Coalbed Methane Resources in Colombia*

Mario Garcia-Gonzalez¹

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¹Geology, Universidad Industrial de Santander, Bucaramanga, Colombia  (mgarciag@uis.edu.co)

Abstract

A preliminary evaluation of the coal-bed methane (cbm) resources of Colombia indicates that there are at least 8 regions with large cbm potential. The main coal-bearing formations of Colombia range in age from Maastrichtian to Eocene and the coal ranks varies from semianthracite to sub-bituminous. The cbm resource in the main coaly regions of Colombia has been calculated in 17 TCF.

The largest cbm potential is located in the Cesar and Rancheria basins. In the Rancheria Basin the Cerrejón Formation of Paleocene age contains up to 55 coal seams of sub-bituminous and bituminous rank with vitrinite reflectance (Ro) values between 0.4 to 0.8%. Coal seams of the Cerrejón Formation present an excellent lateral extension and a large net-coal thickness of more than 50 meters. These parameters allow expectation of a large cbm resource.

In the Cesar Basin the Barco-Cuervos Formation of Paleocene age also presents a large coal resource with thick coal seams (from 1 to 8 meters) of sub-bituminous and bituminous rank (Ro 0.5 to 0.8%). The cbm potential has been evaluated using hydrous pyrolysis (HP) experiments indicating an excellent potential.

The Bogota Plateau in the Eastern Cordillera is a large area of 3,000 km² with 9 coalfields. The Guaduas Formation of Maastichtian to Paleocene age is present in numerous synclinal structures that are the main target for cbm exploration. The coal rank is low to high volatile bituminous, and the Ro values vary between 0.5 and 1.5%. The cbm potential was evaluated using desorption experiments and HP indicating a good cbm potential on the location and stratigraphic position.
The Guachinte-Ferreira Formation of Oligocene to Miocene age in the Cauca Basin is characterized by sub-bituminous coals (Ro 0.4 to 0.7%) with excellent hydrogen index that explains the large gas generation potential as demonstrated by HP tests. A cbm resource of 2 TFC has been calculated for this basin.

The Lower Magdalena Basin presents several large coal deposits in the Cienaga de Oro and Cerrito formations of Oligocene and Miocene ages. These deposits are characterized by sub-bituminous (Ro 0.4 to 0.5%) coals with net coal thicknesses ranging from 16 to 28 meters which contain biogenic cbm gases. Other regions with potentially large cbm potential are the Catatumbo Basin, the Llanos Foothill Basin, the Middle Magdalena Basin, and the Cauca-Patia Basin.
COALBED METHANE RESOURCES IN COLOMBIA

MARIO GARCÍA GONZÁLEZ
mgarciag@uis.edu.co

Research Group on Hydrocarbons and Coal Geology
UNIVERSIDAD INDUSTRIAL DE SANTANDER

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Methodology used to calculate Coalbed methane resources

- Stratigraphy of the coal-bearing formations
- Coal rank and coal quality
- Coal resources
- Coal desorption tests
- Isothermal adsorption tests
- Hydrous pyrolysis
- Geochemical modeling
Stratigraphy of Coal-bearing Formations in Colombia
Coaly regions in Colombia with Coalbed methane potential
Coal desorption test using computer-controlled canister
Isothermal desorption curves, Guaduas Formation Coal

![Graph showing isothermal desorption curves for Guaduas Formation Coal with different moisture and ash conditions.]
Hydrous Pyrolysis of immature coal samples

The Guaduas Fm. Coal Shows a great gas generation potential; as indicated by HP experiment, where it generated up to 2400 scft gas/Ton coal at an Ro value of 1.5%. The generated gases were Mainly HC gases.
Geochemical Modeling

- Burial History
- Thermal history
- Kinetic of oil to gas reaction
- Calibration of the geochemical model
CBM Resources

Coal rank:
Sub-bituminous to Bituminous

CBM resource

Cerrejón: 2.8 TCF

La Jagua-La Loma: 2 TCF
The Valledupar uplift split the basin into sub-basin.
Cerrejón Thrust Fault, Ranchería Basin

Sub-thrust Gas kitchen

After Kellogs & Bollini, 1982
Cerrejón Stratigraphic Column

Net coal thickness
110 meters

Coal rank
Sub-bituminous

After Bayona et al. 2004
SEISMIC LINE CV 89 1100.
RANCHERIA SUB-BASIN
2D Geochemical Model of the Seismic line CV 89 1100
Ranhería Sub-Basin
Location of Coal-fields
In the Cesar sub-basin
<table>
<thead>
<tr>
<th>EDAD</th>
<th>ESPESOR</th>
<th>LITOGRAFÍA</th>
<th>FORMACIÓN</th>
<th>OBSERVACIONES</th>
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<tbody>
<tr>
<td>Eoceno ?</td>
<td>220</td>
<td>Miembro</td>
<td>Depósito Aluvial</td>
<td>Grava yarenas, arcillas</td>
</tr>
<tr>
<td></td>
<td>460</td>
<td>Medio</td>
<td>Formación Los Cuervos</td>
<td>Arcillas, arcillas de cuarzo, arcillas y limoas verdes</td>
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<tr>
<td></td>
<td>76-278</td>
<td>Inferior</td>
<td>Formación Barco</td>
<td>Arcillas de cuarzo con intercalaciones de  arcillas</td>
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<td></td>
<td>±460</td>
<td></td>
<td>Formación Molino</td>
<td>Lutitas con costra y arcillas de cuarzo y capas de carbón</td>
</tr>
<tr>
<td></td>
<td>265</td>
<td></td>
<td>Formación Llano</td>
<td>Calizas, arcillas y bancos de arcillas de cuarzo</td>
</tr>
</tbody>
</table>

- **Cesar Sub-basin**
- **Cuervos Formation**
- **Paleocene**

- Net coal thickness: Up to 40 meters
- **Coal Rank**: High to Medium
- **Volatile Matter**: Bituminous
- **Ro**: 0.5 -0.8%
SEISMIC LINE CR 88-1200. CESAR SUB-BASIN
2D Geochemical Model of Seismic Line CR 1200 Showing Maturation stages and Hydrocarbon Migration Pathways Cesar Sub-basin
CBM Potential in The Eastern Cordillera

Guaduas Formation
Coal rank:
Bituminous and Sub-bituminous coals
Ro 0.45 to 1.0%

CBM resource:
6 TCF
Bogotá Plateau

Coal Rank
Sub-bituminous
To
L V. Bituminous

Ro 0.5 to 1.5%
Guaduas Formation

Ro vs. Depth profile

Ro Range: 0.45 to 0.95%

Depth range 500 m
COALBED METHANE RESOURCE IN THE BOGOTA BASIN

CBM Resources, Bogota Basin

- Subachoque
- Río Frio
- Cogua
- Checuá - Lenguazaque
- Santa Rosita
- Tomine - Guatavita
- Suesca
- Albaracin
- Tunja Duitama
- Sojamoso - Jericó
- TOTAL

CFT Gas

- 0.00E+00
- 1.00E+12
- 2.00E+12
- 3.00E+12
- 4.00E+12
- 5.00E+12
- 6.00E+12
- 7.00E+12
Cauca Basin
CBM Potential
Coal-bearing Fms: Guachinte Ferreira

Coal rank: Bituminous and Sub-Bit. Coals

CBM resource 1.9 TCF
# Stratigraphy of the Cauca Valley Basin Colombia

<table>
<thead>
<tr>
<th>EDAD</th>
<th>UNIDADES LITOESTRATIGRÁFICAS</th>
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<tbody>
<tr>
<td>Plio-Pleistoceno</td>
<td>PL-zl</td>
</tr>
<tr>
<td>Mioceno</td>
<td>inconformidad angular</td>
</tr>
<tr>
<td></td>
<td>Tmp</td>
</tr>
<tr>
<td>Oligoceno</td>
<td>inconformidad angular</td>
</tr>
<tr>
<td></td>
<td>TOg</td>
</tr>
<tr>
<td></td>
<td>Tocp</td>
</tr>
<tr>
<td>Eoceno</td>
<td>Tvj</td>
</tr>
<tr>
<td></td>
<td>?</td>
</tr>
<tr>
<td>Cretáceo-Paleoceno</td>
<td>UNIDAD BASAL inconformidad angular</td>
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<tr>
<td></td>
<td>BASAMENTO PRE-TERCIARIO</td>
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<tr>
<td></td>
<td>FM. ZARZAL</td>
</tr>
<tr>
<td></td>
<td>FM. LA PAILA</td>
</tr>
<tr>
<td></td>
<td>FM. CINTA DE PIEDRA</td>
</tr>
<tr>
<td></td>
<td>FM. GUACHINTE</td>
</tr>
<tr>
<td></td>
<td>FM. VIJES</td>
</tr>
<tr>
<td></td>
<td>ARENISCA DE CUARZO BASAL</td>
</tr>
<tr>
<td></td>
<td>Y COLUVION VOLCANICO</td>
</tr>
<tr>
<td></td>
<td>COMPLEJO OFIOLÍTICO ACRECIONARIO</td>
</tr>
</tbody>
</table>
Gas shows in the Candelaria -1 well associated with coal seams
Gas Generation Potential of the Guachinte Fm. coal at different Ro values
Determined with Hydropyrolisis experiments
### CBM Resources in Colombia

<table>
<thead>
<tr>
<th>Cuenca</th>
<th>Edad</th>
<th>Rango Carbon</th>
<th>CBM</th>
</tr>
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<tbody>
<tr>
<td>Cerrejon</td>
<td>Paleoceno</td>
<td>Bituminous</td>
<td>2.8</td>
</tr>
<tr>
<td>La Jagua</td>
<td>Paleoceno</td>
<td>Bituminous</td>
<td>2.1</td>
</tr>
<tr>
<td>Altiplano Cun.</td>
<td>Maaestrichtian</td>
<td>Sub-Bituminous to Bitum.</td>
<td>6.0</td>
</tr>
<tr>
<td>Valle Cauc</td>
<td>Oligoceno</td>
<td>Sub-Bituminous to Bitum.</td>
<td>1.9</td>
</tr>
<tr>
<td>Magdalena M.</td>
<td>Maaestrichtian</td>
<td>Bituminous</td>
<td>0.1</td>
</tr>
<tr>
<td>Catatumbo</td>
<td>Paleo.-Oligo.</td>
<td>Sub-Bituminous to Bitum.</td>
<td>0.2</td>
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<tr>
<td>San Jorge</td>
<td>Oligo.-Mioceno</td>
<td>Lignite to Sub-Bitum.</td>
<td>4.3</td>
</tr>
<tr>
<td>Antioquia</td>
<td>Oligo.-Mioceno</td>
<td>Sub-Bituminous to Bitum.</td>
<td>0.1</td>
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<tr>
<td><strong>TOTAL resources</strong></td>
<td></td>
<td></td>
<td><strong>17.5</strong></td>
</tr>
</tbody>
</table>
The Coalbed methane resources in Colombia can reach 17.5 TCF. This figure is conservative because in some basins deep coal seam at depth greater than 300 m were not taken into account.

The main coal-bearing areas with the largest CBM potential are Maestrichtian-Paleocene in age and are located in the Cesar, Rancheria, and Bogotá basins.