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IMPLEMENTATION OF GRANITE MASS MANAGEMENT SYSTEM (MMS) IN COMMERCIAL GRANITE QUARRIES- A SCIENTIFIC SOLUTION FOR ASSESSMENT OF RECOVERY PERCENTAGE-CASE STUDY BASED ON INDIAN CONTEXT

B.Kanishkan,
Research Scholar, University of Madras, India
Prof. Dr. R.Sivakumar,
Tamil Nadu Government Higher Education Service, India.
Ramanarendra Charry,
Mining Engineer, Ongole. India.

ABSTRACT: *Mass Management System (MMS) is considered as an important tool within the operating system of commercial granite quarries which are spread across the southern peninsular India where huge deposits for exploiting both black and multicolored granite varieties occur. The history of commercial granite exploitation dates back to late sixties and is now considered as one of the commodities having potential for earning foreign exchange besides for employment generation in rural sector. With the exponential growth of the granite industry during recent times, the quarrying techniques have been advanced by adopting the State of the Art technology to suit its mass exploitation. Due to various geological factors like regional tectonics and associated structural styles viz. faults, folds, shear fractures, restrict its recovery to the minimal and as a result huge quantity of granite wastes generate in all the quarry fronts causing a major environmental problem. In this context, implementation of MMS in quarries play a vital role in enhancing its recovery percentage and also for proper upkeep of records quantifying the total mass generated within approved mining scheme period of five years vis a vis establishing the actual recovery of saleable blocks in that quarry. This will help the quarry owners not only to prognosticate the monthly production but also to safeguard at times of crisis whenever any dispute arise with Government authorities in quantifying the saleable blocks and for payment of huge penalty amount running to several crores of rupees. As such maintenance of such records is mandatory as per Granite Conservation and Development Rules 1999, it is observed that most of the quarries lack proper data or no scientific method adopted to quantify the total mass of granite excavated in a particular quarry month/year wise. Therefore, based on the problems experienced by quarry owners during recent times, it is apprehended the need for a scientific method viz MMS for implementation in quarries not only to defend themselves at times dispute with authorities but also to plan their quarry operations in a more meaningful manner*

KEYWORDS: Implementation, granite mass management system (MMS), commercial granite, quarries, Indian

INTRODUCTION

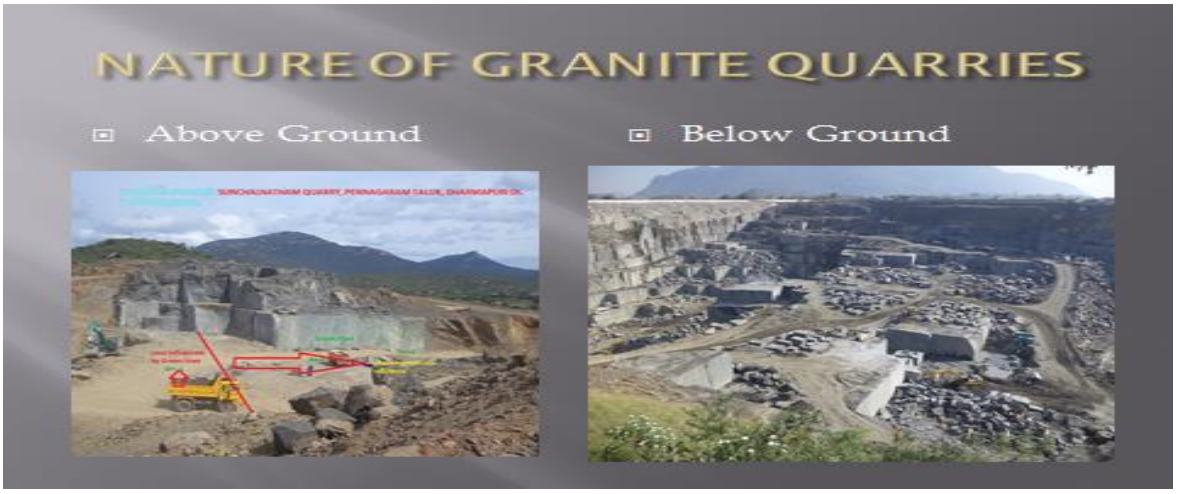
Commercial Granites in a Nutshell:

All over the World, shield areas are the best geological entities where vast resources of granites and other rock types occur. Indian sub-continent is a potential area for locating and exploiting such rock resources (Natarajan.V and Kanishkan.B (1995) . By now, it is well realized that India has vast and significant resources of multi-coloured granites mostly occurring within the Southern States. To quote a few examples, rocks like 'Ebony Black Granite of Sweden', 'Petit granite of Belgium', 'Black granite of South Africa', black varieties of China and black and multi-coloured granite occurrences of India are considered to be premium varieties in the World Market to-day. Atleast more than 200 attractive commercial names have been assigned to various rock types in the world marketed to-day, out of which atleast 80 types can be identified to occur in India alone. Today, Indian export of granites stands around Rs14,000 crores.

2. Scenario of Indian Granite Quarries :

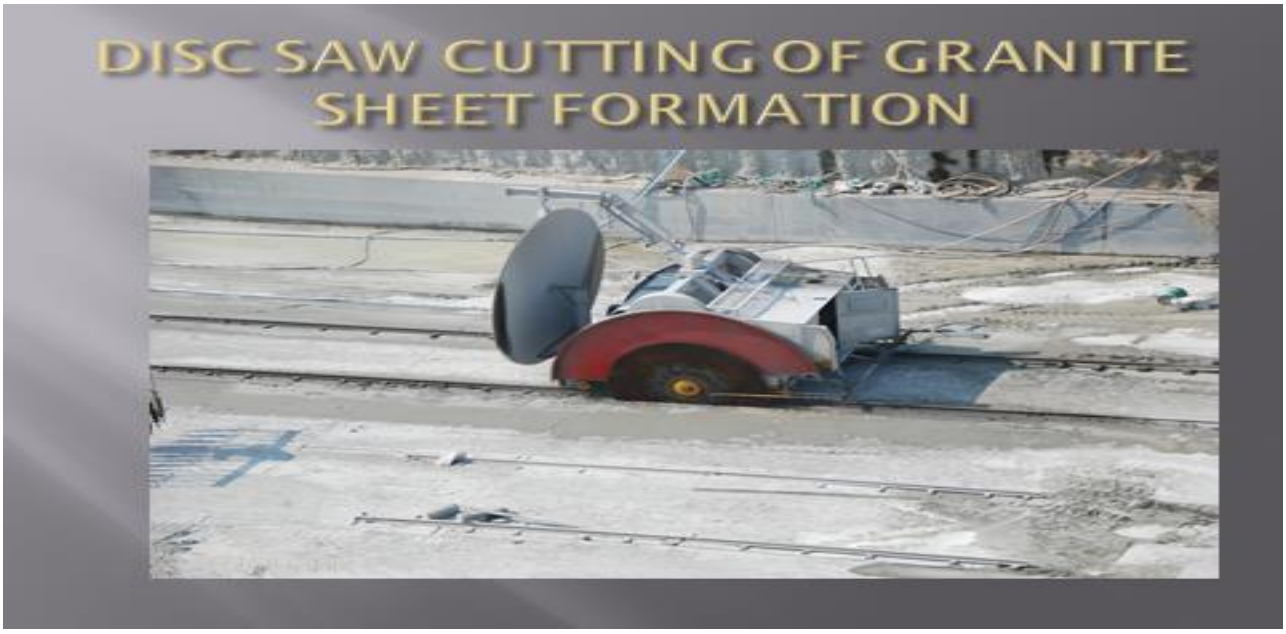
The Indian granite industry as on today has advanced at par with other European countries in applying the latest State of the art technology both in mining and in processing industries as compared to the conventional methods of mining carried out two decades back. Deployment of diamond wire cutting of sheet rocks, secondary splitting techniques facilitated not only in enhancing the recovery in quarries but also to minimize the generation of huge quantity of granite wastes to cause enormous environmental problems within such quarry clusters mainly due to non-liberalisation of rules by Government for its end use mainly in construction industry.

3. A glimpse of Granite quarry Operations:



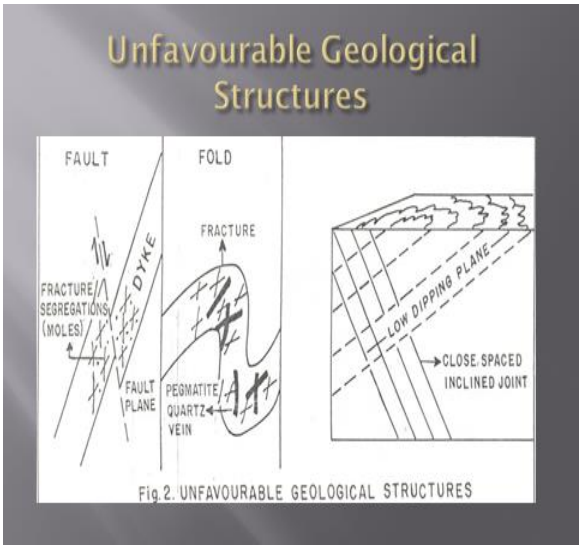
Diamond Wire Cutting

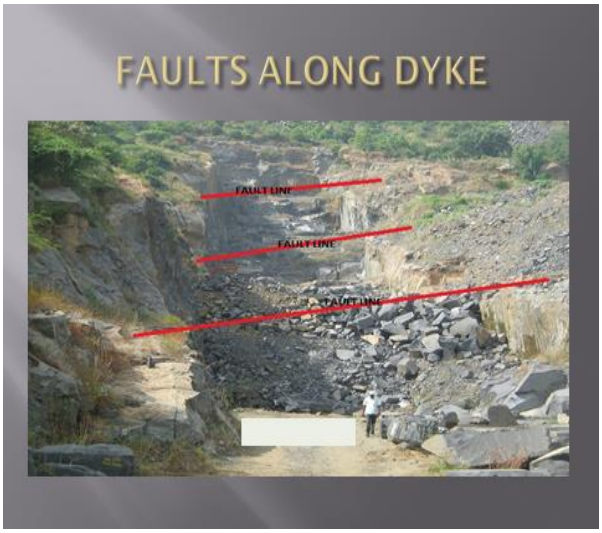
Air Sacs to push the Mass down



Geological Constraints in recovery of blocks in a quarry:

Though resource wise the potential for commercial granites including the black granites is unlimited, its exploitation is restricted by market preference besides other geological factors and as a result the failure rate of quarry operations is also quite high. Recovery in the quarries are quite low say less than 10% in black granite quarries and around 15 to 20% in multi-coloured quarries and in this context the geological factors like petrological and structural style of the formation play a dominant role. Regional geology and its tectonic style have a bearing on the individual quarries and its recovery. Therefore, the role of a GEOLOGIST with good hard rock mapping experience can help the quarry owners in minimising its failures as well as in identifying the potential pockets within the deposit to increase its recovery in quarry operations.





These structural architecture in a granite body play a significant role in determining the economic viability of any quarry/prospect. Normal geological structures encountered are mainly the joints, faults, shear, later intrusions etc. Critical geo-structural mapping of the granite deposits demarcating the zones of such influence of these structural disturbances will be the key indicator or a basic tool to bring out the geometry of the deposit which ultimately decides on the future of the operation. Regional geology combined with the study of individual tectonic belt characteristics help to interpret the deposit more prudentially. Such detailed study helps to demarcate the defective and productive zones within the Mining Lease area besides on quality of the material and will be the basic document for an investor to plan for deployment of expensive capital mining equipment and on methods of working, keeping in mind of both development and production components of the quarry.

GRANITE MASS MANAGEMENT:

The term MASS in granite quarries goes synonymous with the mining terminology the' RUN OFF MINE (ROM). This term nowadays has been widely used in most of the quarries and the implications and advantages are as follows:

i. Assessment of MASS/ROM in a quarry irrespective of its size and operation has become mandatory in preparation of Mining Plan/ Scheme for a period of five years.

ii. Based on the market demand and geological complications of the individual granite deposits, the recovery percentage has to be estimated for the scheme period more scientifically.

iii. Based on the combination of the recovery and production demand the mine planning in deployment of mining equipment to be considered to achieve the production target.

iv. Recovery in the quarry is a variable factor depending on the geological complexity of the deposit and accordingly Mass Quantification (ROM) during the period has to be done more prudentially so that the quarry operations have to be sustained for a long whether above ground or below ground operations.

v. Therefore, in most of the quarry clusters located in Chimakurthy belt, it is a thumb rule to adopt the Mass Planning for every month of quarry operation so that they will achieve the monthly targeted production irrespective of its recovery of the deposit viz. low/medium/better zones the quarry to advance during that month. Accordingly, proper planning to increase the drilling power and slicing techniques etc., have to be planned to achieve the Mass excavation.

vi. Quantification of Mass can be either in terms of Cubic metre (CBM) or in metric tonnes (MT) which includes quantity of overburden soil, weathered rock, saleable granite blocks(Gross Volume) besides huge quantity of waste rocks having defects to be dumped in the waste yard.

vii. As per GCDR 1999, the approved Mining Plan/Scheme of the quarry, the ROM quantity should be a constant factor and if exceeded, it is considered as a major violation to attract credible action under law both under GCDR and Environment Act and also may lead for determination of the Mining Lease. Therefore, the importance of the MASS/ROM planning in working quarries have to be realized and accordingly the quarry operations to be planned more prudentially.

viii. Government authorities periodically carryout Electronic Total Station Survey (ETS) to check the quantum of mass excavated vis a vis saleable quantity of granite blocks extracted based on the recovery percentage estimated in the Mining Plan/Scheme period by fixing the datum line (RL-Relative Level) indicated at the time of commencement of the Scheme period. In this context, it is observed that there is a huge gap/variation in quantity assessment both mass and saleable quantity of blocks by this volumetric method of survey ignoring the geological inputs. This anomaly will be a causative factor in terms of assessing the penalty running to several crores of rupees.

ix. Considering the recent incidents in certain States, the importance of maintaining the Mass/Recovery records in the statutory registers become imperative in order to

substantiate the variations pointed out by the Government by use of a semi-quantitative method which is not a scientific one to accept.

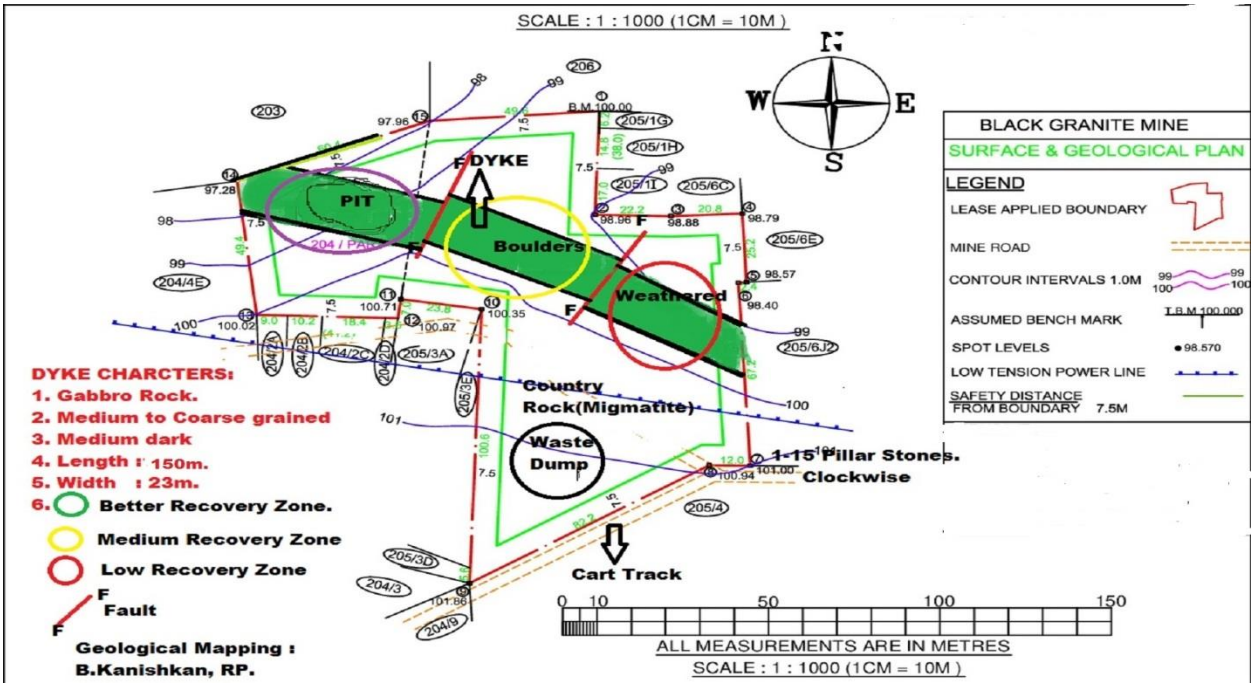
x. Implementation of Mass Management System (MMS) based on geological attributes combined with RL data, Mass Catalogue details and data on recovery in each of the slices and by adopting other mass monitoring mechanism is a pragmatic solution to counter any such problems that may arise in future during the period of Mining operation.

In short, the MMS is similar to Enterprise Resource Planning (ERP) software used for complete planning besides documentation of entire input and the output in an Enterprise but the scope of MMS is restricted to its main objective of scientific assessment of Recovery percentage and quantification of ROM in a quarry during a particular period of time**.**

Key inputs for adopting the Mass Management System (MMS):

Implementation of MMS in a quarry requires the following key inputs:

i. A DGPS Survey plan of the Mining Lease area indicating the bench mark/RL and contours of the ML area.
ii. A Geo-structural map of the quarry demarcating the structural defects like interception of faults, folds, shear, intrusion of black bands etc., highlighting the defective and productive zones based on the recovery factor of the quarry. A sample of the combined map of a quarry is shown below:



iii. Bed rock profiling in a virgin deposit by using Ground Penetrating Radar (GPR) to demarcate the overburden thickness and the weathered zone in a below ground deposit.

iv. Based on all these scientific inputs, the Mining Plan/Scheme which is mandatory under GCDR and for Environment Act, a scientific prognostication of year wise mining scheme for a period of five years can be prepared highlighting the total Mass removal/ROM during that period.

Monitoring mechanism of MMS in day to day operation of the quarry:

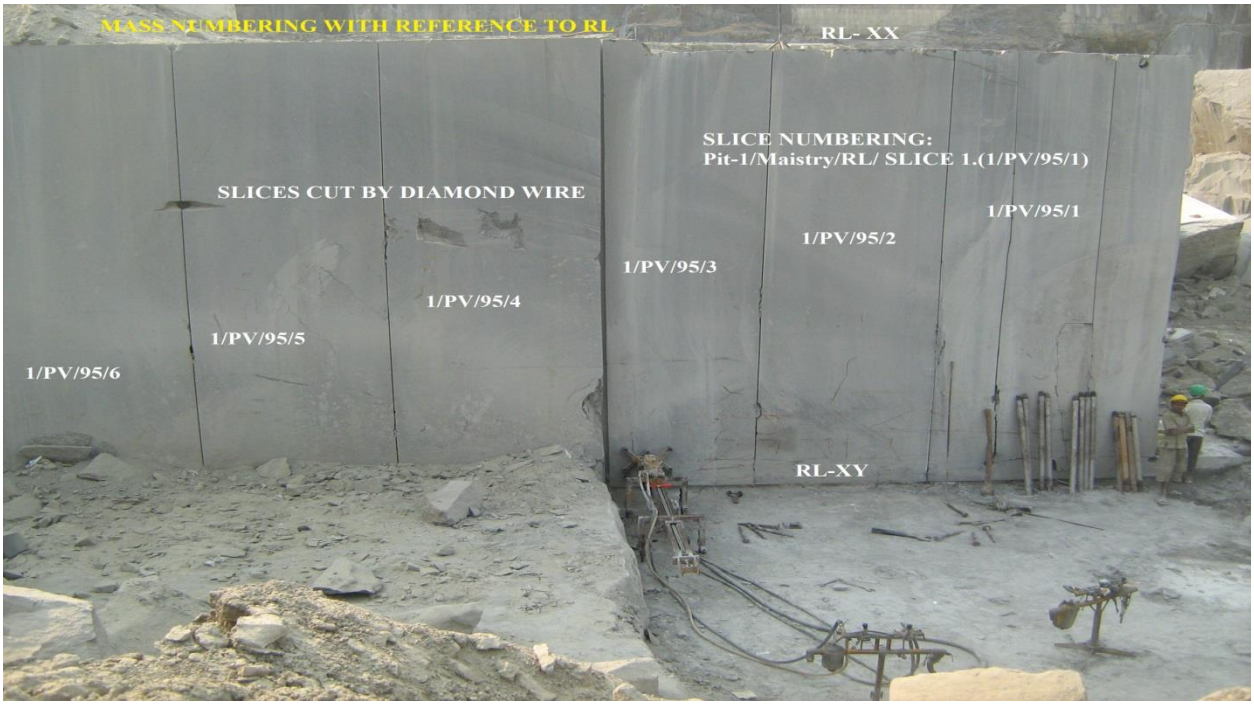
Monitoring of MMS in a quarry requires the following data:

i. Monthly Planning of area of operation considering the men and machinery resources with reference to its RL and estimating the total quantum of Mass removal in that identified sheet area. RL can be easily measured with the help of hand held GPS.

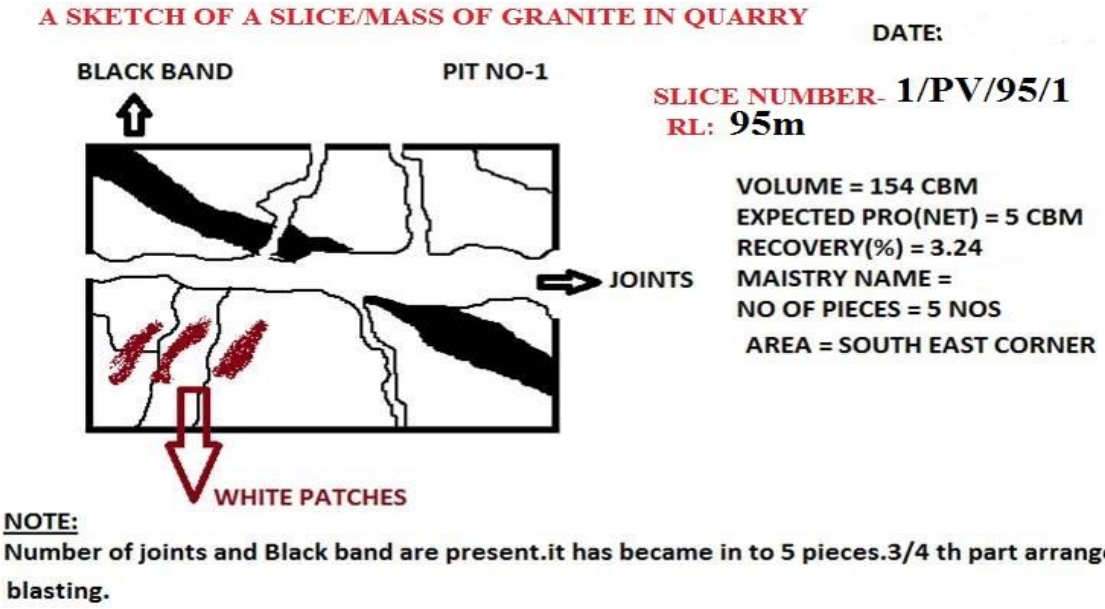
ii. Once the area of operation is demarcated, the geological interferences as mentioned above to be examined to cut open the faces.

iii. The estimated work load has to be monitored day wise movement of quantity of mass in dumpers/loaders, which account for both undressed saleable blocks and the waste rock mass having defects The following picture will show the Total quantum of Mass removal including the Over burden and sheet rock in section of a quarry.

iv. Once the sheet rock slices are cut by using the Diamond wire saws, numbering them with reference to Pit, Initial of the Maistry, RL of the Mass (sheet rock) followed by serial number of each cut as shown below. According to convenience numbering can be modified to suit the location. The main advantage of numbering with reference to RL is that we can easily identify the behavior of the sheet formation as well as its recovery at different levels of operation in the past and to prognosticate the future pattern of the natural of sheet formation at depth.



v. Each slices of the Mass to be sketched with a number and date and recovery to be documented for future reference as shown below:

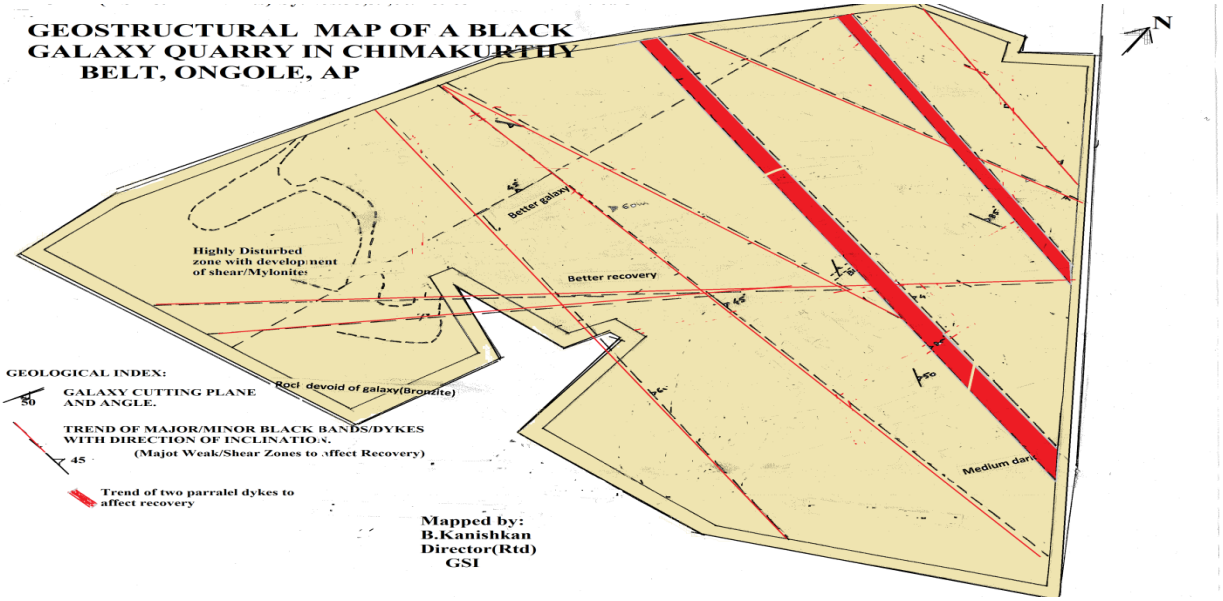


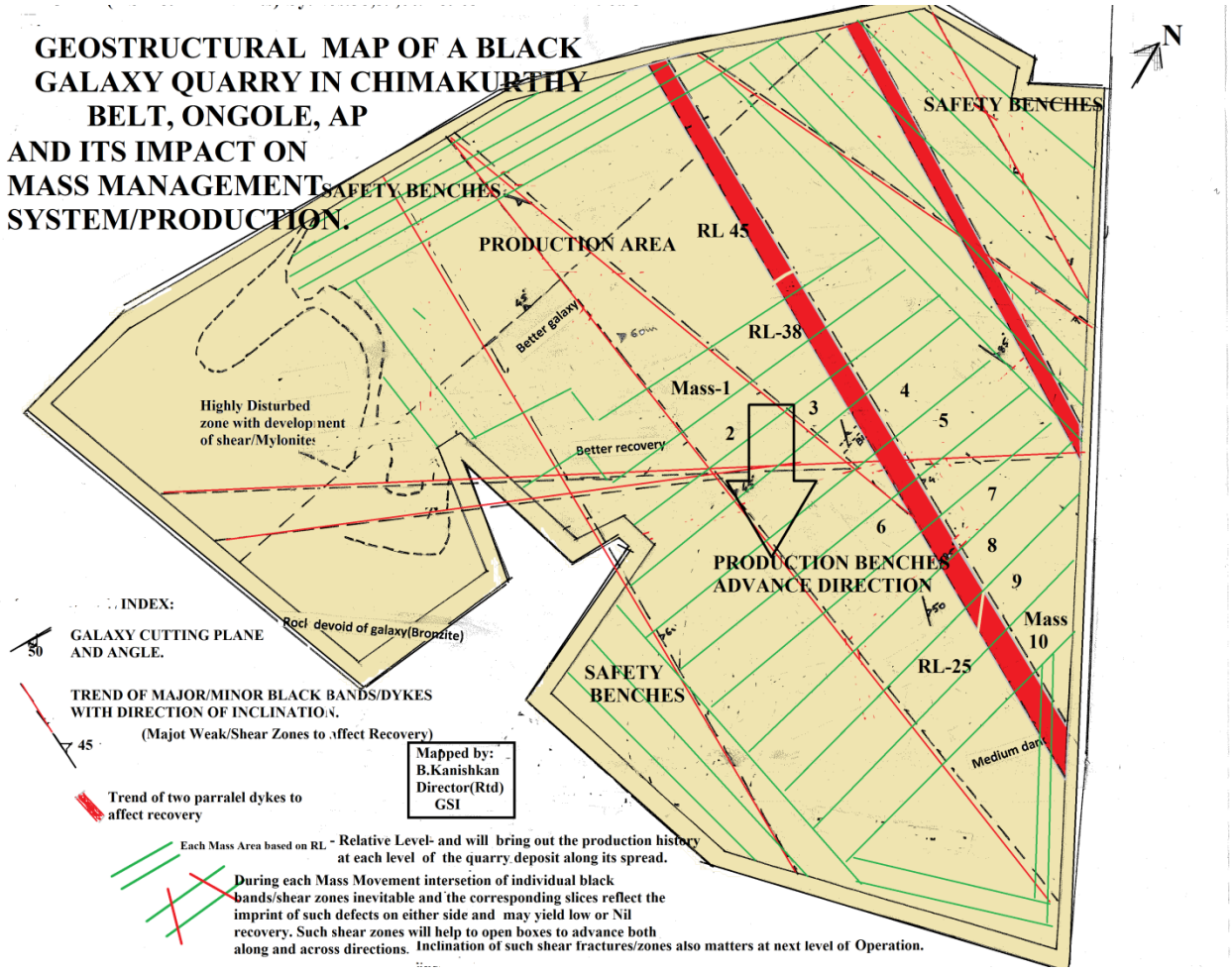
vi. Individual numbering of blocks at the next stage dressed from each of the above slices can be made suitably hiding the pit characteristics and ageing data for the reason some

of the Buyers have the tendency to skip the blocks for inspection superficially looking at the number by tracing its origin/location and date of dressing whether it is new or old ones. In this context, instead of serial numbering alpha numerical can be used with some codes like PZ/XX on the block. If you feed this code in the computer, the history of the block will be known. BAR CODING is also a best option to number the blocks.

SUCCESSFUL IMPLEMENTATION OF MMS IN ONGOLE BLACK GALAXY QUARRIES:

The occurrence of black galaxy deposit in Chimakurthy pluton, Ongole belt, Andhra Pradesh is unique in the world and the demand for the material for all it block sizes is unimaginable for more than two decades. Though the occurrence is confined to around 5 sq.km area, more than 50 quarries are actively engaged in exploiting this material and the nature of quarry operation is below ground and most of them have reached a depth below 50-60m from ground level. The geologically, the deposit is intercepted with a number of shear zones manifested in the form of linear black bands/dykes and as a result, development of black/ white lines predominantly seen both along and across the deposit of each mine area. The recovery of block on an average is around 6-8% only on net volume of sales. Therefore, it is imperative to study the geo-structural pattern of each quarry and its foliation direction along which plane only the golden galaxy is visible and any wrong direction of cutting will spoil the recovery. With all these constraints in exploitation of the deposit, large investment on Mining Machineries is mandatory for removal of huge quantity of rock mass in a particular month to achieve the monthly production target with a low recovery percentage. Implementation of Mass Management System (MMS) within this cluster is found to be the most successful tool in winning the material over decades. Following maps and pictures will elucidate further on the success of MMS within the belt. The same system can be used in any granite deposit either, black or multi-coloured, below or above ground deposits.


GEOSTRUCTURAL MAP OF A BLACK GALAXY QUARRY IN CHIMAKURTHY BELT, ONGOLE, AP
N
Highly Disturbed zone with development of shear/Mylonites
Better galaxy
Better recovery
Rock devoid of galaxy(Bronzite)
Medium dark
GEOLOGICAL INDEX:
GALAXY CUTTING PLANE AND ANGLE.
TREND OF MAJOR/MINOR BLACK BANDS/DYKES WITH DIRECTION OF INCLINATION.
(Major Weak/Shear Zones to affect Recovery)
45
Trend of two parralel dykes to affect recovery
Mapped by:
B.Kanishkan
Director(Rtd)
GSI


GEOSTRUCTURAL MAP OF A BLACK GALAXY QUARRY IN CHIMAKURTHY BELT, ONGOLE, AP AND ITS IMPACT ON MASS MANAGEMENT SYSTEM/PRODUCTION.
N
SAFETY BENCHES
SAFETY BENCHES
PRODUCTION AREA
RL 45
RL-38
RL-25
Mass-1
Mass 10
Better galaxy
Better recovery
Highly Disturbed zone with development of shear/Mylonites
PRODUCTION BENCHES ADVANCE DIRECTION
SAFETY BENCHES
Rock devoid of galaxy(Bronzite)
Medium dark
INDEX:
GALAXY CUTTING PLANE AND ANGLE.
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Each Mass Area based on RL - Relative Level- and will bring out the production history at each level of the quarry deposit along its spread.
During each Mass Movement intersetion of individual black bands/shear zones inevitable and the corresponding slices reflect the imprint of such defects on either side and may yield low or Nil recovery. Such shear zones will help to open boxes to advance both along and across directions. Inclination of such shear fractures/zones also matters at next level of Operation.


RL BASED PLATFORM
FOR MASS REMOVAL IN
A QUARRY, ONGOLE


A CLOSER LOOK OF SYSTEMATIC REMOVAL OF MASS IN A PARTICULAR MONTH INTERCEPTING THE SHEAR AND OTHER DEFECTIVE ZONES ALONG ITS LINE OF ADVANCEMENT.
TOTAL MASS REMOVAL IN A MONTH (TARGET) DETERMINES THE MONTHLY PRODUCTION WITH A LOW RECOVERY.

CONCLUSION

The history of Commercial granite quarrying in India dates back to late 1960s and today it has emerged out as a major potential source to tap ornamental stones to meet the global demand. The technology adopted in Quarrying and Processing has become a world class. However, the quarry owners at times get in to problem while Government authorities inspect and reassess the quantum of saleable blocks recovered at a period of time based on volumetric survey of the pit, which is only a semi-quantitative technique adopted by them and may not establish their objective scientifically. In this context, it is logical to incorporate the volumetric survey data with geological inputs which are variable in a natural formation from one RL to another RL of exploitation at depth within the same quarry, and from one quarry to another, and from one terrain to another. Therefore, implementation of Mass Management System(MMS) with the inputs of geological data of each of Relative Levels (RL) of Granite Mass will more or less accurately estimate the recovery in that particular level as well as to estimate the total waste generation. This data is not only helpful for upkeep of the records more scientifically but also to safeguard the investors at times of difficult situations as mentioned above to establish their stand under scientific consideration. Further, the MMS is based on RL and the data will be much useful to back track the recovery at any level of operation in the past and to prognosticate for the future operation at depth.

REFERENCE

Anttonen M, Kumpula J, Colpaert A. Range selection by semi-domesticated reindeer (*Rangifer tarandus tarandus*) in relation to infrastructure and human activity in the boreal forest environment, northern Finland. Arctic. 2011:1–14.

Appleton J, Weeks J, Calvez J, Beinhoff C. Impacts of mercury contaminated mining waste on soil quality, crops, bivalves, and fish in the Naboc River area, Mindanao, Philippines. Sci Total Environ. 2006;354:198–211.

Chetty T.R.K, Yellappa.T, Santosh.M. Crustal architecture and tectonic evolution of the Cauvery Suture zone, Southern India. Journal of Asian Earth Science(2016)

District Resource Map of Dharmapuri district, GSI (1996).

Dudka S, Adriano DC. Environmental impacts of metal ore mining and processing: a review. J Environ Qual. 1997;26:590–602.

Fleming DA, Measham TG. Local job multipliers of mining. Resour Policy. 2014;41:9–15.

Geological Map of TamilNadu and Puducherry(0.5million Scale) published in 1995.

Gibson G, Klinck J. Canada's resilient north: the impact of mining on aboriginal communities. Pimatisiwin. 2005;3:116–39.

Gopalakrishnan.K, Venkat Rao.V, Viswanathan.T.V.Role of palaeo sutures in the evolution of Southern Indian Granulite Terrain-Group discussion on suture zones-Young & Old. Wadia Institute of Himalayan Geology(1990).

Hilson G. An overview of land use conflicts in mining communities. Land Use Policy. 2002;19:65–73.

Hossain D, Gorman D, Chapelle B, Mann W, Saal R, Penton G. Impact of the mining industry on the mental health of landholders and rural communities in southwest Queensland. Aust Psychiatry. 2013;21:32–7.

Jain R, Cui Z, Domen J. Environmental impact of mining and mineral processing: management, monitoring, and auditing strategies. Oxford: Butterworth-Heinemann; 2016.

Jain R, Cui Z, Domen J. Environmental impacts of mining. In: Jain R, Cui Z, Domen J, editors. Environmental impact of mining and mineral processing: management, monitoring, and auditing strategies. Amsterdam: Elsevier; 2016. p. 53–157.

Johnson CJ, Boyce MS, Case RL, Cluff HD, Gau RJ, Gunn A, Mulders R. Cumulative effects of human developments on arctic wildlife. Wild Monogr. 2005;160:1–36.

Joy.Gopal Ghosh et.al Age and Tectonic evolution of Neoproterozoic ductile shear zones in SGT of India with implications of Gondwana Studies.Volume 23 published in Tectonics.(2004).

Kanishkan.B. Selection Criteria for dimensional stone granites in India, published in National Symposium on Commercial Granite volume (1995).

Keeling A, Sandlos J. Ghost towns and zombie mines: the historical dimensions of mine abandonment, reclamation, and redevelopment in the Canadian North. In: Bocking S, Martin B, editors. Ice Blink: Navigating Northern Environmental History; 2011. p. 377–420.

Knobblock EA, Pettersson Ö. Restructuring and risk-reduction in mining: employment implications for northern Sweden. Fenn Int J Geogr. 2010;188:61–75.

Krishna Rao.A.V, Nathan.N.P, Petrography and petrochemistry of the basic dykes of Harur-Dharmapuri and Kaveripatnam-Mattur Sections in Dharmapuri and Vellore districts. Tamil Nadu. Progress Report of GSI F.S 1994-95, May 1996 uploaded in GSI Portal.

Krishna Rao.A.V, Nathan.N.P, Petrography and petrochemistry of the mafic dykes of Krishnagiri-Tiruppattur-Chengam areas, Dharmapuri and Vellore districts, Tamil Nadu. GSI report uploaded in portal(1999).

Loayza N, Rigolini J. The local impact of mining on poverty and inequality: evidence from the commodity boom in Peru. World Dev. 2016;84:219–34.

Mchaina D. Environmental planning considerations for the decommissioning, closure and reclamation of a mine site. Int J Surf Min Reclam Environ. 2001;15:163–76.

Mitchell CJ, O'Neill K. The Sherriff Creek Wildlife Sanctuary: further evidence of mine-site repurposing and economic transition in northern Ontario. Extr Ind Soc. 2017;4:24–35.

Miyazaki et.al. Rb-Sr Geochronology, Nd-Sr Isotopes and whole rock chemistry of Yelagiri and Sevattur Syenites, TamilNadu, South India. Gondwana Research (Jan.2000).

Nakazawa K, Nagafuchi O, Kawakami T, Inoue T, Yokota K, Serikawa Y, Cyio B, Elvince R. Human health risk assessment of mercury vapor around artisanal small-scale gold mining area, Palu city, Central Sulawesi, Indonesia. Ecotoxicol Environ Saf. 2016;124:155–62.

Natarajan.V.Kanishkan.B. Availability of Granite Raw Materials in India, published in National Symposium on Commercial Granite volume (1995).

Navarro M, Pérez-Sirvent C, Martínez-Sánchez M, Vidal J, Tovar P, Bech J. Abandoned mine sites as a source of contamination by heavy metals: a case study in a semi-arid zone. J Geochem Explor. 008;96:183–93.

Radhakrishna and Mathew Joseph –Proterozoic paleomagmatism of South Indian shield and Tectonic constraints in continental crust of south India.Journal of Geological Society of India.Volume.25.

Sarmistha Mukhopadhyay et.al Significance of mineral chemistry of syentes and associated rocks of Elagiri Complex, Southern Granulite Terrane of Indian Shield.Journal of Geological Society of India.Volume 77.

Sonter LJ, Moran CJ, Barrett DJ, Soares-Filho BS. Processes of land use change in mining regions. J Clean Prod. 2014;84:494–501.

Stephens C, Ahern M. Worker and community health impacts related to mining internationally: a rapid review of the literature. 2001.

Swenson JJ, Carter CE, Domec J-C, Delgado CI. Gold mining in the Peruvian Amazon: global prices, deforestation, and mercury imports. PLoS ONE. 2011;6:e18875.

The Sustainable Development Working Group (SDWG) of the Arctic Council. Circumpolar Information Guide on Mining for Indigenous Peoples and Northern Communities. 2011.

Veiga MM, Hinton JJ. Abandoned artisanal gold mines in the BrazilianvAmazon: a legacy of mercury pollution. In: Natural resources forum. Wiley Online Library. 2002. p. 15–26.

Warhate S, Yenkie M, Chaudhari M, Pokale W. Impacts of mining activities on water and soil. J Environ Sci Eng. 2006;48:81–90.

Zhang X, Yang L, Li Y, Li H, Wang W, Ye B. Impacts of lead/zinc mining and smelting on the environment and human health in China. Environ Monit Assess. 2012;184:2261–73.