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National and Global Petroleum Assessment

# Assessment of Shale-Gas Resources of the Karoo Province, South Africa and Lesotho, Africa, 2016

*Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resource of 44.5 trillion cubic feet of shale gas in the Karoo Province of South Africa and Lesotho, Africa.*

## Introduction

The U.S. Geological Survey (USGS) completed an assessment of continuous (unconventional) shale-gas resources within the Karoo Province (fig. 1), a geologically complex region of approximately 608,000 square kilometers in South Africa and Lesotho. As much as 8 kilometers of Carboniferous to Jurassic sedimentary rocks are present in the Karoo Province (Smith and others, 1993). Organic-rich petroleum source rocks are present in Lower Permian Prince Albert, Collingham, and Whitehill Formations, and these rocks are thermally mature with respect to gas generation. Eighty oil and gas exploration wells were drilled in the Karoo Province between 1965 and 1977, with several reported gas shows but no conventional gas discoveries (IHS Energy, 2014).

## Total Petroleum System and Assessment Units

For the Karoo Province, the USGS defined a Lower Permian Composite Total Petroleum System (TPS) and two shale gas assessment units (AUs) within this TPS. Gas shows from several wells in the province provide limited evidence that this petroleum system is viable.

The assessment of shale-gas resources by the USGS requires that the potential source-reservoir system must (1) have total organic carbon contents greater than 2 weight percent, (2) contain Type I or Type II organic matter, (3) be within the proper thermal maturity generation window, (4) have organic-rich shale greater than 15 meters in thickness, and (5) generally occur at depths greater than 1,500 meters (Charpentier and Cook, 2011). Using these parameters, the USGS defined the Whitehill-Collingham Shale Gas AU that includes Lower Permian lacustrine source rocks and the Prince Albert Shale Gas AU (fig. 1) that includes Lower Permian lacustrine source rocks (Faure and Cole, 1999).

The major risk for the occurrence of recoverable shale gas in these AUs is considered to be retention of recoverable gas within the source rocks. The geologic model for this study is that an intrusion event began in the Early Jurassic and continued into the Late Jurassic (approximately 190 to 154 million years ago) and

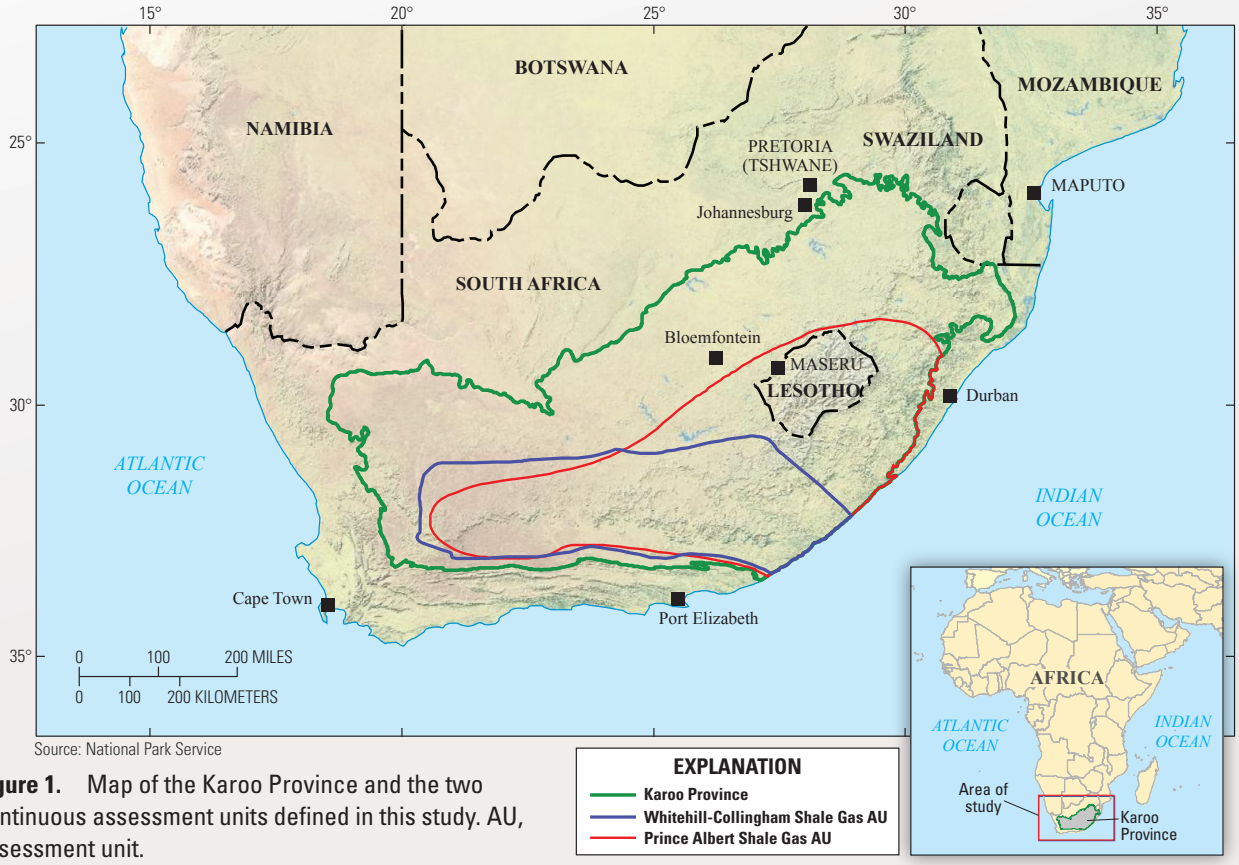


**Figure 1.** Map of the Karoo Province and the two continuous assessment units defined in this study. AU, assessment unit.

thermally altered Lower Permian source rocks in localized areas, resulting in the migration of gas from the source rocks. Breccia pipes in the Karoo Province are most likely vents for loss of gas following this intrusive event. Drilling and testing for recoverable gas in these source rocks will test the validity of this assessment model.

Assessment input data for each assessment unit are shown in table 1. Well drainage areas, estimated ultimate recoveries, and success ratios are taken from U.S. shale-gas analogs.

## Undiscovered Resource Summary

The USGS quantitatively assessed undiscovered gas resources within two shale gas assessment units in the Karoo Province (table 2). For shale-gas resources, the estimated mean totals for the Whitehill-Collingham Shale Gas AU are 16,993 billion cubic feet of gas (BCFG), with an F95–F5 range from 0 to 62,132 BCFG; 170 million barrels of natural gas liquids (MMBNGL), with an F95–F5 range from 0 to 632 MMBNGL. Estimated mean totals for the Prince Albert Shale Gas AU are 27,518 BCFG, with an F95–F5 range from 0 to 101,118 BCFG; 275 MMBNGL, with an F95–F5 range from 0 to 1,028 MMBNGL. The major source of geologic risk for shale-gas resources within the organic-rich shales of the Karoo Province is the retention of some portion of the generated gas within the source rock following any phases of gas migration.

## References


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**Table 1.** Key assessment input data for the two continuous assessment units in the Karoo Province, South Africa.

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

| Assessment input data | Whitehill-Collingham Shale Gas AU | | | | Prince Albert Shale Gas AU | | | |
|---|---|---|---|---|---|---|---|---|
| | Minimum | Mode | Maximum | Calculated mean | Minimum | Mode | Maximum | Calculated mean |
| Potential production area of AU (acres) | 10,000 | 5,808,000 | 42,000,000 | 15,939,333 | 10,000 | 9,610,770 | 68,249,000 | 25,956,590 |
| Average drainage area of wells (acres) | 80 | 120 | 160 | 120 | 80 | 120 | 160 | 120 |
| Percentage of area untested in AU | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Success ratios (%) | 10 | 50 | 90 | 50 | 10 | 50 | 90 | 50 |
| Average EUR (BCFG) | 0.08 | 0.4 | 1.0 | 0.427 | 0.08 | 0.4 | 1.0 | 0.427 |
| AU probability | 0.6 | | | | 0.6 | | | |

**Table 2.** Assessment results for the two continuous assessment units in the Karoo Province, South Africa.

[AU, assessment unit; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included under the NGL 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 units (AU) | AU probability | Accumulation type | Total undiscovered resources | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gas (BCFG) | | | | NGL (MMBNGL) | | | |
| | | | F95 | F50 | F5 | Mean | F95 | F50 | F5 | Mean |
| Lower Permian Composite Total Petroleum System | | | | | | | | | | |
| Whitehill-Collingham Shale Gas AU | 0.6 | Gas | 0 | 8,977 | 62,132 | 16,993 | 0 | 86 | 632 | 170 |
| Prince Albert Shale Gas AU | 0.6 | Gas | 0 | 14,617 | 101,118 | 27,518 | 0 | 139 | 1,028 | 275 |
| **Total undiscovered unconventional resources** | | | **0** | **23,594** | **163,250** | **44,511** | **0** | **225** | **1,660** | **445** |

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## For More Information

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


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