REPORT

Early Pleistocene human footprints at Happisburgh, Norfolk

The coastal sequence at Happisburgh, Norfolk has long been known for the preservation of Early Pleistocene sediments. Since 2005 large numbers of humanly made flint artefacts have been recorded here and in other such sites in North Norfolk. These artefacts have extended the record of human occupation of Northern Europe back by some 350,000 years. Then in May 2013, the first footprints were recorded (Ashton et al., 2014). These date back to between 780,000 and 1 million years ago, and are thus the oldest known hominin footprints outside Africa.

In Africa, the earliest fossil footprints known anywhere are preserved in volcanic ash at Laetoli in Tanzania, and these demonstrate bipedalism in *Australopithecus afarensis* dating back to 3.66 Ma. Larger footprints known east of Lake Turkana in Kenya, formed by *Homo erectus* or possibly *Paranthropus boisei,* indicate that by 1.5 Ma years ago hominins had developed an essentially modern walking gait and had reached the stature of modern humans. Footprints are however rare since quite remarkable conditions are required for the preservation and then re-emergence of the print. Preservation requires a combination of the correct strength of sediment to preserve the print until it can be buried, along with burial in a low-energy setting such as slow-flowing water or air fall deposition. Several classic sites involve burial by volcanic ash or aeolian sand or silt, whereas burial by flowing water, such as at Happisburgh, is remarkable since the rate of flow must be just right to wash in sediment while not destroying the print. Exposing the footprints during re-emergence is also a problem, and here Happisburgh is an ideal situation since rapid coastal erosion has stripped back the overlying strata to reveal a planar surface on which the footprints were revealed.

The footprints were in laminated silty sediments, part of a sequence of sands, gravels and laminated silts laid down within the upper reaches of the estuary of a large river. These belong to the Hill House Formation of Early Pleistocene age. They underlie the Happisburgh Till of Middle Pleistocene age, believed to date from Marine Isotope Stage (MIS) 16, the oldest till in the considerable Norfolk succession of glacial sediments. The palynology of the laminated silts indicates an interglacial vegetation succession ascribed to the later part of an interglacial period, possibly MIS 21 or 25. The footprints were found as hollows on the surface of one of the laminated silt horizons over an area of c12 square metres. Removal of beach sand exposed the laminated sediments to wave erosion, washing out the more sandy sediment and exposing the more resistant silts. Most of these silt surfaces were flat or gently undulating and displayed ripple structures or other bedforms from current action during deposition, but one surface was clearly different, with a series of hollows ranging from circular to elongate in outline. The marked dissimilarity of this bed to adjacent areas of rippled laminated silts suggested that the features were not the product of normal depositional or erosional processes within an estuarine environment, and on detailed examination the hollows were interpreted as hominin footprints. A recent origin for the footprints was discounted since the exposed surfaces were compacted and had low moisture content. They were too firm to have accepted modern footprints after exposure, so the footprints must date from a date before the burial of the sediment, before it became compacted.

The exposure of bedding planes that contained the human footprints within the Early Pleistocene Hill House Formation, inside the old sea defences along the rapidly eroding foreshore at Happisburgh, Norfolk (photo: Martin Bates).

Some of the human footprints set into the Early Pleistocene Hill House Formation, and exposed on the foreshore at Happisburgh, Norfolk, during the short interval before they were lost to the same wave action that had previously exposed them (photo: The Guardian).

Since the exposed surface was located in the intertidal zone it was clearly subject to rapid destruction by wave action, or to re-burial as the beach was re-established, and so the surface was recorded over a period of two weeks by multi-image photogrammetry (MIP) and laser-scanning techniques. However, the features became less distinct as a result of tidal erosion, and had been completely destroyed by the end of May 2013. The combination of high tides, encroaching beach sand, poor weather conditions and time constraints made recording extremely difficult. Prior to recordings, water was used to wash away beach sand introduced by the previous high tide, but complete clearance was impossible due to persistent rain. Detailed field measurements were impossible due to the time constraints, but MIP proved effective for rapid recording. This technique produces a 3D record of the surface by processing digital photographs taken from multiple positions around and above the subject. Laser scanning was less successful due to the steady deterioration of the site.

In all, 152 hollows were studied, and lengths and widths were measured from the MIP 3D images. The elongate hollows were generally 30-50 mm deep, 140-260 mm long and 60-110 mm widee, although the depths could not be accurately measured where water or sand remained in the base of the prints. However many of the hollows were seen to be distinctly elongate and fell within the range of adult and juvenile hominin foot sizes, while none was consistent with the footprints of other mammals. In some cases, left or right and front or back of the foot was apparent, and in one case toes could be deciphered. The orientation of the footprints indicated movement in a southward direction on mud-flats along the river edge. The less elongate impressions might also be hominin footprints, with the impression simply recording the heel or the front of the foot. The depth of the imprints is consistent with a soft to stiff muddy substrate; firm mud does not retain footprint impressions, while semi-liquid mud has insufficient strength to retain a clear, undeformed impression.

Analysis of the footprints suggests the presence of both adults and juveniles. Stature can be estimated from foot length; for recent populations, foot-length:stature data for adults, juveniles and both sexes produce a mean ratio of 0.15. Skeletal evidence from African populations suggest that the body proportions of Middle Pleistocene hominins was similar to modern humans, so this length:stature ratio should be the same. Using this figure, the Happisburgh hominins ranged from 0.93 to 1.73 m in height, which is reasonable for a group of adults and children. Body mass estimates can also be made from the footprint area, and figures obtained for the adult hominins were 48-53 kg based on footprint area or 48-52 kg based on footprint length alone. These figures must obviously be treated with caution, but the Happisburgh footprints do provide the first indication of body size of the earliest hominins in northern Europe.

Comparing these results with the species of early humans known in Europe in the Early and Middle Pleistocene, the estimated foot size, foot area and stature of the Happisburgh hominins correspond best with the estimates for *Homo antecessor*, known from Atapuerca in Spain, rather than for *Homo heidelbergensis* as known from Boxgrove or for *Homo neanderthalensis* as known from Swanscombe. Overall it is clear that there was a group of at least five adults and juveniles, moving in a southward direction across the mudflats of a tidally influenced river within the upper reaches of its estuary. Palynological analysis of the vegetation indicates a mosaic of open coniferous forest of pine *(Pinus)* and spruce *(Picea)* with some birch *(Betula),* with patches of heath and grassland in the drier areas and some alder *(Alnus)* growing in wetter areas. Thus we can derive a good image of a human population that lived in Norfolk almost a million years ago.

Reference

Ashton, N, Lewis, SG, De Groote, I, Duffy, SM & Bates, M, 2014. Hominin footprints from Early Pleistocene deposits at Happisburgh, UK. PLoS ONE 9(2): e88329. doi:10.1371/journal.pone.0088329.

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