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# खनन विज्ञान
# minetech

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जुलाई-सितम्बर, 2023

Volume 44, No. 3
July-September, 2023


## Special issue on
## Opencast Mining

# खनन विज्ञान minetech

सीएमपीडीआई प्रकाशन

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Manoj Kumar
Chairman-cum-Managing Director



सेन्ट्रल माईन प्लानिंग एण्ड डिजाइन इन्सटीच्यूट लिमिटेड
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## Message

It gives me immense pleasure to know that CMPDI is publishing a special issue of Minetech on the subject of Opencast Mining.

Since nationalization of Coal sector in India in 1975, the coal production in Coal India Limited (CIL) from opencast mining has increased significantly touching an all-time high of 677.72 MT in year 2022-23 with opencast accounted for almost 96% of total coal production. This transition is evident due to various factors, including reduced production expenses, enhanced productivity, elevated recovery rates, decreased safety risks, simplified geological and mining challenges, and heightened mechanization, among other influences. In pursuit of the twin goals of securing the nation's energy supply and stimulating economic expansion, CIL has established an ambitious long-term vision to reach a coal production of 1 billion tonnes by 2025-26. This target signifies a substantial increase of over 50% in production, with opencast mining slated to be the primary driver behind this significant surge in output.

In light of this situation, the adoption of a contemporary, technologically sophisticated, secure, and sustainable approach to opencast mining is not merely a technological requirement but also an essential economic imperative.

In this context, the release of this Minetech publication is well-timed. I have confidence that it delves into a range of pivotal aspects of opencast mining, encompassing technological innovations, modernization, R&D, productivity enhancements, safety protocols, as well as social and environmental considerations. Anticipated outcomes include substantial benefits for the industry, as the insights shared in this edition are poised to propel our opencast mining operations towards technological advancement, efficiency, environmental responsibility, and social accountability.

I extend my best wishes for the success of this special issue of Minetech.".

Best regards,

(Manoj Kumar)
Chairman-cum-Managing Director


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Director Technical (CRD)

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It is pleasant to note that the publication department of CMPDI is bringing out a special edition of MINETECH Journal on OC Mining.

Having regard to the importance of Coal in the rapidly developing industrial economy of the country since nationalization, a major thrust has been given on systematic Coal Exploration resulting in quantum jump in identification of proved/majored coal resources from 21 BT in 1975 -76 to 199 BT in 2022-23. This has also resulted in exceptional increase in coal production from 79.03 MTs in 1973-74 to 703.20 MTs in 2022-23 with 677.7 MTs through OC Mining with the production of individual mine to reach as high as 52.50 MTs.

The growth in OC Mining is the testimony of CMPDI's endeavor in proper mine planning with deployment of state of art Heavy Earth Moving machinery. As CIL is gearing up to achieve ambitious target of 1 BTs, the onus lies on the department to adopt more mechanization and adopt high degree of technology. The above activity has to be carried out with taking due care the environmental aspect as per the govt. guidelines.

I hope that the technical papers in this edition of MINETECH will take care of all the above issues and will be beneficial for the Coal Industry.

My best wishes to the authors as well as entire team of MINETECH.

S K Gomasta
(S K GOMASTA)

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**Shankar Nagachari**
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सेन्ट्रल माईन प्लानिंग एंड डिजाइन इंस्टिट्यूट लिमिटेड
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# Message

I feel immense pride and pleasure to know about the publication of another edition of our cherished in-house technical journal. This special publication of **'Minetech'** focused on **'Opencast Mining'** serves as a testament to the collective brilliance and dedication that defines our organization.

In recent years, the coal mining sector has witnessed transformative advancements in technology and practices, driven by the collective commitment to environmental stewardship. As pioneers in this field, we must continue to lead the charge towards sustainable solutions that balance economic vitality with ecological responsibility.

Our in-house journal plays a pivotal role in this endeavor, providing a platform for us to share insights, discoveries, and achievements that shape not only our organization but also the broader Coal industry.

As we move forward, let us embark on this journey hand-in-hand, united by our shared commitment to a sustainable and prosperous future. In the ever-evolving landscape of Coal mining, it is imperative that we remain at the forefront of innovation and knowledge.

I commend the tireless efforts of the editorial team, reviewers, and contributors who have worked diligently to curate this edition and am looking forward to witness the impact of your collective efforts.

Shankar Nagachari

INTERNATIONAL YEAR OF MILLETS 2023

आज़ादी का अमृत महोत्सव

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निदेशक(त./पी. एंड डी.)

**AJAY KUMAR**
**DIRECTOR (TECH. /P.&D.)**

## *Message*

It is pleasant to note that the publication department of CMPDI is bringing out a special edition of Minetech journal on Opencast Mining.

Coal being the most important and abundant resource of India that has contributed to the industrial growth of the country. The very rapid growth of industry necessitated the huge demand of coal as an energy source. With increasing demand of coal, safe and sustainable mining has become need of the hour. The sharp augmentation of coal production as to meet the ambitious target of 1BT coal production of CIL by 2025-2026 can only be met by induction of higher degree of mechanization and adoption of newer technologies in opencast mining.

India is the second largest producer of coal. Opencast mining contributing more than 90% of domestic coal is facing challenges of environment, safety and adverse socio economic impact. This necessitates urgent and emergent need to act upon sustainable mining in social and environmental friendly manner by promoting innovations and continuous upgradation of infrastructures and technological set up. Thrust are to be given on planning of larger opencast mines with state of the art technologies, elevated digitization and automation to ensure higher efficiency in operations, enhanced safety to achieve sustainable growth in opencast mining.

I am quite hopeful that the technical papers in this special edition of Minetech would address all the relevant areas of opencast mining and would be of greater benefit of the coal industry.

(Ajay Kumar)

सेन्ट्रल माईन प्लानिंग एण्ड डिजाइन इन्स्टीच्यूट लिमिटेड
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# MESSAGE

I am pleased to introduce the special edition of our internal journal, 'MINETECH,' dedicated to the topic of 'Opencast Mining.'

The landscape of Opencast Mining within Coal India Limited has undergone a profound transformation since its nationalization. This transformation has been instrumental in elevating CIL's overall coal production from 79 MT in 1974-75 to an impressive 703 MT by 2022-23, with individual mine production reaching a peak of 52.50 MT.

This remarkable growth stands as a testament to the successful planning and execution of capital intensive projects incorporating cutting-edge Heavy Earth Moving Machinery. While Opencast Mining has been the focal point for bulk coal production during this period, Underground Mining has played a complementary role.

The predominant technology in use continues to be the Shovel-Dumper system. Moreover, the widespread adoption of Surface Miners across various projects is highly encouraging, both in terms of facilitating selective mining and boosting overall output with elimination of crusher in coal dispatch system.

Notably, employee productivity at Opencast Mines has exhibited a steady improvement in the post-nationalization era.

I anticipate that the technical papers featured in this edition of Minetech will provide invaluable insights to engineers actively involved in the realm of 'Opencast Mining.' These papers will delve into a range of industry-related issues, enriching our understanding of this critical field.

(SATISH JHA)
Director Technical (RD&T)

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खनन विज्ञान
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# विषय सूची
# Contents

खण्ड 44, अंक 3
जुलाई–सितम्बर, 2023

Volume 44, No. 3
July-September, 2023

# Mathematical modelling for productivity computationand face length optimisation for surface miner

*R.Sharma[1], Shobhit Mehta[2], Rakesh Kumar [3], A.K. Mishra[4]*

***Abstract***

*In the early 1980s, surface miner entered into the mining domain. However, it took another 10 years to make this technology mine proven. In mid 1990s, this machine started working in cement and limestone companies in India. Surface Miners made their debut in Indian coal mining industry in late 1990's. Since then, this machine has proved its sustainability and success over the period of time, as in 2022-23 it contributed 54 %( 378 MT) out of total coal production of 703.21 MT in CIL. Further, coal mining through surface miner has helped to achieve the twin objective - to increase coal production with minimal impact to environment.*

*Considering the strategic importance of surface miner for coal production in highly competitive global scenario, it is imperative to further look at optimizing the efficiency of the surface miner during operation. To monitor the efficiency, a productivity computation model is required to be developed.*

*An attempt has been made in this paper to develop a productivity computation model, considering the cutting depth, cutting width, cutting length and cutting speed, based on field study in CIL mines. Further, an attempt has also been made to derive a productivity relationship with length of cut, using graphical and statistical tool, for optimum planning of the working face of surface miner.*

## OBJECTIVE

The study has been conducted for surface miner, operating in windrowing application, with Turn-back mode of operation.

Deriving Productivity of a surface miner, by using technical specified parameters alone, such as cutting depth, drum width and cutting speed, does not reflect the variations encountered during actual operating condition.

The objective of the study was to identify and evaluate these variations, and to deduce a suitable empirical methodology for deriving the productivity. Hence, to capture these variations under actual working conditions in mines, field trials were conducted in few mines of CIL. Methodology was to take the experimental readings under different conditions, and to incorporate the observed parameters in formulating the productivity of Surface Miners.

Another objective of the study was to establish a mathematical relationship between productivity and length of cut/pass. Capturing this relationship is very important, as the length of cut/pass is the most dominant variable, responsible for variation in productivity. Effort needs to be made in establishing a trend line equation incorporating the relationship, which would help in planning purpose, and optimisation of working face dimensions.

*[1]Manager(Excavation), [2]CheifManager(Excavation), [3] CheifManager(Mining), [4]GM(S&T)CMPDI(HQ), Ranchi*

## BACKGROUND

Development of surface miner was initiated in 1970s. The design concept for the surface miner is based on the milling principle and owes its origin to the road milling machines which cuts the old road surface for road construction. Since 1990s, surface miners have gained its popularity in mining industry in India, with improved design of cutting drum and higher machine power. This has enabled the users to excavate rock from in-situ in cost effective and eco-friendly manner.

Surface miners now offer an effective alternative to conventional coal mining practices. It allows for cutting, crushing and loading of material in one pass. Selective mining with high quality produce without drilling and blasting as well as high production rate with small size products are some of the advantages of this machine. Therefore it assists and relieves the pressure on drilling, blasting and crushing.

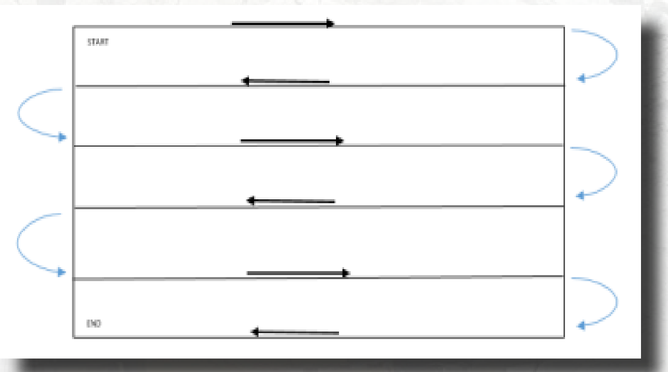
In mid 1990s, surface miners started working in cement companies in India. The machines proved the ability of mining and sizing the soft limestone without blasting. Since then surface miners have become the standard mining machine in all soft to medium hard limestone mines in India.

This success led coal industry in India to look more closely at this technology. Since then this machine has proved its sustainability and success in coal extraction over the period of time.

In Indian coal industry, windrowing application of Surface Miner with turn back method is widely used. In Windrowing application, Cut/Milled coal is discharged directly behind the machine without the use of a conveyor. This coal is evacuated using pay-loader and dumper / tipper.

The Turn Back method is the most common operating mode utilised. After making a straight cut of one strip, the cutting drum is raised, and the Surface Miner turns back to make an adjacent cut heading in the opposite direction; Fig.1 shows this process. This is the most widely used method of Surface Miner operation as it increases production and recovery of the resource. However, a long pit length and favourable conditions for turning around are required to optimise this mode.

Analysis in this paper in regards to productivity has been done considering the same.




**(Figure.1)**

## PERFORMANCE OF SURFACE MINERS IN COAL INDIA LIMITED

Surface Miners have gained great applicability and acceptability for coal production in CIL (world's largest coal producer) due to their inherent advantages, such as, elimination of drilling & blasting, production of sized coal etc. Use of surface miner has certain limitations too. It requires relatively large working area to operate efficiently to get optimum output.

It has been more than two decades, when the first Surface Miner was introduced in CIL at Lakhanpur opencast mine of MCL in year 1999. Since then the deployment of this equipment in opencast mines of CIL has expanded at a very fast rate.

Presently 40 nos. of departmental and around 100 nos. of outsourced surface miners (Make– L&T, Wirtgen and Puzzolana) are deployed in different opencast mines of CIL. Contribution of coal production by surface miners has increased significantly over the years. During 2022-23 around 54% of total coal produced from mines of CIL, was by surface miners. Presently, surface miners are working in opencast mines of different subsidiaries of CIL, namely- ECL, CCL, WCL, SECL, NCL and MCL

**Table-1: Last five years Coal Production in CIL**

| Year | Coal Production by Surface Miner (MT) | Total Coal Production (MT) |
|---|---|---|
| 2022-23 | 378 | 703.21 |
| 2021-22 | 312.33 | 622.64 |
| 2020-21 | 279.4 | 596.2 |
| 2019-20 | 269.1 | 602.1 |
| 2018-19 | 280.7 | 606.8 |

## OBSERVATION FROM FIELD STUDY

Field study was conducted on surface miners with cutting drum width 4000 mm and cutting depth 0 - 300 mm, and engine power 900 HP.

Based on the field trial observations, Summary has been prepared, containing the technical details–Drum Width, Length of Pass, Depth of Cut, Cutting Time, Cutting Speed, Turning Back & Repositioning Time, Cycle Time & Effective Width per Pass. The same is shown in Table-2.

| Sl No. | Mines | Reading Number | Depth of Cut (m) | Legth of pass (m) | Cutting Time (min) | Cutting Speed (m/min) | Turning & Repositioning Time (min) | Effective Width per pass (m) |
|---|---|---|---|---|---|---|---|---|
| 1 | MINE-A | C-1/O-1 | 0.180 | 62 | 3.68 | 16.85 | 2.820 | 3.53 |
| 2 | MINE-A | C-2/O-1 | 0.180 | 62 | 3.55 | 17.46 | 2.850 | |
| 3 | MINE-A | C-1/O-3 | 0.230 | 113 | 5.76 | 19.62 | 1.940 | 3.74 |
| 4 | MINE-A | C-2/O-3 | 0.230 | 113 | 5.73 | 19.72 | 2.760 | |
| 5 | MINE-A | C-3/O-3 | 0.230 | 51 | 2.50 | 20.40 | 2.240 | 3.7 |
| 6 | MINE-A | C-4/O-3 | 0.230 | 51 | 2.59 | 19.69 | 2.700 | |
| 7 | MINE-A | C-1/O-6 | 0.215 | 70 | 4.05 | 17.28 | 2.740 | 3.57 |
| 8 | MINE-A | C-2/O-6 | 0.215 | 70 | 4.23 | 16.55 | 2.780 | |
| 9 | MINE-A | C-3/O-6 | 0.215 | 70 | 4.07 | 17.20 | 2.820 | |
| 10 | MINE-A | C-1/O-9 | 0.190 | 20 | 1.17 | 17.09 | 2.833 | 3.54 |
| 11 | MINE-A | C-2/O-9 | 0.190 | 20 | 1.21 | 16.53 | 2.940 | |
| 12 | MINE-A | C-3/O-9 | 0.190 | 20 | 1.20 | 16.67 | 3.010 | |
| 13 | MINE-B | C-1/O-12 | 0.180 | 70 | 3.85 | 18.18 | 2.98 | 3.44 |
| 14 | MINE-B | C-2/O-12 | 0.180 | 70 | 4.00 | 17.50 | 2.78 | |
| 15 | MINE-B | C-3/O-12 | 0.180 | 70 | 4.02 | 17.41 | 2.72 | |
| 16 | MINE-B | C-4/O-12 | 0.180 | 70 | 3.75 | 18.67 | 2.88 | |
| 17 | MINE-B | C-5/O-12 | 0.180 | 70 | 3.50 | 20.00 | 2.75 | |
| 18 | MINE-B | C-6/O-12 | 0.180 | 70 | 4.05 | 17.28 | 2.90 | |

| Sl No. | Mines | Reading Number | Depth of Cut (m | Legth of pass (m) | Cutting Time (min) | Cutting Speed (m/min) | urning & Repositioning Time (min) | Effective Width per pass (m) |
|---|---|---|---|---|---|---|---|---|
| 19 | MINE-C | C-1/O-13 | 0.200 | 140 | 8.25 | 16.97 | 2.72 | 3.61 |
| 20 | MINE-C | C-2/O-13 | 0.200 | 140 | 8.20 | 17.07 | 2.83 | |
| 21 | MINE-C | C-3/O-13 | 0.200 | 140 | 8.33 | 16.81 | 2.54 | |
| 22 | MINE-C | C-4/O-13 | 0.200 | 140 | 8.22 | 17.03 | 2.73 | |
| 23 | MINE-C | C-5/O-13 | 0.200 | 140 | 7.95 | 17.61 | 2.88 | |
| 24 | MINE-C | C-6/O-13 | 0.200 | 140 | 8.15 | 17.18 | 2.75 | |
| 25 | MINE-C | C-1/O-14 | 0.190 | 130 | 7.08 | 18.36 | 2.53 | 3.65 |
| 26 | MINE-C | C-2/O-14 | 0.190 | 130 | 7.22 | 18.01 | 2.80 | |
| 27 | MINE-C | C-3/O-14 | 0.190 | 130 | 6.83 | 19.03 | 2.78 | |
| 28 | MINE-C | C-4/O-14 | 0.190 | 130 | 7.50 | 17.33 | 1.93 | |
| 29 | MINE-C | C-5/O-14 | 0.190 | 130 | 7.58 | 17.15 | 2.63 | |
| 30 | MINE-B | C-1/O-15 | 0.200 | 90 | 5.25 | 17.14 | 2.93 | 3.74 |
| 31 | MINE-B | C-2/O-15 | 0.200 | 90 | 5.31 | 16.95 | 2.83 | |
| 32 | MINE-B | C-3/O-15 | 0.200 | 90 | 5.18 | 17.37 | 2.78 | |
| 33 | MINE-B | C-4/O-15 | 0.200 | 90 | 5.21 | 17.27 | 2.69 | |
| 34 | MINE-B | C-5/O-15 | 0.200 | 90 | 5.45 | 16.51 | 2.91 | |
| 35 | MINE-B | C-1/O-16 | 0.200 | 120 | 6.55 | 18.32 | 2.85 | 3.75 |
| 36 | MINE-B | C-2/O-16 | 0.200 | 120 | 6.86 | 17.49 | 2.91 | |
| 37 | MINE-B | C-3/O-16 | 0.200 | 120 | 7.05 | 17.02 | 2.88 | |
| 38 | MINE-B | C-4/O-16 | 0.200 | 120 | 7.25 | 16.55 | 2.72 | |
| 39 | MINE-B | C-5/O-16 | 0.200 | 120 | 6.90 | 17.39 | 2.25 | |
| 40 | MINE-B | C-6/O-16 | 0.200 | 120 | 7.10 | 16.90 | 2.77 | |
| 41 | MINE-B | C-1/O-17 | 0.210 | 120 | 7.11 | 16.88 | 2.83 | 3.60 |
| 42 | MINE-B | C-2/O-17 | 0.210 | 120 | 6.98 | 17.19 | 2.76 | |
| 43 | MINE-B | C-3/O-17 | 0.210 | 120 | 7.02 | 17.09 | 2.83 | |
| 44 | MINE-B | C-4/O-17 | 0.210 | 120 | 6.88 | 17.44 | 2.70 | |
| 45 | MINE-B | C-5/O-17 | 0.210 | 120 | 7.25 | 16.55 | 2.83 | |
| 46 | MINE-B | C-6/O-17 | 0.210 | 120 | 7.15 | 16.78 | 2.80 | |
| 47 | MINE-D | C-1/O-11 | 0.220 | 43 | 2.45 | 17.55 | 2.82 | 3.50 |
| 48 | MINE-D | C-2/O-11 | 0.220 | 43 | 2.50 | 17.20 | 2.92 | |
| 49 | MINE-D | C-3/O-11 | 0.220 | 43 | 2.45 | 17.55 | 2.83 | |
| 50 | MINE-D | C-4/O-11 | 0.220 | 43 | 2.52 | 17.06 | 2.94 | |
| Minimum Depth of Cut (m) | | | 0.180 | | | | | |
| Maximum Depth of Cut (m) | | | 0.230 | | | | | |
| Average Depth of cut (m) | | | 0.201 | | | | | |
| Minimum Cutting Speed (m/min) | | | | | | 16.51 | | |

| | | | |
|---|---|---|---|
| Maximum Cutting Speed (m/min) | 20.40 | | |
| Average Cutting Speed (m/min) | 17.54 | | |
| Minimum Turning & Repositioning Time (min) | | 1.93 | |
| Maximum Turning & Repositioning Time (min) | | 3.01 | |
| AverageTurning & Repositioning Time (min) | | 2.75 | |
| Minimum Effective Width Per Pass (m) | | | 3.44 |
| Maximum Effective Width Per Pass (m) | | | 3.75 |
| Average Effective Width Per Pass (m) | | | 3.61 |

**Mean Effective Cutting Width-** It has been observed that overlapping of adjacent passes (cut width) occurs during multiple- pass operation, and mean effective width of cut per pass was around 90% - 92% of the drum width. This factor may be termed as Overlap Coefficient (α), and defined as α = (Effective Cutting width of pass)/ (Width of Cutting Drum). Overlapping occurs because the operator takes precaution not to allow any uncut portion between two successive passes. Otherwise, the left out uncut portion might lead to its evacuation problem. However, the overlapping may be minimised (and hence α may be maximised by:

1. Equipping the machine with sophisticated features/sensors to precisely judge the previous cut area, and
2. Upgrading the operator's skill.

| Width of Cutting Drum of Machine (m) | Mean Effective Cutting Width obtained (m) | Overlap Coefficient (α) |
|---|---|---|
| 4.00 | 3.61 | 0.9025 |

**Mean Effective Cutting Depth**– Maximum cutting depth of machine, as specified by the manufacturer, was not being achieved. Mean effective depth was around 65%-70% of it. This factor may be termed as **Depth Coefficient (ß)**, and defined as ß= (Effective Cutting depth)/ (Maximum Cutting Depth). It happens due to:

1. Seam inclination,
2. Undulations of the surface,
3. Nature of material to be cut, and
4. Operator's skill.

| Width of Cutting Drum of Machine (m) | Mean Effective Cutting Width obtained (m) | Overlap Coefficient (α) |
|---|---|---|
| 4.00 | 3.61 | 0.9025 |

**Mean Cutting Speed (s)**– Mean Cutting Speed has been calculated from field study data of Length of Cut and corresponding Cutting Time. It may vary with the material being cut, as well as the skill of the operator.

**Mean Turning back and repositioning time (t)**– In Turn-Back method of operation, after completion of a particular pass of cut, the machine is turned back and repositioned for successive cut. During this period cutting/milling does not take place. Mean Turning Back and Repositioning Time has been computed from the captured field study data.

This mainly depends on:

1. Turning radius of the machine,
2. Available space beyond the pass length,
3. Operator's skill

## MATHEMATICAL MODELLING FOR PRODUCTIVITY

Productivity of the machine is the function of –

a) Cutting depth of the machine
b) Cutting drum width of the machine
c) Cutting speed of the machine
d) Turning back and repositioning time of the machine
e) Length of cut

While carrying out the field trials, it was observed that there was some variation in the effective depth of cut and effective width per pass.

Productivity of Surface Miner may be expressed as

$$P = \frac{L \times s\,(W \times \alpha)\,(D \times \beta) \times 60}{(L + t \times s)} \text{ ------------ (i)}$$

Where,

P=Productivity of the machine (m3/h)
L=Length of Cut of pass (m)
W=Cutting Drum Width of machine (m)
α=Overlap Coefficient
D=Maximum Cutting Depth of machine (m)
ß=Depth Coefficient
s=Cutting Speed for a length of pass (m/min)
t=Turning back and Repositioning Time for successive pass (min)

Based on the field trials, following values have been obtained

Overlap Coefficient, α = 0.9025
Depth Coefficient, ß = 0. 67
Mean Cutting Speed, s = 17.54 m/min
Mean Turning back & repositioning time, t= 2.75 min

Now, the Productivity (P) can be expressed as-

$$P = \frac{L \times W \times D \times 636.36}{L + 48.235} \text{ -------------------- (ii)}$$

The above is the hourly productivity, derived for continuous operation. However, to calculate the productivity for longer period of time, an additional Operational Factor should also be incorporated, to address the operational constraints.

## PRODUCTIVITY RELATIONSHIP WITH LENGTH OF CUT (PASS)

To obtain the optimum production from surface miner, its relationship with length of cut has to be understood, as it is the most influencing parameter affecting productivity. Based on the mathematical modelling derived above in (ii), the productivity at different length of cut was computed. This is productivity for surface miner with cutting drum width 4000 mm, cutting depth 300 mm, and engine power 900 HP. An additional Operational Factor of 0.8 has been considered in this case.

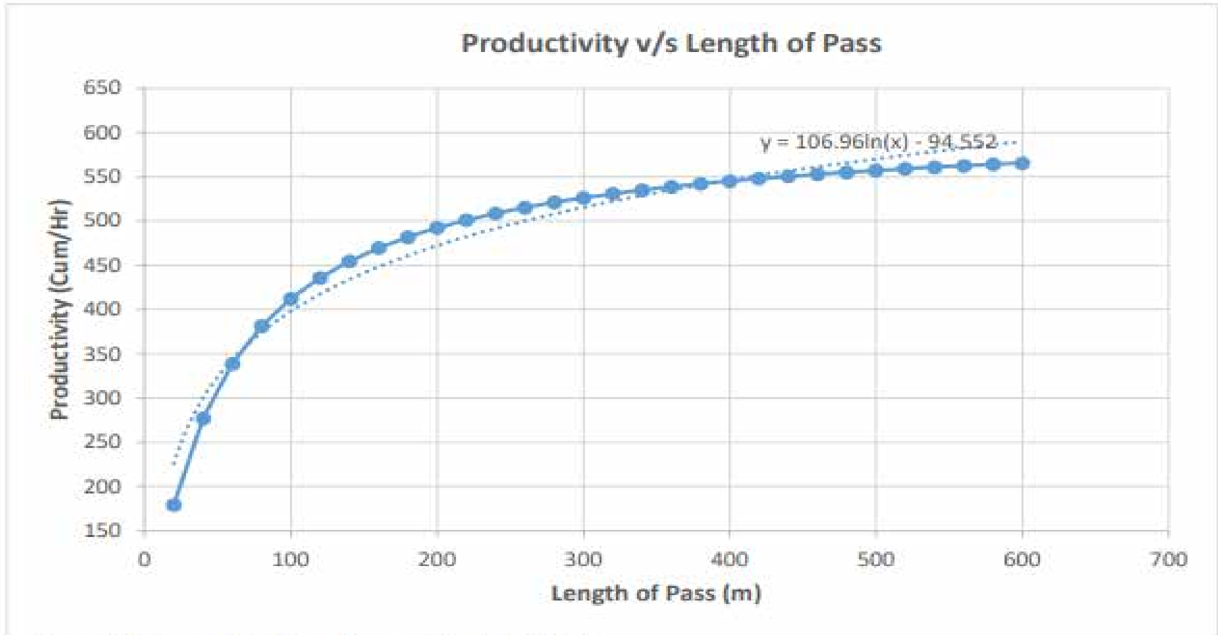
Productivity (cum/hour) v/s Length of Cut/ Pass (m) have been plotted as below. It is observed from the plotted data, that the optimum productivity lies around 300-350m, although the productivity always keeps on increasing with increase in length of pass. It is further evident, that for length of pass <200m, the productivity starts decreasing sharply; and below 100m length of pass, there is tremendous loss of productivity of a surface miner.

As we further observed that relationship of productivity and length of pass follows a logarithmic curve. Therefore, trend line equation has been obtained for the plotted data, accordingly, which is as follows:

$$y = 106.96\ln(x) - 94.552 \text{ ---------------------- (iii)}$$

So, the relationship trend line equation may be re-written as –

Productivity=106.96 x ln(Length of Pass)-94.552 --------------------- (iv)




*The graph has been derived based on extrapolation of field data.

**Figure: 2**

## SCOPE FOR FURTHER STUDY

Relationship between productivity, and physico-mechanical property of the material being cut, and their-inter dependence on machine power may be studied. It would help in better evaluation of productivity for different rock properties, by deploying the most appropriate Surface Miner under specific requirement.

Relationship between turning back plus repositioning time, and Turning Radius of the machine may be studied. It may help in selecting suitable machine for efficient operation.

## CONCLUSION

Productivity (P) has been deduced in relation with cutting width, cutting depth, length of cut, cutting speed and turning back plus repositioning time.

$$P = \frac{L \times s\,(W \times \alpha)\,(D \times \beta) \times 60}{(L + t \times s)}$$

Through field study, the values of α, ß, s and t have been determined, by considering the surface miner (drum width 4000 mm, max cutting depth 300 mm) in coal, using windrowing operation and turn back operating mode. These values may be affected by changed working scenario.

Based on our field study, the above generalised formula may be simplified as

$$P = \frac{L \times W \times D \times 636.36}{L + 48.235}$$

Length of Pass is the most dominant parameter in the expression. It is observed from the plotted data of productivity v/s length of pass, that the optimum productivity lies around 300-350m, although the productivity always keeps on increasing with increase in length of pass. It is further evident, that for length of pass <200m, the productivity starts decreasing sharply; and below 100m length of pass, there is tremendous loss of productivity of a surface miner.

Therefore, a relationship trend line equation between productivity and length of pass has been obtained-

Productivity=106.96 x ln(Length of Pass) - 94.552

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# Vibro-ripper- a blast free technology for ob removal (A case study)

*Randip Singh [1], Rakesh Kumar [2], D.P.Singh[2]*

## Abstract

*The present paper highlights the use of Vibro-ripper as a blast free technology used for OB removal in Opencast coal mines. Traditionally, drilling and blasting is considered to be the most efficient and cost effective method for fragmenting rock for bulk handling by excavators, but has adverse impact related to blasting, especially when operating under constrained conditions like proximity to habitation, important surface features and infrastructural facilities. Technology like ripping by high capacity dozers has found applicability in certain formations/areas which limit the use of blasting. Another technological option is a Vibro-ripper which is being tried in MCL and SECL. The Vibro Ripper is used as an excavator (shovel) attachment for breaking and ripping of rock with high frequency vibration. As the Vibro-ripper technology is being operated contractually, the data was also collected for the contractual drilling and blasting operations being executed in Kaniha and Hingula OCPs of MCL, in this case study.*

***Keywords— Vibro-ripper; blast free technology; OB removal; thin parting; etc.***

## I. Introduction

Vibro-Ripper is an excavator attachment developed with the latest advances in excavation, demolition/construction projects. It is a hydraulic rock breaker in which hydraulic pump is the power source and hydraulic oil as the working medium. It converts hydraulic energy into mechanical energy of an actuator mechanism. It works by the impact force


**Figure 1: Photograph of a Vbro-Ripper working at Kaniha Opencast Project, MCL**

*[1]GeneralManager(OC), [2]CheifManager(Mining), CMPDI(HQ),Ranchi*

## Working principal

The Vibro Ripper consists of a vibration exciter, drag link mechanism, knife board, aseismic airbag, bucket teeth, hydraulic motor and bedplate.

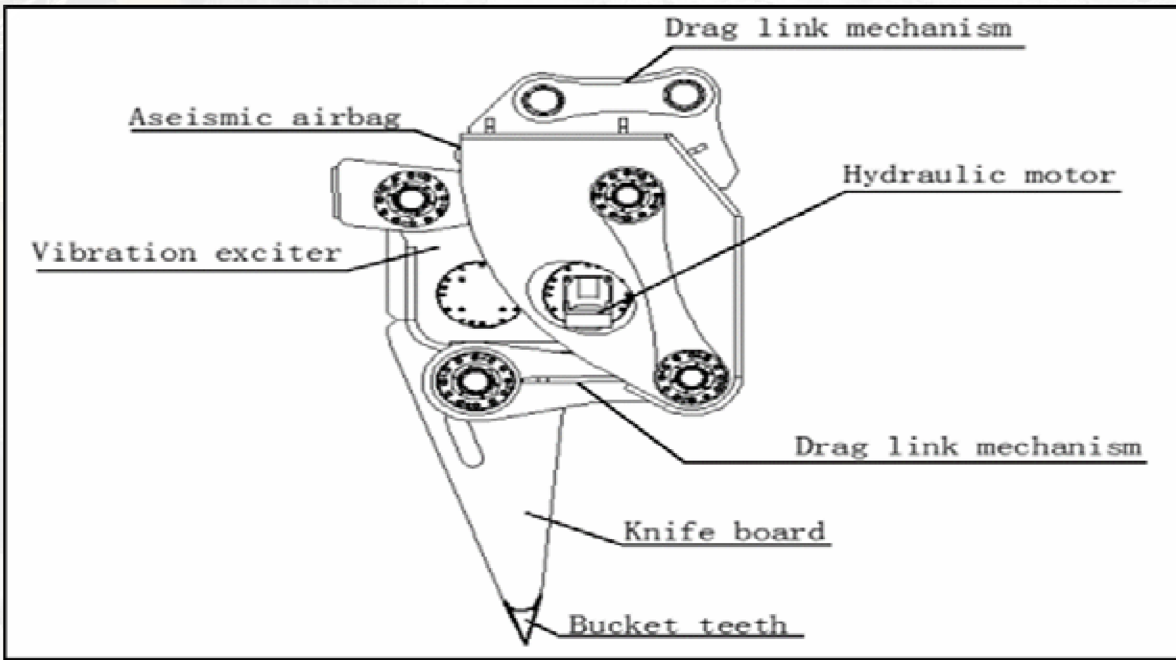



**Figure 2: Working principle**

The crushing force is derived from the high speed vibration of exciter. The hydraulic motor supplies energy which drives the eccentric block. The excavator offers energy to hydraulic motor, so the final energy is provided the excavator hydraulic system.

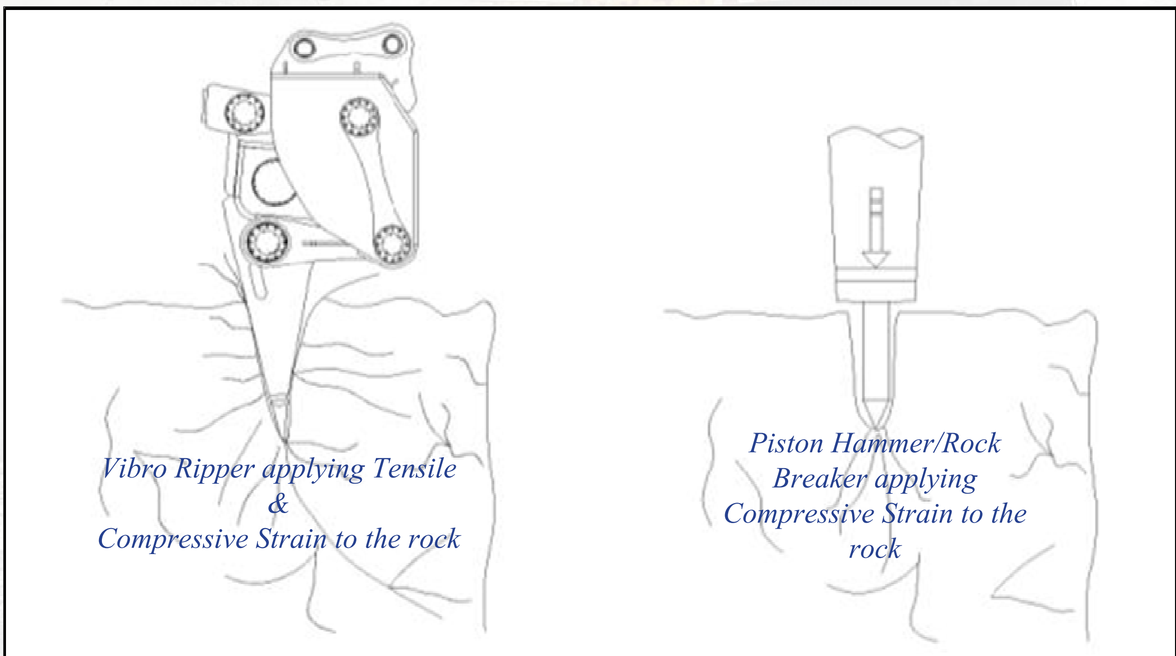



**Figure 3: Cutting forces of Vibro-ripper Vrs Piston Hammer rock breaker**

As the tensile strength of the rock is far less than the compressive strength, the Vibro-Ripper applies tensile and compressive strain to the rock, whereas, the Piston-hammer/Rock Breaker applies only compressive strain to the rock. This leads to better performance in Vibro-Ripper than in Piston-hammer/Rock Breakers.

## Applicability

- Application in areas where blasting is not permitted due to proximity to critical infrastructure like dams/roads/tracks/buildings etc for safety, ground vibrations and fly-rock related issues.

- Thin partings and inseam bands less than 2-3 m thick, where drilling and blasting may not be the most efficient method due to blast hole design constraints.

- Fractured softer formations (Ref Figure 4). Can provide a solution in conditions related to poor toe formation especially in dragline benches and secondary blasting.

## Limitations

- May not be effective in hard rocks and massive formations (unfractured formations)

- Limited cut depth of around 1m is likely to affect the productivity of loading equipment.

- May not be suitable for managing fast advancement requiring bulk excavation volumes.

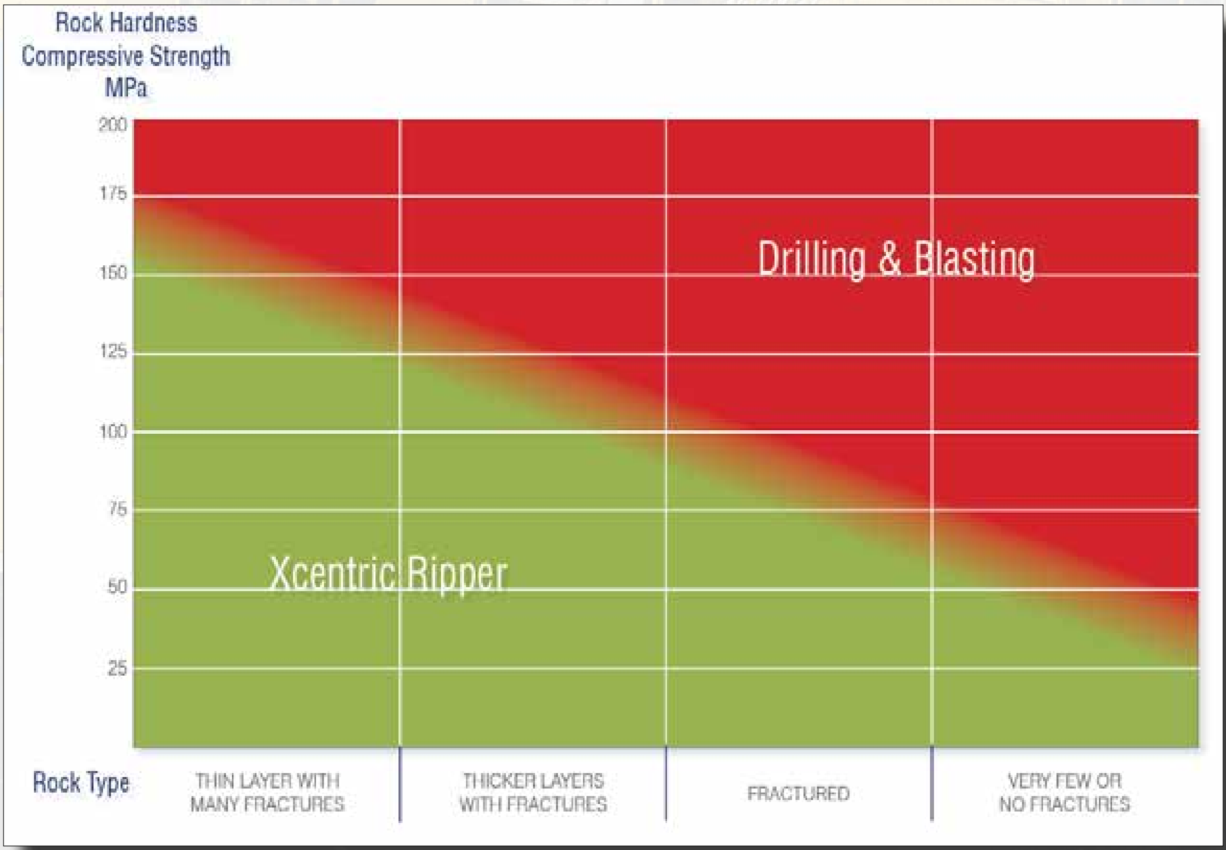



**Figure 4: Source: Xcentric Ripper, Product Brochure**

## II Drilling and Blasting

The conventional drilling and blasting consists of drilling blast holes of a particular diameter, at a set pattern (burden, spacing and depth) for a bench, charging the holes with explosives and blasting it to get fragmented/loosened rock for effective bulk handling by excavators. This is considered to be the most efficient and cost effective method but has adverse impact related to blasting.

## III Field Study

A field study was undertaken at Hingula and Kaniha opencast mines of MCL, as the two operational contracts for deployment of Vibro-rippers are under execution.

Selected area/patches in the two mines could not be being mined, because of opposition to blasting by nearby local villagers. In both the mines, the "drilling and blasting" as well as blast-free technology of OB removal is being executed through two different contracts in different patches.

The patches situated near the villages (Jarda basti and Telisingha basti in Kaniha OCP) and Jambudhara basti and Goddess Hingula temple in Hingula OCP where "drilling and blasting" was not undertaken due to opposition, were awarded for blast-free method for OB removal contract.

The Working Plan of Kaniha Opencast Project and Hingula Opencast Project showing "Drilling & Blasting patch and Ripper patch respectively is presented in Figure 5 and 6 respectively.

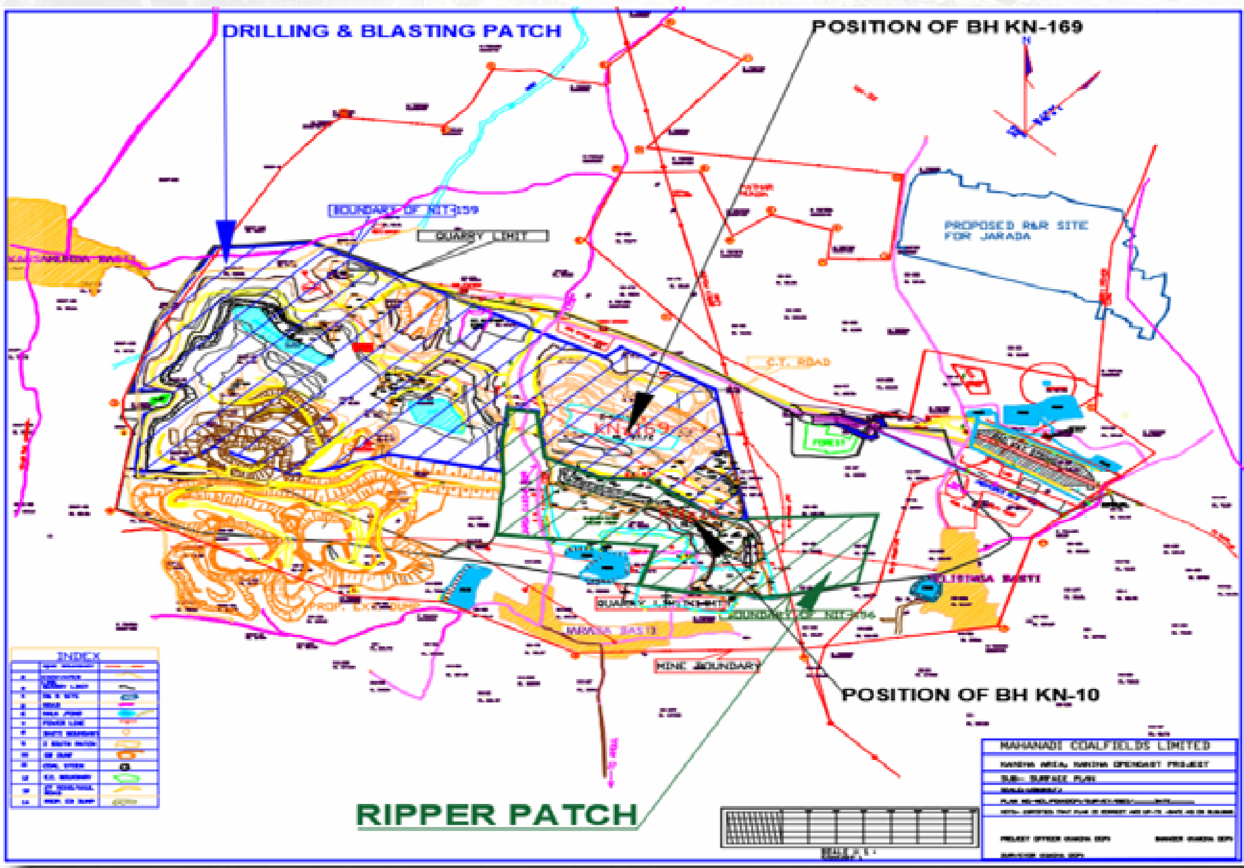



**Figure 5: Working Plan of Kaniha Opencast Project showing "Drilling & Blasting patch and Ripper patch**

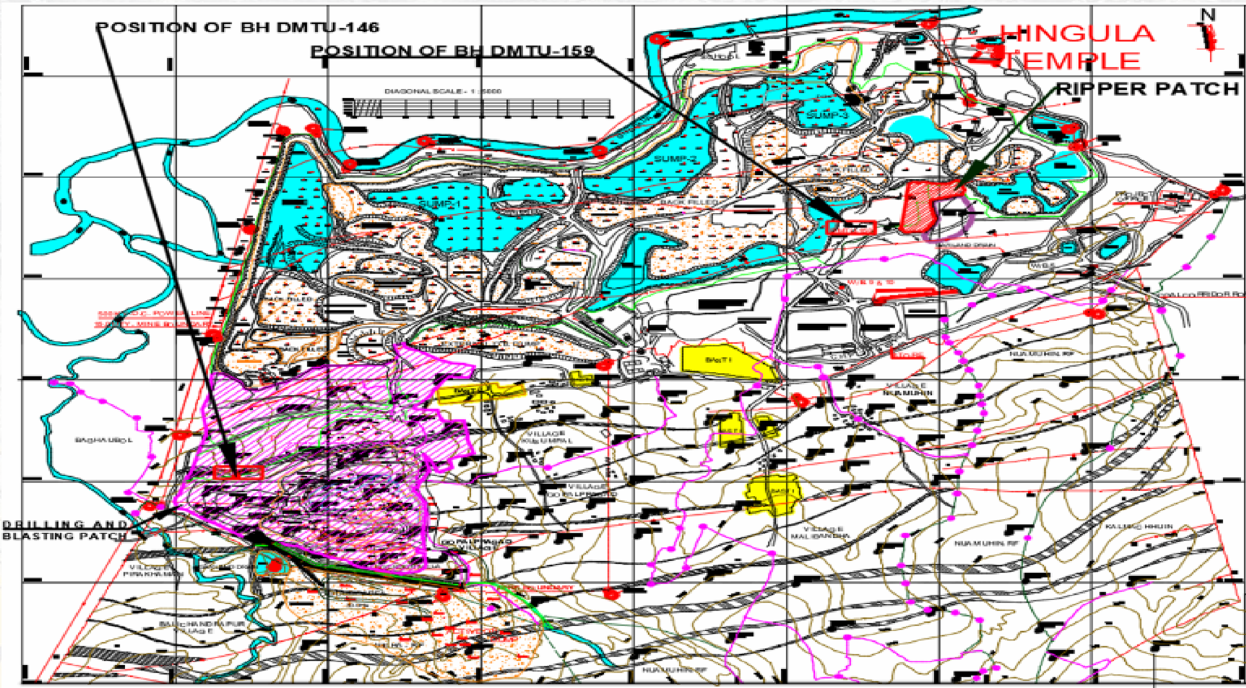
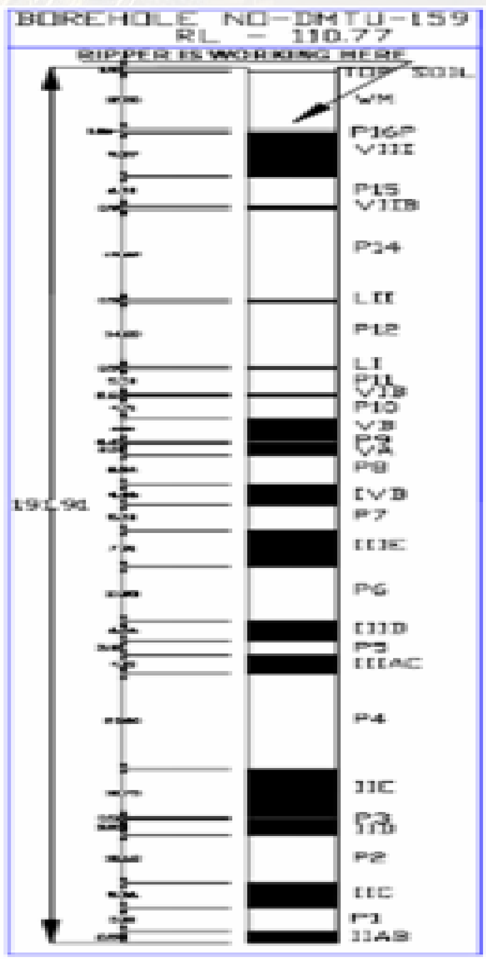



**Figure 6: Working Plan of Hingula Opencast Project showing "Drilling & Blasting patch and Ripper patch**

**Deployment of vibro-ripper in Hingula OCP (Ref: Figure 7)**

02 (two) nos. of ripper machine are currently deployed for OB removal to expose Seam-VIII (in hard OB below top soil and soft rock). The contract for OB removal through ripper was awarded on 29th December 2020 for 327 days for 1.414Mcum of hard OB material. The work commenced on 5th February 2021. Till 22nd December 2021, 1.154Mcum of hard OB has been removed.

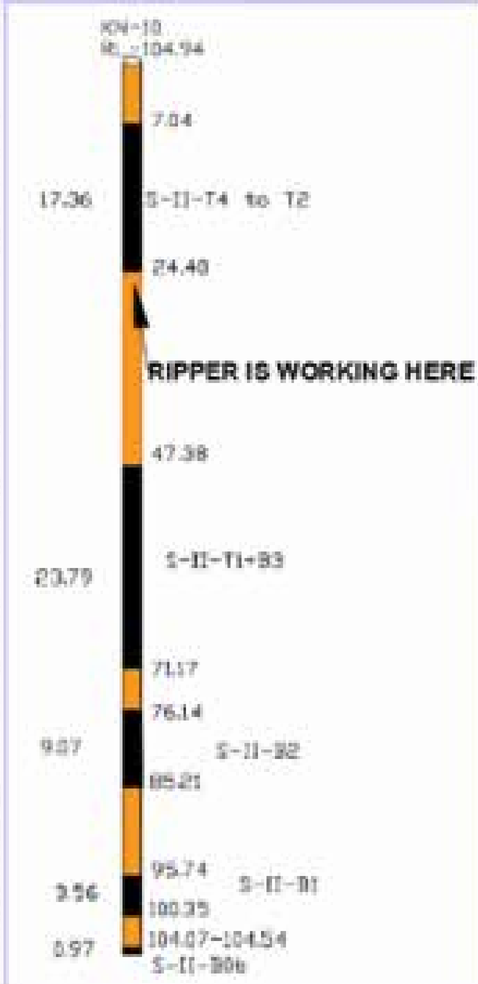

**Figure 7: Deployment in Hingula OCP**



## Deployment of Vibro-rippers in Kaniha OCP (Ref: Figure 8)

03 (three) nos. of ripper machine are currently deployed for OB removal of the parting between Seam-II-T4 to T2 and Seam-II-T1 to B3. The contract for OB removal through ripper was awarded on 25th September 2020 for 1825 days for 25.25Mcum of hard OB material. The work commenced on 24th March 2021. Till 30th November 2021, 0.677Mcum of hard OB was removed.

Figure 8: Deployment in Kaniha OCP




## Brief Description of the projects and geo-mining conditions

### Kaniha opencast project

The PR for Kaniha OCP was approved for a rated capacity of 10 Mt/annum with a mineable reserve base (as on 1.4.2009) of 658.54 Mt at the average stripping ratio of 1.63. Seam IX to Seam II in multiple sections/splits is proposed to be mined in the projectised area.

The mine is proposed to be worked in 3 quarries. Quarry-1 will be opened first and will be completed in 22 years. Quarry-2 will be operate from 18th year to 47th year. Quarry-3 will operate from 45th year to 70th year. The Final quarry Plan is appended as Annexure IA.

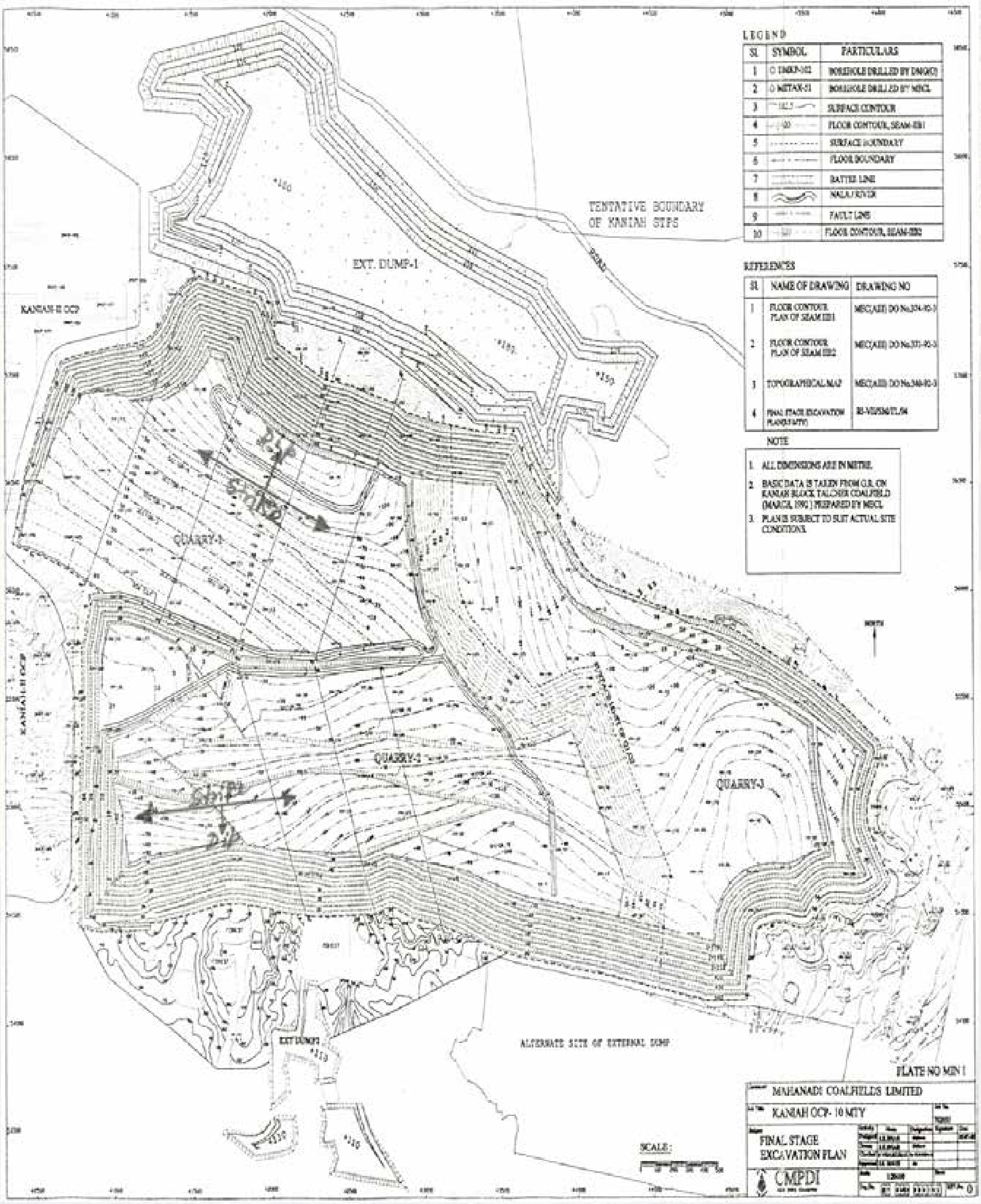
A stratigraphic sequence of the seam in the project is appended as Annexure IIA.

The details of the Physio-mechanical properties (in Borehole No KN 169) is appended as Annexure IIIA.

In 2020-21, the mine has produced 7.94 Mt of coal and removed 3.85 Mcum of OB through hired equipment/outsourcing.

# FINAL STAGE QUARRY PLAN OF PR FOR KANIHA OCP

**Annexure IA**



## STRATEGRAPHIC SEAM SEQUENCE & PARTINGS IN KANIHA OCP

**Annexure IIA**

| Seams/Parting | Thickness Range |
|---|---|
| SEAM-IX | 0.76-4.23 |
| PARTING | 21.22-29.55 |
| SEAM-VIII-T | 0.80-6.74 |
| PARTING | 3.63-10.14 |
| SEAM-VIII-M | 0.43-2.89 |
| PARTING | 3.21-17.80 |
| SEAM-VIII-B | 0.50-5.30 |
| PARTING | 27.04-29.73 |
| SEAM-VII | 0.48-1.85 |
| PARTING | 12.39-17.71 |
| SEAM-VI | 0.38-2.30 |
| PARTING | 49.06-51.22 |
| SEAM-V-T | 2.09-4.05 |
| PARTING | 11.28-15.30 |
| SEAM-V-B | 0.47-4.55 |
| PARTING | 26.33-27.85 |
| SEAM-IV-T | 0.21-1.87 |
| PARTING | (w.r.t. VB) 23.40-26.28 |
| SEAM-IV-T+M | 6.90-13.02 |
| PARTING | (w.r.t. IVT) 2.95-25.18 |
| SEAM-IV-M | 0.30-5.17 |
| PARTING | (w.r.t. IV-T+M) 4.46-18.35<br>(w.r.t. IVM) 3.53-25.63 |
| SEAM-IV-B | 0.15-10.13 |
| PARTING | 33.06-56.20 |
| SEAM-III-T | 0.27-8.08 |
| PARTING | 3.30-8.35 |
| SEAM-III-B | 0.20-6.59 |
| PARTING | (w.r.t. IVB)23.75-49.23 |
| SEAM-III-COMB. | 2.20-26.29 |
| PARTING | 5.85-21.65 |
| SEAM-II-LOCAL | 0.30-3.66 |
| PARTING | (w.r.t. II-LOCAL) 2.66-16.12 |
| SEAM-II-T4 | 0.49-10.97 |
| PARTING | (w.r.t. II-LOCAL) 2.48-9.44;<br>(w.r.t. III-COMB.) 15.45-21.37<br>(w.r.t. III-B) 16.75-37.94 |

| Seams/Parting | Thickness Range |
|---|---|
| SEAM- II-T4+T3 | 4.22-16.93 |
| PARTING | (w.r.t. II-T4) 3.43-11.41 |
| SEAM- II-T3 | 0.32-3.46 |
| PARTING | (w.r.t. II-T4) 3.43-11.41 |
| SEAM- II-T4 TO T2 | 13.60-31.70 |
| PARTING | (w.r.t. II-T4+T3) 3.15-10.9<br>(w.r.t. II-T3) 3.30-11.83 |
| SEAM- II-T2 | 0.30-9.71 |
| PARTING | w.r.t. III-B) 17.44-24.60<br>(w.r.t. III-COMB.) 12.15-28.67 |
| SEAM- II-T4 TO T1 | 24.00-50.45 |
| PARTING | (w.r.t. II-T4+T3) 3.04-7.40 |
| SEAM- II-T2+T1 | 12.92-20.13 |
| PARTING | (w.r.t. II-T2) 3.10-19.67<br>(w.r.t. II-T4 TO T2) 3.20-19.18 |
| SEAM-II-T1 | 4.45-15.52 |
| PARTING | (w.r.t. II-L) 2.81-5.32<br>(w.r.t. III-COMB.) 13.88 |
| SEAM- II-T4 TO B3 | 46.98-56.51 |
| PARTING | (w.r.t. II-T2) 9.96-36.01<br>(w.r.t. II-T4 TO T2) 9.92-32.02 |
| SEAM- II-T1+B3 | 10.56-26.26 |
| PARTING | (w.r.t. II-T1) 3.48-24.55<br>(w.r.t. II-T2+T1) 14.49-20.50<br>(w.r.t. II-T4 TO T1) 3.07-37.91 |
| SEAM-II-B3 | 0.45-10.04 |
| SEAM-II-T4 TO B2 | 56.29 |
| PARTING | (w.r.t. II-LOCAL) 6.27 |
| SEAM-II-T1 TO B2 | 36.82-40.84 |
| PARTING | (w.r.t. II-T2) 8.70<br>(w.r.t. II-T4 TO T2) 8.46-15.01<br>(w.r.t. II-B3) 7.92-28.33<br>(w.r.t. II-T1+B3) 4.97-12.94<br>(w.r.t. II-T4 TO B3) 3.11-16.15 |
| SEAM-II-B2 | 0.23-13.78 |
| PARTING | (w.r.t. II-T2) 11.35-36.34<br>(w.r.t. II-T4 TO T2) 14.73-25.16 |
| SEAM-II-T1 TO B1 | 29.33-52.13 |
| PARTING | (w.r.t. II-1) 3.30-5.35<br>(w.r.t. II-T2 + T1) 11.92-14.53<br>(w.r.t. II-T4 TO T1) 4.38-9.40 |
| SEAM-II-B3 TO B1 | 16.44-27.35 |
| PARTING | (w.r.t. II-T1 + B3) 3.02-11.21<br>(w.r.t. II-B3) 1.30-17.75 |

| Seams/Parting | Thickness Range |
|---|---|
| SEAM-II-B2+B1 | 8.77-22.23 |
| PARTING | (w.r.t. II-T4 TO B2) 8.84-15.63<br>(w.r.t. II-T1 + B2) 3.64-15.48<br>(w.r.t. II-B2) 3.20-20.55 |
| SEAM-II- B1 | 0.27-8.65 |
| PARTING | (w.r.t. II-T1 TO B1) 1.42-8.34<br>(w.r.t. II-B3 TO B1) 2.40-9.44<br>(w.r.t. II-B2+B1) 3.70-10.02<br>(w.r.t. II-B1) 1.25-12.90 |
| SEAM-II-Bob | 0.13-8.55 |
| PARTING | 1.29-16.87 |
| SEAM-II-Boa | 0.12-2.43 |

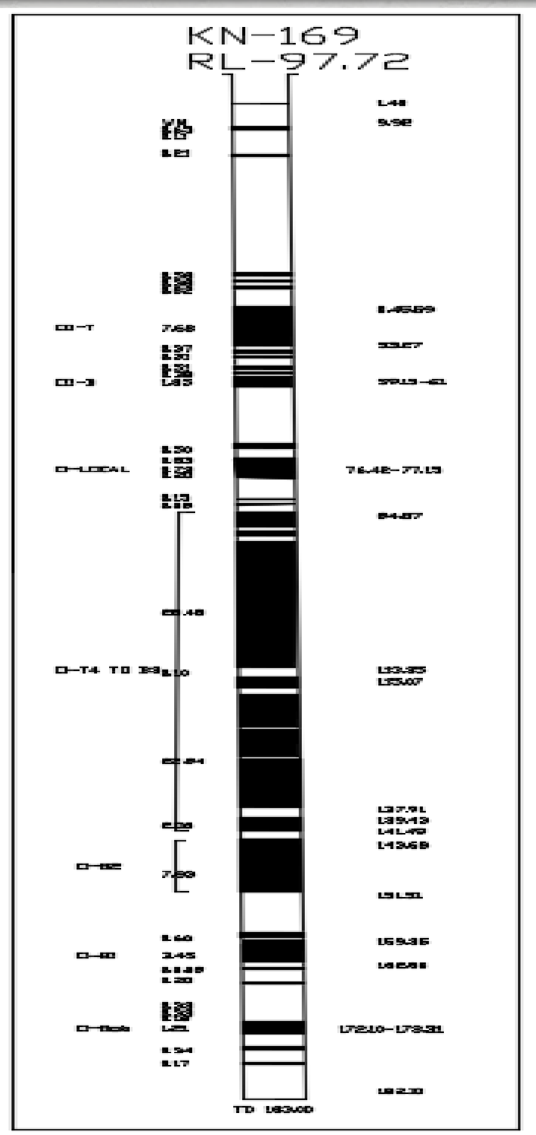
## PHYSICO-MECHANICAL PROPERTY OF BH NO. KN-169 IN KANIHA OCP

**Annexure IIIA**

| DEPTH | | DEPTH OF SAMPLE | | COMPRESSIVE STRENGTH Kg/sq.cm | TENSILE STRENGTH Kg/sq.cm | SHEAR STRENGT H Kg/sq.cm | DENSITY gm/cc | LITHOLOGY |
|---|---|---|---|---|---|---|---|---|
| FROM | TO | FROM | TO | | | | | |
| 0.00 | 10.00 | N/A | N/A | N/A | N/A | N/A | | |
| 10.00 | 17.59 | 12.20 | 12.67 | 357.55 | 13.55 | 26.98 | 2.45 | SHALE WITH COAL LAMI-NAE |
| | | 12.67 | 12.90 | 213.37 | 32.07 | 22.59 | 2.46 | |
| | | 13.85 | 14.15 | 259.51 | 13.55 | 13.83 | 2.53 | |
| | | 16.60 | 16.95 | 250.86 | 31.62 | 24.44 | 2.40 | |
| | | 17.35 | 17.59 | 288.35 | 12.42 | N/A | 2.44 | |
| 17.59 | 32.00 | 19.00 | 19.30 | 225.83 | 13.00 | 7.15 | 2.19 | SHALE |
| | | 21.15 | 21.55 | 343.88 | 15.18 | 14.99 | 2.11 | |
| | | 24.40 | 25.40 | 265.28 | 15.81 | 13.14 | 2.22 | |
| | | 27.65 | 28.10 | 282.58 | 13.55 | 20.06 | 2.18 | |
| 32.00 | 44.56 | 33.85 | 34.15 | 213.37 | 14.78 | 13.83 | 2.19 | SANDSTONE |
| | | 39.30 | 39.62 | 132.64 | 14.78 | 17.75 | 2.09 | |
| | | 40.15 | 40.45 | 198.07 | 17.25 | 25.13 | 2.32 | |
| | | 41.90 | 42.17 | 190.31 | 10.16 | 26.51 | 1.94 | |
| | | 42.70 | 42.97 | 236.44 | 16.51 | 23.52 | 2.11 | |
| 44.56 | 55.41 | 45.60 | 46.00 | 178.77 | 14.68 | 9.22 | 1.46 | COAL |
| | | 49.00 | 49.35 | 115.34 | 12.42 | 6.46 | 0.17 | |
| | | 51.35 | 51.70 | 305.65 | 21.46 | 10.38 | 1.83 | |
| | | 52.85 | 53.15 | 115.34 | 9.38 | 10.07 | 1.48 | |
| | | 53.35 | 53.67 | 219.14 | 18.86 | 7.38 | N/A | |

| DEPTH | | DEPTH OF SAMPLE | | COMPRESSIVE STRENGTH Kg/sq.cm | TENSILE STRENGTH Kg/sq.cm | SHEAR STRENGTH Kg/sq.cm | DENSITY gm/cc | LITHOLOGY |
|---|---|---|---|---|---|---|---|---|
| FROM | TO | FROM | TO | | | | | |
| 55.41 | 59.15 | 55.41 | 55.63 | 338.75 | 25.97 | N/A | 2.31 | SHALE |
| | | 56.15 | 56.40 | 297.69 | 6.79 | N/A | 2.42 | |
| | | 56.95 | 57.20 | 292.56 | 12.82 | N/A | 1.79 | |
| | | 57.85 | 58.15 | 18.99 | 28.23 | 1.84 | N/A | |
| | | 58.35 | 58.60 | 149.94 | 13.55 | 9.22 | 1.47 | |
| 59.15 | 61.00 | 59.85 | 60.25 | N/A | 38.14 | N/A | N/A | COAL |
| | | 60.20 | 60.48 | N/A | 12.05 | N/A | N/A | |
| 61.00 | 84.87 | 62.15 | 62.72 | 1384.08 | 72.27 | 152.74 | 2.56 | CSH-WITH SHALE |
| | | 63.30 | 63.47 | 1384.08 | 110.67 | 216.15 | 2.76 | |
| | | 73.50 | 73.85 | 830.44 | 101.26 | 106.75 | 2.94 | |
| | | 78.80 | 79.20 | 276.81 | 44.35 | 36.89 | 2.36 | |
| | | 80.20 | 80.70 | 369.08 | 60.66 | 40.35 | 0.25 | |
| 84.87 | 113.35 | 95.15 | 95.45 | 132.64 | 24.09 | 5.30 | 1.25 | COAL |
| | | 97.25 | 97.60 | 220.70 | 31.72 | 2.31 | 1.28 | |
| | | 110.2 | 110.50 | 287.42 | 55.44 | 8.07 | 1.68 | |
| | | 110.95 | 111.25 | 455.59 | 31.29 | 2.08 | 1.60 | |
| | | 112.85 | 113.35 | 161.47 | 5.02 | 1.84 | 1.32 | |
| 113.35 | 115.07 | 113.35 | 113.65 | 251.49 | 3.39 | 5.07 | 1.66 | SHALE |
| | | 113.65 | 114.00 | 225.83 | 22.59 | 10.38 | 0.89 | |
| | | 114.00 | 114.50 | 195.04 | 17.42 | 1.61 | 1.32 | |
| | | 114.5 | 115.00 | 181.77 | 3.39 | 3.23 | 1.52 | |
| 115.07 | 137.91 | 115.07 | 115.47 | N/A | 46.30 | 12.68 | 2.21 | COAL |
| | | 119.15 | 119.55 | 143.71 | 12.05 | 5.99 | 1.36 | |
| | | 134.45 | 134.85 | 259.51 | 14.14 | 2.01 | 1.87 | |
| | | 136.85 | 137.45 | 200.17 | 14.68 | 9.22 | 1.97 | |
| | | 137.50 | 137.90 | 190.31 | 5.65 | 2.31 | 1.70 | |
| 137.91 | 139.43 | 137.91 | 138.41 | 294.11 | 6.25 | 3.69 | 1.80 | SHALE |
| | | 138.80 | 139.25 | 205.30 | 9.76 | 1.73 | 1.43 | |
| 139.43 | 151.51 | 140.45 | 140.90 | 219.14 | 28.23 | 19.02 | 2.53 | COAL WITH SH PARTING |
| | | 142.70 | 143.15 | 351.78 | 25.00 | 32.97 | 2.28 | |
| | | 143.25 | 143.60 | 312.37 | 36.40 | 23.98 | 2.35 | |
| | | 147.15 | 147.45 | N/A | N/A | N/A | N/A | |
| | | 149.00 | 149.35 | N/A | N/A | N/A | N/A | |
| 151.51 | 159.35 | 153.70 | 154.05 | 519.03 | 35.36 | 1.73 | 2.14 | SHALE |
| | | 154.65 | 155.05 | 173.01 | 14.14 | 43.80 | 2.41 | |
| | | 155.20 | 155.60 | 144.17 | 10.60 | 10.38 | 2.07 | |
| | | 156.65 | 157.07 | 144.05 | 44.35 | 10.38 | 2.56 | |
| | | 157.30 | 157.75 | 271.04 | 32.03 | 26.98 | 2.32 | |

| DEPTH | | DEPTH OF SAMPLE | | COMPRESSIVE STRENGTH Kg/sq.cm | TENSILE STRENGTH Kg/sq.cm | SHEAR STRENGTH Kg/sq.cm | DENSITY gm/cc | LITHOLOGY |
|---|---|---|---|---|---|---|---|---|
| FROM | TO | FROM | TO | | | | | |
| 159.35 | 162.80 | 159.35 | 159.61 | 167.24 | 7.23 | 2.30 | 1.05 | COAL |
| | | 162.25 | 162.60 | 230.68 | 10.84 | 2.05 | 1.26 | |
| 162.80 | 181.60 | 164.10 | 164.50 | 299.88 | 36.14 | 61.56 | N/A | SST WITH SHALE AND CSH |
| | | 165.30 | 165.70 | N/A | 30.80 | 23.82 | 2.31 | |
| | | 176.05 | 176.40 | 530.56 | 57.86 | 45.53 | 2.45 | |
| | | 177.80 | 178.10 | 121.10 | 9.43 | 35.04 | 2.29 | |
| | | 178.50 | 178.85 | 173.01 | 44.78 | 22.45 | 2.47 | |
| 181.60 | 183.00 | 181.70 | 182.00 | 173.01 | 14.14 | 14.99 | 2.01 | BOULDER |
| | | 182.10 | 182.40 | 80.73 | 3.54 | 16.14 | 2.39 | |
| | | 182.40 | 182.70 | 133.44 | 10.84 | 8.07 | 2.26 | |
| | | 182.70 | 183.00 | 196.07 | 32.52 | 24.67 | 2.48 | |



## Hingula opencast project

The Recast PR for Hingula-II Expn. OCP (Phase-II) was approved for a rated capacity of 15 Mt/annum with a mineable reserve base (as on 1.4.2009) of 513.92Mt at an average stripping ratio of 1.95cum/t. Seam X to Seam IID in multiple sections/ splits is proposed to be mined in the projectised area.

The mine is proposed to be developed in 2 stages: I & II. Stage-I has 2 quarries: West & East and Stage-II has only one quarry: South Quarry. Stage-I: Working will start in West Quarry and achieve the rated capacity of 15Mty and advance northerly. In 14th year coal production from East quarry will start and advance northerly. Stage-II: After 24th year South quarry will be opened and mine will continue to produce 15Mty upto 34th year.

The stratigraphic sequence of the project is appended as Annexure IIB.

The details of the Physio-mechanical properties (in Borehole No DMTU 146) is appended as Annexure IIIB.

In 2020-21, the mine had produced 6.35 Mt of coal (Dept: 4.73 Mt, Hired: 1.62 Mt) and removed 9.67 Mcum of OB (Dept: 0.55 Mcum, Hired: 9.12 Mcum).

## STRATEGRAPHIC SEAM SEQUENCE & PARTINGS IN HINGULA OCP

**Annexure IIB**

| Seams/Parting | Thickness Range |
|---|---|
| SOIL | 0-16.70 |
| WM | 0-30.81 |
| PARTING ABOVE SEAM-X | 0.75-0.80 |
| SEAM-X | 4.86-5.39 |
| PARTING | 1.40-9.18 |
| SEAM-IX | 18.09-31.55 |
| PARTING | 0.50-8.65 |
| SEAM-VIII | 0.96-13.28 |
| PARTING | 3.00-24.48 |
| SEAM-VII-B | 0.02-2.33 |
| PARTING | 4.28-23.50 |
| SEAM-VIII-A | 0.05-2.69 |
| PARTING | 0.30-23.32 |
| SEAM-L-II | 0.08-5.52 |
| PARTING | 1.10-19.67 |
| SEAM-L-I | 0.04-3.70 |
| PARTING | 0.37-16.35 |
| SEAM-VI-B | 015-9.21 |
| PARTING | 1.61-13.70 |
| SEAM-V-B | 0.10-7.17 |
| PARTING | 0.14-11.54 |
| SEAM-V-A | 0.22-5.73 |
| PARTING | 1.15-10.85 |
| SEAM-IV-B | 0.22-9.15 |
| PARTING | 1.32-21.35 |
| SEAM-III-E | 0.45-10.70 |
| PARTING | 1.39-17.26 |
| SEAM-III-D | 0.31-8.60 |
| PARTING | 0.22-21.67 |
| SEAM-III-AC. | 0.16-9.71 |
| PARTING | 5.86-23.42 |
| SEAM-II-E | 0.20-11.43 |
| PARTING | 0.16-26.64 |
| SEAM-II-D | 0.06-9.66 |

## PHYSICO-MECHANICAL PROPERTY OF BH NO. DMTU-146 IN HINGULA OCP

**Annexure IIIB**

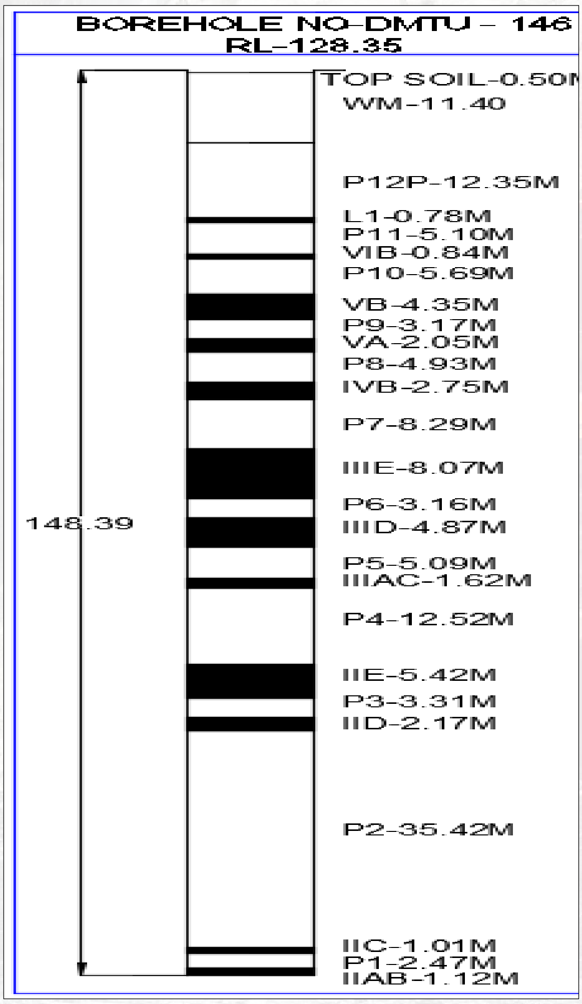
| Zone No. | Depth (metre) From | Depth (metre) To | Compressive Strength Kg/cm$^2$ | Tensile Strength Kg/cm$^2$ | Shear Strength Kg/cm$^2$ | Density gm/c.c | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 0.50 | 14.70 | x | x | x | x | x |
| | | | Test could not be conducted due to non-availability of samples | | | | |
| 2 | 14.70 | 22.55 | 518.84 | 8.11 | 9.88 | 2.58 | Shale and shaly coal |
| | | | 610.75 | 5.55 | 12.56 | 2.35 | |
| | | | 174.50 | 7.52 | 25.12 | 2.12 | |
| | | | 383.43 | 5.58 | 18.61 | 2.30 | |
| | | | 349.00 | 7.77 | 27.68 | 2.35 | |
| | | | 407.03 | 6.94 | 18.77 | 2.34 | |
| | Average Standard Deviation | | 149.60 | 1.07 | 6.88 | 0.14 | |
| 3 | 22.55 | 30.13 | 231.91 | 3.11 | 6.90 | 1.09 | Grey shale and shaly coal |
| | | | 91.49 | 1.10 | 8.84 | 1.11 | |
| | | | 274.99 | 2.61 | | 1.25 | |
| | | | 53.83 | 2.29 | | 1.24 | |
| | | | | | | 1.29 | |
| | | | 163.05 | 2.27 | 7.87 | 1.19 | |
| | Average Standard Deviation | | 92.63 | 0.73 | 0.97 | 0.08 | |
| 4 | 30.13 | 32.94 | 280.89 | 6.66 | 7.63 | 1.66 | Coal and shaly coal |
| | | | 207.06 | 7.31 | 4.83 | 1.78 | |
| | | | 217.00 | 2.19 | 4.65 | 1.96 | |
| | | | | 1.51 | 7.53 | 1.76 | |
| | | | | 2.15 | 7.91 | 1.84 | |
| | | | 237.98 | 3.96 | 6.51 | 1.80 | |
| | Average Standard Deviation | | 36.90 | 2.48 | 1.45 | 0.09 | |
| 5 | 32.94 | 37.09 | 192.98 | 12.15 | 4.46 | 1.43 | Grey shale and Carbona-ceous shale |
| | | | 169.80 | 9.87 | 4.65 | 2.05 | |
| | | | | 4.00 | 7.25 | 1.42 | |
| | | | | 10.46 | 4.65 | 1.46 | |
| | | | | | 1.39 | 1.94 | |
| | | | 181.39 | 9.12 | 4.48 | 1.66 | |
| | Average Standard Deviation | | 11.59 | 3.07 | 1.85 | 0.27 | |

| Zone No. | Depth (metre) From | Depth (metre) To | Compressive Strength $Kg/cm^2$ | Tensile Strength $Kg/cm^2$ | Shear Strength $Kg/cm^2$ | Density gm/c.c | Remarks |
|---|---|---|---|---|---|---|---|
| 6 | 37.09 | 41.01 | 209.39 | 3.44 | 8.84 | 1.13 | Coal and shaly coal |
| | | | 124.24 | 5.97 | 4.00 | 1.27 | |
| | | | 107.67 | 4.41 | 2.79 | 1.33 | |
| | | | | 1.95 | 4.46 | 1.28 | |
| | | | | | 5.58 | 1.21 | |
| | | | 147.10 | 3.94 | 5.13 | 1.24 | |
| | Average Standard Deviation | | 44.56 | 1.46 | 2.05 | 0.06 | |
| 7 | 41.01 | 42.83 | 53.84 | 6.13 | 6.97 | 1.53 | Grey shale |
| | | | 107.67 | 13.62 | 14.89 | 1.94 | |
| | | | 83.65 | 4.54 | 17.40 | 2.07 | |
| | | | | 4.80 | 7.44 | 2.15 | |
| | | | 81.72 | 6.39 | 10.45 | 1.94 | |
| | Average Standard Deviation | | 22.01 | 3.75 | 4.75 | 0.21 | |
| 8 | 42.83 | 46.23 | 231.08 | 5.75 | 3.90 | 1.18 | Shaly coal and coal |
| | | | 198.78 | 16.77 | 8.84 | 1.33 | |
| | | | 211.20 | 10.04 | 9.86 | 1.18 | |
| | | | 194.64 | 4.75 | 18.98 | 1.06 | |
| | | | 204.37 | | 10.42 | 1.36 | |
| | | | 208.01 | 9.32 | 10.40 | 1.22 | |
| | Average Standard Deviation | | 12.80 | 4.73 | 4.87 | 0.11 | |
| 9 | 46.23 | 49.74 | 74.70 | 21.63 | 5.58 | 2.10 | Grey shale and sandstone |
| | | | 210.19 | 26.45 | 7.63 | 2.10 | |
| | | | | 17.96 | 7.91 | 2.19 | |
| | | | | 15.92 | 10.23 | 1.96 | |
| | | | | 22.02 | 13.95 | 2.14 | |
| | | | | 20.82 | 9.06 | 2.10 | |
| | Average Standard Deviation | | | 4.06 | 3.19 | 0.08 | |
| 10 | 49.74 | 55.14 | 277.30 | 18.25 | 8.37 | 1.84 | Grey shale and Carb. Shale |
| | | | 190.38 | 23.12 | 13.58 | 1.43 | |
| | | | 244.18 | 20.65 | 5.77 | 1.55 | |
| | | | | 21.65 | 4.19 | 1.80 | |
| | | | | 16.40 | | 1.61 | |
| | | | 237.29 | 20.01 | 7.98 | 1.65 | |
| | Average Standard Deviation | | 43.87 | 2.69 | 4.11 | 0.17 | |

| Zone No. | Depth (metre) From | Depth (metre) To | Compressive Strength Kg/cm$^2$ | Tensile Strength Kg/cm$^2$ | Shear Strength Kg/cm$^2$ | Density gm/c.c | Remarks |
|---|---|---|---|---|---|---|---|
| 11 | 55.14 | 56.45 | 161.41 | 15.59 | 9.30 | 1.13 | Coal seam + Carb shale |
| | | | 140.72 | 13.44 | 5.30 | 1.04 | |
| | | | 100.16 | 12.78 | 6.70 | 1.31 | |
| | | | 165.55 | 28.27 | 4.42 | 1.46 | |
| | | | | 23.54 | 3.49 | 1.20 | |
| | | | 141.96 | 18.72 | 5.84 | 1.23 | |
| | Average Standard Deviation | | 29.91 | 6.84 | 2.27 | 0.16 | |
| 12 | 56.45 | 62.00 | 138.62 | 18.76 | 4.65 | 1.90 | Sandstone |
| | | | 152.34 | 12.27 | 13.95 | 1.90 | |
| | | | 111.75 | 12.04 | 5.58 | 1.71 | |
| | | | 206.93 | 20.52 | 5.12 | 1.68 | |
| | | | 115.89 | | | 1.87 | |
| | | | 145.11 | 15.90 | 7.33 | 1.77 | |
| | Average Standard Deviation | | 38.85 | 4.38 | 4.43 | 0.10 | |
| 13 | 62.00 | 63.96 | 336.89 | 32.84 | 7.91 | 1.83 | Carb shale and coal |
| | | | 339.37 | 24.84 | 18.42 | 2.32 | |
| | | | 342.69 | 22.26 | 13.02 | 1.78 | |
| | | | 277.88 | 27.96 | 18.88 | 2.41 | |
| | | | 230.11 | 20.53 | 9.30 | 2.34 | |
| | | | 305.39 | 25.69 | 13.51 | 2.14 | |
| | Average Standard Deviation | | 49.91 | 4.88 | 5.06 | 0.30 | |
| 14 | 63.96 | 65.36 | 107.42 | 19.20 | 6.70 | 2.48 | Grey shale and carb. Shale |
| | | | 76.47 | 5.88 | 7.44 | 2.15 | |
| | | | 24.83 | 4.88 | 3.81 | 2.12 | |
| | | | 36.84 | 7.22 | 4.74 | 2.08 | |
| | | | | 6.39 | | 2.93 | |
| | | | 61.39 | | 5.67 | 2.35 | |
| | Average Standard Deviation | | 37.80 | | 1.69 | 0.36 | |
| 15 | 65.36 | 70.27 | 163.22 | 16.71 | 9.16 | 1.18 | Coal seam and shale |
| | | | 169.92 | 20.75 | 27.99 | 1.10 | |
| | | | 271.45 | 11.77 | 15.93 | 1.08 | |
| | | | 170.51 | 11.93 | 14.60 | 1.21 | |
| | | | | 18.35 | 12.37 | 1.16 | |
| | | | 193.78 | 15.90 | 16.73 | 1.15 | |
| | Average Standard Deviation | | 51.89 | 3.97 | 7.33 | 0.05 | |

| Zone No. | Depth (metre) | | Compressive Strength Kg/cm$^2$ | Tensile Strength Kg/cm$^2$ | Shear Strength Kg/cm$^2$ | Density gm/c.c | Remarks |
|---|---|---|---|---|---|---|---|
| | From | To | | | | | |
| 16 | 70.27 | 73.43 | 163.22 | 2.94 | 9.16 | 2.20 | Sandstone and shale |
| | | | 169.92 | 22.75 | 27.99 | 2.05 | |
| | | | 271.45 | 34.89 | 19.53 | 2.10 | |
| | | | 170.51 | 33.46 | 14.60 | 2.20 | |
| | | | | 20.09 | 12.37 | 2.26 | |
| | | | 193.78 | 26.83 | 16.73 | 2.16 | |
| | Average Standard Deviation | | 51.89 | 6.82 | 7.33 | 0.03 | |
| 17 | 73.43 | 78.94 | 264.25 | 19.87 | 20.47 | 1.35 | Coal seam with shale |
| | | | 306.40 | 25.75 | 17.40 | 1.23 | |
| | | | 339.52 | 13.54 | 13.58 | 1.14 | |
| | | | 382.58 | 13.54 | 13.58 | 1.14 | |
| | | | 267.06 | 18.44 | 13.17 | 1.33 | |
| | | | 311.96 | 18.12 | 15.65 | 1.24 | |
| | Average Standard Deviation | | 44.88 | 4.64 | 2.86 | 0.09 | |
| 18 | 78.94 | 81.70 | 294.80 | 39.12 | 20.00 | 2.11 | Sandstone |
| | | | 147.40 | 35.29 | 25.59 | 2.27 | |
| | | | 308.88 | 2.50 | 20.00 | 2.03 | |
| | | | 370.99 | 27.05 | 24.19 | 2.35 | |
| | | | 277.41 | | 16.75 | 2.14 | |
| | | | 279.90 | 30.99 | 21.31 | 2.18 | |
| | Average Standard Deviation | | 73.38 | 6.56 | 3.19 | 0.11 | |
| 19 | 81.70 | 85.01 | 99.37 | 17.49 | 8.84 | 1.13 | Shaly coal and Grey shale |
| | | | 122.56 | 20.55 | 4.65 | 1.26 | |
| | | | 180.53 | 15.00 | 6.05 | 1.24 | |
| | | | 144.92 | 9.53 | 4.84 | 1.12 | |
| | | | | 7.12 | 4.65 | 1.24 | |
| | | | 1436.85 | 13.94 | 5.81 | 1.20 | |
| | Average Standard Deviation | | 29.92 | 4.97 | 1.60 | 0.06 | |
| 20 | 85.01 | 97.55 | 65.50 | 7.28 | 6.04 | 2.11 | Sandstone |
| | | | 153.52 | 10.61 | 7.49 | 2.00 | |
| | | | 62.81 | 6.03 | 6.51 | 2.33 | |
| | | | 44.20 | 4.92 | 9.30 | 2.03 | |
| | | | 63.74 | 4.59 | 8.84 | 2.18 | |
| | | | 77.97 | 6.69 | 7.63 | 2.12 | |
| | Average Standard Deviation | | 38.56 | 2.18 | 1.27 | 0.07 | |

| Zone No. | Depth (metre) | | Compressive Strength Kg/cm$^2$ | Tensile Strength Kg/cm$^2$ | Shear Strength Kg/cm$^2$ | Density gm/c.c | Remarks |
|---|---|---|---|---|---|---|---|
| | From | To | | | | | |
| 21 | 97.55 | 108.43 | 322.96 | 18.30 | 14.14 | 1.13 | Coal seam and shale |
| | | | 357.73 | 23.68 | 15.35 | 1.23 | |
| | | | 190.46 | 16.35 | 13.49 | 1.38 | |
| | | | 287.35 | 26.36 | 12.56 | 1.16 | |
| | | | 314.68 | 16.78 | 12.56 | 1.00 | |
| | | | 294.64 | 20.29 | 13.62 | 1.24 | |
| | Average Standard Deviation | | 56.73 | 4.00 | 1.05 | 0.09 | |
| 22 | 108.43 | 118.10 | 88.39 | 7.44 | 15.35 | 2.18 | Sandstone |
| | | | 100.02 | 8.13 | 11.35 | 2.08 | |
| | | | 165.50 | 6.47 | 15.82 | 1.65 | |
| | | | 119.10 | 7.30 | 16.28 | 2.02 | |
| | | | 70.25 | 5.43 | 13.96 | 2.33 | |
| | | | 107.65 | 6.95 | 14.61 | 2.05 | |
| | Average Standard Deviation | | 30.83 | 0.93 | 1.68 | 0.23 | |



## Field operations

### Vibro-ripper

The ripper model which is being deployed in Hingula and Kaniha Mine is MAX BRIO BR 55 (M/S Daedong Engineering Co Ltd., South Korea). It is attached to a 3.2 cum capacity, diesel operated hydraulic shovel (Model: Volvo EC 480 DL).

The ripper runs for an hour before standard stoppage for 30 min needed for necessary cool down. During the working hour, the ripper digs an average 1 meter in depth. Two or three such rippers are deployed in tandem in an available patch of width of around 20-30 m and length 150 m on the designated OB patch. the rippers start from one end of the patch and start breaking rock/OB in front of it while moving forward on the broken material. After working for about 25 m along the length of OB patch, the broken rock/OB is available for loading and transport.

Thereafter, the crushed/broken/ripped OB is loaded through 3.2 cum Hyd. Backhoe into the Tipper (Volvo 460 FMX, capacity: 20.3 m3) and transported to the designated dumping place.


## Drilling and blasting

The drilling operation under study was being executed through a drill machine fabricated by M/S Velson Groundhog on an excavator base of Kobelco make (Model: 220) and Atlas Copco (Model XRH 1100 Plus) compressor. Two nos of such drill machines were being used. Drilling pattern is 4m x 4m and depth is 5-6 m. The drill machine is sent to the designated site in the field marked for blasting on next day. The drilling operations starts at around 3 pm and continues till all the holes of the demarcated area are drilled. The drilling is executed in two shifts.

After completion of drilling, the drilling machine is brought to a safe place for charging and blasting operation.

Site Mix Emulsion (SME) explosive, cast boosters of 100 gm, Down to hole (DTH) & Trunk Line Delay (TLD) and electric detonators are used for blasting.

The operational, performance and cost data was collected for the contractual drilling and blasting operations being carried out.

## Techno-economic analysis

The operational inputs along with performance and cost data was collected during the field visit for techno-economic analysis of Vibro-ripper technology vis-vis drilling and blasting technology being executed through outsourcing contracts in Hingula and Kaniha opencast projects of MCL.

## IV VIBRO-RIPPER

### PRODUCTION AND PRODUCTIVITY

| | |
|---|---|
| OPERATING HOURS/DAY | 14 HRS (IN 3 SHIFT OPERATION) |
| HOURLY PRODUCTIVITY | 210 CUM/HOUR (AS PER CURRENT DEPLOYMENT) |
| NO OF DAYS/ANNUM | 330 DAYS (4620 HOURS OF OPERATION/ANNUM) |
| ANNUAL PRODUCTIVITY | 0.97 MCUM |

### MANPOWER REQUIREMENT /MACHINE

| | |
|---|---|
| OPERATORS | 3 |
| HELPERS | 4 |
| FITTER | 1 |
| OTHERS (SUPERVISION, SUPPORT ETC) | 0.2 |
| | |
| TOTAL | 8.2 |

### CAPITAL & CONSUMABLE CONSUMPTION DATA

| SL.NO | EQUIPMENT | NOS | LIFE |
|---|---|---|---|
| A | VIBRO-RIPPER | | |
| A.1 | VOLVO EC 480DL 3.2 CUM (HS UNIT) | 1 | 5 YEARS |
| A.2 | MAX BRIO BR 55 | 1 | 5 YEARS |
| B | CONSUMABLES | | |
| B.1 | RIPPER TOOTH | 1 | 100 HRS IN SHALE |
| B.2 | PAD | 9 | 700 HRS |
| B.3 | ROCK BOLT | 26 | 450 HRS |
| B.4 | GEAR OIL | 4 | 100 HRS |
| B.5 | GREASE/MONTH (LITRES) | 15 | 450HRS |
| B.6 | DIESEL (L/HR) | 55 | PER HOUR |

## DRILLING AND BLASTING

### PRODUCTION AND PRODUCTIVITY

| Parameter | |
|---|---|
| Operating Hours/Day | 7.5 Hrs. of drilling (2 shift operation) |
| Hourly Productivity | 140m/hour (As per current deployment) |
| No. of Days/annum | 330 days (2475 hours/ annum) |
| Annual Productivity | 3.46 Lakh m/annum (drilling on a 4m x 4m pattern) |
| Annual Blasted Output | 5.54 MCum |
| Powder Factor | 2.26 Cum/Kg |

## MANPOWER REQUIREMENT /MACHINE

| | |
|---|---|
| OPERATORS | 2 |
| HELPERS | 2 |
| FITTER | 1 |
| OTHERS (SUPERVISION, SUPPORT ETC) | 1 |
| BLASTING PERSONNELS (SUPERVISION, OVERMAN, MAZDOORS, MAGAZINE, DRIVER, SECURITY) | 6 |
| **TOTAL** | **12** |

## CAPITAL AND CONSUMABLE -CONSUMPTION DATA

| SL.NO | EQUIPMENT | NOS | LIFE |
|---|---|---|---|
| A | DRILL MACHINE | | |
| A.1 | KOBELCO 220 EXCAVATOR ATLAS COPCO COMPRESSOR XRH1100 FABRICATED BY VELSON GROUND HOG | 1 | 7 YEARS |

| B | CONSUMABLES | | |
|---|---|---|---|
| B.1 | DRILL BIT | 1 | 3000 M |
| B.2 | EXPLOSIVE COST – SME | | |
| | EXPLOSIVE COST – CAST BOOSTER | | |
| B.3 | DIESEL (L/HR) | 55 | PER HOUR |

## V FINDINGS AND CONCLUSION

1. Vibro Ripper technology for extraction of OB is expensive in comparison to conventional Drilling & Blasting. (In this case study, both the methods being executed in outsourcing mode)

2. Vibro-ripper can achieve a reasonable production (around 1 Mcum /machine) in semi-fractured formations with 15-30 MPa compressive strength, from places where drilling & blasting is not permitted/desired for environmental, safety or other reasons.

3. Productivity of Vibro-rippers could be adversely affected in harder unfractured rock formations.

4. Vibro-rippers could find applicability in removing inseam bands and thin parting upto 2-3 m thickness, where blasthole drilling may not be very efficient due to design constraints

5. May not be suitable when large production rates are desired as the machine rips about 1m of thickness in one layered cut. Loading 1m of ripped material may affect the productivity, if large size excavators are deployed for loading.

# Delineation the Extents of Intrusive Dyke using Magnetic Survey in Jamuna Opencast Mine, Jamuna-Kotma Area SECL, Madhya Pradesh.

*Dr. Sayan Ghosh[2], Bikas Kumar[2], Debjeet Mondal[1] Amit Joshi[2] and Ayush[2]*

## ABSTRACT

*This study is focussed on delineation and pinpoint the location and extents of an intrusive dyke passing through the mine boundary of Jamuna OCM, Jamuna-Kotma (J&K) area, SECL in Sohagpur coalfield of Central India. The encounter of dyke with its uncertain extents from the eastern side of the mine boundary was a challenge for the mine authorities of Jaumna OCM towards advancement of their working bench. The direct method through drilling inside the working area would have been challenging and time consuming for the production of the said mine. CMPDI RI-V, Bilaspur proposed to execute magnetic survey inside the mine area with a window of least HEMM working in the patch during the duration of the data acquisition and acquired 8 numbers of profile lines all along N-S direction which is the typical dipping direction the entire Sohagpur coalfield. After acquisition of all the 8 profile lines and processing and interpretation of the acquired data in relevant software, the trend along with the exact location of the extents of the dyke could be understood and explained inexplicably. The positive magnetic anomalies exhibited a clear indication of the dyke trending E-W and was thereafter projected on the mine plan with lateral extents varying from 20m to 30m as delivered in this study. The mine plan with the location, extents and orientation of the magnetic intrusive body was submitted to SECL for further planning the mine development operations in Jamuna OCM resolving their issue to much extent.*

***Keywords—***

Intrusive body,
Magnetic susceptibility,
Magnetic Anomaly,
Opencast Mining.

*[1]CMPDI (HQ) Ranchi,*
*[2]CMPDI RI-V, Bilaspur*

## 1. INTRODUCTION

Magnetic susceptibility is the inheriting of magnetic property of a material in the natural environment mainly tell us about Fe-bearing minerals that are found in soils, bricks, rocks, dust and sediments (Thomson and Oldfield, 1986). Magnetic susceptibility is a function of the concentration and mineralogy of the ferromagnetic (magnetite, Fe-sulphides) minerals present, but can also depend on the strength of the applied magnetic field and the particle size distribution of the magnetic grains. As per proposal initiated by SECL, magnetic survey was carried out in Jamuna OCM, Sohagpur CF, Madhya Pradesh to prove the presence of dykes its extension and its lateral thickness so as to support the production from Eastern side of Jamuna OCM. The colliery is situated Jamuna Kotma area SECL in Shahdol district of Madhya Pradesh and to the north of Anuppur-Chirimiri line of S.E.Rly. The opencast zones lie in the geological block IV which is in between latitides 230-07' North and 230-13' N and longitudes 810- 52' E and 810-56' E (Topo Sheet No. 64E/16). Harrad railway station on Anuppur-Chirimiri line, 894 kms away from Howrah, is almost in the centre of block IV. The reduced level at Harrad station is 505.58m. Kotma railway station is 9 kms away from Harrad towards Chirimiri. The existing opencast project is connected to Kotma railway station through Jamuna underground project which is connected with other coal mines in the coalfield. As per the proposal received from SECL Jamuna area, magnetic survey was carried out in Jamuna OCM, Sohagpur coalfield, Madhya Pradesh to prove the existence of dyke in the eastern portion of the block. This magnetic survey was taken up for providing the production support in terms of initiating/opening a closed portion of mine. The data were acquired by the geophysical team posted in the CMPDI RI-V Bilaspur, and interpreted to obtain the results. Thus to prove the trend, nature, inclination thickness and extension of dyke in Jamuna OCM, magnetic survey was undertaken to support the production from recently closed mine due to unknown nature of dyke. The magnetic survey was carried out with 8 nos. of profile lines. The total area was covered by 8 profile lines covering a linear extent of 2.38 line km.

## 2. GEOLOGY OF THE STUDY AREA

The geological stratigraphy of Jamuna OCM typically follows the geological succession of Sohagpur coalfield and is mainly deciphered by the several rock exposures in the block. The most important structural feature is the prominent zone of ENE-WSW fault trending dislocation-designated as Bamni-Chilpi fault. This, in fact, appears to be a set of faults having a variable net downthrown towards north. The structural interpretation worked out on the basis of surface, sub-surface and mine data shows that the broad configuration of the coal beds and associated data are of shallow dome flexure. The area has been dissected by a set of faults which can be broadly grouped as N-S to NE-SW trending faults and E-W trending faults. The major coal seams of the area belonged to the Barakar and the Supra-Barakar formation of Lower Permian and Upper Triassic Age of the Gondwana Supergroup.

The satellite imagery of the magnetic lines locations over Jamuna OCM, Sohagpur coalfield is shown in Figure 2.1.

A generalized stratigraphic succession of the Sohagpur Coalfield and geological formation are shown in Table 2.1 which is considered from a borehole data in nearby block.

**Figure 2.1**

| Formation | Thickness Range (m) | |
|---|---|---|
| | **Minimum** | **Maximum** |
| Weathered Mantle | 3.00 (CMJBH-032) | 20.30 (CMJBH-130) |
| Barren Measures/Supra Barakar | 135.92 (CMJBH-108) | 342.72 (CMJBH-171) |
| Barakar | 143.87 (SBJ-039) | 327.06 (SBJ-031) |
| Talchir | 26.31 (SBJ-037) | 98.70 (SBJ-036) |

**Table 2.1: Geological formation intersecting the Behraband North Extension**

## 3. MAGNETIC SURVEY IN THE STUDY AREA

The Magnetic Survey is one of the most important geophysical tools for delineating the lithology and sub-surface structures. The magnetic survey involves measuring variations of the earth's magnetic field and using the results to study localized geological structures (Hinze et al 2013). Delineating trends and subsurface structures are the main objective of this study, magnetic survey data were subjected to a quantitative and qualitative interpretation involved in some geophysical processing techniques. Magnetic anomaly interpretations were used in extensive of applications in geophysics, including prospecting purposes (Abedi et al., 2013).

Magnetic survey was carried out in eastern part of the block in 8 profile lines were laid. All these profile lines were laid in N-S direction. All the profile lines were tried to extend up to the block boundary but due to the limitations in terms of inaccessibility of area it laid up to its maximum extent to find out the presence of dyke and its extension. The location of the profile lines is shown in Figure 2.1 and the profiles on mine plan is shown in Figure 3.4.9 whereas respective lengths of profile line are shown in Table 3.1.

| Sl No. | Profile No. | Linear extent of Profile line (m) |
|---|---|---|
| 1 | P-1 | 400 |
| 2 | P-2 | 400 |
| 3 | P-3 | 470 |
| 4 | P-3A | 140 |
| 5 | P-4 | 190 |
| 6 | P-5 | 180 |
| 7 | P-6 | 240 |
| 8 | P-7 | 360 |

Table 3.1: Length of Profile Lines in Jamuna OCM, Sohagpur Coalfields

## 3.1 INSTRUMENT MAGNETOMETER USED

The GEM Systems (Canadian based) GSMP-35 (k-mag) used by Modern Mag is 4 times more sensitive than the Geometrics G858/9 and 10 times more sensitive than the GEM GSM19 Overhauser magnetometer. The k-mag also has a higher gradient tolerance than other magnetometers and is ideal for highly magnetic environments such as iron ore exploration. The k-mag has a negligible heading error (0.1nT) compared to the G858/9 (1.5 nT) which makes the kmag ideal for mineral sands exploration. The k-mag is available as an airborne survey magnetometer as the GEM GSMP35A. This magnetometer is ideal for UAV applications and comes in a lightweight shell.

## 3.2 MAGNETIC DATA ACQUISITION AND DATA REDUCTION

In magnetic survey profile lines were laid on the ground by fixing pickets at every 10m interval along a line. In the present survey the profiles were laid in North - South direction covering the eastern portion of the block. Magnetic observations were taken at every 10m station interval along each profile.

The normal corrections are applicable to a wider area which are attributed to the variations in geomagnetic intensity across the Latitude and Longitude using National and International contour maps for the regional values of F, H and Z, i.e. the Resultant, Horizontal and Vertical components of the geomagnetic field. The area under investigation being small, normal corrections have not been considered.

The secular variations are long term geomagnetic field variations that are monitored continuously at various geomagnetic field observatories around the globe. These corrections are not applicable in this case as the duration of the survey work was very short.

These corrections are applied for time dependent variations in the geomagnetic field. If the geomagnetic field at any point is to be monitored continuously, it could be found that the geomagnetic field intensity changes in magnitude by tens of Gammas during a normal "Quiet day", while a change of hundreds of Gammas is to be expected on a "Disturbed day", these variations are associated with the sun spot activity.

## 3.3 ASSUMPTIONS & LIMITATIONS

The assumptions and limitations of this survey are as follows;

a. The dyke present in the area are uniformly magnetized.

b. The magnetic elements present in the dyke/sill of the area are having sufficient positive susceptibility contrast to be registered by the instrument.

c. No anomalous polarization effect is produced by the intrusive body.

d. The demagnetization effects produced by the body in the magnetic field of the earth have not been taken into account in this study. All the results obtained from this study must be viewed in the light of above mentioned assumptions and limitations.

## 3.4 DATA INTERPRETATION AND RESULTS DISCUSSION.

The trend of the encountered dyke was obtained by joining the locations of the picket's positions having the maximum magnetic anomaly along each of the profile lines over the plan. Due to the forward magnetization, a positive anomaly is seen in all the profile lines except P-1, (because it may be possible that P-1 does not passes over the dyke. If it could have passed through little bit more in southern direction as originally begins from origin, then there would be a probability of getting positive anomaly signature but it could not have happened due to limited field accessibility) which are due to the presence of magnetic body (Dolerite) lying beneath the surface and magnetization occurred in the direction to Earth's magnetic field i.e forward magnetization. The trend of the anomalous zone tentatively follows East-West direction in the concerned block. The processed data in the final form is shown in Fig. 3.4.1 to 3.4.8. The lateral thickness of the dyke over various profile lines has been calculated from the magnetic plotted data and it is also marked on the graph itself. The trend and thickness of the dykes are shown in the mine plan shown in Figure 3.4.9. The summarized results are given in Table-8.1. Apart of Lateral extension of a dyke, a theoretically based graphical method was used and is known as Peter's half slope method. It is a rule of thumb to find the depth to the magnetic source. In the case of Profile P-1, which does not show any kind of positive anomaly because it may be possible that P-1 does not passes over the dyke. If it could have passed through little bit more in southern direction as originally begins from origin, then there would be a probability of getting positive anomaly signature but it could not have happened due to limited field accessibility. However, length of the line was 400 m.

In case of profile P-2, a positive anomaly has been observed between 60 m to 80 m. Anomaly depicts the presence of dykes whose lateral thickness was 20 m. Length of the line was 400 m. Depth of a dyke (distance from the surface) using Peter's half slope method is calculated as 6.3m at observation point which is at 70 m lateral distance from Zero of profile 2.

In case of profile P-3, a positive anomaly has been observed between 90 m and 120 m. Anomaly depicts the presence of dykes whose lateral thickness is 30 m. Length of the line was 470 m. Peter's half slope method gives the depth of a dyke as 6m at observation point which is at 100 m lateral distance from Zero of profile 3. In case of profile P-3A, an anomaly has can be seen in between picket no. 20 m and 40 m. Lateral thickness of dyke is 20 m. Due to field restriction it extends upto 140 m only.

In case of profile P-4, magnetic anomaly can be seen between 130 m and 150 m. Lateral thickness of dyke is 20 m. It extends upto 190 m. Depth of a dyke (distance from the surface to the top point of the dyke) using Peter's half slope method is calculated as 404m at observation point which is at 140 m lateral distance from Zero of profile 4.

As far as profile P-5 is concerned, magnetic anomaly can be seen between 130 m and 150 m station. Lateral thickness comes as 20 m. It extends upto 180 m

Similarly in case of profile P-6, anomaly can be seen between the stations at 120 m and 140 m. Again lateral thickness comes as 20 m and its extends upto 240 m. Peter's half slope method gives the depth of a dyke as 4.3m at observation point which is at 120 m lateral distance from Zero of profile 6.

In case of profile P-7, magnetic anomaly can be seen between 110 m and 140 m station. Lateral thickness comes as 30 m. It extends upto 360 m. Among all the profile lines, P-7 was the only line which practically crosses the partially subsurface dyke on the field and whose signature is perfectly matched with existing dyke on the plan.

The thickness of the dyke over various profile lines has been calculated from the magnetic plotted data. The trend and thickness of the dykes are shown in Fig.3.4.1 to Fig.3.4.8. The summarized results are given in Table-3.4.2.

| Sl No. | Profile No. | Distance of the dyke from Zero point | | |
|---|---|---|---|---|
| | | From (m) | To (m) | Lateral Extent (m) |
| 1 | P-1 | -- | -- | -- |
| 2 | P-2 | 60 | 80 | 20 |
| 3 | P-3 | 90 | 120 | 30 |
| 4 | P-3A | 20 | 40 | 20 |
| 5 | P-4 | 130 | 150 | 20 |
| 6 | P-5 | 130 | 150 | 20 |
| 7 | P-6 | 120 | 140 | 20 |
| 8 | P-7 | 110 | 140 | 30 |

Table 3.4.1

| Profile No. | Distance of a point from Zero at which depth is calculated in m | Tentative Depth in m |
|---|---|---|
| 2 | 70 | 6.3 |
| 3 | 100 | 6 |
| 4 | 140 | 4.4 |
| 6 | 120 | 4.3 |

Table 3.4.2


Figure 3.4.1

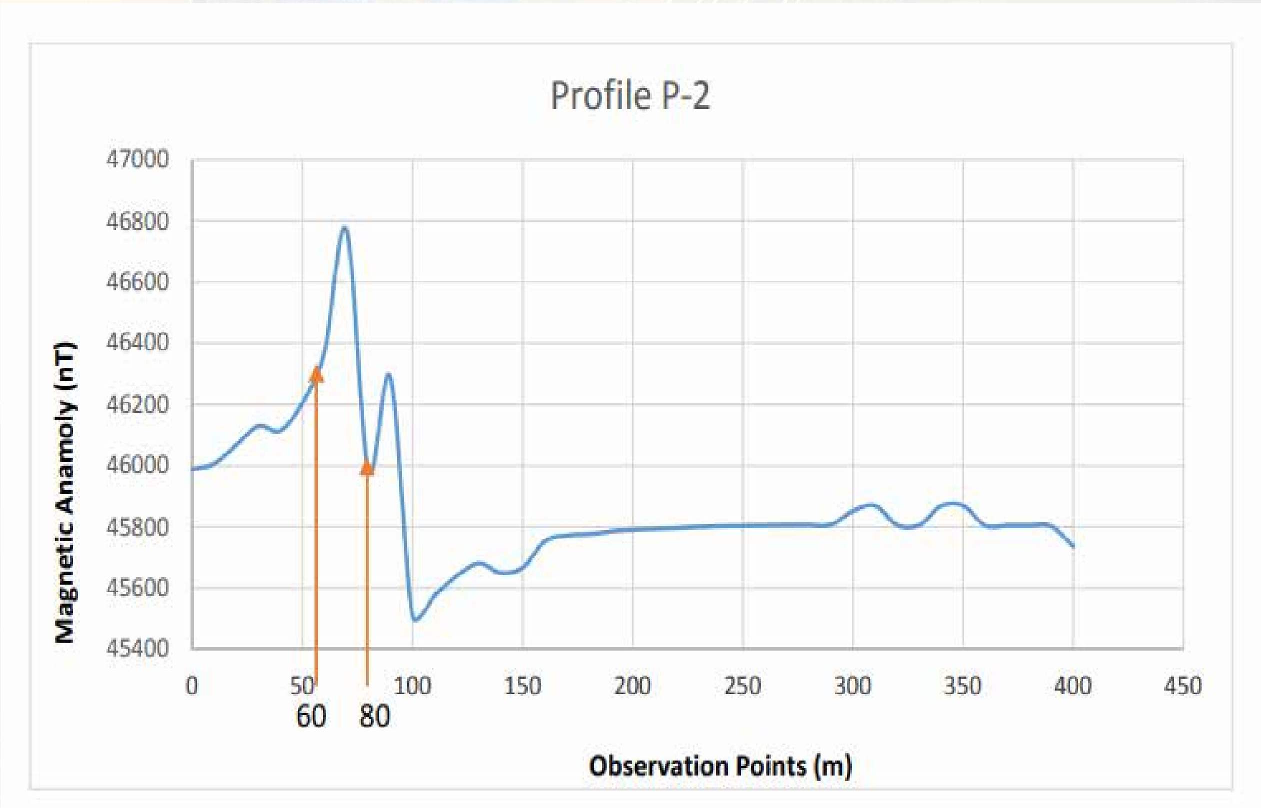



Figure 3.4.2

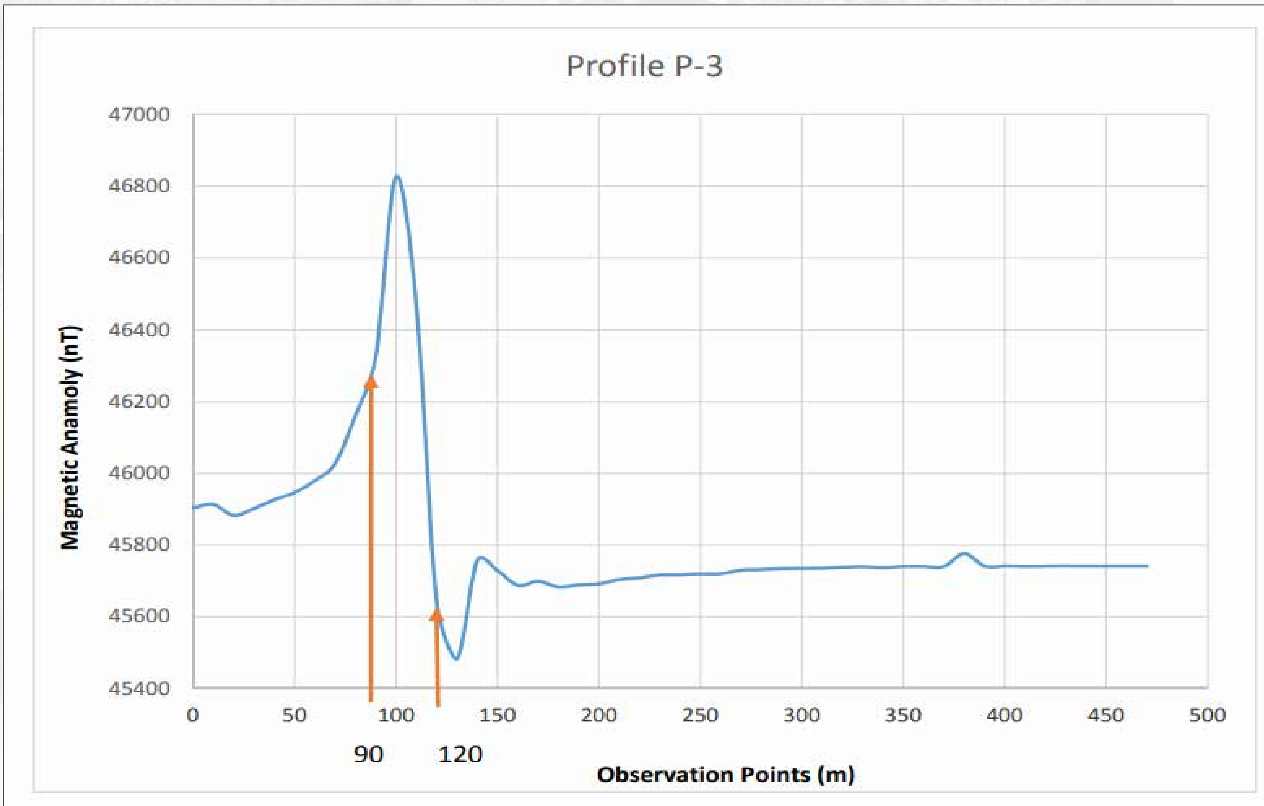



Figure 3.4.3

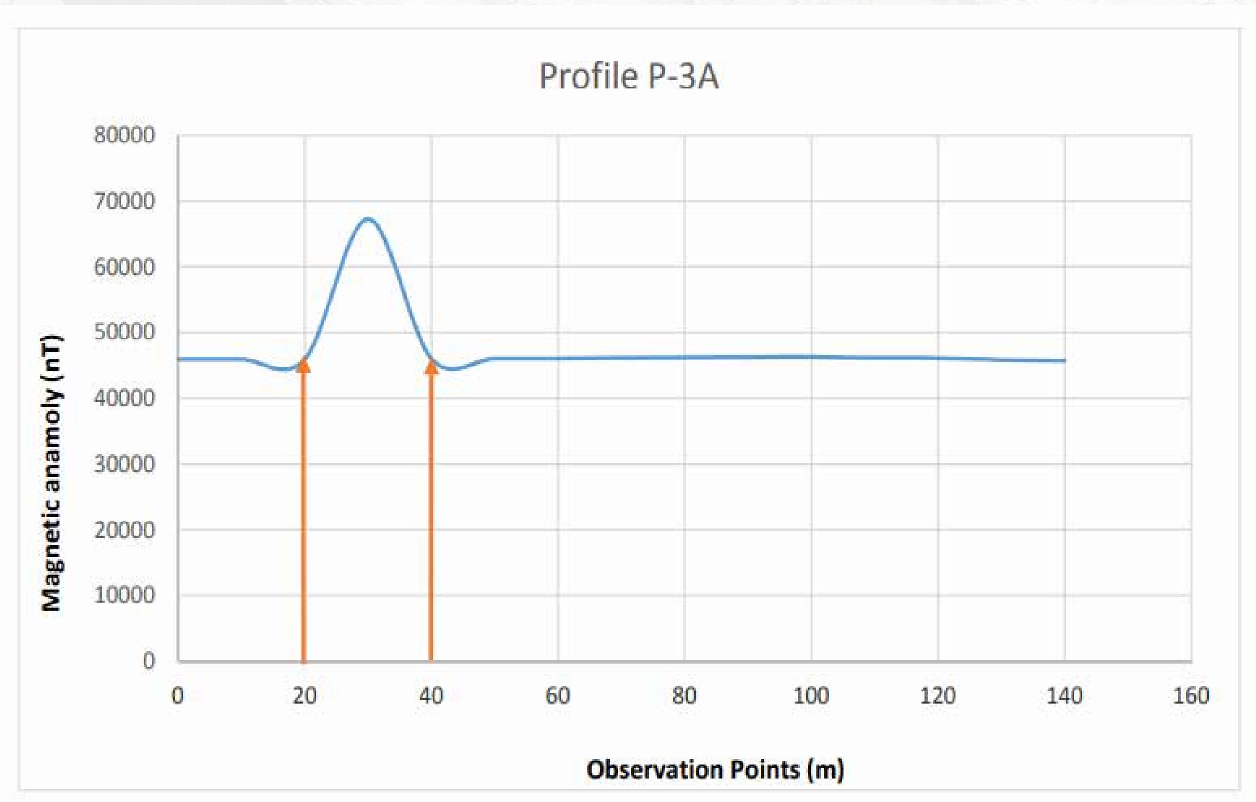



Figure 3.4.4

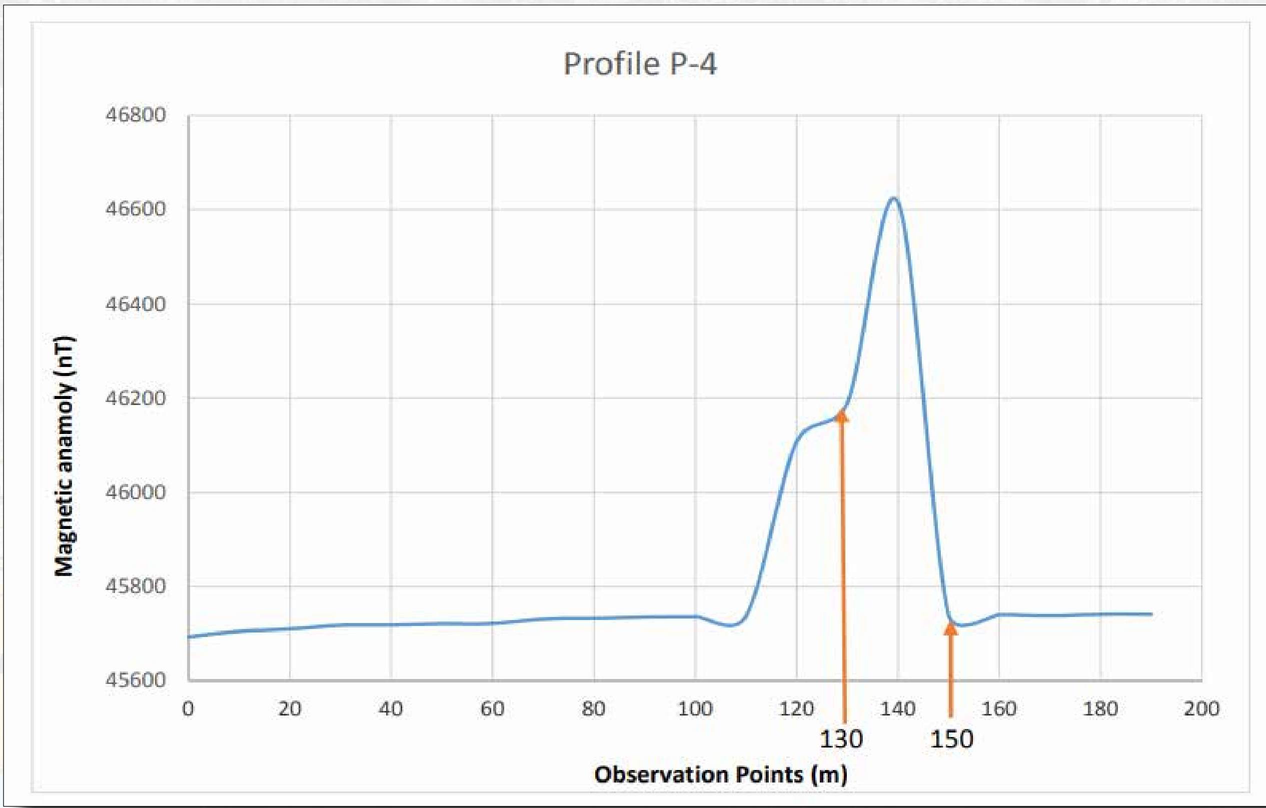



Figure 3.4.5

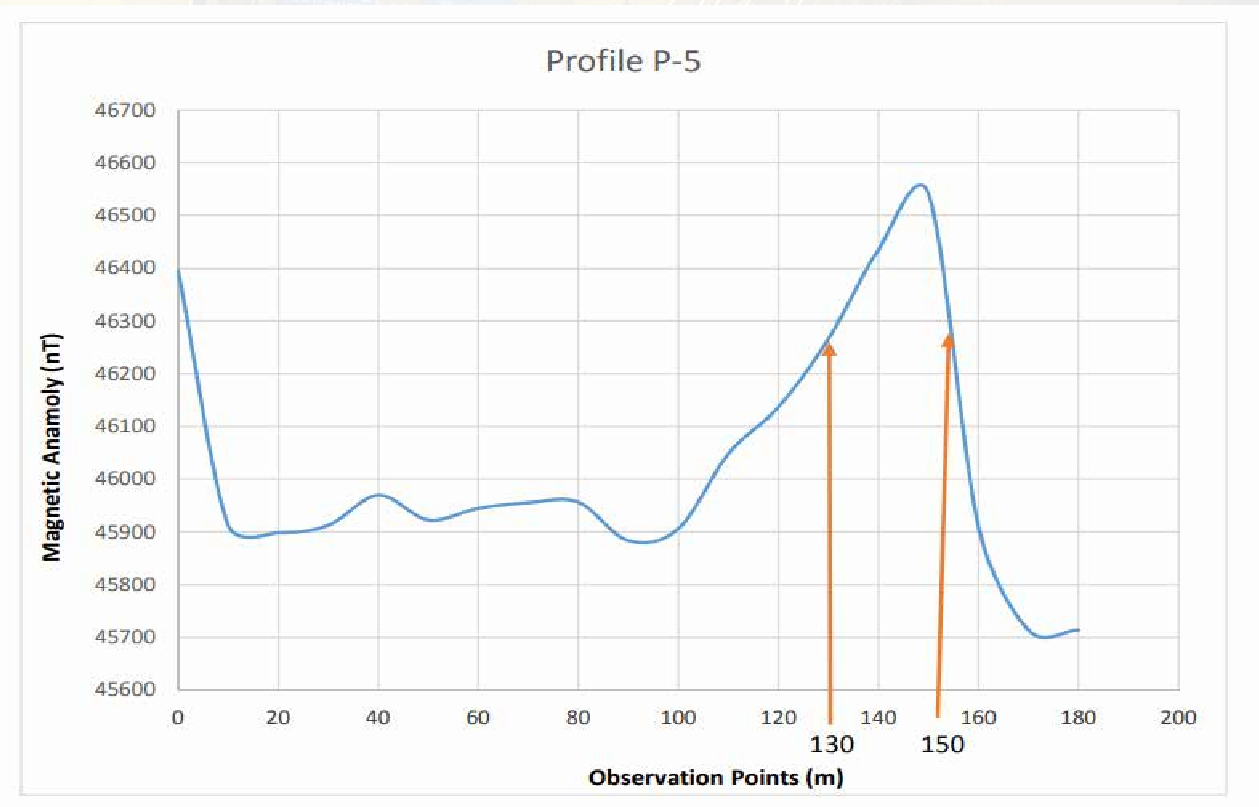



Figure 3.4.6

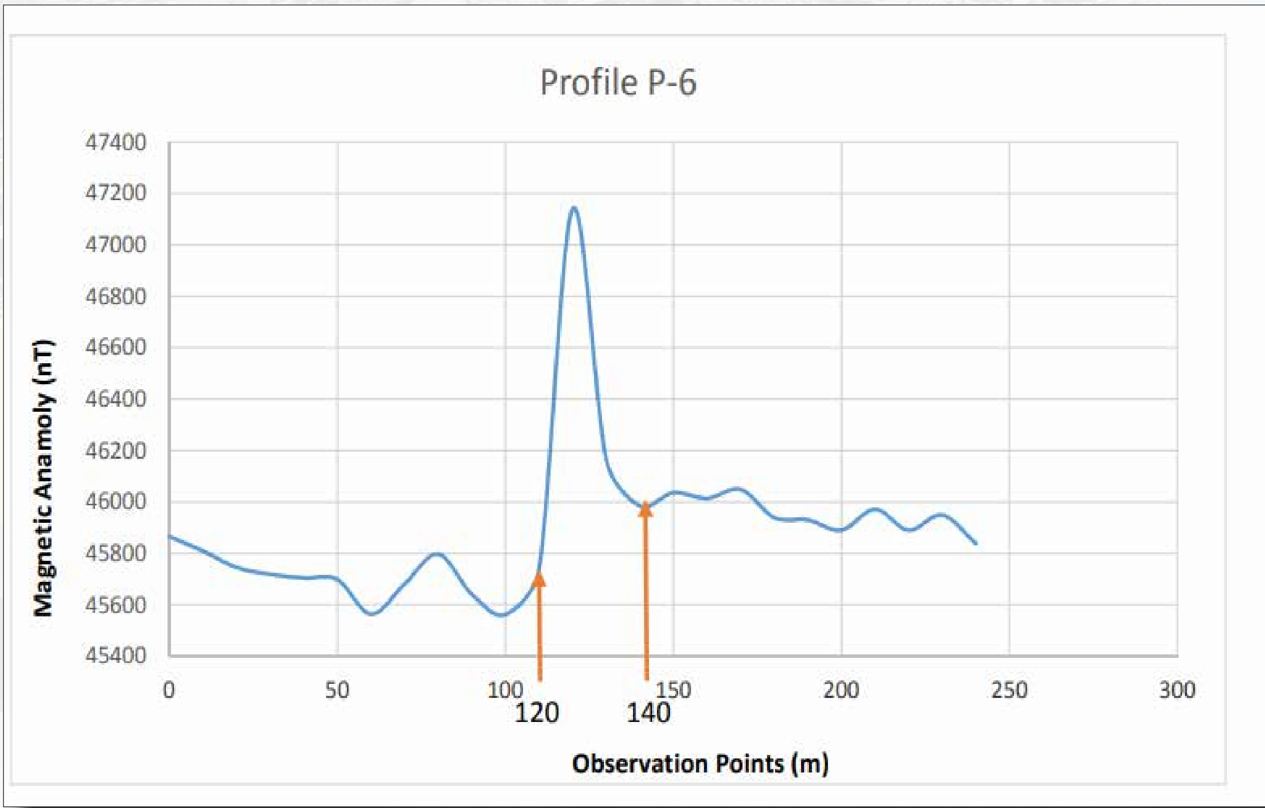



Figure 3.4.7

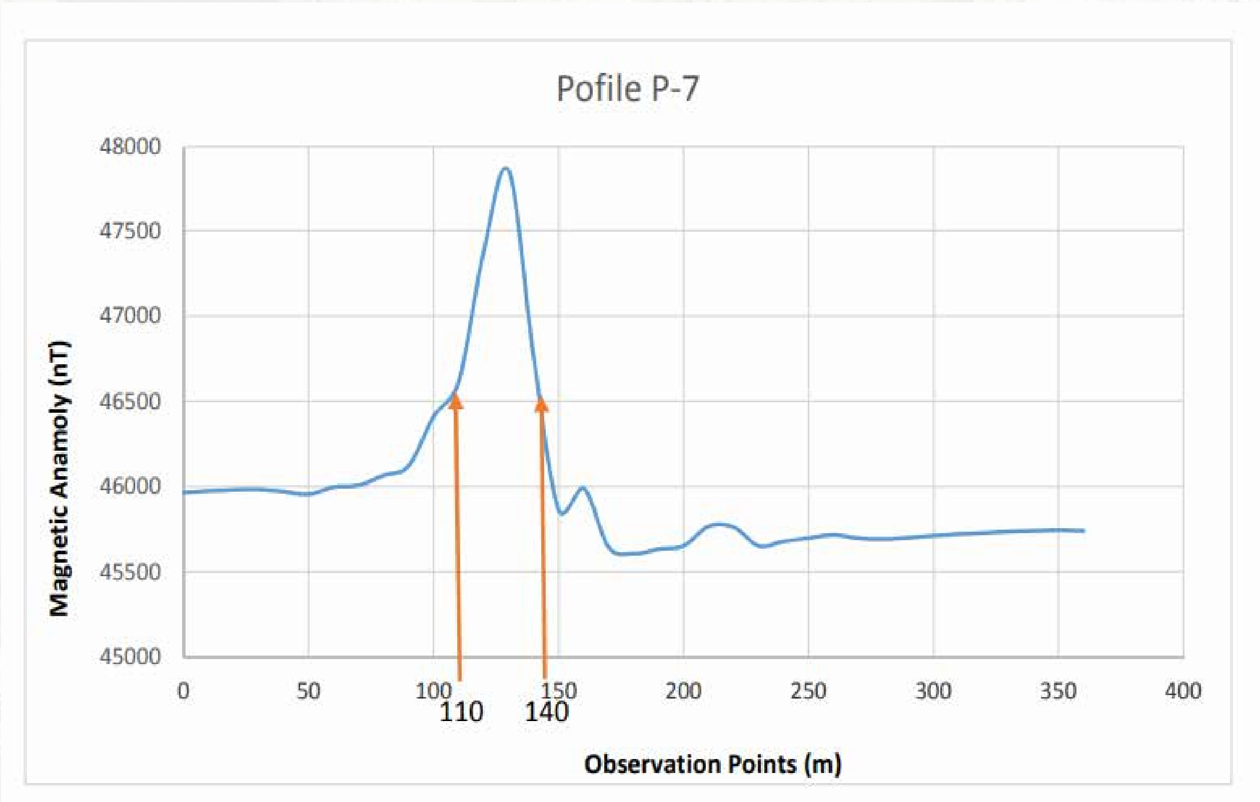



Figure 3.4.8

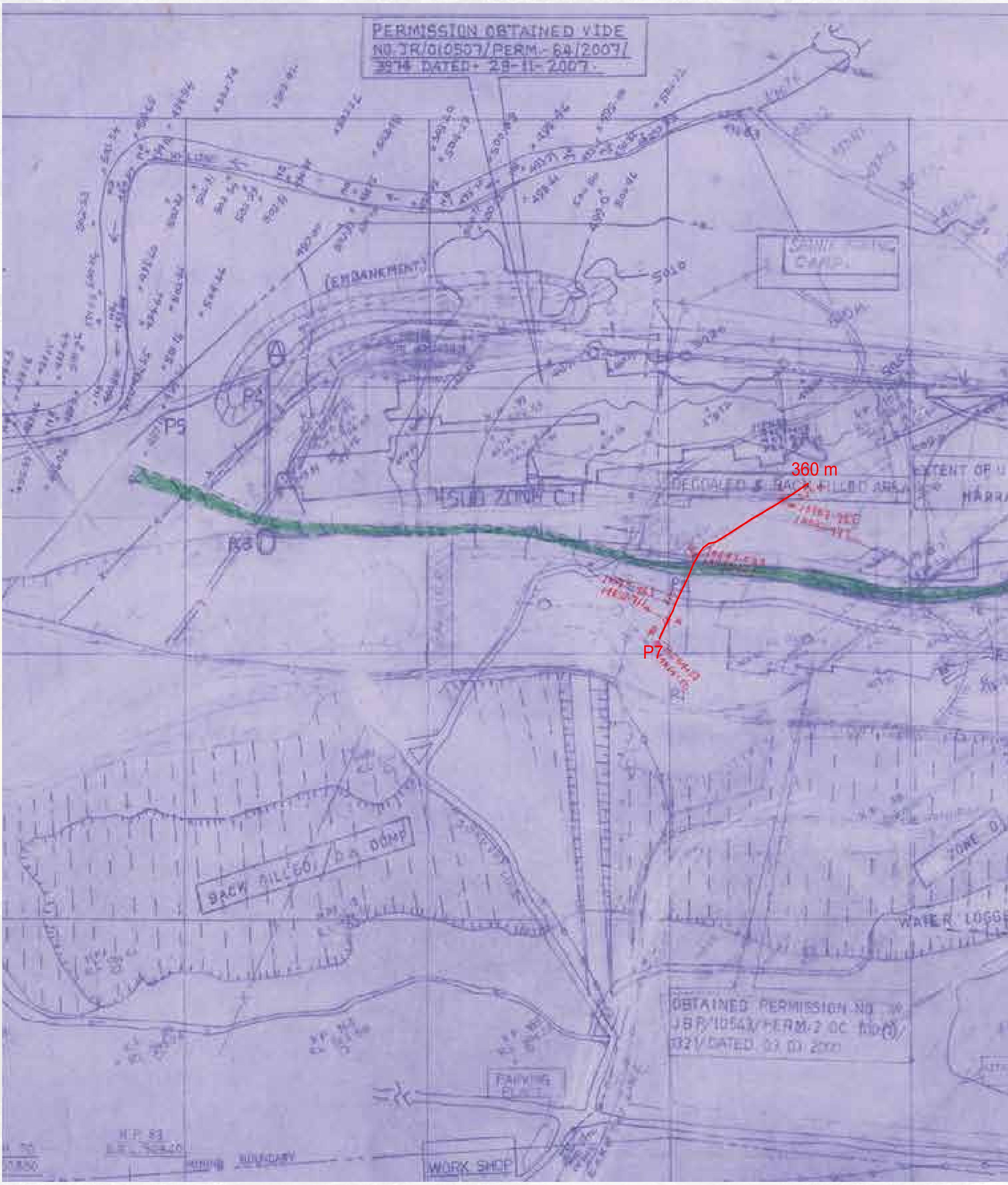
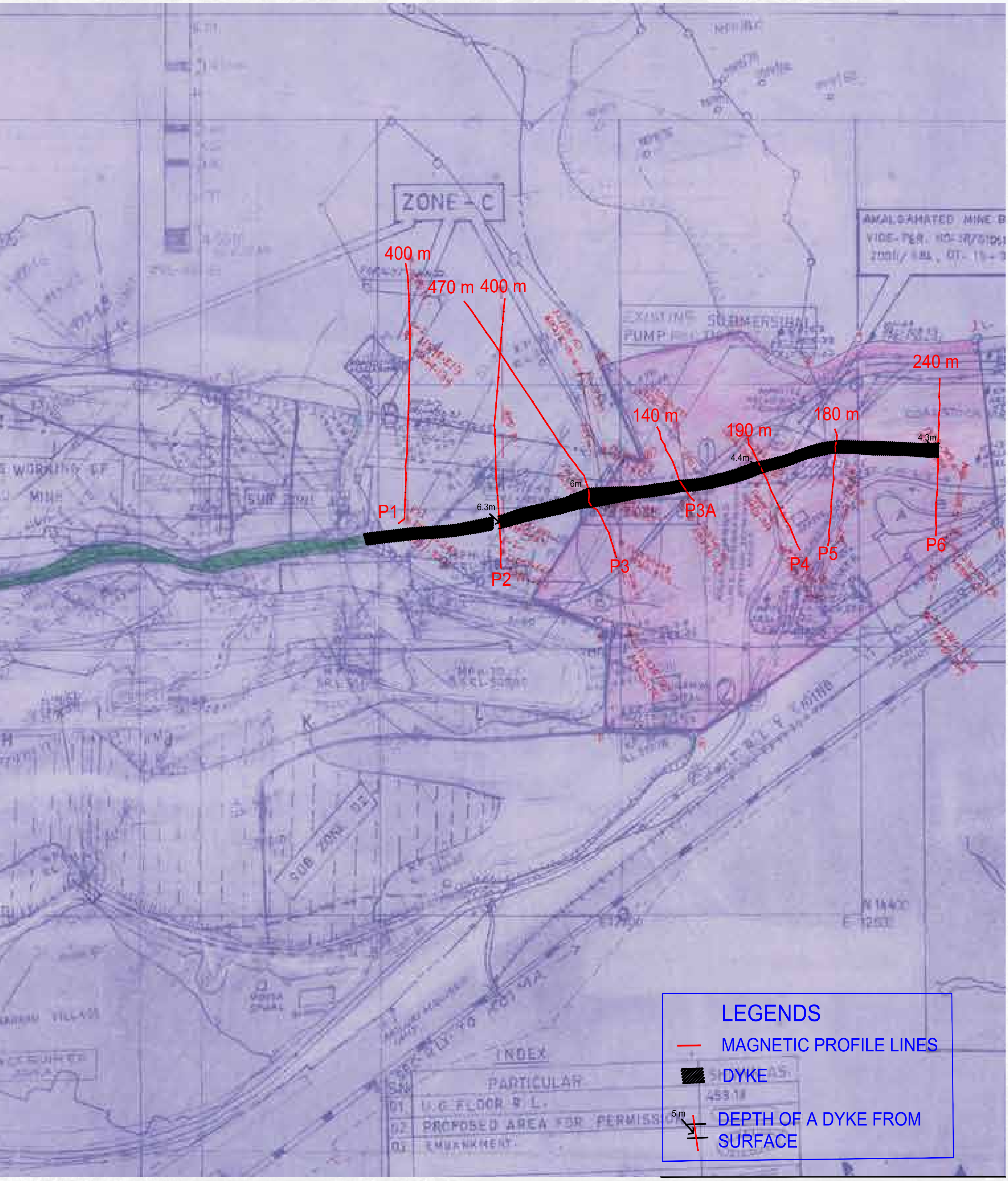

PERMISSION OBTAINED VIDE
NO. JR/010507/PERM.-64/2007/
3974 DATED- 29-11-2007.
(EMBANKMENT)
SUB ZONE C1
360 m
P7
P5
P6
BACK FILLED / O.B. DUMP
WATER LOGGED
PARKING
WORK SHOP
MINING BOUNDARY
ZONE D

**Figure 3.4.8**


ZONE - C
400 m
470 m
400 m
140 m
190 m
180 m
240 m
6.3m
6m
4.4m
4.3m
P1
P2
P3
P3A
P4
P5
P6
EXISTING SUBMERSIBAL PUMP
LEGENDS
MAGNETIC PROFILE LINES
DYKE
5 m
DEPTH OF A DYKE FROM SURFACE
INDEX
PARTICULAR
U.G FLOOR R.L.
PROPOSED AREA FOR PERMISSION
EMBANKMENT

## 4. CONCLUSION

On the basis of magnetic anomaly observed from the graph, complete interpretation of dyke was done which can be seen on the Figure 3.4.9. It has got similar pattern as it was existed on western portion. Lateral thickness of the dyke vary from 20 to 30 m. Strike of the dyke seems to be following E-W direction. However, it may be possible that vertical thickness of dyke that encountered in the early phase of mining in Jamuna OCM would be similar since it is in continuation of previous mapped dyke (done by BHU team) and moreover it shows similar kind of trend or nature. The depths of the dyke below the respective profile lines are estimated manually through Peter's Half Slope method which is quiet tentative and for the determination of actual depths of the dyke from the surface, drilling of few boreholes may be suggested over the positions of the dyke shown in Figure 3.4.9

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|---|---|---|---|---|---|---|
| | Half Page | Full Page | Black & White | Multicolor | Single issue | Yearly |
| **2nd Cover** | ✓ | | ✓ | | 40000 | 140000 |
| | ✓ | | | ✓ | 60000 | 200000 |
| | | ✓ | ✓ | | 80000 | 280000 |
| | | ✓ | | ✓ | 120000 | 400000 |
| **3rd Cover** | ✓ | | ✓ | | 37500 | 131250 |
| | ✓ | | | ✓ | 56250 | 187500 |
| | | ✓ | ✓ | | 75000 | 262500 |
| | | ✓ | | ✓ | 112500 | 375000 |
| **4th Cover** | ✓ | | ✓ | | 50000 | 175000 |
| | ✓ | | | ✓ | 75000 | 250000 |
| | | ✓ | ✓ | | 100000 | 350000 |
| | | ✓ | | ✓ | 150000 | 500000 |
| **Inner Page** | ✓ | | ✓ | | 20000 | 70000 |
| | ✓ | | | ✓ | 30000 | 100000 |
| | | ✓ | ✓ | | 40000 | 140000 |
| | | ✓ | | ✓ | 60000 | 200000 |

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**Sustainable Unearthing of Mineral Resources Begins Here**

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- Coal Preparation
- Management Services
- Research & Development
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- Environment
- Mining Electronics
- Geomatics
- Specialised Services
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- Coal Bed Methane
- Civil Engineering and Architectural Services
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