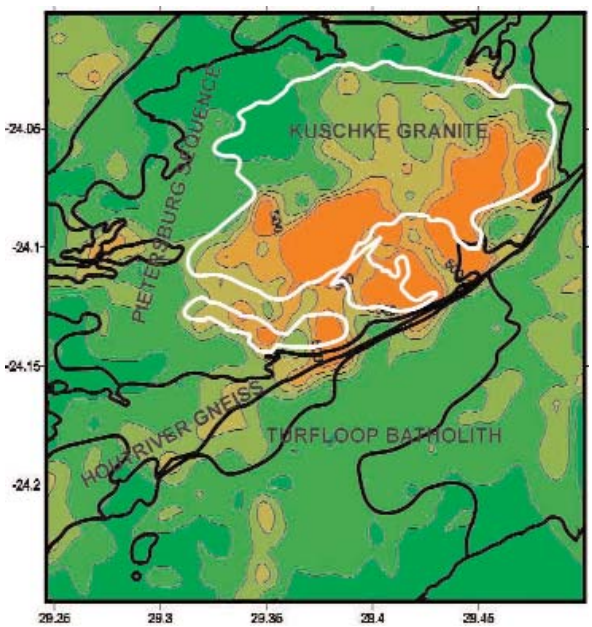
The mapping is complete, the map has been redraughted onto a stable base, and overlays have been made of fossil localities and quarry locations. The explanation is three quarters complete and the stratigraphic profiles have been draughted from the field notes; fossils have been identified. Work still needs to be done on the outcrop and thin-section descriptions, and geochemical analysis of dolerites and shales must be carried out.

Project 0755

2429AB NEW SMITSDORP
(M. Dippenaar, G. Brandl, N. Baglow)

The New Smitsdorp sheet area is underlain by the Swazian Pietersburg Group, which was intruded by the Hout River Gneiss, the Turfloop Granite, the Meinhardtskraal Granite, and the newly named Kuschke Granite*. These basement rocks are overlain by Wolkberg Group, Black Reef Formation and Malmani Subgroup sediments of the Transvaal Supergroup in the southeastern corner of the sheet area.

The Pietersburg Group occurs in an arc occupying the northern half of the sheet area, and comprises metalava and amphibolite of the basal Mothiba Formation, overlain by banded ironstone, ferruginous shale, and subordinate



Delineation of the Kuschke Granite based on regional geochemical data (Sr).

* not yet approved by SACS.

metavolcanics of the Eersteling Formation, with the clastic terrigenous sediments of the Uitkyk Formation at the top. The contact between the two lower units and the Uitkyk Formation is discordant, the Uitkyk Formation having been overthrust onto the Mothiba and Eersteling Formations.

The Hout River Gneiss occurs along the southern sheared margin of the greenstone belt, as well as in the northwestern corner of the sheet area where the Ysterberg fault separates the gneiss from the greenstone. The Turfloop batholith (2 778 Ma) intruded between the greenstone belt and the sediments of the Transvaal Supergroup over the southern portion of the sheet area, and was in turn intruded by the porphyritic Meinhardtskraal Granite in the southwest. Two small stocks of Bushveld Granophyre occur within this granitic unit.

The Kuschke Granite*, previously not recognised as a separate intrusion, was emplaced into the greenstone belt and resulted in the latter's arcuate nature in this area. This granite has been delineated on the basis of trace-element geochemistry. The plot (from regional soil-geochemistry data) in the accompanying figure shows the different trace-element signatures of the Turfloop batholith in the south, as contrasted with the Kuschke Granite. Physically this is a "wet" granite, with hornblende aggregates common throughout the biotite-feldspar-quartz groundmass.

Minor exposures of Transvaal strata occur along the western margin and southeastern corner of the sheet area. The Wolkberg quartzites form the prominent Chuniesberg, with an extensive dip slope to the north well exposed in Chuniespoort.

Diabase and dolerite dykes occur throughout the area, the majority trending east-northeast to northeast, parallel to the major faulting in the region. A subordinate set of dykes trend west to northwest. Kimberlite and lamprophyre dykes also occur in the southwest, with one known kimberlite pipe on Marsfontein 91 KS.

A detailed survey of the mineral potential of the area was undertaken, with particular emphasis on the smaller gold deposits in the Eersteling area (where gold was first discovered in South Africa).

Project 0761

2524CD GEMSBOKVLAKTE (TSHIDILAMOLOMO)

(F. Gabbrielli)

Located on the southwestern margin of the Kalahari desert, this area has the Molopo River as its Northern border. It is flat to slightly undulating, with an almost imperceptible rise toward the east; a few low hills and ridges occur in the southeast. The main rivers are the ephemeral Molopo and Setlagole; villages and farming centres include Logageng, Tshidilamolomo, Mabule, Gemsbokvlakte and Eensaamheid.

Lithologies present in the mapped area include Archaeozoic sedimentary and volcanic rocks of the Kraaipan Group, Tertiary sedimentary rocks and Quaternary deposits.

The Kraaipan Group, a belt of iron-formation and volcanic rocks in the northern part of the area, extends towards the southeast. Exposures usually consist of isolated outcrops separated by sand-covered areas. Good outcrops can be seen to the west of Tshidilamolomo, but to the south the Kraaipan rocks are buried beneath sand for a considerable distance until they crop out in the southeastern part of the area, where they are exposed northeast and southeast of Logageng.

In the northern part of the area the Kraaipan Group consists of iron formation, phyllite, quartz schist and amphibolite. In the southeast the group consists of iron formation, amphibolite, trachyte, chlorite schist and limestone. In the north, to the west of Tshidilamolomo, the dominant feature of the Kraaipan Group rocks consists of two prominent parallel layers of iron formation which extend west-northwest along the left bank of the Molopo. These layers are separated by a sand-covered area 200 m wide, and each bed is approximately 200 m thick.

The softer beds, which presumably occur below the sand-covered area, are not exposed. The iron-formation is highly contorted in places and repeatedly folded, each fold plunging in a south-southwesterly direction at a very high angle. Where not folded, the strata generally strike west-northwest and dip at 80 to 87 towards the south-southwest. Aerial photographs show that the beds stretch towards the west-northwest up to the Setlagole River, where they appear to turn towards the southeast as they form another closed plunging fold. Southwest of Tshidilamolomo they extend towards the southeast and appear to be unaffected by folding.

The layer which appears to be higher in the succession consists mostly of alternating beds of quartzite and magnetite, with alternating beds of reddish jaspilite and black or brown chert occurring in places.

The lower layer consists of alternating beds of chert and ferruginous quartzite, the latter usually thin and including magnetite and siderite.

The lower layer of the succession is underlain by a thick sequence of softer rocks which in turn is preceded by another bed of iron formation. The sequence of softer rocks is approximately 500 m thick, and some of these rocks can be seen in a small quarry near the bed of the Molopo River, where they consist of phyllite and quartz schist. The iron-formation bed is up to 300 m thick and consists mostly of quartzite with thin interbedded layers of siderite and subordinate magnetite. It forms small outcrops along the left bank of the Molopo River. The rocks underlying this bed are not exposed. Fragments of phyllite and quartz schist were found in a small pit dug to the east of these outcrops. The entire succession is flanked to the east by amphibolite, encountered in a borehole drilled at Tshidilamolomo.

In the southeastern part of the map area the two parallel layers of iron formation again crop out southeast of

Logageng, along the left bank of the Setlagole River, and are separated by beds of amphibolite. In this area the strata are contorted in places and generally dip to the southwest, with dips varying from 70 to 80. Northeast of Logageng only the upper layer is exposed, where it is approximately 500 m thick. It is flanked on either side by amphibolite and, in places, by what appears to be a metamorphosed trachyte.

The amphibolite alternates with the iron formations, is greenish and weakly foliated, and appears to have originally been a lava, possibly a basalt. It shows flow structures and contains amygdales in places. Good exposures can be seen east and southeast of Logageng along the Setlagole. Large boulders of iron formation, and lenses and fragments of limestone embedded in the amphibolite, are found occasionally. A small outcrop of chlorite schist, surrounded by amphibolite, occurs just to the east of Logageng.

The trachyte is poorly exposed to the west of the iron formations southeast of Logageng, along the Setlagole River. It appears to be a lenticular bed, about 50 m thick, flanking the iron formation to the west and stretching for about 1,5 km along the left bank of the Setlagole. A very small outcrop occurs to the east of the same layer of iron formation near the southeastern margin of the map area. The rock is pink to light brown in colour, has a greasy feel, is highly weathered in places and usually displays a weak schistosity. A large boulder of quartzite was found embedded in the trachyte exposed along the Setlagole River.

In the north, to the west of Tshidilamolomo, the iron formations of the Kraaipan Group cause an O-shaped magnetic anomaly, which extends and shrinks southwards. Further south, to the east of the Matloding village, the anomaly swells out, but across the Setlagole River it shrinks again and terminates abruptly. In the southeast the pattern of magnetic anomalies is poorly defined, although the general trend is south-southeast.

The Kraaipan Group sediments in the map area possibly form an elongated south-southeast-trending anticline, with culminations and depressions occurring as a result of cross-folding. The axial plane of the anticline probably dips towards the west-southwest at a very high angle and this makes the anticline an overturned one, or possibly a thrust fold moving towards the east-northeast. The plunging folds which occur to the west of Tshidilamolomo are interpreted as minor sets of folds, and either postdate or are coeval with the development of the entire structure.

It is believed that the strata forming the top and the western limbs of the anticline have been deeply eroded, and that remnants of the strata forming the overturned limbs of the anticline are represented by the beds which occur to the west of Tshidilamolomo and in the southeastern part of the area. It is therefore envisaged that the sedimentary succession in the area is inverted. It also appears that the basaltic and trachytic rocks which in places alternate with the iron formations are intrusive, and that both these and the sediments were metamorphosed later. The mineralogical assemblage of both lithologies is characteristic of low-grade metamorphism.

Tertiary sediments represented mostly by calcareous sandstone of the Eden Formation occur along the Molopo and the Setlagole Rivers. Locally the sandstone is extensively silicified so that it could often be classified as quartzite. The rock is usually well bedded and contains layers of conglomerate in places. Thin beds of limestone are found along the right bank of the Setlagole River, to the east of Logageng. Trace fossils, mostly voids and tubular burrows which were excavated or inhabited by worms, are present. Algal mats can be seen in places. Quaternary aeolian sand covers most of the area. Alluvium comprising sand and fine-grained silt fills the beds of the Molopo and Setlagole Rivers.

The map of this area has now been completed, and the explanation is 70 per cent complete.

Project 0795

2926AB MASELSPOORT
(P.J.A. Bosch)

The area was mapped during November 2003 on 1:10 000-scale orthophoto maps. The spatial distribution of the rocks was determined by outlining their outcrop on

Percussion drilling in preparation for blasting fresh dolerite for aggregate at the Olive Hill Quarry northeast of Bloemfontein.

Photomicrograph of olivine-bearing dolorite from the Olive Hill Quarry. Crossed nicols.

aerial photographs and confirming the outcrop positions in the field, where the rocks were characterised according to type, colour and grain size. Geological profiles, and bedding, joint and dyke orientations were measured.

The geological units encountered include sedimentary rocks of the Karoo Supergroup, dolerite intrusions and unconsolidated sediments. It was found that the Katberg Formation occurs much further west than previously thought, occurring as thick sandstone beds on higher ground. A thick band of coarse-grained feldspathic sandstone strikes northeast–southwest through the centre of the map area. This arkose corresponds to the informally named Musgrave Member of Loock and also correlates with the Northern Beaufort Formation of Theron (1970). Correlation with the Rooinek Member of the Normandien Formation of Groenewald (1989) is also being investigated. The discovery of a *Lystrosaurus* skull and *Dadaxylon* plant-fossil remains at Springfield Kop, east of Bloemfontein, also suggests the presence of the Palingkloof Member of the Balfour Formation in the area. Geophysical work and interpretations by Fourie led to the discovery of a ring-like dyke with a cross-cutting fault in the area. A small window of Archaean granite is present on the farm Groenteplein 2354 in the centre of the eastern portion of the map area.

Small patches of alluvium are present along some of the major streams and rivers, such as the Modder. Hardpan and nodular calcrete patches have developed in the soil horizons. Large portions of the area are underlain by red Hutton Form soil which is suitable for agricultural purposes.

Shale of the Balfour Formation is used to manufacture bricks. One area of concern is the mining of dolerite for aggregate where, in many instances, the weathered dolerite is mined by uncontrolled small-scale operations, leaving scarred areas, devoid of natural vegetation and no longer suitable for grazing or any other purpose.

During the investigation some populations of endangered plants, which include *Chortolirion Angolense* and *Raphionachme sp.* were discovered.

Project 0718

2930DD AND 2931CC DURBAN

(B.M. Clarke, M.W. Kota, F.N. Ngcobo, G.A. Botha, R.G. Grow)

Detailed mapping on 1:10 000 scale of the greater Durban region, one of the most rapidly urbanising nodes in southern Africa, has achieved significant improvements to the geological map. The expansion of the Durban metropolitan-area boundaries, and associated infrastructure and housing development, has created widespread rock exposure and numerous geotechnical trial-pit records that were used to improve the detail on the map.

With the majority of the pre-Cenozoic mapping completed in 2002–2003, the main focus of the geological mapping during the past year has been the sourcing and interpretation of geotechnical borehole records for the river valleys and low-lying areas east of the Berea ridge. This includes the Prospecton to Bayhead areas in the south, the Durban port, and the CBD and light-industrial areas to the Mgeni River in the north. Development within the city has been constrained by the variable Quaternary alluvial and estuarine strata that cover a marine-planed land surface eroded into soft Cretaceous sandstone and siltstone. Efforts have been made to identify channels eroded into the Cretaceous surface and to delineate layers of soft estuarine muds that are interbedded within the coarse river-sand deposits. Data from multiple sources have been collated to produce cross-sections that highlight the lateral variations that occur in the unconsolidated deposits beneath the Durban city and industrial areas. This data can be utilised to define the seismic-hazard risk profile for this area.

Detailed mapping of the weathered Neogene strata that form the Berea and Wentworth ridges has traced the stepped bedrock surface that is mantled with a variable layer of boulders beneath the typical Berea red-sand weathering-profile cover. Most of the sites that were described during the mapping depicted on the 1964 map have been thoroughly decalcified or degraded, but the recent mapping did reveal new exposures that provide insight into these strata. The thickness and texture of the Berea red-sand weathering profile were investigated through a series of deep auger holes drilled into the Berea, Wentworth and Bluff ridges. The convex crest of the steep-sided Bluff ridge is formed of a sandy decalcified Isipingo Formation profile, whereas the Wentworth ridge to the west comprises both clayey soils formed in weathered Neogene rocks and possible younger sand cover. Newly created exposures along the crest of the Berea ridge near Burman Bush revealed the relationship between the Neogene to Pleistocene calcarenite and the typical thick Berea red-sand weathering profile comprising reddish-brown to yellowish-brown rubified soil. The composite nature of the weathering profile that is formed on parent materials of different ages on the separate ridges can be demonstrated on the basis of soil development index curves based on sedimentological and pedological analysis of samples from the augered profiles.

Project 0742

3227DC KING WILLIAM'S TOWN

(L.B. Majokweni)

The map area is underlain by the Permian Adelaide Subgroup, which is intruded by the Jurassic dolerites. Alluvium is present in the river valleys.

Dolerites in the map area display some interesting trends, and samples that were collected fall into two distinct groups. The first of these are olivine free, ophitic to subophitic textured. The second has a high Olivine and MgO content. The second type of rock can be more properly classified as picrites. These picrites lie in the lower parts of the dolerite sheet northwest of the mapped area. The exact relationship of the picrite to the overlying dolerite

is unclear. It is possible that the picrites represent either a separate more-mafic intrusion, or that this sheet has undergone magma differentiation with the picritic rocks representing accumulations of early formed liquidus minerals that had undergone settling from a more broadly doleritic parent.

Suitable construction materials and potential mineral deposits were identified in places. The mapping was carried out ahead of schedule, and the report is in progress, with final submission intended in 2004/2005.

Project 0750

3129CC COFFEE BAY
(J.S.V. Reddering)

The CGS completed 689 km^2 of mapping, much of it on a scale of 1:10 000, to complete the last map of a five-part map set covering the Wild Coast area, centred on Port St Johns and extending up to Lusikisiki. The explanation for the entire map set was expanded to include the new information for sheet 3129CC Coffee Bay. Final publication production is under way. The mapping revealed, ***inter alia***, that the Ecca Group in the area has a higher than average sandstone content, indicating that the basin edge of the Ecca Group lay nearby, to the southeast of the map area.

Thick dolerite sheets were found in the northeastern, northwestern and southern sectors of the area covered by the map. The occurrence of these dolerite outcrops, and of several other stratigraphic units, required significant map revision, which was successfully and accurately carried out.

Dolerite weathers to good farming soil and the bedrock outcrops are, in places, suitable for extracting construction material and road aggregate. As a result of the Wild Coast mapping initiative, specific investigations are under way to develop the Port St Johns travertine deposit. Other similar ventures are investigated in the map area.

Project 0822

2429AC ZEBEDIELA WEST and 2429AD ZEBEDIELA EAST
(N. Baglow, M. Dippenaar, N. Kasa)

These two 1:50 000-scale sheets cover the northern portion of the Springbok Flats basin, the study of which incorporated the use of available borehole data, geochemistry and geophysical data, as well as LANDSAT imagery and aerial photographs. Combined with historical research, an attempt was made to refine the basin development model, as well as the boundaries and depositional settings of the various formations.

Significant findings to date include the identification of a large (10x5 km) Quaternary alluvial fan and flood-plain deposit that overlies the Karoo strata, the identification of major faults in the complex Zebediela Fault Zone, and the recognition of the Irrigasie Formation strata up to that fault. The latter finding is based on the CGS' regional-geochemistry data, and will be verified in the coming year.

7.2 RESEARCH AND DEVELOPMENT

Project 0767

STRUCTURAL MAPPING, EASTERN BUSHVELD CONTACT MARGIN

(B.M. Clarke)

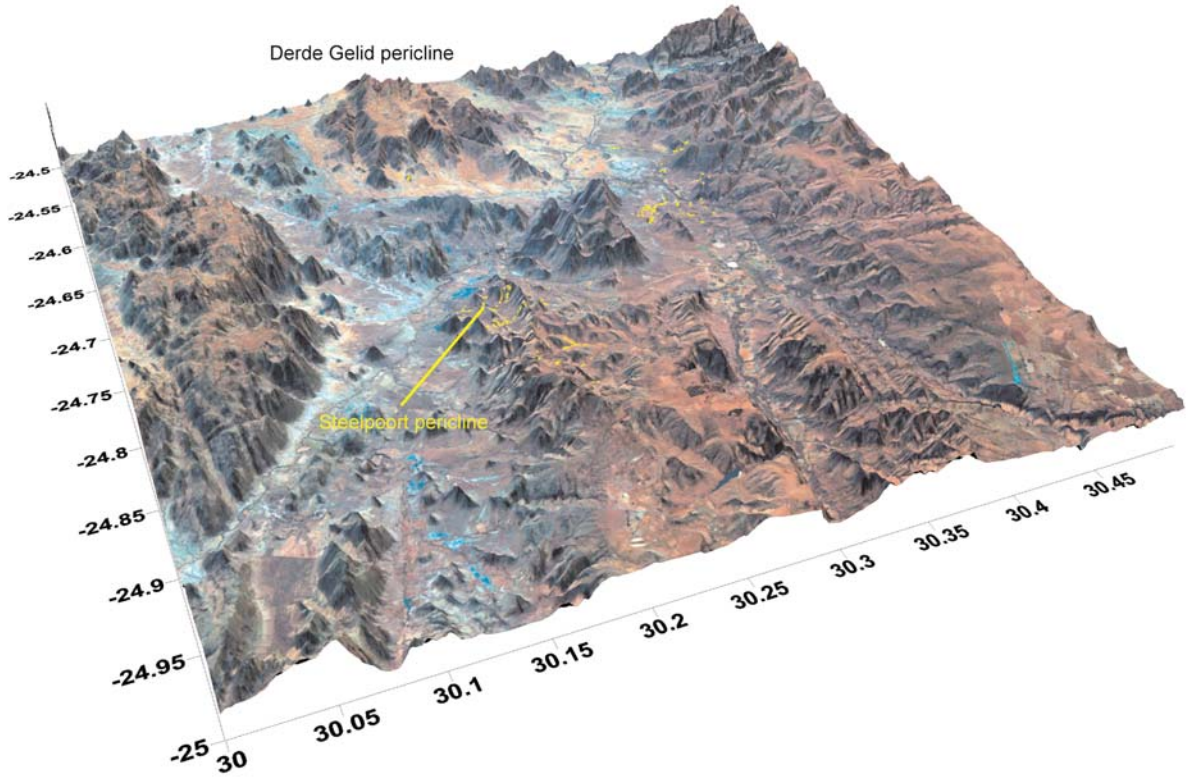
Objective:

to determine the structural and metamorphic evolution of parts of the eastern Bushveld Complex contact aureole in order to elucidate the mechanisms of emplacement of the Bushveld Complex.

The second of three planned field seasons was completed in July and August of 2003. Detailed structural mapping of the Steelpoort pericline has facilitated a thorough structural interpretation of the aureole in this area of the Bushveld Complex, particularly where combined with insight gained during the first field season which focussed on the floor rocks around Burgersfort. Syn-Bushveld penetrative fabrics within the dome are only developed in pelitic lithologies in the core of the structure and not in the pelitic lithologies on the dome flanks. Folded and occasionally foliated leucosome veins, viewed in conjuction with essentially undeformed leucosomes, suggest that melting in the aureole had started prior to diapirism, but continued for the duration of the deformational event. Metamorphic garnets from a locality near Steelpoort, measuring up to 5 cm in diameter, have been sampled for detailed microprobe work. The detailed mapping of the Steelpoort dome will be used to further enhance existing finite-element numerical models of the aureole.

Collaboration with staff of the Universities of KwaZulu-Natal and Bochum (Germany) has continued and resulted in successful thermomechanical modelling of the contact aureole, the results of which were presented at the GSA meeting in Seattle and published in *Geology*. Preliminary results of the study were also presented at a workshop in Rustenburg dedicated to Bushveld Complex structural geology, organised by the Bushveld Branch of the Geological Society of South Africa.

A further field season is planned for June 2004. This visit will focus primarily on adding detail to exisiting mapping, and quantification and mapping of deformation in igneous rocks peripheral to the dome. Sampling for anisotropy of magnetic-susceptibility (AMS) analysis will also be carried out.



Northeast-facing LANDSAT false-colour composite (RGB 521) draped on a 20 m DTM of the area covered by 1:50 000-scale maps 2430CA-CD around Steelpoort. The mountainous terrain (left) is underlain by the Main Zone of the Rustenburg Layered Suite (RLS), while the more subdued topography (right) is underlain by Pretoria Group floor rocks. Two large domal floor structures, which protrude upwards into the RLS, are shown. The Steelpoort lineament is clearly visible as the prominent valley stretching from the bottom left to the top right of the image. Yellow dots on the image represent mapping observation points at this stage in the project. Vertical exaggeration about 3x.

Project 0069

KWAZULU-NATAL COASTAL-PLAIN MAPPING AND RESEARCH

(G.A. Botha, Dr N. Porat (Geological Survey of Israel))

Objective:

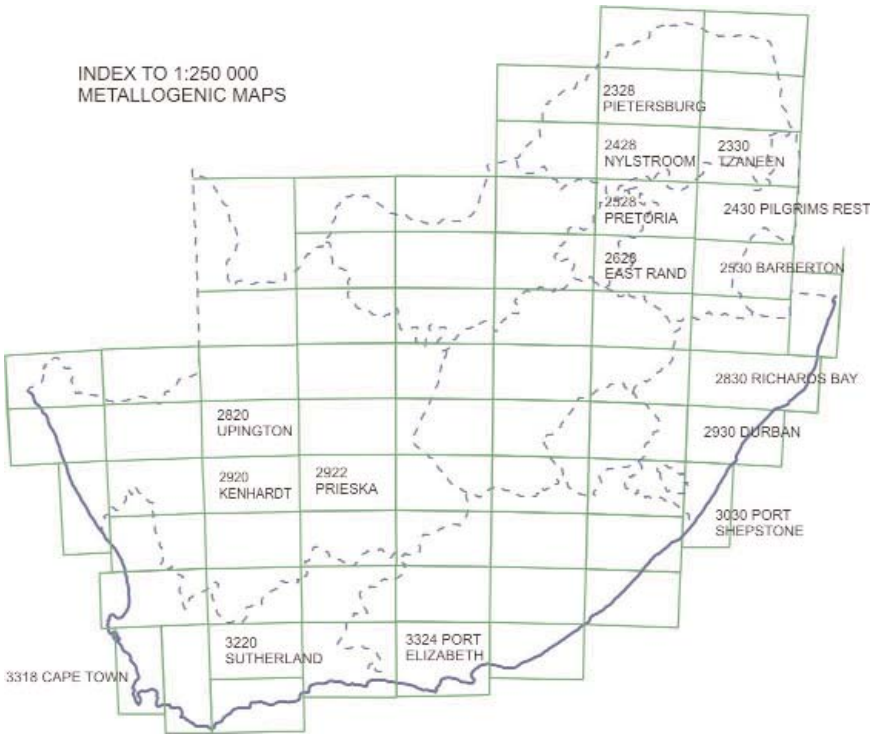
to map the geology of the Maputaland coastal plain, differentiate the dune-sand deposits, review the Cenozoic stratigraphy and date the dune systems.

Developments in this long-term research programme have led to a research project on the raised shorelines around lake St Lucia in the Greater St Lucia Wetland Park World Heritage Site. This work was funded by the Norwegian NUFU programme for geological and ecological relationships in the region. At five sites around the shores of the lake there are sets of subparallel to slightly oblique sand ridges that probably represent swash-zone beach ridges related to higher lake levels. The very low relief of the lake basin on the Maputaland coastal plain and the river systems feeding into the lake makes any long-term rise in lake level an ecologically significant event. Traverses across the beach ridges were surveyed into order to compare ridge heights between the widely spaced sites. The ridges were augered and sampled for sedimentological, granulometric and luminescence dating. Collaborators from laboratories in Wales, UK and Israel will undertake age determinations to determine when the beach sands accreted. By comparing the dated shorelines and probable phased recession of the lake level with known sea-level curves and proxy records of palaeoclimatic change in southeastern Africa, it may be possible to highlight significant environmental changes in the lake. This data will be important in the modelling of the physical and ecological responses to future sea-level rise in response to global climatic change. The research findings are being compiled for publication and presentation at an international conference. This work will form an important new chapter in the memoir on the Cenozoic evolution of the Maputaland coastal plain that is nearing completion. Samples obtained from deep augering along a transect across the Western Shores of St Lucia have been analysed sedimentologically and will be subject to soil-fertility analysis as part of the NUFU-funded programme. This data will be used in the management of this former plantation, some of which will be incorporated into the World Heritage Site.

7.3 METALLOGENIC MAPPING PROGRAMME

7.3.1 1:250 000-SCALE METALLOGENIC MAPS

Objective:
The CGS is producing a 1:250 000-scale metallogenic map coverage of South Africa. Each 2X1 sheet is accompanied by a printed explanation, and each mineral occurrence is listed on SAMINDABA. The final product will be a synthesis of the geology and mineralisation of the area in a database-backed format which will be of practical use to entrepreneurs and other role players in the mineral industry.



Project 0459

3324 PORT ELIZABETH
(S. Frost-Killian, J.S.V. Reddering, M.L. Goedhart, L.B. Majokweni)

The compilation of the explanation has progressed, and the chapters on geology have been completed. Further information has been added to the database, following field visits to the PPC operations at Loerie and Grassridge, and to Moregrove Quarry (Lafarge) and Coega Kop (courtesy of the National Ports Authority, Port of Ngqura). Other deposits of interest were visited and photographed for inclusion in the explanation. Information on the proposed and current borders of the Greater Addo National Park has been obtained. Updates in GIS shapefile format will be made available from the Planning and Development Offices of the South African National Parks Board as the expansion of the park progresses. In the interest of promoting the current work being done on the Port Elizabeth Metallogenic Map, derived products were produced for the Eastern Cape Unit. These include two maps showing the existing and potential silica and building-sand resources within the map region, a map showing existing and potential limestone, gypsum, phosphate and road-material resources, and a general map showing sample points (highlighting those which have been analysed), as well as known deposits and existing SAMINDABA records. These maps have created interest in the data set and other information available, drawing clients from the government, private and PDI (poverty alleviation) sectors.

Project 0760

2628 EAST RAND
(G. Henry)

Of the 49 occurrences of brick, and refractory and plastic clay in the current SAMINDABA database for sheet 2628 East Rand, at least six require field verification. Similarly, two of the 50 building-sand or quartz and 15 of the 70 stone-aggregate occurrences still need to be checked. Of the remaining 68 mineral occurrences, spread over 18 commodities, three need field follow-up. The explanation to the metallogenic map, including the current views on the metallogenesis of the different commodity deposits, is progressing well, and two-thirds of the draft is complete.

Brick-clay cutting machine at Kuilfontein Sand on the farm Kuilfontein 502 IR, 13 km north-northwest of Balfour. Sand is derived from highly decomposed Archaean granitic gneiss and sold commercially. Clay is trucked in and mixed with sand and water to make the brick mixture. This machine cuts a continuous extrusion of clay into bricks, which are then fired in a kiln.

7.3.2 OTHER METALLOGENIC MAPPING PROJECTS

Project 0827

REPORT ON FEASIBILITY OF A BUSHVELD COMPLEX METALLOGENIC MAP
(M.G.C. Wilson, D.L. Ehlers)

Objective:
to investigate the production of a metallogenic map of the Bushveld Complex.

The Bushveld Complex is the largest layered intrusion on earth and, in terms of economic potential, most certainly one of the world's most valuable mineral resources. Worldwide demand for platinum increased by 8,5 per cent during 2002 and is expected to maintain a steady rate of increase into the foreseeable future. As the known reserves of the Bushveld Complex could sustain the demand for platinum-group elements for the next 100 years, the implications for the South African economy are enormous.

Despite the phenomenal economic importance of the Bushveld Complex to South Africa, not enough has been done from a statutory perspective in terms of interrogating the wealth of new information that has become available, and which has been generated over the past 30 years through the exploration and mining activities in the private sector. The CGS' existing 1:250 000-scale geological maps of the Bushveld Complex do not reflect any information which has accumulated in company files during these last three decades. Major leaps in the understanding of the structure and controls of associated mineralisation of the Bushveld Complex have been made during this period and it is suggested that this information be unlocked, in partnership with the mining companies actively involved in research into the Bushveld Complex. The first phase in this project would be to coordinate and integrate the information contributed by mining companies with the ultimate objective of producing a multilayered modified map of the Bushveld Complex using GIS (lithological background, structural elements, trace of mineralised reefs, mining leases, and gravity layer).

More than 90 per cent of the mining companies in active mining operations and intensive exploration programmes have been consulted in an attempt to ensure their cooperation in providing the required geological information for this project. The idea of a new geological/metallogenic map of the Bushveld Complex, in digital format, has been well received by the representatives of the platinum industry in general. As a first step the companies have agreed to provide the information for the Bushveld Complex map-compilation venture, but were not prepared to pledge financial support for this purpose. However, the CGS should not miss out on an opportunity not only to keep abreast of existing developments in the Bushveld Complex in terms of capacity building, but especially for the sustainable development of South Africa's last superlative mineral resource for the benefit of all its people.

A feasibility report has been compiled and submitted for consideration.

7.4 GEOTECHNICAL MAPPING

7.4.1 1:50 000-SCALE GEOTECHNICAL MAPS

Objective:
The objectives of these projects are (i) to revise all geotechnical mapping in urban areas which could assist in urban planning and development, (ii) to identify areas where geological parameters pose a hazard to urban development, (iii) to provide information on the distribution and characteristics of minerals employed in construction (ferricrete, silcrete, calcrete, aggregate, sand and clay), and (iv) to capture the information onto a database.

Project 0823

2429BA GA-MAJA
(N. Mpateni)

Part of this sheet falls within the Polokwane Municipal area. The field work included the excavation of 32 trial pits, with soil profiling and sample collection. The results of laboratory analyses, together with the relevant data from consultants' reports and overall landform interpretation, were utilised in the compilation of the geotechnical map. Construction-material locations, quarries and borehole positions were incorporated into the final product.

Project 0762

2930DD AND 2931CC DURBAN
(N.P. Richards)

A regional geotechnical mapping programme for the Durban area was implemented during 2002 to supplement the detailed 1:10 000-scale geological mapping. The field-mapping phase is complete and delineates areas of hazardous geological or morphological conditions which could impose environmental constraints or elevated cost implications on future infrastructure development, including water and fuel pipeline routes, road upgrading, development of low-cost housing and service-related infrastructure. Various site-investigation trial pits and exposure profiles have been used to improve the demarcation of areas of differing geotechnical conditions.

The geological and terrain morphological diversity of the Durban area has resulted in a complexity of geotechnical constraints to development. The deeply weathered granite saprolite soils are potentially highly erodible, may possess a collapsible fabric, and produce fills that are poorly consolidated. In areas underlain by sandstone of the Natal Group, excavatibility and erodible soils are constraints to development. The predominant geotechnical constraint to development in areas underlain by Dwyka Group bedrock is excavatibility.

Excavation problems also arise in areas of Pietermaritzburg Formation shale bedrock, where thin soil mantles occur in crest and mid-slope areas. However, the most notorious problem in the shale areas is slope instability. Numerous slope failures have occurred in situations where the dip and direction of shale bedding (regionally dipping to the east and south east) are concordant with slope dip and direction, with failure often occurring at or near the soil/rock interface. Other constraints to development associated with the shale areas is activity or expansiveness in the residual soils in lower-slope positions. The soils developed in dolerite areas comprise silty clays which, under poorly drained conditions, exhibit active or expansive properties, particularly where associated with shales of the Pietermaritzburg Formation.

The "Berea-type" red-sand weathering profile developed in Plio–Pleistocene dune sands is characterised by a number of constraints to development, including possible collapse potential, high erodibility and slope instability. The CBD and harbour areas of Durban are underlain by unconsolidated, interstratified, estuarine and alluvial deposits, ranging in texture from sands to silty clays. In places the sands give way to extensive areas of highly compressible, soft silty clay (black-mud stratum) known locally as "Hippo Mud". A database of investigation boreholes in the areas of estuarine and alluvial deposits provides information regarding the depth to, and thickness of, the compressible clays. Various cross-sections have been extrapolated from the borehole data, and isopach maps will be provided indicating the thickness of the black-mud stratum. The availability of borehole data has enabled the modification of the inland boundary extent of the Hippo Muds and has provided a more accurate determination of areas where settlement problems may arise.

Project 0802

2431CC BOSBOKRANT
(J.T. Shongwe, M.A. Dippenaar)

The Bosbokrant geotechnical map was completed. The dominant geotechnical factors are:

- Weathering of the granites in the map area, except the Lower Nelspruit Granite, to coarse-grained sands and gravels from which the clay fraction has been leached. These materials are therefore susceptible to collapse and erodibility.
- Weathering of the Lower Nelspruit granites to soft pinkish clays that may have compressibility problems and are expansive in some areas.
- Slope instability and excavatibility problems are anticipated in areas with prominent topographical features and rock outcrop.
- A shallow water table associated with the Cunning Moor Tonalite in the northern portion of the map area.
- Potentially expansive soils derived from gabbro and diabase.

Project 0821

2528CB SILVERTON
(J.S. Venter)

The field work was 90 per cent finished during March 2004. Permission to excavate test pits in the boundaries of the Tshwane Municipality could not be obtained, and therefore test pits were only excavated within the boundaries of Nokeng Tsa Taemane (Rayton) municipality.

In total forty-six test pits, road cuttings and borrow pits were excavated and/or profiled. Thirty disturbed samples were taken and submitted to Soillab for foundation-indicator tests. All of the test pits were excavated exclusively in the road reserve of the provincial roads in the area.

The map area is underlain by granite, tuff, gabbro, diabase, shale, quartzite and alluvium. The andesite present in the Silverton area, notorious for its swelling and shrinking characteristics, has significant geotechnical ramifications, but is not found elsewhere on the map area. Collapsible soils are often associated with granite, as well as with sandstone and quartzite. Those areas on the map underlain by granite, sandstone, quartzite, quartzitic sandstone and gabbro may exhibit excavatibility problems to differing degrees. Soils derived from shale, gabbro, norite and especially andesite may possess expansive properties. The large areas covered by alluvium may also show expansive properties, as well as possible compressible soils.

Typical test pit excavated during field work.

Completion of the map and the accompanying explanation will be carried into the 2004/2005 technical year.

7.5 ENVIRONMENTAL-IMPACT ASSESSMENTS

Project 0770

GEOLOGY AND ECOSYSTEMS OF THE WESTERN CAPE

(D. Cole, L. Chevallier, A.L.D. Agenbacht)

Objective:

(i) to promote research on the role played in the spatial distribution of plant species, (ii) to delineate areas of past and present mining and their effect on biodiversity conservation, (iii) to outline sites of future mining and set priority targets for plant conservation and (iv) to investigate toxicity in plants and their relationship with geology.

Two projects have been launched: (1) Cape Fynbos Biodiversity region. (2) Succulent Karoo Ecosystem Plan. The CGS are advisors for mining areas and priorities. Plant-distribution maps must be compiled and CGS will be involved in this project by providing geological data on the basis of correlation of plant species and geology.

Field work, and a poster presentation entitled "Mining in the Knersvlakte, past, present and future — accommodation, rejection or compromise?" were completed in the case of Namaqualand, and field work and a report entitled "Preliminary report on geology/botany relationships in the Groenefontein Nature Reserve, near Calitzdorp, Western Cape Province" were completed as a contribution to the southern Karoo. These products were presented at the Sixth International Succulent Congress in Calitzdorp, held between 29 September and 3 October 2003.

Project 0843

BLESBOKSPRUIT CATCHMENT AND WETLANDS

(H. Coetzee, L.A. Gibson, L. Chevallier, U. Horstman)

Objective:

to study the degradation of wetland systems in the Blesbokspruit river catchment using remote sensing and geochemical analysis.

This project is a pilot study on the degradation of the wetland systems in the Blesbokspruit catchment using remote-sensing data, geochemical analysis, applications of high-resolution imaging and hyperspectral data.

Spatial data, a Digital Elevation Model (DEM) and Satellite images have been collected. The topographical map has been completed. Image processing of open-water wetlands was done using EnVI. A report has been completed, and work has started on the spatiotemporal evolution by time series analyses using existing spatial data.

Dwarf succulents *Argyroderma delaetii* (light green), *Psilocaulon* sp. (red) and *Cephalophyllum* sp. (green) growing in a surface layer of white quartz pebbles in the Knersvlakte near Van Rhynsdorp. The quartz frequently overlies diamondiferous gravel, but mining destroys the habitat of these endemics.

8. GEOPHYSICAL MAPPING AND SURVEYS

8.1 GEOPHYSICAL MAPPING

Project 0673

AIRBORNE HIGH-DENSITY GEOPHYSICAL SURVEYS OF SHEETS 2429AC ZEBEDIELA WEST, 2528DD BALMORAL AND FOUR OTHER 1:50 000-SCALE SHEETS

(Project leader: P. Cole. Co-workers: K.R. Beare, Southern Exploration Surveys, J. Cole, M. Kotzé, M. Adlem, J.G. Barkhuizen)

Objective:
to produce geophysical coverages and interpretation reports.

Surveys were completed for the 1:50 000-scale sheets 2429AC Zebediela West, 2525DD Rooigrond, 2526CC Bakerville, 2625BB Itsoseng, 2626AB Twee Buffels, 2528DD Balmoral, 2723BD Kamden, 2723DB Khaw and nineteen 1:50 000-scale sheets covering the southeastern limb of the Bushveld Complex. Magnetic and radiometric data were collected at a line spacing of 200 m and a nominal flying height of 80 m for all the sheets, except 2525DD Rooigrond, 2526CC Bakerville, 2625BB Itsoseng and 2626AB Twee Buffels, where a line spacing of 110 m was maintained.

Interpretation reports showing basic surface interpretations of the geophysical data were completed for 2429AC Zebediela, 2525DD Rooigrond, 2526CC Bakerville, 2625BB Itsoseng, 2626AB Twee Buffels and the sheets covering the southeastern limb of the Bushveld Complex. Geophysical anomalies were identified and delineated and, where possible, correlated with known geological features. Data collected over the southeastern limb of the Bushveld Complex were used in the creation of a three-dimensional model (project 0839).

8.2 GEOPHYSICAL INTERPRETATION

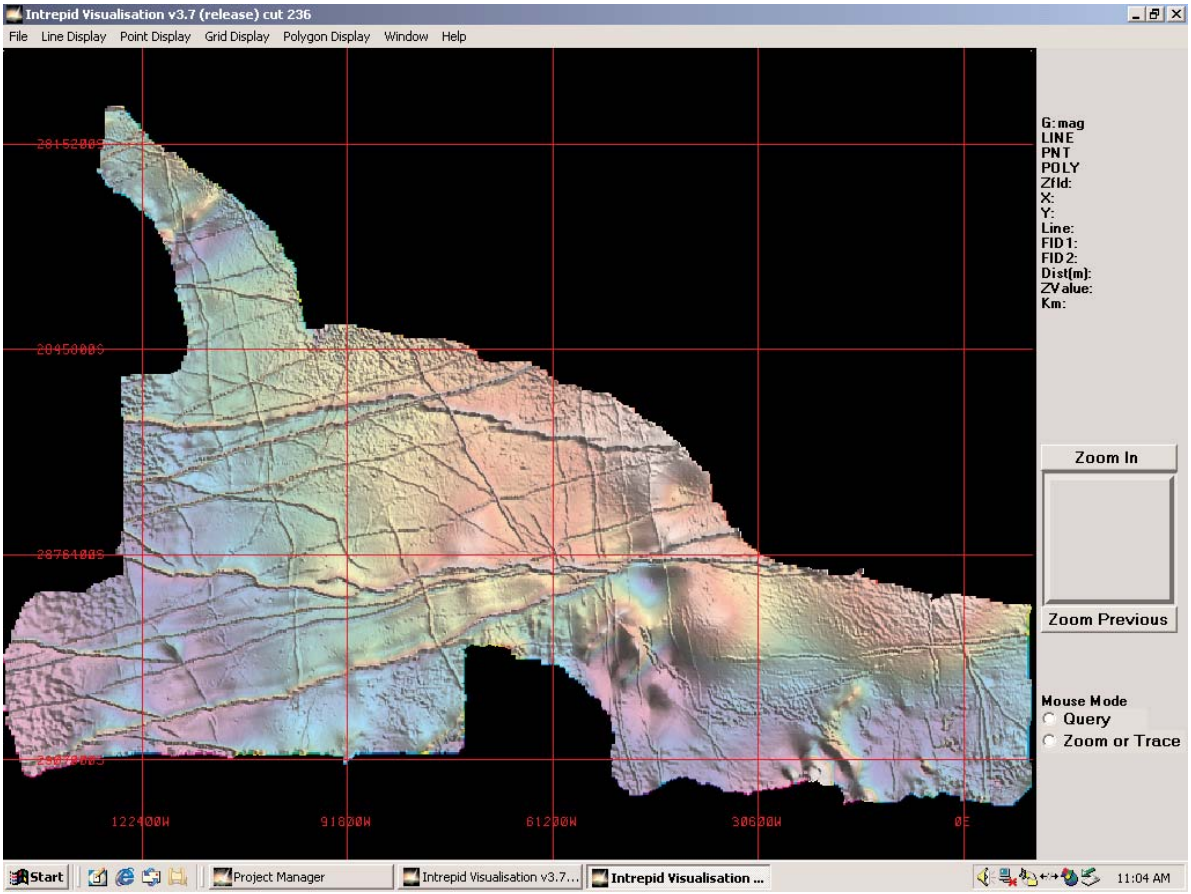
Project 0831

MAGNETIC, PALAEOMAGNETIC, GRAVITY AND ROCK-PROPERTY SURVEY OF THE THABA NCHU AREA, FREE STATE PROVINCE

(A.B. Rutherford, L.P. Maré, L.R. Tabane)

Objective:
to investigate the physical properties of rocks in the Thaba Nchu area, and to investigate the possibilities of exploitation of a known Kimberlite deposit.

In addition to the existing regional aeromagnetic and gravity data, more than 100 oriented cores were drilled



across the Permo–Triassic boundary. Preliminary analyses indicate that the CGS' palaeomagnetic equipment may be unable to determine the palaeogeomagnetic polarity and palaeolatitude, probably owing to the weak magnetisation of the samples. An overseas facility was approached to assist in this regard.

A gravity survey was conducted over a known and previously mined kimberlite complex in the area which appears to consist of a number of pipes and dykes. Poor mineralisation and mineral-rights disputes may inhibit exploitation of the deposit.

Project 0844

COMPILATION OF A HIGH-DENSITY AERO-MAGNETIC MAP FOR THE NORTH WEST PROVINCE — INTERPRETATION OF DATA FOR THE DETERMINATION OF GROUNDWATER TARGETS

(C.J. de W. Raath, C.J.S. Fourie)

Objective:
to find potable groundwater in rural parts of the Vryburg area.

Groundwater exploration, for siting boreholes for potable water, is an essential process in rural development. High-density aeromagnetic data for twelve 1:50 000-scale sheets — 2624AC Cumnor, 2624AD Tlhakgameng, 2624BC Dirkiesrus, 624BD Papiesvlakte, 2624CA Ganyesa, 2624CB Lourensgeluk, 2624CC Louwna, 2624CD Coetzersdam, 2624DA Vreugde, 2624DB Stella, 2624DC Vryburg and 2624DD Devondale, on the 1:250 000-scale sheet 2624 Vryburg, were interpreted for the delineation of possible groundwater-bearing structures. The DWAF's national groundwater and borehole database was incorporated into this interpretation by correlating it with the identified lineaments from geophysical and geological data. This approach was used to establish the groundwater potential for each 1:50 000-scale sheet, and forms part of a methodology to develop and extract groundwater in these areas, minimising costs and time spent on field work in finding possible groundwater targets.

8.3 RESEARCH AND DEVELOPMENT

Project 0830

MAGNETOTELLURIC SURVEY ACROSS THE KAAPVAAL CRATON, SOUTHERN AFRICA

(E.H. Stettler, M. Adlem, J.G. Barkhuizen, J. Cole, C.J.S. Fourie, J. Groenewald, C.J. de W. Raath, J.P. Smit, R.H. Stettler)

Objective:
to create an image of the deep crust and upper mantle based on the electric properties of rocks, defining the deeper compositional rock types and structures of the crust and upper mantle.

Phase I of one of the world's largest magnetotelluric traverses was conducted in South Africa as part of an internationally funded research programme to create an image of the deep crust and upper mantle. The traverse stretches from Sutherland in the Western Cape Province to Musina in the Limpopo Province, and was funded by the American National Science Foundation, De Beers, the Department of Science and Technology and the CGS. Collaborators from the Woods Hole Oceanographic Institute (WHOI), the Canadian Geological Survey, the Dublin Institute for Advanced Studies (DIAS), the Universities of Pretoria and the Witwatersrand, and De Beers assisted with the deployment of the sensors.

The traverse partially transects the Karoo basin, the Namaqua Metamorphic Belt, the Kaapvaal craton and the Limpopo Metamorphic Belt. More than 50 long-period magnetometers and six broadband instruments were available for deployment. The recording-station interval was approximately 60 km for the long-period magnetometers and 20 km for the broadband sensors.

The magnetotelluric technique enables one to probe the mantle of the earth, and depths of 500 km have been achieved in this case. The results are still being processed, and the product will be an image of the earth's interior based on the earth's electrical properties. This image will provide a better understanding of rock compositions and structure at great depths, as well as the processes involved in the formation of diamonds.

Project 0841

IN-SITU DENSITY MEASUREMENTS

(C.J.S. Fourie, P. Cole)

Objective:
to development technique for in-situ regolith-density measurements.

This project has as its objective the development of a new technique to measure in-situ densities of the weathered layer by using a seismic technique. A mathematical methodology was developed, and a single-layer example was used to evaluate the feasibility of the technique. This proved to be successful and the technique is being developed further.

8.4 NEW TECHNOLOGIES

Project 0247

SEMI-AUTOMATIC 2D AND 3D INTERPRETATION: INTEGRATION OF MODELLING TECHNIQUES, INCLUDING NEURAL NETWORKS, FUZZY LOGIC AND WAVELETS; REFINEMENT OF MODELLING TECHNIQUES AND VISUALISATION

(P. Cole, J. Cole, E.H. Stettler, D. Eberle (Bundesanstalt für Geowissenschaften und Rohstoffe))

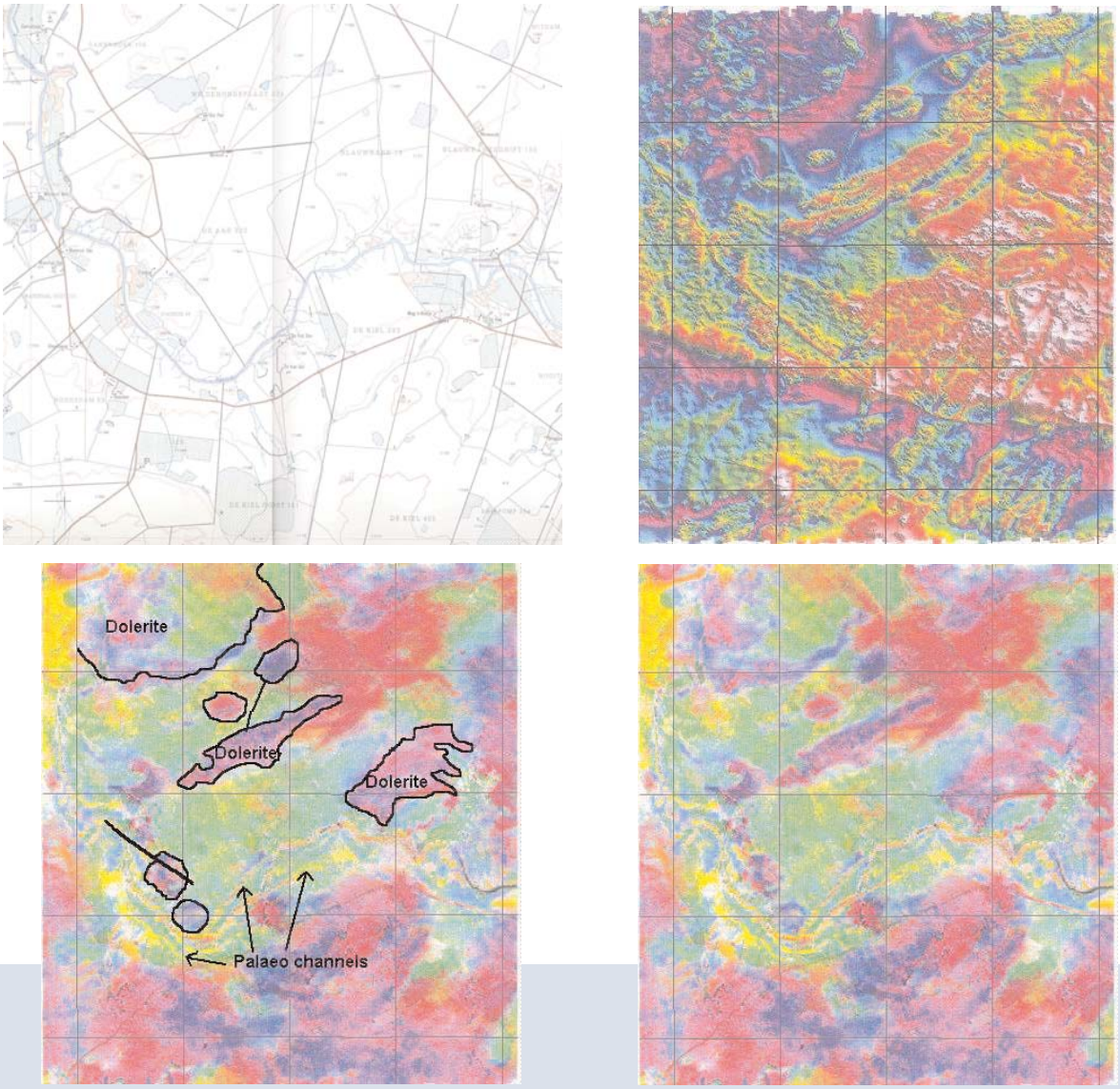
Objective:
to create geophysical modelling software that can display geologically realistic three-dimensional models based on potential field data.

Initial assessment into the forward-modelling process has been completed. A number of statutory and commercial project models were created. In all cases, the modelling process was far longer than anticipated, owing to the extensive editing that had to take place and the lengthy calculation of the forward model. Solutions have been proposed for both cases. Plug-ins for 3DS Max can be purchased (one has already been purchased) which improve the speed at which models can be created, by minimising the editing. Improvements were made to the software to increase the speed of forward modelling by eliminating calculations from bodies that are too far away. This can improve situations where the area is composed of separate bodies, dykes and faults. In the case of sills, or normal layering, no improvement is seen owing to the nature of the calculation. The calculation speed can be improved further by performing only those calculations necessary for updating the model, and not the full calculation each time.

Presentation of the 3D models has been investigated. The current solution is to present the data as a series of slices. In addition, the data can be saved as a Shockwave® file, for 3D viewing in a free Shockwave viewer. The 3D viewing is limited.

Compact volume inversion in magnetics applied to 3D is completed. It consists of two 2D calculations applied in perpendicular directions.

A user's manual describing the operation of the software was completed, and will be expanded as more features become available.



An example of an image recorded by the CGS' near-infra-red (NIR) scanner. Top left: topocadastral map 2924BD Bloubankdrif. Top right: total-field magnetic colour image, artificially sun shaded. Bottom left: combination of three spectral windows (out of a possible 1 024) as a ternary image. Qualitative interpretation of the ternary NIR image.

Project 0481

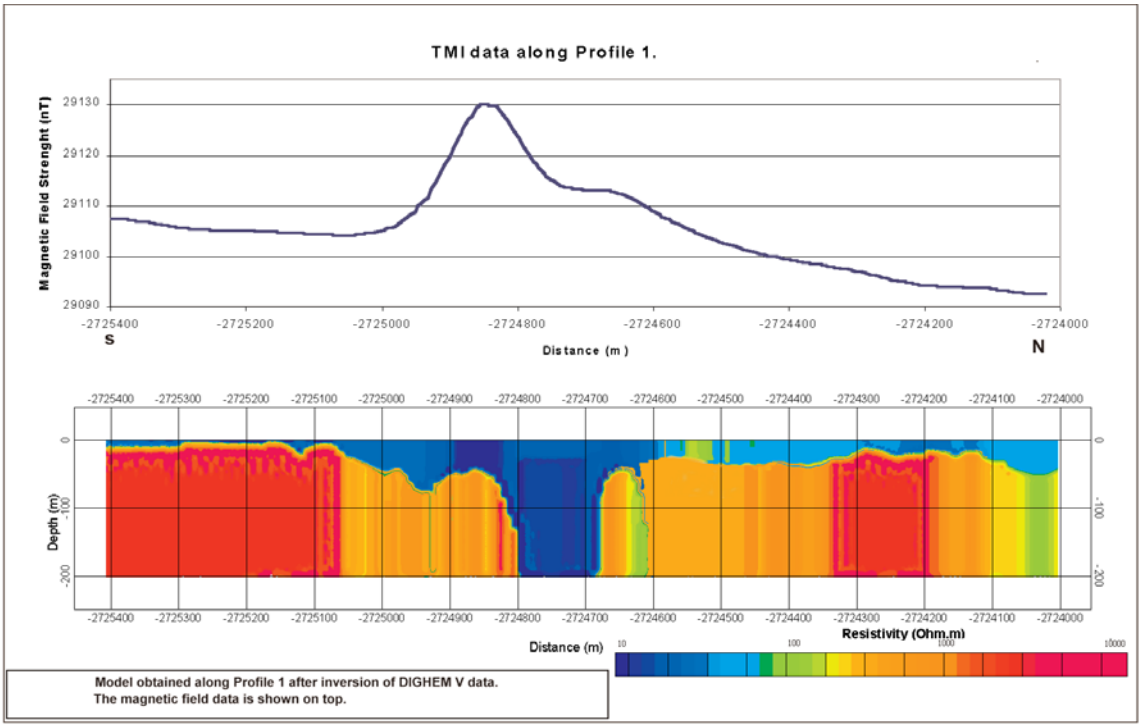
NEAR INFRA-RED (NIR) SENSOR — UNMIXING OF THE NIR SPECTRUM

(E.H. Stettler, Southern Exploration Surveys)

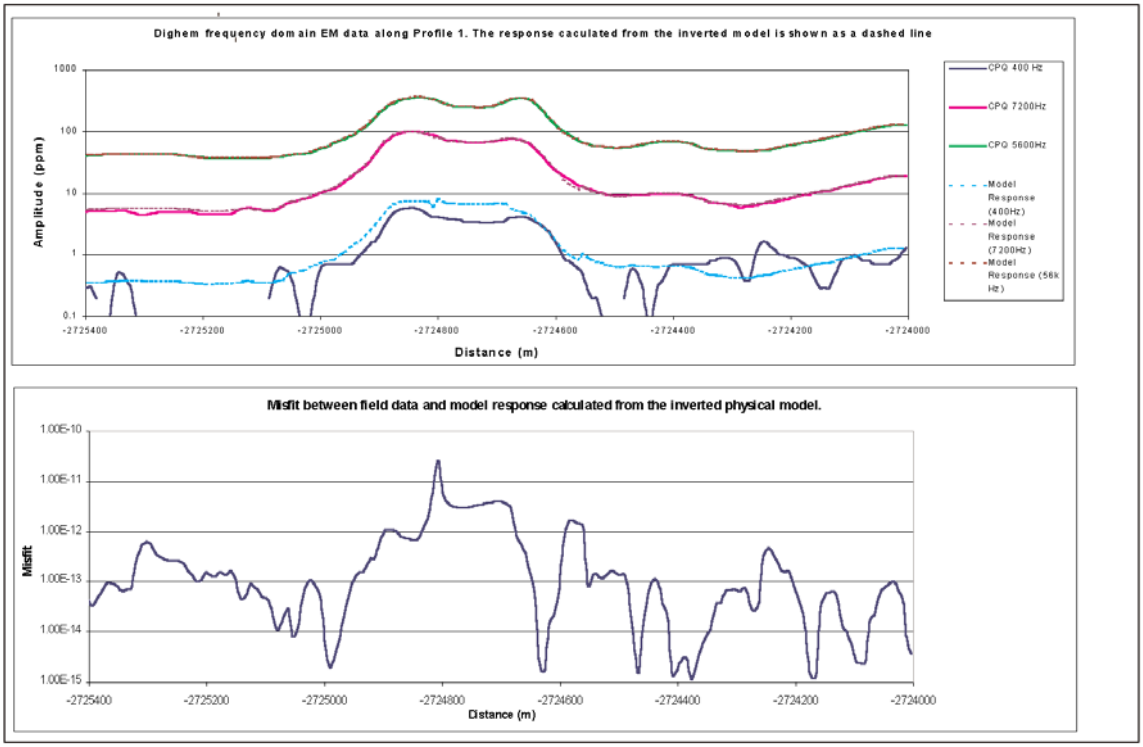
Objective:

to investigate the feasibility of using the Near Infra-Red spectrum measured by the CGS' airborne geophysical platform to determine rock composition.

The near-infra-red (NIR) sensor on the CGS' airborne geophysical platform measures the intensity of sunlight as reflected from the surface of the earth as a function of wavelength, simplistically called the intensity spectrum. Because of the ability of surface rocks and sediments to absorb sunlight the reflected light is altered, allowing inferences to be made about the composition of the reflecting surface. Although the NIR behaviour of individual minerals over a range of wavelengths is well known, the airborne sensor registers the combination of many individual mineral contributions superimposed on each



Model obtained along Profile 1 after inversion of DIGHEM V data.
The magnetic field data is shown on top.



Comparison between field data and response caculated from model obtained after inversion.

other, intermixed with contributions from plants and moisture. Many of these spectra overlap in amplitude and the aim is to identify which mineral species or rock types are present in the surface footprint of the sensor. The most successful way to determine rock composition is to identify the wavelengths where intensity peaks in the range 1,1–2,0 m, and to compare them with the peaks for known minerals. From these results, a choice of minerals leads to an ambiguous selection of rock types. By using other information, such as gamma-ray spectrometric ratios, the rock-type choice can be constrained.

Project 0840

ALGORITHMS FOR THE INTERPRETATION OF AIRBORNE EM DATA

(J.P. Smit, E.H. Stettler)

Objective:

to create a suite of programs to process the new time-domain electromagnetic equipment being developed and installed on our aircraft.

Least-squares inversion of airborne TDEM (Time-Domain electromagnetic) data provides a robust automatic interpretation tool for large data sets. Used in conjunction with popular imaging methods, full 1D non-linear inversion can resolve parameters that might be overlooked otherwise. Following the primary field removal of airborne TDEM data, time-domain data can be transformed to the frequency domain through a discrete Fourier transform (DFT). Once in the frequency domain, full non-linear inversion will minimise the misfit between the data and the physical-model response in a least-squares sense. Utilising algorithms under development a 1D layered earth model can be generated semi-automatically from airborne electromagnetic (EM) data.

The Geophysics Unit is investigating the acquisition or development of an airborne EM platform, and further research will allow the incorporation of airborne EM data in the 3D modelling of gravity and magnetics. This will add an extra dimension to the data and improve the final physical model that is obtained through an iterative inversion process.

Project 0172

CALIBRATION PADS AND STRIP FOR AIRBORNE RADIOMETRIC OPERATIONS

(A.B. Rutherford, C.J. de W. Raath, E.H. Stettler)

Objective:

to manufacture calibration pads for our airborne spectrometer.

Four calibration pads were constructed, each 1x1x0,4 m. Three of the pads contain known amounts of one of the elements uranium, thorium and potassium, and the fourth is used to determine background radiation. The known concentrations, along with the counts per channel, will then be used to determine the ground concentrations of these elements in future radiometric surveys. The calibration strip, situated near Papendorp in the Western Cape, will be used to determine attenuation of radiation with height. The calibration strip consists of a dirt road along which the ground concentrations of the three elements are known. The pads replaced a damaged facility that existed at Lanseria Airport.

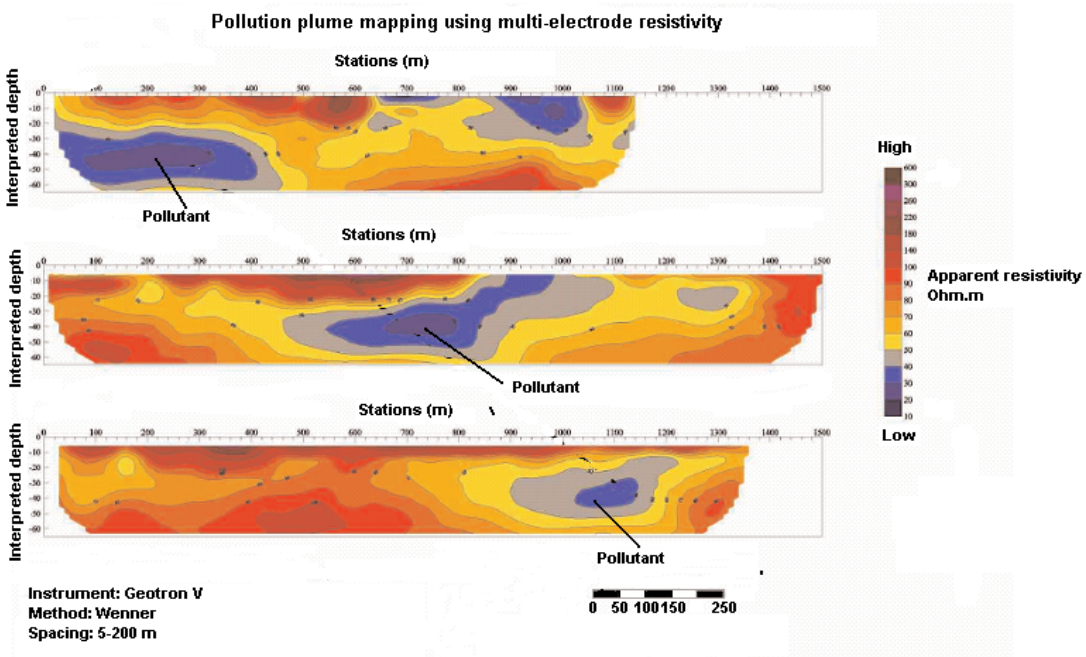
Project 0665

MULTI-ELECTRODE DC TECHNIQUE — FOUR CASE STUDIES

(P.J. Mahanyele)

Objective:

to investigate the use of DC electrical techniques in the location of grykes and in environmental-pollution problems.



Electrical resistivity methods are carried out by injecting current into the ground through two electrodes and the resulting potential is measured through two potential electrodes. A dipole-dipole-type array was employed with spacings of two and ten metres, and several profiles were measured. A total of three sites (two on dolomite and one on shale) was surveyed. The main aim was to test the effectiveness of this technique for the detection of small cavities, especially grykes (vertical solution fissures), and to image the subsurface geology. The maximum depths covered were 3,5 and 17 m respectively for 2- and 10-m separations.

The data were obtained via an adaptor using two cables with 19 takeouts connected to a Geotron G-41 resistivity meter. The Centurion and Valhalla results show possible grykes, and the Botanical Gardens' results show a tomographic image with weathered shale in some places.

Project 0839

BUSHVELD COMPLEX MODEL — APPLICATION OF 3-DIMENSIONAL INVERSION SOFTWARE TO GRAVITY AND MAGNETIC DATA IN THE BETHAL AREA

(Project leader: J. Cole. Co-workers: L.P. Maré, E.H. Stettler)

Objective:
to delineate new prospecting areas in the relatively unknown southern limb of the Bushveld Complex.

All of the available regional geophysical data, as well as newly acquired high-resolution airborne geophysical data, were used to create conceptual models for the southeastern limb (the Bethal area) of the Bushveld Igneous Complex. The regional data included gravity and aeromagnetic data, both of which form part of the nationwide coverage. A search of the literature shows that little attention has been paid to this limb of the Bushveld Complex and, in most cases, its presence is indicated on maps but not discussed in detail. The only references to work done on it that could be found were by Buchanan (1975, 1976, 1977 and 1979).

Advanced in-house-developed three-dimensional modelling software was used in this interpretation. The resulting three-dimensional model will assist in providing significant insights for the geology of this area.

Project 0838

DEVELOPMENT OF A SYSTEM TO GENERATE GROUNDWATER-POTENTIAL MAPS USING MULTIVARIATE STATISTICAL ANALYSES AND NEURAL NETWORKS

(C.J. de W. Raath, J. Cole, P. Cole)

Objective:
to produce a 1:50 000-scale groundwater target map for an area in the Limpopo Province.

Neural networks and multivariate statistical analysis were used in the production of groundwater target maps for the Limpopo Province. Two 1:50 000-scale sheets, 2229CC Skeenshoek and 2228DD Raditshaba, were used for an experiment and, on the basis of this, further groundwater target maps were generated. Data sets such as magnetics, gravity, LANDSAT and borehole information were used. The strengths and weaknesses of the technique have been highlighted, and it was found that most of the weaknesses resulted from a lack of data for an area, or variables being sampled at differing resolutions.

9. REGIONAL GEOCHEMICAL MAPPING

9.1 REGIONAL GEOCHEMICAL SAMPLING PROGRAMME

Objective:
These projects aim at compiling a geochemical database to aid exploration activities, to study the environment and to assist in geological mapping in areas of poor outcrop. The regional geochemical sampling programme will eventually cover the entire country. The soil samples of the Regional Geochemical Mapping Programme are analysed using Simultaneous XRF in order to obtain accurate and precise data for the geochemical data set.

Project 0905

2628 EAST RAND
T.O. Petso)

A geochemical sampling programme was planned for the suburban areas covering the 1:250 000-scale sheet 2628 East Rand. Soil samples from the sheet 2628AA Johannesburg were taken on foot and by using a 4X4 vehicle, as helicopter flying in the city areas is prohibited. One-kilometre-spaced grids were projected onto the 1:50 000-scale topocadastral map to assist the geologist in navigating to the sampling positions.

Project 0737

2820 UPINGTON
(J.H. Elsenbroek)

The soil samples, taken by helicopter-supported transport at a density of one sample per square kilometre, were dry-sieved to extract the -75 micron fraction, which was then pressed into powder briquettes and analysed on a Philips 1606 Simultaneous X-ray Fluorescence Spectrometer for the following elements: Sc, TiO_2, V, Cr, MnO, Fe_2O_3 (Total), Co, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Sn, Sb, Ba, W, Pb, Th and U. On the western degree square of sheet 2820 Upington, approximately 11 000 samples were prepared and analysed. The sample-position coordinates were merged with the analytical data to compile the geochemical maps.

9.2 RESEARCH PROJECTS

Project 0777

THE GEOCHEMICAL MAP OF THE KINGDOM OF LESOTHO
(J.H. Elsenbroek)

Objective:
to produce a geochemical map of Lesotho.

The Kingdom of Lesotho and the Republic of South Africa signed an agreement in 2000 in which South Africa would assist Lesotho to rise above the status of "least developed country" in five years. The Department of Mines and Geology of Lesotho proposed the project ***Geochemical Mapping of Lesotho.***

The Department of Mines and Geology of Lesotho and the United Nations Development Programme (UNDP) had collected stream-sediment samples in Lesotho during exploration for diamonds from 1971 to 1981. These samples were never chemically analysed, so it was proposed that these analyses be carried out on the CGS' Simultaneous XRF for the 23 elements Sc, TiO_2, V, Cr, MnO, Fe_2O_3 (Total), Co, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Sn, Sb, Ba, W, Pb, Th and U. The geochemical maps compiled from this data will complement the geological, magnetic and gravity maps that already exist and will aid in mineral exploration.

10. ENGINEERING GEOLOGY

10.1 DAMS AND UNDERGROUND

This Unit works closely with the Department of Water Affairs and Forestry, as well as with consultants appointed by that Department, and provides the engineering-geological expertise required for the development of the country's surface water resources.

A main focus for the period under review was engineering-geological investigations of existing dams as mandated for the on-going dam-safety inspection programme. State dams across the country were assessed as part of this programme.

In terms of the development/upgrading of the water infrastructure, there was major involvement in construction of the Nandoni Dam and Xikundu Weir, located on the Luvuvhu River near Thohoyandou, all constructed for primary water supply in Limpopo Province. In addition, construction of the Mutale Weir, also located near Thohoyondou in Limpopo Province, required significant engineering-geological input. The Department of Water Affairs and Forestry (DWAF) has been busy with construction of an apron at the Bulshoek Dam near Clanwilliam in the Western Cape, and personnel of the Dam and Underground Unit have provided engineering-geological input for design purposes, as well as construction monitoring.

New schemes for which engineering-geological investigations were conducted included the Berg River Dam, to be constructed near Franschhoek in the Western Cape, the planned raising of the Clanwilliam Dam and improvements to the Misverstand Weir on the Berg River. In Limpopo Province investigations were conducted for the planned raising of the Flag Boshielo Dam, as well as the proposed Rooipoort Dam at Mafef and the proposed De Hoop Dam near Steelpoort. Investigations were also conducted for the Fish Barrier Weir on the Mooi River in KwaZulu-Natal, while investigations are ongoing at sites for water abstraction on the southern KwaZulu-Natal coastal strip.

10.2 NON-DOLOMITIC URBAN INVESTIGATIONS

Project 0739

PHUTADITJHABA MUNICIPAL AREA
(B. Keyter, N.Y.G. Trollip)

The maps and reports for these urban development plans were completed. These projects are designed to be relevant and applicable to development for a particular municipality, ensuring that the CGS works closely with the municipality concerned, whose input and cooperation is vital to the success of each product. It was found that where town-planning departments are well organised, the product becomes an integral part of the tools used for town-planning purposes.

Dominant features in the Phutaditjhaba area include steep slopes, dongas and drainage channels. Expansive soils are associated with residual mudrock and dolerite, while erodible soils are associated with the Masotcheni Formation.

Project 0806:

THOYANDOU MUNICIPAL AREA
(L. Croucamp)

Objective:
to produce an Urban Development Map of the Town and surrounds of Thoyandou.

This project was fully funded by the CGS, and consisted of field work, sampling and profiling of about 100 profiles. A report describes approximately thirteen geotechnical parameters in detail and several maps are included. The master map indicates, by way of traffic-light colours, areas of preferential development, areas with cost-limiting factors, areas with environmental-limiting factors and areas that should preferably not be developed for urban purposes.

Steep slopes and expansive soils characterise the western section around the town of Thoyandou, while the eastern section, around Kwa Malamulele, is characterised by poor excavatibility and flat-lying areas susceptible to ponding. The different geotechnical properties for each area were mapped separately, and then combined to form a single zonation map, which depicts development potential.

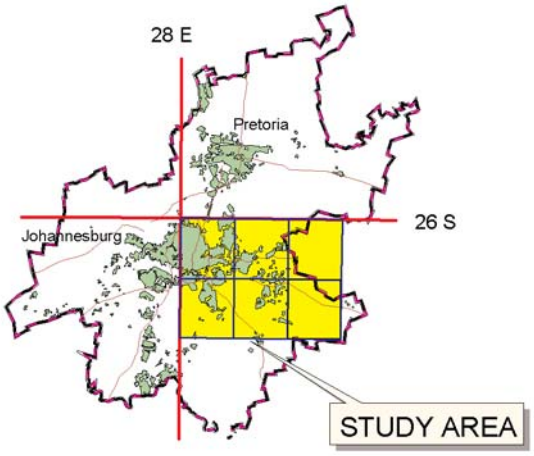
10.3 DOLOMITE STABILITY RESEARCH AND DEVELOPMENT

Project 0685

EAST RAND DOLOMITE-HAZARD MAP
(C. Forbes)

Objective:
to prepare a 1:100 000-scale dolomite subsidence hazard susceptibility map, covering 3 840 km² of the East Rand, with an explanation.

Work on the Malmani Dolomite (Black Reef marker) and Karoo sedimentary cover maps, using recent 1:50 000-scale geological mapping and various borehole data, as well as a non-compartmentalised groundwater-level map compiled from the Department of Water Affairs data for the Johannesburg, Benoni, Delmas, Alberton, Springs and Endicott sheets (2628AA, AB, BA, AC, AD and BC), was finalised. An initial analysis of the integrated hazard themes, using a GIS-weighted overlay software model, points to the expected relevance of slope class, bedrock fracturing (aeromagnetic and aerial photo sourced) and



prior subsidence-event distribution, where this is reliably known. The subsidence events are primarily concentrated in two areas (i) on the Alberton sheet in the Katlehong and Vosloorus areas, where anthropogenic factors (disrupted and poor surface drainage, abandoned open trenches, leaking pipes and taps) have accelerated the natural incidence of karst development, and (ii) on the Delmas sheet, along the contact with the overlying, northeast-dipping Pretoria Group.

Recorded subsidence sites correlate strongly with major northwest–southeast-trending dykes and associated faulting, such as the Sesfontein and Delmas dykes, while fold axes (once zones of open tensional joints acting as water-ingress pathways) were also found to have influenced their location, but to a lesser extent.

The sparse distribution of boreholes intersecting dolomite in the younger Karoo cover areas (including some large outliers) resulted in the interpolated surfaces or contours being considered unreliable over many areas. This is unfortunate as, in the absence of reliable isopach maps in these areas, drilling to depths of 100 m will be required to satisfy NHBRC dolomite-stability criteria for individual township and erf investigations. It was noted that no sinkhole has been found within the project area where the Karoo cover is thicker than 15–20 m. Published research also indicates that important karst-instability features, critical where cover is thin (<10 m), are masked by the protective Karoo cover — there are deep infilled dykes and erodible wad along the interface in many places. Furthermore, available regional gravity data do not expose such features, and highlight a crucial need for much more-detailed and extensive gravity surveys. The Department of Water Affairs and Forestry's gravity surveys in the Delmas area during the mid 1980s pinpointed significant gravity lows extending beneath Karoo cover.

The National Groundwater Database (NGWDB) of the DWAF for the period 1990–2003 produced a relatively usable interpolated water-level surface for the entire study area. The majority of subsidence events have occurred over areas where the interpolated water level indicates an apparent depth range of 10–21 m. Significant draw-down areas (>30 m) were also identified in the Alberton, Springs and Benoni sheets. Significant draw-downs also occur on the Delmas sheet area in the northeast and southern Karoo covered parts. These areas of steepened and closed groundwater gradients are attributable to gold mining, farm-irrigation activities (vegetables, maize) and municipal well fields (Delmas). Groundwater draw-down is an accepted trigger of inherent instability, because of buoyancy losses and material piping enlarging and weakening the roof cover of subsurface voids.

The provisional 1:100 000-scale (A1-sized) dolomite subsidence hazard (sinkholes and dolines) susceptibility map of the study area incorporates eight parameters considered crucial to or influencing subsidence development. These are slope, terrain type, soil group, water level, subsidence density, chert breccia, structure and Karoo cover. Each was classed according to histogram analysis augmented by the findings of a review of published case-history data (historical expert knowledge). Data were then integrated according to their considered destabilising or moderating effect, with iterations to examine the model's sensitivity to class and/or weighting changes. Four hazard-susceptibility classes are presented on the map: Very low, Low, Moderate and High. Feedback on this new map product will be invited from the geotechnical and town-planning communities in terms of its usefulness and applicability to their fields of practice. The map will be updated annually as new subsidence sites are reported, and its integration with a hazard-vulnerability map (potential injuries or deaths and infrastructure damages and losses — classed in terms of vulnerability exposure: high, medium, low, very low) will provide a regional dolomite-subsidence-risk map.

Completion of this project is now scheduled for 31 March 2005.

11. SEISMOLOGY

11.1 SEISMIC MONITORING

Projects 0184 & 0475

COLLECTION AND ANALYSIS OF SEISMOLOGICAL DATA

(Project leaders: M.R.G. Smith (analysis), J. von L. Pretorius (technical), Co-workers: L. Brink, T.T. Molea, B.E. Sutherland, L. Buso, D.L. Ngcobo, M. Ndyamba, A. Graham, E. Hattingh, D.L. Roblin, P.J.A. Bosch, A.L.D. Agenbacht, M.B.C. Brandt, E.M. Kgaswane, G. Graham)

Objective:

to compile quarterly seismological bulletins up to and including December 2003, to produce a SADC bulletin up to December 2003, to compile and edit an earthquake catalogue for the year 2000, and to maintain the SANSN.

Natural earthquakes in southern Africa recorded between October 2002 and September 2003 are listed below:

Date	*Time (SAST)*	*Region*	*ML*
2002/10/05	09:27:00.0	George	4.3
2002/10/12	22:19:20.7	Tsarisberge, Namibia	4.7
2002/11/01	12:20:32.9	Ceres	2.8
2002/11/06	10:20:46.3	Gariep Dam	1.3
2002/11/18	08:59:32.2	Ceres	3.1
2002/11/18	09:09:51.7	Ceres	2.2
2002/11/18	16:13:23.4	Groot Swartberge	3.5
2002/11/26	18:37:52.5	Ceres	2.5
2003/01/02	17:05:04.8	Ceres	2.4
2003/01/04	19:29:42.6	Ceres	2.4
2003/02/16	07:18:24.0	Ceres	1.5
2003/03/03	23:17:44.8	Ceres	1.8
2003/03/06	05:32:53.0	Ceres	2.4
2003/03/08	04:04:44.2	Ceres	2.0
2003/03/15	19:37:52.6	Ceres	2.1
2003/04/02	07:39:59.0	Gariep Dam	2.1
2003/04/03	06:37:55.5	Hofmeyr	1.9
2003/04/11	23:25:02.1	Ceres	1.8
2003/04/15	01:06:20.4	Ceres	2.0
2003/04/19	16:26:21.0	Ceres	2.3
2003/04/24	18:39:25.9	Ceres	2.5
2003/04/24	17:23:28.2	Gariep Dam	2.1
2003/05/04	04:58:45.2	Koffiefontein	2.8
2003/05/04	06:19:04.7	Koffiefontein	2.4
2003/05/05	14:53:27.1	Griekwastad	2.9
2003/05/07	17:11:54.1	Gariep Dam	1.8
2003/05/08	23:26:14.4	Koffiefontein	2.6
2003/05/12	15:10:00.9	Koffiefontein	3.5
2003/05/13	16:20:23.3	Plooysburg	3.4
2003/05/16	02:09:17.6	Ceres	1.6
2003/05/19	09:00:54.1	Bellville	3.4
2003/05/22	03:36:03.1	Ceres	2.4
2003/05/23	16:01:07.4	Gariep Dam	1.3
2003/06/01	09:23:15.5	Gariep Dam	2.0
2003/06/01	09:53:51.3	Koppies	2.7
2003/06/03	19:35:05.1	Thabazimbi	2.1
2003/06/05	04:39:41.5	Thabazimbi	1.7
2003/06/06	15:15:10.2	Thabazimbi	2.6
2003/06/07	14:18:19.5	Kirkwood	1.1
2003/06/12	13:33:20.1	Off SE coast of SA	1.4
2003/06/15	11:03:33.5	Thabazimbi	2.8
2003/06/19	20:19:16.4	Thabazimbi	2.0
2003/06/19	21:09:02.5	Thabazimbi	2.3
2003/06/20	15:16:38.8	Rustenburg	2.4
2003/06/21	05:28:16.6	Rustenburg	2.9
2003/06/26	10:05:52.7	North of Butterworth	1.7
2003/06/26	19:22:01.8	Northam	2.5
2003/06/30	13:23:41.0	Off SE coast of SA	1.2
2003/06/30	19:09:50.7	Thabazimbi	3.0
2003/07/02	01:49:10.6	Rustenburg	2.7
2003/07/03	01:46:24.8	Border of Lesotho	3.0
2003/07/04	15:17:10.7	Border of Lesotho	3.3
2003/07/04	16:10:09.8	Border of Lesotho	3.0
2003/07/04	16:12:58.0	Ceres	1.6
2003/07/05	03:21:59.5	Ceres	2.0
2003/07/05	08:56:00.6	Rustenburg	2.4
2003/07/05	15:44:07.8	Rustenburg	2.6
2003/07/05	15:49:05.4	Rustenburg	2.8
2003/07/05	19:00:06.7	Rustenburg	2.9
2003/07/06	00:02:11.5	Rustenburg	1.8
2003/07/06	15:05:33.4	Rustenburg	2.5
2003/07/06	19:10:02.7	Rustenburg	1.9
2003/07/07	06:23:35.1	Rustenburg	3.1
Date	*Time (SAST)*	*Region*	*ML*
2003/07/07	09:09:52.3	Gariep Dam	0.1
2003/07/08	01:39:35.3	Border of Lesotho	2.8
2003/07/10	09:13:30.6	Sade	2.0
2003/07/11	05:03:13.5	Border of Lesotho	2.8
2003/07/12	18:44:34.6	Rustenburg	2.0
2003/07/12	19:28:41.8	Rustenburg	2.8
2003/07/14	13:21:43.2	Bedford	1.3
2003/07/15	22:35:48.5	Border of Lesotho	3.4
2003/07/16	00:33:53.9	Rustenburg	2.2
2003/07/16	08:15:54.4	Balfour	2.3
2003/07/16	20:31:55.4	Ceres	1.1
2003/07/19	02:02:35.0	Ceres	1.7
2003/07/23	13:32:28.3	Cradock	1.4
2003/07/23	16:54:05.3	Meyerton	2.2
2003/07/24	15:54:05.8	Ceres	2.9
2003/07/26	13:26:13.0	Somerset East	1.1
2003/07/31	10:13:02.9	Ceres	2.3
2003/08/02	22:48:21.4	Petrusville	2.8
2003/08/03	07:28:50.1	Nylstroom	1.0
2003/08/05	20:30:31.4	Northam	2.8
2003/08/07	12:38:41.0	Swaziland	3.9
2003/08/15	03:42:42.1	Springbok	0.4
2003/08/15	07:37:14.8	Rustenburg	2.6
2003/08/16	15:20:59.0	Rustenburg	2.1
2003/08/16	16:57:58.1	Mabeskraal	1.6
2003/08/18	07:22:14.1	Springbok	2.8
2003/08/20	03:45:20.6	Gariep Dam	2.7
2003/08/21	14:03:18.6	Kokstad	4.7
2003/08/23	13:16:48.5	Sada	1.4
2003/08/24	21:26:40.3	Ceres	1.9
2003/08/30	18:34:56.3	Bethlehem	3.5
2003/09/01	10:07:29.5	Sheepmoor	3.5
2003/09/03	09:36:07.9	Richmond	3.6
2003/09/03	13:20:23.9	Rietbron, Groot Karoo	2.1
2003/09/03	18:03:05.7	Bethlehem	3.5
2003/09/04	15:48:14.2	Ceres	1.6
2003/09/07	17:08:36.8	Huib-Hoch, Namibia	2.5
2003/09/07	18:57:51.6	Hantam	2.2
2003/09/09	03:05:51.1	Augrabies Falls	2.6
2003/09/10	16:11:28.5	Springbok	0.6

2003/09/11	21:40:04.7	Petrusville	2.2
2003/09/12	09:05:51.4	Springbok	0.6
2003/09/12	12:51:06.4	Ceres	4.0
2003/09/12	12:54:25.9	Ceres	2.3
2003/09/12	19:17:19.4	Ceres	2.2
2003/09/12	23:32:45.3	Ceres	1.5
2003/09/16	09:25:47.9	Springbok	1.3
2003/09/17	18:40:53.5	Ceres	2.3
2003/09/17	21:10:20.7	Ceres	1.2
2003/09/19	03:06:46.8	Ceres	2.4
2003/09/19	15:28:49.3	Nababeep	0.7
2003/09/21	15:18:43.5	Ceres	1.7
2003/09/23	01:13:16.2	Springbok	0.6
2003/09/23	06:23:42.4	Ceres	1.9
2003/09/25	05:28:30.0	Tzaneen	3.3
2003/09/25	20:45:10.6	Ceres	4.4
2003/09/27	13:46:21.2	Petrusville	2.7
2003/09/28	10:10:40.0	De Aar	2.7
2003/09/29	13:03:49.3	Ceres	1.2
2003/09/29	13:54:42.9	Offshore of Jeffreys Bay	1.2
2003/09/30	02:50:19.7	Granaatboskolk	3.8

The list below shows mining-related earthquakes with a Local Richter magnitude of 4,0 or larger in the goldfields of South Africa during the period October 2002 to September 2003.

Date	*Time (SAST)*	*Region*	*ML*
2003/04/05	16:47:04.20	Far West Rand	4,2
2003/07/20	01:05:02.90	Far West Rand	4,2
2003/08/14	09:36:14.60	Klerksdorp mines	4,0

The latest release of the International Seismological Centre's (ISC) Global Bulletin was received and integrated into the national catalogues. The catalogue of earthquakes located in southern Africa and surrounding oceans for 2000 was completed. Phase data from the earthquakes recorded and located during the year were supplied to the ISC in the United Kingdom.

An annual SADC bulletin for the period January 2003 to December 2003 was compiled using data from the CGS, the Direcçao Nacional de Geologia de Moçambique, the National Earthquake Information Centre (NEIC) of the United States Geological Survey (USGS), and the International Data Centre (IDC) of the Comprehensive Nuclear Test-Ban Treaty Organisation (CTBTO).

Eleven CMG 40T and three KS 2000 seismometers were purchased and are being deployed in the network as part of the SANSN upgrade to include broadband technology. As some of this equipment will be installed at Somerset East, Parys, Koster, Lephalale, Calvinia, Upington, Prieska and Musina, vault conditions were improved at these sites, and site surveys and noise tests were conducted. New vaults were constructed at the Parys, Lephalale, Prieska, Upington and Calvinia stations. A new station was installed at Mopani, a site previously used by the University of the Witwatersrand for the Kaapvaal craton project.

Project 0813

ESTABLISHMENT OF A LOCAL RICHTER- AND MOMENT-MAGNITUDE SCALE FOR SOUTHERN AFRICA

(Project leader: M.B.C. Brandt, Co-worker: E.M. Kgaswane)

Objective:

The CGS operates the South African National Seismograph Network (SANSN), and publishes the data in quarterly seismological bulletins and annual catalogues. In the seismological bulletins the earthquake hypocentre, origin time and local magnitudes are reported, together with the phase readings and amplitudes and periods as determined from the individual stations. Until now the original definition of Local Richter magnitude, as first developed by Richter for California, has been used, which could lead to over- or underestimations of earthquake magnitudes in South Africa, as determined by the SANSN. An investigation was completed to quantify the extent of magnitude over- or underestimation in order to devise a strategy to develop a Local Richer magnitude scale for South Africa, especially in the light of deploying broadband technology. The Local Richter magnitude scale was updated in October 1996 from the original definition, as given by Richter, to a refined definition by Hutton and Boore (1987). The Local Richter magnitude scale, as currently used by the CGS, was compared with (a) the Local magnitudes reported by the International Data Centre and (b) the energy magnitude as reported by the mine seismograph networks installed in South Africa's deep gold-mining areas. Finally, the internal consistency of the SANSN was investigated by comparing it with the local magnitudes as determined by the analogue seismograph at the World Wide Standardised Seismograph Network (WWSSN) station at Silverton.

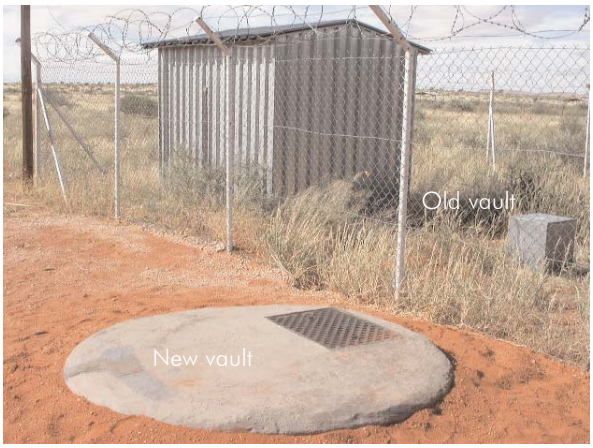
Project 5414

COMPREHENSIVE TEST-BAN TREATY ORGANISATION

(Project leader: G. Graham, Co-workers: A. Graham, M.B.C. Brandt, J.J. du Plessis, D.L. Roblin, M.R.G. Smith, J. Steyn, D.L. Ngcobo)

Objective:

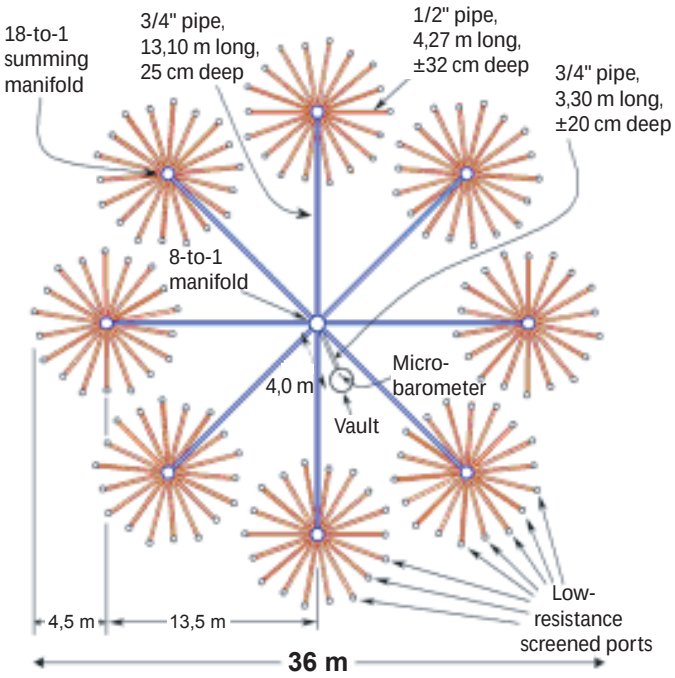
to establish a basic National Data Centre framework.



Photographs of some of the upgraded vaults that have been constructed: (1) the new and old vaults of the Upington station, (2) inside the new vault of the Calvinia station, (3) the new vault of the Lephalale station, (4) the new vault of the Prieska station, and (5) the new vault of the Upington station. Note the distinct improvement between the old and new vaults.

The aim of this project is to establish a National Data Centre (NDC). In order to establish a reliable data communications infrastructure for transmitting continuous seismic-waveform data from the borehole site at Boshof to the recipients, two satellite dishes were installed. Construction and installation of the VSAT dishes were completed at the remote site and the central site in Pretoria. The communication equipment was licensed at the Independent Communications Authority of South Africa (ICASA) and link stability tested. A proposal for the operation and maintenance of the equipment was submitted to the CTBTO.

A computer was connected to the VSAT dish at Pretoria in order to connect directly to the International Data Centre of the CTBTO. The latest version of the NDC-in-a-box



144-port, 36-m diameter, long period-optimized wind-noise-reducing pipe array to be installed at elements A, B, C, D and E. The pipes from the 18-to-1 summing manifolds to the 8-to-1 summing manifold are standard ¾" galvanised iron water pipes. The pipe from the 8-to-1 manifold to the vault is also ¾" pipe. The shorter radial pipes are standard ½" galvanised iron water pipes. Connections to the manifolds are by means of ½" and ¾" pressure tubing and clamps. The curved end pieces (hoops) are attached by means of ½" "easy bends". These hoops are turned alternately to the outside and inside, as one moves from one radial pipe to the next. The port filters are attached by means of standard tapered ½" NPT thread.

software was installed, and testing of automatic data requests commenced.

Project 5415 I

NFRASOUND STATION IS47

(C.R. Randall, J. Pretorius, E. Kgaswane)

Infrasound station IS47 is one of the 60 infrasound stations of the IMS (international Monitoring System) of the CTBTO (Comprehensive Test-Ban Treaty Organisation). 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, hydroacoustic and radionuclide, for monitoring adherence to the Comprehensive Nuclear-Test Ban Treaty, which was opened for signing in 1996. As a signatory to the treaty, South Africa is under obligation to work together with the CTBTO, and the CGS is privileged to have a major role in this cooperation.

IS47 is on the farm Magdalenas-Rust near Boshof, about 50 km from Kimberley. The CGS' proposal for the construction of the "civil works" of the infrasound array was accepted by the CTBTO and the contract, worth about R3,5m, was signed in December 2003. Construction should begin at the end of August 2004 and be completed in December. Preliminary data should be available from February 2005.

The diagram shows the piping of one of the eight elements of the array.

Project 0479

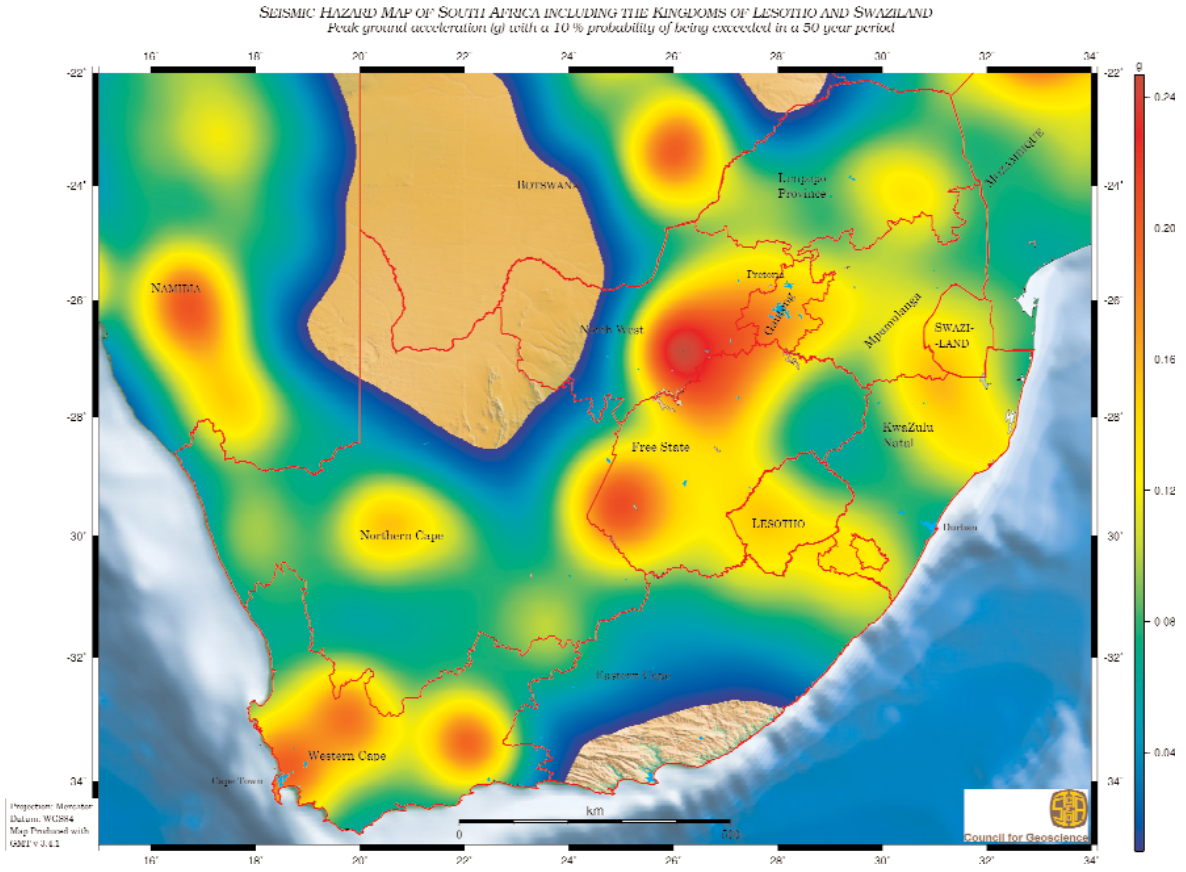
SEISMIC-HAZARD ASSESSMENT

(A. Kijko, G. Graham, M. Bejaichund, D.L. Roblin, A. Graham)

Objective:

to produce seismic hazard maps in terms of probabilistic peak ground acceleration (PGA) and probabilistic spectral acceleration for South Africa. The purpose of these maps is to show the earthquake-hazard potential in South Africa, and they should be interpreted as an overview of the seismic hazard for the region.

Several maps depicting seismic hazard in South Africa were produced. A map of peak horizontal ground acceleration (PGA), with a 10 per cent probability of exceedance in 50 years, formed the basis of the analysis, and maps depicting spectral accelerations for different frequencies were also determined. These maps provide a regional view of the



seismic hazard in South Africa and are complemented by site-specific seismic-hazard curves for some of the main centres. The maps are accompanied by explanatory notes on the methodology used and results obtained, and are available on CD.

Project 0717

DATA COLLECTION AND ANALYSIS FOR THE SEISMOTECTONIC MAP OF SOUTHERN AFRICA

(G. Graham, M.B.C. Brandt, D.L. Roblin, L.G. Wolmarans)

The earthquake database for southern Africa has been compiled and, in conjunction with the tectonic information for southern Africa, will form the core of the seismotectonic map. The legend for the map has been completed in accordance with the guidelines of the International Commission of the Geological Map of the World.

11.2 RESEARCH AND DEVELOPMENT

Project 0784

RE-EVALUATION OF EPICENTRES OF HISTORICAL EARTHQUAKES (1620–1910) FOR THE SOUTHWESTERN CAPE

(M.B.C. Brandt, E.M. Kgaswane, M. Bejaichund, D.L. Roblin)

A revised historical seismological catalogue to replace Seismologic Series No. 9, 'Seismic History of Southern Africa' (Fernández and Guzmán, 1979), was compiled and will be prepared for publication next year. Seismological information contained in different publications has been collected, and a uniform catalogue of earthquakes in southern Africa from 1620 to 1970 was compiled. The region covered by this catalogue lies between latitudes 17 and 35°S, and longitudes 10 and 35°E. For the period 1620 to 1902 the seismological information contained in Theron (1974) was re-evaluated and the epicentres listed in Finsen (1950) improved. Publications, only recently discovered by De Klerk and Read (1988), were used to re-evaluate one event and update the catalogue with seven previously unknown earthquakes, and one previously unknown event was discovered in Russel (1971). All the major earthquakes for the period 1900 to 1930 were updated with re-appraised information published by Ambraseys and Adams (1992): four events were updated and three previously unknown events were included. Small earthquakes for the period 1903 to 1930 and all the events from 1931 to 1970 have been taken from the former catalogue, Seismologic Series 9, without modification, except to slightly improve the readability. De Klerk and Read (1988) found one previously unknown event for the 20th

Century that could also be included. The earthquakes are specified in terms of date, region of maximum reported intensity and value of this intensity on the modified Mercalli scale. Only earthquakes of clear natural origin were included before, and those induced or triggered by deep-mining activity or by artificial water reservoirs are also not reported in this updated catalogue. The seismicity of southern Africa is typical of that of the interior of a global plate influenced by a wide plate boundary, namely the East African Rift System, and the present catalogue must be interpreted in terms of the laws describing this seismicity. Earthquakes in this region for the period 1971 onwards are listed in the annual "Seismological catalogue for southern Africa and surrounding oceans" published by the CGS.

Project 0819

ASSESSMENT OF A GLOBAL MAXIMUM POSSIBLE MAGNITUDE FOR EARTHQUAKES IN STABLE CONTINENTAL REGIONS OF AFRICA

(M. Bejaichund, A. Kijko, E. Hattingh)

The purpose of this project is to assess the maximum possible earthquake magnitude that could be experienced on stable continents such as Africa. This assessment makes use of newly developed methods for maximum possible seismic-event magnitude m_{max}. This study is a first of its kind and can serve as a platform for further investigation into the causes of seismicity in stable continental regions. The primary outputs of the project are maps containing the m_{max} expected for stable continental regions of Africa, as well as a discussion of the results. A report "Estimation of Maximum Earthquake Magnitudes for Stable Continental Regions of Africa" by M. Bejaichund, A. Kijko and E. Hattingh, Report 2004-0065, was completed.

Maps of m_{max} were produced for South Africa, West Africa and Central Africa. Most of Africa has a m_{max} of 5 and the regions of higher m_{max} include the Western Cape Province in SA (6,3–6,7), the Democratic Republic of Congo (5,0–7,4), southern Sudan (7,2), Algeria (5,0–6,0), Ghana (6,5) and Cameroon (5,0–6,2).

Project 0814

APPLICATION OF THE "REFERENCE SPECTRAL NOISE RATIO METHOD"

(M.B.C. Brandt, E.M. Kgaswane, J. von L. Pretorius, D.L. Ngcobo)

The study assessed site response (near-surface effects and amplification of elastic waves) to microseismic noise and signals from mine-related earthquakes. A softrock site at the Donkerhoek core storage facility (having a 1,2–1,8-m soil layer resting on shale) was compared with a hardrock site at the World Wide Standardised Seismograph Network station at Silverton (SLR, in a 30-m-long quartzite tunnel) in the Botanical Gardens. The technique is called the 'Reference spectral noise ratio method' and is a variation of Nakamura's method. The data were analysed using a method similar to that used for the numerical modelling, when the Herrmann synthetic seismogram software program was used. When modelling with the software it was found that spectral 'peaks' at certain frequencies confirm the existence of layers of softrock (responsible for the site response) near the surface. However, the modelled peak frequency and amplitude are not a quantitative measure of cumulative soil thickness. The purpose of the application experiment is to calibrate the surface wave penetration of both microseismic noise and signals from mine-related earthquakes against the well-known sites (with geological, geotechnical and geophysical information available) at Donkerhoek and Silverton station. Furthermore the temporary set-up at Donkerhoek was to establish the independent use of noise in evaluating the seismic response of soft layering such that site amplification related to future tremors or earthquakes can be predicted. However, an unambiguous interpretation of resonances around the receiver site at various frequencies is still very much a matter of further investigation (Bard ***et al.***, 1997, 2003). The results of the 15 seismic recordings selected from the Donkerhoek experiment indicate a linear trend of both noise and earthquake spectra along or near the x-axis. When both spectra are viewed on the log-log axes, both spectra are shifted by amplitude units in the order of 0–4 at a frequency of 1 Hz. This implies that both

noise and earthquake spectra are not perfectly correlated and it is therefore necessary to account for this small variation when using the noise spectra independently to evaluate site effects.

Project 0820

COMPARISON OF PRE- AND POSTMINE-CLOSURE SEISMICITY IN THE EAST RAND
(A. Kijko, M. Bejaichund)

Most of the East Rand is situated on or near deep gold mines. In the past decade mining in this area has decreased dramatically, largely owing to the high interest rates and the low gold price which rendered gold mining in this area ineffective in terms of financial returns. Mining has had a direct effect on the seismicity of the area, which was quantitatively evaluated in this project. Results show that there has been a decline in seismic events by as much as 80 per cent since 1990.

11.3 NEW TECHNOLOGIES

Project 0774

QUALITY CHECKS OF P AND S TRAVEL TIMES FOR RELIABLE LOCATION ESTIMATES
(E.M. Kgaswane, M. Bejaichund, A. Kijko, T.T. Molea)

A fundamental location code has been written, using MATLAB software for locating mining-related seismic events or earthquakes in close proximity to one another. The current code is capable of providing event locations in terms of latitude, longitude and origin time, with the depth being fixed around 2–3 km for mining events. The location algorithm is based largely on the ideas of Spence (1980), and Gibowicz and Kijko (1994).

Additional features to the present existing code are:

1. System coordinates have been converted from the usual (x,y,z) coordinates to the (8,n,z) coordinate frame, where the symbol 8 refers to longitude, n is latitude and z refers to depth.
2. There has been an extension to get rid of the origin time of the master event (which is sometimes not available).
3. There is a weak dependence on crustal structure in the location of the events. This is an advantage because the crustal structure is often not known.

The relocation algorithm is currently in its testing phase and it is envisaged that, with further modification, the location of events can be made significantly independent of ***a priori*** knowledge of crustal structure. Data from the CGS and mining-earthquake bulletins have been selected to test the efficiency of this program. This program is a starting point for many other areas of research, including determination of crustal structure, depth determination, focal mechanism and stress.

COOPERATION WITH GEOFORSCHUNGS-ZENTRUM ON 2003 SEISMOLOGY TRAINING COURSE
(C.R. Randall, D. Duarte, G. Graham, M.B.C. Brandt, D.L. Roblin, I. Saunders, A. Kijko, A. Graham, S. Shaik, R.K. Robbertse, M.A. Otto, P. Adamos, M.D. Oosthuizen, N. Reddy, M. Paweska)

The CGS hosted and organised locally the prestigious "International Training Course on Seismology, Hazard Assessment and Risk Mitigation" in cooperation with the GeoForschungsZentrum (GFZ) of Potsdam, from 8 September to 10 October 2003. This annual course is held alternately in Germany and a foreign country. Thirty-two students from twenty countries in Africa and the Middle East participated. There were nine lecturers from Europe, two from the Comprehensive Test-Ban Treaty Organisation and eight from Africa, including four of the CGS staff. Excursions were arranged to the Katse Dam in Lesotho, the Tau Tona Mine of Anglogold, the Vredefort Dome and the Tswaing crater. Financial assistance came from the German Foreign Office, the United Nations, the CGS and Integrated Seismic Systems International.

Some 120 pages of complementary lecture notes were provided by staff of the CGS to the students of the GFZ course:

- "Introduction to Seismicity and Seismic Monitoring in Sub-Saharan Africa" (G. Graham)
- "Some Elements of Probabilistic Seismic Hazard and Risk Analysis" (A. Kijko)
- "Background Lectures on Signal Processing" (C.R. Randall)
- "A Review of the reservoir-induced seismicity at the Katse Dam, Kingdom of Lesotho — November 1995 to March 1999, pp. 119–132, Fifth International Symposium on Rockburst and Seismicity in Mines, 2001" (M.B.C. Brandt).

12. GEOHYDROLOGY

EXPLANATIONS TO 1:250 000-SCALE GEOLOGICAL MAPS — CHAPTERS ON GEOHYDROLOGY

Project 0102

2426 THABAZIMBI
(K.A. Majola)

The description of the hydrology of this sheet evaluates the mapped aquifers in relation to groundwater potential, and identifies geological structures that can be targeted for groundwater exploration in the Thabazimbi area, enhancing the map's use as an aid to water-resource managers meeting the water demands for the region. A conceptual hydrogeological model of the mapped geological units of the Thabazimbi geological map is presented. Statistical analyses of data obtained from the National Groundwater Database (NGDB) indicate the groundwater potential of the individual geological units on the Thabazimbi sheet area.

Project 0106

2524 MAFIKENG
(J. Groenewald)

This project has focussed on the statistical analysis of the borehole data provided by the National Groundwater Database (NGDB) of the Department of Water Affairs and Forestry (DWAF), and on the water-quality samples from the related Water-Quality Database (WQDB). The analyses statistically examine the depth of the boreholes, the reported air-lift yields, the depth and frequency below ground surface of the water levels, the depth and frequency below ground surface and water level of water strikes and yields. The analyses were conducted on regions identified on the maps by their lithology and therefore by hydrostratigraphic units. This method characterises the optimal drilling depths of each region, based on the success rate of the boreholes. Where possible, attempts were made to relate this analysis to structural features in the regions.

Project 0101

2624 VRYBURG
(N. Motebe)

The hydrogeology chapter for the 1:250 000-scale geological map 2624 Vryburg involves statistical analyses of available groundwater data in order to improve future exploration programmes of groundwater resources in the Vryburg area. Data such as water levels, depth of boreholes and yields obtained from the National Groundwater Database (NGDB) of the Department of Water Affairs and Forestry (DWAF) were used in the analyses. A hydrogeological conceptual model of the area was developed to understand the demarcated aquifer/aquifers of the area. This forms the basis for the analysis of the data. Information such as the depth at which groundwater may be intersected, the water level and the expected yield can be provided. The hydrogeochemical data, also available from DWAF, were analysed in order to inform decision makers on the intended usage of the groundwater. Such analyses, based on the major ions found in groundwater, assist in classifying the water in terms of water-quality guidelines.

13. MARINE GEOLOGY

Project 0612

MARINE GEOLOGY OF ALIWAL SHOAL

(C. Bosman)

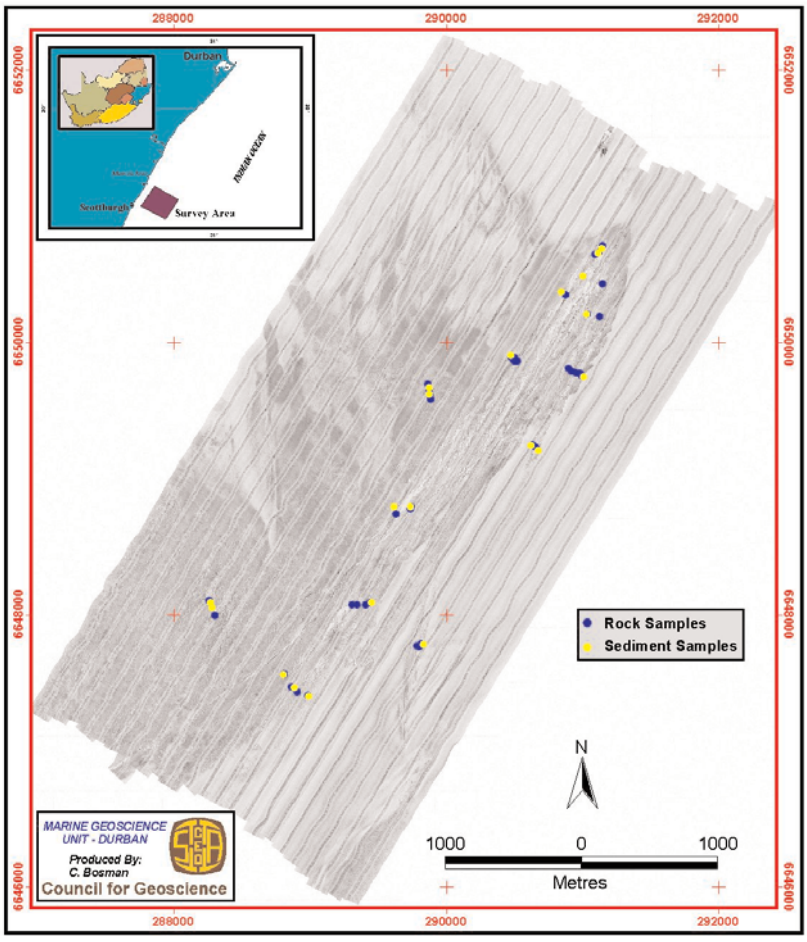
An extensive underwater SCUBA-diving, ground-truthing and sampling phase was conducted around the Aliwal Shoal and the surrounding sea floor. Dive sites were selected from the compiled sea-floor maps (side-scan sonar mosaic, interpreted sea-floor geological and bathymetry). An innovative method of real-time positioning of dive transects was developed, resulting in underwater sample localities and observations being georeferenced to an accuracy of 5 m. The dive programme was undertaken in collaboration with scientific divers from the Geology Department of the University of KwaZulu-Natal.

A total of 47 rock and 20 sediment samples was collected in 14 dives. Petrographic analyses of the rock samples and grain-size-distribution analysis of the sediment samples have been conducted. Samples are currently being selected for geochronological analysis.

Dive transects, together with the sample localities and underwater field observations, have been collated with the various sea-floor maps. The activities and findings of the ground truthing and sampling will be written up as a report. Results (geophysics, laboratory and field work) indicate that Aliwal Shoal is composed of aeolianite and beachrock outcrops.

Future programme

- Geochronological dating of samples collected during the ground-truthing phase of the project.
- Extending the coverage of underwater sampling and ground truthing, as the initial sampling phase concentrated only on Aliwal Shoal and its immediate surrounding.
- Vibrocoring of marine sediments shoreward and seaward of Aliwal Shoal to obtain undisturbed sedimentary profiles. Integration of all of the interpreted geophysical, field and laboratory data into an evolutionary model for Aliwal Shoal.



The Aliwal shoal survey map

Project 0462

MARINE GEOLOGY OF THE DURBAN SHELF

(R. Leuci, A. Richardson (University of KwaZulu-Natal))

This project was re-initialised as a collaborative project between the CGS and the Geology Department of the University of KwaZulu-Natal.

Additional side-scan sonar (sss) data were postprocessed and a new sss mosaic of the Durban Shelf, covering an area of 142 km^2, was produced. The splicing of two different sonar data sets, varying in scan ranges, was achieved by using new, innovative side-scan sonar processing software developed for the NRF Innovation Fund Project. Approximately 900 line kilometres of pinger seismic data were postprocessed, interpreted and digitised. A preliminary isopach map has been compiled. A report "Recent advances in the processing of geophysical data collected on the Durban Bight", Report 2004-0029, was completed.

Future programme

- Interpretation of the side-scan sonar mosaic to produce a geological facies map of the Durban Shelf.

- Finalisation of the sediment isopach and bathymetry maps of the Durban Shelf.
- Undertaking of a comprehensive sediment- and rock-sampling programme, coupled with underwater SCUBA-diving observations.
- Collation of interpreted geophysical and sedimentological/geological data into an evolutionary model for the Continental Shelf off Durban.

Project 0753

STRATEGIC HARBOUR-APPROACH SURVEYS — DURBAN HARBOUR

(R. Leuci, C. Bosman)

Sea-floor characterisation of the Durban Harbour approach is required by the South African Navy for strategic purposes. Side-scan sonar, seismic and bathymetric data, collected during geophysical surveys conducted on the Durban Bight from 1999 onward, have been processed. A smaller higher-resolution survey of the approach has been carried out to allow for an analysis of potential changes on the sea floor. A side-scan sonar mosaic, bathymetry and a preliminary sediment-thickness map for the Durban Harbour approach have been produced.

Future programme

- Interpretation of the side-scan sonar mosaic to produce a sediment-facies map of the Durban Harbour approach.
- A final survey of the approach and compilation of the sediment isopach and bathymetry maps.
- Production of GIS products for the South African Navy.

Project 5533

SOUTH AFRICAN EXTENDED CONTINENTAL SHELF CLAIM PROJECT (SA EEZ)

(S.K.P. Coles, A. Faull)

A complete investigation was made of analogue and digital data archived by the Marine Geoscience Unit and other sources. These were catalogued (cruise, year, type of geophysical data, formats of data) using Microsoft Access, and a customised database was created to allow querying. A second database allowing for literature searches was also developed. These two databases are being combined to form an all-encompassing database that will be searchable for all geophysical data and literature that are applicable to SA EEZ claim, and will also benefit the Marine Geoscience Unit on other projects. A comprehensive bathymetric data set, derived from various sources, is being collated in order to produce a bathymetric map of the South African Continental Shelf.

To facilitate effective work on both the South African and African EEZ projects, the Caris LOTS software package was acquired to integrate all available geophysical (seismic, magnetic, bathymetric) data with the United Nations Law of the Sea Regulations (Article 76) in order to delimit potential EEZ claims. The Caris LOTS course was beneficial to the attendees and facilitated a preliminary assessment of Coastal African States with regard to possible Extended EEZ Claims according to UNCLOS Article 76 by staff in the Unit.

A highly successful and enlightening international conference on the Legal and Scientific Aspects of Continental Shelf Limits, held in Reykjavik, Iceland, was attended by two members of the Unit (S. Perritt and S.K.P. Coles). S. Perritt continued his journey to visit Ireland after the conference and spent a week with the Irish Geological Survey, who are coordinating much of the Irish Continental Shelf Delimiting Survey Programme.

Future programme

A more advanced Caris LOTS course, hosted by the CGS, is scheduled for April 2004. Further refinement of the database structure, and establishment of links between the various databases is planned. The future role of the CGS in the SA EEZ project has recently been revisited/re-assessed in response to significant changes in the programme. These changes have come about as a result of increased knowledge about the relevance and potential limits of various data sets available to the organisations forming the collaborative venture, and the change of directorship of the project to the Petroleum Agency of South Africa. The new roles, and thereby involvement, of the various organisations involved in the project joint venture are presently being redefined in the light of the above and will drive the future programme.

Project 0680

MARINE GEOLOGY AROUND ROBBEN ISLAND

(P. van den Bossche, S.K.P. Coles)

An extensive underwater (SCUBA)-diving sampling programme was conducted within approximately 1 nautical mile (~1,8 km) around Robben Island, in order to ground truth previously acquired geophysical data. Sampling/dive sites were established, based on previously collected geophysical data of the sea floor, predominantly from side-scan sonar mosaics and associated bathymetry data/maps. Because of the occurrence predominantly of sedimentary facies to the northeast and southeast of Robben Island, a 500-m sample-separation 'grid' was set up to obtain representative samples in these areas. In areas of predominantly homogeneous bedrock outcrop to

the southwest, northwest and north of the Island, wider-spaced sample sites were setup to give a representative sample at these locations. The predefined sample/dive sites were positioned using a precision navigation system (DGPS). The actual positions at which the divers obtained the samples are estimated to be within 5–10 m of the predetermined sites. The diving sampling programme was undertaken with the assistance of the Simon's Town Defence Force Underwater Club divers and affiliated members.

A total of 42 rock and 53 sediment samples were collected in 69 dives. The samples are currently in our laboratory awaiting analysis. The sediment samples will undergo grain-size and carbonate-content analyses, and the rock samples will undergo thin-section analysis for determination of lithology and, potentially, age. The sample-locality maps have been generated, and dive logs with diver observations have been completed. A diving sampling operations report has been compiled as an internal CGS report, adding to the two reports already submitted for phases completed for this project. It would appear that the majority of bedrock surrounding Robben Island consists of shale and fine-grained sandstone (Tygerberg Formation?) of the Malmesbury Group.

The sediment grain-size distribution varies from fine to coarse (typically consists of a quartz- and bioclast-rich assemblage), with certain areas comprised of conglomeratic sediment (pebble to cobble size).

Future programme

The rock and sediment samples will undergo thin-section and grain-size/carbonate-content analyses respectively, as part of the next phase of the project. Limited further diving/sampling may also be undertaken in the following phase, pending the outcome of the results of the samples already collected. Assimilation of all of the interpreted geophysical, ground-truthed and laboratory data results, in order to produce a final report and GIS-based product, will be conducted and will outline the surficial sea-floor geology around Robben Island.

Project 0460

MARINE SURVEY TECHNOLOGIES

(P. van den Bossche, C. Bosman)

Development of new side-scan sonar processing software

New side-scan sonar postprocessing software was developed for the Marine Geoscience Unit by Marine GeoSolutions (Pty) Ltd, Durban. This was initiated by an NRF-funded project entitled "Development of an expert marine geographical information system to provide an environmental and economic decision support system for coastal tourism and leisure development within the Lubombo/Greater St Lucia wetland park spatial development initiative". The software replaces older side-scan sonar processing software, with the development of three postprocessing utilities, (a) Klein 2000 to XTF format converter, (b) Side-scan sonar processing utility and (c) Side-scan sonar mosaicing utility. The main differences to our existing postprocessing software include: A systematic three-module processing utility (as mentioned above), an automated side-scan sonar tape 'dumping' routine (i.e. encoded tape data to hard-drive copying and conversion — Klein 2000 to XTF format) and enhanced postprocessing and mosaicing utilities. These developments/modifications were designed to speed up processing time and thus improve processing productivity.

Development of new side-scan sonar processing software: Both of the above-mentioned project leaders have undertaken a one-day course in the operation of the new postprocessing software with Marine GeoSolutions. The software has been implemented in both the Durban and Cape Town offices, and is being used as the primary side-scan sonar processing tool. A report detailing the use of the new software is being finalised and is due for submission as an internal CGS report in March 2004.

Implementation of HYDROpro Navigation Software and production of in-house operations report.

In 2003 a newly purchased Windows-based marine-survey navigation software package (HYDROpro) was introduced into the Marine Geoscience Unit to replace the older, DOS-based navigational software.

The new navigation software (HYDROPro) has been implemented, and some basic training by the supplier has been given to one of the staff members. Some of this training has been passed on to other members, mainly to staff stationed at Bellville. In order to make the knowledge available to all users within the unit, a basic operational guide has been written.

Future programme

Two members of the Marine Geoscience Unit will attend Oceanology International 2004 — a Marine Technical Exhibition, in London, in March. This is the world's largest marine-survey technical exhibition, and presents a good opportunity for exposure to the latest marine geophysical software and equipment developments. The Marine Geoscience Unit takes pride in being up-to-date with modern marine geophysical data-acquisition and processing techniques, and uses this exhibition as a means of staying abreast of modern marine geophysical developments. A report will be written and submitted.

A Reson 8125 swath bathymetry system will be tested, to compare it with present side-scan sonar and bathymetry

data, and to assess the suitability of this survey tool and its cost efficiency for future projects.

Project 0463

MARITIME WRECK SURVEYS

(P. van den Bossche, S.K.P. Coles)

Plans to undertake a marine magnetometer search for the wreck of the Meermin, a three-masted "Hoeker", apparently wrecked in the mouth of the Zoetendals River Vallei in Struisbaai in 1766, are under way. Meetings have been held with the SAMM (South African Maritime Museum), and a site visit to the area has been conducted. The project has been awaiting approval of lottery funding by the SAMM, and some delays have been experienced in the process. The search for the wreck, believed to be buried in beach sediments, has commenced.

Future programme

The wreck programme will continue on an annual basis in order to conduct searches and surveys for the archaeological preservation of shipwrecks on the Cape Peninsula shipwreck route, or greater Cape coastal area, for the SAMM (South African Maritime Museum) and SAHRA (South African Heritage Resources Agency).

14. ANALYTICAL SERVICES

The Laboratory Unit supplies analytical and research services to other units of the CGS and to the general public. A range of analytical instruments such as the scanning electron microscope (SEM), electron microprobe (EM), X-ray diffractometers, X-ray fluorescence spectrometers (XRF), mass spectrometers (MS), and inductively coupled plasma mass spectrometer (ICP-MS) is available. Some of these instruments are ageing to such a degree that they are no longer financially viable or serviceable, and must be replaced. Both the radiogenic and stable-isotope mass spectrometers are in urgent need of replacement and efforts to correct this situation are under way in certain instances. Because of the high demand for specific trace-element analyses at the CGS, a pending purchase of an XRF instrument was deferred for an ICP-MS analyser.

14.1 CHEMICAL SERVICES

The Analytical Chemistry Laboratory showed significant advances during the year. A new state-of-the-art ICP-MS will be installed, which will put the CGS at the cutting edge of trace-element analyses in geological and environmental investigations. Additional sample-preparation laboratories are also under construction. The laboratory further succeeded in completing analytical contracts using hydrofluoric and perchloric acids on a large scale, which required significant training in preventative- and emergency-medical procedures. Staff were trained in the operation of the existing ICP-MS and ICP-AES instrumentation, while laboratory assistants underwent refresher courses in analytical procedures. A very successful project was launched to verify internal laboratory standards. To improve the quality and reliability of analytical data, several additional instrument-monitoring procedures were implemented.

14.2 X-RAY FLUORESCENCE SECTION

Besides the analysis of samples for major and trace elements by X-ray fluorescence spectrometry (XRF), the XRF-section is also responsible for the crushing, milling and splitting of samples required by all other analytical sections in the Laboratory Unit. Analytical work performed by the XRF section during the year, excluding commercial analytical and geochemical contracts, amounted to approximately 2 000 samples, to a value of R165 205,00.

Despite the ageing XRF-instrumentation leading to many breakdowns, the XRF-section managed to complete the Morocco contract 27 B2002 DG (800 samples) on time. The section is still busy with the Morocco geochemical contract where about 9 600 samples are to be analysed for some trace elements. The section also acquired a (Beadmaster) fluxer, at a cost of R475 500,00, for the analysis of major elements on glass discs. It is a vast improvement on the old (<15 years) fluxer previously used to prepare fusion disks.

A laboratory information-management system (LabLIMS) software was created and implemented by the head of the section. This is a database to keep track of all the work performed by the different sections in the Laboratory Unit. Another database, namely LithoGeo, was also created to include all information of internal samples analysed by the Laboratory. A process to store all hand specimens and milled subsamples is being set up and will be stored at the new Donkerhoek storage facility.

14.3 ELECTRON PROBE

The electron probe was used to provide an ongoing service to exploration groups for the analyses of kimberlite indicator minerals for exploration purposes, as well as the diamond-bearing potential of kimberlites. Services for in-house mineralogical investigations were also provided on a variety of rock types. On-going research was conducted on the composition of xenocrysts and mantle-derived xenoliths from the Kolo, Palmietgat and Vaalboschfontein kimberlites. Garnet compositions from diamond alluvial diggings at Mahura Mhutla, Goudplaas and Vaalbank were analysed and characterised, to try and determine the source region of the diamonds.

14.4 CERAMIC LABORATORY

The aim of the Ceramics Laboratory is to determine the suitability of terrigenous materials (sand, clay, feldspar, limestone, diatomite, etc.) for brick and tile manufacturing. Main concerns are to maximise use of waste materials, such as overburden in open-cast workings, for bricks and tile making for the purpose of job creation, poverty alleviation and new businesses. The services include raw-material evaluation, body-mix development based on the characteristics of the individual raw materials, and problem solving.

Investigation, research and development of waste material from an iron-ore mine in the Northern Cape Province were conducted. Successful mixes for the manufacturing of wall and floor tiles were developed. This would also be to the benefit of the local community in assisting with job creation if a tile factory were to be built. In Gauteng the mixes for the start-up of a new tile-manufacturing plant were redeveloped, to solve problems with the initial start-up of the plant. Research and development work were done by the Ceramic Section to assist in improving their raw-material mixes to enable them to produce first-grade tiles.

In another instance, new raw materials needed to be identified by a client to improve the output of ceramic products. After identification of the raw materials, they were characterised physically and chemically which lead to the successful improvement of the products.

14.5 STABLE AND RADIOGENIC ISOTOPE LABORATORY

In the past year, radiogenic isotope research has been dogged by old unreliable instruments and laboratory problems. The following problems have been addressed: (1) vacuum pump services on the mass spectrometers have been carried out for the first time in several years, (2) a number of electronic problems on the one (Finnigan MAT261) mass spectrometer have been solved, (3) new distillation apparatus for the production of clean acids has been installed, and the airflow to the clean labs has been adjusted so that the labs now have positive pressure, clean air and extraction, and (4) a way forward has been mapped out for the repair and regular maintenance of the two mass spectrometers. During the year water samples were analysed for strontium isotopic composition for the DME-funded project on mine-water ingress, University of the Witwatersrand and the Department of Water Affairs and Forestry.

A limited number of sediment samples from the Pretoria area have been analysed for lead isotopic composition. A number of sequential extraction analyses and leach tests have been undertaken in the laboratory, for both the WRC and DME projects.

The stable-isotope laboratory continued its work supporting other units of the CGS in their need for S, C and O stable-isotope analyses. Most of the of stable-isotope work this year carried out for the CGS was for the DME mine-water ingress project (5512). A multistable-isotope study yielded first results finding that, at least in one case, where an ingress of surface dam water into underground working was assumed, groundwater is in fact the major contributor to waters reported underground. Progress on this project will be documented later this year and next year. Further requests for stable sulphur-isotope analyses came from the University of the Witwatersrand, and for carbon- and oxygen-isotope analyses from the Rand Afrikaans University and from the Bellville Regional Office of the CGS. Unfortunately these endeavours suffered a severe setback when, in October 2003, both gas mass-spectrometers broke down. The recovery of these instruments has recently been completed. Problems with ageing and slow analytical equipment, as well as staff shortages, have been experienced for years and the situation is not expected to improve.

A capacity-building collaboration with the Environmental Isotope Laboratory of the Schonland Institute at the University of the Witwatersrand finally led to success. An analytical facility set up for sulphur-isotope analysis is now in routine operation for joint future water- and environmentally related projects. A visit to an international workshop in Canada was undertaken, resulting in valuable insights into modern stable-isotope analytical technique and application, which helped to complete the S-isotope analytical facility at Schonland.

14.6 X-RAY DIFFRACTION (XRD)

The XRD section 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. Analytical results comprise qualitative and semiquantitative evaluation of XRD traces. Geological and geotechnical interpretation of mineralogical data is provided to assist clients in evaluation of data. A total of about 1 200 samples has been analysed for their mineral composition.

14.7 PHOTOGRAPHY

The photographic section of the Laboratory provides a support service for the whole organisation which, during the past years, saw the emphasis shifting from laboratory- and film-based services to an advisory function on how to optimally convert to the new digital technology. The nature of these digital methods has enabled many units to meet their imaging needs independently, with substantial cost savings.

14.8 PETROGRAPHIC SECTION

The section provides routine petrographic services to the private sector and other parastatal organisations. The services rendered included the evaluation of about 120 samples, not only for traditional rock classifications, but also evaluation of mineralisation, suitability for use in concrete, road building, ground durability for sighting of mine shafts and various mineralogical industries. The Unit's thin-section preparation facility is equipped to serve the needs of the CGS, as well as those of some private sector and tertiary educational institutions. During the past year 2 000 thin sections and other preparations were made.

15. GEOSCIENCE DATABASES

Project 0061

ENGEODE
(L. Croukamp)

Objective:
to provide an electronic database of engineering-geological data, including information on soil type, soil grading, activity, Atterberg limits and other parameters.

A total of 820 documents, 703 soil profiles and 100 dolomite profiles was captured during the year, bringing the total number of soil profiles on the database to 53 064 and the total number of dolomite profiles to 2 617, figures which were limited owing to insufficient computing power and staff. The township-name database has also been updated where possible.

During the same period a total of 600 new township applications was handled and 299 new reports were added to the database system. Coding of the soil and dolomite profiles progressed more slowly, but a total number of 1 400 soil profiles has been coded and checked.

Project 0765

KWAZULU-NATAL GEOHAZARDS DATABASE
(N.P. Richards, R. Grow)

The geohazards programme has been deployed in response to requests by provincial disaster-management teams, and municipalities at district and local level, for geological information to mitigate the impact of geological hazards and minimise community vulnerability. A component of the geohazards programme is a database of geohazards, flooding and landslides throughout KwaZulu-Natal. The KwaZulu-Natal Unit services focus on areas highlighted as priority development and growth areas in the provincial spatial-growth and development framework.

The geohazards database programme includes details of the engineering-geological and geohazard mapping methodology deployed by the KwaZulu-Natal Unit, details of geohazard warning signs and a public-awareness programme, current geohazard research information and the introduction of a geohazards report form through which identified hazards can be included in the database. The format of the database programme is complete and explanatory pages have been posted on the internet.

A CD-ROM, providing information on all the potential geohazard problems in KwaZulu-Natal, has been created for distribution to interested parties, including local and district authorities. Interaction with district councils has led to the investigation of potentially hazardous conditions created by illegal shallow coal mining, where adequate support systems and environmental controls to ensure the safety of miners are not employed. GIS-based hazard maps for each municipal area are ready for publication and these will be accessible on the internet.

Slope instability or mass-movement sites form one of the GIS-based hazard maps. This format will be extended to provide a comprehensive database of all known slope failures as part of the mass-movement statutory project to be implemented in 2004/2005.

Project 0174

PHYSICAL-PROPERTIES DATABASE
(L.P. Maré, L.R. Tabane, M.E. Hauger, V. Hallbauer-Zadoroshnaya, A. Graham)

Objective:
to collect samples and expand the web-based database, and to research the IP and resistivity of rocks.

During the 2003/2004 technical year a total of 393 samples (826 specimens) was analysed and added to the Physical Properties Atlas. A set of 48 dune samples (144 specimens) was also analysed, but will only be added to the Physical-Properties Atlas after publication.

A palaeomagnetic and physical-property study was carried out on 195 core samples (324 specimens) from 30 sites on the Thaba Nchu 1:50 000-scale map sheet (project 0831), and these results were also added to the Atlas. The physical properties measured were density, magnetic susceptibility, magnetic intensity, electrical resistivity and induced polarisation, as well as a limited number of seismic velocities (P-wave). The rocks analysed originated from the following map sheets: 3120 Williston, 3122 Victoria West, 3220 Sutherland, 3222 Beaufort West, 2924 Bloemfontein, 2926BB Thaba Nchu, 2816 Alexander Bay, 3319CA Bain's Kloof, 3320CC Montagu, 2826BB Virginia, 3419DA Baardskeerdersbos, 3424BA Kruisfontein, 2917CB Wolfberg, 2819CA Upington, 3218AD Lambert's Bay, 2830 Richards Bay, and 2632 Mkuze.

Nine oriented dolerite-dyke samples (24 specimens) from an established coal mine were also analysed and incorporated into the Atlas. The updated Atlas (version V) was made available through the CGS' website. The updated Atlas was further exploited to produce a comprehensive set of ranges for the physical properties of every rock type in South Africa. These updated ranges are also available on the CGS' website.

It is now also possible to determine the average shape and sizes of pores in a rock sample from data collected with the in-house-developed resistivity/induced polarisation (RIP) instrument, using membrane-type polarisation as occurs in sediments and rocks with interconnected capillaries which are filled with electrolyte. Results were obtained where distinct decay curves, that depend on parameters relating to the shape and size of the pores, were calculated. This method was tested on a few samples (kimberlites and sandstones). The results obtained indicated differences in rock porosity.

Project 0679

UPKEEP AND DEVELOPMENT OF DATABASES
(M. Kotzé, P. Cole, A. Graham)

Objective:
to maintain and expand geophysical databases, including GIS coverages.

In 2003 it was decided that all the geophysical data should be stored in a searchable database with a web-based front end. In order to reach this objective the following steps had to be taken:

- Deciding on the software to be used
- MySQL® as the database, Apache® as the webserver for the front-end, PHP® as the language to communicate between the database and the web server, and MapServer® as the means of creating a GIS-type web interface to the data.
- Establishing a storage structure for the data
- Designing the database structure
- Creating the database
- Creating the front-end
- The front-end was created using HTML, PHP and MapServer. The database can be searched by data type (e.g. gravity, magnetic), locality (e.g. 2526AB or Prieska) or data format (ER Mapper® raster or MS Word document). There is also a reference to CD-Roms that contain data.
- Screening and entering the data
- As the data are entered into the database, they are validated
- Maintaining the database and front-end
- The database and its front-end are continuously maintained to ensure real-time access.
- Update the data.

To date 75 per cent of all the ultralight airborne data collected by the Council, which include information such as line spacing, flight height, line direction, etc., has been screened and entered into the database.

Other data that have already been captured in the database include geophysical interpretations of 1:250 000- and 1:50 000-scale map sheets, geophysical data, LANDSAT data, ASTER data, digital terrain models, geological data, drainage and infrastructure data, reports, posters, presentations, publications, photographs and graphics. There are currently about 2 568 entries in the database.

The administration database was redesigned and upgraded to accommodate the project costing system.

Project 0166

SAMINDABA
(C.J. Vorster)

During the year SAMINDABA-derived mineral maps, with simplified geological backgrounds, were compiled for the Ukwahlambau, Thabo Mofutsanyane, O.R. Tambo (Eastern Cape) and KwaZulu-Natal areas. These maps are integrated rural-development-node mineral maps for selected districts/municipal areas. SAMINDABA was also used to provide mineral-deposit information for both 1:50 000-scale geological and construction maps and 1:250 000-scale metallogenic maps. In the process 750 new database records were captured, 550 were updated and 530 checked, providing information for both internal and external enquiries on South Africa's mineralisation, as well as for maps and other products.

The SAMINDABA webpage was further developed and enhanced. The functionality and services of SAMINDABA, and products available, were publicised to increase the general awareness and usage of the database.

SAMINDABA also participated in South Africa's bid for the Square Kilometre radio telescope: a report on the mineral economic potential for possible sites was compiled, as well as a geological map.

NATIONAL CORE LIBRARY DATABASE
(R.R.M. Price)

The National Core Library Database, which provides information on the holdings of the National Core Library, has been restructured to be compatible with GEODE, although it remains on a Paradox platform. Provision has been made for deflections, and for boreholes which are extensions of older holes. The user interface shows the locality of the core or chips, as well as the lithostratigraphic units intersected in each borehole. The boreholes are also referenced by farm, by latitude and longitude, and, where available, by LO coordinates.

16. SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY

NATIONAL STRATIGRAPHIC PROGRAMME

The following lithostratigraphic descriptions were published by the South African Committee for Stratigraphy (SACS) in its Lithostratigraphic Series during 2003:

- Durban Formation (Natal Group) (including six members);
- Mariannhill Formation (Natal Group) (including three members);
- Voorstehoek Formation (Bokkeveld Group);
- Elandsvlei Formation (Dwyka Group);
- Robberg Formation (Uitenhage Group) (including one member).
- Volume 7 of the Catalogue of South African Lithostratigraphic Units, encompassing 12 descriptions of the groups, subgroups, formations and members of the Gariep Supergroup, was finalised for publication.
- Volumes 8 and 9 are being finalised for publication.

Five of the SACS task groups met during the year. In the case of the Cape Granites task group, two meetings were held, each combined with field trips to individual plutons. The Task Group for Pre-Gariep Rocks in the Northern and Western Capes organised a four-day field trip which resulted in certain changes being made to the stratigraphic subdivision and nomenclature on Sheet 2918 Pofadder, which is currently being prepared for publication by the CGS.

The Secretary of SACS continued to be heavily involved in the compilation and editing of a new textbook of South African geology, which will be a joint publication of the CGS and the Geological Society of South Africa. Nearly all of the 33 chapters (each of which is being prepared by a recognised specialist in his field) have been refereed, revised and edited, the diagrams have been produced, and good progress is being made with the layout by the Publications Section.

Project 0622

SACS LITHOSTRATIGRAPHIC DESCRIPTIONS

(D. Roberts, J.H.A. Viljoen, L.P. Chevallier)

Objective:

to provide descriptions of various lithostratigraphic units for publication in the SACS catalogue series.

Descriptions were produced for the following lithostratigraphic units, for publication in the SACS catalogue series:

- Robertson-Heidelberg Melilitite Suite
- Abrahams Kraal Formation
- Velddrif Formation
- Prospect Hill Formation
- Kimberley Kimberlite Suite

At the Alkaline rock meeting on 16/10/2003 it was decided to reconsider the Kimberley Kimberlite Suite in the light of the proposed chapter on Kimberlites by M.W. Skinner in the new book "Geology of South Africa".

Project 0751

SACS LITHOSTRATIGRAPHIC DESCRIPTIONS

(P.M.W. Botha, A.L.D. Agenbacht, H. Minnaar)

Objective:

to provide descriptions of various lithostratigraphic units for publication in the SACS catalogue series.

Descriptions of the Dabidas Formation, Swartmodder Granite and Bantamberg Granite have been completed and submitted. A field visit was paid to the Aggeneys area, in conjunction with the Geology Department of the University of the Free State.

The Dabidas Formation

The Dabidas Formation consists of pelitic gneisses constituting a small volume of the total rock mass, but occurring throughout the Namaqua Metamorphic Complex on the area covered by sheet 3018 Loeriesfontein. The gneisses are comprised of various combinations of cordierite, aluminium-rich garnet, sillimanite, biotite, hypersthene, alkali-feldspar, plagioclase, quartz, spinel, magnetite, ilmenite and corundum, and are interlayered on various scales, forming discreet horizons several hundred metres thick. The Dabidas Formation varies from melanocratic to mesocratic and exhibits a grey, greenish-grey, dark-grey to black colour on fresh surfaces. Grain size varies from fine to coarse grained and the gneisses are generally banded, although some poorly banded and even massive varieties occur. The bulk composition of the metapelitic gneisses suggests that they are the metamorphic equivalents of platform shales. They are characterised by the presence of sillimanite and cordierite in the field. Three different groups of pelitic gneisses were distinguished by both Baars (1990) and Jackson (1998), and can be classified as aluminous quartzofeldspathic gneiss, pelitic gneiss and magnesian gneiss.

Project 0824

SACS CATALOGUE DESCRIPTIONS

(G. Brandl, N. Baglow)

Objective:

to provide descriptions of various litho-stratigraphic units for publication in the SACS catalogue series.

Descriptions were produced for the Uitkyk Formation and the Matok Granite for publication in the SACS catalogue series.

17. INFORMATION MANAGEMENT

17.1 COLLECTIONS MANAGEMENT

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, and the new "World of Minerals" display provides an exciting introduction to minerals and mineralogy.

During the past year the Geoscience Museum conducted a particularly active education programme, which included the following presentations:

- Laudium Heights Primary School Science Expo;
- Atteridgeville Outreach for International Museum Day;
- Career Awareness project in Mamelodi;
- Lehlabile Circuit Teachers and Brits Circuit Principals programmes;
- Museum Park Tourism Expo;
- Transvaal Museum Bugs Week;
- Pretoria Zoo fossils exhibition.

In addition, bonds were forged with the following Gauteng-based educational organisations:

- FEST Science Museum, Pretoria;
- Inkwe Ridge Observatory, Pretoria East;
- Johannesburg Planetarium;
- Museum Africa, and the Palaeontology 21 and Geology Museums, University of the Witwatersrand, in Johannesburg;
- University of Pretoria: Geology Museum and Discovery Centre.

During the year the Unit also provided input into or manned stands at a number of national and international expositions, conferences and workshops, including

- The Council for Geoscience Open Day, in May, at the CGS' Headquarters in Pretoria.
- The National SET Week of the Department of Science and Technology, in May, in the Gauteng, North West, Northern Cape and Western Cape Provinces. Five new information leaflets were prepared for the exhibition.
- The Department of Science and Technology's pavilion at the Rand Show, held at NASREC in April and May.
- The exhibition at the annual Geoforum of the Geological Society of South Africa, held in June in Midrand.
- The International Cartographic Congress, in August, in Durban.
- The Museum Park exhibition at the Pretoria Show, at the end of August.
- The Economic Empowerment exhibition of the Department of Trade and Industry, in September, in Johannesburg.
- The bi-annual congress of the Geographic Society of South Africa, in September, in Bloemfontein.
- The Mining Week of the Department of Minerals and Energy, in October, in Johannesburg.
- The Northern Cape Trade Expo, in December, in Kimberley.
- The 9th Annual Investing in Africa Mining Conference (INDABA 2004), in February, in Cape Town.
- The Centennial congress of the Geological Survey of Ghana, in March, in Accra, Ghana.
- The annual PDAC Trade Show, in March, in Toronto, Canada.
- A one-day Careers and Information Exhibition at Lehurutshe, in August.
- Three excursions, one for Chinese visitors, one for Indian visitors and one for Gauteng visitors, took place to the Lichtenburg Diamondiferous Gravels.
- Two talks on the importance of geology to the community.

17.2 LIBRARY SERVICES

The **Library and Information Centre** of the CGS is responsible for the collection and maintenance of information, for the dissemination of information to employees of the CGS and external clients, and for the maintenance of the CGS' collections of reports, plans, unpublished geological maps and borehole logs.

The **Publication Shop** is responsible for the sale of publications and reports of the CGS and publications of the Geological Society of South Africa. Staff maintain both the CGS' and the Geological Society of South Africa's lists of exchange publications, and provide copy services and base materials such as orthophoto maps, topographic maps and aerial photographs. The following statistics are indicative of the activities of the Publication Shop and Unpublished Reports Sections:

Visitors	4 456
Enquiries received	4 397
Unpublished reports received	628
Publications sold	2 414
Maps sold	3 510
Map sets sold	307
CD-ROMS sold	142
Publications donated	842
Geological Society of SA publications sold	179
Aerial photographs issued	1 255
Orthophotos issued	46

The Library currently houses 16 000 book titles, and 3 846 journal titles of which 337 are current subscriptions and 908 are received on exchange. The Library holds 2 601

journal titles that have been discontinued and has a collection of 12 000 other documents. Membership of Sabinet was continued during the year and the library remains an active member of the interlending scheme. The extensive catalogue can be accessed via a sophisticated computer-based search facility on the Library's Webpage. Catalogues of unpublished CGS, STK and Goldfields reports are available on the CGS' website. Access to full-text electronic journals or e-journals has also been made possible through the library's subscription agent, a facility for the exclusive use of staff of the CGS.

To expand the Library's electronic catalogue and automated loan system, the staff have embarked on an extensive retrospective serials cataloguing project. This applies to items such as the CGS' bulletins and memoirs. A CD-ROM collection is also catalogued and housed in the library. The production of information on CDs is a growing trend and the library currently has 220 CDs.

External visitors	335
Queries received	2 117
Documentation functions:	
Book publications catalogued	247
Maps catalogued	4 492
Pamphlets catalogued	316
New journal titles catalogued	31
CD-ROMs catalogued	30
New journal issues received	4 054
Circulation and loans:	
Journals circulated	6 532
Book publications	7 022
Maps loaned	46
Interlibrary Loans	
Requests received from other libraries (3 international)	972
Requests sent to other libraries	327
Articles supplied to regional offices	4 276
Articles sent to other organisations	424

17.3 BIBLIOGRAPHIC DATABASES

Project 0374

SAGEOLIT
(R.R.M. Price)

SAGEOLIT (**S**outh **A**frican **Geo**logical **Lit**erature Database) now contains more than 215 000 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 46 000 links from a table of farm information to SAGEOLIT records. An index to the publications of the Geological Society of South Africa was published on CD-Rom.

The Map Library database contains references to more than 47 672 maps, including unpublished maps of the CGS. These items are spatially referenced to enable access by Geode/GIS.

A database of photographic and other material stored in the Archives of the CGS lists approximately 2 200 items. This database is under reconstruction in order to integrate it with SAGEOLIT.

17.4 NATIONAL CORE LIBRARY
(L.D. Motloi)

The National Core Library is a repository of borehole core collected from exploration and mining activities of the past few decades. It is a national resource of considerable value to geological research, as it preserves material that has been obtained at great expense, sometimes from kilometres beneath the surface of the earth.

The storage facility at Donkerhoek is being enlarged, and the second phase was completed during the year with a grant from the Department of Science and Technology. The third phase of the storage facility is in progress, the main structure having been completed.

The Core Library has now accessioned samples from more than 2 000 boreholes, representing 580 km of drilling. Notable new acquisitions include samples from 16 boreholes from the Pering Base-Metal Mine near Reivilo. These holes add considerably to the material available on the Griqualand West Sequence.

17.5 PALAEONTOLOGY

Project 0488

INVESTIGATION OF THE BIOSTRATIGRAPHIC CONTACT BETWEEN THE *LYSTROSAURUS* AND *CYNOGNATHUS* ASSEMBLAGE ZONES: AN INTEGRATED APPROACH TO BIO-STRATIGRAPHY, LITHOSTRATIGRAPHY AND SEDIMENTOLOGY
(J. Neveling)

The investigation of the apparent extinction event at the contact between the ***Lystrosaurus*** and ***Cynognathus*** assemblage zones in the main Karoo basin was completed, and the results will be published as a bulletin. The current subdivision of the ***Cynognathus*** Assemblage Zone into three subzones should stand, although the aerial and

stratigraphic distribution of these subunits should be revised. Improved lithostratigraphic data for the Katberg and Burgersdorp Formations enabled a better correlation between the proximal and distal exposures and, together with biostratigraphic data, were incorporated into a synthesis that explains deposition in the Karoo basin in terms of current theories of basin development. Improved global correlation, resulting from the biostratigraphic work, has enabled more accurate and improved relative dating, which in turn has enabled correlation of biotic changes in the Karoo basin with global transgressive-regressive cycles and biotic migration patterns. Further collaborative research has been published in two papers, describing a new Early Triassic locality in the Karoo and the first evidence of burrowing behaviour in the ancestral lineage of mammals. Two collaborative papers, describing new cynodont and pararеptile genera found in Karoo strata, have been submitted for publication.

18. ADMINISTRATION

ADMINISTRATION: HUMAN RESOURCES

1. Qualifications of staff

Qualification	Percentage	
	2002/3	2003/4
Doctorate	9,27	9,45
Masters	11,59	12,70
Honours	22,19	19,87
Bachelors	7,95	10,75
Diploma	10,26	9,77
Matric	20,20	19,87
Sub	18,54	17,59

2. Racial composition of staff

	2002/3	2003/4
Black	95	104
Indian	5	5
White	191	187
Coloured	11	11
Total	302	307

3. Sex of staff

	2002/3	2003/4
Male	189	193
Female	113	114
Total	302	307

4. Staff movements

Year	Total number of staff
1996	340
1997	358
1998	390
1999	417
2000	307
2001	302
2002	302
2003	307

STAFF:

CEO: T. RAMONTJA

Secretary:	I.T. SINDANE
EXECUTIVE MANAGER (SECONDED TO DST)	M.S. MZIMBA
EXECUTIVE MANAGER SCIENTIFIC SERVICES	G. GRAHAM
EXECUTIVE MANAGER REGIONAL GEOLOGY AND MAPPING	P.K. ZAWADA
COMPANY SECRETARY	N.R. RADEBE
Secretary:	M.L. DE KLERK

CENTRAL REGIONAL MAPPING

PRETORIA UNIT

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HADDON IG
INGRAM BA
GRANTHAM GH
CRONWRIGHT MS
OPPERMAN R
DE KOCK GS
NOLTE JC
JOHNSON MR

TECHNICAL OFFICER
BRITZ M

KWAZULU-NATAL UNIT

UNIT HEAD
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SCIENTIFIC OFFICER
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WILLARD CA
KOTA MW
CLARKE BM
GROW RG
NGCOBO FN

ADMINISTRATIVE OFFICER
DLAMINI P

GENERAL CLERK
MPOFANA B
NGCOBO LE

WESTERN CAPE UNIT

UNIT HEAD
CHEVALLIER LP

SCIENTIFIC OFFICER
MACEY PH
STAPELBERG FDJ
COLE DI
ROBERTS DL
NHLEKO OLC
GIBSON LA
SIEGFRIED HP
DE BEER CH
HARTZER FJ
VILJOEN JHA

TECHNICAL OFFICER
OOSTHUIZEN BC

ADMINISTRATIVE OFFICER
MALHERBE JE
PETERSEN C

GENERAL CLERK
MOSES D
DE BRUIN E

NORTH WEST UNIT

SCIENTIFIC OFFICER
GABBRIELLI F

TECHNICAL OFFICER
MOLEFE SM

GENERAL CLERK
CHOLO ZB

NORTHERN CAPE UNIT

SCIENTIFIC OFFICER
AGENBACHT ALDP
BOTHA PMW
MINNAAR H
McDONALD AJ
MOEN HFG

TECHNICAL OFFICER
DELIE J
SKEFFERS CJ

ADMINISTRATIVE OFFICER
MANS A

LIMPOPO PROVINCE UNIT

UNIT HEAD
BAGLOW N

SCIENTIFIC OFFICER
BRANDL G
MPATENI NT
DIPPENAAR M
KASA PN

ADMINISTRATIVE OFFICER
MAKHUBELE GS

GENERAL CLERK
MANGANYE TM
MASHAO TP

EASTERN CAPE UNIT

UNIT HEAD
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SCIENTIFIC OFFICER
REDDERING JSV
ROBERTS MP
ROHWER MH

TECHNICAL OFFICER
MAJOKWENI LB

ADMINISTRATIVE OFFICER
WENTLEY CR

GENERAL CLERK
MXATULE BJ

GEOHYDROLOGY

MANAGER
TITUS RA

SCIENTIFIC OFFICER
SWANEPOEL TL
SHONGWE JT
STRACHAN LKC
MAJOLA KA
GROENEWALD J

TECHNICAL OFFICER
MINNAAR FH
LEWIN TGA

ADMINISTRATIVE OFFICER
GOUVERNEUR M

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COETZEE H
VENTER JS

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DAVIS GN
HEATH GJ
TROLLIP NYG
CROUKAMP L

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MOTJALE MI
NTSHABELE NL
ENGELBRECHT HP
PEER V

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RADEBE JS
MAHLANGU MM

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RAATH CJDW
RUTHERFORD AB
HALLBAUER-
ZADOROZHNAYA VY
COLE J
MARE LP
FOURIE CJS
SMIT JP

TECHNICAL OFFICER
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TABANE LR
STETTLER RH
KOTZÉ M
ADLEM M

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GRAHAM A

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NIEBUHR L

LIBRARIAN
VILJOEN EE
MAKHAFOLA RS
VAN WYK J
BREYTENBACH L

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GENERAL CLERK
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CHAUKE PR
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DOMINGO EE
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ADMINISTRATIVE OFFICER
GROBLER JD

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UNIT HEAD
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FRIEDLAND J
DE BRUIN D
REDDY K
PIENAAR C
HORSTMANN UWE
ROELOFSE T
ROELOFSE F

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PAPO RM
VUMA SM
SEPENG TWA
WILLIAMS QD
DELPORT FA
NKOSI ME
WALLISER JE
MATJI JM
KGADITSE SD
SELLO RH
MABE E
MONYAYI ST
LEHAHA MT
TSAAGANE ME
DIKGOMO SA

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HENRY G
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BUSO L
SUTHERLAND BE
NGCOBO DL
SMITH MRG
SAUNDERS I
STEYN J
NDYAMBA M

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DUARTE D

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BRYNARD HJ
VAN ROOYEN PJ
VAN DER WALT DM
WOLMARANS LG
RIES CW

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THOMAS C
KGARI CS
MSIZA P
MAGAGANE MEM
CLOETE AJ
VOORS WA
ROOS HM
NKOSI MP
LETSOALO M
GROBBELLAR DA
VAN DER WESTHUIZEN CBA
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DU PLESSIS J J

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ADMINISTRATIVE OFFICER
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OOSTHUIZEN MD
PAWESKA MD
REDDY N
POWER S
ROBINSON JJ
DIRKER E
BREYTENBACH AF
SNYMAN SE
QAYISO NA
MOSTERT JCN
NKADIMENG G

HUMAN RESOURCES

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ADMINISTRATIVE OFFICER
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MAEMA JJ

RECRUITMENT SPECIALIST
MKHIZE ZJL

TRAINING AND DEVELOPMENT SPECIALIST
SCHEPPERS N

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UNIT HEAD
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TECHNICAL OFFICER
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ADAMOS P
MADZHIE M
MNISI JV
STEVENS R
RANTJIE JM
MAKITLA PS
MAHLANGU E
SMYTHE MM

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BOTHA JD

ADMINISTRATIVE OFFICER
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PHUSHELA PSH
HUGO JLM
MANDA M
ROBBERTSE RK
SNYMAN J
RAMOTHWALA MBH
NKWASHU SM
RAMOTHWALA NJ
JIJANA CK

GENERAL CLERK
MOLEFE NS
MOTALAUTE TS
MASOGA ME
LESO JM
DIKETANE MW
TJIANE LC

INTERNAL AUDIT

UNIT HEAD INTERNAL AUDIT
MOTLOUNG SM

SENIOR INTERNAL AUDIT CLERK
NGUTSHANA CD

19. APPENDIX

19.1 REPRESENTATION ON COUNCILS, COMMITTEES, AND WORKING AND STUDY GROUPS

Board of the Council for Geoscience (C. Frick)
Museum Park Board of Directors (D.J. Barnardo)
Tswaing Crater Museum Board of Directors (D.J. Barnardo)
Advisory Board of the Science Engineering and Technology (SET) Discovery Centre, University of Pretoria (P. Bender)
Council for National Monuments (A.L.D. Agenbacht)
Council of the Geological Society of South Africa (GSSA) (Vice-president: M.G.C. Wilson)
- Board of Trustees (M. Wilson)
- Management Committee of the Geological Society of South Africa (GSSA) (M.G.C. Wilson)
- Committee of the Groundwater Division (R. Titus)
- Committee of the Mineralogical Association of South Africa (MINSA) (M. Cloete)
- Committee of the Limpopo Branch (G. Brandl, N. Baglow)
- Committee of the Pretoria Branch (A.B. Rutherford)
- Committee of the Western Province Branch (C.H. de Beer)
- Conservation Committee of the Western Province Branch (Secretary: C.H. de Beer)
- Co-editor of Geological Society of South Africa–CGS, Geology Text Book (Geology of South Africa) (M.R. Johnson)
- Editorial Board of the South African Journal of Geology (SAJG) (M. Cloete)
- Environmental and Conservation Committee (D. van Tonder)

Council of the Southern African Society for Quaternary Research (SASQUA) (Treasurer: G.A. Botha)
Advisory Council of the Economic Geology Research Institute of the University of the Witwatersrand (C. Frick)
South African Council for Natural Scientific Professions (SACNASP) and some of its Committees (C. Frick)
- Professional Affairs Committee (PAC) for Earth Sciences (Chairperson: E.H. Stettler)

Committee for Heads of Research and Technology (COHORT) (formerly Committee of Heads of Science Councils (CHSC) (C. Frick)
- Science Council Champions of Indigenous Knowledge Systems (IKS) (M.S. Mzimba)

Committee for Site Investigation of the Department of Water Affairs and Forestry (DWAF) (G.N. Davis)
Committee of the Palaeontological Society of Southern Africa (PSSA) (J. Neveling)
- PALNEWS (Newsletter of the PSSA) Editor (J. Neveling)

Advisory Committee on the West Coast Biosphere Project (D.L. Roberts)
Economic/Government/Institutional Support Committee for Small-Scale Miners of the Minerals and Energy Policy Centre (Northern Cape) (H.P. Siegfried)
Executive Committee of the South African National Council on Tunnelling (SANCOT) (G.N. Davis)
Local (RSA) Organising Committee for the 9th International Association of Engineering Geology (IAEG) Congress (2002) (Treasurer: L. Croukamp)
Management Committee of the Far West Rand Dolomitic Water Association of the Chamber of Mines (N.Y.G. Trollip)
Quaternary Research Committee of the Southwestern Cape (QUARC) (D.L. Roberts)
South African Committee for Stratigraphy (SACS) (Secretary: M.R. Johnson, N. Keyser)
- Task Group for Alkaline and Basic Intrusive (Secretary: L.P. Chevallier)
- Task Group for Biostratigraphy (Secretary: J. Neveling)
- Task Group for Cape Granite Suite (Secretary: H.P. Siegfried)
- Task Group for the Cenozoic (Secretary: G.A. Botha)
- Task Group for Chronostratigraphy (Secretary: G.S. de Kock)
- Task Group for Gariep — Cape Rocks (Secretary: C.H. de Beer)
- Task Group for Jurassic and Cretaceous Rocks (Secretary: J.S.V. Reddering)
- Task Group for the Bushveld Complex and Surrounding Basic Intrusives (Secretary: Vacant)
- Task Group for the Karoo Igneous Province (Secretary: Vacant)
- Task Group for the Karoo Rocks (Secretary: D.I. Cole; J.H.A. Viljoen)
- Task Group for pre-Bushveld Intrusive and Swazian Rocks (Secretary: N. Baglow, G. Brandl)
- Task Group for pre-Gariep Rocks in the Northern and Western Cape (Secretary: P.H. Macey; C.H. de Beer, H.F.G. Moen, A.L.D. Agenbacht)
- Task Group for pre-Karoo Rocks in KwaZulu-Natal and southern Mpumalanga (Secretary: Vacant)
- Task Group for the Transvaal Supergroup East of 25E (Secretary: P.J.A. Bosch, F.J. Hartzer)
- Task Group for the Transvaal Supergroup West of 25E and Olifantshoek Supergroups (Secretary: H.P. Siegfried)
- Task Group for the Ventersdorp Supergroup (N. Keyser)
- Task Group for the Waterberg and Soutpansberg Groups (Chairman: G. Brandl)
- Task Group for the Witwatersrand Supergroup (Secretary: Vacant)

South African Mineral Resource Committee (SAMREC) and the Working Group on the compilation of the main South African code for the reporting of mineral resources and mineral reserves (P.E. Wipplinger)
South African Committee on Antarctic Research (SACAR) Physical Science Task Group (G. Graham)
National Steering Committee of Service Providers to the Small-Scale Mining Sector (NSC) (P.E. Wipplinger)
National Steering Committee on the Code for the Valuation of Mineral Properties in South Africa (M.G.C. Wilson)
Programme Steering Committee of the Department of Water Affairs and Forestry for the Norwegian-associated Programme on Sustainable Groundwater Development for the Community Water and Sanitation Programme in South Africa (R.J. Kleywegt)
State Coordinating Technical Committee on Sinkholes and Subsidences on the Far West Rand Dolomitic Areas (SCTC) (Acting Chairperson: N.Y.G. Trollip)
Steering Committee of the Geoinformation Consortium (GIC) (H.J. Brynard)
Steering Committee of the Library and Information Services of the Science Councils (LISSCO) (L. Niebuhr)
Steering Committee of the Interest Group for the Applied Studies on Dolomite (N.Y.G. Trollip)
Steering Committee of the Water Research Commission (WRC)
- Deep Artesian Groundwater Exploration for Oudtshoorn (J.H.A. Viljoen)
- Deep Groundwater Flow Dynamics (C.H. de Beer)
- Geohydrology of Western Namaqualand (C.H. de Beer)
- Project on the Assessment of Short-, Medium- and Long-Term Impacts on Groundwater Quality associated with the filling of sinkholes (R.J. Kleywegt)
- Reconstruction of Long-term, High-Resolution Records of Summer Rainfall and its Variability in South Africa from Cave Speleotherms (P.K. Zawada)

- Statistical-based Regionalised Flood-frequency Estimation Study for South Africa using systematic, historical and palaeoflood data (P.K. Zawada)
- Research on the Correlation of High Uranium, Arsenic and other Chemical-Element Values in Groundwater in the Northwestern Cape (P. Bosch)

Steering Committee for the South African Environmental Observatory Network (SAEON) (P.K. Zawada)
Technical Committee for the Development on Controls under the proposed Mineral and Petroleum Resources Development Act, 2002 (H.J. Brynard, D.J. Barnardo, P.E. Wipplinger)
Technical Committee for the Radioactivity Monitoring of the Monitoring Programme in the Mooi River (Wonderfonteinspruit) and Klip River Catchments, Institute for Water Quality Studies, Department of Water Affairs and Forestry (H. Coetzee)
Working Committee for Diversification of Product and Service and Market Access (J. Horn)
Action Group of the Western Cape Wetland (L. Gibson)
Commodity Working Group, Department of Mineral and Energy (DME)

- Diamonds (D. de Bruin)
- Gold (M.G.C. Wilson)
- Platinum (G. Henry)

National Reference Group on Indigenous Knowledge Systems (M. Mzimba)
Research Group on Mining Activities for the Succulent Karoo Ecosystem Plan for Conservation (D. Cole, L. Chevallier)
Small-Scale Mining Standards Generating Group (SGG)
Technical Working Group of the National Nuclear Regulator
Working Group for Luminescence Dating of the South African Coastal Dunes (Western Cape leader: D.L. Roberts)
Working Group of Water Research Commission Strategic Planning for Groundwater Studies in the Eastern Cape (L.P. Chevallier)
Cartographic Association of South Africa (CASA) (H.M. Roos)
Department of Arts, Science and Technology (DCST)

- Committee on Key Performance Indicators for Science Councils (M.S. Mzimba)

Mining Qualifications Authority (MQA)
Mining and Exploration Geology. Technical Review Group (SGG), South African Qualifications Authority and Department of Minerals and Energy (C. Forbes)
National Research Foundation Open Research Programme. Advisory Panel for Bushveld Complex Research (M. Cloete)
National Science and Technology Forum (M.S. Mzimba)
Palaeontology Advisory Panel, South African Heritage Resources Agency (SAHRA) (P. Bender)
Reader for J.S.E. Securities Exchange S.A. for assessment of resource/reserve statements on coal and base metals on the basis of guidelines as set out by the South African Mineral Resource Committee (SAMREC) (P.E. Wipplinger)
South African Bureau of Standards (SABS)

- South African Qualification and Certification Committee (SAQCC) (Boreholes) (J.G. Barkhuizen)
- South African Code of Practice to the systematic evaluation of coal resources and coal reserves (P.E. Wipplinger)
- Solid Mineral Fuels (P.E. Wipplinger)
- The use of galvanised piping in the building industry (P.E. Wipplinger)
- Subcommittee on National Standards for Groundwater Extraction (J.G. Barkhuizen)

South African Chapter of the African Renaissance (SACAR) (M.S. Mzimba)
South African Institute of Engineering and Environmental Geologists (SAIEG) (President: L. Croukamp, G. Davis)
Technology Demonstration Centre (TDC) — Zenzele (P.E. Wipplinger)

19.2 INTERNATIONAL COOPERATION

Council of the International Seismological Centre (ISC) (G. Graham)
Editorial Advisory Board Africa Geoscience Review (G.S. de Kock, M.R. Johnson, D.I. Cole)
Editorial Board of Geochemistry: Exploration Environment Analysis (D. de Bruin)
Editorial Board of Gondwana Research (G.H. Grantham)
Executive Committee of the Association of World Geological Surveys (C. Frick)
Geology Subcommittee of the Mining Sector Coordinating Unit of the South African Development Community (SADC) (C. Frick, I.G. Haddon)

- Engineering-Geology Working Group (P.K. Zawada)
- Geochemical Working Group (D. de Bruin)
- Hydrogeology Working Group (L.P. Chevallier)
- Kalahari Working Group (Secretary: I.G. Haddon)
- Karoo Working Group (I.G. Haddon)
- Regional/National Geological, Mineral and Bibliographic Databases Working Group (D.J. Barnardo)
- Stratigraphy Working Group (Chairman: F.J. Hartzer)

International Association of Engineering Geologists: Commission No. 1: Engineering-Geological Mapping of South Africa (L. Croukamp)
International Association on the Genesis of Ore Deposits (IAGOD) (President: E.C.I. Hammerbeck)

- Southern African representative of the Industrial Minerals Working Group (G.F.J. Horn)

Commission for the Geological Map of the World (CGMW) (Vice-president for Africa: C. Frick)

- Subcommission for the Metallogenic Map of the World (President: E.C.I. Hammerbeck)
- Working Group on Common Standards for Digital Geological Data and Data Structures, Digital Data Dissemination (DIMAS) (H.J. Brynard)

Commission for Museums of the International Mineralogical Association (IMA) (P.A. Bender)
International Commission on Stratigraphy (ICS)

- Subcommission on Precambrian Stratigraphy (Corresponding member: F.J. Hartzer)
- International Subcommission on Stratigraphic Classification (ISSC) (SACS representative: M.R. Johnson)

International Geological Map of the World (IGMW)

- Coordinator for the Tectonic Map of Africa (Subequatorial chief compiler: G. de Kock)

International Union for Quaternary Research (INQUA)

- Commission on Coastal and Marine Processes (G.A. Botha)
- Commission on Paleopedology and the International Union for Soil Science (ISSS) (G.A. Botha)
- Organising Committee (Member: I. Haddon)
- South African National Committee, National representative to the INQUA Congress, Reno, USA 2003 (Chairman: G.A. Botha)

IUGS/UNESCO International Geological Correlation Programme
- IGCP 368 — Proterozoic Events in East Gondwana (G.H. Grantham)
- IGCP 478 — The Vendian-Cambrian of West Gondwana (C.H. de Beer)

National Committee for the International Union of Geodesy and Geophysics (IUGG) (R.J. Kleywegt)

National Committee of the International Union of Geological Sciences (IUGS) and the International Geological Correlation Programme (IGCP) (C. Frick, L. Croukamp, S. Frost-Killian)

Pan-African START Secretariat (PASS) (R. Titus)

Scientific Advisory Committee for the 3rd Uranium Mining and Hydrogeology Conference, Technical University Bergakademie Freiberg, Germany (H. Coetzee)

Steering Committee of the Geoscience Information Consortium (previously the International Consortium of Geological Surveys for Earth Computer Sciences (H.J. Brynard)

19.3 COLLABORATION WITH NEIGHBOURING AND OTHER COUNTRIES

Collaborative Project	Mexico	E. Hattingh
Collaborative Project	Germany	J. Cole P. Cole E.H. Stettler
Collaborative Project	Ghana	J.G. Barkhuizen
Collaborative Project	Malawi	M.R.G. Smith
Collaborative project	Mozambique	M.R.G. Smith J. von L. Pretorius

19.4 ATTENDANCE AT SCIENTIFIC AND TECHNICAL MEETINGS (Conferences, Congresses, Symposiums, Seminars, Meetings, Courses, Excursions, Workshops)

EVENT	PRESENTER	VENUE, CITY	DATE	STAFF ATTENDED
"The Microstructural interpretation of metamorphic rocks". First ISPET (International Seminars on Petrology)		Venice, Italy	12–18 October 2003	B.M. Clarke
23rd Annual ESRI Conference	ESRI	San Diego, USA	July 2003	K.J. Wilkinson, L. Wolmarans
Geographical Information Systems (Pty)Ltd User Conference	Geographical Information Systems (Pty)Ltd	Johannesburg	September 2003	H.J. Brynard, M. Roos, L. Wolmarans, K.J. Wilkinson
International Cartographic Conference		Durban	August 2003	W. Ries
8th South African Geophysical Association Biennial Technical Meeting and Exhibition: Tracking the Big Five	South African Geophysical Association	Pilanesberg, North West Province	6–10 October 2003	E.H. Stettler, J.P. Smit, R.H. Stettler, L.P. Maré, J. Cole, P. Cole, C.J.S. Fourie, A.B. Rutherford, V. Hallbauer-Zadorozhnaya
ICOLD 21st Congress on Large Dams	International Commission on Large Dams	Montreal, Canada	16–20 June 2003	A. Kijko, M.B.C. Brandt
XXIII General Assembly of the International Union of Geodesy and Geophysics	International Union of Geodesy and Geophysics	Sapporo, Japan	30 June–11 July 2003	G. Graham, E.H. Stettler
Indaba	Investor Resource Media	Cape Town	10–12 February 2004	L. Chevallier, F. Hartzer, O.L. Nhleko, D.I. Cole
GW Modelling Course	IGS Department	University of the Free State	11–15 August 2003	O.L. Nhleko
Indian Ocean Research Development	Regional Council	St Denis, Reunion	3–6 June 2003	L.P. Chevallier
GRIP Programme	DWAF	King William's Town	28–29 January 2004	L.P. Chevallier
TMG Project	University of the Western Cape	UWC	2 September 2003	L. Chevallier, O.L Nhleko, C.H. de Beer
Ecosystem	SKEP	Calitzdorp	29 September–3 October 2003	D.I. Cole
XVI INQUA Congress field trip	INQUA	Reno, Nevada, USA	23–30 July 2003	D.L. Roberts
XVI INQUA Congress Shaping the Earth: A Quaternary Perspective	INQUA	Reno, Nevada, USA	23–30 July 2003	G.A. Botha
XVI INQUA Congress field trip. Quaternary stratigraphy, geomorphology, soils, alpine archaeology in an alpine-to-plains transect, Colorado Front Range	INQUA	Colorado, USA	16–23 July 2003	G.A. Botha
Ecosystem	Enviromental Network Limited	Tarland, Scotland	16 January 2004	D.I. Cole
IGCP 478 Vendian-Cambrian of Western Gondwana	IUGS	Cape Town	23 October–1 November 2003	C.H. de Beer, P.H. Macey, A. Agenbach, P. Botha, H. Minnaar
Students Geography Conference	University of Pretoria	Hammanskraal Campus	14–18 September 2003	L.A. Gibson, L. Nel

Students Geography Conference	University of Pretoria	Hammanskraal Campus	14–18 September 2003	L.A. Gibson, L. Nel
International Conference on 'Groundwater in Fractured Rocks'	International Association of Hydrogeologists	Prague, Czech Republic	15–19 September 2003	R. Titus
The Pan-African Implementation and Partnership Conference on Water	The African Ministers' Council on Water (AMCOW)	Addis Ababa, Ethiopia	8–12 December 2003	R. Titus, L. Strachan
Installation of field stations	Magneto Tellurics Kaapval Craton Project		3–14 November 2003	J. Groenewald
The 6th Pan African Start Committee (PACOM) Meeting		Addis Ababa, Ethiopia	4–6 December 2003	R. Titus, L. Strachan
Abuja Geocongress	Africa Geoscience Review, UNESCO, Geol. Soc. Of Africa, Federal Ministry for solid minerals development and Federal Ministry for petroleum resources, Nigeria	Sheraton Hotel and Towers Abuja, Nigeria	18–24 May 2003	M.L. Goedhart, G. de Kock, S. Frost-Killian
IAMG 2003	International Association for Mathematical Geology	University of Portsmouth, U.K.	7–12 September 2003	P.K. Zawada
25th Annual NAAMLP Conference	Kentucky Dept for surface Mining's Division of Abandoned Mine Lands	Galt House, Louisville, Kentucky, USA	28 September–1 October 2003	L. Croukamp
90th Anniversary Conference	Geological Survey Department of Ghana	Accra International Conference Centre Accra, Ghana	24–27 February 2004	P.K. Zawada, S. Frost-Killian, G. Brandl
1st Young Geotechnical Engineers Conference	University of the Witwatersrand	Strand Hotel, Swakopmund, Namibia	14–16 April 2003	N.Y.G. Trollip
8th Arab Conference for Mineral Resources	AIDMO	Sana'a, Yemen	13–16 October 2003	S. Frost-Killian, G. Grantham
IGCP 485 Meeting: Cratons, metacratons and mobile belts: keys from the West African craton boundaries Eburnian versus Pan-African signature, magmatic, tectonic and metallogenic implications	The International Geological Correlation Program (IGCP), United Nations Educational, Scientific and Cultural Organization (UNESCO) and International Union of Geological Sciences (IUGS)	University Chouaïb Doukkali Faculty of Sciences, El Jadida, Morocco	1–8 December 2003	B.A. Ingram
Urban Geology Meeting	School of Mines, University of Zambia	Lusaka, Zambia	4–5 December 2003	I. Deale
GeoForum 2003	GSSA, Professional Programmes	Volkswagen Conference Centre, Halfway House	26–27 June 2003	M.G.C. Wilson, L. Ehlers, P.K. Zawada
4th International HTN Forum "Initiating Key Drivers in Managing Rural Water-Supply Programs"		The Royal Hotel, Durban	2–5 June 2003	T.L. Swanepoel
6th International Succulent Congress	Succulent Society of South Africa	N.G.K. Church Hall, Calitzdorp	29 September–3 October 2003	P. Bosch
Structural geology of the Bushveld Complex	Bushveld Branch of the GSSA	Anglo Platinum RPM Club, Waterval, Rustenburg	9 May 2003	G. Henry, R. Burnett, B. Ingram, M. Cronwright, I. Haddon, R. Opperman, B.M. Clarke
Design of Mine Waste-Disposal Systems 3	The School of Civil and Environmental Engineering, University of the Witwatersrand	University of the Witwatersrand	3–7 November 2003	J.S. Venter
Plate Tectonics and Precambrian Geology	School of Geoscience, University of the Witwatersrand	University of the Witwatersrand	3–5 September 2003	G. Henry, S. Frost-Killian, R. Opperman
Modern Aspects of GIS and RS for Professionals in the Earth Sciences	ITC Netherlands in collaboration with the School of Geoscience, University of the Witwatersrand	Hillman Building (Civil Engineering), University of the Witwatersrand	29 September–10 October 2003	C. Forbes
Project Management Forum	Quantum Leap Investments/Global Dynamix	Burgers Park Hotel, Pretoria	12–13 February 2004	L. Croukamp

Project Management Forum	Quantum Leap Investments/Global Dynamix	Burgers Park Hotel, Pretoria	12–13 February 2004	L. Croukamp
8th IMWA Congress	International Association of Mine Water (IMWA)	Protea Hotel, Sandton	20–25 October 2003	L. Croukamp
The Engineering Geology of South Africa	Geotechnical Division of SAICE	Misty Hills Country Hotel, Muldersdrift	28 October 2003	P.K. Zawada, N.Y.G. Trollip
Field Visit to Exploration and Mining Projects in the Eastern Bushveld Complex	Bushveld Branch of the GSSA		17–19 October 2003	G. Henry
The Rand Goldfields – old deposits and new mines in Egoli	Egoli-Joburg Branch of the GSSA	Wits Club, University of the Witwatersrand	21 November 2003	G. Henry

WORKSHOPS				
Workshop on Vulnerability of Water Resources to Environmental Change in Africa	UNEP/START	Nairobi, Kenya	20–22 October 2003	R. Titus
Workshop: Alluvial Diamonds in South Africa	Professional Programmes of the GSSA	Glen Hove Conferencing Centre, Melrose, Johannesburg	2–5 April 2003	M. Wilson, G. Henry, R. Burnett
Workshop on "Clays and other industrial minerals in South Africa"	Professional Programmes of the GSSA	Glen Hove Conferencing Centre, Melrose, Johannesburg	5–6 August 2003	M. Dippenaar, L. Ntshabele, J. Venter, J.S.V. Reddering
South African National Antarctic Programme (SANAP) workshop		University of Stellenbosch	1–2 July 2003	M.R.G. Smith
First All-Russian Workshop of Electromagnetic Sounding of the Earth		Moscow, Russia	10–15 November 2003	V. Hallbauer-Zadorozhnaya
Regional (AFRA) Training Workshop on "Tracer Demonstration Technique in Isotope Hydrology with Particular Emphasis on Dam Safety"	IAEA	Pretoria		G.N. Davis
Regional (AFRA) Training Workshop on "Isotope Hydrology with particular emphasis on Risk Analysis and Risk Assessment in Dam Safety and Sustainability"	IAEA	Addis Ababa		G.N. Davis

COURSES				
A short course on palaeomagnetism applied to palaeogeography, tectonics and exploration	Prof. Trond H. Torsvik, Geological Survey of Norway (Head, Palaeomagnetic and Petrophysics Lab), Norwegian University of Sciences and Technology	Sturrock Park Sports Administration Conference Facilities, University of the Witwatersrand	28–29 August 2003	L.P. Maré, J. Cole, P. Cole, C.J.S. Fourie, A.B. Rutherford, J.P. Smit
International Training Course on Seismology, Hazard Assessment and Risk Mitigation	GeoForschungsZentrum Potsdam	CGS, Pretoria	8 September–10 October 2003	M. Bejaichund, E. Hattingh, E.M. Kgaswane, T.T. Molea, M.R.G. Smith
Lectures on Reconstruction Methods and Palaeogeography	T.H. Torsvik	School of Geosciences, University of the Witwatersrand		L.P. Maré, A.B. Rutherford, C.J.S. Fourie, J. Cole, P. Cole
Processing of magnetotelluric data	A.G. Jones	School of Geosciences, University of the Witwatersrand	25th October 2003	J. Cole, P. Cole, E.H. Stettler, J.P. Smit
Course: Groundwater modelling	Feflow-Software		14 October 2003 and 11 January 2004	J. Groenewald
Introduction to ArcGIS I		Midrand	Various dates	E. Magagane, C. Thomas, L. Cloete
Introduction to ArcGIS II		Midrand	February 2004	E. Magagane
M.Sc. Exploration Geology	Department of Geology	Rhodes University, Grahamstown	February 2003 to January 2004	M.W. Kota, BHP Billiton scholarship

19.5 COURSES AND LECTURES PRESENTED BY COUNCIL EMPLOYEES

The use of controlled sources audiofrequency magnetotellurics in exploration. Eighth South African Geophysical Association Biennial Technical Meeting and Exhibition: Tracking the Big Five. Pilanesberg 6–10 October 2003. (J. Cole and J. van der Walt)

Seismic-Risk Assessment in South Africa. School of Statistics and Actuarial Sciences, University of the Witwatersrand, Johannesburg. (A. Kijko)

Procedures for Seismic-Hazard Assessment. "International Training Course on Seismology, Hazard Assessment and Risk Mitigation", CGS, Pretoria. (A. Kijko)

Introduction to Seismicity and Seismic Monitoring in Sub-Saharan Africa. "International Training Course on Seismology, Hazard Assessment and Risk Mitigation", CGS, Pretoria. (G. Graham)

Seismological Outliers: L1 or LP norm Application. Conference of the South African Statistical Association, Johannesburg, 5–9 November 2003. (A. Kijko)

A methodology for Seismic-Risk Assessment with an Application to the Insurance Industry. Conference of the South African Statistical Association, Johannesburg, 5–9 November 2003. (A. Kijko)

Assessment of Seismic Hazard when Palaeo-, Historic and Instrumental Seismic Information is available. The Southern Earthquake Centre, University of Southern California, United States of America. (A. Kijko)

Probabilistic Seismic-Hazard Evaluation with Incomplete Catalogues. Centro de Investigacion Cientifics y Educacion Superior de Estenada (CICESE), Mexico. (A. Kijko)

Mining-Induced Seismicity in Gauteng and its Potential Hazard to Infrastructure. GE Frankona Industry Symposium in South Africa, "Earthquakes and their Impact on Greater Johannesburg and Pretoria". (G. Graham and A. Kijko).

19.6 PUBLICATIONS IN ACADEMIC JOURNALS AND BOOKS

BOSMAN, D.E., HUIZINGA, P., REDDERING, J.S.V. and SCHUMANN, E.H. 2003. Options and techniques to move marine sediment ***in*** Towards the management of marine sedimentation in South African estuaries with special reference to the Eastern Cape (Schumann, E.H., ed.). Report, Water Research Commission, Pretoria, pp. 65–86.

BRANDT, M.B.C., KIJKO, A. and GRAHAM, G. 2003. Seismic hazard analysis and micro-seismic monitoring at southern African dams. ICOLD Twenty-First International Congress on Large Dams, 3, pp. 731–752.

BRANDT, M.B.C., KIJKO, A. and GRAHAM, G. 2003. Seismic hazard analysis and micro-seismic monitoring at southern African dams. Proceedings of the ICOLD 21st Congress, Montreal 2003, Paper Q. 83-R, 42, pp. 731–752.

CHEVALLIER, L., GIBSON, L., WOODFORD, A., NHLEKO, O.L., NOMQUPHU, W. and KIPPIE, I. 2004. Hydrogeology of fractured rock aquifer and related ecosystems within the Qoqodala dolerite ring and sill complex, Great Kei catchment. Report, Water Research Commission, Pretoria, 1238, 134 pp.

CLARKE, M.L., VOGEL, J.C., BOTHA, G.A. and WINTLE, A.G. 2003. Late Quaternary hillslope evolution recorded in eastern South African colluvial badlands. Palaeogeography, Palaeoclimatology, Palaeoecology, 197 (3/4), pp. 199–212.

COLE, P. and COLE, J. 2003. Modelling geophysics down the earth science catwalk. 8th SAGA Biennial Technical Meeting, 2003, Pilanesberg.

DAVIES, N. and KIJKO, A. 2003. Seismic risk assessment: with an application to the South African Insurance Industry. SA Actuarial Journal, 3, pp. 1–28.

FOURIE, C.J.S., COLE, J. and BOSCH, P.J.A. 2003. Geophysical interpretation on 2926AB Maselspoort 1:50 000 sheet. 8th SAGA Biennial Technical Meeting, 2003, Pilanesberg.

FROST-KILLIAN, S. and HAMMERBECK, E.C.I. 2003. A new CGMW map released: The International Metallogenic Map of Africa on a scale of 1:5 000 000. Episodes, 26 (2), pp. 116–118.

GERYA, T.V., UKEN, R., REINHARDT, J., WATKEYS, M.K., MARESCH, B.M. and CLARKE, B.M. 2003. Cold fingers in a hot magma: modelling of diapirs in the Bushveld Complex, South Africa. Geology, 31, pp. 753–756.

GOEDHART, M.L. 2003. Geology and oil/gas potential of the Emirate of Fujairah, eastern U.A.E. Abstracts and Technical Papers, Abuja Geocongress, Abuja Sheraton Hotel and Towers Conference Centre, Nigeria, 20–24 May 2003, pp. 8–9.

GRAHAM, G. 2003. A seismic hazard and risk assessment for the Tulbagh area in South Africa: Application of the parametric-historic procedure. XXIII General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan.

GRANTHAM, G.H., ARMSTRONG, R.A. and MOYES, A.B. In press. The age, chemistry and structure of mafic dykes at Roerkulten, H.U. Sverdrupfjella, western Dronning Maud Land, Antarctica. Proceedings of the Fourth International Dyke Conference (IDC4), Itala, South Africa. Balkema Press.

HALLBAUER-ZADOROZHNAYA, V.Yu. and STETTLER, E.H. 2003. The electrokinetic sounding technique: algorithm development for the modelling of sounding results. First All-Russian Workshop of Electromagnetic Sounding of the Earth, Moscow, Russia.

HALLBAUER-ZADOROZHNAYA, V.Yu. and STETTLER, E.H. 2003. The IP effect in TDEM sounding as indicator of hydrocarbon contaminated groundwater. First All-Russian Workshop of Electromagnetic Sounding of the Earth, Moscow, Russia.

HUIZINGA, P. and REDDERING, J.S.V. 2003. Management of causes of sedimentation ***in*** Towards the management of marine sedimentation in South African estuaries with special reference to the Eastern Cape (Schumann,

E.H., ed.). Report, Water Research Commission, Pretoria, pp. 50–64.

KIJKO, A., RETIEF, S.J.P. and GRAHAM, G. 2003. Seismic hazard and risk assessment for the Tulbagh Area, Part II. Assessment of Seismic Risk. Natural Hazards, 30, pp. 25–41.

KIJKO, A. 2004, Estimation of the maximum earthquake magnitude, mmax. Pure. Appl. Geophys. (in print).

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MÄNTYNIEMI, P., MARZA, V.I., KIJKO, A. and RETIEF, P. 2003, A New probabilistic seismic hazard analysis for Vrancea (Romania) Seismogenic Zone. Natural Hazards, 29, pp. 371–385.

MÄNTYNIEMI, P., TSAPANOS, T.M. and KIJKO, A. 2003. An estimate of probabilistic seismic hazard for five cities in Greece by using the parametric-historic procedure. (in print)

MARÉ, L.P. and COLE, J. 2003. The Trompsburg Complex revisited, 8th SAGA Biennial Technical Meeting, 2003, Pilanesberg.

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IUGG Conference	Japan	G. Graham, E.H. Stettler
CTBTO Workshop	Jordan	G. Graham
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Electromagnetic Workshop	Russia	V.Yu. Hallbauer-Zadorozhnaya
	United Arab Emirates	A. Kijko, J. Steyn
8th Arabic Conference of Mineral Resources	Yemen	E.H. Stettler, J.P. Smit
Congress on Indian Ocean Research Development	Reunion (France)	L. Chevallier
Workshop on Image Processing, Water and Wetlands, University of Reunion	Reunion (France)	L. Chevallier
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