

GEOLOGICAL SURVEY OF NAMIBIA

Ministry of Mines and Energy

ANNUAL REPORT 1997

EARTH SCIENCES FOR NAMIBIA'S SUSTAINABLE DEVELOPMENT

Foreword

The Geological Survey of Namibia is the national institution for earth sciences and geological resources. As such it is entrusted with management and research of one of Namibia's most important assets: the land in which the life support system of the Namibian people is rooted. The Geological Survey's mission is to enhance the knowledge and awareness of Namibia's geological resources. These resources include mineral resources (land based and marine), energy resources (fossil and nuclear fuels), building materials, land resources, groundwater and soil resources. Through scientific investigation as well as application and dissemination of quality research data, the Geological Survey is facilitating the search for and the assessment of mineral resources, geological engineering and land use planning and sustainable development with due regard to the environment.

In pursuing its objectives, the Geological Survey as a Directorate within the Ministry of Mines and Energy plays a vital role as an advisor to Government and individual Ministries in the formulation of policies related to the management of Namibia's natural geological resources and their utilisation by man. Consequently, an important aspect of the Geological Survey's work is participation in multi-disciplinary research and integrated land use planning.

Tasks regularly performed by the Geological Survey are regional geological and geophysical mapping; research and appraisal of mineral deposits and mineral exploration and exploitation; geochemical research for mineral exploration and environmental baseline studies; engineering and environmental appraisal of the impacts of mineral extraction, building activities, urbanisation, agricultural activities and erosion, natural hazards and any other utilization of Namibia's diverse ecosystems. The resulting research data are disseminated in a number of formats to the various stakeholders to stimulate and facilitate activities in the private sector.

This Annual Report gives an overview of the activities and achievements during 1997, and endeavors to inform the Geological Survey's customers, public and private, about the services available from this institution.

REGIONAL GEOSCIENCE DIVISION

Mapping and Cartography

Geological Mapping

Geological Mapping and field-based research has continued during the past year in different parts of the country focussing on areas considered to be of importance for mineral exploration and metallogeny.

These studies are undertaken in close conjunction with field checking and updating of existing maps, new mapping, and subsequent digital processing of map data for incorporation into the Geological Survey's Map Data Base. The latter forms the basis for the compilation of 1:250.000-scale maps

FOREWORD



GEOLOGICAL MAPPING

using computer-based (GIS) digital map processing facilities established through technical cooperation with the Geological Survey of Finland and funded by the Finnish International Development Agency (FINNIDA) over a five-year period between 1991 and 1995.

Following the printing of the first two digitally produced 1:250.000-scale map sheets (2314 Kuiseb and 2214 Walvis Bay) in 1994 and 1995, final editing and test printing of sheet 2114 Omaruru was carried out during the year and will be followed by final printing in 1998. This brings the number of quarter-million scale geological maps produced by modern digital computer technology, and available both, in hard copy and digital format, to three, and the total number of printed maps covering the country to eight. Together, the three maps now provide full coverage of the mostly well-exposed and well studied areas of the mineral-rich central Damara Belt (e.g. Rössing Uranium Mine, Navachab Gold Mine) of the Erongo Region of central-western Namibia. Field checking and reconnaissance mapping is currently being carried out on the Fransfontein 2014 sheet which adjoins the Omaruru sheet to the north.

Compilation and digitizing of three additional sheets 2216 Windhoek, 2316 Rehoboth and 2218 Gobabis was continued, and mapping and field checking of critical areas to resolve outstanding stratigraphic and structural key problems is in progress. Together, these three maps cover diverse structural-stratigraphic belts with high mineral potential represented by various Mesoproterozoic and Neoproterozoic rocks of the Khomas, the southern Omaheke and the northern Hardap Regions.

In addition, a provisional compilation of sheet 2818 Warmbad of the Karas Region of southern Namibia has been completed and released on Open File. This map sheet covers major parts of the Namaqua Belt, which hosts important base-metal deposits across the border in South Africa (e.g. Aggenys Cu-Pb-Zn Mine and the Gamsberg Zn Deposit), the Richtersveld Province in which the Haib Porphyry Copper Deposit occurs, and the younger cover of the Nama Group and the Karoo Sequence.

In an effort to extend high-quality detailed geological mapping into areas with only reconnaissance map coverage available but with perceived high mineral prospectivity, new mapping at 1:50.000-scale was started in the Kaokoveld of the western Kunene Region (sheet Tomakas 1813 CD) during the year. The general aim is to resolve complex cover-basement relationships and to address problems of stratigraphy and regional correlation of the Damara Sequence within the internal metamorphic parts of the Kaoko Belt west of the Sesfontein Thrust. A more specific aim is to more precisely define the stratigraphic and structural position of the important sediment-hosted base-metal (Pb-Zn) sulfide mineralisation of the Tsongoari area.

In addition, digitizing, editing and plotting of a number of map sheets in scales 1:50.000, 1:100.000, 1:250.000, 1:1.000.000 and 1:250.000 is ongoing to constantly increase the digital data set.

Regional Studies

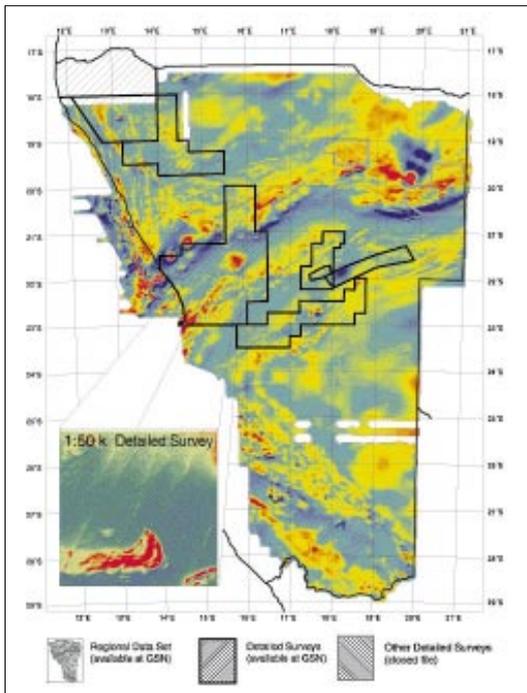
REGIONAL STUDIES

Apart from surveys tied to specific map sheets, there has been an involvement in ongoing multidisciplinary regional studies on stratigraphy and tectonics. Foremost amongst these is research undertaken partly in collaboration with foreign university researchers on Neoproterozoic stratigraphy and correlation of the Damara, Kaoko and Gariiep Belts, involving 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 markers to constrain the history and geometry of basin development and tectonics during Neoproterozoic rifting and continental breakup.

During the year, there has also been active participation in several international collaborative projects in the southern African sub-region. These include the Kalahari Basin and the Stratigraphy Working Groups of the Mining Coordinating Unit of SADC, and three International Geological Correlation Programme (IGCP) projects, namely IGCP Project 363 - Palaeoproterozoic of sub-equatorial Africa, IGCP Project 418 - Evolution of the Kibaran Belt system in south-western Africa, and IGCP Project 419 - Foreland basins of the Neoproterozoic belts in central-southern Africa and South America.

Geophysics and Remote Sensing

High Resolution Airborne Surveys



During 1997 the Geological Survey continued its programme of high resolution airborne magnetic and radiometric surveys. The surveys, flown with a line spacing of 200 metres at a survey height of 80-100 m, provide quality data for the exploration community and complement the existing regional coverage. The recent surveys have been funded through the Namibian Government Development Budget supplemented by a grant from the Mineral Development Fund (MDF) and through the European Union SYSMIN programme. All the surveys are planned and supervised by the Geological Survey.

The improvement in the data quality is clearly demonstrated by a comparison of the high resolution data and the regional magnetic data. Structures such as folds and faults together with dykes become clearly visible with high resolution magnetic data, and different lithological units can easily be recognised using the new radiometric images. The geological interpretation of the high resolution geophysical data will be used in

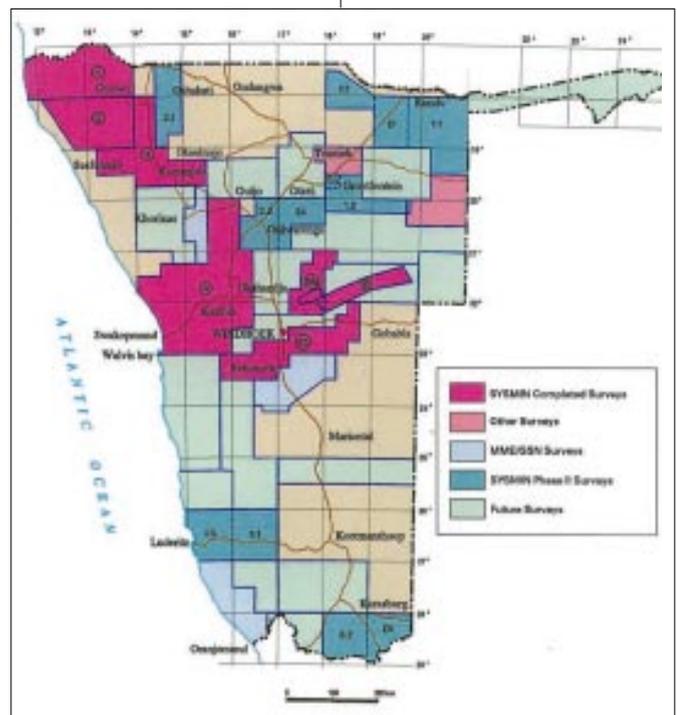
upgrading the geological mapping of Namibia and early interpretations of the magnetic data clearly show the importance it will have in mapping concealed geology. More importantly, the new data is providing fresh impetus to mineral exploration in Namibia and several companies have purchased the data to support their exploration ventures. Revenue from data sales are held in the Mineral Development Fund which has been established to provide finance for the development of mineral exploration and the mining industry. This fund is also being used, in part, to support future Government funded high resolution airborne geophysical surveys. The existing survey coverage together with the proposed programme of future surveys is shown right.

The contractor was awarded a survey area of approximately 34.300 line-kilometers in the vicinity of Khorixas at a cost of N\$.1.1.million. Survey flying commenced in January 1997 and was completed during February. Processing of the data is complete and final deliverables include digital grids and line archives together with colour maps, black-and-white contours on base film and an operations report.

In November, the contractor commenced survey operations in the Rehoboth area. This survey consists of a main area of approximately 43.000 line-kilometers costing N\$ 1.2 million funded by the Namibian Government, and supplementary areas consisting of approximately 33.000 line-kilometers at a cost of N\$ 910.000 funded through a grant from the Minerals Development Fund. Delivery of processed data and final products is anticipated for March 1998.

Phase 1 of the SYSMIN funded surveys commenced during September 1994 (Areas 4, 5N and 5S) and December 1994 (Areas 1,2 and 3). Survey operations continued through 1995 followed by data processing and map production during 1996 and with the final delivery of all products early in 1997, these contracts were concluded to the satisfaction of the Ministry of Mines and Energy.

HIGH RESOLUTION AIRBORNE SURVEYS



In areas 1, 2 and 3 a total of 301.554 km of high resolution magnetic and radiometric data were acquired, 24.021 km of which were flown by helicopter. Areas 4, 5N and 5S were flown with a total of 437.724 km of high resolution magnetic and radiometric data. Final deliverable products included digital grids and archive data, colour magnetic and radiometric maps at scales of 1:50.000, 1:100.000 and 1:250.000 and black and white contours on film, together with an operations/processing report.

Area 6 was a combined electromagnetic (QUESTEM) and magnetic survey. Final products included digital grids and archives, magnetic contourmaps and a series of electromagnetic maps for selected channels. In addition to the main survey area, test surveys were flown over selected ore bodies to provide reference data sets. In total, 40.692 km of electromagnetic data were acquired.

Prior to the completion of Phase 1, the Geological Survey applied for a re-allocation of SYSMIN funds to survey areas in northeastern and southern Namibia. In October 1997, the European Union grant this allocation and made available N\$ 13.35 million for additional surveying. The tender documents are currently in preparation.

Gravity Surveys

GRAVITY SURVEYS

The Geological Survey continues to upgrade the regional gravity coverage of Namibia by in-filling along roads and tracks. As part of this process, the Geological Survey, in conjunction with the National Imagery and Mapping agency (NIMA) of the USA, established four absolute gravity stations at Arandis, Tsumeb, Keetmanshoop and Windhoek during April/May this year. These stations are being linked to secondary reference stations in a series of loops to provide a national gravity reference network to which all future surveys will be tied. At year end, 21 secondary reference stations had been established at localities in northern and central Namibia using two gravity meters on loan from NIMA. The establishment of further reference stations in southern Namibia is planned for early 1998. Thereafter infilling of the gravity coverage will be resumed with all data tied to the new reference network.

German-Namibian Mineral Prospecting Promotion Project

GERMAN-NAMIBIAN MINERAL PROSPECTING PROMOTION PROJECT

The Technical Cooperation Project between the Geological Survey and the Federal Institute for Geosciences and Natural Resources (BGR) funded by the Federal German Government came to a close during the year. The achievements of this four year project are summarised in a brochure entitled "Promising Patterns - a New Approach to the Mineral Potential of Southern Namibia" available from the Geological Survey.

In addition to providing a merged compatible data set from existing regional geophysical surveys, the project used this data to identify areas with potential for mineral exploration and conducted detailed ground truthing investigations over some potential targets. Products emanating from the project include published papers, open-file technical reports, maps and digital data sets, all of which are listed in "Promising Patterns".

Seismic Stations and Surveys

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).

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.

The Windhoek Seismological Station has developed a fault with the antiquated timing mechanism and some integrated circuit boards and is currently in-operable. The Seismological Group of the Council for Geoscience, South Africa, has been contacted regarding possible replacements as the Windhoek Station once formed part of the South African Seismological Network.

To further establish the level of seismic activity, three micro-seismic stations have been established in the environs of Windhoek in collaboration with the Institute of Geophysics and Meteorology of

Frankfurt University, Germany.

Geodesa

Also, the Geological Survey's Chief Geophysicist was elected chairman of the Geodesa (Geological Data Management in Eastern and Southern Africa) Technical Committee (GTC) and appointed to the Geodesa Steering Committee (GSC). The purpose of the GTC is to review the status, progress and objectives of the Geodesa project particularly with regard to its contributions to regional geophysics, in relation to SADC and all member states. The first meeting of the GTC was held in Dar-Es-Salaam in September.

GEODESA

APPLIED GEOSCIENCE DIVISION

Economic Geology

NAMDAT Database

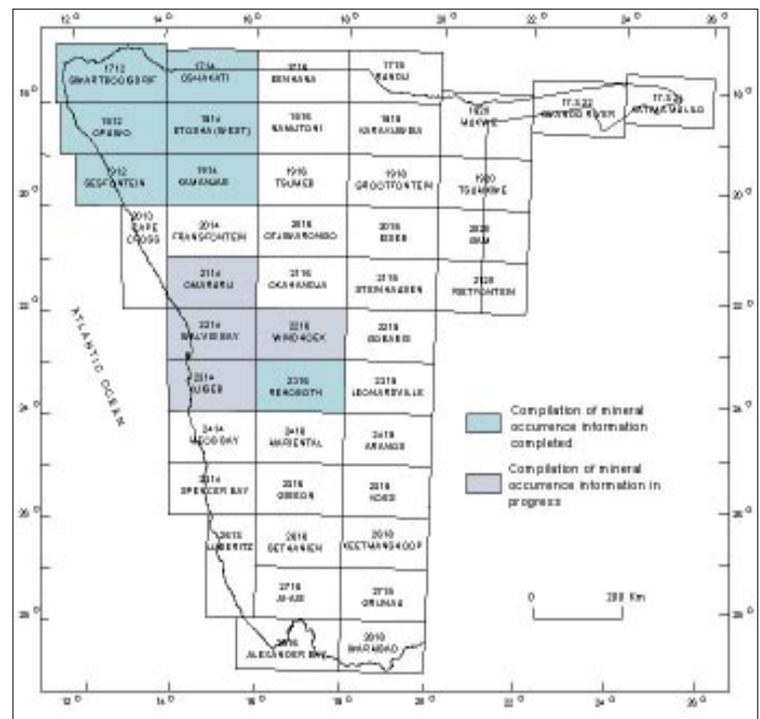
Data capturing from exploration archives for the NAMDAT database has continued throughout 1997. A planned conversion of the existing database into "Access" will be completed in 1998. Once all the data is verified, it is planned to produce a CD-ROM.

NAMDAT DATABASE

Extensive mineral exploration programmes in Namibia have generated an enormous amount of data in the form of reports and maps. Reports of mineral exploration activities over terminated grants are kept in the Library of the Geological Survey under open file and can be accessed by any interested person. The Geological Survey has now started to summarize these reports. The objective of this compilation is to provide prospective investors with comprehensive information on the mineral occurrences in any given area, including level of work done and results achieved. With improved knowledge and understanding of the geology coupled with a better understanding of mineralisation controls and ore genesis models, some of the occurrences delineated in the past may be of interest to future mineral investors and might lead to the discovery of a mine.

Summaries are compiled on the basis of 1:250.000 map sheets and contain the following information:

- Localities of mineral occurrences, prospects and mines on 1:250.000 and 1:50.000 sheets
- Completion of data forms for each of the occurrences for database (NAMDAT) entry, using the Geological Survey's numbering system and deposit names identification
- Brief, 1-page information sheets for all occurrences, highlighting the salient points of location, regional geology, deposit geology, resources and level of investigations
- A comprehensive summary of each occurrence, consisting of a description of the occurrence and results of investigations. It contains salient details of geological environment, work done and results as documented.

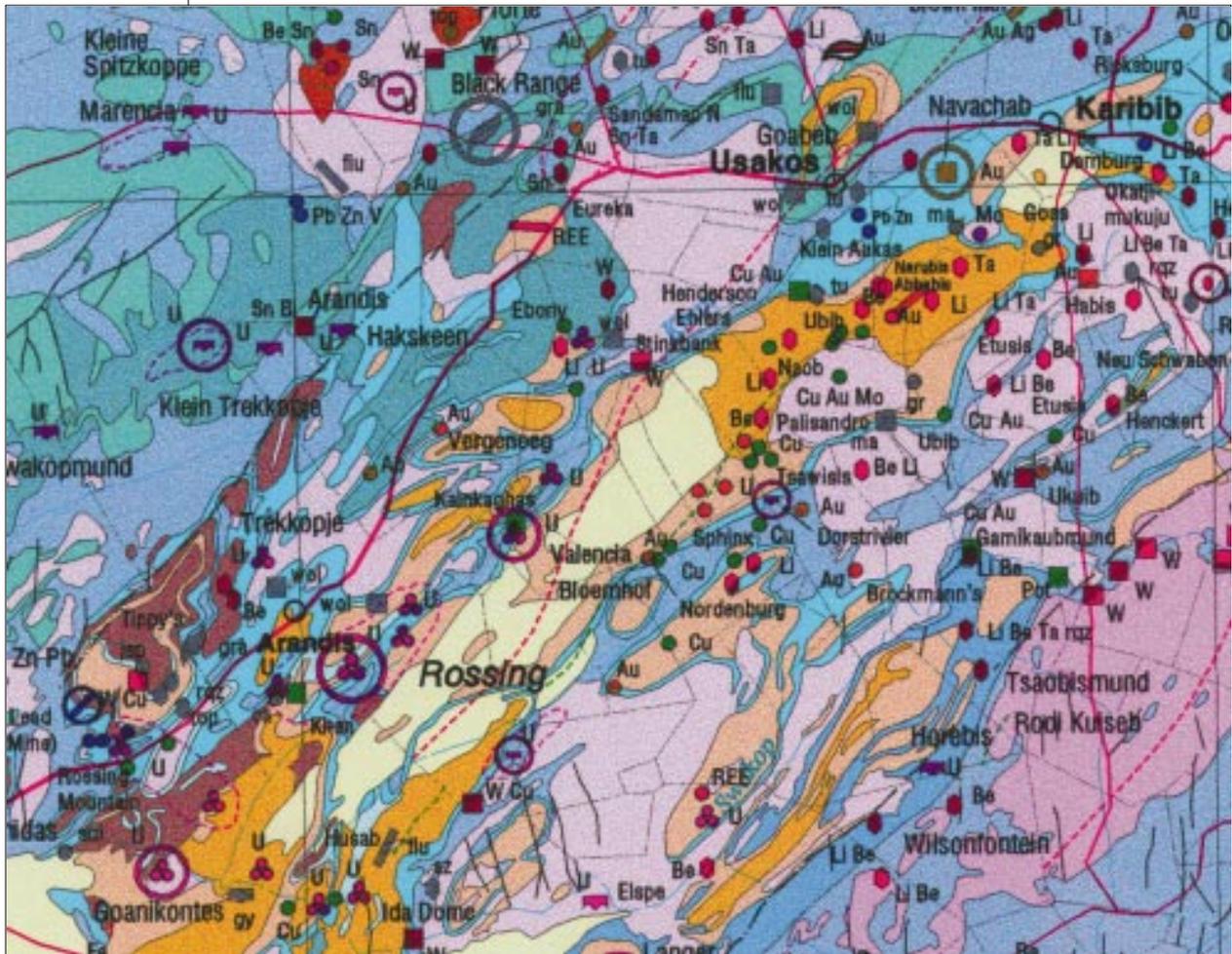


To date, seven out of forty-four 1:250.000 sheets, consisting of Swartbooisdrif, Oshakati, Opuwo, Etosha West, Sesfontein, Kamanjab and Rehoboth have been completed and are awaiting final editing. The compilations of the Walvis Bay, Kuiseb, Omaruru and Windhoek sheets are currently in progress.

MINERAL MAP OF
NAMIBIA

Mineral Map of Namibia

The compilation of the Mineral Map of Namibia forms part of the technical cooperation project started in 1993 between the Namibian Ministry of Mines and Energy and the Federal Institute for Geosciences and Natural Resources of Germany. The mineral map depicts all known mineral occurrences on a simplified 1:1.000.000 geological map backdrop. The map is currently being edited and will be available in printed and digital format during the course of 1998. Due to the high demand for this map, computer plot pre-prints were made available to interested parties. Work on the International Mineral Deposits Map for Africa was completed in cooperation with the Commission for the Geological Map of the World of UNESCO, and the map has been published during 1997.



Gold Database

GOLD DATABASE

Due to an upswing in precious metal exploration early in 1997, all information on gold mineralisation in Namibia and held by the Geological Survey was updated and collated in a user-friendly format to promote gold exploration in Namibia and aid investors. A comprehensive review of all available literature has resulted in an Excel/Access twenty-field database being compiled of 244 gold occurrences ranging from exploration anomalies to active gold producers. The information is available as a spreadsheet and a mineral occurrence map. Subsequently, the gold chapter in the 1992 edition of "The Mineral Resources of Namibia" has been rewritten to incorporate all these 244 gold occurrences. The revised chapter will be published shortly. To further promote Namibia's gold potential, the Geological Survey has established a contact with the International Liaison Group on Gold Mineralisation, based in the UK, and is actively involved with the SADC Gold Deposits Working Group.

Japanese-Namibian Cooperation

Phase III of the Technical Cooperation Project between the Japanese International Cooperation Agency (JICA) and the Ministry of Mines and Energy was completed during 1997. The area in the Otavi Mountainland, which was investigated has no outcrop and no previous drilling has been done. The project focussed on exploration for base metals of the Tsumeb and Mississippi Valley Types in an area east of Tsumeb, that was withdrawn from exploration at the start of the project in 1995.

Phase I of the project consisted of a high-resolution aeromagnetic and radiometric survey. Phase II comprised an airborne high-resolution electromagnetic survey and the drilling of 4 boreholes on targets identified during phase I. Even though no significant mineralisation was intersected, valuable geological information was obtained as no geological records existed for this area. The interpretation of the electromagnetic survey suggested several targets for additional drilling during Phase III. The model proposed focuses on the intersection of low resistivity lineaments with the the regional bedding, which could form the loci for massive sulphide mineralisation. An additional 8 boreholes with a total depth of 2.300 m were drilled during Phase III of the project. The results of this phase are being analysed and the final report will be completed by March 1998. A project extension has been proposed to the relevant authorities and a final decision in this regard is awaited.



JAPANESE-NAMIBIAN
COOPERATION

Geochemistry and Laboratory

Laboratory Infrastructure

The Geological Survey complex houses an extensive laboratory infrastructure which comprises two wings, separating noisy and dusty sample preparation activities from chemical preparation and instrument laboratories.

In order to meet the challenges of new programmes in the Ministry of Mines and Energy, and what is perceived to be increased interest in the Geological Survey's laboratory facilities by the private sector, the geochemistry and laboratory subdivision has been actively expanding.

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 specimen (rock saws and lapping plates)
- Preparation of thin sections and polished sections using a Logitech
- Preparation of ultra-pure de-ionised water and acids in dual subboiling quartz-glass still

Analysis:

- Mineral identification by x-ray diffraction (XRD) and optical microscopy
- Spectrophotometer for the more accurate identification of ore minerals in polished sections
- Investigation of fluid inclusion properties
- Moisture content and loss on ignition (ovens and furnaces)
- Weighing (5 digit balance)
- Sample dissolution (lithium tetraborate fusion or by HF/HNO₃ attack in teflon bombs)
- Determination of major and minor elements by ICP-AES.

In addition to these facilities the laboratory complex also houses two specialist laboratories, one for the testing of industrial minerals and one for engineering geological tests.

The Geological Survey has been successful in obtaining funding of approximately N\$.1.5 million from the Namibian Government for the setting up of an X-ray fluorescence (XRF) laboratory. The XRF laboratory, which will include an XRF instrument, an automatic fusion machine and semi-

LABORATORY
INFRASTRUCTURE

automatic pelletising press, will greatly improve the analytical capabilities of the Geological Survey, providing fast, accurate analysis of a wide variety of geological materials. The tendering procedure was completed in September, and delivery of a Phillips PW2404 instrument is expected in February 1998.

Complementing their donation of an ICP instrument in 1995, the Japanese aid agency JICA made an additional donation (approximately N\$.240.000) of a microwave labstation, which was delivered in November 1997. The microwave labstation is a multi-function system for the dissolution of samples for ICP analysis. It includes high-pressure/high-temperature acid digestion, vacuum drying and evaporation of acids and the safe removal/disposal of acid vapours. The system will greatly reduce sample preparation time, yield more complete sample dissolution and provide a variety of safety features protecting the user against dangerous acids.

Accurate mineral identification is an essential requirement for the Geological Survey, particularly for the testing and evaluation of industrial minerals. SYSMIN funds have been made available for the purchase of a new XRD to replace the Survey's ageing instrument, and delivery is expected in mid-1998.

Geochemical Surveys

At the Geological Survey, significant advances have been made with high-resolution airborne geophysical surveys, which have resulted in increased exploration areage and a diversification of exploration companies in Namibia. It is now vitally important to combine these geophysical surveys with comprehensive regional geochemical data. Geochemical surveys will provide a large amount of information about the concentration of amongst others metals such as copper, zinc, lead, uranium and gold, and potentially lead to the discovery of new ore bodies. They are also indispensable for environmental geology and engineering, as well as land use planning.

Regional geochemical surveys are carried out by collecting stream-sediment or soil samples over a wide area. A country-wide survey with a moderate sampling density of approximately 1 sample per 10 km² will require the analysis of over 80.000 samples. Since sampling and analysis is both time consuming and expensive, it is important to carry out pilot studies in order to best determine how, what and where to sample. Sampling procedures will vary from one geomorphological terrain to another, for example, sampling procedures suitable for the Otavi Mountainland will not be the same as for the Namib Desert.

The first pilot study was carried out in the area around Spitzkoppe in collaboration with the Finnish Geological Survey (GSF). The GSF has considerable expertise in regional geochemical mapping and the multi-element analyses carried out on splits of the Spitzkoppe samples at the GSF provided impetus to the project, as well as a suite of samples for inter-laboratory calibration. Sampling in a second area commenced in the Kaokoveld in cooperation with the University of Frankfurt, Germany, and additional areas in the Kalahari and Otavi regions will be selected and sampled in the forthcoming year.

In addition to collecting new regional geochemical data, the capture of older company data on open file is also ongoing. These data include regional sampling programmes as well as more detailed sampling grids and drill samples. The integration and levelling of adjacent geochemical survey areas into one data set is a difficult issue, but one which is receiving consideration.

Industrial Minerals Project

The Geological Survey has been developing a sustainable capability in the evaluation of industrial minerals in order to diversity Namibia's mineral portfolio, to attract inward investment and to provide technical advice to small scale producers in this sector of the mining industry. The Industrial Minerals Project, which forms part of the SYSMIN programme in Namibia, commenced in late 1995 with the arrival of two residential advisers from the British Geological Survey (BGS). Following the completion, in late 1997, of the first phase of the project, a professional linkage between Geological Survey industrial minerals staff and the BGS has developed.

GEOCHEMICAL SURVEYS

INDUSTRIAL MINERALS PROJECT

The project comprised of five principal components:

- to establish a laboratory and technical testing capability at the Geological Survey
- to undertake a survey of local and regional markets to identify opportunities for, and constraints on, Namibia's industrial minerals industry
- to enhance existing information on Namibia's industrial mineral resources by undertaking field and laboratory investigations.
- to train counterpart technical and professional staff to ensure that capabilities developed during the project are sustainable
- to prepare documentation and databases relating to project activities and findings

A fully equipped industrial minerals laboratory was established during 1996/97 within the Geological Survey laboratory complex to provide basic data for the evaluation of a wide range of industrial minerals and products. The laboratory can carry out mineralogical, physical and use-related testing against published standards. Facilities include:

- thermogravimeter for the quantitative determination of carbonates, kaolin, gypsum, talc, etc.
- x-ray sedigraph for the automated sub-sieve particle size analysis of mineral powders,
- a reflectance spectrophotometer for the quantitative colour measurement of powders and pigments
- aggregate impact value testing apparatus.
- a hydrocyclone test rig which supplements the Geological Survey's Wilfley shaking table and
- magnetic separator for mineral separation and beneficiation trials.

A series of industrial minerals market surveys have been carried out. Reports describing macroeconomic indicators for the industrial minerals industry, import substitution possibilities and export opportunities have been lodged on open file within the Economic Geology Series of the Geological Survey. Provisional spreadsheets, providing a sorted view of known industrial mineral occurrences, have been prepared and represent the foundations on which the industrial mineral resource database is being constructed. A short-term consultant from the BGS visited Namibia towards the end of 1997 to conduct a full user-requirement analysis and begin database construction. Formal dissemination of field and laboratory analysis data is also carried out in the form of project technical reports. Investigations and reviews judged to have a broader appeal than technical reports are published as part of the Geological Survey's Economic Geology Open File Series.

Field and laboratory investigations have concentrated on those commodities with export potential as feedstocks for export-oriented manufacturing. Commodities such as carbonates, feldspar, bentonite, garnet and ceramic clays have been identified for investigation. A reconnaissance survey of the Karibib-Swakopmund area for carbonates for diverse industrial applications has been completed. Processing trials of waste feldspar-rich sands from the former tin mine at Uis have been carried out to test their suitability for the glass and ceramics industries. Preliminary laboratory evaluation of bentonite from pegmatites in the Strathmore area shows it to be an Mg-saponite with exceptional rheological properties and very high brightness. Results from field and laboratory tests of clay deposits in the vicinity of Mariental have been incorporated in a pre-feasibility study to establish the economic viability of an industrial ceramics plant in the area. This study, prepared by the Industrial Planning Division of the Ministry of Trade and Industry, has been sent to a donor interested in providing further specialist technical assistance.

In addition to conducting its own field and laboratory investigations, the industrial minerals group provided an enquiry service for a broad range of customers including private sector mining, trading and manufacturing companies, small-scale and informal miners, including the Small Miners Assistance Centre (SMAC), and Government. Enquiries typically involve the collation of technical data available at the Geological Survey, interpreting this data for the enquirer, offering geological advice on exploration and additional resource potential, examining submitted samples, undertaking preliminary laboratory testing and reporting.

The Industrial Minerals Project will continue for a further two years, with the BGS as contractors. During this period it will change in character from being a project led by residential advisors to a professional linkage led by trained local staff but with expert assistance available from BGS. In the

short term, work will continue on the field appraisal of carbonates and carbonate-hosted industrial minerals, in particular talc and wollastonite. The project will also continue to assist the Industrial Planning Division of the Ministry of Trade and Industry with regard to proposed market and resource surveys on the Mariental clay deposit.

Engineering and Environmental Geology

ENGINEERING AND ENVIRONMENTAL GEOLOGY

The Engineering and Environment subdivision of the Geological Survey is tasked to perform scientific and technical research and investigation related to engineering and environmental geology throughout the country and to provide information and assistance to all affected and concerned parties such as Government Ministries and private companies operating in the fields of civil and mining engineering.

Throughout 1997 the correct implementation of engineering works was promoted and encouraged by giving the most appropriate scientific information on geological, geotechnical and hydrogeological properties of building sites and materials. Contributions were made to environmental safeguarding through research on environmental geology and through appropriate inputs on Environmental Impact Assessment studies, Environmental Management Programs and environmental rehabilitation programmes to engineering and mining.

Requests for information on engineering and environmental issues related to new town extensions are received from Municipalities and are dealt with on a regular basis.

Lüderitz Waste Disposal Site

LÜDERITZ WASTE DISPOSAL SITE

Namcor has requested the Geological Survey to conduct studies for the location of sites for the construction of a new hazardous waste disposal site for the city of Lüderitz. A recent Environmental Impact Assessment, conducted by the CSIR, for the construction of a new quay in the harbor, has shown the necessity for a new waste disposal site for the town. A hazardous waste disposal site will be indispensable for the collection and disposal of urban waste from the fast developing town; hazardous waste from ships, waste from industrial activities and oily mud from the Kudu Gas Field marine drilling. Activities started in January 1997 with the compilation of a project management strategy. In accordance with the planned schedule, the following tasks have been undertaken and accomplished during 1997:

Information on quality and quantity of waste, that will be dumped at the new waste disposal site, was collected. Links have been established with the Lüderitz local authorities, Shell, Namcor, Namport, the Walvis Bay and Windhoek local authorities and the Energy Directorate of the Ministry of Mines and Energy. Information on the present waste management in Lüderitz and in Namibia in general, and on new applicable techniques and strategies to improve the existing waste management (i.e. waste collection, transport and disposal) was collected.

The most suitable procedures, principles, techniques and technologies for conducting investigations on hazard waste disposal sites were evaluated. Information on the topography, the geology and the hydrogeology of the considered area was collected.

This step consisted of two stages, namely a preparation study, during which available existing documentation has been consulted; and a reconnaissance tour to the area of the project, during which 5 sites have been located, which were considered suitable for further investigation. A more detailed investigation of the 5 sites was conducted during November 1997 with the assistance of a Commonwealth Environmental Advisor, and 3 of the 5 sites were considered to be suitable for a waste disposal site and will be studied in detail in 1998. Another suitable site was located outside the considered circular area, having a 30 km radius from Lüderitz.

Khan Dam Project

KHAN DAM PROJECT

Contacts were established with Rössing Uranium Ltd aiming to acquire information on the Khan Dam project.

The Geological Survey has been participating in the project as an interested and affected party, and a constant flow of information was provided through newsletters by the communication facilitator appointed by Rössing.

A visit to the site has been undertaken in September 1997 and more detailed information has been acquired on the project, which, however, subsequently has been shelved.

Engineering Laboratory

During 1997, a start was made to equip the engineering laboratory for rock and soil testing for engineering geology research purpose. Equipment purchased has been carefully selected to meet, as close as possible, the present needs of engineering and building 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
- Computerized California Bearing Ratio (CBR)
- Direct shear test for cohesionless and cohesive soils

ENGINEERING
LABORATORY

Engineering and Environmental Monitoring

A new project on engineering and environmental management and monitoring for Namibia was formulated during 1997. The key issues were identified along with costs and budget estimations. Some of the most important challenges that Namibia faces are housing shortages, construction and maintenance of new infrastructures, the increasing need for energy and water, coastal erosion and environmental problems related to mining.

The engineering and environmental management and monitoring project aims to establish a permanent and powerful tool to find and implement appropriate solutions for these issues. The project will consist of two phases, namely

(a) Production of detailed geological and geotechnical maps (1:5000 up to 1:10000) will represent areas within the country in which significant infrastructures will be developed. Some of the information provided by the maps will be:

- Topography and Geology
- Geotechnical features of the existing geological formations
- Dip slope, stability and building risk assessment
- Dimension stone/aggregate occurrences
- Dimension stone/aggregate resources and reserves
- Dimension stone/aggregate geomechanical properties
- Hydrogeology

(b) The database will contain information on existing and recently changed geological, geotechnical and hydrogeological conditions of considered sites. It will constantly be updated in order to continuously monitor environmental impacts and promptly find appropriate solutions to particular problems.

The project, which can be seen as a pilot project, will initially be implemented in one or two areas of the country - yet to be chosen - and will demonstrate how a careful monitoring of geological - geotechnical aspects in developing areas will result in a powerful tool for environmental impact management and national economy improvement.

ENGINEERING AND
ENVIRONMENTAL
MONITORING

SADC

Namibia holds the chairmanship of the Environmental Subcommittee of the Mining Coordination Unit of SADC. The following projects are carried out by this Subcommittee:

Environmental impact of mining and related industries of the Zambezi River Basin
Air Pollution from mine emissions

SADC

Investigation of the pollution caused by Small Scale Mining in river bank degradation, river siltation and the use of mercury and cyanide
 Regulatory environmental framework for mining
 Assessment of the status of environmental expertise and training requirements in the SADC mining sector
 Assessment of the impact of exploration, mining and mineral processing in the coastal and marine environment within SADC member states.

GEOTECHNOLOGY DIVISION

Information Technology

The year 1997 saw the culmination of computer hardware and software acquisitions enabled by development budget funding. The following computer hardware and software were acquired:

Hardware:

- 3 x PowerTower PowerPCs with 604e Risc 180Mhz CPUs
- 1 x Linotronic Mark 40EX Imagesetter with Apple Mac 180Mhz PowerPC RIP processor
- 1 x LinoType Hell Saphir A4 colour scanner
- 2 x Summagraphics A0 digitisers with stands
- 2 x Hewlett Packard Envizex X-Terminals
- 8 x IBM compatible PCs with 200MHz CPUs including one with a CD-R writer
- 1 x QMS MagicolorLX colour postscript laser printer
- 3 x HP 6MP postscript laser printers

Software:

- MiniCad
- Adobe Pagemaker
- Adobe Photoshop
- LinoColor scanner software for MacOS
- WinOnCD CD writer software
- 8 x Eudora Professional e-mail software
- 8 x FTP Network Access Suite network software
- 8 x MS Office Professional for Windows 95 and others.

The new hardware and software complements the existing computer and network facilities and has enabled the Geological Survey Staff to perform their duties much more effectively.

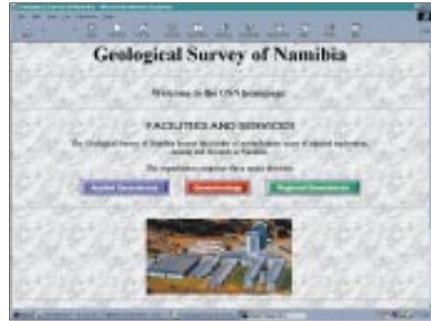
Other software acquired during the year to complement existing Unix-based Arc/Info GIS and PC-based geophysics and geochemistry software includes:

- 4 x PC ARC/Info for Windows 95
- 11 x PC ArcView for Windows 95
- 2 x ArcView for MacOS 7.x
- 1 x Erdas Image Professional version 8.3 for HP-UX (Unix workstation)
- 1 x Oasis Montaj geophysics software from Geosoft Inc.
- 1 x Oasis Montaj Chimera geochemistry software from Geosoft Inc.

This software will help to improve the effectiveness of both the Applied and Regional Geoscience Divisions. In addition, being able to have a copy of ArcView on virtually every geologist's PC, will allow more informed and faster decision making.

The GSN Website

The Geological Survey's "Home Page" Internet Web Site was published on the Internet for the first time this year. It has received many favourable comments and will go a long way towards publicizing the many and varied products and facilities that the Geological Survey has to offer to local and foreign investors and other interested parties. The page also has many hyperlinks to other Geological Surveys and related institutions around the world. The Home Page must be considered to be dynamic in that it will be continually expanded and improved upon.



GSN WEB SITE

Museum

The museum was established in 1994 at the new premises of the Geological Survey. Its aim is to illustrate, give prominence to and teach aspects of the Namibian earth sciences not only to experts but also to a public of interested laymen like school classes and tourists, thereby promoting the knowledge of Namibia's geological history and its implications for modern day life.

Main subjects of the displays are the minerals of Namibia and the resulting mineral industry, regional geology and palaeontology. To illustrate mineral occurrences and their exploitation, displays of specific mines like Navachab, Rosh Pinah, Rössing, Tsumeb and Otjihase are presently under construction. Industrial minerals also feature.

In the palaeontological section an about 5m long reptile, *Erythrosuchus Africanus*, was excavated and is in the process of being prepared with the assistance of the South African Museum in Cape Town. The presentation of that fossil to the public in 1997 created great interest and was reported by the media widely.

Two display areas in the entrance hall next to the auditorium were prepared during 1997 for old instruments, once used for mineral exploration and research, like microscopes and geophysical equipment, to demonstrate the progress made in those technical fields.



MUSEUM

During the year the museum had about 200 visitors. Their number is due to increase after the completion of the 40 display cabinets, when the museum will be more widely advertised. The museum is a member of the Museum's Association of Namibia.

The museum also houses the study collections of the Geological Survey, containing a wealth of information for experts: minerals, rocks, regional collections and fossil collections. Many of the famous Namibian meteorites which, by law, are property of the State, are located in the museum.

National Core Archive

The National Core Archive is a collection of borehole core from all over the country which is of economic, stratigraphic, engineering and/or scientific significance. These boreholes were mainly drilled by mining and exploration companies. At the moment about 65.000 m of core of nearly 400 drillholes have been stored. This core represents an enormous wealth of information and all efforts are made to preserve it for the future. It is available to interested persons and institutions for inspection and further investigation, together with the basic equipment for handling (forklift, concrete tables, etc.).

TCL made their core from Tsumeb available to the Geological Survey during 1997. This core will be housed on the plot of the Seismic Station near Tsumeb, while only representative samples will be transferred to the Windhoek core shed.

NATIONAL CORE ARCHIVE

National Earth Science and Energy Information Centre

The National Earth Science and Energy Information Centre houses the National Geological Library which provides a comprehensive information service to all staff members, the mining community and other interested parties. It is a reference library for external clients, e.g. researchers and investors, as well as for the Ministry of Mines and Energy staff.

The following are available:

- +10.000 monographs
- +750 titles of periodicals
- +4.500 indexed reprints
- theses on Namibian earth science
- +1.000 open file and internal reports
- +6.000 maps (geological, geophysical, topographic)
- satellite images covering virtually the whole country
- aerial photographs covering the whole country
- exploration reports of mining companies

The Geological Survey has an existing agreement with 360 institutions worldwide. In this way contact with the international geoscience community is upheld. The library is also a member of the Southern African Interlending Scheme (SAIS). This way, clients have access to selected holdings through inter-library loans.

Towards the end of 1997 the Information Centre received three new Pentium computers which are on an internal network facilitating information searches and data input. In order to access relevant information the Information Centre uses the following databases:

- CDS/ISIS databases - catalogues for monographs, reprints, reports, periodicals, maps
- GEOREF - CD-ROM system of indexed periodical articles

During 1997, a total of 1250 holdings were added onto the computer, including bound periodicals and articles. The Information Centre was intensively used for research by 493 external library clients. 1373 company reports were requested and 254 inquiries were made. A complete set of Namibian topographical maps (1:250.000, 1:50.000) was accessioned. Other statistics are as follows:

Internal loans:

- 654 books
- 131 periodicals
- 108 maps
- New accessions:
- 335 books
- 346 reprints
- 1288 periodicals
- 99 satellite images
- 1477 topographical maps.

Publications

Published papers by Geological Survey members of staff

BURNETT, R. (1997): The mineral wealth of Namibia and its development. *Acque & Terre*, 3.97.

BURNETT, R. (1997): Gold in Namibia. *International Liaison Group on Gold Mineralisation Newsletter*, 25.

PETZEL, V., EBERLE, D., HUTCHINS, D.G. & . (1997): The regional radiometric data set of Namibia: Comments on compilation of the data from west central and southern Namibia and on anomaly patterns thereof. *Geol. Surv. Namibia, Bulletin*, 3, 50 p.

EWART, A., MILNER, S.C., ARMSTRONG, R.A. & DUNCAN, A.R. (in press): 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*.

EWART, A., MILNER, S.C., ARMSTRONG, R.A. & DUNCAN, A.R. (in press): Etendeka volcanism of the Goboboseb

- Mountains and Messum igneous complex, Namibia, Part II: Voluminous quartz latite volcanism of the Awahab magma system. *J. Petrology*.
- GLENN, J.M., RENNE, P.R., MILNER, S.C. & COE, R.S. (in press): Magma flow inferred from anisotropy of magnetic susceptibility in the coastal Parana-Etendeka igneous province: evidence for rifting before flood volcanism. *Geology*.
- GLENN, J.M., RENNE, P.R., MILNER, S.C. & COE, R.S. (1997): AMS inferred magma flow in the coastal Parana-Etendeka igneous province: Evidence for rifting before flood volcanism. Abstract, *Eos Transactions American Geophysical Union*.
- GLENN, J.M., RENNE, P.R., MILNER, S.C. & ERNESTO, M. (1997): Palaeomagnetism of the Etendeka and Parana Igneous Provinces: Inter- and intra-province magnetostratigraphic correlations, duration of volcanism and palaeomagnetic pole determinations. Abstract, *Eos Transactions American Geophysical Union*.
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- HUTCHINS, D.G., MILNER, S.C. & KORKIAKOSKI, E. (1997): Regional airborne geophysics and geochemistry: A Namibian perspective. In: AG Gubins (Ed.) *Proceedings of Exploration '97: Fourth Decennial International Conference on Mineral Exploration*. 779-792.
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- KENNEDY, M.J., PRAVE, A.R. & HOFFMANN, K.H. (1997): A carbon isotopic record through a Neoproterozoic glacial cycle. *GSA abstracts*, 29 No. 6, p. 196.
- MILNER, S.C. (1997): The Etendeka Province of NW Namibia: Its contribution to understanding the Parana-Etendeka Province. Abstract, *Eos Transactions American Geophysical Union*.
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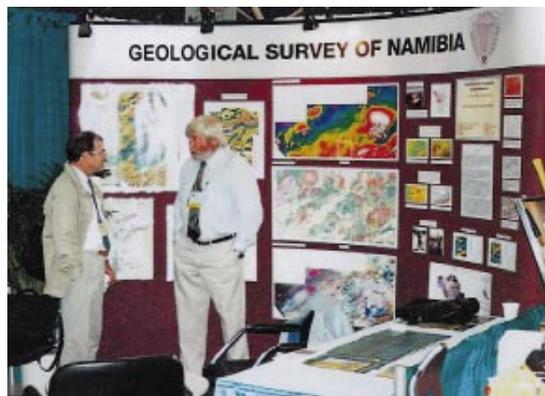
- ANDRITZKI, G., EBERLE, D., OSTWALD, J. & WACKERLE, R.: Integrated investigation of magnetic patterns in the Sinclair-Helmeringhausen area. *Geophysical Reports MPPP, Series No 7*, 25 p., 13 maps.
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- ANDRITZKI, G., EBERLE, D., OSTWALD, J. & WACKERLE, R.: Synopsis of geological and geophysical data as a guide to new mineral exploration areas in central and northern Namibia. *Geophysical Reports MPPP, Series No 12*, 96 p., 2 maps.
- BLOODWORTH, A.J. & PIPER, D.P.: Namibia: A new source of ceramic raw materials. EG 094, 6p.
- BURNETT, R.: Nai-Nais tin-tantalite. EG 098, 23 p.
- BURNETT, R.: Investigation of green garnet occurrences on farm Tumus 20 and environs. EG 099, 20 p.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map 1:250.000, Area 2314 Kuiseb.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map 1:250.000, Area 2114 Omaruru.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2114A Messum Crater.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2114B Uis.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2114C Strathmore.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2114D Lewater.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2115A Nainais.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2115B Omaruru.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2115C Spitzkuppen.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2115D Karibib.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2216A Otjimbingwe.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2216B Gross Barmen.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2217A Onganja.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2217B Seeis.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2217C Windhoek.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2217D Dordabis.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2218A Witvlei.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2218B Gobabis.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2218C Nina.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2218D Honiton.
- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2316C Solitaire.

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- GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2316D Klein Aub.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2317A Rehoboth.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plot 1:100.000, Area 2317B Garib.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2317C Tsumis Park.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2317D Uhlenhorst.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2818A Bondelswarts.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2818B Karasburg.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2818C Witputz.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2818D Tantalite Valley.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2819A Hogeis.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2819B Ariamsvlei.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2819C Velloor.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:100.000, Area 2819D RSA.
 GEOLOGICAL SURVEY OF NAMIBIA: Geological Map colour plots 1:250.000, Area 2818 Warmbad.
 GEOLOGICAL SURVEY OF NAMIBIA: ARC/INFO data from the Finnish-Namibian mapping and maps project, Area 2114 Omaruru.
 MOLLAT, H. & SCHAEFFER, U.: Satellite image interpretation applied to the mineral provinces of southern Namibia. Geophysical Reports MPPP, Series No 8, 52 p.
 PIPER, D.P.: Industrial minerals in the Namibian economy. EG 092, 20p.
 PIPER, D.P.: Namibian imports of industrial minerals. EG 093, 28 p.
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 PIPER, D.P.: Industrial mineral resources of Namibia: Provisional spreadsheets. EG 096, 53 p.
 PIPER, D.P.: A preliminary survey of marbles in the Karibib-Swakopmund area: Geology and laboratory evaluation.

Conferences and Seminars

During 1997, a number of conferences were attended and Namibia's exploration potential was advertised through presentations and information booths. These were the annual Prospector's and Developer's Conference in Toronto, the Sub-Saharan Oil and Mineral Exploration Conference in Mauritius, and the Exploration '97 Conference in Toronto. Various local seminars were attended in order to increase expertise at the Geological Survey, these dealt with sedimentology and sequence stratigraphy of carbonates; isotope geochronology and geochemistry; mobile metal ion technology; the results of the German-Namibian mineral prospecting promotion project and the application of various software packages.



CONFERENCES AND SEMINARS

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