PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Sub-Bottom Infilled Channels in an Area of the Eastern English Channel

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Sub-bottom infilled channels in an area of the eastern English Channel

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Contouring of geophysical and hydrographic data obtained during a regional geological and geophysical reconnaisance programme has resulted in the discovery of an extensive system of narrow, steep-sided, sub-bottom infilled channels.

These channels, which occur to the north of the Cherbourg Peninsula, are, to a certain extent, structurally and stratigraphically controlled by the Cretaceous and Jurassic age strata into which they are cut, and appear to be the remnants of earlier river valleys filled with locally derived bedded and unbedded sands, silts, flints, boulders, clays and gravels. The depth reached by this infilling material is variable, ranging up to 200 m below sea-bed.

It is suggested that this system may have originated during late Tertiary (Miocene) and that during the Plio-Pleistocene, when sea level was lower, a combination of tidal scour and fluvial erosion entrenched the system into the exposed sea floor. The present tidal régime and the differing physical characteristics of the strata involved suggest that the present bathymetry is a result of tidal scour.

Introduction

Between 1968 and 1970 a continuous seismic profiling, echo-sounding, magnetic and solid rock sampling programme was carried out over a portion of the eastern English Channel. Results of this survey have been summarized by Dingwall (1971). This paper is concerned with the system of sub-bottom infill channels which occur to the north of the Cherbourg Peninsula and is a continuation of work carried out by Hamilton & Smith (1970, 1972); Curry, Hamilton & Smith (1970) and Larsonneur (1971*a*, *b*).

Detailed geological, geophysical and hydrographic data published on the Hurd Deep (Boillot 1963; Hamilton & Smith 1968, 1970, 1972), the Fosse du Hague and the Fosse du Cotentin (Robert 1969) has resulted in several different hypotheses for their origins. Hamilton & Smith (1972, pp. 60–61) have discussed these hypotheses in detail and it is therefore proposed not to enter into details but rather to suggest within the area under discussion and in the light of the additional geophysical data a possible regional interpretation.

Present investigations

Surveying was carried out on the R.R.S. *John Murray*, the M.V. *Moray Firth IV* and the M.V. *Scaldis*.

Navigation and position finding throughout the survey was on the Decca southwest British chain. Two ships were fitted with Mark 12 receivers and the M.V. *Scaldis* used a Mark 5 receiver in conjunction with an automatic track plotter. On all ships position fixes were taken every 10 min.

Gravity coring and Shipek grab sampling were the main methods of collecting rock and sediment samples. In the area under discussion a thin veneer of sediments prevented penetration

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by the gravity cover but Shipek grab samples contained pebbles and gravels. Fragments, angular and rounded, of granitic rocks and flints were predominant in the pebble size fraction while coarse sand usually made up the finer fraction of the sample. The basic Edgerton, Grier and Germeshausen sparker system operating at approximately 250 J was used throughout the survey to produce the continuous seismic profiles. A velocity of 2000 m/s was chosen to represent the acoustic properties of the infill material and 1600 m/s used for the velocity of sound in sea water.

Results

The continuous seismic profiling data showed that, south of latitude 50° 05′ N, a major system of buried erosion channels has been cut below the level of the present sea-bed. Details of this system are shown in figures 5, 6 and 7 and are discussed later. However, due to the wide traverse interval of 4.5 km correlation of individual sub-bottom reflectors from profile to profile was impossible. Figure 2 is therefore a generalized contour chart of an area which has been subjected to an extremely complex geological and geomorphological history.

From figure 2 it can be seen that although a general westerly deepening towards the Hurd Deep occurs large areas consist of over-deepened, steep-sided, linear hollows (49° 49′ N, 1° 25′ W), long and sinuous valley-like forms (48° 48′ N, 1° 00′ W) and features which are of a more open nature (49° 57′ N, 1° 10′ W). Possible indications of the origin of these depressions are illustrated by figures 3, 5, 6 and 7.

From the continuous profiling data it is seen that the acoustic reflectors indicate a large variation in the physical characteristics of the infill material from one section of the system to another. The different acoustic properties probably indicate the variety of infill materials: clays, sands, flints, boulders, silts and gravels.

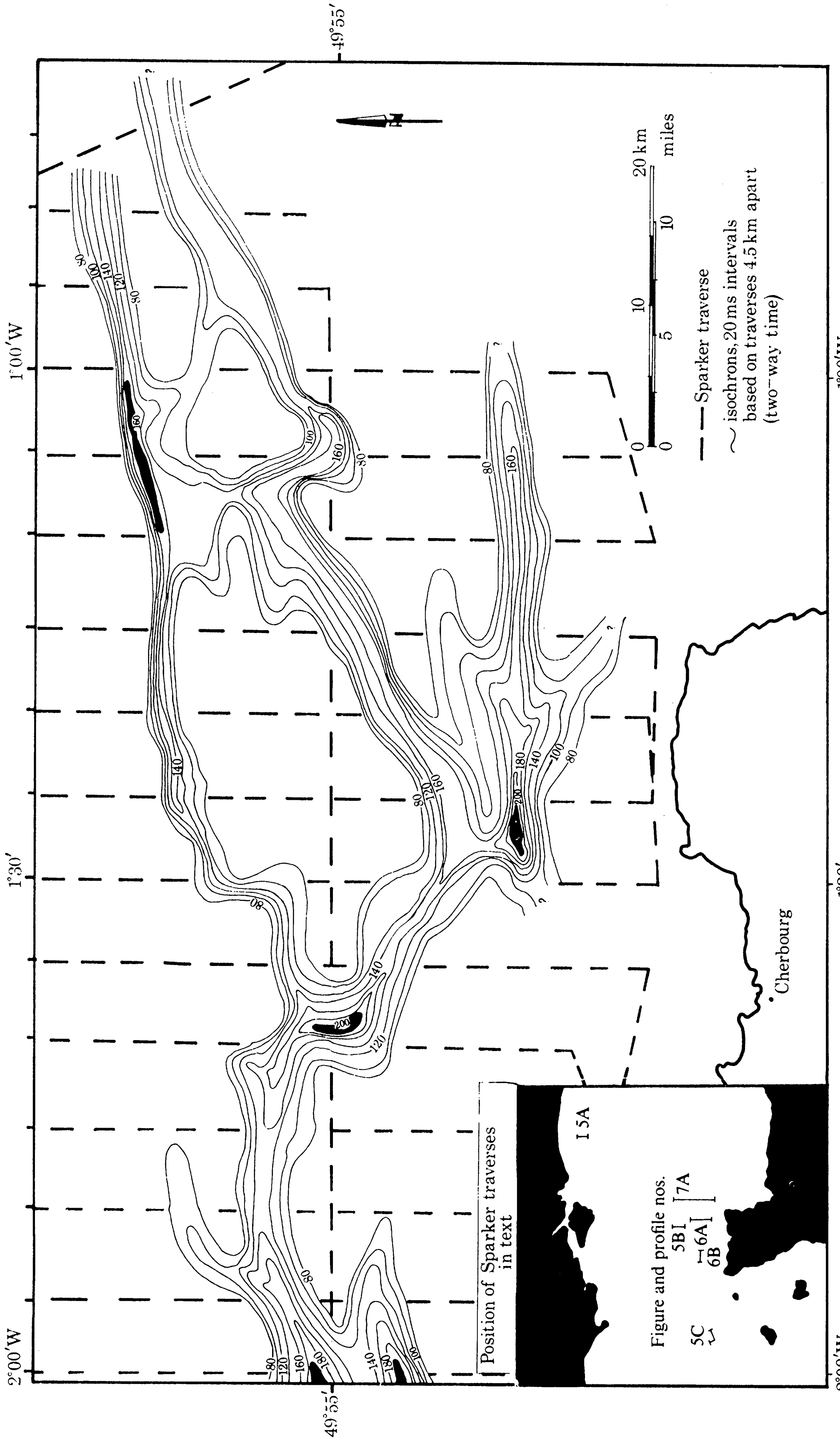
A regional interpretation of this system shows that there are two important infill systems which meet north of the Cherbourg Peninsula and converge on the Hurd Deep. These are an east–west trending system (The English Channel palaeovalley) and an east-southeast–west-northwest trending valley system (the palaeovalley of the Seine) (figure 4).

Details

Hamilton & Smith (1972) have shown that present valley-like features are much smaller than the infilled ancestral valley on the same site. This is particularly true with respect to the Hurd Deep.

The greatest width of ancestral Hurd Deep occurs at the confluence of the English Channel palaeovalley and the palaeovalley of the Seine. This is well illustrated by figure 6 profile A which shows that the width of this former system is 14 km at 49° 45′ N, 1° 25′ W and infill material occurs at a depth of 200 m below the sea-bed. Between the solid rock outcrops A^1 and A^2 at least three periods of deposition are recorded by a series of truncated and disrupted reflecting horizons.

Figure 7, profile A illustrates the complex erosional history that occurs within this system: at 49° 51′ N, 1° 10′ W a channel 2.8 km wide with infill material to a depth of 130 m below the sea-bed again shows evidence of at least three periods of infill. At B, K and M northward dipping solid strata outcrops while at C a thin layer of superficial sediments rest on solid strata.



FIGURES 1 and 2. Location of sparker traverses and isochron chart of the infilled system.

D, I, J and L are examples of infill features controlled by the stratigraphy and structure while at E many of the reflecting horizons have been disrupted and truncated by later infill material. At G a series of parabolic reflectors occur which suggest that the infill material consists of boulders or pebbles.

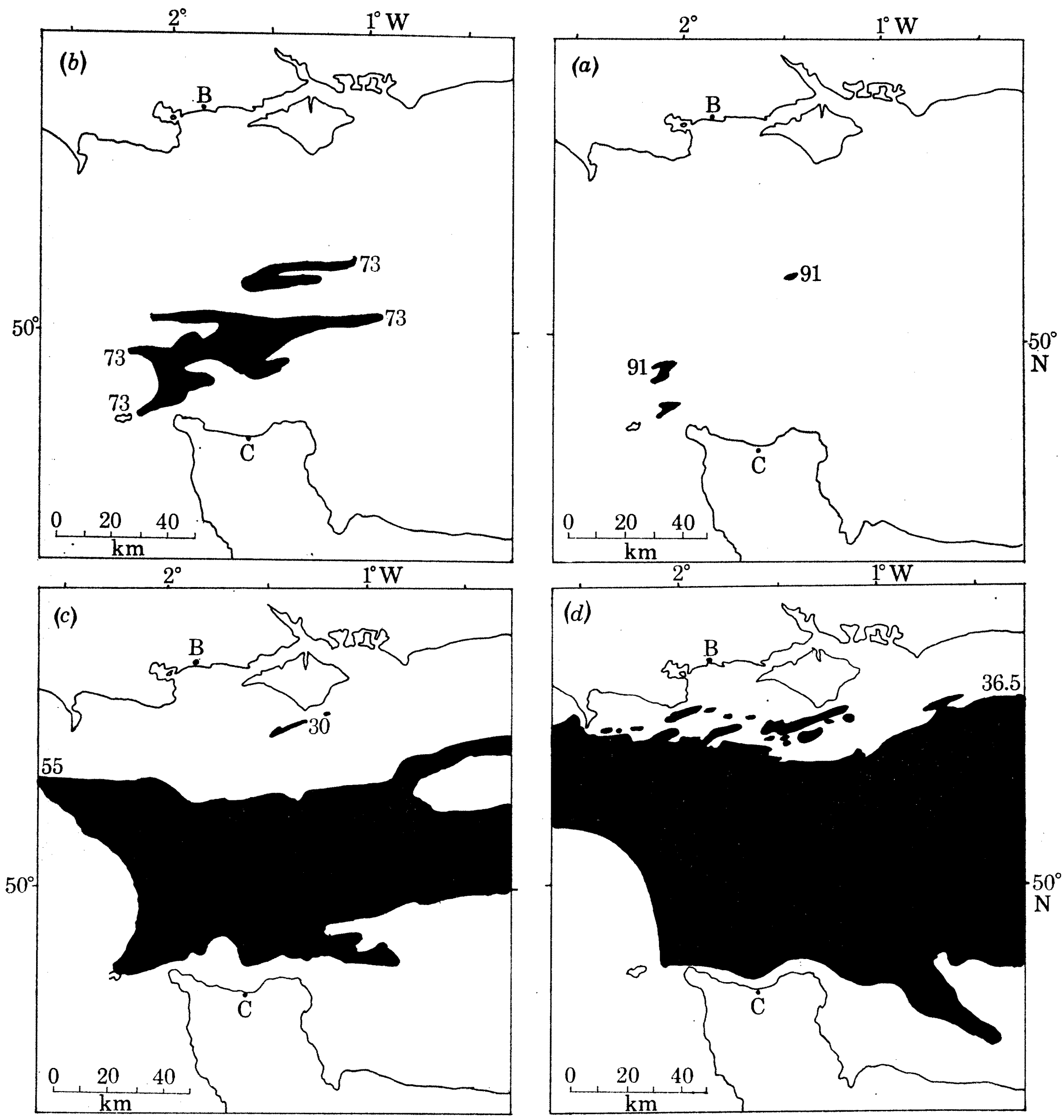


FIGURE 3. Sea-level at the present (*a*) 91, (*b*) 73, (*c*) 55 and (*d*) 36.5 m sea-bed levels.

Longitudinal traverses (figure 5, profile C and figure 6, profile B) show that the system is sinuous and that it is cut into both Cretaceous and Jurassic age strata. North of the major infills is a channel which again illustrates the importance of structural and stratigraphic control (figure 5, profile B). This infill, approximately 1.8 km wide, is cut into Jurassic strata (A), exhibits at least two phases of infilling (D), lies adjacent to the Upper Cretaceous unconformity (B) and coincides, on the south, with a buried fault line (C).

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The only other infilled channel found in the rest of the surveyed area occurred in the offshore extension of the Hampshire Basin. Figure 5, profile A shows that this east–west alined infill is 0.9 km wide with a rock base at 60 m below sea-bed.

Discussion

Mode of origin

Buried river channels have been found in the rivers Dart (Green 1949), Taw-Torridge and Erme (McFarlane 1955) and the Exe (Durrance 1969). On the north coast of France studies of the Somme, Seine and Meuse have revealed similar features (Comment 1910; Lamothe 1906). On the mainland of Britain the greatest infill depths are confined to the system of sunken valleys in Suffolk (Boswell 1913) and in East Anglia (Woodland 1970). Boswell (1913) described these features as 'long, deep and narrow, often having steep or even vertical sides and appear to be a succession of narrow, steep-sided basins'. This aptly describes the infilled channel system found in the section of the English Channel that this paper covers. More recent offshore surveys conducted by French and British scientists have shown several other areas in which similar infilled channels occur (Hamilton & Smith 1970, 1972; Robert 1969; Andreieff, Bouysse, Horn & Monciardini 1970; Larsonneur 1971 *a*, *b*).

Quaternary research has shown that complex and considerable sea-level variations have occurred within the Weichselian. Fairbridge (1961) has shown that the early Weichselian sea-

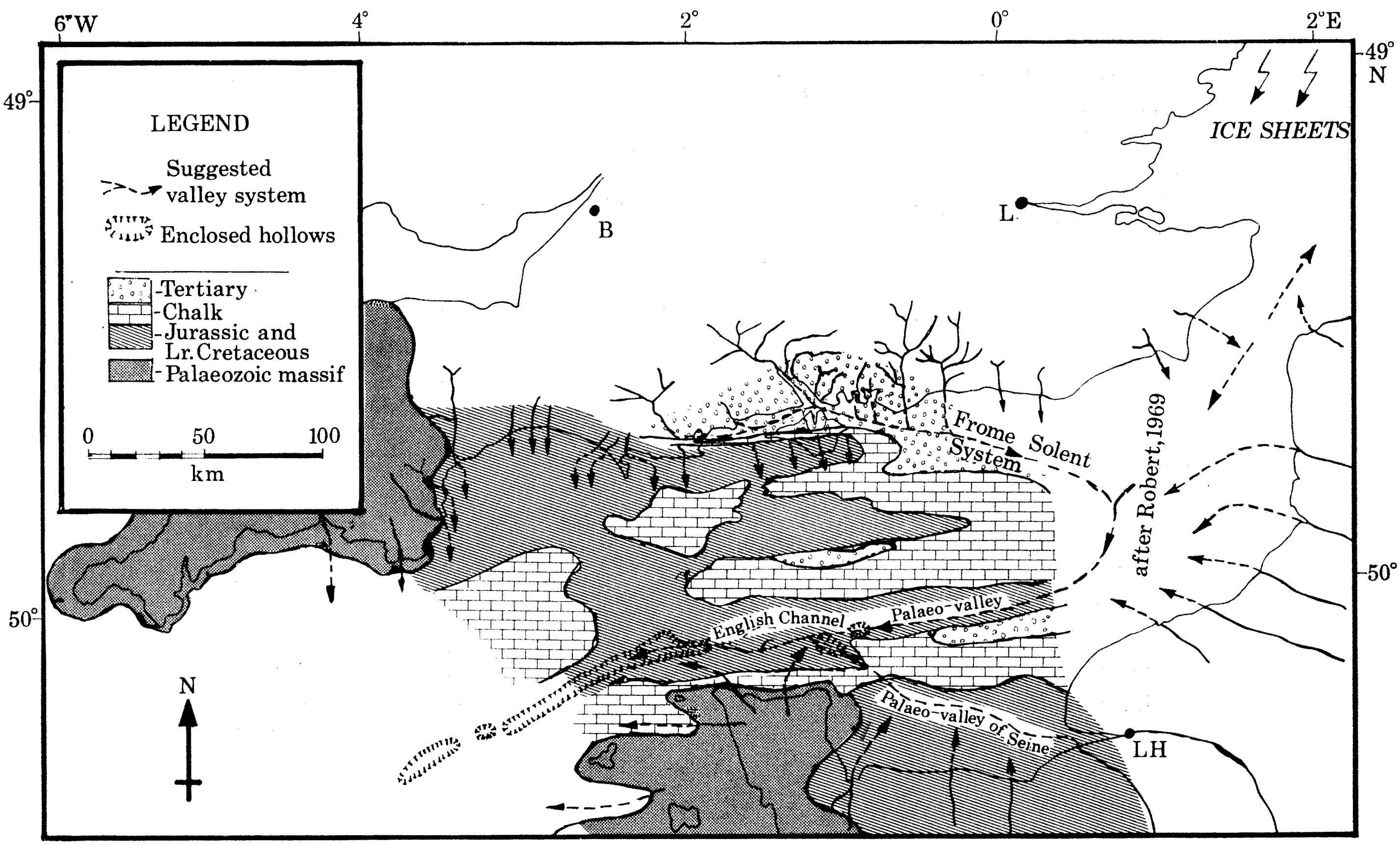

FIGURE 4. Suggested valley systems of the English Channel during Tertiary and Quaternary.

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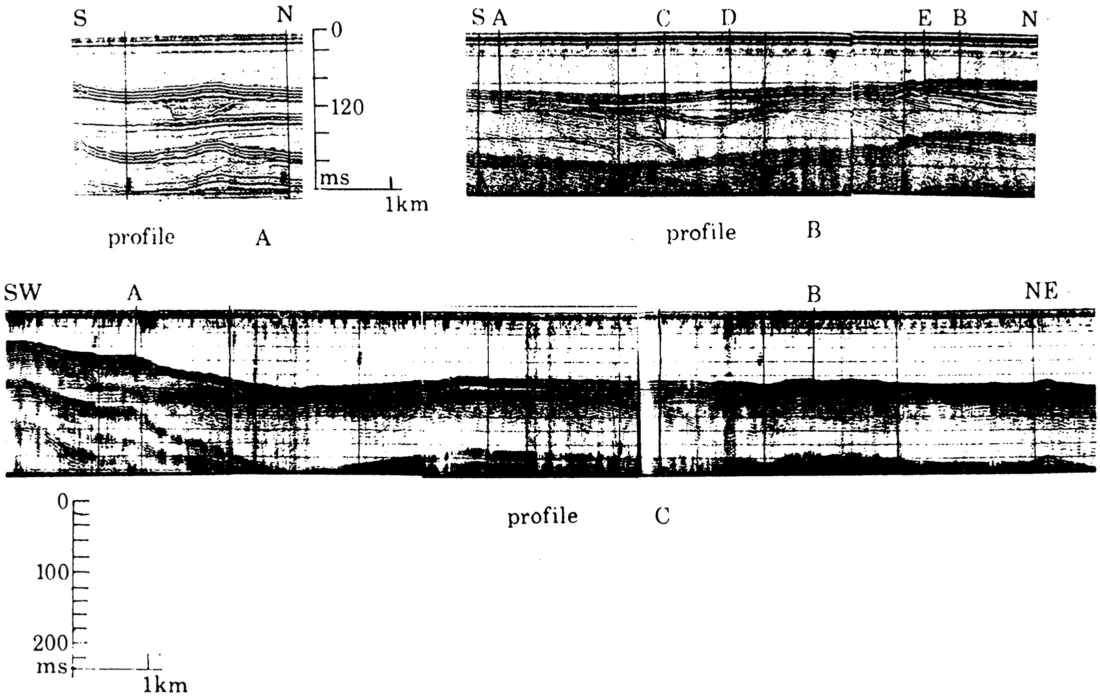

FIGURE 5

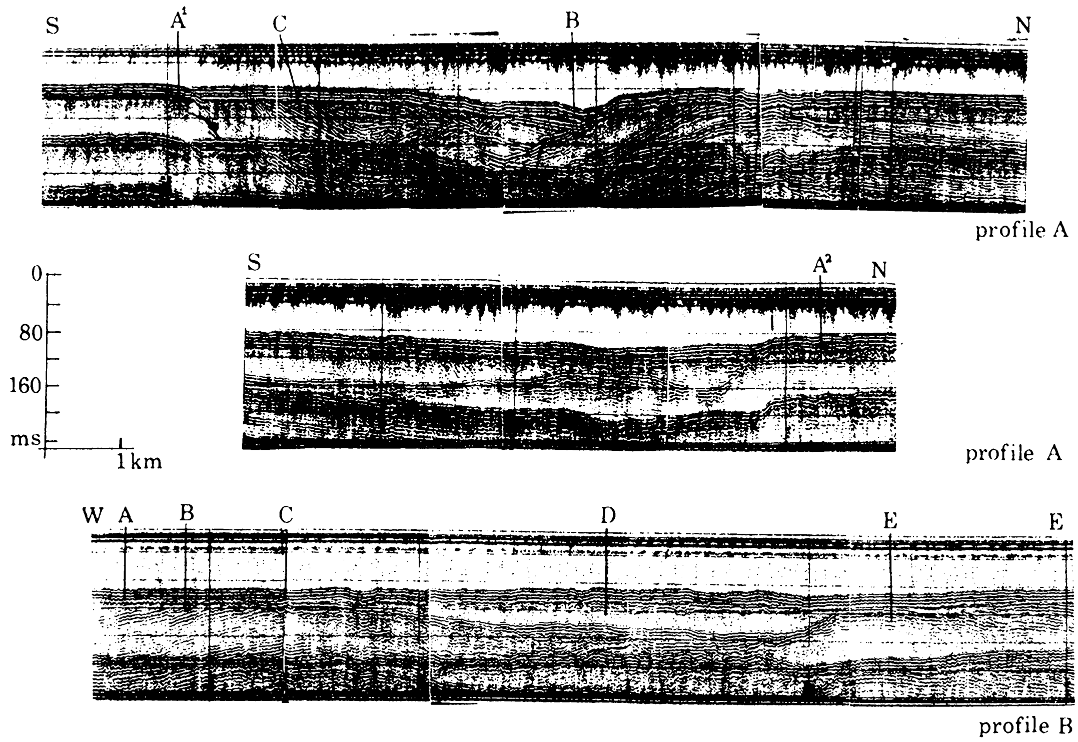

FIGURE 6

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level was probably −90 m O.D. Coope, Shotton & Strachan (1961) have shown that the middle Weichselian sea-level was similar to the present level and Stride (1963) suggests that in the Celtic Sea the late Weichselian sea-level lay at −110 m. However, from the geophysical evidence presented here, it can be seen that many of the erosion planes are in channels at deeper levels than the low stand levels suggested by Quaternary studies of the continental shelf and an alternative mechanism is required to explain the deep channels.

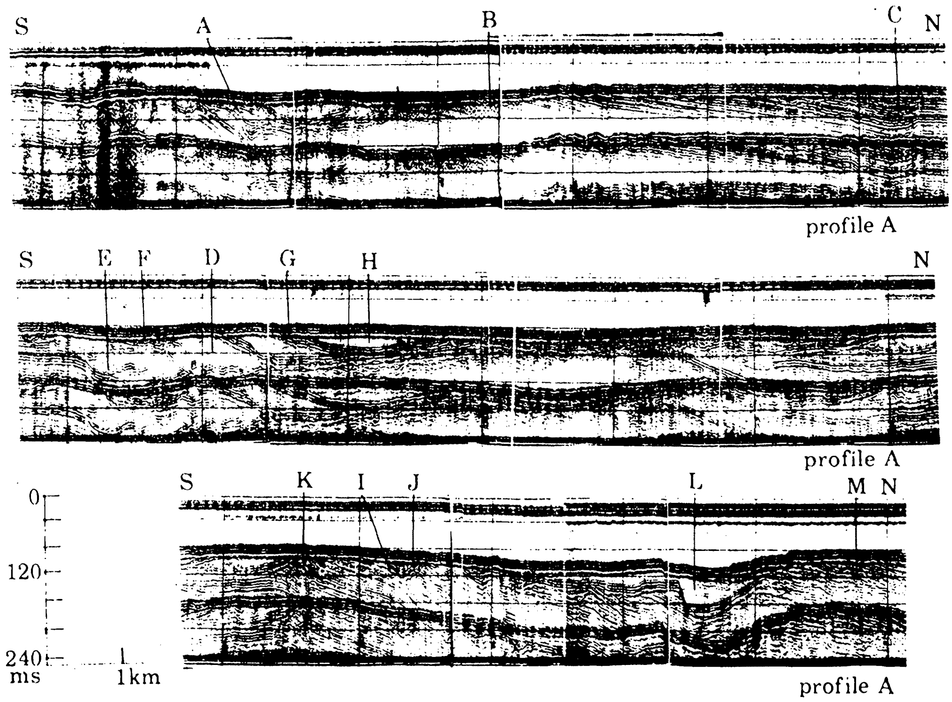

FIGURE 7

Donovan & Stride (1961), Stride (1963), Kenyon (1970), Dingwall (1971) and Hamilton & Smith (1970, 1972) have all shown that, at present, tidal scour is an important eroding agent. Dingwall (1970) also shows that the outline and general positioning of the infill system coincides with the area at present undergoing the greatest tidal scour.

It is therefore suggested that the buried features to the north of the Cherbourg Peninsula are the remnants of the confluence of two major river systems. The features were eroded during periods of low Quaternary sea-level by the sea and by the rivers swollen by glacial meltwater. Together these agents etched out the principal structural and stratigraphical weaknesses.

During periods of lowering sea-level the river mouth would follow the retreating shoreline, the river cutting a new channel into the exposed sea-bed. These channels would be partially infilled by sediments during temporary advances of the sea onto the newly exposed land, and re-eroded during retreats. Sea-level oscillations during the Quaternary meant that this process was repeated several times and resulted in the complex erosional and depositional history as illustrated by figures 5, 6 and 7.

History

Comment (1910) suggested that the Somme and the Seine were eroded to deep levels pre-glacially and were aggraded during the Quaternary. This would raise the speculative possibility, based on the present information, that the age of origin of this system is late Tertiary, possibly Miocene.

Geomorphological work which supports this argument is given by Wooldridge & Linton (1938, 1955). They have noted the contrast between the Miocene drainage pattern, which was consequent upon the folding and faulting episodes, and the main structural elements in the present drainage pattern. The former system was essentially longitudinal (west to east), the present system being north to south. Figure 5, profile A, illustrates part of an east–west alined infill channel in the offshore extension of the Hampshire Basin which may have been part of the ancient west to east flowing Hampshire Basin drainage pattern. Dingwall (1971, Fig. 4) showed that the offshore structures are similar to those found in southeast England and northern France. It is therefore reasonable to assume that a drainage pattern similar to that found onshore existed and that this pattern was also of a Miocene age.

Reid (1902) has shown that the former major drainage pattern probably flowed along the general axial line of the Hampshire Basin from west to east. Assuming that the ancestral Atlantic Ocean lay to the west this would mean that the main Hampshire Basin drainage turned southeastwards and joined a westerly flowing river system in the southern half of the English Channel. The number of infill channels south of 50° 05′ N support this argument.

Larsonneur (1971 *a*, *b*) and Robert (1969) show that many of the northward flowing rivers on the north coast of France have offshore infill channels. It is suggested that these were tributaries of the major English Channel palaeovalley. Dingwall (1971) and Robert (1969) show that in the Baie de la Seine there are extensive remnants of the infill channels of the River Seine. These remnants can be traced to the northeastern tip of the Cherbourg Peninsula where they merge with the English Channel palaeovalley (figure 4).

An overall gradual rise in sea-level up to the present day has slowly destroyed this system and finally resulted in the breaching of the Dover Straits, the drowned estuaries and valleys along the southern coast of England and the silted estuaries on the northern coast of France.

The collection of data was made possible through the provision by the N.E.R.C. of ship time on the R.R.S. *John Murray* and M.V. *Moray Firth IV* and a three-year research grant with which to pursue this topic at University College London.

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