

Granite Characterisation of Three Asynchronous Quarries of the Archaeological Site of *Touças* (North of Portugal)

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Quarries deepen as extraction techniques evolve over time. Quarries were superficial in the Iron Age, and the granite extracted from them had more developed exfoliation microcracks than the one extracted from medieval quarries, when new techniques allowed to extract a sounder granite. Today's quarries can go tens of meters deep and produce sound granite, whose exfoliation microcracks are less developed.

Prehistoric, medieval and current quarries of the same granite exist near the archaeological site of *Touças*. It is located 500 meters to the northeast of *Garganta* village, in *São Martinho de Anta*, municipality of *Sabrosa* (North of Portugal). It consists of about 70 prehistoric standing stones of granite, several medieval granite sarcophagi, a twin carved grave in the outcropping granite and a granite landmark of Malta military order dated from 1776. In addition, *Madorras* dolmen has been excavated at approximately 700 meters from the archaeological site of *Touças*. These elements have been built with the same granite but with different degrees of alteration.

Granite from each quarry has been sampled for an in-depth analytical study. Eight cubic samples of each granite with dimensions of $5 \times 5 \times 5 \pm 0.5$ cm were characterised. Effective porosity, water absorption and bulk density were obtained using the Natural Stone Test Method described in European standard UNE-EN 1936. Ultrasonic pulse velocity (wave propagation in??) of the granite cubes was measured with a CNS Electronics PUNDIT equipment following European standard UNE-EN 14579. The colour was assessed with an X-Rite colorimeter (model 964), using the three chromatic coordinates of CIE-L*a*b*system. Thin sections were prepared and analysed under a Leica DM-4500-P polarisation microscope equipped with a Leica DFC290-HD digital camera and LAS-4.9 software. Mercury intrusion porosimetry was conducted on single prismatic specimens (12 ± 2 mm in diameter and 20 ± 2 mm high) in a Micromeritics Autopore IV 9520 porosimeter. The capillary coefficient of each alteration grade of the granite was calculated based on the NF-EN 15801 standard. Infrared thermography monitoring was used to evaluate the alteration degree by means of the cooling rate index.

This archaeological site presents extremely relevant evidence for the understanding of the use of quarries throughout human occupation of *Trás-os-Montes e Alto Douro* territory. The main building granite of the archaeological site is a coarse-crystal-size granite with elongated pseudo-oriented feldspars. Granites mined in prehistoric times are much more susceptible to decay than those mined from deeper quarries. The alteration degree of the granite is directly related to the colour, number of microcracks, ultrasonic pulse velocity, hydric properties and thermal effect. Consequently, the conservation of granite must be adapted to its state of alteration.

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