

Challenges of Coalbed Natural Gas Development in Northwestern Bangladesh*

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Abstract

Scattered, isolated deposits of Permian high-volatile bituminous coal constitute a potential resource for the energy-deficient region west of the Jamuna (Brahmaputra) River. Five coalfields (Barapukuria, Dighipara, Jamalganj, Khalaspir, and Phulbari) have been delineated so far by remote geophysical surveys and subsequent exploratory drilling. Individual coal beds, as much as 47 m thick, have been reported at depths between 100 and 1200 m below surface level. Total coal resource estimates range from 2000 to 5000 Mt. Total gas-in-place estimates calculated by various indirect methods range from 31 to 60 Gm³ (1 to 2 Tcf).

To date, no comprehensive investigation to define discovered coal gas resources and establish commerciality for any of these prospective reservoirs has been attempted. General coal composition (proximate analysis), petrography, and thermal maturity (Ro) data are available for each coalfield. Other reservoir conditions that need to be quantified by exploratory drilling and core sampling include direct-gas-content measurements, gas composition and gas-storage-capacity analyses, as well as reservoir volume and density measurements.

In-situ permeability and hydrologic tests of prospective reservoirs are also needed to evaluate the production potential of the coal gas prospects. Studies of the Barakapuria coal deposit, in conjunction with development of the first underground coal mine in the region, indicate that hydrologic conditions within the basin may be problematic for dewatering reservoirs to initiate gas production. Hydrogeology of the Jamalganj deposit may be more favorable for reservoir dewatering.

Comprehensive desktop studies of the five coalfields that consider gas content information from analogous areas would provide a basis for ranking the coal-gas potential of each prospective basin. Then, a site-specific exploratory drilling program could be designed to evaluate the gas-resource potential of the most likely prospect.

Challenges of Coalbed Natural Gas Development in Northwestern Bangladesh

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• **38 LABORATORY LOCATIONS IN 18 COUNTRIES**

NORTH AMERICA
Canada
United States
EUROPE
Norway
United Kingdom

LATIN AMERICA
Brazil
Mexico
Trinidad
Venezuela

MIDDLE EAST / NORTH AFRICA
Kuwait
Libya
Oman
Saudi Arabia
United Arab Emirates

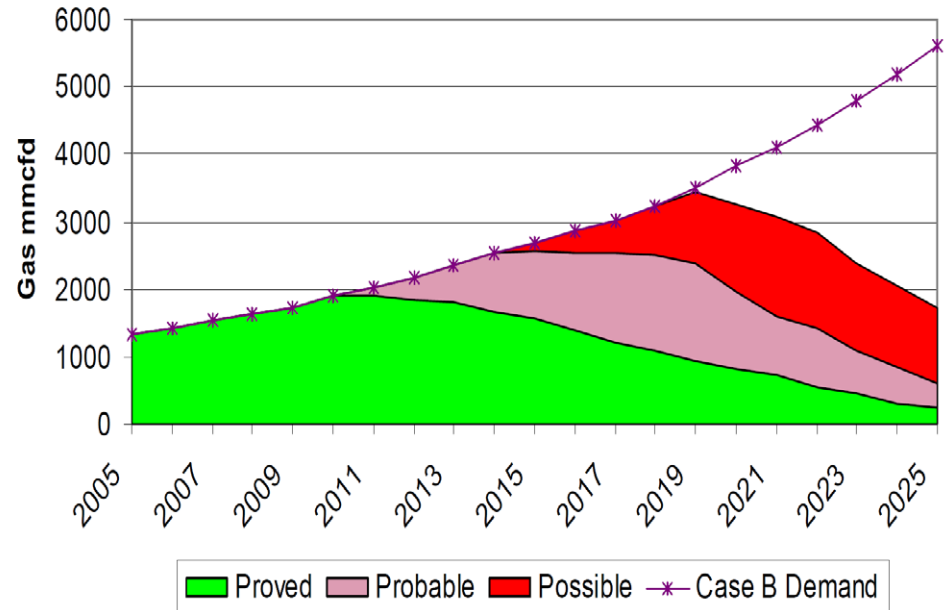
ASIA PACIFIC
Australia
India
Malaysia
Thailand
New Zealand

Outline

- ❖ **Introduction**
- ❖ **Coal and CBNG in Bangladesh**
 - ✧ Deep wells
 - ✧ Barapukuria
 - ✧ Phulbari
 - ✧ Khalaspir
 - ✧ Dighipara
 - ✧ Jamalganj
- ❖ **Challenges of CBNG Development**
 - ✧ Reservoir Parameters, Gas Content
 - ✧ Geologic and Hydrologic Conditions
 - ✧ Market and Infrastructure
- ❖ **Conclusions**



Bangladesh Energy Supply and Demand



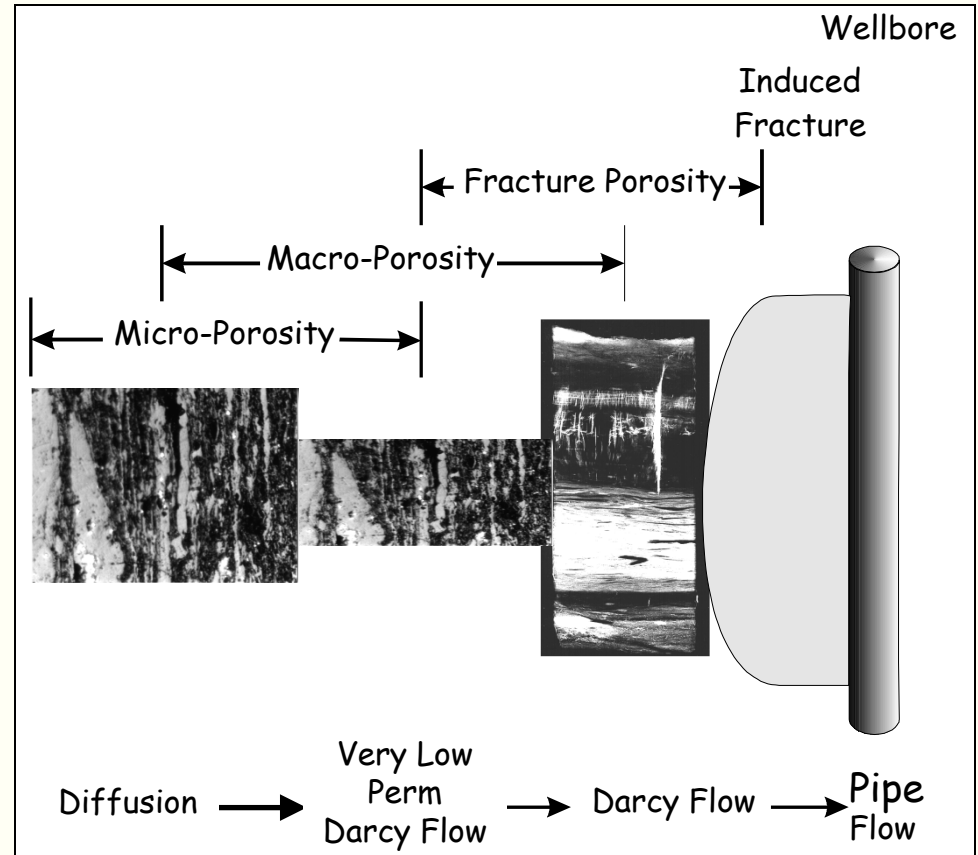
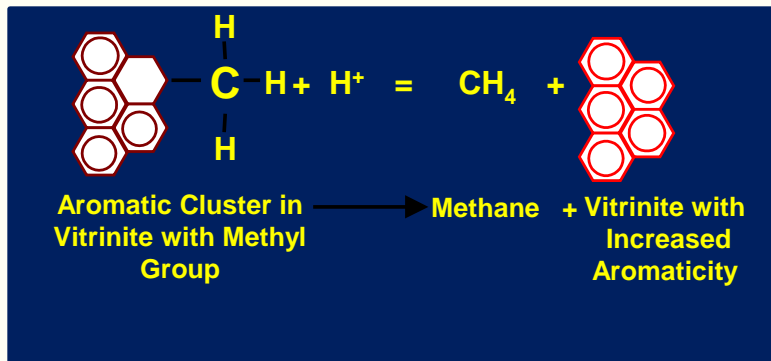
Data from Hydrocarbon Unit, 2009, Guidelines for exploration and development strategy for Bangladesh: Bangladesh Energy & Mineral Resources Division Report, 18 p.

- ❖ Current Remaining Gas Reserves (2009) = 18.8 Tscf (532 Gm³)
- ❖ Domestic Demand Growth Rate = 7%/yr (Case B)



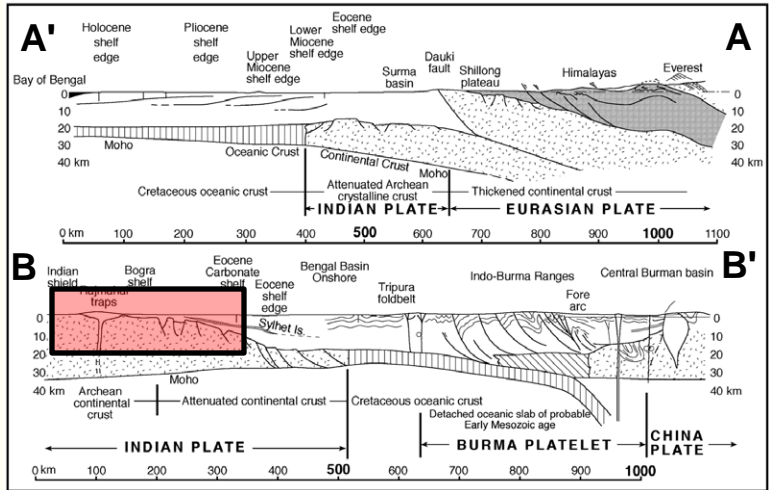
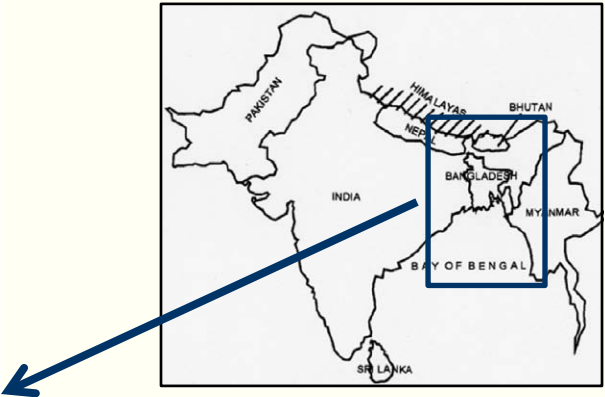
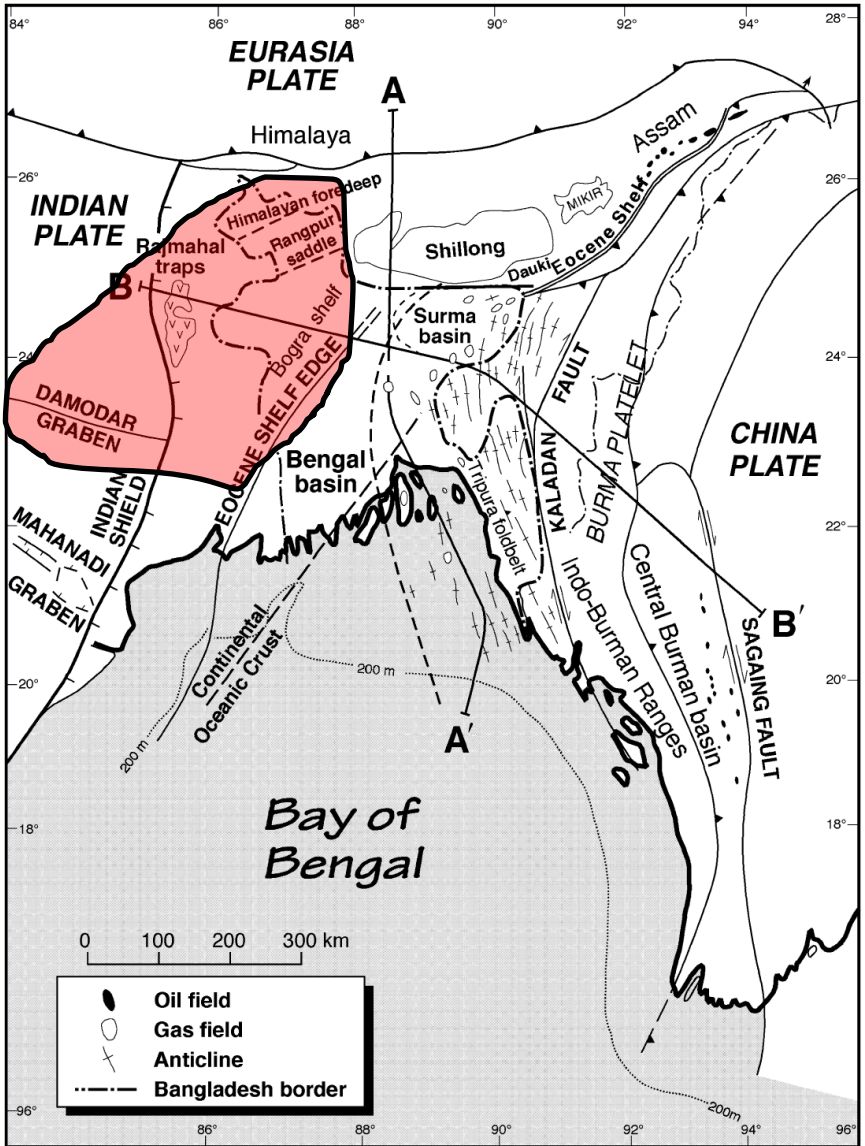
CBNG — A Potential Energy Resource

- ❖ a.k.a. CBM, CSM, CSG, CMM
- ❖ Continuous accumulation
- ❖ CH₄ is most abundant gas
- ❖ Reservoir is source rock
- ❖ Primarily sorbed gas
- ❖ Typically water saturated

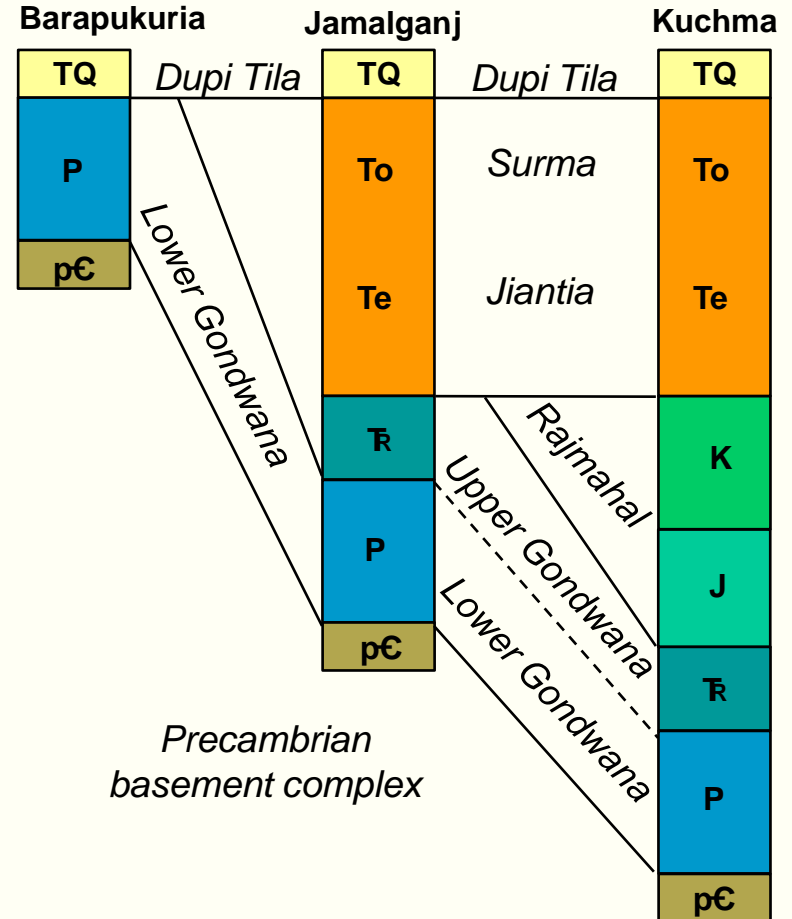
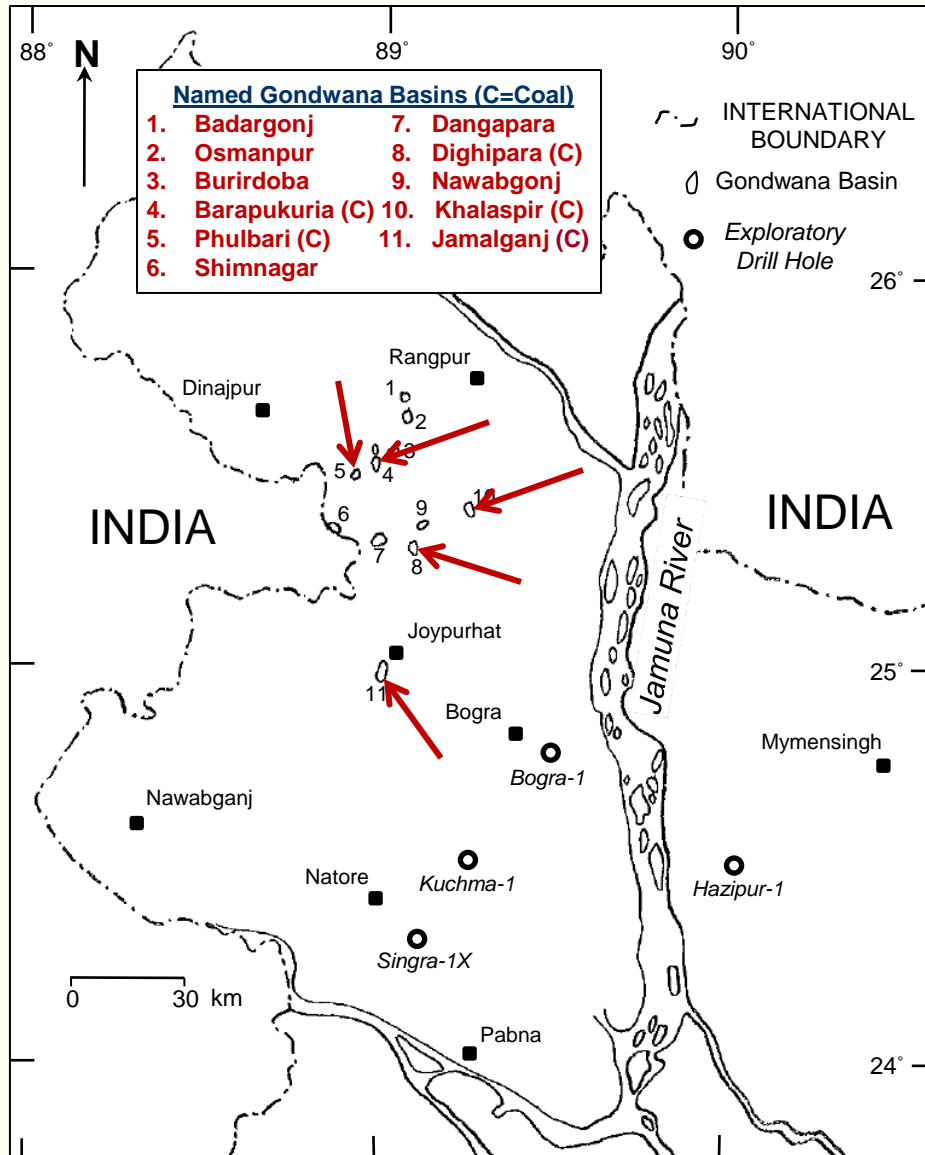


$$1 < \phi_s < 5 \text{ vol\%} \quad k_a > 0.1 \text{ mD}$$





Index map of Bangladesh showing geologic provinces, tectonic plates, and regional cross sections (modified from Curiale and others, 2002)



Location of Gondwana basins and general stratigraphy, northwestern Bangladesh (modified from Uddin and Islam, 1992; Elahi, 1995; Frielingsdorf and others, 2008; and Islam and Hayashi, 2008)

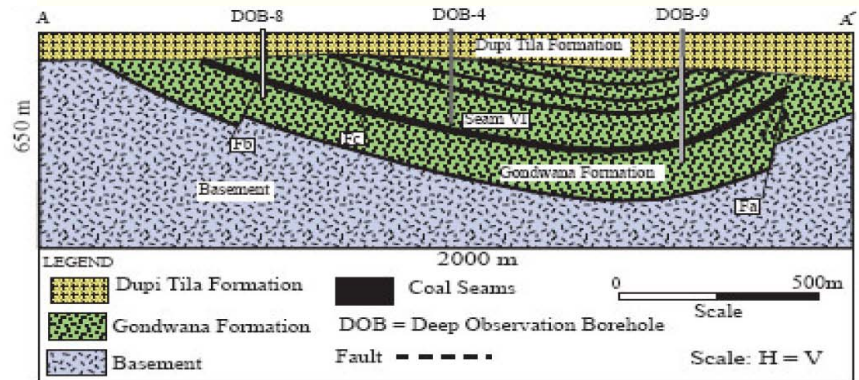
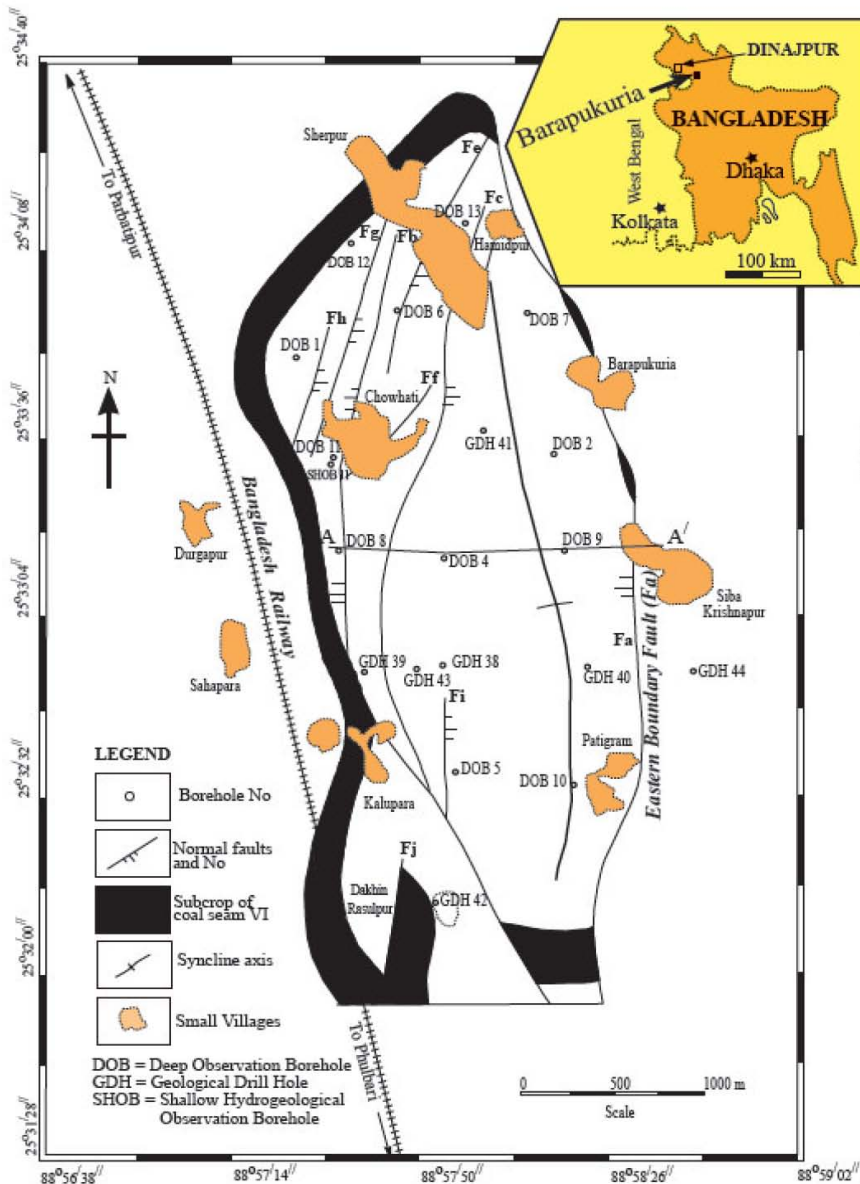
Coal in Bangladesh

Coalfield (District)	Year of Discovery	Known Area (km ²) [Planimeter ¹]	Aggregate Coal Thickness (m)	Number of Coal Beds or Zones	Depth of Coal (m)	Coal Rank	In-situ Coal Resources (million tonnes)
Barapukuria ² (Dinajpur)	1985	5.16 [7.2]	21.63–74.31	7	118–518	HVB Bituminous	377
Phulbari ³ (Dinajpur)	1997 ⁴	[12.4]	15–70	3	120–240	HVB to HVA Bituminous	572
Khalaspir ⁵ (Rangpur)	1989	12.26 [12.2]	23.21–59.10	8	257.2–482.9	HVA to LV Bituminous	685
Dighipara ⁶ (Dinajpur)	1995	5 [NA]	61.38 (Avg.)	6	323–408	HV Bituminous	600
Jamalganj ⁷ (Joypurhat)	1962	6.8–41 ⁸ [24.5]	18.59–99.49	7	640–1,158	HVB to HVA Bituminous	1,053 (11.7 km ² area)
Coal Occurrence (District)	Year Drilled	Total Depth (m) [Fm]	Aggregate Coal Thickness (m)	Number of Coal Beds	Depth of Coal Range (m)	Coal Rank	In-situ Coal Resources (million tonnes)
Kuchma-1 ^{4,8} (Bogra)	1959	2,875 [L. Gondwana]	52	5	2,380–2,876	Bituminous	ND
Bogra-1 ⁸ (Bogra)	1960	3,816 [Precambrian]	NA	NA	NA	Coal seams encountered	ND
Singra-1X ⁹ (Natore)	1980	4,100 [L. Gondwana]	100	20	2,900-4,100	Bituminous	ND

NA – Not Available
ND – Not Determined

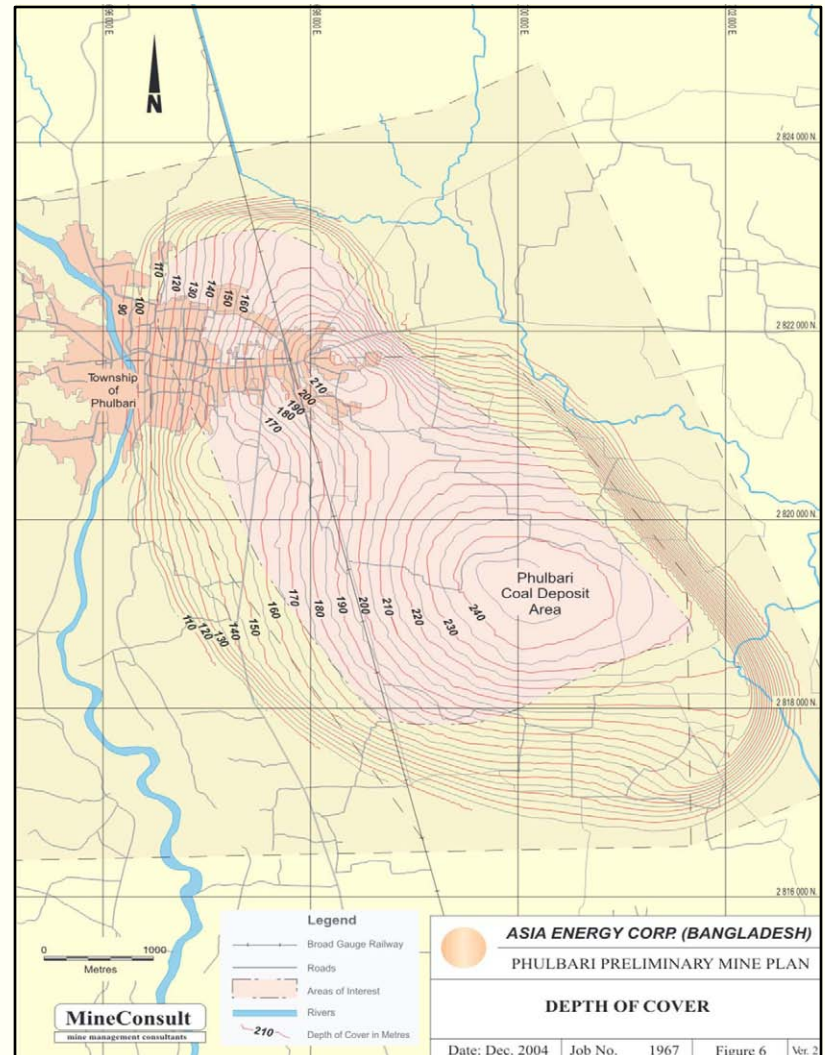
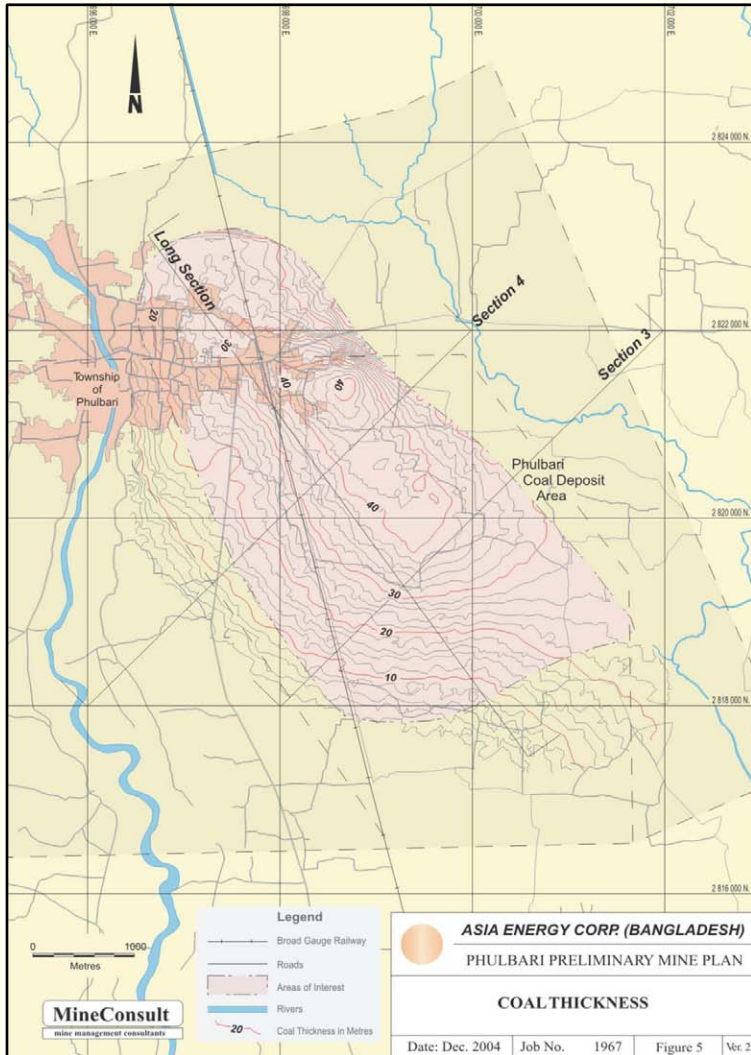
- ¹ Area of available map measured by planimeter
- ² Islam and Hayashi, 2008
- ³ GCM Resources plc (Asia Energy plc), 2005
- ⁴ Akhtar, 2000
- ⁵ Islam and others, 1992
- ⁶ Ghose, 2009
- ⁷ Imam and others, 2002
- ⁸ Ball and others, 1983
- ⁹ Elahi, 1995; Frielingsdorf and others, 2008





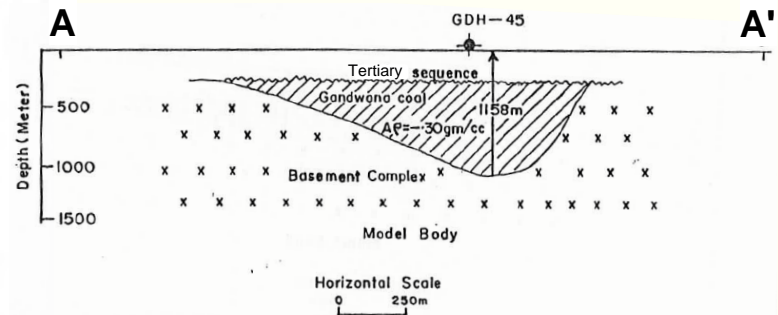
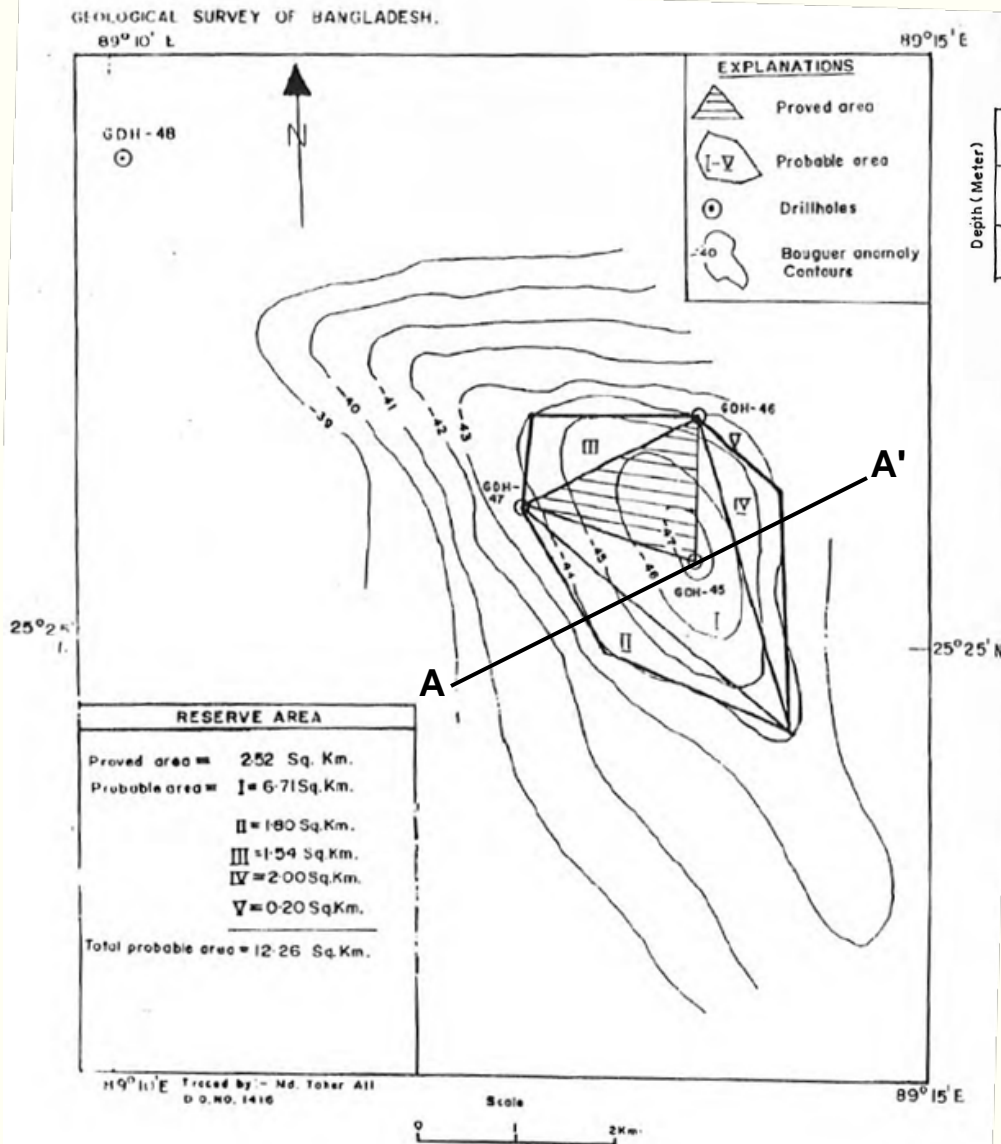
Map and cross section of the Barapukuria basin (modified from Islam, 2009)





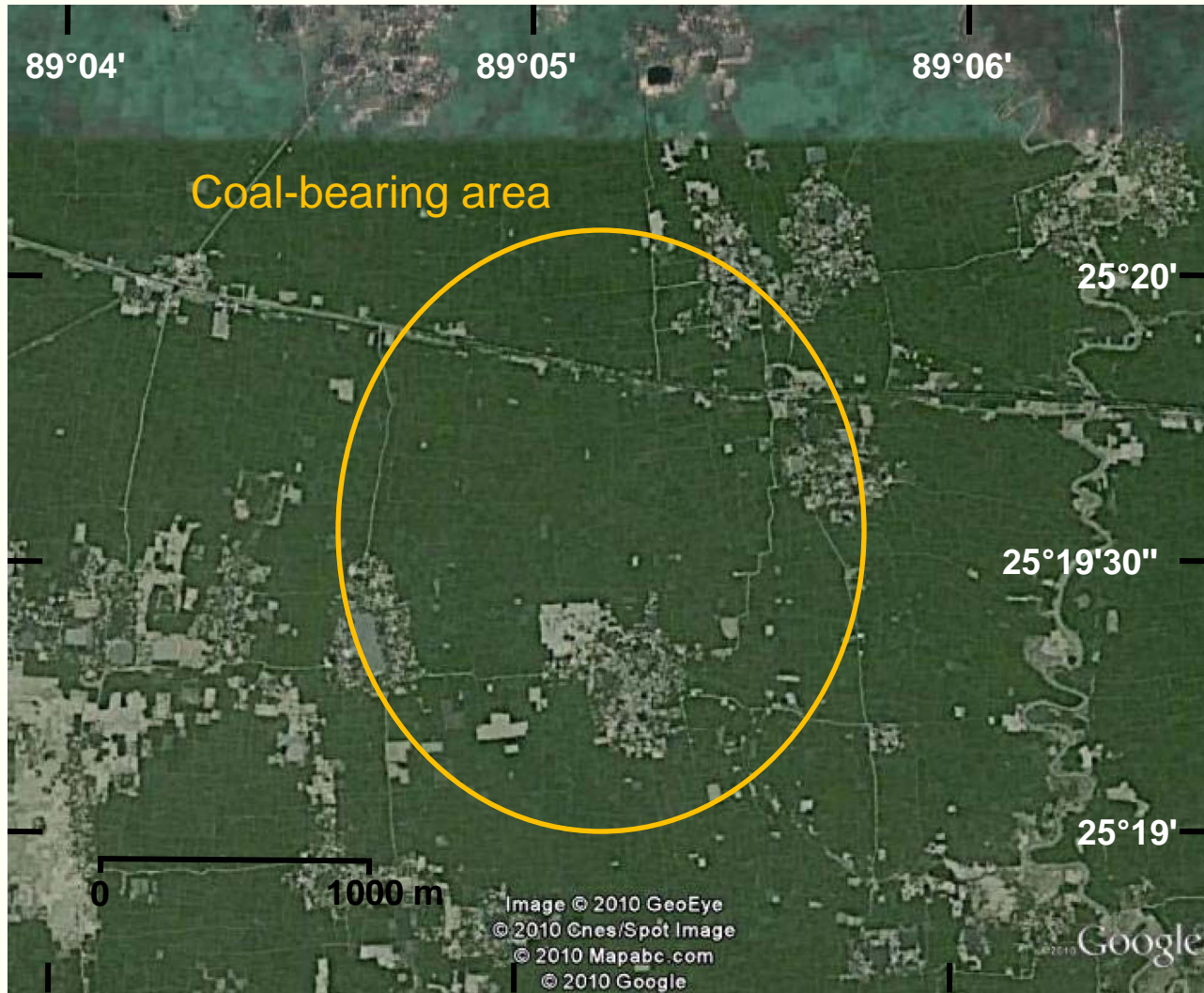
Maps showing total coal thickness and depth of cover in the Phulbari basin (GCM Resources, 2005)



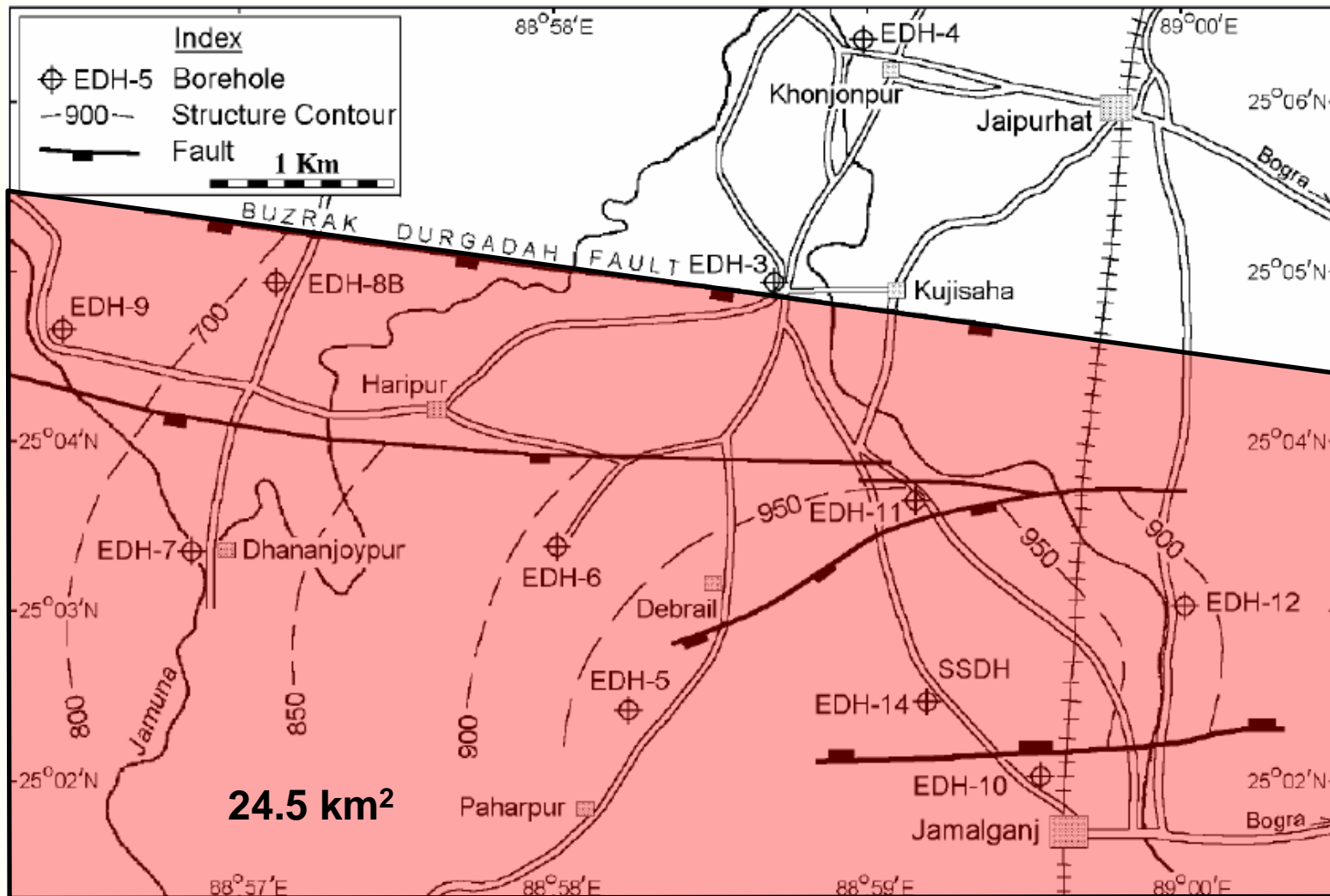


Map showing proved and probable areas of coal in the Khalaspir basin, and general cross section (modified from Hasan and Kamaluddin, 1990; and Islam and others, 1992)





**Location map of the Dighipara basin
(Ghose, 2009; Google Earth, 2010)**



**Location map of the Jamalganj basin
(modified from Imam and others, 2002)**



CBNG Reservoir Parameters

Coalfield	Maturity (R _o)	Aggregate Coal Thickness (m)	Depth of Burial (m)	Estimated Gas Content (m ³ /t) ‡	Coal Resources (billion tonnes)	Permeability (mD)	Potential OGIP (Gm ³)‡
Target Value¹	>0.7	>30	152–1,524*	6–7	>1	>1.5	—
Barapukuria ²	0.55–0.84	21.63–74.31	118–518	6.51–12.68	0.377	9.8–137.8	3.6–5.1
Phulbari ³	0.82	15–70	120–240	9.6	0.572	ND	5.5
Khalaspir ⁴	0.79–0.94	23.21–59.10	257–483	9.6	0.685	ND	6.6
Dighipara ⁵	0.7–1.1	61.38 (Avg.)	323–408	9.6	0.6	ND	5.8
Jamalganj ¹	0.66–0.84	18.59–99.49	640–1,158	10.7–12.8	1.053	ND	12.3
Jharia (India) ⁶	0.84–1.46	75–110	300–1,200	9.8–21.7	12.3 [†]	0.03–3.0	85
Bokaro (India) ⁷	0.95–1.06	70–140	300–1,500	15.8–17.0	3.2 [†]	ND	45
U.S. Projects ⁸ (Bituminous)	0.7–1.2	7.6–30.5	150–1,000+	7.8–18.7	2.6–7.7	1–100	22.9–49.8

‡ Gas content reported on a dry, ash-free basis if known

*Typical depth range of productive CBNG reservoirs (Murray, 1996; Nolde and Spears, 1998)

[†]India coal resources from Chandra, K., 1997, *Alternative hydrocarbon resources in the next millenium: Geohorizons (Society of Petroleum Geophysicists)*, 18 p.

¹ Imam and others, 2002

² Islam and Hayashi, 2008

³ Asia Energy plc (GCM Resources plc), 2005

⁴ Islam and others, 1992

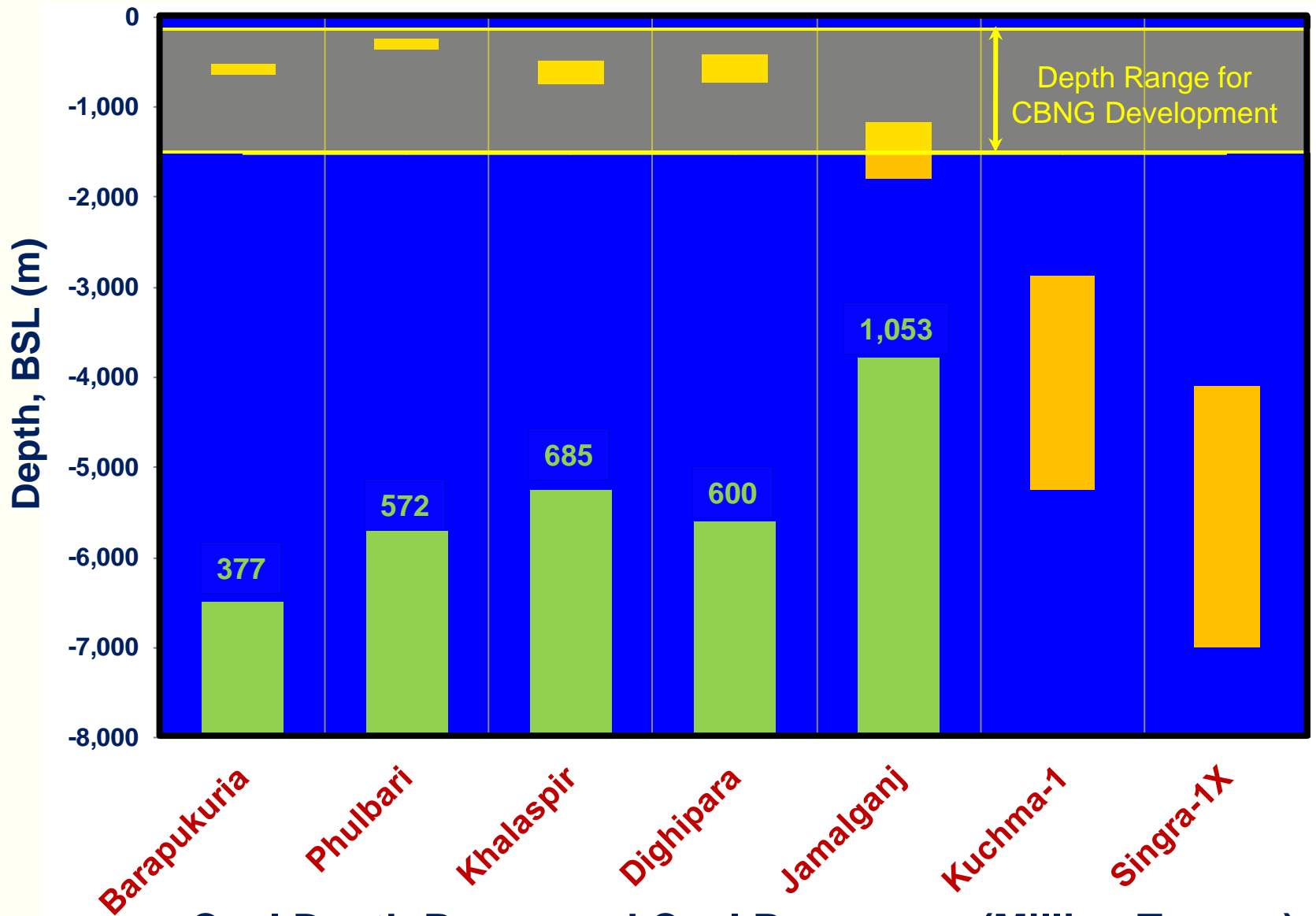
⁵ Ghose, 2009

⁶ Laxminarayana and Crosdale, 2002; Peters, 2000; Verma, 2005

⁷ Laxminarayana and Crosdale, 2002; Pophare and others, 2008; Verma, 2005

⁸ Jenkins and Boyer, 2008





**Coal Depth Range and Coal Resources (Million Tonnes)
for Coal Occurrences in Bangladesh**

Determination of Gas Content

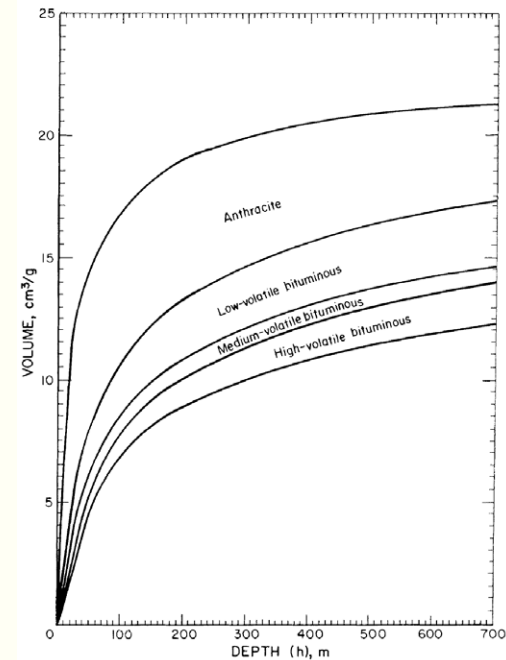
❖ Direct Measurement

- ❖ Lost gas
- ❖ Measured gas
- ❖ Residual gas



❖ Indirect Measurement

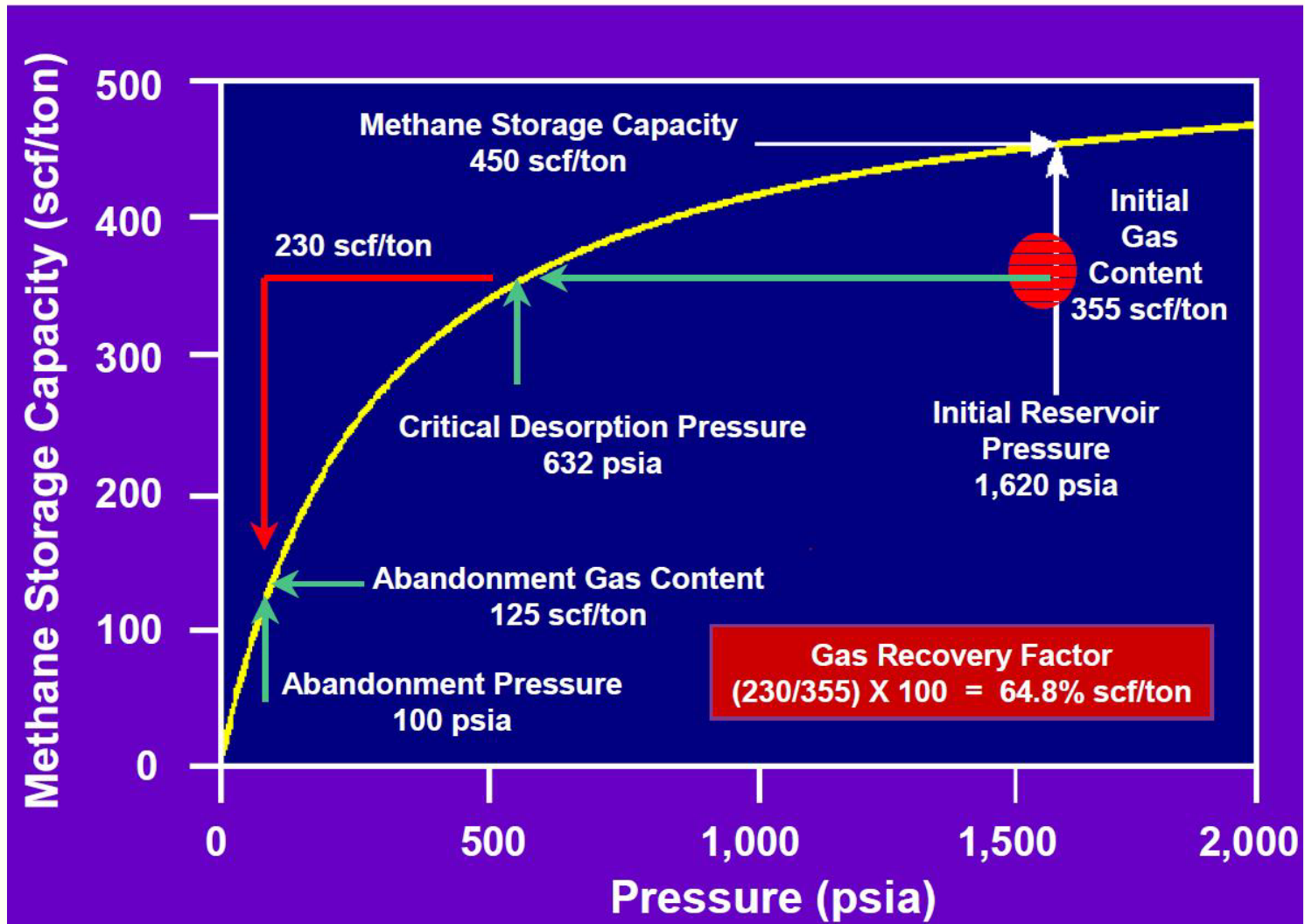
- ❖ Analogy
- ❖ Empirical formula
- ❖ Adsorption Isotherm



Kim, A.G., 1977, Estimating methane content of bituminous coalbeds from adsorption data: U.S. Bureau of Mines Report of Investigations 8245, 22 p.

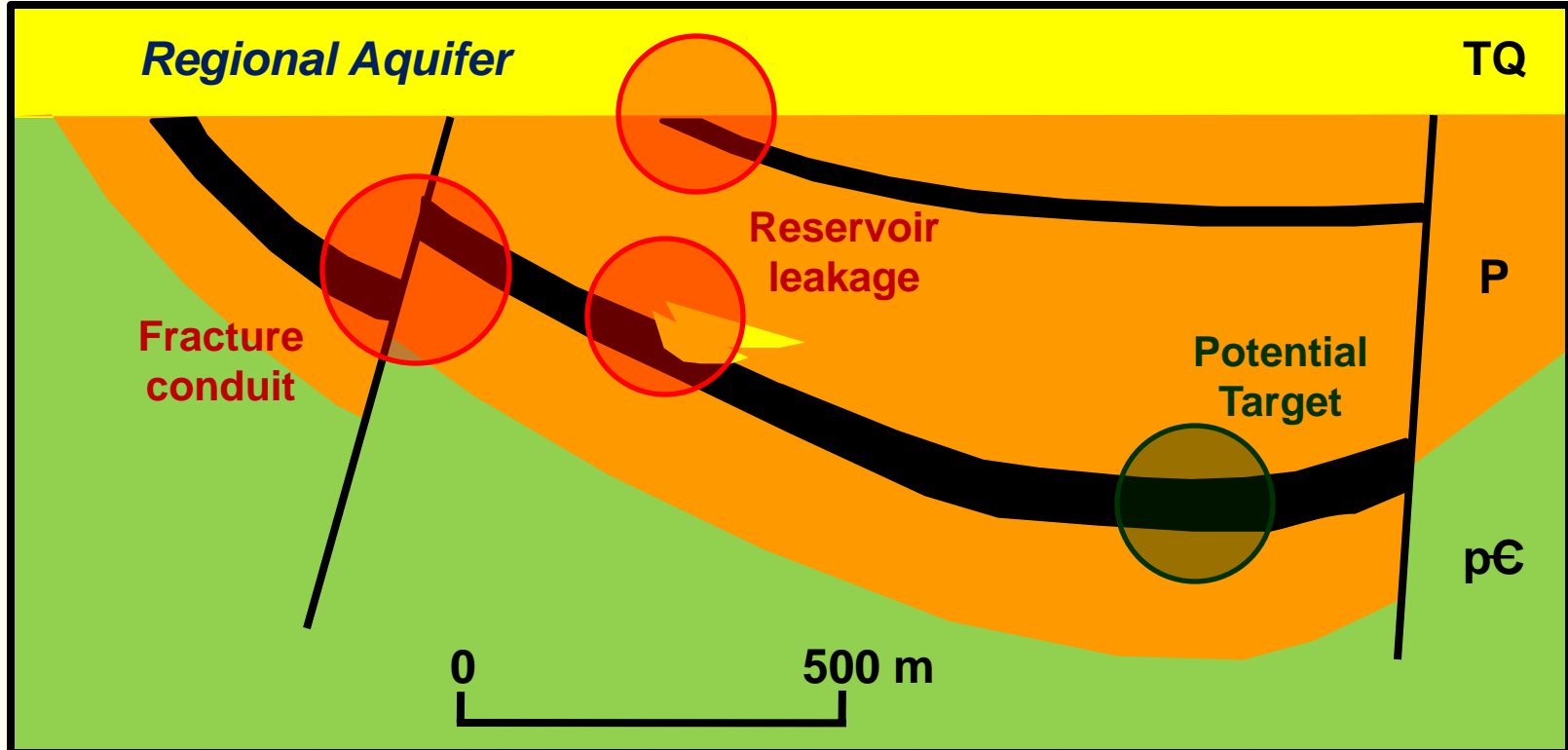


Gas Storage Capacity (Isotherm)



Geologic and Hydrologic Conditions

- ❖ Depositional environment (facies, organic source and preservation)
- ❖ Diagenetic history (thermal maturity)
- ❖ Structure (folds, faults), topography
- ❖ Alteration (igneous intrusion, mineralization)
- ❖ Character of aquifers (dimensions, lithology, permeability, pressure)



CBNG — Markets and Infrastructure

Natural Gas for Domestic and Industrial Use



Gas-fired Combustion Turbine Generators



Natural Gas Fertilizer Factory, Fenchuganj



Gas Pipeline



Power Transmission Lines



Conclusions

- ❖ **CBNG Resource Small Compared to Conventional Gas**
 - ✧ 34 Gm³ potential OGIP vs. 532 Gm³ remaining reserves
 - ✧ Total known coal area 80 km²
 - ✧ Deep coal beds (>2,000 m BSL) problematic

- ❖ **Jamalganj Most Likely CBNG Prospect**
 - ✧ Best geologic and hydrologic setting
 - ✧ Reservoir parameters favorable for exploration
 - ✧ Sampling program needed to determine gas content

- ❖ **Frontier Area with Potential Undiscovered Resources**
 - ✧ Known Gondwana basins still untested for coal
 - ✧ Uncertain CBNG potential in coal-bearing areas
 - ✧ Infrastructure underdeveloped in region



Thank You for Your Attention

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