

The molluscan fauna of the Coralline Crag (Pliocene, Zanclean) at Raydon Hall, Suffolk, UK: Palaeoecological significance reassessed

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ABSTRACT

This study assesses the environmental implications of a quantitative study of the unusually well preserved molluscan fauna of over 200 species (about 47% extinct) from six samples from both the Ramsholt and Sudbourne Members of the Coralline Crag Formation at a British Geological Survey borehole at Raydon Hall, near Orford, Suffolk, UK. It reveals a shallow shelf fauna locally transported from a variety of habitats dominated by infaunal species (*Spisula*, *Turritella*, *Abra*, *Amyclina*) from relatively fine sediments, plus epifauna (especially *Heteranomia*) possibly in part originating from nearby bryozoan communities as well as dead bivalve shells. There was a small but consistent component of deeper water elements, such as *Limopsis*, and a lack of strictly littoral species. Overall, a water depth of about 50 m is suggested, with bottom temperatures at times perhaps warmer than the present southern North Sea (but not as high as the modern Mediterranean), and a more oceanic setting. This is in contrast to inferences from previous nineteenth century studies of Coralline Crag molluscs, which viewed it as largely Mediterranean in character, but understated the regular presence of boreal forms such as *Arctica*. Current interpretations still have to account for the coexistence of some Lusitanian or Mediterranean molluscan taxa alongside the cooler water elements.

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1. Introduction

There have been no publications on the mollusc fauna of the Coralline Crag Formation for nearly a hundred years, since those of pioneer palaeontologists from the early 19th to early 20th centuries (Wood, 1848, 1851–60, 1872, 1879, 1882 and Harmer, 1914–18, 1920–25). Recently attention has refocused on just two Coralline Crag bivalves, *Aequipecten opercularis* and *Arctica islandica* (Johnson et al., 2000, 2008, 2009; Williams et al., 2009) as sources of paleoclimatic data from a shelf environment linked to the concept (Dowsett, 2007; Dowsett et al., 2009) of a mid-Piacenzian Warm Period (3.29 Ma to 2.97 Ma), with additional palaeoclimatic input from studies on cheilostome Bryozoa (Knowles et al., 2009). Current dinoflagellate-based dating of the Coralline Crag (De Schepper et al., 2009), however, places it in the Zanclean at 4.4 to 3.8 Ma. The present paper is the first quantitative study of Coralline Crag molluscs and is based on six sediment samples from a British Geological Survey borehole at Raydon Hall near Orford, Suffolk (Balson et al., 1993).

A particularly perceptive and critical review of nineteenth century work on the Coralline Crag fauna is Reid (1890) in *The Pliocene Deposits of Britain*, where he adopted a cautionary approach to differing taxonomic opinions and their effects on Lyellian ratios of living to extinct species of molluscs. He succinctly concludes “The nature of the

deposits and the character of the fauna point to the Coralline Crag as having originated as a sandbank far from shore in a warm, moderately shallow sea”. This is close to some present day views but the question of precisely how warm the sea was remains unresolved. Reid (1890) in a later chapter points out the Coralline Crag mollusc fauna is closer to that of the modern Mediterranean than to the Pliocene Mediterranean fauna. Current questions about Coralline Crag mollusc fauna include whether it really reflects a warmer climate than present and, if so, how to account for the apparently anomalously low sea bottom water temperatures reported in the recent studies involving *Aequipecten* and *Arctica* (Johnson et al., 2009; Williams et al., 2009). The Coralline Crag and the nearly equivalent Luchtbal Sand Member of the Lillo Formation (De Schepper et al., 2009) show, too, a surprisingly high level of marine molluscan biodiversity towards the end of the early Pliocene (Zanclean) in the southern North Sea and the reason for this has been unclear.

2. Geological setting

The Coralline Crag Formation (Fig. 1) forms a largely buried ridge some 12 km long by 2 km wide running SSW to NNE that outcrops in the Aldeburgh/Orford area of Suffolk, eastern England, with an offshore subsurface extension for some 20 km to the northeast off Dunwich (Balson et al., 1993). It is mostly 15–20 m thick, the contact with the underlying London Clay ranging from near Ordnance Datum in the extreme southwest to over 20 m below sea level in the extreme northeast. There are small isolated remnants further south, notably at

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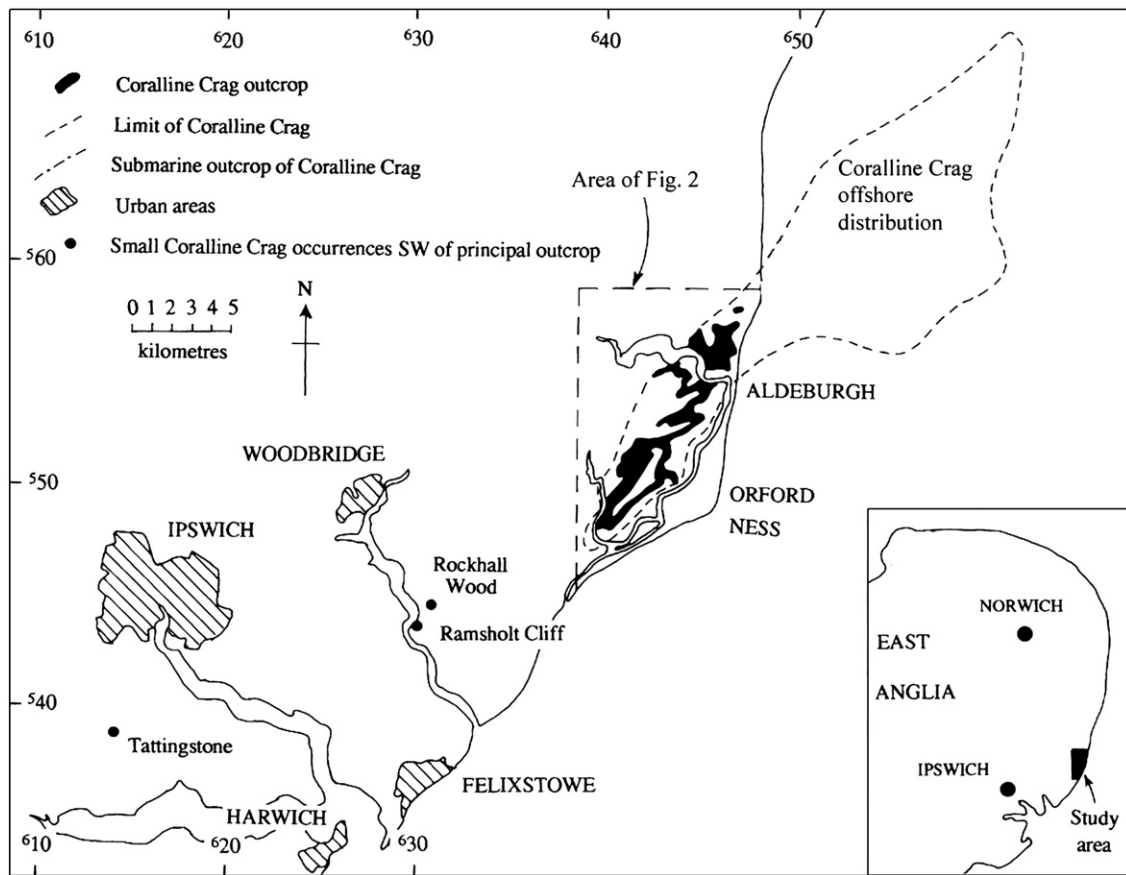


Fig. 1. Distribution of the Coralline Crag. Redrawn from Balson et al. (1993).

Ramsholt and Rockhall Wood, Sutton. It has been correlated with, but probably predates at 4.4 to 3.8 Ma, the Luchtbal Sand Member of the Lillo Formation in the Antwerp area on the basis of molluscs (Cambridge, 1977), foraminifera (Jenkins and Houghton, 1987) and dinoflagellate cysts (Louwye et al., 2004; De Schepper et al., 2009), placing it in the latter part of the early Pliocene (Zanclean 2) of the southern North Sea.

Balson et al. (1993) examined the sedimentology of the Coralline Crag using both surface exposures and a series of purpose-drilled boreholes. They subdivided the marine carbonate sands into a lower Ramsholt Member, the overlying (possibly unconformable) cross-stratified Sudbourne Member, and its probable equivalent the Aldeburgh Member, found in the northern part of the main outcrop. The lower, partially silty, Ramsholt Member preserves both aragonitic and calcitic marine fossils and is a famous source of collections of molluscs, bryozoa and other marine invertebrates. In particular its molluscs were described and collected extensively in the nineteenth and early twentieth century (Wood 1848, 1851–60, 1872, 1879, 1882; Harmer, 1914–18, 1920–25), the species lists so obtained being used for correlation, based on presence or absence of taxa, with some speculation on environments (Prestwich, 1871; Wood and Harmer, 1872; Harmer, 1896, 1898). These early authors gave crude frequency measures but there have been no previous quantitative studies on Coralline Crag molluscs of the type carried out on assemblages from the Norwich Crag (Norton, 1968) and Red Crag (Dixon, 1977).

3. Materials and methods

3.1. Samples

The Raydon Hall (see Fig. 2) samples came from borehole “B” of Balson et al. (1993) which was drilled percussively using the shell and

auger technique. It was located at National Grid Reference TM4326 5017 and was near to an earlier auger borehole from which Andrew and West (1977) had described an early Pliocene Brunsummanian pollen stage spectrum. Details of the samples analysed for molluscs and the corresponding drilling log entries are given in Table 1; all came from below Ordnance Datum. The Coralline Crag at this location is unusual in that aragonitic fossils are conserved in both the Ramsholt and Sudbourne Members. The uppermost sample studied (OR 7a) came from the latter. Samples from the BGS were received as untreated sediments with excellent preservation of both aragonitic and calcitic fossils. Four of the six samples were largely unoxidised. Ostracod data from these samples was included in a reconstruction of southern North Sea Pliocene palaeotemperatures (Wood et al., 1993).

3.2. Processing

Borehole sediments were dried at 40 °C and washed through a series of sieves. The first two (OR 14, OR 15) were originally processed for otolith recovery using a 1.6 mm sieve. For counting molluscs the finer residues from these were then redried, reweighed, subsampled and washed through sieves of 1 mm, 500 µm and 250 µm mesh size. Subsequent samples (OR 7a, OR 12, OR 13, OR 17) were first passed for counting through a 2 mm mesh (1 kg dried sediment) and then through the remainder of the sieve series (100 g dried sediment). Fig. 3 shows a typical example of the washed coarsest fraction (>2 mm OR 14) with shell and bryozoan fragments (*Metrarabdodus*) and some very well preserved gastropods (*Trophonopsis muricatus*, *Cytherea* sp.) plus a predated bivalve *Cyclocardia scalaris*. Any sediment unused in the counting process was washed through 2 mm and 1 mm sieves to recover specimens to add to the species lists.

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