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" A REVIEW OF THE NEOGENE AND LOWER PLEISTOCENE DEPOSITS IN EAST ANGLIA."

The Crags.

Between the Eocene and the lowest part of the Crag series there is a considerable unconformity. Thw whole of the Miocene and probably the lower part of the Pliocene are missing, although rare traces of their faunas are found as derivatives in later beds. Before describing the East Anglian succession it is as well to discuss the meaning of the word Crag. This was a local name of unknown origin for shelly sands and was applied to various beds of Plio-Pleistocene age in East Anglia. Later writers, such as F.W.Harmer, applied the name to any beds of similar age, and the whole series were referred to as Crag. The usage was even extended to the Bridlington Beds and the series of deposits in N.W. Iceland. Later still D.Wirtz referred to the Sylter Crag of Germany. These extensions of the use are inaccurate and misleading, but the term Crag itself is a convenient loose term for the East Anglian beds and has been used for so long and in such an extensive literature, that it is unlikely to be easily dislodged.

Coralline Crag (Gedgravian.)

The Coralline Crag consists of a series of calcareous sands or soft limestones of Pliocene age and comprise a main mass, with the village of Gedgrave somewhere near its centre, and a number of smaller outliers at Sutton, Ramsholt, Tattingstone Park etc. Two main lithologies occur, the upper Rock Bed, and below this the sands. But it has been shown that the Rock Bed has been formed by the partial decalcification and induration of the sands, with the removal of the aragonitic shells leaving only calcitic fossils such as echinoids, pectens, crustaceans, polyzoans etc. Both the sands and the Rock Beds are leached to a cream, yellow or brownish colour when seen near the surface, but at depth in borings the Coralline Crag is a greyish colour, similar to the Scaldisien of the Low Countries.

In large sections the sands are usually seen to be strongly current bedded and there is considerable sorting of material, suggesting that the deposit accumulated as banks in turbulent water. Several attempts have been made to divide the Coralline Crag into a series of zones but without success. D.J.Carter showed that an upper and lower division can be distinguished using certain foraminifera but considerable work remains to be done on the taxonomy of most groups.

The full extent of the sea at this period is unknown but faunistically the Coralline Crag and the Scaldisien of Holland and Belgium formed one basin. No other marine deposit of the same age is known in the British Isles.

The Coralline Crag often contains phosphatic nodules, either scattered or in thin seams. Professors Lankester and Prestwich recorded a nodule bed at the base of the Coralline Crag identical in character with that at the base of the Red Crag. However, apart from this record of a single pit at Sutton, it has not been demonstrated elsewhere and at the section alongside the river at the opposite side of the valley Coralline Crag is seen to rest on London Clay with no intervening nodule bed. The Coralline Crag was formerly worked on a small scale as a source of lime for local agriculture while the harder parts of the rock bed were used for local building and rough walling. Nearly all the pits are now much overgrown.

The Red Crag.

Surrounding the Coralline Crag, and in places overlapping it, are beds of shelly sands of a prevailing reddish colour. Like the Coralline Crag these beds are a bluish grey colour at depth. Large amounts of iron, in a reduced condition, colour the Red Crag and forms slabs, "stalactites " and partings where the iron has followed the burrows of marine organisms or percolated between beds. The sands, especially towards their base, are strongly current bedded , and the molluscan remains usually fragmentary, disassociated and worn, with occasional seams of molluscs, in which one species often predominates. The bedding of the upper part of the deposit is usually less strongly inclined and often almost horizontal. The lower part of the deposit tends to have a richer and more diverse indigenous fauna and derivative material is more common.

A Review of the Neogene and Lower Pleistocene Deposits in East Anglia.

The Red Crag. (Cont.)

In places the derivative material filled hollows in the London Clay, and consists of large flints, derived London Clay material, pieces of fossiliferous Miocene Sandstone, rare Mesozoic fossils, teeth and bone fragments of mammals (especially whales), and above all large numbers of phosphatic nodules which may have originated in the Coralline Crag or other Neogene deposits. This discontinuous layer of nodules was formerly worked as a source of phosphates and is variously referred to in the literature as the Red Crag Nodule bed, the Bone Bed, the Coprolite Bed,etc. As a result of the bed being hand - worked, and the presence of a number of wealthy local collectors, a large proportion of the more interesting material has been preserved in collections. Large teeth of Carcharodon, Mastodon, Rhinoceros,etc. fetched good prices. Throughout the whole thickness of the deposit, minor seams of phosphatic nodules of small size, pebbles, shark teeth, etc., may occur,but never in workable quantities.

Although the total Red Crag fauna is very rich, quantitively the majority of the fossils belong to a few species, especially such molluscan genera as Macoma, Glycimeris, Spisula, Mya, Nucella and Neptunea, which are abundant everywhere. Many of the species recorded in lists in the literature are present only in broken fragments or as rare and very worn examples, and there can be little doubt that the Red Crag contains a great deal of material derivative from Pliocene sources.

The presence of fragments of typical Coralline Rock Bed in the Red Crag shows that the Coralline Crag had already been leached and partially decalcified before the Red Crag transgression. During this transgression mammaliferous valley deposits were probably destroyed and the more resistant elements are now included in the base of the Red Crag.The worn and fragmentary condition of the fossils, together with their rarity, make certain identification difficult and various ages from Miocene to Early Pleistocene have been suggested. The mammalian fauna of the Crags is dealt with in more detail in the faunal notes. It has been suggested that the derivative marine Miocene and Eocene in the Red Crag represents the break-up in-situ of a Miocene sandstone, and in the upper (very fossiliferous) beds of London Clay, leaving only the lower (sparsely fossiliferous) beds of the latter in the area. Equally the material may have been transported some miles from sites now covered by the North Sea. Among the mollusca found in the Red Crag are many which are probably of Pliocene age though not necessarily from the Coralline Crag. Either beds of Upper Pliocene age, similar to the upper part of the Scaldisien, were deposited and subsequently dispersed by the Red Crag seas, or material of this age was transported into the district.

F.W.Harmer established a series of "zones" for the Red Crag for which he gave names and listed typical faunas. While much of his palaeontological data is now outdated, certain basic premises he made have never been improved. His Waltonian, Newbournian and Butleyan zones , while difficult to define geographically show a gradual lateral change in the Red Crag from South to North. There is a steady drop in temperature from the Coralline Crag : 14° - 24° C to the Butleyan 5° - 18°C which can be compared ~~to~~ with that of the present Dogger Bank : 6° - 10°C. The sub-tropical conditions of the Eocene and Miocene were followed in the Pliocene by the arrival of certain Pacific genera such as Neptunea and Nucella which probably entered the area via the Behring Straits. The Waltonian conditions were very similar to the earlier Coralline but during the Newbournian there was a further influx of forms from the North , which continued to live in the area during the Icenian. As well as a change in temperature there is a gradual reduction in the number of derivative species in the Butleyan, although in all the Red Crag deposits there was a continual reworking of the existing material and derivation from the lower to higher beds. The lateral distribution of the Red Crag zones has meant that there are no recognisable cases of one zone occurring in position over another, in the normal sense.

Large areas occupied by Red Crag are now covered by glacial deposits, so that it is mainly along the river valleys,where the Red Crag out - cropped, that it has been revealed by pits and "Coprolite" workings.

Little is known of large areas, and the conveniently NW-SE running estuaries were used by Harmer to delineate the limits of his zones. Thus the Waltonian is confined to the area about Walton-on-the-Naze, with a "subzone" with a similar fauna at Little Oakley. The majority of the Newbournian lies between the estuaries of the Orwell and the Deben, while pits about Butley and Hollesley show the Butleyan. This has resulted in some areas being doubtfully zoned. The Crag at Sutton may be Newbournian while the exposure in the cliffs at Bawdsey is clearly similar in fauna to that at Felixstowe, although these places are on opposite sides of the Deben estuary.

At present inland exposures in the Red Crag are few, and mostly in the upper parts of the various zones as the lower parts of the pits become infilled. The twofold division into highly-inclined and current-bedded lower beds is seen in all three zones, and it is mainly the upper beds with a limited fauna whixh are visible in the remaining old pits.

As regards geographical conditions a little more is known about the Red Crag. The Coralline Crag knoll at Sutton was certainly an island or submarine knoll in Red Crag times. Rock loving species such as Nucella lapillus abound in perfect condition in the Red Crag about the knoll, which in the past was seen to abut against Coralline Crag cliffs and to contain numerous pieces and boulders of fallen Coralline Crag. There can be no doubt that other Coralline Crag prominence helped to produce tidal currents in the area which may have contributed to the cross-bedded nature of the Red Crag. Harmer believed that the London Clay formed the border of the Red Crag sea, but since then two pits at Hascot Hill have revealed a Red Crag beach resting on the Chalk and containing a fauna, which while demonstrably Red Crag, cannot be assigned easily to one or the other of its zones, although the presence of Cardium angustatum suggests a post-Waltonian age. Fragmentary remains at a similar level in various Chalk pits in the area, show that the Red Crag at that period reached the present 150ft. contour mark. The presence of shells of Crag age at Sudbury, and possibly at Clare, suggest that Crag seas also penetrated the Stour valley to a similar height.

The "Scrobicularia" Crag.

In some of the pits around Butley, and extending towards Aldeburgh, is a pale-coloured sand with abundant shell fragments containing pockets and seams of complete shells. The size and thickness of the shells, the more limited fauna, and the increasing presence of Scrobicularia plana indicate a change in conditions. The beds are seen to rest on Butleyan Red Crag at Chillesford and on Coralline Crag at Aldeburgh, and may be considered as transitional between the Red Crag and the Icenian. Passing upwards beds of silt become more dominant until the Chillesford Crag with its in situ bivalves and limited fauna show a further change. At the type section clays referred to as Chillesford Clay cap the section. The Chillesford Crag may be considered as the most southerly known extension of the Icenian.

The Icenian.

The Crag between Aldeburgh and the North Norfolk coast rarely exposed in most of the area, was termed the Icenian by F.W.Harmer who divided it into three :

Norwich Crag
Chillesford Crag and Clay
Weybourne Crag

The molluscan fauna,which he studied, is with minor exceptions,fairly uniform for the whole series. To the east and the south the Icenian rests on London Clay, the base becoming deeper towards Lowestoft and Yarmouth, passes over onto the Chalk towards Norwich and the coast of North Norfolk in a shallow water facies bordered by gravels without fossils. In the upper part of the deposit the materials are extremely variable, passing from sand to pebbles, clay to shell pockets, often within a few yards. The presence of vast numbers of Nucella lapillus and various species of Littorina suggest very shallow water. In the deeper parts of the basin dark grey or bluish sands with sparse shell beds replace the littoral deposits but have only been seen from boreholes. Work is at present in hand on a number of boreholes to determine the age of the lowest Crag in this basin.

Norwich Crag.

The macrofauna of the Norwich Crag is distinct from the Red Crag though many of the species continue. There is a decrease in the number of species and a strong non-marine element is present, which was predicated by the increase of land and freshwater shells in the Butleyan Crag. The beds show great variation, both vertically and laterally, and include sands, shelly sands, pebble beds, clays and all intermediate grades.

Near Norwich the Norwich Crag can be seen resting on Chalk of the mucronata zone. The surface of the Chalk sometimes shows borings of molluscs, annelids and other marine organisms and the junction is marked by the Stone Bed, somewhat analogous to the basal bed of the Red Crag. Large comparatively unworn flints occur, presumably derived from the underlying Chalk. Mammalian bones occur scattered throughout the Norwich Crag but are more plentiful in the Stone Bed. The mineralogical state of these bones suggests that at least two distinct faunas are present, and like the earlier Red Crag transgression, the advancing Icenian seas no doubt broke up river deposits of varying ages, as well as including in its deposits stray examples of contempory mammals. However, the scarcity of these remains, their fragmentary state, and the amount of wear they have often suffered makes taxonomic work difficult. Derived pebbles and Mesozoic fossils, including ammonite fragments, are sometimes found in the Norwich Crag, but are much scarcer than in the Red Crag. London Clay fossils are very rare if not unknown, but a few fragments of polyzoans and large foraminifera from the Pliocene have been detected.

Chillesford Clay.

Various deposits of somewhat similar clay were plotted in East Anglia by F.W.Harmer who considered the resulting map to be the sinuous course of a river or estuary, roughly aligned north-south. Later work has shown that the clays are not all at the same horizon and that several similar clays occur at different depths in the Norwich Crag Series.

Weybourne Crag.

On the North Norfolk coast, and inland in the Bure Valley in old pits at Crostwick, Belaugh, etc., Crag resembling the Norwich Crag is to be seen. The fauna is slightly more restricted and shows the sudden appearance in large numbers of the bivalve Macoma balthica. Like the Norwich Crag it has at its base a Stone Bed, often containing many pieces of wood, as well as mammalian remains, where it rests on the Chalk. At Weybourne this Crag rests on a disturbed Chalk surface some twenty feet above high water mark; at West Runton the Weybournian beach level coincides with the recent beach level and a few miles away to the south east it has disappeared below the sea level.

In coastal sections near Sidestrand large rafts of Chalk may be seen in the glacial deposits, overlain and underlain by Boulder Clay. On top of most of these a Crag with Macoma balthica may be seen practically undisturbed, despite the tremendous kinetic forces involved in raising and moving such huge masses of Chalk. The Chalk is zonally some of the highest in Britain.

Cromer Forest Bed.

In the 'classic' succession the pre-Glacial beds come to an end with a series of Estuarine, freshwater and marine deposits. The plant remains varied from Arctic to Temperate and there is a large mammalian fauna. Many of the beds are poorly and irregulary exposed so that earlier workers found great difficulty in correlating the various deposits.

Corton Beds.

The Upper Arctic Freshwater Bed shows the oncoming of severe cold conditions and is followed by the Cromer and Lowestoft Tills. At various points within the tills, or resting on them in the form of basins, are sands referred to as the Corton Sands. Although strictly speaking outside the scope of the present guide, the presence of Neogene fossils in these sands makes (a) mention necessary. For the most part the contained molluscan fragments are the same as those in the Till but rare examples of Scaphella, Nassarius, Neptunea, etc. show a link with the earlier Crag Beds. On the other hand, near West Runton, Cromerian non-marine shells have been found in these sands.

Some geologists have claimed the sands represent an interglacial with the return of warm-loving molluscs to the area, after being eliminated by glacial conditions. The condition of the shells, however, the structure of the beds, and the distribution of the species along the coast all point to the material being derived from existing Crag beds and the finding of at least one of the species considered unique to the Corton beds in the Ludham borehole helps to confirm this view.

Recent Work on the Crags.

In the preceding paragraphs what may be termed the "classic" succession has been followed, but recent work, particularly on the 'Icenian' has thrown new light on the conditions under which these deposits were laid down. Emphasis has been on the evidence of microfossils rather than molluscs and whereever these are present they have been used to determine the climatic conditions. In the main, work on foraminifera and pollen has tended to complement each other. Boreholes have been made specially to investigate the deposits at depth and work still continues on the material thus collected.

Coralline and Red Crag.

Very little has been published on either of these deposits during the last thirty years. Work on a small group of Gedgravian foraminifera by D.J.Carter has already been mentioned. In 1960 D.F.W.Baden-Powell published a paper on the Coralline Crag in which he attempted to correlate the British Crags with the deposits of the Mediterranean area. The difficulty of doing this with such widely separated basins in our present state of knowledge is perhaps too great, and the choice of a genus like Turritella (whose species tend to be extremely variable) as fossils with zonal significance is unfortunate.

Attempts to find suitable pollen-bearing clays in the Red Crag at outcrop have been unfruitful and the foraminifera are generally missing or poorly preserved.

Icenian.

In 1958 B.M.Funnell examined the Norwich Crag on Bramerton Common, in an excavation specially made for the purpose. Earlier workers on the mollusca had suggested that some change in temperature had occurred during the deposition of the Crag in the area and an examination of the foraminifera not only confirmed this view but showed that three stages could be recognised, the lowest of which was comparatively warm while the highest was extremely cold or even glacial.

Deep borings at Ludham in 1950 and 1959 penetrated more than 130 feet of Crag, and subsequent study of the cores has enabled a series of stages based on climatic conditions to be recognised. Since then attempts at correlating the surface exposures in various parts of East Anglia with these stages has commenced. The various stages, in ascending order are briefly discussed.

Ludhamian.

Shelly marine sands, 25m thick at the base of the borehole with a temperate flora including the hemlock spruce Tsuga. The stage is named after the borehole locality. Its exact relationship to the Red Crag is unknown but it may either entirely post-date it or possibly represent the later part of it. The presence of the ostracod Cythere hoptonensis, first described from the Corton Beds, is of interest.

Thurnian

Silty clays 7m thick at Ludham indicate cooler conditions. This stage is named after the River Thurne to the east of Ludham and it has been recognised in a borehole at Southwold.

Antian.

The River Ant gives its name to this stage. At Ludham it is 3m thick with a temperate marine fauna and a flora including Tsuga. The Norwich Crag at Easton Bavents probably belongs to this stage.

Baventian.

Marine silty clays, 8m thick at Ludham with a cool flora and flora also known at Easton Bavents, South Cove, Aldeby and in parts of the Weybourne Crag on the Norfolk coast.

(Cont.)

Pastonian.

R.G.West includes estuarine silts, freshwater peat of the Cromer Forest Bed Series, Norwich Crag (in part), Weybourne Crag (in part) and the beach gravels of the Westleton Beds in this stage which is a few metres thick at Ludham, and has a temperate flora without *Tsuga*.

Beestonian.

Sands and gravels overlying the Pastonian silts in the Norfolk cliffs with Artic freshwater plants & evidence of permafrost, includes the so-called Lower Freshwater Bed of the old Cromer Forest Bed Series.

Cromerian.

Temperate freshwater peaty muds overlain by marine sands and gravels, include the so-called Upper Freshwater Bed.

Lowestoftian.

The top of the Upper Freshwater Bed of the Cromer Forest Bed Series shows a return to Artic conditions and is followed by the Cromer and Lowestoft Tills with the intercalated Corton Beds.

The stages quoted above are based largely on the evidence of pollen spectra and foraminifera. Only a synthesis of all available evidence can give the best answer and it now remains to see how new studies of the marine mollusca, and groups which have not yet been fully studied, such as the non-marine mollusca, or the small mammals whose remains are common in some Icenian beds, will fit into the structure outlined above.

BEDS RELATED TO THE CRAGS OUTSIDE EAST ANGLIA.

Lenham.

Marine beds of Miocene age occur as sandstone in Chalk pipes at Lenham, Kent. The chalk pits are no longer being worked and therefore specimens can no longer be obtained, but casts in sandstone reveal a molluscan fauna and the abundance of *Anadara diluvi* suggests a younger age for the Lenham Beds compared with the Red Crag Boxstone fauna.

Rothamsted, Herts.

Several large blocks of ferruginous sandstone were discovered in sandy clay and nine specimens of lamellibranchs were determined from impressions. Such species as *Pholas cylindrica* and *Cardium parkinsoni* indicate the Red Crag age of the specimens.

Netley Heath, Surrey.

Similar ferruginous sandstone was discovered on the North Downs at Netley Heath where *Lentidium complanatum* was the most abundant species. In both cases the amount of material was limited and scattered, and it is not certain whether either is *in situ*. Ironstone with casts of Crag shells has also been found at Sudbury, Suffolk, and in parts of Essex.

Ireland.

Glacial gravels at Killincarrig, Co. Wicklow, Ireland, have yielded worn shells which include such typical Crag species as *Scaphella lamberti*, *Nassarius reticosus*, *Neptunea antiqua*, *Glycymeris glycymeris* and several forms of *Searlesia* which where described by Mrs. N. McMillan as new species.

Elsewhere in Ireland and the Isle of Man are various gravels and shell beds containing shells of Pleistocene age but most of these appear to be Atlantic rather than Crag forms. the St. Erth clays, Cornwall, with a fauna which includes *Euthria corneus*, *Turritella erthensis* and other distinctive forms, while of Upper Pliocene age, have no connection with the Crag beds of East Anglia.

Scotland.

In Aberdeenshire Professor Jamieson recorded shells of Crag Age from glacial gravels. Since then the specimens appear to have been lost and no further examples have come to light. The shells recorded include such distinctive forms as *Scaphella lamberti* which could hardly have been misidentified and thus forms a link with the County Wicklow occurrence.

(cont.)

Corton Beds.

As already mentioned the Corton sands interbedded in East Anglian tills include such typical forms of Crag shells as Scaphella lamberti, Nässarius reticosus and Glycymeris glycymeris, as well as Cromerian freshwater species such as Valvata goldfussiana and Viviparus. The Corton sands also usually contain a large amount of Chalk debris and among this are many derivative Chalk fossils, including small Terebratulina, worm tubes, echinoid remains and polyzoa, some of which show that they were derived from Chalk of a higher zone than that at present occurring in East Anglia. The inference is that the chalk from which these Cretaceous fossils were derived came from areas now covered by the North Sea rather from the Chalk to the west.

Bridlington Crag.

Apart from the name, this 'Crag' bears no connection with the East Anglian Crags. In consists of masses of material caught up in the base of Saale or earlier Till, yielding a cold fauna including Tachyrhynchus erosa, Astarte montagui, A sulcata, Dentalium and many other species. The Bridlington Beds include the Dimlington Clay and the Bridlington Sands.

The term Crag has also been misapplied elsewhere. D.Wirtz referred to part of the Sylter Stufe as the Sylter Crag and presumed a Waltonian age for the fossils occurring as casts in a ferruginous sandstone ("Limonitsandstein"). Due to misidentifications the fauna was made to look more like that of the Red Crag, whereas the bed is almost certainly late Miocene in age.

The term Iceland Crag or Tjörnes Crag was also another unfortunate use of this term, especially as the material has even less resemblance to the shelly sands of East Anglia. Nevertheless the study of these Icelandic beds will eventually lead to a wider understanding of many problems in the Pleistocene.

PALAEONTOLOGY.

Eocene.

Where exposed, the London Clay of East Anglia is almost unfossiliferous. Pyritised wood and sharks' teeth are the most commonly met fossils. Mollusca, when the occur, are generally in pockets, sometimes in association with large pieces of drift wood. Fossil turtles are reported as being dredged off Harwich when septaria were sought for use in making cement.

The Crags.

The Crag beds are dominated by the Mollusca, which occurs in vast numbers in many of the sections. Early classifications were almost all based on the abundance of certain species or on associations of species of Mollusca. Thus Harmer referred to the Walton Horizon as the zone of Neptunea contraria, : an unfortunate choice as the species is known from the Pliocene of Holland and Belgium; it occurs throughout the Red Crag and is found in the Weybournian, and continues to live to the present day.

The Coralline Crag.

In the Coralline Crag Polyzoa equal the Mollusca in quantity, and it was from their presence that the name Coralline was derived. Several pieces of solitary corals occur, as well as the unusual Cryptangia which occurs intimately related with a polyzoan and a barnacle Pyrgoma anglica. In some parts, as at Ramsholt, beds of oysters and large barnacles, show fairly static conditions; elsewhere the Coralline Crag may consist wholly of well-sorted, strongly-drifted and current-bedded material including disarticulated remains of echinoids, barnacles, fish otoliths, foraminiferans, small shells and fragments of polyzoans.

The Red Crag.

Once again Mollusca dominate the fauna. A solitary coral, Balanophyllia is probably the only true Red Crag form, and is commonly met with. Polyzoa are mainly adnate mainly occurring inside the valves of bivalves, and usually forming only small colonies before the host shell was buried. Bilvalves frequently for the majority of the beds in which they occur; gastropods occur less frequently.

Red Crag. (Cont.)

The only common echinoid is the small Echinocyamus. Large gastropods sometimes have a covering of balanids of several species. Dermal tubercles of rays occur occasionally; other fish remains are mostly derivative shark teeth.

Nucella lapillus is among the commoner gastropods and shows useful evolutionary tendencies. The large, heavy N.lapillus incrassata which is the form met with in the Scaldisien, occurs rarely in the Waltonian and the lower parts of the Newbournian. The characteristic form in the Red Crag is smaller, and while retaining the angularity and strong shoulder keel, is thinner and less strongly ribbed than incrassata, with a tendency for varices to occur. Less angular and finer ribbed specimens occur more often in the Upper Red Crag and the form found in the Icenian approaches the modern shell. Several other persistent species show similar evolutionary tendencies and can be used to separate the different Crags in a broad way.

The Upper Red Crag at Butley begins to show the first arrival of species more characteristic of the Icenian - rare examples of Turritella communis, Macoma calcarea, and Scrobicularia plana for instance. Certain derivative Pliocene shells, such as Cardita senilis and Astarte omali occur as high as the Scrobicularia Crag.

The Icenian.

Lower temperatures, and perhaps lower salinity result in fewer species. Many groups are unrepresented, e.g. the corals. Polyzoa are rare and few in species. Apart from isolated spines, echinoids are restricted to Echinocyamus. Mollusca still dominate the fossiliferous beds but the shells are mostly smaller, thinner and more eroded. In typical Norwich Crag, bones of a remarkable fish, described by Agassiz as Platax woodwardi are not uncommon. These bones are remarkably thickened, a condition known in modern examples of Platax. However, it is possible that the bones do not all belong to the same genus. Dermal defences of Raia are common and the teeth of Mimomys and other small mammals are common in parts of the Norwich and Weybourne Crags. Non-marine shells, both land and freshwater, occur and Corbicula fluminalis makes its appearance in the Norwich Crag of Wangford and Yarn Hill.

Some remarkably distorted fossils occur in a limited area around Bramerton and Postwick in the Norwich Crag. This has been suggested as due to decreased salinity or stagnation but no theory seems to satisfy all the facts. While Nucella and Littorina are affected no other species of mollusc is affected. The distortion consists of a remarkable series of monstrosities, including heavily ribbed forms, keeled examples, depressed or elongate forms or any combination of these. This is all the more remarkable in a genus like Littorina, where any variation is extremely unusual and whose members are frequently found in contact with brackish or stagnant waters. No common food factor is apparent and all the other shells are normal and abundant. Certain foraminifera are also affected. A series of these monstrosities were figured by Woodward, Wood and Harmer. Elsewhere in the Norwich Crag similar communities of Nucella and Littorina are unaffected.

P.G. CAMBRIDGE.

(The above article is a reprint (with permission) and with some additions, from 'A Review and Guide to the Neogene and Lower Pleistocene deposits of East Anglia', for the Norwich meeting (1970) of the 'Colloque pour l'etude du Neogene Nordique'.).

INCLUSIONS IN AMBER.

I recently took the opportunity to examine the North Sea amber in the collection of the Ipswich Museum. Of 57 pieces,,22 contained real inclusions.(Other pieces had fractured internally,forming circular patches of discontinuity which resembled seeds when viewed in certain lights.)

Two pieces contained wood and wood fibres and three more contained small dicotyledonous leaves.One of these latter also contained a twig. Other plant material comprised a portion of thick leaf and a small spray of cypress leaves.One piece of smooth bark was found. This was particularly interesting for on it were attached spangle galls, similar to those seen on the underside of oak leaves.

The insects and spiders were distributed as follows :

FLIES - (Diptera)

Chironomidae -one piece contained a veritable swarm of small midges.

Dolichopodidae - Five individuals in three pieces of amber. These flies resembled those of a common bark-frequenting genus,Medeterus, but are much larger than the present British Species.

Empididae - A pair of Rhamphomyia species in one piece.

Ceratopogonidae - Three specimens in two pieces, of these small biting midges. (I wonder what they were annoying then ?)

Sciaridae- Two specimens in separate pieces of amber.

Cecidomyidae - One specimen of a gall midge.

Phoridae - One specimen in poor condition,

and one intriguingly large, but unidentifiable fly.

BEETLES - (Coleoptera.)

Altogether there were one weevil(Curculionidae),one small rove beetle (Staphylinidae) and two beetles which I could not place in a family.

BUGS - (Hemiptera)

Two bugs were found. These were a last-instar(pre-adult)leaf hopper (Cicadellidae) and a very immature unidentified bug.

OTHER INSECTS.

Hymenoptera - one minute gall-wasp (Cynipidae) .It is conceivable that the species was that which caused the spangle galls mentioned above.

Trichoptera - one adult caddisfly. An indication of the proximity of fresh water.

? Isoptera - one badly -preserved winged neuropteran,which resembled a termite.

Dictyoptera - one cockroach (Blattidae.)

Collembola -two springtails,in one piece of amber which also contained the rove beetle and the weevil. The amount of particulate dirt in this piece suggested that it was very close to,or in contact with the ground. This would also explain the presence of springtails which are not normally bark -frequenting insects.

This piece of amber also contained two different spiders.

Two other spiders were present in separate pieces of amber.All the spiders were of the orb-web type (like our common garden spider.)

One mite (Prostigmata) was found.

There remains but one inclusion I have not mentioned. This still evades a satisfactory explanation. The piece of amber was a cut slice and well polished.The inclusions resembled nothing more closely than breadcrumbs.? Any suggestions ?

Many of the pieces described above can be viewed in a new display of amber at Ipswich Museum.

A.G. IRWIN.

LITTLE OAKLEY EXCAVATION 1973 - 1975.

Location : TM224292. Upper surface of Red Crag 21.39 metres.(70ft.)O.D.

Extent and Orientation : The excavation is about 8ft. in length, in a N.E. to S.W.direction. The width (N.E.end) is 3ft. 2ins, and the depth at the N.E. end is 7ft. 6ins. to the Water Table, and 11ins below W.T. giving a total depth of 8ft.5ins. The pit is stepped downwards from the S.W. end.

Section description :-

The surface slopes gently downward in a southerly direction :

9" soil. There is a fairly constant cover of at least 9" of soil. In a few placed the Crag occurs above this, but is has probably been brought up by agricultural activity.

15" soil or crag or mixed soil and crag. Sharp drops occur in the line of junction between soil and crag. In places soil can be found, without a trace of crag, down to a depth of about 2f t.

21" mostly crag, some mixed crag and soil. Soil tends to be encountered at a greater depth at the N.E. end of the pit.

45" Crag (to Water Table) } Shells, which are abundant towards the
11" Crag (below Water Table) } surface, tend to become scarcer with increasing depth, also shell particles become finer. However, whole and reasonable well preserved specimens, chiefly of N.contraria, S.arcuata and G.glycymeria occur throughout. I have also found C.scalaris, C.opercularis, T.incrassata, H.reticosa ?costata, Gibbula ? cineroides and Natica Sp. down to the base of the crag. These seem to occur in thin bands, separated by more or less unfossiliferous sand. The colour of the deposit ranges from a distinct orange at the top to almost grey towards the base.

The London Clay :

The base of the Crag rests on London Clay, the junction, being below water, is obscured, but samples brought up from the surface of the clay show it to be light greyish-brown in colour, such as one would expect had the clay been subjected to weathering prior to the deposition of the Crag. Pebbles of clay of a similar colour and texture occur throughout the Crag, suggesting an exposed clay surface, probably at no great distance, at the time of crag deposition.

Stratigraphy of the Crag :

The bedding of the Crag appears to be almost horizontal; however, there is a slight dip detectable - about 8° - in a southerly direction. The fewer, and better preserved shells at the lower levels have probably not been carried far from the place in which they lived; the occurrence of a S.arcuata with both valves united seems to support this view. On the other hand, the shells of the upper levels show signs (in most cases) of considerable wear, and have probably been transported from a greater distance or subjected to more disturbed conditions. The more frequent occurrence, and larger size of clay pebbles towards the top would also indicate a stronger current. The presence of these pebbles might also be taken to indicate a decrease in the depth of water,

(cont.)

... thus the shells in the upper part of the deposit may have at some time come under the influence of wave action. Throughout, the Lamellibranch valves lie in the position of greatest stability.

Fossils of the Crag :

In general, the assemblage of fossils I have found so far is similar to that of Walton-on-the-Naze. However, a few differences do emerge. (At this point I must stress that the following is based entirely on my own somewhat limited observations to date, and do not take into account faunal lists produced by workers in the past.) Some species, rare, or possibly absent at Walton, occur fairly commonly at Little Oakley. Most notable among these are M.praetenuis and (to a somewhat lesser extent) M.obliqua. N.Tetragona (both typica and var. alveolata) may be found at Little Oakley but not as frequently as at Walton. N.lapillus, on the other hand seems slightly more common. I have found a few specimens of H.reticosa at Little Oakley, which look fairly typical, but by no means as many as at Walton. However, the variety costata seems to be abundant at Little Oakley. So far, I have the impression that H.granulata (typica and var.gracilis) and T.muricatus are less common at Little Oakley than at Walton. Also, L.catenoides may come into this category as well. Obviously these are early impressions, but I think I have progressed sufficiently to make them of some value. The following faunal list contains only those species and varieties of which I am reasonably certain of the identity. The comments accompanying the list are also restricted entirely to my own observations to date, and are intended primarily for comparison with previously published literature, not as an attempt to supersede this.

FAUNAL LIST.

Abra (Sydesmya) alba	W.Wood	
Aporrhais pes-pelecani	Linne	
Astarte burtini	De la Jonkaire	
" gracilis	Munster	
" obliquata	J.Sowerby	
" omalii	De la Jonkaire	
Balanophyllia caliculus	S.V.Wood	
Balanus ? porcatus	Da Costa	One whole specimen
Calliostoma subexcavatum	S.V.Wood	Not as common as at Walton
Calyptraea chinensis muricata	Linne(Brocchi)	Not common
Capulus ungaricus	Linne	Not common
Cardita senilis	Lamarck	
Cardium edule	Linne	Common
" " clodiense	" (.S.V.Wood)	One specimen found
" ? interruptum	S.V.Wood	No whole specimen found
" parkinsoni	J.Sowerby	
Cassidaria bicatenata	J.Sowerby	Fragment

Little Oakley Excavation

FAUNAL LIST (CONT.)

CHlamys harmeri	Pennant	
" opercularis	Linne	
" tigrina Var. γ	Muller (S.V.Wood)	One specimen found
Carbula ?gibba	Olivi	
Corbulomya complanata	J.Sowerby	Typical form
" "		Shorter rounded form more common
Cryptangia woodi	Edwards & Haime	In bryozoan : Poss.derived from Coralline Crag.
Cyclocardia chamaeformis	Leathes	Less common than C. scalaris.
" scalaris	J.Sowerby	Fairly common
Digitaria digitaria	Linne	Some quite large specimens
Dosinia exolita	Linne	Remarkably common
Drillia icenorum	S.V.Wood	One specimen found
Echinocyamus pusillis	Muller	
Fissurella graeca	Linne	Not common
Gastrochaenia dubia	Pennant	
Gibbula ?cineroides	S.V.Wood	
Glycymeris glycymeris	Linne	Very common
Hiatella arctica	Linne	Not common
Hinia granulata	J.Sowerby	Not as common as at Walton
" " elongata	" (Harmer)	" " " "
" " gracilis	"	" " " "
Hinia propinqua	"	
" reticosa	"	
" " costata	" (J.Sowerby)	Poss.more common than "Type"
" " ? curta	" ?	
" " pulchra	J.Sowerby (Harmer)	
" " tiara	" "	Not common
Leiomesus dalei	J.Sowerby	
Lunatia catena	Da Costa	Not common
" Catenoides	S.V.Wood	Not common
" (Natica)proxima	S.V.Wood	
" " " woodii	" (Harmer)	Poss.= Polinices hemiclausus oakleyensis.
Macoma obliqua	J.Sowerby	
" praetenuis	Woodward	More common than M.obliqua.
Murex tortuosa	J.Sowerby	One specimen found
N assa?dautzenbergi crassisculpta Harmer(Harmer)		
Nassa labiosa	J.Sowerby	
Natica affinis	Gmelin	Shell thicker than N.affinis. from exposures farther north.
" cirriformis	J.Sowerby	Immature specimens.
" multipunctata	S.V.Wood	Common
" " ?consors	" (S.V.W.)	Poss.=N.stercus-muscarum
" pusilla	Say	
" stercus-muscarum	Gmelin	Poss.=N.multipunctata consors.
" tigrina	Defrance	

Neptunia contraria	Linne	Good specimens very common
" " angulata	"	Not common
" " sinistrorsa	" (Deshays)	
" " informis	" (Harmer)	
" despecta	Linne	Not common
" " decemcostata	Linne	" "
Nucella lapillus ?imbricata	Linne(Lamarck)	
" " oakleyensis	" (Harmer)	
" " (varieties)	"	Not common
" tetragona	J.Sowerby	Not as common as at Walton
" " alveolata	" (J.Sowerby)	Not as common as at Walton
Nucula laevigata	J.Sowerby	Not common
" ?nucleus	Linne	More common than N.laevigata.
Pecten maximus	Linne	Fragments
Phacoides borealis	Linne	
Pholas crispata	Linne	No whole specimens found
" cylindrica	J.Sowerby	No whole specimens found
Polinices hemiclausus	J.Sowerby	
" " oakleyensis	" (Harmer)	Poss.=L.proxima woodii
Pteromeris corbis	Philippi	
Pycnodonte cochlear	Poli	Not common
Scaphella lamberti	J.Sowerby	
Searlesia costifera(varietes)	S.V.Wood	
Sipho Curtus	Jeffreys	
" ?gracilis	Da Costa	
Sphenotrochus boytonensis	Tomes	Not common
" intermedius	Munster	
Spisula arcuata	J.Sowerby	Common.One specimen with united valves.
" ?solida	Linne	
Tectura virginia	Muller	
" " conica	" (S.V.Wood)	
Terebratula Sp.		One specimen found,broken and rather worn.
Trivia avellana	J.Sowerby.	One specimen found.
Trivia coccinelloides	J.Sowerby	
Trophon muricatus	Montagu	Not common
" clathratus attenuata	Linne(Harmer)	Not common (doubtful variety.)
Turritella incrassata	J.Sowerby	
" tricarinata	Brocchi	
" ?triplicata	Brocchi	Poss.= T.incrassata

The exposure has also yielded :

Barnacle valves, with occassional whole specimens.

Belemnites, very worn and obviously derived.

Bryozoa

Scaphopods (fragments)

Sharks teeth.

(Cont.)

Section on N.W. side of pit at Lt. Oakley, Essex.

Key: 1. Soil with some crag at lower levels.

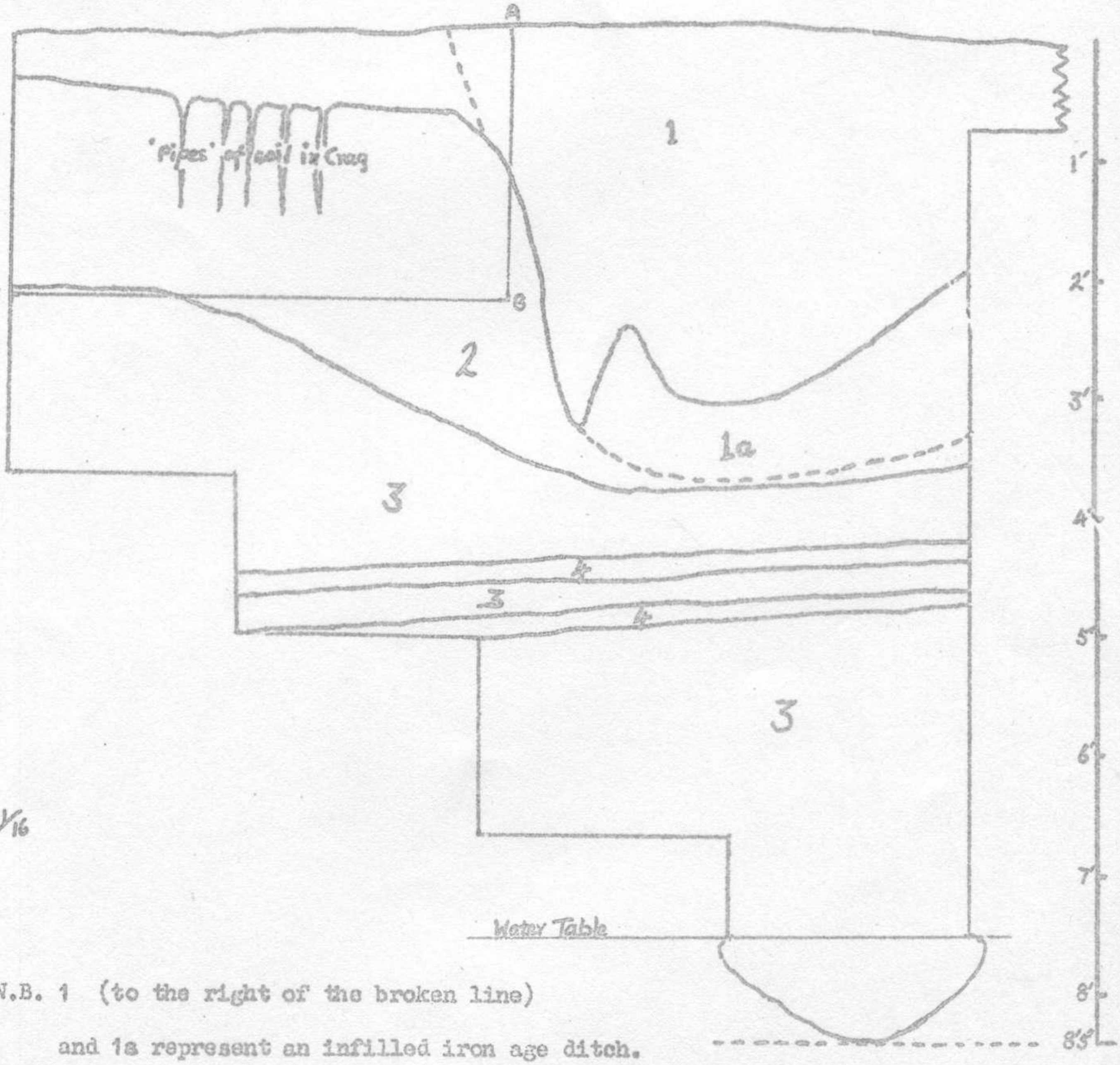
1a. Mixed crag and soil.

2. Orange coloured crag with some mixed soil in places.

3. Lighter coloured crag.

4. Shelly bands (apparent dip about [illegible]°). 3°)

The line "A" "B" "C" represents a step out into the N.W. face.



Scale 1/16

N.B. 1 (to the right of the broken line)

and 1a represent an infilled iron age ditch.

London Clay

Little Oakley Excavatioh (Cont.)

Since writing this account it has been demonstrated to me by Capt.R. Farrands that the north-west face of the excavation cuts across an Iron Age ditch, which is a continuation of one of the twin ditches visible in his archaeological excavation some 200 yards W.N.W. This ditch is shown in Fig.1 by the broken line which encloses section 1a and the greater part of section 2. It will be seen that the lower part of the ditch is infilled with mixed crag and soil, while the upper part is infilled almost entirely with soil; thus the sudden drop in the upper crag surface at the eastern end of the pit is explained. Possibly the "pipes" of soil in the crag to the west of the ditch section may have resulted from cracks which developed in association with the ditch.

A further point of interest is the apparent absence in the Red Crag in this exposure of a marked upper zone of decalcification. In fact, shell fragments tend to be larger and more numerous in the upper layers. That these upper layers have been subjected to surface oxidation is apparent from the rich orange colour, but I could find no evidence of more decalcification at this level than deeper; nor does the crag at greater depth show any indication of cementation by re-precipitated calcium carbonate.

The following information, kindly made available to me by Mr. A. Boatman, refers to a sample taken from the lower part of the excavatioh at Little Oakley.

Description of sample: sand, fine-medium grained, yellow. Thw whole sample contained 68% finely comminuted shell debris, but this was not included in the particle size analysis.

Particle sizes range from 0.055mm to 1.0mm; the median diameter being 0.29mm.

It appears that the sand grains are white, or almost so, and that the colouration of the deposit is due to the abundance of iron oxide present in the silt fraction.

W.I. STIDWELL.
