Evaluating Coalbed Methane Plays in Frontier Areas — From Example from Southern Africa*

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Abstract

Increasing global energy demands make the exploration for coalbed methane (CBM) plays in frontier areas attractive. CBM can be used as a feedstock to generate power and manufacture alternative products such as diesel (gas-to-liquids), liquid natural gas, and fertilizer. Challenges to economic development of CBM resources in remote areas of the world include undeveloped markets, distance to markets, and lack of infrastructure.

The four stages in the evaluation of a CBM project follow:
1. Formulate a strategic plan to define the objectives and duration of the project.
2. Conduct a feasibility study to analyze the economic and market potential of the project and determine appropriate production methods.
3. Initiate an exploratory drilling program to identify contingent resources and “sweet spots” for pilot wells.
4. Prepare a reserve estimate report based on production from the pilot wells to obtain financing for project development.

The relatively unexplored Kalahari Basin in southern Africa has all of the prerequisites for a giant CBM play. Permo-Triassic (Gondwana) coal-bearing strata of the Karoo Supergroup underlie 60 percent of Botswana. Coal and organic-rich shale intervals are as much as 100 meters thick at depths between 300 and 1000 meters. Impermeable massive calcareous mudstone seals overlie the coal-bearing rocks throughout the basin. Estimated gas-in-place in the central part of the basin is as much as 196 TCF. These conditions suggest that the area has enormous economic potential.
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Rick Hildebrand, Michele Bishop, Mark Cronshaw
Outline

• **Introduction**
  • Frontier Area
  • Coalbed Methane

• Project Stages

• Summary
Frontier Area Defined

A frontier area is an area or basin in which exploration activities have been limited and a large proportion of resources present are categorized as undiscovered.
Location of World Coal Deposits

Modified from iueassociation.org
Coalbed Methane – CBM

- a.k.a. CBNG, CSM, CSG, CMM
- CH$_4$ most abundant gas
- Reservoir is also source
- Continuous accumulation
- Typically water saturated
CBM Reservoir Characteristics

Dual Porosity Reservoir System

Primary Diffusion → Secondary Darcy flow

Modified from Flores, 2004

From USGS Fact Sheet FS-158-02, 2002
Potential Project Stages

1. Enthusiasm
2. Disillusionment
3. Panic
4. Search for the Guilty
5. Punishment of the Innocent
6. Praise and Glory for the Non-participants

3rd Party Advice

Feasibility Study
- Resource Estimate
- Market Identification
- Economics
- Geologic Confirmation
Outline

• Introduction

• Project Stages
  1. Strategic Planning
  2. Feasibility Study
  3. Exploratory Drilling
  4. Reserve Estimation

• Summary
PROJECT STAGES

From Petroleum Resources Management System, 2007 (www.spe.org)

MILESTONES

London, New York, Toronto
Financial Institutions for Development

3rd Party Independent Evaluation of Drilling Results

Exploratory Drilling

Raise Money for Exploration

3rd Party Advice

Seed Money
Potential & Enthusiasm
Idea
Project Stages

1. Strategic Planning

- Idea
- Potential
- Enthusiasm
- Seed Money
Sedimentary Basins in Southern Africa

From Catuneanu and others, 2005

From Scheffler, 2004
Estimate Prospective Resources

CBM Study Results

- Exploration 2001-2003
- 41,459 km² Study Area
- Four Boreholes Tested
- Reservoir thickness: ≤ 80 m
- Reservoir ≤ 30% coal
- Gas Content: 50-100 scf/ton (as-received)
- Estimated GIP
  - 60 Tcf (coal)
  - 136 Tcf (carb. shale)
  - 196 Tcf total

Data from Botswana DGS
(www.gov.bw)
### Lithostratigraphy and Paleoenvironments, Karoo Supergroup, Kalahari Basin

<table>
<thead>
<tr>
<th>AGE</th>
<th>STRATIGRAPHY</th>
<th>LITHOLOGY</th>
<th>DEPOSITIONAL ENVIRONMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;181 Ma</td>
<td>BEAUFORT</td>
<td>Red beds, sandstone, siltstone, mudstone</td>
<td>Arid continental palaeo-climate</td>
</tr>
<tr>
<td></td>
<td>LEBUUNG GROUP</td>
<td>&gt;sandstone, siltstone, mudstone, limestone</td>
<td>Transitional &gt;Lacustrine</td>
</tr>
<tr>
<td></td>
<td>STORMBERG LAVA GROUP</td>
<td>Basalt, amygdaloidal</td>
<td>Continental flood basalts &gt;extensional tectonics related to on-set of Gondwana break-up.</td>
</tr>
<tr>
<td>Late Carboniferous - Early Jurassic</td>
<td>ECCA GROUP</td>
<td>Sandstone, siltstone, carbonaceous mudstone, and coal</td>
<td>De-glaciation, and amelioration of the palaeo-climate. &gt;Fluvio-deltaic &gt;Swamps &gt;Lacustrine/marginal marine</td>
</tr>
<tr>
<td></td>
<td>DWYKA GROUP</td>
<td>Mudstone, varvites, siltstone, sandstone, and tillites</td>
<td>Glacial palaeo-climate &gt;Subglacial &gt;Glacio-fluvial &gt;Glacio-lacustrine</td>
</tr>
</tbody>
</table>

Modified From Modie, 2007
Basin Analogue – Eastern Australia

Sydney-Gunnedah Basin
CBM Potential

~59,000 km² Area
Coal thickness: 32-230 m
Gas Content: 32-700 scf/ft (daf)
Estimated GIP: 139Tcf

Data from Scott and others, 2004

Permian-Triassic Sediments
Hydrocarbons Generated During Coalification

Modified From Montgomery, 1999
Project Stages

2. Feasibility Study

3rd Party Advice

Prospect
Lead
Play

What are the Markets?
Where are the Markets?
How do you Deliver?
Will it be Profitable?
Play Confirmation
Resource Estimate
Coal Bed Methane Utilization Alternatives

What are the Markets?

CBM

Reformer

SYNHETIC CRUDE OIL PRODUCTS

ELECTRICITY

FERTILIZER

Gas Sales

LNG

Power

Reinjection

DME

Hydrogen

Ammonia

Urea

Clean Fuels

Specialties

Methanol

MTBE

Solvents

Olefins

Acetlys

Linear Paraffins

Clean Distillates

Fuels

Wax/Lubes

Fischer-Tropsch (F-T) Conversion
CBM Market Alternatives

LNG Facility, Indonesia
(www.japanfocus.org)

Synfuels Plant, South Africa
(www.grinaker-ita.co.za)

Gas-fired Combustion Turbine
Generators, Wyoming
(www.basinelectric.com)

Natural Gas for
Domestic Use
(www.freefoto.com)

Fertilizer Complex, India
(www.linde-le.com)
Potential CBM Markets in South Africa

Legend

- CBM play
- Existing gas pipeline
- Proposed gas pipeline
- Gas Turbine
- Refinery or chemical plant
- LNG Facility (New, Proposed)

Data from South Africa DME (2006) and iGas (2009)

Where are the Markets?
CBM Delivery Alternatives

Gas Pipeline (www.un.org)

LNG Tanker (www.lngworldwide.com)

Electricity Transmission Lines (GNU Photo)

LNG Truck (www.paccar.com)

How do you Deliver?
Hypothetical CBM Economics

Scenario
• 200 miles from field to city
• Construct gas pipeline to city
• Construct city gas distribution system
• 1 million households

Numbers
• 80 MMCFD gas
• 330 wells
• Capital cost $million
  – Pipeline $100
  – Distribution $1,000
  – Wells $82
• Delivered cost of gas >$5.00 / MMBTU

Will it be Profitable?
“No matter how good a coal seam methane project is, it is very hard to fund and to bank a project that is going to be based solely on coal seam methane gas.”

Mr. Greg Martin, Managing Director, Australian Gas Light Company (AGL), 2001

The Simple Presence of a CBM deposit does not Ensure a Commercial Project
Project Stages

3. Exploratory Drilling

- Pending
- Unclarified
- Not Viable

From Stricker and others, 2006
Estimate Contingent Resources

Exploration/Appraisal Wells

Subsurface Data
- Reservoir depth(s)
- Reservoir thickness(es)
- Areal extent
- Lithologies

Samples for Analysis
- Gas content/composition
- Coal composition
- Mineralogy/petrophysics

Hydrology/Reservoir Properties
- Permeability
- Flow rates
- Water Quality

1 square = 160 acres (1/4 section)
CBM Reservoir Saturation

From GRI, 1997

From Botswana DGS, 2003
Project Stages

4. Reserve Estimation

Proven
Probable
Possible

Development Financing

3rd Party Independent Evaluation of Drilling Results

“… successful pilots or operating projects in the subject reservoir or successful projects in analogous reservoirs may be required to establish a distribution of recovery efficiencies for nonconventional accumulations.”

From Petroleum Resources Management System, 2007 (www.spe.org)
Demonstrate Economic Gas Production and Reserve Base

1 square = 160 acres (1/4 section)

Contingent Resources
Possible Reserves
Probable Reserves
PUD

5-well Pilot Development (PDP)
- Reservoir communication
- Accelerated dewatering
- Production flow rates
- Well completion effectiveness

From Anderson and others, 2003
Outline

• Introduction

• Project Stages

• Summary
Summary

Strategic Planning
- Define team, product, market, infrastructure, duration

Feasibility Study
- Show economic viability (product, market, delivery)

Exploratory Drilling
- Improve economic aspects (gas content and production)

Reserve Estimation
- Establish reserve base, raise capital for development
Selected References


Botswana DGS: http://www.gov.bw/

Catuneanu, O. and A.R. Sweet, 2000, Tectonic control on fluvial styles; examples from the Karoo and Western Canada Basins: Program with Abstracts Geological Association of Canada; Mineralogical Association of Canada Joint Annual Meeting, v. 25, unpaginated.


USGS Fact Sheet FS-158-02 (Supercedes USGS Fact Sheet FS-110-01) February 2003: Web accessed 08/24/09
http://pubs.usgs.gov/fs/fs-158-02/