Chapter 1 Introduction to the Tertiary

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The Tertiary Sub-Era: Subdivision and nomenclature

The Tertiary Sub-era comprises all but the final two million years or so of the Cenozoic (Cainozoic, Kainozoic), the era of recent life (from the Greek *kainos:* recent), which encompasses the history of the Earth from the end of the Cretaceous to the present day. The beginning of the Tertiary is widely accepted as 65 Ma. Anderton *et al.* (1979) put its end at 2.5 Ma; Pomerol (1982a) made it 2 Ma and Harland *et al.* (1990) placed it at 1.64 Ma (see (Figure 1.1)). The definition of the top of the Tertiary Sub-era, the Pliocene–Pleistocene boundary, is considered in more detail in Chapter 8 of this volume.

The term Tertiary was first introduced by Cuvier and Brongniart (1810) to describe the strata above the Chalk in the Paris Basin. In 1833, Charles Lyell subdivided the Tertiary into three, based on a recognition that increasingly younger strata contain fossils more closely related to present-day species. These were the Eocene (*eos:* dawn of), the Miocene (*meios:* less) and the Pliocene (*pleios:* more). Beyrich (1854) subsequently introduced the term Oligocene (*oligos:* few) and Schimper (1874) the term Palaeocene (*palaeos:* ancient) for the youngest and oldest part of the Eocene respectively, to complete the currently accepted grouping of the Tertiary Sub-era into five epochs. At around the same time, a recognition that the younger part of the Tertiary had fossils with a 'Mediterranean' affinity whilst the older strata were characterized by those of a 'tropical' nature, led to its division into two. According to Pomerol (1982a, p. 12), Hoernes placed the Miocene and Pliocene together into the Neogene (from *neos:* new and *genos:* birth) shortly before Naumann (1866) grouped the three earlier epochs into the Palaeogene (Figure 1.1).

Understanding the Tertiary

That Tertiary faunas and floras are essentially modem in aspect has made the task of palaeogeographical and palaeoenvironmental interpretation considerably easier than for earlier periods of geological time. Though by no means devoid of problems, the possibility of interpretation based on a knowledge of their modern relatives has facilitated a more confident approach to interpretation and a degree of 'fine tuning' not readily practicable where more ancient fossils are concerned. Using ostracods and forams, for example, it has been possible to determine quite narrow ranges of salinity and depth, rather than the broader generalizations so often unavoidable with older strata. The dinosaurs that had dominated the Earth in Mesozoic times had died out before the Tertiary began, to be replaced by the more readily comprehensible mammals, which began to establish themselves in the Palaeocene prior to their great diversification at the beginning of the Eocene (Pomerol, 1982a). The flora too became distinctly modern in aspect; the angiosperms flourished and their development throughout the sub-era has made it considerably easier for researchers to develop an understanding of Tertiary palaeogeography and climatic change, compared with earlier geological times.

Other aspects of the Tertiary Sub-era also facilitated interpretation. For example, Tertiary land masses can be positioned with some certainty and in some cases even elevations may be inferred. Although some 12° of latitude further south in the early Tertiary than at present (Irving, 1967), Palaeogene 'Proto-Britain', bounded by its equivalents to the present Celtic Sea, English Channel and North Sea, was probably broadly recognizable as the ancestor of our present-day Britain.

Understanding the Tertiary has been particularly enhanced by the existence of large expanses of undisturbed and non-lithified oceanic sediments which provide unbroken successions representing the whole of the sub-era and contain a record of organic, isotopic and other data for this period of geological time. Much of stratigraphical as well as palaeoenvironmental value has been derived from such areas. Zonal schemes using planktonic foraminifera and calcareous marine nannoplankton, so important in Tertiary biostratigraphy, have been developed in this context. Information from deep ocean studies has also provided a framework for the development of a comprehensive magnetostratigraphical scheme for the Tertiary Sub-era. The subsequent correlation between geomagnetic polarity reversal sequences and biostratigraphical zones has facilitated the development of an integrated magneto-biostratigraphy that has significantly improved the time-scale for the Tertiary. Aubry *et al.* (1986) have stressed the importance of its value in the Palaeogene stratigraphy of north-western Europe, where the accurate correlation of a series of discontinuous sedimentary sequences, both in space and time, is particularly important since they contain the classic stratotypes of the Palaeogene epochs. More recently, a better understanding of the Tertiary succession in this area is being realized by the application of the techniques of sequence stratigraphy (see, for example, Neal (1996) on the Palaeogene).

The global context

As the Cenozoic began, the Earth presented several unusual aspects. It had been warm for many millions of years, with the Jurassic to Cretaceous the longest period of the Phanerozoic without a global glaciation. Such global warmth continued into the Cenozoic. Apparently there were no ice-caps at either the North or South Poles. Oxygen isotope studies of oceanic sediments from high southern latitudes suggest that temperatures were 10–15°C higher than at present. Whilst isotopic data for analogous northern latitudes are largely lacking, the evidence from faunal and floral studies tells largely the same story (Walker and Sloan, 1992). As these authors point out, perhaps more surprising is the fact that the tropics in the early Tertiary were no warmer then than they are now. Whilst the difference between tropical and polar temperatures today is about 40°C, in the Eocene this was smaller by one-quarter to one-third (see also Sloan *et al.,* 1992).

Not surprisingly, global sea level was considerably higher during the early Tertiary than at the present day, producing a wide expanse of epicontinental seas. Later, sea levels were generally lower but there is evidence for a succession of rises and falls throughout the whole of the sub-era ((Figure 1.2); Vail and Hardenbol, 1979). As the Tertiary began, the separation of Europe and North America continued in the North Atlantic area, with the breakup of the Greenland–Rockall Plate and the production of volcanic rocks including those of Northern Ireland and Scotland. Movement of Eurasia south-eastwards was to result in compression and shear in the Mediterranean region culminating in the various Alpine orogenic mountain-building phases.

Tertiary rocks in Britain

Britain is well endowed with rocks of Tertiary age. Furthermore, it has a number of localities of 'classic' nature that are amongst the most geologically significant in Western Europe.

Tertiary rocks of igneous origin are particularly well developed in Scotland (see the GCR volume by Emeleus and Gyopari, 1992), but are also represented much further to the south by, for example, the Lundy Granite. By contrast, whilst plant-bearing sediments have been found interbedded with Tertiary lavas in Scotland (the Interbasaltic sediments' of Curry *et al.,* 1978, pp. 29–30) and some of the lavas have been lateritized by contemporaneous weathering, epigenic processes are mainly represented by much thicker sedimentary accumulations in southern England (Figure 1.3). Here, Palaeogene rocks are preserved in two E–W trending tectonic basins, the London Basin and the Hampshire Basin, and in small outliers further west as far as Devon. The Neogene is most widespread in East Anglia, though to a considerable extent below a Pleistocene cover, whilst elsewhere, a few outliers include the limestone fissure fills of Lenham in the North Downs, and of Brassington, Derbyshire.

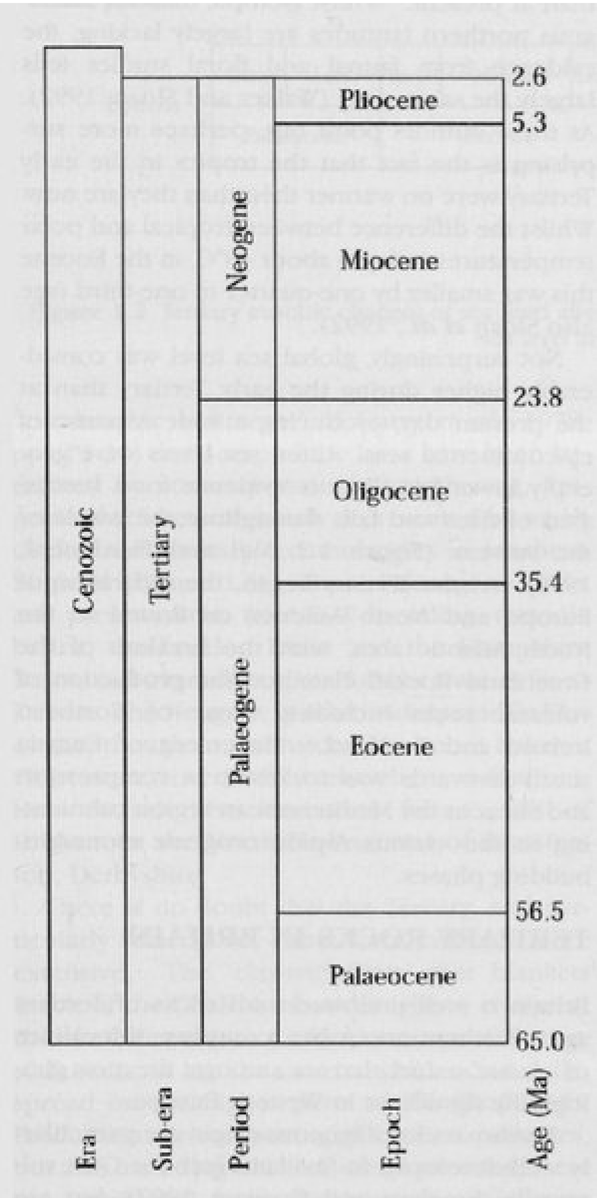
There is no doubt that the Tertiary, and particularly Palaeogene, strata were formerly more extensive. The 'clay-with-flints' that blankets much of the Chalk is now thought to comprise the altered remains of a former cover of Tertiary sediments, as are the sarsens which occur widespread on the higher parts of the Chalklands. Predominantly comprising siliceous sandstones, but also including silicified conglomerates, these are considered to be the remnants of silcrete duricrusts, which developed in a variety of Tertiary sediments in Palaeogene times (Jones, 1981, pp. 94–9; Hepworth, 1998).

What seems equally clear is that, for a long period, dating from about the end of Cretaceous times (65 Ma), much of the land mass of what is now Britain had been uplifted and was being actively eroded. The first seven million years or so of the Tertiary appear to be unrepresented by any onshore sediments, but in the late Palaeocene there began a long period of sedimentation in south-eastern England that lasted at least until the beginning of Oligocene times.

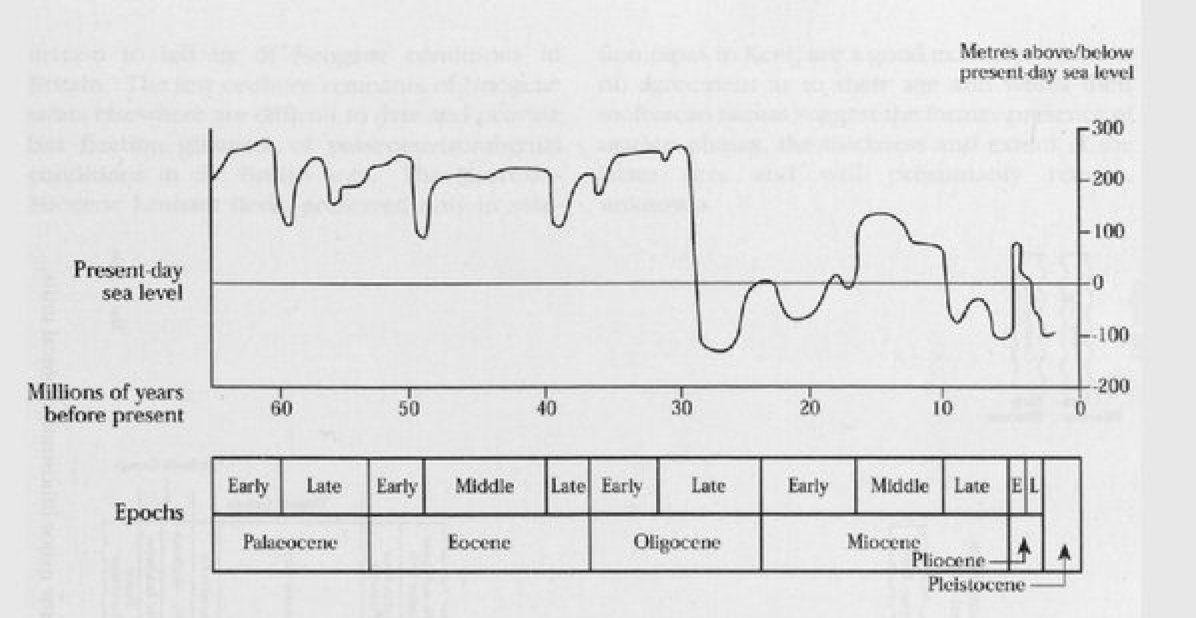
With the exception of a few outliers of early Palaeogene age that provide information about the contemporaneous palaeogeography of the south-western areas, there is little tangible onshore evidence to help with our determination of the Palaeogene palaeogeography of much of the British area away from the south-east. It is clear that in the western part of this Palaeogene 'Proto-Britain', sediments were accumulating in basins such as that recognized in the Mochras borehole in North Wales (Woodland, 1971) where some 525 m of sediment were deposited in late Oligocene and perhaps early Miocene times. However, for strata as early as those of Palaeocene age, the provenance of pebbles from central southern England suggests that, in places, active erosion had already breached the Chalk cover to erode older Mesozoic strata.

Apart from that derived from a study of the Pliocene strata in East Anglia, there is little information to tell us of Neogene conditions in Britain. The few onshore remnants of Neogene strata elsewhere are difficult to date and provide but fleeting glimpses of palaeoenvironmental conditions in the British area. The Miocene–Pliocene Lenham Beds, preserved only in solu tion pipes in Kent, are a good example. There is no agreement as to their age and whilst their molluscan faunas suggest the former presence of marine phases, the thickness and extent of the latter are, and will presumably remain, unknown.

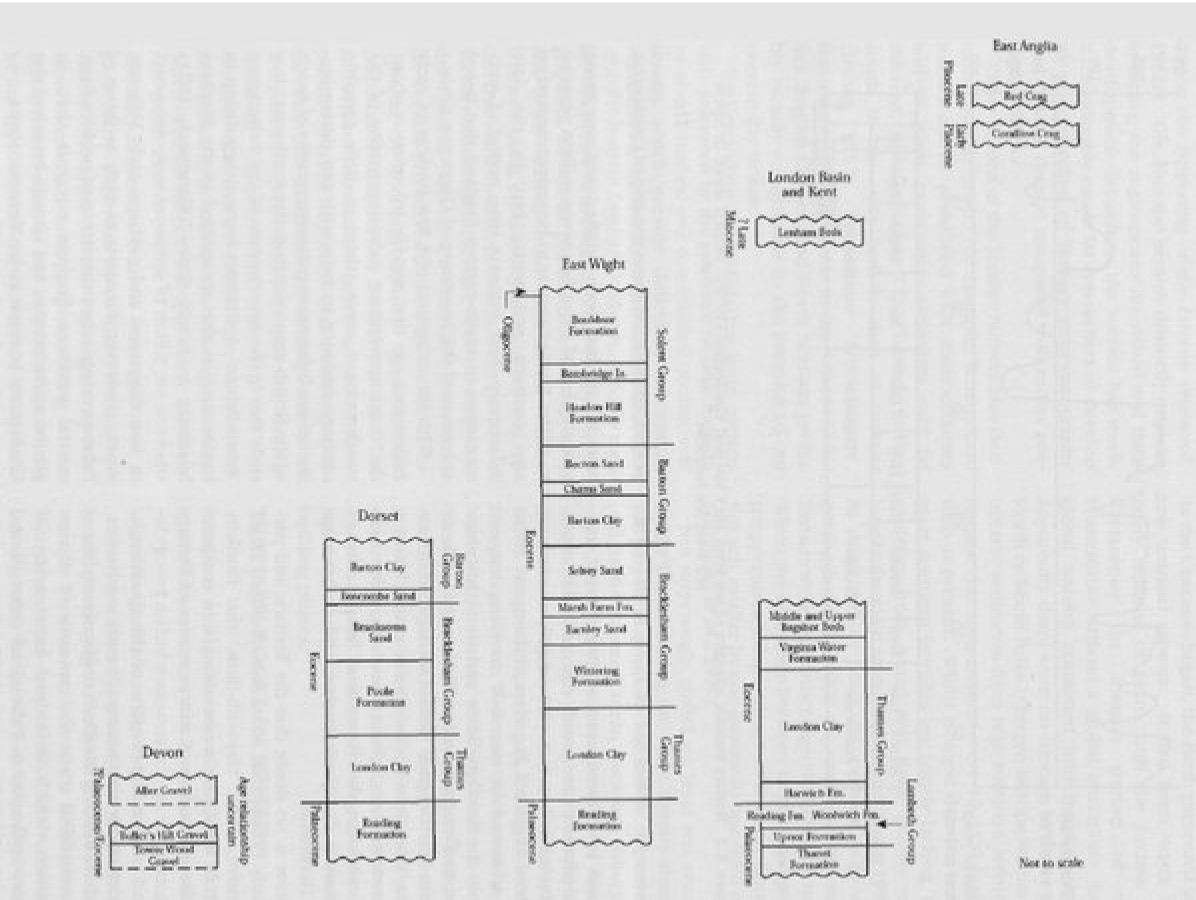
References



(Figure 1.1) A time-scale for the Tertiary Sub-era after Harland et al. (1990), with the Plio–Pleistocene boundary dated at 2.6 Ma (after Berggren et al., 1995). See Chapter 8 for a discussion of Plio-Pleistocene boundary dates.



(Figure 1.2) Tertiary eustatic changes of sea level after Vail and Hardenbol (1979). Metres above or below sea level are tentative.



(Figure 1.3) Generalized Tertiary succession in southern and eastern England, to show major lithostratigraphical units.