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

Basement Control of Structures in the Mesozoic Rocks in the Strait of Dover Region, and Its Reflexion in Certain Features of the Present Land and Submarine Topography

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Basement control of structures in the Mesozoic rocks in the Strait of Dover region, and its reflexion in certain features of the present land and submarine topography

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with an Appendix

Faulting in the Kent Coalfield

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Introduction

The purpose of this paper is to review current information and opinions on the structures of the concealed Palaeozoic rocks of southeastern England and adjacent parts of northwestern Europe. The authors attempt a regional synthesis, which suggests that certain structural trends in these older rocks have been reactivated several times in the subsequent history of the area, and in some cases control the alinement of present-day surface features.

We have drawn on the accumulated data of field surveys, deep boreholes and geophysical investigations carried out by the Institute of Geological Sciences, and also information obtained during the commercial search for coal and oil. The results of marine gravity measurements recently made by I.G.S. and the Admiralty in the eastern English Channel and southern North Sea are presented for the first time. Similarly, we are glad to include data from Mr P. L. Rumsby's recent analyses of fault trends in the Kent collieries, for the National Coal Board. Reference is also made to some of the results of the Channel Tunnel site investigation 1964–5 (Destombes & Shephard-Thorn 1971). Published literature and maps form the basis of our remarks on northern Europe, though we are grateful to Destombes for unpublished information on the Boulonnais.

The geological problems of the Strait of Dover have attracted the attention of British and Continental geologists over a long period. Godwin Austen perhaps deserves the title of founding father of this school in that his classic paper (1856), which attempted to trace the structural and stratigraphic links between the known British coalfields and those of Northern Europe, set out the broad structural basis of future research. His forecast of the presence of Coal Measures concealed beneath the Mesozoic rocks of Kent, was confirmed by a borehole at Shakespeare Cliff in 1890, ironically using machinery assembled for an abortive attempt to drive a Channel Tunnel. His followers included Bertrand (1893), Strahan (1913), Lamplugh (1920). Latterly, van Waterschoot van der Gracht (1935), King (1949, 1954) and Terris & Bullerwell (1965) have contributed valuable syntheses.

The authors have collaborated closely in preparing the paper and are jointly responsible for the opinions expressed. However, it should be stated that E.A.A. has compiled and reviewed the geophysical evidence, while R.D.L. and E.R.S.-T. have treated the regional geological and structural data.

Regional structure and deformational history

(a) *General*

The area we are discussing forms the eastern part of the late Tertiary Weald–Boulonnais anticlinorium, which Strahan (1913) demonstrated to be superimposed on a basin which had subsided through Jurassic times to accommodate up to 1700 m (5500 ft) of sediments. Just south of the latitude of London, the Palaeozoic floor rises steeply to the 'platform' of Devonian and older rocks which underlies our capital and the Thames Valley region. This platform is the western extremity of the London–Brabant massif which separates the Mesozoic basins of the Weald and the North Sea.

The Hercynian orogeny in late Palaeozoic times caused the thrusting of Silurian, Devonian and Carboniferous rocks from the south over their counterparts on the foreland or 'massif' to the north. The 'Hercynian front' is generally taken to be marked by a major thrust, the Grande Faille du Midi, that extends across Belgium and Northern France for some hundreds of kilometres (Bouroz 1960). It has been recognized in the Boulonnais and traced to the coast just south of Cap Gris-Nez. There is clear evidence in the Boulonnais of normal and wrench faulting post-dating the thrusting, but predating the earliest Jurassic rocks (Pruvost & Pringle 1924). The dominant trend of the normal faults is about E 10° S, while that of the wrenches is about N 20° E. There is also evidence of post-Jurassic movements of these faults. There is little direct evidence for the location of the Hercynian front westwards across the Channel and beneath southern England. The absence of thrusting in the Kent coalfield implies that it crosses our coast somewhat to the south of the known coalfield. The Bouguer anomaly map (figure 1) compiled for this paper throws new light on the westward continuation of this structure.

The majority of faults proved in the workings of the Kent collieries (figure 2 and figure 1 in Appendix) have a NW–SE trend parallel to that of the axis of the coalfield basin. They appear to be near-vertical, when proved in more than one seam at the same colliery and to have vertical displacements under 15 m (50 ft), with a few notable exceptions. Evidence exists that these faults predate the deposition of the Mesozoic formations, but have moved subsequently in late-Jurassic times to produce a graben at Tilmanstone (Plumptre 1959). There is also a strong suggestion that they have moved in post-Cretaceous times. The abrupt westward rise of the base of the Coal Measures inferred from boreholes, has been interpreted as due either to marginal subsidence of the basin during deposition or to subsequent faulting.

The faults and folds of the central Weald have a dominant W–E trend. Some of the structural 'highs' have a complex horst-like structure (Howitt 1964), and borehole evidence of reversed faulting in the thick underlying Jurassic sediments (Brightling no. 1 borehole) is indicative of basement control.

We now proceed to review the geophysical evidence and attempt a synthesis of the structural patterns of the Palaeozoic rocks flooring the Mesozoic basin of southern England, before considering the Strait of Dover region in somewhat greater detail.

(b) *Review of geophysical anomalies*

Both Bouguer anomaly (gravity) and aeromagnetic maps have been consulted, but it is apparent that the former is most meaningful in the present context. The gravity map (figure 1) has accordingly been compiled. Data for the land areas is derived from officially published British and French sources, while that for marine sectors includes the published results of

Collette (1960) and Browne & Cooper (1952) with the hitherto unpublished results of two shipborne gravimeter surveys by an Admiralty team on H.M.S. *Hydra* in 1968 and by the Marine Geophysics Unit of the I.G.S. in 1970.

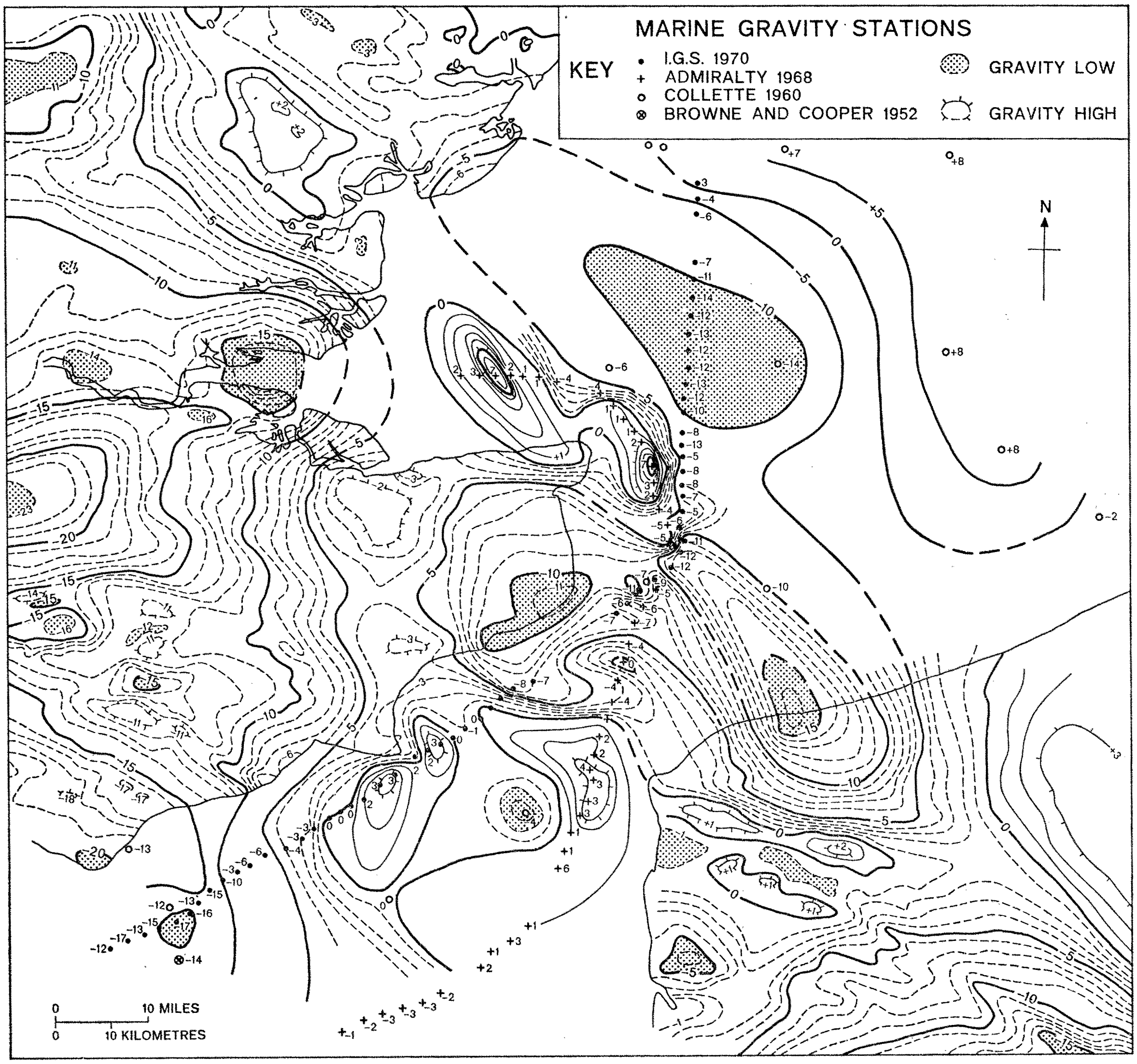

FIGURE 1. Bouguer anomaly map of southeastern England and adjacent areas.

The lower density of gravity measurements at sea, compared with the land areas, does not permit a detailed interpretation at present, and in consequence the following discussion has been restricted to consideration of the broad trends and dominant features revealed.

All values and contours represent Bouguer anomalies derived assuming a value at Pendulum House, Cambridge, of 981265 mGal† and calculated against the international gravity formula (1930) at mean sea level (Woollard & Rose 1930).

The NW–SE oriented gravity ridge with a complementary trough to the north running south-eastwards from northern Essex was suggested by Terris & Bullerwell (1965) as possibly linked with the high anomaly values on the Isle of Thanet and the offshore gravity information now

† 1 mGal = 10^{-5} m/s²

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lends support to the south-easterly continuation of the ridge. In Belgium the aeromagnetic map (1964) shows a belt of alternate positive and negative axes all trending NW–SE. The most southerly of these axes corresponds to the gravity 'high' on the border between France and Belgium shown at the eastern margin of the gravity map. It is tempting to connect this axis with the Essex–Thanet ridge. These broad NW–SE gravity features probably represent structures within the rocks forming the Brabant Massif.

The offshore data also indicate a southerly extension of the N–S gravity ridge running through east central Kent. This feature has been referred to previously by Terris & Bullerwell, (1965) and attributed to a zone in which the sub-Mesozoic floor comprises Silurian rocks; the local gravity closures possibly indicating the crossing points of WNW–ESE anticlinal structures. The sub-Mesozoic floor in this area may be pre-Silurian in some places, since revised dating by microfaunal studies indicates an Upper Ordovician age for the rocks in the Bobbing borehole (Lister 1971).

The gravity basin centred on Canvey Island has been interpreted as due to relatively light Old Red Sandstone sediments reaching a thickness of the order of 1000 m (3000 ft), (Bullerwell in Smart, Sabine & Bullerwell 1964). In France, east of Calais there is a similar gravity trough which has been previously attributed mainly to the existence of a granitic batholith at depth (C.F.P.(M), Copesep, R.A.P. et S.N.P.A. 1965). A borehole sited near the centre of this gravity basin penetrated Lower Carboniferous and Upper Devonian rocks (C.F.P.(M), Copesep, R.A.P., et S.N.P.A. 1966). It is therefore feasible that the gravity deficiency is due largely to Old Red Sandstone deposits of relatively low density, particularly since a second borehole about 8 km to the southwest of the anomaly centre reached older Devonian rocks (Frasnian). These two gravity basins may be linked, again along a NW–SE axis. It is worth mentioning that in a gravity model prepared for the northern area of the Kent coalfield and the Isle of Thanet, a considerable thickness of rocks with a density lower than that of the Carboniferous Limestone had to be introduced in the area immediately south of the Isle of Thanet, in order to get the theoretical values to agree with the observed gravity values. Thick Old Red Sandstone deposits may therefore also be present to the south of the Isle of Thanet, beneath the known Carboniferous rocks of the coalfield.

In France a zone of steep gravity gradients to the south of the gravity basin mentioned above corresponds to the Silurian–Devonian contact along the Faille de Landrethun (and hence approximately with the Hercynian front), which is the most northerly of the belt of major faults which trend WNW across the north of France. A similar zone of relatively steep gradient exists in the Dover Strait area and links with the western edge of the Kent coalfield in the Hythe–Folkestone area. In western Kent there is also a comparable zone of relatively steep gradient which is in alinement with that in the Dover Strait area. These two zones, however, are offset from that on the French side, and it is tentatively suggested that this may be due to dextral wrench-faulting in the eastern part of the Dover Strait giving a total displacement of the order of 10 km (see figure 2). The zone of steep gradient which is assumed to correspond to the contact between Lower Palaeozoic rocks and less dense rocks (i.e. Coal Measures or Old Red Sandstone) to the north, cannot be traced through the N–S gravity ridge to the west of the Kent coalfield. Along this ridge rocks of Upper Palaeozoic age are probably absent, and therefore any Hercynian faulting would not be revealed as a gravity feature because of the lack of density contrasts in the Lower Palaeozoic rocks.

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(c) *Structures of the Palaeozoic basement*

The Wealden Mesozoic basin is delineated to the north and east by the London–Brabant massif, a basement 'high' of pre-Hercynian age, which has exerted a palaeogeographic influence since Devonian times (Ager & Wallace 1966). In the Thames Valley area of north and east Kent, the massif has a broad flat surface at about 300 m (1000 ft) below sea level. Since the surficial Lower Palaeozoic rocks of this 'London Platform', as known from borehole cores, are only weakly tectonized, an older tectonic core of pre-Silurian age is probable. Terris & Bullerwell (1965) recognized a NW–SE trend, between the Thanet and Witham–Colchester (Essex) areas, that is further substantiated by the new marine gravity data presented above (p. 101).

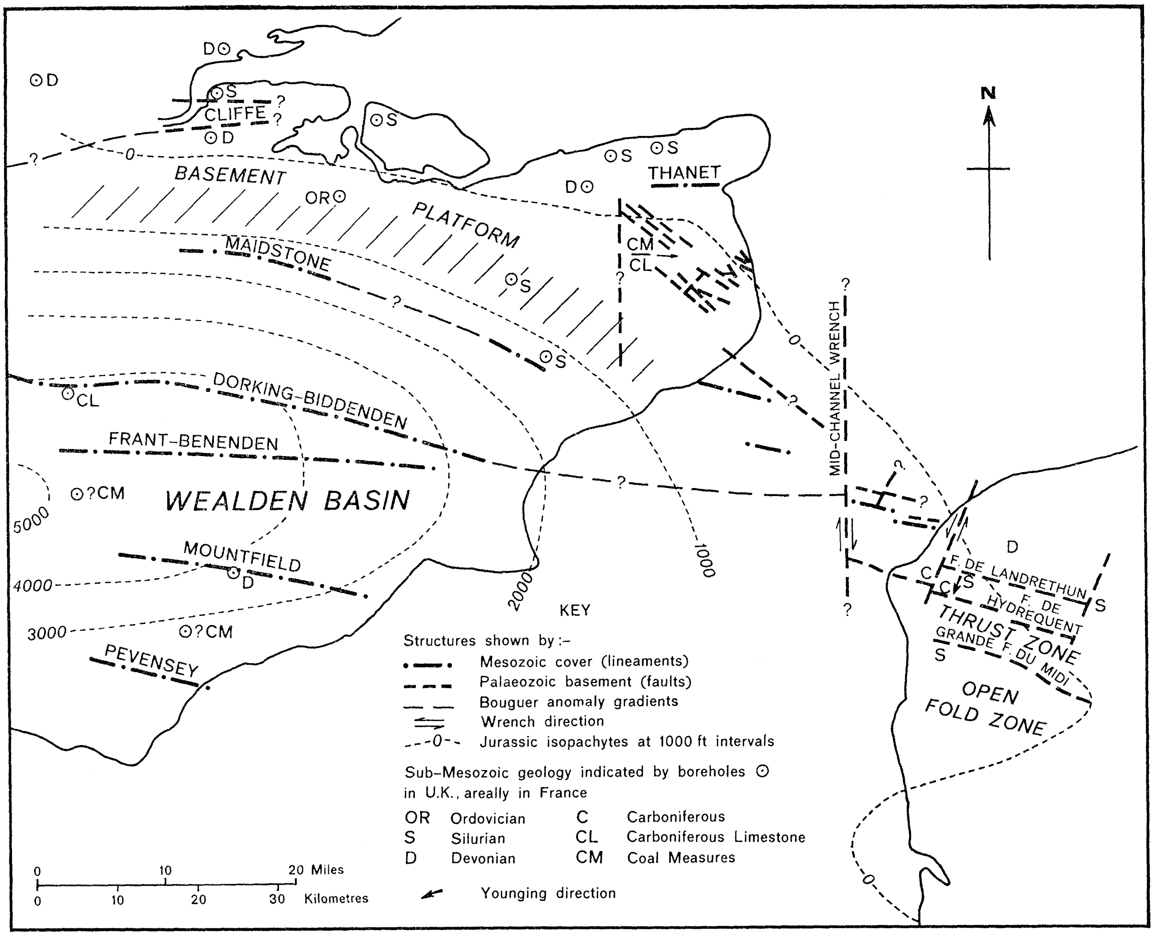

FIGURE 2. Structural lineaments in southeastern England and adjacent areas.

In the Boulonnais, Palaeozoic rocks of the Hercynian foreland 'nappe slices' are thrust against the Brabant massif. Although the basement here at present shelves gently southward with no obvious evidence of a hinge structure between 'foreland' and 'orogen', the Grande Faille du Midi appears to divide the overthrust zone from one of open folding to the south (Bouroz 1960). A linear 'ramp' of Silurian rocks, bounded by the normal northerly downthrowing Faille de Landrethun on the north, and a steeply inclined contact with Devono-Carboniferous strata to the south demarcates the northern margin of the structural complex associated with the Hercynian front (J.-P. Destombes, personal communication). This feature is reflected by a strong gravity gradient (p. 102); borehole evidence shows the 'ramp' to be offset by a SSW–NNE sinistral wrench fault, a fault of similar trend some 18 km to the east is deduced from aeromagnetic surveys and boreholes (C.F.P.(M), Copesep, R.A.P. and S.N.P.A. 1965), both these faults have a substantial normal component. Other normal faults of similar WNW–ESE trends to the Faille de Landrethun occur to the south; they appear to post-date the major thrusting and to pre-date the earliest Jurassic deposits, they have also moved subsequently to displace these latter. Minor wrenching in the Palaeozoic inlier of Ferques (Wallace 1970; Robinson 1920) parallels the trend of the major wrenches mentioned above but is dextral.

The comparatively simple structure of the Kent Coalfield has been noted above with the possibility that its western margin may be fault-bounded. In this area plentiful borehole information (Lamplugh, Kitchin & Pringle 1923) has shown that the basement shelves gently westward into the centre of the Wealden Mesozoic basin. South of London, however, a gradient of about 1 in 13 can be demonstrated with respect to the base of the Gault; this steeper slope is reflected in the Bouguer anomaly map (figure 1) and suggests the presence of a tectonic hinge which permitted subsidence of the Wealden basin by block-faulting to occur. The gravity map also indicates an ENE–WSW trend for this feature, contrary to the regional structural grain of the Weald, but akin to those of certain synclinal structures observed in the Tertiary formations of the east London area. The eastern extension of this feature within the basement platform area is approximately alined with the Cliffe structure (Owen 1971), a surficial Tertiary anticline superimposed on a graben preserving Jurassic rocks.

Deep boreholes indicate the presence of Palaeozoic rocks, generally similar in facies to those of Boulonnais, beneath the Mesozoic infilling of the Wealden basin, and it is probable that the basement structure is comparable to that south of the Grande Faille du Midi, with increased faulting to facilitate the basin subsidence.

(*d*) *Structures of the Mesozoic and Tertiary cover rocks*

Although southeastern England and northern France were gently folded on a regional scale during the Alpine (mid-Miocene) orogeny, little evidence exists of a pre-Cenomanian deformation comparable with that known from Dorset (Chatwin 1960). Where Upper and Lower Cretaceous strata outcrop along the structural grain in the western Weald there is ambiguous evidence (Thurrell, Worssam & Edmonds 1968) Palaeontological evidence of Aptian movements has been recorded from the Hog's Back ridge by Arkell (1939) and Casey (1961). Post-Oxford Clay movements of the faults limiting the Cliffe (Owen 1971) and Tilmanstone grabens (Plumptre 1959) are recorded. Owen's stratigraphical studies of the Gault from the Gas Council's series of boreholes at Cliffe indicate that the presumed northern boundary fault of the graben was again active in Albian times.

Similiar post-Jurassic movements have been noted from the Boulonnais by Pruvost & Pringle (1924) and other workers, but Ager & Wallace (1966) were not convinced by the surface evidence. Here, as in southeastern England (Casey 1961) the structural interpretation is confused by stratigraphic onlapping within the Mesozoic sequence. In the Weald, the thick Weald Clay formation (up to 500 m) appears to have deformed incompetently failing to transmit clear reflexions of basement structures; this effect is reduced when the Wealden thins out on the flanks of the Brabant massif.

The more competent rocks of the Hastings and Purbeck Beds outcropping in the central Weald show more clearly defined surface structures. Certain persistent structural lines may be

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related to deeper-seated (basement) structures with the aid of geophysics. At their lowest exposed structural level these structures are modified horsts; four such lineaments have been traced westwards from the Channel coast into the Weald (figure 2). No definite lineaments are apparent north of this group of four, although structures near Maidstone and elsewhere along the line of the North Downs Chalk escarpment may be collinear, possibly related to the southern edge of the London Platform.

In the Boulonnais the major normal and wrench faults described from the basement above are represented in the cover rocks chiefly as faults (or as their monoclinal modifications).

(*e*) *Interrelationships of basement and basin structures*

It becomes evident from the preceding considerations that the major structures of the area under consideration are, to a large extent, basement controlled. We can therefore expect to find a parallel situation, in the basement rocks of southeastern England to that of the Boulonnais. There the Hercynian 'front', conveniently taken at the Grande Faille du Midi, separates a southern area with Hercynian structures from a northern area with an older structural imprint.

The difficulty of tracing the 'front' beneath the Wealden Basin has been stated by Dunning (1964). One may take the line of argument that the sedimentary blanket over this lineament reflects zones of distinct tectonic trend, namely of rejuvenated Hercynian structures and of obverse pre-Hercynian structures. To the northeast of the North Downs Chalk escarpment in Kent, E–W structural trends are dominant in the Cretaceous and Tertiary formations (Worssam 1963). Similar E-W trends are also observed in the Thanet anticline and geophysical lineation and possibly the Cliffe structure. These trends are obverse to the suggested Maidstone lineament and the subparallel lineaments to the south.

The review of geophysical data has demonstrated the likelihood that the Hercynian 'front' zone of the Boulonnais can be traced into southeastern England by the most northerly of the defined lineaments of the central Weald, the Dorking–Biddenden lineation of figure 2. This has a strong surface expression in the Biddenden Fault of the Tenterden area (Shephard-Thorn, Smart, Bisson & Edmonds 1966; Smart & Shephard-Thorn 1969). The Maidstone lineament must on this premise reflect a less important foreland structure.

TABLE 1. SUMMARY OF AGES OF MOVEMENTS OF THE STRUCTURES PRESENT

movement period	structural effects	remarks
1. mid-Miocene	regional warping producing Weald-Boulonnais anticlinal with some rejuvenation of earlier structures	—
2. intra-Cenomanian Albian-Cenomanian Aptian-Albian	rejuvenation of 3, 4 and ? 6	—
3. pre-Jurassic	major wrench faulting	most probably rejuvenation of 7 adjacent to Hercynian front (3 and 4)
4. pre-Jurassic	major normal faulting	
5. post-Carboniferous	Hercynian foreland thrusting and associated minor wrenching	—
6. post-Carboniferous	main Hercynian deformation	
7. pre-Silurian	pre-Hercynian deformation(s)	—

The Strait of Dover region

(a) *The Kent coalfield*

The dominant NW–SE alinement of known faults in the coalfield is apparent from Appendix, figure 1, which also shows the simple form of the coal basin. Other fault directions seem random at first sight but resolve into distinct trends when plotted statistically on a diagram.

Faults from the Snowdown Colliery workings analysed by Rumsby (see Appendix) show a dominant NW–SE trend with a subordinate one about W 20° N–E 20° S and lesser ones approximately N–S and W–E. At Tilmanstone 4 km ($2\frac{1}{2}$ mi) eastward the NW–SE trend again dominates with one at W 20° N–E 20° S subordinate as before; some small indication of W–E and NNE–SSW trends are present, but none for a N–S direction.

Workings in the recently closed Chislet Colliery showed the Stodmarsh and other major faults to trend NW–SE, with a lesser group approximately W–E. Less faulting has been experienced in the Betteshanger Colliery take, but it is probable that the Stodmarsh fault group (of Chislet) extends through the unworked ground between here and Tilmanstone as indicated in Appendix, figure 1.

Many of these faults are near vertical and of small throw as far as can be judged from their known intersections in colliery workings. It is difficult to visualize a tectonic picture linking the origin of these faults with that of the simple basin structure of the coalfield.

It is, however, interesting to consider the fault pattern within the coalfield as the result of wrenching between major N–S discontinuities on its western margin and in mid channel (figure 2). The existence of such discontinuities is speculative, but some circumstantial evidence lends support to the hypothesis. Reference has already been made to the western margin of the coalfield (p. 100), and the immediately adjacent N–S gravity high due to the presence of presumed Silurian rocks (Terris & Bullerwell 1965, and p. 102). Geophysics likewise lends support to the presence of a major dislocation of the Hercynian front in mid-Channel (p. 102), although further gravity measurements are needed before a critical interpretation can be made. Wallace (1968) has suggested the presence of a discontinuity in the sub-Channel Palaeozoic rocks in comparing those of the Boulonnais with their known counterparts in southeastern England. Structural evidence from the Channel Tunnel investigations (see p. 107 below) also lends support to a mid-Channel discontinuity.

Accepting these premises, the major N–S structures can be taken as primary wrenches according to the theory of Moody & Hill (1956). The predominant NW–SE structures can then be regarded as second-order wrenches. The small vertical throws of these faults, plus occasionally observed horizontal slickensiding on fault planes supports the wrench theory of their origin. It is interesting to note that Mr Rumsby's plots of fault directions fall in very closely with this scheme, even to the point of revealing a N–S group of faults in the western part of the Snowdown Colliery workings (due to its proximity to the western margin of the coalfield?).

(b) *The Channel Tunnel study area*

Investigations carried out on behalf of the British and French governments in 1964–5 have recently been described by Destombes & Shephard-Thorn (1971). A simplified version of the geological map accompanying their paper is presented as figure 3. The investigation for a bored tunnel set out to prove the continuity of the Lower Chalk, between Dover and Sangatte, and to investigate its structure and physical properties *vis-à-vis* the routing of a dual rail tunnel. A very detailed picture was obtained by a close network of seismic reflexion ('Sparker') profiles and numerous cored boreholes.

Within the study area the Cretaceous formations dip north-northeastwards, at only a few degrees in the western or English half, but steepening up to 15° in the French half, between the mid-Channel deep and Sangatte. The width of the submarine Lower Chalk outcrop reflects this change of dip (figure 3) being much narrower in the French sector. (The Lower Chalk thins from about 80 m at Dover to 68 m on the French coast, but most of the reduction in width of the outcrop is due to the higher dip.) Important anticlines, whose axes trend W 20°N–E 20°S,

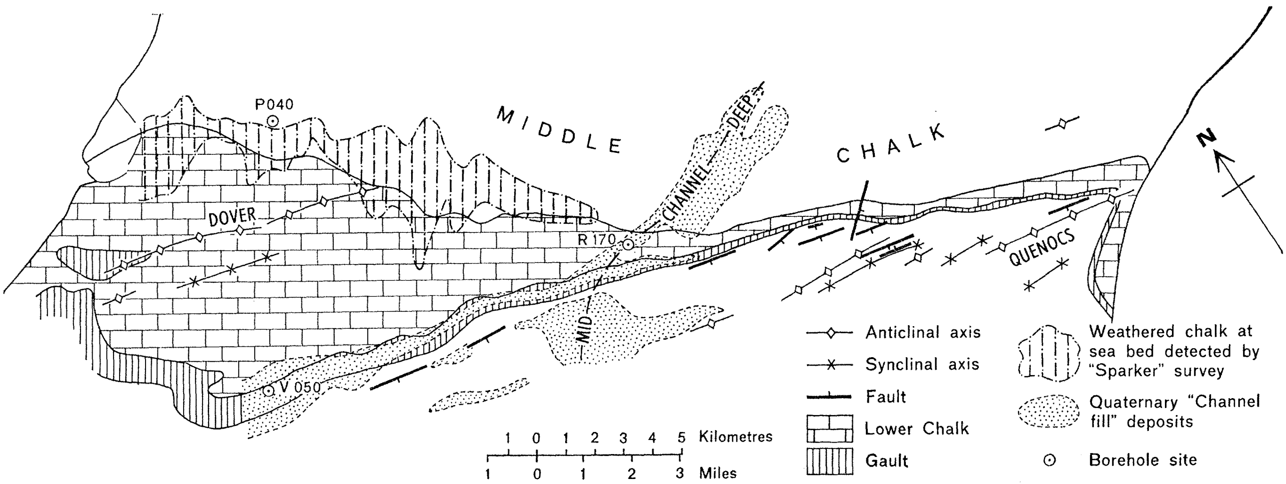

FIGURE 3. Simplified geology of the Strait of Dover based on the Channel Tunnel site investigations 1964–5.

occur off Dover and at Quenocs, near Sangatte (Destombes & Destombes 1963); other lesser folds and some minor faults have a parallel trend. Many sharp features of the sea bed on the French side appear to be controlled by these structures. It is possible to suggest a posthumous relation between these structures and older ones such as the Faille de Landrethun (p. 103) which have a similar trend. A single 'dip' fault, about 10 km seaward of Sangatte, throws down the Lower Chalk some 10 m to the southeast.

Micropalaeontological studies on the Chalk and Gault cores from the Channel Tunnel boreholes have revealed the presence of infra-Cenomanian (Lower Chalk) and Albian–Cenomanian (Gault–Lower Chalk) unconformities (Carter & Destombes 1971).

A NW–SE elongated zone of 'weathered' chalk (figure 3) has been detected, continuing the trend of the Dour Valley, south eastward from Dover, ending abruptly at the mid-Channel deep. It is marked by relatively severe subaerial Pleistocene weathering of the Chalk beneath the sea bed which can be deduced from core examination and Sparker record interpretations, and by comparatively high values given by in-borehole permeability tests. In the past this zone of weathered chalk has caused difficulties in construction works in Dover Harbour.

The presence of the Dour Valley, transecting the Chalk escarpment at Dover, is anomalous on geomorphological grounds. The parallelism of the trend of the valley and its seaward continuation with the major fault direction of the Kent coalfield, suggests a tectonic linkage. Some 'Sparker' profiles across the 'weathered' chalk zone suggest a very shallow graben-like structure; surface mapping of the Dover (290) one-inch geological sheet gives no indication of fault displacement of the Chalk outcrops across the valley. It seems very probable therefore that the location of the Dour Valley and the 'weathered' zone are controlled by a highly fissured

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area of chalk, due to slight post-Cretaceous movement of late-Hercynian wrench faults in the underlying Coal Measures and older rocks. Viewing the whole study area, the contrast in dip between English and French sides and the abrupt termination of the 'weathered' zone at the mid-Channel deep, lend some support to the presence of a N–S discontinuity in the basement rocks in mid-Channel as discussed in the preceding section (p. 102). The Chalk is very close to the basement on the French side, having a much thinner Lower Cretaceous–Jurassic sequence intervening, than in the Dover area, accordingly its mid-Miocene deformation has been somewhat more severe on the French side.

An interesting sequence of Quaternary channel-fill deposits were localized by Sparker surveys during the investigations and penetrated by two boreholes. East of Folkestone, such a 'buried channel' largely cut in the submarine outcrop of the Gault has been traced for 20 km. Sparker records suggest that its base extends to 140 m below sea level; in borehole V. 050 (figure 3) about 60 m of finely laminated pale sands and grey clays of estuarine facies were penetrated beneath the sea bed at 30 m below sea level. The alinement of this feature appears to owe something to the older structures of W 20° N–E 20° S trend. No material suitable for radiocarbon dating was recovered in the cores from this borehole. Mr D. J. Carter has identified Pleistocene microfaunas of estuarine aspect from top and bottom of the deposit. This and the overall uniform estuarine character of the sediments suggest that the 'valley' was filled in pace with a gradually rising sea level in late Pleistocene–Holocene times. The extension of the buried valley northeastward through the central deep has not been cut down so deeply, only 12 m of sediments above the Chalk being recorded from borehole R. 170.

Peat and peaty clay recovered from a minor valley filling at 36 m below sea level, in borehole P. 040 (about 6 km east-southeast of Dover) yielded radiocarbon dates of 9910 ± 120 and 10530 ± 120 years B.P. respectively (Callow, Baker & Hassall 1966). Professor Godwin was able to confirm these dates with pollen spectra indicating pollen zones III and IV spanning the late-Glacial–Holocene junction. No aquatic species were represented in these spectra, so that a relative rise of sea level of at least 36 m during the Holocene is indicated, unless a reduction of about 6 m is made to correct for the subsidence of southeastern England over the last 6500 years suggested by Churchill (1965).

Conclusions

Our paper has ranged wide and drawn information from many scattered sources, but we hope nonetheless to have made a case for the strong influence that Palaeozoic basement structures have had on many of these we now see in the surface Mesozoic and Tertiary rocks of southeastern England.

The tectonic history suggested provides a framework within which many surface structures can be traced back to a basement feature. Lack of borehole information of the nature of the Palaeozoic rocks beneath the Wealden Mesozoic basin, limits the degree to which we can detail a reconstruction of the rocks of the basin floor and their structures. Possibly a clearer picture would emerge from the Bouguer anomaly distribution if areal correction could be made for the varying thicknesses of Mesozoic rocks in the Wealden Basin. More gravity measurements at sea will be needed to complete the picture sketched in figure 1.

The history of the area, in terms of sedimentation and tectonics, inclines us to take the view that basement structures have always been important, either as major palaeogeographic features or in permitting the accommodation of the area to differential subsidence in pace with the filling of its Mesozoic basin. In particular, the expression of the mid-Miocene Alpine earth movements bear the strong imprint of these earlier structures. It is a short step in geological time from this most recent orogeny to the present topographic features of the southeast and its neighbouring sea bed, which also reflect the trends of the Palaeozoic basement structures to a large degree.

Recent advances in the understanding of the deep crustal processes of the continental margins (reviewed by Taylor & Smalley 1969) and detailed dating of recent events by the radiocarbon method (Churchill 1965) and archaeological studies force our acceptance of the reality of the slow subsidence which the southeastern corner of our island is undergoing. It is separate in cause from, but cumulative in effect with, the post-Glacial rise of sea-level. It is obviously vital in the national interest for the short and long term causes and effects of this subsidence to be fully understood, to permit the safe future planning and development of this crowded corner of our country.

We are grateful to Dr K. C. Dunham for the invitation to participate in this meeting. Many of our colleagues at the Institute of Geological Sciences have helped by discussion or through their published works; in particular we would like to thank Mr F. W. Dunning, Curator of the Geological Museum, and Drs W. Bullerwell and D. Masson-Smith of the Geophysics Division.

Our thanks are also due to the National Coal Board for information from the Kent Coalfield, and permission to include Mr P. L. Rumsby's Appendix. The Channel Tunnel Division of the Department of the Environment has kindly permitted the inclusion of material from the recent investigations in the Strait of Dover. The Hydrographic Department of the Admiralty have permitted the incorporation of gravity measurements made aboard H.M.S. *Hydra* in 1968. Finally, our French colleague Monsieur J.-P. Destombes commands our thanks for friendly discussion and information from his unpublished work on the Boulonnais. The illustrations have been prepared in the Drawing Office of the Institute of Geological Sciences.

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