MINISTRY OF MINES AND ENERGY

GEOLOGICAL SURVEY OF NAMIBIA

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100 YEARS OF GEOLOGICAL SURVEYING IN NAMIBIA

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ECONOMIC GEOLOGY
- Incentives to stimulate and sustain Mineral Exploration -

by
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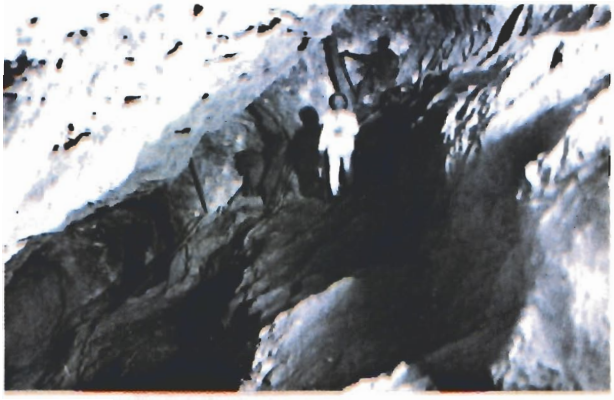
The Oldest Branch of Geology

Economic geology is the research of the origin of mineralization and its economic significance and, as the demand for metals and raw materials is almost as old as humankind, it is easily the oldest branch of geology. With the important role that mining and mineral exploration play in the Namibian economy, the Economic Geology Subdivision is one of the most public-oriented departments within the Geological Survey. Through scientific investigation as well as the application and dissemination of high-quality historic exploration and research data, the Subdivision is helping to realize one of the prime objectives of the institution, which is to promote sustainable development and investment in Namibia's geological resources.

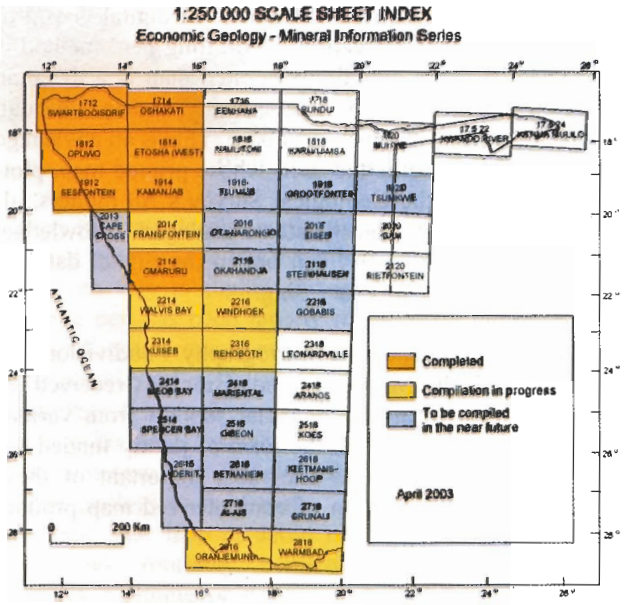


Underground mining at the beginning of the last century

With a very interesting and rich geological history spanning from the Archaean (older than 2600 million years) to the Cenozoic (65 million years ago to the present), that has been associated with processes such as intracontinental rifting, continental break-up, spreading, subduction and continental collision, Namibia hosts a wide variety of minerals and mineralization styles in almost all the major stratigraphic units. These include world-class placer deposits of gem quality diamonds, uranium, base metals (e.g. copper, lead and zinc), gold, gemstones (e.g. tourmaline and beryl) and industrial minerals.

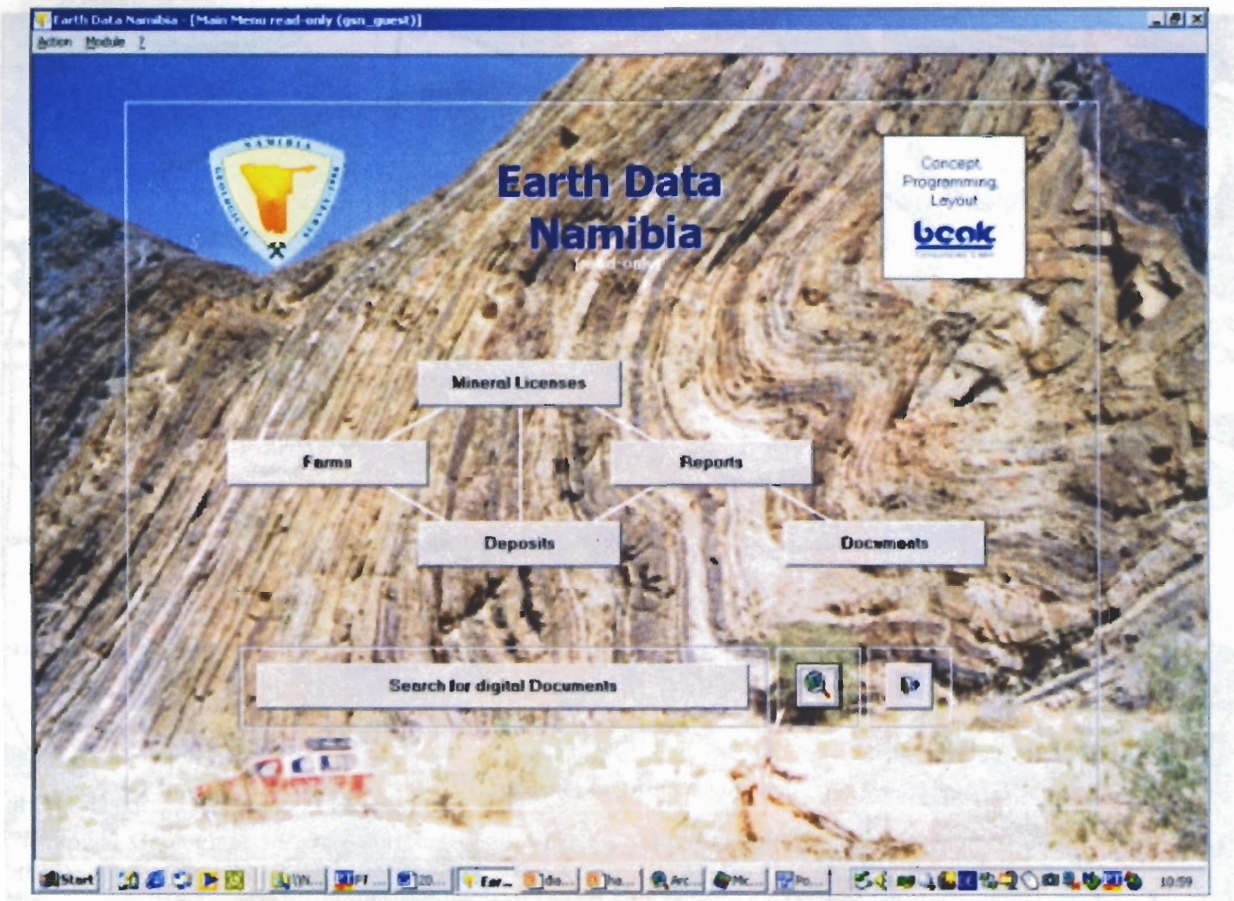
100 Years of Mineral Exploration

Exploration for these natural resources has been going on in Namibia for more than 100 years, and reports on previous exploration, research and mining activities are held by the "National Earth Science and Energy Information Centre" at the Geological Survey under the Open File Grant report system. This very valuable source of information is currently being converted into a more useable format to help prospective mineral investors. The "Economic Geology Mineral Resources Information Series" is a comprehensive compilation of archival exploration data designed to save prospective investors the lengthy time required to go through numerous reports and files. It is a compilation of reported and known mineral occurrences with the objective of providing a comprehensive overview of the mineralization in any given area to stimulate renewed exploration interest. With improved knowledge and understanding of the geology of the country, coupled with a better understanding of the controls on localization of mineralization, and the advancement in exploration technology, some of the mineral occurrences may be worthy of further investigation. To date, the series covers seven of the fourty-four 1:250 000 topographic sheets covering the country. Work is continuing with the aim of covering the whole country. It is also intended that the series will be regularly updated as and when new data and information become available.



Economic Geology Mineral Resources Information Series

In addition to the ongoing report compilation, the "Earth Data Namibia Database" was launched in October 2002, with most of the development cost having been covered by the Minerals Development Fund. Mineral investors or other interested parties can now access all scanned historic exploration data, in addition to a vast amount of information on mineral occurrences captured during the compilation of the Economic Geology Mineral Resources Information Series, using one



Earth Data Namibia Database – Start screen

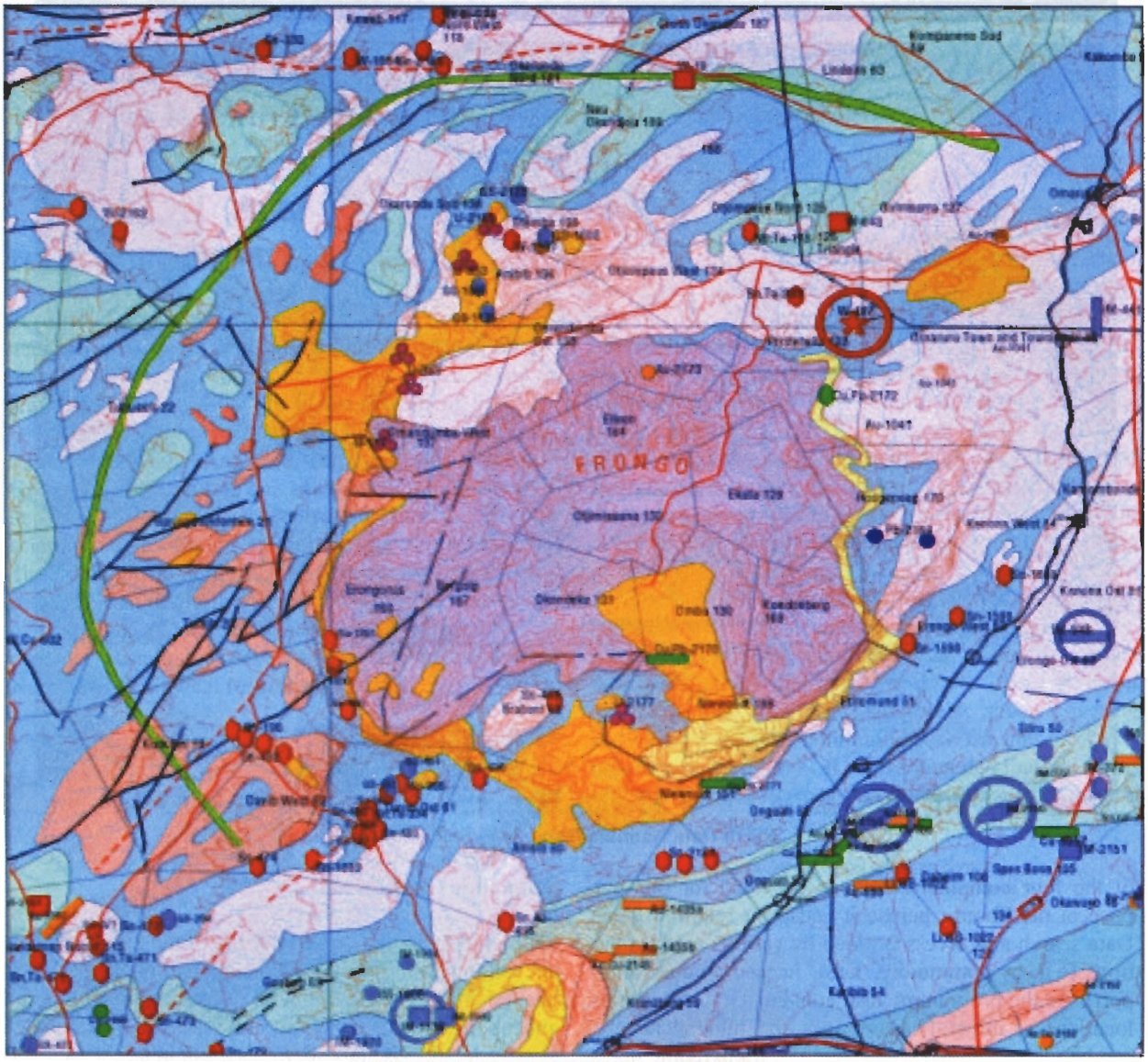
of the four computer terminals provided for this purpose in the library, peruse it and print required items. Data search and access is aided by various search functions (e.g. by commodity, farm, license number or report). As the programme also contains GIS capabilities, locations of mineral occurrences and mineral licenses can be viewed with a background of topographic maps, satellite images or other geographic and geological data. Future extensions to the database will include a borehole, dimension stone and geochemistry module, which will provide the mineral investor with access to more detailed exploration data, covering almost the entire spectrum of mineral exploration.

The Open File Grant Report System currently holds about 3000 Exclusive Prospecting Licence Grant Reports, which are being scanned and stored in the database to save irreplaceable documents from deterioration through frequent handling and use. To date over 700 such reports have been scanned and can be accessed by members of the public. To speed up the scanning process a second scanner was purchased and temporarily installed in Tsumeb, where the capturing of invaluable historic Tsumeb Corporation Limited exploration data has begun. Upon completion these data will be integrated into the database at the Geological Survey along with the other Open File data and made accessible to any interested stakeholders.

Economic Geology Maps

Of high priority on the activity list of the Subdivision is the compilation of economic geological maps, of which the 1:1 million scale "Mineral Map of Namibia" is the most popular. The map shows all known mineral occurrences in the country in relation to major geological units, as well as mineralization type and deposit size if known. The current map was first released on open file in 1998 and is being updated regularly as new occurrences are identified from the mineral occurrences reports, and ongoing exploration.

The compilation of mineral prospectivity maps started in 2001, with the main objective of providing a guide to mineral exploration investors in areas of high prospectivity for specific minerals. This product is essentially an integration of research and available exploration data pertinent to a particular mineral or group of minerals. In view of the important role that diamonds play in the economy of the country, the first map compiled was the "Diamondiferous Kimberlite Potential Map of Namibia", which delineated several areas of high prospectivity for diamondiferous kimberlites. This map generated large interest both locally and internationally. A similar prospectivity map for gold mineralization is in progress, while a thematic map has been produced for the Besshi-type copper deposits along the Matchless Amphibolite Belt, indicating lithologies, halos of the mineralized shoots and typical mineralised sections.



Part of the "Mineral Map of Namibia" - Erongo area, showing mineral occurrences

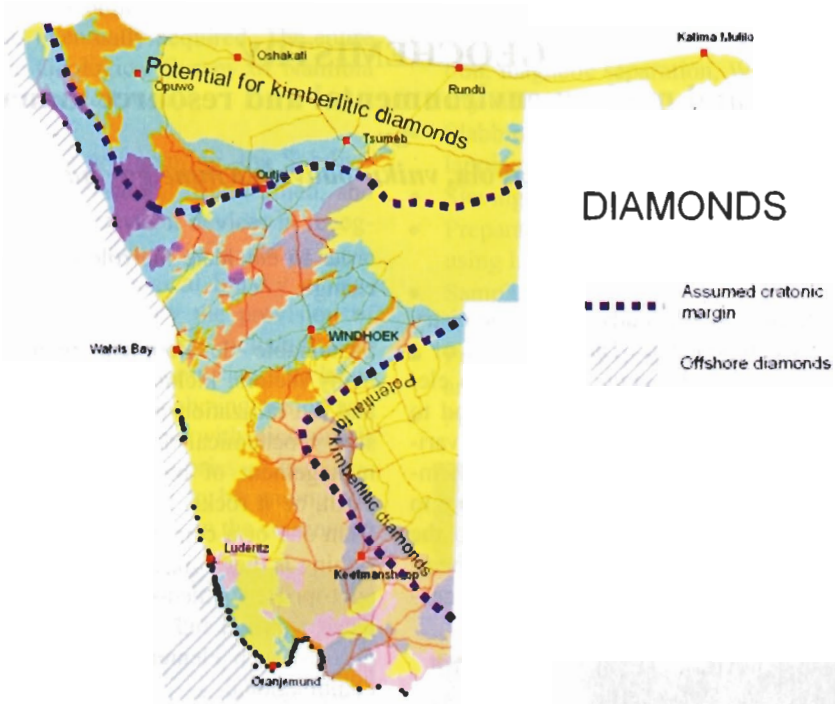
The National Core Archive

The National Core Archive is part of the Geological Survey of Namibia and administered by the Economic Geology Subdivision. It houses drillcore from more than 400 diamond drill boreholes, as well as numerous percussion chip sections of water boreholes drilled by commercial farmers and the Department of Water Affairs. These cores and drill chips are sources of invaluable information for research in the fields of mineral and water exploration, as well as stratigraphy and may be inspected by investors and members of the public.

Investment Promotion

To promote mineral investment in the country, the Geological Survey of Namibia, represented mainly by the Economic Geology Subdivision, attends major international mineral investment conventions and trade shows, such as the Prospectors and Developers Association of Canada Convention (PDAC) in Toronto, the Mining Resources Convention in Australia, and Stonetech in Germany, on a regular basis to present exhibitions aiming at promoting Namibia's mineral resources and thus attract mineral exploration investment into the country.

National Core Archive

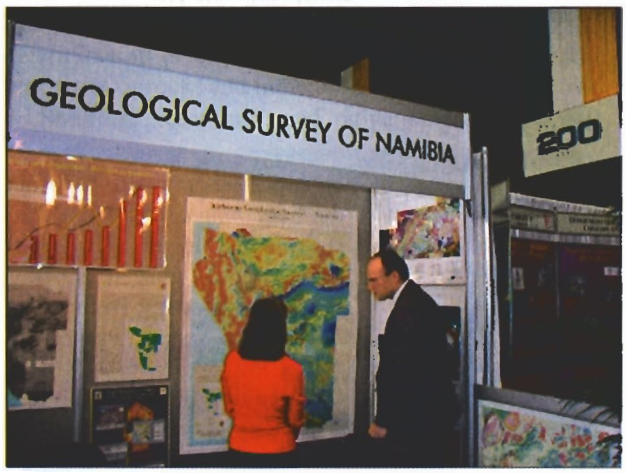


Diamond prospectivity map

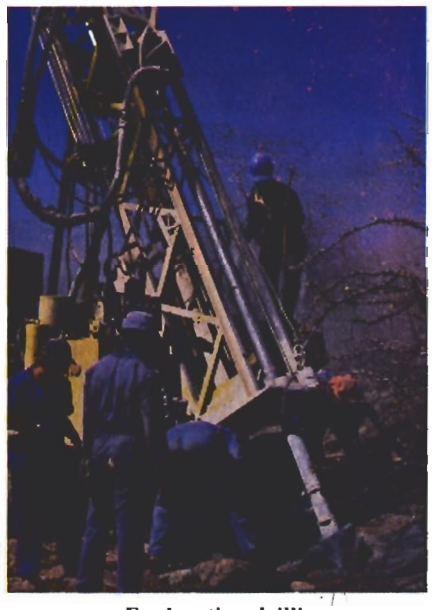
A typical Geological Survey exhibition booth displays the geological, minerals and airborne geophysical maps of Namibia; mineral prospectivity maps; publications related to investment opportunities and incentives; details of the Minerals Act and procedures for acquiring exploration and mining licences. The conferences also provide an ideal opportunity to promote the potential of Namibia as an exceptional tourist destination.

In Windhoek, staff of the Subdivision are available at all times to answer enquiries on aspects of economic geology and the mineral resources of Namibia by prospective investors, small miners and members of the public. Assistance is also rendered with the use of the Earth Data Namibia Database, the Open File Grant Report system and the Core Archive.

Despite the considerable exploration archive, Namibia is still regarded as having a high potential for the discovery of new mineral deposits. The country remains under-explored in comparison to major mining countries such as Australia, Canada, the United States and parts of South America, and there is no doubt that some parts of the country with highly prospective geology have not been exhaustively explored with modern techniques. The Economic Geology Mineral Resources Information Series, mineral prospectivity maps and research will continue to highlight such areas. These products are therefore essential in attracting the much-needed investment in the minerals sector of the Namibian economy.



Minerals investment promotion



Exploration drilling

GEOCHEMISTRY
- Research and modern environmental and resource management -

by
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The Chemistry of the Earth

Geochemistry is defined as the study of the chemistry of the earth and its components. The main task of a geochemist is to determine the abundance of the elements and their isotopes in rocks and minerals and to study the distribution and migration of elements in various components of the earth. The science of geochemistry is young, and the application of geochemistry to prospecting is even younger, dating back only to the 1930's. It is only during the last 50 years that geochemistry has become a common and important tool in geological research.

ICP analysis

Because of the growing demands on mineral and energy resources, water, soils and materials, problems of pollution and waste disposal on a scale never seen before, and the rise of ever growing towns and human settlements vulnerable to natural and anthropogenic hazards, more knowledge of the structure, composition and dynamics of the earth's crust and its effects upon the human life-support system is required. Furthermore, a better understanding of natural physical and chemical fluctuations influencing the environment is important in order to elucidate the role of the lithosphere in global change.

Wet chemistry laboratory

Sustainable development requires the balancing of many factors, including the health of the environment and the utilization of natural resources. A comprehensive geochemical database is required for the optimal management of both. Everything on and within the earth, be it rocks, minerals, animals or plants, is made from one or a combination of chemical elements. Everything is therefore depending on the availability of the appropriate elements. Even more important, the existence, survival and quality of life depend upon the presence of such elements in the correct proportions and combinations.

It is important to determine the present abundance and spatial distribution of the elements in the earth's crust, because natural processes and human activities, including the utilization of natural resources, are continuously modifying the chemical composition of our environment.

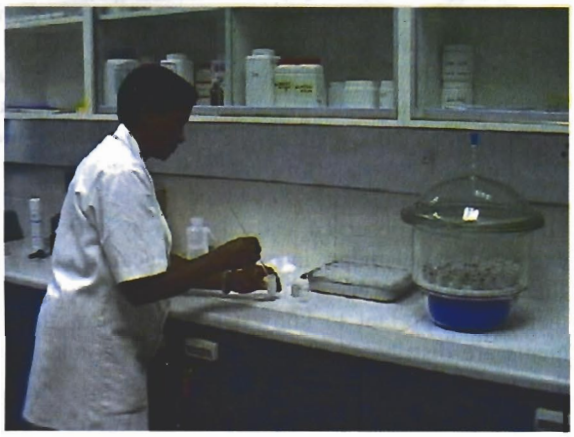
Producing fusion disks

History

The laboratory of the Geological Survey of Namibia was established only at the beginning of the 1980's, in response to the need of geologists to have chemical analyses of rock and mineral samples, as well as being able to determine their physical properties. Before that time, samples were sent to Pretoria for analysis at the laboratories of the Geological Survey of South Africa. During the early days, the laboratory only had limited equipment which included a jaw crusher, various mills, a magnetic separator, a sieve shaker and limited facilities for wet chemical analysis. The production of thin sections for microscopic investigations of rocks was

automated later, and an Atomic Absorption Spectrophotometer (AAS) was eventually acquired. The entire analytical needs of the Geological Survey of Namibia had to be met with these modest tools.

After Independence, during restructuring, the Subdivision "Geochemistry and Laboratory" was formed, and was equipped with modern analytical devices in recognition of the need and importance of a strong geo-analytical capability at the Geological Survey of Namibia. This was greatly assisted by the provision of new premises for the institution, which included tailor designed and generously spaced laboratories. The laboratory now has the capability of analyzing major and trace elements in rocks and minerals with high precision and accuracy. Today the laboratories of the Geological Survey of Namibia are said to be among the best-equipped geoscience laboratories on the continent.



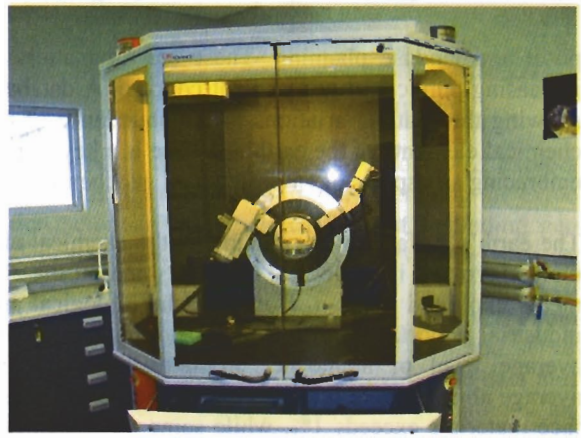
Sample preparation

A Modern Laboratory

Apart from the analyses done for in-house geological research, the laboratory handles enquiries from a variety of sources, including other directorates of the Ministry of Mines and Energy, mining companies, the general public, the Small Miners Assistance Centre (SMAC) and the Namibian Police. It provides assistance with a wide range of geo-analytical problems. The facilities available for sample preparation and the determination of chemical, mineralogical and physical properties of rocks and minerals are summarised below:

- Splitting, crushing and pulverising of rock and mineral samples
- Mineral separation by heavy liquid media separation, magnetic separation, Wilfley table and air density table
- Slabbing and polishing of specimens (rock saws and lapping plates)
- Sieving of unconsolidated material
- Preparation of thin sections and polished sections using Logitech equipment
- Sample dissolution (by lithium tetraborate fusion or HF/HNO_3 attack in teflon bombs)
- Preparation of pressed powder pellets for XRF analysis
- Preparation of fusion discs for XRF analysis

Thin section preparation



XRD analysis

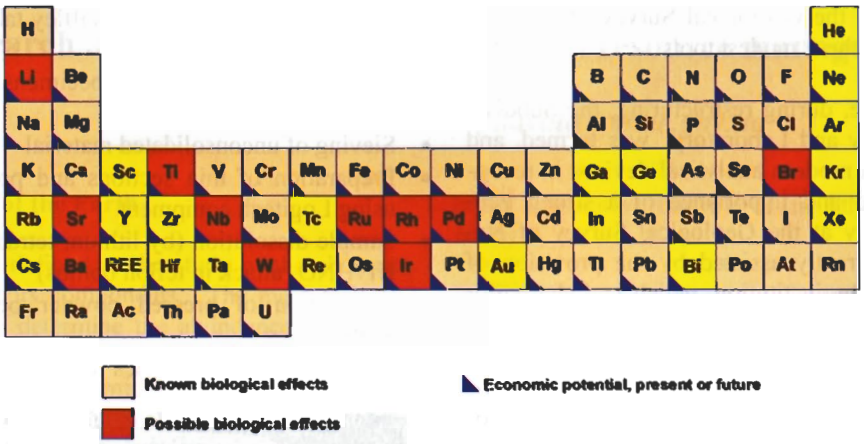
- Loss on ignition (LOI) and moisture content
- Sample digestion using microwave (MILESTONE MCR)
- PH determination for acidity and alkalinity of samples
- Particle size analysis
- Mineral identification by x-ray diffraction (BRUKER AXS D8 ADVANCE) and optical microscopy
- Reflectometer for the more accurate identification of ore minerals in polished section
- Fluid inclusion stage
- Determination of major and minor elements by wavelength dispersion XRF (PHILIPS PW2404) and ICP-AES (Varian)
- Test floatation cell

In addition to this, the laboratory also houses two specialised facilities, one for the testing of industrial minerals and another for engineering geological tests.

Regional Geochemistry – A Modern Tool for Environmental and Resource Management

A geochemical database contains information directly relevant to economic and environmental decisions involving minerals exploration, extraction and processing, manufacturing industries, agriculture, forestry, many aspects of human and animal health, waste dis-

ELEMENTS OF BIOLOGICAL AND ECONOMIC SIGNIFICANCE



posal and landuse planning. These are all matters of increasing public and government concern. A database showing the spatial variations in the abundance of the chemical elements of the earth's surface is a key step in embracing all aspects of environmental geochemistry.

The earth's surface layer contains all the chemical elements involved in biological processes and all the elements exploited by man. However, the biological and industrial importance of elements is not related to their average level of abundance in the earth's crust. The average abundance of major elements in the earth's surface materials exceeds 1%, while some trace elements with biological significance have an average abundance in the order of 0.0001% only.

Geochemical mapping was originally devised as a method of mineral prospecting. During the last 40 years, large areas have been explored this way and with varying degrees of accuracy, and as a result, many mineral deposits in many parts of the world have been found. Geochemical Surveys provide a large amount of valuable information about the concentration of chemical elements that can still lead to the discovery of new ore bodies. However, quite apart from the obvious benefits to mineral exploration, baseline geochemical data have direct relevance to economic and environmental studies involving agriculture, forestry, animal and human health and land-use planning.

The biological applications of geochemical mapping have developed from research into the trace element composition of soils. As geochemical maps covering larger areas have become available, a number of biochemical phenomena have been recognized through the empirical association between certain trace element concentrations or deficiencies and the morbidity in organisms. More recently, as the variability of the natural geochemical background has become better known, it has been recognized that in order to identify and qualify anthropogenic pollution, it is necessary to have a map of the natural background.

The role played by trace elements in biological processes has only been recognized as analytical procedures have advanced. The importance of iron in blood was first suspected some 300 years ago, but only during the past 50 years has the biological importance of, for example, cobalt, molybdenum, chromium, selenium, fluorine, tin and vanadium been established. It now appears that for most organisms there is an optimum range of concentration for particular elements, specific to the organism. Outside this range potentially harmful effects may be observed, caused either by deficiency or excess of the elements in question. Because of the influence of surface geochemistry upon the biosphere it is therefore important to know where and how the elements are distributed in their natural state, and where they may have been redistributed my man.

Trace element deficiencies or imbalances in soils are responsible for low production and reproduction problems in grazing livestock. For example, studies have shown that deficiencies in copper, iodine, manganese and zinc, coupled with an excess in fluorine and molybdenum, may particularly lead to adverse health effects in humans and animals. Chemical elements such as lead, arsenic, cadmium, mercury and aluminum may also be toxic.

Realising the importance of geochemical data to Namibia as a whole and investors in the minerals sector, the Geological Survey of Namibia in 2000 embarked upon a programme of Regional Geochemical Surveys and Geochemical Mapping. Geochemical sampling started in areas where geophysical and geological maps are available. The aim of this program is to acquire the base line concentration of a large number of elements in the anthropogenically undisturbed and disturbed geosphere. The samples consist of stream sediments and soil sediments taken in such a way that they represent a full coverage of any given area. Sampling protocols have been compiled for the different geological and climatic regions of Namibia.

The data generated by this program can be used for:

- Mineral exploration, notably the setting of natural backgrounds with respect to lithology, and the de-

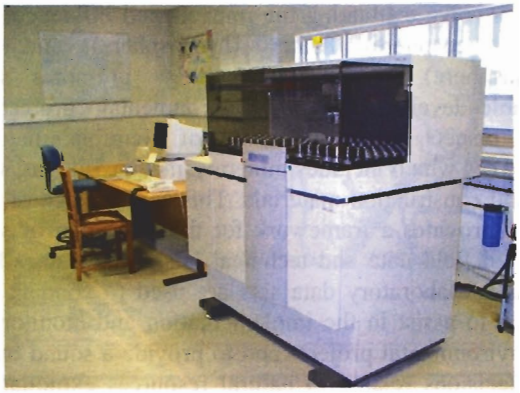
lineation of broad geochemical anomalies
- A reference network for environmental monitoring, and the setting of realistic environmental thresholds
- Agriculture
- Land-use planning and land reform
- Information to decision makers to provide a sound basis for policies and legislation

The Western part of the Rehoboth Sheet has been geochemically sampled during the years 2000 and 2001. The Windhoek and Okahandja sheets are ongoing and the Omaruru sheet is planned for 2005. The geochemical sampling programme is envisaged to continue until the whole country is covered.

Geochemical sampling team

Subsequent to sampling the stream and soil sediments, the samples are prepared for analysis and analysed by XRF and ICP in the laboratory of the Geological Survey of Namibia for the following elements: Fluorine, sodium, magnesium, aluminum, silicon, phosphorous, sulphur, chlorine, potassium, calcium, scandium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, gallium, arsenic, rubidium, strontium, yttrium, zirconium, niobium, molybdenum, tin, antimony, cesium, barium, lanthanium, hafnium, tantalum, tungsten, platinum, gold, lead, bismuth, cerium, praseodymium, neodymium, samarium, thorium and uranium.

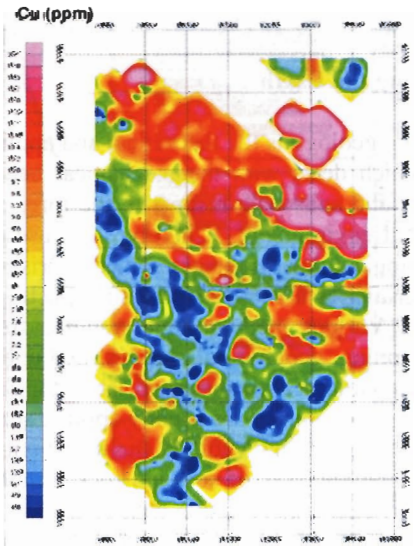
Geochemical maps are the standard method to represent geochemical data. Once analysed, sample data are therefore stored in a database, from which geochemical maps are produced. By utilization of a colour scale, the weighted average of a specific element can be shown at any point of the map. The colour scale increases from cold to warm, with the cold colours representing low concentrations and the warm colours showing high concentrations. There are separate maps for individual elements.



XRF analysis

Taking geochemical samples

In compliance with the Minerals Act of 1992, exploration companies must submit reports detailing the exploration activities they have carried out, including geochemical surveys. Inventorising and reviewing archived geochemical surveys is therefore also an ongoing activity of the Geochemistry Subdivision. However, exploration surveys usually cover a single area and survey parameters differ from survey to survey. The data must hence be processed using specialised technology and



Geochemical map for copper

presented as maps at different scales. Nevertheless, these maps contain a wealth of information and are compiled to complement the ongoing Regional Geochemical Survey.

Acknowledgement

Parts of this article were taken with the kind permission of UNESCO from the final report of IGCP Project 259 "A global geochemical database for environmental and resource management".