INTRODUCTION TO NUASAHI CHROMITE MINE – AN UNDER GROUND CHROMITE MINE

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ABSTRACT

IMFA Group is the largest producer of Charge chrome not only in India but also in Asia. This Group has plants situated at Therubali and at Choudwar. They also have a Thermal power plant at Choudwar which not only caters to the power requirement of Choudwar plant but also supplies power to Therubali . The plants are fed for Chromite ore through the captive mines namely Nuasahi Chromite mines (40.47 Ha) , Bangur Chromite mines(37.34Ha), Sukinda chromite mines (116.76 Ha), Mahagiri Chromite Mine(73.777 Ha) and Chingudipal Chromite mines (26.62 Ha).

Nuasahi Chromite Mine, which is situated in Keonjhar district, is an underground mine and is based upon best technological advancements in the industry. The underground mining operation is certified under ISO-9002, ISO-14001and OHSAS 18001. This not only shows the concern for the quality, environment but also for the health of the employees. The Nuashahi is the first chromite mine to backfill the opencast excavations created during the last 50 years and carry out the production from underground area below the opencast workings.

This paper deals with the state of art technology of sub-level open stopping in thin ore bodies. The underground mine openings was started in the year 1997. In next four years the production of chromite from underground was started.(2001). At present the mine is in a good shape with several running stopes. Today it is producing around 10,000 Mt per month of chromite. The development of the mine is carried out with an average of 200 mtr per month of tunneling. The mine is having a mechanical ventilator having a capacity of 24000 M3 per hour at 50mm water gauge, thus feeding sufficient air for the persons working in underground. The mine is being dewatered through a most modern positive suction sump, having a capacity of 500 cum and operated with 120 HP pumps. After commissioning of this sump in the year 2003, the mine has taken a quantum jump in production with remarkable saving in power consumption.

1. INTRODUCTION

Indian Metals and Ferro Alloys Limited, a leading producer of Charge Chrome/ Ferro chrome in the country, has adopted underground mining technology in one of its mines in the district of Keonjhar to produce chrome ore, which is predominantly lumpy, to meet the requirement of its plants at Therubali & Choudwar. Production of charge chrome being power intensive, the company has set up its own thermal power plant(108MW) at Choudwar to meet the requirement of electricity.

As a Corporate Policy, all the plants, mines are certified with ISO-9001, ISO-14001.Apart from this the Power Plant and the Nuasahi Mines are also certified with OSHAS-18001.

Use of 100% chromite ore fines in the electric smelting furnace is not feasible as fines reduce the permeability of the bed inside the furnace and prevents the escape of gasses produced in the reduction process. In order to run the furnace in an efficient manner, a blend (normally30% of lumpy & 70% of friable) of fines and lumpy ore is fed to the furnace. Friable ore is mostly available in Sukinda belt. But hard lumpy ore is scarce and is found in one of the bands in Sukinda valley and parts of Keonjhar district in Nuasahi- Boula

belt under Anandapur Tahsil . M/s IMFA LTD has got the lease for mining Chromite Ore over an area of 40.47 Ha in the above mentioned Nuasahi area.

2. LOCATION

Nuasahi Chromite Mines of M/s. Indian Metals & Ferro Alloys Ltd is situated in and around village of Dhanurjayapur and Bangur in the district of Keonjhar, Orissa. The lease for Mining was held by M/s. Serajuddin since yr-1944 and IMFA took over the mining rights from the later in the year 1991. Since then, Opencast mining was continued for some years and Underground mining started in 1997, although in a small way. Lease is shown in Figure 1.

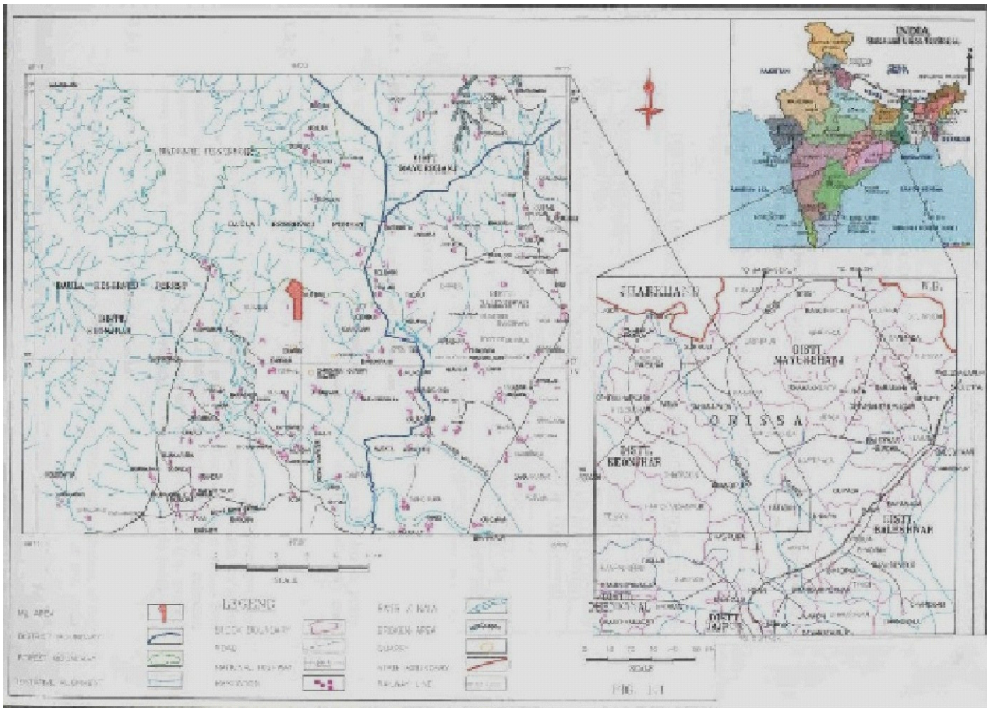

Figure 1: Location of Nuasahi Chromite Mine

Latitude	- 21^0 16’ 08” to 21^0 16’ 46” N
Longitude	- 86^0 19’ 20” to 86^0 19’ 40” E
Survey of India Topo sheet No	- 73K/7
Elevation above Mean Sea Level	- +26 to +123 AMSL
Total lease area (in Ha.)	- 40.468

3. GEOLOGY

The Ultramafic rock hosting the chromite ore bodies is principally a layered complex and is intrusive into the basal member of the Iron Ore Super Group of Rocks. The ultramafic magmatism occurred in two distinctly separate pulses with a time gap. The older ultramafite is dunite-peridotite sequence hosting the high and medium grade chromite ore bodies.Namely,two ore bodies ie. Laxmi and Durga lodes, fall under this sequence.

The second or later ultramafite also called the Newer peridotite is poorly segregated ultramafite with wide variation in the composition particularly in respect of the ore and rock variation in space. This ore body is

known as Shankar lode. These ultramafites are followed in time and space by intrusives of gabbro and dykes of peridotite and dolerite.

3.1 Durga Lode

Various dykes and faults geologically disturb the area. Out of the 3 lodes, Durga lode is more prominent in 3 sections i.e. northern, central and southern. It is the footwall most lode. The northern section is having a strike length of around 100 meters with an ore width of 4 meters. In central section, the strike length is 250 meters and the average width is around 4 meters. In southern section, the length is around 325 meters with the width of around 4 meters. The reserve in this lode is taken up to -105 mRL in proved category and it is likely to continue in depth.

3.2 Laxmi Lode

The Laxmi lode is around 120m away from Durga lode and 50m west of crustal dyke. The lode has been found for 180m in strike direction. The strike of the lode is controlled by 2 faults – one in northern and another on southern side. Both the faults are south dipping. This band has 2 distinct sub bands namely south band and north band. The thickness in south band is 1.5 – 2m. North band has well developed ore and dissemination zone having a thickness from 2.5-3.5m. The parting between both the bands is around 6m. This band is also proved up to -105m levels and is likely to continue below.

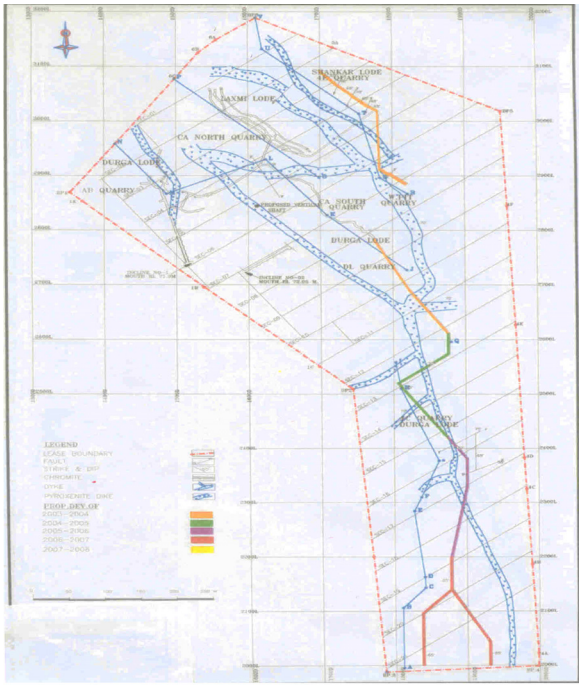

Figure 2: Plan Showing Dyke (Durga Lode)

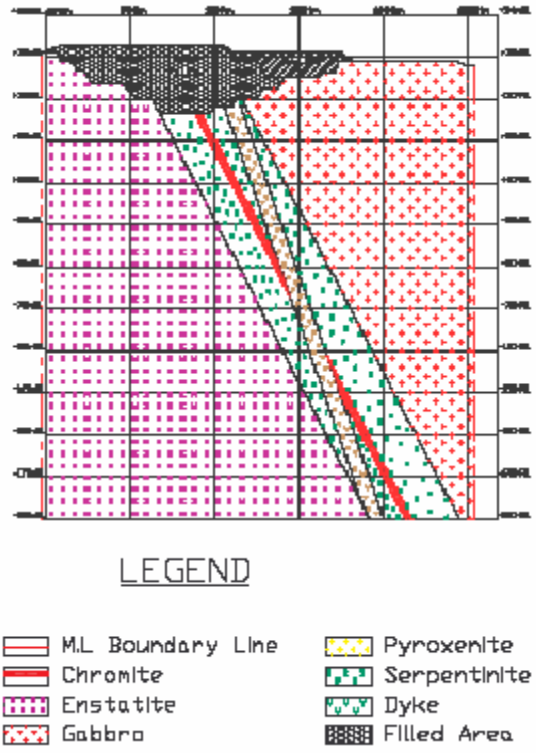

Figure 3: Section Showing Dyke (Durga Lode)

3.3 Shankar Lode

The Shankar lode is developed at the eastern margin of Serpentine and Gabbro contact. This is genetically related to the newer Peritododite, younger in age to the east of crystal dyke. The thickness of this lode varies from 3 to 4 m with the strike length of 120m. The reserves estimated in Shankar lode up to - 65 mRL are taken into proved category and are likely to be extended below.

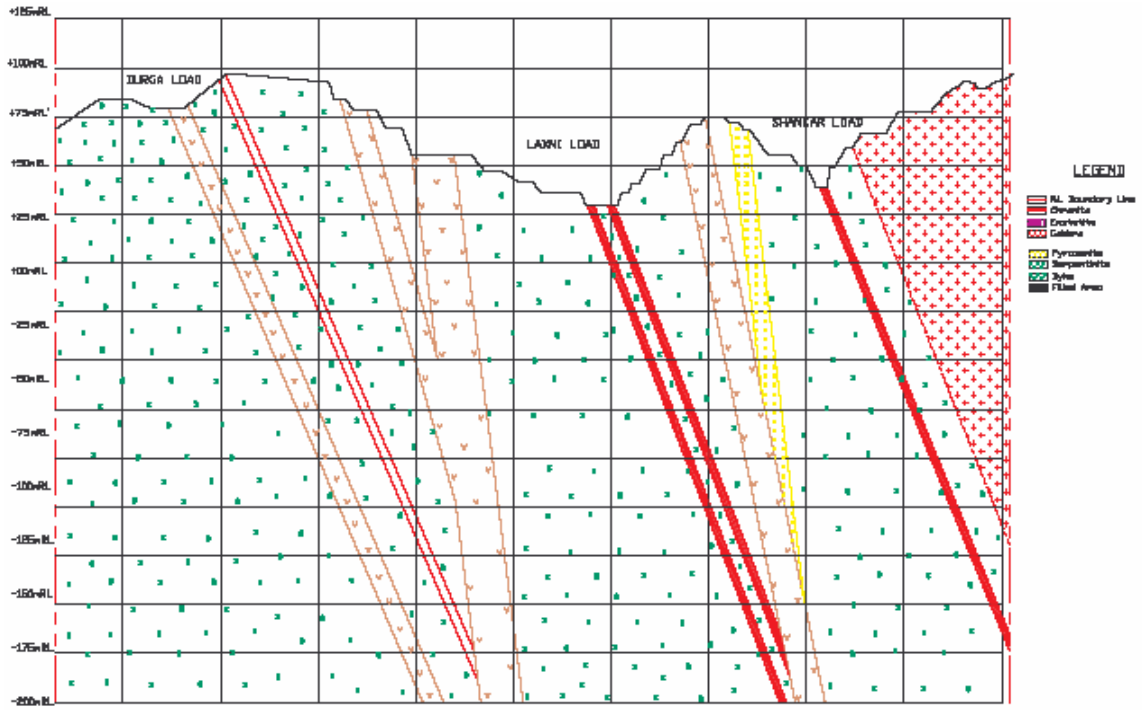

Figure 4: Section Showing Dykes in all Lodes

The exploration for all the lodes in depths is continuing from surface as well as from underground by diamond core drilling.

The lodes are highly disturbed by the faults. These faults can be seen in the plan.

The Laxmi lode in the lease is cut across by the two major faults on both sides and shifting at every level possess difficulty in mining .Also, the intrusion of the dyke makes it difficult to find the limits of the ore body at times.

4. SWITCHING OVER TO UNDER GROUND MINING

As the ore bodies are comparatively narrow, disturbed and the ultimate pit limit was fast approaching, it was decided to go for underground method of mining. Two inclined shafts were sunk to access the veins from the footwall of Durga ore body(being the footwall most lode). The underground operation was planned in such a way that there was overlapping of surface operation to maintain production from the mine for sustaining charge chrome production by plants.

4.1 Mode of Entry

The underground mining operations have been started through two inclines i.e. No.1 & 2 both dipping at 30deg to horizontal.

4.2 Incline No. 1

The surface RL of Incline No.1 is at +72mRL. It is sunk upto -45mRL, beyond which further extension is not possible due to the boundary restriction of the property. The cross section of this incline is 3mx2m. A ladder way is provided in this Incline for passage of men.

Single Drum Direct Haulage with mine tubs

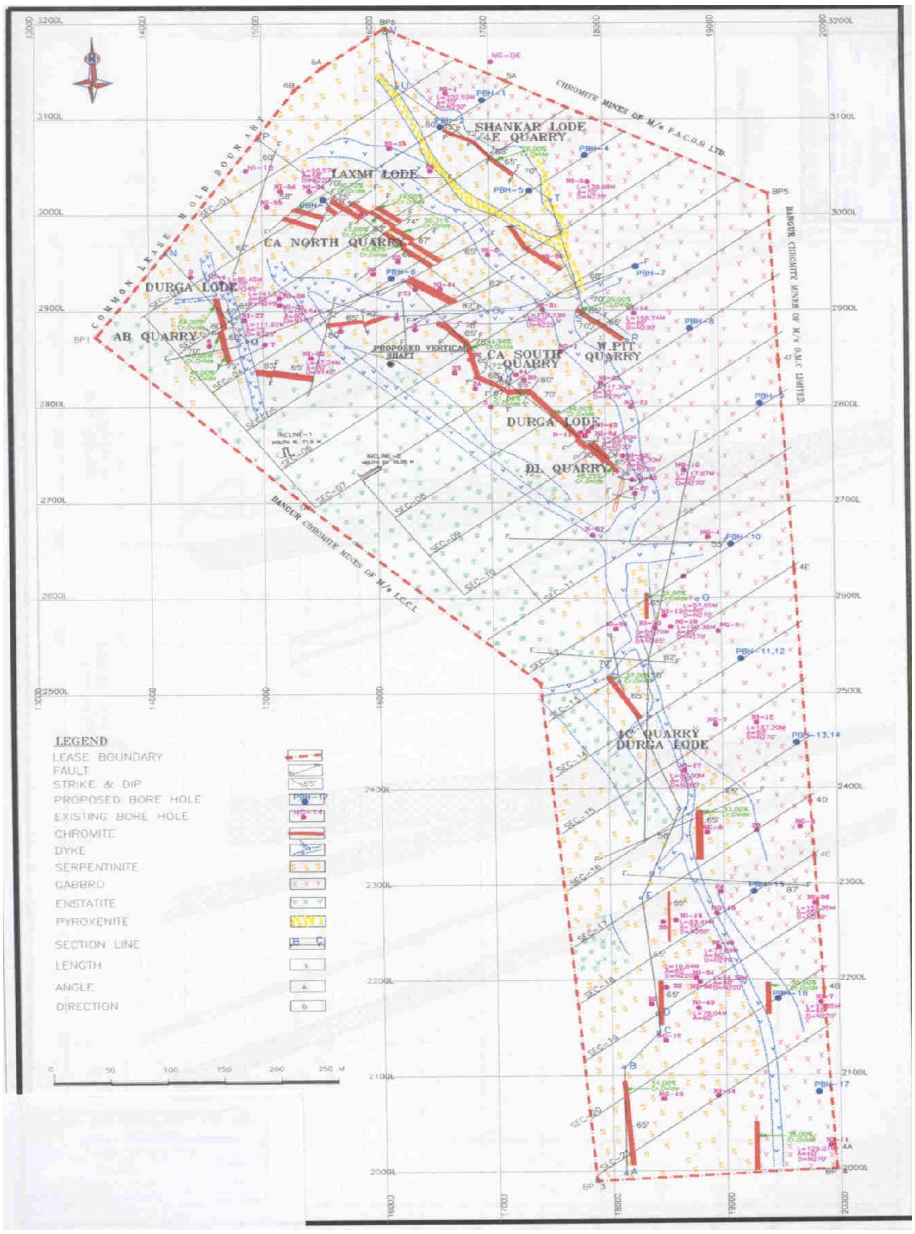

Figure 5: Plan Showing Lodes with Faults

Capacity of Motor – 60 HP
Maximum speed of Hoist – 1m per Second
Maximum Pay load – 2 Tonnes
Maximum hoisting capacity from ultimate level - 55,000 Tonnes/ Annum

4.3 Incline No. 2

The surface RL is +72mRL. It is sunk up to -105mRL with a cross section of 5m X 2m and will extend up to –185mRL because of boundary limit.

Hoist specifications – Double Drum balanced winder with 4 MT skip

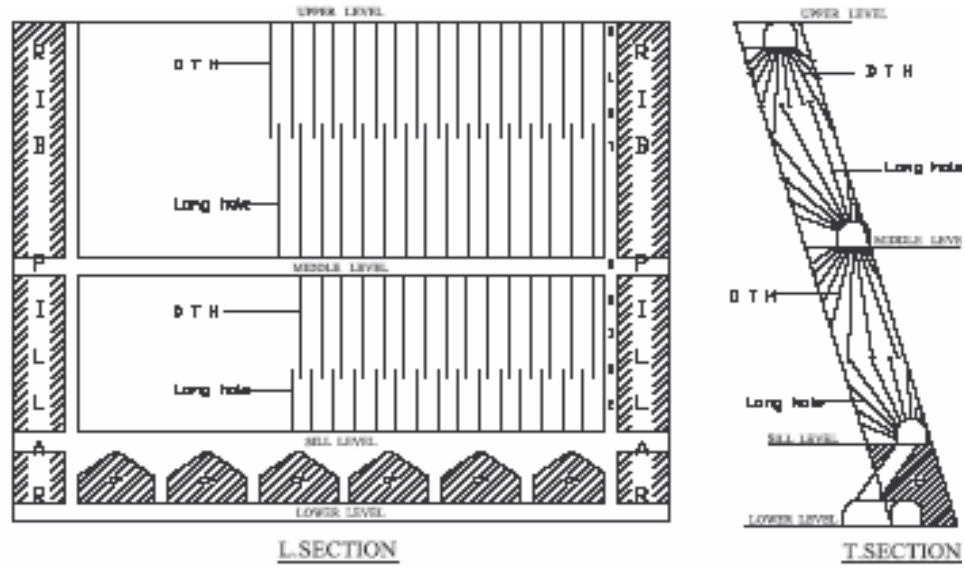

Figure 6: Long Hole Drilling Pattern

Capacity of Motor – 150 HP with PLC based control
Maximum speed of Hoist – 2.5m per Second
Maximum Pay load – 4 Tonnes
Maximum hoisting capacity from ultimate level - 400,000 Tonnes/ Annum

A ladder way has been provided in the incline right through for passage of men along with man winding facility.

5. METHOD OF WORKING

In this method the ore-body is opened up through levels and sub-levels. The level interval is 60m and the sub-level are developed at 30m interval. In case of irregular deposits of ore over a disturbed area, the sub-level interval is some times reduced to even 10m. These sub-levels are of 3m x 2.5m cross section, so as to accommodate BBC 120 drifter and are generally driven following the foot wall contact of the ore body.

A sill level is developed at 7.5m above the tramming level. This tramming level is connected through cross cuts and a transfer raises to the sill level. Drilling is carried out from sill level and various sublevels as shown in figure5.

Ore is produced by drilling and blasting long-holes of 57mm diameter. Some times holes of 112.5mm, drilled by DTH are also used. The length of the holes range from 5m to 19m in general, and at times upto 22m depending on the requirement. The method of mining is as shown above in figure 7.

A slot raise is developed in the orebody at the footwall contact and is widened upto the hanging wall. The Long hole rings are blasted against this free face .The rock so blasted is loaded at the tramming level with EIMCO 21 loaders into mine tubs.The various parameters of drilling and blasting are given below:

Diameter of the hole	- 57mm
Length of the hole	- 5m to 19m
Drill factor	- 3.5 tons per meter
Explosives used	- Presently Powergel.(in future ANFO)
Power factor	- 0.29 kg of explosives per ton of ore
Loading equipment	- EIMCO 21 Rocker Shovel
Mine tubs	- 0.67 Cum capacity side tipping

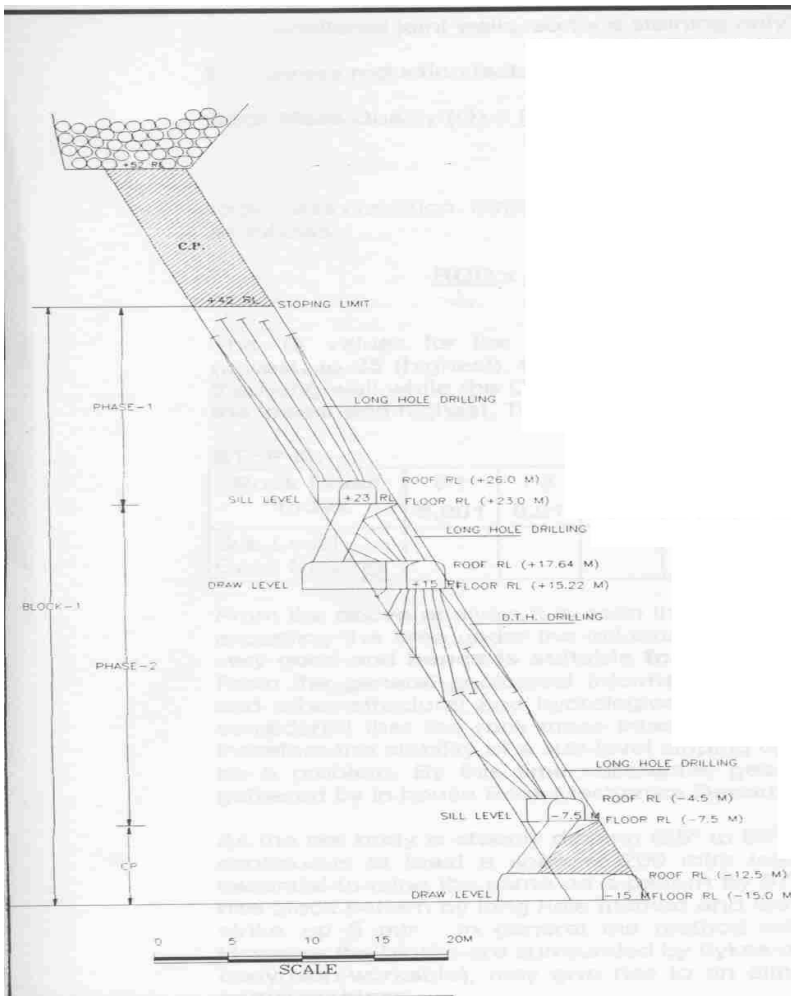

Figure 7: A Typical Section of Durga Lode at +15mRL and -15mRL

Tramming	- Manual tramming up to main line and thereafter by 4 MT Battery operated Locomotive upto dumping point.
Track	- 610mm gauge of 30 lb rails

5.1 Changes Made in Method of Working

Presently sublevel open stoping is being experimented in Durga ore body by developing trough in the draw level. In this method we can avoid the sill level and thus stope development is faster. An extraction drive is driven in the footwall of the ore body which runs parallel to it, keeping a parting of 8m between trough drive & extraction drive. The X- cuts are driven at 8 m intervals which acts as the draw points. In this method we need not wait till we reach the end of the property as in the earlier version of sublevel stoping due to the extraction drive. Once a small portion of the strike length is developed, stoping can be started.

Advantages of trough level over transfer raise sublevel open stoping method :

1. Faster Development of stopes.
2. Arduous task of making finger raises are eliminated altogether.

3. Stope inspection is possible even after the stope is exhausted Stope inspection is possible even after the stope is exhausted Stope inspection is possible even after the stope is exhausted.
4. Ventilation can be planned in a better way.

6. DEVELOPMENT HEADINGS

The development headings are of 2.5m x 2.5m cross section. The raises are developed of 2m x 2 m cross section. The development headings are drilled with Jackhammer and stoper. EIMCO 21 &12B loaders are used for mucking operations.The raising operation is done manually by conventional methods but sometimes drop raising is also resorted to. The development parameters are as follows:

Size of the drive	- 2.5m x 2.5m
No. of holes drilled	- 34 nos
Explosive	- 17 kgs per round
Powder factor	- 0.65 kgs per ton
Diameter of the hole	- 33mm
Depth of the round	- 1.8m
Pull per round	- 1.4m

Average monthly development is around 200 m at present.

6.1 Changes Made to the Development

Previously a single development round of 1.8m was taken. The cycle of operation was as follows :

Drilling, Blasting, Face checking & Mucking, Face Preparation –and repetition. Generally in a day one round per face was achieved with a pull of 1.4 m. The major reasons for the poor progress of faces are given below:

1. Unclean breakage of faces leading to sockets.
2. Longer time was consumed in dealing with sockets, face preparation and loose dressing.
3. Longer depths of holes require more time for drilling and higher accuracy. Thus drilling required very experienced and skilled drillers. A typical 2.4 m round required almost 5 to 6 hours for completion of drilling but only gave a progress of 1.8 m per round.
4. A typical 1.8 m round produced almost 25 tubs of muck and this took about 4 hours for mucking. In case of 2.4 m. round 32 tubs were produced which require around 6 hrs for mucking.

In the new method shorter holes of 1.0m depths were drilled and the frequency of rounds was increased to one round per shift. This method proved to be successful and gave a progress of 2.4m/day.

Advantages of present method

1. Shorter rounds resulted in better face cutting and socket less faces.
2. Less inspection time
3. Loose dressing and face cleaning took very little time, as breakage was clean.
4. Strata control was easier in jointed rocks.
5. Mucking operations could be completed in a single shift.
6. A complete cycle of drilling, blasting & mucking took only one single shift.

6.2 Comparative statement of past and present method

Table 1: Comparative Statement of past and present method

Depth of round	*No of holes*	*Drilling time*	*No of tubs*	*Mucking time*	*Face preparation time*	*Pull per round*	*Pull per day*
1.8 m	36	4hrs	25	4 hrs	3hrs	1.4 m	1.4 m
2.4 m	40	8hrs	32	6 hrs	3hrs	1.8 m	1.8 m
1.0 m	28	2hrs	15	3hrs	1hrs	0.8 m	2.4 m

7. SUPPORT SYSTEM

Detailed study of the Strata has been carried out for rock mass classification purpose. Rock mass rating of the Strata has been determined as per CSIR-ISM, guidelines and Q-system developed by Norway Geo-technical Institute. To determine rock mass rating, the RQD, joint pattern, joint density, joint orientation, type of in-fill material, joint plane details, joint water seepage and also uni-axial compressive strength of the rock has been considered. Based on the above studies, the supporting system has been developed as follows :

1.5m long and 20mm dia torque steel rock bolts are grouted with cement in the roof with 1.0m distance between rows and the rock bolts.

Wherever required, crossbar, screw props and cogs are also used. The relevant systematic support rules for development headings & stoping operation are approved by DGMS.

8. MINE VENTILATION

The Mine Ventilation is planned with intake from both the inclines and exhaust through a raise over which a 75HP fan is mounted. This ventilation raise is located in the northern side of the property connecting the Laxmi stope from surface. As the stoping progresses below the ventilation raise also gets extended and connected.

This fan is having a capacity of 2400CuM of air/min at 50mm of w.g.This will be sufficient to meet the ventilation requirement upto year 2011.

9. MINE DRAINAGE

The mine has a 500 Cum capacity sump at -45mRL which is having two numbers of 120HP pumps working with positive suction. The water from all over the mine is brought here and is pumped out through 150 mm dia pipelines laid in Incline No.2 to the surface. Some minor quantity of water is also trapped at +37mRL of incline no-1 and is pumped out to surface.The total quantity of water pumped out during the year 2005 was 5.38 lakh Cum. The sump at –45 mRL was established considering the maximum working pressure of 15Kg/sq cm in pipe lines. The surface being at 72mRl the pressure becomes 11.7kg/sq cm upto –45mRl. Similarly, another sump will be established at –105mRL from where the water will be pumped in stages to surface through the sump at –45mRL.

10. CONCLUSION

Nuasahi Mine has gone a long way both in production and technological advancements in underground mining. The mine development has improved considerably and now a progress of 65 to 70m in a face per month is easily achievable as against 20 to 25m per month previously. A comparative statement year – wise is given below.

Table 2: Production and Development

Year	*Production (MT)*	*Development (m)*
2000-01	14697	917
2001-02	28104	1679
2002-03	44671	2141
2003-04	52438	2257
2004-05	70324	2146
2005-06	81919	2461

Thus, we can see that continuous improvement in mining technology and operations have become way of life at Nuasahi.

REFFERENCES

[1] Study report by Central Mining Research Institute.
[2] Design of RCC Plugging by Department of Mining Engineering, IIT Kharagpur.
[3] Ventilation Study by Department of Mining Engineering, IIT Kharagpur.