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NEW CHALLENGES ON DIMENSION STONES, FROM PORTUGAL TO THE WORLD

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Structural, physical and compositional proprieties analysis of marbles in a quarry face: a study case application on Estremoz Anticline

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Abstract

The application of scientific and technological research activities to innovation and to social and economic development is one of the great challenges of contemporary times. Such aspects are even more significant in the industrial sector, because the R&D activities can have a remarkable impact on the sustainable production of raw materials and on the economic viability of companies. Indeed, the development of innovative and expeditious scientific and technological methods, which can reply to the usual and specific challenges of the exploitation, manufacture and transformation of dimension stones, are extremely important in the business dynamics.

The Estremoz Anticline is one of the most significant active poles of the extractive industry in Portugal, being one of the main marble-producing poles at the European scale. The extractive activity takes place in the three municipalities of the so-called Marble Triangle (Borba, Estremoz, Vila Viçosa), exploiting calcite marbles from the Estremoz Volcano-Sedimentary Carbonated Complex, whose geological age has not been fully clarified (Cambrian to Devonian ages were attributed to this unit). The marble exploitation, manufacture and transformation is one of the main drivers of development in the Marble Triangle, presenting great local and regional socio- economic significance. Beyond this, it is also central to increase the rock coefficient of utilization (20-25% in Estremoz marble quarries) in order to decrease the volume of wastes and increase the marble productivity in this region and therefore marble's production sustainability.

Indeed, in order to support the raw material exploitation process, the management of mineral masses and the potential rock coefficient of utilization and blockometrics, detailed geological mapping of quarry faces were carried out. These detailed geological mapping include: (1) Lithological and structural characterization of quarry faces, including detailed characterization of the existing lithotypes, their mineralogical composition and lateral variations of marble typologies, as well as the geometric and kinematic detailed characterization of the main structures, namely foliation, shear zones and fractures, including the density characterization of fracturing; and (2) In situ evaluation of aesthetic, compositional and physical-mechanical features of marbles, using multiple portable equipment's (e.g. X-ray fluorescence, colorimeter, Schmidt sclerometer). The application of this innovative and expeditious methodology, using a fine sampling matrix of the vertical and horizontal quarry faces, allowed the construction of detailed two- and three-dimensional maps, which could allow better management of the extractive activity.

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Structural, physical and compositional properties analysis of marbles in a quarry face: a study case application on Estremoz Anticline

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INTRODUCTION

The Leeb Hardness Tester (LHT) can be used to measure the hardness of the different types of lithotypes (Ghorbani et al. 2022). In the present work, LHT was used in different marble varieties identified in MSB quarry (Bencatel, Vila Viçosa, Alentejo), located in the Estremoz Anticline (Ossa-Morena Zone), the most important marble exploitation center in Portugal. In the MSB quarry front, it was evaluated the aesthetic, structural and mineralogical features of marbles, aiming to relate those features with the hardness results obtained by the LHT.

At the same time, it was truly important to understand the limitations of the method and assess its real usefulness for understanding physical features: if any relation between the mineralogical composition of marbles, structural features and the hardness results obtained through LHT are verified, this equipment can be a very useful tool, simple and quick to use for the identification and possible resolution of problems associated with the exploitation of marble.

METHODS

Figure 1: Leeb Hardness Tester equipment.

To understand the distinctive values for each marble variety found in the quarry, a set of measurements was carried out on each lithotype: White, Pink, Ruivina and Pele de Tigre marbles, dolomitized domains (in which the breccia cement and clasts are distinguished), quartz veins in silicified areas and green silicate banding, present in the pink marble. After collecting *in situ* data in each lithotype, measurements were carried on most significant rock-forming minerals: quartz and calcite.

Mineral samples must be at least 5 cm thick, a measure from which the HLD hardness is constant (Ghorbani et al. 2022). All data was then analyzed through descriptive statistics (Figure 1).

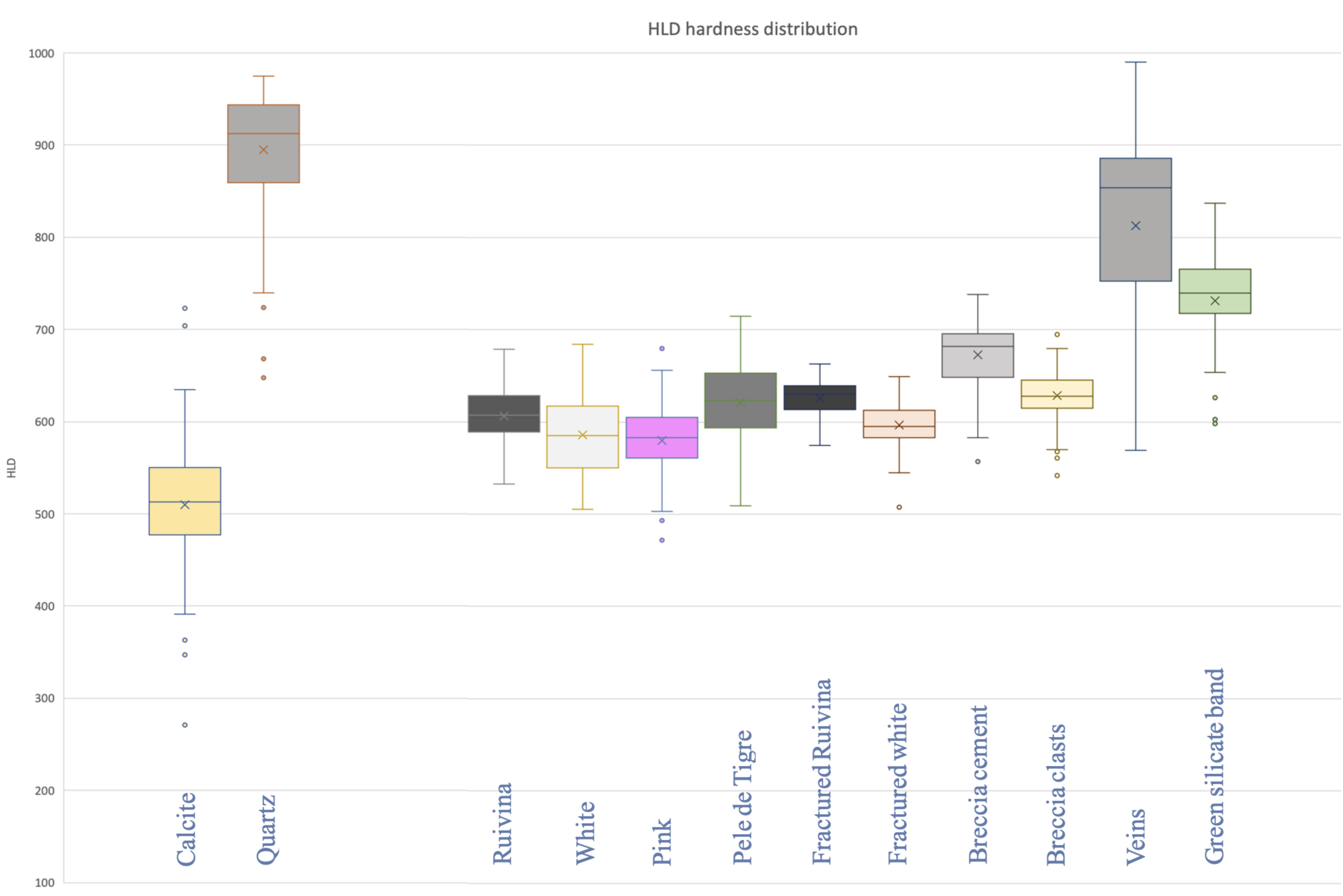

Figure 2: Boxplots with statistical distributions of HLD results obtained in different types of marbles and quartz ad calcite.

QUARRY FRONT RESULTS

A quarry front with varied lithologies was chosen where a 30x30 cm grid was marked, with a total length of 4,80x4,50 m. At each grid point, 6 measurements were taken around it and the HLD hardness value of each point corresponds to the average of the 6 measurements. The front consists of white marble and Pele de Tigre marble, with silicified domains with quartz veins and breccias.

Figure 3: Marked quarry front with identified lithologies and HLD values corresponding to each grid point.

The HLD values of the different types of marble do not differ significantly, although the light-coulored marbles typically have lower values than the dark ones. The HLD values of the breccia cement (dolomitic) and silicified zones are considerably higher, thus a clear and rapid distinction can be made between these lithologies on a quarry front.

CONCLUSIONS

The LHT proves to be useful to quickly distinguish lithotypes with discrepant mineralogy, but not well discriminate different types of marbles. It was quite accurate to discriminate carbonate-rich rocks from silicate-rich ones, since they have very different HLD values. The most significant limitation of LHT is related with the limit of detection, once quartz rich rocks have hardness values quite comparable to uppermost limit of detection of the equipment, and so, most of quartz-rich rocks will have similar LHT hardness. In calcite marble lithotypes, LHT can be used to quickly identify silicified or dolomitized domains and so, help to the management of exploitation and transformation process.

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