

The Late Quaternary extinction of woolly mammoth (*Mammuthus primigenius*), straight-tusked elephant (*Palaeoloxodon antiquus*) and other megafauna in Europe

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We are engaged in a research project (funded by the Natural Environment Research Council - NERC) on megafaunal extinctions throughout Europe within the period ca. 50,000 to 9000 ¹⁴C years BP. The work involves a survey of stratigraphic information and available ¹⁴C dates, and also sampling crucial material for a major programme of AMS ¹⁴C dating. Both of the elephant species present in the European Late Pleistocene: *Mammuthus primigenius* and *Palaeoloxodon antiquus* are included in the project.

Our target species include most of those that became extinct, or regionally extinct, after ca. 15,000 BP: woolly mammoth *Mammuthus primigenius*, woolly rhinoceros *Coelodonta antiquitatis*; giant deer *Megaloceros giganteus*; lion *Panthera leo*; and spotted hyaena *Crocuta crocuta*. We are also targeting species which retreated to the south of Europe (Iberia, Italy, Balkans) prior to extinction, probably before 20,000-30,000 BP: straight-tusked elephant *Palaeoloxodon antiquus*; narrow-nosed rhinoceros *Stephanorhinus hemitoechus* (perhaps also Merck's rhinoceros *Stephanorhinus kirchbergensis*); and hippopotamus *Hippopotamus amphibius*.

Radiocarbon dating of samples of elephants and other European megafauna is currently in progress, and we are actively seeking more material to be dated.

The strategy is to follow in some detail the patterns of shrinking geographical distributions that preceded extinction. From the data available

at present, it is apparent that these range changes were not the same for each species; for example the "last stands" of *Mammuthus primigenius*, *Megaloceros giganteus* and *Palaeoloxodon antiquus* appear to have been made in very different regions of Europe. Tracking these changes involves firstly gathering data from the literature and from colleagues in each region. By these means we are building up an approximate picture and specifying the likely latest material of our target species for each region. In order to obtain a much more accurate database, we are sampling the putatively latest material and submitting it for ¹⁴C dating.

Late Quaternary extinctions have been variously attributed to overkill by human hunters (Martin 1984; Martin & Steadman 1999), to environmental changes (Graham & Lundelius 1984; Graham 1990; Guthrie 1984, 1990; Lister & Sher 1995) and more recently to "hyperdisease" (MacPhee & Marx 1997). Stuart (1991, 1999) has proposed that the proximate cause was hunting by humans, but only when megafaunal populations were already stressed and reduced in numbers and geographical range by major climatic changes. Our current project aims to test these rival hypotheses in Europe by seeking correlations between ¹⁴C dated extinction patterns and proxy data for climatic/environmental changes on the one hand, and the appearance of modern humans and upper palaeolithic artefacts on the other.

Woolly mammoth *Mammuthus primigenius*, widespread over most of Europe in the Last

Cold Stage, became extinct during the Late Glacial (Stuart 1991). There are a number of records from north-western and central Europe as late as 13,000 to 12,000 BP, but none so far after this time. Woolly mammoth may have retreated first from southern Europe, and it is anticipated that forthcoming dates will clarify this picture. Our research on mammoth extinction in Europe links with ongoing work in Siberia and the Russian Far East (Orlova *et al.* 2000; Sher 1997).

In marked contrast, *Palaeoloxodon antiquus* was widespread in north-western, central and southern Europe ca. 120,000 BP ("Last Interglacial", Oxygen Isotope Stage 5e) (Stuart 1991). Prior to extinction, we hypothesise that it retreated to southern Europe (Iberia, Italy, and probably the Balkans) in the early part of the Last Cold Stage (OIS 4 and possibly OIS 3), presumably in response to climatic cooling and a similar contraction in range of temperate vegetation. It may prove difficult to determine the timing of its extinction with any accuracy, as *Palaeoloxodon* material of this age is very rare, and much or all of it close to or beyond the range of ¹⁴C dating.

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