New airborne geophysical data from the Waterberg Coalfield – South Africa's major future energy source

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INTRODUCTION

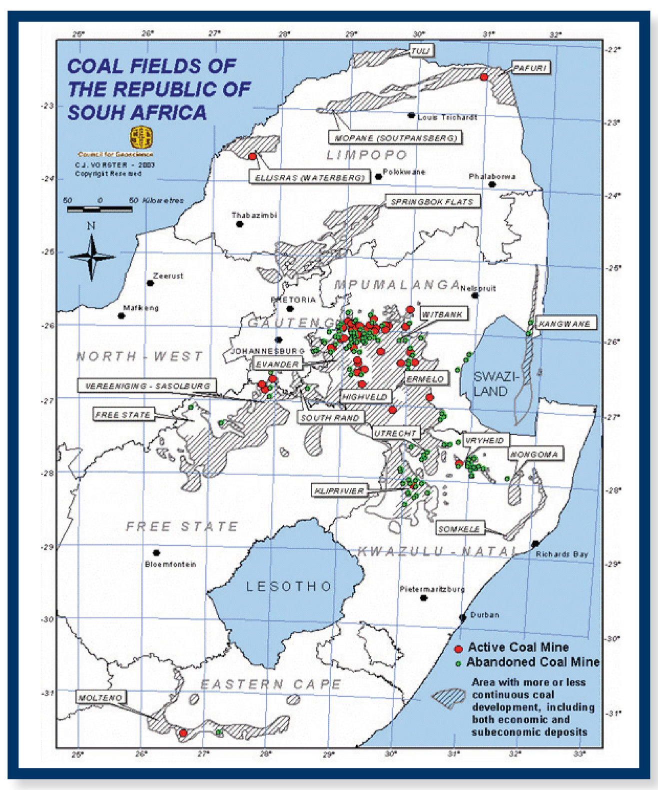

Figure 1: Spatial distribution of South African Coalfields (after CGS)

South Africa is highly dependent on coal to generate 75% of its electricity. The majority of this coal comes from the Witbank Coalfield, but this source will be exhausted in the next century (Prevost 2007). The Waterberg Coalfield (**Figure 1**) in the Limpopo province contains vast resources of coal and is the next area that will supply South Africa with energy well into the future. The coalfield is in the Karoo-age Ellisras Basin. Coal was discovered in the Basin in 1920, but little exploration was conducted since.

The Coaltech Research Association commissioned an airborne geophysical survey of the area to enhance the structural understanding of the basin. The magnetic and radiometric methods were applied. The datasets collected were:

- Magnetics
- Total count radiometrics (**Figure 2**)
- Uranium count radiometrics
- Thorium count radiometric
- Potassium count radiometrics
- Digital elevation model (DTM).

The magnetic susceptibility in the Ellisras Basin is low; however the application of a phase operator on this data (**Figure 3**) reveals a large amount of weakly-magnetised anomalies that could be due to pre-Karoo features in the basin floor. The radiometric data complemented the magnetic data by delineating the basin boundaries and indicated large block faulting.

IMPORTANCE OF THE STUDY

Eskom currently uses 110 million metric tonnes (Mt) of coal in its power stations per year (2007). Export coal is currently 70Mt and 50Mt is used for synthetic fuel (Prevost 2007). There is currently only one mine in the Waterberg Coalfield (GrooteGeluk), which is the sole supplier to the Matimba Power Station. The Medupi Power Station of similar size is currently under construction in the same area and will also source its coal from Grootegeluk, which could cause delivery capacity problems.

The Waterberg Coalfield's infrastructure raises various concerns and the precise location of the faults and structures will greatly impact on the estimation of both the shallow and deep coal resources. This has not been investigated to date. Information regarding the basement underneath the Waterberg will also help understanding the genesis of the basin.

GEOLOGICAL SETTING

The coal-bearing rocks belong to the Karoo Supergroup and were deposited between 260 and 190Ma ago. They formed as a large graben structure bounded by the following basin edge faults:

- In the north on older basin rocks (the Melinda Fault zone) that belong to the Limpopo mobile belt
- In the south with the Waterberg Group (Eenzaamheid and Ellisras Faults)
- Post Karoo faults (Daarby Fault) that disrupt coal seams.

The formation of the basin was controlled by structures that were formed and reactivated over time (Daarby Fault) and is the basis for the block faulting that occurs through the basin. To avoid confusion, the term 'Ellisras Basin' will be used for coal-bearing rocks (Johnson *et al.*, 2006a).

STRATIGRAPHY

The area covered by the geophysical investigation constitutes mainly the following geological terrains:

- The Limpopo Mobile Belt – highly metamorphosed gneiss which is 2700Ma (Kramer *et al.*, 2006)
- The Ellisras Basin – consist of Waterberg Group (Barker *et al.*, 2006) and the Karoo Supergroup (Johnson *et al.*, 2006b) and contains the coal. Most of it in the Grootegeluk Formation (110m thick in the south)
- Recent cover is from the weathering of gneiss of the Limpopo Mobile Belt and the Karoo rock in the north; but from Waterberg sandstones in the south
- Intrusive rocks – the most important of these rocks are those that cut through the coal-bearing rocks and disrupt the seams. They occur less frequently in the Ellisras Basin.

GEOPHYSICAL SURVEY

This survey was conducted in 2007 and covered eight 1:50 000 sheets. The survey was flown in a north-southerly direction at a 200m line-spacing. The flying height was 80m at a speed of 230km/h. The sampling frequency was 10Hz, implicating a measurement every 6.5m.

The survey was flown in blocks of 5km by 5km with a tie-line every 1km in an east-westerly direction. The purpose of the tie lines is to facilitate the levelling of the data. The magnetic data was collected with a caesium vapour magnetometer (resolution 100pT). The radiometric data was collected with an 80 litre NaI crystal and the elevation was measured using a laser altimeter.

The contact between the Limpopo Mobile belt and the Ellisras Basin can easily be seen on the magnetic data. It also shows the absence of strongly magnetised structures in the basin.

The total count radiometric data (**Figure 2**) shows the northern contact of the Ellisras Basin clearly. It also shows the large block faulting and radioactive material eroding from the source (Waterberg Sandstones) in the south into the sediment load of the north-flowing Mokolo River. These sandstones are mainly the feldspar-enriched kranskop sandstones, which indicate that the original source was granitic in composition. The source in the north is the gneiss of the Limpopo Mobile Belt.

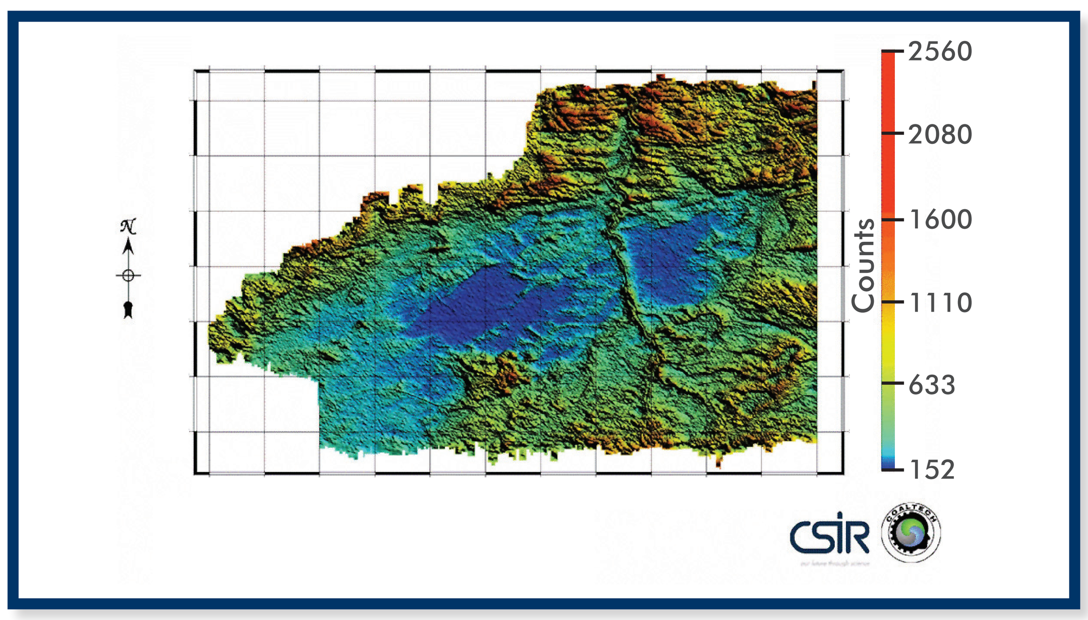

Figure 2: The total count radiometric data of the Waterberg Coalfield

The uranium count and the thorium count show a similar pattern. However, the concentrations are low. The higher thorium count suggests that the source of the radioactivity is much older; i.e. the current source is a second generation source.

The potassium count is the highest and maps the distribution of the radioactive isotope of Feldspar. The high concentrations are due to the sandstones, gneiss and granites in the area.

GEOPHYSICAL INTERPRETATION

A phase operator was calculated on the magnetic data (**Figure 3**). The enhanced data show all the smaller anomalies in the data. This confirms that the structure in the Ellisras Basin is either weakly magnetic or all structures are below the Karoo cover in the basement material (Waterberg).

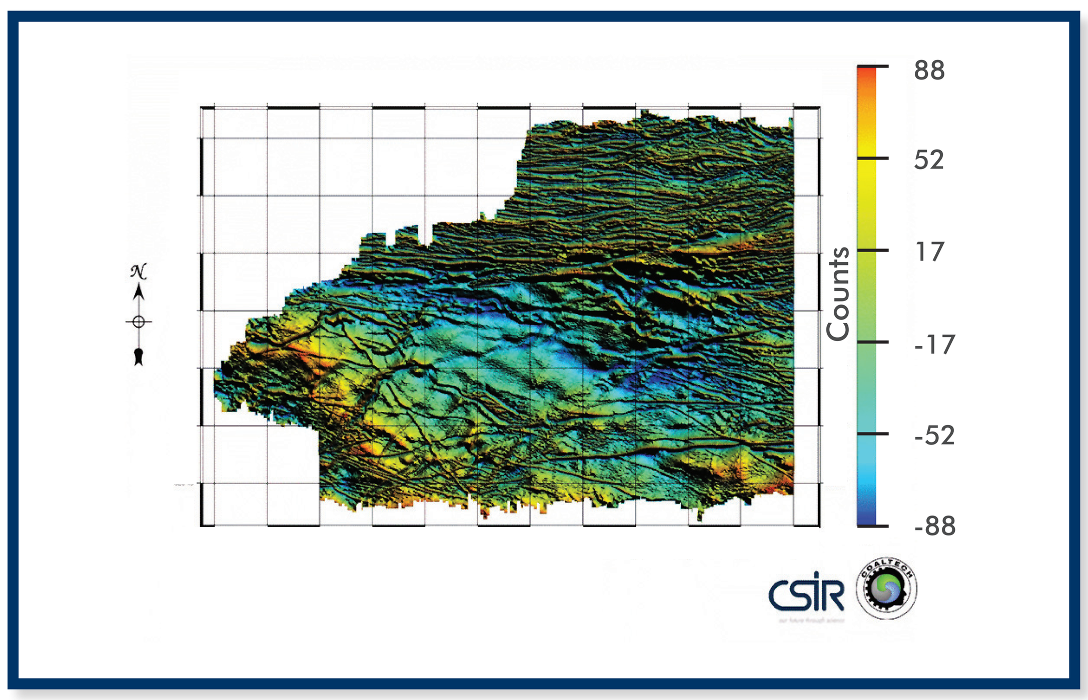

Figure 3: The phasemag image of the Waterberg Coalfield

Fieldwork indicated that dykes are scarce and highly weathered. The complete dataset was used to conduct a lineament interpretation (**Figure 4**). All interpreted dykes and faults were indicated.

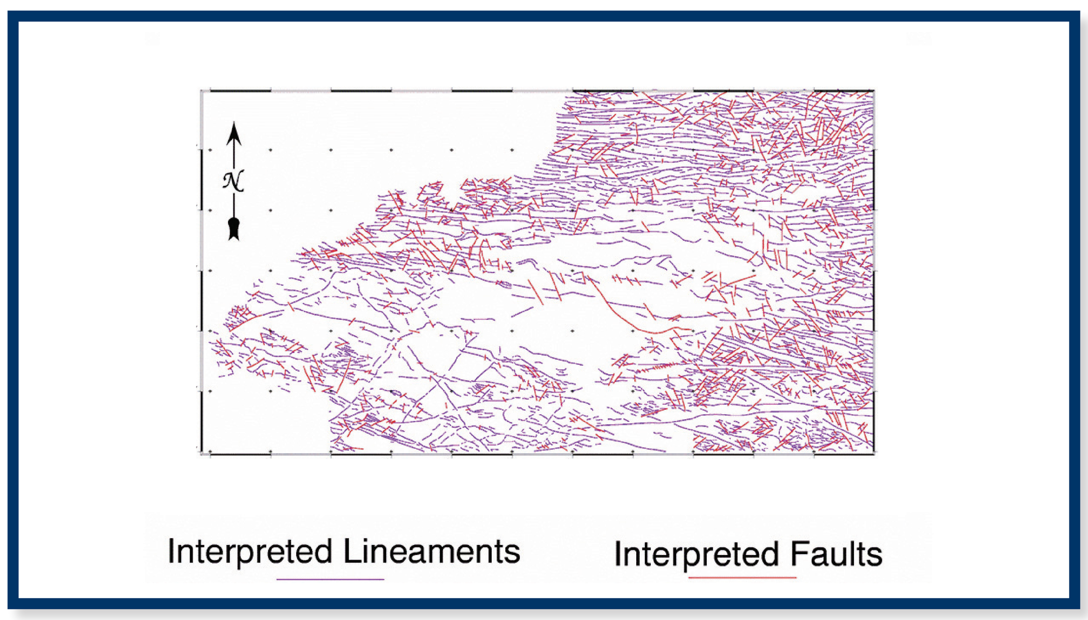

Figure 4: Waterberg Coalfield lineament interpretation of the phasemag data

A surface geology interpretation was done by using a ternary radiometric image. It was calculated by using potassium count in the 'red channel', total count in the 'green channel' and uranium count in the 'blue channel'.

PHYSICAL PROPERTIES

To conduct a credible geophysical interpretation and modelling, it is always necessary to sample the geology and measure the physical properties of the different lithologies. Samples were taken of the Karoo lavas (Letaba Basalt), Karoo sandstones (Molteno Formation) and Waterberg sandstones (Kranskop, Holkrans and Mogolakwena formations).

A specimen was taken from what we first believed was a Hydrothermal or Felsitic Dyke. Microscope studies showed that it is an iron rich pisolite with growth rings around a quartz nucleus. This means that the origin was not hydrothermal, but hygroscopic.

South Africa's current coal source will be exhausted in the next century – new airborne geophysical data sheds new light on an alternative energy source.

The physical properties show that the basalts and shale are magnetic and conductive. The sandstones are mostly non-magnetic. Densities of the shale and sandstones vary.

CONCLUSIONS

The airborne geophysical survey was a major contribution towards gaining knowledge about the Ellisras Basin. The data and the first interpretation have shown that the basin has undergone much more structural disturbance than what was previously suspected. The survey also revealed a large amount of previously unknown structure in the basin.

This poses the question - How many of these structures remain undetected because they are non-magnetic in nature? The question can most likely be satisfactorily answered by an airborne electromagnetic survey. This would produce much more additional data and greatly enhance the structural understanding of the Ellisras Basin. This will also ensure better coal delineation and ultimately better mining practices with a better coal recovery.

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