

GEOLOGICAL SURVEY OF NAMIBIA

Ministry of Mines and Energy
ANNUAL REPORT 1998

EARTH SCIENCES FOR NAMIBIA'S SUSTAINABLE DEVELOPMENT

Foreword

The Geological Survey of Namibia is the central geoscience institution in Namibia dealing with information and research to promote the sustainable management and utilisation of the land surface and subsurface and its natural resources. During 1998, the Geological Survey of Namibia has continued to provide government and policy-makers, industry and the public at large with information and data pertaining to such issues as exploration, mining, building and construction, environmental engineering, land use planning, coastal zone management and natural hazards.

In the past, the principal role of Geological Surveys worldwide has remained virtually unchanged for a century. Until recently, it was dominated by mapping the country at increasingly smaller scales, studying mineral and fossil fuel deposits to establish future potential and delineating areas prone to natural disasters. While these tasks remain of vital importance, more recently the concept of human destruction of the environment has made environmental geology an issue of ever increasing importance.

In today's world with its increasing population and an ever increasing demand for better quality of life for all people, the strain on the limited resources has never been as dramatic as now. To ensure any prospect for future generations, sustainable development has become a first and foremost task.

Also, global changes in ecosystems are evident today, and Namibia is no exception. Global warming and the anticipated associated sea level changes are believed to be amongst the reasons for the dramatic changes seen along the Namibian coastline and for the extended periods of draught experienced recently. In contrast to historical times, when changes in ecosystems were dominated by Earth's own dynamics, today's changes are induced to an unprecedented extent by human activities. In Namibia, with its extremely fragile arid ecosystem, the pressure exerted by a rapidly growing population necessitates innovative ideas for sustainable development.

Worldwide, the overall economy has shifted from one that was driven by the primary and natural-resources-based sector to the tertiary sector. This development is also evident in Namibia, where value-adding is encouraged to enhance the creation of wealth. This development has also caused a change in the requirements for Geological Survey products, with thematic geological information including added intelligence in the form of interpretation being high in demand.

Namibia's economy rests on four pillars, namely mining, agriculture, fishing and tourism. Co-existence of these four sectors is not always without conflict. Nevertheless, the development of all of Namibia's economic sectors is a political priority to ensure quality of life for all Namibians. Coupled with the growing population this leads to ever increasing demands in terms of electricity,

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consumption of disposable goods, and grazing and arable land. The Geological Survey of Namibia has fully recognised this situation, and consequently tasks such as land use planning, waste disposal siting, engineering geology for town and other developments, geochemical mapping and mineralogy for purposes other than exploration (e.g. health), coastal zone management and environmental impact management have gained increasing importance. Nevertheless, the traditional tasks of mapping and resource evaluation have not been neglected.

The Geological Survey of Namibia has started to establish a constant dialogue with all its customers, and this Annual Report is part of this endeavour. It gives an overview of the activities and achievements in 1998, and informs about the services available from this institution.

REGIONAL GEOSCIENCE DIVISION

Regional Mapping

Geological Mapping

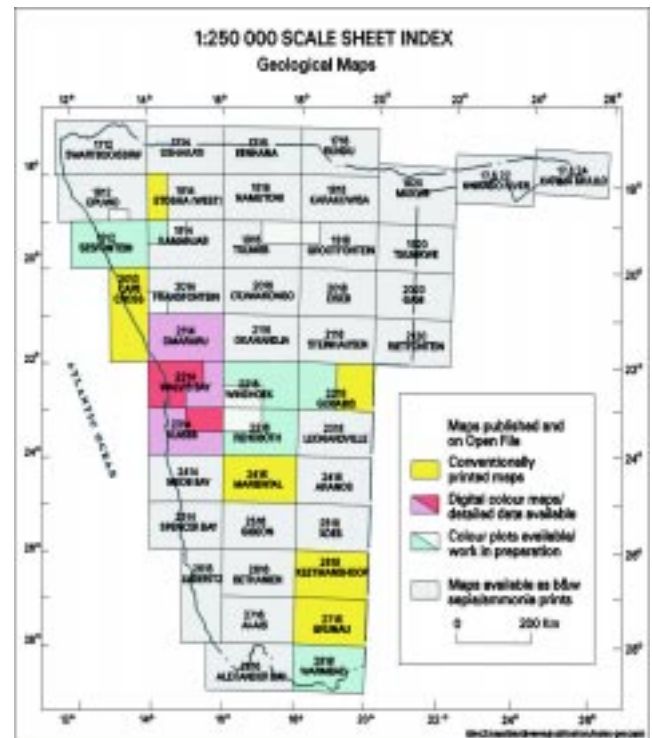
Field mapping as continued during the year and has involved checking and updating of existing maps, as well as systematic new mapping. The work has concentrated on map sheets that cover areas considered of importance for mineral exploration and over which high-resolution airborne geophysical data has been acquired as part of the SYSMIN Phase 1 and Government funded survey programme.

On the **Rehoboth 2316** map sheet mapping and field checking of 1:50 000 and 1:100 000 scale maps has been carried out with the aim of resolving longstanding structural and stratigraphic relationships between Palaeo- to Mesoproterozoic supracrustal metasedimentary and metavolcanic units of the Rehoboth Sequence, the Sinclair Sequence and associated granitoid intrusive rocks. This work has so far focused on the better exposed area of the eastern Rehoboth Basement Inlier covering 1:50 000 scale map sheets 2316 AC, AD, BC, BD and 2316 DA to DD.

Parts of the northern Naukluft Nappe Complex were remapped and revised in the light of new field evidence which indicates direct stratigraphic correlations with the metamorphic Damara Sequence (Hakos Group) to the north and sediments of the Witvlei and lower Nama Groups.

Systematic mapping at 1:50 000-scale of the south-western parts of the **Opuwo 1812** map sheet which started in the Kaokoveld of the western Kunene region in the previous year, has made good progress in producing new, detailed mapping of poorly accessible areas with only reconnaissance map coverage previously available. The aim of this work is to map complex cover-basement relationships between metamorphic Neoproterozoic cover and older high-grade basement, and to establish a stratigraphy and regional correlation of the Damara Sequence within the internal metamorphic parts of the Kaoko Belt west of the Sesfontein Thrust. This will help to more precisely define the stratigraphic and structural position of the Tsongoari (Pb-Zn) sulfide deposits and related base-metal mineralization in the area.

Detailed mapping of the 1:50 000 scale Omapunguwe sheet (1813 CC) in the south and the Orupembe



sheet (1812 BA) in the north, has been completed. Compilation of the Omapunguwe and adjoining Tomakas sheet (1813 CD) mapped in 1997 and together covering a full transect of the central Kaoko Belt between the Sesfontein and Purros Lineament, is in preparation. Reconnaissance mapping has been carried out in several adjoining sheets (1812 BB and BD, 1812 AA, AB and AC; 1812 BB and BD; 1813 AC; 1812 DA, DB and DD) to facilitate planning of future mapping of adjacent areas.

Field checking and reconnaissance mapping was carried out on the **Sesfontein 1912** sheet which adjoins the Opuwa sheet to the south and was compiled during the year for Open File release, as well as on the **Fransfontein 2014** sheet, which adjoins the recently published **Omaruru 2114** sheet.

Detailed mapping and structural analysis as part of an geotechnical evaluation of four waste disposal sites near Lüderitz was done in cooperation with the Engineering and Environmental Geology Subdivision.

Regional Studies

Apart from the mapping activities tied to specific 1:250 000 scale map sheets, the Subdivision Mapping carried out multidisciplinary regional research studies on stratigraphy and tectonics, some of them in collaboration with foreign university research workers from various countries.

Damara Stratigraphy and Geochronology

Neoproterozoic stratigraphy and correlation of the Damara, Kaoko and Gariiep Belts involves studies of sequence stratigraphy and sedimentology, stable isotope chemostratigraphy and precise single zircon geochronology. These studies are focussed in particular on dating and correlating recently identified multiple glaciogenic horizons and their use as reliable time-stratigraphic horizons to constrain the history and geometry of basin development and timing of tectonics during Neoproterozoic rifting and continental breakup and convergence. These involve diverse stratigraphic divisions of the sedimentary Otavi- and Mulden Groups of the northern Namibia, the Nama Group of southern Namibia, and correlative metamorphic units of the Kaoko Belt, the northern and central Damara Belt, and the Gariiep Belt. Preliminary U/Pb single zircon data are available from the northern Damara Belt and the Gariiep Belt.

Kaoko Belt

Field based structural and metamorphic studies in the Kaoko belt have revealed a 2.5 km wide mylonite and ultra-mylonite zone, named the Purros Mylonite Zone (PMZ), located immediately west of the Purros Lineament. It separates domains of contrasting stratigraphy and metamorphic grade and involves sinistral displacement estimated to be in the order of tens of kilometres, and thus marks a major terrane. Stratigraphic correlations of mapped lithologic units require further work to be resolved, however, initial indications are that a thick sequence of metasediments and metavolcanic rocks of the Okapuka Formation, that was previously correlated with the Khoabendus Group, may form part of the Damara Sequence.

Processing of structural orientation and kinematic data collected during field mapping is in progress, and work has started on electron-microprobe studies of metamorphic mineral phases, U/Pb zircon geochronology of intrusive rocks and partial melt phases, and whole-rock geochemistry of mafic schists and gneisses. A preliminary tectono-metamorphic map of the Kaoko Belt has been compiled from existing and new data.

REGIONAL STUDIES





Rehoboth-Sinclair Belt

Detailed mapping together with new U/Pb zircon geochronological data in the Gaub Valley and adjacent area in the western Rehoboth Basement Inlier show that the present classification of units into pre-Rehoboth basement units (Moorivier Metamorphic Complex and Elim Formation) and Rehoboth Sequence (Gaub Valley, Marienhof and Billstein Formations) now need to be revised. Instead, the Gaub Valley Formation represents the oldest unit of the Rehoboth Sequence which is overlain by the Elim Formation sediments and mafic volcanic rocks and, further east, the Marienhof Formation. The migmatitic Moorivier Complex which was previously thought to represent older high-grade metamorphic basement to the Rehoboth Sequence is now interpreted to be the result of contact metamorphism and injection migmatization of the Gaub Valley

and Elim Formations. Several units composed of metasediments and metavolcanic rocks, which have been classified in the past into the Marienhof Formation, appear to be younger and, together with Billstein Formation, probably belong to the Sinclair Sequence.

Laboratory studies including U/Pb zircon age dating, whole-rock trace element and isotope geochemistry, and kinematic analysis of structural orientation field data are in progress on the above units of the Rehoboth-Sinclair Sequence.

UNIVERSITY RESEARCH

University Research

The Geological Survey actively promotes university research work that is considered to be of benefit to Namibia, and has supported a number of projects by foreign university research institutions during the year. Three of these projects on the Naukluft Nappe Complex (St Andrews University), the Kaoko Belt (University of Mainz) and the Etendeka Group (University of Cape Town) involve direct participation by Geological Survey personnel. The following projects are ongoing:

- * Characterization of spatial variability of carbonate facies of the Terminal Proterozoic Lower Nama Group. Massachusetts Institute of Technology, Harvard University, USA.
- * Stratigraphic framework and sedimentology of the Naukluft Nappe Complex. University of St. Andrews, Scotland, Great Britain and Geological Survey of Namibia.
- * Petrography, petrology and geochemistry of the magmatic rocks from mafic and alkaline satellite intrusions and carbonatites of the Kunene Anorthosite Complex. University of Wuerzburg, Germany.
- * Saline fluids in orogenic belts of southern Africa: the role of Neoproterozoic evaporites in Pan-African metallogenesis. University of Cape Town, South Africa.
- * Tectonic evolution of the southern Kaoko and Damara Belts in the Lower Ugab region. Johannes Gutenberg University, Mainz, Germany and Geological Survey of Namibia.
- * Geochemistry and petrogenesis of feeder dykes associated with the Goboboseb basalts, southern Etendeka, and their relationship to upwelling of the early Tristan plume. University of Cape Town, South Africa and Geological Survey of Namibia.

INTERNATIONAL CO-OPERATION

International Co-operation

The Mapping Subdivision has participated in collaborative projects of the Mining Coordinating Unit of SADC involving member countries of the southern African sub-region, and has committed itself to contribute to several ongoing and recently inaugurated and proposed new projects of the International Geological Correlation Programme (IGCP) of the International Union of Geological Sciences.

Kalahari Basin Working Group

After completion of the Kalahari Basin Isopach Map (1:5 million scale) in the previous year, work has continue with the compilation of the pre-Kalahari Geology Map which portrays the pre-Kalahari geology exposed around the margins of the basin and interpreted sub-surface geology based on geophysics and borehole data.

Stratigraphy Working Group

The Stratigraphic Table of the SADC region countries was completed and printed during the second half of the year. The chart will form the basis for the geological legend of the 1:2.5 million scale Geological Map of the SADC Region, which was started this year with the compilation and digitizing of existing 1:1 million scale geological map data of all member countries.

International Geological Correlations Programme (IGCP) Projects

Contributions to the following ongoing and new IGCP Projects were made :

- * IGCP Project 363 - Palaeoproterozoic of sub-equatorial Africa
- * IGCP Project 418 - Evolution of the Mesoproterozoic (Kibaran) Belt System of south-western Africa.
- * IGCP Project 419 - Foreland basins of the Neoproterozoic Belts of central-southern Africa and south America.
- * IGCP Project (Proposed) - Mesoproterozoic assembly and Neoproterozoic breakup of the Rodinia Supercontinent.

The Geological Survey has accepted to act as national representative for Projects 418 and 419 at the inaugural meetings held during the 50th Anniversary Conference of the Botswana Geological Survey held in Gaborone in June 1998.

Cartography

Digitizing and computer processing of geological maps for incorporation into the Geological Survey's Geological Digital Map Data Base using computer-based (GIS) map processing facilities established through technical co-operation with the Geological Survey of Finland and funded by the Finnish International Development Agency (FINNIDA) over a five-year period between 1991 and 1995, now is an important routine function of the Subdivision: Cartography. The digital map data forms the basis for the compilation and digital cartographic processing of 1:250 000-scale maps for publication and release as digital data sets.



Printed Geological Maps

Omaruru 2116 sheet (1:250 000 scale) was printed in March this year and brings the number of printed maps produced by computer-based digital cartographic technology and available in both hard copy and digital format to a total of three. Together with the **Kuiseb 2314** and **Walvis Bay 2214** sheets printed in 1994 and 1995 respectively, these three maps now provide full coverage of the central Damara Belt, which hosts amongst others the important Rössing Uranium Mine and the Navachab Gold Mine of the Erongo Region of central-western Namibia.

Checking and editing of the **Simplified Geological Map of Namibia** (scale 1:2 million) was finalized and the map was printed in August as a joint effort with the Geological Society of Namibia.

1:250 000 Scale Geological Maps in Preparation for Printing

Digitizing and editing/updating of map data and the compilation of draft legends and map lay-outs of the **Rehoboth 2316** and **Windhoek 2216** sheets started in 1997 continued during the year. Both maps including mineral occurrence data are available as hard copy 1:250 000 scale provisional maps on Open File, as well as 1:100 000 scale maps for the completed parts of the full map sheets.

1:250 000 and 1:100 000 Scale Geological Maps in Preparation for Open File

Work on the **Warmbad 2818** sheet was finalized during the year and the sheet was released on Open

File with mineral occurrence data. Compilation and digitizing of **Sesfontein 1912** started and 1:100 000 scale map sheets 1913 A and B of the northeastern part of sheet are completed. Digitizing of new detailed 1:50 000 scale maps of the **Opuwo 1812** sheet mapped in 1997 (**Tomakas 1813 CD**) and this year (**Omupunguwe 1813 CC**) is in progress.

Thematic Maps

The following thematic maps at different scales are in preparation:

- * **Minerals Map of Namibia (1:1 million scale)**
Checking and editing of mineral occurrences has been ongoing.
- * **Geological Map of the Otavi Mountainland**
Detailed geology and structural data were captured and edited from 1:100 000 scale map sheets 1917 A, B, C and D as well as sheets 1918 A and C. Provisional legends have been compiled and digitized for each sheet.
- * **SADC Environmental Map**
Two complimentary 1:5 million scale maps of the maritime areas of the SADC countries are in preparation, showing the distribution of commercial fishing grounds, spawning areas and offshore mining/exploration areas; as well as coastal mineral deposits.
- * **Environmental Atlas of Namibia**
The Environmental Atlas of Namibia is prepared in co-operation with the Ministry of Environment and Tourism. It encompasses all data relevant for the assessment of mining and exploration in Namibia, such as for example power supply, infrastructure, rainfall, agricultural zones, grazing capacity, fishing grounds, it also includes 1:2 million scale versions of the Namibian coastal region from the above SADC Environmental Map.

Geophysics and Remote Sensing

Airborne Geophysical Surveys

The Geological Survey's programme of high resolution airborne magnetic and radiometric surveys continued during 1998. The surveys, flown with a line spacing of 200 metres at a survey height of 80-100 metres, provide quality data for mineral exploration and complement the regional coverage. The geophysics subdivision is responsible for survey planning, specifications, tender preparation, evaluation and award, and quality control of data acquisition and processing, including the supervision of the contractor's performance.

Survey operations in the Rehoboth area, which commenced in November 1997, continued through January and February 1998. This survey consists of a main area of approximately 43 000 line-kilometres costing N\$1,2 million funded by the Namibian

Government, and three supplementary areas consisting of approximately 33 000 line-kilometres at a cost of N\$830 000 funded through a grant from the Minerals Development Fund. Data processing was completed during the second quarter and final deliverables include digital grids and line archives together with colour maps, black and white contours on mylar and an operations report. The official release of the data was launched at a reception held by the contractor Poseidon Geophysics on 7th August 1998.

Following survey planning, tender procedures, evaluation and award, Poseidon Geophysics commenced survey operations over Diamond Area 1 early in August 1998. The survey comprises 91 310 line kilometres and is funded by the Namibian Government (N\$2 million) with a supplement of N\$300 000 from the Minerals Development Fund. Survey operations were completed early in October and data processing is well advanced

with delivery of final products expected during the first quarter of 1999. This is the first airborne

AIRBORNE GEOPHYSICAL SURVEYS



geophysical survey over an area where the geology is concealed by sands of the Namib Desert with the Skorpion lead-zinc deposit and the Rosh Pinah mine in the vicinity, the data release is awaited with anticipation by the exploration community.

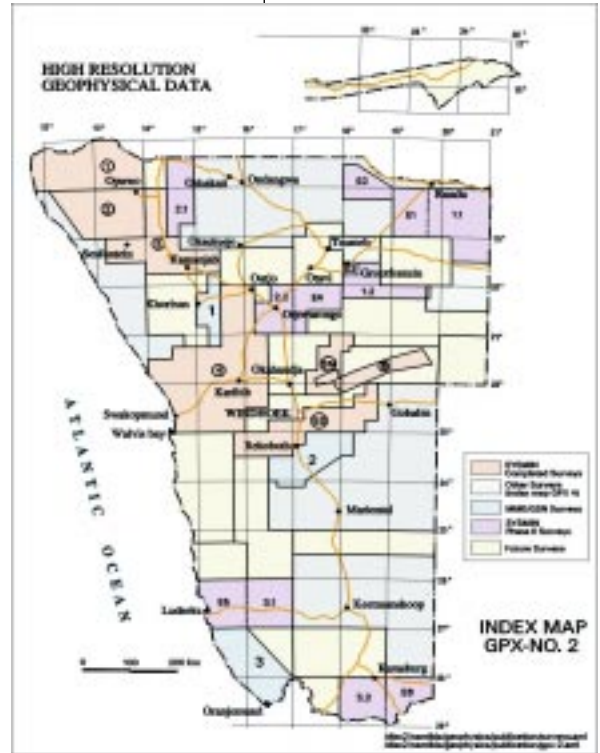
Whilst Government funded surveys are proceeding smoothly, administrative and procedural problems have resulted in considerable delays to the six areas planned for surveying as part of the European Union SYSMIN Phase II programme. Tender documents and technical specifications were prepared in January but in June the European Union requested a pre-qualification tender. The pre-qualification closed on November 6th and the evaluation report has been completed. Provided European Union approval of the pre-qualification evaluation report is forthcoming, the final tender process is scheduled for early 1999. Even so it is unlikely that survey operations will commence until much later in the year.

As part of the European Union Phase II allocation, funds were also made available for the interpretation of the SYSMIN airborne surveys and the purchase of appropriate computer hardware and software. A European Union Consultant is to be appointed to verify the requirements of the Geological Survey in this regard. In the meantime, interpretation of the regional airborne magnetic data has been completed and interpretation of the government funded surveys will commence next year.

Henties Bay Test Range

As part of the European Union SYSMIN Phase I airborne geophysical surveys, a dynamic test range was established at Henties Bay. Namibia is the only country in Africa offering field radiometric calibration facilities and the test range is now increasingly being used by airborne geophysical contractors operating in southern Africa. To upgrade the range and provide additional ground control for airborne radiometric data acquisition and processing, ground radiometric measurements were taken over a 12 km x 2 km grid.

This data has been processed, maps compiled and a bulletin is in preparation for publication next year.

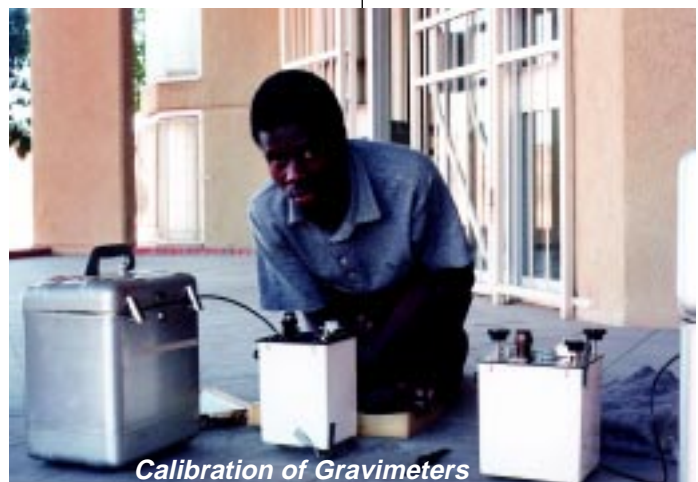


Gravity Surveys

Gravity observations in southern Namibia for the national gravity reference network were conducted and the network of secondary reference stations is now complete.

GRAVITY SURVEYS

Preliminary processing of the data in conjunction with the University of Namibia is underway and the data will then be sent to the National Imagery and Mapping Agency (NIMA) of the USA for final processing and verification. The secondary reference network is linked to the four absolute gravity stations established by NIMA in 1997, and is a pre-requisite for resumption of the upgrading of the regional gravity coverage by in-filling along roads and tracks.



Seismic Stations and Surveys

The Tsumeb Station continued to monitor seismic activity as part of the Global Seismological Network (GSN), funded and operated by the Incorporated Research Institutions for Seismology (IRIS - a consortium of 80 universities in the USA) in cooperation with the United States Geological Survey (USGS). An operational performance of over 96% was achieved which is excellent and ranks Tsumeb within the top IRIS stations worldwide.

The Tsumeb Station also continued to monitor magnetic secular variation in cooperation with the Hermanus Observatory, South Africa and neutron emissions in conjunction with the University of Potchefstroom, South Africa. A team from the Hermanus Observatory also conducted magnetic observations at sites in Namibia as part of their regular programme of observations in Southern Africa. The observations are used to derive more accurate mathematical models and maps of the regional magnetic field and its components in Southern Africa.

Following a visit by the Experts Assignment Department for the Japanese International Cooperation Agency (JICA), it has been agreed that JICA will replace the obsolete seismological equipment at Windhoek with modern equipment which will be linked to the Tsumeb Station.

The microseismic stations established by the Institute of Geophysics and Meteorology of Frankfurt University, Germany were serviced routinely on a monthly basis and the data sent to Germany for evaluation and interpretation. Despite some instrument problems the data is providing valuable information and an interim report is expected during 1999.

The GeoForschungsZentrum (GFZ) of Potsdam has also established five stations located throughout central Namibia as part of the seismic investigations in the Messum-Brandberg Area (SIMBA) project. As part of the same project, 44 broad band magneto-telluric observations traversed the conductivity anomaly recognised in the vicinity of the Brandberg.

GERMAN-NAMIBIAN CO-OPERATION PROJECT

German-Namibian Cooperation Project

In March 1998, cooperation with Federal Institute for Geosciences and Natural Resources of Germany (BGR) continued with a new project 'Advisory Services to the Geological Survey'. This project attaches special emphasis on institution and capacity building aiming to strengthen the capacities of the geophysics sub-division and to promote interdisciplinary working methods. The project has three main elements:

- * Six project-funded scholarships in geophysics, engineering geology and geotechnology have been awarded to junior GSN-staff members since 1995. Graduates and post-graduates are expected to return from late 1999 onwards and will strengthen human resources within the geophysics sub-division.
- * Selected state-of-the-art geophysical techniques are presented to GSN staff by holding lectures and practical field exercises.
- * Advice, advanced training and technical support is provided to interdisciplinary in-house projects. During the year engineering geology and geophysics staff together with experts from BGR conducted EM and seismic refraction surveys over 5 potential waste dump sites in the ecologically extremely sensitive area of the Namib Desert.

GEODESA

Geodesa

The GEODESA Technical Committee GTC, of which the Geological Survey's Chief Geophysicist is the chairman, met in Dar Es Salaam in June and reviewed the progress and objectives of the project. A Geodesa course in managing, processing and presentation of regional geophysical surveys in Dar Es Salaam, Tanzania from 8th February to 3rd April 1998 was attended and the Geological Survey received one IBM PC, one ER Mapper Licence and two Oasis Montaj licences from the Geodesa Project during the year.

APPLIED GEOSCIENCE DIVISION

Economic Geology

ECONOMIC GEOLOGY

Economic Geology 1:250 000 Mineral Series

The process of compiling open file exploration data for the 1:250 000 map sheets continued during 1998. This information will form part of a GIS system which will include geology, geochemistry, geophysics, Landsat interpretation and bibliographic databases. Data for an additional four sheets was compiled during 1998 (Warmbad 2818, Kuiseb 2314, Walvis Bay 2214 and Omaruru 2114).

The data compilation includes the following:

- * Localities of all mineral occurrences, prospects and mines
- * Completion of data forms for each of the occurrences, prospects and mines for database entry (NAMDAT) using the Geological Survey's numbering system
- * A brief one page description of each occurrence, prospect and mine including exploration results. This description also contains salient details of the geology, type of mineralisation, and exploration.

Promotion of Namibia's Mineral Wealth

The Economic Geology Sub-division's drive to proactively promote Namibia's mineral wealth continued during the year with the GSN exhibits at numerous conferences. This activity provides dividends in the form of continued mineral licence applications despite the global economic and exploration depressions. There were 176 new and 40 renewed mineral licence applications over the past year. During the year EPLs issued by the Mining Directorate increased from 165 to 252 while 3 more mining licences were issued, bringing the total to 84. Several key exploration and mining companies have been focusing on Namibia with for example Cominco, the world's largest zinc, producer, opening an office in Windhoek.

During the year, the Economic Geology Sub-division has continued with its assistance to the Mining Commissioners Office, thereby significantly reducing the mineral licence application backlog. In addition to conducting geotechnical reviews of all mineral licence applications, this has included producing pro-formas for applications and reports and streamlining mineral licence processing and reporting procedures. As a result of this the line function activities had to be put on hold, as mineral licences were of priority. However, the backlog has now been eliminated and line function duties can again be pursued.

Geochemistry and Laboratory

Laboratory

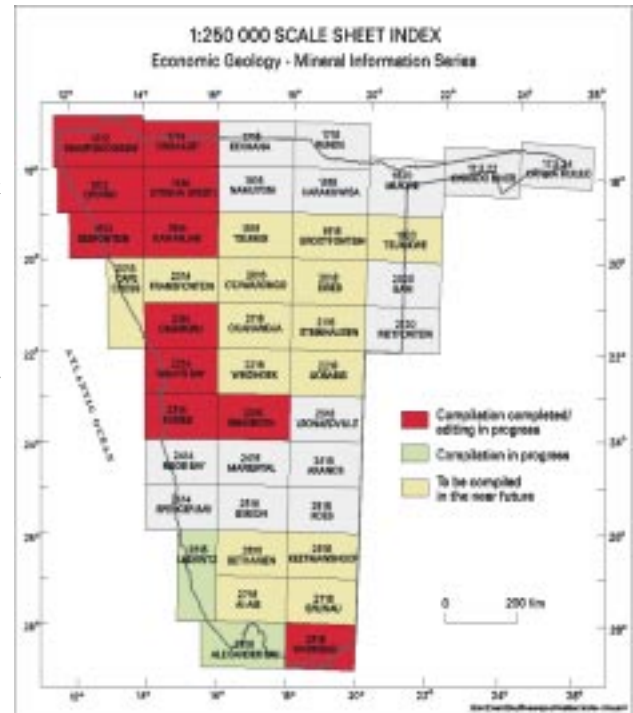
The Geological Survey has an extensive laboratory complex. A range of facilities are available for the sample preparation and the determination of chemical, mineralogical and physical properties as summarised below :

Sample preparation:

- * Splitting, crushing and pulverising of rock and mineral samples
- * Sieving of unconsolidated material
- * Mineral separation by heavy liquid media separation, magnetic separation and Wilfley table
- * Slabbing and polishing of specimens (rock saws and lapping plates)
- * Automatic preparation of thin sections and polished sections
- * Preparation of ultra-pure deionised water and acids in dual sub-boiling quartz glass still
- * Sample dissolution (lithium tetraborate fusion or by HF/HNO₃ attack in teflon bomb)
- * Weighing (5 figure balance)
- * Preparation of pressed powder pellets for XRF analysis
- * Preparation of fusion discs for XRF analysis

Analysis

- * Mineral identification by x-ray diffraction (XRF) and optical microscopy
- * Spectrophotometer for the more accurate identification of ore minerals in polished section
- * Investigation of fluid inclusion properties
- * Moisture content and loss on ignition (ovens and furnaces)
- * Determination of major and minor elements by XRF and ICP-AES.



**PROMOTION OF
NAMIBIA'S
MINERAL WEALTH**

LABORATORY



ICP Analysis

In addition to these facilities, the Laboratory complex also houses two specialist laboratories, one for the testing of Industrial Minerals and another for engineering geological tests.

The sub-division handles enquiries from a variety of sources, including general public and the Namibian Police and Customs, giving advice on rock and mineral identification and sample assay. Tin- and Tantalum-bearing concentrates are routinely analysed for the Small Miners Assistance Centre, forming part of their efforts to improve the socio-economic climate of the Uis area.

New Instruments :

In March the GSN took delivery of the Philips 2404 X-Ray Fluorescence (XRF) Spectro-meter. This instrument, together with automatic fusion and pelletizing sample preparation apparatus, comprises a major capital development project (N\$1.5m) funded by the Namibian Government. The XRF will enable the Geological

Survey to produce high quality major and trace element data on a variety of geological materials for programmes within the Ministry of Mines and Energy, as well as for the private sector. Commissioning the XRF instrument, together with software familiarisation, sample preparation techniques and analytical method development have taken priority during 1998 and will continue to do so during 1999.

Mineral identification is an essential requirement for the Geological Survey, particularly for the testing and evaluation of industrial minerals. Replacement of the Geological Survey's aging X-Ray diffractometer is being made possible through SYSMIN funds in an extension to the Industrial Minerals Project. Tendering procedures were completed in September and an order has been placed for a Bruker axs D8 Advance diffractometer system, with expected delivery and installation in the first quarter of 1999.



The new XRF

INDUSTRIAL MINERALS PROJECT

Industrial Minerals Project

The Industrial Minerals Project, which forms part of the SYSMIN programme in Namibia, is aimed at assisting the Geological Survey to develop a sustainable capacity in the evaluation of industrial minerals, to attract inward investment and to provide technical advice to small-scale producers. The project commenced in late 1995 with the arrival of two resident advisors from the British Geological Survey (BGS). During this phase a fully equipped testing laboratory was set up, market surveys were carried out, field and laboratory trials conducted and an enquiry service implemented.

The second phase of the project involves a professional linkage between trained local staff and expert assistance from the BGS. One of the BGS advisors remained resident in Namibia for the first 8 months of this second phase and there were three additional short-term visits from other BGS advisors providing specialist technical support. Field and laboratory training of Geological Survey counterparts continued until they departed in September for their studies overseas. Development and population of an Industrial Minerals Resource Database was one of the principal

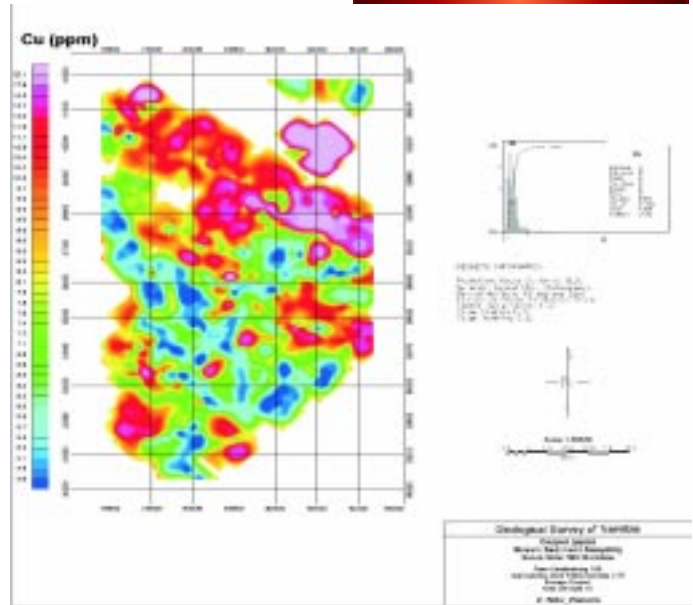
achievements of the project this year. Laboratory work involved extensive testing of clay bodies as part of a pre-feasibility study of the Mariental clay deposit in collaboration with the Ministry of Trade and Industry.

GEOCHEMICAL SURVEYS

Geochemical Surveys

Progress on pilot studies for regional geochemical surveys has been rather disappointing. These surveys are a new endeavour at the Geological Survey and are labourintensive. Unfortunately, in the present economic climate the GSN is unable to recruit the personnel required to carry out the sampling needed. Efforts have been made to secure funding of contract-out sample collection, but at this time it is not known whether these have been successful.

Capture of older archive data on open file is, however, ongoing. Manipulation of these data and the generation of maps have been greatly assisted by training under the auspices of the GEODESA Project (see illustration). Pilot studies for regional geochemical are planned for the near future.



Engineering and Environmental Geology

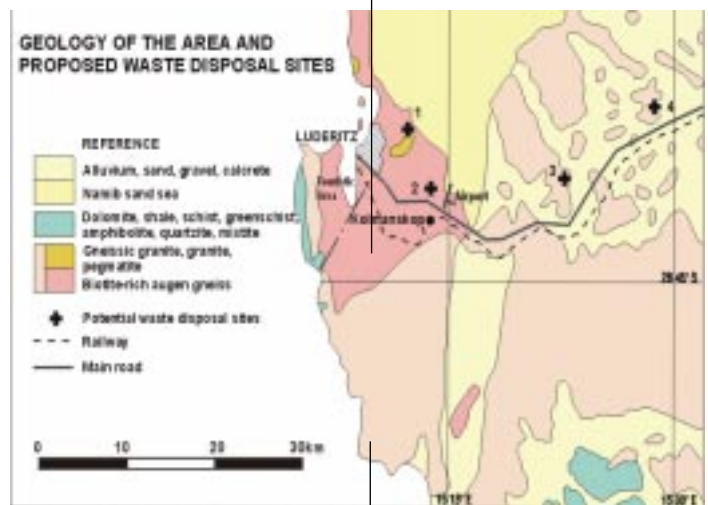
The Engineering and Environmental sub-division of the Geological Survey is tasked to perform scientific and technical research and investigation related to engineering and environmental geology throughout the country. Assistance and information are provided to all affected and concerned parties, such as government institutions and the private sector operating in the fields of civil and mining engineering. During 1998, significant contributions were provided to town planning, the new “Environmental Management Act of Namibia”, the “Pollution Control and Waste Management Legislation”, the establishment of a “Namibian Construction Research Institute”.

WASTE DISPOSAL SITES

Lüderitz Hazardous Waste Disposal Site Investigation

The implementation of this study was the main task of the Subdivision and absorbed about the 65% of available time resource during 1998. Extensive offshore drilling activities are expected to take place in connection with the Kudu Gas Field, and Lüderitz harbour is considered the most suitable base for supply vessels. Ordinary domestic waste together with particularly hazardous waste, such as used oil and drilling muds, are expected to be produced in large quantities during gas exploration and gas extraction activities. Ships involved in marine diamond mining and fishing will also contribute to the production of ordinary and hazardous waste.

The study has been undertaken by addressing mayor environmental issues, in order to strictly conform to the Namibian Environmental Policy. This project can be considered as a first reconnaissance step towards the implementation of a wider and more complex project, aimed to improve the waste management for the Lüderitz town. The investigation will also provide baselines and guidelines for similar projects to be implemented within Namibia and specially within arid coastal regions with extreme climatic conditions.



The aim is to select a suitable site within a distance of thirty kilometres from Lüderitz. A total area of about 3 000 square kilometres were covered during this survey and four potentially

suitable sites were delineated. The site investigations involved detailed topographical mapping, geological mapping and geophysical surveys including magnetic, electromagnetic and seismic surveys.

ENGINEERING LABORATORY

Engineering Geology and Geotechnical Laboratory

The sub-division runs a geotechnical laboratory for rocks and soil testing. The choice of the equipment has been carefully evaluated to meet, as close as possible, the current needs of the engineering and building industry in Namibia.

The laboratory has been equipped to run the following tests:

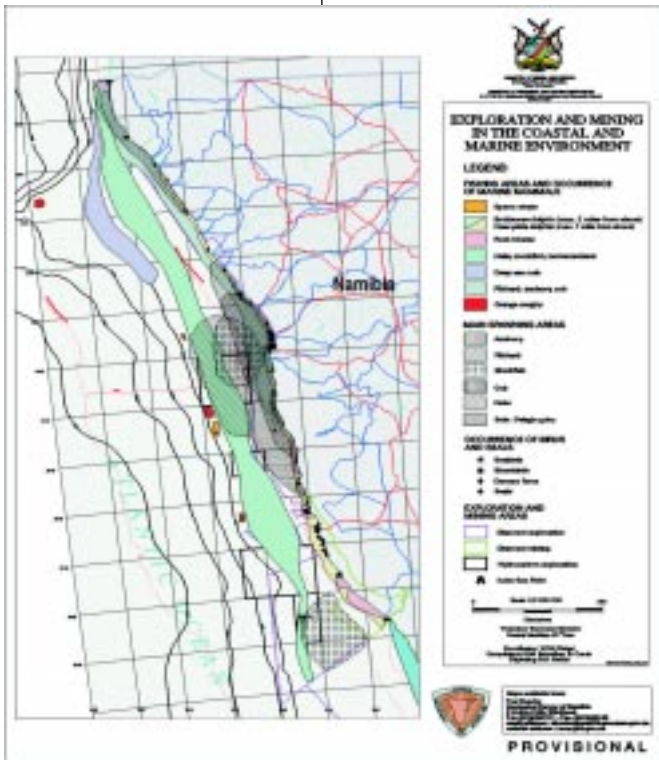
- * Grain Size Analysis (Sieve analysis and Hydrometer test)
- * Specific Gravity Test
- * Atterberg limits and indices
- * Permeability Test
- * Compaction Test
- * Consolidation Test
- * Computerised California Bearing Ratio (CBR)
- * Direct Shear Test for cohesionless and cohesive Soils.

SADC

SADC - Mining Sector Environmental Subcommittee

Namibia chairs the sub-committee through the Geological Survey and is tasked with Project AAA.4.7 - "Assessment of the Impact of Exploration, Mining and Mineral, processing in the Coastal and Marine Environment within SADC Member States".

Considerable progress was made on the project with the production of two maps for the SADC region. The maps depict the exploration, mining and mineral occurrences in the coastal, marine and lacustrine environment and the overlap of exploration, mining and mineral processing areas with neritic and bathyal zone fauna respectively.



United Nations Convention on the Law of the Sea

Namibia is a signatory to this convention and is therefore involved in the drafting of the regulations on prospecting and exploration for polymetallic nodules in the sea. The Geological Survey of Namibia participates on this forum in a technical capacity and gives advice on environmental issues regarding prospecting and exploration in international waters.

Geotechnology Division

Museum

After a long period of vacancy, the Geological Survey of Namibia was able to fill the position of the curator again in December, 1998. A vast mineral collection, donated by TCL, could be transferred to the museum and will be made accessible in the near future. Rössing Uranium Ltd designed and donated a display unit with an introduction to geology, mining, mineral beneficiation, human resources development and environmental protection at the mine. An exhibition on aspects of diamond mining by Namdeb, one of the most important operations in the country, is in preparation.

The conference of the Southern African Palaeontological Society with international participation was held at the Geological Survey of Namibia and participants made good use of the palaeontological collections. As every year, the Namibia Palaeontological Expedition of the Museum National d'Histoire Naturelle, Paris, took place with participants from several countries. All fossils recovered by these expeditions will be stored in the museum after scientific evaluation.

Preparation of the Karoo age reptile *Erythrosuchus africanus* from Mount Etjo progressed well and it is hoped this can be exhibited during the next year. An incomplete specimen of a juvenile dinosaur was detected by German geology students in the lowermost beds of the Etjo Formation on Waterberg and eventually transferred to the museum. Prof. B. Rubidge of the Bernhard Price Institute identified it as *Massospondylus*, one of the early dinosaurs and therefore important for the age determination of the Etjo Formation.



The Museum

Another important discovery made by Dr B Senut and Dr M Pickford of the French-Namibian Palaeontology Expedition, is a human skull believed to be between 100 000 and 200 000 years old, and possibly representing a link between the transition from *Homo erectus* to the earliest modern humans. Africa has long been recognised as the cradle of mankind, and about a dozen examples of fossils that help fill the gap in human evolution are present on the entire continent. In the decade since independence, fossil hominoid remains of diverse ages have been collected at several localities in the country indicating that the potential for further discoveries is good. To enable more research in this field, the Geological Survey of Namibia has embarked upon a joint project with the French Government and entitled "Hominoid and Human Evolution in Namibia".



Fossil preparation

During the year the museum had more than 400 visitors, including classes from schools and institutions of tertiary education. The new geology department of UNAM used the museum for courses. Custom officials from the Ministry of Finance were taught the basic knowledge of minerals, fossils and meteorites in 4 courses for a better enforcement of customs regulations.

National Earth Science and Energy Information Centre

The National Earth Science and Energy Information Centre was visited by some 400 visitors during 1998. In addition, 650 inquiries were made. The following statistics pertaining to the Centre for the year 1998 are available

Internal loans :

- 750 company reports
- 295 books
- reprints
- 206 periodicals
- 374 maps

New accessions:

- 154 books
- 315 reprints
- 138 periodicals
- 30 maps

*Erythrosuchus africanus*

Interlibrary loan:

140 requests made

15 requests received

NATIONAL CORE ARCHIVE

National Core Archive

Sorting of samples from cores and percussions boreholes continued. Chip samples from 44 water boreholes were logged. Due to the lack of funds, the planned extension of the coreshed could not be carried out. The provisional liquidation of TCL also hindered the transfer of Tsumeb core.



PUBLICATIONS

Publications

Published papers by Geological Survey members of staff

BURNETT, R. (1998): Dimension Stone in Namibia: an untapped Potential. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 52-55, Namibia Foundation, Windhoek.*

EWART, A., MILNER, S.C., ARMSTRONG, R.A. & DUNCAN, A.R. (1998): Etendeka volcanism of the Goboboseb Mountains and Messum igneous complex, Namibia, Part I: Geochemical evidence of early Cretaceous Tristan plume melts and the role of crustal contamination in the Parana-Etendeka CFB. *J. Petrology, 39 (2), 191-225.*

EWART, A., MILNER, S.C., ARMSTRONG, R.A. & DUNCAN, A.R. (1998): Etendeka volcanism of the Goboboseb Mountains and Messum igneous complex, Namibia, Part II: Voluminous quartz latite volcanism of the Awahab magma system. *J. Petrology, 39 (2), 227-253.*

GLEN, L.M., RENNE, P.R., MILNER, S.C. & COE, R.S. (1998): Magma flow in units of the Coastal Parana-Etendeka Igneous Province: Constraints on source regions of silicics and on the relative timing of rifting and flood volcanism. *Abstracts, IAVCEI International Volcanological Congress: Magmatic Diversity: Volcanoes and their roots, 22, 80 pp.*

GOSCOMBE, B.D., ARMSTRONG R., & BARTON, J.M. (1998): Tectonometamorphic evolution of the Chewore Inliers: Partial re-equilibration of high-grade basement during the Pan-African Orogeny. *Journal of Petrology, 39, 1347-1384.*

GOSCOMBE, B.D., ARMSTRONG, R., & BARTON, J.M. (1998): Tectonometamorphic evolution and geochronology of the Chewore Inliers: Constraining the tectonic evolution of the Zambezi Belt. *Journal of African Earth Science.*

GOSCOMBE, B.D. & TROUW, R. (1998): The geometry of refolding of tectonic shear sense indicators. *Journal of Structural Geology.*

HUTCHINS, D.G. (1998): Airborne Geophysical Surveys : Stimulating Exploration Activity. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 128-132, Namibia Foundation, Windhoek.*

JERRAM, D.A., STOLLHOFEN, H., LORENZ, V. & MILNER, S.C. & DUNCAN, A.R. (1998): Plume related pahoehoe lava flows of the basal Etendeka flood basalts, NW Namibia. *Abstracts, IAVCEI International Volcanological Contress : Magmatic Diversity : Volcanoes and their roots, 28, 80 pp.*



- KENNEDY, M.J., RUNNEGAR, B., PRAVE, A.R. & HOFFMANN, K.-H. & ARTHUR, M.A. (1998): Two or Four Neoproterozoic Glaciations? *Geology* (in press).
- LEGNANI, A. (1998): Mining and Environmental Management in Namibia. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 86-90, Namibia Foundation, Windhoek.*
- MILLER, R. McG. & SCHNEIDER, G.I.C. (1998): The Coastal Geology of Namibia. *Namibia Review, Vol. 7, No. 3, 1-11, Windhoek.*
- MILLER, R. McG. & SCHNEIDER, G.I.C. (1998): The Search for Oil. *Namibia Review, Vol. 7, No. 3, 11-13, Windhoek.*
- PETZEL, V.F.W. & MCGREGOR, G. (1998): Mineral exploration in Namibia. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 134-138, Namibia Foundation, Windhoek.*
- PIPER, D. (1998): Minerals for Industry: Raw Materials for Development. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 12-17, Namibia Foundation, Windhoek.*
- RENNE, P.R., LUDWIG, K.R., ERNESTO, M., MILNER, S.C. GLEN, J.M. & FANNING, C.M. (1998): Geochronology of the Parana-Etendeka Magmatic Province. Abstracts, IAVCEI International Volcanological Congress: Magmatic Diversity: Volcanoes and their roots, 49, 80 pp.
- ROESENER, H. & SCHREUDER, C.P. (1998): Uranium. *In: The Mineral Resources of Namibia Geological Survey of Namibia. 7.1/1 - 7.1/55.*
- SCHNEIDER, G.I.C. (1998): The Role of National Geological Surveys in Sustainable Development with Special Reference to Namibia. International Conference on the Role of National Geological Surveys in Sustainable Development, Abstracts. Geological Survey of Botswana, 23rd - 25th June 1998, Gaborone.
- SCHNEIDER, G.I.C. (1998): Diamonds in Namibia. *In: SADC-MCU - D Cole (Comp.): Diamonds in the SADC Region. Project AAA 1.2, Mineral Resource Survey Programme No. 3, 14-18, Lusaka.*
- SCHNEIDER, G.I.C. (1998): Diamond Mining Off the Coast of Namibia and the Marine Environment. First regional Workshop on the Benguela Current Large Marine Ecosystem (BCLME), UNDP, Cape Town, 22-24 July 1998.
- SCHNEIDER, G.I.C. & MILLER, R. McG. (1998): Did Nature compensate Namibia with Diamonds? *Namibia Review, Vol. 7, No. 3, 1-10, Windhoek.*
- SCHNEIDER, G.I.C. & MILLER, R. McG. (1998): Salt, Guano and other Minerals. *Namibia Review, Vol. 7, No. 3, 14-21, Windhoek.*
- SCHNEIDER, G.I.C. (1998): Sustainable Development - How does the Geological Survey of Namibia respond to a changing Role? International Symposium on the Role of African Geological Surveys Beyond 2000, Abstracts, 16-20 November 1998, Harare.
- SCHNEIDER, G.I.C. (1998): History of Mining in Namibia. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 19-31, Namibia Foundation, Windhoek.*
- SCHNEIDER, G.I.C. (1998): The Geological Survey of Namibia and Geological Research. *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 118-127, Namibia Foundation, Windhoek.*
- SCHNEIDER, G.I.C. (1998): Gemstones in Namibia *In: Focus on Mining and Research. Namibia Brief No. 21, 12/98, 61-62, Namibia Foundation, Windhoek.*
- SCHNEIDER, G.I.C. (in print): The Gemstone Resources of Namibia. SADC Report, Lusaka.

New releases on open file

- BESSINGER, G.E. AND PIPER, D.P. (1998) : Talc-dolomite marbles of the Waldburg Formation, Oamites area: Mineralogy and Use-related properties. Open-file Report EG100, Economic Geology Series, Geological Survey of Namibia. 9 pp, Map, 3 Figures, 3 Tables.
- BLOODWORTH, A. AND PIPER, D.P. (1998) : A preliminary survey of Marbles in the Karibib-Swakopmund area: Geology and Laboratory Evaluation. Open-file Report EG097, Economic Geology Series, Geological Survey of Namibia. 39 pp, 9 Plates, 19 Figures, 4 Tables.
- PIPER, D.P. (1998) : Namibia's principal industrial mineral deposits (A country submission to the SADC Industrial Minerals Working Group: July 1998. Open-file Report EG103, Economic Geology Series, Geological Survey of Namibia. 15 pp.
- PIPER, D.P., BLOODWORTH, A.J., AND SIYAMBANGO, M. (1998) : Ceramic Clay Resources, Mariental: Preliminary resource assessment and laboratory evaluation. Open-file Report EG101, Economic Geology Series, Geological Survey of Namibia. 42 pp, Maps, 16 Figures, 6 Tables.
- PIPER, D.P. AND KYL, Y. (1998) : Ceramic Clay Resources, Mariental: Results of forming and

**NEW RELEASES
ON OPEN FILE**

firing trails of ceramic bodies. Open-file Report EG102, Economic Geology Series, Geological Survey of Namibia. 37 pp.

Following extensive demand, the Geological Survey of Namibia has furthermore started to compile a book on the roadside geology of Namibia for the information of interested members of the public and tourists.

CONFERENCES AND SEMINARS

Conferences and Seminars

In an effort to promote Namibia's geological potential and to interact with the international geoscientific community, the following Conferences were attended:

- * 1998 International Conference on Airborne Electromagnetics in Sydney Australia, 23rd-25th February 1998 and the post conference workshop on Recent Developments in the processing of Airborne Gamma-ray Spectrometric Data.
- * Meeting of the Commonwealth Heads of Geological Surveys, Nottingham, UK.
- * 25th Anniversary Conference of the Botswana Geological Survey in Gaborone, Botswana.
- * Conference on the Management of the Benguela Current Large Marine Ecosystem, Cape Town, South Africa
- * EXPO 98, Lisbon, Portugal
- * 13th International Australian Society of Exploration Geophysicists Conference and Exhibition in Hobart, Tasmania, 8th-12th November and a preceding conference on Africa: Geology and Mineral Exploration in Perth, Western Australia on 6th November.
- * Symposium on African Geological Surveys beyond 2000, Harare, Zimbabwe
- * Conference of the Regional Centre for Mapping of Resources for Development, Swakopmund.

Considerable emphasis has been placed this year on staff training. To supplement in-house training carried out by the Chief Geochemist together with contract personnel from the British Geological Survey formal courses of instruction included the following:

- * The theory and practice of X-Ray Fluorescence spectrometry (University of Cape Town - 2 weeks)
- * The theory and practice of emission (ICP) spectrometry (University of Stellenbosch - 1 week)
- * A workshop on Industrial Minerals (Geological Survey of Namibia - 1 week)
- * Manipulation of regional geochemical data and the use of the GEOSOFT package (GEODESA Project, Dar Es Salaam, Tanzania - 8 weeks).

In addition to these courses, two counterpart personnel attached to the SYSMIN-funded Industrial Minerals Project have commenced MSc degree courses in Mining Geology in the United Kingdom.

Various staff members attended workshops and training courses on ArcView, ArcInfo, ERDAS Imagine, ER Mapper and Aeromagnetic Interpretation.

CONTACT ADDRESS

Contact Address

GEOLOGICAL SURVEY OF NAMIBIA
P.O.Box 2168
1 Aviation Road
Windhoek
NAMIBIA
Fon: +264-61-208-5111
Fax: +264-61-24 91 46
E-Mail: director@mme.gov.na
URL: <http://www.gsn.gov.na>



Miss Namibia '97 at Expo '98