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Proposal of Open Pit Mining of Barapukuria Coal field, Dinajpur, Bangladesh

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Abstract – The advancement of the Energy sectors has suffering from a lack of long-term planning; therefore, the worse still is that there are no firm statistics available to exemplify the country's demand, supply and capability of power and gas generation. Low availability of commercial energy source can be one of the major decisive obstacles to the country's economic development; however, almost 70% of total commercial energy needs is met by natural gas in Bangladesh. Many experts believe that the hypo situation of energy is due to the unconditional reliance on gas that abridges the country's progress to one step forward. The probable alternative solution ensuring the energy security for sustainable human development is to implement of using the proper inhabitant energy sources, particularly in case of coal that is the second largest energy sources of Bangladesh. Having an impressive reserve of coal, the in-sight development of that sector cannot highly noticeable; additionally the country is leading with only one operating coal mine - Barapukuria coal mine. The annual production rate of Barapukuria coal mine is about 1 million tons that is both far beyond to fulfill the energy crisis of the nation and also much lower in terms of its demonstrative reserve. Although the mining progression only in the central part is not a single cause of low production, however, the lacking of the modern technology, inability of controlling the mining related hazards and challenge of renovating the mine vastly obstructs the mine to reach its target. A massive survey of that field provides a positive sign of mining towards Northern and Southern part of the basin. Numerical models illustrate a clear view of the overall strip ratio, ranging 3.5:1 to 11:1 where the minimal variation has found towards Northern part of the basin with an estimated range of 4.706:1. Considering the perspective analysis of the results of some numerical models and mining-engineering parameters, authors are suggesting a small scale opening up of the Northern and Southern part through an appropriate method and also proposing some safety measures of some possible or probable recognized hazards related to the proposed mining method.

Terms of Index– Strip Ratio, Recovery, Groundwater Problems, Open Pit Mine, Barapukuria Coal Field

I. General

Bangladesh is not well endowed with the term of proper energy mix, thus the role of different types of energy in power generation are getting asymmetric whereas natural gas fill-up the overwhelming percentage of demand. Ensuring the proper energy mix for power generation, the Government has launchedsome prospective plans (table 1). According to those plans, the share of coal will be much higher within 2021 but at present, in 2016, there is no significant improvement so far carried out in this field. Moreover to control this situation, the Government has decided to import large amount of fossil fuels at a rate of about 18.04% (source: World Bank 2012) from nearby countries that may create an extra pressure on the country's economy.

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Never the less so far Bangladesh has discovered five coal fields with an estimated reserve of 3500 million tons. With the positive overview of geology, Barapukuria has starting mining from 2005 but due to inability of handling the negative impacts of mining local agitation entrapped coal production in some extent.

Table 1: Governmental Prospective plan for power generation (Source: IAEA report 2013)

Energy Sources	Current Percentage	Target Period	
		2021	2030
Gas	88%	30%	28%
Coal	3.70%	53%	38%
Oil	6%	3%	5%
Hydro	2.70%	1%	4%
Nuclear	0%	10%	19%
Renewable	0%	3%	6%

Despite the difficulties of coal extraction, Barapukuria has the potentiality6 to produce more by using advanced technologies and if the circumference of the mine is extended towards the Northern and Southern part.

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By considering and comparing some mining-engineering parameters and also calculating the total demonstrated reserve of the individual sections of mine, on behalf of the above circumstances, a vast investigation has been done here, for proposing suitable mining method in the Northern and Southern part of Barapukuria coal mine.

II. Barapukuria Coal Basin

Barapukuria coal mine is situated in Hamidpur union council under Parbatipur Thana of Dinajpur District (fig 1). Within VII encountered Gondwana coal seams, Barapukuria has the proved reserve of about 390 million tons of coal (Wardell Armstrong 1991). Coal seam VI, the thickest coal seam, contains about 90% of the total reserve of the basin. Theannual production rate is about 1 million ton that is equivalent to the 7, 00,000 tons of oil.

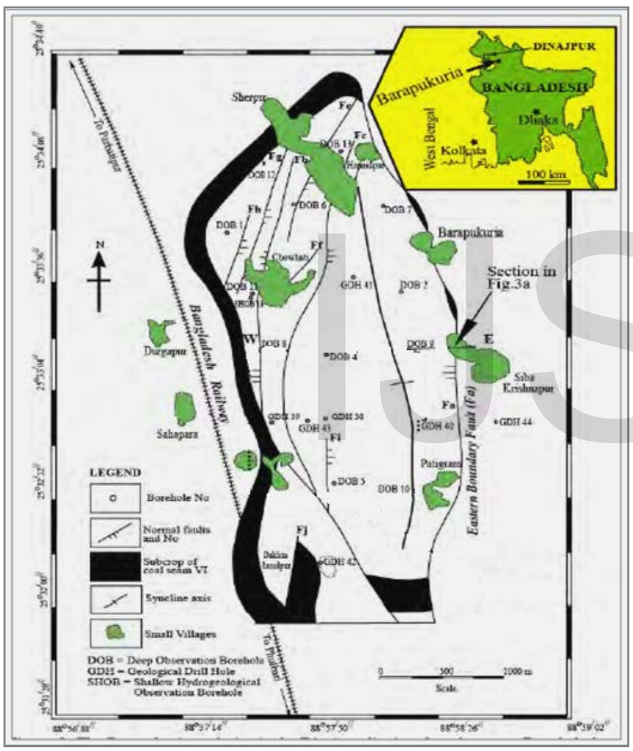


Fig 1: Location map of Barapukuria coal mine

Structurally, Barapukuria is a narrow and shallow asymmetrical synclinal basin that underlines with four major formations, in sequence – Madhupur clay, Upper Dupitila unit, Lower Dupitila unit, Gondwana unit (fig 2, 3).

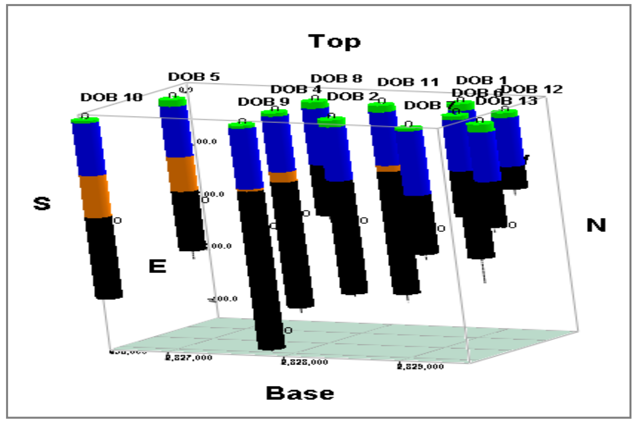
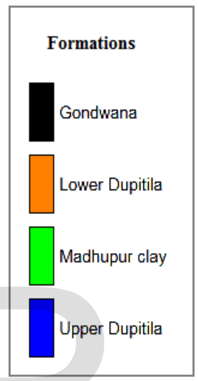


Fig 2: Formations delineation per borehole in Barapukuria



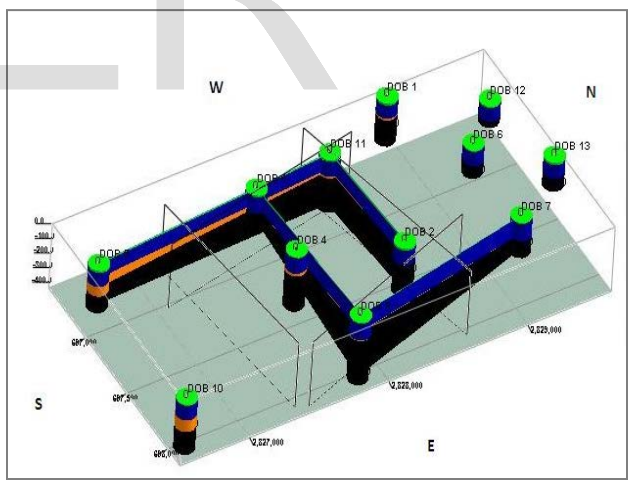


Fig 3: Areal distribution of Formations in Barapukuria

Confiding the positive feasibility study of Wardell Armstrong (Consultant of UK) (1988-1990), Barapukuria started mining only in the central portion by multi-slice longwall mining without backfilling method since 2005. Within the expected mine life (64 years) (fig 4), the mine will recover about 64 million tons of coal that is only 21% of the total coal whereas the maximum (about 79%) coal will be left behind (data source: IWM report, 2013).

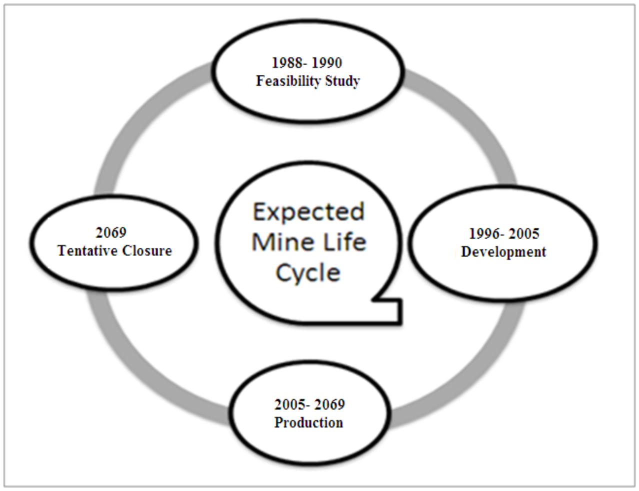


Fig 4: Expected mine life cycle of Barapukuria

III. Data Acquisition And Methods Of Research

A number of seismic reflection data has been processed manually and run through the software to delineate the distributional change of the strata and also to characterize the individual formations. The whole work procedure follows a systematic manner.

For the efficiency of the work, the entire area of Barapukuria is divided into three extensions in perspective of the depth of coal and the thickness of overburden (table 2).

Table 2: The distributed extensions of the Barapukuria coal mine

Extensions	Area (km^2)
Northern portion	1.837
Southern portion	0.87
Central portion	2.543
Total	5.25

Modeling

a. Coal seam VI model

With an average thickness about 35.367m, the frequently distributed coal seam (seam VI) varies within a depth range of 118 to 381m. In DOB 9, the maximum thickness, ranges 39.75m, has encountered whereas the minimal thickness (about 21.63m) has reached in the adjoining borehole DOB 8 (table 3, fig 4, 5).

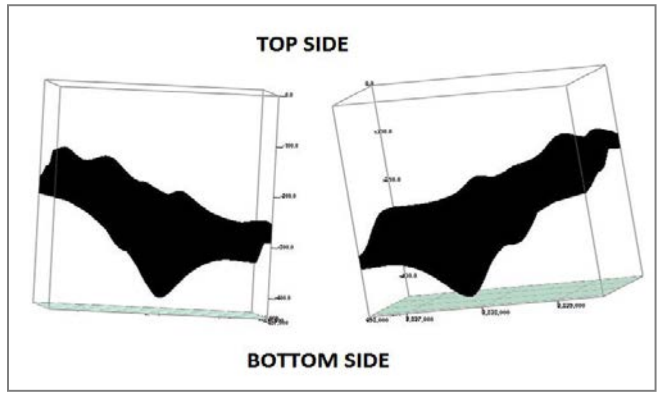


Fig 4: Thickness and Depth variation of coal seam VI all over the mine (3D view)

Table 3: Thickness variation of coal seam VI per DOB

Borehole	Seam roof (m)	Seam floor (m)	Thickness (m)
DOB 1	131.80	161.20	29.4
DOB 2	297.6	328.50	30.9
DOB 4	331.5	370	38.5
DOB 5	249.40	289.37	39.97
DOB 6	163.35	196.72	30.37
DOB 7	199.55	237.60	38.05
DOB 8	195.80	217.43	21.63
DOB 9	381.62	421.37	39.75
DOB 10	312.70	341.40	28.7
DOB 11	180.64	213.77	33.13
DOB 12	118.65	149.49	30.84
DOB 13	162.17	197.54	35.37

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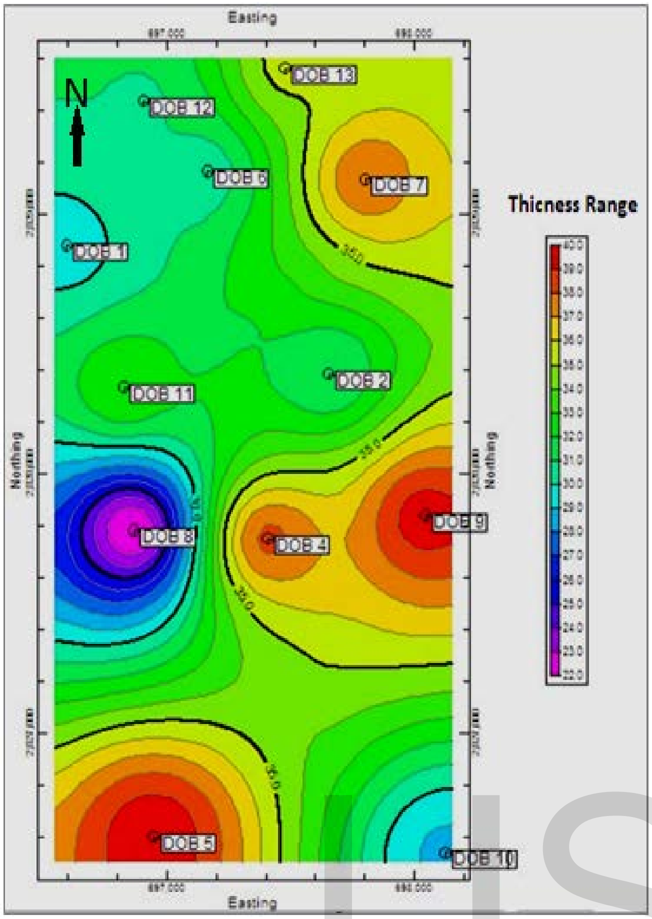

Fig 5: Thickness variation of Coal seam VI (2D view)

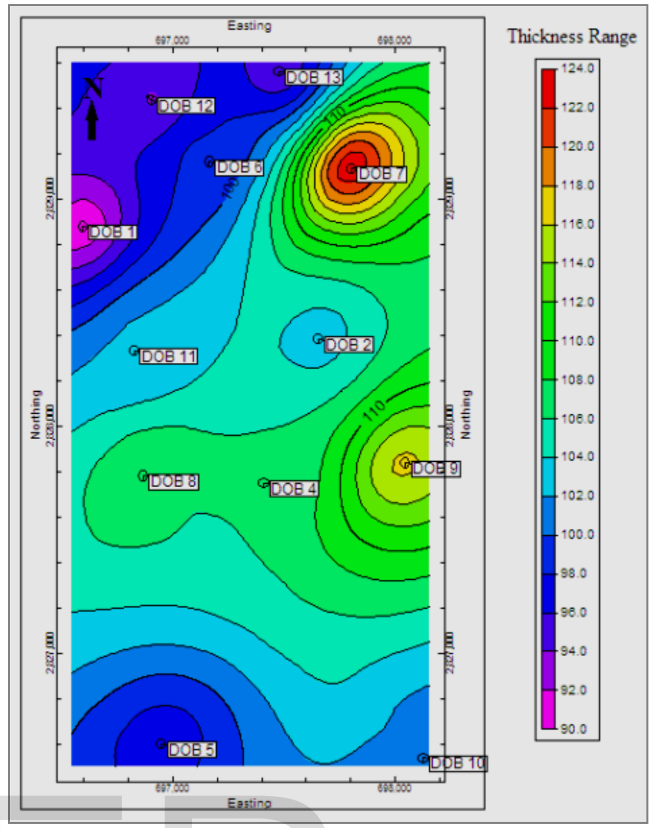

Fig 6: Thickness variation of aquifer (2D view)

b. Aquifer model

The randomly variation of thickness, range 90 to 124m, of the aquifer create an extra haphazard situation on mining operation. The thickest zone has reached into the Northern sub-crop side compared to the other part of the mine (fig 6).

c. Overall Stripping Ratio

Overall stripping ratio is the ratio of the waste (overburden) rock stripped to haul out the ore. The specific changes of strip can trigger the selection of suitable mining method. In general, suitable range of strip for open pit mine is 6:1 but the extended acceptable allowance ranges 7:1 for the same course of action.

In Northern side, the stripping ratio (average 4.706:1) tends to be lower due to the minimal amount of overburden. In case of the southern side the average strip is 8.4:1. On average, the strip varies within a range of 6.55:1.

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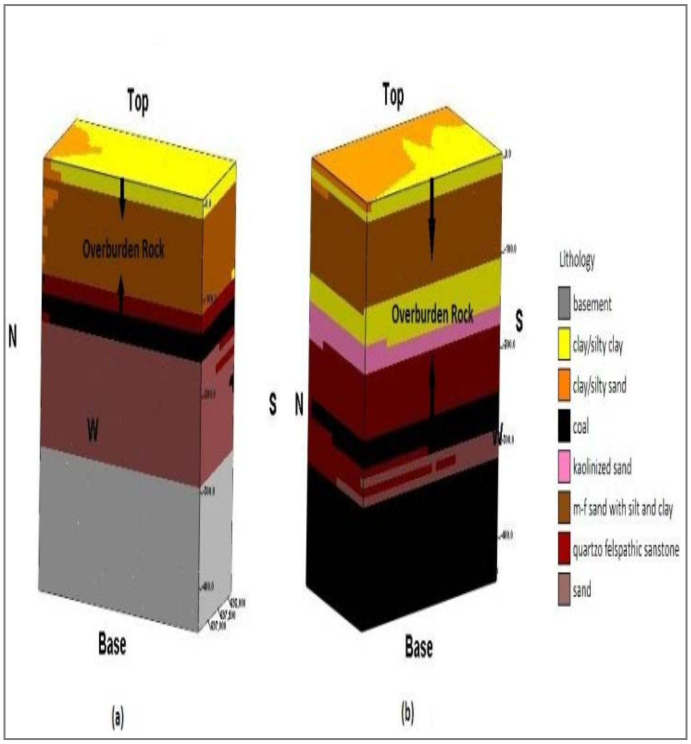

Fig 7: Litho Model of mine area indicating overburden rock thickness (a) Northern (b) Southern sub-crop area

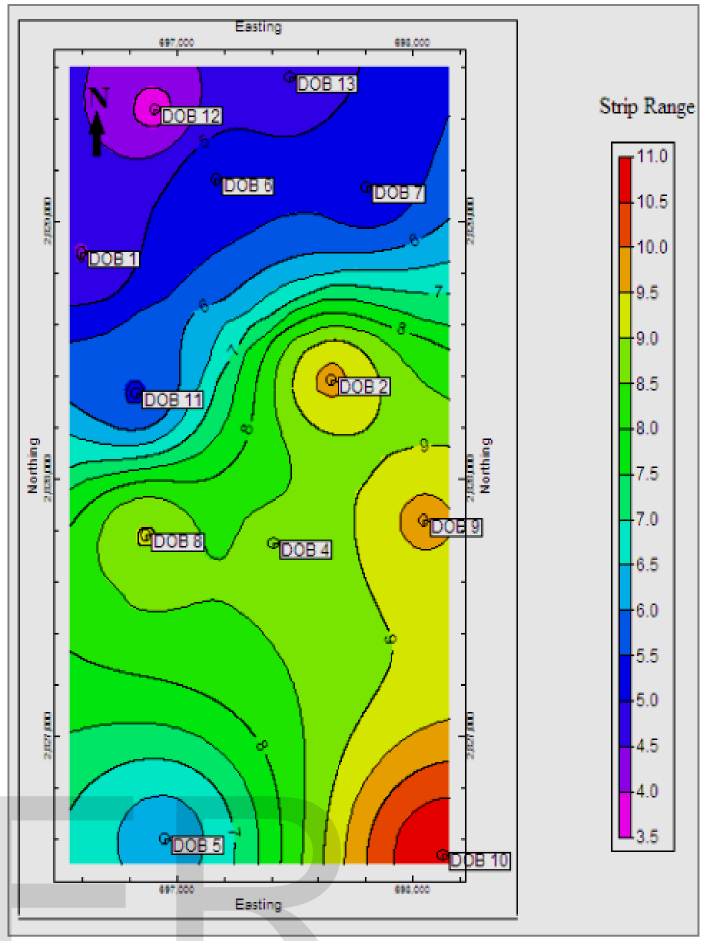

Fig 8: Map showing the Stripping ratio per borehole

IV. Selection Of Mining Method

Have an idea of the above delineations, some mining and engineering parameters are judged through a massive survey of physical investigation (table 4) of the area for selection of a suitable mining method.

Table 4: Mining-engineering parameters comparison for selection of mining method

Considering parameters	Northern part	Southern part	Total/Average	Result
I.MINING PARAMETERS				
Calculated reserve (million tons)	93.189	52.426	145.615	1/3 of total reserve
Recovery rate (million tons) Open pit mine Underground mine	 83.8701 23.30	 47.1834 13.11	 131.05 36.41	% of total - 90% 25%
Depth of coal seam VI (m)	155.104	281.05	218.077	Within feasible range
Thickness of coal seam VI (m)	32.806	34.335	33.5705	Within feasible range
Strip variation	4.706:1	8.4:1	6.55:1	Feasible for open pit mine
II.ENGINEERING PARAMETERS				

Grade Distribution	Fine to Medium with minor coarse	Fine to Medium with minor coarse	-	Uniform distribution, Feasible for mining
RQD Above strata coal	 58.6% 20.96%	 72% 6.45%	 65.3% 13.7%	 Fair Quality, resist slope failure Poor strength, feasible for open pit mine
Plunge	14.5^0 to 21^0	20^0 to 22.5^0	17.25^0 to 21.75^0	Stable range for open pit mine

Depending on the theoretical observation of some hypothetical parameters, the suitability of mining method selection has also been considered and shown through an executive comparison chart.

Table 5: Executive comparison of hypothetical parameters for suitability analysis of mining method

Considering parameters	Open pit mine	Underground mine
Operational cost	Much lower	Much higher
Risks and accidents	Much lower	3.8 times higher (according to the research of U.S Mine Safety & Health Administration)
Social impacts	Require vast surface area mostly are of irrigated land	Requires relatively small area but causes subsidence in the vicinity area
Environmental problems	Hazardous method	Relatively lower hazardous method
GW pollution	Lowering the water table, contaminants the groundwater source but can be manageable by proper planning of mine	Adversely affect the overlying aquifer, changes the streamflow, shaft sinking, GW contamination, sudden water inrush; these adversity can't be properly manageable due to the sudden occurrences of hazards but with some safety precaution the impacts of the hazards can be minimized

With a view of the positive sign of the above demonstrative parameters, open pit mining is very much feasible to apply in the study area rather than underground mining. The pursue of controlling the negative impacts of open pit mine is essential before mining operation, so a number of safety measures must be taken to restrict the direct and indirect impacts of mining method.

V. Related Problems And Safety Measures

1. Continuous Dewatering especially during mining operation

Unless dewatering process, the mining operation will be in risk because of the presence of aquifer just above the coal layer towards the Northern part. The water should be lowered down around 33m with an estimated total drawdown volume about 60.621 km^3.

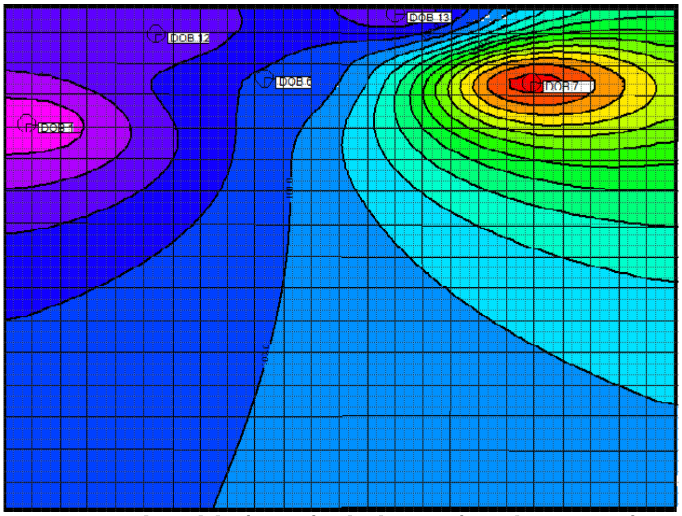

Fig 9: Grid Model of Aquifer thickness of Northern part of Barapukuria

The proper design of the dewatering system according to the daily draw down rate and the thickness of aquifer is a vital phenomenon. Without having a proper plan or idea, this dewatering process may disturb the mining action. Northeastern part has marked as a thicker zone of aquifer (fig 9), so the number of the discharge well should be boosted in that location.

2. Isolate the mine area from outer surface

Another suspicion is the pollution of the major aquifer during mining operation. This situation can partly be managed by isolating the mine area from the outer portion through European technology (fig 10). This is the technology that capture the whole mine area within an impermeable membrane so that the outer side is totally unconnected from the inner side. This method is done partly by grouting wherein the impermeable rock units with some chemicals are injected into the hole to separate out the extensions (fig 11).

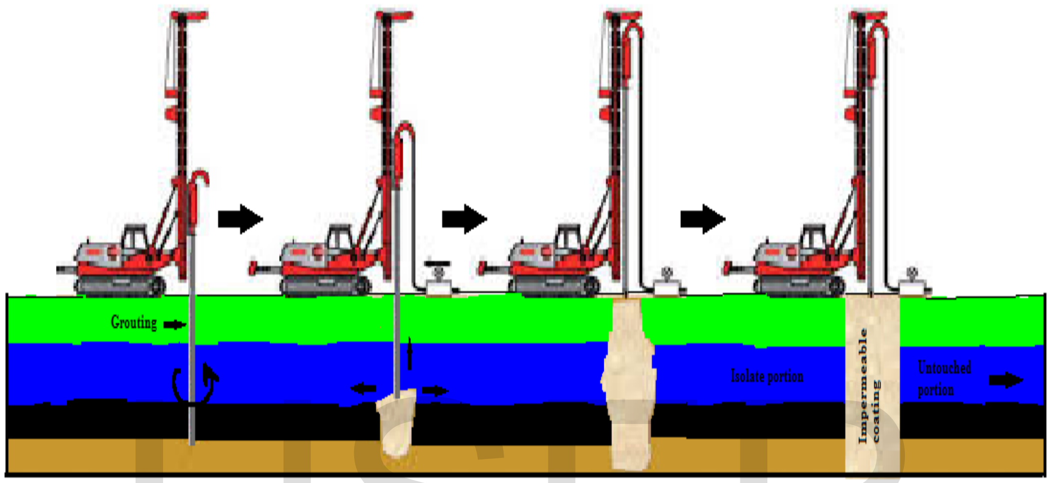

Fig 10: Principal of the proposed isolation method

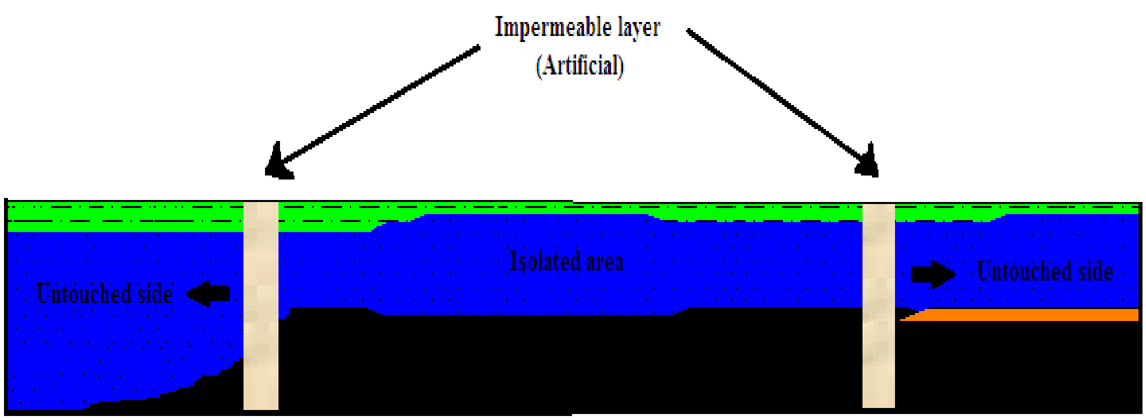

Fig 11: Schematic cross-section of the Northern part showing isolation grouting technique

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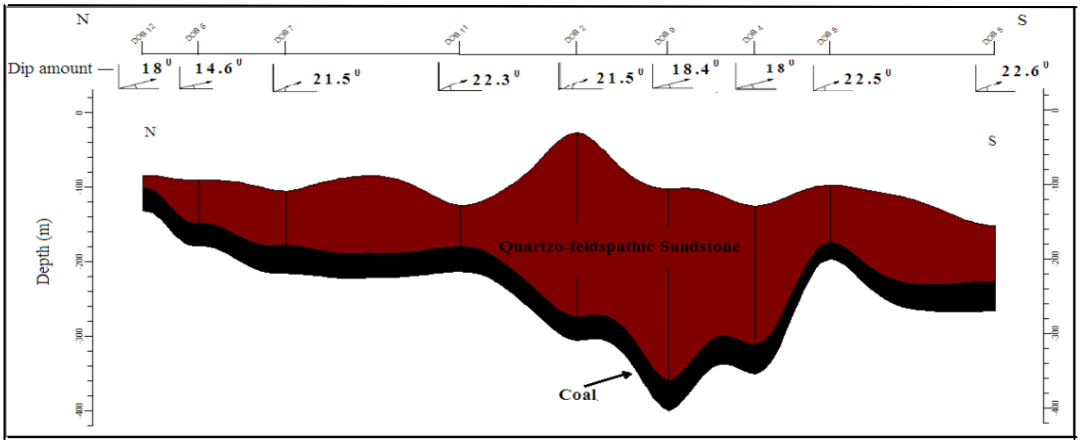

Fig 12: Cross-section of overlying unit of coal showing dip amount

3. Maintaining a preferable bench slope

The dip amount of the entire strata of the basin shows a discrepancy from around 14.6^0 to 30.5^0 whereas the overlying rock unit of the coal seam VI (quartzo-feldspathic sandstone) oscillates from 14.6^0 to 22.6^0 (fig 12, 14) and the coal seam VI varies from 15.5^0 to 30.5^0.

For a suitable mining, the bench slope should be maintained within the average of the dip of all overlying strata. So in that connection, to diminish the slope failure, theoretical investigation find that around 18^0 dip should be maintained in the Northern extension and around 21.5^0 should be maintained towards the Southern extension (fig 13) of the mine.

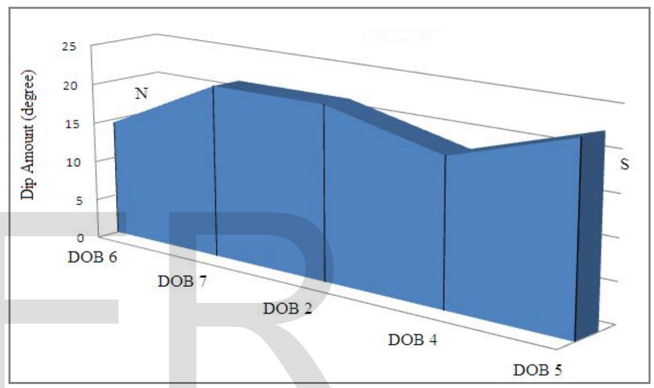

Fig 13: Graphical representation of dip variation, N-S straight view

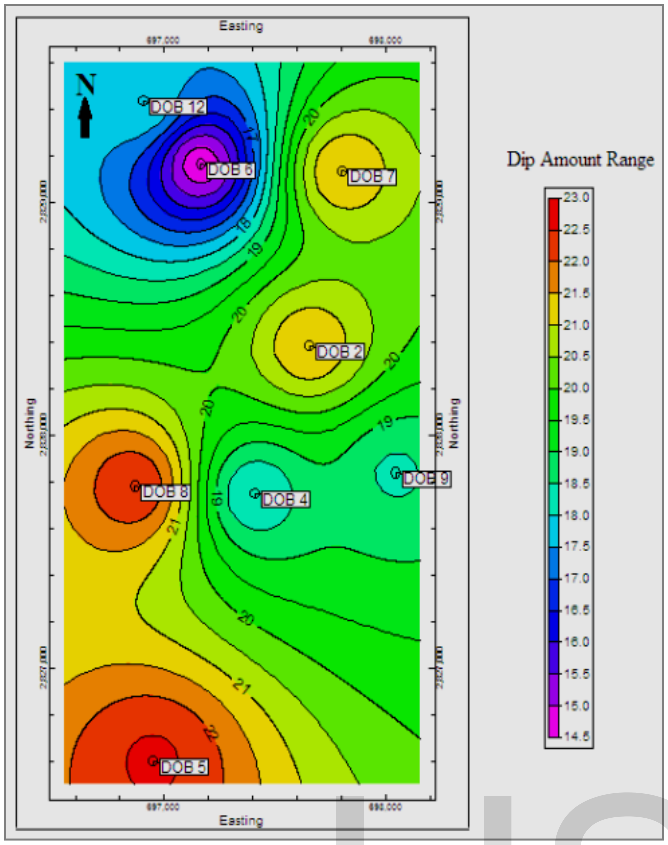

Fig 14: Dip variation of the overlying strata of coal seam VI (2D view)

4. Controlling the dust spreading

Open pit mining method is a hazardous method that generates a huge amount of dust, causing environmental pollution. A modern technology like water spray and air shocker technology can be applied to avert the spreading of the dust in air during mining.

However, the mining hazards often come without any pre-warning at any time and create the mining site as well as the surroundings vulnerable to environmental degradation. So the regular auditing, essential EIA programs and the pre-caution of any sudden mining hazard should be adopted. Additionally it should be restricted to abide by the mining rules and environmental regulations precisely.

V. Conclusion

In view of the need to reconcile the often conflicting demands of energy, Bangladesh poses a formidable challenge to maintain this growing pressure. To sustain the increasing pressure, the country addresses, at the same time, some energy security programs and related sustainable development programs. Coal exploitation program is one of them programs. Almost one era ago, Barapukuria started its journey as an underground coal mine with an initial target production rate of 1 million ton of coal per year. The whole basinal area has been divided into three portions; however the present study only focuses on the Northern and Southern portion. Depending on the specific mining-engineering parameters, an attempt has been taken out to propose a suitable mining method in these two extensions.

Both two extensions (Northern and Southern) apprehend almost one third of the total reserve of mine. The overall strip varies all over the area at a range of 3.5:1 to 11:1 in where the Northern part shows 4.706:1 (on average) and the Southern part shows 8.4:1 (on average) strip variation. Some engineering parameters have also been judged to select suitable mining method. The utmost indication of the mining-engineering parameters shows that the area is extensively feasible for open pit mining. On the other hand, the theoretical observations show a positive overview of open pit mining method. “It is impossible to make some one better off without making another one worse off”- so considering the benefits of open pit mine besides its bad effects on environment, the local community of Bangladesh yet to accept the open pit mine and vice versa. With a proposal of open pit mine towards the extension part of Barapukuria, the current article also proposes some safety measures and necessary initiatives of this mine.

VI. Recommendations

1. A small scale opening up the Northern and Southern part of Barapukuria through open pit mining method
2. Strictly following up the mining safety policy and regulations
3. Uphold the benefit of open pit mine besides its destruction to the local community and try to inspire them
4. Analyze the socio-economic appraisal of coal mine through vast numbers of investigations

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