NON-INVASIVE NUCLEAR TECHNIQUES APPLIED TO STONE IDOLS FROM PRE-HISTORICAL PERDIGÕES SITE: A CONTRIBUTION TO UNDERSTAND INTERACTION NETWORKS

RONCSOLÁSMENTES NUKLEÁRIS TECHNIKA ALKALMAZÁSA PERDIGÕES ŐSKORI LELŐHELYRŐL SZÁRMAZÓ KŐ IDOLOKON: ADATOK AZ KAPCSOLATI HÁLÓZATOK MEGISMERÉSÉHEZ

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Abstract

Perdigões is a large ditched enclosure dated from the Late Neolithic to the Late Chalcolithic/Early Bronze Age (cal BC 3400-2100), located in Reguengos de Monsaraz municipality (Évora district, South Portugal). Hexogen raw materials as ivory, variscite, cinnabar were recorded and several objects made of locally available raw materials show stylistic criteria that seem to reveal external provenances.

This paper will address a specific assemblage of objects: stone idols and stone recipients recorded in funerary contexts. This assemblage presents different typologies and raw materials, apparently marble or limestone, suggesting different origins for these artefacts, since both rocks do not occur locally, but regionally or even longer distance.

One of the main goals of this work is to determine the nature of the used raw materials, by studying the composition of a set of stone idols and ritual stone vessels, together with geological samples (marbles and limestones), trying to evaluate the degree of compositional homogeneity between items and possible areas of origin, thus contributing to understand the interaction network in which Perdigões was involved. Another important achievement of the study was to determine whether Prompt Gamma Activation Analyses (PGAA) could be successfully used to trace the source(s) of those artefacts made of carbonate rich raw materials.

The analysis of obtained results, particularly the statistical results obtained by Principal Component Analysis (PCA) and clustering methods applied on the chemical contents, clearly detach five groups between the stone idols, while the vase sample analyzed has also a different chemical behaviour. The analyzed stone artefacts from Perdigões show signs of both nearby and long distance procurement, as well as of unknown attribution.

Kivonat

Perdigões, az. i.e. 3400-2100 között fennálló település a mai Reguengos de Monsaraz város területén található. (Évora, Dél- Portugália). Távoli nyersanyagok – elefántcsont, variszcit, cinnabarit – bizonyítják kiterjedt külső kapcsolatait. Ez a tanulmány egy különleges tárgycsoporttal foglalkozik, kőből készült idolokkal, amelyek sírmellékletként kerülnek elő. Különféle típusok és nyersanyagok figyelhetők meg ezek között, többnyire márványból vagy mészkőből készültek, amely nyersanyagok a lelőhely közvetlen közelében nem fordulnak elő. Vizsgálataink célja az idolok nyersanyagának alaposabb megismerése volt, egy sorozat kő idol és néhány kőből készült edény anyagának kémiai összetétel vizsgálatával, amelyek mellett márvány és mészkő összehasonlító mintákat is mértünk. Vizsgáltuk a tárgyak összetételének egységes voltát, és összehasonlítottuk adatainkat a feltételezhető származási területről gyűjtött összehasonlító mintákkal. A vizsgálatok célja Perdigões település kiterjedt kapcsolatrendszerének jobb megismerése volt. A vizsgálatok másik célja a prompt gamma aktivációs analízis (PGAA) alkalmazási lehetőségeinek megismerése volt karbonátos anyagú kőzetek lelőhely azonosítására. Eredményeink szerint, amelyeket statisztikai módszerekkel (főkomponens analízis és klaszter-elemzés) értékeltünk ki, a kő idolok között öt csoportot tudtunk elkülöníteni a kémiai összetétel alapján. A kőedény ezektől összetételében különbözött. A vizsgált összehasonlító minták alapján a kő idolok részben helyi, részben távolsági eredetűek, de találtunk eddig azonosítatlan nyersanyag forrásból származó példányokat is.

KEYWORDS: PGAA; STONE IDOLS; PREHISTORY; PERDIGÕES SITE

KULCSSZAVAK: PGAA; KŐBŐL KÉSZÜLT IDOLOK; ŐSKOR; PERDIGÕES LELŐHELY (PORTUGÁLIA)

Introduction

The Perdigões site is one of the largest known Portuguese Chalcolithic ditched en-closures, occupied during the 4th-3rd millennium B.C. (Valera et al. 2014a) in the Reguengos de Monsaraz region, in the South of Portugal. Like all the large ditched enclosures of southern Iberia, the site presents a significant amount and variety of hexogen objects, frequently made of exotic and nonlocal raw materials (Valera et al. 2012a; 2012b).

In the case of Perdigões enclosure, hexogen raw materials as ivory, variscite, cinnabar were recorded and several objects made of locally available raw materials show stylistic criteria that seem to reveal external provenances. Pottery artefacts include all the typical morphologies of the Late Neolithic and Chalcolithic of the South West of the Iberian Peninsula and there are differences between the style, production technology and provenance of funerary and settlement pottery (Dias et al. 2005).

This paper will address a specific assemblage of objects: stone idols and stone recipients recorded in funerary contexts. This assemblage presents different typologies and raw materials, apparently marble or limestone, suggesting different origins for these artefacts, since both rocks do not occur locally.

One of the main goals of this work is to determine if diverse raw materials resources were used, by studying the composition of a set of stone idols and ritual stone vessels, together with geological samples (marbles and limestones), trying to evaluate the degree of compositional homogeneity between items, as well as possible areas of origin, contributing to understand the interaction network in which Perdigões was involved. Another important achievement of the study was to determine whether Prompt Gamma Activation Analyses (PGAA) could be successfully used to trace the source(s) of those artefacts made of carbonate rich raw materials.

It is a well-known debate the problem in sourcing carbonate rich artefacts due to the fact that macroscopically they may look similar, even if they come from different source. From a mineralogical point of view, they are almost pure $CaCO_3$ with a very heterogeneous mixture of impurities. In this case of carbonate artefacts, especially those deriving from the metamorphic evolution of previous carbonates (marbles), are often rather similar to each other in many respects (i.e. mineralogical, physical–structural and chemical), and thus difficult to identify. Due to the fact that impurities are generally heterogeneous in this kind of geological source, a significant overlap with other sources may occur.

Another important issue related with the analysis of these artefacts is the fact that the objects involved are often unique in nature. To achieve the main goals, and regarding the importance of these stone artefacts, only non-invasive analysis was possible, respecting the physical integrity of the material/ object. PGAA is one of the new techniques available to deal with this problem.

Methods

The non-invasive method PGAA was applied to both stone idols, stone vessels, and potential raw materials. Its basis is the radioactive capture of neutrons, or the (n,γ) reaction. During this nuclear reaction, an atomic nucleus captures a thermal or sub-thermal neutron, and emits a number of gamma photons promptly. Because of the low intensity of external neutron beams, PGAA can be considered non-destructive, and is applicable to samples that must be preserved intact and do not require sample preparation, being positioned directly in the neutron beam. The PGAA facility used was the one from the Budapest Neutron Centre, which has become a leading laboratory for applications of PGAA in archaeometry (Szilágyi et al. 2012; Kasztovszky, et al., 2004). For the statistical interpretation of the PGAA data, only the oxides/elements which were above the quantification limit in most of the samples were used i.e. CaO, CO_2, LOI (H_2O), SiO_2, Fe_2O_{3t}, MnO, K_2O, Mg, B, Ti, Cl, Sm and Gd.

The stone artefacts

Seven limestone samples (Moleanos limestone: MOL-1, MOL-2, MOL-3; Lioz limestone: LIOZ-1, LIOZ-2, LIOZ-3; Tavira breccia BT) and four marble samples (MNR, MAL, MBC, MER) were analyzed from nearby sources (~40Km the “marble triangle” Estremoz – Borba – Vila Viçosa, in Alentejo’s northeast), moderate distance areas (~130 Km - limestone from Tavira, Algarve) and c) remote areas (160 to 200 Km -Limestones from Pêro Pinheiro and from the Maciço Calcário Estremenho MCE). Regarding artefact samples, thirteen stone idols from the cremation contexts (PDI-1 – PDI-13) and one votive vessel (PDV-7) from a tholoi tomb were analyzed (**Fig. 1.**).

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Fig. 1.: Stone idol from cremation funerary context and stone vessel from tholoi tomb of Perdigões enclosure.

1. ábra: Kőből készült idol hamvasztásos temetkezésből és kőedény a Perdigões-i körárkos település halomsíros temetkezéséből

Results

In the studied samples CaO is the prevailing major component, ranging from 50 and 57 wt% in artifact samples, and between~51 to ~56 wt% in the geological samples. All analyzed samples have a relatively low MgO concentration (< 2 %).

The studied geological samples are all included in calcitic type marble and pure limestone, but the breccia Tavira sample (BT) is a limestone more enriched in Mg. Regarding the artifact samples, they are all pure limestones / calcitic marbles.

The SiO_2 content in the marble samples range from 0.64% to 3.7%, in the limestones ranges from 0.27% to 2%, and in the stone idols from 0.09% to 2.9%.

The alkali elements, such as Na and K, were below detection limit in almost all the samples, or were detected in a few stone idols.

The other oxides contents are generally low. Iron oxide (Fe_2O_3 Total %) and titanium oxides were detected in most of the samples.

We can infer L.O.I by the content of volatiles (CO_2, H_2O) present in the samples. In general, the sums of both values are high, indicating high volatile content and by implication high carbonate content.

Regarding trace elements, immobile trace elements such as the Rare Earth Elements (REE) are usually important for provenance determination. With PGAA we have determined Sm and Gd. Gadolinium were detected only in two geological samples, and in a few stone artefacts, and Sm was not detected in two idols and in the vase.

Boron contents of limestones are generally low, and are only elevated when the clay or organic contents are high.

PGAA results correspond to the bulk sample, and idols have not been cleaned from surface deposits, and in some of them it appears in considerable amounts, particularly as crashed bones and soil. A special care was taken in order to evaluate if analyzed chemical contents might have been enlarged due these contamination, and not specifically to the nature of geological source, but no correlation was directly established.

The analysis of obtained results, particularly the statistical results obtained by PCA and clustering methods applied on the chemical contents (**Fig. 2.**), clearly detach five “groups” between the stone idols, while the vase sample analyzed has also a different chemical behaviour (Dias and Valera, in press). Each of these five groups is made of only a few samples (2-3 samples), enhancing the difficulty in establishing geochemical fingerprints in these materials. Even so, it was possible to establish that PDV-7 is an extreme outlier, and the idols PDI 3 and PDI-11 even clustered together, have differences among them and with the others. Also some correlation was established between these five “groups” and the potential raw materials.

Among geological samples, those from the nearby sources in the same “marble triangle” have chemical heterogeneities that enhance the difficulty in establishing geochemical fingerprints in these materials. However, some correlations were possible to establish. For Groups 3, 4 and 5 artefacts the most likely source includes samples from the “marble triangle” Estremoz – Borba – Vila Viçosa. The medium distance area sample - Tavira Breccia, like the later doesn’t present any chemical affinity with the analysed artefacts. Considering the remote areas geological samples don’t point to be a source for the stone idols, but stone vessel is the only sample that has chemical similarity with a limestone sample from the MCE.

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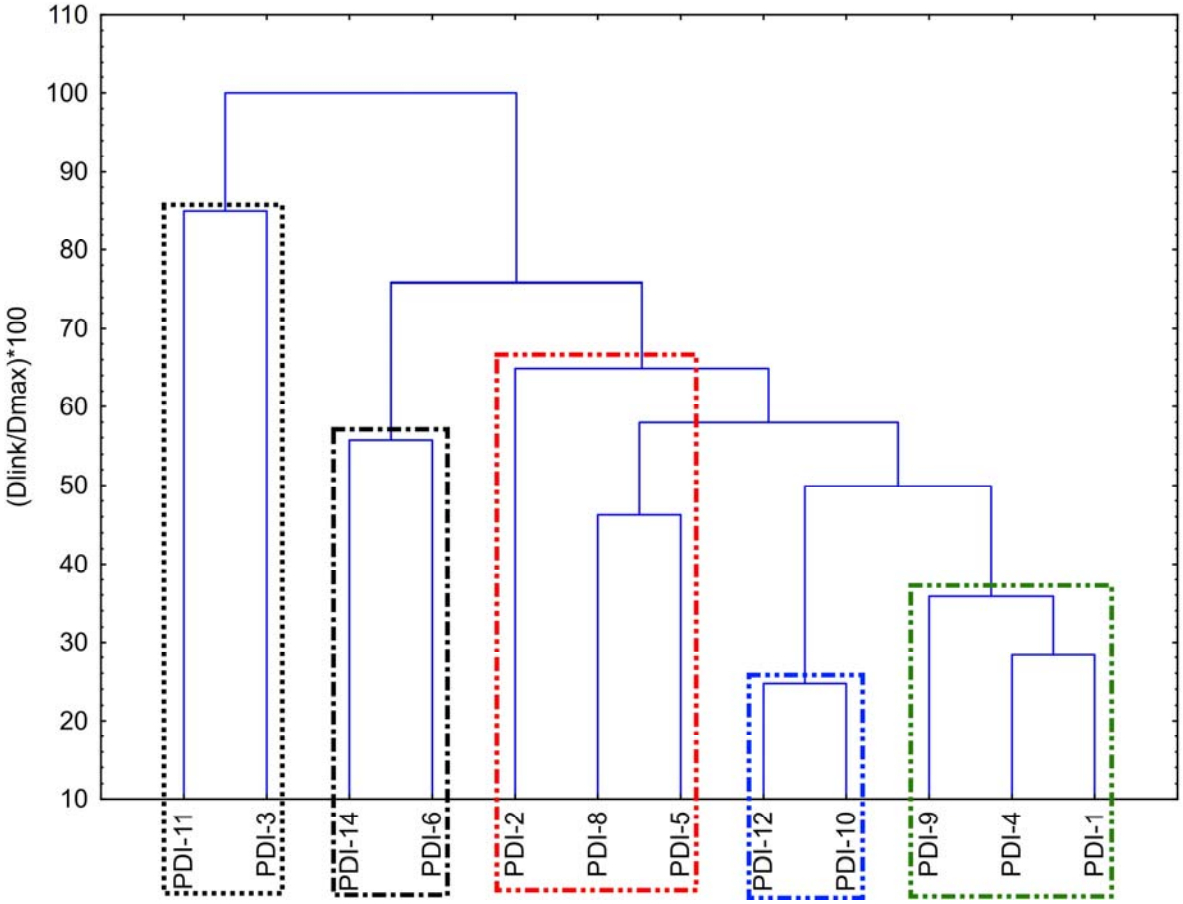

Fig. 2.: Cluster analysis: joining (tree clustering) for the stone idols, with chemical elements obtained by PGAA as variables (standardized), by using the unweighted pair-group average as amalgamation (joining) rule and the Euclidean distances as distance measurement.

2. ábra: A kő idolok klaszter analízise a PGAA adatok alapján. A csoportképzés módszere a súlyozatlan páronkénti csoportátlagok számítása volt, közelségüket az euklidészi távolságok alapján határozták meg.

Conclusions

Therefore, the analyzed stone artefacts from Perdigões show signs of both nearby and long distance procurement, as well as of unknown attribution. More than a half (57%) appears to have been made of materials from the marble triangle Estremoz – Borba – Vila Viçosa. Only one artifact, the only stone vessels analyzed, point to long distance materials (in particular MCE limestones). The rest do not match the analyzed raw materials and are from unknown sources.

The traditional idea that these objects in Alentejo might have come from the Lisboan Peninsula is now nuanced. Only the vessel from the tholoi tomb is compatible with the Estremadura limestones. This seems to suggest that, not just the tholoi tombs and the pits with cremations present different architectures, different body treatments (Valera et al., 14b), different material assemblages, but that these particular set of object have also different raw materials with different provenances.

This study, although preliminary, shows that this line of inquiry comprising the use of PGAA has potential to contribute to the definition of the spatiality of the Perdigões interaction network and to the characterization of the diversity existing between the several funerary contexts already excavated at the site.

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