Chapter IX

SUMMARY AND CONCLUSIONS
Chapter IX

All the information documented in the aforesaid chapters has been summarized in this chapter.

The area of present study lies in Chittoor division of Chittoor district in Andhra Pradesh. It is located between North Latitude $13^\circ05'1$ and $13^\circ35'$ East Longitude $78^\circ35'1$ and $79^\circ25'$ covered in the Survey of India toposheet nos. 570/3, 570/4, 570/7, 570/8, 570/9, 57K/14, 57K/15, 57K/16 and geologically mapped. The southern part of Peninsular India is endowed with innumerable commercial granite varieties. Of which, Andhra Pradesh is a veritable store house for commercial granite of both Black and Colour granite varieties, where in, the Chittoor district studded with number of granite massifs, has formed the source for commercial varieties of Dimension Stone Granite Deposits (DSGD) particularly G-20 variety.

Since, the value addition on export of a cubic meter of commercial varieties was multifold than its cost of production, there was a mad rush for quarrying these granite massifs. Hence, more number of Dimension stone quarries were opened up, fresh investments were made by the entrepreneurs, resulting in importing modern machineries for granite quarrying and processing units. Amidst this hectic phase of activities, the most vital aspect of ascertaining the quality and the quantity of the granite deposits was totally forgotten or rather taken for granted. As a result, there was a sudden downward trend in the granite industry, quarries after quarries and processing units after units became abandoned with heavy financial loss to the investors as well as in squandering away the valuable non-replenishable natural resources. Realising this vital aspects, the present work was taken up giving a main thrust on "Quantification and commercial evaluation of dimensional stone black granite deposits in parts of Chittoor district, Andhra Pradesh, south India by geological and geochemical studies" and the information is presented in nine chapters.
The general geological features of chittoor district, definition of dimensional stone black granite, reference to dimensional stone black granite deposits of India and Andhra Pradesh, in general, and chittoor district, in particular, are dealt in chapter-I, INTRODUCTION. An understanding of location and accessibility, physiography, rivers, climate and rainfall, flora, fauna, irrigation along with methodology adopted has been documented in this chapter.

The chapter-II, REGIONAL GEOLOGICAL SIGNIFICANCE, deals with the Precambrian geology with an emphasis on the geological setting and structural setup of chittoor district. Geological structures throwing light on morphotectonic features, field characters, contact relations and various structural parameters of commercial geological significance are also highlighted. In addition, a gist of previous work carried out in this part of the area is also presented. The study reveals that the rock types in general are found to have undergone polyphase deformation and accordingly they exhibit a variety of structures which have a definite bearing on the degree of commercial exploitation. With reference to the field characters, dominantly the dykes are linear, tabular and vertical to sub vertical, which occur in clusters, pinch and swell, bifurcate and reunite along strike and swing in their trends along strike. Chilled margins, pitted nature are quite common. Contacts between the dykes and the country rocks are generally sharp, but in most cases are highly weathered or under cover of debris. Tensional fractures as well as compression related conjugate pairs of shear fractures played a major role in the evolution of mafic dyke swarms; they are emplaced along both N-S and E-W trending extensional zones and conjugate sets of strike slip fractures.

Primary igneous features which are evidences for flowage differentiation and mineral segregation have been observed. The secondary structures which are most consolidation features include fractures, faults and, joints, a number of faults, offsetting the trend of dykes have been noticed. The dykes show well developed jointing. Most joints are sub vertical to vertical with paucity of low dipping planes.
In the III chapter, all the varieties of Dimensional stone black granite deposits in the study area have been delineated and demarcated, individual rock types characterized and their feasibility levels were tested, resource and revenue potentials were brought out in detail. The various geological parameters that govern black granite deposit from commercial point of view are expressed in colonial terms such as colour, grain size, texture, flowers, moles, oil patches, lines, boulders, sheet rock, etc. A glimpse of major litho-units with corresponding commercial black granite varieties, their annual production of chittoor district, revenue realized and with special reference to village wise distribution of G-20 Dimensional stone black granite has been summerised in this chapter.

As the utility and the export value of Dimensional Stone Black Granite Deposits (DSBGD) is based on its physical and chemical properties, the characteristics related to petrology and geochemistry are highlighted in chapter IV & V respectively.

In the chapter IV PETROLOGY, the petrographic study has cleared many misconceptions recording the intrinsic properties of individual outcrops. In this chapter, main thrust is laid on mafic dyke swarms of dolerites and gabbros which are the prominent Dimensional Stone Black Granite Deposits. The mineral assemblage classifies the dykes of the study area into gabbro dykes and dolerite dykes with quartz and micro pegmatite. The textural varieties are formed under varying plutonic to volcanic conditions. The petrological signatures of the study area provide us ample information to evaluate the commercial characteristics of rock types.

In the chapter V, GEOCHEMISTRY, an attempt is made to understand the chemical diversity of dimensional stone black granites of the study area with the help of major oxides and trace elements. The geochemical parameter is more essential to evaluate the commercial characteristics of black granite deposits. The colour of the deposit is controlled by the proportions of major oxides and trace elements. presence of iron in some may impart shades
of pink, yellow, green, brown and even black. Presence of barium and chromium may impart greenish shades.

The SiO₂ and total alkali contents of the Dolerite dykes are within the range of 45% to 60% and less than 5% respectively suggesting their basaltic affinity. The major and trace elements concentrations of the dolerites of the study area resemble those of continental tholeiites. The geochemical data has been plotted on different variation diagrams to infer the petro genesis and crustal thickness of the study area. The chemical classification diagrams depict a restricted range of alkalis for the dolerites and confirm their tholeiitic nature and continental affinity. The presence of quartz in most of the dolerites indicates tholeiitic parent magma. All dyke samples fall on a continuous petrographic trend i.e., tholeiitic trend in all chemical classification diagrams, suggesting their derivation from a common magma through variable degrees of fractional crystallization. The presence of olivine in some dolerites, its absence in some and the presence of quartz and micropegmatite in some dolerites indicate that they are early, intermediate and late differentiate respectively. The high content of Ni and Cr in dolerites, indicate that they might have been derived from the mantle source. The ‘θ’ value of the study area dolerites suggest that the thickness of the crust was of the order of 30 to 40 kms, at the time of emplacement of these dykes.

In the chapter VI, DEPOSIT CHARACTERIZATION OF VIRGIN OUTCROPS IN THE STUDY AREA, certain parameters like orientation, space, persistence, termination index, roughness, wall strength, aperture, seapage and block size are used as indicators for the deposit characterization of virgin outcrops. During the course of present study, geology of the study area along with remote sensing application, significant structural features and Field Index Tests have been utilized in arriving at seven virgin outcrops namely Chettapenta, Chowdepalli, Kesavakuppam, Kotamakulapalli, Mallakunta, Mogilivaripalli, Puthramaddi. A significant study in this direction has given scope to locate potential G-20 dimensional stone granite deposits of chittoor division.
In chapter VII, GRINITE INDUSTRY IN CHITTOOR DISTRICT AND ITS QUARRYING METHODS AND PROBLEMS, significance of granite quarrying techniques and their requirements in various phases are highlighted in the chapter. As the method of quarrying has a direct relationship with productivity and marketability, the problems encountered in dimension stone quarries are also presented. The various quarrying methods suitable for excavation of the DSBG deposits are discussed. Granite quarry normally consists of yard, work face, edge, foot, dump and plant. The quarrying operations begin in the yard and this gets larger as the excavation proceeds. The mining/stopeface/workface is the area where excavation actually taken place. The waste dumps are used to dispose off the cut off grades and waste material. The top of the quarry is called edge, the foot is the base of stopeface. The traditional equipments and techniques used in stone quarrying of black granites are hellicoidal wire cutting equipments, diamond wire cutter, chain cutter, pneumatic block cutter, etc.

In chapter VIII MARKETABILITY, it is attempted to concrete the fact that for every successful quarrying operation, marketability plays a vital role in the global trade. Fetching higher values for the excavated blocks in the international market scenario especially for the black granite deposits are mostly based on the uniformity in colour, grain size, texture, design pattern, size of the blocks, besides lesser percentage of black opques, segregations, inclusions and other inherited defects. Likes and dislikes may vary from buyers to buyers, countries to countries e.g. Japan like black granite mostly for monuments on sentimental basis, where as the European countries are fond of colour granites. The resources estimation of granite deposits on regional scale has no relevance, only the individual outcrops/deposits to be assessed. Apart from these, the price index, resource and revenue potential, rate of recovery and other related evaluation techniques are also highlighted in this chapter.
Significant appraisal format for dimensional stone black granite deposits (DSBGD): From the aforementioned interpretations a database has been created and introduced for practical application in deposit evaluation. As such, an appraisal format of Dimensional Stone Black Granite Deposits (DSBGD) for quantifying the qualitative features has been designed which certainly help the entrepreneurs and new entrants in the granite will field, when the deposit can be viable, operatable, marketable etc, (Appraisal format).
1. Name of the rock : Dolerite Dyke
2. Trade Name : G-20
3. Name of the DSG Belt : Peninsular Gneissic Complex
4. Location : Chittoor Division Andhra Pradesh,
5. Accessibility & Infrastructure : Near Nellipatla
6. Field characteristics : Massive sheet rock exposed 3m. below the surface level. In the hill, massive sheet rocks are expected to get at a height of 20-30m
a. Topography Rising ground
b. Relief High
c. Vegetation: Sheet/virgin areas fall under Patta Reserve Forest.
d. Genesis: Metamorphic – gneissic
e. Color: Grey
f. Geomorphic expression Linear ridge.
g. Mode of occurrence: Sheet
h. Mineralogical composition: Quartzy feldspar, biotite Garnet and opaque.
i. Trend Almost E-W
j. Tectonic effects : Contact with country rock:
k. Fabric : -Wavy, flow, banded, streaky, plagioclase feldspar shows adventuring lusture after polishing.
7. Quality of Stone
   a. Granularity: inequigranular/medium
   b. Defects: inherited defects, high intensity of shearing and fracturing
   c. Joints: Wide spaced, massive sheet
   Density: Low
   Spacing: Wide spaced
   d. Sheet joining: 5-7m.

8. Resources: Overall aggregate length: 3,000m.
   Average width: 30-40m.
   Depth: 20m.
   Recovery: 15.20%
   Recoverable reserves: 4,37,750 cuM

9. Chemistry (%):

   **SiO2**  73.05%  **MgO**  0.28%
   **Al2O3** 13.86%  **CaO**  1.49%
   **Fe2O3/FeO** 1.13%  **K2O**  4.10%
   **MnO** 0.04%  **Na2O**  3.78%

10. Mining Amenable:
   a. Amenability to extraction of blocks
   b. Method of mining: Open Cost
   c. Block sizes expected (with proportion):
      Gang saw size
   d. Nature & thickness of overburden: soil and weathered rocks: 3-5m

11. Status
   a. Virgin/under development production
   b. Monthly production: 30-40 blocks, virgin areas are also identified for its commercial viability.
12. Physico-mechanical properties:

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