Parbatpur Mine Degassing - A Model for Commercial CMM Project in India*

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Search and Discovery Article #80259 (2012)**
Posted October 22, 2012

*Adapted from extended abstract prepared in conjunction with oral presentation at AAPG International Convention and Exhibition, Singapore, 16-19 September 2012, AAPG©2012

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Abstract

Commercial exploitation of Coal Mine Methane (CMM) from deeper seams within active coal mines or pre-mining drainage from the mine leasehold is still in infancy in India. The Eastern Indian coal basins of Raniganj, Jharia, Bokaro, Karanpura, and Assam have a history of "Firedamp" explosions, coal mine fires; that have resulted in the loss of human lives and closure on many mines. Continuing with the challenges of mining deeper and more gassy coals in Jharia and Raniganj Coalfields in one hand with the societal commitment of green environment on the other, CMM development may usher an era of low methane emitting coal mines.

The 8.8 sq km Parbatpur Mine leasehold is located in the south central part of the Jharia coalfield and hosts 18 (I to XVIII) major Barakar seams. The pack of Seams XVIII, XVII, XVIA, XVIB, XVA, and XVB among these occurring up to 650 m depth and with 20-25 m net coal are to be mined over the next 30 years; are targets for CMM development. These seams are low to medium volatile (14.9-26.5 VM%), bituminous coal with 29 to 62% of vitrinite content (vmf) with good thermal maturity (RoM1.0-1.45%). With 3-11 m^3/ton gas content (daf) and 60-90% saturation, this pack has good potential for multiseam completion for CMM drainage. The GIP estimates of this pack are about 0.29 TCF. With low to medium permeability in these coals suitable completion methods will be employed for the quicker drainage of seam gas. The structural complexity and presence of close spaced sub-vertical faults the reservoir has been compartmentalized into smaller areas. Vertical well is the only option to degas in this geologic set up. The degassing has to be planned keeping parity with the mine development timeline. Shallower better permeable seams shall be degassed within a period of 4-6 years through vertical, 16" under reamed wells. Larger sized production casing will be used such that post mining (after about 5-6 years) the well would be drilled further down to the deeper seams (XV). Because of lower permeability these

wells would be completed by casing/cementing and stimulated by hydro-fracking. In the adjoining areas the CBM produced water was found to be potable. Produced water from CMM wells can be used in the pit head washery for the mine as well as for local irrigation ensuring minimum water handling cost.

To make the project commercially successful the gas will be marketed locally as CNG to maximize the revenue.

Introduction

Production and commercial exploitation of Coal Mine Methane (CMM) from deeper seams within active coal mines or pre-mining drainage from the mine leasehold is still in infancy in India. India is the world's third largest coal producer targeting 554 MT production in 2012 from 562 active underground and opencast mines (Table 1). Emission of methane from mines is a major environment concern. In 1990 the emission of methane from mines is estimated at 763 Mm^3 which is projected to be 1987 Mm^3 in 2015 (Table 2). Absence of a structured CMM policy deterred development of CMM in India, though possibility of it exists as both technical and commercial feasibility has been proved for CMM exploitation in other parts of the globe. Coal Mines Planning and development India Ltd. (CMPDIL) is running successfully a demonstration project at Munidih Mines of Bharat Coking Coal Ltd. (BCCL) since 2009. The US $14.9 million project of the United Nations Development Programme (UNDP 2009), the Global Environmental Facility (GEF), and the Indian Ministry of Coal called "Coalbed Methane Recovery and Commercial Utilisation" has successfully demonstrated the commercial feasibility of utilizing methane gas recovered before, during, and after coal extraction. Recovered CBM/CMM is currently used to generate up to 250 kW to meet local power needs (with a maximum capacity of 500 kW), as well as being used in 50-ton mine dump trucks, powered by converted bi-fuel engines (UNDP, 2009). Future results of the project could lead to expanded application of CMM technologies, such as the production of compressed natural gas fuel for mine vehicles and commercial scale projects. In April 2011, five prospective CMM blocks had been identified in the mining leasehold areas of BCCL and Central Coalfields Ltd. (CCL) areas and a tender had been floated for selection of a suitable developer. But pendency of the issue of operationalisation of commercial development of CMM within mining leasehold areas is sorted out between the Ministry of Coal (MoC) and the Ministry of Petroleum and Natural Gas (MoP&NG) Government of India, further actions have been deferred.

Methane in coal mines can create an explosive hazard to coal miners, cause firedamp explosions, trigger secondary catastrophic coal dust explosion, and mine fire in various mines across the globe with huge loss of lives and resources. Methane released from coal seams in active mines due to lowering of geological pressure is removed through ventilation systems and released to atmosphere which is environmentally unethical as it is a potent GHG.

Coal mining activities in India will remain in the central stage as coal meets around 52% of primary commercial energy needs in India against 29% the world over. The mining companies are targeting deeper and gassier seams to meet the demand for more production.

With increased coal production, threats of large quantity of fugitive methane can be mitigated through harnessing CMM. Around 66% of India's power generation is coal based. India produces 183 GW of electricity with a shortfall of about 20GW in national demand. Part of this demand can be met though CMM generated power at mine heads and can contribute significantly in attaining energy security in India in a greener way.

Opportunity

CMM can be developed as:

1. Pre-mining drainage from coal seams before staring mining in the lease hold by drilling vertical or/and surface-to-in-seam wells or a combination. Gas produced is nearly pure methane (~98%).

2. Degasification systems at active underground mines employing vertical and/or horizontal wells to recover methane from active mine face in mine horizontal long hole or short hole wells before mining takes place to help the ventilation system keep the in-mine methane concentrations sufficiently low (well below the explosive limit) to protect miners. Produced gas this way is nearly pure methane.

3. Trapping ventilation air methane (VAM) - the very dilute methane (is typically < 1%) that is released from underground mine ventilation shafts. Although in low concentration it is the single largest source of CMM emissions globally.

4. Abandoned mine methane (AMM). After closure of mines the pillars, side walls, roof and floor of remaining coal continue to produce methane emissions and are stored in gob zones and have potential for atmospheric emission of low- to medium-quality gas from failed stopping, ventilation shafts, boreholes, or fissures in the ground. This methane can be trapped by driving gob wells. The produced gas is mixed with air and lean in methane content.

There are many mining benefits that accrue from a methane drainage system. Methane drainage systems can:

(1) Enhance coal productivity by lowering downtime or production slowdowns caused by gas
(2) Decrease fan operating costs because of reduced air requirements for methane dilution
(3) Decrease dust concentrations due to reduction of velocities at the working face and reduce risk of coal dust explosion
(4) Improve mine safety resulting from lower methane contents in the face, returns, and gobs
(5) Reduce problems with water
(6) Improve worker comfort through reduction of ventilation air velocities in the working faces and

(7) Recovering and using CMM is considered emissions avoidance and qualifies for carbon credits.

The Parbatpur Lease Hold JV

In March 2011, Dart Energy Limited (Dart) has entered into a joint venture agreement (JV) with Electrosteel Castings Ltd (ECL), for the exclusive rights to produce and sale of CMM from ECL's coal mine license area in Parbatpur, India. Parbatpur coal mine license area is currently owned and operated by ECL with a producing open cast mine. ECL has engaged mining consultancy companies from Europe to help it start the longwall method of mining in the block and has already started underground mine construction work like incline drivage and shaft sinking. It is expected that commercial production from the underground mine shall start by FY 2011-2012. ECL's Parbatpur Mine is located in the Jharia Basin within the coal rich state of Jharkhand in eastern India. Geological studies on the Parbatpur Mine have identified eighteen coal seams in the Barakar Formation with a cumulative thickness of over 80 metres at depths between 200 and 1,100 metres. The Parbatpur coal seams have high gas content and gas saturation close to 100%, requiring extraction of the CMM ahead of mining for regulatory and mine safety purposes. Dart has commissioned an independent evaluation of the resources on the ECL mining license area from Netherland, Sewell and Associates Inc (NSAI). As a result of the evaluation, NSAI have estimated:

- Best Estimate Gas-in-Place resource (gross): 168 BCF
- Gross Contingent Resources (2C): 62 BCF
- Gross Prospective Resources (Best Estimate): 50 BCF

Given the high gas contents and coal thicknesses, a vertical well completion technology is intended. The JV expects to ultimately achieve an annual field production of approximately 3 BCF when all wells have been completed.

Dart anticipates the first gas from the pilot wells in late 2013. Any produced gas can be sold immediately. In a bid to maximize early access to domestic gas markets Dart and ECL are already in advanced discussions with domestic Compressed Natural Gas players about potential gas off-take contracts. Dart's joint venture partner, ECL, has the option to ultimately acquire produced gas for use at ECL's nearby steel plant.

Geological Setup

The 8.8 sq km Parbatpur Mine leasehold area (The Block) is located in the south central part of Jharia Coalfield (Figure 1) - the second coalfield adjacent to the eastern most Raniganj Coalfield in the east-west trending Gondwana Basins belt of Eastern India. In the block, the coal bearing Lower Gondwana Barakar Formation is overlain by the Barren Measures and underlain by Talchir

Formation. Gondwana sediments of the Jharia Basin are disposed as sickle shaped synclinal basin extending over 450 sq km formed over crystalline metamorphic basement of Proterozoic granite gneiss, migmatites etc. The southern boundary is a roughly E-W trending northerly dipping high angle high throw fault (Southern Boundary Fault) while the arcuate northern margin of this sub-basin is thought to be the resultant of a series of normal faults of different generations trending NW-SE towards the west, N-S in the central part, and NE-SW towards the east.

The Barakar Formation (900 m) is the only coal measure in the block and forms the reservoir for the CMM to be degassed from the coal seams before mining. This formation can be classified stratigraphically into three members:

- Basal Member: Consisting of coarse grained sandstone with occasional shale and thick coal seams.
- Middle Member: Represented by thin coal seams with shale and sandstone interbeds.
- Upper Member: Marked by predominance of shale with very thin fine grained sandstone bands and coal seams.

Major part of the Block exposes the Middle Permian Barren Measures (~100 m) which forms a cap rock over the Barakar Coal Measure. The Barren Measures are made up of alternations of flaggy, thinly cross bedded, ripple laminated, ferruginous sandstones and shale beds.

The Parbatpur block is situated in the south central part of the coalfield and located at the crestal part of an antiformal structure with the development of two sets of normal dip slip oblique to strike slip faults having variable throw. This area forms a folded domal structure and the strike varies widely. In the western part of the block the seams are disposed along N-S strike, dipping at 8-15 degrees westerly and swing in an E-W strike direction along the southern boundary of the block with a southerly dip. Steeper dip of 15 – 20 recorded in the area is possibly due to the effect of faulting. The area around the ECL mining lease has been thoroughly explored for coal by the company, drilling about 35 core holes within an area of 8.8 sq km. But these core holes went only up to Seam No XV (400-550 m depth). But there were not any historic desorption or insitu permeability data generated during the detailed coal exploration phase in the block. In their exploration stage Dart has drilled two core wells to assess the maceral composition, thermal maturity, and lay of the coal seams, content and composition of coal seam gas, geomechanical properties of roof and floor rocks of the coal seams, and reservoir parameters of the block.

During exploration 18 (I to XVIII in ascending order) major Barakar coal seams with a few splits and coalescences were intersected within 357 m to 1042 m depths in the Barakar Formation with 57 m to 85 m cumulative coal thickness. A few local coal seams are also intersected. Two seams have been completely pyrolitised by lamprophyre intrusion. The pack of 6 seams XVIII, XVII, XVIA, XVIB, XVA, and XVB among these occurring between 210 and 650 m depths having 20-25 m net coal are to be mined over the next 30 years period and are targets for CMM development. These coal seams are low to medium volatile (14.9-26.5 VM%), bituminous coal with 29 to 62% of vitrinite content (vmf) and good thermal maturity (Ro Mean 1.0-1.45%). With 3-11 m^3/ton gas content (daf) and 60-90% saturation, this sequence is best produced by multiseam completion for methane drainage.

The generalized geological sequence of the area is given in Table 3 below:

CMM Development Plan

Keeping the need to degas coal seams before mine development, two clusters of pilot wells are planned in the eastern and western parts of the Block, each having 4 wells with a life span of about 7-8 years (Figure 2). The estimated drainage area for the eastern cluster is 160 acres while for the western luster drainage area is 400 acres (Figure 3). To check on the well deliverability vis-à-vis completion technology, two pilot wells of each 4-spot cluster which are on the down-dip side are planned to be Hydro-Fracked (wells with suffix F) and the remaining two shallower wells to be under-reamed (wells with suffix U).

The eastern cluster is located within 1 km north of the core well ES002C and has four wells ES001U, ES002U, ES003F, and ES004F arranged as three corners and one central well. Two wells at shallower depths with U suffix will have open hole, while the other two with F as suffix are planned to be hydro-fractured. The western cluster of four wells, located 2 km north of the core well ES001C, has the wells ES005U, ES006U, ES007F, and ES008F. All the wells have five target seams (seam XVIII, XVII, XVIA, XVIB, XVA, and XVB) to be degassed by multiseam completion.

In the eastern cluster, the target coal seams are expected between the depths 210 m and 550 m in pilot wells ES001U and ES002U, expecting higher permeability the well completion will be by open hole and under reaming (16”). Pilot well ES004F and ES003F will have the coal intervals 100 to 175 m deeper with the bottommost target seam at 725 m and 635 m respectively. At this depth, permeability is expected to be low (0.25 mD and 4.2 mD) and therefore will be fracked.

In the western cluster: the target seams in pilot wells ES005U and ES006U are expected between the depths 240 m and 580 m, being in the up-dip direction, will be completed by under reaming; while the wells ES007F and ES008F with the target seams between 310 m and 650 m, will be completed by fracturing. The casing/liner selection is made to accommodate the anticipated pressures and the desired core/hole diameter through the identified coal section. The well design will consist of a 13 3/8” conductor, 9 5/8” surface casing, and 6 5/8” reservoir section (Figure 4 and Figure 5).

Based on reservoir data, the preliminary completion design can be summarized as follows: 2 7/8”,6.5 PPF production tubing; 1800 bpd rod driven PCP pump (final pump sizing to be make on-site pending well productivity); a 50 m rat hole should be provided below production casing (depending on well type) to allow adequate accommodation space for produced solids below pump inlet; and a permanent downhole pressure gauge (PDHG) system will be installed with centralised cross-coupling protectors installed on coupling (depending on trajectory etc).

During the exploratory corehole drilling, coal fines generation was observed and many of the lower seams had the tendency of collapsing. As the coal is fragile, slow drawdown is recommended and need to be watchful of coal fines in the production stream. Moreover, as there are fracked wells too, slow drawdown and monitoring sand in production stream is recommended, as proppant sand has tendency to flow back during early production stage. However, due to multiseam completions, limited drawdown for lower seams is expected. Pumps and surface facilities should be designed keeping above points.

Acknowledgement

The authors acknowledge the encouragement and support of the Dart Energy team in preparing and publish the article.

Disclaimer

The views expressed in the article are solely by authors.

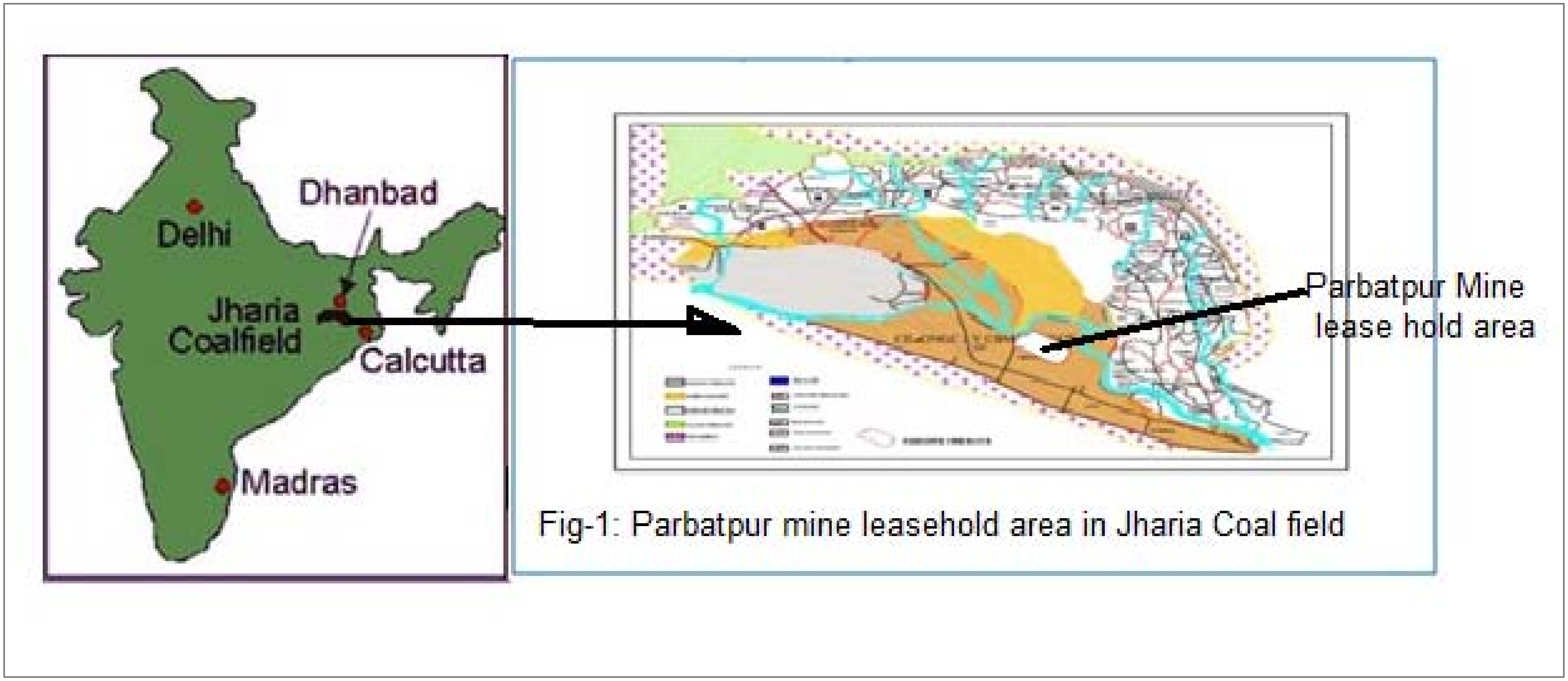

Figure 1. Location of the Parbatpur Mine leasehold area in Jharia Coalfield, India.

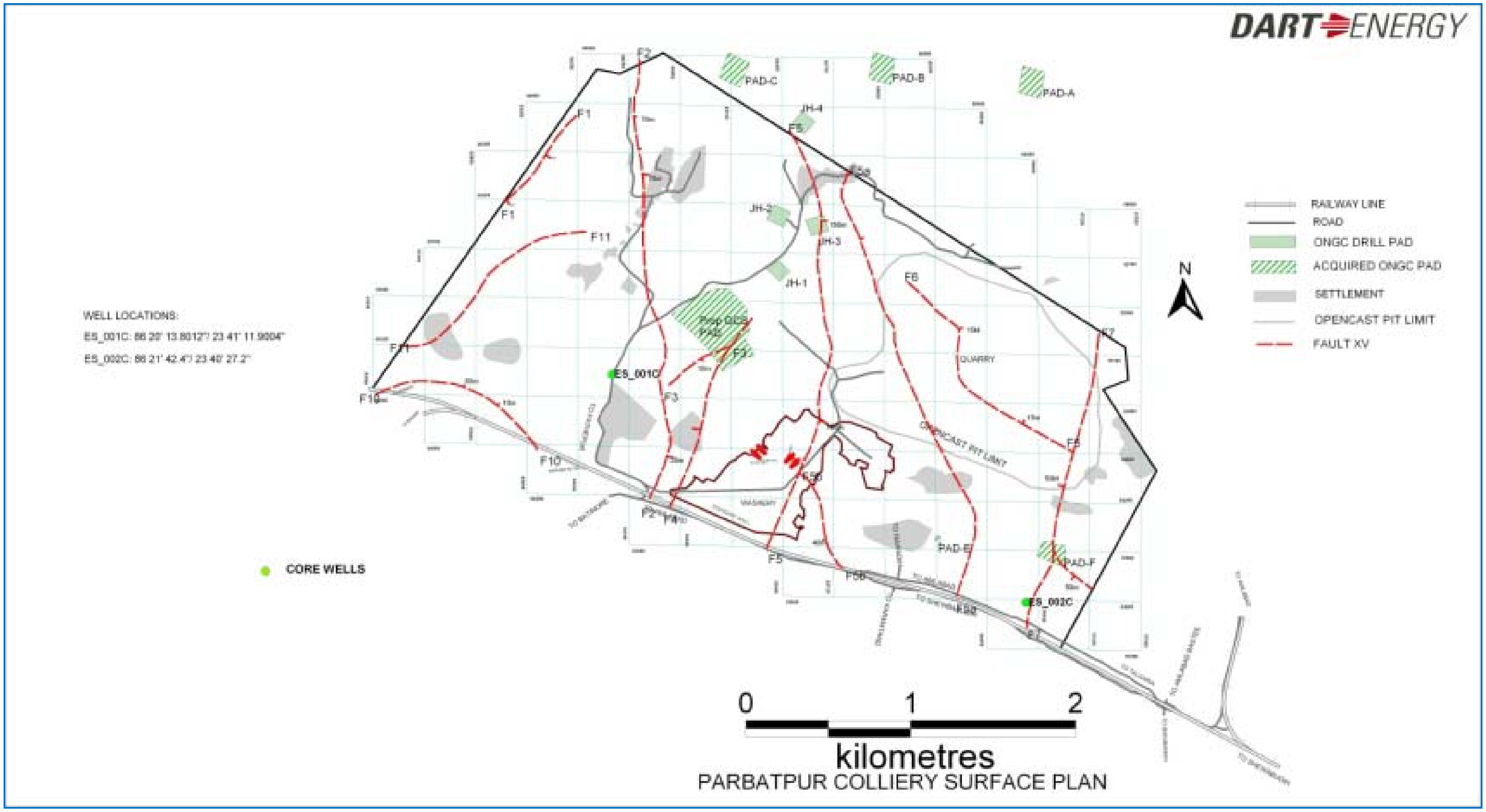

Figure 2. Core well locations in the Parbatpur Mine leasehold area, Jharia Coalfield, India.

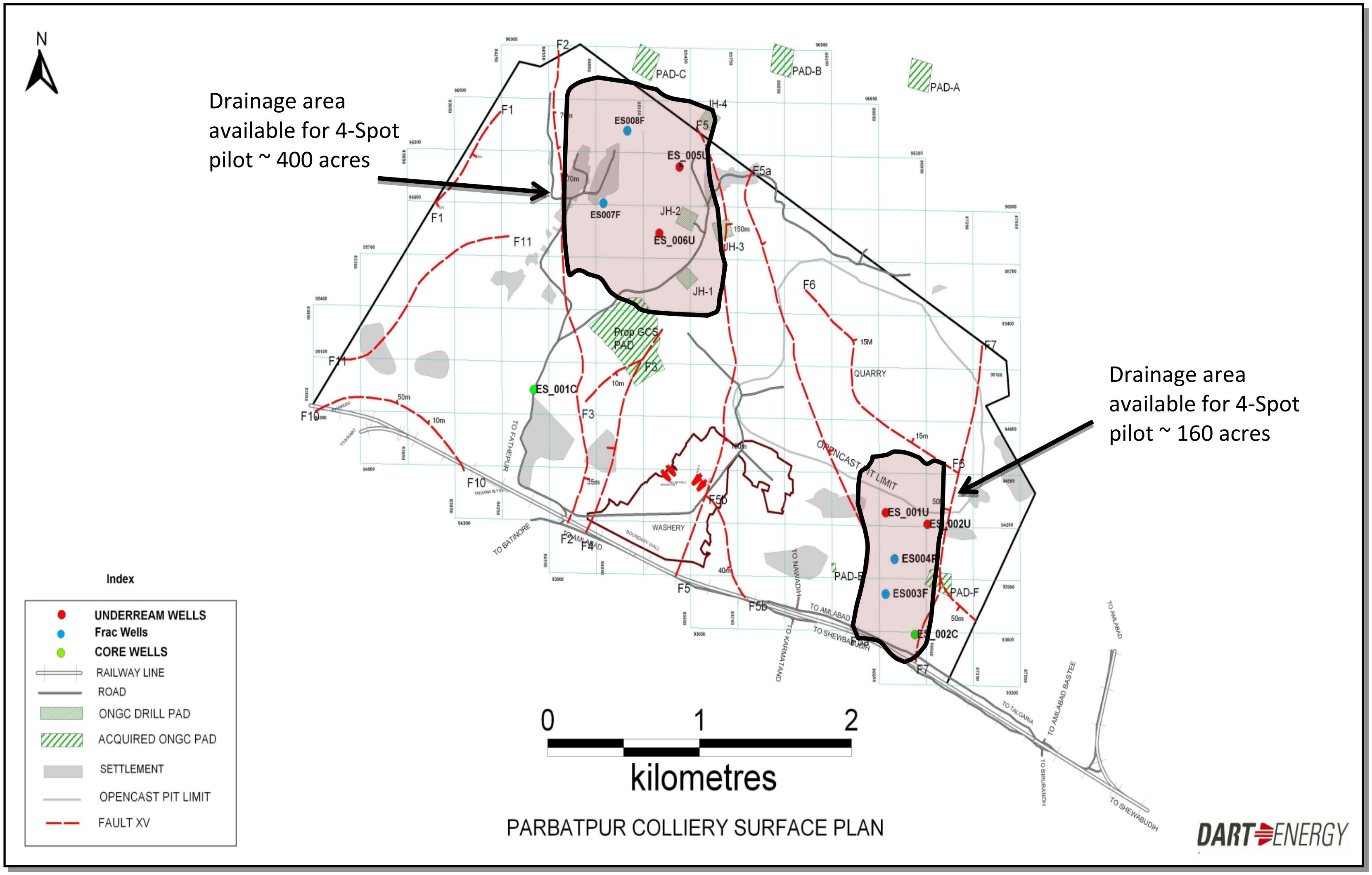

Figure 3. Estimated CMM drainage area in the Parbatpur Mine leasehold area, Jharia Coalfield, India.

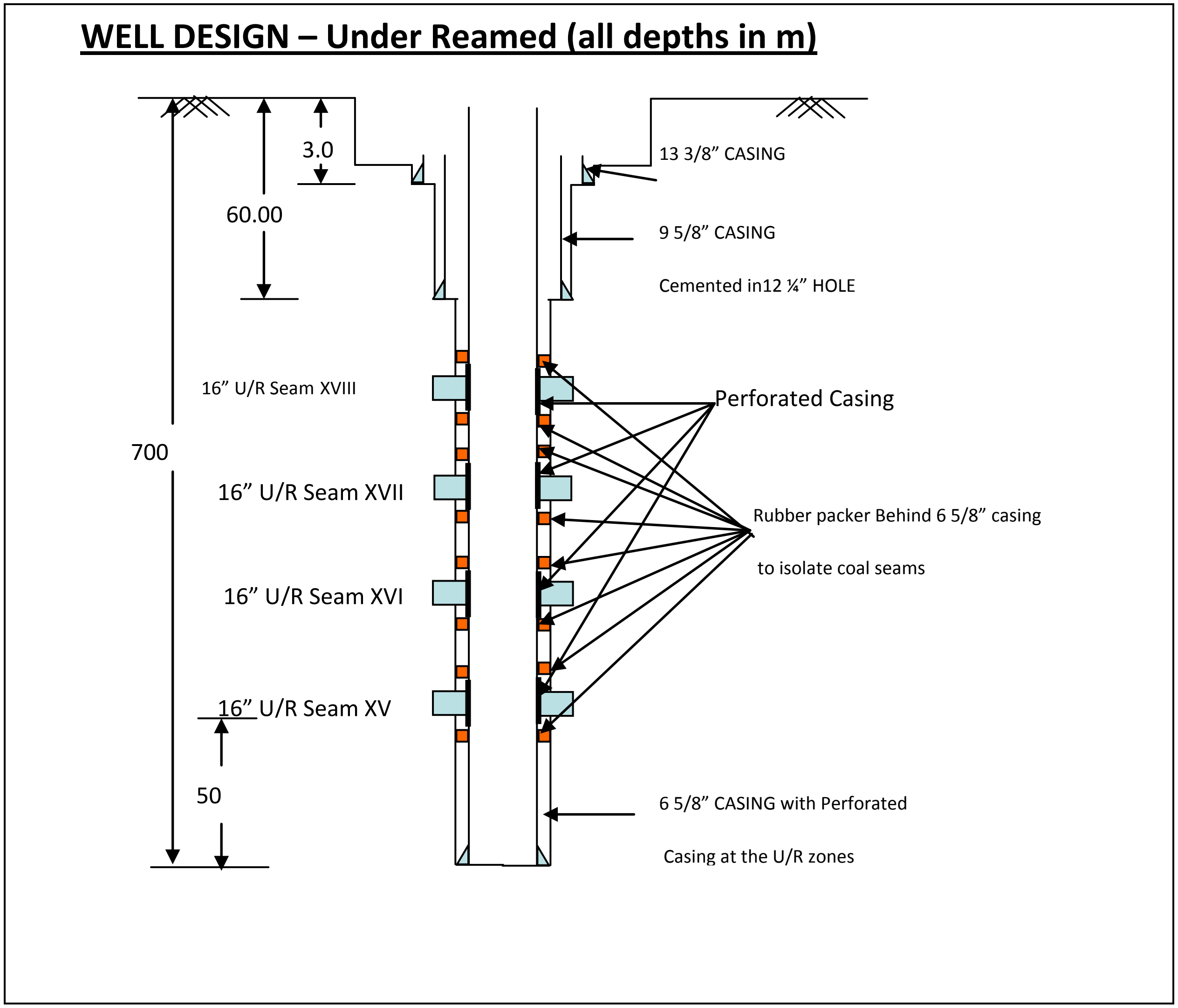

Figure 4. Well design of the under ream well in the Parbatpur Mine leasehold area, Jharia Coalfield, India.

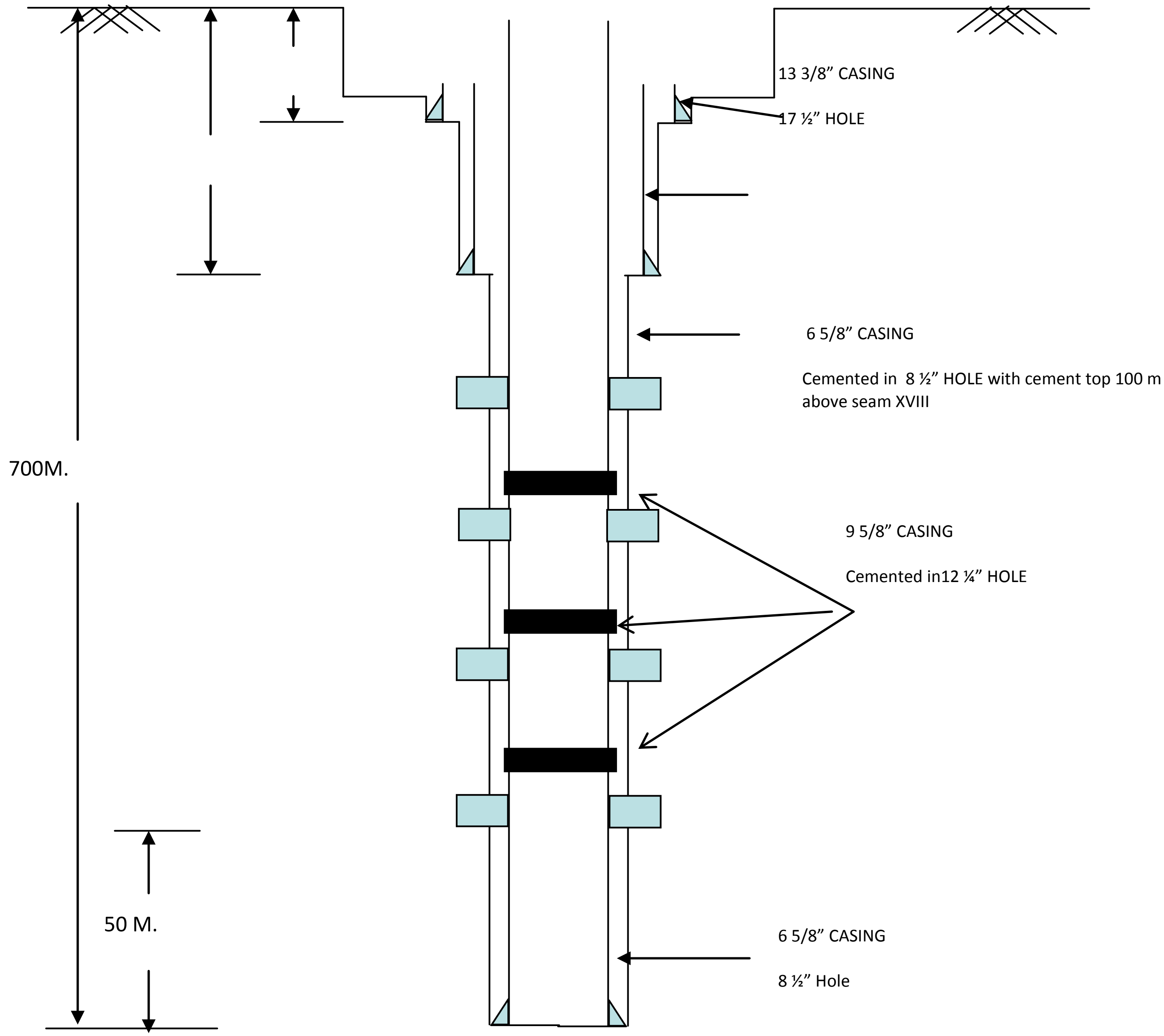

Figure 5. Well design of the hydro-fracked well in the Parbatpur Mine leasehold area, Jharia Coalfield, India.

Age	Formation	Intersected Thickness (m)	Lithology
Recent	Alluviuml	12	Sandy Soil
^^^^^^^^^^^^^^^^^^Unconformity^^^^^^^^^^^^^^^			
Jurassic	Igneous Intrusives	--------	Dykes and sills of dolerites & mica peridotites.
Upper Permian	Barren Measures	94.40	Predominantly grey to black shale with light grey fine to medium-grained feldspathic sandstone.
Lower Permian	Barakar	883.95	Conglomerate, gritty sandstones, shales, carbonaceous shales and coal seams.
^^^^^^^^^^^^^^^^^^^^ Faulted Contact ^^^^^^^^^^^			
Pre-Cambrian	Chotanagpur Gneissic complex	6.20	Granite gneiss with smoky quartz vein, migmatites

Table 1. Company-wise operating coal mines in India.

Company	No. of Collieries			
	OC	UG	Mixed	Total
COAL:				
1. ECL	18	92	2	112
2. BCCL	15	49	16	80
3. CCL	35	22	6	63
4. NCL	8	0	0	8
5. WCL	33	42	5	80
6. SECL	19	76	2	97
7.MCL	14	9	0	23
8.NEC	2	5	0	7
Total Coal India Ltd (1 to 8)	**144**	**295**	**31**	**470**
SCCL	12	55	0	67
BSMDCL	1	0	0	1
DVC	1	0	0	1
IISCO	0	1	2	3
JKML	1	3	0	4
BECML	1	0	0	1
ICML	1	0	0	1
JSPL	1	0	0	1
TISCO	2	5	0	7
TOTAL COAL	**164**	**359**	**33**	**556**
LIGNITE:				
NLC	2			2
GMDCL	2			2
GIPCL	1			1
RSMDCL	1			1
TOTAL LIGNITE	6			6
TOTAL COAL + LIGNITE	**170**	**359**	**33**	**576**

Table 2. India's CMM Emissions (million cubic meters).

Source	1990	1994	1995	2000	2005	2010	2015
CMM emissions (no utilization)	763*	957.3	959*	1,106*	1,363*	1,616*	1,987*

Table 3. Generalized Geological Sequence, Parbatpur CMM Block.