REPUBLIC OF SOUTH AFRICA

COALBED METHANE RESOURCE POTENTIAL OF THE NORTHERN KAROO BASINS

The Karoo Basin contains the major coal resources of South Africa, although significant deposits are also present in the subsidiary basins to the north of the main Karoo Basins. Coal seams are hosted in early to late Permian and Triassic-aged rocks of the Karoo Supergroup. Overall, South Africa's coal deposit occur in 18 coalfields distributed across the Main Karoo Basin and extensional rift-related sub-basins (Fig. 1). Coals are predominantly high to medium volatile bituminous rank, and there is a general trend of increasing rank from west to east, across South African coalfields (Cairncross, 2001). Many of the coalfields in South Africa have been extensively explored and exploited, those in the north of the country have until recently received much less attention and have been the focus of recent exploration interest due to the presence of large coking and thermal coal resources, as well as for their coalbed methane potential.

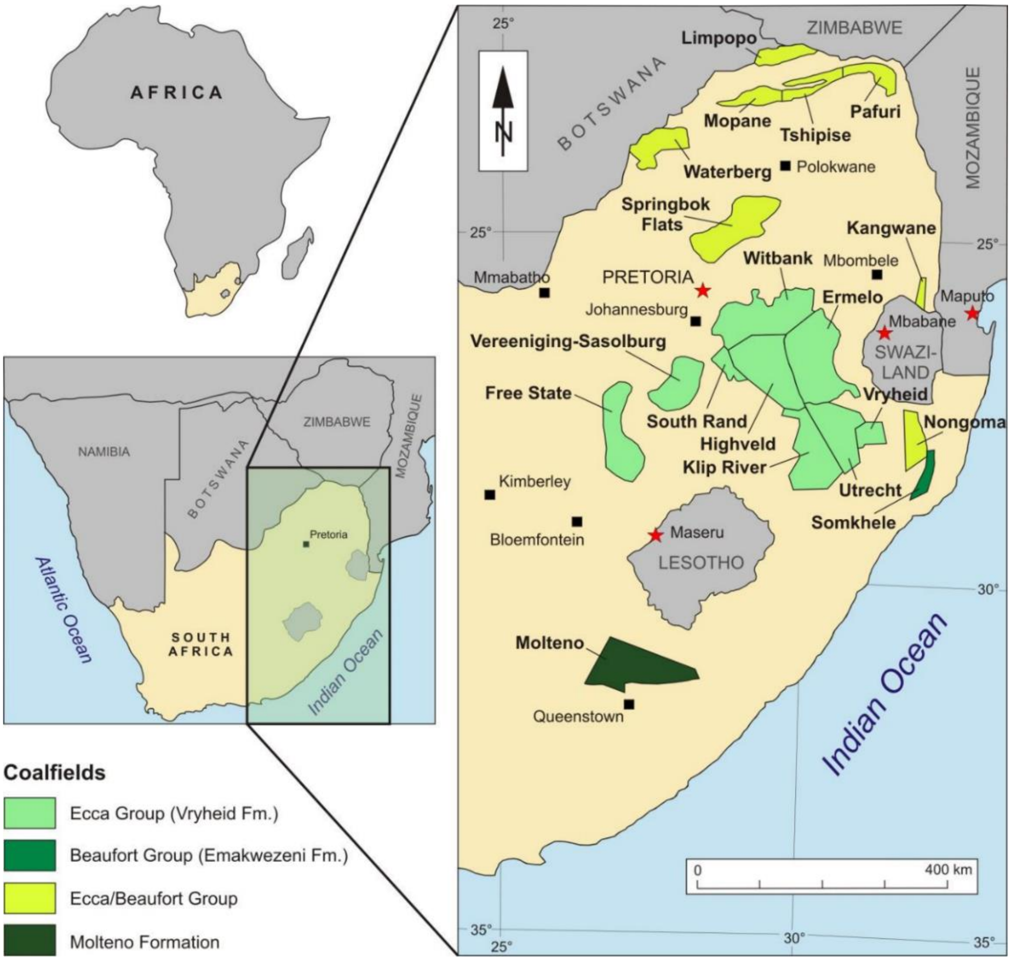

Figure 1: Distribution of coalfields across the main Karoo Basin and extensional subsidiary basins (Hancox et al. 2014).

Table 1: Parameters influencing CBM potential for the coalfields of South Africa based on resource evaluation by Petroleum Agency SA.

Geological Parameters	Assessment of CBM Resource Potential of the Karoo-aged sub-basins					
Coalfields	**Springbok Flats**	**Lephalale**	**Mopane**	**Tshipise-Pafuri**	**Tuli**	**Ermelo**
Depth of burial	>600	>400	>100	>100	>200	>200
Thickness of Individual Seams	2 - 8	3 - 9	0.5 - 5	0.5 - 6	1.5 - 5	1.5 - 4
Net Coal Thickness (m), Max.	18	61	39	30	21	24
Gas Content (scf/ton)	105	102	275	285.8	95	98
Gas In Place (Tcf)	2	3.5	1.9	1.6	1.4	2.4
Rank	Bituminous	Bituminous	Bituminous	Bituminous	Bituminous	Bituminous
Percentage Vitrinite	V=70-90%	V>90%	V=70%	V=70%	V>90%	No data
External Factors						
Dolerite alteration	low	low	low	low	low	moderate to high
Access to markets	moderate	poor	poor	poor	poor	good

Based on empirical analysis of coal exploration core holes and proximate analysis data, the Petroleum Agency SA deterministically estimated gas-in-place resources (Table 1). The deterministic estimates provide an indication of the estimated volumes of hydrocarbons present in known structures. The values are in-place volumes calculated as the Best Estimate scenario. However, it is expected that the estimated volumes of gas-in-place will change over time as new exploration data becomes available. The section below provides an overview of the CBM resource potential of the prospective basins based on Agency resource evaluation for each basin.

Lephalale Basin is the country's most promising target for CBM exploration at present. The basin's Grootgeluk Formation coals in the northeastern parts of the basin have good CBM potential, buried to depths of greater than 400 m, are up to 61 m thick (net coals) and have a high vitrinite content. More than 110 exploration core holes drilled and a single 5-spot pilot production wells. On the basis of the reservoir parameters used in our estimation process, the Agency's evaluation with the assumption that coal is gas saturated suggests that coals in the Lephalale basin has a gas storage capacity (gas-in-place) in the order of 4 Tcf. Anglo Thermal Coal has reported a technical recoverable reserve at 1 trillion cubic feet.

Springbok Flats Basin is largely untested, and contains appreciable quantities of coal and potentially significant quantities of natural gas that may be associated with the coal. The basin has thick coal seams which are buried at greater depths (>600 m) with resulting overburden pressure. Based on empirical analysis of coal exploration core holes and proximate analysis data, the Agency deterministically estimated a gas-in-place resource in the order of 2 trillion cubic feet.

Mopane sub-basin in the Soutpansberg Basin is considered favourable for the occurrence of CBM due to the presence of extensive coal deposits and depths adequate for CBM development and preservation. Exploration results for the basin indicate coal-shale sequences up to 130 m thick, with net coal up to 39 m and buried to depths greater than 100m below surface. The coal seams are similar in quality and formation to those that have been successfully developed in the nearby Lephalale Basin. Based on empirical analysis of coal exploration core holes and proximate analysis data, a deterministically estimated gas-in-place resource in the order of 1.2 Tcf. Recent exploration efforts based on newly drilled wells suggests a resource potential best Estimate GIP of 1.9 Tcf for the basin (Umbono in joint venture with Sunbird Energy).

Tshipise-Pafuri sub-basin in the Soutpansberg Basin also considered favourable for the occurrence of CBM due to the presence of extensive coal deposits and former Exxaro's Tshikondeni Colliery, which produced premium hard coking coal. Potential mineable composite coal seams (or zones) have been identified within the 30-40 m thick carbonaceous zone. Our evaluation with the assumption that coal is gas saturated suggests that coals in the sub-basin has a gas storage capacity (gas-in-place) in the order of 1.6 Tcf. An interpretation of the data in this region suggest that individual coal individual seams may vary in thickness over short distances; could be absent from the total package at the locality or the individual seams are discontinuous over short distances.

Tuli Basin is considered favourable for the occurrence of CBM due to the presence of coal deposits. The coal seams are reported to be buried to a depth greater than 200 m, with average net thickness of up to 21 m in places. Although the coal interval is thinner and more restricted in extent than the equivalents in the main Karoo Basin, the coal component is usually bright and brittle with a high proportion of vitrinite. A potential gas-initially-in-place resources for the Permian coal interval in the studied area in the southern Tuli Basin has a best estimate of 1.4 Tcf. The coal thickness and depth are adequate for the storage of large volumes of gas.

Ermelo coalfield comprises of Amersfoort gas project which is also the most promising target for CBM production, and the area is nearby existing coal based energy and power generation infrastructure and within close proximity to major industrial, mining and manufacturing areas. Average depths to the most significant coal seams are reported to be greater than 200 m and coal thicknesses range from less than 1 m to 16 m. The coals vary in rank from high volatile bituminous to medium bituminous. Afro Energy (joint venture between Badimo Gas and Kinetiko Energy) have drilled 21 exploration core holes and estimated P50 prospective resources to be approximately 2.4 Tcf of gas-in-place.

Highveld Coalfield is known to hosts a low-grade bituminous coal with relatively high ash contents than the northern Karoo-aged sub-basins, containing a valuable percentage of South Africa's coal consumed in power stations and for the production of syn-fuels. The coalfield is considered favourable for the occurrence of coalbed methane (CBM) due to the presence of coal deposits that remain inaccessible by conventional mining operations. The coalfield is structurally undeformed, although post depositional intrusion of dolerite dykes and sills throughout the coalfield have compartmentalised the coal seams. Average depths to the most significant coal seams range from < 200 to 300 m and coal thicknesses range from < 0.5 to 8 m. Based on our evaluation, the coal in the Highveld Coalfield potentially host gas-initially-in-place resources in the order of 2.5 Tcf.

CBM resource potential in the northern Karoo basins is largely defined based on coal thicknesses, historical presence of gas in coal exploration boreholes and coal quality. The most significant exploration work conducted in the northern Karoo Basin has occurred in the Lephalale, Mopane and Ermelo coalfields, where a technically recoverable CBM resource is reported. Other prospective areas for CBM development at present are considered highly prospective with well documented, gassy coal measures and with gassy sandstones overlying the coal horizons.

REFERENCES

Cairncross, B. (2001). An overview of the Permian (Karoo) coal deposits of southern Africa. *Journal African Earth Sciences*, **33**, 529-562pp.

Hancox, P.J., Götz, A.E. (2014). South Africa's coalfields – A 2014 perspective. *International Journal of Coal Geology* **132**, 170-154 pp.