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

The Stratigraphy of the Post-Palaeozoic Sequences in Part of the Western Channel [and Discussion]

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The stratigraphy of the post-Palaeozoic sequences in part of the western Channel

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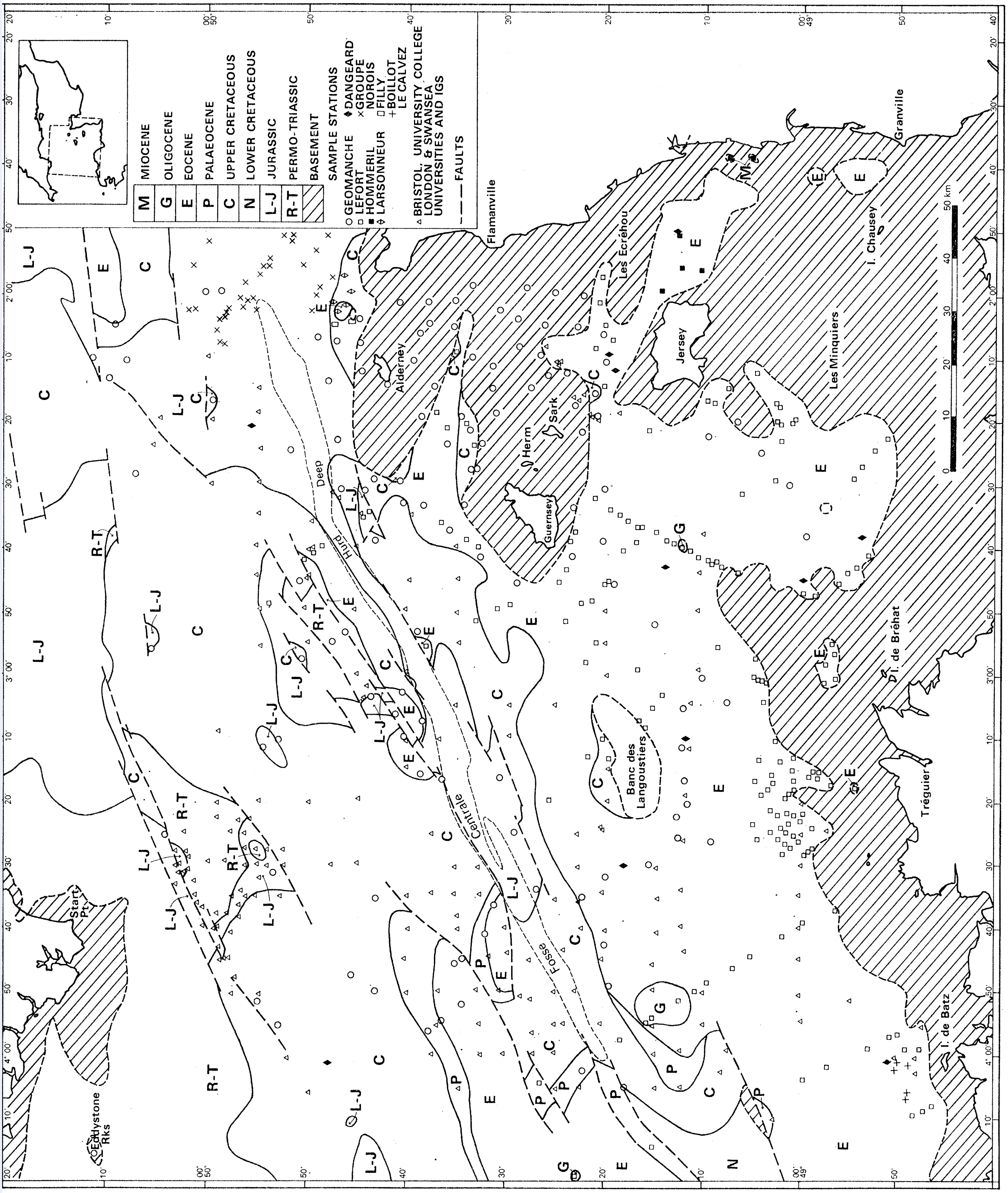
The micropalaeontological investigation of rock samples collected in the western part of the English Channel during the Anglo-French research cruise Géomanche II together with samples collected by French and British university workers, have been used to produce a stratigraphic synthesis of the area. The age determinations of samples ranges from Permo-Triassic to Neogene.

The interpretation of the structure is based upon continuous reflexion seismic profiling obtained during the Géomanche I cruise. The major structural feature of the area is the large syncline with its axial plane striking WSW–ENE and its axis plunging gently westwards. Two important structures include the structural high between Jersey and Start Point and the Alderney–Ushant structural line. The paper includes a geological map and a list of sample stations.

1. Introduction

This paper is concerned with the stratigraphy of the post-Palaeozoic sediments in the eastern part of the western Channel and in particular with the area covered by the Guernsey sheet. The forthcoming Guernsey sheet is a geological map on the 1:250000 Universal Transverse Mercator scale covering the area from latitude 49° 00′ N to 50° 00′ N and longitude 2° 00′ W to 4° 00′ W which will be published jointly by the Institute of Geological Sciences (I.G.S.) and the Bureau de Recherches Géologiques et Minières (B.R.G.M.). It forms one of a series of maps, at this scale, of the Continental Shelf being produced by the I.G.S.

This account is based upon the results of the Géomanche projects I and II which were carried out on the French research vessel *Noroit* using continuous reflexion profiling equipment, supplemented by gravity core sampling. This Franco-British sampling programme was directed by Ph. Bouysse assisted by P. Andreieff, J.-P. Auffret, A. Crosby, B. N. Fletcher, P. Hommeril, F. Le Lann, G. Monclar and G. Quarantotti. The total number of bedrock samples obtained was 131 and micropalaeontological determinations were made on 82 of these core samples by P. Andreieff, D. Curry and C. Monciardini. In addition, a total of 178 samples previously taken by British workers at Bristol University, University College London and University College Swansea have been used in the stratigraphic synthesis, together with those by the French workers J. P. Lefort (Lefort 1970*a*, *b*; Andreieff & Lefort 1972), L. Dangeard (1928),



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G. Fily (1972), the Groupe Norois (1972), P. Hommeril (1967) and C. Larsonneur (1972). Samples referred to in this paper are listed in Appendix A.

The boundary of the post-Palaeozoic cover is based upon the work of J. P. Lefort (1970*a*) and P. Giresse, P. Hommeril & M. Lamboy (1972).

Additional continuous seismic profiling has recently been completed in the area by the I.G.S. This has not been included in the map with this paper (figure 1) but will be incorporated in the forthcoming publication of the Guernsey sheet.

The major structural feature of the area is the large syncline with its axial plane striking WSW–ENE and its axis plunging gently westwards towards the edge of the Continental Shelf. To the northwest and southeast it is flanked by Palaeozoic and basement rocks. The main faulting trends WSW–ENE parallel to the fold axis. One of the major faults in the area is that to the northwest of the Hurd deep which brings Eocene beds against the Triassic.

Two important structures include the structural high between Jersey and Start Point which separates two unequally subsiding areas, and the Alderney–Ushant structural line, southeast of which the basement has remained a positive area where marine Jurassic was probably never deposited. The detailed structural interpretation of the continuous reflexion profiling of the Géomanche I and II campaigns is described elsewhere in this volume (Bouysse, Horn, Lefort & Le Lann 1974).

2. Stratigraphy

(*a*) *Permo-Triassic*

Brick-red clays and sandstones of presumed Permo-Triassic age extend seawards into the area from the pre-Permian rocks of south Devon. They have been proved at SB stations 648, 649, 655, 656, 660, 1130, 1139, 1141, 1182, 1183, 1191, 1293, 1294, 1308, 1309, 1312 and 1315. SB1182 is a fine-grained sandstone; all of the others are clays. Presumed Triassic beds occur also in the upfaulted region around 49° 45′ N, 3° W. Samples GM33 and GM34 are coarse brick-red sands and SB1621 is a red silty clay. SB1622 is a pale green silty clay, while samples IGS177 and 180 are mottled green and red mudstone of Keuper Marl lithology. These samples have yielded no fossils.

(*b*) *Liassic*

Pale calcareous marls with small dolomite rhombs were collected at SB stations around 49° 55′ N between 3° 25′ and 3° 35′ W. Pale grey-green clays have been found at 1122, 1132, 1133, 1134, 1138, 1140 and 1142. Pale buff limestones occur at 1125, 1126, 1136 and 1317. Only 1126 has yielded fossils; it contains the ostracod *Ogmoconcha* in abundance. In the general absence of fossils it is not possible to date these samples closely and as they show certain lithological similarities to the Tea Green Marls it may be that they should be referred to the Triassic.

SB samples of grey mudstones from the region of 50° 03′ N, 3° 30′ W have yielded the foraminiferids *Geinitzinita tenera* (Terquem) (1288, 1290, 1295, 1300); *Marginulina prima* d'Orb. (1284, 1295, 1300); *Ichthyolaria sulcata* (Bornemann) (1284). In these samples small, smooth ostracods are not uncommon, of unidentified species which can be matched in the Hettangian and Sinemurian of Lyme Regis. This series of ostracods, with ?*Geinitzinita* occurs also in SB1148, seven miles to the southeast. The above samples are dated as Lower Lias. Dark grey shales with brown flecks and layers of 'beef' were cored at SB1280 and 1282. They yielded no identified fossils but probably are also of the same age. Eastwards of the 1200 series of samples, GM38, a fine-grained sparite with rare spicules and echinoderm remains, has yielded a microflora including *Perinopollenites elatoides* Couper, *Tsugaepollenites mesozoicus* Couper, *Classopollis bussoni* Reyre and Tasmanaceae, and on that evidence is dated as Upper Liassic.

Samples GM51 and 52, collected to the north of Alderney, are micrites with gastropods, rare ostracods and echinoderm fragments. They are dated as Lower Lias on the basis of the following microflora, recovered from GM52: *Apiculatisporites parvispinosus* (Lech.), *Camarozonosporites aulosenensis* Schulz, *Heliosporites altmarkensis* (Schulz). Farther north again, a grey clay (SB1588) has yielded *Ichthyolaria sulcata* with *Marginulina* cf. *prima* and ?*Geinitzinita* and is probably also Lower Liassic. A sample nearby (SB1587) is a buff calcareous sandstone with *Lenticulina orbignyi* (Roemer), *Trocholina* sp., *Ogmoconcha* sp. and small, ornate ostracods. It is probably Middle or Upper Liassic.

Two samples, GM27 and GM46, which have yielded only a microflora, are dated as probably Liassic. GM27, from the area to the NW of the Hurd Deep, is a micrite with a poor assemblage including *Deltoidospora* sp., *Classopollis* type *classoides*, *C.* type *torosus*. GM46, in the northeastern part of the area, is a black clay with a rich assemblage of pollens and microplankton dominated by *Classopollis* (90 % of the population), together with *Tsugaepollenites mesozoicus*, *Piceaepollenites alatus* Potonié, *Cymatiosphaera* cf. *pachytheca* (Eis.) and *Micrhystridium hymensis variglissum* Wall. Finally, sample IGS182 has yielded an assemblage of miospores and microplankton which is dominated by *Classopollis torosus* (Reissinger) and also includes *Heliosporites altmarkensis*, *Cymatiosphaera* sp., *Baltisphaeridium delicatum* Wall and *Micrhystridium* cf. *stellatum* Deflandre. The flora suggests a possible Hettangian or Sinemurian age.

(*c*) *Bathonian*

Ten samples in all are considered to be Bathonian. SB1076 and SB1647 were collected in the narrow strip of Jurassic beds along the Hurd Deep. SB1627 is from the nearby faulted inlier west of Jersey and the remainder were collected from the large expanse of Jurassic to the northwest of the Cotentin. GM43 has yielded a rich microfauna of foraminiferids and ostracods which indicates an Upper Bathonian age. It includes *Verneuilina haeusleri* (Galloway), *Paalzowella feifeli* (Paalzow), *Planularia tricarinella* (Reuss), *Oligocythereis* gr. *fullonica* (Jones), *Parariscus bathonicus* Oertli and *Acanthocythere spinisulcata* Bradley. SB1627, an oolitic microbiosparite, with abundant molluscan, polyzoan and crinoid remains, contains a similar microfauna. SB samples 1076, 1585, 1605 and 1607 are cream or pale grey biosparites and 1606 is a grey mudstone. All contain spicules and molluscan fragments and all have yielded rather small microfaunas which however include *V. haeusleri* and so suggest a Bathonian age.

GM48 is dated as Bathonian on the following ostracod assemblage: *Praeschuleridea caudata* (Donze), *Lophocythere* cf. *ostreata* (Jones & Sherborn), *Oligocythereis bouvadensis* Depeche, *Bradyana* sp., *Pleurocythere* sp. GM44, with no distinctive calcareous microfauna, has yielded an Upper Bathonian suite of pollens and microplankton including *Zonalopollenites trilobatus* Balme, *Z. dampieri* Balme, *Matonisporites equiexinus* Couper, *Rhaetogonyaulax* sp. and *Nannoceratopsis* cf. *pellucida* Deflandre.

Finally, GM41, a blue-grey marl has yielded a microfauna without highly distinctive elements. These include *Lenticulina subalata* (Reuss), *L.* gr. *muensteri* (Roemer), *Oligocythereis* cf. *fullonica*, *O. bouvadensis*, *Cytherella* cf. *collapsa* Grekoff. This sample is either Upper Bathonian or Lower Callovian.

(d) *Jurassic undifferentiated*

Several samples have yielded pollen assemblages of a Jurassic aspect. GM36, collected northwest of the Hurd Deep, is a purple marl with *Pteruchipollenites* cf. *microsaccus* Couper, *Perinopollenites elatoides* Couper, *Inaperturipollenites* sp. and *Classopollis*. Its facies resembles that of the nearby Triassic. Taken southeast of the Deep, three samples of grey-green clay (GM150, 151, 152) are dated as Jurassic on the presence of *Sphaeripollenites* with diatoms in GM151. GM53, collected northwest of Alderney, is a micrite with *Micrhystridium fragile* Deflandre, *Crassosphaera* sp. and *Classopollis* sp. A particularly interesting sample of black carbonaceous rock (GM95), taken south of Alderney and west of Flamanville, is possibly of Middle Jurassic age. It has yielded *Densoisporites perinatus* Couper, *Perinopollenites elatoides* and *Zonalopollenites triangularis* (Levet-Carette). It appears to be a continental deposit, resting on Basement, and suggests that the region of the Channel Islands was emergent in mid-Jurassic times. Finally, three samples of beige micrites (GM8, GM30, SB1582) are dated as Jurassic on seismic evidence.

(e) *Lower Cretaceous*

The area of Lower Cretaceous beds of continental aspect mapped by Curry, Hamilton & Smith (1970) appears not to extend eastwards into the region covered by the proposed Guernsey sheet.

(f) *Upper Cretaceous*

Upper Cretaceous beds occupy most of the northwestern sector of the map west of 2° 30′ W, extending from its northerly and westerly boundaries towards and somewhat beyond the Hurd Deep. Immediately to the south of the Hurd Deep the outcrop continues eastwards in a narrow strip off the north coast of the Cherbourg peninsula. Farther south again, outliers occur close to the Banc des Langoustiers, between Guernsey and Alderney and between Guernsey and Jersey. In addition an outlier occurs at 50° N, 2° 17′ W (GM 47) and another at 49° 51′ N, 2° 57′ W (GM31). Each of these outliers is downfaulted along its northern flank.

Everywhere the lowest Upper Cretaceous beds rest unconformably on earlier strata. This sub-Upper Cretaceous unconformity develops progressively westwards from the regions of Dorset and Cap d'Antifer respectively. South of Start Point the Upper Cretaceous rests on Triassic or Liassic beds; along the Hurd Deep it rests mostly on Middle Jurassic beds, but also locally on Trias or Lias. Near the Channel Islands and the Banc des Langoustiers it rests on Basement.

Lithologically the Upper Cretaceous beds are comparable with those of southern England and northern France. They are more or less well cemented biomicrites with variable amounts of bioclastic components such as prisms of *Inoceramus*, foraminiferids, echinoid fragments and, in some samples, abundant polyzoans. Their fauna indicates that they are wholly marine. Samples taken near the base of the local sequence may contain glauconite or quartz grains, and dolomite rhombs occur in several samples (GM35, GM42, GM53, SB1092, 1093, 1626).

Five samples are considered to be of Cenomanian age. Of the remaining samples which have been dated none appears to be earlier than Coniacian. One is dated as doubtfully Coniacian and six as Santonian. Of the remainder more than one third are probably Campanian and the rest are regarded as Maestrichtian.

(i) *Cenomanian*

These are samples GM5, 6, 47, SB475, 1599. All were taken in the nothernmost part of the area, close to the Jurassic–Cretaceous boundary and all are of glauconitic, calcareous sandstone. The facies of this group of samples is well known in the marginal Upper Cretaceous of Sarthe and northern Aquitaine (France) and Devon (England). The presence in samples GM5 and GM47 of *Orbitolina* sp. of an advanced type, known in the Lower Cenomanian of these regions, provides evidence for the dating here proposed. *Rotalipora* cf. *cushmani* (Morrow) and *Praeglobotruncana* sp. were seen in thin sections of GM6 and SB475, which are therefore probably Middle or Upper Cenomanian. GM6 contained also *Hedbergella* sp., *Pithonella* sp., together with *Gavelinella* sp., *Lenticulina* sp. and Textulariidae.

(ii) *Coniacian*

For the dating of post-Cenomanian samples, comparison was made with the microfaunas of 40 samples collected serially in the well-documented section (Barr 1962, 1966) at Culver Cliff, at the eastern end of the Isle of Wight. SB1105 is a glauconitic chalk taken very close to the Jurassic boundary south of the Hurd Deep. It contains *Globotruncana lapparenti coronata* Bolli, *Allomorphina* sp., *Gublerina* sp., *Eouvigerina aculeata* (Ehr.), *E. gracilis* (Egger), *Gavelinopsis eriksdalensis* (Brotzen), *Loxostomum eleyi* (Cushman). *L. eleyi* in the absence of *Stensioeina* suggests that this sample is of Cortestudinarium age. *Gublerina* has not, it seems, previously been recorded from NW Europe.

(iii) *Santonian*

Zoning from Santonian times onwards is based in part on the successive occurrences of species of *Bolivinoides*, such as *strigillatus* (Chapman), Uintacrinus-Marsupites; *culverensis* Barr, Pillula-Quadratus; *decoratus* (Wright), Mucronata; *giganteus* Hiltermann & Koch, Maestrichtian. Some species of *Pseudovalvulineria* are also of value: *pseudoexcolata* (Kalinin), Uintacrinus, rare later; *glabra* Goel, Pillula and Quadratus; *clementiana* (d'Orb.), Mucronata. Of the samples here considered to be Santonian SB455 and SB1096 have yielded *B. strigillatus*. *B. culverensis* occurs in SB652 and SB1614. GM31, SB237, 455 and 1614 have yielded *P. pseudoexcolata*. GM31, SB237, 455, 1614 contain *Stensioeina*, which first appears in the Coranguinum Zone. Other species present in this group of samples include *Gavelinella stelligera* (Marie), *G. pertusa* (Marsson), *G. costata* Brotzen and *Pyramidina cushmani* (Brotzen). One specimen of what appears to be *Planoglobulina* was found in SB455. On the basis of this analysis SB455 and 1096 are believed to be Lower Santonian, SB1614 to be Upper Santonian and GM31, SB237 and 652 are not dated more precisely than Santonian.

Samples GM31, SB1096 and 1614 occur near the base of the Chalk sequence along the line of the Hurd Deep and SB455 occurs near the crest of an anticline in the same area. SB237 is near to the boundary with the Liassic SSW of Start Point.

(iv) *Campanian*

In addition to species already mentioned the following are useful guide forms. The species-group *Praebulimina cushmani* (Sandidge) – *laevis* (Beissel) first appears in late Santonian times, when adult specimens are about 2 mm long. The mean dimensions increase with time and at the Campanian–Maestrichtian boundary the length is 4–5 mm. Finally at high Maestrichtian levels adults may be 6–8 mm long. *Gavelinopsis voltziana* (d'Orb.) is dominant from the top of the Quadratus Zone onwards and it also increases in mean size with time. *G. monterelensis* Marie appears in the Mucronata Zone but is more common in the Lower Maestrichtian. *Globorotalites meudonensis* Goel is a short-ranged form in the highest Campanian. *Bolivina incrassata* Reuss appears at about the same time and is common throughout the Maestrichtian. *Pullenia* is not uncommon.

Of the samples to which a Campanian age has been allocated six only (GM54, 153, SB453, 456, 1094 and 1098) have yielded good faunas. All have yielded *G. voltziana* and *P. laevis* of moderate size. *G. monterelensis* occurs in GM40, 153 and SB1094. *Bolivinoides decoratus* occurs in GM54, 153, SB453, 456 and 1098, and *B. laevigatus* Marie in SB1094. *Pseudovalvulineria clementiana* occurs in SB456 and 1094. *G. meudonensis* is present in SB453, 1094 and 1098 and *B. incrassata* in SB1098. These samples are therefore placed in the Upper Campanian and SB453, 1094 and 1098 must be close to the Maestrichtian boundary. Samples SB1144, 1589, 1614 and Q2 contain *B. culverensis* with small *G. voltziana*. They are probably Lower Campanian. GM40 and SB70 contain *B. ?decoratus* and GM samples 9, 10, 24, 29, 39 and 85 and SB samples 248, 622, 634, 1199, 1591, 1592 and 1596 have yielded *G. voltziana* and are probably Campanian but may be Maestrichtian. Finally SB623 and 1603 contain large *G. voltziana* with *Bolivinoides* intermediate between *decoratus* and *giganteus*. They are probably highest Campanian or lowest Maestrichtian.

(v) *Maestrichtian*

No faunas of Maestrichtian age are known from nearby land except in the Calcaire à *Baculites* of the region of Valognes, Manche. This is a thin (20 m) biocalcarenite believed to be of Upper Maestrichtian age (Hofker 1959; Curry 1962). Its rich fauna appears to be uniform throughout so it is of no value for establishing a local faunal sequence. Reference has been made therefore to the faunas of beds of lowest Maestrichtian age exposed on the coast of Norfolk and to sequences in Holland, North Germany and Denmark (see Hofker 1957).

Among forms found in the chalks of the area of the present study, species occurring for the first time in the Lower Maestrichtian beds of Trimingham, Norfolk include *Gavelinella ekblomi* (Brotzen) and *Tappanina selmensis* (Cushman). Several of the species mentioned by Hofker as characterizing the Maestrichtian of Denmark and North Germany also are present. These include *Bolivinoides giganteus*, *Gavelinella incerta* Hofker, *Eponides toulmini* Brotzen, *E. beisseli* Schijfsma, *Coleites reticulosus* (Plummer), *Anomalinoides nobilis* Brotzen, *Pyramidina cristata* (Marsson) and *P. cimbrica* (Troelsen). *Racemiguembelina fructicosa* (Egger), confined in Denmark to the highest beds of the Maestrichtian (cf. Hofker 1957, pp. 424, 444), occurs in some samples. *Gavelinopsis voltziana*, *Praebulimina laevis*, *Bolivina incrassata*, *B. plaita* Carsey and *Eponides biconvexa* Marie, which range up from the Campanian, are abundant and *Anomalinoides* cf. *danicus* Brotzen occurs frequently. Also present are species of *Stensioeina* and *Eouvigerina*.

It was suspected that more than one distinct faunal assemblage might be present among the samples believed to be of Maestrichtian age. The faunas of 20 samples were therefore analysed using the method described by Curry (1975). This analysis showed strong positive correlations between the species *R. fructicosa*, *E. toulmini*, *T. selmensis*, *Globotruncana arca* (Cushman) and *G. stuarti* (de Lapp.). This group is identified as Group A. There is a positive correlation between occurrences of *Stensioeina*, *Eouvigerina*, *E. biconvexa* and *A.* cf. *danicus*, here identified as Group B. Other species listed show no strong correlations either with Group A or Group B. As *R. fructicosa* and *E. toulmini* are confined to Upper Maestrichtian beds in northern Europe it is suggested that the presence of Group A indicates an Upper Maestrichtian age. The presence of Group B, in the absence of Group A, is taken to indicate a Lower Maestrichtian age. Samples in which neither Group A nor Group B occurs are not more closely dated than Maestrichtian.

On the basis of the above analysis many samples appear to be of Lower Maestrichtian age. They include the following from the SB series: 157, 457, 633, 825, 1078, 1090, 1091, 1092, 1093, 1097, 1626 and 1645. The following samples of the SB series – 178, 454, 624, 627, 1067, 1634, 1638 and 1639 – contain the Group A fauna and so are dated as Upper Maestrichtian. Sample GM58 and samples from the SB series 288, 625, 626, 632, 824, 1581, 1615, 1624 and 1644, and sample R2, containing one or more Maestrichtian markers, could not be dated more precisely than Maestrichtian.

Three samples (GM69, 76, 110), taken near Guernsey close to Basement, are of special interest as they have yielded *Globotruncana gansseri* Bolli, *G. stuarti* and (in 69 and 76) the important *G. contusa* (Cushman). The last has not previously been found in the Channel, though it occurs in the Calcaire à *Baculites*. In addition, GM110 contains *Racemiguembelina*. The samples are no doubt of Maestrichtian age. Sample GM74, containing *B. incrassata*, *Gavelinopsis* cf. *involuta* (Reuss), *Bolivinoides australis* Edgell and *Globotruncana stuartiformis* Dalbiez, is highest Campanian or Maestrichtian.

(vi) *Upper Cretaceous undifferentiated*

The following samples of indurated Chalk have been dated on thin sections: GM42, 148, 157, post-Middle Turonian (*Globotruncana* cf. *linneiana* (d'Orb.); GM35, Campanian (*G. voltziana* and *P. clementiana*); GM45, 59, 84, probably Maestrichtian (*G. involuta*).

(vii) *Stratigraphical comments*

Everywhere the Upper Cretaceous beds are horizontal or nearly so and dips rarely exceed 1–2°. Two c.s.p. traverses south of Start Point between 49° 40′ and 50° N give two-way travel times through the complete succession of about 230 ms. At an estimated velocity of 2.2 km/s this gives a thickness of 250 m. The maximum thickness recorded southeast of Start Point (at 50° 03′ N, 3° 13′ W) in an incomplete succession (base to Upper Campanian; see sample 1596, with *G. voltziana*, *B. plaita*, *P.* cf. *cimbrica*) is 140 m. Adjacent to the Hurd Deep at about 2° 50′ W two pairs of traverses suggest a thickness of the total succession on the northwest side of about 150 m, with perhaps 130 m to the southeast. In this region the majority of the samples are Maestrichtian. The solitary Santonian (SB1614) and Lower Campanian (Q2) samples nearby are both glauconitic and invite comparison with the marginal Cenomanian already referred to. Samples taken close to the Banc à Langoustiers and near Guernsey and Alderney are exclusively Maestrichtian and some are taken very close to Basement.

The distribution of samples in relation to the observed thicknesses suggests that Turonian chalks may be absent from the area, that the Albian and/or Cenomanian are very thin and restricted to the northern part of the map and that they may well be absent altogether in the region of the Start–Cotentin 'high'. Santonian and perhaps even Campanian chalks may be absent from the region underlain by Basement at shallow depth southeast of the Alderney–Ushant line. As suggested by Larsonneur (1972), this area may have been transgressed only in the Maestrichtian. Tentative maximum thicknesses for the stages are: Cenomanian, Coniacian and Santonian, locally, up to 30 m each; Campanian and Maestrichtian, each about 100–120 m.

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(g) *Palaeocene*

In this paper the Danian stage is included in the Palaeocene. Palaeocene beds have been found only in the more central parts of the English Channel in a region between Devon and Finistère. They appear to rest comformably on the Maestrichtian and to be overlain with unconformity by Upper Lutetian beds.

(i) *Danian and/or Montian*

These are marine biomicrites of high porosity, typically with small (less than 0.1 mm) biogenic components. Microspar may occur and one sample (1101) is an uncemented arenite. Foraminiferids are abundant and polyzoan and echinoderm fragments may be present. Planktonic foraminiferids occur more or less commonly in all samples. The association of the species *Globigerina pseudobulloides*, *G. triloculinoides* Plummer and *Globoconusa daubjergensis* (Brönnimann) is particularly characteristic of the type Danian. Forms of the *G. pseudobulloides – varianta* (Subbotina) group occur in GM11, and SB samples 165, 291, 452, 462, 463, 471, 1066 and 1101; *G. daubjergensis* in 165, 291, 1064, 1095 and 1101; *G. triloculinoides* in GM11, SB291 and 1095; forms of the *Globorotalia compressa* (Plummer)–*ehrenbergi* Bolli group are present in GM11, SB462 and 463. Among the benthonic foraminiferids *Eponides toulmini*, *Tappanina selmensis*, *Gavelinella ekblomi* and *Coleites reticulosus* survive from the Maestrichtian while important newcomers are *Alabamina dorsoplana* (Brotzen), *Bolivinopsis scanica* Brotzen, *Pseudoparrella meeternae* Visser and *Pulsiphonina prima* (Plummer). By comparison with the type Danian there is a high proportion of genera indicating shallow water, such as *Rosalina*, *Epistominella* and ?*Pararotalia*. *Elphidium primum* ten Dam (present in SB1064, 1095 and 1101) provides a similar indication. While most of the samples are clearly Danian, the presence of *Globorotalia perclara* Loeblich & Tappan (known from the Selandian, but not the Danian, of Denmark) in SB1095 and of *G.* cf. *ehrenbergi* in GM11 suggests that these samples are of Selandian (? = Montian) age. They may thus be referable to the *Globorotalia uncinata* Zone of Bolli (1957), and Zone P2 of Berggren (1971). Sample 464, without determined fossils, is included in this section on the basis of its lithology.

(ii) *Thanetian*

Andreieff & Lefort (1972) ascribed to the Thanetian a sample (302) of grey marine sandy clay with a well-preserved microfauna, which, however, included no planktonic Foraminifera. No other sample of this age has been recognized in the area.

Samples GM15 and GM146 are biocalcarenites, thin sections of which display indeterminate thin-walled globigerinids. From this fact and their geographical position they are assumed to be of Palaeocene age.

(h) *Eocene*

Eocene beds occupy a band some 40 km in average width which extends in a west-southwest direction from the Channel Islands. To the eastwards the outcrop continues between Guernsey and Alderney and also between Sark and Les Ecréhou on the northeast and Jersey on the northwest. It also occupies a large area in the centre of the Bay of St Malo.

Eocene beds extend a short distance into the area of the map from the main Western English Channel Syncline at around 49° 35′ N. They are bounded to the south-southeast by members of the WSW–ENE trending system of faults which forms a dominant structural feature in the region of the Hurd Deep. Further to the east along the line of this suite of faults at least two small outliers of Eocene beds have been located in the general latitudes of 49° 40′ to 49° 50′ N. A small outlier also occurs in a region about 10 km northwest of Cap de la Hague.

Around the Channel Islands and along the north coast of Brittany the Eocene beds rest on Basement, except for small areas northeast of Guernsey and north of the Banc des Langoustiers where they rest on Chalk. In the areas on either side of the Hurd Deep and west of 3° 30′ W the Eocene beds rest, probably disconformably, on the Palaeocene.

Very many samples have been collected from rock in place and descriptions of lithologies and faunas have been given by Curry (1960), Bignot & Hommeril (1964), Bignot, Hommeril & Larsonneur (1968), Lefort (1970*a*, *b*) and Andreieff & Lefort (1972). The samples are of predominantly calcareous rocks of marine origin and include biocalcarenites and biomicrites, with sparites and microsparites. Glauconite is present in silty biomicrites and microsparites at the eastern end of the Western English Channel syncline. Typical samples are SB series 67, 458, 465, 468, 469, 1082 and 1103. These possibly indicate lower rates of sedimentation and current agitation. Outside the area, dominantly arenaceous rocks of Middle and Upper Eocene age are present in the region of 49° 45′ N between 4° and 6° W. This situation may be explained by derivation from the higher ground of Devon and Cornwall, whose relief may have been considerable during Eocene times. Near the Brittany coast, on the other hand, quartz is typically rare or absent, except in a few samples taken very close to the contact with Basement, suggesting that the relief of Brittany was low by contrast with that of Cornubia.

Samples have a high content of recognizable organic remains, being composed more or less completely of aggregates of foraminiferids, polyzoans and echinoid fragments, with some ostracods. Calcareous algae and fragments of shells of molluscs may occur, and calcareous algae are present in rock-forming abundance at some sites along the Brittany coast. Curry (1960), Bignot *et al.* (1968) and Andreieff & Lefort (1972) have commented on the faunal content in a stratigraphical context, and Wright & Murray (1972) have analysed the foraminiferal faunas and have drawn conclusions from these about the conditions under which the deposits were laid down.

The oldest beds recognized were described by Lefort (1970*b*) and are limestones with abundant *Nummulites laevigatus* (Brug.) and fish-teeth, collected north-northwest of Tréguier. These are clearly of Lower Lutetian age. In the rest of the samples nummulites and planktonic foraminiferids are absent or very rare and the foraminiferal fauna is dominated by miliolids, agglutinating genera such as *Valvulina* and *Discorinopsis*, and an assemblage of larger benthonic foraminiferids, most of which have tests with a relatively complicated structure. These include especially *Fasciolites* cf. *bosci* (Defr.), *Orbitolites complanatus* Lk., *Gyroidinella magna* Le Calvez, *Linderina brugesi* Schlumberger, *Halkyardia minima* (Liebus) and *Asterocyclina stellata* (d'Archiac). Wright & Murray (1972) have concluded that this assemblage indicates deposition in shallow, warm, more or less hypersaline water and that samples in which miliolids dominate were probably formed in lagoons.

Bignot *et al.* (1968) assigned an Upper Lutetian age to all their samples, but Andreieff & Lefort (1972) suggested for their material that, in addition to the Lower Lutetian occurrence already mentioned, Upper Lutetian, Bartonian and Stampian levels are represented. In the almost complete absence of nummulites and planktonic foraminiferids precise dating has proved difficult. Comparison with Eocene sequences in the Cotentin and Loire-Atlantique is unhelpful because of the apparently short time-span of their deposits. The sequence of time-ranges of benthonic foraminiferid species established on land in the Anglo–Paris–Belgian Basin has been found to be invalid for the western English Channel (Curry 1975), and it has not yet proved possible in this latter area to establish a faunal sequence which is based on a series of core-samples in relation to c.s.p. records of good quality. In these circumstances recourse was made to a statistical analysis, the methodology and results of which are described in (Curry 1975). This identified the presence of two groups of foraminiferid species which tended not to occur in association and which are provisionally regarded as indicating an Upper Lutetian and a Bartonian age respectively. The associations are, briefly, (*a*) *Fasciolites* and the associated species quoted earlier but *not H. minima*, (*b*) *H. minima* and *Discorbis discoides* (d'Orb.).

On the basis of the above analysis the following identifications are proposed: (*a*) Upper Lutetian; GM samples 61, 62, 63, 104, 105, 111, 118, 120, 121, 122, 123, 129, 130, 131, 133, 136, 137, 138, 147, SB samples 74, 451, 458, 465, 468, 826, 1048, 1053, 1054, 1107, 1251, 1253, 1254, 1255, 1256, 1257, 1258, 1633, and other samples as follows: C379, C380, C382, C384, C385, C386, B410, B532, B611, B763, B832, UCL1602 and BE308; (*b*) Bartonian; GM samples 132, 143, 144, SB samples 72, 469, 829, 1061, 1106, 1252; (*c*) Upper Lutetian or Bartonian; GM samples 12, 23, 26, 55, 135, 139, SB samples 67, 290, 1043, 1057, 1058, 1059, 1063, 1082, 1100, 1103, 1108, 1114, 1616, 1628, 1630, 1642; (*d*) Middle or Upper Eocene; the following, without distinctive faunas, could not be more precisely dated: GM samples 13, 60, 70, 134, 142, 145, 154, SB samples 827, 828, 830, 1051, 1065, 1629, 1631, 1640. The following samples have yielded no faunal information and are dated as Palaeogene on their collecting site and lithology: GM samples 18, 125, 140, 141, 155.

Although, as already stated, nummulites and planktonic foraminiferids are infrequent in the Upper Lutetian and Bartonian samples, any such occurrences are important from the point of view both of correlation and of palaeogeography and so they are noted herewith. Nummulites occur in six samples, in quantities as follows: GM104 *N. aturicus* Joly & Leymerie (2); SB74 *N.* cf. *striatus* (Brug.) (1); SB1053 *N.* cf. *variolarius* Lk. (2); SB67, 1043, 1258 *N. spp. indet.* (1 each). In the Aquitaine Basin *N. aturicus* is characteristic of Upper Lutetian horizons and *N. striatus* occurs in the highest Lutetian and in Lower Bartonian beds. *N. variolarius* occurs in Lutetian and in Lower Bartonian beds in the Anglo–Paris–Belgian Basin. It may be significant that all but one of the stations at which nummulites were collected are close to Basement and thus presumably very low in the local Eocene sequence.

Planktonic foraminiferids occur in three samples, all in the western half of the map, as follows: SB74 *Turborotalia* cf. *rotundimarginata* (Subbotina) (2); SB830 *Globigerina* sp. indet. (1); SB1258 *Globigerapsis higginsi* (Bolli) (2). The two named species have been recorded at Lutetian horizons in Belgium and the Paris Basin (Brönnimann *et al.* 1968, pp. 102–3).

(*i*) *Oligocene*

Buff limestone (SB1060) was collected at 49° 15′ N, 3° 49′ W. This has yielded moulds of charophytes and moulds and shells of freshwater gastropods including undetermined species of *Lymnaea* and *Planorbis*. Also found were two complete apertural margins of a species of *Nystia*, which appears to be *N. duchasteli* (Nyst). This gastropod is widespread in early Middle Oligocene times, occurring abundantly in the Hamstead Beds of the Isle of Wight, the Upper Tongrian of Belgium and also in clays overlying the Eocene limestones of the Cotentin (Vieillard & Dollfus 1875, p. 130). Sample SB1060 is thus provisionally dated as Oligocene. In the region westwards of SB1060 Andreieff & Lefort (1972, p. 54) record the presence of marine limestones which they have dated as Stampian. To the west of Jersey they collected a sample of grey clay

(Lefort no. 112) which yielded a brackish microfauna, and which they compared with the type Sannoisian of the Paris Basin.

(j) *Neogene*

Miocene shelly sands of Savignean facies were recorded by Hommeril (1967) from a restricted area seawards of Gouville, on the western side of the Cotentin peninsula.

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Appendix A. List of samples

I.G.S. registered number	sample number	latitude N	longitude W	
		Géomanche II samples		
49/04/129	GM 5	49° 55.5′	3° 50.8′	L. Cenomanian
49/04/130	6	49° 52.6′	3° 55.9′	M. to U. Cenomanian
49/04/132	8	49° 53.6′	3° 30.7′	? Jurassic
49/04/133	9	49° 45.5′	3° 47.7′	U. Campanian or Maestrichtian
49/04/134	10	49° 43.3′	3° 49.9′	U. Campanian or Maestrichtian
49/04/135	11	49° 37.7′	3° 56.4′	Danian (or Montian?)
49/04/136	12	49° 36.5′	3° 54.5′	U. Lutetian or Bartonian
49/04/137	13	49° 34.3′	3° 52.0′	U. Lutetian or Bartonian
49/05/155	15	49° 22.3′	4° 02.5′	Palaeocene
49/04/139	18	49° 32.3′	3° 40.9′	Palaeogene
49/04/144	23	49° 40.6′	3° 09.5′	U. Lutetian or Bartonian
49/04/145	24	49° 41.4′	3° 06.2′	U. Campanian or Maestrichtian
49/04/147	26	49° 40.8′	3° 02.7′	U. Lutetian or Bartonian
49/04/148	27	49° 43.9′	3° 03.6′	Liassic
49/04/151	29	49° 53.2′	3° 10.3′	U. Campanian or Maestrichtian
49/04/152	30	49° 54.3′	3° 11.6′	? Jurassic
49/03/46	31	49° 50.7′	2° 58.0′	U. Campanian
49/03/49	33	49° 47.5′	2° 55.0′	Triassic
49/03/50	34	49° 46.0′	2° 54.0′	Triassic
49/03/51	35	49° 43.5′	2° 39.2′	Campanian
49/03/52	36	49° 51.3′	2° 45.7′	Jurassic

List of samples (*cont.*)

I.G.S. registered number	sample number	latitude N	longitude W	
50/04/30	GM 38	50° 03.9′	3° 25.6′	U. Liassic
50/03/56	39	50° 05.72′	2° 56.3′	U. Campanian or Maestrichtian
50/03/57	40	50° 07.4′	2° 28.7′	U. Campanian or Maestrichtian
50/03/58	41	50° 10.0′	2° 14.5′	U. Bathonian or L. Callovian
50/03/59	42	50° 11.5′	2° 10.9′	U. Cretaceous (M. Turonian or later)
49/02/1	43	49° 59.0′	1° 59.5′	U. Bathonian
50/02/76	44	50° 00.6′	1° 59.9′	U. Bathonian
50/02/60	45	50° 09.6′	2° 06.1′	U. Campanian or Maestrichtian
50/03/61	46	50° 08.4′	2° 10.9′	Liassic
49/03/54	47	49° 59.7′	2° 17.0′	L. Cenomanian
49/03/57	48	49° 52.0′	2° 25.0′	U. Bathonian
49/03/60	51	49° 49.0′	2° 07.0′	Hettangian or Sinemurian
49/03/61	52	49° 48.1′	2° 14.1′	Hettangian or Sinemurian
49/03/62	53	49° 47.2′	2° 23.2′	Jurassic
49/03/63	54	49° 46.6′	2° 31.6′	U. Campanian
49/03/64	55	49° 44.3′	2° 31.1′	U. Lutetian or Bartonian
49/03/67	58	49° 41.0′	2° 29.6′	L. Maestrichtian
49/03/68	59	49° 40.7′	2° 32.9′	U. Campanian or Maestrichtian
49/03/69	60	49° 38.6′	2° 33.5′	Lutetian or Bartonian
49/03/70	61	49° 36.0′	2° 37.4′	U. Lutetian
49/03/71	62	49° 32.8′	2° 41.6′	U. Lutetian
49/03/72	63	49° 29.5′	2° 45.6′	U. Lutetian
49/03/76	67	49° 43.4′	2° 29.5′	Lutetian (remanié)
49/03/78	69	49° 33.7′	2° 27.8′	Maestrichtian
49/03/79	70	49° 36.4′	2° 24.1′	Lutetian or Bartonian
49/03/83	74	49° 35.1′	2° 19.6′	U. Campanian or Maestrichtian
49/03/85	76	49° 33.9′	2° 21.6′	Maestrichtian
49/03/93	84	49° 47.5′	2° 07.6′	U. Campanian or Maestrichtian
49/03/94	85	49° 45.2′	2° 04.3′	U. Campanian or Maestrichtian
49/03/104	95	49° 31.6′	2° 11.6′	Jurassic
49/03/113	104	49° 20.8′	2° 06.5′	U. Lutetian
49/03/114	105	49° 20.5′	2° 10.9′	U. Lutetian
49/03/119	110	49° 21.5′	2° 15.8′	Maestrichtian
49/03/120	111	49° 21.1′	2° 19.3′	U. Lutetian
49/03/127	118	49° 20.4′	2° 30.9′	U. Lutetian
49/03/129	120	49° 23.5′	2° 41.4′	U. Lutetian
48/03/2	121	48° 59.6′	2° 37.7′	U. Lutetian
49/03/132	122	49° 01.8′	2° 29.9′	U. Lutetian
49/03/133	123	49° 04.2′	2° 25.0′	U. Lutetian
49/03/135	125	49° 10.0′	2° 22.3′	Palaeogene
49/03/139	129	49° 20.4′	2° 39.1′	U. Lutetian
49/03/140	130	49° 19.2′	2° 45.8′	U. Lutetian
49/03/130	131	49° 20.0′	2° 47.7′	U. Lutetian
49/04/153	132	49° 10.9′	3° 00.2′	U. Eocene or L. Oligocene
49/04/154	133	49° 07.7′	3° 04.3′	U. Lutetian
49/04/155	134	49° 12.0′	3° 05.2′	Lutetian or Bartonian
49/04/156	135	49° 12.1′	3° 11.5′	U. Lutetian or Bartonian
49/04/157	136	49° 12.0′	3° 16.6′	U. Lutetian
49/04/158	137	49° 11.7′	3° 20.2′	U. Lutetian
49/04/159	138	49° 12.9′	3° 22.2′	U. Lutetian
49/04/160	139	49° 09.3′	3° 26.0′	U. Lutetian or Bartonian
49/04/161	140	49° 12.6′	3° 25.7′	Palaeogene
49/04/162	141	49° 15.5′	3° 29.8′	Palaeogene
49/04/163	142	49° 20.0′	3° 31.7′	Lutetian or Bartonian
49/04/164	143	49° 22.4′	3° 35.0′	U. Eocene or L. Oligocene
49/04/165	144	49° 20.0′	3° 42.8′	U. Eocene or L. Oligocene
49/04/166	145	49° 19.9′	3° 49.2′	Lutetian–Bartonian
49/05/164	146	49° 17.7′	4° 05.5′	Palaeocene

I.G.S. registered number	sample number	latitude N	longitude W	
49/04/167	GM 147	49° 35.4′	3° 45.4′	U. Lutetian
49/04/168	148	49° 43.2′	3° 35.1′	U. Cretaceous (M. Turonian or later)
49/04/169	149	49° 31.5′	3° 36.2′	U. Lutetian
49/04/170	150	49° 27.1′	3° 33.6′	? Jurassic
49/04/171	151	49° 29.6′	3° 24.8′	Jurassic
49/04/172	152	49° 30.7′	3° 16.5′	? Jurassic
49/04/173	153	49° 36.5′	3° 16.6′	U. Campanian
49/04/174	154	49° 39.2′	3° 15.5′	Lutetian or Bartonian
49/04/175	155	49° 38.7′	3° 07.5′	Palaeogene
49/03/141	157	49° 39.3′	2° 53.4′	Senonian
		Bristol University samples		
49/04/187	SB 67	49° 30′	4° 00′	U. Lutetian or Bartonian
49/04/183	70	49° 07.0′	4° 00.0′	Campanian or Maestrichtian
49/04/188	72	49° 02.0′	4° 00.0′	Bartonian
49/04/189	74	48° 50.0′	4° 00.0′	U. Lutetian
49/05/42	157	49°08.0′	4° 03.0′	L. Maestrichtian
49/05/46	165	49° 03.0′	4° 10.0′	Danian
49/05/56	178	49° 06.0′	4° 03.0′	U. Maestrichtian
49/05/171	237	49° 52.2′	4° 00.0′	Santonian
49/05/63	248	49° 50.0′	4° 05.0′	Campanian or Maestrichtian
49/04/125	288	49° 37.6′	3° 59.4′	Maestrichtian
49/04/126	290	49° 32.7′	3° 59.8′	U. Lutetian or Bartonian
49/05/172	291	49° 34.7′	4° 05.0′	Danian
49/05/88	451	49° 22.5′	4° 05.0′	U. Lutetian
49/05/89	452	49° 25.0′	4° 05.5′	Danian
49/04/185	453	49° 25.0′	4° 00.0′	U. Campanian
49/05/91	454	49° 27.3′	4° 00.0′	U. Maestrichtian
49/04/1	455	49° 27.4′	3° 56.2′	L. Santonian
49/04/2	456	49° 27.6′	3° 51.0′	U. Campanian
49/04/3	457	49° 28.6′	3° 50.5′	L. Maestrichtian
49/04/4	458	49° 29.9′	3° 43.6′	U. Lutetian
49/04/6	462	49° 40.1′	3° 39.9′	Danian
49/04/7	463	49° 40.4′	3° 44.8′	Danian
49/04/8	464	49° 40.0′	3° 50.0′	? Danian
49/04/9	465	49° 37.0′	3° 49.7′	U. Lutetian
49/04/10	468	49° 30.9′	3° 49.6′	U. Lutetian
49/04/11	469	49° 32.4′	3° 54.9′	Bartonian
49/04/13	471	49° 37.2′	3° 55.0′	Danian
49/04/15	475	49° 58.2′	3° 44.3′	Cenomanian
49/04/17	622	49° 40.1′	3° 34.7′	Campanian or Maestrichtian
49/04/18	623	49° 37.6′	3° 34.2′	U. Campanian or L. Maestrichtian
49/04/19	624	49° 32.5′	3° 34.3′	U. Maestrichtian
49/04/20	625	49° 35.4′	3° 34.3′	Maestrichtian
49/04/21	626	49° 35.1′	3° 37.3′	Maestrichtian
49/04/22	627	49° 35.1′	3° 39.9′	U. Maestrichtian
49/04/23	632	49° 45.0′	3° 19.5′	Maestrichtian
49/04/24	633	49° 50.0′	3° 20.1′	L. Maestrichtian
49/04/25	634	49° 54.8′	3° 19.9′	Campanian or Maestrichtian
50/04/22	648	50° 02.6′	3° 25.0′	Triassic
49/04/27	649	49° 57.7′	3° 24.8′	Triassic
49/04/30	652	49° 52.6′	3° 34.8′	Santonian
49/04/32	655	49° 58.4′	3° 29.4′	Triassic
50/04/23	656	50° 0.36′	3° 29.69′	Triassic
49/04/33	660	49° 57.6′	3° 34.8′	Triassic
49/04/35	824	49° 19.9′	3° 15.0′	Maestrichtian
49/04/36	825	49° 19.9′	3° 19.8′	L. Maestrichtian
49/04/37	826	49° 20.4′	3° 23.9′	U. Lutetian
49/04/38	827	49° 20.4′	3° 23.9′	M. or U. Eocene
49/04/39	828	49° 20.3′	3° 34.0′	M. or U. Eocene

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

List of samples (*cont.*)

I.G.S. registered number	sample number	latitude N	longitude W	
49/04/40	SB 829	49° 20.0′	3° 40.2′	Bartonian
49/04/41	830	49° 15.2′	3° 45.5′	M. or U. Eocene
48/04/1	1043	48° 57.5′	3° 25.0′	U. Lutetian or Bartonian
48/04/2	1048	48° 55.0′	3° 50.0′	U. Lutetian
48/04/3	1051	48° 47.5′	3° 55.0′	M. or U. Eocene
48/05/23	1053	48° 48.0′	4° 00.0′	U. Lutetian
48/05/24	1054	48° 48.0′	4° 02.5′	U. Lutetian
49/04/51	1057	49° 14.8′	3° 30.2′	U. Lutetian or Bartonian
49/04/52	1058	49° 14.7′	3° 35.1′	U. Lutetian or Bartonian
49/04/53	1059	49° 14.7′	3° 40.5′	U. Lutetian or Bartonian
49/04/54	1060	49° 15.2′	3° 49.4′	Oligocene
49/04/55	1061	49° 10.1′	3° 49.9′	Bartonian
49/04/57	1063	49° 15.2′	3° 55.2′	U. Lutetian or Bartonian
49/04/186	1064	49° 15.0′	4° 00.0′	Danian
49/05/142	1065	49° 12.5′	4° 00.0′	M. or U. Eocene
49/05/173	1066	49° 12.5′	4° 05.0′	Danian
49/05/143	1067	49° 15.0′	4° 05.0′	U. Maestrichtian
49/04/59	1076	49° 36.8′	3° 10.3′	Bathonian
49/04/60	1078	49° 29.9′	3° 09.7′	L. Maestrichtian
49/04/62	1082	49° 40.3′	3° 14.6′	U. Lutetian or Bartonian
49/04/67	1090	49° 37.6′	3° 24.7′	L. Maestrichtian
49/04/68	1091	49° 35.4′	3° 30.0′	L. Maestrichtian
49/04/190	1092	49° 33.0′	3° 30.0′	L. Maestrichtian
49/04/69	1093	49° 25.2′	3° 54.9′	L. Maestrichtian
49/04/70	1094	49° 20.6′	3° 54.8′	U. Campanian
49/04/71	1095	49° 24.3′	3° 43.2′	Montian?
49/04/72	1096	49° 23.1′	3° 49.7′	L. Santonian
49/04/73	1097	49° 25.2′	3° 49.9′	L. Maestrichtian
49/04/74	1098	49° 27.7′	3° 44.9′	U. Campanian
49/04/75	1100	49° 20.4′	3° 44.7′	U. Lutetian or Bartonian
49/04/191	1101	49° 22.5′	3° 40.0′	Danian
49/04/76	1103	49° 30.2′	3° 39.6′	U. Lutetian or Bartonian
49/04/77	1105	49° 25.1′	3° 35.4′	? Coniacian
49/04/192	1106	49° 22.5′	3° 35.0′	Bartonian
49/04/78	1107	49° 22.8′	3° 30.3′	U. Lutetian
49/04/193	1108	49° 22.5′	3° 25.0′	U. Lutetian or Bartonian
48/03/3	1114	48° 50.0′	2° 20.0′	U. Lutetian or Bartonian
49/04/82	1122	49° 58.9′	3° 42.9′	? Liassic
49/04/83	1125	49° 59.1′	3° 40.0′	? Liassic
50/04/35	1126	50° 0.2′	3° 40.2′	? Liassic
49/04/85	1130	49° 58.1′	3° 37.6′	Triassic
49/04/87	1132	49° 56.9′	3° 36.0	? Liassic
49/04/88	1133	49° 56.2′	3° 34.7′	? Liassic
49/04/89	1134	49° 56.7′	3° 33.8′	? Liassic
49/04/194	1136	49° 55.0′	3° 32.5′	? Liassic
49/04/90	1138	49° 54.2′	3° 30.0′	? Liassic
49/04/91	1139	49° 56.3′	3° 29.9′	Triassic
49/03/92	1140	49° 56.3′	3° 27.2′	? Liassic
49/04/93	1141	49° 55.2′	3° 27.4′	Triassic
49/04/94	1142	49° 54.1′	3° 27.4′	? Liassic
49/04/95	1144	49° 52.5′	3° 27.4′	(L?) Campanian
49/04/96	1148	49° 56.4′	3° 24.9′	L. Liassic
49/04/97	1182	49° 59.2′	3° 22.4′	Triassic
49/04/98	1183	49° 59.2′	3° 20.1′	Triassic
49/04/103	1191	49° 56.9′	3° 22.9′	Triassic
49/04/107	1199	49° 45.1′	3° 29.6′	Campanian or Maestrichtian
49/04/42	1251	49° 00.0′	3° 54.4′	U. Lutetian
49/04/43	1252	49° 00.2′	3° 50.4′	Bartonian

I.G.S. registered number	sample number	latitude N	longitude W	
49/04/44	SB 1253	49° 00.3′	3° 44.6′	U. Lutetian
49/04/45	1254	49° 00.3′	3° 40.0′	U. Lutetian
49/04/46	1255	49° 00.2′	3° 34.8′	U. Lutetian
49/04/47	1256	49° 00.1′	3° 30.2′	U. Lutetian
49/04/48	1257	49° 00.0′	3° 25.1′	U. Lutetian
48/04/4	1258	49° 00.0′	3° 20.0′	U. Lutetian
50/04/87	1280	50° 03.2′	3° 28.1′	Liassic (L?)
50/04/89	1282	50° 03.02′	3° 30.36′	Liassic (L?)
50/04/91	1284	50° 03.0′	3° 30.4′	L. Liassic
50/04/93	1288	50° 02.6′	3° 31.8′	L. Liassic
50/04/94	1290	50° 02.6′	3° 30.0′	L. Liassic
50/04/96	1293	50° 01.99′	3° 28.0′	Triassic
50/04/177	1294	50° 02.0′	3° 29.0′	Triassic
50/04/97	1295	50° 02.1′	3° 30.9′	L. Liassic
50/04/100	1300	50° 01.8′	3° 35.7′	L. Liassic
50/04/102	1308	50° 00.6′	3° 36.8′	Triassic
50/04/103	1309	50° 01.3′	3° 36.0′	Triassic
50/04/105	1312	50° 01.2′	3° 34.8′	Triassic
50/04/108	1315	50° 01.1′	3° 32.1′	Triassic
49/04/108	1317	49° 58.6′	3° 45.0′	? Liassic
50/03/9	1581	50° 05.3′	2° 24.5′	Maestrichtian
50/03/10	1582	50° 05.0′	2° 20.3′	Jurassic
50/03/13	1585	50° 00.2′	2° 09.9′	Bathonian
49/03/144	1587	49° 59.9′	2° 20.4′	Liassic (M. or U.)
50/03/16	1588	50° 00.1′	2° 25.0′	Liassic (? L.)
49/03/145	1589	49° 59.9′	2° 30.2′	Campanian (? L.)
49/03/157	1591	49° 59.9′	2° 40.2′	Campanian or Maestrichtian
50/03/19	1592	50° 00.1′	2° 45.0′	Campanian or Maestrichtian
50/04/143	1596	50° 00.0′	3° 05.0′	Campanian or Maestrichtian
49/03/158	1599	49° 55.0′	2° 55.0′	? Cenomanian
49/03/6	1603	49° 55.1′	2° 34.7′	U? Campanian or L? Maestrichtian
49/03/8	1605	49° 54.9′	2° 24.7′	Bathonian
49/03/9	1606	49° 55.3′	2° 19.0′	Bathonian
49/03/159	1607	49° 55.0′	2° 15.0′	Bathonian
49/03/15	1614	49° 49.8′	2° 35.8′	U. Santonian
49/03/16	1615	49° 50.2′	2° 40.4′	Maestrichtian
49/03/17	1616	49° 50.4′	2° 44.7′	U. Lutetian or Bartonian
49/04/115	1621	49° 45.1′	3° 04.8′	Triassic
49/04/116	1622	49° 45.3′	3° 00.0′	Triassic
49/03/20	1624	49° 45.4′	2° 49.7′	Maestrichtian
49/03/21	1626	49° 45.2′	2° 39.9′	L. Maestrichtian
49/03/22	1627	49° 44.9′	2° 35.0′	U. Bathonian
49/03/23	1628	49° 23.5′	2° 52.7′	U. Lutetian or Bartonian
49/03/24	1629	49° 20.2′	2° 49.9′	M. or U. Eocene
49/03/25	1630	49° 20.0′	2° 55.0′	U. Lutetian or Bartonian
49/04/117	1631	49° 20.0′	3° 00.2′	M. or U. Eocene
49/04/119	1633	49° 25.1′	3° 04.9′	U. Lutetian
49/04/120	1634	49° 29.9′	3° 40.8′	U. Maestrichtian
49/03/27	1638	49° 35.1′	2° 50.1′	U. Maestrichtian
49/03/28	1639	49° 35.1′	2° 45.0′	U. Maestrichtian
49/03/29	1640	49° 35.0′	2° 40.0′	Eocene
49/03/31	1642	49° 39.9′	2° 35.0′	U. Lutetian or Bartonian
49/03/33	1644	49° 40.0′	2° 45.0′	Maestrichtian
49/03/34	1645	49° 40.4′	2° 49.4′	L. Maestrichtian
49/03/45	1647	49° 40.3′	2° 59.6′	Bathonian

List of samples (*cont.*)

I.G.S. registered number	sample number	latitude N	longitude W	
		Curry (1960) samples		
49/03/160	C 379	49° 10.8′	2° 43.7′	U. Lutetian
49/03/161	380	49° 10.9′	2° 49.8′	U. Lutetian
49/04/195	382	49° 11.6′	3° 04.5′	U. Lutetian
49/04/196	384	49° 12.0′	3° 18.6′	U. Lutetian
49/04/197	385	49° 12.2′	3° 26.0′	U. Lutetian
49/04/198	386	49° 12.3′	3° 33.8′	U. Lutetian
		University College Swansea samples		
49/03/147	S 1	49° 21.2′	2° 20.0′	Lutetian
49/03/148	2	49° 21.5′	2° 19.0′	Lutetian
49/03/149	3	49° 21.8′	2° 18.5′	Eocene
49/03/150	5	49° 22.4′	2° 17.0′	? Devonian ? Triassic
49/03/151	6	49° 22.7′	2° 17.0′	? Devonian ? Triassic
49/03/152	7	49° 23.0′	2° 16.2′	? Devonian ? Triassic
49/03/153	8	49° 24.7′	2° 11.3′	? Lutetian
49/03/154	10	49° 25.5′	2° 12.0′	Eocene
49/03/155	11	49° 25.2′	2° 11.0′	Eocene
49/03/156	12	49° 26.7′	2° 10.0′	Eocene
		Boillot & Le Calvez samples (1961)		
48/05/25	B 410	48° 50.2′	4° 01.6′	Upper Lutetian
48/05/26	532	48° 48.8′	4° 00.6′	Upper Lutetian
48/05/27	611	48° 49.7′	4° 06.4′	Upper Lutetian
48/05/28	763	48° 49.7′	4° 00.2′	Upper Lutetian
48/05/29	832	48° 48.9′	4° 05.7′	Upper Lutetian
		Donovan samples		
49/03/162	Q 2	49° 47.8′	2° 31.8′	Campanian (Lower ?)
49/03/163	R 2	49° 47.1′	2° 32.6′	Maestrichtian
		Institute of Geological Sciences samples		
49/04/177	—	49° 45.2′	3° 04.9′	Triassic
49/04/180	—	49° 44.6′	3° 04.0′	Triassic
49/04/182	—	49° 44.0′	3° 02.0′	L. Liassic
		University College London samples		
49/03/164	UCL 1602	49° 21.0′	2° 19.0′	Upper Lutetian
		Best's sample		
48/03/4	BE 308	48° 52′	2° 39.3′	Upper Lutetian

Discussion

R. McQuillin (*Marine Geophysics Unit*, 15 *Braefoot Terrace*, *Edinburgh* 16)

Mr R. McQuillin commented on the structural features shown on shallow seismic profiles obtained in the western Channel, in particular the high apparent dips seen on Sparker records. He enquired whether true dip values had been calculated from line intersections. Usually, shallow seismic records show highly exaggerated apparent dip angles and it would be of interest to have data on maximum dip values in the more intense structures, as well as regional dip values within the broad basin structures. With regard to folding in Mesozoic rocks, monoclinal and asymmetric folds appear to be common which might suggest that such folding relates to normal faulting in more competent beds lower in the crust. If so this could indicate that the folding took place under conditions of crustal tension, not compression.

D. Curry replied to Mr McQuillin that true dip values have been calculated where possible and these values have been used in regional interpretations. The authors agreed that fold structures in Mesozoic, and indeed in Tertiary strata in other parts of the Channel, reflect fault movements on block boundaries. Caution is required in any interpretation since reversals of movement may have taken place within the history of any one fault and some faults may have had a horizontal component of movement.

C. Pomerol (*Géologie* 1–4, *Université Paris VI*, *France*)

What are the relationships between the Lutetian and Bartonian facies of the western Channel and those of the Paris Basin?

D. Curry replied that the facies of the western Channel show marked similarities to the more calcareous levels within marine developments of the Paris Basin. There is an even closer resemblance to that of the Faluns à Cérithes of the region of Valognes, Manche.