CHAPTER 5 GEOPHYSICAL SURVEY

5.1 Purpose of Survey

The objective of the Time Domain Electro- Magnetic (TDEM) survey was to define the electrical structure of the Stampriet Artesian Basin and relate this structure to lithological, structural, and groundwater parameters. As the results of the survey, geoelectrical sections and profiles were prepared in the study area.

In addition to TDEM survey, aeromagnetic data set, made available by the Geological Survey of Namibia (GSN) was interpreted in order to identify the location of faults and to delineate the areas underlain by Karoo basalts and sills. Two magnetic field image maps were created as the results of the interpretation.

5.2 Time Domain Electro-Magnetic Survey (TEM Method)

5.2.1 Survey Area

The study area defined is bounded by the latitudes 22^{o}45'S and 26^{o}S and longitudes 17^{o}E and 20^{o}E. The position of each of the TDEM soundings is shown on the TDEM location map in Fig.5.2-1.

5.2.2 Survey Method and Interpretation Procedures

1) Survey Method

TDEM was performed applying transient electro-magnetic method (vertical sounding), using Zonge GGD10 Transmitter and GDP 32 Receiver. The data collected in the field consists of 200 soundings at 1Hz, 4Hz, and 32Hz duty cycles.

Basically the method allows calculation of resistivity from the transient decay waveform of eddy current induced secondary magnetic fields, produced by the negative part of a pulsed transmitter current. The Central loop (In-loop) configuration (Transmitter Loop size is 300m square) is used in the survey.

2) Theoretical Background

Resistiviry as measured by DC soundings, electromagnetic soundings, or during borehole logging is dependant on water saturation, water salinity, porosity, temperature and the conductivity of the matrix. Fundamental to the understanding of the data collected in this study is to determine how these parameters are related.

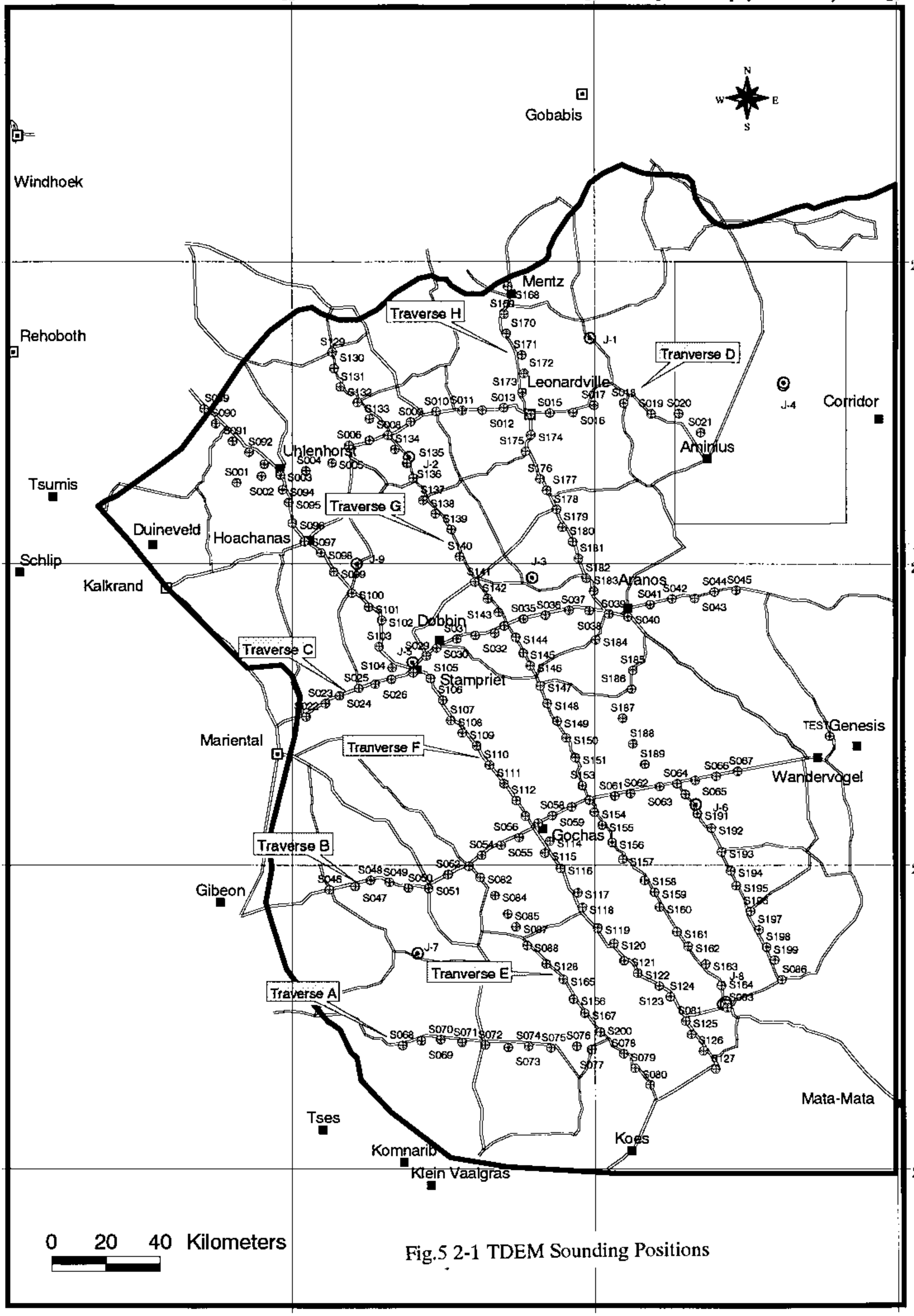

Fig.5 2-1 TDEM Sounding Positions

(1) Archie's Law

The empirical relating some of the above parameters to the measured apparent resistivity is known as Archie's Law (1942) and is formulated as follows:

$$F = \frac{R_O}{R_W} = \frac{af^{-m}}{S_W{}^2}$$

where F is defined as the formation factor, R_O is the measured apparent resistivity, R_W is the resistivity of the formation water, f the porosity, m is the cementation factor, and S_W is the water saturation.

Examining this formula in isolation, we note that a decrease in measured resistivity can be caused by a decrease in the resistivity of the formation water or by increases in porosity and water saturation.

When applied to "clean sands" that are saturated, Archie (1942) found a=1 and m=2. In application to a variety of arenaceous, argillaceous and carbonate lithologies, it was found that the cementation factor m, varied from 1.5 to above 2, while the a factor varied in a manner that could not be related to any physical parameter.

(2) De Witte's Empirical Law

De Witte (1957) concluded from further empirical considerations that the conductive behaviour of sands and sandstones and shaly sand could be represented by:

$$s_O = ms_R(1-f)^m \mathrm{S_W} + s_W f^m \mathrm{S_W}^2$$

This formula can also be derived from theoretical considerations (Bussian, 1983) and leads to a reasonably successful model for arenaceous and argillaceous lithologies. The terms s_O, s_R and s_W referto conductivity as measured, conductivity of the matrix and conductivity of the medium (formation waters) respectively. The second term in de Witte's formula is identical to Archie's equation with a =1 and is only dependant of the conductivity of the pore water s_W. The first term is dependant on the conductivity of the matrix s_R, resulting specifically from the conductivity of cations in water bound between unit layers of the clay particles. The cementation factor m is related to the shape of particles in the rock matrix and takes on a value of 1.5 for spherical particles, increasing as the particles becomes less spherical.

The presence of clay will thus increase the conductivity measured over and above the conductivity dependant on Archie's law i.e., that due to pore water and porosity.

3) Interpretation Procedures

The following steps were followed in the processing and modelling of the data.

- The Zonge program SHRED was used to process data from raw dump files into a column based ASCII format.
- The Zonge program TEMAVG was used to average repeat readings.
- The TDEM sounding and location data was imported into the program called TEMIXXL as supplied by Interpex.
- Elevation data for each sounding position was degitized from 1:50000 topographical maps. GPS positional data was converted from WGS 84 Latitude and Longitude format into the local LO19 Transverse Mercator Swartzeck coordinate system based on a Bessel 1841 ellipsoid, 19^{o}E central meridian and a $22\,^{o}$S parallel.
- A number of data channels within each sounding curve, especially those close to or bellow the ambient noise level of ±1 μV, were masked. Masking removes data from any future consideration in the interpretation process. Noise at late time produces a voltage decay curve that flattens off. When converting the data from voltage to apparent resistivity, this late time flattening gives an erroneous descending branch, which can be incorrectly interpreted as a conductor at depth.
- Modelling was conducted using a four-layer inversion scheme. Forward, inverse, and equivalent models were calculated for each sounding.
- Modelling was also conducted using a 19-layer smooth inversion scheme, between depths of 5 to 500m, with the Occam's smoothing option switched off. The smoothing option was removed in an attempt to resolve subtle features in conductive areas of the sounding curve.

5.2.3 Survey Results

1) Resistivity Trends in the Stampriet Aquifer

A number of trends can be seen in the data, especially in the eight resistivity depth sections A to H, and the plan sections. Resistivity depth section C is shown in Fig.5.2-2 as an example and the resistivity pla sections at 1000, 900 and 800m AMSL are shown in Fig.5.2-3~ 5. These trends are categorized into effects of different order.

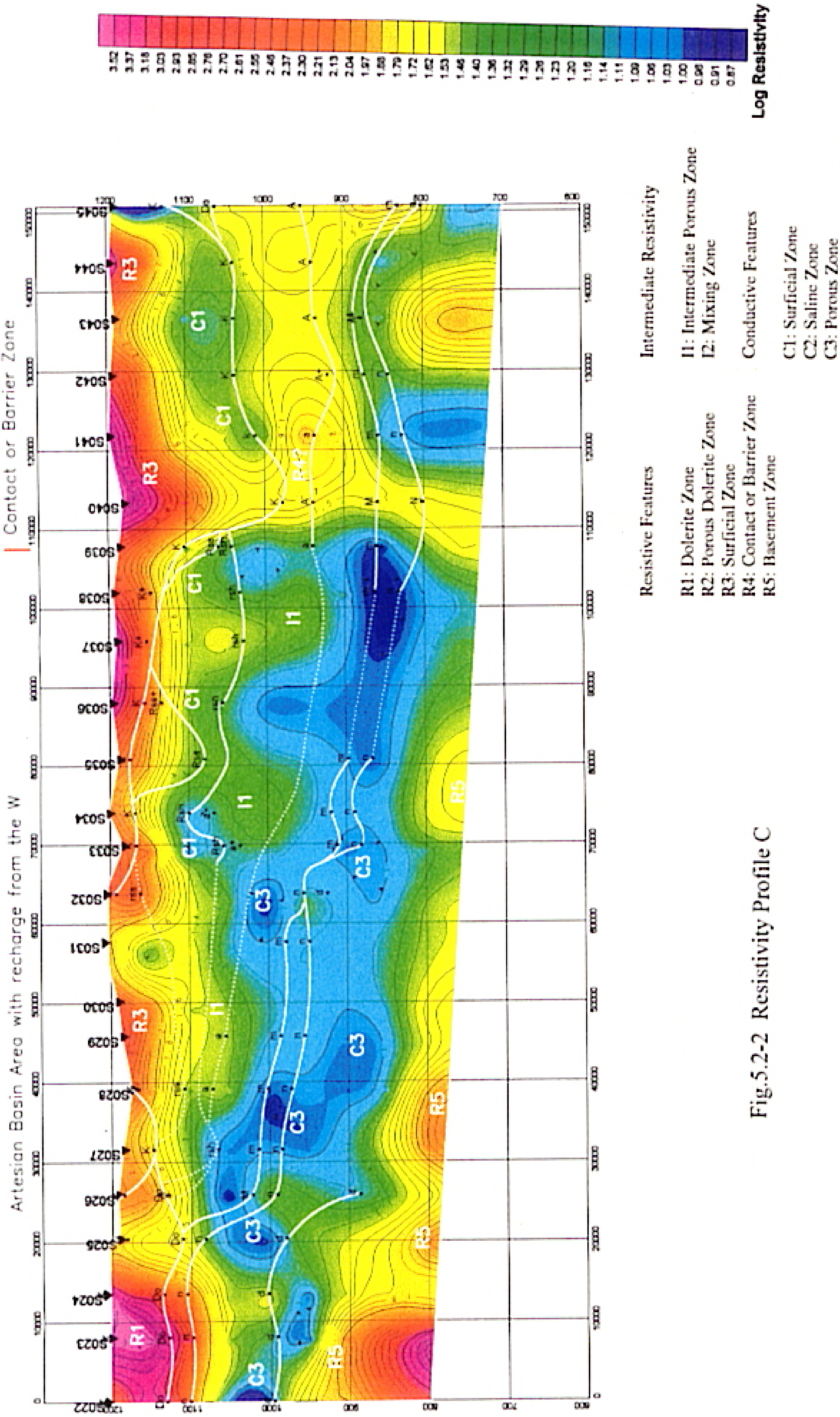

Fig.5.2-2 Resistivity Profile C