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The northernmost discovery of a Miocene proboscidean bone in Europe

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ABSTRACT

We discuss a proboscidean bone fragment discovered in southern Finland, including the morphological analysis of the bone, as well as pollen and diatom analyses from sediment contained in the marrow cavity. Preliminary analysis of the bone suggested petrification and thus an apparently old age, while the microfossil assemblages include numerous unequivocally pre-Quaternary pollen, spore, and diatom types. A Miocene age for the bone is determined based on the presence of the diatom genus *Alveolophora*, indicating a minimum age of 5 Ma, and based on the earliest appearance of proboscideans outside Africa, setting a maximum age of 19 Ma. Based on morphology, the bone is determined as a partial humerus of the left foreleg of a large proboscidean. The bone is tentatively assigned to cf. *Deinotherium* sp., which is consistent with the diatom-based minimum age. The pollen assemblage is rich in spores of shoreline pteridophytes, while the diatom assemblage is also consistent with a shoreline freshwater environment, suggesting that the bone was deposited post-mortem near the shore of a lake or a stream. Miocene sediments do not currently exist in southern Finland or in the near vicinity. This implies that the bone has been transported over a considerable distance. Due to the discovery of the bone in early-Holocene Baltic Sea clay, the final transport phase and deposition must have taken place via iceberg rafting. This was likely preceded by one or more phases of glacial and/or glacio-fluvial transport. While we are unable to conclusive ascertain the region of origin, the alkaline composition of the contained sediment and diatoms point towards the Russian Plain region in the east. This specimen represents the oldest mammalian bone discovered in Finland and the northernmost discovery of a Miocene proboscidean bone in Europe.

1. Introduction

1.1. Discovery of the bone

In about 1960, a 25-cm-long bone fragment was found during autumn gardening at a lake-shore "summer house" situated in the municipality of Suomusjärvi, southern Finland (Fig. 1a–b). The finder, young biology student Marja Sorsa, discovered the bone fragment in sandy clay at a depth of about 50–60 cm. The piece, first thought to be a remnant of a ploughing ox or a piece of a mammoth, was stored in a cardboard box in a garden shelter. The bone was later removed from its original finding site into a city garage storage and forgotten until finally in 2006, the finder (M.S.) presented the bone to professor Mikael Fortelius at the meeting of the Finnish Academy of Science and Letters. The bone was identified as a partial humerus of the left foreleg of a proboscidean. Due to its big size and structure, the original hypothesis was that the bone belongs to a proboscidean of Quaternary age, as all fossil mammal specimens previously discovered in Finland have been of late Quaternary or Holocene age, including the ten finds of woolly mammoth (e.g. Ukkonen et al., 2011) the oldest of which is dated to ca. 120 ka (Ukkonen et al., 2010). However, the Suomusjärvi bone raised special interest as it was partly eroded and heavy, possibly indicating a petrification and thus a greater age. As the information available at that point was too sparse for inferring the age of the bone, we performed sedimentological and microfossil analyses (pollen, diatoms) in order to estimate the age and the depositional environment of the bone. In addition, the morphology and structure of the bone were thoroughly investigated.

1.2. Geological setting

Finland is situated at the centre of the area covered by the Scandinavian Ice Sheet during the Late Pleistocene, and thus in the vicinity of

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large periglacial centres of terrestrial mammals in Europe and Siberia (Ukkonen, 2001). The Finnish geological setting is mainly composed of Precambrian bedrock (with some small bits of Palaeozoic), stripped clean of younger layers by repeated glacial erosion during the Pleistocene, with the crystalline Precambrian bedrock typically only overlain by glacial deposits of the last glaciation. As the repeated glaciations have generated a landscape consisting of bedrock that is up to 3.2 Ga old and a sediment layer less than 20 ka old, practically no fossil bearing deposits have survived (Ukkonen, 2001). For example, deposits of the Neogene or the Palaeogene do not exist in southern Finland. In contrast, isolated remains of sediments representing these periods have been preserved in northern Finland, where Pleistocene glacial erosion has been weaker due to the location closer to the Fennoscandian ice divide. These deposits include the Palaeogene marine clay at Akanvaara, as well as a Neogene freshwater diatomite in Naruskajärvi (Hirvas and Tynni, 1976; Tynni, 1982; Rasmussen et al., 2008).

The site of bone discovery is situated in the west of Lake Enäjärvi, in the municipality of Suomusjärvi, in southern Finland (60°17′47″N 23°38′28″E) (Fig. 1a). Today the site is located 60 m above the present sea level. The bone was found in clay sediment covered by a thin agricultural soil, at a depth of about 50 cm. The depth and character of the clay layer was confirmed in a later excavation in 2006 (Fig. 1c). The area was released from the late Weichselian ice sheet at the onset of the Holocene around 11,500 years ago (Saarnisto and Saarinen, 2001), and the site of discovery is located between the Salpausselkä II and III ice-marginal formations. In the Baltic Sea history, this timing corresponds with the Yoldia Sea stage, which started when the Baltic Ice Lake was drained to ocean level through channels in central Sweden and water level dropped around 25 m in the Baltic basin ca. 11,700 years ago (e.g. Björck, 1995). During the Yoldia Sea stage, clayish sediments and ice-rafted material from icebergs accumulated at the site within the water depth of around 60 m at this time.

1.3. Outline of this study

Examination of the bone revealed hard-packed brownish silty sediment preserved in the bone marrow cavity (Fig. 1b,d). As microfossils such as pollen and diatoms often contain useful chronological and environmental indicators, the preservation of the sediment thus presents an opportunity to provide further constrains on the history of the bone, both in terms of its age and its geographic origin, as well as the systematic determination of the animal.

Here we present the results of a multidisciplinary investigation into the origin of the Suomusjärvi bone, including (A) the analysis of the bone fragment itself, (B) pollen and diatom analyses for the sediment contained within the bone, and (C) consideration of the geological context and processes in the setting in which the bone was found. In assessing the results we especially focus on the following four questions:

1. Is it possible to provide a species or genus level identification for the animal based on bone morphology and size?
2. Is it possible to narrow down the age of the bone based on the species identification together with the microfossil assemblages?
3. Is it possible to reconstruct the living environment of the animal based on the microfossil assemblages?
4. If yes, does the environmental reconstruction help confirm the geographic origin of the bone?

2. Methods

2.1. Analysis of the bone

The specimen from Suomusjärvi is confirmed to be a fragment of a left humerus diaphysis of a proboscidean. We describe the specimen

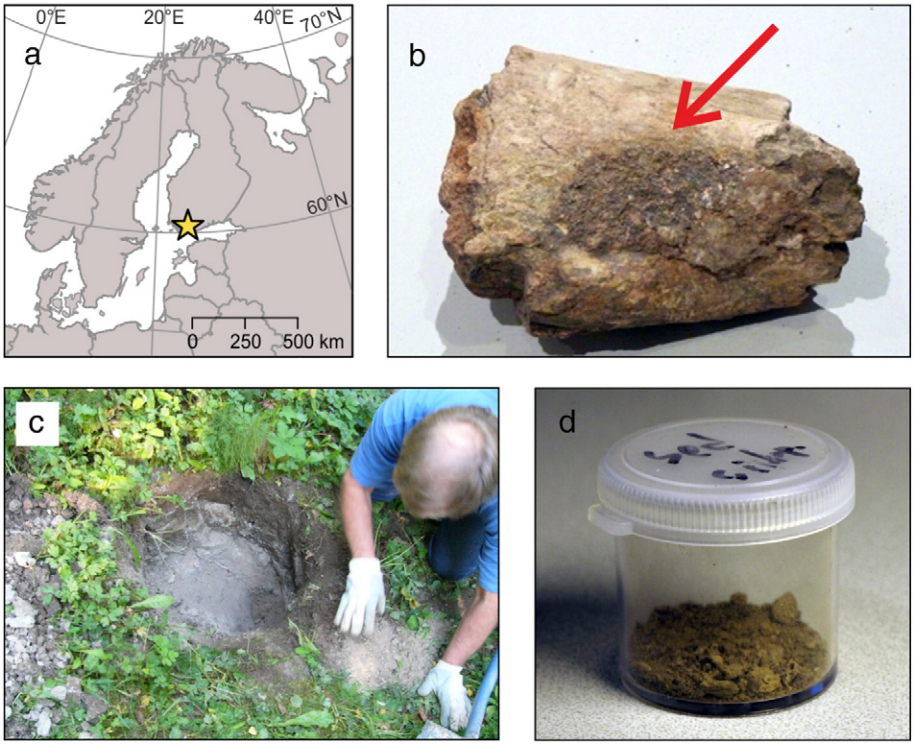

Fig. 1. (a) Site of bone discovery. (b) Photograph of the bone (the brownish sediment indicated with a red arrow) (Photo: Laura Hiisivuori, the Finnish Museum of Natural History). (c) An excavation in 2006 at the site of discovery, showing the Yoldia Sea clay layer (light grey) in which the bone was found (Photo: Veikko Sorsa, University of Helsinki). (d) Some of the sediment sample on which the diatom and pollen analyses were performed.