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Malta

Quarrying of Hard Stone for the Restoration of Buildings

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FOREWORD

For the restoration of old official buildings in Malta, blocks from old pavements were used in 1973. These blocks, approximately 2 x 3 x 6 dm, were cut into sheets 2 cm thick at the stone-cutting factory, La Rosa Ltd., and laid and finished as floors in the buildings in a satisfactory way.

However, as these blocks will be exhausted in 1974, the present investigation was carried out in order to investigate the possibility of quarrying blocks in the future for the above-mentioned purpose, from Malta's "hard stone".

During the three weeks I spent in Malta, I received help and information from the civil servants I met in Ministries and Departments as well as from representatives of private enterprise. However, without the helpful assistance of my contact man, Mr. Michael Ellul, Head of the Antiquities Section, I would never have been able to gather so quickly the general information I needed nor to see the practical details which enabled me to form an overall opinion of the question in such a short time.

1. CONCLUSIONS AND RECOMMENDATIONS

1.1 CONCLUSIONS

At present no suitable quarry or deposit is available to start quarrying blocks, the reason being that no survey has ever been undertaken for this purpose. Information from geological literature, from people specialized in industry and from samples investigated and polished, indicates that good deposits of the kind, as well as deposits of other industrial raw materials are to be found.

To recommend methods and equipment for quarrying blocks before having a full knowledge of the deposit and the stone quality is technically and economically inadvisable.

It will certainly not be possible to use the same quarries for blasting and for excavating blocks, as different methods apply to each operation and there would be a risk of blasting cracks in the blocks. From my own experience, sheets are never cut directly from the quarry, furthermore with the equipment available it would not be possible to obtain square sheets of uniform thickness, and they would have to be adjusted in machines commonly used for cutting blocks and slabs.

For these reasons, this report has been written for use as background information for a survey of the particular quality of stone required.

If, however, the supply of old pavement blocks is exhausted before a good deposit has been found and prepared, it should be possible to select boulders of good quality from the present hard-stone quarries and to cut them into sheets in the factory as has been done with the pavement blocks. The square footage of sheet obtainable per cubic yard of boulder will of course be low in comparison with the cutting from blocks because of the irregularity of the boulders and risk of blasting cracks. But I believe it will still be satisfactory as a temporary supply for the Government's requirements for flooring, and the cost will be moderate.

1.2 RECOMMENDATIONS

1.21 Recommendation to use boulders as temporary supply of raw material

With a view to ascertaining the best site for size and quality of boulders for use as a temporary supply of raw material for cutting into sheets, I would suggest proceeding as follows From each of the quarries mentioned below, one lorryload (4 cubic yards) of good-quality boulders should be selected by the Management of the quarry and La Rosa Ltd, in co-operation with a representative of the Section of Antiquities. The team should take into consideration:

the quality (as hard and non-porous as possible),

the size (most suitable for the cutting operation at the factory)

and the colour (matching the floor).

The boulders should be sent to the factory and small samples should be cut and polished to secure the quality required before starting the operation. Once the load from one quarry has been cut and measured, the next load can follow.

Estimated price of floor from boulders (assuming the price of selected boulders arriving at the factory as 270 cents per cubic yard including transport) and that one cubic yard of boulder will yield 90 square feet of sheet:

Cost of boulders (270 cents: 90 sq.ft = 3 c/sq.ft.)	3 cent/sq.ft.
Cost of cutting sheets at factory	10 cent/sq.ft.
Cost of laying and grinding	10 cent/sq.ft.
Total cost of floor:	23 cent/sq.ft.

From my own investigation of hard-stone quarries, I found that the best quality is that of C. Abdilla's quarry, at ta Zuta, but reasonably good-quality stone is to be found in parts of Debone's quarry near Zurrieq and at the Government's Quarry at ta Zuta.

1.22 Recommendations for a survey of Malta's minerals

In order to select deposits of good-quality raw material and to investigate methods and costs of extraction, capital requirements and marketing for export of the finished products, the following survey should be undertaken:

Surface investigation for finding polishable limestone or marble of good quality and other minerals suitable for industrial exploitation;

Core drilling of deposits with good surface indications;

Tests and analyses of samples;

Calculation of methods and costs of industrial exploitation;

Investigation of the capital required and marketing for export;

Possible industrial exploitation of Malta's mineral resources;

Manufacturing of floors, steps, windows, etc. from hard limestone or marble;

Manufacturing of building material from limestone and sand;

Production of cement from limestone and clay

Production of fertilizer from phosphatic rock

Industrial carving of limestone, etc.

2. QUARRY CONDITIONS TO BE MET FOR QUARRYING BLOCKS AND THE GOVERNMENT'S REQUIREMENTS FOR FLOORING

2.1 Quarry conditions to be met for quarrying blocks

Find a deposit of sufficient size and quality for exploitation;

Ascertain the availability of the deposit for exploitation;

Investigate and test the most efficient and economical production methods and equipment;

Prepare the deposit for the method of production chosen.

2.2 The Government's requirements for flooring

In 1973, approximately 40,000 sq.ft. of sheets for flooring were cut from old pavement blocks. For the next 4 to 5 years, the requirement is estimated at

80,000 sq. ft. per year. One cubic yard of block should yield 250 sq. ft. of sheets, so that 320 cubic yards of block a year would be needed.

3. THE PRESENT QUARRY SITUATION IN MALTA

3.1 Need of investigations

The industrial quality of the minerals in Malta varies considerably. According to the information obtained during my visit, exploitation of all the quarries seems to have started without adequate preliminary surveys, and no investigation by core-drilling below the surface was ever undertaken. However, an old "hard-stone" quarry recently had to be closed down when a survey undertaken to secure a supply of material for a certain construction revealed that no more "hard stone" was available. Many other quarries might be in a similar situation.

Although there has been considerable amount of drilling for water and oil in Malta, no rock samples have been tested for quality. The Water Department, the Public Works Department, the Museum Department, the Government Office of Statistics, the Ministry of Trade and Industry, about ten private enterprises and a professional geologist all informed me that, as far as they knew, no investigation or survey of mineral qualities had ever been undertaken. In the ten "hard stone" quarries I visited, the quality and quantity of "hard stone" differed considerably. The best quarry I visited contained approximately 70-80% of polishable limestone or marble, or what is called "hard stone". To avoid uneconomical investment, unnecessary import and shortage of raw material, and to increase the efficiency of industry based on Malta's mineral resources, I believe that a survey of these resources, for domestic use and for export, should be undertaken.

3.2 "Hard stone" quarries

There are approximately 15 quarrying establishments for "Hard stone" which should be first or second quality limestone (see paragraph 5). The products are all aggregates for roads, concrete-work, etc. which are produced by drilling and blasting and eventually crushing and screening. The total production is approximately 400,000 cubic yards per year and the average price is 70 cents/cubic yard.

3.3 "Soft stone" quarries

There are approximately 55 establishments quarrying "soft stone" or building stone. The method of quarrying is by sawing blocks with circular saws, directly from the rock, into the size of the blocks used for the building. The production is approximately 400,000 cubic yards per year, and the average price is 70 cents per cubic yard.

The total quarrying industry employs approximately 400 people. There are 58 establishments employing 1 to 5 persons; 10 employing 11 to 19 persons; and 2 employing 20 to 39 persons.

4. TECHNIQUES AND EQUIPMENT FOR QUARRYING BLOCKS OF HARD LIMESTONE OR MARBLE AND CUTTING THEM INTO SHEETS

4.1 Excavation of blocks

The basic methods for the excavation of blocks are:

Drilling with eventual blasting or wedging;

Sawing by circular saws or chainsaws

Wiresawing.

Drilling is carried out by pneumatic rockdrills, usually erected on drill rigs running on rails. When an area is prepared, two sides of the rock are free. The next step is vertical drilling or channelling to separate three more sides of the block, followed by horizontal drilling or seamdrilling at the bottom of the blocks and eventually blasting or wedging to release the block. Blocks of any size can be excavated by this method.

In Malta, the same method is usually used for excavation by circular or chain saws as for "soft stone" sawing. For hard stone, however, diamond segments are erected on the disc or chain. This method is not efficient or economical unless the rock is of uniform hardness and free of cracks, as the diamond tools are expensive and break easily under bad conditions. The size of the block is limited by this method.

Excavating blocks by wiresawing is mostly done in big deposits, where large blocks are sawn from the rock and eventually divided into smaller blocks. Water and sand or carborundum, etc. can be used as the sawing medium, but this depends on the homogeneity of the deposit. Wires with diamond segments can also be used. Any size of block can be excavated by this method.

Whatever method of quarrying is used, the blocks have to be lifted from the quarry mostly by cranes and transported to the factory for eventual cutting.

4.2 Cutting the blocks into slabs and sheets

Basic methods of cutting blocks are by:frame saws, wire saws and circular saws.

The frame saw has blades mounted on a frame which is moved by means of a crank shaft forwards and backwards over the stone. There are sash gang-frame saws with sand, quartz sand, carborundum or steel shot as sawing medium, and diamond frame saws with diamond segments as sawing medium. One or more slabs can be sawn at the same time, depending on the number of saw blades.

Wire saws consist of a frame on which the wheels, around which the wires rotate, can be raised or lowered. The wire is normally made of two threads twisted alternately to the right and to the left. Carborundum grains or diamond segments can be used as sawing medium. Circular saws with one or more discs and diamond segments as sawing medium are most common, but saws with one or more vertical discs and one horizontal disc are more efficient as one edge of the slabs will be cut at the same time as the slabs. A steady foundation is very important for efficiency and economy.

Edge cutting of the slabs is also done by circular discs, and single disc machines with diamond segments can be used for all products.

Grinding and polishing ought also to be mentioned in this connexion. The radical machine is still popular for all products, but automatic grinding and polishing machines are increasingly used and especially for lines consisting of conveyer belts and a number of grinding and polishing stations. By different grain sizes of carborundum or corundum, it is possible to obtain a different finish of the surface.

5. THE INDUSTRIAL MINERAL RESOURCES IN MALTA

The industrial minerals in Malta have been classified as follows:

FIRST QUALITY LIMESTONE (locally Gebel tal Qammi or Zonqor Tal Prima)
It is a hard, non-porous, recrystallized and polishable limestone or marble. Varies in colour from white, yellow and brownish to reddish and greenish.

SECOND QUALITY LIMESTONE(locally Zonqor tas-Seconda)
It is a hard, porous, recrystallized and polishable limestone or marble. It also varies in colour as does the first quality limestone. However, it is softer and less resistant to weather.

Both qualities have been used for floors, pavements, steps and foundations, and laid in blocks; today they are used only as raw material for manufacturing aggregates.

THIRD QUALITY LIMESTONE (locally Franca, Freestone or Building stone)
It is a soft limestone and can easily be cut into any shape desired by saw or axe. The colour is mostly light yellow. Considerable quantities of building stone have been exported to Mediterranean countries, particularly to Turkey. Most of the buildings in Malta have been and are still being built in this stone.

HEAT-RESISTANT LIMESTONE (locally: Gebla tal Kwiener)
It has been quarried and used for building ovens and manufacturing the local stone stoves, called Kwiener.

THE BLUE CLAY, or CLAYS AND MARLS
This clay is made of very fine particles, mainly of aluminous material, rich in water. It never hardens completely, but remains plastic and makes, when mixed with water, a thick sticky past. It can be grey, brown, yellow or blue. The blue clay retains the upper water-table which permits activities including agriculture and animal husbandry in the area, before use of the lower water-table at the sea level. The clay has also been used for pottery.

THE GREENSAND is a non-crystalline rock with rounded grains of sand, cemented together by various iron oxides, silica, lime and clay. It has no practical use.

PHOSPHATIC NODULES with 40% phosphate of lime has been developed in horizons of the Globegerina limestone. It has been estimated that Malta has 8,000 million cubic feet of phosphatic rock. It has no practical use.

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APPENDIX

THE MINERALS IN MALTA AND EXAMPLES OF ANALYSES (Extracts from "Geology of Maltese Islands and Malta, Background for Development" see reference)

The minerals in Malta are entirely composed of tertiary limestone with subsidiary clays and sands, and the succession is:

5.	Upper coralline limestone	at least	530 ft.
4.	Greensand		0-50 ft.
3.	Blue Clay		0-230 ft.
2.	Globegerina limestone		75-680 ft.
1.	Lower Coralline limestone	at least	626 ft.

The lower coralline limestone and lower globegerina limestone belong to the Aquitanian stage and the middle and upper globegerina limestone and blue clay to the Burdigalian. The Helvetian stage is represented by the greensand and the Tortonnian by the upper coralline limestone. All these stages fall within the Miocene period, following Eames' hypothesis according to which the Aquitanian is Miocene rather than Oligocene.

The strata have an undulating regional dip to the southeast and the Islands are cut by a system of normal faults, striking ENE, affecting especially Malta and which is responsible for cutting that island into a series of horst and rift blocks.

The upper coralline limestone is the youngest tertiary formation in Malta. Analyses of several specimens by Murray gave from 82.97 to 90.0% $CaCO_3$ and nearly all contained traces of phosphatic acid. The residue after removal of $CaCO_3$ consisted of clayey matter and oxides of iron with small fragments of quartz, augite, zircon, tourmaline and a few grains of glauconite exceeding 0.5 mm in diameter and some specimens a few sponge spicules.

The greensand is a coarse, orange-brown, thick bedded fragmental limestone which usually forms the beds to the upper coralline limestone cliffs. Tested on ten specimens, the content is $CaCO_3$ ranging from 26.65 to 89.63%. Phosphoric acid, iron and a small quantity of magnesium were present in nearly all specimens. After removal of $CaCO_3$ by dilute acid, glauconite minerals with a mean diameter of 0.5 mm. and fragments of quartz, felspar, augite, hornblende, magnetite, zircon and tourmaline were found.

The blue clay, often called clays and marls, consists of very fine particles, mainly of aluminous material, rich in water. The clay is compact when dry and grey, brown, yellow or blue.

Analytic data of blue clay:

Carbonate of lime	2 - 67%
Sulphate of lime	4 - 30%
Phosphate of lime	traces 2%
Carbonate of magnesium	traces

Alumina	25 - 58%
Oxide of Iron	4 - 10%
Residue insoluble in dilute HCl	3 - 10%

The globegerina limestone is a fine grade, white-yellow calcarenite, completely composed of calcareous tests of globigerinids, anamalinids, and other small foraminiferans. This formation provides most of the soft building stone.

Analyses by C.H. Colson of two specimens from New Dock:

	I	II
Carbonate of Lime	80.24	78.39
Phosphate of Lime	3.57	2.70
Magnesium Carbonate	1.63	0.44
Calcium Sulphate	0.06	0.33
Iron and Alumina	1.13	- -
Insoluble in dilute HCl 1:10	12.88	17.87
	99.51	99.73

The insoluble residue contains iron in ferrous condition, abundant alumina and small quantities of lime.

This formation contains many foreign bodies, a considerable amount of which are found in thin beds of up to four feet, with phosphatic nodules varying in diameter of from pea size to 7 inches.

Analyses of typical nodules:

	I Nodule from Fomm-if-Rih	II Inter-stitial cement	III Nodule inters + equiv. cement
Sulphate of Lime	2.26	0.07	1.97
Carbonate of Lime	47.14	86.69	51.12
Phosphate of Lime	38.34	1.24	31.66
Alumina	5.98	1.28	10.59
Oxide of Iron	trace	- -	- -
Residue	6.08	9.87	- -
Silica	- -	- -	3.83
Moisture	- -	- -	0.87
	99.80	99.15	100.04

The Residue I contained iron oxide in ferric conditions, alumina, and a small quantity of silica and lime. Phosphatic acid: nil.

The lower coralline limestone is usually a dense semi-crystalline, massive to moderately bedded limestone, occasionally silicified and varying in colour. Analyses of three typical rock specimens gave 98.58, 96.66 and 98.14% of $CaCO_3$.

The reddish residue after removal of $CaCO_3$ consisted of clayey iron oxide, a few grains from igneous or metamorphic rocks in the not very distant continental land mass. The larger mineral fragments did not exceed 0.1 mm. in diameter. Phosphoric acid and magnesia were found in small quantities.