Chapter 11 The Red Crag

P Balson

Introduction

The Red Crag was first identified as a separate part of the 'crag-formation' by Charlesworth (1835) who named it after its characteristic reddish-brown coloration caused by iron oxides in surface exposures. For a fuller discussion see the section The Crags of East Anglia' in the previous chapter. At depth in boreholes and below the water table the sediments are grey in colour. Although later workers attempted to change the name (e.g. 'Middle Crag': Jones and Parker, 1864; or 'Upper Crag': Woodward, 1891), the term 'Red Crag' has remained in use to the present day.

The 'classic' Red Crag of early workers (e.g. Harmer, 1900b) is restricted to south-east Suffolk and north-east Essex (Figure 11.1). In this area the formation is up to 20 m thick and is separated from the Coralline Crag by a marked unconformity. The Red Crag unconformably overlies the London Clay Formation over most of its outcrop but oversteps Palaeocene Formations on to the Late Cretaceous Chalk to the west (e.g. Hascot Hill, Battisford). Locally it may overlie the Coralline Crag with marked unconformity as, for instance, at Ramsholt Cliff and Rockhall Wood, Sutton. At the base of the Red Crag is a discontinuous basal conglomeratic lag up to 30 cm thick. This varies from a deposit dominantly composed of pebbles of phosphatic mudstone to a deposit dominated by flint pebbles and cobbles. These phosphate-rich deposits were discovered in the mid-19th century and were the first rock phosphate deposits in the world to be commercially exploited for the manufacture of fertilizers. Production peaked around 1850–1880 but the discovery of more extensive deposits in the Cretaceous Cambridge Greensand in 1854 caused the demise of the Suffolk phosphate industry, and with it the closure of many pits in the Red Crag (Reid, 1890). The commercial exploitation resulted in extensive collections of fossils from these deposits that include a large vertebrate fauna including many species of marine and terrestrial mammal. Most of the major collections to be found in museum collections were assembled during this period. Phosphatic pebbles are also found at some places within the Red Crag, either scattered or in discontinuous layers. The basal lag deposit is occasionally exposed in the cliff sections at Bawdsey and Walton-on-the-Naze and has been proven in excavations around Rockhall Wood, Sutton.

This basal lag deposit has been known by many names including Suffolk Bone-Bed (Lankester, 1868), Nodule Bed (Reid, 1890), Coprolite Bed (Lankester, 1868), Basement-bed (Prestwich, 1871a,b), Boxstone Bed (Boswell, 1915) and sub-Crag Detritus Bed (Bell, 1915).

The material that constitutes this deposit originates from many sources. The phosphatic mudstone pebbles, which form the dominant component in most places, originate from the London Clay Formation. Pebbles containing phosphatized crabs and lobsters and many of the phosphatized shark and ray teeth are similarly derived from the London Clay. Cobbles of a phosphate-cemented sandstone known locally as 'boxstones' or 'Suffolk boxstones', which often contain moulds of marine molluscs (e.g. (Figure 8.4)), are derived from a Neogene formation of muddy sands which formerly existed in the area. This former deposit was informally named the 'Trimley Sands' by Balson (1990a). A rich vertebrate fauna including terrestrial mammals like *Mastodon* and marine mammals including walrus and cetaceans may be partly contemporaneous with the 'Trimley Sands' but other members of the vertebrate fauna, e.g. the giant shark *Carcharocles megalodon* (Figure 8.3), are clearly older. Other components of the deposit include an assortment of exotic rock types including Jurassic limestone, Cretaceous Chalk flints and Mesozoic fossils including belemnites (Bell, 1915).

Since the work of Harmer (1900b) and others in the early 20th century it has become obvious that deposits of equivalent age to the Red Crag are found over a much wider area than that shown in (Figure 11.1). To the west, the Red Crag has been traced as a near-continuous sheet of coarse-grained, locally shelly sediment extending to just beyond Bishop's Stortford (Mathers and Zalasiewicz, 1988). Beyond this, small isolated outcrops have been described from Rothamsted (Dines and Chatwin, 1930; Moffat and Catt, 1986) and, possibly, even further to the west (Moffat and Catt, 1986). This sheet ascends steadily inland at *c.* 1 m/km until at Bishop's Stortford the base is at +90 m OD, and at Rothamsted at +131 m OD. This rise is probably due to crustal warping (Van Voorthuysen, 1954; West, 1972; Moffat and Catt, 1986;

Mathers and Zalasiewicz, 1988) which was also responsible for the elevation of the Lenham Beds described in Chapter 9.

To the north, sediments equivalent in age to the Red Crag were found in a borehole at Stradbroke (Figure 11.1). These sediments are finer-grained than the Red Crag further south and are believed to represent a more offshore facies. North of Aldeburgh the Red Crag succession has been divided into two members: a lower member of shelly coarse sands with interbedded clays (the Sizewell Member) overlain by cycles of shelly fine to medium sands (the Thorpeness Member). To the east, in the offshore southern North Sea, sediments of Red Crag age have an extensive outcrop (Cameron *et al.,* 1984; Balson, 1989).

This report mainly concerns sites within the area of 'classic' Red Crag as defined by Harmer (1900b) but also includes the site at Hascot Hill, Battisford which was unknown at the time of Harmer's review (see (Figure 11.2)).

The relationship of the Red Crag to the succeeding Norwich Crag is difficult to assess. Zalasiewicz and Mathers (1985) found little evidence of a hiatus between the Red Crag and the Chillesford Sand Member of the Norwich Crag Formation. The stratigraphical arrangement of these deposits is shown in (Figure 10.1).

The Red Crag is renowned for its mollusc fauna which numbers several hundred species. However, many of the mollusc species and other taxa within the Red Crag deposits may have been derived from reworking of the earlier Coralline Crag deposits. Wood (1859) believed that up to 50 of the 240 mollusc species by then described could have been derived in this way. This list of derived species was later increased to 118 species (Wood, 1848–1882). A contrary view was expressed by Harmer (1900b) who did not believe that there was any significant derived component in the Red Crag fauna. Many shells that are abundant and well-preserved in the Coralline Crag occur only as abraded and worn specimens in the Red Crag; for instance, *Venericardia aculeata scaldensis* (Figure 10.7) and many bryozoan species. Small fragments of lithified Coralline Crag sediment occur commonly in the Red Crag indicating extensive reworking of the earlier deposit. Such fragments have even been found in the Red Crag of Walton-on-the-Naze (Prestwich, 1871b) which even Wood (1859) had believed contained no derivative shells. It is likely therefore that a proportion of the Red Crag fauna has been derived from reworking of the Coralline Crag. The controversy over the extent of this contribution was significant in the early debate over the age of the formation determined by the percentage test of Charles Lyell (Wood, 1859) and is an important factor to consider when using the fauna for palaeoenvironmental reconstructions or for stratigraphical comparison with formations of similar age elsewhere.

Although the subdivision of the Red Crag on the basis of mollusc faunas is usually attributed to Harmer (1900a), it was Wood who, in 1866, first divided the Red Crag on this basis. His divisions, which comprised the Walton Crag, Sutton Crag, Butley Crag and Scrobicularia Crag, were defined on geographical areas and an observed general increase in 'northern' or cooler water forms as the Red Crag was traced northwards (Wood,1866). Thus the Walton Crag in the south contained the warmest water fauna and the Scrobicularia Crag contained the most boreal. The sinistral gastropod *Neptunea contraria* (Figure 11.3) is an immigrant from the Pacific (Strauch, 1972) and first appears in the British Neogene in the Red Crag of Walton-on-the-Naze. The replacement of this species by dextral species of the genus as the Red Crag is traced northwards was thought to reflect a progressive cooling with time.

Harmer (1900a) formalized Wood's divisions into three 'stages'. The southernmost Red Crag of Walton-on-the-Naze in Essex and nearby areas, the 'Walton Crag' of Wood (1866), was assigned to the Waltonian stage' which was believed to represent the oldest Red Crag sediments with the warmest water fauna, containing many species which are rare or absent elsewhere. It also contains the benthic foraminifer *Pararotalia serrata*, indicating warm temperate conditions. Further north, sediments belonging to Wood's 'Sutton Crag' became the 'Newbournian', and the 'Butley Crag' became the 'Butleyan' stage. These latter deposits were probably deposited under cool temperate conditions (Funnell and West, 1977).

In an attempt to erect a formal lithostratigraphy, Funnell and West (1977) divided the Red Crag series into an upper Ludham Member and a lower Red Crag Member. The latter member was then further subdivided into the Butley, Newbourne and Walton Crags thus representing a return to Wood's original lithostratigraphical concept.

Stratigraphically the Red Crag has traditionally been placed at the base of the Pleistocene in Britain. However, more recently the Red Crag Formation has been assigned entirely to the late Pliocene with an age between 3.2 and 2.4 Ma (Funnell, 1987, 1988) based on the presence of the planktonic foraminiferid *Neogloboquadrina atlantica.* Benthic foraminifera from the Walton Red Crag have been compared with deposits in the Netherlands from which Reuverian 'C' pollen has been obtained (Funnell, 1996).

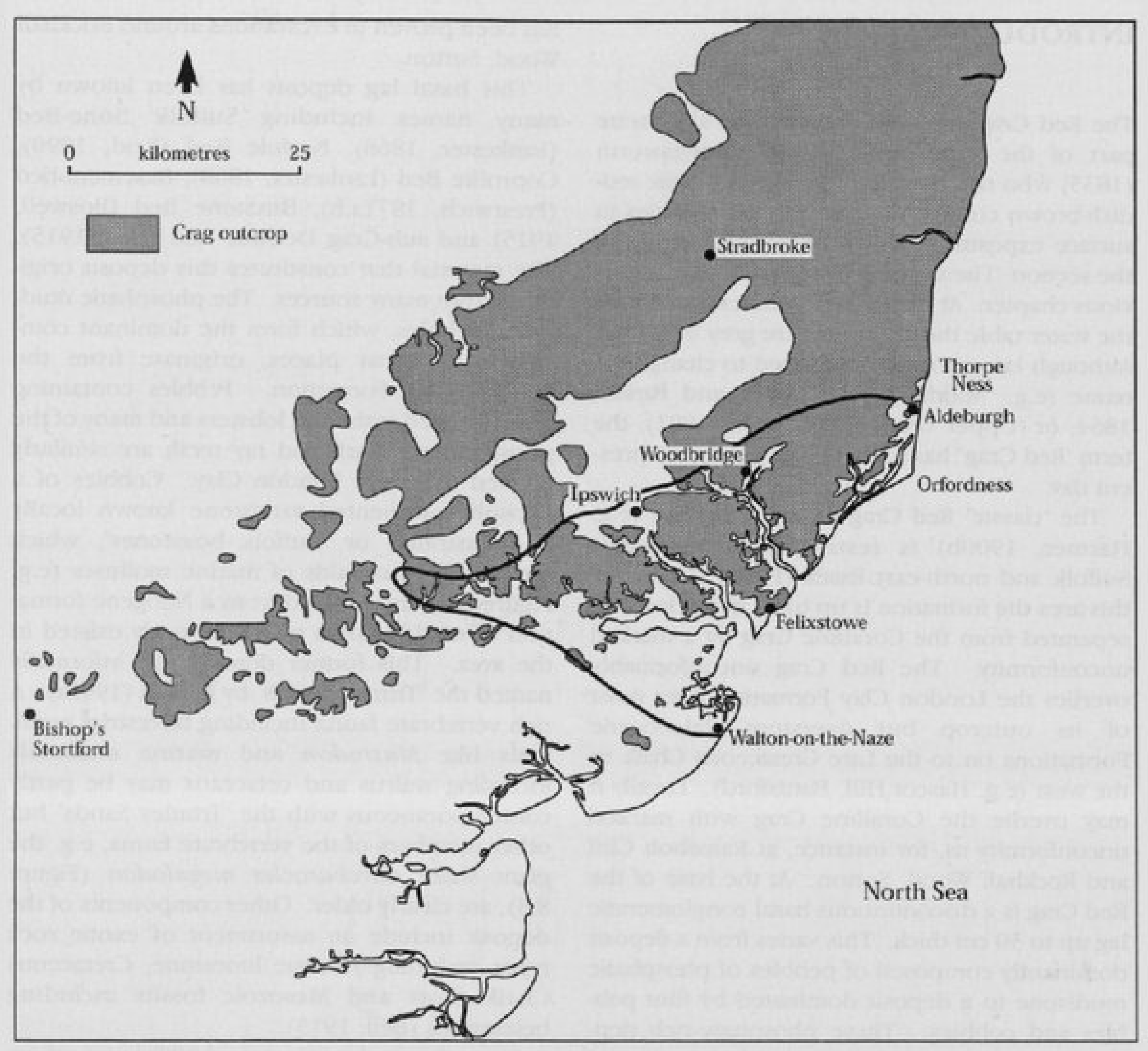
A pollen assemblage obtained from sediments at the base of the Walton Red Crag is closely comparable with Reuverian 'C' assemblages in the Netherlands (Hunt, 1989). Mollusc assemblages from the Walton Red Crag closely resemble those of the MOL C assemblage zone of the Netherlands (Spaink, 1975) and can be correlated with the upper part of the Oosterhout Formation of the Netherlands and the Kruisschans Member of the Lillo Formation in Belgium (Funnell, 1996). Mollusc assemblages from the Burley Crag resemble those of the MOL B zone of the Netherlands.

The Red Crag of south-east Suffolk and northeast Essex was deposited near the mouth of a funnel-shaped embayment of the North Sea, which extended west-south-westwards through southern East Anglia towards the southern Midlands. The palaeogeography was probably similar to that during deposition of the Coralline Crag (Figure 8.2).

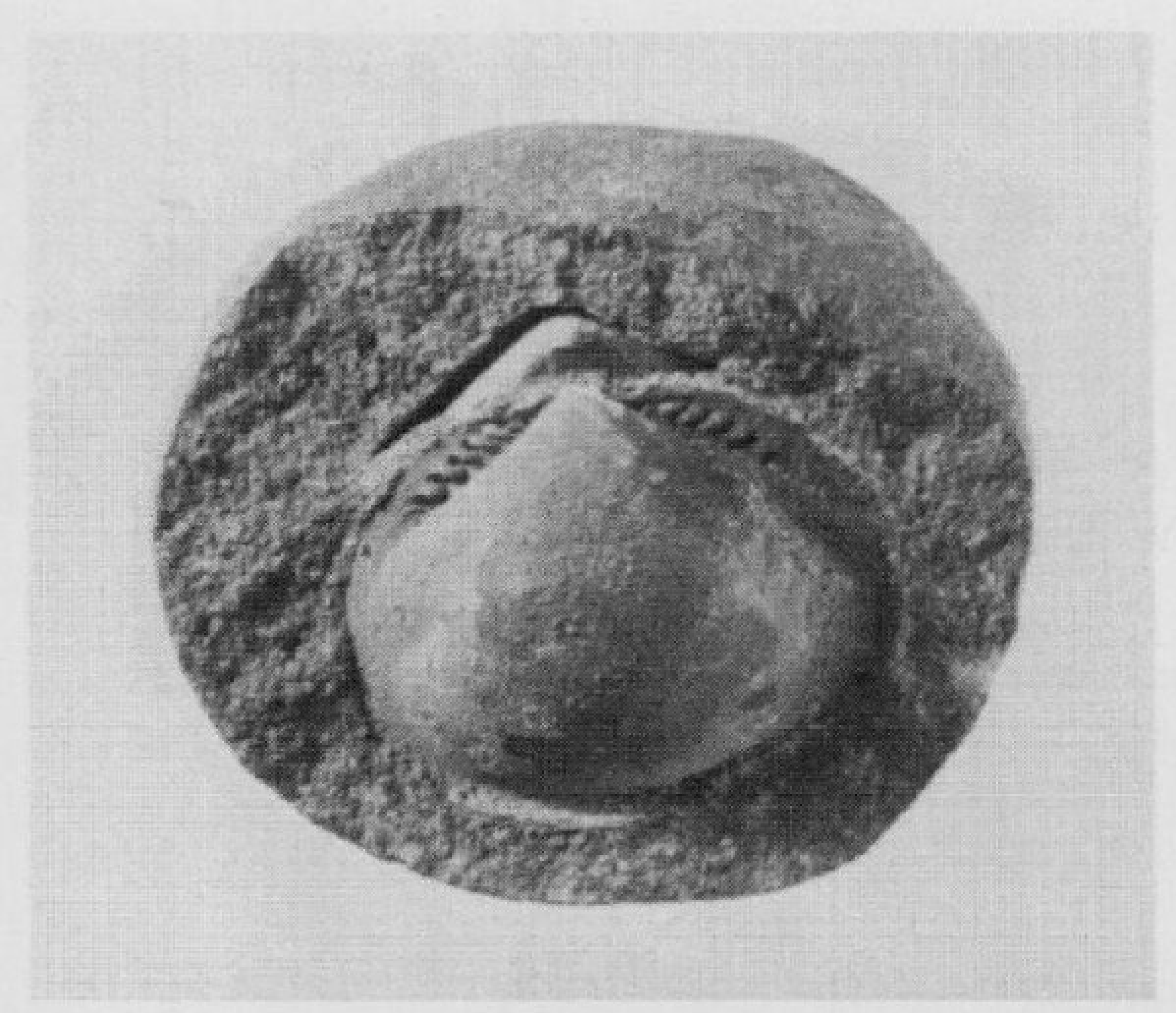
The Red Crag represents high-energy, tide-dominated shallow marine conditions, the sedimentology of which was most recently described by Dixon (1979) and Balson *et* al. (1991). An overall regional stratigraphical pattern seems to be present, with the lower part of the deposit being dominated by large-scale, high-angle, approximately planar tabular cross-sets (e.g. at Walton-on-the-Naze, Bawdsey, and the lowermost part of the sequence at Vale Farm, Broom Covert and Orford Lodge); a middle part with complex trough-cross-bedding, low-angle bedding and common mud-drapes (e.g. at Vale Farm, Broom Covert and Orford Lodge); and an upper, more heterogeneous part dominated by horizontal or near-horizontal bedding (e.g. at Vale Farm, Broom Covert) (Figure 11.2). This sequence results from overall shallowing, as inferred by Dixon (1979), and more precisely from the increasing constriction of a tide-dominated embayment.

Palaeotemperatures were generally cooler than those during the Coralline Crag. Temperatures implied by a study of the bivalve *Hiatella arctica* range from 12–24°C in the Waltonian, 8–22°C in the Newbournian, to 5–17.5°C in the Butleyan (Strauch, 1968).

References

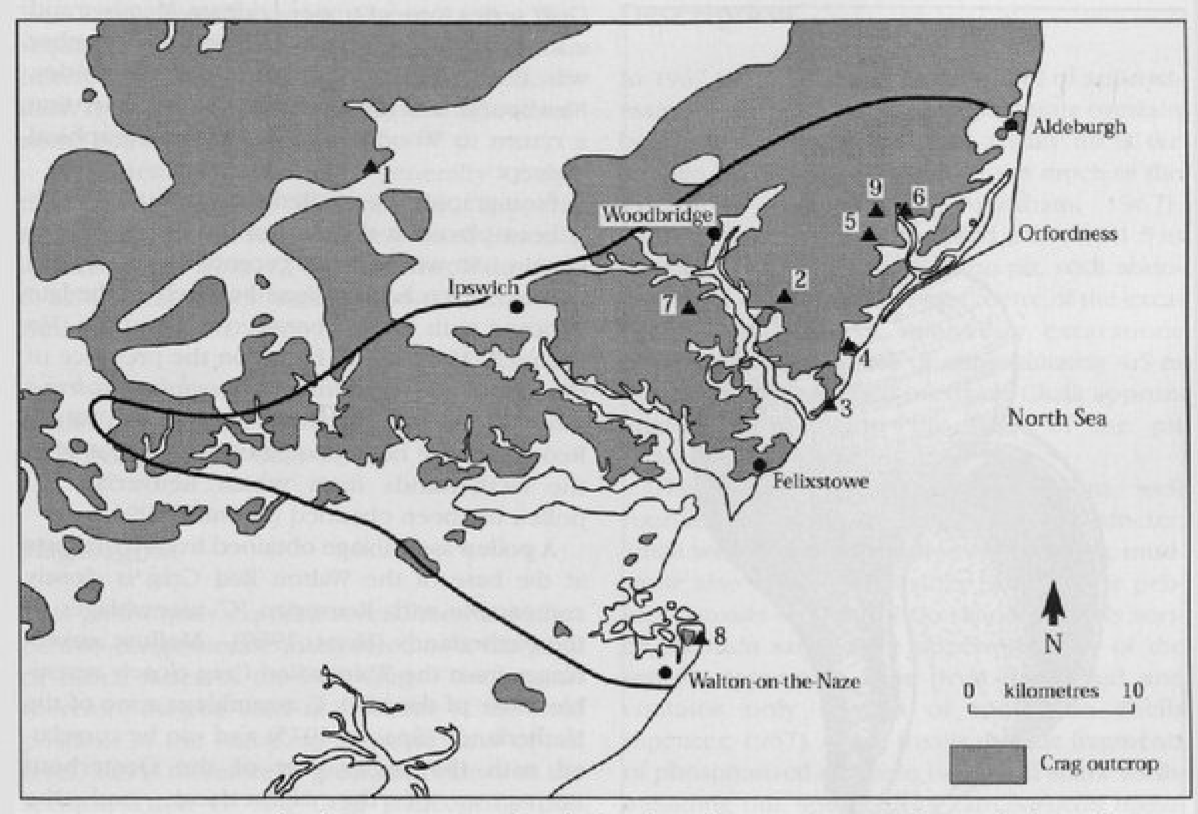


(Figure 11.1) Map of the Crag outcrop in southern East Anglia. The Crag limit is after British Geological Survey (1985, 1989). The bold line indicates the limit of the 'Red Crag' after Harmer (1900b). The locations of the GCR sites are shown on (Figure 11.2).

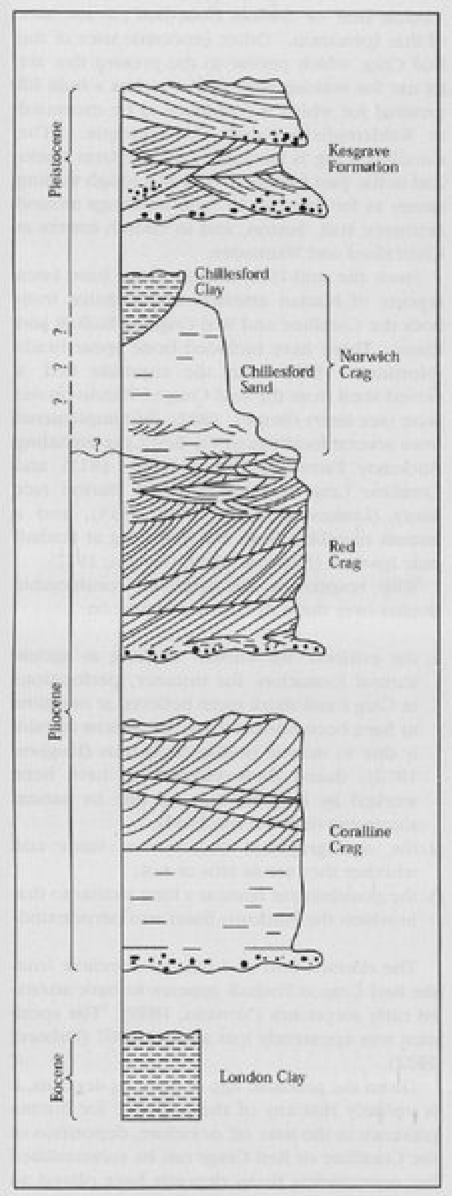


(Figure 8.4) Phosphatic sandstone concretion (`boxstone) showing enclosed mould of Glycymeris. (Sedgwick Museum specimen C48553.) (Specimen is 74 mm across.)

(Figure 8.3) Phosphatized tooth of the giant shark Carcharocles megalodon from the basal `coprolite bed' of the Red Crag. (British Geological Survey specimen no. GSM 3100.) (Tooth is 133 mm long.)

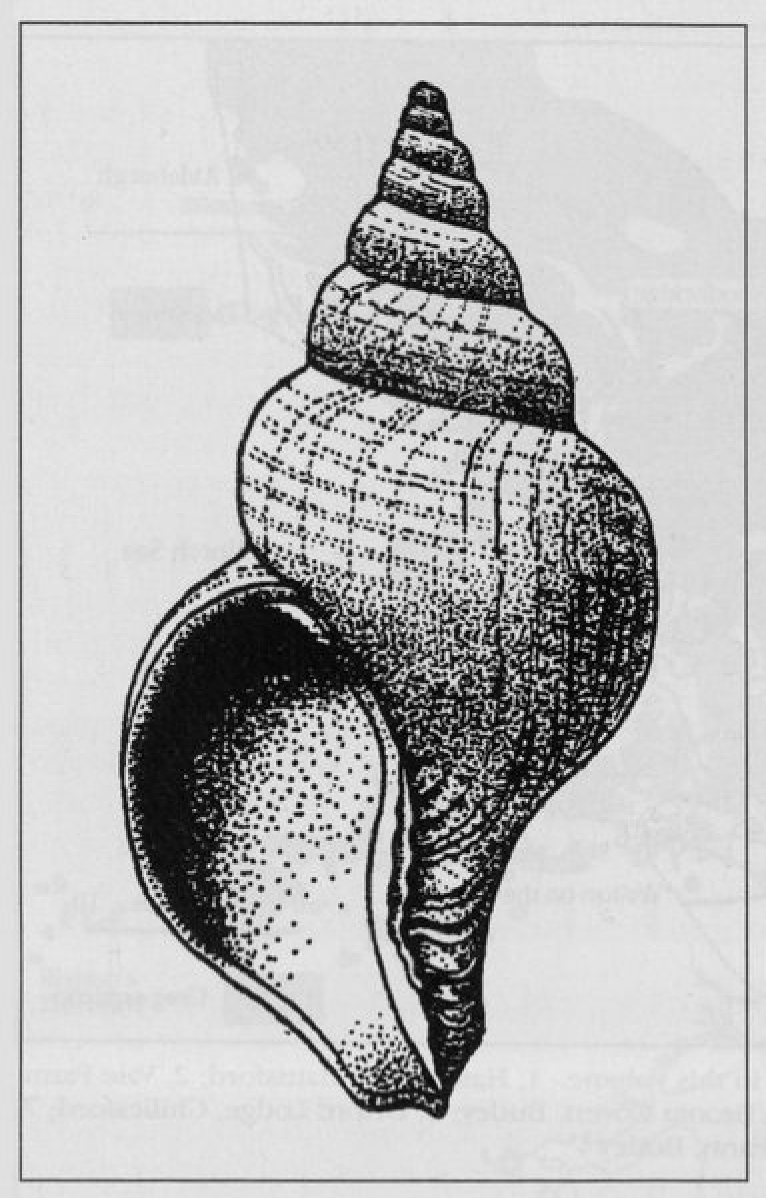


(Figure 11.2) Location of Red Crag exposures described in this volume. 1, Hascot Hill, Battisford; 2, Vale Farm, Sutton; 3, Bawdsey Cliff; 4, Buckanay Farm, Alderton; 5, Broom Covert, Butley; 6, Orford Lodge, Chillesford; 7, Waldringfield Heath; 8, Walton-on-the-Naze; 9, Neutral Farm, Butley.

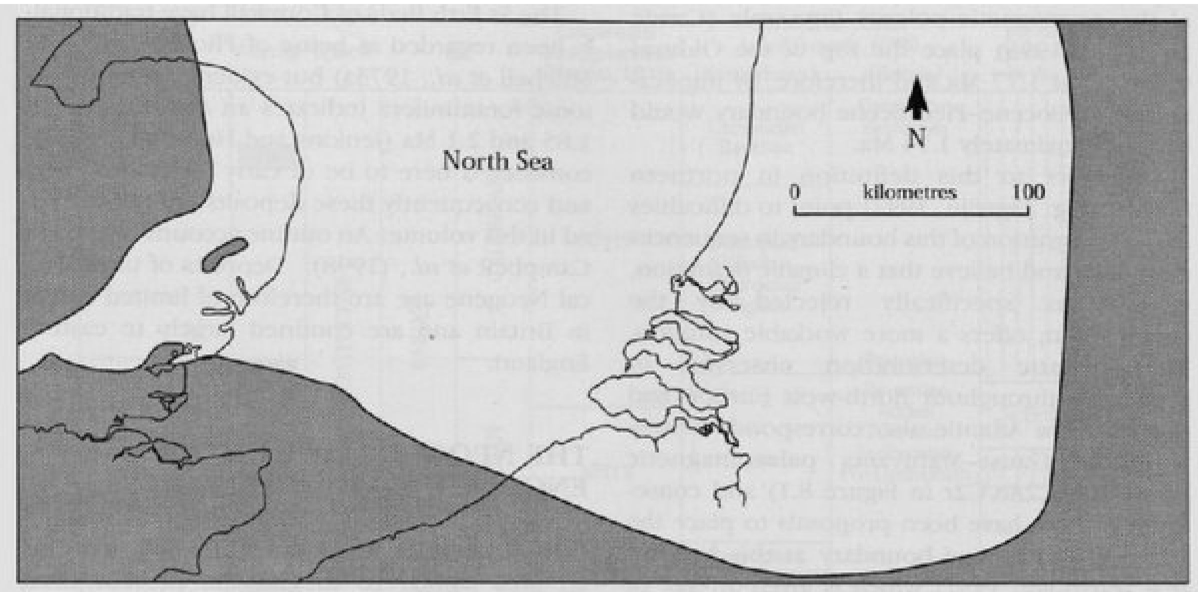


(Figure 10.1) Schematic sequence (not to scale) of the Crag formations in Suffolk and north Essex (modified after Mathers and Zalasiewicz, 1985).

(Figure 10.7) *Venericardia (Glans) aculeata scaldensis* (formerly *Cardita senilis*). Shell is 35 mm across. (Illustration after British Caenozoic Fossils, Plate 35:1 BM(NH), reproduced courtesy of The Natural History Museum, London.)



(Figure 11.3) Neptunea contraria. The shell is 120 mm long. (Illustration after British Caenozoic Fossils, Plate 40:7 BM(NH), reproduced courtesy of The Natural History Museum, London.)



(Figure 8.2) Palaeogeography of the southern North Sea during Pliocene times.