2 HISTORY

2.1 PREVIOUS WORK ON THE ECONOMIC GEOLOGICAL ASPECT OF THE REGION (1969 – 1994)

2.1.1 Introduction

Iscor Ltd, lately Kumba Resources Ltd, assigned Cain to undertake an extensive desktop and literature survey into the economic potential of the Areachap Group (Cain, 1994). He requested the help of Blignault and Van Schalkwyk for Zn and Cu target generation within the Areachap Group and their results are summarised in Appendix A (Blignault and Van Schalkwyk, 1995). These surveys indicated that numerous companies, including Anglo American (AAC), Phelps Dodge, Anglovaal, JCI and a few others have explored the region. The central part of the belt, however, seemed to be very poorly known or understood from a potential economic point of view (Blignault and Van Schalkwyk, 1995).

The last active base-metal prospecting ventures took place mainly in the early/mid-1970s with some work done in the early 1980s. Most of this early exploration was done at a time when the VHMS conceptual model had not attained full maturity. Some authors, however, started using the model, or parts of it, as we know it at this stage in time, to explain their deposits. Middleton, for instance, applied the model to the Prieska Zn-Cu mine in 1976, Gorton used this model to explain Kielder, in his thesis in 1981, and Voet and King used the model at the Areachap deposit in 1986.

Lithogeochemical sampling, as an exploration tool and of this magnitude, has probably never been applied in previous exploration campaigns, since this type of sampling only started in the early 1990s.

Mineralised targets of the past, for example Kielder (Gorton, 1981), were all of a surface or sub-outcropping nature and defined by regional soil/gossan geochemical surveys and follow-up geophysical (magnetic, IP, pulse EM and gravity) surveys and relatively shallow drilling (Gorton, 1981 and Gresse, 1978). Conceptual volcanic-strata mapping was limited, to virtually non-existent, except on a deposit scale. In addition, the then available EM geophysical methods of application had very limited penetration capability. Regional airborne electromagnetic (INPUT and McPhar 400) and magnetic surveys sometimes missed the bodies owing to parallel and not perpendicular flight lines to the strike of the geology. Some deposits were however found successfully, as in the case of Jacomynspan and Prieska Annex (Attridge, 1986; Blignault and Van Schalkwyk, 1995).

2.1.2 Known Deposits

Known deposits and base metal occurrences are briefly described below and localities are shown in Figure 4. The deposits are listed and described in greater detail in Appendix A.

2.1.2.1 Upington area

Exploration was previously undertaken by Iscor on the Areachap deposit (Figure 2) with the objective to mine massive pyrite portions of the Areachap body for sulphuric acid production. The Areachap copper-zinc massive sulphide is one of two similar VHMS deposits found in the belt; the other being Anglo Vaal's 47 Mt Prieska Zn-Cu mine.

The Areachap deposit was discovered in approximately 1885 due to the recognition of mineralisation in gossan float (Rogers and Du Toit, 1908). Drilling of Areachap from the 1960s indicated resources of 1,6 Mt massive sulphides to between 200 m and 300 m depth (including a reserve of 0,5 Mt grading 2,3% Zn, 0,5% Cu and 42% sulphur, considered to be a mining prospect). Shaft-sinking to 200 m was carried out, with stations cut at 91, 122, 152 and 182 m levels and a cross-cut at 91 m (which intersected the old 1909 – 1917 workings for supergene-enriched sulphide). The project was deferred with the discovery of the Prieska Cu-Zn deposit (Voet and King, 1986).

Cape Asbestos obtained exploration rights from Iscor in 1971 and, in a joint venture with AAC, proved 8,1 Mt grading 2,4% Zn and 0,54% Cu to 750 rn depth by diamond drilling between 1971 and 1973 (Voet and King, 1986).

Cape Asbestos ceded its rights to AAC in 1974, which in turn relinquished these back to Iscor in 1977 after further geological and geophysical work and drilling had failed to locate additional mineralisation. AAC was of the opinion, however, that it would be possible to locate extensions to the present body by deep drilling (Voet and King, 1986).

The Jannelsepan sulphide body of presumed VHMS affinity occurs crudely on strike with Areachap on the south side of the Orange River (Geringer, 1994).

2.1.2.2 Klein Begin and Boksputs areas

A number of small base metal mineral occurrences have been reported for this area, which include Klipbakke, Boksputs, Kantienpan, Van Wyks Pan and Edenville (Theart, 1985).

It is known that Shell undertook exploration work in the Boksputs centre until the early 1980s, but no details are known.

2.1.2.3 Copperton area

The Prieska Zn-Cu mine commenced mining operations on the massive sulphide at Copperton in 1972 with reserves of 47 Mt grading at 1.74% Cu and 3.87% Zn, 8.0 g/t Ag and 0.4 g/t Au. The massive sulphide is 1 to 30 m thick, extends along strike by 2 000 m and persists to a depth of 1 000 m. The massive sulphide consists of various lenses and is strata-bound within fine-grained, laminated gneisses of the Copperton Formation. Sulphide minerals include pyrite, sphalerite, pyrrhotite and galena. Traces of Ag and Au are present (Middleton, 1976; Theart, 1985 and Wagener and Van Schalkwyk, 1986). The mine was closed during 1991.

A copper lode with a north-westerly strike is shown on the Rogers and Du Toit regional geological map of 1910, but the economic potential was only realised in 1968 (Theart, 1985). After its discovery, Middleton did the first comprehensive description of the Prieska Zn-Cu mine, in a thesis in 1976.

The Annex Cu-Zn massive sulphide deposit was discovered in 1969 and is situated 5 km south of the Prieska Zn-Cu mine. Chlorite-biotite schist correlated with the Copperton Formation hosts the deposit. The ore reserves are estimated to be 1,5 Mt of 1,5 % Cu and <0,5 % Zn (Middleton, 1976; Wagener and Van Schalkwyk, 1986 and Blignault and Van Schalkwyk, 1995).

Other occurrences in the Copperton centre include Kielder and Hedley Plains. Newmont carried out regional prospecting in the Kielder area in the late 1970s, making virgin discoveries (Gordon, 1981 and Gresse, 1978).

The massive Zn, Cu and Pb sulphides reported from portions of Kielder included one lens delineated (K3) and two only partly delineated (K1 and K6) by diamond drilling. Using a 2,5% Zn + Cu cut-off for the K3 body, an estimate of 1,3 Mt grading 4.32 % Zn, 0.33 % Cu and 4.45 g/t Ag was arrived at. A crude estimate of K6 gave 1 Mt grading 8.85 % Zn, 0.42 % Cu and 15 g/t. The highest Pb value in some of the core was in the order of ±1 %. The Newmont report of 1978 states that three anomalies (K2, K4 and K5) remained to be investigated (Gorton, 1981 and Gresse, 1978). K2 and K4 had only been drilled with one diamond hole each and disseminated pyrite mineralisation was found.

The K7 gossan was disclosed by soil geochemistry, but not drilled. Widespread gossan float was noted on the southeastern portion of Grassmoor, bordering Vogelstruisbult, as well as on Eureka (Gorton, 1981 and Gresse, 1978).

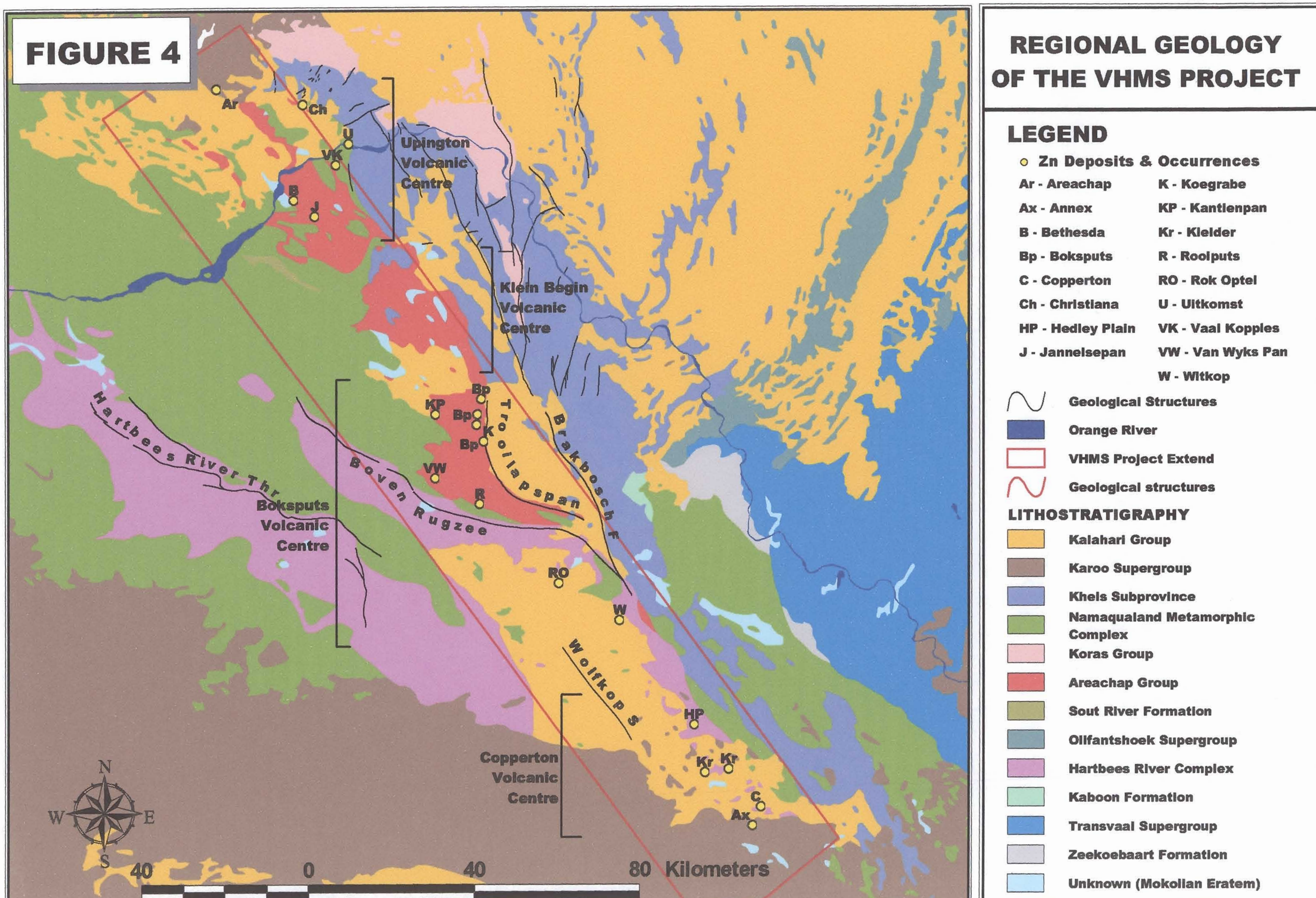

Figure 4. Regional geological map of the VHMS project (Modified after Geringer et al., 1994)

2.2 WORK DONE FOR THIS STUDY

2.2.1 Introduction

The Areachap Group volcano-sedimentary stratigraphic package was targeted for VHMS deposits based on Cain's application of VHMS models as used by Falconbridge and updated by Australian researchers (Cain, 1994).

Four possible volcanic centres were proposed by Middleton (1976) and Geringer (1994), and these are show in Figure 4. Regional lithogeochemical sampling was done of these centres comprising the entire Areachap Group (250 x 40 km), from Areachap Mine in the north to Copperton in the south (Figure 5). Regional geological maps (1:25 000) were then prepared, using the data gathered along the lithogeochemical sampling lines and photo geological interpretation of aeromagnetic survey data supplemented by published geological maps and literature. Lithogeochemical maps were prepared which incorporated the alteration zones and which also fitted the exploration model's criteria (Appendix C). Protolithological maps were prepared by means of lithogeochemical parameters and geostatistical methods, which included cluster analysis (Rossouw and Geraghty, 1997).

The volcanic centres were prioritised by means of identification of fractionation trends i.e. tholeiitic vs. calc-alkaline, as well as Zn and Cu anomalies. The Boksputs centre was selected as first priority in consultation with Dr A Galley of the Canadian Geological Survey (Rossouw and Geraghty, 1997). A geographical information system (GIS) was used in generating targets within the Boksputs centre by applying the exploration model, which used alteration signatures, protolithology and geochemistry (Rossouw and Geraghty, 1997). Negotiations started in 1998 to obtain options for mineral rights on the prioritised farms which properties can be seen in Figure 3.

Detailed follow-up mapping of the targets on the optioned farms were done and limited grab rock sampling was used for geochemical confirmation. Detailed ground magnetic and TDEM surveys were conducted to prioritise targets, which were then tested with diamond drilling for confirmation and resource estimation (Rossouw, 1999).

2.2.2 Lithogeochemical Survey

Regional exploration began in January 1995, and started with the taking of lithogeochemical rock samples along roads and fence lines at intervals of 100 m, with a line spacing of 1 to 2 km and a sample density of 8 samples per km^2. Rock sampling positions are shown in Figure 5.

A total of 6 010 lithological rock samples were taken across the Areachap Group, with 1 279 samples being taken in the Upington area, 1 734 samples in the Kleinbegin area and 2 997 samples in the Boksputs area (Figure 4). A further 160 rock samples were collected from the entire Areachap Group area to provide a reference set for further geochemical exploration, while 24 samples were taken from the Areachap core (Geraghty *et al*, 1996).

Threshold analyses using probability graphs were done and the relevant geochemical intervals were established to highlight possible alteration chemistry. Problems were however encountered due to the geochemical differences among the four centres (Figure 4).

Whole rock analyses (oxides and traces) were conducted on the rock samples and the results for each element and various ratios were plotted on geochemical maps for each region. The following aspects were considered during this investigation (Large, 2001):

- Enrichment in Ba is an indication of the exhalative in the direct vicinity of the massive sulphide lens of a VHMS deposit.
- Zn is depleted in zones of regional leaching related to VHMS deposit.
- Na_2O/SiO_2 ratio is lower in the leached zone relative to rock unaffected by hydrothermal alteration related to VHMS deposit.

Rock types were described along the sampling traverses and recorded for later reference.

2.2.3 Geophysical Surveys

2.2.3.1 Aerial Magnetic Survey

Two aerial magnetic surveys were done over the area.

- Newmont conducted a survey in 1970 that was flown perpendicularly to the strike of the Areachap Group (1 km line-spacing). Structural lineament analysis was done using the geology as an overlay to locate volcanic lentoid piles. This did not work owing to the structural complexity of the areas.
- The Council for Geoscience conducted a survey (available in electronic format), but the survey was flown parallel to the strike of the Areachap Group, in other words with north-south flight lines.

The combination of the two data sets would enhance the quality of the interpretation, but it was impossible, owing to computing limitations.

2.2.3.2 Ground Magnetic and TDEM Surveys

Detailed ground magnetic (Geotron G9) and TDEM (Geonics EM37) surveys were conducted across the targets and identified TDEM anomalies were followed-up with more detailed TDEM surveys to a defined drilling target. The drilling targets were tested with diamond drilling in conjunction with core logging and additional lithogeochemistry (Appendix E). Down-the-hole TDEM surveys were done in all the holes and drilling commenced to estimate reserve (Rossouw, 1999).

2.2.3.3 Radiometric and Gravity Test Surveys

Radiometric and gravity test surveys were also done on some of the proved conductors (Rossouw, 1999). An additional ground magnetic survey was carried out over the sand covered area to map the underlying stratigraphy. This survey identified interesting features that should still be followed up with more fieldwork (Geraghty *et al.*, 1996).

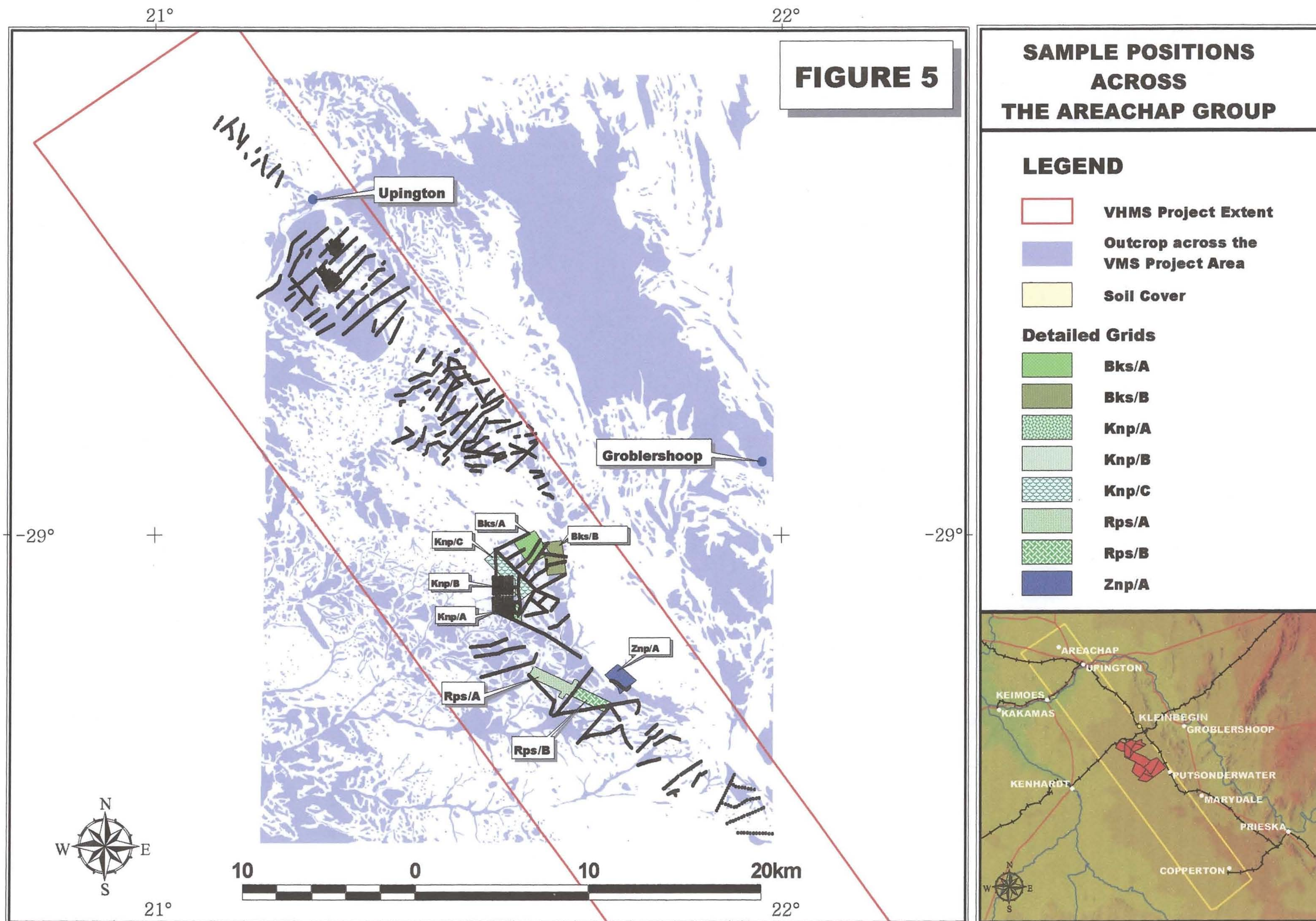

Figure 5. Rock sample positions across the Areachap Group.

2.2.4 Soil Survey

South of the Boven Rugseer Shearsone (Figure 4), the whole area is covered with sand and a decision was made by Iscor's management to conduct a soil survey across the area during 1995. Samples were collected every 100 m along the roads and fences on a 1 km line-spacing, which meant that approximately 1 000 samples were taken (Geraghty *et al*, 1996).

The purpose of the soil sampling exercise was to find gahnite, a dark-green to yellowish, zinc mineral of the spinel series. This mineral was found at the Prieska Zn-Cu mine and is believed to be a good indicator mineral for Zn mineralisation.

The following method was used:
Soil samples were collected every 100 m with a sampling size of 340 ml (cool drink can). Composites were made of every 10 samples collected over a distance of 1 km. The composite was then split with a riffler to finish with a 340 ml soil sample. Samples were washed and screened to dispose of the dust size fraction. Magnetic components were then removed with a magnet. Bromoform, with a density of 2.9 g/cm^3, was used to concentrate heavy minerals like pyroxene, amphibole, ilmenite and garnet in the dense fraction. This sample was then studied with a bi-ocular hand specimen microscope and it was found that 95 % of the heavy mineral fraction consists of garnet. Any blue or green minerals were handpicked and send for microprobe analysis. Unfortunately no gahnite was detected during this survey and it is suggested that the sampling technique employed, was not detailed enough to detect a mineral that may have a very limited dispersion in the secondary environment.

Other potentially negative aspects regarding this survey are the fact that the strike of the rocks was frequently not known and that it is not curtain if the sampling took place perpendicularly to the strike. Rock samples were also taken where outcrops occurred, but it could not be demonstrated that these samples contributed to a systematic interpretation of the region's lithology.

The heavy minerals programme was unsuccessful and abandoned (Geraghty *et al.*, 1996) and the conclusion was drawn that gahnite is so rare that it does not lend itself as a pathfinder mineral in this environment.

Further possibilities for this region are:

- Re-evaluate the samples to extract magnetite, pyroxene and amphibole for identifying enrichment in different areas that could be used as a mapping tool of specific lithological units.
- To find the possible existence of pyrrhotite and magnetite that is enriched in the massive sulphide zone, for which purpose a magnetic survey has already been conducted.
- Look for tourmaline, which is more abundant at Copperton rather than gahnite (Theart, 1985). Tourmaline can also be used as a pathfinder mineral and to map lithology.

A separate soil survey was conducted across parts of the lithogeochemical-surveyed areas. This reconnaissance mobile metal ion (MMI) soil survey was conducted to establish if this method is suitability for identifying base metal mineralisation (Appendix D). Traverses were sampled across known TDEM conductors to assist in prioritising these anomalies. The method proved to be successful and it is recommended that it should be considered in further exploration.