(7) 17

List of Fossils from the English Crag which can be supplied for the sum of £5..15..0

"Mammaliferous Crag" Charlesworth, 1836
"Norwich Crag" Lyell + 1840

Astarte sulcata
Cerithium reticulatum
Cardium edule
Littorina littorea
Lucina borealis
Mactra subtruncata
Mya arenaria
Nucula Cobboldiæ
Paludestrina subumbilicata
Purpura lapillus
Tellina obliqua
Tellina lata
Tellina proxlemnis

Vertebræ of Fish

"Red Crag" Charlesworth - 1835

Aporrhais pespelicani
Astarte mutabilis
" obliquata
Artemis lenticularis
Buccinum Dalei
" tenuicostum
Calyptræa Chinensis
Cancellaria costellifera
Capulus Hungaricus
Cardium angustatum
Edulinum
Parkinsoni
venustatum
Cardita senilis
Columbella sulcata
Conovulus pyramidalis
Clavatula mitrula
Cyprina Islandica
Cyprea avellana
" Europea
" ovula
Emarginula fissura
Fissurella græca
Gastrana laminosa
Nellia suborbicularis
Lucina Borealis
Mactra arcuata
" ovalis
Modiola costulata
Mya Lata
Mytilus edulis
Nucula tortuosa
Nassa elegans
" granulata
Nassa angosa
" elongata
" propinqua
Natica catenoides
" hemiclausa
" multipunctata
Pectunculus subobliquus
" glycimeris
Pecten grandis
" tigrinus
Pholas dilatata
" cylindrica
Purpura lapillus
" lineata
" alveolata
" tetragona
Ringicula ventricosa
Saxicava rugosa
Tectura virginea

Red Crag (continued)

Tellina crassa
Trochus subexcavatus
" ziziphinus
Trophon antiquum
" contrarium

Trophon costiferum
" gracile
" muricatum
" scalariforme
Terebratula grandis

Turritella incrassata
Venus casina
" imbricata
Voluta Lamberti

Fish teeth &c.
Lamna · Myliobates
Carcharodon Raia
Otodus Edaphodon
Oxyrhina

Mammalia
Balænodon physaloides
teeth, Vertebræ, tympanic
bones &c. &c.

Corals, Cirrhipeda
Balanophyllia
Flabellum
Balanus crenatus
" porcatus

"Coralline Crag", Charlesworth, 1835

Anomia striata
Astarte Basterotti
" Burtini
" gracilis
" Omallii

Cardita senilis
" scalaris
Circe minima
Corbula striata
Cyprina Islandica
" rustica
Dentalium costatum
Diplodonta rotundata
Emarginula fissura
Lima Loscombi
Lucina crenulata

Limopsis aurita
" pygmaea
Mactra trigonalis
Ostrea spectrum
" edulis

Pecten maximus
" dubius
" opercularis
" pusio
" tigrinus

Pectunculus glycimeris
Pyramidella laeviuscula
Ringicula buccinea
Scalaria clathratula
" foliacea
Terebratula grandis
Tellina donacina

Trochus obconicus
Turritella incrassata
Venus ovata

Polyzoa

Fascicularia
Alveolaria
Cellepora
Hornera
Heteropora
Eschara

Cirrhipeda

Balanus concavus

also Fish Otolites
&c. &c.

Total 140 Species, all of which will be sent carefully labelled and securely packed. Edw. Charlesworth.

ON THE PROSPECTIVE ANNIHILATION OF THE SUFFOLK RED CRAG AS A GEOLOGICAL FORMATION, WITH A FEW REMARKS ABOUT THE RED CRAG PHOSPHATIC STONES, "COPROLITE."

By EDWARD CHARLESWORTH, Esq., F.G.S., &c.

Read at a Meeting of the Norwich and Norfolk Geological Society, and Published in the *Norwich Mercury* of Oct. 10th, 1868.

The remarkable deposit to which, in 1835, I gave the name "Red" Crag, and which forms one of the well-known group of Tertiary Formations that are spread over a limited area in the counties of Norfolk, Suffolk, and Essex may possibly have, at no very distant day, to be expunged from an enumeration of the strata that now make up the list of the British Fossiliferous Rocks. The destruction of this deposit is being brought about, partly by the encroachment of the sea, as at Harwich, where the Crag, which in Dale's time (1730) capped the London Clay cliffs, and furnished that author with the shells, the engravings of which constitute the earliest published figures of Crag Fossils, but of which Crag not a vestige is now to be seen; and partly by the artificial breaking up of the Crag to get at the layer of Phosphatic Nodules which lies at its base, and the commercial value of which to agriculturalists, under the mis-nomer "coprolite," forms the famous discovery of the late Professor Henslow. Hence it is allowable to speculate on the high value which collections of Red Crag fossils will bear when this stratum becomes a thing of the past, known to coming generations of geologists only from what they may read in books or gather from the examination of such Crag specimens as are preserved in Geological Museums. And even if any portion of the Red Crag not rich enough in phosphatic nodules to pay for the operations of digging, sifting, washing, &c., should be left in its integrity, still thus much is certain:—When the coprolite workings are closed, no such collections of Red Crag fossils can ever be made as are made now. All the most productive fossiliferous portions of the Red Crag will then have been mixed up with the overlying sand, gravel, and vegetable soil, which, shovelled up, by the coprolite miners, with the Crag in one common mass, are thrown back into the diggings, as field by field is trenched over, and the black treasure taken out.

Now if some of the curious problems connected with the history of this Suffolk Red Crag are ever to be solved, the most likely way to get at the necessary data would be by a systematic periodical visitation of the coprolite diggings. The workmen are sharp enough in looking after teeth of the mastodon and of the gigantic extinct shark carcharias megalodon; and among shells the voluta, cassidaria, ostrea princeps, &c. But many things, which to the geologically educated eye would be of inestimable value, escape the workmen and are consigned to the coprolite crushing mills. Of the truth of this I have had ample evidence during the occasional flying visits which at distant intervals I have made to the Crag district since the year 1840.

Such a system of Crag coprolite-working visitation as I now suggest might be carried into effect through the co-operation of public institutions and private cultivators of geology, desirous of possessing collections made in this way. These collections might consist either of suites of fossils illustrating the different divisions of the beds formerly confounded under one common term "Crag," or of desiderata to enrich cabinets already furnished with the ordinary run of the Crag fossils. To any one who may care to promote the cause of East Anglian Tertiary Geology or to add to his cabinet authentic and carefully determined Crag fossils I shall have pleasure in furnishing details, the introduction of which here would for obvious reasons be out of place.

In illustration of the important results which might follow from systematic coprolite-working supervision, I may here quote the unique series of Crag stone-boring molluscs (Saxicava and Pholas) exhibited by me at one of our former meetings, and which are now in the superb private collection of Mr. Wm. Reed, of York, M.R.C.S. For the rarity of such specimens as fossils of the Suffolk Crag, I need only refer to the details of Mr. Searles Wood's experience in his researches upon the Crag stone borers, as given by him under the heads Pholas and Saxicava, in the work upon Crag shells, by Mr. Wood, forming part of the Memoirs of the Palæontographical Society. The finding of these specimens was the result of two days spent last July in the examination of the Suffolk coprolite stone heaps, and, but for this visit of mine, these unique fossil shells of the stone boring tribe instead of being, as now, available for the purposes of science would, by the aid of the crushing mill and sulphuric acid, have been converted into mineral manure, and in that form have borne a purely commercial value, amounting to some infinitesimal fraction of a farthing.

In the course of a most interesting geological article in the *Edinburgh Review* for July, 1839, after referring to the value of the unique collection of Crag fossils made by Mr. Searles Wood, then of Hasketon, near Woodbridge, the *Review* thus proceeds:—"A principal step in advance was made by Mr. Charlesworth in 1835 and 1836, and the following is an abstract of his arrangement of all the beds above the chalk in Norfolk, Suffolk, and Essex:"—

A.—BEDS WITH REMAINS OF TERRESTRIAL MAMMALIA.

1.—Superficial gravel containing bones of land animals probably washed out of stratified deposits

2.—Superficial marine deposits of clay, sand, &c., in which the shells, very few in number (10 to 15 species), may all be identified with such as are now existing.

Examples—Brick earth of the Nar, Norfolk.

3.—Fluviatile and lacustrine deposits, containing a considerable number of land and fresh water shells, of which a small proportion are of extinct species. Mammalian remains in great abundance.

Examples—Ilford, Copford, and Grays, in Essex; Stutton, in Suffolk.

4.—Mammaliferous Crag of Norfolk and Suffolk, hitherto confounded with Red Crag, containing about 90 species of shells.

Examples—Bramerton, near Norwich; Southwold and Thorpe, in Suffolk.

B.—BEDS IN WHICH NO TERRESTRIAL MAMMALS HAVE YET BEEN OBSERVED.

5.—Red Crag, containing 150 to 200 species of shells.

Examples—Walton-Naze and Dovercourt, Essex; Felixstow, Newbourne, and Bawdesey, Suffolk.

6.—Coralline Crag, containing 300 to 400 species of shells.

Examples—Ramsholt, Sutton, Tattingstone, Aldbro', and Orford, Suffolk

7.—London Clay.

8.—Plastic clay.

The above abstract, which I have quoted in the shape in which it is printed in the report of the Bristol meeting of the British Association as more correct than the reprint in the *Edinburgh Review*, bears the date of 1836. Since then the extensive breaking up of the Suffolk Red Crag to extract the phosphatic nodules has brought to light abundant evidence of a Suffolk Red Crag terrestrial Mammal Fauna. And this addition to our knowledge of Red Crag Palæontology is sometimes advanced as an objection to the designation "Mammaliferous" for the Crag of Norfolk, with its extension to Southwold and Thorpe, in Suffolk. But those who advance this objection lose sight of the fact that this Norfolk Crag has produced its catalogue of Mammal teeth and bones without the trenching and sifting process which since 1840 has enlightened geologists with respect to the occurrence of Mammal teeth and bones in the Suffolk Red Crag. The known facts with respect to the search for Terrestrial Mammal remains in these separate deposits before the establishment of coprolite workings in the Red Crag, and when the conditions for research were alike in both, fully warrant the assumption that were the Norfolk Crag subjected to the "sifting" process its Mammal remains would so greatly exceed those

(on an average)
Of rare species there would be One Specimen
Of more common — — — two Specimens
Of Common — — Three Specimens

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of the Suffolk Red Crag as fully to justify the applicability of my name "Mammaliferous," without mooting considerations arising out of the law of priority, so strongly insisted upon by the highest authorities in Natural History Science.

Another phase in Crag history, depending upon later investigations, is the alleged evidence of a fourth Crag period, founded upon the examination of the Crag at Chillesford, Aldeby, and (as a consequence of Mr. J. E. Taylor's observations) the Upper Crag bed at Bramerton.

That I was fully prepared for such a modification of my original tripartite crag division will be evident to any one upon the perusal of the various memoirs which I published on the Crag in 1835, 6, 7, and 8. In the Magazine of Natural History, vol. 1, new series, 1837, I remarked—

Were it not for the extensive denudation to which our Eastern coast has been subjected, I firmly believe that in those tertiary strata, of which now only a remnant is left, we should find a series of fossiliferous beds connecting the oldest members of the tertiary group with those in which all the shells can be identified with existing species." * * * "Elephant's bones have been dredged up 20 miles from the shore, and within that distance of the coast line deposits of a dozen different ages may have been swallowed up by the encroachments of the ocean." And again, at page 42, "I am, however, sanguine enough to hope that the discrepancies will be in some measure reconciled when the tertiary formations in Norfolk and Suffolk are no longer referred to by geologists as "the Crag," and when the nature of the separate deposits and their relation to one another are more clearly established."

Probably it may be a long time before there is a complete uniformity of opinion among geologists as to the classification of the various Tertiary Strata which present so prominent a feature in the geology of East Anglia. Notwithstanding all the time and labour that has been expended upon the working out of the palæontology and the geological relations of this most remarkable group of deposits, and the array of distinguished names that are associated with their investigation, they still offer a most inviting field for further research, and one that comes especially within the province of the Norfolk and Norwich Geological Society.

Before concluding I will venture to add a few words about the phosphatic nodules;—the so-called crag coprolites. The idea of the nature of these nodules being coprolitic originated with Professor Henslow—a mistake, but one, perhaps, of the happiest mistakes ever made by a man of science; for had not Professor Henslow believed these stones to be coprolites (fossil dung), he would never, in all probability, have had them analyzed, and the phosphatic nature and consequent agricultural value of these stones might possibly for centuries to come have remained unknown.

What then is the history of Suffolk Red Crag Coprolites? I am afraid I am presenting to the members of this society a problem almost as difficult to solve as the problem of chalk flints, which has on more than one occasion been before us. Any one coming for the first time upon such a stratum of stones as that which some of us saw the other day at the base of the Waldringfield Red Crag Digging would I think, at the first glance, imagine he had before him unmistakeable evidence of the former existence of a pebble beach. But a very little investigation would dispel any such conviction. Beach pebbles, I need hardly remark, have derived their form and surface from one stone being ground against many others; and this grinding process goes on until a mass of stones that were originally of the most irregular shapes and and of all sizes, are worn down to that smooth surfaced and oval or rounded stone so familiar to us as a "pebble." If fossils are enclosed in these stones they are not left projecting from the surface of the pebble, but are reduced by the grinding process to the level of its contour. Now, if we examine a large number of the coprolite stones, every now and then we come across one that has a shark's tooth sticking out of it, and yet the stones from which these teeth project have the same spherical type of form as that presented by the generality of the coprolite stones, a form which in the cases of the tooth-projecting stones could not possibly have been produced by friction. Then again coprolite stones are sometimes as round as grape shot —sometimes perfectly oviform, presenting us with such regular figures as we seek in vain for among pebbles Consequently without going more at length into the evidence, I think the pebble hypothesis cannot be entertained for a moment. But I have no theory of my own to advance in explanation of the formation of Crag coprolite stones. It appears to me, however, that they have some points in common with the occurrence of flint stones in chalk. In the chalk we see flint seizing so to speak upon the root of a sponge or ventriculite and forming round it an oval or spherical mass, while the rest of the ventriculite when circumstances admit of the observation being made, can often be traced in the contiguous mass of chalk. But as the workmen in chalk quarries break up the chalk in small pieces, a ventriculite in connexion with its flint-invested root is rarely presented to our notice. Now there were no rooted ventriculites in the Crag Sea for the Crag phosphatic or so-called coprolitic matter to adhere to; but there were an abundance of sharks' teeth with roots, and upon these roots, *alias* fangs, we find the phosphatic stone clinging in a more or less spherical mass; while the greater portion of the organic body—that is, the tooth proper, has none of this phosphatic investment. And when the Crag is broken up, were these teeth delicate and fragile organisms, they would, after the fashion of the fragile chalk ventriculites, break away from their stone-invested roots.

In comparing phosphatic stones in Red Crag with flint stones in White Chalk there is one point which is well worthy of notice as being specially suggestive. Chalk flint stones when broken often present to us enclosed shells, sharks' teeth, and other organic bodies. But in all cases these flint enclosed organic bodies are of the same species as the organic bodies found in the chalk itself. It is otherwise with the organic bodies enclosed in the Crag *phosphatic* stones. We find these stones lying in immediate contact with numerous shells, but if we break a phosphatic stone, and find a shell enclosed, this Crag stone-enclosed shell is not of the kind found in the Crag, but of some species found in the underlying and much more ancient formation than Crag, the London Clay. And though the shark's teeth which are enclosed in these Crag stones may be quoted as an exception to this rule, yet they really support it, for there are two groups of shark's teeth found in the Crag, one group containing species peculiar to the Crag, the other containing species which are found in both the Crag and the London Clay. Now whenever a Crag shark's tooth is in a phosphatic nodule, or even if it have the smallest piece of phosphatic matter investing it, it is invariably a tooth of the London Clay group. Again, no phosphatic stone has ever been seen investing one of the many thousand teeth of the whale tribe which have turned up at the diggings, and it is a well known fact that these Cetacean (that is whale, grampus, &c.) teeth are not found in the London Clay, but are a speciality of the Crag, so that we may set it down as a rule so far as the Crag is concerned, that we only find Crag fossils in union with phosphatic stone when the fossil is of a London Clay species; and this leads to the inevitable conclusion that all the Crag coprolite stones were originally in the London Clay. The soft London Clay itself when it formed the bed of the Crag ocean would be abraded by the action of tides and currents, bringing about the separation from it of the hard and heavy phosphatic stones. These stones having been thus removed from their parent bed, became a portion of the new deposit, the Crag, then in process of formation upon and around them.

Suffolk coprolite then must be considered as phosphatic stone, transferred from London Clay to Crag, and changed in its appearance by the new chemical and physical conditions with which it has been surrounded.

What the precise nature is of those changes, including the curious glaze with which these transported stones are now covered, may be an interesting problem for a chemist to solve.

~~Whittington Club, London, W.C.~~

W. H. Stand