USGS
science for a changing world

National and Global Petroleum Assessment

Assessment of Permian Coalbed Gas Resources of the Karoo Basin Province, South Africa and Lesotho, 2016

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 5.27 trillion cubic feet of coalbed gas in the Karoo Basin Province.

Introduction

The U.S. Geological Survey (USGS) completed an assessment of undiscovered, technically recoverable coalbed gas resources within the Karoo Basin Province of South Africa and Lesotho (fig. 1). The Karoo Basin is a Permian retroarc foreland basin that formed as the Cape fold belt developed by subduction-related compression (Cadle and others, 1993). As the Cape fold belt developed, thrust loading caused lithospheric subsidence, forming an asymmetric foreland basin that was deepest in the south and shallower to the north. In the southern foredeep, the Permian section is dominated by deep-water shales and sandstones, whereas to the north and northeast the Permian section contains fluvial-deltaic conglomerates, sandstones, shales, and coals (Cairncross, 2001; Hancox and Götz, 2014). The focus of this study is the potential for coalbed gas resources in the coal-bearing sequences of the Vryheid Formation of the Ecca Group (fig. 2). The Vryheid Formation contains several coarsening-upward sequences with coals in the upper part of each sequence, and the coals can be traced throughout the study area (Hancox and Götz, 2014). Coal thickness is variable, but individual coals can be as much as 10-meters thick. Coal rank is reported to be high- to low-volatile bituminous with higher rank in the eastern part of the study area. Permian sedimentation in the Karoo Basin Province ended with extensive volcanism related to the breakup of the Gondwana supercontinent. Dolerites associated with volcanism might have had a negative impact on potential coalbed gas resources, although there are differing interpretations as to the impact of the intrusives (Gröcke and others, 2009; Hancox and Götz, 2014). Distal Ecca Group shales include the Whitehill and Prince Albert Formations, which contain potential shale-gas resources (Brownfield and others, 2016), but the resource potential of shale gas may also have been affected by local thermal maturation and loss of gas by the emplacement of widespread intrusives.

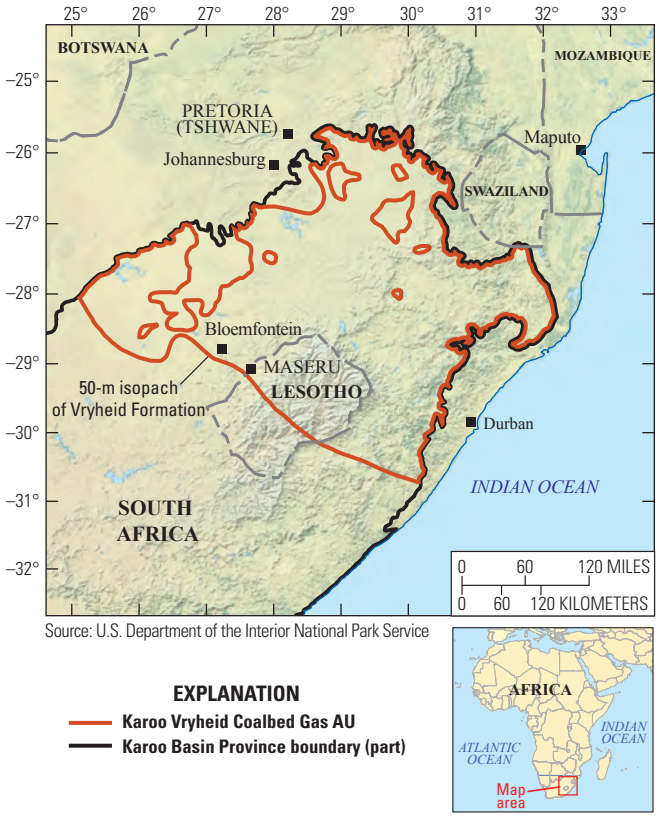


Figure 1. Location of the Karoo Basin Province, South Africa and Lesotho, and the coalbed gas assessment unit (AU) defined in this study. m, meter.

Total Petroleum System and Assessment Units

For the Karoo Basin Province, the USGS defined a Vryheid Coal Total Petroleum System (TPS) and a Karoo Vryheid Coalbed Gas Assessment Unit (AU) within this TPS. The boundary of the AU is defined mainly by the Karoo Basin Province boundary in the northeastern part of the basin and by the 50-meter isopach contour of the Vryheid Formation for the southwestern boundary (fig. 3). The mined areas were removed from the total area of the AU. The major geologic risk for the occurrence of recoverable coalbed gas in this AU is retention of recoverable gas within the coals following emplacement of widespread intrusives. The geologic model proposed in this study is for some portion

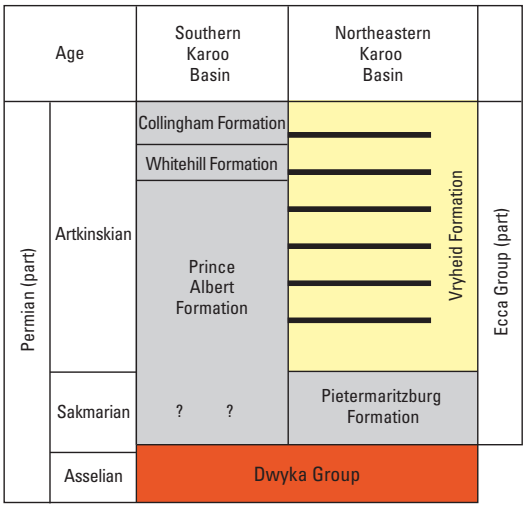
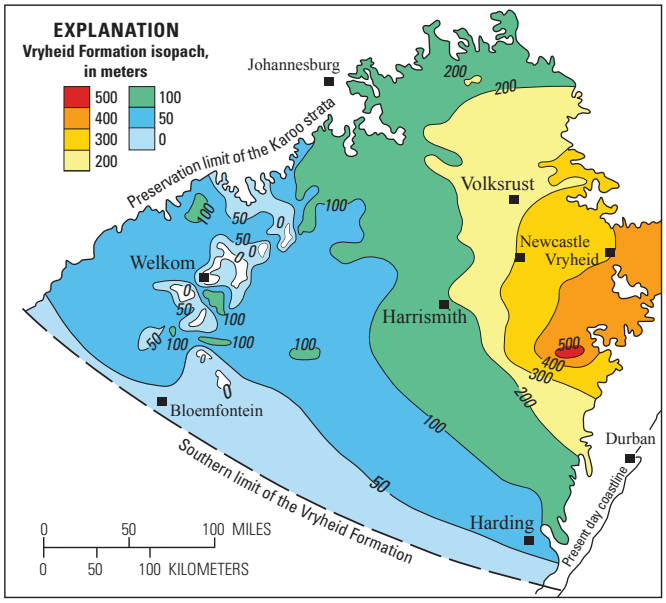


Figure 2. Stratigraphic column of Lower Permian units in the Karoo Basin Province, South Africa and Lesotho, with the Vryheid Formation and the correlative Collingham, Whitehill, and Prince Albert Formations (modified from Hancox and Götz, 2014). Black horizontal lines are coal seams.



of the gas to have been retained within the coals following the intrusion of dolerites as the Gondwana supercontinent began to breakup in the Mesozoic.

Assessment input data for the Karoo Vryheid Coalbed Gas AU are shown in table 1. Well drainage areas, estimated ultimate recoveries, and success ratios were guided by U.S. coalbed gas analog assessment units.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered continuous coalbed gas resources within the Karoo Basin Province (table 2). For coalbed gas resources, the estimated mean is 5,271 billion cubic feet of gas (BCFG), or 5.27 trillion cubic feet of gas, with an F95–F5 range from 1,207 to 11,870 BCFG. The major source of geologic risk is the retention of gas in the coals following dolerite emplacement during the Mesozoic breakup of the Gondwana supercontinent.

Figure 3. Isopach map of the Vryheid Formation in the northeastern part of the Karoo Basin Province, South Africa and Lesotho (modified from Hancox and Götz, 2014).

Table 1. Key assessment input data for one assessment unit in the Karoo Basin Province, South Africa and Lesotho.

[AU, assessment unit; %, percent; EUR, estimated ultimate recovery per well; BCFG, billion cubic feet of gas. Well drainage areas, estimated ultimate recoveries, and well success ratios are taken from U.S. coalbed gas analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable]

Assessment input data—Continuous AU	Karoo Vryheid Coalbed Gas AU			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	26,449,000	41,928,000	22,792,667
Average drainage area of wells (acres)	40	80	120	80
Success ratio (%)	5	20	35	20
Average EUR (BCFG)	0.04	0.08	0.3	0.092
AU probability	1.0			

Table 2. Assessment results for one assessment unit in the Karoo Basin Province, South Africa and Lesotho.

[BCFG, billions of cubic feet of gas; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included under the NGL (natural gas liquids) category. F95 represents a 95-percent chance of at least the amount tabulated. Other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. Shading indicates not applicable]

Total petroleum system and assessment unit (AU)	AU probability	Accumulation type	Total undiscovered resources							
			Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean
Vryheid Coal Total Petroleum System										
Karoo Vryheid Coalbed Gas AU	1.0	Gas	1,207	4,540	11,870	5,271	0	0	0	0
Total undiscovered continuous resources			**1,207**	**4,540**	**11,870**	**5,271**	**0**	**0**	**0**	**0**

References Cited

Brownfield, M.E., Schenk, C.J., Klett, T.R., Pitman, J.K., Tennyson, M.E., Gaswirth, S.B., Le, P.A., Leathers-Miller, H.M., Mercier, T.J., and Finn, T.M., 2016, Assessment of shale-gas resources of the Karoo Province, South Africa and Lesotho, Africa, 2016: U.S. Geological Survey Fact Sheet 2016–3038, 2 p.

Cadle, A.B., Cairncross, Bruce, Christie, A.D.M., and Roberts, D.L., 1993, The Karoo Basin of South Africa—Type basin for the coal-bearing deposits of southern Africa: International Journal of Coal Geology, v. 23, nos. 1–4, p. 117–157.

Cairncross, Bruce, 2001, An overview of the Permian (Karoo) coal deposits of southern Africa: Journal of African Earth Sciences, v. 33, nos. 1–3, p. 529–562.

Gröcke, D.R., Rimmer, S.M., Yoksoulian, L.E., Cairncross, Bruce, Tsikos, Harilaos, and van Hunen, Jeroen, 2009, No evidence for thermogenic methane release in coal from the Karoo–Ferrar large igneous province: Earth and Planetary Science Letters, v. 277, nos. 1–2, p. 204–212.

Hancox, P.J., and Götz, A.E., 2014, South Africa's coalfields—A 2014 perspective: International Journal of Coal Geology, v. 132, p. 170–254.

Karoo Basin Province Assessment Team

Christopher J. Schenk, Michael E. Brownfield, Marilyn E. Tennyson, Timothy R. Klett, Tracey J. Mercier, Sarah J. Hawkins, Stephanie B. Gaswirth, Kristen R. Marra, Thomas M. Finn, Phuong A. Le, and Heidi M. Leathers-Miller

For More Information

Assessment results also are available at the USGS Energy Resources Program website at http://energy.usgs.gov.

ISSN 2327-6916 (print) ISSN 2327-6932 (online) https://doi.org/10.3133/fs20163103