NEWS & VIEWS

ARCHAEOLOGY

Life on the Costa del Cromer

Wil Roebroeks

Flint fragments from eastern England constitute the earliest known evidence of human occupation of Britain. The climate was balmy, and the environment was home to a wide range of animals and plants.

About 700,000 years ago, Britain was connected to continental Europe, and the large rivers that drained central and eastern England meandered sluggishly into the North Sea basin. Sediments laid down by these lowland rivers are found today along the coastline of northern Suffolk and Norfolk. As the sediments were deposited, remains of animals and plants became trapped in them: large and small mammals, reptiles, molluscs, and even trees, fruits and seeds, after which the Cromer Forest-bed Formation was named. Parfitt *et al.* (page 1008 of this issue[1]) show that, along with hippos, rhinos and elephants, early humans were evidently roaming the banks of these rivers. They did so during a warm interglacial period, and much earlier than hitherto thought for this part of Europe.

Charles Lyell, the Victorian geologist, would have been pleased with Parfitt and colleagues' report — in the 1860s he had predicted[2] that evidence of human occupation would show up in the Cromer Forest-bed (the well-exposed deposits were then considered to be more or less of the same age as sediments already yielding early artefacts on the other side of the English Channel, in France). But despite the efforts of generations of fossil hunters, no unambiguous evidence was found until the discoveries reported by Parfitt *et al.*, which come from ancient river sediments exposed near the village of Pakefield, Suffolk. Much of Pakefield village as Lyell would have known it has been lost to the sea through coastal erosion of the cliffs, a serious problem in this part of Britain. But what can be a disaster for the home-owner represents an opportunity for the collector of fossils and artefacts.

Archaeologically speaking, Parfitt and his colleagues[1] have struck Stone Age gold. From part of the Forest-bed, they have recovered clear evidence for the presence of humans at an estimated 700,000 years ago. Working with intense effort at low tides, they have excavated 32 pieces of worked flint from the exposures along the shoreline near Pakefield (Fig. 1). They have also gathered together a remarkably rich set of data on the interglacial environment of these early pioneers.

Natural processes acting on flints sometimes produce artefact-like forms. Especially in the early days of their discipline, prehistorians often had great difficulty in telling the difference between such pseudo-artefacts and pieces of flint modified by human agency. Indeed, in the early 1900s the Forest-bed exposures yielded controversial primitive flint 'tools', which were promoted by some as evidence of early occupation[3] but were eventually debunked as natural products by others[4]. Archaeologists have learned from such debates, and the Pakefield evidence for human activity is rock solid. The small assemblage consists mostly of waste flakes produced during flint knapping.

S. A. PARFITT

Figure 1 | The cliff at Pakefield on the Suffolk coast. The Cromer Forest-bed Formation investigated by Parfitt *et al.*[1] — the lowermost dark band — is overlain by thick glacial deposits.

The assemblage is too small to be representative of the whole range of tools that was probably produced, and it is useless to speculate on the technological capacities of its makers. But I would not be surprised if some of the sharp edges revealed microscopic evidence of their former use as butchering tools, because animal products must have been part of the human diet in that environment[5].

Small and simple though the Pakefield set of artefacts is, for archaeologists it has grand implications. Hitherto, the earliest unambiguous traces of a human presence in Europe north of the Alps were dated to about half-a-million years ago[6], and included the spectacular finds from Boxgrove, on the southern coast of England. There, thousands of flint artefacts have been excavated, together with the bones of butchered large mammals and even some human remains[7,8]. The earliest traces of human presence in southern Europe — for example the rich materials from Atapuerca in Spain[9] — are at least 800,000 years old (Fig. 2, overleaf). The southern European evidence suggested that there had been a long time-lag between the first occupation of this zone and that of the more northern parts of Europe, with humans being confined to the Mediterranean perimeter and Spain for a few hundreds of thousands of years before moving into the north.

The work at Pakefield has now shown this view to be flawed. No matter that one can quibble about the intricacies of the dating arguments for Pakefield (and I am sure people will), the site is probably 200,000 years older than any known previously from Europe north of the Pyrenees and Alps. In that sense, the discoveries come as a big surprise. In another sense,

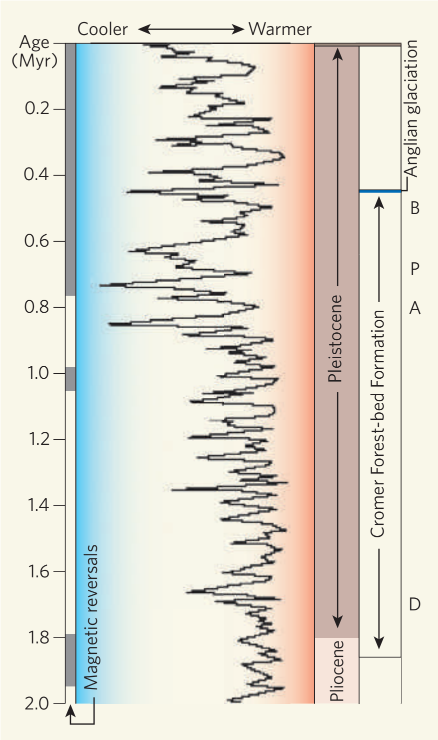

Figure 2 | Dating the human occupation of Europe. This chronology (in millions of years) shows the incidence of reversals in the geomagnetic field, and the cooler and warmer intervals as judged by oxygen-isotope studies, which provide benchmarks for dating. The Cromer Forest-bed Formation is capped by glacial deposits of the Anglian glaciation. The Boxgrove site (B) dates to the temperate period before the Anglian; Pakefield[1] (P) is at least two interglacials older. The Spanish site Atapuerca (A) is older than Pakefield, dating to just before the period of 'normal' geomagnetic polarity that started about 800,000 years ago. All of these sites are much younger than that at Dmanisi in Georgia (D), which is situated in the Caucasus at the 'gates of Europe'. This site yielded a rich fossil collection of small-brained humans dating to about 1.7 million years ago.

however, Pakefield fits well into earlier views of the colonization of Europe[5,10,11]. As Parfitt *et al.*[1] point out, the environmental context of the flint assemblage provides a good explanation for the presence of humans in northern Europe: judging from the rich palaeoecological and climatic data from Pakefield, the range of these pioneers expanded temporarily in parallel with an expansion of their familiar warm, Mediterranean-like habitat. The Pakefield artefacts probably do not testify to a colonization of the colder temperate environments of northern Europe, but more to a short-lived human expansion of range, in rhythm with climatic oscillations. Although they occur in England, the finds are basically still 'Mediterranean' in that they were produced along the balmy shores of what can be seen as an early Middle Pleistocene Costa del Cromer. As in Asia[12], more significant occupation of the northern (colder) parts of Europe did not occur until later, maybe from the times of the Boxgrove *Homo heidelbergensis* population onwards[5]. But the sea continues to expose long-buried sediments, and in due course more surprises may turn up — especially now that Parfitt *et al.* have finally demonstrated the archaeological potential of the Cromer Forest-bed.

Seen yet another way, however, the Pakefield evidence is just plain tantalizing. The Cromer Forest-bed is among the best-studied Pleistocene exposures anywhere in the world: it is a place where many generations of scientists have kept a sharp eye out for traces of early humans[3,4]. If chronological surprises can turn up in such a location, what are the implications for other parts of Europe and of the world that have seen less and sometimes no archaeological attention? The finds from Pakefield will surely influence our understanding of the human occupation of Europe. But especially on a global scale, they are a reminder that we must be terribly careful with translating absence of evidence into evidence of absence. ■

Wil Roebroeks is in the Department of Archaeology, Leiden University, PO Box 9515, 2300RA Leiden, The Netherlands.
e-mail: w.roebroeks@arch.leidenuniv.nl

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FLUID DYNAMICS

Drat such custard!

Troy Shinbrot

The mixing of festive sweetmeats and the stirring of cream into coffee are toothsome examples of the irreversibility of physical processes. In certain systems, however, the concept gets its just desserts.

Running a film sequence in reverse is a joke used to great effect in early moving pictures: the Keystone Cops round a corner backwards on two wheels and fall back into their wagon; collapsed buildings reassemble; and water climbs up a mountainside. The humour, and surprise, of these actions arises because we readily detect that time is travelling in the wrong direction. Similarly, when we stir cream into coffee, we know the two will mix; equally, were we to reverse the direction of stirring, we would be startled to see the coffee and cream return to their original, separated state.

On page 997 of this issue, Pine and colleagues[1] establish exactly when and where this counterintuitive phenomenon can occur. They examine suspensions of simple spheres in a liquid, and in their supplementary information supply graphic video evidence of a transition between a reversible flow (which returns to its original state when stirring is reversed) and an irreversible flow (which continues to mix regardless of the direction it is stirred in). Suspended particles can thus, like the Keystone Cops, exactly retrace their steps as the direction of stirring is reversed, or alternatively can diffuse irreversibly over time — as experience teaches us to expect. The transition between a reversible and an irreversible flow depends both on the concentration of solid matter and on how far the liquid has been stirred: for low concentrations of solids stirred short distances, mixing can be reversed, whereas for higher concentrations stirred further, it cannot.

For their demonstration, Pine *et al.* used the flow of a fluid held between two concentric rotating cylinders. This system has had a long history in investigations of reversibility, ever since a celebrated demonstration in 1966 by the renowned fluid dynamicist and educator G. I. Taylor. Taylor injected a spot of dye into glycerine trapped between two concentric cylinders, and mixed one into the other by rotating the inner cylinder clockwise. Then, startlingly, by rotating the same cylinder anticlockwise, he was able to return the dye to its original state.

The flow between rotating cylinders has since been scrutinized numerous times[2–5] in attempts to understand when suspended or dry grains behave like a solid, bouncing off one another in an irreversible manner like ping-pong balls, and when they behave like Taylor's viscous fluid, returning to their original positions when the cylinder rotations are reversed.

Pine *et al.* show[1] that both reversible and irreversible flows can be obtained predictably in such a system. Moreover, they demonstrate that irreversibility is directly associated with the occurrence of multiple collisions between