Chapter 3

OVERVIEW ON THE MINING

3.1 OVERVIEW OF INDIAN STONE INDUSTRY PROFILE

India has major resources of marble, granite, sandstone, Kotah stone, quartzite & slate. Granite resources are largely in South India and Marble deposits are largely in Western India (Rajasthan & Gujarat).

The highest producer of stones

- Highest producer of dimensional stones in the world accounting for over 27% of the world stone production.
- 16.16 million tons of stone production in the year 1997-98 out of a total world production of 61 million tons.
- Over 2 million people are employed in stone sector.

Indian Stone Production (In Thousand tons)

	1991-92	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**
Marble	1966	2244	2086	2627	3186	3712	3622
Granite	989	3073	3618	4460	4555	4550	4950
Sandstone	4411	4435	3978	3304	4562	5501	5461
Flaggy Limestone	620	996	823	1407	1760	1710	2118
Slate	3	5	4	9	7	11	8
Total	**7989**	**10753**	**10509**	**11807**	**14070**	**15484**	**16159**

(Source: State Department of Mines & Geology and All India Granites & Stones Association)

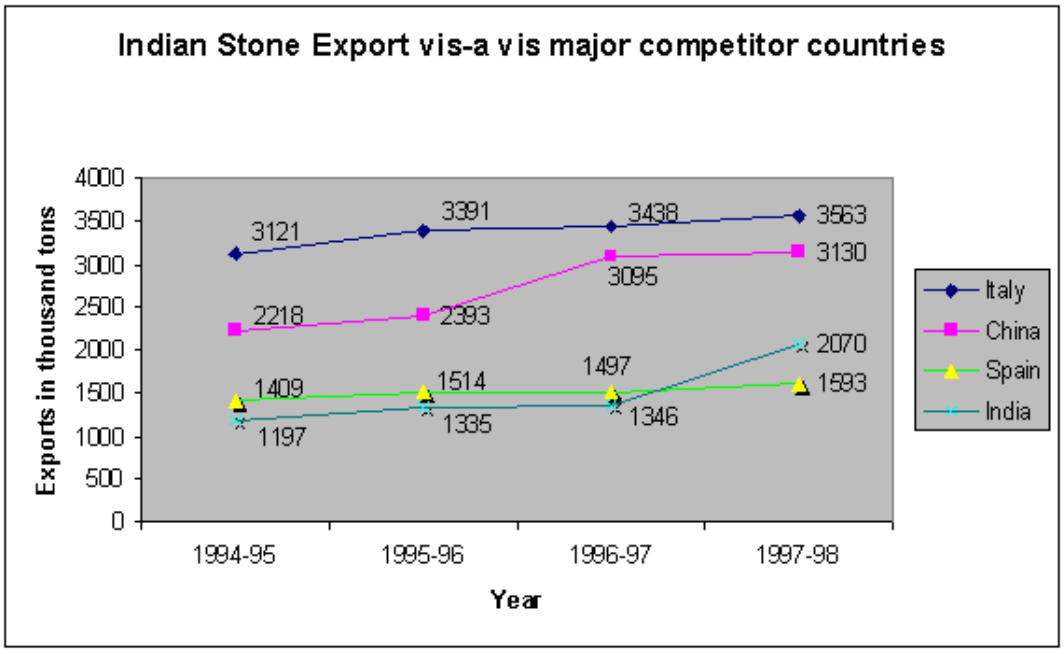
Marching towards global leadership

- Export of Stones - US $ 301 million (Rs.13,000 million) in 1997--98
- India ranks 3rd in world stone exports with a 10.8% share in 1997 (in terms of tonnage).
- India ranks 1st in Raw Siliceous product (Granite & Sandstone) exports.
- India ranks 5th in Raw Calcareous product (Marble & Flaggy Limestone) exports.
- India ranks 9th in exports of finished stone products.

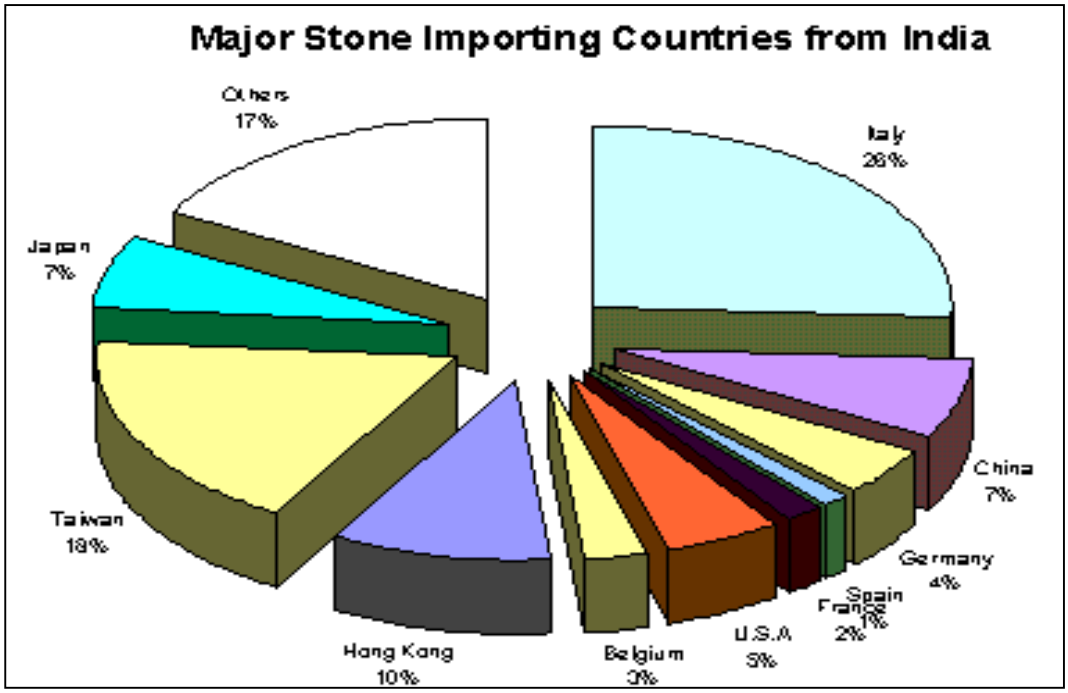
The bulk (90%) of the Indian stone exports is by way rough granite and marble blocks and only about 10% is by way of value added or branded products. Indian stone industry and the Government have set a target of raising this to 50% over the next 5 years.

The bulk of the Indian stones are produced in the Indian states of Rajasthan, Tamilnadu, Karnataka and Andhra Pradesh. Rajasthan accounts for nearly 90% of all the marble produced and the other three states in Southern India produce almost all the granite exported.

3.2 STATISTICAL OUTLOOK



Major Importers



Marble the pride of India

- Practically inexhaustible marble deposits -over 1200 million tons
- Splendid varieties of white, green, black, grey, pink, yellow
- Physical and mechanical properties complying with international standards
- Amongst the top 5 countries in marble exports

A Vibrant Industry

- Total Investment - over Rs.40,000 million (US $1,000 million)
- About 4,000 mining leases
- Block production 3.7 million tons in 1996-97
- About 1,100 modern gang saw units and 50 Automatic tiling plants
- More than 5,000 trading companies

- Employing about 1 million people
- Fast developing modern mechanised quarries
- Over 300 quarries using diamond wiresaw& chainsaw cutter quarrying technology
- Modern & well equipped factories with advanced Italian technology for cutting, processing, polishing and handling
- Marble slab & tile production: 1300 million sq. ft per annum

Impressive Marble Export

- Increase of over 300% from US $ 9 million in 1992-93 to US $ 27 million in 1996-97
- Excellent quality export varieties - Green, Onyx, Indo Italian, White and Pink marble
- High quality polished marble tiles & slabs and green & white marble blocks correspond to demand in the foreign market
- High export demand for marble handicrafts
- Key marble export markets - USA, Canada, Japan, Singapore, UAE, EC countries

3.3 OVERVIEW ON THE MARBLE

The term "Marble" is derived from Latin word "Marmor" which itself comes from the Greek root "Marmaros" meaning thereby a shining stone. Technically marble is a recrystallised, compact variety of metamorphosed limestone capable of taking polish. Commercially, marble is any crystalline rock composed predominantly of calcite, dolomite or serpentine, having 3-4 hardness, which can be excavated as blocks and can be sawed and takes good polish.

3.4 PHYSICAL ORIGINS MARBLE

Marble is a rock resulting from metamorphism of sedimentary carbonate rocks, most commonly limestone or dolomite rock. Metamorphism causes variable recrystallization of the original carbonate mineral grains. The resulting marble rock is typically composed of an interlocking mosaic of carbonate crystals. Primary sedimentary textures and structures of the original carbonate rock (protolith) have typically been modified or destroyed.

Pure white marble is the result of metamorphism of a very pure (silicate-poor) limestone or dolomite protolith. The characteristic swirls and veins of many colored marble varieties are usually due to various mineral impurities such as clay, silt, sand, iron oxides, or chert which were originally present as grains or layers in the limestone. Green coloration is often due to serpentine resulting from originally high magnesium limestone or dolostone with silica impurities. These various impurities have been mobilized and recrystallized by the intense pressure and heat of the metamorphism. (Source: https://en.wikipedia.org/wiki/Marble)

3.5 MAJOR SITES OF MARBLE IN INDIA

Rajasthan is the richest state in the country with regards to marble deposits both in quality and quantity. The state is most important centre (Mandi) of marble processing in the country with about 95% of the total processing units. Rajasthan possesses large reserves of about 1100 million tonnes (M.T) of good quality marble. Rajasthan, the largest State in the country in terms of geographical area, is located in the north-western part of the country. It has a geographical area of 3, 42,239 sq.km, which constitute 10.41 per cent area of the country. There are 2,849 mining leases for major minerals and 11,849 minor leases and 16,297 quarry licenses existing in the State. Mineral survey and prospecting on projects have been taken up or are being carried out. Udaipur is one of the major producers of marble. The important marble deposits are seen in Nagaur, Jaipur, Alwar, Dausa, Jaisalmer, Rajsamand, Pali, Banswara, Udaipur, Bundi, Sirohi, Dungarpur, Ajmer, Sikar, Jodhpur, Bhilwara, Chittaurgarh, Churu

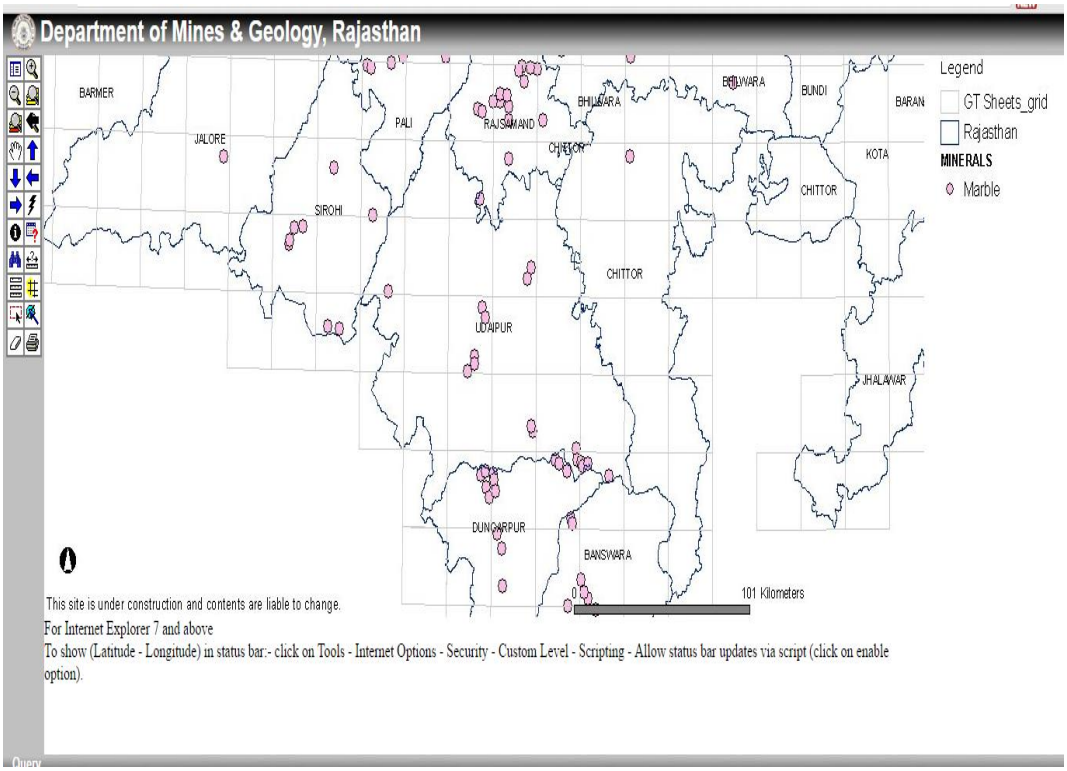


Figure 1. Udaipur Mining area Map

(Source: http://gis1.dmg-raj.org/website/DMGGIS/viewer.htm?Service=Marble)

3.6 CLASSIFICATION OF TYPES OF MARBLE

Marble has been classified into 10 groups by Bureau of Indian Standards (Indian Standard Institute i.e. ISI) (IS 1130-1969) on the basis of colour, shade and pattern. Rajasthan is the most fortunate state where all the 10 groups specified below are occurring:

1. Plain White Marble
2. Panther Marble
3. White Veined Marble
4. Plain Black Marble
5. Black Zebra Marble
6. Green Marble
7. Pink Adanga Marble
8. Pink Marble
9. Grey Marble
10. Brown Marble

3.7 PROCESSING OF MARBLE

A large number of processing centres have been developed in the state at Makarana, Jaipur, Alwar, Ajmer, Udaipur, Nathdwara, Rajsamand, Morchana, Amet, Abu Road, Kishangarh, Banswara, Chittaurgarh, Sirohi etc. where more than 1100 gangsaws and 50 automatic tiling plants are in operation. A large number of tiny units are also working.

Chemical Properties of the Marble

Marble Area	**CaO**	**MgO**	**SiO_2**	**Fe_2O_3**	**LOI**
Jhiri, Alwar	26-33	21-25	0.01-3.18	0.73-1.01	40-47
Tripura Sundari, Banswara	32	23-24	<=23.4	0.200.84	42-44
Mandaldeh, Chittaurgarh	35.92	3.01	18.52	2.93	33.18
Sandwa, Churu	31-37	13-22.6	<=6.44	0.12-0.26	45-46
Dungarpur	48.18	2.04	10.75	1.13	35.55
Bhainslana, Jaipur	48-54	2-4	1-3	1.5-3	35-45
Phalodi, Jodhpur	39.03	9.36	8.70	0.48	42.83
Makrana, Nagaur	50-56	0.8-1.8	0.33-1.20	0.10-0.28	34.8-43.2
Rajnagar	30-33	16-25	0.01-7.6	0.12-0.95	36-44
Sirohi	51.49	0.90	8.52	0.54	39.36
Keshariyaji, Udaipur	18.56	21.29	31.51	5.33	21.82
Babarmal, Udaipur	20.79	2.21	1		

TECHNICAL INFORMATION OF MARBLE									
Technical Details →	**Water Absorption, % by weight**	**Density, bulk specific gravity**	**Modulus of rupture, N/mm²**		**Compressive strength N/mm²**		**Abrassion resistance to wear**		**Flexural strength, N/mm²**
ASTM/ Indian Standard →	C-97	C-97	C-99		C-170		IS 1237 Guidelines		IS 4860 Guidelines
Area ↓			Dry	Wet	Dry	Wet	Avg. Wear mm	Mxm. Wear mm	
Makrana	0.04	2.68	14	16	88	81	3.1	3.2	16
Andhi Indo	0.05	2.68	13	11	130	109	6.6	6.8	11
Andhi Modern art	0.08	2.68	14	17	94	114	3.8	4.1	16
Jhiri Onyx	0.06	2.68	9.00	8	142	108	5.5	5.7	8
Agaria, Rajnagar	0.06	2.84	17	16	106	102	4.0	4.2	15
Morwad, Rajnagar	0.04	2.84	12	13	111	80	3.1	3.2	13
Keshariyaji Green	0.07	2.66	42	35	286	194	1.1	1.2	35
Bidasar	2.38 - 2.43	2.55 - 2.47	19 - 24	13 - 20	138 - 114	83 - 81	1.45	1.6	12 - 20
Phalodi	0.64	2.62	15	21	212	116	2.0	2.2	20

3.7.1 How is Marble Formed?

Marble stone is formed due to metamorphism of sedimentary carbonate rocks, most commonly known as dolomite rocks or limestone. Marble stone are recrystallization of carbonate minerals. Today technology is growing very rapidly

and it's being very useful to marble, making it more beautiful and has increased availability across the world. Marble fabrication is the process which explains all the steps in marble processing.

3.7.2 Marble processing steps

1. **Quarrying** The first step to finding the perfect slab is finding an optimal deposit of material with desirable color, pattern, and composition. This requires geologists to look for stone outcrops which are more easily examined since the bedrock is exposed. Samples are then obtained by boring into the earth to take core samples with expensive diamond-tipped drill bits. These samples are then tested to determine if the stone is suitable for use as dimensional building stone. Later they are polished so that their color and pattern can be examined to determine marketability.

2. **Extraction** -After the quarry manager decides how to extract the blocks, the drilling can begin. The process starts by taking down a "bench wall," a large dimensional chunk of rock that is then cut into smaller blocks which will eventually be sent to the factory for processing. The bench walls are cut using a combination of diamond wire cables, drills and even high temperature torches that will melt the stone. Dirt is pushed up against the base of the wall to cushion the fall, and small dynamite charges jar the wall loose to bring it down to a horizontal position. The blocks can then be drilled from the bench wall. Blocks of a given type of stone usually have a fairly uniform size, due to the size of the processing equipment used. Granite blocks usually weigh between 38-42,000 pounds, while lighter marble and travertine blocks weigh between 15-25,000 pounds.

3. **Gang Sawing** - After the transportation of marble to their respective location, they are taken to Fabrication area where marble are cut into more fine pieces. The fabrication area is a big warehouse where the slabs of marble are cut with steel blades with the help of hydraulic lifts. In this process marble slabs are placed on an assembly line which are lifted by

hydraulic pressured jacks and marble slabs are cut by giant sets of saw or Gang saws which are just above the assembly, this saw's are connected to crankshaft and pistons which are connected to engines moves this crankshaft, resulting the saw's to move horizontally at a rapid speed. Marbles slabs on assembly line are pushed by the hydraulic pressure and the saw cuts the marble slabs. Then the marble small pieces are to taken carefully to the finishing and polishing room for further processing.

4. **Polishing and Sealing -** Polishing and sealing is the main procedure in marble fabrication as it defines the true value of marble. The slabs of marble are placed on a platform where machine with artificial diamonds smoothens the surface of the marble until partial reflection are visible on the marble. This process is repeated on both sides and then cleaned properly so that dust particles are removed. Polished marbles are then taken for a uniform spray of epoxy sealer on the surface of the stone and dried under heat lamps for 48 hours. Finished Marble are send to the retailers and sellers to their respective location for further procedure and selling.

5. **Water jet Cutting and Wet Sawing** - Retailer's sell the marble stone to their customer as per their requirement, which includes the design, quantity, and most important the size of marble stones. Customer demands different sizes of stone which can fit there in their kitchen, bathroom, countertops, floors etc. hence for this retailer themselves shape the size of the marble, to do this they use wet sawing or water jet cutting. In wet sawing the marble stone is being cut by the saws and water is kept flowing over the marble to reduced heat from friction. Water jet cutting is a new and unique method. In this process water with powdered minerals are pressurized at 60000 psi and shot on the marble for clean and better cut. This is very common today and almost all fabricator use water jet cutting.

   (Source: http://www.selfgrowth.com/articles/marble-stone-fabrication-process)