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The Condover mammoth site: excavation and research 1986-93

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SUMMARY

A chance discovery at Condover, Shropshire in west central England in 1986 led to the excavation of an almost complete adult skeleton of mammoth (*Mammuthus primigenius* (Blum.)), together with partial skeletons of at least three juveniles. The remains occurred in a kettle hole infill and date to c. 12,500 BP, within the late glacial interstadial. Organic remains within the kettle hole deposits give a detailed picture of environmental change through the Late Glacial, and the excellent preservation of the mammoth skeletons has encouraged multidisciplinary research at the osteological, histological and molecular levels.

SAMENVATTING

Een toevallige ontdekking in Condover, Shropshire in Engeland in 1986 leidde tot het opgraven van een bijna kompleet skelet van een volwassen mammoet (*Mammuthus primigenius* (Blum.)), samen met gedeeltelijke skeletten van minstens drie jongen. De resten zijn afkomstig uit een opvulling van een "kettle hole" en hebben een ouderdom van ongeveer 12.500 v. Chr. Organische resten afkomstig van de sedimenten uit de "kettle hole" geven een gedetailleerd beeld van de veranderingen tijdens de laatste ijstijd. De uitstekende staat van conservering van de skeletten maakte een multidisciplinair onderzoek mogelijk op osteologisch, histologisch en moleculair nivo.

Discovery and excavation

The story of the Condover mammoths began on Saturday 27th September 1986, when Mrs Eve Roberts was walking with her dogs around the perimeter of a working gravel pit near the village of Condover in Shropshire (Fig. 1). With no special interest in palaeontology or archaeology, but of an observant and inquisitive nature, she noticed some large bones projecting from a pile of mud, and on returning home telephoned the Shropshire Museums Officer, Mr G.I. McCabe, to report her discovery. He visited the site and recognising the possible importance of the find, contacted Dr G.R. Coope of Birmingham University. It soon became evident that the remains were part of the skeleton of an elephantid, probably a mammoth, and ARC gravel company agreed to cease work in that part of the pit to allow an emergency excavation.

Over much of the Condover site, glacial sands and gravels occur close to the surface, and are being commercially exploited. In the area of the mammoth finds, however, a filled basin of clay and peat deposits, some 50-75 m in diameter, had been encountered (Fig. 2). The bones were uncovered by large mechanical digging machines, standing on a field at the edge of the pit and digging into the pit to remove the 'useless' clay andpeat. At a certain depth they had hit the bones, but instead of stopping, the workmen had dug them all up, throwing them into the spoil heap on the field behind them. Thus the articulated skeletons became jumbled and many of the bones broken, removing much information which could have been retrieved *in situ*. Nonetheless, a great deal of scientific research has been possible on the bones and sediments, remarkable considering the conditions of excavation.

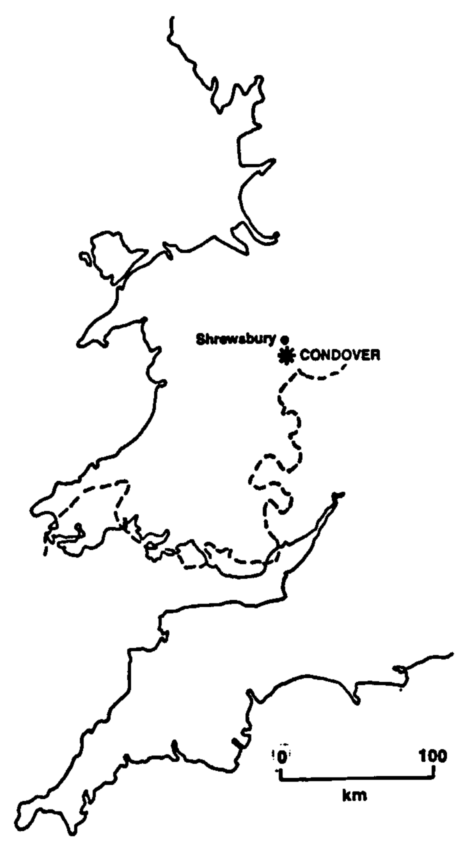

Fig. 1: Map of Western England and Wales, showing the position of the Condover site. The southern limit of the late Devensian ice advance is indicated as a dashed line.

Fig. 1: Kaart van West Engeland en Wales waarin de vindplaats Condover is aangegeven. De Zuidgrens van de Devensian ijsuitbreiding is aangegeven met een stippellijn.

Fig. 2: The Condover gravel pit in the area of the mammoth finds. A machine working from approximately the position of the one in the photograph had dug down and encountered the skeletons in the area marked with a asterisk, turing and throwing them onto a spoil heap where the figures are standing. At the time of this photograph, slumping had obscured much of the section, but the upper clay and peat horizons can be seen at the top of the face. Photo author.

Fig. 2: Overzicht van de groeve Condover. De machine is ongeveer op de plaats vanwaar de skeletten op een hoop zijn gegooid. De bovenste kleilagen zijn te zien, de rest van het profiel is onduidelijk op het moment dat deze foto werd genomen (foto: A. Lister).

A few days after the initial discovery, announcements in the local media brought forth a small army of willing volunteers, who together with Shropshire Museums Service staff began the arduous process of digging through the mountainous spoil heaps looking for bones (Fig. 3). Mechanical diggers were used to pick up batches of the heavy clay deposit and spread it more thinly over the field, where it could be sorted with spades. This process continued sporadically through October and November 1986, and resulted in the recovery of many bones, including the first that indicated the presence of juvenile as well as adult mammoth remains.
After a break, during which preliminary scientific studies were carried out, further excavations were mounted over three weeks from June to July 1987. At this time also, and again in January 1988, a programme of geological investigation at the site incuded the mechanical cutting of clean sections, and logging a series of boreholes. It is believed that almost all bones present in the spoil heap have been recovered, but others certainly remain in bottom of the original pit, now flooded.
The excavation and original processing of the bones was largely co-ordinated by G.I. McCabe, who also organised an exhibition on the mammoths on behalf of Shropshire County Council.
Scientific work, involving over thirty specialists, has been co-ordinated by G.R. Coope and the present author, and will be fully presented elsewhere (LISTER & COOPE, in preparation). Some of the main results are summarised here.

Geology

Detailed geological studies at the site have been undertaken by Dr J.D. Scourse (Bangor). The sediment-filled basin within which the mammoths occurred is interpreted as a 'kettle hole', of which many are known from the surrounding area, some filled up to the modern surface, others containing standing water. Kettle holes are formed as a result of large, buried blocks of ice being left by a retreating glacier. As the block slowly melts, overlying sediments collapse, forming a crater-like structure which may subsequently fill with sediment. Evidence of this collapse at Condover is seen in the contact surfaces between the basin infill and the underlying gravels, which dip towards the centre of the basin at angles of up to 60° from the horizontal. At its centre the Condover kettle hole is some ten metres deep.

The Condover site lies just within the limit of the main ice advance of the Devensian Cold Stage (Fig. 1), which occurred c. 20-15 kyr ago. It was the retreat of this glacier which led to the formation of the local kettle holes, so a very late date for the mammoths, post-dating 15 kyr BP, is likely from the geological setting alone, and has been confirmed by radiocarbon dating (see later).

The lower part of the kettle hole infill (Fig. 4, units 3&4) shows an alternation of, on the one hand, clay and silt layers indicating standing or very slow water conditions, and on the other hand, gravel horizons suggesting that at times the basin was part of a fluval system. The horizon within which the mammoth bones occurred

Fig. 3: Dr Russell Coope unearths another bone from the spoil heap, as television cameras watch from above. Photo Shropshire County Council.
Fig. 3: Dr Russell Coope maakt een bot schoon. (Foto: Shropshire County Council).

(Fig. 4, unit 5) was a dark grey silt about a metre deep and some five metres below the modern land surface. Very few bones were found *in situ* within the pit, but those found on the spoil heap were generally coated with the characteristic dark grey silt, and pollen analysis of sediment dug out of bones gave a perfect match with in situ samples from that horizon.

The upper part of the sequence, above the mammoth horizon, comprised an alternation of clay layers with highly organic peaty deposits (Fig. 2; Fig. 4, units 6-8). Within one of the peat layers, an associated skeleton of red deer (*Cervus elaphus*) was recovered. The age of these levels will be discussed later.

The mammoth skeletons

The mammoth bones, when cleaned of sediment, were a chocolate brown color of unusually fresh appearance, leading one colleague to remark that they looked as though they had come "straight from a butcher's shop". Many of them were covered with a dusting of the blue mineral vivianite. To avoid cracking on drying, the bones were treated with a dilute aqueous solution of PVA before being allowed to slowly dry out (Fig. 5).

The osteology of the skeletons has been the responsibility of the author. Approximately four hundred specimens were recovered from the site, but because of breakage during excavation, these represented fewer actual bones which had to be reconstructed like a giant jigsaw puzzle. Of the adult mammoth skeleton we have all of the major limb bones (Fig. 6) and about 50% of the hand and foot bones, the lower jaws, two hyoid bones, six of the seven neck vertebrae, seventeen of the nineteen thoracics, four of the five lumbars, two tail vertebrae, the sacrum and pelvic girdle, thirtysix of the thireight ribs, and the complete sternum. The chief element lacking is the cranium, of which no part was recovered except fragments of tusk and parts of the second and third molars. There is no duplication of adult skeletal elements, indicating that a single articulated skeleton of

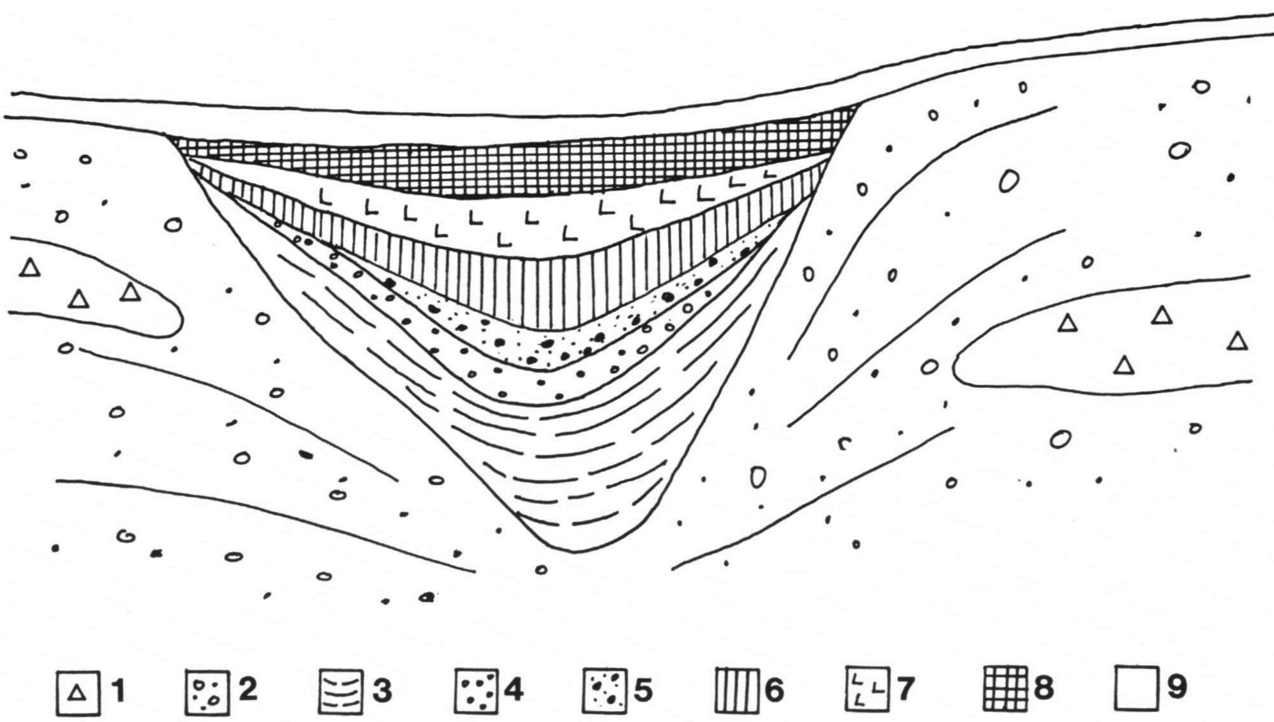

Fig. 4: Schematic logitudinal section of the Condover kettle hole, based on Scourse, in Lister & Coope (in prep.) Key: 1, till; 2, glacio-fluvial sands; 3, pink glacio-lacustrine clay; 4, gravel; 5, dark grey silt (mammoth stratum); 6, sedge peat; 7, grey clay; 8, humified peat; 9, ploughsoil. Not to scale.

Fig. 4: Schematische lengte doorsnede van het Condover "kettle hole" naar Scourse, in Lister & Coope (in prep.). (niet op schaal).

Fig. 5: Eve Roberts (left) helps Sheila Griffiths of Shropshire Museums Service to clean the left mandible of the adult mammoth. Photo author.

Fig. 5: De linker onderkaak van de volwassen mammoet wordt schoongemaakt. (foto: A. Lister).

Mammuthus primigenius was present in the deposit. The Condover skeleton is the most complete known from the British Isles, and one of approximately six comparably complete specimens from Europe outside Russia.

Approximately one hundred bones of juvenile mammoth were recovered. These include mandibles, partial crania and teeth, a hyoid bone, vertebrae, ribs and limb bones (Fig. 6). The presence of three lower jaws indicates that at least three individuals are represented, but the very similar skeletal size of the individuals precludes sorting of the other bones into discrete skeletons. A single rib markedly larger than those of the other juveniles, but smaller than the adult ribs, and probably represent a fifth individual. A series of juvenile thoracic vertebrae were recovered in partial articulation, implying that the skeletons had been articulated *in situ*.

The excellent state of preservation of the bones encouraged testing for the presence of biological macromolecules. Dr J.M. Lowenstein (San Fransisco) has extracted two proteins, albumin and collagen, from samples of adult mammoth bone, and compared them by radioimmunoassay with antisera from a variety of living mammals. The mammoth proteins showed strong similarity with those of modern Asian and African elephant, and much less with bovines and other mammals. As expected, the Condover sample also compared closely with antisera raised against proteins from flesh of the Siberian frozen baby mammoth 'Dima'. Further molecular work is being undertaken by Dr E. Hagelberg (Cambridge), with the aim of extracting and sequencing genetic material (DNA) from the skeleton.

The adult mandible contains the second molars in late wear, with the third molars ready to come into wear behind (Fig. 5). By comparison with modern Asian and African elephants (JACHMANN, 1988; ROTH & SHOSHANI, 1988), this indicates an age at death of about 28 years. Many of the long bone epiphyses were still open, so the animal had not yet completed growth, despite an estimated living shoulder height of c. 320 cm. The sex of the animal can be determined from the morphology of its pelvic girdle (LISTER, in press), the relatively narrow birth canal and wide ilium clearly indicating a male.

Two of the juvenile mandibles are almost identical in size and form, containing the last vestiges of the second molariform teeth (dP3), and the third tooth (dP4) in early wear. This indicates an age of three to four years for these two individuals. The third juvenile has a slightly larger mandible with dP4 in a more advanced stage of wear, corresponding to an age of five or six (COOPER & LISTER, 1987). Two preserved juvenile ilia differ in shape in such a way as to suggest different sexes, but these cannot be associated with specific jaws or other bones.

By analogy with modern elephants, these make it unlikely that the individuals were a family group. Juvenile elephants stay with their mother, not their father, and adult males of 28 years roam alone or in bachelor groups, not with their kin. Moreover, twinning is rare in elephants, and the birth interval for a given female generally at least 4 years (MOSS, 1988), so it is unlikely that the juveniles were sibs. The adult and juvenile animals at Condover could in theory have been part of the same herd, or alternatively may have entered the kettle hole at widely spaced intervals.

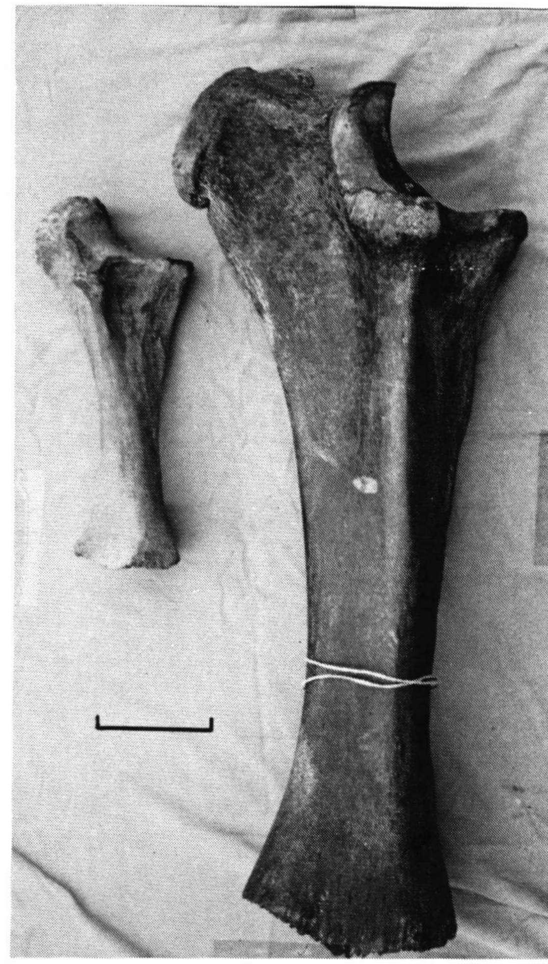

Fig. 6: Right ulnae of adult and juvenile mammoth. The distal epiphysis is still unfused in both specimens. Scale bar 10 cm; photo author.

Fig. 6: Rechter ulna van een volwassen en een jonge mammoet. De distale epiphyse is nog niet vergroeid (maatstreep = 10 cm). (foto: A. Lister).

A very interesting aspect of the adult's morphology has been srudied by Drs J. Baker (Liverpool) and E. Clark (London). The mammoth's left scapula shows pathological features indicating that it had suffered a fracture during life which had subsequently rehealed. The fracture line is positioned a few centimetres below the dorsal edge of the bone, and is approximately 35cm long. The top part of the shoulder blade had completely snapped off at least two years before death, and had re-

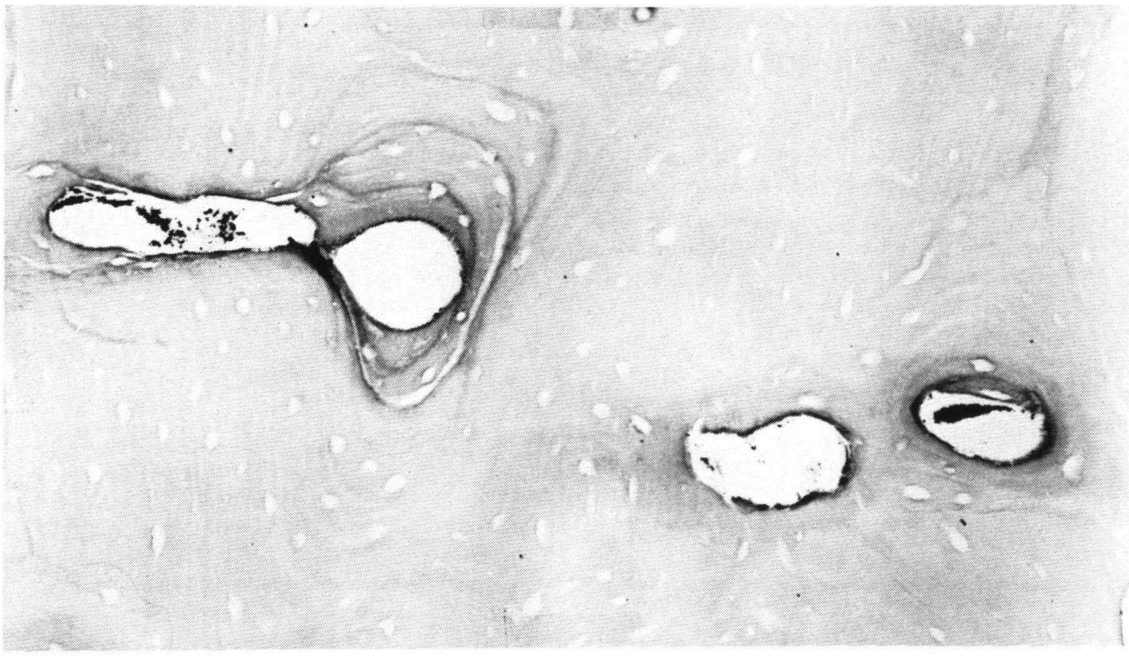

Fig. 7: Microscopic thin section of lamellar bone from the adult mammoth. Bone cell spaces organised into Haversian systems, and larger vessel spaces, can be clearly seen. The mineral fraction was dissolved before preparation of the slide., illustrating the excellent preservation of the protein matrix. Magnification approximately x200; photo J. Baker.

Fig. 7: Microscopisch dunne doorsnede van het bot van de volwassen mammoet. Goed zichtbaar zijn de botcellen en de grotere bloedvaten (vergroting: +/- 200x; foto: J. Baker).

healed in an overlapping position with pathological bone thickening. The cause of the fracture is a matter for speculation: falling down a hole perhaps, or a fight with another male?

At the time of their death, however, the mammoths appear to have been in a good state of nutritional health. Histological and X-ray studies by J. Baker show dense lamellar bone (Fig. 7) and no sign of seasonal stress, indicating a favourable environment with abundant year-round food.

Environmental studies, dating and taphonomy

The clay silt and peaty horizons at Condover have yielded an abundance of organic remains in addition to the mammoth skeletons. These include pollen (studied by J.D. Scourse), plant macrofossils (A.R. Hall, York), beetles (G.R. Coope), midge and caddis-fly larvae, and ostracods, as well as localised fish and amphibian remains. Together with radiocarbon dating carried out by the Oxford AMS laboratory, these remains have given a detailed picture of environmental changes during the infill of the Condover kettle hole.

The lowest and thickest level of the sequence (Fig. 4, unit 3), a pink laminated clay; was devoid of organic remains. Above it lay a seam of gravel and then the dark grey silt forming the mammoth horizon (unit 5), containing an abundant pollen record indicating a treeless environment dominated by grasses and sedges (the latter probably associated in life with the partly water-filled kettle hole itself). This stratum was also rich in insect remains, the beetle fauna being notable for the presence of numerous taxa today inhabiting the high arctic, forming an assemblage characteristic of the cold period prior to 12900 BP (ATKINSON et al., 1987). This contrasts with five accelerator dates on the mammoth skeletons themselves, which gave ages ranging from c. 12,700 to c. 12300 BP, with a weighted mean of 12480 +/- 96 BP (HEDGES et al., 1989; LISTER, 1991). These dates indicate that the mammoths were living during the late-glacial interstadial, a time of temperate climate. It is possible that the association with arctic insects is due to the mammoths having sunk into soft clay deposited several hundred years prior to their demise.

Above the mammoth stratum, a layer of brown sedge peat (unit 6) occurs, with radiocarbon dates indicating deposition between c.11600 and 10600 BP. This peat contained a richer plant assemblage than the mammoth stratum, including *Betula* (birch, both tree and dwarf), *Salix* (willow), *Populus* (poplar) and a variety of herbaceous plants, corresponding to the later part (Allerød) of the late-glacial interstadial. It is succeeded by a layer of clay (unit 7) where tree pollen has again declined but grasses, sedges, and taxa such as *Artemisia* and *Rumex* have increased. This layer, corresponding to the Younger Dryas stadial, is capped by further peaty deposits (unit 8) indicating the forested conditions of the early Flandrian, with a date of 9350 +/- 100 BP (Ox-A 2234) at its base.

A particulary intriguing part of the insect fauna was found not in the general matrix of the mammoth stratum, but within the cavities of the skull and jaw bones themselves. These bones yielded hundreds of puparia, which have been identified by Dr Y.Z. Erzinclioglu (Cambridge), as *Phormia terraenovae*, a species of fly which feeds on rotting flesh. Similar puparia have been found associated with a number of other Quaternay mammal remains, including mammoth crania from Germany and The Netherlands (HEINRICH, 1988). The Condover puparia were empty, indicating that the mammoth carcasses (or at least, the heads) had been aerially exposed for at least two weeks before burial or submergence, since this is the minimum time required by the flies between egg-laying and hatching of the new adult. Associated with the fly puparia were abundant remains of the dung beetle *Aphodius prodromus*, adding to the vivid scenario of the mammoths'demise.

The steep sedimentary dips at the sides of the Condover kettle hole led initially to the suggestion that the animals had wandered in -perhaps in search of food or drink- and been unable to escape because of the steep, slippery sides of the basin (COOPE & LISTER, 1987). Detailed geological analysis by J.D. Scourse now indicates, however, that a considerable part of this subsidence happened after the entry of the mammoths, so that the sides were considerably less steep at the time. It is more likely, therefore, that the animals met their end by miring in the sticky mud at the bottom, as occasionally happens to elephants in Africa today (HAYNES, 1988).

The significance of the finds

The Condover mammoths were the first to demonstrate the presence of the species in Britain after the retreat of the ice; previous dated records were all earlier than 20 kyr BP.

A few other European finds indicate return of the species after 13 kyr BP: these includde the engravings from Gönnersdorf, Germany (BOSINSKI, 1979) and the skeleton from Praz Rodet, Switzerland (WEIDMANN, 1969). The Condover discoveries stimulated a programme of radiocarbon dating other possible late mammoth fossils in Britain, resulting in dates from several other sites in the range 13 - 12 kyr BP (LISTER, 1991). These make it clear that the cause of extinction of the mammoth in Europe was not the main ice advance of c. 20 - 15 kyr BP, but events in the late-glacial, whether climatic human, or a combination of the two (STUART, 1991). Currently, the date of extinction of mammoth in Europe appears to be c. 12 kyr BP, at least a thousand years before its demise in North America and Siberia.

The Condover mammoths are remarkable for their tangible evidence of late survival, their completeness, and the associated environmental information. Their discovery was also exceptional for the degree of public interest and media coverage which it caused, for the multidisciplinary research it stimulated, and for demonstrating how the observational powers of nonspecialists can lead to scientific discoveries of major importance.

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