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Possibility of Largest Underground Limestone Deposit and Coal Resource at Tajpur Basin in Bangladesh

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ABSTRACT

Tajpur Basin is located at southern slope of Rangpur Saddle/Platform which is the eastern continuation of Indian shield covering the area of around 400 sq. km. Two Geological Drilling Holes (GDH-70/15 and GDH-71/16) were drilled in order to explore any economic deposit. Thick layer of limestone was present below the 648 m surface, the thickness is varies from hole to hole (29 m-30 m) and contains 92-94% $CaCO_3$. If the thickness of limestone occurs throughout the whole basin, the reserve of limestone will be around 25000 million ton which may be the largest underground limestone deposit in the world. GDH 70/15 and GDH-71/16 were closed at the depth of 843.3 m and 960 m due to unavoidable circumstances. Chronologically, all geological formations (from Alluvium to Upper Gondwana) were found in both drill holes in the respective depth and Upper Gondwana is overlain the coal bearing Lower Gondwana in our country's respect of geological point of view. Presence of Gondwana sediments, presence of chronological all geological formations and position of the basin (surrounded by coal bearing area) revealed that possible strong indication of the existence of coal bearing lower Gondwana formation at greater depth of that basin.

Keywords: Basin, Formation, Limestone, Gondwana. Tajpur

1. Introduction

The discovery of limestone bearing area is the eastern continuation of the Indian Shield which is tectonically designated as Bogra slope of Rangpur platform/saddle (Alam. et. al.2003) (fig. 1). The area is unconformably thick pile of Cenozoic sediments including with Gondwana sediments which is unconformably overlies the Precambrian Basement Complex and depth ranging from1371 m to 1830 m (Haque et. al, 2012). The Tajpur basin is located in the Sothern slope of Rangpur saddle/Bogra slope where basement complex is comparatively shallower depth than adjoining area and the basement rocks are similar in nature to those in West Bengal and Shillong Plateau (Zaher and et. al, 1980). Generally, GSB is undertaking of some geo-exploration activities (survey) in the area of Rangpur Platform to find out the subsurface basin where the economic deposits might be found. Tajpur basin is the outcome of such kinds of survey where two bouguer anomaly profiles have been putted. One is the north-south trending (fig. 2) and other is the east-west trending (fig. 3) where a basin like structure has been delineated covered the area of around 400 square kilometer. Magnetic profiles also were done in that region where shown as anomalies are insignificant and gentle which is the indication of absence of any magnetic body (Hasan and et. al, 2014). Two exploratory drilling programs have completed in that basin like as GDH-70 and GDH-71 (Hoque et. al, 2018) where found thick layer of limestone started around 648 m below the surface. Limestone formation conformably overlies the Tura formation of early Eocene period which is unconformably overlies the upper Gondwana formation. Generally, upper Gondwana formation conformably overlies the coal bearing lower Gondwana formation. Due to unavoidable circumstances both of drilling programs suspended in the upper Gondwana formation. As a result, it was not possible to touch the possibility of coal bearing lower Gondwana formation.

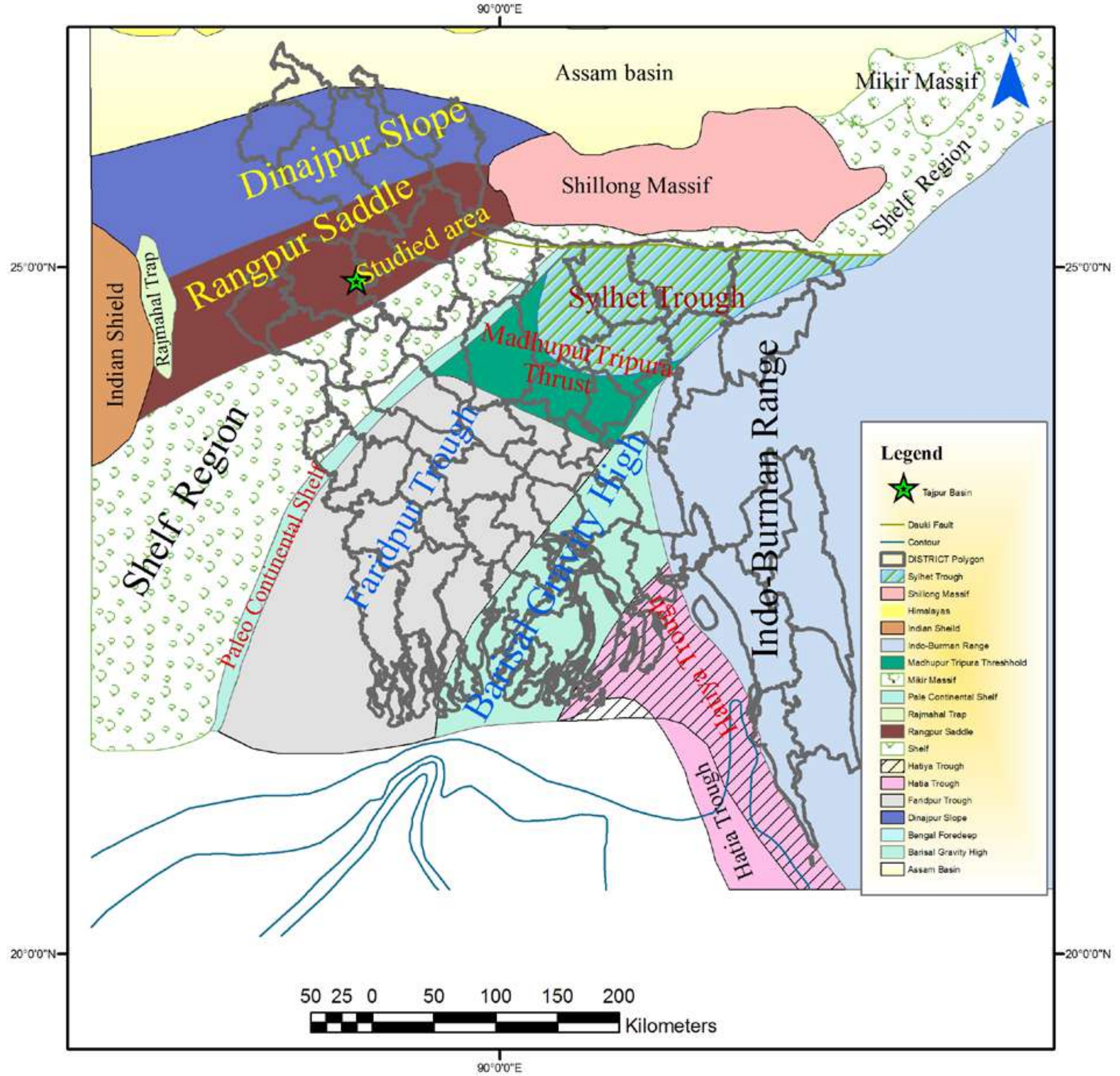

Figure-1: Location map of the studied area and Geological and tectonic framework of Bangladesh and adjoining areas, showing SE sloping basement, its thick cover and deformation near the Indo-Myanmar Ranges. Modified Geological map of Bangladesh (2011) (http://en.banglapedia.org/index.php?title=Tectonic_Framework).

2. Geological Settings

Bangladesh is in the northeastern parts of the Indian Subcontinent between the Indian Shield to the west and the Indo-Myanmar Ranges to the east and shares the geology of the Bengal Basin. In the north, the basin is bounded by the Himalayan Foredeep, the Shillong Plateau and the Assam Basin (Najman et al.2016). The western and southwestern parts of the Bengal Basin consist of an easterly inclined shelf, separated from the Singhbhum Craton of the northeastern part of the Indian Shield (Mukherjee et al. 2017).The Bengal basin demonstrates a broad spectacular combination of three special geological systems and draws individual interests for its relation to the world's largest orogeny system the Great Himalayan Range, the world's largest fluvio-deltaic system; the Bengal Delta (present Bengal Basin) and the world's largest submarine fan system-the Bengal Deep Sea Fan (Jain et.al, 2020). The evolution of the basin started in the early cretaceous with the rifting of Indian plate away from Antarctica. However, the basin did not become a major depocentre until the northward drifting Indian plate collided with the Eurasian plate resulting in the initial uplift of the Himalayan (Lindsay et.al., 1991).

The Bengal Basin is one of the largest peripheral collisional foreland basins in South Asia (Mukherjee and Mukherjee et al. 2017; De Celles et al. 2014) consisting of Permo-carboniferous to Mesozoic and Tertiary deposits covered by the Recent alluvium. The geotectonic of the eastern part of the Indian Plate is dominantly influenced by its collision with the Eurasian Plate (Mukherjee 2011;) to the north and the Burmese Plate to the east, uplifting the Himalaya. Based on its tectonic style and sedimentation history, the Bangladesh part of the Bengal Basin may be divided into three major tectono-stratigraphic units (Mitchell, 1993). Stable platform in the northwest, 2) NE-SW trending oriented Hinge Zone and 3) Deep (Geosynclinal) Basin to the east and southeast. The Stable Platform is geologically stable in relative term and has not been affected by fold movement. The NW platform, a gently SE dipping epirogenic platform, is believed to be a part of Gondwanaland, was down warped from Upper Carboniferous onwards creating a number of troughs or graben in the crystalline basement. These grabens are the depositional centers for detritus (coal bearing rock units) derived from nearby elevated shield areas (Rahman and et. al, 2000). Gondwana sedimentation continued till late Jurassic under terrestrial and lacustrine environments. On the basis of thickness of sedimentary cover, Stable Platform is divided into: 1) Rangpur Saddle in the north and 2) Bogra Shelf in the south. Rangpur Saddle is believed to be in the form of a dome bounded by N-S trending faults in the east and the west. Rangpur Saddle covers the area of shallow basement representing subsurface continuation of the Indian Shield between the Rajmahal Hills in the west and the Shillong Plateau and Mikir Hills in the east (Khan, 1991). It slopes both ways towards north and south and forms an oval shaped body. The northern slope of the Rangpur Saddle (Dinajpur Slope) slopes towards northwest, where basement dips sharply towards Sub-Himalayan Foredeep (Khan. et. al, 1957).

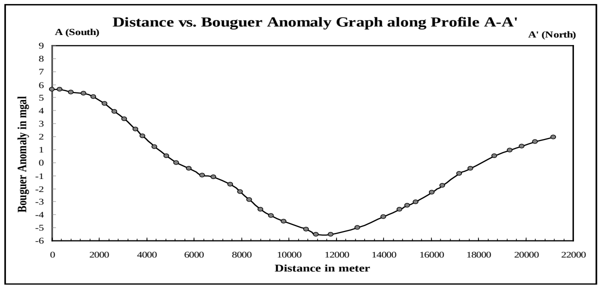

Figure-2: Figure showing the Bouguer anomaly, North-South trending direction. Studied area, Naogaon, (generally, all coal bearing Gondwana basins of Bangladesh have shown almost same reading) Bangladesh.

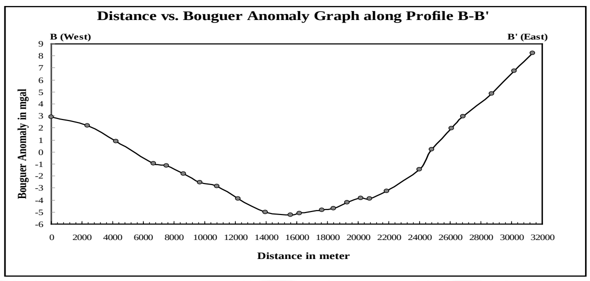

Figure-3: Figure showing the Bouguer anomaly, East-West direction. Studied area, Naogaon, (generally, all coal bearing Gondwana basins of Bangladesh have shown almost same reading) Bangladesh .

3. Stratigraphy of the studied area

The chronologically of all geological formations (Upper Gondwana to Alluvium-from bottom to top) have been found (Hoque and et. al, 2018). The units of all lithological chronology also supported that the presence of coal bearing lower Gondwana formation in that basin, for this reason all lithological unit/ geological formations of that area are chronologically (from bottom to top) briefly are described below:

3.1. Upper Gondwana Formation

The Upper Gondwana Formation unconformably underlies the Shibganj (Trapwash) Formation of late Cretaceous age. The formation is 36 m+ thick in GDH-70/15 but in GDH-71/16 it started from 795 m and continued upto the drilling depth 960 m. Generally the age of the formation is Permian to Upper Carboniferous. The formation consists of sandstone with interlaminated shale, feldspathic sandstone and red ferruginous sandstone etc. and sometimes highly fractures. This formation conformably overlies the coal bearing Lower Gondwana formation. Presence of Gondwana sediments in this borehole within a half graben which is revealed that possible indication of the existence of coal bearing Lower Gondwana formation with appreciable thickness at greater depth of that basin

3.2. Shibganj (Trapwash)

Volcanic materials bearing Shibganj of late Cretaceous age unconformably overlies upper Gondwana formation and it also unconformably overlain by the Tura formation. Mainly volcanic materials, few white clay present.

3.3. Tura Formation

Good aquifer bearing Tura Formation of lower Eocene age unconformably overlies Shibganj Formation and conformably underlies the Sylhet Limestone Formation in that investigated area.

3.4. Sylhet Limestone Formation

Stratigraphically, Sylhet limestone formation of Middle Eocene age is conformably overlying the Tura Formation and conformably underlying the Kopili Formation found in that studied area. Thick layer of almost crystalline and high quality limestone found in this formation.

3.5. Kopili Shale Formation

The Kopili Shale Formation of upper Eocene age conformably overlies the Sylhet Limestone and unconformably underlies the Jamalganj Formation of middle Miocene age.

3.6. Bogra Formation

This Formation of Oligocene age unconformably overlies the Kopili Shale Formation of upper Eocene and unconformably underlies the Jamalganj Formation.

3.7 Jamalganj/ Undifferentiated Surma Formation

The Jamalganj Formation unconformably overlies the Kopili Shale Formation of upper Eocene age and unconformably underlies the Dupi Tila Formation. This group has been recorded as undifferentiated Bokabil and Bhuban Formation in the area so, it is called like as Undifferentiated Surma.

3.8. Dupi Tila Formation

The Dupi Tila Formation unconformably overlies the Jamalganj Formation and underlies the Barind Clay Residuum Formation.

3.9. Alluvium Formation

This Formation unconformably overlies the Barind Clay Residuum Formation. This sediment is deposited by the present day fluvial process. The age of the formation is Recent.

4. Sampling and Technique

Due to the presence of thick layer of limestone in the study area, only focusing the coring sampling method which was applied in both drill holes and started from Limestone formation to the last depth of drill holes during the field. Generally, core samples (core bearing tube) were collected (every 3 m interval) from the exploratory drill holes by the over-shot (Wire line method). Each sample washed it properly with water and examined with hand tools such as pocket 20 times magnifying hand lense, diluted HCl (10%) and other necessary tools (colour chart, grain size chart) before leaving them for dryingin in the open air. Standard Rock Colour Chart was used for color identification of samples. About 30 core samples were collected at depth for farther lab analysis.

5. Geochemistry (XRF).

The chemical composition of the FA and BA samples were examined using XRF (PW 2400, Philips, Netherlands) technique in Petrology and Mineralogy laboratory of GSB. The oven dried milled samples (3 g) were placed in a porcelain crucible and thereafter were milled with binder (wax: sample, 1:3) and were then shaken for 2 h. The resulting mixture was spooned into an aluminum cap (30mm) that was sandwiched between two tungsten carbide pellets. Finally, the pellet was ready for analysis. Around 6 samples were analyzed where % CaO is high (62-76%) (table. 1).

6. Geochemistry (Colourametric method)

Some core samples of limestone were collected at an interval of about 3.05 meters throughout the thickness of limestone. Around 30 samples were analyzed in the Analytical Chemistry Branch of GSB. In this method, firstly crushing the samples by the crushing machine, digestion this sample by hydro-fluorite then applied colourametric method by UV spectrophotometer and finally percentage of different oxide of minerals calculated, the other name of that method is colouometric method. Around 17 samples were analyzed and then another 11 samples were also analyzed at different depth. Every result of that analysis shown that the dominancy of CaO and $CacO_3$ in collected samples (table 2 and 3).

7. Description of Limestone

Limestone is light grey (N7) to very light grey (N8) with greenish tints at places, massive, medium to fine grained, fossiliferous and very hard and compat, crystallized and gives strong effervescene with HCl. The fossils (both mega and micro) contain nummulites and assilina in large numbers. Nummulites Perforatus, Nummulites Planulatus, Nankinelia Ovata, Boultonia Willsi fossils are common. Shape of the fossils are oval,circular,disc shaped, triangular and irregular. Amount of calcareous cement is >70%. Some cavities are filled up with calcite cement as secondary growth. Due to chemical weathering, greenish (greenish black- 5GY 2/1) type of minerals (Chlorite/Glauconite) have been formed along which fracture occurs. Fractures are irregular, sometimes conchoidal. Some microfractures are also found throughout the samples. Kaolinite is present along slickenside. From the analysis, it is revealed that the values of $CaCO_3$ is greater than 90% in upper layer of limestone and in lower part of the layer the values are above 80% (table. 2 and 3). In case of CaO content, most values of CaO are greater than

50% in upper layer of limestone and in lower part of the layer the values are above 45% (table.1, 2 and 3). In case of MgO content, values of MgO are in between 0.4 to 2.8 % while in case of SiO_2 content, values of SiO_2 range from 0.6 to 10.2 % (fig. 4). It indicates that in first layer of limestone the depositional environment was constant for a considerable period but in case of second layer, the depositional environment was disturbed by some other factors and inorganic clasts may be inserted or impregnated within the limestone.

Table 01: Results of oxide analyses (XRF method) of limestone samples.

Sample no.	Depth (m)	% of CaO	% of SiO_2	% of Al_2O_3	% of Fe_2O_3	% of MgO	% of SO_3
01	716	64.8	6.68	2.40	2.08	0.753	0.531
02	714	62.9	6.61	2.85	3.24	0.747	0.567
03	702	62.5	9.83	3.21	1.56	1.20	0.449
04	700	66.9	5.43	2.11	0.965	0.911	0.286
05	692	70.8	2.50	1.23	0.532	0.694	0.259
06	686	76.4	1.37	0.990	0.247	0.786	0.168

Table 02: Results of Chemical Analyses of limestone samples (Colourimetric method)

Sample no.	Depth (m)	% of $CaCO_3$	% of CaO	% of MgO	% of SiO_2
01	716.00	86.00	48.16	2.8	4.80
02	714.00	81.00	45.36	1.6	10.2
03	702.00	87.00	48.72	1.2	7.1
04	700.00	91.00	50.96	0.4	5.5
05	696.03	93.50	52.36	1.60	1.80
06	696.00	93.21	52.20	1.2	3.4
07	692.00	93.21	52.20	0.8	2.0
08	688.11	92.50	51.80	1.60	1.40
09	686.00	93.92	52.60	1.2	0.6
10	685.36	92.50	51.80	2.00	1.90
11	685.06	92.50	51.80	1.60	2.60
12	684.14	94.00	52.64	1.80	0.60
13	682.00	93.21	52.20	1.6	2.1
14	681.09	94.28	52.80	1.00	1.00
15	678.00	94.21	52.76	1.2	0.6
16	677.13	94.64	53.00	1.00	1.00
17	675.00	80.00	44.80	1.6	8.0

Table 03: Results of Chemical Analyses of limestone samples(Colourametric method).

Sample no.	Depth (m)	% of $CaCO_3$	% of CaO	% of MgO	% of SiO_2

S-1	642.23	90.5	50.68	1.6	2
S-2	645.18	89.5	50.12	1.4	2.8
S-3	646.91	86.5	48.44	1.2	0.7
S-4	648.39	89.0	49.84	3.4	1.5
S-5	650.55	81.0	45.36	2.6	8.7
S-6	652.64	93.0	52.08	1.6	1.1
S-7	655.49	91.0	50.96	2.0	3.9
S-8	657.93	86.0	48.16	2.4	7.2
S-9	661.38	94.0	52.64	1.6	1.0
S-10	666.92	90.0	50.40	2.4	6.0
S-11	671.46	91.0	50.96	1.2	5.5

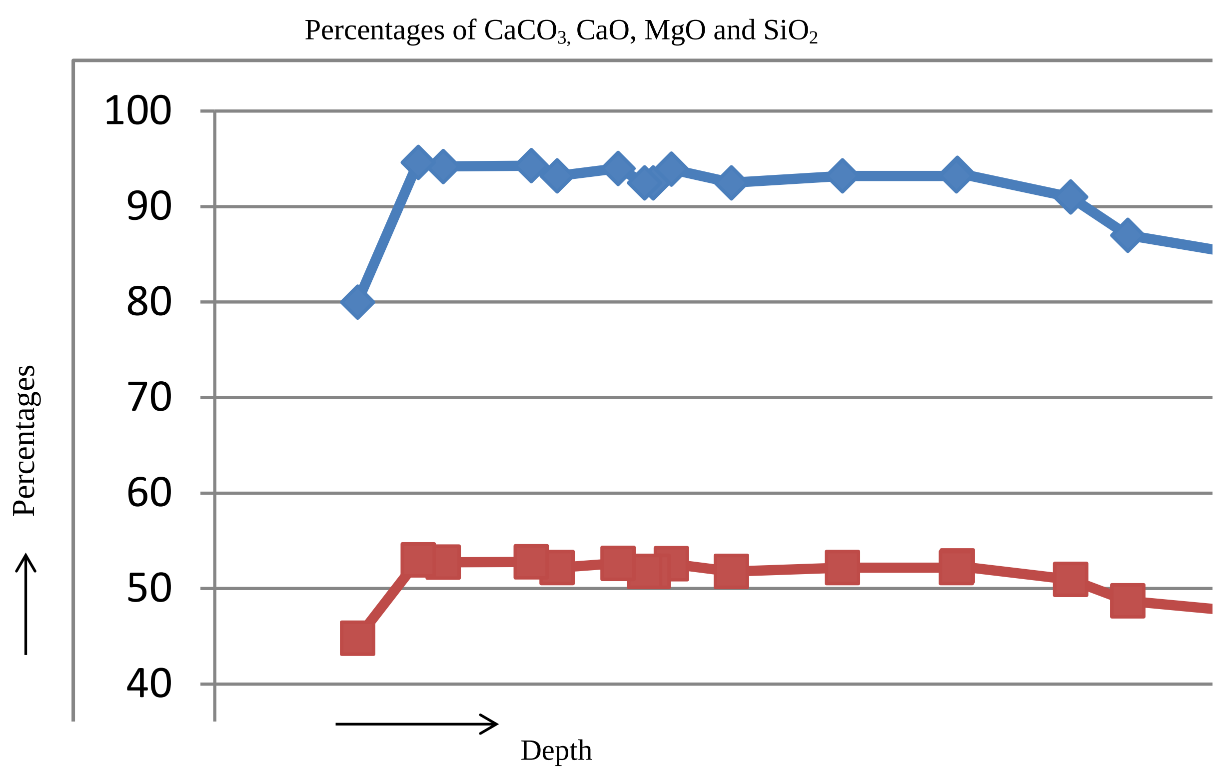

Figure-04: Plot of Depth (m) vs percentages of $CaCO_3$, CaO, MgO and SiO_2 present in limestone samples of the studied area.

8. Reserve of Limestone

The total area of the Tajpur basin is about 400 square kilometer (according to the Bouguer anomaly map in the figure 2 and 3). The average thickness is 29 meter (approximately). If the same thickness of limestone found in whole of the basin, the reserve of limestone seem to be very large. The primary probable estimated reserve of limestone of Tajpur basin is about 25000 million ton. Possibility of largest underground limestone deposit found in that basin which is the largest limestone reserve in Bangladesh and even that this is largest underground limestone reserve around the world.

9. Possibility of Coal Resource

The lithological description of the study area and the gravity magnetic data suggested that the area will be half graben basin where Gondwana sediments were developed. Coal bearing lower Gondwana formation may be form in that basin. Generally from the geological point of view of Indian shield, upper Gondwana is found over the coal bearing lower Gondwana, upper Gondwana sediments is not composed of any coal seam. Due to the upper Gondwana sediments in that basin strong possibility to develop lower Gondwana in greater depth

9.1. Position of Tajpur Basin

The Tajpur basin is almost surrounded by in the north Jamalganj coal basin, in the south-east Kuchma coal basin and east Bogra coal bearing basin (fig. 5) which is the another indication to find coal bearing lower Gondwana in the greater depth in that basin.

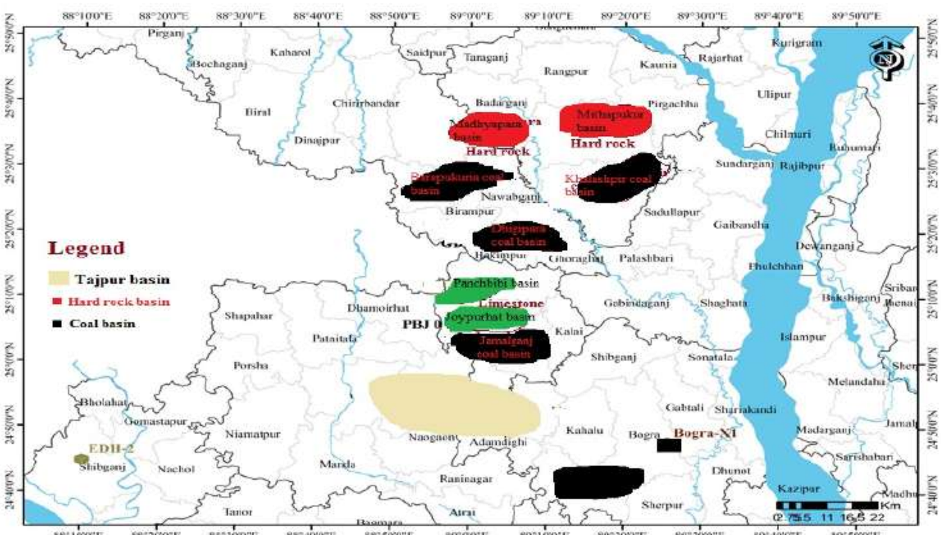

Figure-5: Figure showing the Tajpur basin and coal bearing surroundings basins, southern slope of Rangpur platform area, South-Western part of Bangladesh.

9.2. Similarity of Jamalganj Coal Basin

Lithological description of Jamalganj coal basin is very close to the Tajpur basin which is clearly shown in the following figures. In these figures GDH/Geological Drill Hole-70 and 71 were drilled in the Tajpur basin but EDH/Exploration Drill Hole-16, 29 and GDH/Geological Drill Hole -30 were drilled in the Jamalganj coal basin (fig. 6). The similarity of both basins also indicated that the Tajpur basin may be containing coal bearing lower Gondwana formation.

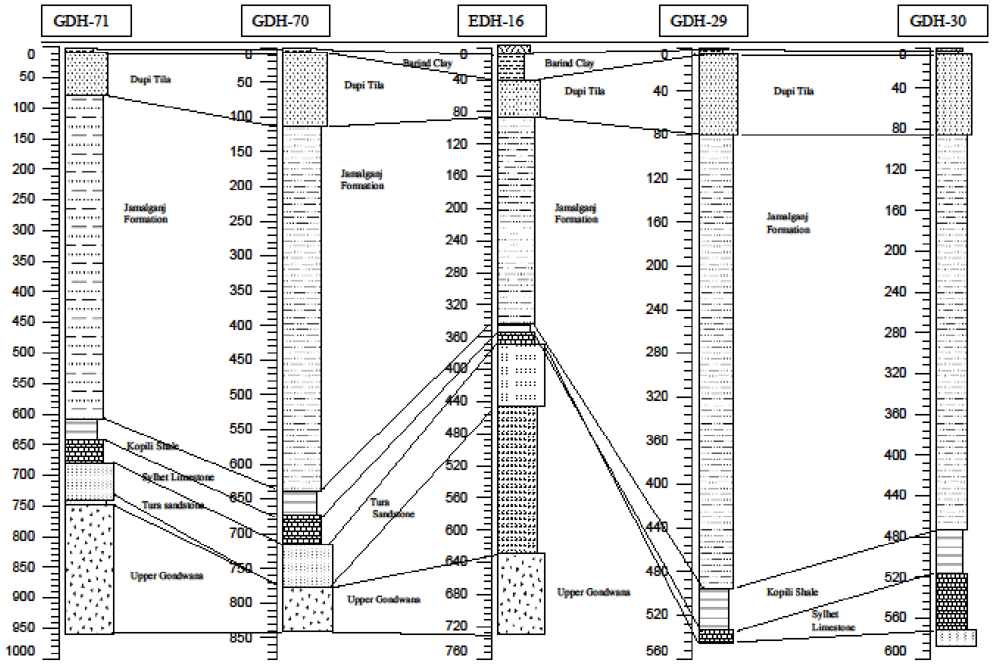

Figure-6: Figures showing the Tajpur basin (covering the GDH-**70 and 71**) and coal bearing Jamalganj basins (covering the GDH-**29, 30 and EDH-16**).

10. Conclusion and Recommendation

Total thickness of limestone at GDH-70 is 30.18 meter and at GDH-71 is 28.96 meter. Appropriate laboratory analyses have been carried out to estimate the quality and usability of limestone deposits. From physical as well as chemical characteristics of this limestone, it is concluded that this limestone is of good quality and suitable for manufacturing best quality cement. The geological study in this area reveals that there is a possibility of finding large deposits of limestone at shallower depth towards north-west and may be exploitable in future. According to the geophysical survey, the area of Tajpur basin is more than 400 square km. Limestone might have extended over the whole area of Tajpur basin which thickness may varies from place to place and their probable reserve is 25000 million ton, it might be a largest subsurface limestone deposits in the world. Presence of Gondwana sediments in these boreholes within a graben as is revealed by structural analysis of the area, presence of chronology of all lithological units (upto the last depth of each hole) and position of that basin (basin almost surrounded by coal bearing basin) gives possible indication of the existence of Permian coal with appreciable thickness at greater depth of this Tajpur basin. It should be needed to initiate more drilling activities to know the real pictures of that basin.

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