Archaeology and forensics: interpreting the death of a 4000-year-old child in southern Scandinavia

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The discovery of a child skeleton in a Late Neolithic well in southern Sweden raises again the issue of watery rituals and human sacrifice in prehistoric societies. Analysis of diatoms from the right humerus and from the surrounding sediment indicated that the child had died by drowning and had not simply been disposed of in the well after death. Various scenarios are examined to account for this discovery. The child may have fallen accidentally into the well and drowned, or have been the victim of murder. The preferred hypothesis, based on a comparative study of other similar finds from north-western Europe, interprets this instead as a ritual sacrifice. The use of diatom analysis to establish drowning as the cause of death brings a new weapon into the armoury of forensic archaeology.

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Supplementary material: forensic analysis concerning the presence of diatoms in human skeletal remains from Lindängelund, Malmö

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The analysis

Material

Before the analysis, different bones from the skeleton were examined: humerus, pelvic bone and vertebrae. The pelvis and the vertebrae, however, were too porous to allow the interpretation of any positive find of diatoms in view of the possibility of exchange between the bone marrow and the surroundings. At one end of the humerus there was also a small opening, but only with a twisted channel through compact and trabecular bone, which seriously reduces the possibility of any such exchange. Apart from the analysis of the skeleton, soil from the find spot was also sampled and analysed.

Method—bone marrow

For all processing of samples we used double-distilled water (ddH_2O). Gloves and instruments were also rinsed.

The bone was scraped off on the outside to capture any external occurrence of diatoms. The bone was then rinsed with ddH_2O so that further remains could be collected. The shaft of the bone was then sawn longitudinally so that a long narrow lid was created. When the lid was opened, a thin greyish-brown film was found in the marrow space, coating the walls: probably remains of bone marrow. All this residue of soft tissue was collected with a spoon and rinsed with ddH_2O (see Figure 7 in the main paper).

The external sample and the residue of bone marrow were treated separately, with 20ml of a solution consisting of 1ml of TRIS-HCL 2 M (pH 7.5), 20ml of SDS (20%) in 200ml ddH_2O, and 100µl of proteinase K (10mg/ml) for 8 hours at 50°C with magnetic stirring. The procedure was repeated once again. Residual turbidity required treatment with 40% HCO_3 for 2 plus 3 days with magnetic stirring, after which both samples became optically transparent. The liquid was then neutralised in stages before filtering.

The samples were then filtered through an 80µm synthetic filter, and subsequently a 40µm synthetic filter. Remaining liquid was then filtered through a 1µm synthetic filter, from which stubs with glue were used to transfer the sample directly to the filter stub which, after sputtering with gold, was installed in a Scanning Electron Microscope, Oxford X-pert.

Method—soil samples

Four soil samples from Lindängelund were analysed for their content of silicon microfossils. The samples were treated first with 10% HCl to dissolve any carbonates. We used 17% H_2O_2 to oxidise organic material. The clay fraction was decanted off at two-hour intervals from 100ml beakers. Grains of sand were removed after 5 seconds' sedimentation. The remainder was embedded in Naphrax, after which an overall analysis was performed in X1000 with immersion oil.

Results

The samples from the bone are divided into two fractions, internal ('bone marrow') and external (the external surface of the bone). Four remains of diatoms were found in the first fraction: *Epithemia adnata*, *Pinnularia* sp. (two examples), and a fragment of *Pinnularia* sp. Figure 8a–b (in main paper) shows these diatoms at high enlargement. In the external fraction only one fragment was found, which could be *Aulacoseira crenulata*.

The soil samples had a uniform content of silicon microfossils and are therefore presented together. Diatoms and chrysophyte cysts were very common. Sponge spicules and phytoliths were more scarce. The predominant diatom species were *Aulacoseira crenulata*, *Amphora libyca* and *Pinnularia* spp. There were less common occurrences of *Eunotia* spp., *Epithemia adnata*, *Navicula elginensis*, *Navicula laevissima*, *Rhopalodia gibba* var. *ventricosa*, and *Gomphonema* spp.

Interpretation

Aulacoseira crenulata, perhaps the most common species in the soil sample, is reported to be common in low-nutrient, calcareous water with a small area. *Amphora libyca* is likewise favoured by slightly elevated pH. Otherwise it may be said that the species represents fresh water.

The diatoms found in the marrow space are sufficiently small to have been able to enter it in connection with drowning. The mechanism is that diatoms in water, which are sucked into the pulmonary alveoli, can enter the blood because the alveolar walls commonly burst in connection with drowning. The diatoms are then transported further with the blood to the capillary network of the great circulatory system, including the bone marrow, where they can be trapped.

There was a small opening in the upper part of the humerus which created a link (albeit very small and narrow) between the outside of the bone and the marrow space. This means that one can consider the possibility that the diatoms we found could have entered the marrow space passively due to submersion in diatom-rich water after the individual died of other causes. It is more likely, however, that the decomposition of the bone took place long after death and in a dryer environment, with few or no diatoms. The results of the analysis thus give support for the interpretation that the child drowned.

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