CHAPTER 1

Rocks and Stones

1.1 Introduction

LEARNING OBJECTIVES

- What is rock?
- What is stone (Dimensional stone, decorative stone, ornamental stone)?
- Rock reveals life on planets-Mars.
- Rock sciences and rock engineering importance.
- Rock mass with discontinuities and their impact in rock quality designation.
- Rocks , stones utilisation in ancient, architectural, monumental and constructional engineering. Latest trends and reviews by stone experts.
- Visions of national and International Stone Industry.
- References and further study.

Rocks and stones are being utilising in civil engineering, architectural engineering and industrial applications. Constructional engineers, architects, builders and users have chosen and used attractive rocks and stones for their performance and durability. Usage of rocks and stones are differing on the basis of requirements, specifications and rock engineering properties. All-natural rocks are not suitable for engineering architectural and industrial usage applications. Engineering, architectural and stone industry require specific standards specified by National and international institutions prior to usage. Utilisation of rock and stone requires in detailed specifications and quality prior to mining or quarrying. Rock exploration and usage requires understanding in detail the composition and petro genesis of rocks, quality standards and rock engineering properties. Mineralogical and petrological parameters play significant role in formation of natural rock deposits. The present book brought out keeping the mineralogical, petrological, geological, rock engineering, requirements, usages, National and International standards, reserves and resources of rock deposits of India, exploration, mining, quarrying chapters. Each chapter is listed learning objectives with latest research, technical developments in the concerned topic in subjects. With illustrative explanations and references further reading. Review case-in points from experts are added in selective chapters.

1.1.1 What is Rock?

Rocks are naturally occurring aggregates of minerals or mineraloids such as glass, opal coal etc). Most rocks are made up of poly minerals. Rocks are

large masses of materials which make up the earth's crust. Making up the majority of the Earth's crust, rocks are usually defined as 'natural aggregates of minerals formed under geological process'. Rocks and stones are an integral part of the history of mankind, first being used as tools for hunting and defense, and as building materials to construct shelters and monuments (Villa, et al 2016).

Rocks which are occurred as natural *in –situ* conditions are shown in Fig 1.1.

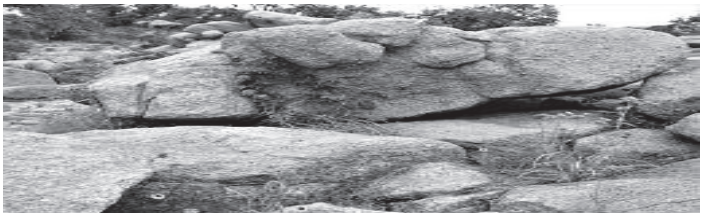

Fig. 1.1 Natural rocks in out crop in Chickmagalur district, Karnataka, India (Photo-DVReddy, 2018).

1.1.2 What is Stone and Dimension Stone?

Dimension stone is defined by Ashurst and Dimes (1977) as "any rock that is cut and worked to a specific size or shape for use in building and that the stone should be free from fractures, tough and devoid of minerals that can break down chemically or by weathering"

Any rock specially cut or shaped to specific sizes are called "**Dimensional Stone**" or **fabricated rocks**. Rocks of any type of their genetical, petrological characters cut into required engineering or usage design is called as stones. **Decorative and ornamental stones** are those utilized for exterior and interior decorations. Rocks which are in pleasing colour and textural combinations will be used for decorative and ornamental purposes. Pink granites, porphyries, varied coloured lime stones, sand stones, marbles, jet black dolerites, etc have being utilising for exterior and interior decorations in constructional, architectural and engineering projects. These rocks are also being utilising in various commercial, industrial, educational, worship places, grave-yard, paving stones etc. Decorative and ornamental stone are valued for their pleasing colour, texture, durability and amenability to polishing (Venkat Reddy, 1996, 2008).

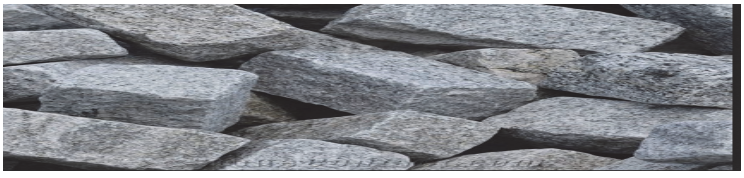

Fig. 1.2 Natural granite rocks dressed as per dimensional requirements called stones.

1.1.3 Rock Reveals Life on any Planet

A spark from a lightning bolt, interstellar dust, or a subsea volcano could have triggered the very first life on the Earth. But what happened next? Life can exist without oxygen, but without plentiful nitrogen to build genes -- essential to viruses, bacteria and all other organisms -- life on the early Earth would have been scarce. The ability to use atmospheric nitrogen to support more widespread life was thought to have appeared roughly 2 billion years ago. Now research looking at some of the planet's oldest rocks finds evidence those 3.2 billion years ago, life was already pulling nitrogen out of the air and converting it into a form that could support larger communities (Anon 2015).

The ability to use atmospheric nitrogen to support more widespread life was thought to have appeared roughly 2 billion years ago. Now research from the University of Washington, USA looking at some of the planet's oldest rocks finds evidence those 3.2 billion years ago, life was already pulling nitrogen out of the air and converting it into a form that could support larger communities (Eva E. Stüeken, et al 2015).

Dry Stüeken and her colleagues from the University of Johannesburg in South Africa and the University of Washington's Department of Earth and Space Sciences analyzed 52 rock samples ranging in age from 2.75 to 3.2 billion years old, collected in South Africa and North western Australia. The rocks were formed from sediment deposited on continental margins, so are free of chemical irregularities that would occur near an underwater volcano. They also formed before the atmosphere gained oxygen, 2.3 – 2.4 billion years ago, and so preserve chemical clues that have disappeared in modern rock (Eva E. Stüeken, et al 2015).

***Steven Newton (2008) suggested*:** "The early evidence for early life formed on planet Earth shows two distinctive stages namely 1. Carbon isotopes, and 2. fossil stromatolites. The isotope evidence prominently predates the fossils. Geological processes, erosion, denudation, plate tectonics have been resulted for destroying the evidence of data from the rocks. Stromatolites are structures created by photosynthetic bacteria (prokaryotes). These rounded, bulbous shapes are usually less than 1 meter across and contain fine layering".

Rock samples collected from any planet will give clues of life was existed or existing. Detailed rock sample analyses will give clues of presence of life. In the world extensive research on going to find out the existing solar system or outside solar system probing for life. Fossilized microbial or stromatolites are found in one of the oldest rocks on the Earth in shallow waters over 3.4 billion years (Doug Hamilton) presented in Fig. 1.3. Stromatolites in rock shown in Fig. 1.4.

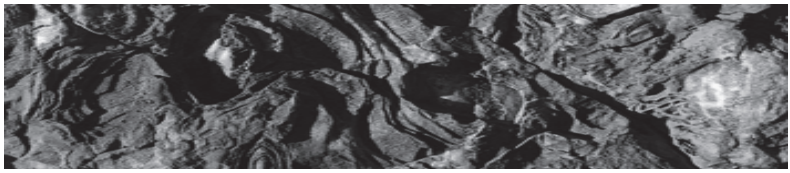

Fig. 1.3 Fossilized microbial mats and stromatolites in shallow water/rocks over 3.4 billion years Doug Hamilton [Source: Courtesy: Steven Newton (2008)].

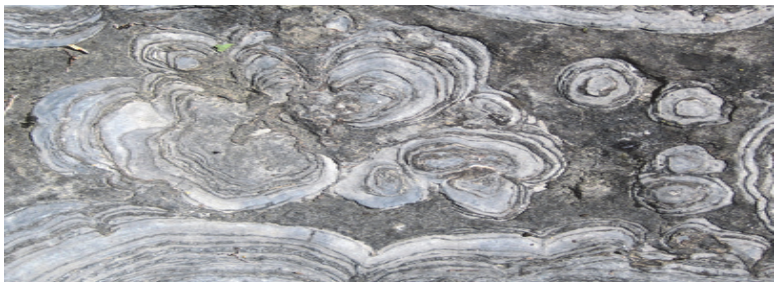

Fig. 1.4 Stromatolites in rock. [Source: Courtesy: Steven Newton (2008)].

1.1.4 Rocks Reveals – Life on Planet Exisited

Fossils presence in natural rocks will reveals their association with environmental deposition, life existed on planet. Plant and animal fossils in Gondwana Rocks, Teritiary rocks indicating their assocations and understanding the depositional environment indicating –environment for formation. Astrogeologists and biologists are working –to trace out the presence of fossils on the planet Mars to probe for depositional environment and formation of the planet. Researchers are probing various techniques and also planning for future space missions to problem rocks and fossils on the red planet to resolve issues of whether life exists or extincted on this planet and the present depositional environment of rocks.

Geochemistry of rocks also suggest the depositional environment of any planet in the universe. Generally, sedimentary rocks will facilitate for deposition of fossils in planets. Iron-rich rocks near ancient lake sites on the Mars could hold vital clues that show life once existed there, researchers have revealed. These rocks - which formed in lake beds - could be our best bet for finding traces of life from billions of years ago. They are rich in iron and mineral called silica, which helps preserve fossils, and researchers believe they could contain fossils of primitive life from four billion years ago.

The Edinburgh team reviewed studies of fossils on the Earth and assessed the results of lab experiments replicating Martian conditions to identify the most promising sites on the planet to explore for traces of ancient life. They determined that sedimentary rocks made of compacted

mud or clay are the most likely to contain fossils. These rocks are rich in iron and mineral called silica, which helps preserve fossils. They formed during the Noachian and Hesperian Periods of Martian history between three and four billion years ago.

The rocks are much better preserved than those of the same age on Earth, because Mars is not subject to plate tectonics - the movement of huge rocky slabs that form the crust of some planets - which over time can destroy rocks and fossils inside them. The team say their findings could help inform NASA's next rover mission to the Red Planet, which will focus on searching for evidence of past life. (Anon-NASA, 2021) Iron-rich rocks near ancient lake sites on Mars could hold vital clues that show life once existed there the Jezero Crater delta, a well-preserved ancient river delta on Mars is presented in Fig 1.5.

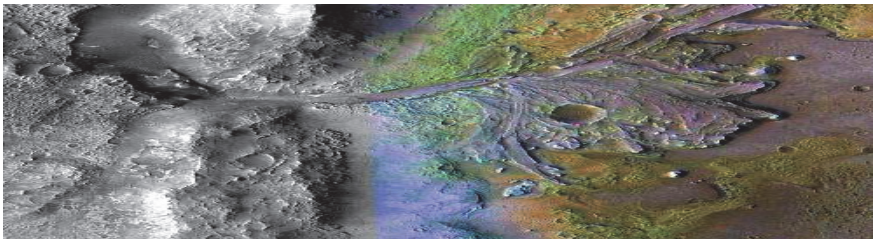

Fig. 1.5 Iron-rich rocks near ancient lake sites on Mars.
Image courtesy NASA-(credit-JP;-Caltech/MSS/JHU-APL).

On Feb. 18, 2021, NASA's Mars Perseverance rover makes its final descent to the Red Planet. The principal investigator is James Bell, Arizona State University in Tempe. technology to benefit future robotic and human exploration of Mars.

- Explore a geologically diverse landing site
- Assess ancient habitability
- Seek signs of ancient life, particularly in special rocks known to preserve signs of life over time
- Gather rock and soil samples that could be returned to Earth by a future NASA mission
- Demonstrate technology for future robotic and human exploration (Anon NASA-2021)

NASA-USA space agency is further planned to explore Mars in future space mission to resolve issues rocks and minerals will help to answer key issues to probe potential for life on planet Mars. The solar planetary systems and existing planets–probe for their depositional environments can be assessed with detailed geochemical and planetological study of rocks. The

study of rocks from any planetary system provides information about the past and present depositional environments.

1.1.5 Rock and Mineral – Martian Meteorite Analyses Suggested-Mars may have Home to a Life

Martin Bizarre –Denmark Centre for Star and Planet formations –published research notes in Nature journal 2018 stated, After analyzing grains of the mineral zircon extracted from a Martin meteorite known as Black Beauty, scientists have found that Mars crust formation –which is the end product of planet formation –took place at least 100 million years earlier than the Earth. Scientists have found that the Red planet outer layer hardened 4.547 million years ago, only 20 million years after the birth of the Sun. Research team concluded that Mars have had an environment with oceans and potentially life, much earlier than Earth. Martian meteorite weighed 320 grams found and researchers secured 44gms of the precious space rock and extracted seven bits of zircon that could be used in experiments. Martian meteorite is presented in Fig.1.6. Scientists measured the lead decaying from uranium that had been trapped in zircon as the young Mars motion magma hardened. Scientists were able to precisely date the crust from which the zircon formed rocks, minerals and meteorite analyses reveal the depositional environment of them. Astro-geological explorations with geochemical analyses of rocks - confirms their age and gives clues for the depositional environment – prevailed during the specified time on the planet (Martin Bizarre, 2018).

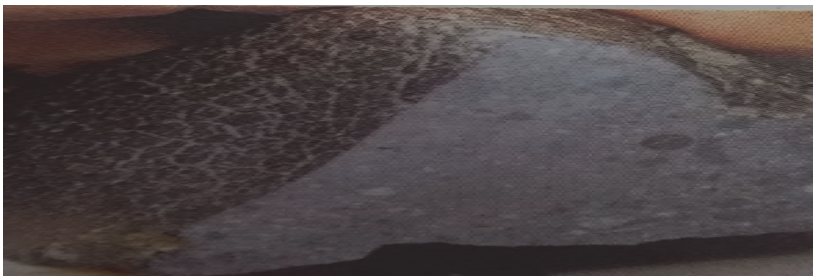

Fig. 1.6 Martian meteorite.

1.2 Rock Science and Rock Engineering

Rock sciences and understanding the process and formation of natural rocks plays significant role in rock quality evaluation and usage of rocks in engineering projects and utilising in industrial and commercial rock industry. Rock is basic inputs of geological process. Understanding of rock requires to know the geological conditions which are resulted to form. Rock utlisers must know the basic inputs of natural rocks and their formation and geological controls and distribution. In this book –basic concepts of petrological formations and their geological parameters are included. Latest

research is ongoing in the field of rock sciences to understand basic issues of planets formations, minerals associations and industrial usage of rocks in engineering projects. Utilisation of rocks and stones in constructional engineering, architectural designs as exterior and interior designing, fabricated stone blocks, panels, slabs, pavement, road metal, railway ballast, concrete aggregates, foundation stones etc requires to follow National and International rock engineering standards.

1.2.1 Rock Engineering-A Brief look back

Rock engineering is one of the fast developed and developing fields which is mainly deals with site investigations and design of structures. These structures are related building foundations, dams and reservoirs, tunnels, underground excavations, storage caverns for crude oil, radioactive waste deposit repositories storage of missiles, geothermal energy projects, and coastal engineering projects, rock quality designations in stone trade industry, architectural designs of stones, surface and subsurface mining activities etc.

Rock mechanics subject explains in depth the basic principles behind rock engineering. ISRM-International Society of Rock Mechanics –ISRM (1966) defined as "***Rock mechanics is the theoretical and applied science of the behavior of rock; it is that branch of mechanics which is concerned with the response of rock to the force field of its environment***". Rock mechanics differs from soil mechanics in understanding and planning for civil and constructional engineering projects. Soil developed from rock disintegration under geological process and time. However –better understanding the site-specific conditions of civil engineering project requires in depth study of soil and rock characteristic of the region.

Soil mechanics gives inputs about soil formations, soil behaviour and applications. Soil is the result of geological weathering of natural rocks. Understanding of soil characteristics plays significant role in planning and designing of civil engineering projects. In civil engineering and mining projects requires in detail study of soil mechanics and rock mechanics for better understanding the site specific geological and natural conditions.

All civil and constructional engineering projects primarily depend upon the strength characters of existing rocks at the site. Most of underground constructions, tunnels and mines primarily depend upon –strength, characters and behaviour of rock mass. Roof and floor of underground excavations and structures primarily depends upon site specific strength behaviour of rocks. Soil and rock mechanics plays significant role in all engineering projects. Soil is the result of natural decay, disintegrations under geological process and time to form. Strength of soil depends upon soil characteristics and their strength behaviour in existing conditions. Rock

strength and durability depends upon the compactness of mineral grains. Minerals in soil and rocks plays significant role in determining strength parameters. Rock engineering and soil engineering have to understand in details and their primary geological conditions –commencing from formation –transformation into rocks and soils. In all field conditions –rock and soils play significant role and poses challenges to engineers –to build constructions. Rock mass which illustrating highly jointed fractures are presented in fig. 1.7.

Fig. 1.7 Jointed and fractured granite rock, Warangal, Telangana.
(Photo D.V. REDDY, author)

1.2.2 Rock Mass with Joints and Fractures

Rock strength decreases due to presence of natural discontinuities. No rock is truly continuous will have minor or micro discontinuities. Generally macro discontinuities such as fracture, joints, and faults will influence strength characters of rock mass. Rock strength is one of the most decisive characters in rock mechanics. Macro and micro discontinuities will reduce the strength behaviour of rock mass. Rock engineering has developed into unique subject on the basis of solid foundation of geology rock sciences and rock mechanics. Historical constructions in the world utilized the knowledge of rock sciences and rock engineering.

Few historical reviews suggest that construction of the **Panama Canal in 1884** and this task was taken over by the US Army Corps of Engineers in 1908. It was noted in the century between 1910 and 1964 about 60 slides were recorded in Panama Canal. In the stage not utilised term as rock mechanics. Lutton et al **1979** US Corps Engineers illustrated slides which influenced Panama Canal were mostly controlled by the structural discontinuities. Josef Stink 1920 considered as founder of technical geology at Vienna Technical University had published about 333 research papers and books (Muller,1979). Joseph Stink started journal **"journal Geology".** This journal considered to be the first to illustrate importance of geological discontinuities on engineering behaviour of rock masses (Lutton et al 1979).

Stink was one of the pioneers of rock mechanics in Europe and he emphasized the importance of structural discontinuities in controlling the behaviour of rock masses (Müller, 1979).

Stink was involved in a wide range of near-surface civil engineering works and it is not surprising that his emphasis was on the role of discontinuities since this was obviously the dominant problem in all his work.

In the first ISRM conference (1966) in Lisbon, accepted definition of rock mechanics is "Rock mechanics is the theoretical and applied science of the behavior of rock; it is that branch of mechanics which is concerned with the response of rock to the force field of its environment".

Rock mechanics and rock engineering developed with advisement of technology and interrelated subjects. Recently latest journals publishing exclusive research papers on rock engineering and rock sciences. Construction engineering is one of the fast-developing field and utilising the rock sciences and rock engineering in foundation engineering. Durability of natural stones to be utilised in architectural designs, engineering and other applications primarily depends upon rock engineering and strength parameters. Selection of quality stone to be utilised in constructional engineering works and architectural usages depends upon their petro-genetical, rock engineering properties. Architectural engineering journals also publishing rock mechanical properties of stones being utilising in exterior and interior designs.

1.3 Rocks and Stones Utilisation – in Ancient Architectural Monumental and Constructional Engineering -A Brief Review by Experts

The earth is equated as a **'Rock factory**", various rocks have come into the existence since the formation of the earth. Even today formation of rocks and minerals is taking place beneath the oceans and inside the continents through volcanoes. There are extensive store houses of ready-made rocks on the earth, surface and beneath cover of soil and vegetation (Vasudev et. al, 1992).

Rock is the basic building materials of the earth's crust used by man from pre-historic time. Rocks, which are fabricated into required dimensions are called stones. In India the use of stones for construction and architecture is as old as civilization (Venkat Reddy, 1989, 2016). Stone is synonymous with the civilization of mankind and the growth of stone industry is interwoven with civilization from stone age to modern age. The same stone which served as utensil and weapon to the primitive man has now spread its usage

in many other forms to improve the elegance, beauty, durability and decoration in architecture of present-day man (Chowdary, 1992).

1.3.1 Introduction to Ancient Monuments and Sculptures of India

The man ever since he dawned on this earth has been using the stones and rocks for his well-being. Pre-historical man used stones on the basis of their physical properties such as hardness, low porosity, permeability, rift, grain, fractures, joints, load-bearing properties etc. The historical records illustrated man was also utilized stones for generation of fire. Stones were also utilized for preparation of sharp weapons to protect him also to kill animals for his survival and food. Monumental constructions, historical architects used available rock engineering technology at that time to curve natural rock into specified designs.

1.3.2 Rock Caves and Shelters

Pre historic man started looking for his shelter and protection from natural rain, wind etc. The natural stone caves formed by the weathering action of geological agents were obviously chosen by the pre-historic man for his shelter. Pre-historic man used them as his "**house"** without windows and doors. Archaeologists are called as rock shelters.

1.4 Utilisation of Rocks and Stones in Constructional Engineering, Architectural Engineering and Industrial Requirement: Rock sciences and Rock Engineering: Experts Review

Venkat Reddy and Pavan Guru (1989) stated in the Journal of the National Building Organisation -UN Regional Housing Centre-Government of India stated "Rock is the basic building material of the Earth's crust and the original building material used by man from pre-historic times. In India the use of stones for construction and architecture is as old as civilization. Despite its antiquity stone is regaining great popularity as a building material through a revolution in the art of quarrying or mining and processing. Field geologist explains the variety of stones durability and occurrences. The ornamental stones valued for their pleasing colour, durability and amenability. Durability of decorative and dimensional building stone depends upon its physical and mechanical properties. In addition to field geologist, the stone industry is dependent upon few specialists like mining engineer to mason and from architects to constructional engineer."

The success of the commercial decorative and dimensional stone industry solely depends upon the availability of large reserves of defect free raw materials. It is uncommon to find that many stone entrepreneurs with all their commercial zeal have taken quarry leases started mining and

abandoned them midway because of bad quality stones. Before taking a lease, an entrepreneur must take into consideration all the factors that governs the quality of the rock deposit (Kota Reddy, et al 1991).

Among all tasks the selection of suitable stone for exterior and interior decoration is the most challenging task for the architectural, structural and civil engineer. They must know the various requirements and specifications and dimensions of the stones before selection. Knowledge of the general parameters and quality aspects of stones are required before utilizations. In many instances civil engineers and architects will prefer the required stones on the basis of colour textural characters. In few instances stones which are utilized for specific designs are not suited. All available natural rock deposits are not suitable for architectural and civil engineering works. Indian granites (industrial ,commercial rock deposits) are sought by many countries of the world because of variety of colours and good hardness due to which it takes mirror polish and visual appeal of numerous patterns and designs. The success of industrial stone industry primarily depends upon the production of defect free rock and stone blocks. India possesses extensive commercial rock deposits. It has been estimated that there are 300 known varieties of ornamental, industrial rock deposits in the world. India possesses more than 150 varieties of natural commercial rock deposits (Venkat Reddy, 2010, 2016).

Despite stone antiquity, it is regaining popularity as a building material through revolution in the art of quarrying and finishing (Winkler, 1975).

The temples, statues, architectural monuments of our country clearly illustrates the usage of stones in historic times. The ruins of the city of Hampi, which was the capital of the Vijayanagar Kingdom a few kilometers from Bellary, Karnataka state) contains many old structures built of the excellent grey and pink gneisses found in the neighborhood (Krishnan, 1982).

Granite has become one of the most popular building materials. It has been used for thousands of years in both interior and exterior applications. Granite dimension stone is used in buildings, bridges, paving, monuments and many other exterior projects. In indoor decoration polished granite slabs and tiles are used in countertops, tile floors, stair treads and many other design elements.

The industry has seen a sudden spurt in granite's use as countertops for example kitchen, bathroom and reception counters. There is massive demand for granite countertops in the United Kingdom, the Middle East, North America and other countries in Far-East and Europe. There has been negative propaganda stating that granite is not safe building material and this has affected demand level by slowing growth. These statements have however started disappearing after scientific studies have proved that granite

is a safe material and it is not causing any harm to mankind. (Stone Panorama 2009, p. 38; Geology).

Indian commercial stone industry has the unique distinction of possessing all varieties of stones which only few countries in the world possess. Geologically the availability of granite and other stones are extensive and are inexhaustible even after several centuries (Murthy, 1991).

India earlier occupied the coveted first position in the natural stone exporting trade in the world till recently. However due to short term policies competing from other countries, India slipped to the lower position. The policies of the government should be changed to boost up exports and earn valuable foreign exchange. Countries like China, Korea, Canada, Portugal, Zimbabwe, South Africa other countries changed their policies (Kota Reddy, 1991).

In industrial stone industries many rocks and stones are used on the name of granites. However, true geological name of granite is differs.

Indian granites now –a –days are very popular in Japan and there is a vast scope for them in the future. Ever increasing competition from other countries is eager to sell their granites to Japan. Indian exporters have to prepare themselves to compete, survive and grow. This is possible only by the clear recognition of changing world granites situation, time bound performance ensuring good quality product and reasonable pricing. Quarry leases in most other countries were given for 30, 60 and 90 years unlike India. Consequently, the Indian granite exporters were forced to recover their investments and expenditure in a short period. We Japanese buyers often visit Indian quarries and regret to observe that there is a lack of proper scientific development of quarries due to short period lease terms. Such hasty quarrying also resulted in higher percentage smaller size blocks and lesser quality materials that would turn make India lose its export market (Taichiro Hobson, 1992).

The quality standard laid down by Indian exporters does not offer means to market requirements of customers and forgetting about customer's service. In the trade of block rocks all important factors like price, quality block size etc., are always determined by Indian side, especially when there is a shortage of material or large demand in market which is the most remarkable. Hence the demand for Indian blocks has fluctuated always and Japanese manufacturers knowing the difficulty in buying Indian rocks have switched over to granite from other countries. Thus, total demand for Indian granite itself has decreased (Yoshida.1992).

Importers of Germany were not entirely happy about the Indian granite exports. In India too many organizations are investing into stone industry with very little or sometimes with no knowledge at all. This resulted in poor

quality outputs and India would lose International market (Heinz Picker, 1992)

Italian export in dimensional stone industry quoted "My country performed a precious promotional activity of importing Indian granites and re-exporting them as finished works. India's highest export share of 40 percent was to Italy. India was poised to occupy a prominence place in the international market along with China and Brazil with their abundant supply of raw materials" (Fabrizio Ponzanelli, 1992).

Indian natural stones were recent entrants in France, but had a **"fantastic trump"** with diversity of colours and designs in ornamental stones (Charvert (1992).

Indian granites are sought by many countries of the world because of variety of colours, good hardness, of which takes mirror polish brightness and visual appeal (Aswath Ram, 1996).

Indian attractive and beautiful natural stones being utilising in architectural engineering designs and stone industry has the unique distinction possessing all varieties of stones which only few countries in the world possess. Indian industrial stones (commercially called as granites)are very popular. Stone importers demand defect less dimensional stone blocks which have to satisfy the rock engineering properties and specifications as suggested by International stone specifications. Detection of defects in decorative and dimensional stone is very important factors in industrial stone and architectural designs. Scientific knowledge of natural rocks and stones is very vital prior to utilisation for industrial and architectural usages (Venkat Reddy, 2016)

Among the top stone producing countries like USA, Italy, Brazil, South Africa, Finland, Spain, Canada and China, India holds a place of pride by its substantial contribution. India is one of the important countries contributing many types of natural stones like granite, marbles, sandstones slates, quartzite, lime stones etc. Similarly, Italy, USA, Brazil, South Africa, China and Spain have good amount of natural stone variety (Veeramani, 1999).

India's export and domestic markets are making improvements. Due to low interest rates and attractive packages for home building, individual housing is rapidly growing and demands for stones are coming up. Our industry friends, the quarries, processors, exporters have faced the new challenges and have to work hard in cutting overheads, costs on each and every aspect to meet the severe competition and perhaps new varied business norms. India, the treasure trove of the natural and stone products, has been a major source of stone by USA. Indian exporters are doing significant trade with various countries (Vinay Kumar Poddar, 2002).

The Indian stones like granites, sandstones and slates predominantly are used in various projects. The projects that have earned high reputation for India.

Today in India granite is used widely in domestic construction sector, monuments construction markets, hospitality industry, export market and handicraft and antiques. The material is starting to be more well-known and popular because of technological advancements, sophisticated quarrying techniques, and decreased cost of mining and growth in usage as material in the decoration sector. Granite as material is showing beauty and long-lasting value and therefore people have started to use it more and more in memorials and in other funerary items. Today granite is popular material in laying floors and cladding walls in airports, hotels and other public and commercial centers (Stone Panorama 2009, p. 39).

A large shopping mall was recently built in Dubai and there was used 30 000 square meters of granite in 26 qualities of granite from all over the world. These kinds of projects can create huge profits to companies and at the same time create competition among different producers (Stone Panorama 2009, p. 39).

Rocks and stones are raw materials are being utilising in industrial, constructional, architectural engineering projects in India and abroad. Rocks are naturally occurring in the crustal layers of the Earth. Rocks which can be extracted cut into required dimensions as per usage termed as dimensional stones. Geological parameters and rock engineering –properties will play significant role for utilization of rock and stone for specific engineering usage.

Indian granites (Most of rocks and fabricated stones are traded in the export, import, architecture and Construction engineering industry on the name of granite (true granite differs). Indian granites are sought by many countries of the world because of variety of colour, good hardness due to which they make mirror polish, brightness and visual appeal of patterns and designs. The Indian granite industry which saw its first export in the year 1935. Among the top stone producing countries India holds a place of pride by its substantial contribution. India is one of the important countries contributing a variety of natural stones like granite, marble, sandstone, slate, quartzite, lime stones etc (Venkat Reddy et al 2005).

Rocks which are to be utilised for engineering, architectural projects export and import requires to understand in depth the geological parameters, rock engineering properties to understand rock quality, durability and industrial importance-Rock utilizers have to understand the basics of formation of rock deposits, and their identifications in the field or plant prior to usage for engineering and architectural designs. Rock is aggregate of natural minerals. Rock identification requires knowing the properties of rock

forming minerals. Minerals are to be identified in the rocks by visual methods or microscopic usage. Most of rocks can be identifiable with basic knowledge of mineral identification techniques. In following chapter, basics of mineralogy and techniques of identification of minerals in rocks by visual and microscopic methods are included. Mineral identification and diagnostic properties of rock forming minerals are included in basic mineralogy chapter. Rock utilizers for engineering projects, architectural design, constructional engineering, commercial and industrial usage for building materials or export to raw stones or finished rock and stone products, requires basic knowledge on rock forming minerals and their role in formation of rocks and identification. Following chapters are designed on basics of mineralogy and petrology before understanding technical, economical and engineering parameters of rocks and stones.

1.5 References and Further Study

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