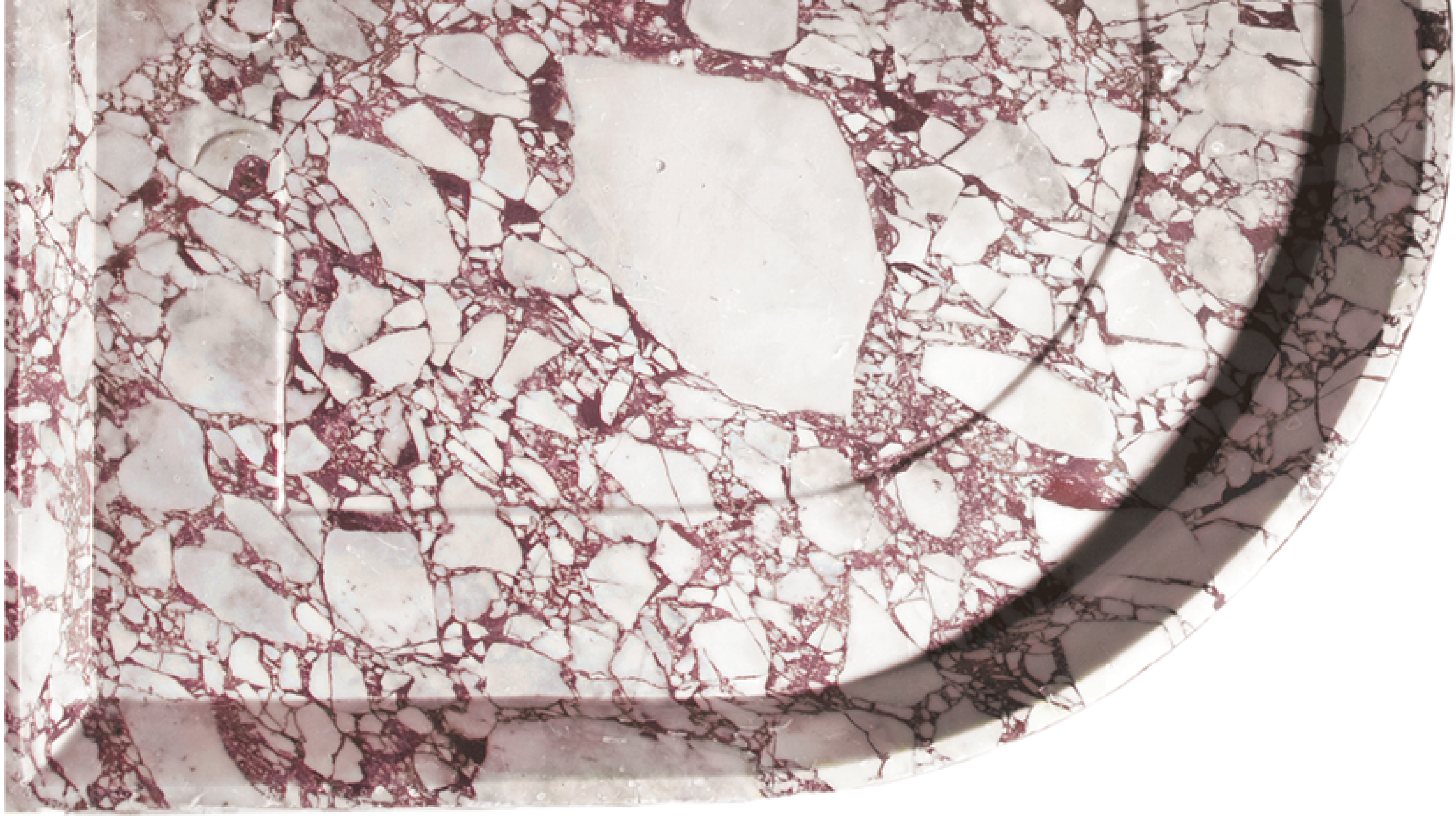
The Stone and Ancient Quarries of Montjuïc Mountain (Barcelona, Spain)

Álvarez, Aureli



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CONTENT

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THE STONE AND ANCIENT QUARRIES OF MONTJUÏC MOUNTAIN (BARCELONA, SPAIN)

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Abstract

The sandstone known as Montjuïc stone has been used throughout history in the city of Barcelona. However, it was during the Roman period that the quarries were extended considerably to supply the stone needed to build the city and its walls, as well as to use for its cultural manifestations (architecture, epigraphy, sculpture, etc.). Montjuïc stone is an easily recognisable sandstone with properties that make it suitable for a wide range of uses. The two varieties used for building, *blanquet* and *rebuig*, have very similar properties and can be distinguished mainly by their colouring (light grey in the case of *blanquet* and reddish ochre for *rebuig*).

Keywords
Montjuïc sandstone, *Blanquet* variety, *Rebuig* variety, Roman quarries, temple of Augustus, wall of the *Barcino Colonia*

Fig. 1. Remains of Roman quarries in the area of El Fossar (now a mass grave) (photo: Archive MUHBA)

Introduction

Barcino was built by the Romans on the coastal strip of Iberian Laietania, between the mouths of the Rivers Llobregat and Besós on so called Mount Taber, to the east of Montjuïc Mountain. Emperor Augustus was the true founder of Roman *Barcino* (15-13 BC).

The find on the south-western side of Montjuïc Mountain of a large area of quarrying, with signs of stone extraction during Roman times (Fig. 1), attests its use for the construction of Roman *Barcino* from the time it was founded during the reign of Emperor Augustus.[1] It was the building material for the first city walls and for the other public buildings; it was also frequently used for sculptures and inscriptions.[2]

The proximity to Barcelona and the urban requirements of the city led to the proliferation of quarries all over Montjuïc Mountain.[3] Some were exploited and abandoned in ancient times while others were worked until more recently.[4]

In preparation for the 1992 Olympic Games, large faces of the Roman quarries facing the sea were excavated and studied.[5]

The Montjuïc sandstone was used outside the city of *Barcino* in other towns and settlements in the Laietania area, such as *Iluro* (modern-day Mataró) and the Vallès area.[6]

1 GUTIÉRREZ 2009, 89-101.

2 GRANADOS 1991, 141-201.

3 FAURA I SANS 1917, 155.

4 ÁLVAREZ 1988, 22-25; ÁLVAREZ 1988b, 34-39; ÁLVAREZ, MAYER 1983, 303-310; ÁLVAREZ, MAYER, RODÀ 1993, 145-151; ÁLVAREZ *et al.* 2009; ROCA I BLANCH 1999, 79-220; VOLTES 1960.

5 GRANADOS 1991.

6 GUTIÉRREZ 2009, 89-101; RODÀ 2009, 513-529.

Fig. 2.
View of Barcelona with Montjuïc Mountain in the background (photo: A. Laborde 1806: "Voyage pittoresque et historique. Description de la principauté de Catalogne", plate IV, Ed. Enciclopedia Catalana, SAU, Barcelona 2008, 6)

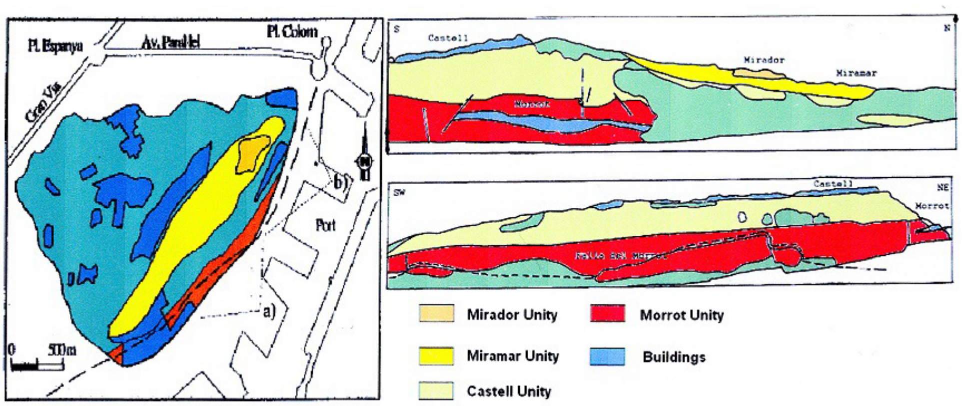


Fig. 3.
Map and geological sections of the Montjuïc area (photo: GÓMEZ-GRAS 1993)

Montjuïc Mountain

Montjuïc Mountain is situated to the south of the city of Barcelona, surrounded by Quaternary deposits and adjacent to the Barcelona graben. To the north and west it comes into contact with the Barcelona Plain. To the south it is bordered by the Llobregat Delta.[7] On the side facing the sea it is cut off by a fault that runs parallel to the coastline (Fig. 2).

The mountain can be considered a dome or anticline of dis-symmetrical branches, being the minor dip of the SW branch. On the lower part of the hinge it is possible to observe a slight tectogenesis originating from the silicification of more porous materials with the development of jaspers and chalcedony and the appearance in the fractures of minerals of hydrothermal origin.[8]

The silicified layers form compact, hard sandstone, passing locally to polygenic conglomerates.[9] The deposits are made up of alternating layers of conglomerates and sandstones, with a lesser presence of mudstones. The vertical development of the layers is not homogeneous and there are numerous lateral changes of facies that make correlations difficult. The sediments that gave rise to the rocks of Montjuïc Mountain were deposited in a deltaic environment. Probably a large river that rose at Montseny Mountain crossed a terrain that descended slowly towards the coastal mountains we know today, flowing into the sea at Collserola. Villalta [10] differentiates 22 stratigraphic levels, which have recently been reduced to five units by Gómez Gras.[11] (Fig. 3).

The materials are dated to the Serravallian (Late Miocene).

The sandstone

The first petrographic observation of Montjuïc stone was made by Jaime Almera in 1880, when he noted that it was made up of siliceous elements resulting from the erosion of granitic material from the coastal mountains.[12]

7 LLOPIS LLADÓ 1942, 321-383.

8 VILLALTA 1964, 99-105.

9 PARCERISA *et al.* 2001, v. 172, no. 6, 751-764.

10 VILLALTA 1964.

11 GÓMEZ-GRAS 1993, 115-161.

12 ALMERA 1880.

TEXTURAL PETROGRAPHIC DESCRIPTION		
CHARACTERISTICS	**BLANQUET**	**REBUIG**
TEXTURE	EPICLASTIC	
GRAIN SIZE	HETEROGRANULAR	
GRAIN DISTRIBUTION	LOW BADLY SORTED	
GRAIN FORM	SPHERICITY AND ROUNDNESS MIDDLE-HEIGHT OCCASIONALLY ANGULAR	
INTERGRANULAR RELATIONS	MANY PENETRATED GRAINS	A FEW PENETRATED GRAINS
MATRIX	LITTLE FILOSILICEOUS MATRIX	SIGNIFICANT AMOUNT OF FILOSILICEOUS MATRIX
CEMENT	LITTLE SILICEOUS CEMENT LITTLE ARGILLACEOUS CEMENT	SIGNIFICANT AMOUNT OF ARGILLACEOUS CEMENT
MINERALOGIC MATURITY	SUBMATURE	
MODAL CLASSIFICATION	SUBARKOSIC ARENITE	ARKOSIC GRAYWACKE

Table 1.

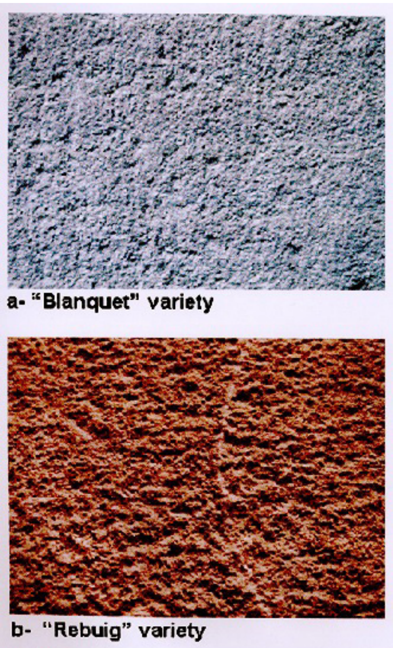


Fig. 4. The two varieties of stone found on Montjuïc Mountain: a) *blanquet*, b) *rebuig* (photo: A. Álvarez)

Faura I Sans (1917) gives us a petrographic description based on polarising microscope observation: "sandstone composed of rounded and perfectly cemented quartz grains".[13]

The sandstone has a siliciclastic composition and can be considered a litharenite. Quartz monocrystals predominate over polycrystalline aggregates; the rock fragments correspond to granitoids, granitic porphyries, quartzite, phyllites, schist, aplites, pegmatites and radiolarites. Associated minerals are biotite, muscovite, zircon, chlorite and tourmaline.

San Miguel and Masriera gave the first percentages of the different components of the rock, indicating a quartz content of more than 50%, accompanied by 10-25% of feldspars (orthoclase, plagioclase and microcline), with the remainder made up of muscovite, biotite and chlorite.[14]

This group of petrographic facies has traditionally been known as Montjuïc stone and includes two varieties. We could consider building stone: the grey-coloured variety (*blanquet*) (Fig. 4a) and a variety with a predominately ochre colour (*rebuig*) (Fig. 4b). They were used without distinction in the construction of buildings and monuments in Barcelona. The grey-coloured variety has the greatest degree of silicification, while the ochre variety owes its colour to the presence of iron minerals (sulphurs, oxides and hydroxides).

The matrix is sparse –less than 15% in volume– and is composed of micas, quartz and clay minerals. In more silicified varieties the remains of chalcedony and quartz can be found. The silicification process removed any presence of carbonated elements, especially in the *blanquet* variety, whereas in the *rebuig* variety the remains of residual calcareous cement may be found.

Table 1 shows a textural petrographic description and a comparative exposition of the two varieties, *blanquet* and *rebuig* (Table 1).

13 FAURA I SANTS 1917.

14 SAN MIGUEL, MASRIERA 1970, 11-34.

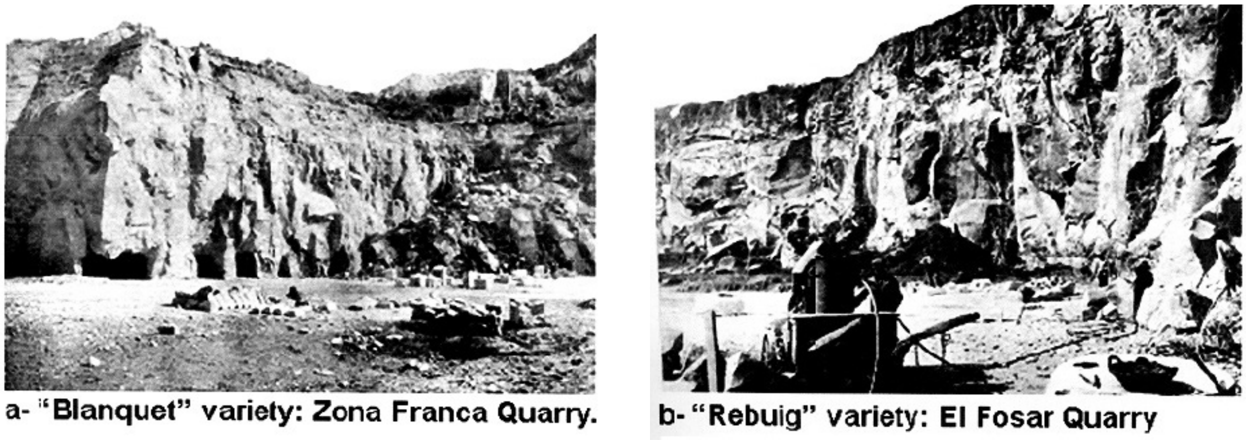
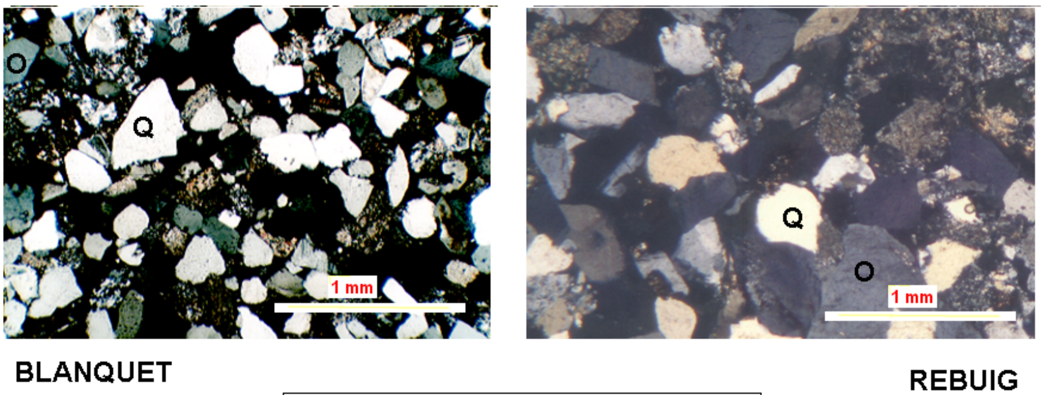


Fig. 5. Photographs of the two main quarries at the beginning of the 20thcentury: a) the Zona Franca quarries, b) the El Fossar quarries (photo: VOLTES 1960)



X-RAYS DIFFRACTION		
BLANQUET		REBUIG
75.0	QUARTZ (Q)	69.0
14.0	ORTHOCLASIS (O)	18.0
5.0	PLAGIOCLASE (P)	8.0
6.0	MICA-ILLITE (M)	6.0

Fig. 6. Microphotographs of the two varieties (*blanquet* and *rebuig*) with their respective mineralogical compositions (photo: A. Álvarez)

Mineralogical composition

The mineralogical composition of Montjuïc sandstone was first analysed using polarised light microscopy. A second stage using X-ray diffraction allowed for a semi-quantitative evaluation of the diverse mineral phases. The results were compared and completed with an elemental analysis using X-ray fluorescence and, in some cases, a scanning electron microscope (SEM).

The polarised light microscope allowed us to identify the minerals and to determine their shape, size and distribution, while with X-ray diffraction we were only able to identify the mineral phases and not their shape and distribution. In some cases the elemental analysis (X-ray fluorescence and scanning electron microscope (SEM)) did not allow the result of a specific mineral phase to be assigned.[15]

For the study of the *blanquet* variety a sample (CRM4) was selected from the quarry located in the Zona Franca (Duty Free Zone) (Fig. 5a). The *rebuig* sample (CFM2) came from the El Fossar quarry (Fig. 5b).

Figure 6 shows the comparative mineralogical composition of the two varieties.

15 WILSON, PITTMAN 1977, 3-31.

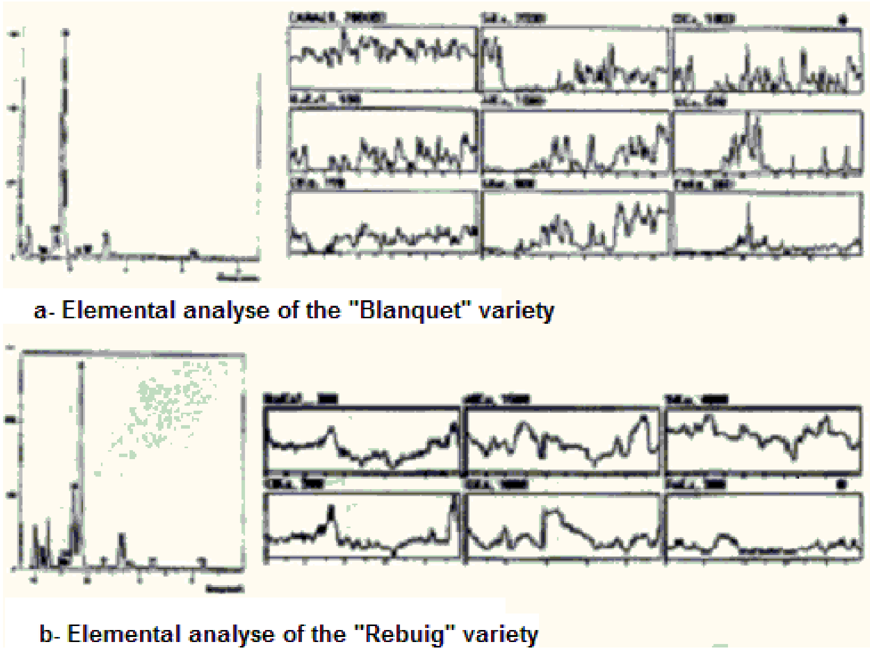


Fig. 7.
Elemental analyses of the two varieties made with a scanning electron microscope (SEM) (UAB)

Elemental analysis

The elemental analysis, which was carried out with a scanning electron microscope equipped with an EDAX detector, confirms the presence of the minerals detected using polarised light microscopy and X-ray diffraction.

The main elements found in the *blanquet* variety are, in order of importance, aluminium (Al), silicon (Si) and potassium (K). There are slight traces of sodium (Na), sulphur (S), chlorine (Cl) and iron (Fe). The predominance of silicon over aluminium indicates large quartz content (Si+O) compared to feldspars (Si+Al). A linear analysis (Fig. 7a) shows the superposition of the constitutive elements of the feldspars (Si, Al, O, Na, and K). The coincidence of sulphur and iron could indicate the presence of pyrite (an abundant mineral in the area).

The *rebuig* variety has the same elements as the *blanquet* except that it also contains titanium (Ti), which can be linked to the presence of iron forming a new mineral, ilmenite, which would have replaced the pyrite found in the previous samples. The linear analysis shows the same coincidences as before in the components of the feldspars (Si, Al, Na and K) (Fig. 7b).

Applications

Montjuïc sandstone had numerous applications and, since it is such a characteristic stone, it is easy to identify.

One of the first Roman inscriptions carved on it was mentioned to the duumvir Caius Coelius (IRC IV,57), who was in charge of building the first walled enclosure of the *Barcino Colonia*.

The Temple of Augustus, with capitals in the Triumvirate period style dates from the foundation period.

The Catalonia Museum of Archaeology (MAC) and the Museum of History of Barcelona (MUHBA) have numerous finds from the excavations and many samples are published in our publications.[16]

16 ÁLVAREZ, MAYER, RODÀ 1993; ÁLVAREZ *et al.* 2009, *op. cit.*, 86-93.

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