

Transactions of the Geological Society of London

XII.—On the Discovery of Coprolites, or Fossil Fæces, in the Lias at Lyme Regis, and in other Formations.

W. BUCKLAND

Transactions of the Geological Society of London 1829, v.s2-3; p223-236.
doi: 10.1144/transgslb.3.1.223

Email alerting service

click [here](#) to receive free e-mail alerts when new articles cite this article

Permission request

click [here](#) to seek permission to re-use all or part of this article

Subscribe

click [here](#) to subscribe to Transactions of the Geological Society of London or the Lyell Collection

Notes

XII.—*On the Discovery of Coprolites, or Fossil Fæces, in the Lias at Lyme Regis, and in other Formations.*

BY THE REV. W. BUCKLAND, D.D. V.P.G.S., F.R.S. F.L.S.
PROFESSOR OF MINERALOGY AND GEOLOGY IN THE UNIVERSITY OF OXFORD,
&c. &c. &c.

[Read Feb. 6th, 1829.]

1. *Coprolites in Lias.*

IT has long been known to the collectors of fossils at Lyme Regis, that among the many curious remains in the lias of that shore, there are numerous bodies which have been called Bezoar stones, from their external resemblance to the concretions in the gall-bladder of the Bezoar goat, once so celebrated in medicine: I used to imagine them to be recent concretions of clay, such as are continually formed by the waves from clay on the present beach; but I have now before me sufficient evidence to show that they are coëval with the lias, and afford another example of the same curious and unexpected class of fossils with the album græcum, which I first discovered in 1822 in the cave of Kirkdale, being the petrified fæces of Saurian animals, whose bones are so numerous in the same strata with themselves*. The Coprolites, which I shall first describe, have yet been noticed chiefly at Lyme Regis; but I think it probable that they exist wherever the remains of Ichthyosauri are abundant; the most likely place to afford them is the extensive coast near Whitby, where, as at Lyme, the lias is exposed to continual destruction by the sea, and abounds in bones of Saurians†. A great number of these so-called Bezoars at Lyme,

* The chemical evidence for this conclusion rests on the high authorities of Dr. Wollaston and Dr. Prout. In Dec. 1825, I submitted to Dr. Wollaston a specimen from Lyme Regis (Plate XXVIII. fig. 12.) and also one from Tilgate Forest (Plate XXXI. fig. 18.); and he then informed me that both these specimens contain much phosphate of lime, and that his analysis appeared to confirm my conjecture as to their fæcal origin.

In the present year Dr. Prout has kindly occupied himself with this subject, and has analysed all the varieties of fæcal substance that are mentioned in this paper.—See his Letter subjoined (p. 237).

† Since this paper was read, I have recognized a Coprolite from Whitby, in the collection of R. I. Murchison, Esq.; it forms the nucleus of a small Septarium. At Bath and Barrow-on-Soar, where large quarries of lias are laid open, and bones of Ichthyosauri are frequently dug up, we shall probably also soon find Coprolites.

occur as loose pebbles upon the shore, having been washed out of the lias ; but many are also found dispersed, like *Septaria*, in the lias shale, and sometimes in the stone lias. Occasionally they form the nuclei of small *Septaria*, or have selenites or crystals of sulphate of barytes adhering to, and radiating from, their surface. These imbedded specimens have undergone no process of rolling, but retain their natural form, as if they had fallen from the animal into soft mud, and there been preserved undisturbed until it was consolidated to the state of lias and lias shale.

The certainty of the origin I am now assigning to these *Coprolites*, is established by their frequent presence in the abdominal region of the numerous small skeletons of *Ichthyosauri*, which, together with many large skeletons of *Ichthyosauri* and *Plesiosauri*, have been found in the cliffs at Lyme, and supplied to various collectors by the skill and industry of Miss Mary Anning. I have two of these skeletons, in each of which the *Coprolites* are very apparent, but flattened ; and Miss Anning informs me that since her attention has been directed to these bodies, she has found them within the ribs or near the pelvis of almost every perfect skeleton of *Ichthyosaurus* which she has discovered. She further informs me, that whereas in the entire thickness of the lias formation there are certain strata that abound in bones, whilst in others they are comparatively rare ; so also the so-called *Bezoars* are most abundant in those parts of the formation in which the bones of *Ichthyosauri* and *Plesiosauri* are most numerous.

I propose to assign the name of *Ichthyosauro-coprus* to the fossil fæces which are thus evidently derived from *Ichthyosauri**.

In variety of size and external form the *Coprolites* at Lyme Regis resemble oblong pebbles or kidney-potatoes. They, for the most part, vary from two to four inches in length, and from one to two inches in diameter. Some few are much larger, and bear a due proportion to the gigantic calibre of the

* We are as yet without direct evidence to show which of the *Coprolites* are derived from *Plesiosauri* ; the discovery of a skeleton containing them within it, will probably ere long decide the question : from the smaller size of their jaws, it should seem the *Plesiosauri* were less voracious, or at least less qualified to swallow large animals, than their neighbours the *Ichthyosauri* ;—still they were carnivorous and swallowed their prey entire, and must have contributed their due proportion to the stores of *Coprolites* that lie buried with them in the lias. There is sufficient variety in these *Coprolites* to allow them to be referred to more than one genus, and to many species of *Saurians*. At present we can with safety apply the term *Ichthyosauro-coprus* to those only which are found within the skeletons of *Ichthyosauri*, and to specimens like those engraved at Plate XXIX. figs. 2. & 5. which contain bones of animals too large to have been swallowed entire by a creature having so small a mouth as the *Plesiosaurus dolichodeirus*. There is no third genus of animals in the lias to which we can refer these largest *Coprolites*.

largest Ichthyosauri* ; others are small, and bear a similar ratio to the more infantine individuals of the same species, and to small fishes† : some are flat and amorphous, as if the substance had been voided in a semifluid state‡ ; others are flattened by pressure of the shale. Their usual colour is ash-grey, sometimes interspersed with black, and sometimes wholly black. Their substance is of a compact earthy texture, resembling indurated clay, and having a conchoidal and glossy fracture. Their general appearance will be best understood by referring to the figures given of them in Plates XXVIII. XXIX. & XXX. The structure of the Coprolites at Lyme Regis is, in most cases, tortuous, but the number of coils is very unequal ; the most common number is three : the greatest I have seen is six§ : these variations may depend on the various species of animals from which they are derived : I find analogous variations in the tortuous intestines of modern skates, and sharks, and dog-fish||. Some Coprolites, especially the small ones, show no traces at all of contortion or any other structure¶.

The sections of these fæcal balls show their interior to be arranged in a folded plate, wrapped spirally round from the centre outwards, somewhat like the whorls of a turbinated shell** ; their exterior also retains the corrugations and minute impressions, which, in their plastic state, they may have received from the intestines of the living animals††. Dispersed irregularly and abundantly throughout these petrified fæces are the scales, and occasionally the teeth and bones, of fishes, that seem to have passed undigested through the bodies of the Saurians, just as the enamel of teeth and sometimes fragments of bone are found undigested both in the recent and fossil album græcum of hyænas. These scales are the hard bright scales of the *Dapedium politum*, and other fishes which abound in the lias, and which thus appear to have formed no small portion of the food of the Saurians. The bones are chiefly vertebræ of fishes and of small Ichthyosauri ; the latter are less frequent than the bones of fishes, but still are sufficiently numerous to show that these monsters of the ancient deep, like many of their successors in our modern oceans, may have devoured the small and weaker individuals of their own species. One large Coprolite‡‡ contains a vertebra, more than an inch in diameter, of an Ichthyosaurus that must have been at least four feet in length : and the jaws of large Ichthyosauri in the collection of the Geological Society, show how competent they were to swallow animals even of much greater size

* Plate XXIX. figs. 1. 2. & 4. † Plate XXX. fig. 6—12. ‡ Plate XXX. fig. 5.

§ Plate XXVIII. figs. 3. 5. 11. 12'. || Plate XXXI. figs. 19. 20. 21. 22.

¶ Plate XXX. fig. 4. & fig. 6—12. ** Plate XXVIII. figs. 3. 4. 10. 11. & 12'.

†† Plate XXVIII. figs. 6. 7. 8. 9. ‡‡ Plate XXIX. fig. 2.

than this *. It appears moreover, probable, that the remains of cuttle-fish occur in these fæcal balls at Lyme Regis. I had requested Dr. Prout to ascertain the cause of the bright jet black colour that pervades some of them : his reply after examination was, that their analysis is very similar to that of the fossil ink from the lias which I had also submitted to him, and to ask me if it was possible that Ichthyosauri could have eaten sepia: Mr. Gray also, whilst examining my specimens of the fossil pens and fossil ink-bags from the lias, asked if I ever found the semi-osseous or horny rings of the suckers of Cephalopodes : I replied that many of the fæcal balls are interspersed with small black circles, which seem to correspond in shape and substance with the horny rings he was inquiring for †, and to confirm the conjecture of Dr. Prout that sepia formed part of the food of the Saurians. Though containing much animal matter and but little lime, these rings, like the scales of fishes that have travelled with them through the intestines of the reptiles, seem to have resisted the destruction which awaited most of the bones that were submitted to this digestive process ‡.

Nearly half of all the Coprolites in the lias at Lyme Regis contain these rings, which, if they are derived, as I imagine them to be, from the suckers of the Loligo or other Cephalopodes, show that the Saurians fed largely on the Cephalopodes of the ancient seas §. I think it, however, right to mention two facts that seem unfavourable to my opinion as to these rings. 1st. That none of them are so large as the largest cup-rings of the modern Loligo. 2nd. That the lias contains the remains of a small fish whose vertebræ are nearly of the same size and shape as the rings in question : it is also possible that the rings in Plate XXX. figs. 2 A. & 3 A. may be sections of a large tuberculated scale or bone.

* Crocodiles in the Ganges, whose jaws are not one half the size of the fossil jaws I allude to, are often found to contain a human body in their stomachs. I possess vertebræ of Ichthyosauri nearly seven inches in diameter.

† Plate XXX. figs. 1. 2. & 3.

‡ It is a question that deserves attention, as connected with animal and mineral chemistry, Why fossil scales are preserved more perfectly than the bones of the fishes to which they belonged, though containing much less lime, and much more animal matter? The substance of the rings in the suckers of the recent Loligo and other Cephalopodes, much resembles the semi-transparent and horn-like substance of recent fish scales. In the case of our Coprolites, both rings of Loligo and scales of fishes appear to have been indestructible ; and in the same lias with them at Lyme Regis, the beaks, and horny pens and ink-bags of a fossil Loligo, and other Cephalopodes, occur in high preservation : these will be described in the next Part of the Geol. Trans.

§ A strong *a priori* probability that the Cephalopodes of the lias period would have been devoured abundantly by the Saurians, arises from the fact mentioned in Loudon's Mag. Nat. Hist.

I now proceed to compare with the Sauro-coprolites of Lyme Regis some similar substances which have long been known to exist at Westbury, Aust Passage, and Watchet, on the banks of the Severn, and which now also prove to be fæcal balls of digested bone: they mostly occur in a thin bed of sandy micaceous lias, so full of the bones and teeth and spines of reptiles and fishes, as to form a bony breccia known to geologists by the name of the bone-bed, and occupying the lowest place at the bottom of the lias formation. The bones are chiefly of unknown small reptiles, but those of *Ichthyosaurus* and *Plesiosaurus* also occur; they are for the most part broken, though not much rolled, and both bones and teeth are separated from the part to which in life they belonged. Mr. Conybeare and myself have described these Coprolites as irregular bodies of various form, usually cylindrical, with rounded ends, some having a black and glossy surface and fracture, others being of a dull brown colour; and have conjectured them to be rolled palates, or rolled fragments of very solid bone: at that time no one suspected that they were bone reduced to the state of fæces*. More recently, Mr. Dillwyn has applied to them the name of *nigrum græcum*, from their resemblance in form to the *album græcum* of the cave of Kirkdale.

Mr. J. S. Miller of Bristol possesses an extensive collection of these bodies, and has also for some time suspected them to be fæcal. He has kindly lent me those which I have engraved at Plate XXX. figs. 13. 14. 16: a few only of these Coprolites from the Severn district resemble those of the lias at Lyme Regis; most of them are much smaller, and differ in the absence of spiral structure, and the rare occurrence of scales or bones in them. Externally they are of a bright glossy black, internally of a dark brown colour; their substance is compact, their fracture splintery, and sometimes conchoidal; their surface often smooth as if they had been polished †. They vary in size from that of

No. 7. p. 153., that the most valuable bait at the Newfoundland fisheries is the *Loligo vulgaris*; with this animal nearly one half of all the codfish there taken is caught. The *Loligo* appears there in throngs about the beginning of August, and it begins to retire from the coast in September. Cuttle-fish are also used as a favourite bait by fishermen on our own coasts. Mr. Clift informs me that he recollects having seen a large shark dissected near Poole, in the stomach of which was found nothing but a mass of beaks of *Sepiæ*. He also informs me that ambergris is often much contaminated by an admixture of the beaks of *Sepiæ*. Since, then, our modern whales and sharks and larger fishes are so voracious of modern Cephalopodes, it is probable that the Cephalopodes of the ancient seas were an equally favourite food to their contemporary Saurians: the discovery of the beak of a *Sepia* within a Coprolite would decide this question in the affirmative.

* Geol. Trans. Second Series, vol. i. p. 302, and Plate XXXVII.

† It is probable their smoothness and form are entirely due to the action of the intestines in which they were moulded; but, as the bones and teeth that are found with them have the same black colour and glossy surface, these common characters may have resulted from agents to which

a small potatoe to a hemp seed: in shape, many of them resemble the sub-angular concretions found in the human gall-bladder, and in the cavities of a diseased kidney; others are spherical, like sheep's dung, or cylindrical, like that of rats and mice, with various intermediate varieties of size and form; some are flat like a bean, others polygonal*.

There is no direct evidence to show from what animals the smaller varieties of these Coprolites have been derived. Many may probably be referred to the small reptiles, and others to the fishes, whose broken and scattered bones, teeth, palates, and spines, are so frequent in the same breccia with themselves: others may possibly be derived from the inhabitants of the Nautili, Ammonites, Belemnites, and other Cephalopodes which abounded at the period of the lias formation †.

The extent and quantity of this coprolitic breccia near the estuary of the Severn is very remarkable. My friend, R. Anstice, Esq. of Bridgwater ‡, has sent me masses of lias, which he found in 1823 at the east extremity of Blue-Anchor Bay, near Watchet, full of these black pupa-shaped fæcal bodies, which he says he never could understand; they are here also mixt with numerous teeth and scattered scales of fishes, and with teeth and bones of small unknown Saurians: he also informs me that Mr. Baker of Bridgwater has recently found the same breccia in the bed of the Parrot, five miles below that town at Combwich, where the lias crosses the river near low-water-mark. In the specimens he has sent me from thence, the fæcal remains and bones are rare, but scales of fishes are very abundant; similar scales occur in the lias at Bawdrip, on the east of Bridgwater, as also in the lias at St. Hilary near Cowbridge, and at Gold Cliff in Glamorganshire, and at Wickwar in Gloucestershire: in all these cases, as in the breccia of Westbury and Aust, the scales are dispersed and dislocated, and seem derived from fishes that died and fell to pieces, and whose scattered bones, scales, and teeth, became mixt with the remains of reptiles and of other inhabitants of those ancient seas. I have

they were all equally exposed, whilst they lay together loose at the bottom of the sea, or since they have been buried together in the lias; the polish in neither case is the effect of rolling; and the cause of the bright jet black colour is probably carbonization; the entire substance of the bones is often black, but the surface only is black in most of the Coprolites; their interior is usually brown.

* Plate XXX. fig. 13—29 inclusive.

† On dissecting a *Sepia officinalis*, I have found the stomach filled with small bones of fishes mixt with fragments of shells of small Solens, and with small bivalves.

‡ We owe to Mr. Anstice our knowledge of the existence of the head of *Plesiosaurus dolichodeirus*, described by Mr. Conybeare in Geol. Trans. Second Series, vol. i. p. 119, as having been found by Mr. Clarke, who presented it to Mr. Anstice.

yet seen no Coprolite in specimens of the bony breccia from these four last localities. The late Rev. J. J. Conybeare gave me specimens of the same breccia from the lias in a shaft dug in the year 1808 at Bath Easton, in fruitless pursuit of coal; in these specimens I now recognize Coprolites; and in a mass of lias breccia, which I collected a long time since at the base of Broadway Hill near Evesham, I find the brecciated character is due also to an *accumulation of Coprolites.*

This remarkable phænomenon of a stratum of stone many miles in extent, and many inches in thickness, and in which sometimes one fourth part of the whole substance is made up of balls of Coprolite, seems explicable only by its position in the lowest region of the great formation of the lias, a position which must for a long time have been the bottom of an ancient sea, and the receptacle of the fæces and bones of its inhabitants, the cloaca maxima, as it were, of primæval Gloucestershire. This period must have occupied the interval between the termination of the red marl, and the beginning of the deposit of the lias formation, and the earthy sediments then deposited must have been inconsiderable in the districts we are now speaking of. In the sediments which next succeeded, and of which the great mass of the lias formation is composed, there is no such abundant accumulation of Coprolites in any single thin stratum, but they occur insulated and dispersed in the slaty clay and stone, or included within the skeletons of the Ichthyosauri*. The fact of so many of these skeletons being those of young animals, proves that they did not die in the course of nature from infirmity or age; and the entire condition both of young and old skeletons shows that they perished suddenly, and were buried immediately after their death; they would otherwise have fallen to pieces, and been dispersed like the bones in the breccia at Westbury and

* Among the strata at Lyme that most abound in bones, is a bed of marl about three feet thick, in which Sauro-coprolites are chiefly found, but even in this bed they are far and widely dispersed; in one case only Miss Anning has found two Coprolites together, and these were close to the skeleton of an Ichthyosaurus, as if they had been voided by it in the struggles of death. In the cliff a quarter of a mile west of the Port of Lyme in the lias marl, above the strata that most abound in the remains of Saurians, I found one bed of stone-lias about 6 inches thick, in which was a congeries of small Coprolites, irregular and subangular, like those in the bone-bed of the Severn district, and so different from those which are associated with the large Saurians in the lower parts of the lias, that I imagine them to be derived from fishes or Cephalopodes, or some other unknown animals; they are, however, important, as affording a geological chronometer whereby we mark at least one short interval in the deposition of the lias marls, during which they must have been accumulated at the bottom of the then existing seas. I found no remains of fishes or Saurians with them, nor any pebbles or other indications of a long period such as seems to have been occupied in the formation of the coprolitic bone-bed at Westbury and Watchet. Nearly the same conclusion as to short intervals between the deposition of the component parts

Aust: moreover, it seems not improbable that the cause of the death of so many animals of every age and condition, may have been the sudden influx of the mud, which has since been indurated to the state of lias and lias shale*. The same inference as to sudden death and immediate burial may be drawn from the generally perfect condition of the fishes in this formation; had they not been speedily enveloped in the sediment of the nascent lias, they would have been devoured by Ichthyosauri, or by other fishes, or by smaller animals, and the bones and scales would have either been involved in Sauro-coprolites, or have been dispersed. A still stronger inference of the same kind arises from the frequent and perfect preservation of fossil ink-bags in contact with the horny pens and other remains of a fossil *Loligo* and other Cephalopodes: had these soft animals not been entombed very speedily after death, the decomposition of their bodies would have separated for ever these parts which we find in contact; moreover, the ink-bags would very speedily have perished, and their contents have been dispersed. The sudden entombment of the animals also in the lias at Lyme Regis, is further shown by a fossil fish in the collection of Miss Philpots retaining a fæcal ball within its body; this individual must have been buried in mud before even the soft parts of its abdomen had undergone displacement or decay. Dr. Prout has analysed this ball; and I would propose to distinguish it, and all similar substances that can be referred to fishes of unknown species, by the name of *Ichthyocopus*.

Should any question be raised as to the antecedent probability of excrementitious substances being preserved in a fossil state, nearly the same argument may be applied as in the case of the fossil album græcum of the hyænas;

of the lias may be drawn from the very rare occurrence of parasitic shells on the bones of the Ichthyosauri and Plesiosauri at Lyme Regis. Had these bones remained long exposed to water at the bottom of the sea, parasites would have attached themselves similar to those we so often find on fossil bones in other strata, showing that a period at least sufficient for the growth of these parasites elapsed between the deposition of the bones and their complete interment in mud or sand. The absence of such parasites, added to the smooth and uninjured state of the surfaces of the bones, shows how immediately after death the animals must have been covered with the mud that is now consolidated into shale and stone: one bone of a *Plesiosaurus* in the collection of Miss Philpots is the only specimen I recollect from the lias at Lyme that has a parasitic shell adhering to it; this one, however, is sufficient to show one short interval in the deposition of the five hundred feet of marl and argillaceous limestones that here compose the lias formation; probably there were many such short intervals; the coprolitic bed on the west of the Port of Lyme is another.

* There may also have been an influx of the bitumen which is so abundant in the lias shale, or a sudden alteration in the temperature of the waters, or a chemical and fatal change in their composition.

in that case it was argued by Dr. Wollaston, *a priori*, that if the hyænas had eaten bones, we might expect to find album græcum preserved, together with the fragments of bones that remained not devoured in their antediluvian dens; and my immediate discovery of this substance fully verified Dr. Wollaston's conjecture: the same argument extends to the case of other fossil animals that swallowed bones; the main condition is, that the osseous fæces shall have been deposited in such places, and under such circumstances as would guard them from destruction till they were imbedded in some protecting matrix; this done, their chemical ingredients are as indestructible as the undigested bones which are preserved in the same strata with themselves. If such perishable impressions on sand as the footsteps of tortoises and other animals, have been retained and moulded on the surfaces of the strata of new red sandstone at Corncockle Muir near Dumfries*, and if such fragile bodies as the eggs of aquatic birds have been preserved in the lacustrine limestones of Cournon in Auvergne †, why should not the indurated and semi-calcareous fæces of Ichthyosauri and other voracious animals have fallen uninjured to the bottom of the sea, and there becoming imbedded in mud or sand, or nascent stone, have remained undisturbed and perfect unto the present hour?

II. *Coprolites in Mountain Limestone.*

The specimens engraved at Plate XXX. fig. 31—41. are the only ones I have seen from strata of older formation than the lias; for my knowledge of them I am indebted exclusively to Mr. J. S. Miller, who has collected a series of them from the bottom of the mountain limestone at Clifton near Bristol. They occur in one bed of limestone nine inches thick, between the black rock limestone and the old red sandstone, and are mixed with small bones and teeth of fishes, palates of at least ten kinds, spines of Balistes, and teeth of sharks, and fragments of old red sandstone, and offer a case apparently analogous to that of the bone-bed at the bottom of the lias; each respectively seems to indicate a period anterior to the deposition of the two great formations of the mountain limestone and the lias, during which the bottom of the then existing oceans received little accession of mineral matter, but was the receptacle both of the indurated fæces of its voracious inhabitants, and of the bones of those individuals among them that escaped violent death and consequent reduction to the state of fæcal balls in the stomachs of one another.

These most ancient Coprolites in the mountain limestone are all small, and are probably varieties of Ichthyocopus.

* See Dr. Duncan's account of footmarks, &c. Trans. Royal Soc. Edinburgh, 1828.

† See Croizet and Jobert's *Récherches sur les Fossiles du Puy de Dôme*, Disc. Prél. p. 27.

III. *Coprolites in Oolite*.

I have very recently discovered Coprolites in limestone of the Oxford oolite formation at Osmington Mill on the coast of Dorset, about four miles east of Weymouth; and Mr. Jelly has found them in the Kimmeridge clay at the base of Shotover Hill near Oxford: they are small, the largest is of the size of a filbert; others are of irregular shape, like those in the lias at Westbury and Watchet; the character, however, of these Coprolites from the oolite and Kimmeridge clay is somewhat obscure.

IV. *Coprolites in Hastings Sand*.

About four years ago, in the collection of Mr. Mantell, I found a specimen from the Hastings sandstone of Tilgate Forest, which I suspected to be fæcal, and of which I then prepared a drawing*, and obtained an analysis from Dr. Wollaston, and subsequently from Dr. Prout, as before stated: it contains much phosphate of lime, and has fish-scales imbedded in it like the Coprolites at Lyme; like them it has also a spiral structure, but differs in the circumstance of the coiled substance being rather cylindrical, whereas in the lime Coprolites it is nearly flat. I know not to which of the many reptiles Mr. Mantell has discovered at Tilgate this Coprolite may be referred. He has lately found other specimens of this same unknown species of Coprolite.

V. *Coprolites in Green-sand*.

To the Rev. B. Richardson of Farley Castle I am indebted for a specimen of Coprolite in green-sand from Wiltshire;—it is nearly of the size of a filbert, and very stony. Dr. Prout's analysis shows it to contain a considerable proportion of siliceous matter; it effervesced moderately in dilute muriatic acid, emitting faintly the peculiar smell usually given off by Coprolites; and the portion dissolved consisted essentially of phosphate and carbonate of lime; it is engraved at Plate XXXI. fig. 17. Miss Anning has recently found similar small Coprolites in the green sand near Lyme.

VI. *Coprolites in Chalk*.

Whilst I was examining and drawing the specimens from the lias that are represented at Plate XXVIII. figs. 3. 4. 5. 10. 11. 12. 12', their structure so much reminded me of the fossil Iuli of the chalk and chalk marl which have been described by Woodward, Parkinson, and other writers, as fir cones of the larch †, that it occurred to me these so-called Iuli must also be of fæcal

* Plate XXXI. fig. 18.

† See Woodward's Catalogue, Part II. p. 22. 6. 72., and Parkinson's *Organic Remains*, vol. i. p. 447. and Plate VI. figs. 16. 17.—Mantell's *Geology of Sussex*, p. 103. et seq.

origin*: this conjecture was soon verified by examination of the specimens in question: like the Coprolites at Lyme, I found them to be composed of a flat plate of digested bone reduced to a plastic state resembling putty, and coiled up spirally like a tape-worm twisted round itself.

This plate is much thinner, and its coils are more numerous than in the Sauro-coprolites from the lias: imbedded in the substance of this plate, I found many scales of fishes †, and around its exterior, corrugations or impressions derived from the membrane of the intestine wherein it was formed ‡.

The analysis of Dr. Prout consummates the evidence of their fæcal origin, showing them to be composed chiefly of phosphate of lime: they vary from one to two inches in length, and from half an inch to an inch in diameter. On comparing the analysis of a fossil vertebra of fish from the chalk near Lewes with that of an Iulus, Dr. Prout found the difference to be scarcely perceptible; its colour and appearance before analysis was also similar §.

Until we can ascertain the animal from which they have been derived, I propose to designate these bodies by the name of Iulo-eido-coprolites. It is obvious, from their form and structure, they cannot be referred to the same animals as the Coprolites at Lyme; indeed the bones of Saurians of any kind are rarely found along with them; probably they may have been produced by some of the sharks, rays, diodons, balistes, or other fishes whose teeth, and palates, and spines, are so common in the chalk formation; the tortuous structure of the intestine of the existing shark, making thirty-four turns in a

* Plate XXXI. fig. 1—11.

† Plate XXXI. fig. 6.

‡ Plate XXXI. figs. 1. 4. 5. 6. 9. 11. compare them with the recent specimens (figs. 20. & 21.) of the same plate.

§ The following accurate description by Mr. Mantell (*Geol. of Sussex*, p. 104.) shows how nearly he approached the discovery of the origin I am now assigning to these Iuli; although he modestly states that, after examining more than fifty specimens, he can add but little to what is known concerning them.

“The remains in question are of a reddish brown colour, from 0.5 inch to two inches long, of a cylindrical form, and generally tapering towards the apex, which is obtuse. They are more or less compressed, and have a scaly, corrugated surface. Their constituent substance is precisely of the same nature as that of the vertebræ and other bones found in the chalk formation; some examples have scales of fishes attached to them. In structure, they differ most essentially from any strobilus or cone; for, instead of an imbricated surface formed by scales containing seed, and proceeding from one common axis, as in the Iuli of the Larch, their scaly appearance is produced by the undulating margin of the substance of which they are composed, the latter being irregularly coiled in a spiral manner round an oval cavity or receptacle.”

Mr. König also had long suspected their animal nature from the offensive odour they emit on being submitted to muriatic acid.—See Mantell's *Geology of Sussex*, pp. 103. 104. 158. and tab. ix.

length of ten inches, offers an analogy which may explain the spiral form of these Iulo-eido-coprolites, and also of the Sauro-coprolites from Lyme Regis*.

I have just learnt from Mr. Millar, that Colonel Houlton of Farley Castle possesses specimens from the mountain of St. Peter near Maestricht, which are identical with these Iulo-eido-coprolites of the English chalk. The Colonel has favoured me with the loan of these specimens †.

The specimen represented in Mr. Mantell's Plate IX. fig. 3. as an unknown body from the chalk at Lewes, has also been ascertained by Dr. Prout to be of a faecal nature ‡; its external form and surface favour this opinion, but as it has no internal spiral coils, it must have been derived from some other animal than those which produced the Iulo-eido-coprolites. Mr. Mantell has just sent me a smaller specimen from the chalk near Lewes§, in which an uncoiled substance of a similar form and colour, and giving a similar analysis, lies within the body of a fossil fish (*Amia Lewesiensis*), and in immediate contact with its air-bladder||. Both these specimens from Lewes are probably varieties of *Ichthyocopus*, and the smaller one may safely be called *Amia-copus*. These uncoiled specimens prevail in the lower chalk, where alone the *Amia* is found, and seldom occur in the chalk marl where the spiral Iulo-eido-coprolites are so common.

VII. *Coprolites in Tertiary Strata.*

Mr. Burtin in his *Oryctographie de Bruxelles* ¶ figures a specimen as a "fruit, ou noyau de fruit inconnu," which seems evidently to be a Coprolite. Mr. Mantell** has referred to it as resembling the Iuli of the chalk; and I have copied it in Plate XXXI. fig. 11a. Also in a collection I recently purchased of fossil fruits from the London clay of Sheppy, there is a Coprolite †† which in form resembles some of those from the lias on the Severn ‡‡.

* An examination of the form and composition of the faeces of living fishes, particularly of the shark and ray and sturgeon tribes, throws much light on the present inquiry. I have recently dissected some rays and dog-fishes, and found in them a short spiral intestine coiled round internally like a screw-pump or winding staircase; injecting these intestines with Roman cement, I have made artificial Coprolites that in form are exactly similar to many of our fossil specimens. Plate XXXI. figs. 19. 20. 21. 22. The vascular structure also of the tortuous intestines of certain species of dog-fishes resembles the minute impressions and ramifications on the surface of the Iulo-eido-coprolites. Plate XXXI. figs. 20. 21.

† Plate XXXI. figs. 9. 10. 11.

‡ Plate XXXI. fig. 13.

§ Plate XXXI. fig. 12.

|| Mantell's *Sussex*, p. 239. and Plate XXXVIII.

¶ Plate V. F. G.

** Mantell's *Sussex*, p. 158.

†† Plate XXXI. fig. 14.

‡‡ In the crag at Southwold in Suffolk, Mr. Lyell has found a remarkable body, apparently a Coprolite, of the size and form of an oblong duck's egg, and almost entirely composed of phosphate of lime and oxyd of iron: it is traversed by cracks like a septarium, and the cracks are filled with oxyd of iron; it however exhibits no internal structure, nor organic remains, nor any other circumstantial evidence to prove incontrovertibly that it is of faecal origin.

VIII. *Coprolites in Fresh-water Formations.*

In a valuable series of specimens recently imported by Mr. Lyell and Mr. Murchison from the fresh-water deposits near Aix in Provence, Mr. Murchison has recognised two distinct species of Coprolite; the one had been collected as a curious concretion from the shale of the fresh-water coal formation at Fuveau*; the other in size and shape resembles a caterpillar, and had been brought home as a fossil insect, being in the laminated fresh-water marl that contains the remarkable deposit of fossil insects above the gypsum formation close to Aix†.—Both these specimens have been examined by Dr. Prout.

IX. *Coprolites in Diluvium.*

I need only refer to the account given in my *Reliquiæ Diluvianæ*, of the fæces of hyænas in the Cave of Kirkdale, and to the large quantities of the same substance that have subsequently been discovered at Torquay and Maidstone, and in the Cave of Lunel, to show how frequent is the occurrence of Hyæno-coprus in diluvial mud and gravel.

Thus, in formations of all ages ‡, from the first creation of vertebral animals to the comparatively recent period in which hyænas accumulated album græcum in their antediluvian dens, we find that the fæces of aquatic or terrestrial carnivorous animals have been preserved. We have them in the lowest region of the carboniferous limestone, the lias, the oolite, the Hastings sandstone, the Wiltshire green-sand, the chalk-marl and chalk of Sussex, at Maestricht, at Brussels, in the London clay at Sheppy, in the fresh-water formation at Aix, and in diluvium. In all these various formations our Coprolites form records of warfare, waged by successive generations of inhabitants of our planet on one another: the imperishable phosphate of lime, derived from their digested skeletons, has become embalmed in the substance and foundations of the everlasting hills; and the general law of Nature which bids all to eat and be eaten in their turn, is shown to have been co-extensive with animal existence upon our globe; the *Carnivora* in each period of the world's history fulfilling their destined office,—to check excess in the progress of life, and maintain the balance of creation.

* Plate XXXI. fig. 15.

† Plate XXXI. fig. 16.

‡ It has been stated in a note at p. 229, that Coprolites, wherever they occur, abundantly afford a chronometer which marks affirmatively the lapse of a period of time sufficient for their accumulation; it should be observed on the other hand that their absence, like the absence of organic remains, is a negative fact, from which nothing can be inferred either as to the rapidity or slowness of any formation whatsoever.

APPENDIX.

The facts established in this paper seem connected with the formation of the remarkable substance called *guano* on the coast of Peru, and on many islands adjacent to it. This guano is composed of an accumulation of the dung and urine of sea-birds, and occurs in beds fifty or sixty feet thick. These beds are often covered over with drifted sand, and, during many centuries past, have been extracted for manure.

In Ferussac's *Bulletin* for January 1829, Art. *Chemistry*, p. 84, there is an abstract of a Memoir on the Guano of Paxaro, by Mariano di Rivero, director of the Corps des Mines in Peru and Lima, 1827. He states that it is certainly nothing else than an accumulation of the excrement of sea-birds that have come to pass the night on these spots during a long series of years: he further adds, that certain deposits of it were worked from time immemorial before the conquest. In the time of the Incas, the use of it was under legal regulations, to prevent waste, and during the breeding season of the birds, no one, under penalty of death, was allowed to land on the islands on which it was forming.

Since the time of the Spaniards the preservation of it has been neglected; and its reproduction diminishes as vessels passing more frequently along the coast, frighten away the birds. In modern times, the average consumption of guano for manure has been about 6250 tons per annum, for which the duty paid at the ports has been about 40,000*l.* sterling per annum.

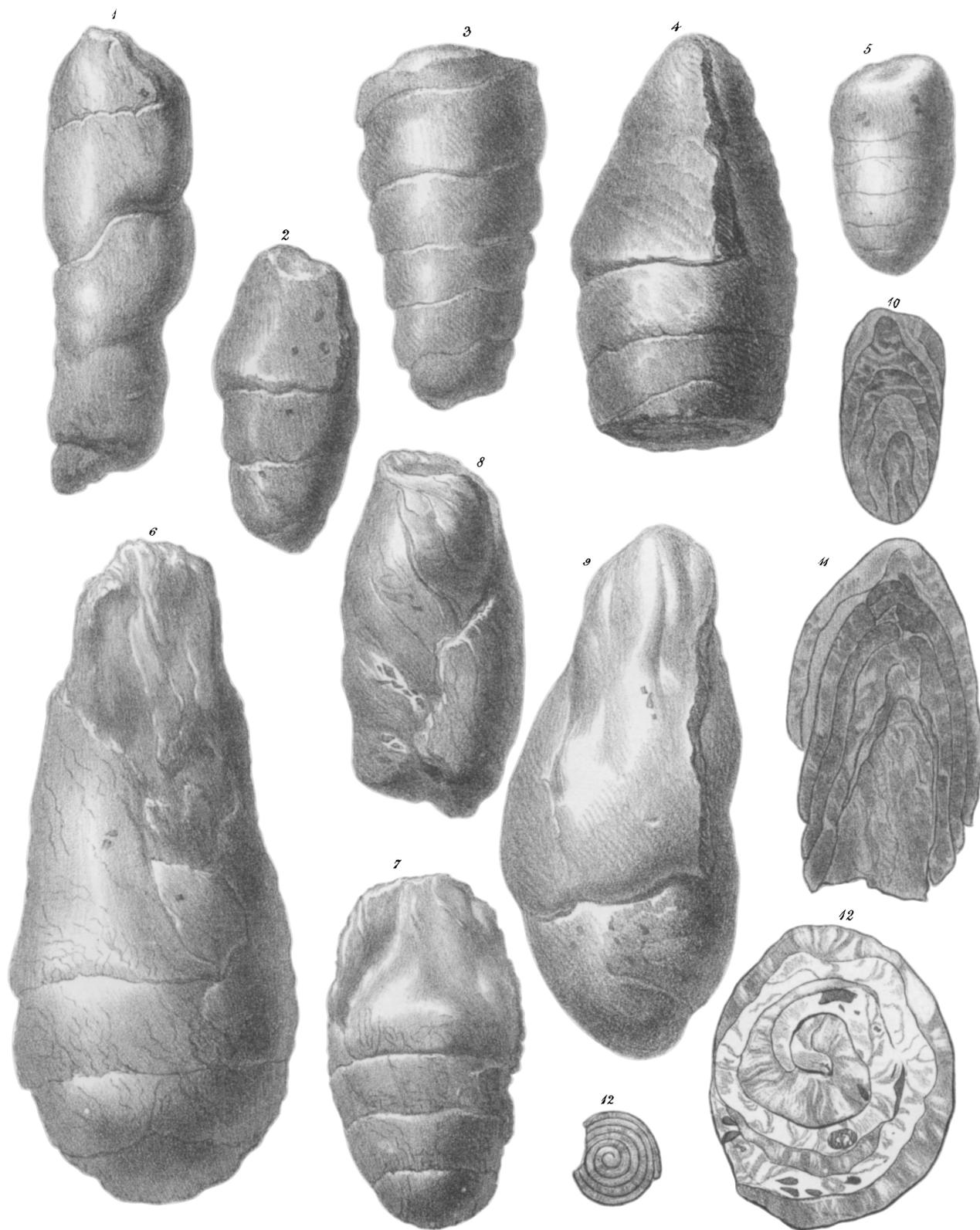
Vauquelin and Fourcroy analysed some specimens of it brought home by Humboldt, and found uric acid partly saturated by ammonia and lime, and oxalic acid partly saturated by ammonia and potash; also phosphoric acid combined with the three same bases, with very small quantities of muriate of ammonia, a little fatty matter, and a little quartzose and ferruginous sand.

We may add this guano to our series of Coprolites, by the name of *Ornithocoprus*. See also Ure's Chemical Dictionary, Art. *Guano*.

Postscript.

During a recent visit to Lyme Regis, I have ascertained that the lias at that place contains other cylindrical concretions resembling Coprolites, which yet seem not to be of fæcal origin, but simply mineral concretions formed like small septaria in clay, or flints and nodules of pyrites in chalk; they agree chemically with Coprolites in containing much phosphate of lime, but differ from them in their relations to their matrix, in structure, and in the organic remains which they envelop.

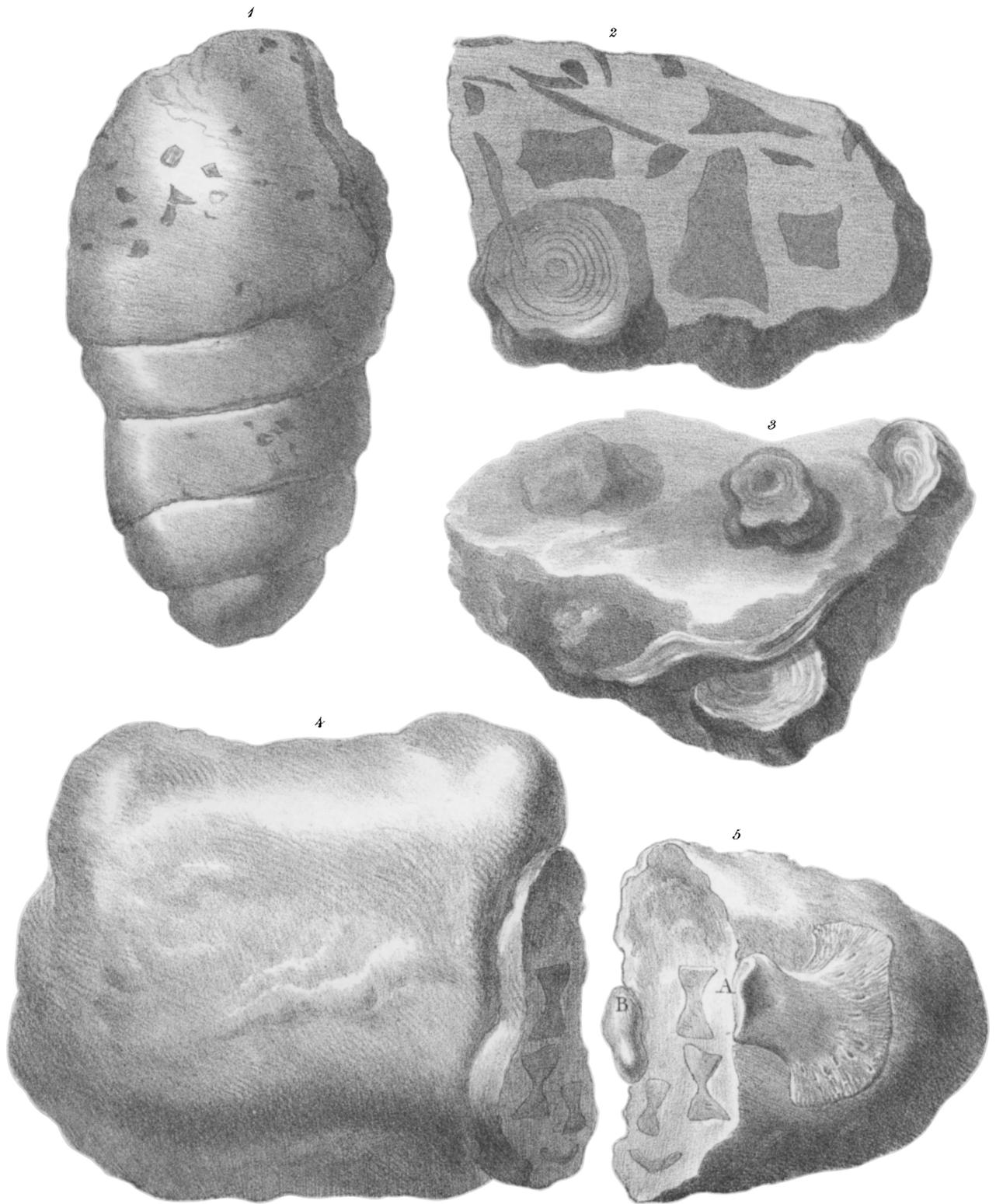
I find also that phosphate of lime occurs in other secondary strata, more generally than has hitherto been supposed. Dr. Daubeny has undertaken the analysis of several specimens which I suspect to contain it, and I hope shortly to lay the result before the Geological Society: at present, I deem it right to mention these circumstances by way of caution, as they tend to increase the difficulty of identifying Coprolites wherever they may occur, and render it impossible for chemistry alone to decide affirmatively respecting any specimen that is the subject of our examination. Still the evidence of chemistry is essential; and when it has shown that a specimen contains phosphate of lime, we must further ascertain its relations to the matrix, its external and internal structure, and the character of the organic remains enveloped in it, before we can pronounce whether it be a genuine Coprolite, or a pseudo-coprolitic concretion of phosphate of lime.



Lithographed from Nature by G. Scharf.

Printed by C. Hullmandel.

Coprolites and Sections of Coprolites from the Lias at Lyme Regis. Scale, Natural Size.

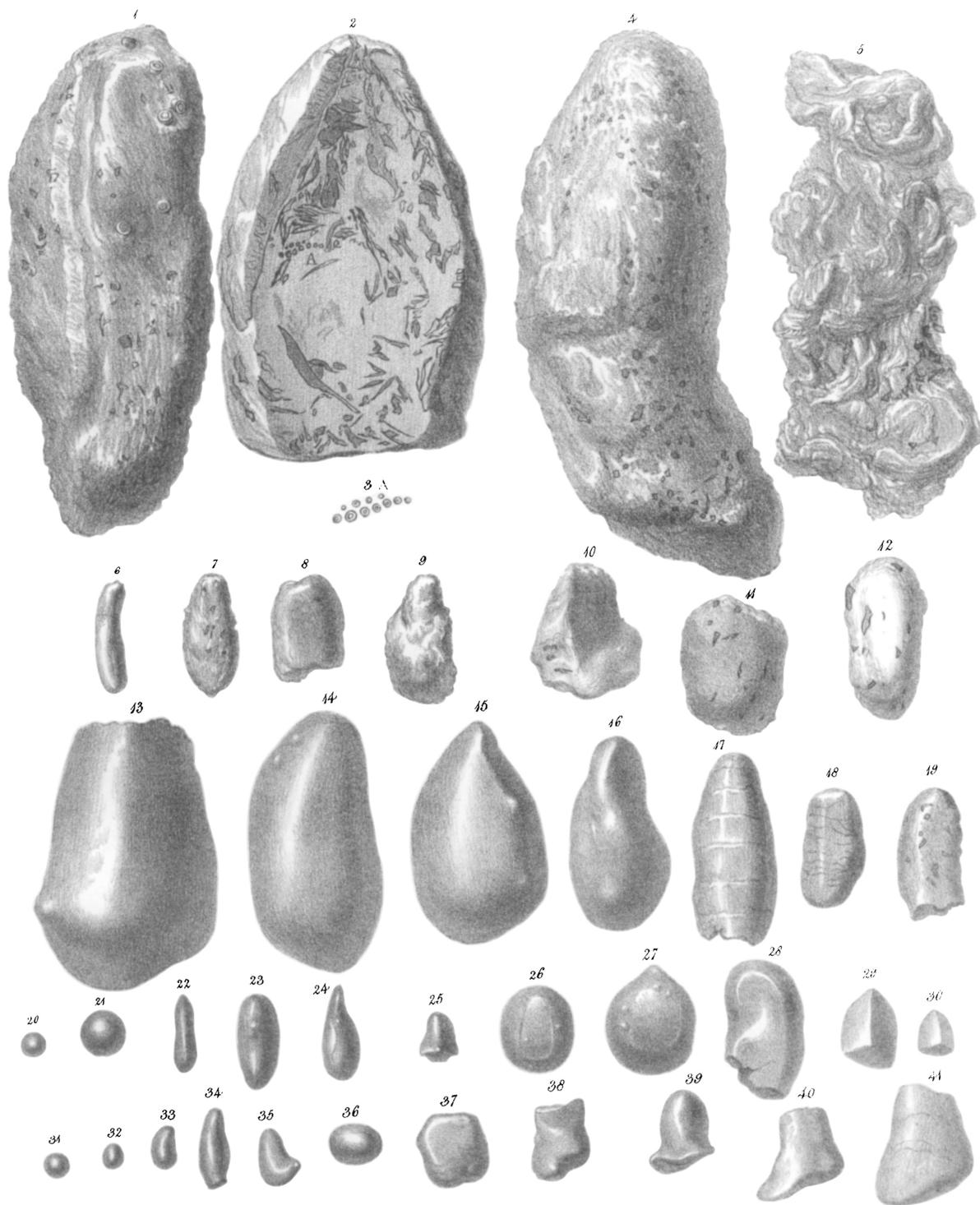


Schaaf del et lithog.

Printed by C. Hullmandel.

Coprolites from the Irias at Lyme Regis containing Scales of Fishes and large undigested Bones.

Scale. Natural Size.

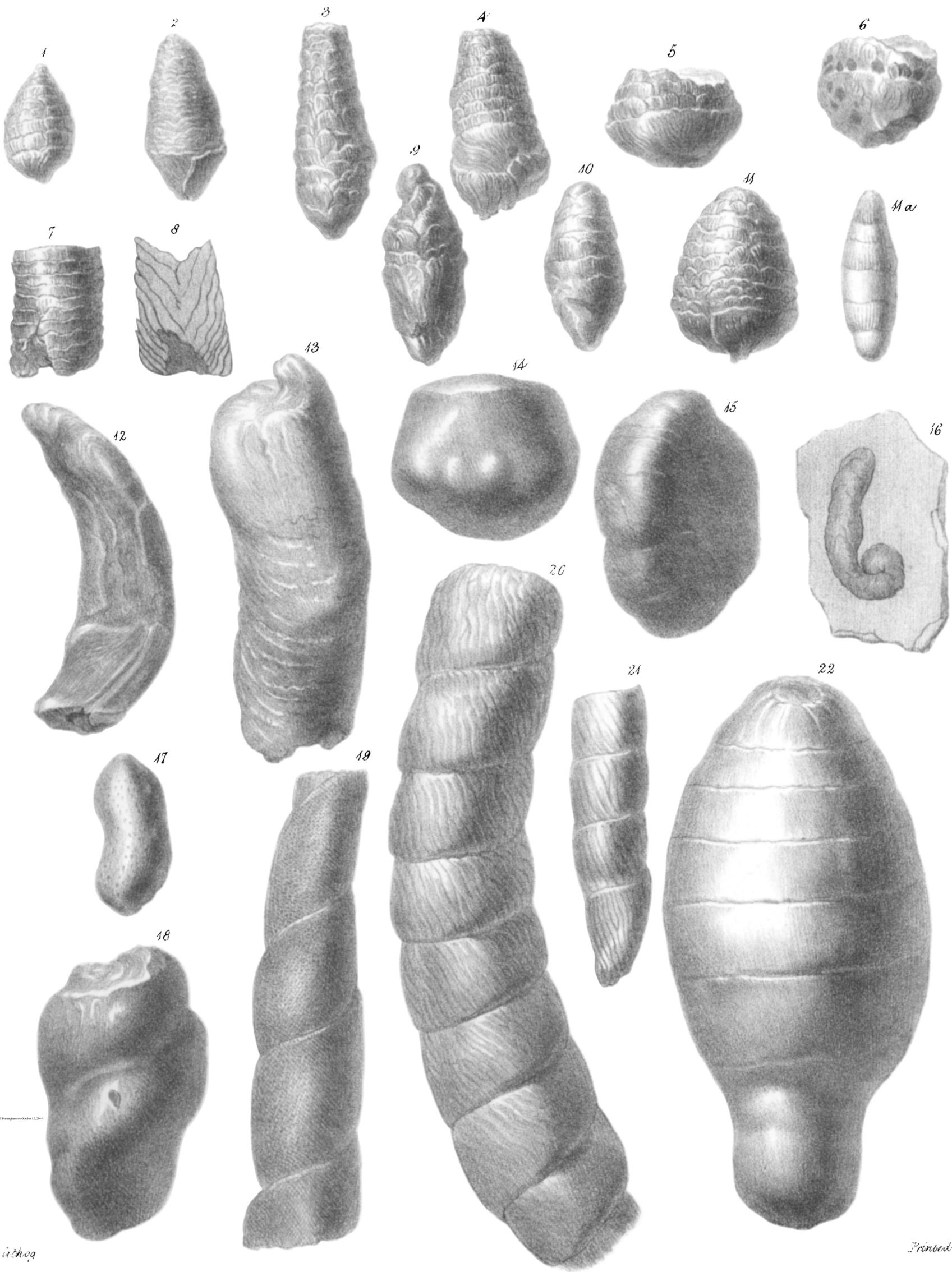


G. Scharf del et lithog.

Printed by C. Halloran and Co.

Coprolites from Lias, at Lyme Regis & Westbury on Severn & from Carboniferous Limestone.

Scale Natural Size.



G. Scharf del. et lithog.

Printed by H. Sturmandel.

Coprolites from Chalk, Tertiary Strata, Green Sand & Tilgate Sandstone: with recent Intestines of Dog-fishes & Skate injected.