The Dynamics of Geo-Mining Aspects that Control the Recovery Percentage in Commercial Granite Quarries - A Case Study from the Black Galaxy Granite Deposit of Ongole, India

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Abstract - Understanding the dynamics of Geology and Mining aspects in Commercial Granite Quarries are the foremost and fundamental aspects which ultimately determine the success and failure of quarry operations.The study involves establishingthe geometry of the prospect which broadly includes an in depth study on regional geology, micro analysis on geomorphology, petrography, structure and its impact on recovery in the quarry. All these factors ultimately decide on the investment plan and production prognostication besides on the marketing strategy.The implications of the study is correlatedwith a case study of a premium black galaxy granite quarry locatedin Chimakurthy belt, Ongole district, Andhra Pradesh, India.

I. BACKGROUND INFORMATION

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. By now, it is well realized that India has vast and significant resources of multi-coloured granites in States like Andhra Pradesh, Tamil Nadu, Karnataka, Orissa, Gujarat, Rajasthan, Kerala, Madhya Pradesh, Uttar Pradesh, Assam and Bihar. Similarly basic/mafic and ultrabasic/ultramafic dykes, anorthosite, alkaline rocks etc., are also found in association with granites and gneiss in these states.Though resource wise, the potential appears to be quite encouraging, it is always a buyers' preference, which controls or even sometimes restricts the demand to certain types having special colour, texture, dimension, and amenability to take polish, mine ability etc. It is quite obvious that the buyers' terminology, which sometimes is exotic and fanciful, somewhat over imprints and even discusses the geological terminology, with the result that commercial nomenclatures like "black granite" is widely used for basic and ultramafic rocks in general and "Multi coloured Granite is used for a variety of rocks of granite family, anorthosite, syenite, leptynite etc., Atleast more than 200 attractive commercial names have been assigned to various rock types in the world marked to-day, out of which atleast 80 types can be identified to occur in India also.(Natarajan.V& B.Kanishkan.1995)

II. GRANITE DEPOSIT CHARACTERIZATION

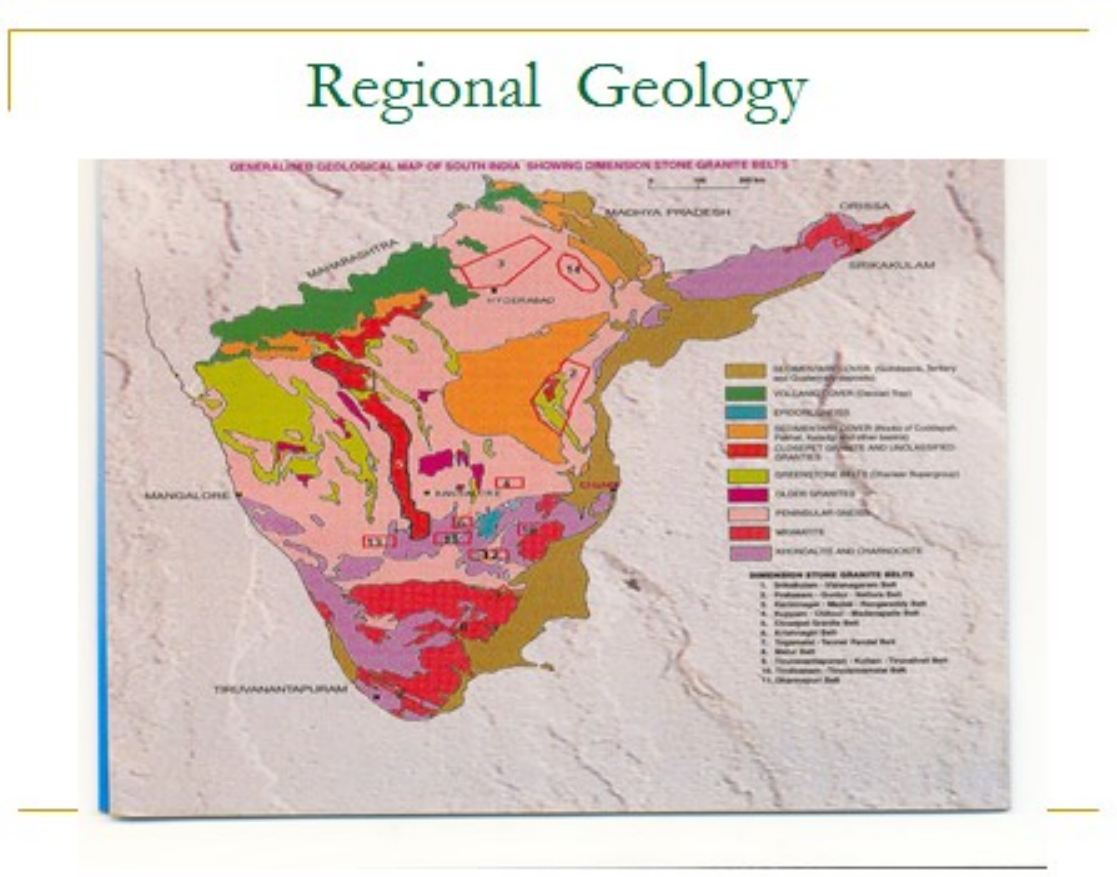
The granite deposit characterizationbroadly includes the following:

- Compilation of regional Geological data.
- Geomorphology & sheet characteristics.
- Petrography. design, fabric and colour characteristics of the rock formation.
- Micro analysis of the structure / geometry of the formation and its impact on recovery of saleable blocks- The most important factor that decides on success of a quarry operation and its life.

a) Compilation of Regional Geological Data.

Regional geological data of a particular terrain where the prospect lies is vital to understand the various rock types occurring and the regional structures like lineaments, major joint pattern and more important on regional shear

pattern which are more related to tectonic features of the area. All these factors can be mainly sourced from the published geological maps and literatures of Geological Survey Of India(GSI). Regional variations in particular the major shear and intrusive pattern will have an impact on the prospect under study and that is why the importance being stressed in this paper.



(Source : Published map of GSI)

b)An in depth study of the Prospect:
i)Geomorphology and Sheet characteristics:

The geomorphology of the prospect under study like above (Hill) and below ground (Plain) and the nature of occurrence of boulders, sheet formation, slope of the area and orientation of small streams soil and weathering pattern will help to infer on the depth of occurrence of sheet rock especially in below ground deposits.

ii)Petrography. design, fabric and colour characteristics of the rock formation:

Petrographic studyincludes bothmegascopy and microscopy to understand the nature of variations of the formation both along and across the deposit like colour design and pattern variations which are vital in determining its price and demand in the global market. Inclusions like black patches intrusive patterns that affect the recovery in multi-coloured granite deposits and inclusions like white moles, lines colour variations like light and dark with its background shades like brown, blue and green in black granite decide on the price and success of exploitation.

iii) Micro analysis of the structure / geometry of the formation and its impact on recovery of saleable blocks:

Geological structures like joint/ fracture pattern, folds, faults, shears play a vital role in determining the success and failure ofany quarry operation vis- vis the recovery percentage. Most of these geological structures are corroborated with the regional structural pattern of the terrain anddirectly related to the tectonic aspects of its origin. Therefore, we need to study them carefully and to analyze in the field and plot them systematically on the geological map/plan and interpret its impact like intrusion of foreign material viz. pegmatite/quartz vein etc. More interference of such geological structures in the study area/prospect and interception while quarrying will decide on the recovery both at the surface and at depth of quarrying. One should not ignore such structures when interfering in operation. Following geological structures which favour and disturbs in operation are highlighted:

Rocks in general have undergone more than one phase of deformations and accordingly exhibit a variety of geological structures which have a definite bearing on the degree of commercial exploitation.

Favourable geological structures (Kanishkan.B) normally facilitate easy recovery of blocks of desired export sizes with minimum usage of men, material and machinery forces. The presence of such favourable structures viz. sheet joints; vertical joints; steep dipping foliation planes; migmatitic structures etc. in a granite deposit can enhance the recovery percentage in quarry operations besides on value addition by way of producing of big gang saw size blocks.

Favourable Geological Structures

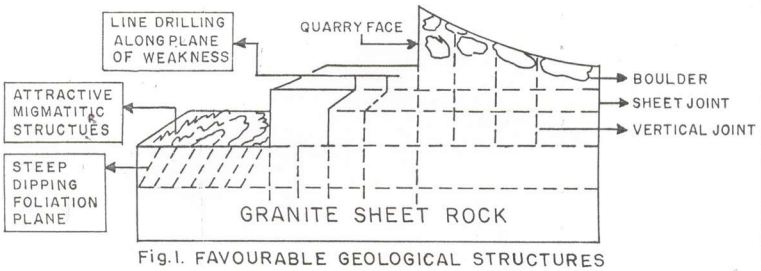


Fig.1. FAVOURABLE GEOLOGICAL STRUCTURES

Favourable Geological Structures

- FAULTSare common structural features in black granite dykes that exhibit dextral and sinistralmovements along its 'Run' which decide on the recovery percentage in that quarry.

Unfavourable Geological Structures

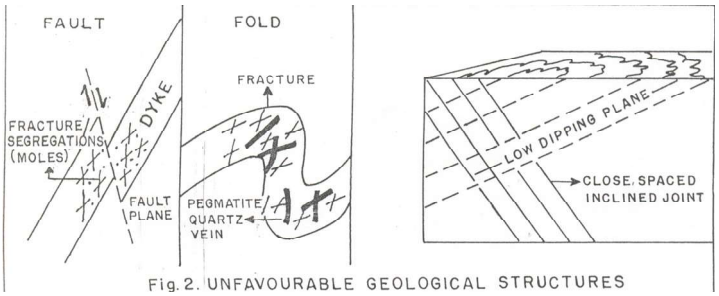


Fig. 2. UNFAVOURABLE GEOLOGICAL STRUCTURES

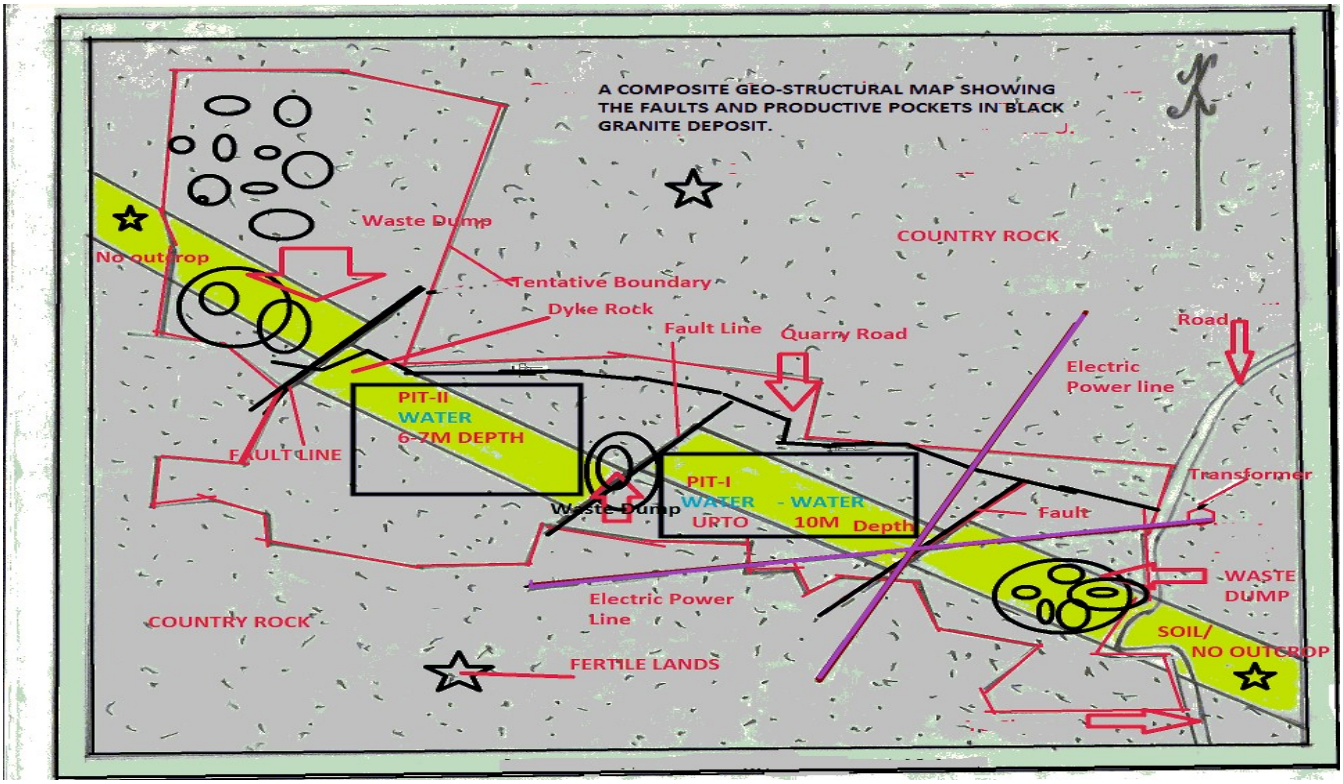
- SHEAR FRACTURES are normally associated within the structurally disturbed zones. The effects of minor shear in a granite deposit is manifested in the form of thin and linear nerve like fractures cross-cutting the formation which are harmful to quarry operations.
- Disastrous geological structures are harmful in totality in granite operations. These structures are of regional phenomena like the lineament zone, major shear zone, suture zone, active fault zone etc.

Sheared Dyke

iv. PREPARATION OF A COMPREHENSIVE GEOLOGICAL MAP:

The critical analysis of all these factors facilitate in preparation of a comprehensive Geological Map of the prospect delineating the zones of productive, defective and promising which ultimately decide on recovery percentage and reserve estimation of the prospect. The geological map will indicate the nature of the deposit, its

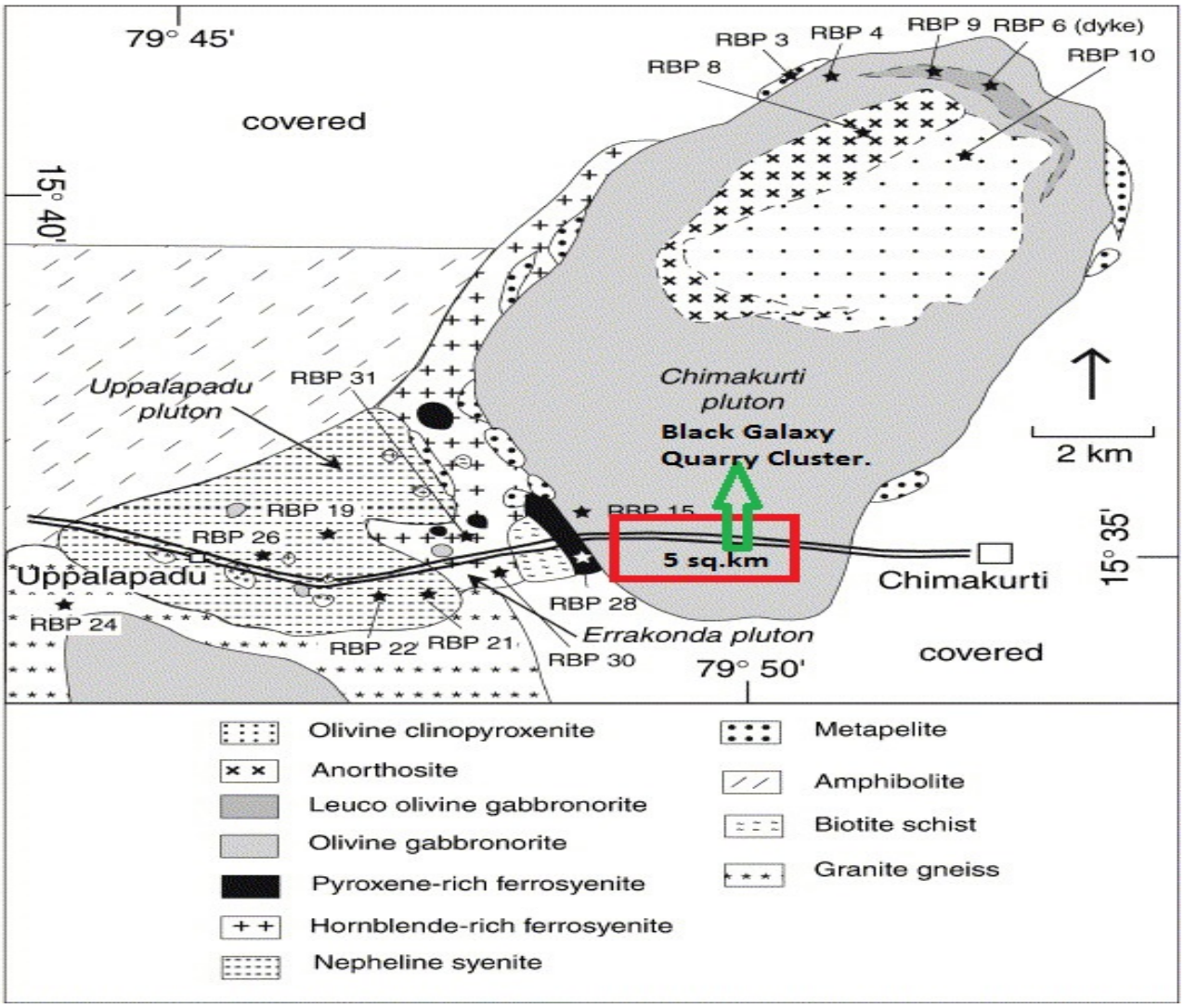
orientation, quality variation besides on the structural discrepancies of the deposit. Based on the accuracy and precision of the geological plan one can make out the investment and Mining Plan for exploitation of the deposit. The accuracy of the interpreted geological plan depends on the field and quarry knowledge of the Geologist who prepares it. This is the basic tool for preliminary assessment of recovery percentage of the virgin quarry and the authenticity of this data can be corroborated with the actual mining data.



(Map prepared by Kanishkan.B)

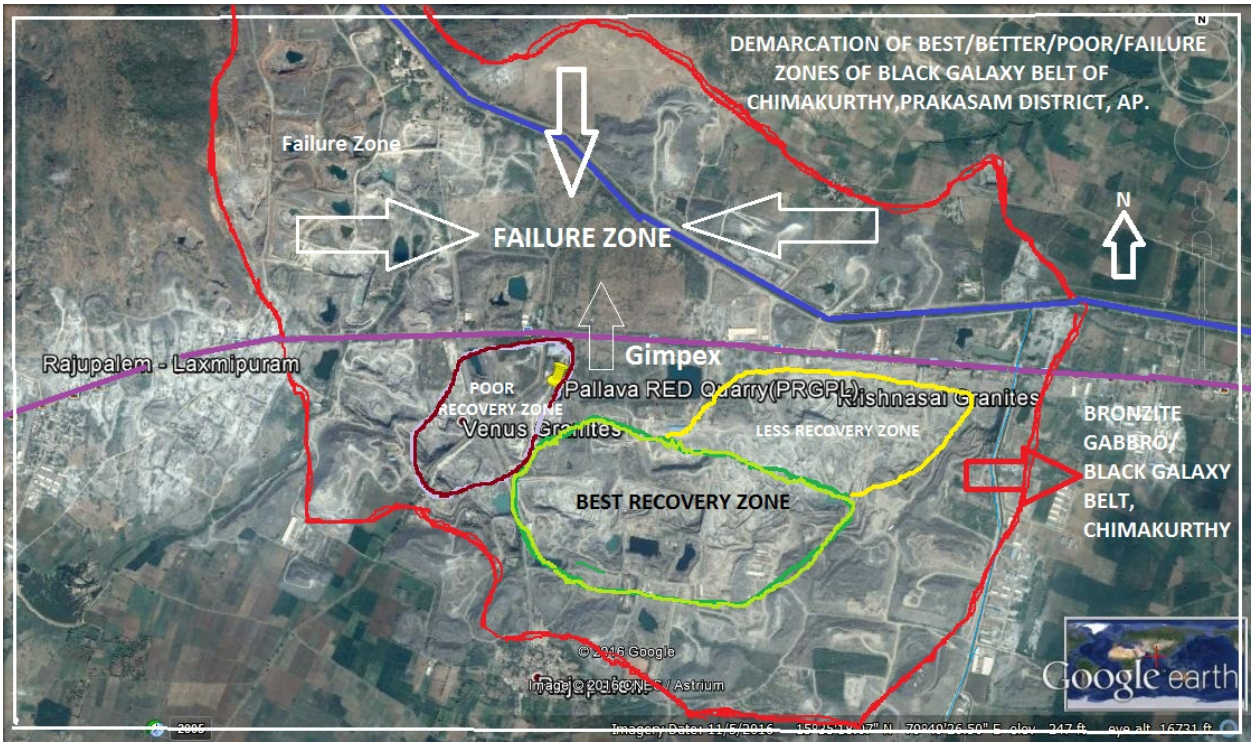
III. BLACK GALAXY GRANITE BELT, CHIMAKURTHY, ONGOLE DISTRICT,ANDHRA PRADESH- A CASE STUDY:

The occurrence of black galaxy deposit(bronzite gabbro) within the Chimakurthy layered complex is unique in the world considering its expanse(5 sq.km) of its occurrence and massiveness of quarry operation within the belt.

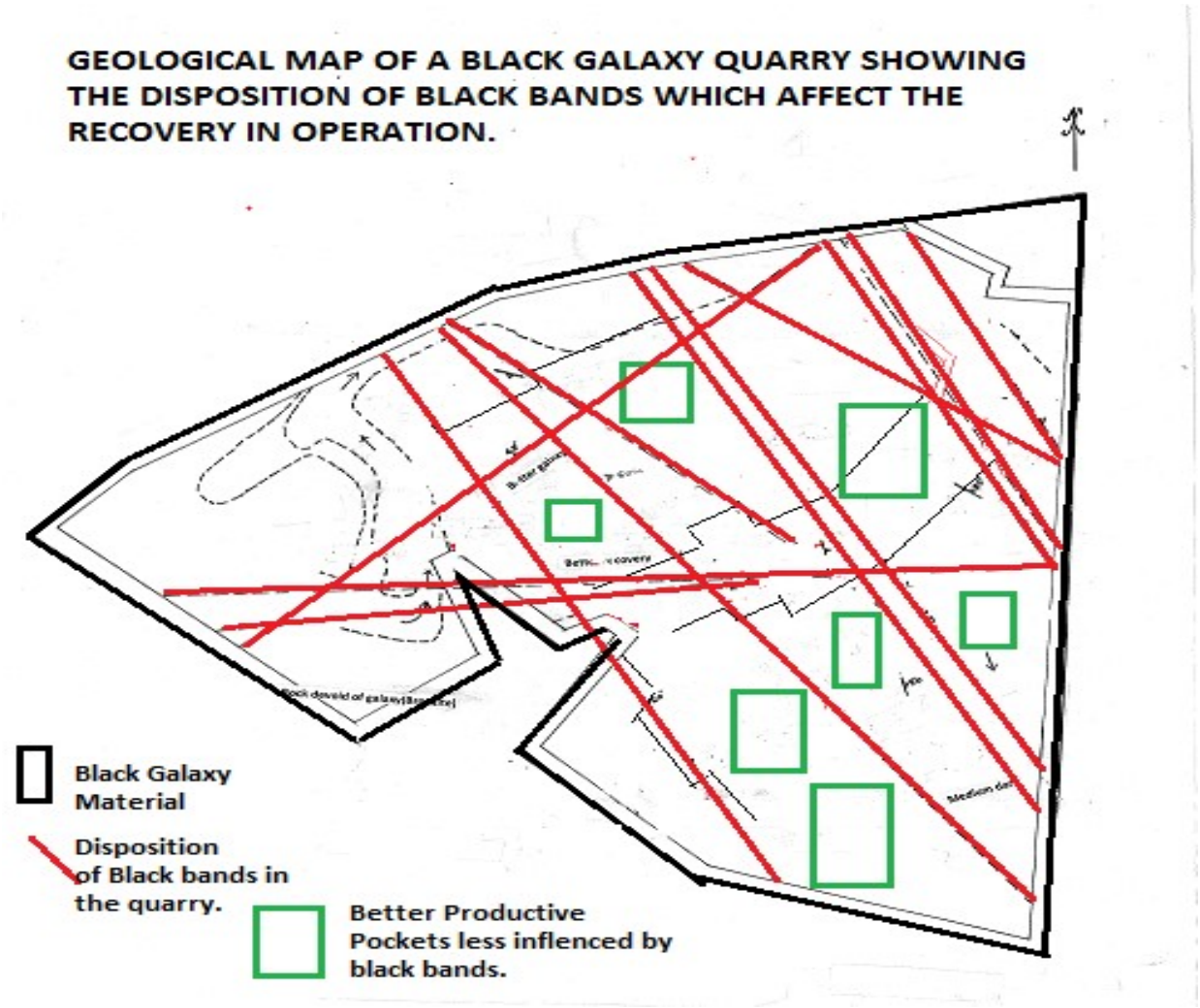


GEOLOGICAL MAP OF CHIMAKURTHY BELT(Volume 97, Issues 1–2, August 2007, Pages 30-57 of Lithos Journal)

The Black galaxydeposit inChimakurthy belt, Andhra Pradesh, India is being quarried since nineties and more than 50 quarries are in operation within this belt. The material is in great demand in the world market and the export price is around 1050 USD/Cbm(net). The quarries are operated below ground and the area is composed of a thin soil cover followed by 2-3 m thickness of weathered zone and below which occurs the black galaxy sheet rock. The bronziteminerals areembedded along the foliation plane and exhibit the golden yellow galaxiesand therefore the cutting plane to expose the galaxy is perpendicular to the foliation direction and any wrong cutting of blocks while quarrying will not expose the galaxy spread. Further, the deposit is intruded by a series of fine grained lineardykes (black bands) mainly oriented along E-W NE-SW and NW-SE directions. The thicknesses of these bands vary from a few cm to 2-3m wide and the inclination of these black band may be either vertical or inclined at depth. All these factors affect badly in recovery of blocks both in size and volume. On an average the recovery percentage within this beltranges between 5 to 8 % only. The effect of such geological disturbances in production is narrated below with the observations made in the quarry operated within this belt.



GOOGLE IMAGE SHOWING THE SPREAD OF BLACK GALAXY QUARRIES



(Geological Map prepared by Kanishkan.B)

i) Impact of shear/ black band intrusions within the deposit in over all production in the quarry:

- Adjacent to the zone of intrusion within the deposit will have black lines/white lines or shear fractures and moles- Nil Recovery.
- In some places the foliation planes exhibit tilting nature and as a result regular method of cutting of blocks will miss the galaxy plane.
- Better productive pockets within the quarry can be demarcated based on the displacement of black bands(Green boxes as shown in the above map)
- Inclination of the black bands at depth may give wrong prediction of production in the next level occurring just below the bench having better recovery.
- Based on the disturbances in the quarry, the quality of the blocks do show background colour variation from dark to light besides the dissemination pattern of galaxy. All these factors decide on the price and marketing potential.
- Based on the behavior of these black bands within the quarry spread one can prognosticate the production every month while the quarry is advancing systematically duly considering the better and defective zones.
- Therefore, it is a thumb rule within this Galaxy belt the Mass excavation(ROM) in a month is the deciding factor on the production achievement.

ii) Following pictures elucidate the impact of these structures in production.

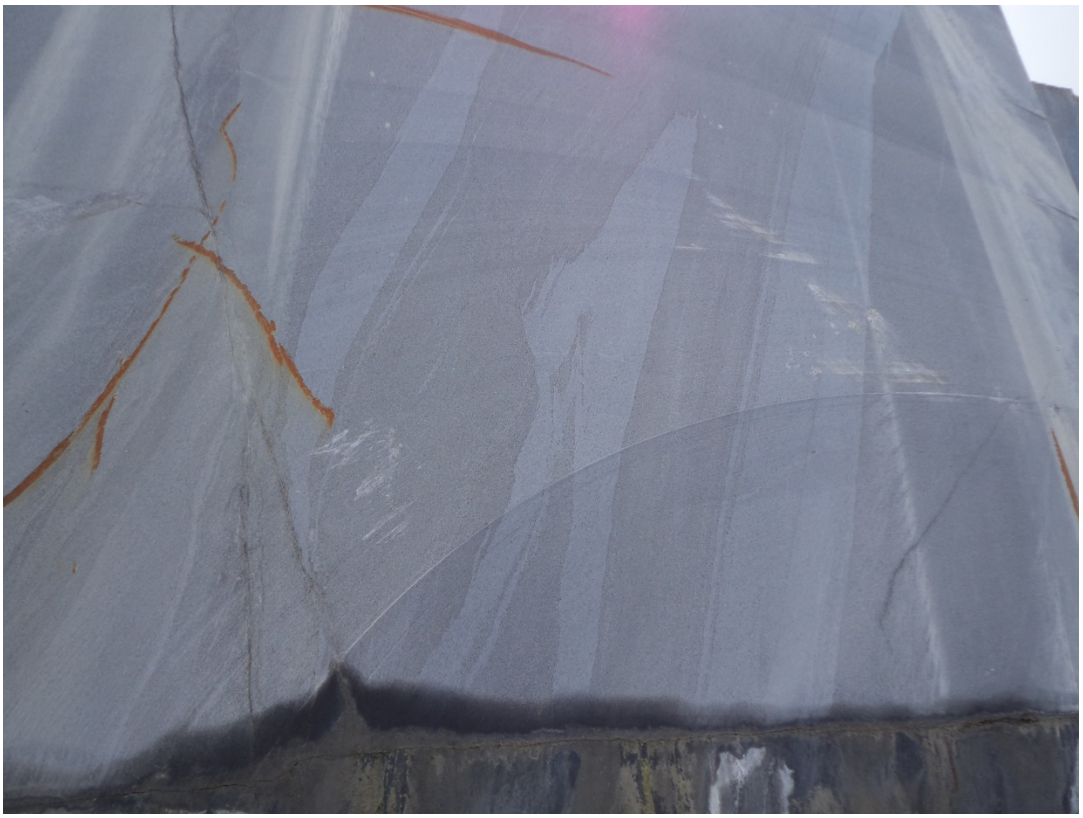
SECTIONAL VIEW OF A BLACK GALAXY QUARRY

DYKE/BLACK BAND INTRUSION SHEAR PLANE(Defective Zone)

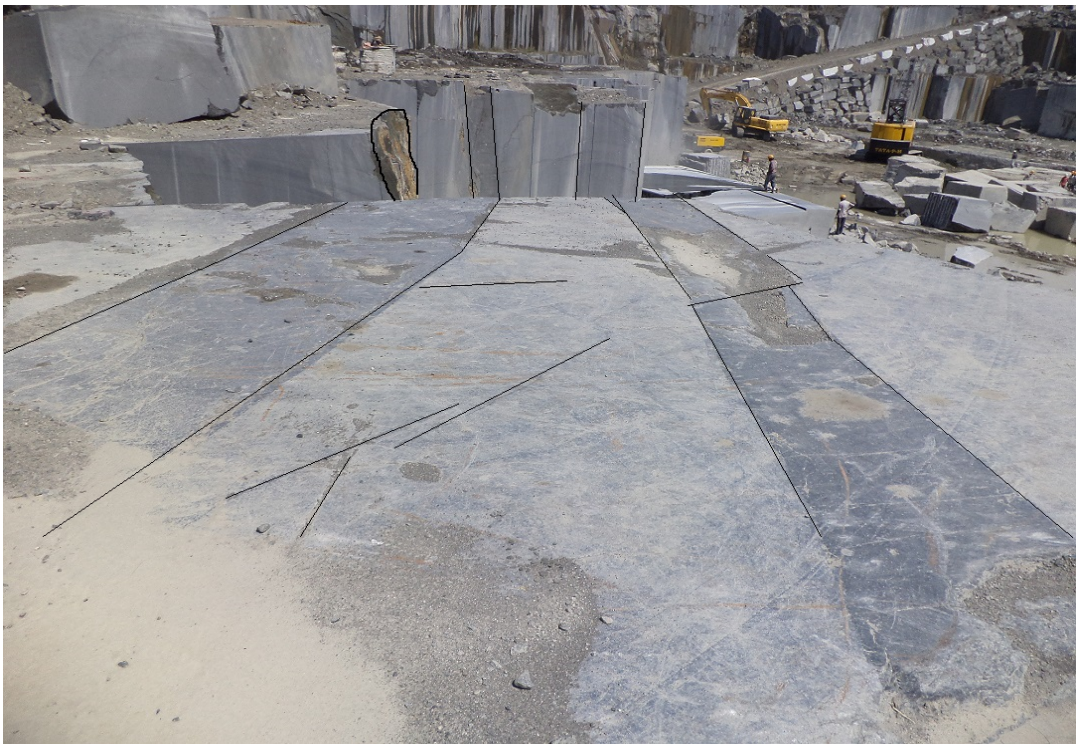
DEFECTIVE SHEAR PLANES WITH NIL PRODUCTION

WIDTH OF A DYKE/BLACK BAND IN THE QUARRY

BLACK BAND/SHEAR EFFECT ALONG VERTICAL SECTION



WHITE PATCHES/LINES AS SEEN ALONG SUCH DISTURBED ZONES



DYKE EMPLACEMENT AS SEEN ON THE SURFACE OF THE QUARRY

DYKE EMPLACEMENT AND CORRESPONDING WHITE/BLACK PATCHES

iii) INFERENCE:

Characterization of a quarry based on geological parameters as discussed in foregoing paragraphs will predetermine the potential of a quarry and its future.

IV. MINING ASPECTS AND ADOPTING THE STATE OF THE ART TECHNIQUES TO ENHANCE THE RECOVERYPERCENTAGE IN QUARRY OPERATIONS

The deposit characterization and preparation of a composite thematic geological map/plan depicting all the structural features will facilitate to prepare a masterquarrying plan and deployment of State of the Art Machineries like Excavators, Dumpers,Drifters, Line drilling machines, Diamond wire cutting machines, LD bore machine, Compressors etc. that are more suitable to target the mass removal(ROM) to achieve the monthly target considering the low recovery potential of the quarry which ranges between 5-10%. In this context, it is vital to understand the nature and behavior (geometry) of the deposit at every level of operation and to deploy the cutting orientation meaningfully to retrieve the best blocks that are possible. Orientation and deployment is the basic tenets of quarrying in such complicated terrain.Blind cutting of the formation without understanding its behavior is a suicidal step to destroy the whole operation.Shear zones/weak planes willhelp to cut trenches to reach the next level of operation. Jumping of galaxy planes as mentioned above to be carefully handled by tilting the slices and to orient the sub-cutting parallel to the foliation/galaxy plan. Regular cutting method will result in wrong cutting of blocks devoid of galaxy exposures. These are some of the critical observations which will enrich our knowledge to orient the production meaningfully.

V.CONCLUSION

Granite Deposit characterization of an area/ quarry requires an in-depth knowledge on geological/structural mapping with application to quarrying. The Black Galaxy belt is a structurally complicated deposit which needs to be operated carefully like a glass duly understanding its nature of occurrence and will help to scientifically enhance its recovery percentage besides conserving the unique occurrence within this belt of 5 sq.km area. Further, the study will also help to avoid major disaster of high wall collapse as it happened during 2010 in a quarry causing huge loss of human lives and property and in this context we need to stabilize the walls with proper treatment from time to time depending upon the intersection of these bands on the walls and development of wedges to prevent major mass fall.

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[2] VijayaKumar.K, Carol D.Frost, B. RonaldFrost, Kevin R.ChamberlainThe Chimakurti, Errakonda, and Uppalapadu plutons, Eastern Ghats Belt, India: An unusual association of tholeiitic and alkaline magmatism. Published in Volume 97, Issues1-2, August 2007, Pages 30-57 inLithos Journal.