New airborne geophysical data from the Waterberg Coalfield

by C J S Fourie, CSIR, and G Henry

South Africa is highly dependant 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 [1].

The Waterberg Coalfield (Fig. 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 has been done since. Coaltech Research Association commissioned an Airborne Geophysical Survey of the area (Fig. 2), to enhance the structural understanding of the basin. Methods applied were the magnetic method and the radiometric method. The datasets collected were:

- Magnetics (Fig. 3)
- Total count radiometrics (Fig. 4)
- Uranium count radiometrics (Fig. 5)
- Thorium count radiometric (Fig. 6)
- Potassium count radiometrics (Fig. 7), and
- Digital elevation model (DTM) (Fig. 8)

The magnetic susceptibility in the Ellisras Basin is low; however the application of a phase operator on this data (Fig. 9) 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.

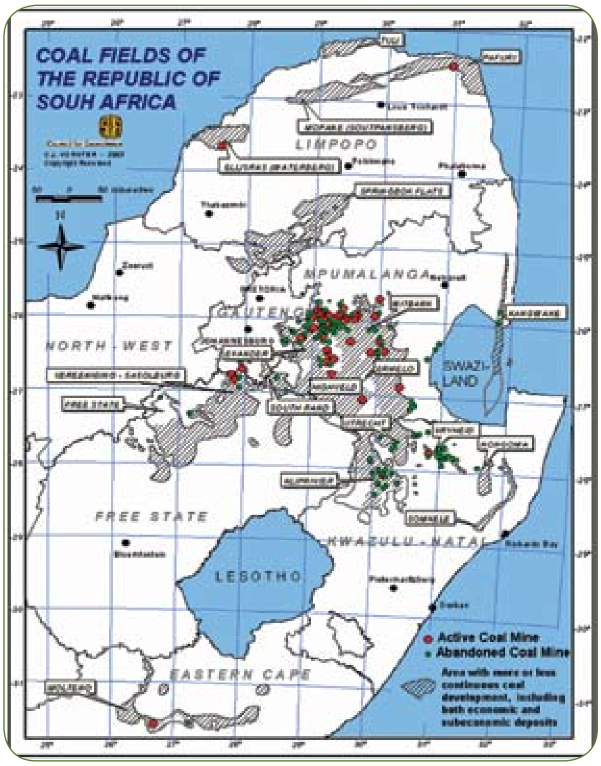

Fig. 1: Spatial distribution of South African coalfields (after CGS).

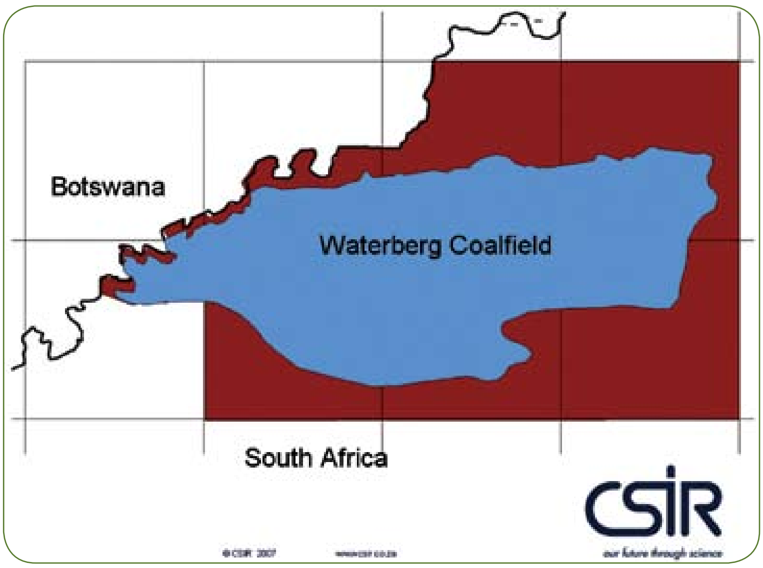

Fig. 2: The approximate extent of the Waterberg Coalfield is shown in blue. The red area shows the extent of the airborne geophysical survey.

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 70 Mt and 50 Mt is used for synthetic fuel [1]. There is currently only one mine in the Waterberg Coalfield (GrooteGeluk) and it is the sole supplier to Matimba Power Station. Medupi Power Station, of similar size, is currently under construction in the same area and will also source its coal from Grootegeluk, which may cause delivery capacity problems.

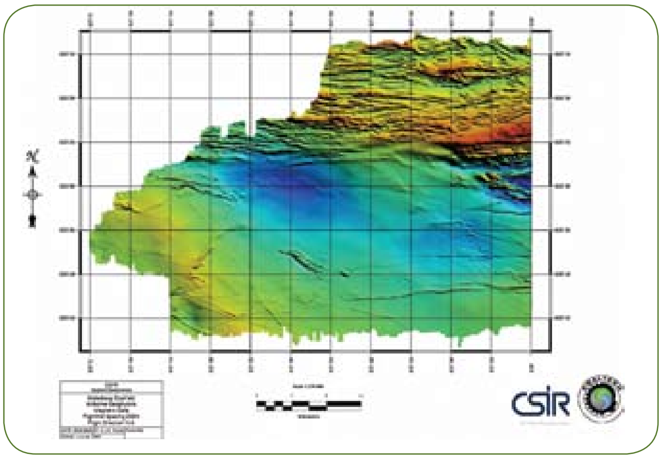

Fig. 3: Magnetic data of the Waterberg Coalfield.

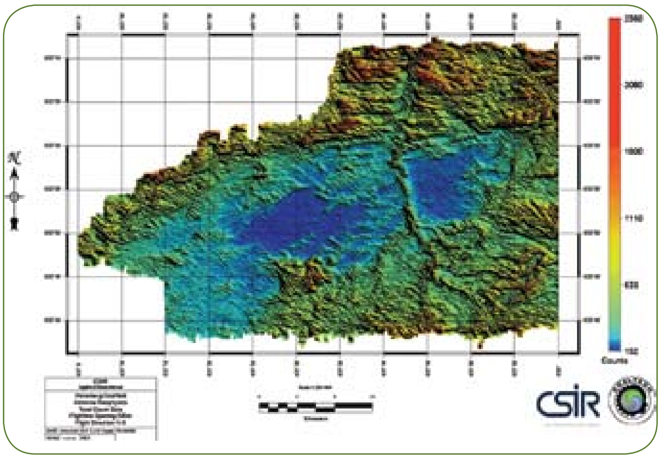

Fig. 4: The total count radiometric data of the Waterberg Coalfield.

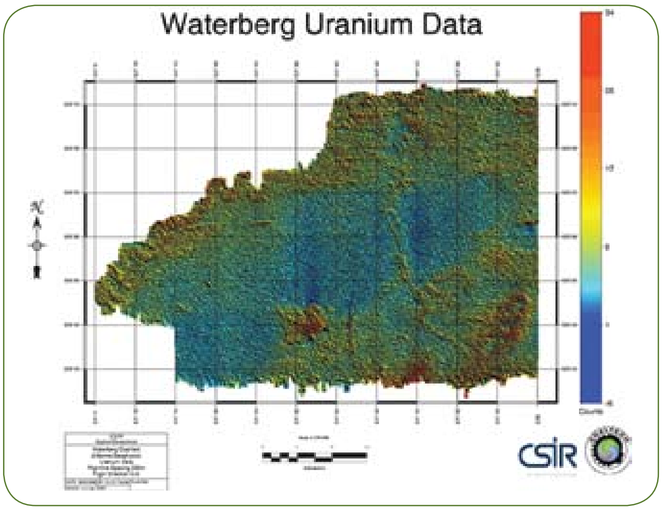

Fig. 5: The uranium count data of the Waterberg Coalfield.

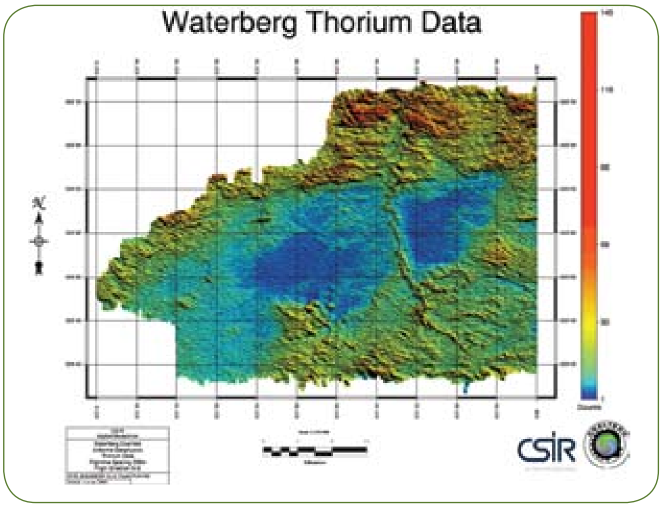

Fig. 6: The thorium count data of the Waterberg Coalfield.

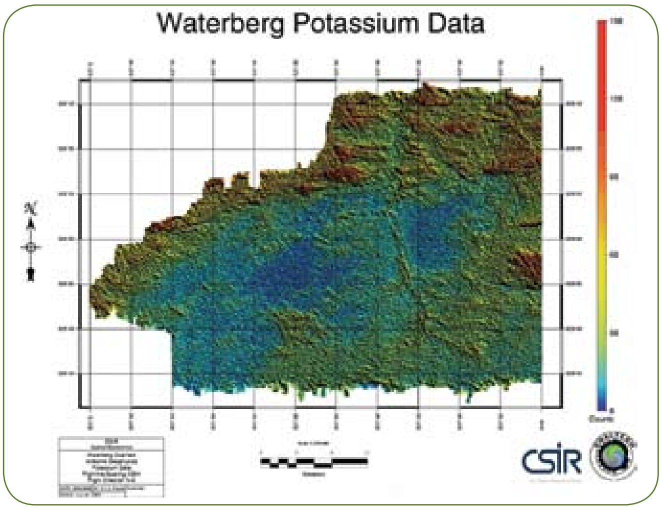

Fig. 7: The potassium count data of the Waterberg Coalfield.

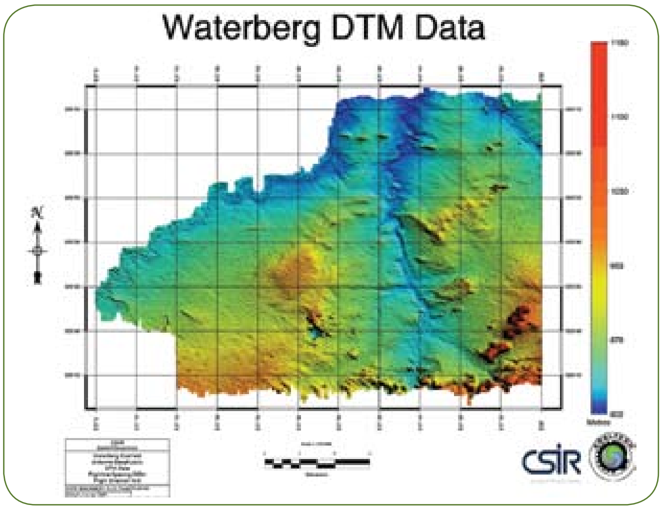

Fig. 8: The DTM data of the Waterberg Coalfield.

The Waterberg Coalfield is highly faulted and all the structures and their effects have not been identified and studied to date. Precise location of the faults and structures will greatly impact on the estimation of both the shallow and deep coal resources, by removing some of the uncertainty regarding the coal resources. Information regarding the basement underneath the Waterberg will also help with the genesis of the basin.

Geological setting

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

- In the north on older basin rocks (Melinda Fault zone) that belong to the Limpopo Mobile belt.
- In the south with the Waterberg Group (Eenzaamheid and Ellisras Faults).

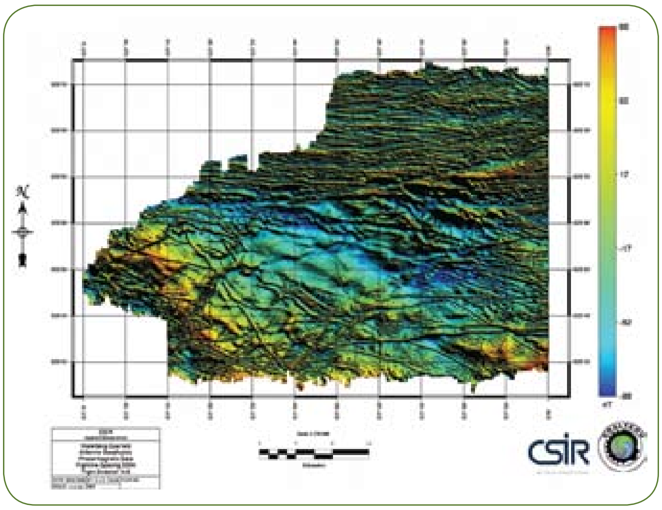

Fig. 9: The phasemag image of the Waterberg Coalfield.

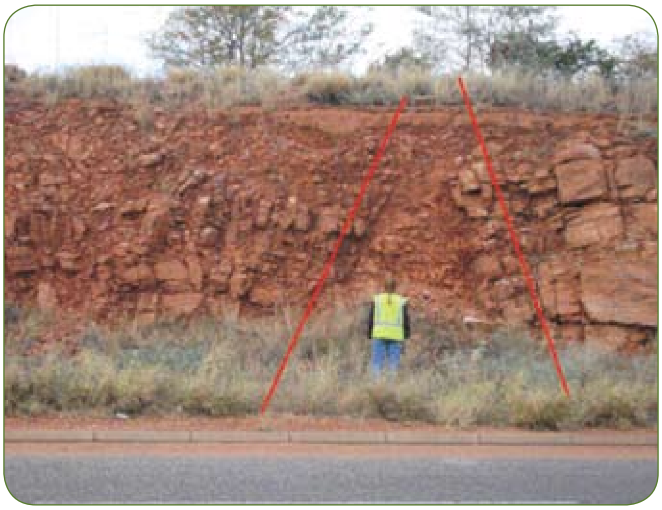

Fig. 10: Totally weathered dyke indicated between red lines.

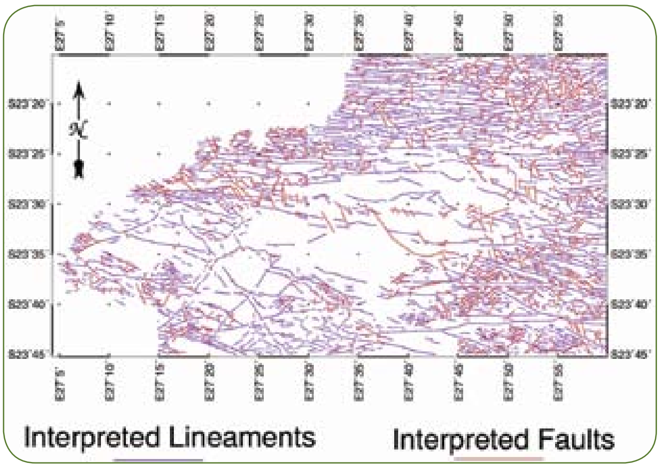

Fig. 11: Waterberg Coalfield Lineament interpretation of the phasemag data.

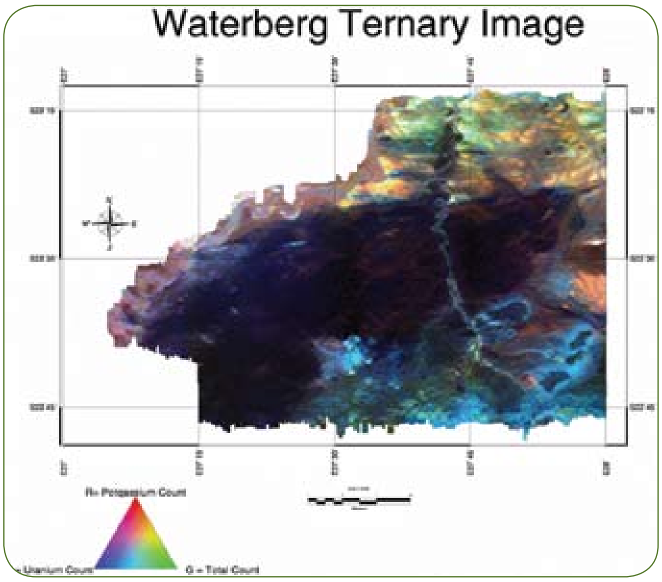

Fig. 12: Ternary image of the Waterberg Coalfield. The red channel is the potassium count. The green channel is the total count and the blue channel is the uranium count.

- 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 with regards to the coal-bearing rocks [2].

Stratigraphy

The area covered by the geophysical investigation, constitutes mainly of three geological terrains:

- *The Limpopo Mobile Belt:* Highly metamorphosed gneiss which is 2700 Ma [3].
- *The Ellisras Basin:* Consists of Waterberg Group [4] and the Karoo Supergroup [5] and contains the coal. Most of it in the Grootegeluk Formation (110 m 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

The survey was conducted in 2007, and covered eight 1:50 000 sheets. The survey was flown in a north-south direction at a 200 m line spacing. The flying height was 80 m at a speed of 230 km/h. The sampling frequency was 10 Hz, implicating a measurement every 6,5 m.

The survey was flown in blocks of 5 by 5 km with a tie line every 1 km in a east-west direction. The purpose of the tie lines is to facilitate in the levelling of the data. The magnetic data was collected with a caesium vapour magnetometer (resolution 100 pT). The radiometric data was collected with 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 (Fig. 3). It also shows the absence of

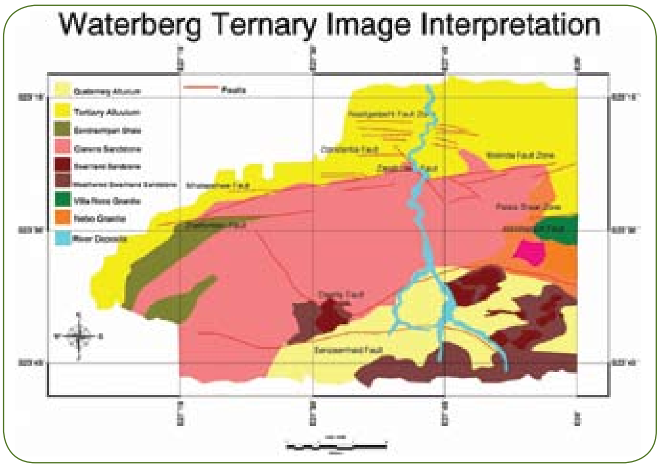

Fig. 13: Surface geology interpretation of the Waterberg Coalfield. The interpretation was done from the Ternary image.

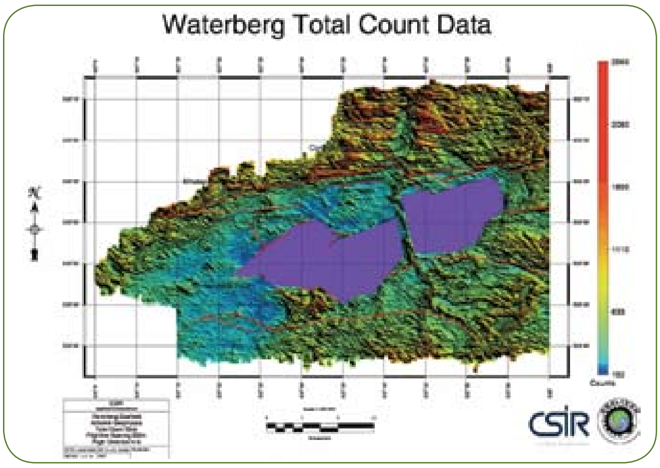

Fig. 14: Block entities in the Waterberg Coalfields due to previous faulting (Block faulting).

strongly magnetised structures in the basin.

The total count radiometric data (Fig. 4) shows the northern contact of the Ellisras Basin clearly as well as the large block faulting. It also showed 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.

The uranium count (Fig. 5) and the thorium count (Fig. 6) show a similar pattern. The concentrations are just low. The higher thorium count suggests that the source of the radio activity is much older; i.e. the current source is a second generation source.

The potassium count (Fig. 7) 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 (see Fig. 9). This enhanced the data to show all the smaller anomalies in the data. This confirms the idea that the structure in the Ellisras Basin is either weakly magnetic, or all structure is below the Karoo cover in the basement material (Waterberg).

Fieldwork indicated that dykes are scarce and highly weathered (Fig. 10). The complete dataset was used to do a lineament interpretation (Fig. 11). All interpreted dykes and faults were indicated.

A surface geology interpretation was done by using a ternary radiometric image (Fig. 12). It was calculated by using potassium count in the "red channel", total count in the "green channel" and uranium count in the "blue channel". The interpreted surface geology is shown in Fig. 13. The major interpreted block faulting is shown in Fig. 14.

Physical properties

To do 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) (Fig. 15).

A specimen was taken from what we first believed was a hydrothermal or felsitic dyke (Fig. 16). Microscope studies showed that it is an iron rich pisolite with growth rings around a quartz nucleus. This means that origin was not hydrothermal, but hygroscopic.

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

Conclusions

The airborne geophysical survey was a major contribution towards the knowledge of 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 showed 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. It will produce much more additional data that will greatly enhance the structural understanding of the Ellisras Basin. This will ensure better coal delineation and ultimately better mining practices with a better coal recovery.

Acknowledgement

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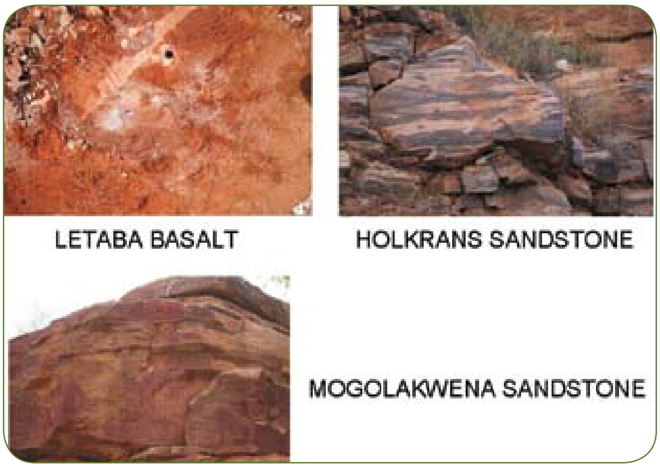

Fig. 15: Examples of geology formations of the Waterberg Coalfield.

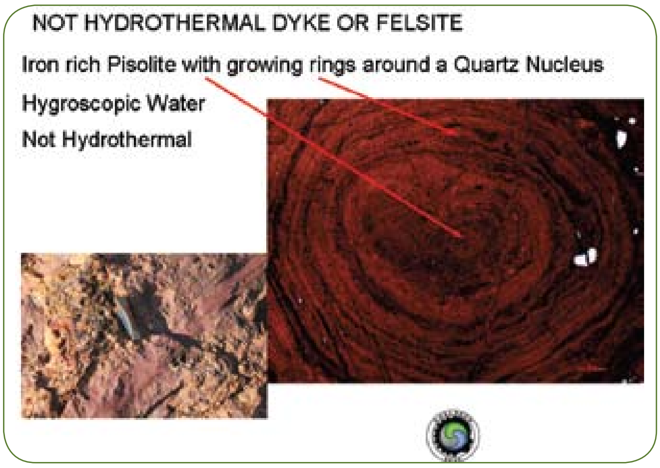

Fig. 16: Pisolite structure discovered in the Waterberg Coalfield.

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