

UNIT 1.3: Stone Mining in India

Unit Objectives

At the end of this unit, you will be able to:

1. Discuss the location and types of marbles in India
2. Discuss various stages in marble mining
3. Discuss location and phases in granite mining in India

1.3.1 Marble Mining

Marble is a 'minor mineral' as defined in the Mines and Minerals Act, 1957. It has multiple pleasant colours, smooth and uniform texture, moderate hardness and can be quarried into big blocks.

Technically, marble is formed from limestone which gets transformed due to heat and pressure, and recrystallises.

For miners and stonemasons, all rocks which contain calcium carbonate and capable of polish are termed as marbles. While marble is not a prime export such as other stone and granite, in India its demand and consumption is high. Marble is used as a building material and for sculptures.

The following figure shows a marble quarry and the use of marble.



Fig. 1.3.1. Use of Marble in building construction and a Marble Quarry site

1.3.1.1 Location of Marble Mines

Marble is found in many states such as Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Jammu & Kashmir, Maharashtra, Sikkim, Uttar Pradesh and West Bengal. Of these, the deposits in Rajasthan, Gujarat, Andhra Pradesh and Madhya Pradesh are economically important.

Rajasthan has the best quality of marble, and the important marble occurrences are shown in the following.

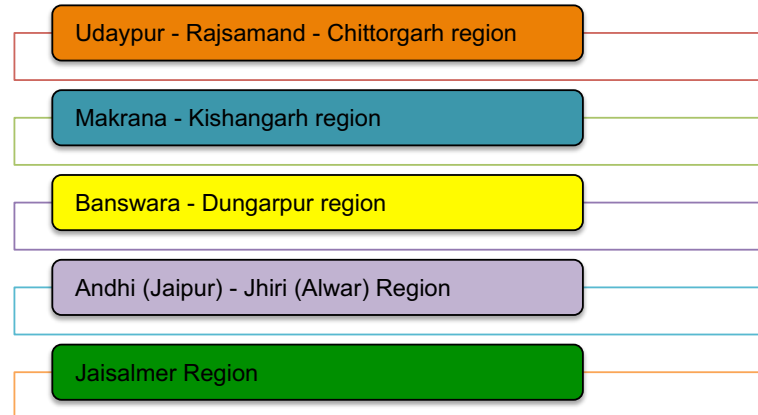


Fig. 1.3.2. Locations of marble sites in India

1.3.1.2 Types of Marble

Following are key types of marbles:

- White marble
- Panther marble
- White veined marble
- Plain black marble
- Black zebra marble
- Green marble
- Pink Adanga marble
- Pink marble
- Grey marble
- Brown marble

Marble can also be classified by their chemical composition and origin. These include:

Calcite marble: crystalline variety of limestone. Less than 5% magnesium carbonate. Varied from grey to white to any colour.

Dolomitic marble: Crystalline variety of limestone. Not less than 5% or more than 20% magnesium carbonate as dolomite molecules.

Dolomite marble: Crystalline dolomite with an excess of 20% magnesium carbonate as dolomite molecules. It has varied colours and textures. The lustre can be enhanced. Low cost and exotic colours. Found in Banswara in Rajasthan and Chhota Udaipur in Gujarat.

- **Siliceous Limestone:** Contains high silica, smooth and fine grained appearance. Difficult to cut and polish, available in various colours. Found in Babarmal and Alwar.
- **Limestone:** Various kinds are available. The Black marble of Bhainslana, Karta and Sirohi and golden-yellow marble of Jaisalmer are soft and requires frequent maintenance.
- **Serpentine or Green marble:** This has large amount of serpentine mineral and is in shades of green. Found in Gogunda, Rikhabdeo, Kesariyaji and Dungarput.
- **Onyx:** This is a dense crystalline form of lime carbonate deposited usually from cold water solutions. Usually transparent or translucent and used in decorative articles. Found in Kupwara district of Jammu and Kashmir.
- **Travertine marbles:** Variety of limestone regarded as a product of chemical precipitation

1.3.1.3 Mining and Processing

In typical mining method, mined out minerals are obtained in small quantities.

On the other hand, in stone mining, including marble mining, large size intact blocks without any cracks or damages are extracted. Today, marble mining in India is done by manual, semi-mechanized or mechanized methods. In mechanized means, various kinds of equipment and machines are used. However, most mines use semi-mechanised methods.

1.3.1.4 Stages in Marble Mining

The various stages of marble mining are:

- Removal of Overburden:** This is the removal of material above the stone deposits. This is generally carried out with heavy earth moving machinery. Sometimes, this is done by drilling holes with **jackhammers** and slim drill machines. The holes are then charged with explosives and blasted in a controlled way, so that the overburden material is loosened. It is then removed with heavy earth-moving machinery such as excavators, tippers, and loaders.
- Marking for Removal:** After the marble is exposed on removal of overburden, the area around is studied well. The joint and fracture pattern in the stone is minutely checked. Then a key block is marked for removal or for quarry front cut.
- Cutting the Quarry front:** In manual operation, a line of shallow holes is made, and by driving in wedges with feathers by constant hammering, a fracture is developed along a block. The block is pulled out by chains or pulley system or is pushed by driving logs. Once the block is toppled, it is again cut and dressed for getting a parallel pipe shape.

In the semi-mechanised operation, jack hammers, slim drills, line drilling machines are used to create a block. The block is pulled out using cranes, winches, dozers, etc. Here the wastage is high and the size of blocks is small and defective.

To overcome these problems, the quarry front cut is made with slim drill machines, diamond wire saw, quarry master, diamond bell saw and chain saw machines.

The following image shows use of a wire saw.



Fig. 1.3.3. A Wire Saw

1.3.1.5 Using Diamond Wire Saw for Cutting Quarry Load

Wire saws are large machines that use diamond-impregnated beads on a cable to cut through marble, granite and other similar rocks. Wire saw is also used for squaring of the cut slab into square shaped blocks before transporting to the production plant.

The drill machines are used to drill holes, through which the diamond wire saw is passed. The block is cut by continuous motion of the diamond wire saw. Once the block is cut, it is toppled with hydrobags, pneumatic pillows, air jacks, etc. In this method, exact sized blocks can be cut with minimum wastage.

The lifting and loading of blocks are done by Derrick cranes and various kinds of loaders. The following figure shows a loader:



Fig. 1.3.4. A Loader

1.3.1.6 Processing of Marbles

Processing is done in two stages.

- **Stage 1:** Here the blocks are cut into 2 to 3 cm slabs using gang saws, wire saws and circular saws. In marble tiled plants, the thickness of tiles can be 10 or 12 mm. The following figure shows using cutting marble:



Fig. 1.3.5. Marble cutting

- **Stage 2:** Tiles are polished using various pneumatically operated or other polishing machines such as line polishers, trimmed and cut to size, buffed, chamfered with various machines before selling.

Rajasthan has the capacity to process 95% of marble in India. Many gang saws and automatic tiling machines are used here.

Craftsmen in India develop art from marble using manual means and simple tools. Stone fairs are regularly organized in Rajasthan to promote stone artifacts and provide encouragement to sculptors and craftsmen.

Markana Marble Mines

The Markana area in Rajasthan is famous for its pure white marble and is known as the 'Marble City' of India. It is believed that marble mining in Markana started more than 1000 years ago, and marble from here was used to build the Taj Mahal. There are approximately 817 licensed quarries in Markana, with more than 50,000 workers.

1.3.1.7 The Indian Standard Recommended Practice for Quarrying Stones for Construction Purpose

The Indian Standard IS 8381: Recommended Practice for Quarrying Stones for Construction Purpose, 1977 lays out the following practices for quarrying and mining of marble.

1.3.1.7.1 Selection of Quarry Site

- Quarrying of marble is done by cutting of the blocks of as big size as possible and free from cracks or flaws.
- One has to be very cautious while marble quarrying to ensure the blocks are of good quality.
- The blocks are separated by joints. Wide spacing of the joints increases the value of the deposit because in that case the blocks of bigger size can be excavated which fetch high prices.
- Besides joints, there are major and minor cracks, more so near the surface which disappears at depths.
- Miners are required to look for such issues.

1.3.1.7.2 Determining Quarrying Method

- The quarrying method should be decided after studying the features of a particular deposit.
- Quarrying of the marble includes removal of the overburden, opening of free faces, demarcation of the marble block and excavation of the block.
- So far underground mining for marble is not adopted in our country.

1.3.1.7.3 Removal of Overburden

- First of all overburden is removed which can be done manually.
- Blasting may be resorted to where hard top layer occur.
- Drilling of the holes may be done either by manual labour or by compressed air drill.
- The waste rock may be transported to sufficient distance away where there may not be any mineral deposit underneath.

1.3.1.7.4 Opening Free Faces

- Removal of the overburden exposes joints and planes of weaknesses at the top of the deposit. These must be examined closely.
- Then one free face is opened along the strike of the deposit while another free face is excavated across the strike.
- The channels of the free faces are cut by blasting holes of about 2.5 cm diameter and about 0.5 to 0.7 m in depth.
- At a time, only limited number of holes are blasted so that no damage may be caused to the block.
- The drilling of the holes for excavation of channels may be carried out either manually or with compressed air drill.

- The width of these channels is approximately 0.6 to 0.8 m.
- The depth of the channels may be from 3 to 6 m depending upon the availability of natural joint in depth. The lengths of these channels are decided upon by the distance between the joints across as well as along the strike.
- These joints thus demarcate the block which is under extraction.

1.3.1.7.5 Loosening the Block

- After opening these free faces, a single hole of about 4 to 5 cm in diameter is drilled roughly at a point where the joint perpendicular to the strike channel meets the joint perpendicular to the channel across the strike.
- The depth of this hole is about 30 to 35 cm less than the depth of the channel, so that effect of blasting may not be passed on to the block underneath.
- The hole is under charged with gun powder and blasted which causes the loosening of the block.

1.3.1.7.6 Separation at Bottom

- The block at the bottom can be separated by drilling the holes along the line determined by the thickness of the block desired, putting in the wedges and then hammering them in succession.
- A series of holes may be drilled with spacing of about 5 to 10 cm.
- These holes may be drilled either manually or by compressed air drills.
- After drilling holes, wedges of about 15 to 20 cm in length are driven in and hammered lightly first followed by hard hammering so as to cause the separation of block from the bottom.

The following figure shows the location of holes for blasting in marble quarries.

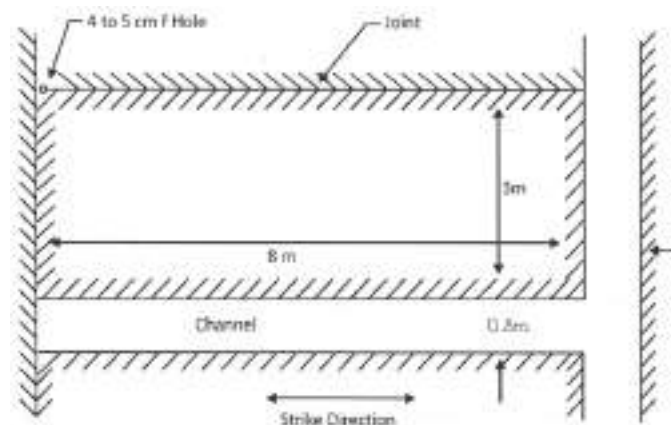


Fig. 1.3.6. Location of holes for blasting in a marble quarry

1.3.1.7.7 Wire Saw Method of Quarrying

Quarrying can be done with wire saw method which consists of the 1 or 3 strand ropes of 10 mm diameter which runs as a belt and cuts by grazing on the rock, when fed with sand and water.

1.3.1.7.8 Subdivision of Block

- The big block of the marble so cut is further subdivided to make smaller blocks.
- The procedure for extracting the smaller block also involves the drilling of the holes.
- The blocks are then dressed by chisels and hammers to make it perfectly rectangular.
- Then the blocks are lifted and loaded in the trucks and transported to the factory for further processing.

Exercise-5



1. What are the some considerations miners should keep in mind while selecting sites for marble quarrying?

2. What is removal of overburden?

3. How is the rock loosened after opening free faces?

1.3.2 Granite Mining

Granite is a light-coloured stone containing other minerals, but commercially, all crystalline rocks with pleasing colours and strength to bear quarrying, cutting and polishing is referred to as granite.

Granite is more resistant to wear and tear, and so is in demand.

1.3.2.1 Location of Granite Mines in India

India has a large deposit of granite, most of which is located in Rajasthan, Odisha and Karnataka, followed by Jharkhand, Gujarat, Andhra Pradesh and Madhya Pradesh. The following shows a granite mine:



Fig. 1.3.7. A granite quarry

There are over 300 varieties of granite, out of which India supplies 200 varieties.

1.3.2.2 Stages in Granite Mining

Mining of granite has two stages of operation.

Stage 1: The actual block splitting from either the sheet rock or boulder. This is done manually mostly, and in some cases by semi-mechanised methods. Some mines however use modern method of block splitting using flame-jet burner and wire saw for cutting.

Stage 2: Removal of overburden or weathered zone, opening of faces, lifting of cut blocks, transportation and other activities. This stage mostly uses mechanised methods. Heavy-duty derrick cranes can handle 50-tonne blocks from a depth of more than 60 m. Another modern method of recovery of dimensional blocks is water jet cutting technique. There is minimum cutting loss here and minimum damage to the adjacent block.

1.3.2.3 Processing Granite

Granite has been traditionally hand polished or semi-hand worked in India. The processing today involves sawing or cutting raw blocks into tiles or slabs or required size and thickness and polishing. Edge cutting, milling, boring and contouring are other operations.

Granite is mostly used as a building material because of its strength, density, water absorption capability, colour and texture.

Environmental Effects of Stone Mining

Mining affects the environment adversely at times. Some effects of stone mining may be:

- Degradation and removal of top soil
- Disturbance of flora, fauna and water quality of the area
- Dumping of overburden or rejected blocks leading to hazards or increase in waste material in nearby areas
- Decrease in fertility of nearby land area
- Air, water and noise pollution

It is important that mining activities ensure these are minimized as much as possible.

Exercise-6



What are the two stages in granite mining?

Notes



UNIT 1.4: Mining Equipment

Unit Objectives

At the end of this unit, you will be able to:

1. List some key machines used in mines
2. Explain some basic electricity and electric motor concepts
3. List some major machinery handling hazards and safety precautions

1.4.1 Machine Used in Mines

Surface mining requires the use of a number of machines and tools. Following are some of the most important tools used.

1.4.1.1 Diamond Wire Saw

A wire saw is a machine-powered saw that uses diamond embedded beads on a metal wire to cut through stones. It uses continuous scratching or rubbing to cut hard stones into large blocks. The wire passes around a fly wheel and is carried on pulleys to the part of the quarry where the cutting is to be done.



Fig. 1.4.1. A diamond wire saw

1.4.1.2 Air Compressor

In mines, air compressors are used as a source of electricity for powering drilling machines, conveyor belts or other machines. They are also used for supplying oxygen in underground mines. The following figure shows an air compressor.



Fig. 1.4.2. A Air Compressor

1.4.1.3 Jackhammer

This is an electrical tool that includes a hammer along with a chisel. With electricity the hammer strikes the chisel back and forth. Sometimes jackhammer also use compressed air supplied by an air compressor. The jackhammer is used for breaking rocks. The following figure shows a jackhammer.



Fig. 1.4.3. A Jackhammer

1.4.1.4 Hydraulic Drill

This is a machine to drill holes on rocks. This machine is powered by hydraulic oil instead of compressed air or electric motor. The following figure shows a hydraulic drill.



Fig. 1.4.4. A Hydraulic Drill

1.4.1.5 Derrick Crane

This is a rock lifting machine with a long tower. It is mostly fixed at a location. The tower helps in moving large pieces of rocks from one location to a nearby location.



Fig. 1.4.5. A Derrick Crane

1.4.1.6 Loader

A loader is a heavy machine with a bucket like front. This is used to scoop heavy material and move it from one place to another.



Fig. 1.4.6. A Loader

1.4.1.7 Chisel

This is a tool with a long blade which has a cutting edge. The blade is attached to a handle. This can be used to cut or shape rocks, or create fractures on the face of the rock.



Fig. 1.4.7. Chisel

1.4.1.8 Wedge

This is a simple tool, triangular in shape with two inclined planes meeting on a sharp edge. Wedges can be used to push to pieces of rocks apart.



Fig. 1.4.8. Wedge

1.4.1.9 Hammer

This is a machine to drill holes on rocks. This machine is powered by hydraulic oil instead of compressed air or electric motor. The following figure shows a hydraulic drill.



Fig. 1.4.9. A Hammer

1.4.1.10 Water Pump

Most mines use a water pump to supply high pressure water for cutting and flushing rocks. Following figure shows a water pump:



Fig. 1.4.10. A Water Pump

1.4.1.11 Excavator

This is a big and heavy earth moving track mounting machine which includes under carriage, machine room, operator's cabin, boom & stick fitted with a bucket as front attachment. The complete machine with boom, stick and bucket can swing / rotate full circle on a platform. The platform sits on swing gear powered by swing motors. The propel mechanism for traveling is also powered by hydraulic motors, which drives under carriage.

These are used in many ways, including loading trucks and removing overburden. The following figure shows an excavator:



Fig. 1.4.11. An Excavator

1.4.1.12 Hydraulic Jacks

A hydraulic jack is a machine which uses hydraulic power to lift heavy load or equipment by applying force. These can crush or break huge chunks of rocks.



Fig. 1.4.12. A Hydraulic Jack

1.4.1.13 Wagon Drills

This is a machine that uses air pressure for rock drilling and blasting. The following figure shows a Wagon Drill



Fig. 1.4.13. A Wagon Drill

1.4.1.14 Diamond Belt Saws

This is a huge cutting or sawing machine for making vertical or horizontal cuts. The tool has a special plastic belt with diamond segments.



Fig. 1.4.14. A Diamond Belt Saw

1.4.1.15 Chain Saw

A machine with a toothed blade that can cut rocks vertically or horizontally. Chainsaws can be of various kinds. Mines use a type which has cutting edge of the blade embedded with diamond. The chain is lubricated with water. The following figure shows a diamond belt saw.



Fig. 1.4.15. A Chain Saw

1.4.1.16 Tipper

A tipper is a truck used for transporting loose material. The following figure shows a tipper.



Fig. 1.4.16. A Tipper

Exercise-7



Write 'Load' for loading / Transportation and 'Ext' for Extraction based on the stages in which these machines are used.



1.4.2 Basic Electricity Concepts

Most of the mining machinery today runs on electricity or motors. Understanding some basic electricity and motor concepts is crucial to understanding how the machines work or perform basic troubleshooting when required.

1.4.2.1 Common Electricity Terminology

In this section, some commonly used electricity concepts such as current, direct (DC) and alternating current (AC), voltage, resistance and electric circuit is explained.

1.4.2.1.1 Electric Current

Electric current is the flow of charged particles, just as water current is the flow of water in a particular direction. Charged electric particles in an electric current are electrons.

Electrons flow through a conducting medium such as metal or wire.

For electricity to flow, there must be a force to push them. This push or force is called voltage. The following figure shows the flow of electric current.

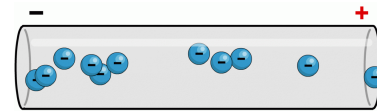


Fig. 1.4.17 Electric Current

1.4.2.1.2 Voltage

Voltage is the force needed to make electricity flow through a conductor. This is also known as electromotive force (emf). Voltage is measured in volts and is represented by symbol 'V' or 'E'. The bigger the voltage, the more current will flow. A battery can be used to provide voltage. A 12 volt battery will produce more current than a 1.5 volt battery.

Voltage is measured by a voltmeter. The following figure shows a voltmeter.



Fig. 1.4.18. A Voltmeter

The flowing electric current is measured with an ammeter. Electric current is measured in amperes or amps (A), and is denoted by symbol (I). Following figure shows an Ammeter.



Fig. 1.4.19. An Ammeter

1.4.2.1.3 Power and Energy

Together voltage and current provide power. The more the voltage and the current, the more power it will provide. Electric power is measured in watts. Power is how much energy a machine is using per second. To find the total energy an electric machine uses, we use the formula:

$$\text{Energy} = \text{Power} \times \text{total number of seconds the machine is used for}$$

Electric Energy is measured in kilowatt per hour (kWh).

1.4.2.1.4 Electric Circuits

To create an electric current to flow in a conductor, we need a circuit. A circuit is a closed path or loop within which the electric current flows. A circuit can be made using a voltage source (such as a battery), conductors (such as wire). We can add an electrical load, which is the section that would consume the energy (such as a bulb, a machine or appliance). We can also add switches that will help us control the flow of electrical current. See in Fig. 1.4.21.



Fig. 1.4.20. A Complete Circuit

1.4.2.1.5 Resistance

Most materials have an in-built property to oppose the flow of electricity. This is called resistance. This is represented by 'R'. It is measured in ohms, with an instrument called ohm meter. The following figure shows an ohm meter.



Fig. 1.4.21. An Ohm Meter

As mentioned, flow of electric current is dependent on voltage.

Voltage can be calculated as:

$$\text{Voltage (V)} = \text{Electric Current (I)} \times \text{Resistance (R)}$$

In other words,

$$I = V/R$$

From this we can say that:

- 1- More the voltage, more the electric current
- 2- More the resistance, less the electric current

1.4.2.1.6 Direct and Alternating Current (DC and AC)

Electricity can flow in two ways.

- Direct Current: When electricity always flows in the same direction, it is called direct current (DC). Some machines and motors use DC current. Batteries create a DC current as electrons flow from the 'negative' end of the battery to 'positive end' as shown in the figure below:



Fig. 1.4.22 Electric Current

- Alternating Current: In this type, the electrons can constantly reverse their direction many times in a second. Though it may seem impossible, but this flow is so quick that the machines or appliances can use this well to work.

The following figure shows direct current and alternating current.

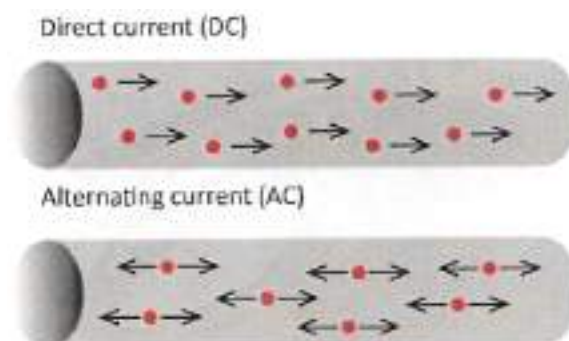


Fig. 1.4.23. DC and AC current