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Regional Airborne Geophysics and Geochemistry: A Namibian Perspective

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ABSTRACT

Namibia, situated on the southwest coast of Africa, is a large, sparsely populated, arid country. Like many developing African nations, the economy is heavily reliant on the mining sector, which contributes approximately 15% to the GDP. The Namibian government commitment to the mining sector is demonstrated by recent initiatives to promote exploration. These include the compilation of a regional aeromagnetic data base, the commencement of a programme of high-resolution airborne geophysical surveys and the initiation of a regional geochemical mapping programme.

As a first step, the magnetic data from forty one regional airborne geophysical surveys, flown between 1962 and 1992 and covering a large proportion of Namibia (approx. 700 000 line-km), were compiled as part of a German-Namibian cooperation project to produce an integrated digital countrywide magnetic data set. Radiometric data from surveys conducted over selected areas of Namibia were similarly compiled to produce compatible data sets.

To enhance the regional magnetic data set the Geological Survey of Namibia has recently embarked on a programme of high-resolution airborne geophysical surveys to provide non-exclusive data for the exploration industry. The first phase, funded by the European Union SYSMIN programme, was completed during 1996 and surveyed approximately 135 000 km^2 (nearly 750 000 line-km). The survey specifications, tolerances, tests, calibrations, and data processing are discussed. Examples of the magnetic and radiometric data are presented and comparisons with the regional airborne magnetics and bedrock geology are illustrated. Increased exploration acreage, applications and a diversification of exploration companies in Namibia demonstrates the importance of this new data to exploration.

Recently, a pilot regional geochemistry project was initiated in collaboration with the Finnish Geological Survey to determine base-line concentration data for a variety of elements in stream sediments. This forms the initial phase of a feasibility study to establish the viability of conducting country-wide surveys, and the importance of regional geochemical data in "adding value" to the high-resolution airborne geophysical surveys. A protocol for regional sampling (stream sediment and regolith) in arid environments is to be developed by studying several test areas representing a variety of geographical and geomorphological settings in Namibia. Preliminary geochemical results for the Spitzkoppe region of Namibia will be presented and discussed in relation to the high resolution magnetic and radiometric data for that area.

INTRODUCTION

The Republic of Namibia is a large (approximately 826 000 km^2), sparsely populated African country, which is bordered by South Africa to the south, Botswana to the east and Angola to the north. It is an arid, sparsely vegetated country with some 46% of its area made up of bedrock exposure. Despite this excellent exposure, only selected areas have been mapped in any great detail. Geologically, Namibia hosts of rocks of Palaeo- to Meso-Proterozoic, late Proterozoic (Pan-African, Damaran Orogen) and Cambrian to recent age (Figure 1) which have been described by various authors (e.g., Miller *et al.*, 1984).

Although mining has long been a cornerstone of the Namibian economy, it is not often recognised that this importance was mainly established at the turn of the century, when a considerable amount of superficial prospecting resulted in the discovery of many outcropping mineral occurrences. Known economic mineral deposits include diamonds, uranium, tin, base and precious metals, industrial minerals and semi-precious stones. Several prospective environments have been

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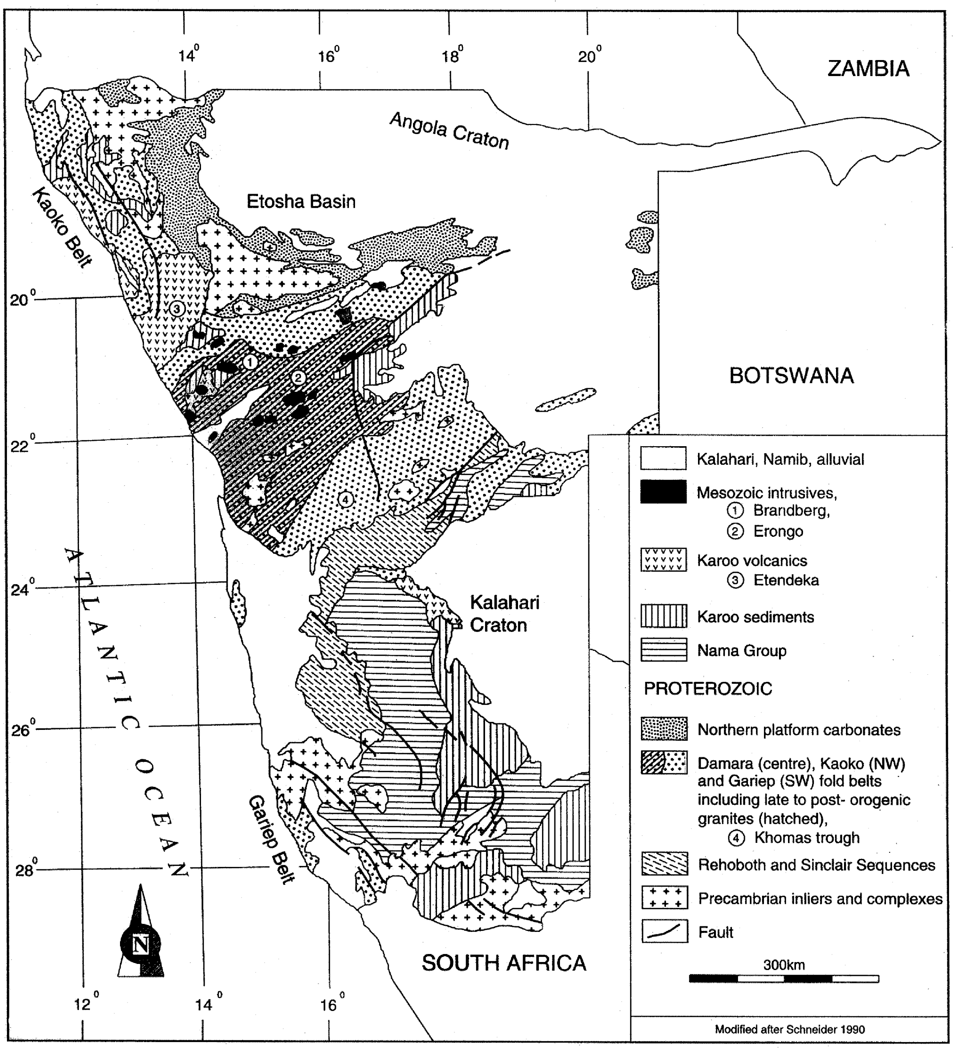


Figure 1: *Generalised geological map of Namibia.*

recognised, including beach diamond placers, volcano-exhalative base metals, sedex lead-zinc, extensive carbonate-hosted base metals, uraniferous granites, tin (and tantalum) pegmatites and skarn-hosted tungsten and gold.

Namibia is a world class producer of diamonds and uranium, and ranks among the top five mining countries in Africa. Despite the importance of mining to the Namibian economy, its contribution to gross domestic product (GDP) fell from 15% in 1994 to 11.5% in 1995, and revenue from mining activities (approximately N$1bn annually over the past 6 years) has fallen in real terms. Over the same period prospecting expenditure by the mining industry has also decreased significantly, despite the fact that large areas of the country remain relatively under explored and that with improved technologies and exploration techniques there is considerable potential for new discoveries.

In an attempt to remedy this situation, and to support the mining sector, the Ministry of Mines and Energy (MME) has devoted considerable attention to the creation of a modern legislative, fiscal and institutional framework to encourage local and foreign investment. Through the Geological Survey, it has also embarked on a number of initiatives to stimulate exploration. Included among these are the compilation of a regional aeromagnetic database, the commencement of a programme of high-resolution airborne geophysical surveys and the initiation of a regional geochemical mapping programme.

HISTORICAL OVERVIEW

Geophysics

It was not until the 1960s and 1970s that companies began to employ modern technology to support their exploration efforts in Namibia. Initially, limited ground geophysical surveys were conducted to investigate geochemical anomalies and to assist in drill site location. Subsequently,

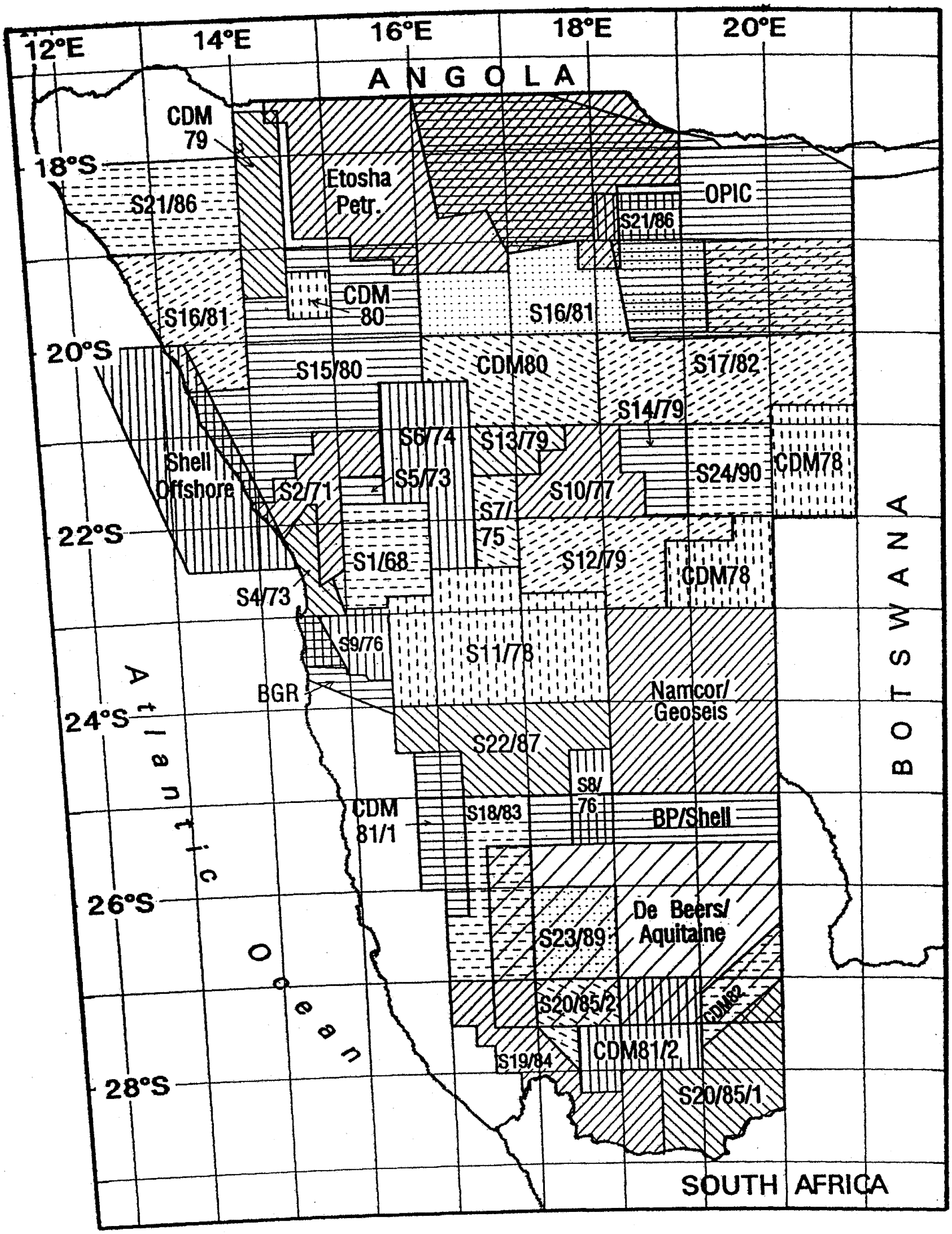


Figure 2: *Location and coverage of regional airborne geophysical surveys. Survey nomenclature indicates the funding agency and, for the S and CDM surveys, the year of execution. (Abbreviations: S = Government; CDM = Consolidated Diamond Mining; BGR = Federal Institute for Geosciences and Natural Resources, Germany; Etosha Petr = Etosha Petroleum Co; OPIC = Overseas Petroleum and Investment Corp.)*

the importance of regional geophysical surveys was recognised and small airborne surveys were carried out to identify potential mineral targets.

The relative success of these early airborne surveys, particularly in the exploration for uranium, led government to fund its first regional airborne survey (magnetics and radiometrics) in 1968. This survey was followed by subsequent surveys on a more or less annual basis. At the same time reconnaissance magnetic surveys were conducted over inland basins to assist hydrocarbon exploration and more detailed regional surveys were carried out during diamond exploration. These data sources, supported to a minor extent by airborne geophysical surveys for groundwater, contribute to the completeness of the Namibian magnetic data set (Figure 2).

Typically the government funded airborne magnetic surveys conducted between 1968 and 1990 were flown with a 1 km line spacing, 10 km ties and a terrain clearance of 100 m. Flight directions varied, but were generally chosen to be perpendicular to the predominant geological strike. In most of these surveys radiometric data were also recorded. Airborne magnetic surveys conducted during hydrocarbon exploration were flown at higher constant barometric ground elevations (500–800 m) and with wider line spacings (2.5–10 km). Some of the surveys, funded by Consolidated Diamond Mines (CDM) during diamond exploration and by the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) for groundwater, used closer line spacings of between 250 m and 500 m, with a terrain clearance of 80 m. In some cases the magnetic data were recorded in conjunction with multi-frequency electromagnetics.

In addition to variations in survey parameters, technological advancements over time meant that data were collected employing improved survey practices and using progressively more advanced instrumentation. For example, up until about 1979, fluxgate magnetometers, with a towed "bird" sensor and a resolution of about 2 nT were mostly used to measure the total magnetic field intensity, although an early version of a caesium vapour magnetometer was used for an inland hydrocarbon survey as early as 1969. These were superseded by Proton magnetometers (with sensors mounted in aircraft tail stingers) having accuracies of 1 nT. In most cases, magnetic readings were sampled at 1 second intervals. More recently, caesium vapour magnetometers with a resolution of 0.01 nT and a sampling interval of 0.2–0.1 sec have become the standard. The survey parameters are summarised in Table 1 and detailed specifications of each individual survey are documented in Eberle and Hutchins (1996).

Geochemistry

Government has not funded or conducted any systematic regional geochemistry surveys and the only data available was acquired by the private sector during exploration programmes for base metals, tin and gold. These data were obtained during regional soil and stream sediment surveys, together with detailed grid sampling over specific anomalies. The data resides in typewritten grant reports which were submitted to the MME when grant areas were relinquished.

Unlike the airborne geophysical surveys, even relatively recent geochemical data are not in digital format and the specifications of individual surveys are not always well documented. Furthermore, the approach to both soil and stream sediment sampling procedures varied between exploration companies, and in some cases from survey to survey, depending on the grant area and the elements of interest. Differences in approach include sample site location, preferred stream orders, bulk sampling (for gold) as well as on-site sieving, variable sieve-size fractions and in some instances the amalgamation of samples to reduce assay costs. Laboratory treatment of the samples include "whole-rock" and partial leach preparations, leading to analysis by atomic absorption and in some cases by XRF. Elements typically assayed for include: Cu, Pb, Zn, Sn, W, Bi, Sb, As, Ag and Au, and in rarer instances Ni and Co. The data are rarely accompanied by analytical details such as sample preparation methods, instrument conditions and estimates of accuracy, precision and lower limits of detection.

The task of levelling and merging such varied data sets to produce regional geochemical maps of any significant accuracy would be difficult. However, the data have not been discarded out of hand and are being captured for use in the Geological Survey's GIS database, particularly where detailed data are available for specific anomalies.

Table 1: ***Summary of parameters used for surveys incorporated in the regional airborne magnetic anomaly map of Namibia.***

Surveys flown by	Stinger-mounted magnetometer, sample rate	Flight height a.g.l.	Flight/Tie line spacing	Navigation	Data acquisition	Coordinate system
Government	Fluxgate, Proton; ≤ 1 sec	70–150 m	0.5–1 km /10 km	mainly visual, aerial photo mosaics, rarely Doppler	early surveys only analogue charts, since mid-1970s on analogue or digital tapes	Gauss Conformal Projection (Namibian Lo-System)
Precious stone prospecting companies	Fluxgate, Proton; ≤ 2 sec	80–120 m	0.5–1 km/10 km	Doppler, flightpath camera, gyrocompass		Gauss Conformal Projection (Namibian Lo-System), rarely UTM
Hydrocarbon prospecting companies	Fluxgate, Atom.Absorpt; ≤ 1 sec	500–800 m	2.5–12 km /10–20 km			

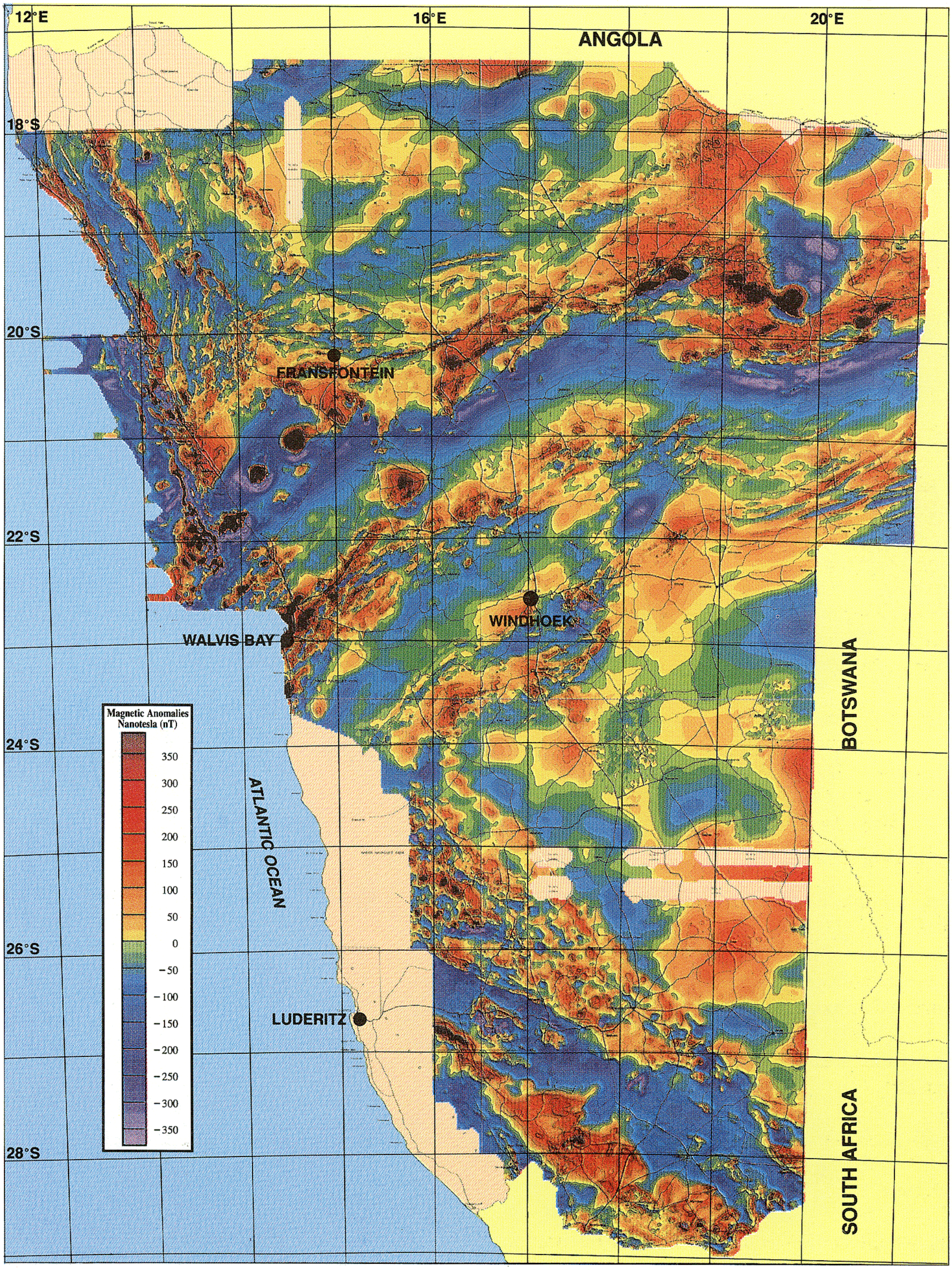


Figure 3: *The integrated regional airborne magnetic anomaly map of Namibia (data sources shown in Figure 2) from Eberle et al. (1995).*

REGIONAL GEOPHYSICAL DATA SET

A total of 41 different surveys with a total of approximately 700 000 line kilometres almost completely cover the country (Figure 2). However, at the time of Namibia's independence in 1990 the magnetic contour maps available to the explorationist were of variable quality. This variable quality was inherent in data collected over 25 years, and was largely caused by differences in contouring procedures (manual to computer) and improvements in survey technology as summarised in Table 1.

To provide airborne geophysical data acceptable to the international exploration community it was necessary to compile and merge the Namibian airborne magnetic data into a single uniform compatible data set. This was undertaken as part of a three year cooperation project between the Geological Survey of Namibia (GSN) and the BGR of Germany, within the framework of technical cooperation between their governments. The compilation was carried out under contract by Simon Petroleum Technology Ltd. (SPT) and supervised jointly by the GSN and BGR.

The data provided by the GSN were derived from two sources. These were, for early analogue surveys data digitised from the contour flight path intercepts, and for more recent surveys data on ASCII digital master tapes (line archive data). The compilation steps leading to the creation of a uniform grid are well documented in Eberle *et al.* (1996) and Somerton (1994). For each survey, anomaly values with arbitrary field references and various flight heights were converted to values with a common level above ground (100 m) using as reference a digital terrain model and the Definitive Geomagnetic Reference Field (DGRF) at the time of acquisition. Downward continuation of the data was achieved by applying a technique very similar to that described by Cordell and Grauch (1985) using an approximation method based on the evaluation of a truncated Taylor Series expansion of vertical derivatives. This technique is very suitable for rapid application to large grids.

The initial merging of data sets was achieved using a procedure of successive DC shift adjustments. After this coarse inter-survey levelling there still remained discrepancies in the data along the seams of some adjacent survey blocks. Conventional merging procedures (Dods *et al.*, 1985) which require survey overlap, could not be used to remove these discrepancies, since many of the surveys had been cut back to their nominal boundaries. To produce an artificial overlap, 2 km grids were created for individual surveys and extrapolated 2–4 km beyond their boundaries allowing pseudo-lines to be generated where necessary. The resulting countrywide data set was then gridded at 2 km, 500 m and 200 m intervals to produce maps at scales of 1:1 000 000, 1:250 000 and 1:50 000, respectively.

The resultant regional magnetic anomaly maps provide a new insight into the crustal evolution of Namibia. The magnetic anomaly pattern of Namibia (Figure 3) is dominated by cratonic areas, mobile belts and anorogenic intrusions, and an initial regional interpretation of the new magnetic data provides evidence for the association of mostly epigenetic mineralisation with magnetic lineations (Eberle *et al.*, 1995). More detailed interpretations will undoubtedly provide fresh impetus to exploration. For example, in southern Namibia alone, evaluation of this magnetic data in conjunction with existing geological information (e.g., geological maps, satellite imagery, exploration reports) has identified ten areas which are considered to have high mineral exploration potential (Andritzky *et al.*, 1997).

As part of the GSN-BGR cooperation project two areas were selected to test the methodology, cost effectiveness and viability of reprocessing radiometric data acquired in pre-1990 airborne surveys. Interpretation of radiometric data across survey boundaries, particularly for the earlier surveys, was complicated by the various detector sizes used, the failure to adopt standard radiometric survey practices and inconsistent map presentation. With the advent of back calibration of radiometric data (Grasty *et al.*, 1992), the merging of radiometric data became feasible. The first area selected comprised the earliest (1968) analogue data and more recently recorded digital data. The merging and reprocessing, including back calibration, was carried out under contract by High Sense Geophysics Ltd. (formerly UDL). The results were sufficiently encouraging, particularly for the more recent data, to warrant compiling the radiometric data of southern Namibia to support the geological mapping and mineral assessment of that region (Eberle *et al.*, 1997).

HIGH-RESOLUTION AIRBORNE GEOPHYSICS

Survey concept

Notwithstanding the success of the regional magnetic and radiometric data compilations, recent advances in airborne geophysical data acquisition, navigation and processing are making high-resolution airborne geophysical surveys a pre-requisite for successful mineral exploration. Recognising this, the Namibian Government has committed resources towards a programme of high resolution surveys to complement and enhance the existing regional data sets.

The first phase, funded by the European Union SYSMIN programme, was completed in 1996 and covered about 135 000 km^2 and consists of nearly 750 000 line-kilometres of magnetic and radiometric data. It is the intention of the government to finance future surveys, at least in part, through non-exclusive data sales at a fraction of acquisition cost. Furthermore, legislation has been enacted to enable funds raised from such sales to be held in a "revolving fund" which has been established to provide finance for the development and support of mineral exploration and the mining industry. Additionally, through the Ministry of Mines and Energy (MME and the GSN), the government will finance similar surveys over the next 5 years. One such survey (33 000 line-kilometres) was recently completed and another is planned for later this year (1997). Larger surveys are also planned and these will be funded by a reallocation of existing SYSMIN funds.

Survey areas and specifications

The areas flown under the SYSMIN-funded high-resolution geophysical survey programme and other similar surveys are shown in Figure 4. SYSMIN areas 1, 2 and 3 were surveyed by Compagnie General de Geophysique (CGG)/Geoterrex and Areas 4, 5S and 5N by Quad Consulting Ltd. in conjunction with Aerodata Botswana, a division of World Geoscience (WGS). Survey area 12 has recently been flown by Poseidon Geophysics Namibia (Pty) Ltd., a wholly owned subsidiary of Geodass (Pty) Ltd., South Africa. Area 6 differs from the other SYSMIN surveys in that the area was surveyed using the QUESTEM system, operated by WGS. This EM survey was designed to delineate the eastward extension of the Matchless Amphibolite belt which hosts several significant copper deposits.

The survey parameters adopted for the SYSMIN high resolution magnetic and radiometric surveys are a line spacing of 200 m, ties of 2.5 km,

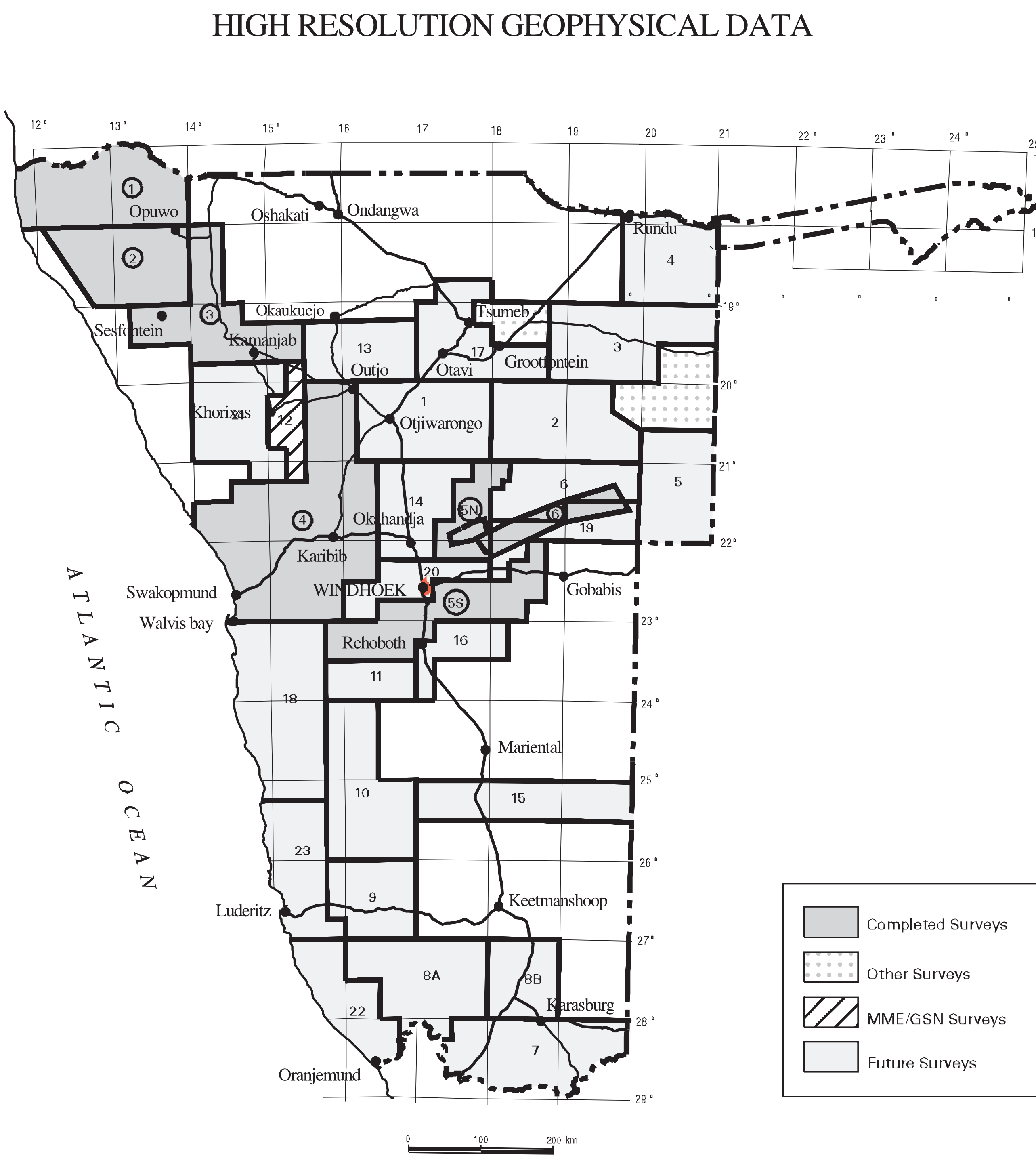
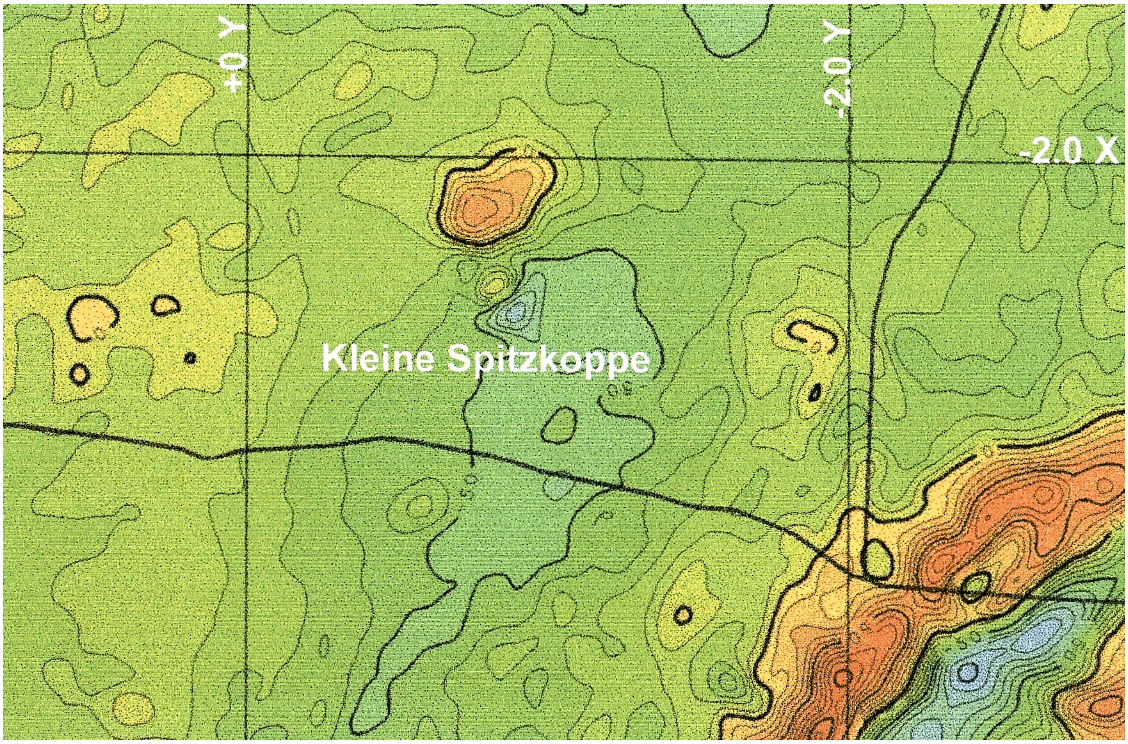


Figure 4: *Location of the SYSMIN high resolution geophysical surveys, other surveys with similar technical specifications, and areas identified for future surveying.*

(a)



(b)

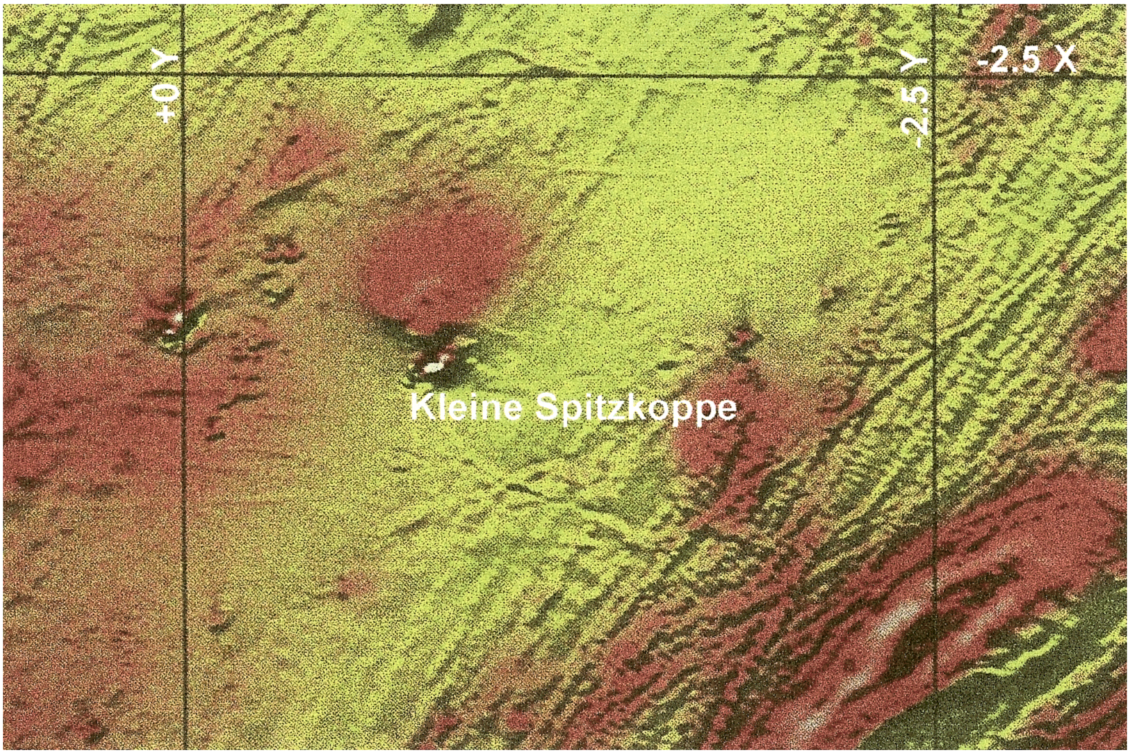


Figure 5: *Comparison of the SYSMIN high resolution magnetic data with the published regional airborne magnetic map (1:250 000) covering the Spitzkoppe area. This area is within the pilot regional geochemical study. (**a**) Regional magnetic contour map. (**b**) High-resolution magnetic image.*

(a)

(b)

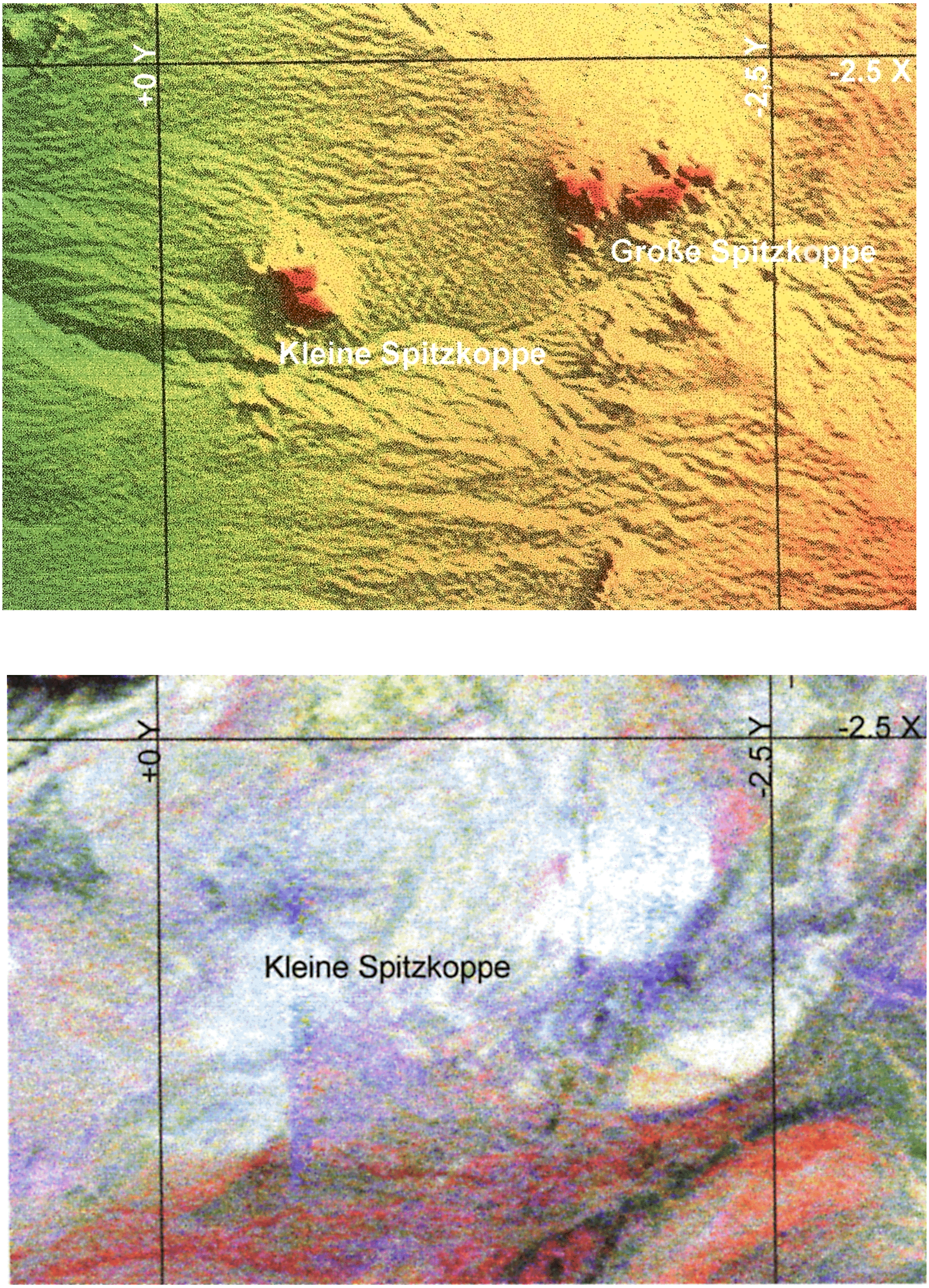


Figure 6: *DTM and ternary radiometric images for the area outlined in Figure 5 (Degradation of radiometric data along certain flight lines was unavoidable due to rugged topography encountered over the Gross and Klein Spitzkoppe inselbergs). (**a**) DTM image. (**b**) Radiometric ternary image.*

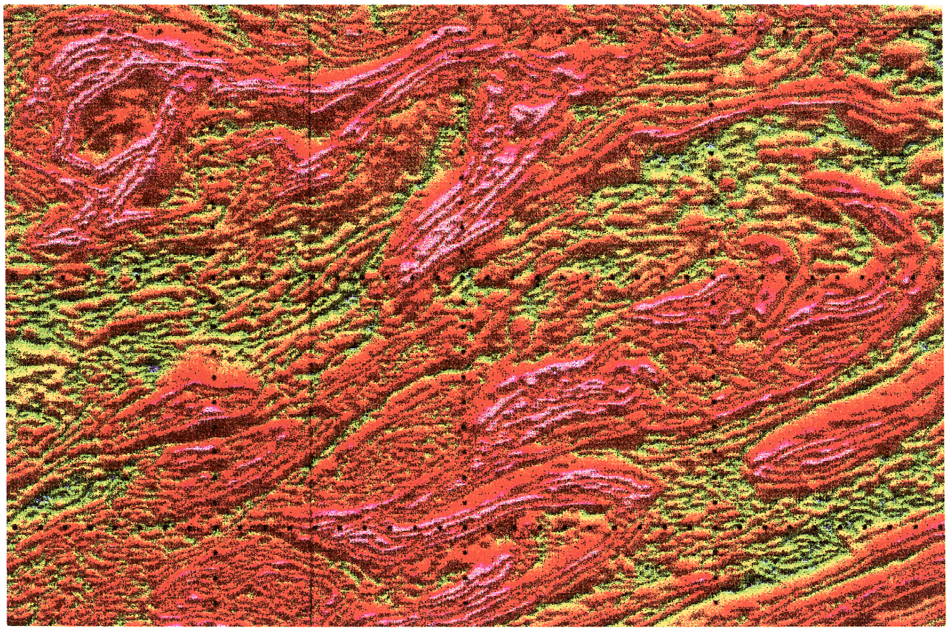


Figure 7a: *Analytical signal image of strongly folded Proterozoic sequences from SYSMIN area 5N (see Figure 4). Image courtesy of Corner Geophysics, Windhoek, Namibia.*

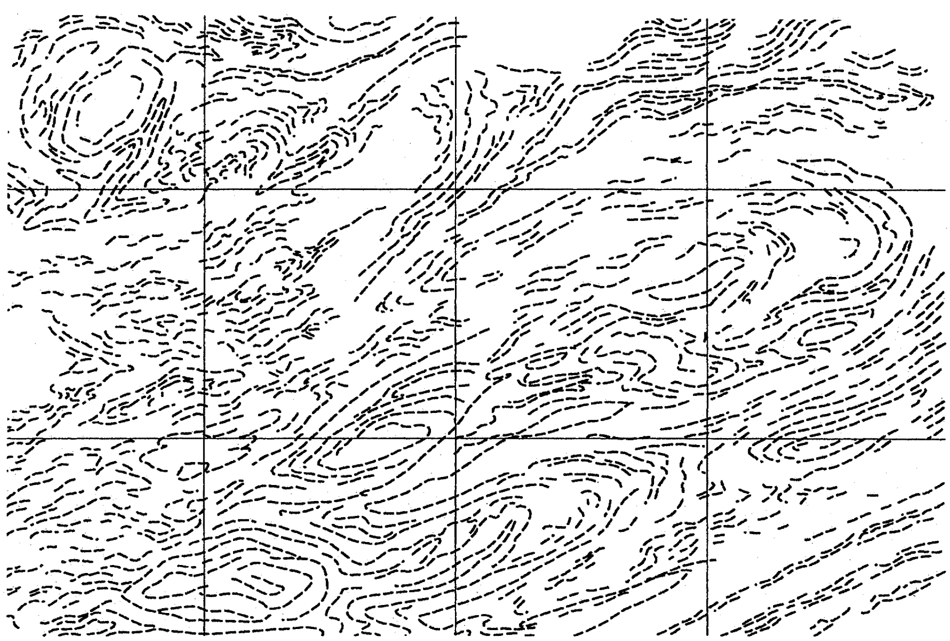


Figure 7b: *High-frequency magnetic trends interpreted from the 1VD image above (after Nash, 1997).*

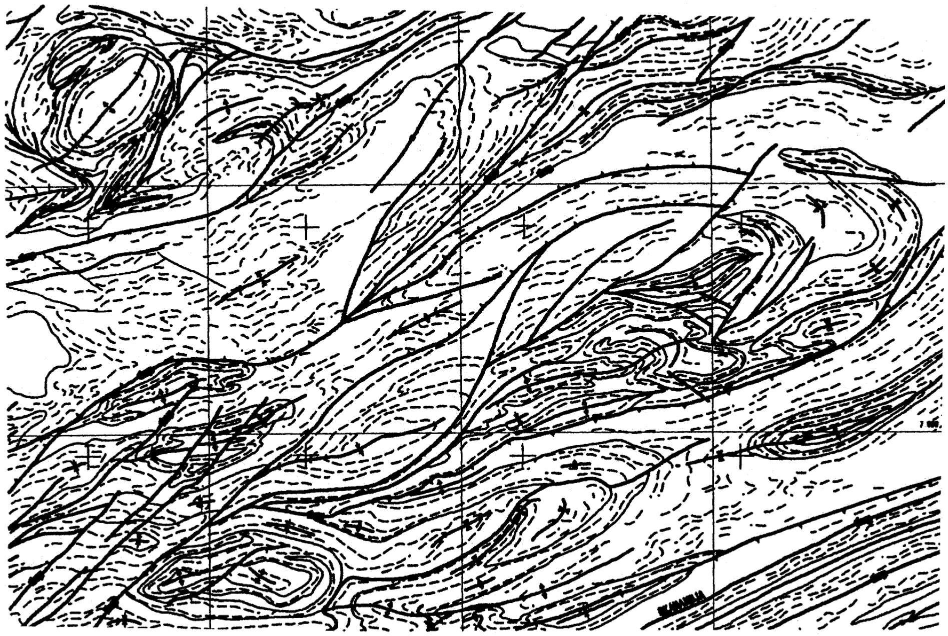


Figure 8a: *Lithomagnetic domains and magnetic pattern breaks are added to the high frequency magnetic trends illustrated in Figure 7 to form a qualitative aeromagnetic interpretation (after Nash, 1997).*

Figure 8b: *Integration of surface geological information produces a solid geology map (after Nash, 1997).*

and a terrain clearance of between 80 m and 100 m depending on topography. Although a 200 m line spacing was the standard, this was expanded to 400 m for those areas which were considered to have low prospectivity or fell within national parks. For most of the areas Cessna 404 fixed-wing aircraft were employed, but in areas of rugged topography a helicopter platform was used. Detailed terms of reference covering survey specifications, tolerances, instrumentation, tests, calibrations, quality control and processing procedures were prepared for the contractors which, for the magnetic surveys was based on a guide published by the Canadian Geological Survey (Teskey *et al.*, 1991). The specifications for radiometric surveys were drawn largely from publications by the International Atomic Energy Agency (IAEA, 1991) and Grasty and Minty (1995). Although tenders from the two successful contractors largely conformed to the terms of reference they adopted different techniques for the removal of background radon. CGG/Geoterrex employed upward looking crystals (IAEA, 1991), whilst Quad/Aerodata adopted the spectral ratio method (Minty 1992).

To calibrate the radiometric systems the GSN established calibration facilities as part of the SYSMIN programme. These facilities include portable calibration pads at Eros Airport, Windhoek and a test range in the vicinity of Henties Bay on the Atlantic coast. The latter is ideally suited for a number of reasons:

1. its location over flat topography;
2. it is easy to navigate by a 17 km straight stretch of unpaved road;
3. convenience of background measurements over water (adjacent Atlantic Ocean);
4. has constant concentrations of K, U and Th; and
5. is close to supporting infrastructure, particularly Swakopmund airport.

The test range procedures and further details on the Henties Bay calibration range are documented by Wendt (1996). These calibration facilities were used by the 1995–1996 SYSMIN surveys to provide consistency between the contractors and survey systems, and will be used for future surveys conducted in Namibia.

In addition to these radiometric calibrations, daily checks and source tests were conducted to maintain quality control throughout the programme. Similarly, magnetic checks were conducted periodically, particularly after magnetometer malfunctions or major aircraft maintenance (e.g., engine change). Quality control procedures adopted by the different contractors were demonstrated to the GSN and subsequently approved prior to survey commencement. Preliminary processing of the data was conducted on-site to provide additional quality control and to monitor survey progress.

Final processing was undertaken in Ottawa (CGG/Geoterrex) and Sydney (WGS), in accordance to GSN specifications. Products include digital magnetic and radiometric grids, line archive data (1 sec. widowed radiometrics, 1 sec. 256-channel radiometric and 0.1 sec. magnetics), colour and monochrome contour maps, selected images (e.g., ternary map, 1st vertical derivative and digital terrain model), RTL plot files and supporting operations/processing reports.

The improvement in the data quality is clearly demonstrated by a comparison of the high resolution data and the regional magnetic data over the area selected for the geochemical pilot study (Figures 5 and 6). Structures such as folds and faults together with dykes are now clearly visible with high resolution magnetic data, and different lithological units can be easily 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. Early interpretations of the magnetic data (Nash, 1997) clearly shows the importance it will have in mapping concealed geology in Namibia (Figures 7 and 8).

REGIONAL GEOCHEMISTRY — PILOT STUDY

The Geological Survey of Namibia is making steady progress in the acquisition of high resolution airborne geophysical data and the compilation and preparation of digital geological maps. However, until recently it has not had the capacity to augment these studies with high quality regional geochemical data. During August 1996 the Geological Survey of Namibia embarked upon a pilot regional geochemical survey with assistance from the Geological Survey of Finland (GSF).

Rationale

As a developing nation, Namibia is trying to attract foreign investment for the exploitation of its mineral resources, furthermore, it has enshrined protection of the environment within its constitution. A high quality regional geochemical database will provide invaluable information about mineral resources and the effects of anthropogenic activities (both mining and non-mining) on Namibia's fragile arid environment. The pilot study aims to assess the constraints in conducting country-wide surveys to provide regional base-line geochemical data for a wide variety of elements.

The assessment criteria fall into two categories. Firstly, those which relate to finance, institutional capacity and policy. Regional geochemical surveys are costly to implement, requiring significant capital expenditure on equipment, sample collection and qualified personnel. In this regard the GSN has limited resources, both financial and human. Therefore, it is important to assess the value of regional geochemical data in attracting exploration investment, particularly, as a supplement to the high-resolution geophysics. Secondly, the pilot programme has been designed to formulate guidelines for future regional geochemical surveys (e.g., logistics, sampling procedures, laboratory practices and data presentation). Of particular concern is the design of a robust sampling technique which will minimise systematic sampling errors.

Survey areas

The protocols for regional sampling (stream sediment and regolith) will vary depending on geographical or geomorphological setting. In Namibia there are three main environments for which protocols need to be developed, these are arid to semi-arid areas dominated by fluvial processes, areas of aeolian transport and limestone karst terrains. To develop these protocols, test surveys are to be conducted in each of these environments, and will be chosen to coincide with areas where high resolution geophysical data is already available. In this way the value of geochemical surveys to augment the airborne geophysical data can also be assessed.

The first test area selected covers the 1:50 000 (2115CC) map sheet of the Spitzkoppe region, which is located in the arid to semi-arid zone on the eastern edge of the Namib desert. With the exception of the Spitzkoppe mountain, the area has a subdued terrain and comprises mixed bedrock lithologies (schists, marble, granite and dolerite) with variable outcrop and superficial cover. The superficial cover is mainly regolith of alluvial and colluvial origin with minimum aeolian component. Vegetation is very sparse and consists of thorn bushes and grasses, which are mainly concentrated along the drainage courses. Access to the area is facilitated by numerous roads and tracks. In addition to high-resolution geophysical coverage (e.g., Figure 5), exploration activity in the area over the past 30 years means that some company geochemical data (Cu, Zn, Pb, Au and Bi) from stream sediment and regolith sampling surveys, grids and percussion drilling are also available.

Methodology

The survey area (720 km^2) was divided into 58 sampling cells, which represented drainage basins each with an average area of 10 km^2. Stream sediment samples were located both by aerial photographs and by GPS and plotted on a 1:50 000 topographic base map. As stream-bed channels were of the order of 10–30 m wide sampling was carried out continuously across the entire width, collecting a variety of material from fine silty sediment at the channel margins to coarser sand and gravel in the centre. Samples were dry-sieved on-site to obtain between 100 g and 200 g of the < 180 μm fraction. To provide control and determine the most appropriate size fraction, sub-samples of different size fractions (< 63 μm, 63–180 μm, 180–250 μm and < 180 μm) were also collected at 10 of the sites.

Aliquots of each sample are currently being prepared and analyzed in both the GSN and GSF laboratories. This duplication was desirable because the GSN laboratories are newly commissioned and require extensive checks and inter-laboratory calibration.

At the GSN samples are prepared for major and trace element analysis by ICP-AES using the following techniques, respectively:

1. Lithium metaborate–lithium tetraborate fusion (using a 3:1 flux:sample ratio) followed by dissolution in 5% HNO_3, and
2. Digestion by HF and HNO_3 acids in a teflon bomb at 150°C, followed by evaporation to near dryness and final dissolution in 5% HNO_3.

Analyses are carried out on a Varian Liberty 220 ICP-AES spectrometer, standardised using South African and Japanese SRMs. Samples from the pilot study are currently being analyzed for the following elements: Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, V, Cr, Co, Ni, Cu, Zn, Sr, Y, Zr, Ba, Pb, (Sn, Ta, Nb, La, Ce, Mo).

In Finland the GSF used a variety of procedures for sample preparation, including whole sample and partial leaching methods. Samples were analyzed for up to 60 elements using the following analytical techniques: XRF, ICP-MS, ICP-AES and GFAAS, details of which have been documented elsewhere (e.g., Sandström, 1996; Kontas *et al.*, 1990).

Once the samples from the pilot study have been analyzed, an assessment of the various sampling parameters and a comparison of the results obtained at the GSN and GSF laboratories will be made. This will enable protocols for future geochemical surveys to be adopted. The geochemical data will be presented as contoured element plots, images and dot maps, which will allow comparison with the archived company data. If feasible, the company data will be levelled and combined to provide regional geochemical coverage and will form an integral part of the GIS currently being developed at the GSN.

SUMMARY

The exploration initiatives reviewed in this paper have already provided the exploration industry with a wealth of new geological and geophysical information. The high resolution airborne geophysical surveys are a particularly significant addition to the geological database as demonstrated by the number of companies who have purchased the data. The success of the Namibian government's commitment to the mining sector is also shown by significant increases in exploration applications and the acreage held under exploration licence. Furthermore, it is noteworthy that several international companies new to Namibia have embarked on exploration programmes and have been significantly encouraged to conduct their own high resolution airborne surveys. This increased activity and expenditure could lead to the discovery of exploitable deposits securing the future of mining in Namibia.

The government programme of high resolution geophysical surveys is continuing and the pilot geochemical study discussed herein forms a part of the Geological Survey's attempts to add value to this high quality data. The first results from the pilot study are expected in mid-1997, but early indications are that these data, and data from future regional surveys, will be a valuable addition to the geological and geophysical database and will assist the investor in generating and developing exploration targets.

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