OR/14/008 Introduction


These articles are the formal statement of the lithostratigraphy of Palaeogene deposits of the London Basin, in south-east England, as adopted by the British Geological Survey. It contains a review of the nomenclature used in BGS publications, including maps, and sets out the currently preferred scheme. This review draws heavily on the work of BGS staff, including that published outside BGS, as well as publications and some unpublished work from outside BGS.

The unit descriptions will also appear in the BGS Lexicon of Rock Unit Names (http://www.bgs.ac.uk/Lexicon/home.html), although as time passes the content of the Lexicon may be revised or expanded.

Scope of the articles

The Palaeogene Stratigraphical Framework of England is concerned mainly with the Palaeogene successions found onshore in the London Basin and in adjacent parts of East Anglia. These are mostly considered as formal groups, formations and members. This document does not describe the Palaeogene rocks of the Hampshire Basin, south-west England, Lundy, northern England, Scotland and Northern Ireland, including the ‘British Tertiary Igneous Province’, nor those found offshore in the North Sea, the English Channel, the Western Approaches, the Bristol Channel and Cardigan Bay.

Certain onshore deposits with a relatively restricted distribution resembling that of ‘superficial deposits’, but whose age pre-dates the Quaternary, have been described in the Stratigraphical Framework Report for the Great Britain Superficial Deposits Supergroup (McMillan et al., 2011). These include units of Neogene age: the Crag Group (Plio- Pleistocene) and the St Erth Formation (Pliocene), and the karstic fissure-fill sediments, of Palaeogene–Neogene and possible latest Mesozoic (Cretaceous) age, that are found on the Durham coast and in the Peak District. These deposits, together with the Castle Eden Fissure-fill Formation and the Brasington Formation, have been assigned formal status but currently remain unattached to a group. Remanié deposits originating during the Palaeogene or Neogene (including the Clay-with-flints Formation, the Lenham Formation and the Buchan Gravels Formation) are assigned to the Residual Deposits Group of the Superficial Deposits Supergroup.

Comparison with the Geological Society of London special report of the Tertiary

By coincidence, the production of this report took place during the later stages of compilation of a new Geological Society of London (GSL) Special Report on the Tertiary (King, in prep.; see also Acknowledgements).

Both the GSL Special Report and the BGS Stratigraphical Framework Report (SFR) are intended to provide a summary and synthesis of existing knowledge, incorporating new and unpublished
information as appropriate and possible.

The BGS SFRs have a largely retrospective role: they are intended to set out the stratigraphical framework as it has been used in BGS publications. They can also be used to recommend future practice, and to refer to alternative practice.

This BGS report specifies future usage in BGS output. Neither the BGS nor the GSL report confers any obligation on other users, who are free to choose which report to follow, or neither.

While the respective authors of these two reports largely agree with each other on the geological interpretation of the Palaeogene sequences, there are some differences in the lithostratigraphical schemes presented in the two reports. In some instances these differences reflect different interpretations of stratigraphical relationships or different judgements about the status (especially the rank) of the units described. In others, they reflect differences in approach by geological surveyors and by stratigraphers.

Stratigraphers seek to base their lithostratigraphical interpretations on the highest quality data, from good exposed sections and cored boreholes. However, outside of BGS their work does not, in general, include systematic geological mapping of the units defined by that work.

The BGS 1:50 000 scale geological maps show units that can be recognised in the field, within the limitations of normal field survey in country where geological exposures are rare. While BGS may accept a certain stratigraphical interpretation of a particular section, it will not adopt a stratigraphical subdivision that cannot be traced across largely unexposed ground in favour of one that can.

Indeed, the concept of ‘mappability’ contributes to the definition of a ‘formation’, although what can be mapped with useful accuracy depends on several factors including the scale of mapping. Moreover, it can be argued that (in general) a stratigraphical boundary that is reflected by topographical features is a better indication of broad lithological assemblage than one that is not. The current geological maps show lithostratigraphical units that can be traced in the field, and this BGS framework report primarily reflects what is shown on the geological maps.

However, the evolving change within BGS from production of geological maps based mainly on survey of surface information to production of 3D geological models based largely on available subsurface information (mainly borehole records) may bring about a change in emphasis, and it is possible that stratigraphical interpretations based on exposed sections will then prove to be more useful than those based on ‘mappability’ in open ground. For this reason, amongst others, this report refers to alternative stratigraphical interpretations where appropriate.

**Palaeogeography and depositional basins**

An overview of the Palaeogene depositional basins in the United Kingdom and adjacent offshore areas is given by King (2006, pp.395–396 and 400–440).

The London Basin forms the middle and lower parts of the Thames Valley and also underlies Essex and coastal areas of North Kent, extending eastwards offshore into the southern North Sea Basin. The Late Paleocene to mid-Eocene successions that occur in these onshore areas were deposited mainly in near-shore marine to coastal plain environments, although a relatively deep-water marine unit (the London Clay Formation) was laid down during times of high sea level in the Ypresian.
The Palaeogene sequences of the London Basin thin northwards over a poorly-defined structural axis in southern Suffolk (the Ipswich-Felixstowe High; Jolley, 1992[6]) and thicken into East Anglia. The onshore occurrence of the Palaeogene in East Anglia coincides approximately with the local western margin of the southern North Sea Basin, and comprises Late Paleocene and Early Eocene deposits of marine origin. These crop out in south-east Suffolk, but otherwise are mostly unconformably overlain by formations of Pliocene age (McMillan et al., 2011[2]) and more generally by Quaternary deposits.

At the present day, the London Basin (as defined by the extent of the onshore Palaeogene outcrop as far north as the Ipswich-Felixstowe High) is elongated south-west to north-east, parallel to a regional set of linear structures in the pre-Mesozoic basement of the region (Figure 1). This is seen most clearly at the end of the Chalk dip slope between Reading and Ipswich, and on the southern edge of the London Basin between Guildford and south-east London with the parallel Wimbledon to Greenwich fault system. The Hampshire Basin lies along strike to the south-west, on the same structural trend. This set of structures can be expected to have controlled basin formation.

The southern margin of the London Basin, however, is extensively controlled by east-west structures related to Late Cretaceous to Miocene inversion of the Mesozoic Weald Basin and reactivation of underlying fault structures in the Variscan fold belt of southern England, so creating the London Basin synform (Figure 1). These east-west structural elements, including anticlinal and monoclinal folds and faults, occur in West Berkshire and North Hampshire, in the Hog’s Back area of Surrey, between central London and the Isle of Grain, and in the Isle of Thanet in north-east Kent. In West Berkshire the northern margin of the basin also follows this trend. These east-west segments are offset by structures parallel to the south-west-north-east trend.

Chadwick (1993[7]) regarded the London Basin as a foreland basin on the northern margin of the inverted Wealden Basin, but viewed in a broader context it is clearly a south-western extension from the southern North Sea towards depocentres in the Western Approaches. The London Basin can be perceived as an east-west-oriented syncline but it is more usefully described as a north-east-south-west-oriented synform.

King (2006, and in prep.)[3] refers to a long-running debate about structural control of the London Basin and the extent to which the present outcrop reflects the shape of the original basin. He concludes that during the Eocene, at least, the London Basin and the Hampshire Basin were part of a single depositional basin, while noting that there may have been limited tectonic control of Palaeogene sedimentation. Given the similarities between the sequences in the two areas, it does seem likely that they formed a single essentially continuous depositional basin. However, the terms ‘London Basin’ and ‘Hampshire Basin’ are retained as convenient terms to refer to geographically-separated structural entities.

Stratigraphical Framework

This report is specifically concerned with lithostratigraphy but many other aspects of the stratigraphy of the Palaeogene have been studied in considerable detail. The following notes are summarised from Knox (1996a) [8] and Ogg et al. (2008)[9], and from the other cited sources. The various stratigraphies are also discussed and summarised by Daley (1999a)[10] and, in more detail, by King (2006)[4] and King (in prep.)[3].

Chronostratigraphy

The subdivision of the Palaeogene into epochs and stages has evolved during the course of research
over the past century or so, in terms of the number of divisions, their names, their defining concepts and the perception of their geochronometric age. The currently accepted scheme is shown in Table 1. Care should be taken over usage when considering the correlation of these units as described in older literature.

King (2006, p.397) points out that the base of the Eocene has been placed at the base of a prominent global negative carbon isotope excursion (Aubry et al., 2003), and that in southern England this lies within the Lambeth Group (Collinson et al., 2003). However, he also points out that the base of the Ypresian, the earliest Eocene stage, lies at approximately the base of the London Clay Formation. There is thus a time interval, during which the upper part of the Lambeth Group was deposited, which is currently not assigned to a named stage.

Biostratigraphy

Comprehensive micropalaeontological schemes of biostratigraphical zonation exist for several faunal or floral groups, including planktonic and benthonic foraminiferids (King, 1989; King and Hughes, 1983), calcareous nannofossils (Aubry, 1986; Aubry et al., 1996; Ellison et al., 1996; Knox et al., 1994; radiolaria, diatoms (King, 2006; Mitlehner, 1996), dinoflagellate cysts and other palynomorphs (Islam, 1983; Jolley, 1992, 1996; Jolley, 1998; King, 2006; Powell, 1992; Powell et al., 1996), and molluscs (Curry, 1966; King, 1981, 2006). Some groups are of limited applicability in some environments, and some present difficulties of correlation between deep-water and shallow-water facies, so that the zonal schemes applicable to the whole of north-west Europe, for example, are less detailed than those developed for individual basins. Palynomorphs seem to provide the most effective means of cross-regional correlation. Macrofossil schemes based on mammal faunas are available for each continent (Hooker, 1991, 1996, 1998, 2010; Vasileiadou et al., 2009).

The marine faunas of the Hampshire and London basins are related to those of the North Sea Basin, which reflect its partial isolation from the open ocean and the fact that its main opening was at a relatively high latitude, so that the oceanic influence it received was from the cooler northern ocean, rather than from lower latitudes in the Atlantic (King, 2006).

Magnetostratigraphy

During most of the Palaeogene, the resolution of magnetic polarity chrons is comparable with that of microfossil zones, although the polarity remained constant over certain relatively long periods, notably including the Paleocene-Eocene boundary (Ali, 1994; Ali et al., 1996; Ali et al., 1993; Ali et al., 2003; Ellison et al., 1996; Rhodes et al., 1999; Townsend and Hailwood, 1985).

The magnetostratigraphy of individual units in the London Basin is summarised from these sources, together with some unpublished data, by King (in prep.), who notes that calibration of some Early and Middle Eocene units in the London Basin is based partly on lithostratigraphical correlation with the Hampshire Basin, where available biostratigraphical and magnetostratigraphical data are more extensive.

Stable isotope stratigraphy

Variations in the stable isotopes of carbon and oxygen in oceanic carbonate-rich sedimentary sequences, in particular, have been used to interpret global climatic variation during the Cenozoic, and can be of value in correlation. Certain periods of exceptional warming are associated with global
‘dissolution events’ found in oceanic sequences, notably the PETM (Paleocene-Eocene Thermal Maximum), at the start of the Eocene (Beerling and Jolley, 1998[10], Collinson et al., 2003[12]). Other examples are mentioned by Ogg et al. (2008)[9] and discussed in references therein.

**Radiometric dating**

Radiometric dating has been performed on minerals of volcanic origin and on glauconite (Curry and Odin, 1982[40]). Aside from providing calibration of the time-scales, the age of volcanic material helps to demonstrate the relationship between phases of volcanism and the tectonic and sea-level history of the region as shown by the sedimentary successions.

**Tephrostratigraphy**

As more ash layers have been found, especially in offshore successions, so their value as a long-distance correlation tool has been recognised and developed. Several phases of ash deposition have been recognised, with compositional changes that can be related to the development of crustal rifting in the north-east Atlantic (Knox, 1984[41], 1985[42], 1996a[8]; Knox and Ellison, 1979[43]; Knox and Morton, 1988[44]; Morton and Knox, 1990[45]).

**Cyclic stratigraphy**

Rhythmic variation in carbonate or clay content in deep sea sediments has been correlated with the various Milankovitch cycles for much of the Palaeogene (Ogg et al., 2008[9]; Westerhold et al., 2009[46]; Westerhold et al., 2008[47]).

**Sequence stratigraphy**

Analysis of global sea-level variation and correlation of the corresponding sedimentary successions has been a very useful tool for stratigraphical analysis, and in hydrocarbons exploration. However, as Knox (1996a[8], b[48]) points out, the Palaeogene sequence stratigraphy of north-west Europe should not be considered without reference to the tectonic development of the region, influenced as it was by crustal rifting in the North Atlantic and crustal compression in the Alpine zone.

**The BGS Lexicon of named rock units**

The BGS Lexicon of Named Rock Units, sometimes also known as the BGS Stratigraphic Lexicon or simply ‘the Lexicon’, is a digital database that defines stratigraphical terms that appear on BGS maps and in other BGS publications. Further information can be found on the BGS website, which also provides free access to the Lexicon (http://www.bgs.ac.uk/Lexicon/home.html).

Each unit in the Lexicon is given a unique alphabetical or alphanumeric computer code that identifies the unit in digital applications, including digital geological maps such as DiGMapGB. In this report, the code is given in parenthesis after the unit name in section headings. The codes are also listed in the Appendices of this report. The Lexicon Code, or ‘Lex Code’, is commonly not the same as the ‘Map Code’, which is a non-unique code used to identify a geological unit on the face of a non-digital BGS geological map.

The Lexicon is complementary to the BGS Stratigraphical Framework Reports, of which this is one. Published Stratigraphical Framework Reports can be downloaded free of charge from the BGS
website (http://www.bgs.ac.uk/downloads/browse.cfm?sec=1&cat=2).

Conventions

In the text and definitions below, National Grid References are given in square brackets, with the 100-kilometre grid square denoted by its Ordnance Survey two-letter code.

Onshore boreholes are identified by the BGS Registration Number in the form SP57SW9 where the first six characters indicate the 1:10 000 National Grid sheet.

BGS 1:50 000 (or 1:63 360) scale sheet numbers are given in parentheses after the sheet name in the form Cirencester (E&W 235) or Broadford (S 71W) indicating England & Wales or Scotland sheets, respectively.

References and footnotes

1. ↑ Currently, BGS uses the earlier spelling of ‘Palaeogene’ for the first Period of the Cenozoic Era, in contrast to Ogg et al. (2008), which uses ‘Paleogene’. Both authorities use ‘Paleocene’ for the first Epoch of the Palaeogene
5. ↑ This report refers to the areas of the traditional English counties, prior to the formation of the modern Boroughs, Districts and Unitary Authorities


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