

United Nations Industrial Development Organisation

Investment Promotion Unit – UNIDO TUNISIA



MARBLE IN TUNISIA

Processing and manufacturing industries

**Tunisian marble stones:
Technical characteristics and available resources**

Investments in the mining sector

Marble industry in Tunisia

The marble sector consists of 215 firms, divided into 3 different sectors.

Firms in the marble sector – distribution by activity; Year 2004

| Activities | Number of firms |
|--------------------------|-----------------|
| Block quarrying | 21 |
| Industrial manufacturing | 57 |
| Cutting | 137 |
| TOTAL | 215 |

Source: TCCMCG, 2004

Regarding block quarrying, there exist 21 important firms in Tunisia (Export companies, companies for both export and domestic market, manufacturing companies for the domestic market only). There are also over 40 other handwork quarries of a basic scale.

The 57 industrial manufacturing firms have at least a sawing or block cutting loom. The 137 firms specialized in cutting are small units with a personnel ranging between 2 and 10 people. They use light sawing and surface treatment equipment. Generally, they get their supplies from manufacturers. They also resort to subcontracting with manufacturers specialized in sawing blocks acquired in Tunisia or imported from abroad.

Regional distribution of firms in the marble sector in Tunisia

| Activities | Region | North | The far Tunis | Cap Bon | Center | South | Total |
|----------------------|--------|-----------|---------------|-----------|-----------|-----------|------------|
| <i>Quarrying</i> | | 6 | 0 | 3 | 12 | 0 | 21 |
| <i>Manufacturing</i> | | 4 | 20 | 8 | 14 | 11 | 57 |
| <i>Cutting</i> | | 16 | 54 | 6 | 27 | 34 | 137 |
| Total | | 26 | 74 | 17 | 53 | 45 | 215 |

Source: TCCMCG, 2004

The marble quarrying activity lies around the big basins within a 30 Km – radius in the South/South-East of Tunis (Jebel Oust, Cap Bon), in the North/North-West (Mateur, Chemtu, Teboursouk, Siliana, El Kef) and in the western central part of the country (Thala-Kasserine), while, hand-made manufacturing and cutting are spread throughout the country, and most exactly around the biggest inhabited areas, which are considered as markets for domestic production and imported marbles.

The production rate has moved from 58 million Tunisian Dinars (TD) in 1996, to 88,4 million TD in 2001 and 96 million TD in 2003. Currently the VAT rate is of 30%.

Evolution of the production value

| | 2001 | 2002 | 2003 | Pred. 2004 |
|------------------------------|-----------|-----------|-----------|------------|
| Production value (MD) | 88.4 | 93.1 | 96.3 | 99.7 |
| Production in m ³ | 1.300.000 | 1.390.000 | 1.438.000 | 1.488.000 |

Source: TCCMCG, 2004

Currently, the marble sector employs about 2.300 people. Recently, it has witnessed a drop in investments, which moved from 6.2 million in 2002 to 4 million in 2003.

Investment evolution in the marble sector – Year 2001-2004

| | 2001 | 2002 | 2003 | Pred. 2004 |
|-------------------|------|------|------|------------|
| Investments in MD | 5.8 | 6.2 | 4.0 | 4.0 |

Source: TCCMCG, 2004

Between 2002 and 2003 imports dropped to 11.6%. They have decreased from 98.800 to 87.300 tons.

During the same period, exports went up from 23.000 to 37.000 tons, with an increase of 60%. In 1998, exports reached 17.000 tons only.

The balance of trade is constantly improving. The import-export ratio was of 24% in 1996, and went up to 55.8% in 2003.

Imports of marble and marble powder - Year 2002-2003

| Product | 2002 | | 2003 | |
|---------------|-----------------|--------------|-----------------|----------------|
| | Marble (blocks) | 91.800 t | 9 MD | 79.000 t |
| Marble (cut) | 9.000 t | 6 MD | 8.300 t | 4.8 MD |
| TOTAL | 98.800 t | 15 MD | 87.300 t | 13,2 MD |
| Marble powder | 127.300 t | 5.7 MD | 142.800 t | 6.7 MD |

Source: TCCMCG, 2004

Exports of marble and marble powder – Year 2002-2003

| Product | 2002 | | 2003 | |
|---------------|-----------------|----------------|-----------------|---------------|
| | Marble (blocks) | 23.000 t | 4.5 MD | 37.000 t |
| Marble (cut) | 5.000 t | 6 MD | 6.000 t | 3.9 MD |
| TOTAL | 28.000 t | 10.5 MD | 43.000 t | 9.7 MD |
| Marble powder | 112.700 t | 2.3 MD | 167.700 t | 1.4 MD |

Source: TCCMCG, 2004

Characteristics and potentialities of ornamental marble stones in Tunisia

In Tunisia, there are three varieties of natural stones:

- Marble stones conforming to required standards (tab. I). They have to be resistant to bad weather, aggressive waters, wearing effects, pressure and bending. They must have a nice colour and polish.
- Ornamental carving stones, having almost the same characteristics as marble stones but which have to be easy to sculpt and carve.
- Building and/or crushing stones that have to be resistant to wearing effects, fragmentation and pressure. They have to be strongly adhesive to hydraulic and bituminous limes.

Table I – German standards DIN required for marble stones.

| | |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Resistance to bad weather | DIN 52106: a piece of marble in water during 28 days at 20°C: no discoloration |
| Resistance to frost | DIN 52104: absorption % < 0.5 |
| Specific weight (SW) | DIN 52102: $2.65 < P_s < 2.85 \text{ g/cm}^3$ |
| Resistance to compression (RC) | DIN 52105: $800 < R.C < 1800 \text{ kg/cm}^2$ |
| Resistance to wearing effects of grinding** (cast-iron disc) (RWE) | DIN 52108: 15 to 40 cm ³ for 50 cm ² trial slab |

Source: NOM, 2000

Literally, marbles do not exist anywhere in Tunisia. However, slightly metamorphosed and/or crystallised carbonates, having a nice polish and colour have been appreciated both in Tunisia and abroad.

From a geological point of view, potential areas belong at least to three eras characterised by sedimentologic and paleographic conditions which are completely different from one another (Gaied, 1996).

The Jurassic era provided marbles of various colours:

- grey and black, Aziza type, within the Aziza massifs, Jebel Raouas and Jebel Oust;
- yellow to reddish, Chemtu type, especially in the Hairesh massif;
- beige and rich in bioclastis, Ghomrassen type, very widely-spread in the region of Tataouine.

The Cretaceous era is characterised by marbles of various colours:

- black, Boulahneche type, dating from the albo-aptian era;
- shades of beige to greyish carbonates in the Gattar ridge, in the south, dating from the Turonian era. These marbles are promoted under the name of Matmata;
- whitish, pink, red and yellowish (Keddel type), dating from the Cenomanian era;
- beige to greyish (Thala type) dating from the Campano-Maastrichtian era. This type is wide-spread in central Tunisia and the northern centre part of this country.

The lowest division of the Eocene system, with its nummulitic limestone facies provided the following marbles:

- beige, whitish, grey and black (Kesra type);
- yellow to pinkish (Mateur).

1. The slightly metamorphic rocks of the CHEMTU type

In northern Tunisia, there are two potential areas where marble stones of the Chemtu type are available. These areas are the Chemtu and Ichkeul massifs.

Jebel Chemtu is made up of slightly metamorphic and thinly recrystallised Jurassic dolomites and limestones, the colours of which are pink and yellow. At the heart of these rocks, there are some greenish schists that are locally used as "green marbles".

Jebel Ichkeul is an anticline, the backbone of which is made up of huge dolomitic limestones surrounded by a marble step located on the west end of this massif. This step has provided two marble varieties:

- white or grey or blue white-veined marble.
- pure yellow to honey yellow marble, or shades of green or pale pink.

All quarrying activities have ceased at the Ichkeul estate because it has become a protected national park. Regarding the Chemtu deposit, reserves have not been certified yet. However, a figure was provided by a German consultancy firm (Salzgitter, 1963), i.e. 80.000 m³ at the level of the Sidi Assem.

These marbles are resistant to bad weather conditions and to the wearing effect of grinding conforming to the DIN standards. This characteristic makes it possible to use these marbles in the making of slabs for external covering as well as for building and decoration.

Geotechnical characteristics of the Chemtu type marble

| S.W. in g/cm ³ | Absorption | Porosity | R.C. in kg/cm ² | R.W.E. | R.B.W.C. |
|---------------------------|------------|----------|----------------------------|------------|------------|
| From 2.67 to 2.69 | < 0.5% | - | From 800 to 1400 | Good (DIN) | Good (DIN) |

Source: NOM, 2000

The exploitation of the Jebel Chemtu quarries resumed in the beginning of the 60's at the rate of 1.000 m³ of marble per year. Hundreds of thousands of m³ can be recovered from the northern part of the country (a sector that is preserved by the Heritage National Agency). In fact, remains of Roman quarries lie in that part. Future exploitation should not be strictly forbidden but guided by an archeological map, delimiting the areas having a historical value.

2. White-beige to pinkish marble stones of the KEDDEL type

These are nearly massive fossiliferous limestones, with a reef-like aspect dating back to the Cenomanian era and having light grey to pink shades. This type of marble stones is largely exploited in the Jebel Keddel massif in the suburbs of Borj Cedria (20 kms south of Tunis).

Reserves are estimated at 3 millions m³ (Salzgitter). With reference to the DIN German standards, the following table shows geotechnical characteristics.

Geotechnical characteristics of the marble stone of the Keddel type

| S.W. in g/cm ³ | Absorption | Porosity | R.C. in kg/cm ² | R.W.E. | R.B.W.C. |
|---------------------------|------------|----------|----------------------------|------------|------------|
| 2.60 | 0.21% | - | From 850 to 1100 | Good (DIN) | Good (DIN) |

Source: NOM, 2000

3. White-beige and grey marble limestones of the THALA type

The Abiod formation belonging to the lowest division of the Campanian-Maastrichtian system is generally composed of two limestone layers separated by a marly one.

In areas affected by tectonics, the formation as a whole is made up of only one ridge.

Diagenetic transformations affect these limestones by making them harder and less porous. Therefore, they are liable to be treated and used in different types of coverings and decoration.

Thala is a town, which lies within a big marlo-calcareous syncline dating from the Eocene epoch and whose sides are mainly composed of the Abiod formation with an only 30 to 40 m-thick calcareous member.

Several traditional quarries are spread around Thala. The majority of blocs are treated on the spot in a marble workshop. The rest is dispatched either abroad or within the country. In order to preserve the brand image of this marble, it would be necessary to define the criteria regarding these blocks.

From a commercial point of view, the Thala marbles are known under several names, the most popular of which are:

1. Thala Royal (golden beige);
2. Thala Impérial (beige to whitish);
3. Thala Gris
4. Thala Veiné (beige but enclosing very fine fissures filled with calcite).

A marble deposit of the Thala Impérial type lies also in the area of Siliana.

A detailed study based on geological cartography of the whole region of Thala is being carried out. Thus, accurate estimations of this type of stone reserves will soon be available.

Geotechnical characteristics of the first two Thala marble varieties are very close to one another and prove that these are marble stones that can be used up as interior and sometimes exterior covering slabs.

Geotechnical characteristics of the Thala type marble stone

| S.W. in g/cm ³ | Absorption | Porosity | R.C. in kg/cm ² | R.W.E. | R.B.W. |
|---------------------------|------------|----------------|----------------------------|---------------------|----------------|
| 2.67 | - | From 4 to 4.5% | From 420 to 1100 | MDE = from 21 to 23 | Mediocre (DIN) |

Source: NOM, 2000

4. Dark marble stones: the AZIZA and BOULAHNECHE types

Black, grey, blue and other coloured marbles are available at the level of two types of outcrops at least:

1. The lias of Jebel Aziza, Jebel Oust and Raouas (marbles of the Aziza type)
2. Albo-aptian outcrops in the northern- central part of Tunisia (black marbles of the Boulahneche type).

In the Jebel Aziza deposit, there are three marble varieties, which differ according to their colour:

1. Aziza Noir – (black);
2. Aziza Berbère – (grey to greyish-blue);
3. Aziza Brun – (brown).

The Jebel Oust's summit is composed of grey to purple carbonates that are extremely fractured. The irregular spacing out of these fractures prevents the collection of regular blocks.

The Jebel Raouas site is an outcrop belonging to the lowest division of the Jurassic system, and is composed of massive limestone with a finely granular structure. Its colour ranges from grey, yellow to purple. The fracture is so important that it is impossible to dig out big blocks.

The Jebel Boulahneche massif is composed of limestones and marls belonging to the Albian era. Potential marbles form two black limestone layers, which are 3 to 5 m thick, and are separated by a 30 to 40 m thick black marly bed. The layers' pendant ranges from 10° to 15° northward. The fracture is relatively big and filled with secondary calcite, iron monoxide and/or ankerite. Quarried blocks generally have a medium size.

Blakish marble reserves are estimated to range between some hundreds of thousands to some millions of m³.

| Place | Trade name | Colour | Reserves (estimation in m ³) |
|-------------------|---------------|-----------------|------------------------------------------|
| Jebel AZIZA | Aziza Noir | Black | 200.000 |
| | Aziza Berbère | Grey | about 1.5 million |
| Jebel OUST | Aziza Berbère | Grey and purple | 350.000 |
| Jebel RAOUAS | Aziza Berbère | Grey and purple | 200.000 |
| Jebel BOULAHNECHE | Thala Noir | Black | about 300.000 |

Source: NOM, 2000

As far as the above mentioned first three quarries are concerned, marble stones have been certified by the Salzgitter team according to the DIN standards, whereas the geotechnical characteristics of Jebel Boulahneche's marbles have been identified by NOM.

Geotechnical characteristics of the AZIZA and BOULANECHÉ types (DIN standards).

| Place | Absorption | S.W. | R.C. | R.W.E. | R.B.W. |
|-------------|-----------------|-----------------------------|---------------------------------|--------|----------|
| Aziza | Weak : < 0.4 % | 2.65/2.85 g/cm ³ | Good : 1390 kg/cm ³ | Normal | Good |
| Oust | Relatively high | Normal | Normal | Good | Mediocre |
| Raouas | Very weak | Normal | Normal: 1220 kg/cm ³ | Good | Good |
| Boulahneche | 2.89 % | 2.70 g/cm ³ | 920 kg/cm ³ | 34 | Good |

Source: NOM, 2000

5. Marble stones belonging to the lowest division of the Eocene epoch: Kesra type

The following three sites have marbles with similar characteristics but different colours, and can be classified as the Kesra type:

1. Jebel Kesra (Kesra-Siliana),
2. Jebel Oueslat (Haffouz-Kairouan),
3. The region of Mateur (Mateur-Bizerta).

a. *Jebel Kesra*

The Kesra plateau is a perched syncline, the backbone of which is composed of 20 to 35 m thick nummulitic limestone layers which are subhorizontal and whose pendant ranges from 6° to 15° South-Eastward.

The limit between limestones and marls of El-Haria formation is marked by a black phosphate calcareous layer which is used as black marble.

The only quarry that is still in operation is located in the far north-eastern part of the Kesra plateau (Dyr Jerouia), the area of which is of 1.5 ha. As for geological reserves, they represent 300.000 m³.

Geotechnical characteristics of the Kesra type marble stone

| S.W. in g/cm ³ | Absorption | Porosity | R.C. in kg/cm ² | R.W.E. | R.B.W. |
|---------------------------|--------------------|----------------|----------------------------|---------------------|------------|
| From 2.50 to 2.68 | From 0.25 to 1.70% | From 1.6 to 4% | From 450 to 1250 | MDE = from 19 to 21 | Good (DIN) |

Source: NOM, 2000

b. *Jebel Oueslat - Haffouz*

Quarries lie on the eastern side of Jebel Oueslat anticline. Beige nummulitic limestones are 50 m thick whereas the layers' pendant ranges from 25 to 30° eastward.

The exploitation of the Haffouz marbles is done according to how the carving slopes towards the layers' pending.

The quarried out blocks are treated on the spot. Reserves are still very important allowing thus the possibility of creating new quarries.

Reserves lying on the eastern side of Jebel Oueslat, which stretches over several kilometers, are very important.

Geotechnical analysis done by NOM, came to the conclusion that the Haffouz nummulitic limestones range from hard to very hard rocks (according to the hardness scale AFNOR B 10.001). They are characterised by:

Geotechnical characteristics Boulahneche type of marble stone

| S.W. in g/cm ³ | Absorption | Porosity | R.C. in kg/cm ² | R.W.E. | R.B.W.C. |
|---------------------------|------------|----------|----------------------------|--------|--------------|
| 2.68 | - | 0.60% | 360 | MDE=20 | Medium (DIN) |

Source: NOM, 2000

c. *The Mateur Region*

In this area, there are several nummulitic limestone domes belonging to the lowest division of the Eocene epoch. Limestones are whitish to reddish, and recrystallised in massive beds allowing thus, the acquisition of blocks of adequate size.

The remarkable extension of these limestone domes as well as the relatively important power of this formation are but a proof that these reserves are very important.

Geotechnical analysis of these marbles in this region are not available yet. However, their good level of recrystallisation suggests that their quality is very similar to that of the Thala marble.

In the Mateur region, nummulitic limestone reserves are so important that it is impossible to establish several other production sites.

R.C. = Resistance to Compression; R.W.E. = Resistance to Wearing Effects; R.B.W. = Resistance to Bad Weather; MDE = Micro-Deval in presence of water; DIN = German qualitative standards regarding marble.

NEW POTENTIALITIES

Marbles of the THALA type

1. The Thala region

The Senonian outcrops of the Thala region are likely to supply royal beige marble blocks. Several studies have been carried out by the NOM. We will now succinctly talk about the following potential areas:

a. Henchir Bou Farda

This site is 5 Km away from the north side of Thala. It holds beige limestones having the same physicommechanical characteristics as those of the western marble workshop quarries.

b. Ain Jedeida

This is a limestone suboutcrop which is about 13 Km away from the western side of Thala and 12 Km from the south-eastern side of Jebel Boulahneche. Limestones are beige and partly pinkish, sublithographic, with conchoidal fractures. They form subhorizontal layers of a metrical to hemimetrical dimension. Geotechnical trials prove that these limestones conform to the current specifications.

Geotechnical characteristics of the Thala type marble stone in the Ain Jedeida deposit

| S.W. | Absorption | Res. compression | MDE | MDS | Res. Fragmentation |
|------------------------|------------|-------------------------------------|---------------|-------------|--------------------|
| 2.75 g/cm ³ | 1.7% | From 700 to 1100 kg/cm ² | From 13 to 16 | From 5 to 6 | From 17 to 18 % |

Source: NOM, 2000

c. Khezana

This is a 5m thick outcrop with beige to greyish limestones, 5 Km away from the southern side of the town of Thala. These limestones form decimetric to metric subhorizontal layers in which there are several flint nodules.

Geotechnical characteristics of the Thala type marble stone in the Khezana deposit

| S. W. | Absorption | Res. Compression | MDE | MDS | Res. Fragmentation |
|-----------------------|------------|------------------------|-----|-----|--------------------|
| 2.7 g/cm ³ | 0.65 % | 700 kg/cm ² | 14 | 5 | 20 % |

Source: NOM, 2000

2. The region of Ksour (El Kef)

Potential marble stones in this area are the same age as those in Thala. The most interesting site is that of Ain Fdhil which is a few kilometers away from the southern side of the town of Ksour. Lithologically speaking, these are light grey limestones, holding in places, lenticular layers of darker limestone.

3. The suburbs of Thelepte (Kasserine)

The region of Feriana is known for pure white-limestone outcrops intended for white cement industry. In certain localities, these limestones are easy to carve and polish. An example of that is the Fej Ennâm site which is, 2 Km away from the Feriana-Telepte-Kasserine-Bouchebka crossroads. The Abiod formation (Lowest Campanian-Maastrichtian) is represented by only one 40m-thick member, the layers of which are

about 15° to 35° north-westward. Marble limestones in the lower part are whitish while those in the middle are white. As for the upper part, it is white with little flecks:

Geotechnical characteristics of the Thala type marble stone in the Thelepte deposit

| S. W. | Porosity | Res. Compression | MDE | MDS | Res. Fragmentation |
|-----------------------|---------------|------------------------------------|---------------|--------------|--------------------|
| 2.7 g/cm ³ | From 7 to 16% | From 225 to 300 kg/cm ² | From 30 to 31 | From 8 to 11 | From 24 to 25% |

Source: NOM, 2000

4. The suburbs of Sakiet Sidi Youssef (El Kef)

The Kodiat Tarja site is 2 Km away from the Kef-Tejerouine-Sakiet crossroads. This is a perched syncline the backbone of which is made up of white to beige limestones belonging to the upper division of the Cretaceous period. The layers' pending ranges from 10 to 20° and are 0.5 to 0.7m thick. Reserves are estimated at 2 million m³. Geotechnical trials stated the following:

Geotechnical characteristics of the Thala type marble stone in Sakiet Sidi Youssef deposit

| | |
|---------------------------|------------------------------------|
| Specific weight | 2.6 g/cm ³ |
| Resistance to compression | From 400 to 800 kg/cm ² |

Source: NOM, 2000

The Kesra Marble types

1. The Tajerouine Syncline

The central part of the Tajerouine syncline holds nummulitic limestones. As far as accessibility, reserves and quality are concerned, Jebel El-Hodh or Kef Berda is the most interesting site. It is 5 Km away from the north-eastern side of Tajerouine. Its nummulitic limestones slab is divided into 2 to 3 m massive subhorizontal layers. Geotechnical analysis show that these are hard rocks which could be used as marble stones.

Geotechnical characteristics of the Kesra type marble stone in the Tajerouine deposit

| | |
|-----------------------------|------------------------------------|
| Specific weight | 2.5 g/cm ³ |
| Resistance à la compression | From 300 to 600 kg/cm ² |

Source: NOM, 2000

2. The region of Dahmani

Most synclinal perched tables dominating the Dahmani region's morphology, had once held Roman quarries in which marble stones had been dug out, allowing thus the building of towns such as Althiburos (Mdeina). The stratigraphical serie regarding these perched tables can be subdivided from bottom to top into three different facies:

- subcrystalline beige-grey limestones lying in metric to hemimetric layers and holding rare small nummulites;
- beige to pinkish crystalline nummulitic limestones generally in huge layers and topped by red-oxyde-veined white limestones having most of the time a chalky aspect and plenty of salient recrystallised nummulites.

Marbles which can be found in the Mdeina plateau enjoy a satisfactory quality.

Geotechnical analysis of a few samples taken from Mdeina and Ebba show the following:

Geotechnical characteristics of the Kesra type marble stone in the Tejerouine deposit

| S. W. | Porosity (Mdeina) | Porosity (Ebba) | Res. compression | MDE | Res. Fragmentation |
|-----------------------------------|-------------------|------------------|------------------------------------|---------------|--------------------|
| From 2.5 to 2.7 g/cm ³ | From 0.9 to 20% | From 0.5 to 2.5% | From 350 to 800 kg/cm ² | From 20 to 30 | From 20 to 30% |

Source: NOM, 2000

Black marbles of the AZIZA and BOULAHNECHE types

Besides the Aziza, Boulahneche, Oust, Rouas and Ben Klab sites, which are well known for this type of marble, two other new sites can attract investors' interest:

1. *Jebel Khelil*

It holds metric black limestone layers alternating with marls from the Albian era. They outcrop on the edge of the A1 motorway and on the periphery of the Jebel Boukornine national park.

2. *The region of Bou Arada*

It has the same geological context as the previous one. However, a detailed study shall be carried out in order to find out the different characteristics of this type of marble stone.

Marble stones in southern Tunisia

In the south of Tunisia, there are important potentialities as far as marble stones are concerned. In fact, two carbonated ridges serving as constant orographic landmarks, can be exploited. They are the Ghomrassen ridge belonging to the upper division of the Jurassic system and the Gattar ridge from the Turonian era.

1. *Marble stones of the Ghomrassen type*

They are dug out of the Ghomrassen ridge dating from the Oxfordian era. This ridge is a constant landmark in southern Tunisia. It provides beige, grey, whitish and yellowish dolomitic limestones.

Geotechnical characteristics of the Ghomrassen type marble stone

| S.W. | Absorption | Porosity | R.C. | R.B.W |
|-------------------------------------|--------------------|----------------|------------------|------------|
| From 2.65 to 2.70 g/cm ³ | From 0.35 to 1.40% | From 0.9 to 4% | From 980 to 1300 | Good (DIN) |

Source: NMO, 2000

2. *Marble stones of the Matmata type*

They belong to the Gattar ridge (from the Turonian epoch) which goes across southern Tunisia. It is made up of beige homogeneous sublithographic dolomites. It stretches over a vast area especially in the suburbs of Matmata from which samples have been taken. The following table shows results of the geotechnical trials:

Geotechnical characteristics of the Matmata type marble stone

| S.W. | Absorption | Porosity | R.C. | R.B.W. |
|-------------------------------------|-----------------|--------------|------------------|-----------------------------|
| From 2.65 to 2.70 g/cm ³ | From 0.90 to 2% | From 2 to 5% | From 600 to 1600 | From good and average (DIN) |

Source: NMO, 2000

CARVING, SCULPTURE AND SQUARING ORNAMENTAL STONES

Ornamental stones are natural stones classified into marble, carving, sculpture and squaring stones.

In the next part we will focus on the last varieties whose potentialities are important.

They consist of:

- "onyx" stones of different colours, often streaked with other ores;
- ornamental stones serving to carving and sculpture similar to those from Dar Chaabane El-Fehri, Gabes and Feriana;
- greenish schists from the Hairesh massif;
- versicoloured squaring carbonates belonging to the upper division of the Jurassic system from Jebel Aziza, Jebel Oust, Jebel Beni Klab and Jebel Raouas;
- algae and sponge limestones from the Cap Bon, having a granite aspect.

Currently these stones are used in a traditional way, by tile factories and in the making of decorative objects.

In view of their average to mediocre geotechnical characteristics, these stones are highly unlikely to be used as exterior covering slabs. However, they could be used as interior design patterns.

1. *Granites of La Galite island.*

In Tunisia, La Galite is the only granite deposit whose reserves are in the order of several million m³.

When comparing these granites' physicommechanical characteristics with all Tunisian marble stones, we can come to the conclusion that:

- These granites are very hard. Their resistance to compression is in the order of 1900 kg/cm²;
- With reference to the DIN standards, their resistance to wearing effects is the weakest;
- These granites tend to become discoloured when enduring bad weather. This type of rocks is suitable for making pillars and internal covering slabs.

2. *Grano-diorites and Rhyodacites of Nefza.*

The fragmentary aspect of the Nefza volcanic rocks can not ensure a satisfactory production of marble slabs. However, a "chipboard marble" can be manufactured out of these materials.

3. *"Imitation onyx"*

a) *The Sejnane Onyx*

The Sejnane onyx site is located within Jebel Ouachi which is 12 Km away from the eastern side of Sejnane. To get there, one has to drive along the GP7 road then through about a 3 Km track. It is a 7 to 10m seam filled with calcite and brown iron carbonates giving it thus, a striped aspect. These ornamental rocks are not resistant to bad weather, therefore, their use is limited to interior decoration.

b) The Jebel Mzar Onyx

The secondary chain of Jebel Mzar is 10 Km away from the south side of Bir Lahmar, a village in the region of Tataouine. It holds a travertine outcrop created at the opening of one or several probably hydrothermal springs.

These travertine stones are uneven. They lie over sands and clays, and belong to the lower division of the Trias system (Kirchaou Formation). In view of the several paleoplants they hold, they probably date from the upper Miocene to Pliocene epoch.

From a mineralogical point of view, they represent vacuolar stalagmites considerably rich in calcite.

CARVING STONES

1. The Cap Bon region

In this region, Dar Chaabane el-Fehri is very famed for carving stones and sculpture. Deposits are inside a clayey formation dating from the Miocene epoch. They form one or two yellowish and hardly whitish sandstone limestone metric layers, the reserves of which have nearly exhausted. Currently these layers are sought underground in a traditional way.

2. The Sahel region

a. Ain Errahma's stones

Ain Errahma's carving stones are white and beige limestones. They belong to the Abiod formation and date from the lower division of the Campanian-Maastrichtian system.

b. Ksour Essaf's stones

These are beige to greyish oolitic limestones dating from the Pliocene epoch. They are bioclastic with lamellibranches and gastropodes.

c. Teboulba's stones

These are yellowish oolitic limestones which have a slightly sandstone aspect. They are bioclastic with lamellibranches, gastropodes and urchins. They probably date from the Messenian era and their reserves have currently exhausted.

3. The Feriana region

Feriana's crystalline limestones can be compared to those of Dar Chaabane el-Fehri as they are easy to sculpt.

4. The Gabes region

In this region, limestones are recrystallised and belong to the lowest division of the Campanian-Maastrichtian era (Abiod Formation). Their colour varies from white to beige and pink. They can easily be carved and they supply ornamental stones used for apartment buildings' façades.

5. The Tataouine region

These are Triassic versicoloured dolomites of Jebel Rehach. They are harder than the previous ones. They are cut and carved into small blocks and used to decorate façades of luxury houses. Eventually, it is worthwhile mentioning that Oued Mestaoua Jurassic alabaster gypsums (suburbs of Tataouine) are easy to sculpt and fashion into ornaments.

CONCLUSIONS

The range of Tunisian marbles is varied in different ways: its nature, colour and aptitudes to polishing. It consists of 8 types, namely:

1. **CHEMTU type:** yellow to reddish marble of dolomitic calcareous nature, slightly metamorphic.
2. **KEDDEL type:** Cenomanian light-grey marble stone of a recrystallised calcareous nature having a reefy or para-reefy origin.
3. **AZIZA type:** Dark grey marble stone belonging to the lower division of the Jurassic system, often of an organogenous calcareous nature, and sometimes dolomitized.
4. **BOULAHNECHE type:** Black marble stone of a fissured calcareous nature filled with secondary calcite. This type of marble is frequently available in Aptian and Albian formations.
5. **KESRA type:** Beige and rarely whitish marble, the nature of which is a limestone rich in nummulites of a centimetric size belonging to the lower division of the Eocene system.
6. **THALA type:** Sublithographic fine limestone marble, divided according to colours into several varieties such as the Thala Royal, the colour of which ranges from beige to yellow and the Thala Impérial whose colour is beige to whitish.
7. **GHOMRASSEN type:** Beige to yellowish algae bioclastic marble stone dating from the Oxfordian era, of a dolomitic calcareous nature.
8. **MATMATA type:** Turonian beige marble stone of a dolomitic nature.

The following table recapitulates the geotechnical characteristics of each type of marble stone.

As for ornamental stones, they are represented by carving, sculpture and squaring stones, used for decoration and ornaments.

Except Dar Chaabane el-Fehri's stone whose reserves have become very limited, potentialities regarding the other stones are very considerable.

Once carved and sculpted, the Jurassic alabaster gypsums in the region of Tataouine, have given greatest satisfaction as far as the cutting of interior decorative patterns are concerned.

Geotechnical characteristics of each type of marble stone in Tunisia

| | S.W. in g/cm ³ | Absorption | Porosity | R.C. in kg/cm ² | R.W.E. (DIN) | R.B.W. (DIN) |
|--------------------|---------------------------|------------|----------|----------------------------|--------------|-----------------|
| Chemtu | 2.67/2.69 | < 0.5% | - | 800/1400 | Good | Good |
| Aziza | 2.65/2.85 | 0.43% | - | 1200/1400 | Good | Good |
| Boulahneche | 2.68 | - | 0.60% | 360 | MDE= 20 | Average |
| Keddel | 2.60 | 0.21% | - | 850/1100 | Good | Good |
| Thala | 2.67 | - | 4/4.5% | 420/1100 | MDE= 21/23 | Mediocre |
| Kesra | 2.50/2.68 | 0.25/1.70% | 1.6/4% | 450/1250 | MDE = 19/21 | Good |
| Ghomrassen | 2.65/2.70 | 0.35/1.40% | 0.9/4% | 980/1300 | Good | Good |
| Matmata | 2.68/2.70 | 0.90/2% | 2/5% | 600/1600 | MDE = 17/23 | Good to Average |

Source: NOM, 2000

INVESTMENTS IN THE MINING SECTOR

Every Tunisian citizen is entitled to exploit a marble quarry. If the Tunisian promoter wishes to form a partnership with a foreign one, then the manager has to be Tunisian and has to hold 51% or more of the company shares.

If a foreign promoter wishes to exploit a marble site by himself, then he has to obtain a special authorization from the Minister of Industry.

In all cases, the Head Office has to be based in Tunisia.

Creating a firm of marble exploitation requires going through 2 stages:

1. At a regional level: place where the marble deposit is
 - a) If the land belongs to the promoter or to a private individual, he/she has to provide an ownership or a renting certificate.
 - b) If the land belongs to the Ministry of State Property and Land Affairs, it can only be exploited as a quarry after being rented by auction every 5 years.

Besides the land ownership or rental documents, the promoter has to submit a request to the Governorate to open a marble quarry with a payment proof of 100 Tunisian Dinars to the treasury and technical data sheet on operating the projected quarry.

The promoter also has to submit a topographic map showing the quarry's location and 12 copies of a side map, oriented and attached to a unique original map.

Once the prior agreement is given, the request is transferred to the Ministry of Equipment, Housing, and Land Planning (Department of Quarries and Explosives).

- 1- At the level of the Ministry of Equipment, Housing, and Land Planning (Department of Quarries and Explosives) (TUNIS):
 - a) The request is examined by members of the National Consultative Commission on Quarries, composed of representatives from different Ministries: Equipment, Housing, and Land Planning, Environment, Defence, Health, Interior, Agriculture,...
 - This commission gives an agreement of principle for opening the quarry after its members pay an onsite visit to the planned project.
 - b) In case of a favourable answer, the Ministry of Equipment delivers to the promoter an agreement of principle for opening the quarry and asks for additional information:
 - 3 copies of the project impact study on environment;
 - An ownership title (land ownership or rental documents);
 - Copy of the Republic of Tunisia Official Journal (JORT) mentioning the setting up of a firm to exploit the quarry;
 - Copy of the firm's internal statute.

The final agreement to exploit the quarry is delivered to the promoter and its length is 5 years renewable.

The texts of this brochure have been collected and adapted from technical documentation provided by:
-Industrial Promotion Agency (API)
-National Office of Mines (ONM)
-Technical Center for Construction Materials, Ceramics and Glass (CTMCCV)

We thank the International Organization for Migration for its valuable cooperation (I.O.M.).

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