IPSWICH GEOLOGICAL GROUP

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CONTENTS

LANDGUARD COMMON, FELIXSTOWE, SUFFOLK.

map reference TM 2831, 2832, 2932. 140 acres.

This area consists of a triangular promontory or ness of marine shingle (2-3 cm, diameter) and sand at the eastern mouth of the Orwell and Stour rivers. For hundreds of years it had belonged to the Ministry of Defence (M.O.D.) but when the Anglian regiment moved out some six or seven years ago there was considerable local controversy as to its future.

It is adjacent to the expanding dock at the west side and to the town of Felixstowe at the north: it is not suitable land for agricultural development in any way.

When vacated by M.O.D. the area had some R.A.F. married quarters. These are still occupied by R.A.F. families. The area also contains an ancient monument, Landguard Fort; a rifle range, several old search light filments, concrete tank traps and other man made artefacts all of which have been allowed to become dilapidated and in a dangerous condition - indeed Landguard Fort interior has been used recently by soldiers to practice street fighting before going to Northern Ireland.

During the last decade Felixstowe has developed into a large flourishing port dealing with E.E.C. trade as well as the U.S. and Middle East and more recently has made great strides as a passenger port. Most of the trade uses containers so large storage areas are necessary. The land acquired by the Felixstowe Dock and Railway Company including that on Landguard Common may be seen on the map in the Felixstowe Centenary Supplement of the Felixstowe Times dated 29 Sept. 1975.

When the Anglian regiment moved cut of the buildings at TM 283 326 these were taken over by Customs and Excise and became part of the dock complex. The Dock area is clearly defined by a high chain-link fence surrounding its area on Landguard Common. The dock area of Landguard Common now occupies some 85 acres, while the R.A.F. married quarters and the Customs and Excise take up about another 5 acres.

In the south west, an area of about 10 acres is owned by Harwich Harbour Conservancy Board (HHCB) and this is technically in Essex. There is an H.H.C.B. employee living on this land who acts as unofficial warden for the adjacent Suffolk Trust for Nature Conservancy (STNC) which will be discussed later. On the H.H.C.B. land there is also a large gravel processing plant operated by Hall Aggregates who produce fine and coarse aggregates from the material being continually dredged to keep open the deep water channel that serves both Harwich and Felixstowe harbours. This firm uses the jetty on the H.H.C.B. land.

Adjacent to these workings is Landguard Port which was first used in a minor way in 1534, the Fort proper was erected in 1620 and a second Fort in 1667 and was in continual use till 1904. However, unfortunately Landguard Fort, albeit scheduled as an ancient monument is something of a white elephant. It has much beauty including a magnificent granite facing - all hand made on the south east wall, a cupola built to defend the moat and the mechanism still left from the drawbridge as well as two ancient cannon at present doing duty as gate posts I It also has a plaque which bears tiie inscription "This battery is named Darell's battery after Captain Nathaniel Darell of Colehill, Kent, Governor of Landguard Common 1667-70.”

The Fort itself has great potential as sometimes suggested in the local press; the Felixstowe Dock and Railway Company considered buying it to make an hotel and restaurant but the expense of doing anything worthwhile with the building would be formidable and quite out of the question in the present economic situation so it is left to the rabbits and brambles - and the D.O.E.! The Dock Company, before the Fort was scheduled as an ancient monument, even considered buying it to demolish it and use the land but even that proved impossible as the Fort could not be blown up as it is too near other buildings and it is too massive and well built to be knocked down!. At present the Fort is in a very dilapidated states it is not open to the public and is in quite a dangerous condition in parts inside but it is a magnificent building which has the potential of the Portr Nigra at Trier, and has spectacular views of both Harwich and Felixstowe Docks and shipping lanes.

The south east shore of Landguard Common particularly at the south end is a prograding coast line somewhat slowed down - according to the local D.O.E. expert - by the removal of so much shingle by dredging. The beach is terraced in four grades or steps each about 20 cm high and 5 m apart and at the sea edge there is alluvial sand and this is being built up inside the 200 m breakwater at TM 283 302. There are groynes along the east side of the common and they seem to collect shingle on each side and have sand in the middle. The direction at which the sea approaches this (fast varies very much with tide .and wind from south-east to north-west.

The sea channel to the west of the spit was blasted in 1969 and the sandstone pieces from this exercise can be seen on the shore and have been used to strengthen the breakwater at the south end, where there is a classic display of seaweeds. There are also plenty of sand hoppers in the bladder wrack and yellow lichen growing on the alkaline cement jetty wall in the splash zone.

The area has been overrun by rabbits but is still one of the few areas where sea spurge and hen bane can be found, and the sea-poppies are beautiful. Apart from rabbits galore and some rats there are fewother mammals but these include the odd stoat, vole and weasel. There are large numbers of cabbage white butterflj.es and a few red admirals, holly blues and brown small heaths. There seemed to be no evidence of land or sea worms.

Little terns nest In the area and thrushes have their cracking stones to crack the shells of the colourful snails in the area but these snails seem to be declining in number.

The marshy ground TM 285 325 area has dried up and cracked this summer (1975) due to the drought and only supports small patches of moss. The whole area is at present unsightly but work is in progress to improve the appearance.

There were many plans to develop the area when M.O.D. announced its intention of withdrawing in 1968-70 time. One was to build a power station on the site - hotly contested by the locals! - but bore holes established, that the shingle etc. was 30m deep before solid chalk, on which foundations could be built, was reached.

Another suggestion was that the whole area should be bought by the Felixstowe Dock and Railway Company and developed and yet another idea that Suffolk Coastal District (which includes the late Felixstowe Urban District Council) should, buy the land for recreational purposes, while naturalists pointed out that this was one of the few areas where the little terns still breed.

The agreed distribution of the land is shown in the Felixstowe Town Map (Development Plan). The dock land is heavily used and has been well fenced off - the RAF married quarters are still MOD property and the area marked CRA now belongs to the Suffolk Coastal District who are clearing away the gun emplacements, tank traps, railway lines etc, levelling the beach, and infilling the marshy area behind the man-made embankments. The coast line has groynes and concrete revetment and these, with the man-made embankments, are being retained as protection against erosion from the sea bearing in mind that in the area immediately north east of the Common, 37 lives were lost in the Fast Coast floods of 1953. Normally there is a 3m tide range. When this work has been finished the area will be used for some recreational purposes, still unspecified; there is a road access to it from Manor Terrace TM 290 320 without going through the dock area.

To the naturalists and the conservationists the most important decision was to sell an area to the Suffolk Trust for Nature Conservation thus maintaining the little terns breeding area-though it should be mentioned that this year they chose to breed on H.H.C.B. land adjacent ! The area also provides a quiet sheltered, place for moulting gulls, resting places for migratory birds and it is hoped that the hen bane and sea spurge continue to flourish. The S.T.N.C. land is screened from the Hall Aggregates Works by an abrupt rise in land that, though obviously man made originally, is quite old as it supports ilex as well as tamarisk and. alder. There are several proposals as to what S.T.N.C. should, do with their land. There is an access road, and small tarmac area that could act as a car park for a few cars and an idea is that a railway sleeper path should be laid through the area so that interested people could, walk through and, observe while still keeping to the path. Another suggestion is that only one third of the area should be open for "viewing" at any one time depending on the season.

The main consensus of opinion is that the area should, be well fenced off and screened from the CRA and then left as it is with the tank traps etc. in position and no access to the public without permission so that the birds can be unmolested but there is certainly a need to exterminate or severely restrict the rabbit population which is destroying so much of the vegetation.

There are two 'groups' against this scheme - the fishermen who regularly use the coast line but this could be possibly be overcome by a permit system, and the group that advocates' the CRA as a water sports centre but this seems very unlikely so near to the major shipping lanes to Felixstowe and Harwich.

Taken as a whole it would seem that this "carve up" of Landguard Common is fair enough the people of Felixstowe have got their CRA, the H.H.C.B. still keeps its "watch dog" corner and the S.T.N.C. has its conservation areas true the docks have the largest slice but they are the life blood of the area. The area is quite exposed to winds from the cold areas of Europe so is not suitable for much outside amusement.

S. Finlay,

(Mrs Finlay's article was originally used for another purpose and has, with permission, been slightly altered where it referred to maps letters not reproduced here.)

THE GREEN CHILDREN OF WOOLPIT

About the green children... .Nor does it seem right to miss out a miracle unheard of for centuries which is known to have happened in Anglia in the reign of Stephen. Indeed, I hesitated about this matter for a long time although it was already mentioned by many people. It seemed ridiculous to me to bring to belief a matter of no rational explanation or a very obtuse one, until I was overwhelmed by the weight of so much evidence of such a kind that I was compelled to believe and be amazed by something which I cannot understand or fathom with any concentration of my mind.

There is a village in East Anglia, four or five miles it is said from the noble monastery of the blessed king and martyr Edmund. Next to this village can be seen certain very ancient ditches, which in the English tongue are called Wifpitts i.e. Wolf pits; and these give the name to the village nearby. From these pits, at harvest time with the harvesters busy in the fields collecting the crops; two children came out, one male and one female, with their whole bodies green and dressed in clothing of unusual colour and material. While they were wandering, amazed through the fields, they were arrested by the harvesters and taken to the village, where many gathered at the sight of such a novelty. For some days they were kept without them eating fond even when they were almost fainting from hunger they would not touch any of the food offered to them. By chance it happened that beans were being brought in from the fields, which seizing immediately they looked for the pith inside the stalks and when finding nothing in the stalks they wept bitterly. Then one of the bystanders ripped out the pith from a pod and offered it to them; this they took at once and ate it, they lived on this food for some months until they got used to bread. Then gradually their colour changed as the nature of our food affected them and, they became like us, they also learned the use of our language. It seemed a good idea to the wise that the children should, receive the sacrament of Holy Baptism, this was clone but the boy who seemed the youngest died soon after, leaving his sister who now was not much different from our own women, and it is said that she later married a man from Kings Lynn. When they had learnt our language and when they were asked who they were; where had they come from?, their answer was that they were from the land of St Martin, who was highly venerated there. They could not explain where this land was or how they had got from that land to where they had been found by the villagers. What they did remember was that when they were looking after their fathers' herds in the fields, they heard a great noise, just like we now usually hear the bells of the Monastery of Saint Edmund, and while they were wondering about this noise they suddenly found themselves amongst the harvesters in strange surroundings. When they were asked if there was any belief in Christ their reply was that there was Christianity and that there were churches. To a question about the sun and its movements, the answer was that the sun did not rise in their country, that the amount of light was small like we have just before sunrise and just after sunset. They did mention that they could clearly see another country from their own, across a very big river. These things and many others, which would take far too long to relate, were answered by the children to those people who had asked. Anyone can say what they like as they puzzle over these things; I am not ashamed to have told, this amazing event, indeed this story is too complicated for our intelligence to understand.

The above passage is a translation from the latin version written by William of Newburgh, and can be found in "Suffolk in the XVII Century": a "Breviary of Suffolk" by Robert Reyce, 1618.

The manuscript from which the breviary is taken is numbered 3875 in the Harleian Collection at the British Museum, where there are two modern versions of the breviary by Jermyn and Davys: additional MSS.8200.1915.5829. Also from breviary - Woolpitt. This place, has by some been thought to be the Roman Sitomagus. The extensive deposits of brick earth tend to support this view. The Romans were great brick makers and. their excavations may account for the second syllable of the name, In all likelihood the first syllable has nothing to do with wool; it may refer to wolves, perhaps it is only a record of a former proprietor named Ulf.

(This article taken with permission from a written copy by V. R. ones of Latin translation by R. Wingfield of Pakenham).

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R. M.

NOTES 0N GEOLOGICAL GROUP 'DIGS' AT GEDGRAVE, BATTISFORD, AND WANGFORD.

1. GOMER FIELD, GEDGRAVE.

The 'dig’ of the weekend 13 and 14 September 1975 was held in the famous ’Gomer Field’ at Gedgrave, near Orford, with a view to exposing the fossiliferous Coralline Crag.

Saturday was a wonderfully sunny day and digging progressed satisfactorily, stopping for a while in order to watch a weasel chasing a rabbit through the site. Sunday was quite a different matter with pouring rain hindering collecting; filling in one of the excavations proved a teaser as water kept coming in at a greater rate than the spoil (driftwood and some bricks), followed by dry weather, solved this problem.

Two holes were dug, no.1 at a lower level than no.2. No.2 was excavated to about 3 feet 6 inches, and no.1 to 4 feet 6 inches, both exposing shelly Coralline Crag.

No.2 showed rather yellowish crag, with some larger shells in the lower part; no.1 was in whiter crag, most of which was below water-table (water-table was only reached in the bottom of no.2 hole.) Use of a hand-pump on Saturday and motor-pump on Sunday enabled us to dig some way below the water-table.

Samples were taken for, later sorting. The following fossils were noted during the course of the ‘dig’.

Bivalve Molluscs -

(D) = double valves

- Arctica islandica
- Pecten
- Chlamys opercularis
- Chlamys dubius
- Chlamys tigerina
- Cardita senilis (D)
- Cyclocardia
- Ensis
- Glycymeris
- Venus casina
- Phacoides borealis (D)
- Diplcdonta (D)
- Thracia (D)
- Ostrea
- Astarte omalii
- Astarte. spp.
- Corbula gibba
- Anomia
- Cardium ?decorticatum

Gastropods -

- Natica multipunctata
- Natica sp.
- Turritella incrassata
- Trivia
- Scala
- Calyptraea chinensis

Brachiopod -

- Terebratula

Corals -

- Flabellum woodi
- Cryptangia woodi

Bryozoa -

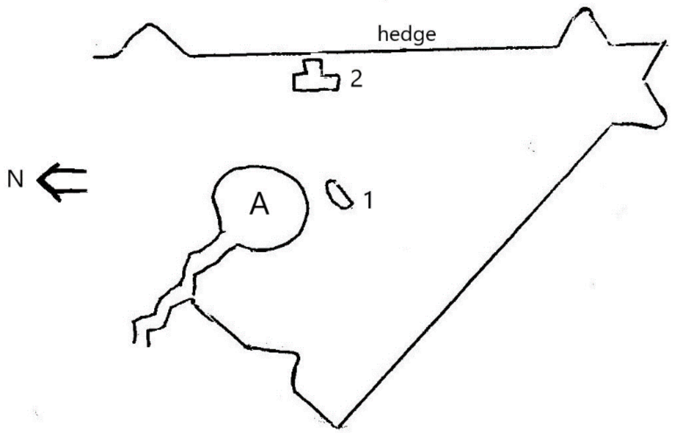
- Cellepora
- Hydractinia

Barnacles

Echinoid -

- Spatangid

Sketch plan of part of Gomer Field, showing pond (A) and positions of trenches 1 and 2.



I wish to thank Mr. Starmer for permission to dig, Mr. Pinney and Mr. Sands for local help, S. MacFarlane for supplying the pumps, R. Cheesman for caravan facilities, and C. Down for sending me a list of fossils found (similar to the above list).

2. BATTISFORD.

The Geological Group 'dig' of January 1967 is fully recorded in our Bulletin no. 3 (August 1967), pp. 1 and 2.

In 1971 the pit (grid ref. TM 061 538) became a geological reserve of the Suffolk Trust for Nature Conservation, and in 1972 the Geological Group undertook the following work

- wire fence and 'gate' put up.
- notice erected.
- most of the rubbish moved to one corner of the pit.
- scrub-clearing started.

 a few small trees taken down.

- section clearing started.

Since then, work has concentrated on our attempt to dig through the pebble bed to reach the Chalk. In January 1967 we had dug through 3 ft. 4 in. of shelly pebble-gravel| a 'dig' in March 1973 increased this to 5 ft., while tfe November 1974 'dig1 took us to 5 ft. 10 in.. Finally, in March 1976, chalk was reached under 6 ft. 10 in. of shelly pebble-gravel, and about 7 ft. 10 in. below the base of the pit. This was no mean feat considering the difficulties of excavating such coarse gravel and dealing with copious inflow of water (the water table has on occasions been about 7 feet above the top of the chalk!).

The total thickness of the Crag pebble deposit at this site is thus about 14 ft. 10 ins.

A few additional fossils may be added to the 1967 list;-

Searlesia costifera
Nucella tetragona
Natica multipunctata
Scaphella lamberti
?Hinia reticosa

Mineralised wood } found by, and kept by,
Edaphodon tooth fragment) } Somersham Youth Club members

I wish to thank Mr. J. Knock for help in connection with our work at this site.

In September 1972, the Geological Group undertook an excavation in opposite the above pit, and an old pit on the south side of the road, opposite the above pit, and obtained the following section-

	thickness	
Soil	10ins	
Till	6ft 8ins	
Sand and Gravel	3ft 4ins	
Pale-coloured sand	5ft 10ins	
Sand and gravel (fossiliferous)	2ft 6ins	}
Sand with thin gravel layers	3ft 1ins	} 12ft 1ins
Ferruginous sand	5ft 2ins	} (Crag pebble deposit)
Sand and gravel	1ft 4ins	}
Chalk	3ft 6ins	

Since then, this site has been worked by Mr. Keen, who kindly gave permission for the Geological Group visit in March 1976.

Some further details of this section may now be added. –

The sand and gravel below the till and above the pale-coloured sand has been measured up to 5 feet 6 inches in thickness, and belongs to the quartz-rich sand and gravel found, below the till in this area.

The pale-coloured sand below the quartz-rich sand, and gravel and above the crag pebble deposit contains thin vertical tubes ('trace fossils'), and may therefore belong to the Crag Series.

The Crag pebble deposit often consists entirely of sand and gravel (without the ferruginous sand layer of the 1972 section): it contains moulds of molluscs (Cardium, Mytilus), encrusting bryozoa, and bone fragments.

3). WANGFORD WOOD.

The site of Dr. P. E. P. Norton's excavation, and of the joint Ipswich Geological Group / Geological Society of Norfolk 'dig' of 16th. May 1976.

The section below is based on measurements and notes by P. Cambridge and R. Markham made on 16 May, and on further notes by R. M. made 20 May, when the section was further deepened to below water-table by C. Garrod.

Soil	1ft 3ins
Banded sandy loam, a few flint pebbles	3ft 6ins
Bed of large flint pebbles	10ins
Cross-bedded units of shelly sand,, with stones; lowest 4ins (+) with prominent black (?manganese dioxide) material	5ft 3ins
Cross-bedded units of shelly sand, with stones? lowest 4ins (+) pale coloured	5ft 3ins
Brown stony crag	1ft 7ins
Brown shelly crag, thin brown silt at base	1ft 4ins
Brown stony crag, some black staining	8ins
Brown crag	11ins
White crag	1ft 0ins
Brown crag	1ft 0ins
Sand, pale, with small shell fragments	1ft 4ins
WT	

(section continued on next page).

Shelly crag	7ins
Dug into, but not directly seen (as under water) - apparently sand, with shell material, and a thin bed of stones c. 5ins down	c. 11ins

(WT - approximate position of water table, just above on 16 May, just below on 20 May).

R. Markham.

THE GENUS NEPTUNEA IN BRITAIN.

Those of us who live in S .E. England and whose acquaintance with our only living representative of the genus Neptunea, N. (Sulcosipho) antiqua (L) is confined to specimens collected at such places as Sandwich, Kent, where it is common, may be excused from knowing that it is the largest British Gastropod. Shells from the south east never exceed 100 mm. in length, but in the northern North Sea and off Ireland shells up to 200 mm. in length are sometimes obtained by trawlers.

Jeffreys (1867) noted that N. antiqua was good bait for codfish and a favourite delicacy of the lower working-classes in London. At Billingsgate it was sold under the name of "almond" or "red whelk"; the tail (liver) was said to be more fat and tender than lobster. As an article of food however, it is now apparently entirely replaced by the "common whelk" Buccinum undatum (L.). Large shells of N. antiqua var alba (Jeffreys) were used by the Shetland Islanders as lamps, the body-chamber was filled with oil and the wick protruded through the siphonal-canal. The shell was then suspended from the ceiling.

N. antiqua is a northern cold-water species and although common in the North and Irish Seas is very rare west of the Straights of Dover. Like all other "whelks" N. antiqua is an epifaunal scavenger. The eggs are contained in cases or capsules, which overlap one another in an imbricated fashion. They are deposited in clusters of from a dozen to a hundred, the capsules in each cluster being equal in size. They spawn at the end of winter and later perfect little snails emerge from the capsules. There is no free swimming larval stage and distribution must therefore be by crawling only and consequently very slow indeed!

N. antiqua inhabits the Coralline zone and extends downwards to deep water. When crawling it holds its shell with the apex up so that it never drags the apex or other parts of the shell over the ground. Neptunea like Buccinum and Murex, moves almost exclusively for the purpose of scavenging. It crawls usually with the broad foot 10 mm deep in the sediment. It tips its shell forward and downward and pushes the elongate siphonal process into the substrate forward of the front edge of its foot. In this way the sediment is ploughed up and pushed sideways. The shell with the siphonal process is moved slowly to and fro while the animal crawls. During this activity the siphon lies protected in the siphonal canal and is never extended as far as in a moving Buccinum. The animal ploughs through the sediment in order to find dead organic material. When the animal crawls about in its search it disturbs the upper sediment layers considerably, down to a depth of 15 mm.

When prosobranch shells have a siphonal (i.e. anterior canal) the canal encloses a muscular and generally mobile siphon from the dorsal side; this extension of the mantle protrudes beyond the shell. A siphon is usually accompanied by a sensory organ (osphradium) which lies at the opening of the siphonal tube in the mantle cavity. Experiments have shown that the osphradium of prosobranchs tests the water for smells. Whereas the existence of an anterior canal on a shell indicates that the carrier must have been a predator or scavenger (e.g. Neptunea) its length does not give any information about the use of the siphon and the environment in which it is used. If the anterior canal is short and flared at the end as in Buccinum, the siphon is used, to test for smells in open water, if however the anterior canal protrudes far (usually in the direction of the shell axis) the canal surrounds the siphon entirely, even when it is extended. Together with its protective calcareous cover it can be moved through the sediment, and can search for dead organic material in the water of the interstices between sand grains.

The genus Neptunea indigenous to the North Pacific, probably originated in Japanese waters during the Eocene period. Early Oligocene demes evolved in a boreal habitat, their descendants migrating northward. During the Beringrin transgression demes of N. tabulata and N. lyrata stocks penetrated the Bering straits and spanned the Arctic, where the N. despecta and N. hercea stock originated and dispersed; reached the North Atlantic via Iceland and eventually the North Sea; where in the early Pleistocene the sinistral N. contraria angulata (S. V. Wood) became abundant. Fossil shells of this sub-species are very common in the Red Crag (Lower Pleistocene) of Walton-on-Naze, Essex. By Upper Pleistocene times N. c. angulata had vanished and was replaced by N. antiqua, still living in the area.

The occurrence of N. despecta (L.) in the Red Crag, in spite of the claim of Harmer (1919-1925) remains unproven, most of his so-called despecta being referable to the striated form of N. antiqua. At the present time N. despecta is Arctic in distribution, the writer has, however, specimens of it dredged in the Shetland-Faroe channel, which would appear to be its most southerly occurrence on this side of the North Sea. The distribution shown for this species by Golikov (1963, 156) which included the southern North Sea as well as the west coast of Ireland and the Irish Sea is certainly based upon erroneous information, as is the same author's suggested distribution for N. (S.) antiqua (L.), which certainly does not extend its range so far south as he would have us believe.

In connection with the occurrence of Neptunea in the Lower Pleistocene of East Anglia, already mentioned, reference should also be made to the work of F. Strauch (1972). This author considered the strongly carinate shells from the Pleistocene, incorrectly referred to the recent species N. despecta (JL) and N. decemcostata (Say) by Harmer, to represent an ancestral stock from which evolved the Atlantic species N. antiqua (L.), N. despecta (L.) and N. demecostata Say). Strauch described a new taxa, N. lyratodespecta, from Iceland, to contain this ancestral Pleistocene race and separated the North Sea population as var. anglica. He also recognised as a subspecies of N. lyratodespecta, Murex striata J. Sowerby, 1812, and designated one of Sowerby's figured specimens (Min. Conch. 1, pi.22) now in the B.M.(N.H.) as the lectotype.

The differences between Strauch’s type of var. anglica (1972, pl.l, fig. 16) and the lectotype of N. striata are very slight, the carinations in the former being slightly stronger, a feature in which these shells are noticeably variable. It would seem probable therefore, that but one species of carinate Neptunea exists in the British Pleistocene and if this is so, then the oldest name available for it is that of Sowerby, 1812. Strauch’s var. anglica would then become a synonym of N. lyratodespecta striata (Sowerby, 1812) together with N. despecta Harmer, 1914, (non Linne, 1758) and N. decemcostata Harmer, (non Say, 1825).

The question of the status of N. lyratodespecta s.s. is unfortunately by no means agreed amongst conchologists and further comparative study of both Pleistocene and recent carinate Neptunea, such as N. antiqua var. striata Jeffreys, which occurs in fairly deep water, off the coast of S.W. Ireland, will be needed before the problem can be resolved.

It is perhaps worth noting here, that Linne’s original specimen of N. contraria is a recent shell, probably from Vigo, Spain, not a Pleistocene fossil as is commonly believed. N. sinistrorsa (Deshayes, 1830) therefore becomes a synonym of it. The sinistral Red Crag Neptunea is certainly worthy of sub-specific rank and the oldest available name for it is N. contraria angulata S. V. Wood, 1848.

In addition to the typical form of N. antiqua as found in S.E. England, a comparatively small shell, usually brown in colour and up to 100 mm. in length, the following varieties have been named and described by J. G. Jeffreys 1867), var. alba, white and very large, up to 200 mm. in length, the interior of the aperture often bright orange in colour, var. ventricosa thinner, the aperture often greatly expanded, var. striata, elongate, with strong spiral striae, especially on the upper whorls and var. gracilis, slender, thinner, and spirally ridged, a rare form found off S. Ireland. Sinistral (left-handed) monsters also occur, which are in no way related to the normally sinistral N. contraria (L.).

With the exception of the typical form and occasionally the var. alba in the north, none of the above-mentioned varieties are likely to be obtained by shore collecting. All live in deep water and can be collected only by dredging or from fishing boats.

References

Jeffreys, J. G., 1867, British Conchology, 4 vols., London.

Harmer; F. W., 1914-1925, The Pliocene Mollusca of Great Britain, Palaeontographical Soc. , 2 vols.
Golikov, A. N., I963, The Mell. gen. Neptunea Bolten. Fauna SSSR. Zool. Inst. Akad. Nauk. SSSR. 5.
Strauch, F., 1972, Phylogenese, Adaptation und Migration einiger nordischer mariner Molluskengenera (Neptunea, etc.). Abb. senckenb. naturforsch. Ges. 531.

T. Pain

(Part of this article first appeared in "The Conchologists' Newsletter No. 50, Sept. 1974)

NOTES ON ITINERARY I, GEOLOGISTS1 ASSOCIATION GUIDE No. 12, "The Estuarine Region of Suffolk and Essex," by J. T.Greensmith, R. G. Blezard, C. R. Bristow, R. Markham and E. V. Tucker. 1973.

My itineraries to Orford and Bawdsey ("IA") and to Walton-on-the-Naze and Wrabness ("IB") had a certain amount of editing, most of which I approve of, but there are a number of additions which are not mine and which I feel should be noted in case they are quoted under my name sometime in the future!

p.2:- the introductory paragraph ("This excursion " to ".....Ardennes region") is an addition,

p.4, para.3: - 'Mya truncata in life position' - most appear to be nearly, but not quite, in life position

p.4, para.3: - "which covers large areas....." to "«o 00 .Rhine delta complex" is an addition,

p.4, para.5:- "normal conformable" is not my wording.

p.6, para.4:- "The Clay is about 3.5 m * thick" should be "Up to 3.5m of the Clay may be seen" (it is thicker than this, going below sea level)

p.6, para.4:- "only organic remains visible" should be "only organic remains usually visible"

p.7, para.3:- removal of the Red Crag would make the Coralline Crag an outlier! (as it would then be encircled by London Clay); it is almost an 'inlier' now.

p.7, para.3:- "lower 'Crag Division'" should be "lower 'shelly sands Division'".

p.10, para.6:- "The band, quite different in appearance....." to ".....in the Skagerrak area" is an addition,

p.10, para.6:- 'platimore' has been added in a wrong way: 'platimore' is an old local term for the foreshore clay surface. The pyritic wood is 'copperas'

p.11, para.1:- most, if not all, of the Red Crag capping the hill above the promenade has been eroded away. The geological map (fig.1, page 3) is based on a 6" map I made c. 1960; the solid-line geological boundaries are after my map, the dotted lines and a small area with solid lines S.E. of Sudbourne Church were not mapped by me.

Since the M.S. notes for the itineraries were sent in, a number of papers have appeared giving further information on the localities;-

CHILLESFORD.

Dixon, R. G. 1972. "A Review of the Chillesford Beds". Ipswich Geol. Group Bull. 11, pp. 2-9.

West, R. G. & Norton, P. E. P. 1974. "The Icenian Crag of southeast Suffolk". Phil. Trans. Roy. Soc. London, B., vol. 269, pp. 1-28.

WALTON-ON-THE-NAZE.

Quaternary Research Association, 1973 Clacton meeting handbook, for Red Crag by A. R. Boatman, and overlying silts by C. Turner.

George, W. H. 1972. "Report of Field Meeting to Walton-on-the-Naze, Essex". Tertiary Times, vol. 1, pp. 124 - 5.

R. Markham.

SEDIMENTARY CHARACTERISTICS OF THE RED CRAG.

The term Red Crag was originally applied to the iron stained unconsolidated shelly sands of North East Essex and South East Suffolk. The Red Crag is now known to include non-shelly iron coated sands, clean sands and clay. The deposit occurs in a triangular shaped area having a base line along the coast between Walton-on-Naze and Orford and then extending inland to an apex near Lavenham in Suffolk. The base of the Red Crag lies at about 17 metres above present day mean sea level. Over most of their extent the beds are buried by later sediments and exposures are confined to coastal cliffs, river banks and pits. In North East Essex the deposits occur as isolated outcrops but north of the River Stour the Red Crag consists of a series of large linear sand bodies.

The area of deposition was in a near-shore marine environment which had a maximum water depth of about 30 metres. The sub-Red Crag surface, which consists of London Clay, slopes at a very shallow angle towards the east. The London Clay was folded in pre-Red Crag times by tectonic activity into a series of ridges and depressions. Bivalve borings and surface pitting occurs in several areas. Occasionally the sub-Red Crag surface has become coated with metallic oxides or impregnated with calcium carbonate but both of these features are considered, to be post-depositional.

In overall composition the Red Crag deposits show a considerable degree of uniformity. However, within closely defined limits, micro-variation is considerable both laterally and vertically. The chief factors affectpg variation are the amount and size of shell debris, the proportions of metallic oxide coated and. uncoated particles, overall size distribution and degree of sorting.

The two major components of the Red Crag are quartz grains and shell debris. The present degree of metallic oxide coating on each of the components depends largely on the conditions in the earlier source areas and the extent of subsequent diagenesis. Considerable quantities of phosphatic nodules occur in the depressions in the sub-Red Crag surface. Pebbles of quartz, quartzite and chert together with mud clasts and, armoured mud balls are found wiithin the shelly-sand matrix. Locally silty clay forms a major component but it is not widespread.

Sedimentary structures within the Red Crag are best considered separately in each of the three units into which the deposit can be subdivided. These stratigraphical sub-divisions consist of the basal beds, occurring in isolated pockets, the Lower Red Crag characterised by the steeply dipping cross-layered shelly sands and the non-shelly sands forming the Upper Red Crag.

The basal beds, which occupy depressions in the sub-Red Crag surface, vary in thickness from 5-20 cm. They are usually grey in colour and consist of a mixture of clean quartz .grains and varying amounts of finely divided shell debris. The near horizontal orientation of these beds resulted from their method of deposition. In many localities these beds overlie deposits of phosphatic nodules that accumulated in the depressions.

The Lower Red Crag consists mainly of the characteristic cross-layered shelly-sands that represent phases of sand body migration. These cross-layered units frequently show large scale cross-layering, formed by the main flow current, overlying small scale, reversed, dipping, cross-layering formed by the associated backflow currents. A considerable degree of interweaving of the toe of foreset beds and backflow beds is evident at Bawdsey. Trough cross-layering, representing reactivation of foreset beds by cross-flow currents is present in a few localities. At several sites bottomset beds are exposed, sometimes being inter-bedded between two units of cross-layered shelly-sands. Where these bottomset beds are composed of fine grained sands, small sand diapirs frequently formed but the latter structures are comparatively rare. Occasionally and usually at the base of the Lower Red Crag are lenses composed, of alternating beds of fine grained sands and silts containing well developed ripple trains. The latter structures sometimes pass laterally into flaser bedding. In addition some lenses show slump structures while others contain ‘rollers’ embedded in a matrix of structureless shelly-sands. The ‘rollers’ consist of a hollow tubular structure composed of metallic oxides surrounded by concentric layers of quartz grains and shell fragments cemented by metallic oxides. Pseudo-nodular structures (Walton-on-Naze, Brightwell) and pseudo-stratification (Walton-on-Naze, Bawdsey) are both post-depositional in origin and formed as a result of the migration of metallic ions in ground water. The individual units of the Lower Red Crag vary from a few centimetres to 5 metres in thickness. Available evidence suggests that the whole of this sub-division had a maximum thickness of about 9 metres.

The Upper Red Crag is composed of medium and fine grained sands coated with metallic oxides. Some parts of this unit are in-situ decalcified Lower Red Crag beds and other parts re-worked sands. Ghost cross-layering occurs where the unit is decalcified Lower Red Crag, but the dip of the foreset beds is usually less than that in the unaltered Lower Red Crag. The re-worked sands contain ripple trains in some areas while in others they exhibit an abundance of sand diapars.

An analysis of the sedimentary structures indicates that they were formed mainly by tidal currents, the few minor exceptions being formed during diagenesis. The direction of the flood currents were predominantly to the west between south-west and north-west while the ebb currents were mainly towards the north-east. Locally current directions were very variable due to the inter-action of the main currents with the submerged sand bodies. The main currents were responsible for moulding the deposit into a series of linear sand complexes while the local variations in current direction produced some of the minor features within the sand bodies. Post Red Crag reworking and redistribution of sediments has tended to even out the variations in thickness of the original deposit.

Due to technical problems it is not possible to estimate current velocities but the thin iron-pans deposited under very quiet conditions and the presence of large fabric elements, mainly found in the bottomset beds, which indicate powerful bottom currents testify to the wide range of current velocities that prevailed.

A. R. C. Boatman.

FINANCIAL STATEMENT: GEOLOGICAL GROUP, 1975.

EXPENDITURE

	£. p.
Postage, Newsletters 48-51.	19-72
Postage, Bulletins 16, 17	7-92
Envelopes, Newsletters 48-51	1-55
Envelopes, Bulletins 16, 17.	3-42
Stencils, Newsletters 48-51.	35
Stencils, Bulletins 16, 17.	3-08
Duplicating Paper	11-96
Petrol for pump (Gedgrave dig)	75
	£48-75

INCOME

	£. p.
Subscriptions (1975)	46-25
Subscriptions (late for 1974)	2-25
Interest on Bank Account	3-97
	£52-47

Carried forward to 1976, £3.72.

There is also £32.43 in the bank account which has been carried forward from previous years 5 this will be used for fieldwork equipment and towards future publications.

R. A. D. M.

Edward Charlesworth was born in Clapham, Surrey, in September 1813. He spent much of his early life and school years in Suffolk where he was an early and youthful investigator of the Crag pits; he separated the Red Crag and Coralline Crag in 1835 (Phil. Mag., ser. 3, vol. vii, p. 8l).

Edward Charlesworth had early connections with several museums. Greenough's Presidential Address to the Geological Society in 1835 noted that "Mr, Charlesworth has placed in our Museum some valuable specomens collected at Stutton in Suffoik". At this time, Charlesworth was elected an Honorary Curator of an early Ipswich Museum, soon to be followed by an appointment on the staff of the British Museum, and afterwards as an Assistant to the Museum of the Zoological Society of London in Leicester Square. In 1837 Charlesworth became (until 1840) Proprietor and Editor of Loudon's "Magazine of Natural History", in which year and journal (N.S., vol. 1, p.225) he gave what seems to be the earliest scientific reference to fossils in Ipswich Museum (giant shark teeth from the Red Crag).

In 1840 Charlesworth accepted an offer to go to Central America, but the visit was shortened to only a few months.

In 1844 he was appointed Curator to the Museum of the Yorkshire Philosophical Society in York, which post he held until 1858.

In 1846 he brought out the "London Geological Journal" (three numbers only, ceased 1847) to which he contributed a paper on Mosasaurus (Jnl. no. 1, Sept. 1846, pp. 23-32).

In I848 Charlesworth organised the "British Natural History Society" for the collection of Hampshire Tertiary fossils (more especially those from Barton Cliff, which he had first visited in I833) and distribution as sets amongst members in return for a small subscription. About 2,000 sets of specimens were issued.

In 1869 he was engaged by Ipswich Museum to name and arrange the Crag shells, and in May of that year, at the first meeting of the Ipswich Science Gossip Society, he gave a description of the collection of Red Crag fossils given to the Museum by Mr. Edward Packard (the Mayor).

Later in his life, Charlesworth became a dealer in fossils, living in London.

In 1869-1870 he was selling sets of molluscan stone-borers of the Red Crag. Buyers of his specimens included William Reed of York (who obtained the unique series exhibited at a meeting of the Norwich Geological Society) and Mr. E. Grimwade, Mayor of Ipswich (who presented his set to Ipswich Museum).

Charlesworth purchased the Crag collection of Mr. W. Whincopp of Woodbridge in I87O5 much of this he sold to William Reed, who later donated it to York Museum.

Mr. James Baker of Woodbridge died in 1873, and his Suffolk Crag collection was advertised for sale in the 'Atheneum'; the collection consisted of over 4.000 specimens including teeth of Mastodon, Rhinoceros, Hipparion, Tapir, Hyaena, Deer, and shells, fish and reptile remains. Edward Charlesworth bought Baker's collection from his executors, and the 'Ipswich Journal' of 11th. May announced the removal of the collection (by Charlesworth) to London. Mr. Waterhouse, Keeper of Geology Department, British Museum, made a selection of the Baker fossils for that Museum, including 5 of the 23 tapir molars in the collection. Much of the Baker collection was purchased by William Reed, and later donated to Yorkshire Museum.

In 1874 Mr. Whincopp died, and Charlesworth purchased the greater part of his fossils acquired since 1870; many of these he sold to William Reed and are now in York Museum.

With the Baker and Whincopp collections, Charlesworth selected one or two large series of the various fossils, which still left duplicates and triplicates of numerous other fossils. William Reed probably had the finest private collection of Crag fossils in England.

From about 1875 to 1878, Edward Charleswotth's '0rford Castle Fossil Exploration' (Crag Investigation Fund) was in progress, buying crag fossils from the diggers engaged in workings to obtain phosphate ("coprolite") from a 'cutting in the River Marshes near Orford Castle, Suffolk'. During this period over 150 collections of these fossils were delivered to subscribers. Specimens may be seen in Ipswich Museum, bearing tiie characteristic labels 'Coralline Crag' (or 'Red Crag') and 'Near Orford Castle'. In connection with this, a M.S. note (in Ipswich Museum) by Edward Charlesworth gives a list of 13 papers (Crag information) sent free of charge to all Subscribers to the Orford Castle series of fossils; the second paper 'List of Fossils found in the Orford Castle (Boyton) Cutting1 is of particular interest as it gives the parish in which the fossils wore found, Boyton seeming more likely than Orford as a source of both Coralline and Red Crag fossils.

In 1883 the 'British Natural History Society' was again distributing sets of specimens to subscribers, examples beings

Crag	35 specimens,	20 species,	7s. 6d.
Chalk	16 specimens,	12 species,	7s. 6d.
Carboniferous Limestone	20 specimens,	15 species,	7s. 6d.

Each specimen (unless it was too large) was sent in one of Charlesworth's well-known circular glass-topped boxes, which could be returned, or kept for a small additional payment.

Also in 1883, upon the death of Mr. Amey of Felixstowe, the Amey crag collection came into Edward Charlesworth's possession and was 'disposed' of in the same way as with the Baker collection. A molar tooth of a young mastodon was presented by William Reed to the York Museum.

A. M.S. list of some of the Purchasers of Charlesworth's Collections of Suffolk Crag Mammalian and other Vertebrate Fossils is kept in Ipswich Museum, and includes the British Museum, Geological Museum, museums at Dublin, Liverpool, Oxford, etc., and a number of private individuals. Another M.S. note mentions the 'unique molar' of 'Mastodon borsoni' purchased by Mr. Wm. Reed and given by him to York Museum.

Edward Charlesworth retired to Saffron Walden, Essex, where he died July 1893. Obituaries appeared in the Geological Magazine (1893, ser. iii, vol.10, pp. 526-528) and the Quarterly Journal of the Geological Society of London (Proceedings, 1894, vol. 50, pp. 47-50). It is interesting to note that he took an active part in the establishment of the "Society for the Prevention of Cruelty to Children".

A list of Charlesworth's articles on local geology is given below.

1835 "On the Crag of part of Essex and Suffolk". Proc. Geol. Soc., vol. ii, no. 41, p.195.

1835 "Observations on the Crag-formation and its Organic Remains with a View to establish a Division of the Tertiary Strata overlying the London Clay in Suffolk". Phil. Mag., ser. 3, vol. vii, p. 8I5 (abstract in Proc. Geol. Soc. , vol. ii, no. 41, p.195.

1835 "Reply to Mr. Woodward's Remarks on the Coralline Crag^ with Observations on Certain Errors which may affect the determination of the Age of Tertiary Deposits". Phil. Mag., ser. 3, vol. vii, p. 464.

1836 "On the Crag of Suffolk, and on the Fallacies connected with the Method now usually employed for ascertaining the relative Age of Tertiary Deposits". Phil. Mag., ser. 3, vol. viii, p. 529. See also (under different title): Edin. New Phil. Journ., vol. xxii, p 110; Rep. Brit. Assoc. for 1836; Mag. Nat. Hist., vol. ix, p. 5375 (Abstract (?in full) in 'Records of General Science', vol. iv, p. 465)

1837 "A Notice of the Remains of Vertebrated Animals found in the Tertiary Beds of Norfolk and Suffolk". Rep. Brit. Assoc. for I836, Sections, p. 84 (in full in I838).

1837 "Observations on the Crag, and on the Fallacies involved in the present System of Classification of Tertiary Deposits". Phil. Mag., ser. 3, vol. x, p. 1.

1837 "Notice of the Occurrence of Voluta Laraberti on the Suffolk Coast; with Observations upon its Claim to rank with existing Species". Mag. Nat. Hist., ser. 2, vol. i, p.35

1837 "Observations upon Voluta Lamberti, with a Description of a gigantic Species of Terebratula from the Coralline Crag". Mag. Nat. Hist., ser. 2, vol. i, p. 90.

1837 "Notice of a new Fossil Shell from the Coast of Suffolk". Mag. Nat. Hist., ser. 2, vol. i, p. 218.

1837 "Notice of the Teeth of Carcharias megalodon occurring in the Red Crag of Suffolk". Mag. Nat. Hist., ser. 2, vol. i, p. 225.

1838 "A Notice of the Remains of Vertebrated Animals occurring in Tertiary Beds of Norfolk and Suffolk". Mag. Nat. Hist., ser. 2, vol. ii, p. 40.

1839 "Illustrated Geological Notices. 1. On the discovery of a Portion of an Opposum's Jaw in the London Clay near Woodbridge, Suffolk. 2. On some Fossil Teeth of the Genus Lamna from the same Deposit". Mag. Nat. Hist. ser. 29 vol. iii, p. 448.

1845 "On the Occurrence of the Genus Physeter (or Sperm Whale) in the Red Crag of Felixstowe". Proc. Geol. Soc., vol. iv, no. 99, p.286, and Quart. Journ. Geol. Soc, vol. i, p. 40.

1846 "On the occurrence of a species of Mosasaurus in the Chalk of England, and on the discovery of Flint within the pulp-cavities of its teeth". London Geological Journal, no.1, Sept. 1846, pp. 23 - 32, Pls. 4- 5.

1859 "On the Fossil Remains of the Mammoth found in the bed of the German Ocean, in the East and South-east portion of England". Proc. Geol. Assoc., vol. i, p. 15.

1868 "On the Prospective Annihilation of the Suffolk Red Crag Phosphatic Stones, "Coprolite"." Norwich Mercury, 10 Oct., & Geol. Mag., vol. v, P. 577

1868 "The Large Fossil Tooth in the Pakefield Cliff". Land and Water, 14 March. 1868

1868 "On the discovery, at Whitlingham, of the Tooth of the Mastodon". (Norwich Geol. Soc., May 5). Norwich Mercury.

1868 "On the Crag Fossils in the Norwich Museum". (Norwich Geol. Soc.).c Norwich Mercury, June 6.

1972 "On Perforated Stones from the Suffolk Crag". Eastern Daily Press, April 6.

1872 "Exhibition and description of some remarkable objects found in the Suffolk Crag Formation simulating human workmanship". Pall Mall Gazette, April 10

1872 ("Perforated Sharks' Teeth found in the Red Crag of Suffolk"). Pall Mall Gazette, April 10.

1872 ("Exhibition and Description of Objects found in the Red Crag of Suffolk simulating Hu man Workmanship"). Journ. Anthrop. Inst., vol. ii, no.1, p.91. ("Primeval Man and the Suffolk Crag"). (from a report of an Edward Charlesworth communication).(source?)

1878 "Fossil Exploration of Suffolk Crag (Orford Castle), and Hampshire Eocene Cliffs11, pp. 8. London. Privately printed.

Charlesworth also added notes to the following-

Clarke, W. B. 1838. "Letter in reference to the alleged occurrence of the bones of terrestrial mammalia in the red and coralline Crag of Suffolk". Mag. Nat. Hist., ser. 2, vol. ii, p. 224.

Desnoyers, J. 1838. "Considerations upon the position of the Tertiary System to which the Faluns of the Loire and the Crag of England ought to be reftered; and upon the difficulty of determining their relative age solely by the law of the proportional number of fossil species analogous to species now in existence". Mag. Nat. Hist., ser. 2, vol. ii, p. Ill (partly translated from Bull. Soc. Geol. France, t. viii, p. 203, (1837).).

Lankester, E. R.1877. "The Crag Fossils in the Ipswich Museum". Suffolk Chronicle, August 4.

R. Markham.

GEOLOGY OF THE SOLAR SYSTEM.

(A write-up, with additional material, of the slide show given to the Orwell Astronomical Society (Ipswich)/lpswich Geological Group joint meeting, 5 December 1975.)

Geology is the study of the composition and origin of rocks, and of the history of the Earth as told by the layers of rocks and their contents. Space probes are now adding to our knowledge of geological processes operating in different physical environments; difficulties may arise in how to interpret data.

In the Solar System, bodies of predominately geological interest are 'high density' (over 3) and rocky, - Mercury, Venus, Earth, Moon, Mars, Io, and Eurppa. 'Low density' bodies (less than density 2½) may have a large percentage of ice(s); these are Jupiter, Saturn, Uranus, Neptune, and most of the satellites of these planets.

Only some aspects of the Geology of the Solar System can be given in this account.

EARTH.

The Earth has a radius of 6,378 km. (c. 4,000 miles), a mean density of 5.5, and a thin rocky crust on a very hot interior. There are large quantities of surface water (the only planet with oceans of water), a nitrogen and oxygen atmosphere, and abundant living organisms. There are, at the present time, polar ice caps. The formation of this environment during geological time is studied by stratigraphers deciphering the events preserved in the sequence of rocks.

Seismological measurements of the Earth suggest that it has a solid core (of nickel-iron alloy), surrounded by a similar alloy in a molten state (where the Earth's magnetic field is thought to originate), with a mantle of silicate rocks essentially of the mineral olivine or of olivine and pyroxene. The crust, generally 6-30 miles thick, forms the outer rigid shell of the planet.

There is evidence of major horizontal movements of great crustal 'plates' (as the result of convection currents, generated by radioactive heat ,within the mantle), these plates sometimes colliding and pushing up chains of 'fold' mountains, at other times and places pulling apart along rift zones such as the mid-Atlantic and East Africa.

Igneous rocks solidify from hot molten lava-like material from within the Earthy the constituent minerals forming an interlocking mass of crystals Sedimentary rocks are formed of fragments and particles eroded from the surface of the Earth, by disintegration and weathering, followed by transporting and deposition (generally in water); they may be cemented together by minerals precipitated from solution.

Metamorphic rocks are formed by the alteration of other rocks, as the result of intense pressure and heat within the crusty new minerals and structures are formed.

Low-lying areas of continental crust are subjected to continuous slow up and down movements leading to marine inundation (and sedimentation in shallow seas) and uplift to form new land.

Meteoric impact craters have been recognised on Earth. They are sometimes associated with fragments of meteorites; however there is no meteoric material known from most of them, and then the formation of the crater by impact is made likely by its shape, shattered and broken rock at the bottom of the crater, and the presence in the crater of minerals formed only under extremely high pressures, such as coesite (a form of quartz). With some craters there is no very convincing evidence that they were caused by a fall of a meteorite.]

A number of 'fossil' craters are known, e.g. on the Canadian Shield, which have been preserved by burial under sediments.

The oldest rocks known on Earth are about 3,700 million years old, dated by the radioactive element breakdown method. Fossils are the remains and traces of once-living animals and plants, and show the evolution of various groups of organisms.

The use of geological information to date the suggested 'capture1 of the Moon by the Earth has led to some highly speculative ideas. The major break (at most localities) in the geological succession at the Pre-Cambrian - Cambrian boundary, nearly 600 million years ago, has been suggested as that date by some, while others place it about 3,000 million years ago, based on growth patterns (? evidence of lunar influenced tides) in stromatolites (fossil plants).

The appearance of green (photosynthesising) plants on Earth in Pre-Cambrian times suggests that the Sun has been shining for a very long time. The apparent correlation of the cyclic nature of annual growth-rings in trees with the Sun's sunspot cycle (including the virtual absence of both cycles in the second half of the seventeenth century) suggests a method of studying the Sun's activity in the geological past by means of fossil trees.

METEORITES.

Meteorites are extra-terrestrial fragments (they are different to Earth rocks) that have fallen on to the -Earth's surface. They are of three main types

(1) 'Irons' (Siderites) - metallic composition, often 90 % iron, about 8% nickel, and traces of other elements. There are several types, e.g. the 'octahedrite' sub-division, containing the '.minerals kamacite and taenite.

(2) 'Stony-irons (Siderolites) - silicate mineral(s) associated with iron. There are several types, e.g. the 'pallasite' subdivision, with nickel-iron alloy enclosing olivine.

(3) 'Stones' (Aerolites) - mainly silicate minerals. Most belong to the group called 'Chondrites' (usually containing spherical particles known as chondrules); they total about 85% of all meteorites, and are subdivided according to the minerals they contain.

Radioactive dating shows that most meteoric material is about 4,600 million years old.

Mineralogy of meteorites gives clues to the temperature and pressure at their formation, palaeomagnetic evidence gives data on primordial magnetic fields, measurement of abundance of certain elements may give clues to the temperature of the early Sun, and tracks left by energetic sub-atomic particles give indications of the post-formational history of the meteorite.

"Meteorites are different to lunar rocks, and are not derived from the Moon. Spectral studies show that they compare well with Asteroids.

One of the groups of chondrites (the carbonaceous chondrites) contains carbon compounds, including amino acids; there is dispute as to whether this is terrestrial contaminant or indigenous, and if indigenous, whether it is of biological origin or not. Some stones, e.g. the Orgueil Carbonaceous Chondrite, contain 'organised elements', which some people have suggested may possibly be microfossils; again, there arce similar disputes as with the amino acids.

Tektites are pieces of glass of disputed origin (terrestrial or extra-terrestrial, or both), dated between 0.3 and 30 million years old. The 'moldavite' tektites in Czechoslovakia have been suggested as being correlated with the 1408 million year old. Ries crater in Germany, and some Far East tektites have been suggested as being correlated with Tycho crater on the Moon.

MOON

The Moon is about ¼ the diameter of Earth. It has a density of about 3.3; there is no atmosphere, no water and no life. Erosion has not destroyed the record of past events (showing the absence of atmosphere and water in the past).

There are two main surface areas, the Uplands or 'Highlands', and the Maria or 'Seas'.

The 'Highlands' are the light coloured areas of the Moon; they are rugged and contain craters in profusion.

The Maria are the dark areas, low-lying and relatively smooth; they are filled with deposits. There are two main types, the first nearly circular and surrounded by near circular mountain arcs (e.g. Mare Imbrium), the second having an irregular outline with no bordering mountain walls (e.g. Mare

Tranquillitatis). Their origin, meteoric or volcanic, is still uncertain, and also the nature of their infilling (lava or ejecta). The Maria consist of a granular regolith (thin deposits of pulverised rock debris) overlying what is probably volcanic lava, but which may possibly be sheets of ejecta. There are unflooded basins (lacking mare material) on the far side.

Three main types of surface material have been returned by Apollo missions, (a) fine powdery material or 'soil', (b) crystalline igneous rocks, (c) breccias (fragmented rock). Moon rocks are unlike common meteoric materials.

The lunar regolith or ‘soil’ consists of minute rock fragments, mineral fragments, glass fragments and glass spheres, all very fine in size. It has been formed over a long period of time by meteor and micrometeorite impacts which have broken up and melted the surface rock. Large rocks are scattered around in the soil and on the surface; they are common around the rims of recently formed craters. The 'soil’ extends down for a few metres.

Basalt, a crystalline rock, originally molten lava material (by analogy with properties of igneous rocks on earth) is found in the maria; maria basalts are composed of feldspar, pyroxene, ilmenite (iron titanium oxide), and smaller quantities of olivine.

The Moon is poorer in volatile elements such as sodium, potassium and phosphorus but richer in refractory (high melting point) elements such as titanium and uranium; the latter are not concentrated as on Earth because of lack of volatiles.

There is some breccia on the maria, produced by meteoric impact breaking up rock and welding together the fragments (shock metamorphism) by compression or with molten material produced.

The 'highlands’ of the Moon are formed mainly of breccia (rocks consisting of broken fragments of pre-existing rocks welded together by impacts); the highlands are cratered by numerous impacts. They are richer in aluminium (and therefore lighter) than the mare basalts. They are mostly composed of (once molten, now crystalline) anorthositic gabbro; anorthositic rocks are the most abundant lunar rock, with their great quantities of the plagioclase feldspar $CaAl_2Si_2O_8$. Some are composed of basalt (known as KREEP basalt], rich in potassium (K), rare earth elements (REE) and phosphorus (P), formed by remelting.

Much work on lunar stratigraphy has been carried out by mapping by the United States Geological Survey; combined with radioactive dating the broad outline of lunar history is now known. Relative ages are established by normal stratigraphic principles of cross-cutting relationships and superposition.

The mountain terrain is the oldest part of the Moon, formed in Pre-Maria time. The highland breccias, the oldest-known moon rocks, are approximately 4,000 million years old, formed at the time of the very high rate of cratering which produced the cratered highlands seen today. The anorthositic gabbro and KREEP basalt now forming the breccias would have originally crystallised at a time prior to its breaking up (brecciation).

The maria (basins) seem to have been formed about the time of the intense bombardment, and between 3,900 million and 3,200 million years ago these basins were filled by basaltic lavas, forming the Maria rocks5 the oldest rocks known on Earth were formed when the lunar basins were being infilled.

A much lower crater density shows that the rate of cratering was very much less during the formation of these plains.

The last 3,200 million years of Moon history (post-maria time) show a low intensity bombardment (occasional craters) and meteoric weathering of the surface. Measure of changes produced by cosmic rays on rocks gives a guide to the ages of post-mare craters. Copernicus is about 850 million years old, Camelot crater about 90 million years old, and South Ray crater about 2 million years old. Ages of other craters can be estimated, based on the freshness of appearance with those of dated craters.

Age relationships between craters are clear where one crater overlaps another directly. Otherwise, age relationships are determined by relative degrees of degradation (whether features are fresh and sharp, or worn), as the steady bombardment by small impacts breaks down original structures. However, secondary ('splash') impacts can accomplish the same thing, and thus in some cases the degree of degradation of an older crater depends on its closeness to another large fresh crater. The ejecta from the most recent impact basins has blanketed much of the earlier surface.

No areas of solid rock have been found on the Moon, all sampled rocks have been separate rocks strewn around the surface and usually partly embedded in the dusty soil. This means that the crystalline rocks did not form where they were found. The basalts are usually interpreted as pieces of lava flow derived from melting of part of the lunar crust; it has also been suggested that melting was made in the course of impact, and that the blocks have been flung to their present positions by impact events. Another suggestion is that the surface rocks are purely the result of 'infall' (accumulation by 'meteorites'), rather than of melting on the Moon; Moon rocks are unlike 'modern' meteoric material, but not necessarily, it is suggested, different from the material the Moon was originally formed from.

Stratification on the Moon has been observed, but it is not yet known whether it is due to lava flows or simply to the compaction of the powdery dust.

The origin (impact or/and volcanic) of the craters on the Moon is uncertain, but evidence, though not conclusive, suggests that many (large ray craters, e.g. Copernicus) are of impact origin. These are circular structures with (when fresh) radiating swarms of small craters and ejecta deposits; the small (secondary) craters are generally thought to have been formed by missiles ejected from the primary crater during excavation. The bright ray systems have been interpreted as "splash" features. Terrace features inside some craters may be due to slumped blocks.

There is some evidence of volcanic activity on the Moon. Some irregular shaped domes appear to be volcanic domes. Possible lava outpourings may have come from vents in the maria, but molten rocks may have been generated by impact. Flow patterns material on the maria are usually interpreted as volcanic lava, but may be flows of other material (?regolith).

The major linear features of tectonic origin ('internal upheavals') so characteristic of Earth's surface are absent on the Moon; there are no signs of contortions in any of the ring shaped structures on this very ancient surface. There are some smaller linear features, such as the Straight Wall Fault, about 75 km. long, in the Mare Nubium. Some sinuous rills may be collapsed 'lava tubes' (formed by lava river flowing beneath consolidated crust of lava).

'Moonquakes' originate at a very great depth (most of those on Earth originate at shallow depths, less than 60 km.). Seismic signals show that the immediate subsurface structure to be different to that of Earth, and interpretation of bedrock as volcanic lava must take this into account.

The Moon has a negligible general magnetic field; any local crustal magnetic fields may be residual.

<u>MERCURY.</u>

Mercury is about two-fifths of the diameter of Earth. It has a density comparable with that of the Earth, suggesting a large metallic core; there is a magnetic field, possibly residual from an earlier phase of mercurian history. The outside of the planet is similar to that of the Moon, with a cratered surface and comparable sequence of events. There is no atmosphere.

Temperature at the surface rises to over 400 °C.

Most of our knowledge of Mercury comes from Mariner fly-by spacecraft observations; more than half of the total surface has still to be seen.

Two broad types of terrain have boon seen-

(a) densely cratered terrain with large craters, resembling the highlands of the Moon.

(b) relatively poorly cratered plains, similar to the lunar maria, and possibly composed of volcanic material; they overlie the cratered surface.

The highlands of Mercury are similar in appearance to the lunar highlands, with close-packed largo basins and craters with superposed smaller craters. The craters are probably impact craters, based on criteria used in connection with the Moon. There are differences between fresh craters on Mercury and those on the Moon. Material ejected from primary impact craters covers a less extensive area than on the Moon, and secondary impact craters are much closer to primary craters; ejecta is not thrown so far because of the greater gravity.

The plains are relatively smooth areas, younger than most of the heavily cratered terrain. They are probably of volcanic (lava) origin rather than sheets of ejecta (as the plains material is not associated solely with large craters).

The Caloris Basin, 1,300 km. in diameter, is probably an impact basin, comparable to the Imbrium Basin on the Moon. It is surrounded by a rim of mountains and the floor is filled with smooth Plains material5 the floor shows a fracture pattern of ridges and cracks, implying post-emplacement movement of plains material in response to stresses.

If the craters of Mercury are 3 or 4 thousand million years old, their shapes show that there has been no crustal plate movement as on Earth. Lack of surface erosion rules out any atmosphere in the past. Subsurface temperatures in equatorial regions are above the freezing point of water, but no evidence of chemiual weathering conceivably associated with occasional release of subsurface water has so far been observed.

It appears that the present surface of Mercury, like that of the Moon, was formed early in its history and has changed little since then.

VENUS.

Venus is about the same size and density as the Earth, and it is possible that the internal structure is similar; if so, the apparent absence of a magnetic field might be explained because Venus rotates very slowly.

Venus has an atmosphere, primarily carbon dioxide, with a surface pressure about ninety times that at the surface of the Earth. The surface temperature is over 450°C, the clouds seeming to 'trap' sunlight to maintain this temperature.

No surface features have been viewed from space because of the cloudy atmosphere. However, radar-reflectivity mapping distinguishes terrain as rough or smooth, and as high or low. Generally, Venus appears to be much flatter than the Moon, Mercury, Mars and Earth. Surface features ("mountains') are often large in extent but with a small range of heights and depths, there are few features more than a mile high. A few large circular craterlike forms are known: one large 'crater' just north of Venus' equator, is about 100 miles in diameter but only about one quarter of a mile high at the rim, while its interior does not appear to be much below the level of the surrounding terrain. Meteoric and volcanic origins have been suggested. Apparent scarcity of small craters, if of meteoric origin, can be attributed to the planet having an atmosphere.

Parts of the surface of Venus have been photographed by 'Venera' landing spacecraft. At one site there were numerous tabular angular boulders, ranging in size from about one foot to over three feet across; the angular boulders are little eroded, indicating fairly recent breakage, -'Venus-quakes' have been suggested as responsible for shaping the blocks. At the other site, the landscape looked appreciably older, a plain with smoother rock outcrops. The composition of the surface is unknown, but observations of radioactivity indicates presence of uranium, thorium and potassium, pointing to igneous rocks.

Reactions at the surface may include the action of wind, heat and rain.

Observed motions of the atmosphere have been interpreted as high-speed winds extending over large areas, but winds at the surface seem to be very gentle.

The high temperatures at the surface may possibly liberate gases from rocks, and may also deform low melting-point materials; information is not yet available on these points.

It is thought that the Venusian clouds possibly contain sulphuric acid; any rain may therefore consist of hot acid, and the action of such a corrosive fluid may be responsible for the shallowness of surface features on the planet. Again, information is not yet available.

It is obvious that there is a great deal of speculation in any discussion about Venus; present and future work should greatly increase our knowledge. Any information about the geological history of Venus will be of great interest, - conditions on the planet may have been very different in the past.

TORO.

Away from the main asteroid belt, the Apollo asteroids cross the orbit of Earth. The spectral characteristics of the Apollo asteroid known as Toro show it to match closely with L-type chondrite meteorite; could the latter possibly be parts of Toro? Many meteorites may be collisional fragments of asteroids.

MARS.

(This was written before the landing of the 1976 'Viking' spacecraft).

Mars is about half the diameter of Earth. It has a density of just under 4, and therefore its interior cannot be like that of Earth. There is a tenuous atmosphere (surface pressure less than 2/100 the pressure at the surface of the Earth) rich in carbon dioxide. There is no liquid water (because of low pressure, and very cold conditions), and, no magnetic field.

Mariner spacecraft have shown that the southern hemisphere of the planet consists of densely cratered highlands, indicating an ancient age. The northern hemisphere is low, smooth and sparsely cratered. (resembeling the Moon maria or plains), indicating youthful age. There is evidence of geological activity, with volcanism, tectonism, and possibly fluvial processes. Thus Mars has both lunar and terrestrial analogues.

Near the equator are several gigantic mounds with craters on top, similar in appearance to terrestrial shield volcanoes; the largest, Olympus Mons, is over twice as large as the largest shield volcano on Earth. The summit features appear to be calderas (collapsed, features once lava vents), and there are long thin lava-like flows and channels on the flanks. The flanks of these volcanic mountains are almost free of impact craters, implying comparative youth. Old volcanic features are also known. The plains show many lobed scarps, resembling volcanic flow fronts, and. indicating possibly basaltic composition. Some areas have more craters than others, implying different periods of lava flooding.

The Valles Marineris complex is a great equatorial rift (fault) valley extending for 5?000 km., in places 75 km. wide and 6 km. deep; there are diagonal subsidiary valleys, possibly of complex origin, including fracturing, landslides, wind, and. perhaps running water. There is evidence of fault blocks elsewhere, as in the Tharsis plateau area.

No linear chain mountains (evidence of horizontal crustal plate motions) have been identified.

Wind plays an important part in erosion and deposition of material on Mars. Scouring by wind may have faceted hills, and possibly etched the irregularly shaped closed depressions in the south-polar region. Craters have been modified and eroded by the scouring action of winds, bright ‘rays' of ejecta are removed, and craters with dust-streak 'tails' also give evidence of wind action. Wind-lain sand-dune fields have also been photographed. Windblown dust is no doubt responsible for the seasonal changes of light and dark coloured material. The light-scattering properties of the surface of Mars are similar to those of the iron oxides limonite and goethite.

At the present time Mars has small permanent ice-caps, apparently chiefly of water ice, with seasonal ice-caps of carbon dioxide ice. Laminated terrain in the polar regions consists of numerous layers (each about 100 m. thick) of sedimentary appearance, perhaps a mixture of dust and. ice. The 'cliff and bench' topography suggests varying resistance to erosion.

There is evidence of fluvial processes on Mars, with valleys which may have "been formed "by running water at the surface.

There are meandering valleys, with highly sinuous courses, but of particular interest are like channels with many tributaries, which seem able to have boon formed only by rainfall, as the water needs to originate over a large area. Some valleys show braided terrain (networks of small channels) on their floors, another indication of fluvial action.

Some channels are degraded and densely cratered, others appear 'fresh' (with very few craters), implying widely differing ages. "Chaotic terrain" (great masses of broken and tilted rocks) gives the impression of subsidence, perhaps due to the melting of subsurface ground ice. The evidence of water action on Mars where there can be no liquid water at the present day (because of 'glacial' conditions), implies the possibility of major climatic variations during Martian history. The duration of warmer climate and water erosion was short, as erosion has not destroyed pre-existing cratered surfaces.

There are several large multi-ringed impact craters on Mars; in the southern highlands, Hellas is nearly twice the size of the Imbrium basin on the Moon.

The lack of free water and lack of atmospheric protection from radiation are not insuperable problems when considering the possibility of 'life' on Mars. It may well be worth looking for Martian fossils.

Martian history may be briefly summarised as follows
1) . Formation of craters and basins of the cratered highlands.
2) . Formation of fault scarps and graben; breakup of northern 'crust'.
3). Formation of 'volcanic lava plains'.
4). Formation of major volcanic shields.

PHOBOS.

Phobos, the larger satellite of Mars, is a cratered (impact-eroded) rocky chunk.

ASTEROIDS.

Asteroids are minute in size, have no significant gravitational field and so can have no atmosphere. Many of them have been spectrophotometrically examined, and compared with the spectra of powdered minerals. The commonest (80%) asteroid surface material resembles that of carbonaceous chondrites; about 10% have a surface resembling laboratory spectra of 'stony iron' meteorites. Surfaces similar to nickel-iron have also been found.

Could the Asteroids have once all been part of one or more bodies which had segregated into a heavy metallic core with lighter material outside ?.

IO & EUROPA.

With densities over 3, these two 'Galilean' satellites of Jupiter seem to be bodies of the type found in the inner solar system. Some surface features are known.

Io is about the same size as Earth's moon, and has a tenuous atmosphere. It seems to be a reddish-brown colour, with darker reddish polar caps,. Both sulphur and sodium-rich evaporite salts have been suggested to account for the colour.

Europa is slightly smaller than the Moon, and has what appear to be snowy-looking polar caps, according to some accounts.

GANYMEDE & CALLISTO

The other two Galilean satellites of Jupiter are not dense enough to be rock bodies, but may eventually yield useful information on such subjects as the erosion of impact craters on icy surfaces. It has been suggested that darker regions may represent rocky material in ice matrix.

Ganymede is larger than the planet Mercury? it has definite dark and light surface areas and may have a thin atmosphere. Pioneer 10 photography showed surface resolution of c. 400 km.

Callisto is about the same size as Mercury, and darker than Ganymede.

TITAN.

Titan, the latest satellite of Saturn, is about the same size as Mercury. Titan is not dense enough to be a rock body, but a hydrogen and methane atmosphere, deeper than that of Mars, makes it of particular interest. It has been suggested that sunlight may be absorbed, this energy heating part of the atmosphere and possibly leading to the formation of complex organic molecules.

IKEYA-SEKI.

The comet Ikeya-Seki passed within ½million km. of the Sun in 1965, and heating from the Sun was enough to vaporise some of the stony matter in the head, spectral analysis providing evidence of sodium, calcium, iron, nickel, chromium and other metallic elements.

COMPARATIVE DATING

Absolute (radioactive) dates are known only from the Earth and Moon.

Comparative dating of events may be possible if reasons are extra-planetary, and if those external conditions (e.g. impacting objects) are from a common source and not of local origin.

Extrapolation of knowledge of age of Moon rocks and cratered surfaces allows estimation of ages for many surface features of Mercury and Mars.

Palaeoclimatology of Earth and Mars may be affected if passing through dust clouds in space at the same time, perhaps giving rise to ‘Ice Ages'.

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ADDENDUM; ‘VIKING' AT MARS, 1976.

Both landing sites show rock boulders everywhere. Sand-dimes are present at site 1; the rocks at site 2 show vesicles similar to those of volcanic rocks on Earth.

The search for life is so far (end of September 1976) inconclusive; 'soil’ material is very 'active’, but the processes are unknown. Material from under rock (sheltered from ultra-violet radiation) is being analysed. Future missions may need to 'look' in cracks in rocks rather than at loose material.

Photographs from orbit show the volcanoes and valleys in greater detail than previous missions. The North Polar Cap is water ice, not carbon dioxide.

The satellites Phobos and Diemos are both heavily cratered; Phobos shows lineation features.

R. M.

SUFFOLK BRICKEARTHS.

The term ‘brickearth* is not a geological description of a rock-type, as these are classified by particle size into sediments of clay, sand, and pebble grade, but means a soft-rock material, particularly silty clay containing an amount of sand, suitable for making bricks. The term may also be used in a stratigraphical sense, as a name for a deposit, for example, 'Stutton Brickearth’; confusion can easily be caused by this, as most bricks made in the Stutton area seem to have been made from London Clay, not ‘Stutton Brickearth’!

STRATIGRAPHY

Chalk underlies the whole of Suffolk but is usually covered by later deposits. Overlying the Chalk in south Suffolk are a series of sands and clays deposited about 50 million years ago during the Eocene period; these are overlain in the east of the county by sands (known as ‘Crag’) with some clays, formed about one to two million years ago during Lower Pleistocene times. Glacial clays and sands, about 400,000 to 50,000 years old, cover most of Suffolk and were deposited during the ‘The Age’ (Middle and Upper Pleistocene); finally, from 10,000 years ago to the present day ('Post-Glacial’ time) sandy alluvial clays have been laid down in river valleys and estuaries and will become the 'brickearths’ of future ages.

Clays older than the Chalk are found in neighbouring counties and although in their original state they cannot be claimed for Suffolk, certain of them form an important part (by glacial derivation) of Suffolk Pleistocene clays. The older clays are of Upper Jurassic (Oxford, Ampthill, and Kimmeridge Clays) and Cretaceous (Snettisham and Gault Clays) ages.

HISTORICAL NOTES.

It is difficult to give geological information on Suffolk brickyards before the nineteenth century for a number of reasons. The earliest geological records are from the early nineteenth century, there are often several different deposits with 'brickearth' qualities in the same area, and there are few indications of the exact localities of brickyards before the second half of the nineteenth century.

Bricks made at Woolpit were widely used in the eighteenth century and earlier, descriptions (Geological Survey Memoir, Sheet 50 N.E.) suggesting the deposits used being the same as those known to later geological observers. A record of Stone-Age axes from Hoxne brickpit in 1797 shows the 'brickearth' to be of the same age as that worked until mid-twentieth century.

There are several early geological descriptions from the years on either side of 1840. London Clay (Eocene age) was being used for brickmaking near Hadleigh, Ipswich, and Woodbridge, and Chillesford Clay (crag age) near Orford.

The Geological Survey Memoirs of 1878-1891 cover the whole of Suffolk and record over eighty brickpits, numerous villages having their own works.

A second series of Geological Survey Memoirs (1927-1929) covering south Suffolk shows far fewer small brickyards, with brickmaking generally confined to a few large yards, especially near Ipswich and Sudbury. By now, most bricks were being imported from outside the county.

In the mid nineteen-seventies, South Cove brickyard (using Baventian Clay of crag age) and Aldeburgh brickyard (using Chillesford Clay of crag age) were still working.

COLOUR OF BRICKS.

The chemical composition of the brickearth is of major importance in determining the colour of bricks. Non-calcareous material containing iron oxide, such as London Clay, gives 'red1 bricks when burnt under ordinary oxidising conditions. Calcareous material (containing a good proportion of lime) with little iron, such as many glacial brickearths, burn to give pale-coloured ('white' or 'buff') bricks.

The colour of the finished brick, rod, pink, grey, yellow, white, blue, can be considerably influenced by manufacturing processes, such as the firing temperature in the kiln, access of oxidising air during firing, and the type of sand used for dusting the moulds.

Both red and white 'Suffolk1 bricks were available from several brickmakers. The two different deposits needed for these bricks were often close to the brickworks, but occasionally one type of brickearth would have to be brought from some distance away, another difficulty when trying to trace bricks to their place and geological deposit of origin.

SUFFOLK BRICKMAKING DEPOSITS

EOCENE

Eocene clays are found near Sudbury, Hadleigh, Ipswich and Woodbridge; there are three main divisions - Thanet Clay, Reading Clay and London Clay.

Thanet and Reading Clays

Reading Clay is of freshwater origin and is mottled, often green and red; it gives red bricks. It was used at Aldham and at Ipswich (Back Hamlet and Stojke) in late Victorian times and at Ipswich in the early years of this century.

Thanet Clay is greenish and of marine origins; it gives red bricks. Several different deposits have been used for brickmaking at and near Sudbury, and Thanet Clay was in use in late Victorian times.

London Clay

Bluish-grey rather sandy clay, weathering brown; it fires to give rod bricks. Of marine origin, with occasional fossils such as shark teeth and pieces of wood; other occasional inclusions are 'selenite'(gypsum), iron pyrites and nodules of calcareous mudstone ('cementstone').

London Clay was important for brick-making from the early nineteenth century to the between World Wars years of the twentieth. In early Victorian times it was being used at Hadleigh, Higham, Layham, Whitton, Ipswich (Argyll Street, St. Helens), and Kingston (Kyson) near Woodbridge. In late Victorian times, among the places it was being used were Hadleigh, Aldham, Whitton, Ipswich (Brooks Hall, Trinity, St. Helens, Back Hamlet, Stoke), Holbrook, Harkstead, Shotley, Hemley, Waldringfield, Woodbridge and Melton (Geological Survey Memoirs). In the 1920s it was being used at Great Cornard, Bramford, Ipswich ('Boltons'), Wherstead and Felixstowe; red bricks from Bolton's Dales Road works were used in Ipswich at this time for the Racecourse housing estate, the Library, and the Ipswich and East Suffolk Hospital. Bolton's yard continued until the late 1950s.

A typical grain-size composition of Suffolk London Clay would be 'sand' (0.1—1.0 mm. diameter grains) 15%, 'silt' (0.01 - 0.1 mm.) 44 %, 'clay' (less than 0.01 mm.) 41%; chemical composition includes silica 71%, alumina 11%, iron oxide 5%, potash 2%, magnesia 1%, and water 3%; mineralogical composition has been calculated as quartz 51%, feldspar 17%, clay substance 20%, with the balance being hydrated iron oxide.

During the First World War, London Clay and Glacial sand were used near Ipswich for making silica bricks for refractory purposes.

CRAG (Chillesford Clay and Baventian Clay)

Bluish-clay beds of limited extent occur within the Crag; they fire to give red bricks. Chillesford Clay was used at Chillesford and Iken throughout Victorian times and continued at Chillesford in the early years of this century.

Clays of crag age were used at Halesworth, Haveningham, Frostenden, South Cove and Aldeburgh in late Victorian times, and have continued at South Cove and Aldeburgh into the second half of the twentieth century.

These clays are probably of marine origin.

'GLACIAL'

'Boulder Clays' are products of direct deposition by ice-sheets; 'Brickearths' or 'Loams' are usually water-lain, but sometimes wind-blown, deposits. At some localities two different boulder clays are present, at others both boulder clay and loam; both deposits have been used at places.

Boulder Clay

__ A stony loam, sometimes called 'Norwich Brickearth', and firing to a red colour, was used in late Victorian times at Somerleyton, Oulton, and near Burgh Castle, also near Blundeston.

Chalky Boulder Clay

A tough "blue-grey, sometimes "brown, unstratified stony clay covering most of Suffolk. It varies greatly in thickness, from a few feet to 150 feet. There are many small pebbles of chalk, other stones and fossils (mainly Jurassic and Cretaceous debris transported from the north-west and north by the glacier) set in a matrix of clay, chips of chalk and flint, and sand; some included boulders ("erratics") may weigh over one ton, tribute to the transporting powers of glaciers. If picked and washed free of stones, the composition of boulder clay is similar to that of glacial 'brickearth', and it has been used for brickmaking; being notably calcareous it yields buff coloured bricks.

Chalky Boulder Clay was used in late Victorian times at Burgh Castle, Lowestoft, Oulton, Carlton Colville, Yoxford, Starston, Pulham South Green, Weybread, Tuddenham and Playford; at Lowestoft brickyard, ¾ mile north-west by west of St. Margarets Church, dark grey and black boulder clay was burnt to give yellowish-white bricks, sometimes mottled with a little red or pink. Boulder clay continued to be used near Ipswich for making white bricks until just before the First World War.

Bluish chalky boulder clay was used at Uggeshall and Somerleyton ('white' bricks in local cottages) throughout Victorian times, and continued until the start of the Second World War (Butler, A & A., 1974). Blomfield's brickworks, a mile east of Uggeshall church, produced both white and red bricks, and these were used in Dennington, Bruisyard, Peasenhall, Darsham, Blythburgh, Southwold, Reydon, Blyford, Frostenden, Wrentham and Brampton. Both white and red Uggeshall bricks were used in Wangford Churuh in I87O5 red bricks were used in Henham Hall Gardens in 1923; and it is interesting to note that in 1921 red bricks were sold to South Cove brickworks. The bluish boulder clay at Uggeshall was no doubt used for the white bricks; the red bricks may have been made from a clear blue clay said to have been found at the site, or from other clay found elsewhere in the district, or perhaps from the normal clay at the site by means of a manufacturing process, - this point needs clearing up.

Boulder clay, mixed with chopped straw, has also been used for making air-dried bricks (used, for example, in cottages at Hockwold, Norfolk).

Brickearths or Loams

Usually of limited extent, generally being deposited either from glacial meltwater or in lakes and rivers during 'interglacials' (temperate phases within the 'Ice Age'). Some burn up to a red colour, but others are quite calcareous and, if low in iron content, yield a buff or whitish coloured brick.

Most brickyards in north-west Suffolk worked 'drift' (glacial) clays and loams. There were numerous small yards throughout the county working drift brickearths in late Victorian times, including Culford, Elvedon, Mildenhall, Icklingham, Troston, Redgrave, Stuston, Bury St. Edmunds, Little Saxham, Westley, Kersey, Ipswich (Foxhall Road), Rushmere, Trimley, Wetherden, Stowmarket, Needham Market, Bradfield St. George, Lavenham, Hasketon, Eyke, Campsey Ash, Snape, Southwold, and sites near Layham, Kedington and Haverhill. Lavenham, Kedington, and Culford were still working in the 1920s (Geological Survey Memoirs).

Bricks were made from drift brickearths at Hoxne, Woolpit, and near Sudbury from the eighteenth century (earlier at Woolpit) until almost mid-twentieth century.

Red and white bricks were both made at Hoxne in the nineteenth century, the white ones from a calcareous grey clay.

Woolpit has long been famous for its white bricks, but red bricks were also made from a brickearth at the site. The best white bricks were made from dark bluish-grey plastic clay; occasional thin ferruginous bands about 1/16 inch thick were responsible for the rusty stains on some bricks. Numerous buildings arc recorded with Wcolpit 'white' bricks, including Woolverstone Hall (1776), Great Glemham House (I8I4), the early nineteenth century front of Higham Hall, frontages in Tavern Street (Tower Street to Northgate Street), Ipswich (1815-1818), and, in Bury St. Edmunds, the front of the Guildhall (I8O9), St. John's Church (consecrated 1841), and houses in Northgate Street. There are many other buildings with 'Woolpit" bricks, but similar white bricks have been made at other localities, and this must of course be taken into account when trying to trace the place of origin of bricks.

Both red and white bricks were made at the Cornards near Sudbury, from London cvlay (Eocene) and Drift brickearths. In 1936, red bricks were used for the Girls High School, York Road, Sudbury and 'brimstone' bricks for the Tax Collectors offices, Curdy Lane, Sudbury.

Those brickearths deposited during 'interglacial' times often contain the flint axes of Old Stone Age man, bones and teeth of the mammals he hunted, and freshwater shells. Many of the fine specimens in museums came from brickpits such as those at Foxhall Road (Ipswich), Leiston, Lavenham and Hoxne.

<u>FURTHER READING</u>

<u>Geological Survey Memoirs</u>

Sheet 47	N. W. Essex , parts of Cambridgeshire and Suffolk (1878)
Sheet 48 NW and NE	Ipswich, Hadleigh and Felixstowe (1885)
Sheet 49 N	Southwold (1887)
Sheet 49 S and 50 SE	Aldeburgh, Framlingham, Orford and Woodbridge (1886)
Sheet 50 NW	Diss, Eye, etc 1884
Sheet 50 NE	Halesworth and Harleston (1887)
Sheet 50 SW	Stowmarket (1881)
Sheet 51 NE and part 51 NW	Parts of Cambridgeshire and Suffolk (1891)
Sheet 51 NE	Bury St Edmunds and Newmarket (1886)
Sheet 67	Yarmouth and Lowestoft (1890)
Sheet 206	Sudbury (1929)
Sheet 207	Ipswich (1927)
Sheet 208 and 225	Woodbridge, Felixstowe and Orford (1928)

<u>Suffolk Record Office, County Hall, Ipswich</u>

HA 11/C 39/1/1-5	Rous Suffolk estate. Brick-kiln books 1825-1887; 1921-1943.
HA 11/C 39/2-3	Brick kiln-ledgers, 1837-1882.
HA 11/C 39/4	Rous Suffolk estate. Brickkiln account books, 1871-1915.
HA 11/C 39/5	Rous Suffolk estate. Blomfield's brick-kiln, goods delivered, 1890-1916.
HA 12/D 5/3/1	Correspondence and papers re price of bricks, 1842-1852.

<u>Other</u>

Boswell, P. G. H. 1920. "Bricks and Brickmaking from a geological standpoint". Trans. Liverpool Engin. Soc., vol.XLI, pp.271-283.

Boswell, P. G. H. 1936. "Brickmaking at Cornard and Sudbury". (?Suffolk) Free Press, 23 January 1936.

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Butler, A. & A. 1974. "The story of Somerleyton Brickfields." (duplicated). (and 2nd edition, 1976)

R. Markham (Ipswich Museum)

COASTAL STUDIES AT ORFORD HAVEN

Based on surveys "by VI form students
Northgate Grammar School for Boys, Ipswich.

(This paper was originally presented at the 1967 meeting of the Geographical Association (Further Education Section) at Felixstowe).

Survey area adopted by the school

Fragmentary area 1 mile north to south, 800 yards west to east, interrupted by open water into three separate study areas- (i) North Weir Point (ii) the Skerry (iii) the mainland north of Shingle Street.

Theme

A precise investigation by surveying into the coastline changes at Orford Haven. Also to establish on North Weir Point, especially, the physical detail of the spit and present degree of vegetational colonisation, in each objective to keep pace with subsequent changes by means of annual inspections

Background data

The East Anglian coastline is in constant change, probably at a faster rate than most coastlines in the British Isles. The unconsolidated glacial drift or recent solid geology, e.g. Norwich and Red Crags which forms most of our low cliffs is vulnerable to the strong tidal scour of the North Sea, especially when backed by dominant N.E. storm winds during the winter months. At Orford Haven, we have a fine local example where regular changes in a shingle shoreline occurs, both erosional and depositional in close juxtaposition, and is thus well suited for periodic investigations. For fuller accounts of these changes, reference should be made to the articles by R. T. Cobb and A. P. Carr, listed in the bibliography. However, two complimentary ideas are important;-
(1) Shoreline changes in the estuary may follow a definite cyclic development.
(2) The Haven should be regarded as a unit, since changes on North Weir Point seem to cause alterations on the mainland at Shingle Street.

The cycle begins with North Weir Point, the southern distal end of Oxford Ness, north of its present position. Ill defined skerries and banks trail south off Shingle Street. Then follows a phase of deposition and consolidation. North Weir extends south annexing some offshore features, while others more than keep pace ahead of the distal point. A known maximum point reached was level with the Martelio Tower, south of Shingle Street (366 426).

Violent storms between the 18th and 20th November, 1893, dissected the south end of the spit into a new series of offshore phenomena, truncating the distal point by 1921 (383 449) some ¾ mile north of its 1966 position. The new growth cycle has reached a middle stage. The rate is erratic but definite, orientated S.S.W. along a similar line to that followed in the late 19th century. Since 1965, the Spit has reorientated S.S.E. The suggested study area on North Weir represents almost 800 yards growth in 21 years, the spit doubling its width in the same period to about 120 yards. Since 1962, the growth rate has accelerated to over three times its pre-1962 average annual rate of 75 feet and shows no signs of slowing down, e.g. March 1966 to March 1967, 195 ft. growth. Many sub-parallel ridges (6 ft, O.D.), often recurved, now mark the riverward side, the tidal salt lagoon being partly enclosed by two such ridges. Intervening hollows are mainly 1-2 feet lower. A storm ridge fringes the entire seaward side (11 - 16 ft. O.D.).

The offshore skerries and banks change their positions, size and altitude with great regularity. In July I966, the main skerry was a low irregular shaped ridge 350 by 75 yards, orientated N.N.W., and submerged at high water, except for a sub-circular summit 25 yard radius and 3 ft. O.D.).

As a result of our latest survey in March 1967, the island seemed to occupy much the same position and shape, but had been peneplaned to a lower level wholly submerged at high water, while the spit in extending S.S.W. had over run the N.W. part of the ridge and is now thoroughly linked to the "island" drying right out at normal low water. In fact, the new trend of the spit S.S.W. since 1965 follows the lino of this ridge, syphoned between the counterbalancing forces of river current and tidal scour from the north east. The skerry is probably part of an arcuate submerged bar (-4 to -10 ft. O.D.). The bar partially blocks the river set in a deeply gouged channel - 28 ft. OD. and it links North Weir Point to the mainland close to the bungalow, called the "Beacons" 371 433. It is probably the route by which the south moving shingle crosses the estuary from North Weir Point to the mainland. Along the Shingle Street beach, the shingle supply divides, some may continuing south towards Felixstowe, some north "beyond the bungalow into the Haven, helped by refracted waves, especially when backed by prevailing S.S.W. winds, and a strong tidal flow of 6 Knots. Net result is the small spit south of Barthorpe Creek.

The detailed changes along Shingle cannot be wholly separated from the post 1921 growth of North Weir Point, S.S.W. and slightly towards land, until 1965. While in its 1945 position, Shingle Street is more exposed to the dominant N.E. storms. Thus, south of the bungalow, e.g. by the Coast Guard station (369 429) erosion has been rapid (at least 500 ft. 1921 - 57). The many lagoons, some still pit marking this coast, and probably aligned along a former course of the River Ore, are themselves ephemeral, being drastically infilled and smoothed off during this landward recession. The bungalow marks a point of'" reasonable equilibrium in the coastline, while northwards compensatory land accretion occurred rapidly up to 1957, partly sheltered by North Weir Point but reached by refracted waves. Since the accelerated growth of North Weir Point S.S.W. certainly after 1962, the erosion rate by the C. G. station has slackened, while the small spit by Barthorpes Creek, now some way upstream and even more protected, has slowed in its northward growth and, in fact, is being worn back and smoothed by strong river current. The river, in seeming to maintain a minimum width has compensated loss on North Weir side by truncating the mainland. The large tidal lagoon, north of the concrete track is now only separated from open water by a low narrow ridge, invariably breached by storm tides, the subsequent outpouring of lagoon water at low water forming minute waterfalls cutting down through shingle to underlying clay.

The vegetative response on North Weir Point over the short 21 years cycle of shingle deposition is remarkable. Some Atriplex has already gained a hold on 1964 shingle. Over 20 different plant species were noted in July 1966, lathyrus and rumex the most common. On the pre-1950 shingle, dense groupings occur on higher levels along the storm ridge, and even in some hollows. On post 1950 shingle, colonisation is sparse, scattered along ridge lines.

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Common Ground Filmstrip "Coastal Plants above high water". C. G. B. 818.

Most useful cartographic sources which provide evidence of more recent changes since 1800 are;-

(1) Admiralty charts 101 (A1) 1811, 2052 (A1) 1847, 2052 (B2) 1872-78, 2052 (B10) 1892, 2052 (B 12) 1894.

(2) Ordnance Survey 1:63,360 1st Edition 1879- 82. 2nd. Edition 1902, partial revisions in 1925, 1953.

(3) Ordnance Survey 1: 63,360, 1838; 1895 sheet No. 208; New Popular series No. 150, 1963; Seventh series No. 150.

(4) Air photographs (a) By R.A.F. in 1945, 1952, 1953, 1955-59 (Scales 1:5,000 to 1:10,000 (b) Photograph No. 78009 by Aerofilms Ltd., 4, Albemarle Street, London W1.

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