

# REPUBLIC OF SOUTH AFRICA

## PETROLEUM POTENTIAL OF THE KAROO BASINS



### The Karoo Basins

The Karoo basins of southern Africa record 100 million years of sedimentation in the heartland of the supercontinent Gondwana, in a range of depositional environments. The erosional remnants of the Main Karoo Basin cover approximately 700 000 km<sup>2</sup> of southern Africa today (see map overleaf), and together with sediments in subsidiary Karoo-aged basins, these rocks play host to the majority of the South Africa's onshore fossil fuel reserves.



Following initial petroleum exploration in the Karoo Basin during the 1960s and 1970s, the focus of exploration activities eventually shifted offshore, due to the perceived low potential for large conventional oil plays onshore. However, the global success of recent technological developments (particularly reservoir fracturing and horizontal drilling) in recovering petroleum from low permeability reservoirs, combined with the emergence of natural gas as an economically viable fossil fuel, has led to renewed interest in the petroleum potential of Karoo sediments, and the emergence of the Karoo Basin as an important exploration target in South Africa.



Current petroleum exploration activities in the Karoo are focused on three unconventional play types: shale gas, coalbed methane and biogenic gas, although the potential for conventional hydrocarbon plays also exists.

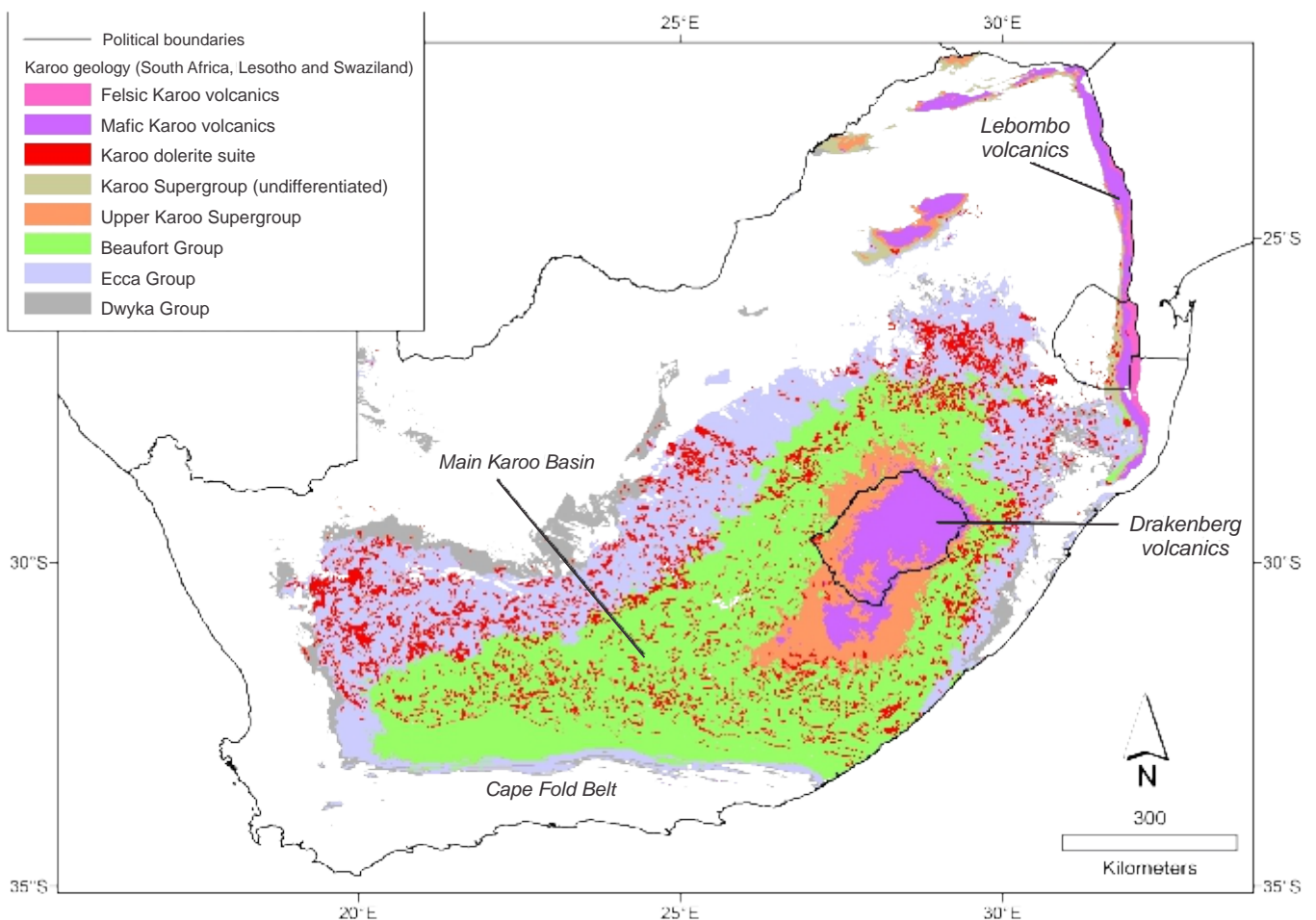
## Shale gas

Gas shows were discovered in the southern Karoo several decades ago, and are indicative of an active petroleum system. Whilst shale gas exploration in the Karoo is still in its infancy, the limited available data suggests that the Karoo Basin has good shale gas potential.

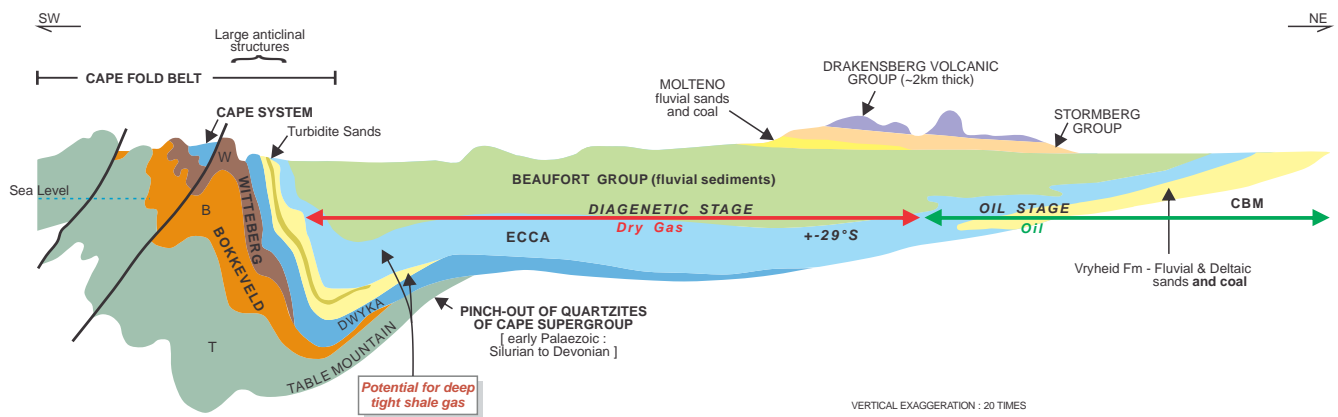
The Whitehill Formation of the Ecca Group in the southern Main Karoo Basin is of particular interest, and satisfies all the basic requirements for a successful shale gas play: it is rich in organic matter, it is thermally mature, it has a high silica content and it is deeply buried. Geophysical surveys (e.g. Branch et al. 2007) and legacy well data also suggest stratigraphic continuity for the Whitehill Formation. On the other hand, there are geological complexities in the basin that may present challenges for

successful shale gas exploitation, including the presence of numerous fractured dolerite dykes and sills and the existence of carbonates at some stratigraphic levels.

The shale gas resource of the Karoo Basin is currently unknown, due to the scarcity of relevant geoscientific data, but preliminary model estimates of the technically recoverable resource range from ~30 Tcf to ~500 Tcf (Decker, 2011; Kuuskraa et al., 2011). A significant uncertainty in estimating the size of the resource is gas content, and favourable flow rates are required for exploitation of the potential shale gas play in the Karoo to be economically viable. A major investment in the infrastructure of this remote and arid region of South Africa will also be required.



Above: Geological map of the Main Karoo Basin and surrounding Karoo-aged sedimentary sub-basins and volcanic outliers in South Africa, Lesotho and Swaziland, modified from Vorster (2001). Opposite page: SW-NE schematic cross section of the Main Karoo Basin, according to a foreland basin model (e.g. Johnson et al., 1997).



## Coalbed methane

There is great interest in the coalbed methane (CBM) potential of South Africa's Ecca Group coal deposits in the north-eastern Main Karoo Basin and in the northern subsidiary basins. The optimal requirements for the production and reservoiring of CBM are that the coal should be high vitrinite, low ash variety, with a porosity of 10-15% and a permeability of 1-10 mD. The coal seam should have a minimum thickness of 1.5m and be buried to a depth greater than 200m, although preferably greater than 600m.

As such, the Waterberg/Ellisras Basin is the country's most promising target for CBM exploration at present. The Ellisras Basin's Grootgeluk Formation coals in the north-eastern parts of the basin have good CBM potential, as they are buried to depths of >300 m, are suitably thick and have a high vitrinite content. Whilst it has been speculated that a resource on the order of ~1 Tcf may exist (e.g. Lloyd, 2008), the size of this resource remains poorly constrained. This is due to both the paucity of suitable gas content data and the fact that the tonnage of the methane-bearing coal remains unknown, due to structural and stratigraphic complexities within the basin.

Other coalfields in South Africa that are considered to have a promising but unproven CBM potential include the deposits of the extensive Springbok Flats sub-basin, and the deposits of the Soutpansberg and Amersfoort coalfields. Challenges to the

CBM potential of some South African coals include inconsistently developed coal thicknesses, thermal alteration by dolerites, thin seams and sometimes low porosity and permeability.



## Biogenic gas

For decades, the methane encountered in underground gold mining of the Archean Witwatersrand Basin in the Free State and Evander gold fields was regarded only as a mine explosion hazard and was flared in large quantities accordingly. Hugo (1963) discusses the early record of CH<sub>4</sub> and He emitted from these underground mines and from the associated gold exploration boreholes.

Gas encountered within the coal-bearing Karoo strata in the region is in fact believed to have migrated from the underlying Witwatersrand Basin. The Witwatersrand methane, in turn, is considered to be biogenic in origin (Ward et al., 2004), and is thus constantly replenished. This former mining hazard may therefore become a potentially renewable future energy source for South Africa.

A number of exploration companies are now investigating if the methane of the Free State, Smaldeel and Evander gas fields can be turned to commercial advantage. Most recently, an application for a gas production right has been received by the Petroleum Agency.

Given the unusual nature of this unconventional biogenic play, it is not possible, as yet, to quantify the volume of the technically recoverable gas resource. However, local gas shows at surface have been known to burn for years without showing any evidence of depletion.



## REFERENCES

- Branch, T., Ritter, O., Weckmann, U., Sachsenhofer, R.F. and Schilling, F., 2007. The Whitehill Formation - a high conductivity marker horizon in the Karoo Basin. *South African Journal of Geology* 110 (Special Inkaba ye Afrika volume), 465-476.
- Decker, J.E., 2011. Preliminary shale gas resource scenarios for the Karoo Basin. Internal PASA Report FG-J04, 7 pp.
- Hugo, P.J., 1963. Helium in the Orange Free State Gold-Field, *Geological Survey Bulletin* 39, 28 pp.
- Johnson, M.R., Van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H. De V., Christie, A.M.D. and Roberts, D.L., 1997. The Foreland Karoo Basin, South Africa. In: Selley, R.C. (ed.): *African Basins - Sedimentary Basins of the World* 3, Elsevier (Amsterdam), p. 269-317.
- Kuuskraa, V., Stevens, S., Van Leeuwen, T. and Moodhe, K., 2011. World shale gas resources: An initial assessment. Prepared for: United States Energy Information Administration, 2011. *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States*. Available at: <http://www.eia.doe.gov/analysis/studies/worldshalegas>.
- Lloyd, P., 2008. Reported in: "Waterberg is a haven for coalbed methane." *TradeInvest SA*, 10 September 2008, URL: <http://www.tradeinvestsa.co.za/news/746454.htm>.
- Vorster, C.J., 2001. Metallogenic Map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland, at a scale of 1: 1 000 000, available on CD-ROM. Council for Geoscience, Pretoria.
- Ward, J.A., Slater, G.F., Moser, D.P., Lin, L.H., Lacrampe-Couloume, G., Bonin, A.S., Davidson, M., Hall, J.A., Mislouack, B., Bellamy, R.E.S., Onstott, T.C., and Sherwood Lollar, B., 2004. Microbial hydrocarbon gases in the Witwatersrand Basin, South Africa: Implications for the deep biosphere. *Geochimica et Cosmochimica Acta* 68 (15), 3239-3250.

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