

## A NOTE ON THE BEHAVIOUR OF CALCAREOUS NANNOFOSSILS DURING THE FIRING OF CERAMICS

Patrick Sean Quinn, Dept. of Archaeology & Prehistory, University of Sheffield, UK

**Abstract:** Firing of ceramics during manufacture deleteriously affects calcareous nannofossil assemblages. Determining the provenance of archaeological ceramics from such assemblages can, therefore, be problematical, and it is important to have an understanding of the behaviour of this calcareous component during firing. The experiments outlined here show that calcareous nannofossil assemblages are degraded by heating above 600°C, and can be completely destroyed at temperatures of over 800°C.

### Introduction

Calcareous nannofossil assemblages in archaeological ceramics can be altered by several processes (Table 1), of which one of the most important is firing. In order to determine the effects of firing on the nature of calcareous nannofossil assemblages in archaeological ceramics, experiments have been conducted on material from the Albian Gault Clay Formation, concentrating on the effects produced by three variables: the maximum temperature of firing, the length of firing, and the firing atmosphere.

1. CONTAMINATION DURING CLAY PROCUREMENT.

2. UNINTENTIONAL CONTAMINATION DURING CLAY PREPARATION AND STORAGE.

3. INTENTIONAL CLAY MIXING.

4. ALTERATION OF CALCAREOUS NANNOFOSSIL ASSEMBLAGES DURING FIRING.

5. POST-FIRING ALTERATION OF CALCAREOUS NANNOFOSSIL ASSEMBLAGES AS A RESULT OF USAGE:

- a. cooking;
- b. storage.

6. ALTERATION AND CONTAMINATION DURING BURIAL.

7. ALTERATION AND CONTAMINATION AFTER EXCAVATION AS A RESULT OF POOR SAMPLE CURATION.

**Table 1:** Processes which can affect calcareous nannofossil assemblages in archaeological ceramics.

### Material and methods

The Gault Clay, which was collected at Strouanne, N France, was chosen because of its abundant, well-preserved calcareous nannofossil assemblages, as well as its suitability as a raw material for the manufacture of ceramics. Several kilogrammes of Gault Clay, procured from a short (~10cm) interval, were left to dry, then crushed, sieved, mixed with water and fashioned into equidimensional briquettes. The dried briquettes were fired in either air (an oxidising atmosphere) or in a reducing atmosphere (4% H<sub>2</sub> by volume) for 1 hour, at maximum temperatures of 600, 700, 800, 900, 1000 and 1100°C. In addition, briquettes were fired for a duration of one, two, three and four hours at a maximum temperature of 600°C, in an oxidising atmosphere. These temperatures were chosen in accordance with the range of temperatures which were

attained by ancient kiln firings.

Calcareous nannofossil smear-slides were prepared from the raw Gault Clay, a processed but unfired briquette, and all of the fired samples.

### Results

Quantitative calcareous nannofossil analysis of smear-slides prepared from the fired briquettes indicated a progressive decrease in the overall abundance, diversity and preservation of the Gault Clay assemblages (Figure 1). Calcareous nannofossils were found to survive a maximum firing temperature of 800°C in an oxidising atmosphere and 700°C in a reducing atmosphere, after which all briquettes were barren and low in calcite. Increasing the length of the firing process was found to have a similar effect, although this was much less severe.

By recording the relative abundances of the various taxa and structural groups of calcareous nannofossils in the fired Gault Clay briquettes, it was possible to document a progressive change in the composition of the assemblages. This will be presented in detail elsewhere (Quinn *et al.*, in prep.), but generally consists of an increase in the relative abundance of *Watznaueria* species (imbricating placoliths), accompanied by a decrease in the relative abundances of all other taxa, with increasing temperature and length of firing. These patterns are probably related to several factors, including variations in the physical resilience of the different groups of calcareous nannofossils to the process of firing, and the degree of ease with which they can be identified from small fragments.

### Conclusions

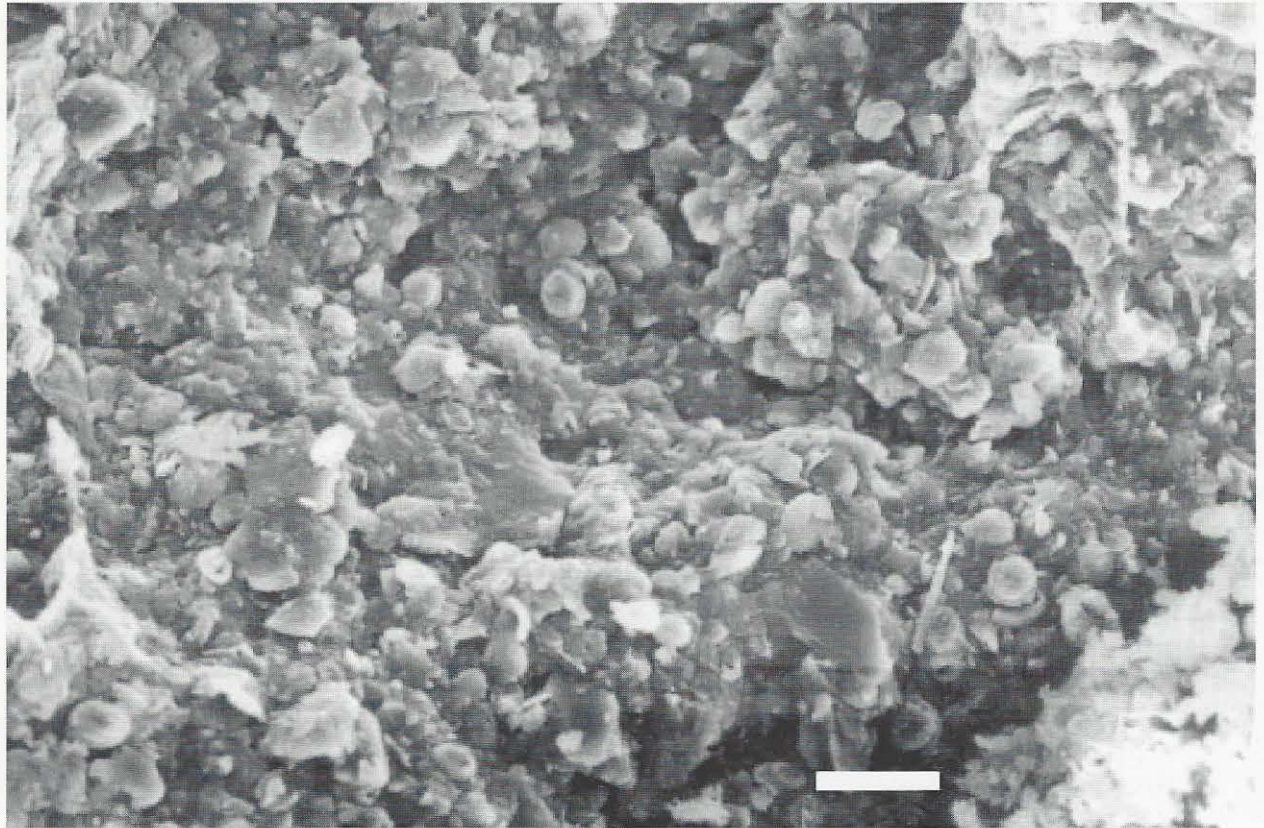
Calcareous nannofossil assemblages can be subjected to excessive heat in several other situations, including the casting of bronze statues (Fiorentino, 1998), and it is important to have an understanding of the way in which assemblages can be affected if the nannofossils are to be used to determine the provenance (stratigraphical and geographical) of the material.

The experiments which are briefly outlined above indicate that calcareous nannofossil assemblages and individuals are degraded by heating above 600°C, and can be completely destroyed at temperatures of 800-900°C. The exact process which leads to the destruction of calcareous nannofossils during the firing of ceramics is suspected to be the chemical decomposition of calcite. This will be fully discussed elsewhere (Quinn *et al.*, in prep.).

**References**

Fiorentino, A. 1998. The potential of nannofossil analysis applied to archaeological studies: the case of the Riace's bronzes. *Journal of Nannoplankton Research*, 20(2): 101-103.

Quinn, P.S., Day, P.M. & Kilioglou, V. In prep. Investigations into the behaviour of calcareous nannofossils during the firing of ceramics. For submission to *Archaeometry*.



**Figure 1:** SEM illustrations of the degradation of calcareous nannofossils during the experimental firing of Gault Clay briquettes (scale bars = 10µm): (a) broken surfaces of Gault Clay briquettes fired at 600°C; and (b) 800°C