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Contributions of non-destructive testing for determining the provenance of the granites used in the Roman Amphitheatre from Emerita Augusta, Badajoz, Spain.

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The Archaeological Ensemble of Emérita Augusta (Mérida, Badajoz, Spain) was listed a World Heritage Site in 1993 by UNESCO. One of the monuments that belongs to this Archaeological Ensemble is the Roman amphitheatre, mainly built with granite from quarries located near the city. Every urban centre in the Roman Empire, in addition to many rural sites, had one or more local quarries from which they extracted the bulk of their stone. In Mérida, there are a group of documented quarries located near the ancient city. In this work the authors have been investigating five of these documented outcrops which, due the distance from the monument or the existence of ancient Roman routes of communication with the city, can be the possible original quarries.
The provenance of these materials with which the monument is built is of significant interest in terms of the restoration and conservation and from a historical point of view of the monument. Nowadays, there are many examples of identification of the original quarries that use destructive procedures and techniques which are based on the physical, petrographical, geochemical, magnetic or mechanical properties that are a function of the mineralogical and textural characteristics of the rock.
In this work, the combined use of two non-destructive and on-site techniques, ultrasonic velocity and surface hardness determined with a Schmidt hammer rebound tester, allows to determine first, the quality and degree of decay in the granites, usually affecting the material surface and consisting of a decline in surface cohesion, and second, it can discriminate possible provenance areas of the rock used in the building. These two techniques are very useful for this purpose for several reasons. Their combined use allows the selection of the most representative blocks and ashlars for sampling. This reduces sampling to a minimum showing representative results for the whole building, especially in the case of performing ageing tests in the laboratory and when assessing consolidating and protecting treatments based on the similar decay condition present in the real structure; the combined values obtained from both techniques are directly and linearly related, can be used to compare the results from the building stones of the monument and from rocks from the surrounding documented quarries. The latter represents a suitable approach for locating the original quarries that supplied stone for construction and, in the case of many quarries having similar values, can be a method to exclude certain quarries. Moreover, the results also allow the identification of changes in determined physical properties of building stones, as porosity, mainly due to the exposure to climatic conditions, compared to fresh rocks from the quarries. The stones from the monument show lower ultrasonic and Schmidt hammer values than the rocks from the quarries.
The obtained values from ultrasounds and from hardness surface measurement in the monument are affected by decay processes different from those in the quarries. This is due to the placement of ashlars in the monument (orientation), besides the cutting and carving of the stone and the surface finishing, which derives in a different correlation between the two sets of results from both techniques.

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