PS The Interrelationship between Coalbed Methane and Produced Ground Water in the Lephalale Basin, South Africa*

Z. Gxaba[1], T. Kanyerere[2], and K. Pietersen[3]

Search and Discovery Article #80573 (2016)**
Posted December 26, 2016

*Adapted from poster presentation given at AAPG 2016 Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016

[1]Petroleum Agency SA (gxabaz@petroleumagencysa.com)
[2]University of Western Cape, South Africa (tkanyerere@uwc.ac.za)
[3]SLR Consulting, Durbanville 7550, South Africa (kpietersen@slrconsulting.com)

Abstract

Methane gas production from unconventional resources has gained increased prominence worldwide. In South Africa, prospective regions for Coalbed Methane (CBM) exploration are Ellisras (Lephalale) Basin, Springbok Flats Basin and the Amersfoort Coalfield in Ermelo. This research focuses on examining the petroleum system, water system and in developing a conceptual hydrogeological model to demonstrate the interdependency of Coalbed Methane and produced groundwater in Lephalale. The hydrochemical analysis approach was used to assess the water quality by detailed assessment of major constituents, total dissolved solids, dissolved gases and trace elements in produced ground water. Historical data was used in order to understand the factors controlling the gas incline and water decline production curves. Results and data from this research have contributed to a greater understanding of interrelationship between Coalbed Methane production rates and groundwater. Comparing these results with global trends in Coalbed Methane development indicates that the identified study area has great potential for Coalbed Methane. Economical production of Coalbed Methane in other coal bearing Karoo basins requires an integrated study of the factors controlling accumulation of the gas, a detailed assessment of salinization levels and an understanding of technological and environmental difficulties encountered during gas production.

References Cited

Aravena, R., S.M. Harrison, J.F. Barker, H. Abercrombie, and D. Rudolph, 2003, Origin of methane in the Elk Valley coalfield, southeastern British Columbia, Canada: Chemical Geology, v. 195/1,p. 219-227.

Fourie, C.J.S., G. Henry, and L.P. Maré, 2009, The structure of the Karoo-age Ellisras Basin in Limpopo Province, South Africa in the light of new airborne geophysical data: a preliminary report: 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16-18 September 2009, p. 27-32.

Fourie, C., G. Henry, and L. Maré, 2014, The Structure of the Karoo-age Ellisras Basin: South African Journal of Geology, v. 117/2, p.207-224.

Hancox, J.P., and A.E. Gotz, 2014, South Africa's coalfields - A 2014 perspective: International Journal of Coal Geology, v. 132, p. 170-254, Web Accessed December 17, 2016, http://kpfu.ru/portal/docs/F409362698/Goetz_2014a.pdf.

Wagner, N., and M.T. Tlotleng, 2012, Distribution of selected trace elements in density fractionated Waterberg: International Journal of Coal Geology, v. 94, p.225-237.

The Interrelationship between coalbed methane and produced groundwater in the Lephalale Basin, South Africa

Z.Gxaba[1], T.Kanyerere[2] and K.Pietersen[3].

[1]Petroleum Agency SA (gxabaz@petroleumagencysa.com), [1,2]University of Western Cape, South Africa (tkanyerere@uwc.ac.za),
[3]SLR Consulting, Durbanville 7550, South Africa (kpietersen@slrconsulting.com).

Introduction

The global energy demands make the exploration for coal bed methane (CBM) plays in frontier areas attractive. The recent energy shortfall in South Africa provides a new impetus for the development of an expanded natural gas industry. Commercial development and production of methane from coal is well-known in many countries around the world such as USA, Canada, Australia, China and India, by comparison, the development of this type of unconventional natural gas in South Africa is still immature. However, exploration for coal and more recently coalbed methane in the Lephalale basin and further in the north eastern limits of the Main Karoo basins (Fig.1) has increased our knowledge and understanding of coal as a source and reservoir for methane. The development of unconventional natural gas resources is faced with environmental, socio-economy and many uncertainties that surround the interdependencies between energy development and water resource protection. The quality and availability of groundwater resources can be vulnerable to impacts from energy development, particularly in conjunction with water scarcity concerns.

Groundwater must be abstracted to lower the reservoir pressure and initiate methane desorption. This raises many water-related concerns including lowering of the groundwater potentiometric surface; groundwater contamination incidents and high salt concentrations in CBM co-produced water. Understanding the water-energy nexus is critical to our country's development. We focus on the Lephalale Basin which is a water-scarce area but earmarked by large-scale energy and mining projects. The purpose of this study is to understand the factors controlling the reservoir characteristics and how it relates to the behaviour of the gas incline –water decline model.

Geological background

The Lephalale Basin is a half-graben structure that is associated with the Main Karoo deposits aged between Late Carboniferous to Mid Jurassic (320 -180 Ma). The airborne geophysical survey data (magnetics and radiometrics) acquired by Coaltech Research Association suggests a half-graben structure with complex, post-depositional faulting, and a maximum depth of ~1,500 m, almost twice as deep as previously believed (Fourie *et al*., 2009). The coals that are of main interest are found in the Swartrant and Grootegeluk Formations of the Ecca Group (equivalents to the Vryheid and Volksrust Formations, respectively). The coal seams were deposited between 260-190 million years ago in an east-west oriented graben. The deposition consist of a succession of clastic rocks, which include mudstones, siltstones, and sandstones, with diamictites at the base and these are capped by basaltic lavas as indicated by cross section on figure 3 (Wagner and Tlotleng, 2012). The Lephalale Basin is believed to host South Africa's most important future coalfield (e.g. Fourie *et al*., 2009). Nevetherless, the Grootegeluk coal mine, Matimba and recently Medupi coal power station are the only current developments in the Lephalale Basin. The basin is currently being explored by Anglo Operations for CBM.

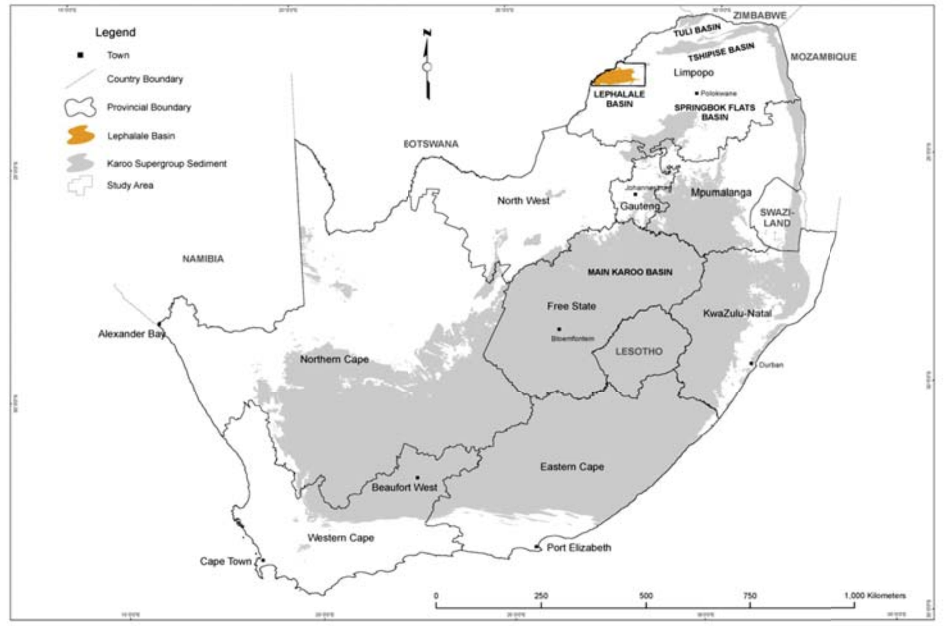

Figure 1: Locality map showing the main Karoo Basin including Lephalale Basin and subsidiary fault controlled basins in South Africa.

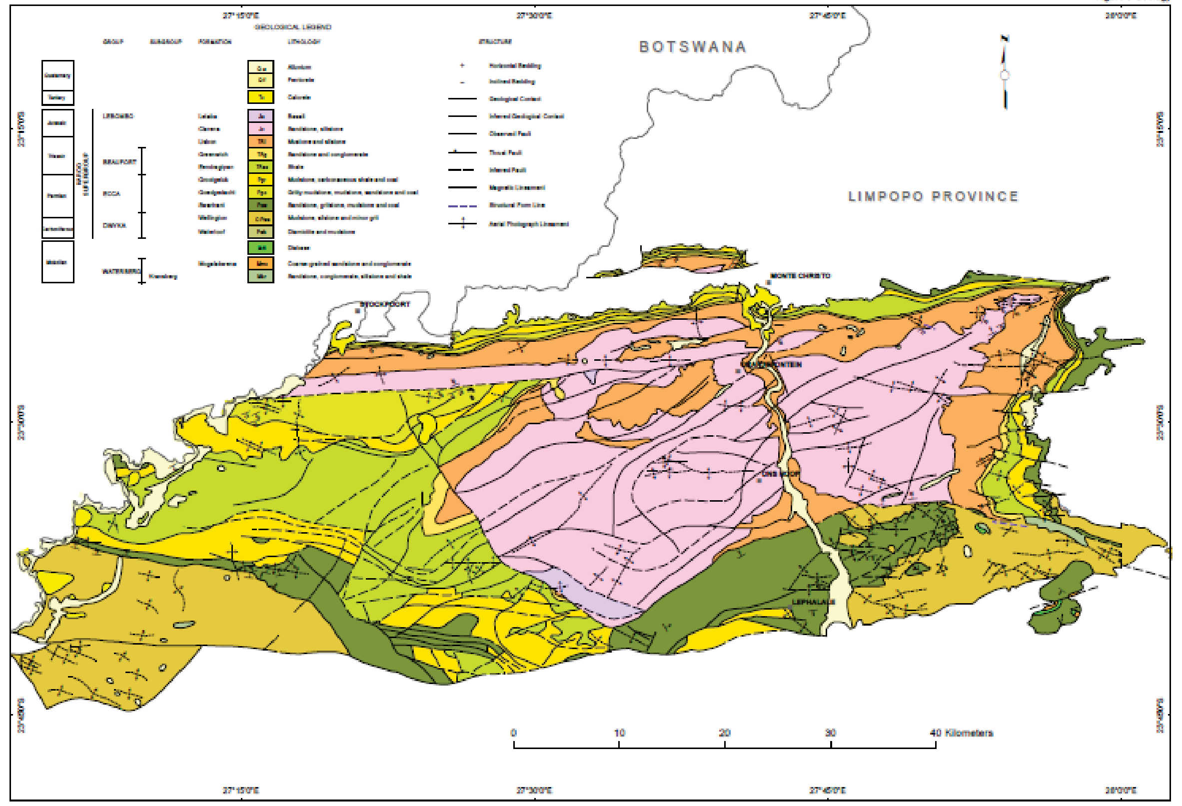

Figure 2: Geology and Lithostratigraphy of Lephalale Basin (PASA, 2014).

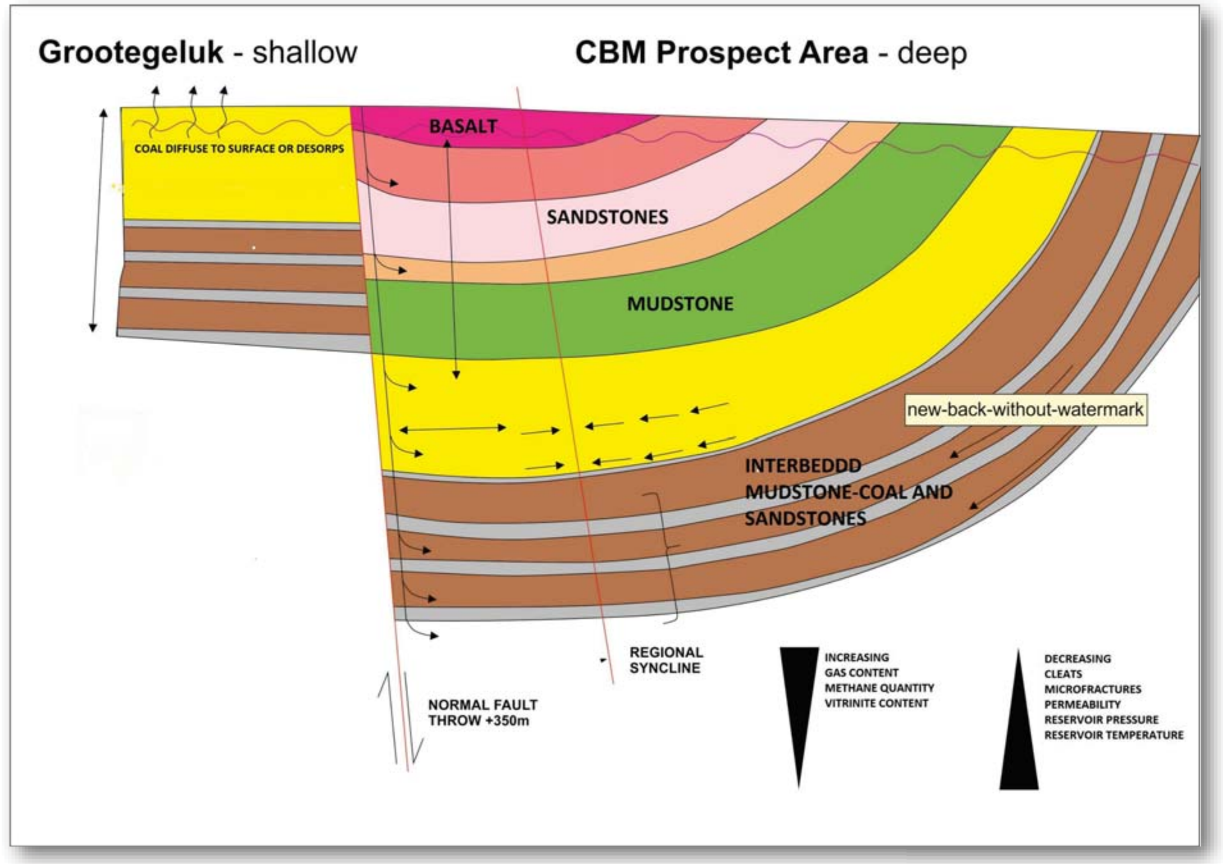

Figure 3: Schematic cross section on the main area of interest, illustrating the shallow and deeper, coal-bearing zones in Waterberg Coalfield (modified from Van Wyk and Barker, 2013 , Banzi Geotechnics cc).

Methodology

The research gives a platform for developing an understanding of the geology, CBM production and groundwater occurrence by reviewing both existing and recent literature publication, especially in countries that already have a success in producing CBM. Hence an investigative approach was ideal for this study. Field visits are planned followed by a laboratory analysis.

The main sampling procedure involves obtaining water samples from existing monitoring boreholes and possibly nearby surface water. The period for sample collection is between May and August as the area receives less rain during this time. These samples will be used in evaluation of hydro-chemical composition of the water, which will give a broader view of physical and chemical quality changes in general for the area under investigation. Aravena et al (2003) applied the same method using open exploratory test-holes, seeps and monitoring piezometers.

The results of the anion and cation analysis will be organized and detailed in an excel spreadsheet for further determining which of the wells will be suitable for development of CBM as well as recognising any dominant pattern or chemical character. Field parameters (Temperature, Electrical conductivity, pH, TDS) will be recorded using a portable Multi Water Quality Checker.

Historical data will be used to understand the factors controlling the gas incline and water decline production curves in the Lephalale. A forecast model will be used to illustrate possible production pattern.

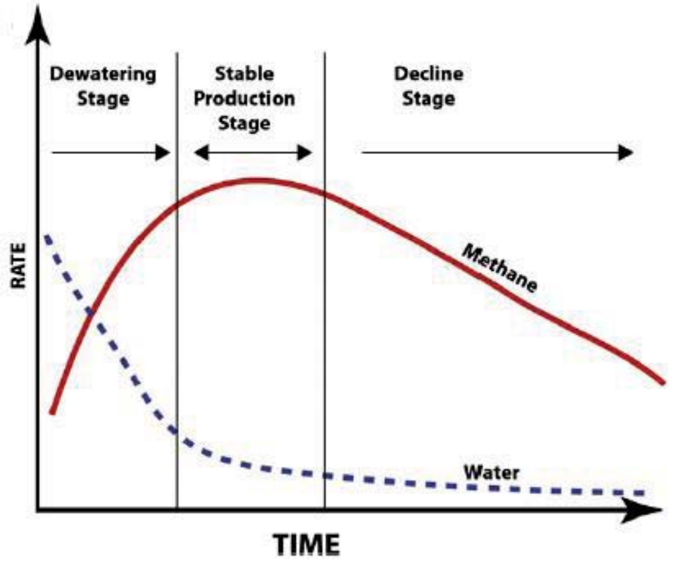

Figure 4: A typical CBM production profile, showing different stages (adapted from Moore, 2012).

Future work

The research is currently on-going. Field visits are scheduled, during which water sampling will be carried out, and samples sent to laboratory for further analysis. Interpretation of results from the laboratory is one of the primary objectives as its relevant in observing specific trends of the tested water. From these results we are able to deduce major cations, concentration levels in each borehole. The results will be plotted on Piper diagram to determine and compare the signatures observed to that of the already producing basins.

Acknowledgements

My deepest gratitude is extended to PASA for financial support and making available data accessible for the purpose of this research. I also thank the DWS Limpopo for sharing their spatial data. My supervisors Dr. Kanyerere, and Dr. Pietersen your input is valued indebtedly.

References

Aravena, R., Harrison, S. M., Barker, J. F., Abercrombie, H., and Rudolph, D. (2003). Origin of methane in the Elk Valley coalfield, southeastern British Columbia, Canada. Chemical Geology, 195(1), 219-227.

Fourie, C.J.S., Henry, G. and Maré, L.P. (2009). The structure of the Karoo-age Ellisras Basin in Limpopo Province, South Africa in the light of new airborne geophysical data: a preliminary report. 11th SAGA Biennial Technical Meeting and Exhibition, Swaziland, 16-18 September 2009, 27-32.

Fourie, C., Henry, G. and Mare, L. (2014). The Structure Of The Karoo-age Ellisras Basin. South African Journal of Geology , Issue 117.2, pp. 207-224.

Hancox, J. P. and Gotz, A. E. (2014). South Africa's coalfields. International Journal of Coal Geology.

Wagner, N. and Tlotleng, M. T. (2012). Distribution of selected trace elements in density fractionated Waterberg. International Journal of Coal Geology, Issue 94, pp. 225-237.