nature

NEWS & VIEWS

PALAEOGEOGRAPHY

Europe cut adrift

Philip Gibbard

The floor of the English Channel provides evidence for two catastrophic floods arising from the drainage of huge glacial lakes in the area of the southern North Sea. These megafloods made Britain what it is today.

"Floods in Channel, Continent Cut Off." This slight variation on a legendary headline in *The Times* — the original supposedly began with "Fog" — might exemplify Britain's notoriously insular view of the world. But it could also be an apt description of the events that led to Britain's becoming an island in the first place. The idea that a single, catastrophic flood was the root cause of this process is controversial. But, as they detail on page 342 of this issue, Gupta *et al.*[1] have just found the best evidence yet for not just one, but two such 'megafloods', in a bathymetric study of the morphology of the current Channel floor.

Standing on the southern English coast today looking at the Channel — or *La Manche*, from the French perspective — it is difficult to imagine that as little as 12,000 years ago the view would have been strikingly different. Then, instead of the sea, one would have been confronted by a vast shallow valley drained by a substantial river, larger than any in Europe today. This westward-flowing Channel river carried water not only from the rivers that currently enter the Channel, but also from those that now drain into the southern North Sea, among them the Rhine, Meuse, Thames and Scheldt[2] (Fig. 1).

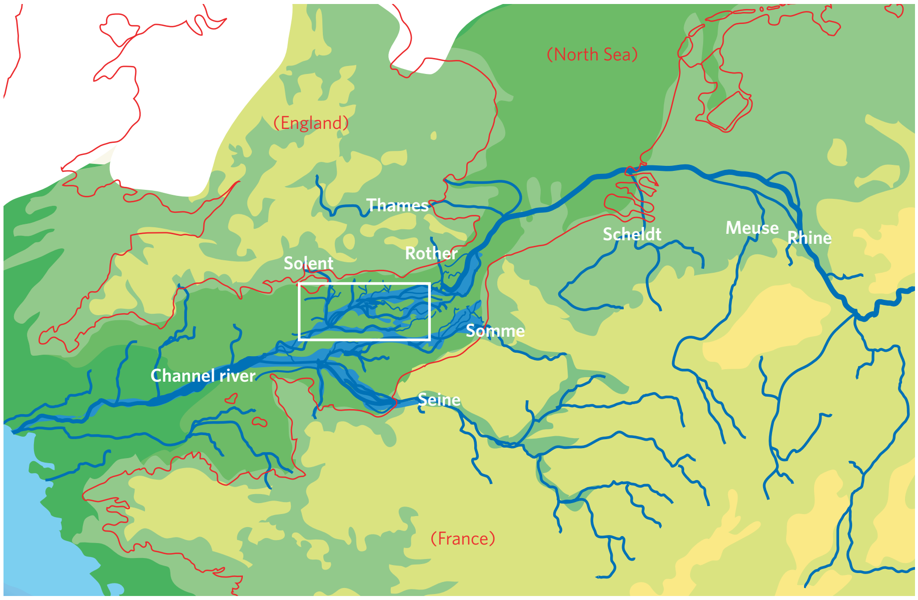

Figure 1 | A river runs through it. Where now the English Channel lies, flowed once a mighty river, draining not just the waterways of northern France (such as the Somme and the Seine) and the southern counties of England (the Solent and the Rother, for example), but also the Scheldt, the Rhine–Meuse and the Thames, which today discharge into the North Sea. Here, the Channel river system is shown during the last glacial maximum, around 20,000 years ago, as it was established after the second of two significant flood events proposed by Gupta *et al.*[1]. The area of the 'Northern Palaeovalley', whose morphology they studied, is marked by a square. (Map modified after ref. 9.)

This changed view was a product of global changes in climate. For most of its 50-million-year existence, the English Channel was a marine embayment. But throughout the past 2–3 million years, the build-up and decay of ice sheets on the continents have driven spectacular changes in global sea level. Today, for example, we live in an interglacial — a period characterized by relatively limited glaciation and therefore high sea levels. But at the peak of the last glaciation, 20,000 years ago, oceans across the globe stood about 100 metres below where they do now.

Throughout these climatic fluctuations, shallow areas such as the Channel basin and the North Sea have repeatedly emerged as dry land. Since its first emergence, about 1 million years ago, the Channel floor has been alternately modified by terrestrial and marine processes. During times of low sea level, a terrestrial drainage system began to form[3], feeding the Channel river aligned along the basin's axis.

Today, the smooth, shallow bedrock of the submerged Channel floor slopes gently for more than 500 km, from the Dover Strait in the east, its narrowest point, towards the Atlantic shelf margin that stretches between Brittany at the western extremity of France and Cornwall in England's extreme southwest. In the central and eastern Channel, this surface is dissected by a network of valleys, many of which are continuations of onshore river valleys: those of the Seine and Somme on the French side, for example, and of the palaeo-Solent and Rother on the English[3,4] (Fig. 1). These valleys join two substantial trunk valleys aligned along the axis of the Channel, the larger of the two being the 'Northern Palaeovalley'. It is from the morphology of this valley that Gupta and colleagues[1] draw their conclusions.

What they find there are distinctive features indicating that the valley formed in a catastrophic flooding event, rather than through normal fluvial erosion processes. The valley is unusually straight and wide, with prominent, streamlined margins and kilometre-scale grooving of the valley floor; the axis of the valley contains elongate islands characteristic of megaflood erosion; and the palaeo-Solent seems to form a 'hanging tributary' to the main valley, suggesting that the main valley's base level was suddenly lowered. What's more, the specific morphology of a bedrock bench at the valley margin, as well as evidence for an intervening period of normal fluvial erosion, indicates that during the evolution of the Channel at least two megafloods occurred, after 450,000 but sometime before 180,000 years ago.

Where did these floods come from? To answer this question, we must cast our eyes eastwards to the Dover Strait, or *Pas de Calais*. The origin of this narrow seaway linking the North Sea to the English Channel, cut through

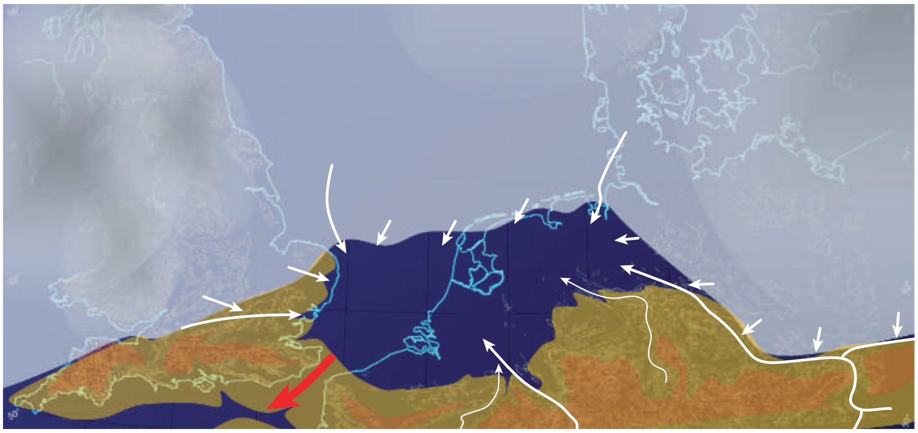

Figure 2 | Dammed lake. The first glacial lake in the area of the southern North Sea existed from around 450,000 to 400,000 years ago. This was dammed to the north by the extension of continental ice from Scandinavia to eastern England and central western Europe, and to the south by a band of higher land, the Weald–Artois anticlinal ridge, stretching from south-east England to northern France. The rivers entering the lake (white arrows) and the overspill at the Dover Strait into the Channel (red arrow) are shown. It was probably this overspill that initiated the first flood identified by Gupta *et al.*[1]. (Map modified, with permission, from ref. 6.)

a gently upfolding ridge of bedrock, has been a point of discussion for more than a century. The consensus now is that its formation was initiated some 450,000 years ago during the first major extension of a continental ice sheet into lowland central Europe and Britain[2,5]. The ice advanced across the emergent North Sea floor from southern Scandinavia, blocking rivers flowing northwards into the Atlantic Ocean and causing an immense glacial lake to develop in front of it, dammed by higher ground to the south and fed by the drainage of much of Western Europe (Fig. 2).

The lowest point of this dam, which was about 30 m above today's sea level[6], stood where the Strait of Dover now lies. Once this 30-km-wide bedrock barrier was overtopped some time around 425,000 years ago, the overflow quickly become torrential. The water would initially have followed existing stream valleys into the Northern Palaeovalley, but the deluge would quickly have overwhelmed these valleys, with the turbulent waters causing dramatic deepening and enlargement. This, in all probability, was the first flood identified by Gupta and colleagues[1].

It is no exaggeration to say that this first Channel flood was probably — on the basis of comparison of the landforms it sculpted with those formed by the Lake Missoula megaflood in the northwestern United States[4,7] — one of the largest ever identified. But although the Channel flood was only of comparable proportions to the Missoula flood, it had more profound long-term geographical consequences.

After the draining of the North Sea lake that resulted from this flood, the Thames and the Scheldt were realigned through the newly formed Dover Strait into the Channel river; the Rhine and Meuse, however, returned to the North Sea after the glaciers withdrew[5,6]. Their diversion to the south was delayed by another 200,000 years until, during a second period of significant glaciation, an ice sheet reached the central Netherlands and again dammed a lake in the southern North Sea[8]. This time, the level of the lake's water remained close to present sea levels, and its southern margin was not at the Dover Strait, but at a ridge further north. This was either an outcrop of bedrock, or possibly a barrier formed from moraine deposited during the previous glaciation.

The failure of this weaker barrier would have been immediate and catastrophic, and almost certainly released a vast volume of water that surged through the Dover Strait and thundered on into the Northern Palaeovalley. This event was probably the second and devastating flood so convincingly demonstrated by Gupta and colleagues[1]. By ensuring that the Dover Strait gap was greatly enlarged — almost to its present form — this single event finally sealed Britain's fate; during periods of high sea level, it would henceforth be an island. And during intervals of low sea level, such as the last glaciation, the Channel river would carry effectively half the drainage of western Europe to the Atlantic Ocean[2,3,9].

As Gupta *et al.* conclude[1], the implications of such significant palaeogeographical changes for plant and animal (including human) migration are manifold, culminating in the impoverishment of the British biota during the last and current interglacials, but also providing a land-bridge during glacial periods. In addition, the almost instantaneous release of huge volumes of freshwater into the Atlantic Ocean could have triggered changes in ocean circulation which might, in turn, have affected the climate of the whole North Atlantic region[10]. Britain's island story began here. ■

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STEM CELLS

The magic brew

Janet Rossant

Researchers have engineered embryonic stem-like cells from normal mouse skin cells. If this method can be translated to humans, patient-specific stem cells could be made without the use of donated eggs or embryos.

Two reports in this issue[1,2] and one elsewhere[3] describe a seemingly simple method for changing differentiated adult cells into pluripotent stem cells. The 'gold-standard' test for pluripotency is the ability of a cell to contribute extensively to all adult cell types, including the germ line. The cells generated by these authors pass this test. The researchers introduced four gene-transcription factors into fibroblast cells originating from mouse skin, and specifically selected those cells that, in response to these factors, expressed genes indicative of a pluripotent state. Not only did all three teams manage to isolate cell lines that resembled mouse embryonic stem (ES) cells, but when they injected these cells into early embryos, the cells differentiated into all normal adult cell types.

A previous study[4] had shown that differentiated adult cells could be transformed into pluripotent cells when fused with ES cells. This hinted that factors found in ES cells might be essential to conferring pluripotency on other cells. However, the transcriptional profiles, modifications to chromatin (complexes of DNA and histone proteins) and DNA methylation status of ES cells are very different from