

THE POTENTIAL OF NANNOFOSSIL ANALYSIS APPLIED TO ARCHAEOLOGICAL STUDIES: THE CASE OF THE RIACE'S BRONZES

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Abstract: The analysis of nannofossil assemblages has rarely been used in the study of art-works in the past but, recently, the situation has improved. In this context, the nannofossil content of the casting material of the Riace bronze statues was examined in order to locate its provenance and to attempt to identify sites of quarrying. Due to the limited amount of sample material that could be collected from inside the statues, nannofossils were of fundamental relevance in the assignment of ages to the material, and more so because no other stratigraphically-meaningful fossils were recovered.

A decently preserved, Upper Paleocene assemblage was found in one of the statues, which allowed a reasonable hypotheses on provenance to be drawn up. The verification that nannofossils could survive the melting process, and that the high temperatures did not affect their preservation, is important. Therefore, they are very promising for future application in the analysis of archaeological remains.

Introduction

Two Greek bronze statues, known as the Riace's bronzes, were recovered some twelve years ago from the Ionian Sea off the coast of Calabria, southern Italy. The statues have been undergoing major restoration for almost two years. All kinds of analyses have been performed during this work, including the study of the palaeontological content of the casting material. This was aimed at the age determination of the material, in order to locate its area of origin. The analysis of nannofossil assemblages has rarely been used in the study of art-works in the past but, in the last few years, this situation has improved (Švábenická,

1993; von Salis, 1995; von Salis & Plather, 1995; Vergerio & Meggiolaro, 1995; Meggiolaro *et al.*, 1997; Quinn *et al.*, 1998, this volume).

The casting material is the material used to make the melting cast. Clay is preferably used for this purpose. It constitutes the inside of the model and is covered by wax. Once the wax is modelled, it is also covered by casting material, with a hole left at the top and a hole at the bottom. The melted bronze is then poured through the upper hole. It melts and replaces the wax, which flows out through the lower hole. When the bronze has solidified, the outer cover is removed. The inside of the statue is then emptied through

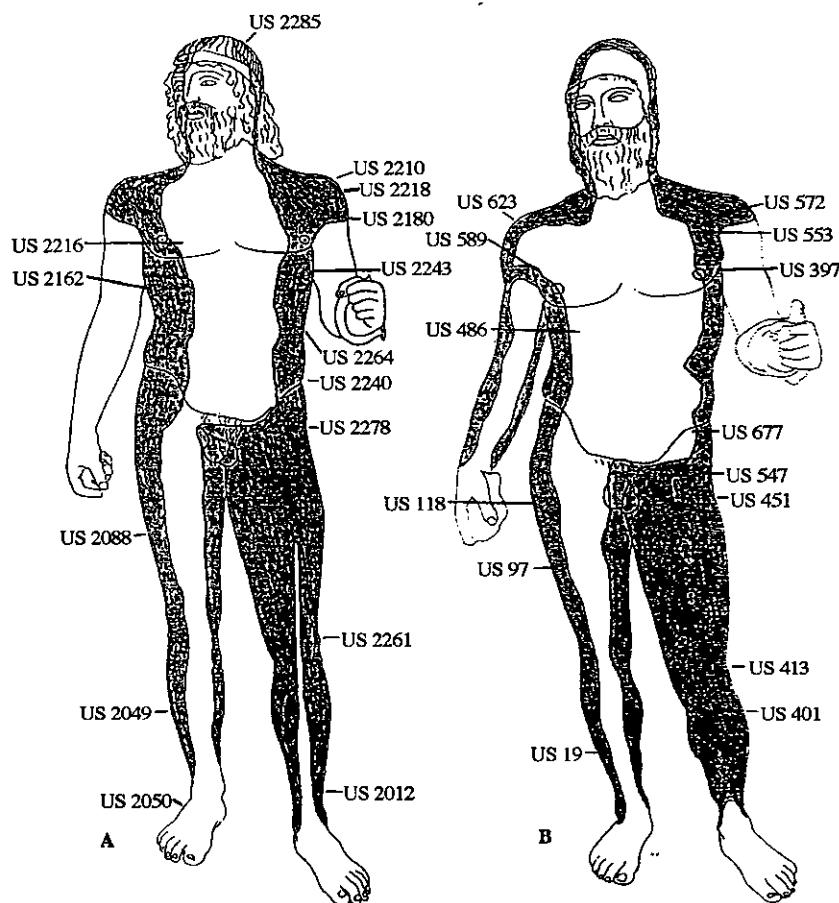


Figure 1: Representation of the remnants of the casting material inside the Riace's bronzes (shaded) and location of the samples collected from Statues A and B.

the lower hole, however, it is not possible to remove all of the material, so that small remnants of casting material can still be found attached to the inner surface of the statue (Figure 1). This material is the object of the present study and, where nannofossils were detected, was used to trace possible quarrying sites. Some of the material contains reasonably well-preserved nannofossil assemblages, allowing for a coarse age-determination.

Methods

The Riace's bronzes have been distinguished as Statue A and Statue B for study purposes (Figure 1). Samples were collected from the residual casting material inside the two statues, at the levels indicated in Figure 1, by means of a mechanical arm inserted through one of the holes. Slides were prepared from dilute suspensions made from very small fragments of the samples. They were observed with the light microscope at $\times 1250$ magnification.

The analysis carried out was exclusively qualitative, according to the scope of the work and the type

STATUE B												
SAMPLE	TAXA	<i>Chiasmolithus</i> spp.	<i>Coccolithus pelagicus</i>	<i>Cruciplacolithus primus</i>	<i>Cruciplacolithus tenuis</i>	<i>Cruciplacolithus mohleri</i>	<i>Discoaster multiradiatus</i>	<i>Ericsonia cava</i>	<i>Ericsonia robusta</i>	<i>Fasciculithus tympaniformis</i>	<i>Heliolithus kleinpelli</i>	<i>Heliolithus riedelii</i>
US 572	P P P	P	P	P	P	P	P	P	P	P	P	P
US 623	P P P			P P P P	P P				P	P	P	P
US 553	P			P P P P	P P				P	P	P	P
US 397	P	P P		P P P P	P P P				P P P P	P P P P	P P P P	P P P P
US 589	P P			P P					P P P P	P P P P	P P P P	P P P P
US 486	P P P			P P	P P				P P P P	P P P P	P P P P	P P P P
US 677	P P			P P P P P P P	P P P				P P P P	P P P P	P P P P	P P P P
US 547	P			P P	P P	P P			P P P P	P P P P	P P P P	P P P P
US 451	P P			P P	P P	P P			P P P P	P P P P	P P P P	P P P P
US 118	P P			P P P P	P P P P	P P P P			P P P P	P P P P	P P P P	P P P P
US 97	P P			P P	P P	P P			P P P P	P P P P	P P P P	P P P P
US 413	P								P P P P	P P P P	P P P P	P P P P
US 401	P P			P P	P P	P P			P P P P	P P P P	P P P P	P P P P
US 19	P P			P P	P P	P P			P P P P	P P P P	P P P P	P P P P

Figure 2a: Presence/absence of nannofossil species in the samples from Statue B. P = present.

of material. Nannofossil species are reported only as present or absent (Figures 2a, 2b). Preservation is mainly poor so that some forms could be identified only to the generic level.

Samples are stored at the Instituto Centrale del Restauro in Rome (sample numbers for Statue A: US 2012, US 2049, US 2050, US 2088, US 2162, US 2180, US 2210, US 2216, US 2218, US 2240, US 2243, US 2261, US 2264, US 2278, US 2285; Statue B: US 19, US 97, US 118, US 397, US 401, US 413, US 451, US 486, US 547, US 553, US 572, US 589, US 623, US 677).

Results

The samples examined are mainly clays (Lombardi *et al.*, in press); in Statue A, a higher content of silty to sandy grains is present. The samples were mostly incoherent, either because this had been their original state or because they had to be scratched to be collected. Only in a few cases was it possible to obtain small grains of material, but even in those cases the particles used to prepare the slides could not be taken from a fresh surface. Contamination between the samples could not be prevented both because of the way in which the material had been handled originally, and because of the way the samples were collected.

The results are consistent for each statue: Statue B yielded the better-preserved material, with a diverse assemblage and a consistent composition, whereas Statue A presented a chaotic assemblage with forms of different ages occurring sporadically in the samples. However, it was possible to define the assemblages in order to relate them to a limited number of possible quarrying locations.

The material used for the two statues has different origins, as confirmed by the chemical analysis (Lombardi *et al.*, in press). The Statue B material was dated as Late Paleocene to Early Eocene, the nannofloras mainly formed by solution-resistant and long-ranging taxa (Figure 2a), and which were evidently also resistant to the high temperatures reached during the melting process (*i.e.* *Coccolithus pelagicus*, *Discoaster* spp., *Ericsonia cava*,

SAMPLE	TAXA	CRETACEOUS TAXA						TERTIARY TAXA						
		<i>Braurodysphaera bigelowii</i>	<i>Conusphaera mexicana</i>	<i>Eiffellithus</i> spp.	<i>Lithraphidites carnioliensis</i>	<i>Micula</i> spp.	<i>Nannoconus</i> spp.	<i>Thoracosphaera</i> spp.	<i>Watznaueria</i> spp.	<i>Chiasmolithus</i> spp.	<i>Discoaster</i> spp.	<i>Ericsonia robusta</i>	<i>Fasciculithus</i> spp.	<i>Markalius inversus</i>
US 2285								P						
US 2210								P P P						
US 2218				P				P						
US 2180														
US 2216								P						
US 2243	P							P						
US 2162	P P							P						
US 2264	.				P			P						
US 2240	P							P P						
US 2278								P					P	
US 2088								P				P		
US 2261				P				P						
US 2049											P P			
US 2050														
US 2012	P				P			P				P		

Figure 2b: Presence/absence of nannofossil species in the samples from Statue A. P = present.

Markalius inversus, *Micula decussata*, *Toweius* spp., *Watznaueria barnesae*). Some Paleocene zonal markers are also present: *Chiasmolithus danicus*, *Cruciplacolithus primus*, *C. tenuis*, *Discoaster mohleri*, *D. multiradiatus*, *Fasciculithus tympaniformis*, *Heliolithus kleinpelli*, *H. riedelii*, but it is difficult to determine if the material comes from a specific zone (or zones) because, due to poor preservation, a younger age cannot be excluded. Reworked forms are also abundant, comprising among others mainly solution-resistant Cretaceous taxa which are often recovered in the Paleocene: *Acuturris scotus*, *Arkhangelskiella cymbiformis*, *Biscutum constans*, *Cribrosphearella ehrenbergii*, *Eiffellithus turriseiffelii*, *Glaukolithus compactus* (= *Zeugrhabdotus bicrescenticus* of some authors), *Microrhabdulus decoratus*, *Micula decussata*, *M. murus*, *M. praemurus*, *Nannoconus* spp., *Prediscosphaera cretacea*, *Stradneria crenulata*, *Watznaueria barnesae*. Reworking within the Paleocene was observed as well (*i.e.* *Cruciplacolithus primus* and *C. tenuis*). It could well be that material of different ages was assembled by the workers who contributed to the making of the statues, although this does not seem to be the case for the reworked Cretaceous taxa: these are Campanian or Maastrichtian species that it is not unusual to find in the Paleocene.

It is possible to imagine that the material used for Statue B was collected in large quantities, and that a specific nannofossil zone cannot thus be identified, unless it was to crop out with a relevant thickness in the area of origin. On the base of the uniformity of the assemblages, the material seems to come from a unique area: the geographical indication obtained is based on markers that characterise fairly widespread, low-latitude assemblages.

On the other hand, Statue A did not yield consistent assemblages (Figure 2b). Species occur sporadically in the samples and are very poorly preserved. They are also typical of low-latitude assemblages, but their stratigraphical distribution ranges from the Early Cretaceous (e.g. *Conusphaera mexicana*, *Nannoconus* spp.) to the Paleogene (e.g. *Ericsonia robusta*, *Fasciculithus* spp., *Toweius* spp.), without any indication of specific nannofossil zones. These specimens are so poorly-preserved that they cannot provide even a remotely reliable age, and occur so sporadically (or do not occur at all, as in sample US 2050), that contamination cannot be excluded as a reason for their presence. In fact, there were many chances for contamination to have occurred during the handling, collection and storage of the material, and the preparation process.

Conclusions

The nannofossil analysis tentatively revealed that these fossils survived the high temperatures reached during the melting process. They are generally present in the types of clays used as casting material, and are thus very promising as a tool for future application in archaeological studies focused on bronze statues.

The nannofloras contributed, together with the mineralogical and chemical results, to the distinction between the material used to make the Riace's bronzes A and B. This distinction also corresponds to a difference in the time of their realisation, of some tens of years (Torelli, 1986).

Age determination, uniquely based on nannofossils, was essential in defining the casting material,

in order to locate its area of provenance, which has consequently been identified as being the environs of Argos (southern Greece), where Paleocene-Eocene clays crop out.

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