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A PERSPECTIVE ANALYSIS OF NONCONVENTIONAL COAL MINING METHOD AT PHULBARI COAL FIELD IN DINAJPUR, BANGLADESH: AN OVERVIEW, PROSPECT AND FATE OF THE ENVIRONMENT

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Abstract- *Coal is a non-renewable fossilized source of energy. Phulbari coal deposit lies in the north-western part of Bangladesh and contains 570 million ton of Permian coal resource at depths of 150-250m, overlain by about 120 m-thick saturated tertiary sandy sediments. A feasibility study was undertaken by Asia Energy Company (AEC) in 2004 to develop the Phulbari coal field and recommended that, Phulbari coal deposit would go for open-pit mining that has been explored by Broken Hill Propreitor in 1997. But, a lot of dispute and social movements against the project have been raised due to the demerits of open-pit mining including flooding, land subsidence, gas contamination effect and so on. AEC's environmental assessment report didn't show the Dupitila aquifer management plan which is overlying the deposit. But growing demand for energy, it is necessary to recover coal deposit by the appropriate method. Experts determined that, nonconventional coal mining method is 75 times economically viable than conventional coal mining method. It is noted that Phulbari coal deposit is enriched with methane (*CH_4*). An investigation on the Phulbari coal deposit regarding Coal Bed Methane (CBM) technology for recovering methane gas may be performed. Studies also suggest that, Phulbari coal field under CBM project may be developed under considering some factors such as true gas content, coal permeability and in-seam pressure in relation to the Barapukuria coal field. Recently neighbouring countries like India have shown some success of underground coal gasification. It is concluded that, non conventional coal mining method may be adopted considering some issues such as economic viability, mitigating subsidence, preventing roof collapse, and minimizing environmental hazards. This paper provides an overview regarding the significant implications for decision making in an effort to extract coal resource in the area studied for the selection of non-conventional mining method.*

Keywords: Coal deposit, Non Conventional method, Coal Bed Methane, Gasification, Environmental hazards.

1. INTRODUCTION

The Phulbari coalfield is located in the Gondwana Basin which is a sub-basin of the Bengal Basin situated in the northwestern part of Bangladesh. It is the oldest sedimentary unit (Permian) lies unconformably on the Precambrian hard rock basement. This basin fulfils all the requirements for the accumulation of coal in the subsurface as deposited in a fluvial environment. There are 5 coal fields have been discovered in Bangladesh till now and only one coal field (Barapukuria) is developed for coal extraction. Among the undeveloped coal fields, Phulbari coal field is more prospective for coal extraction.

The Phulbari coal field is located in Dinajpur district, lies about 10 km south of Barapukuria coal field as shown in Fig.1 [1].

The Phulbari coal field was discovered by Broken Hill Propreiter (BHP), an Australian Mining Company in 1997. A total number of 9 wells were drilled at block B in the cumulative depth of about 2245 meter and resulted in the Phulbari coal field discovery [1]. This field is supposed to contain an amount of 570 Mt Coal, which is about 19% of total in-situ coal resource of Bangladesh. Most of the coal is embedded within major thick and minor thin coal seams. The coal is recorded at a depth ranging from 150-250 m and the average thickness of the coal layer is 38.41m [6].

The Phulbari coal is known for its high volatile bituminous nature and low sulfur content. According to the empirical formula developed by the Central Fuel Research Institute (CFRI), the useful heating value of Phulbari coal is approximately 8878.61 Btu/Ib [7]. Extraction of this coal resource is necessary to meet the country's future energy demand. But the overlying upper and lower Dupitila aquifer is the prime techno-feasibility obstacle in this regard. Asia Energy Company (AEC) recommended for developing open pit mining in Phulbari coal field. But the feasibility report prepared by non-government organizations and other self-motivated experts do not support the choice of open-pit mining in Bangladesh, particularly in a highly populated town like Phulbari.

The objective of this article is to analyze the feasibility of Non-conventional mining such as Underground coal gasification (UCG), coal bed methane (CBM) for application to Phulbari coal mine based on quantitative information available in open literature.

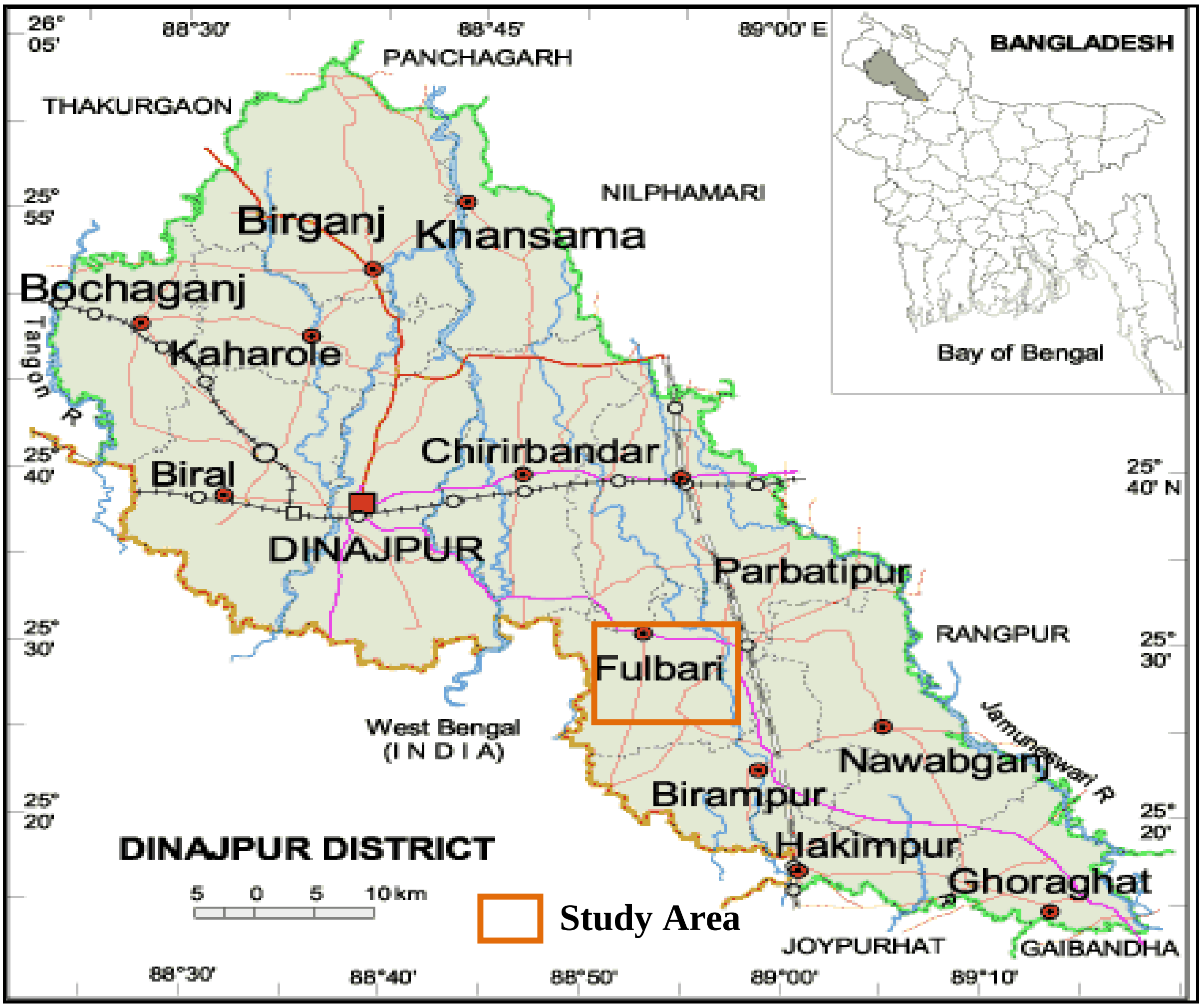

Fig.1: Location map of the study area (source: Banglapedia)

2. CONVENTIONAL MINING METHOD

2.1Open cast mining

The technological planning of open cast mining is a newly one concept to explore coal resources in the aspect of Bangladesh. Open cast mining feasibility study in cage of Phulbari coal field is basically done by AEC. Open cast mining, generally conducts at shallower depth between 100-150 m to extract mineral resources in an environmentally friendly manner. Open cast mine is also preferable world-wide as it is economically viable and relatively low risk mining method.

In most of the countries like Germany, Australia and our neighbouring country India, Open cast mining is performed in a hilly region or relatively low densely populated land area. Because open cast mining requires a large area for its bench development, storing its by-product waste disposal, introducing a large volume of vehicles and equipments.

The feasibility report of AEC's shows that, the proposed Phulbari coal mine would be 30 or more years project in duration. The production rate per annum from this field would be 15 million tons of coal [1]. The recoverable reserve by open pit mining is about 10-15 Mt, which is about 2.62% in account of the total reserve. In addition, open cast mine in the Phulbari area would also co-produce some other economic resources such as near surface clay, white clay from tertiary sand etc [1].

But the fact is that, the Phulbari coal mine will displace near about 40,000 people and also near about 10,000 hectares fertile land will be damaged [13]. Moreover, there is an 80-120 m thick Dupitila aquifer overlying the thicker coal seam. A volume of 400-500 ML/day water needs to be discharged throughout the life of the mine [11].

The techno-feasibility study provided by AEC is not fairly accepted by experts concerning this field. Here we have concentrated focus on several factors which made the AEC's feasibility report questionable.

- The overall stripping ratio SR_o is calculated as 7.61 from the empirical formula; $SR_o=V/W$ [2]. This is not favorable for open cast mining development in Phulbari coal field as it requires a large volume of overburden need to be removed.
- Excessive pumping from Dupitila aquifer will increase the cone of depression and this will result in a massive drawdown in the present Ground water table (GWT).
- Open cast mining generally developed at a depth of about 100 m. Combined or Underground mining is practiced in the depth range of 150-300m.
- Open cast mining in a highly populated area (800/Km^2) like Phulbari is not economically viable.
- The 'mine footprint' of the proposed Phulbari coal mine project will directly affect approximately 5,192 hectares fertile land and cumulative loss in the traditional agricultural production which would be about 7000 million taka [14].
- XRD analysis report shows that, the concentration of arsenic (As) is about 1-2% and other heavy minerals like Be, Pb, Se, Mn, Zn is in the lower concentration [13]. But in the course of mine operation, arsenic in association of other heavy minerals may be mobilized and results in the Acid mine water inrush.

Besides open cast mining is also responsible for the emission of toxic gas containing methane (CH_4), air pollution, noise pollution etc.

3. NONCONVENTIONAL MINING METHOD

Nonconventional coal mining method has getting popularity worldwide as "clean coal technologies". This is because it has less possibility of pollution due to the transport, storage and combustion of coal [7]. By considering the techno-feasibility difficulties, geological complexibility, economic viability and also safety factors of conventional mining method, the decision makers of many countries seeking for a new coal exploration technology. Many countries like UK, China, Russia, Germany, Canada and even our neighbouring country India are now experiment the possibility of nonconventional mining like coal bed methane (CBM), underground coal gasification (UCG). In this research work, we tried to analyze the feasibility study of nonconventional coal mining method for application to Phulbari coal mine based on the quantitative information available in open literature.

3.1 Coal bed methane (CBM)

CBM (Coal Bed Methane) is the method of methane gas extraction from subsurface coal deposits, where the coal itself is located at depths greater than the reach of conventional mining method, or where mining is not possible, or not preferred, for technical, social or environmental reasons. CBM is currently classified as a clean energy resource by the World Bank and its output gas can be liquefied, or used as a direct feedstock to local power stations. We can look up the Phulbari coal deposit for the social or environmental reasons or the energy crisis of Bangladesh.

3.1.1 The major factors in the use of CBM technology

CBM requires understanding a various types of factors so that its prospect may be assessed in developing the Phulbari coal field. Theoretical modeling and experience sharing between the various mine under CBM operation are very much essential in this perspective analysis. Before starting with CBM some factors must be considered including coal rank and methane gas content, depth of the coal seam, areal extent and coal reserve, Permeability of coal seam, capping conditions of overlying layer [4].

In this article we have discussed the prospectivity analysis of CBM development in Phulbari coal field in comparison with standard conditions required for this clean coal technology. This is shown in Table 1.

Table 1 Perspective analysis for CBM in Phulbari coal field

Recommended CBM conditions by experts	CBM conditions for Phulbari coal field.
Coal seam generally deeper than 91.44 m is needed for CBM extraction. In the Raton basin of cretaceous-paleocene age, CBM is practiced at depth range of 75-360 m [3].	Phulbari coal field lies at a depth range from 150m to 250 m.
The thickness of the coal seam needed more than 6.096 meter.	The average thickness of the Phulbari coal seam is about 35 meter.
High rank coal and effective permeability is needed	The Phulbari coal is high volatile bituminous in nature [1]. It also indicates a good permeability than Jamalganj coal field as burial overburden is less than that of Jamalganj coal field.
CBM content greater than 1.98 m^3 /ton is needed for CBM development.	Average in-situ CBM resource in Phulbari coal field is about 4.09 m^3 /ton.
An effective capping layer is necessary to hold the in-situ gas reserve.	The sandstones overlying the coal seams may serve as the impermeable layer due to presence of kaolinite cement [1].

3.1.2 Environmental safety and economics

The major environmental issue associated with CBM is the CO_2 emission. In association of methane gas extraction, it produces some trace quantities of ethane, nitrogen, carbon-di-oxide and few other gases. Additionally, some amount of dissolved particles may be exposed to the overlying aquifer. An effective Environmental Impact statement (EIS), proper investigation of the site and enforcement of the environmental regulations may decrease the environmental constraints to a great extent indeed.

A power plant development up to 2500 MW would suppose to install near the Phulbari coal field site [1]. Additionally, a chemical processing plant needs to install near the mine site. These installation plants would reduce the transportation losses of the extracted methane gas and make the Phulbari coal project economically viable under CBM development.

4. UNDERGROUND COAL GASIFICATION

UCG is an in-situ gasification process which typically involves installation of two wells into the coal seam: one contributes as an injection well and other as a production well [7]. Additionally, the proposal for installation of another pipe for water drainage has been introduced by many authors [8]. The gasification agent like oxygen, steam or water is fed through the injection well at higher temperature (900-1200°C) and higher pressure. These burn the coal seam to produce gaseous products constituting of H_2, CO, CH_4, N_2 etc. in a channel like manner. Finally, these sync-gases are being recovered from production well.

However, UCG is recognized as a clean, cheap and safer method by world coal association (WCA). UCG trials on a pilot scale and commercial scale is now being conducted throughout the world including countries like USA, Russia, New Zealand, South Africa, China, Australia , India etc.

4.1 Economics

Several factors make the UCG process unique. Due to in-situ gasification, the UCG does not require any additional gasification plant. Installation of chemical process plant near the mine site is economically beneficial for the process. Additionally, the produced sync-gases may be used for power generation. Besides, the carbon capture and storage (CCS) may be done more efficiently under UCG method. Gasification of coal would save the labor cost and reduce the disturbance of land [8]. The UCG method is very helpful for extracting gases from non-mined coal reserves particularly for developing countries where conventional mining is not possible.

4.1.1 Environment and safety

The most concerning environmental issues associated with UCG are the CO_2 emissions, land subsidence and water contamination. But UCG in association with CCS is efficient to reduce the CO_2 emissions up to 25% and produce fewer amounts of greenhouse gases [8]. The risk of land subsidence is minimal due to UCG and it may be eliminated by the utilization of UCG-CRIP (control retracting injection point) technology. The most important factor is that, if UCG site is operated properly, there would be no chance for ground water contamination [8]. Moreover, aquifer overlying the coal seam may be managed by capturing the gases and pressure within the cavity.

4.2 UCG field trials

From the last century to till date, UCG experiments have been conducted throughout the various countries by adopting chamber or stream gasification sub-methods. However, the first successful UCG operation was undertaken in Donetsk coal basin on April 24, 1934 [8]. In this article, we focused on those UCG trials that would be suitable to make a theoretical comparative feasibility study for the Phulbari coal field indeed.

A series of successful UCG trials were undertaken in 1979 at a site near Hana, Wyoming, at a depth of about 100 m and an amount of more than 30 thousand tons of coal was being gasified. Another small scale UCG trial was conducted in the same year at a site near Pricetown, West Virginia, at a depth of 270 m. In the year 1999, at a site near Chinchila, Brisbane, UCG trial was conducted at a depth of 130 m and a 40 MW power plant was installed near the site. Various coal fields of Russia like Lisichanskaya, Yuzhno-Abinskaya have experienced the UCG technology for bituminous coal seam. The typical depth of these trials was below 200 m and a total amount of 1000 MW power was produced as the trial output. The USA have also the experienced of conducting UCG trials for shallow depth coal seam (<300 m). During the 1980s, UCG trials were also conducted in India including Rajasthan at a depth of about 100-200 m and Bihar for bituminous coal seam layer.

4.3 Feasibility study of UCG in Phulbari

The Phulbari coal deposit may be compared with the Lisichanskaya and Yuzhno-Abinskaya coal basins where UCG were conducted at the depth range of 60-250 m and 50-300 m respectively. The coal types of both of these basins are bituminous in nature. The proximate analysis of Lisichanskaya basin coal sample shows that it is containing (7-17) % ash, volatile matter (39-40) % where Yuzhno-Abinskaya coal samples having (2.3-5.2) % ash and (27-32) % volatile matter.

The above features of UCG trial closely match with the Phulbari coal deposit in terms of depth (150-250 m), ash content (15%), volatile matter (27.6% as like Barapukuria coal) and coal type nature (Bituminous). So, the UCG trial may be introduced into the Phulbari to extract the coal reserve as on pilot scale basis.

5. CONCLUSION

There have been a lot of debates on coal extraction method for Phulbari coal deposit. But it is the high time for Bangladesh to develop her coal resources to meet the ever increasing energy demand. Every year we have to import a huge amount of low grade coal from India and other countries for power generation. But it is more reasonable to develop the Phulbari coal reserve in an effectual manner. There are challenges both for conventional and nonconventional coal mining. But the authorities have to commence techno-feasibility study concerning both of these methods. Before starting the coal production, nonconventional mining may be undertaken as on the pilot scale basis. Comparing both of the two test reports, the more environmentally sustainable and economically viable method should be conducted for Phulbari coal field. By this way, we can inaugurate coal base fire plant for electricity generation and progress the country's economy to a great extent.

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