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STRATA OF TILGATE FOREST.

ILLUSTRATIONS

OF THE

GEOLOGY OF SUSSEX:

CONTAINING

A GENERAL VIEW OF THE GEOLOGICAL RELATIONS OF THE SOUTH-EASTERN PART OF ENGLAND;

With Figures and Descriptions

OF THE

FOSSILS OF TILGATE FOREST.

BY

GIDEON MANTELL, F. R. S.

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HONORARY MEMBER OF THE PHILOMATHIC SOCIETY OF PARIS,
OF THE PHILOSOPHICAL SOCIETY OF PORTSEA,
&c.

Horum contemplatio multiplicem habet usum. Sunt instar nummorum memorialium, quæ de præteritis globi nostri fatis testantur, ubi omnia silent monumenta historica.

Bergman. Med. de Syst. Foss.

LONDON:

LUPTON RELFE, 13, CORNHILL.

1827

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TO

DAVIES GILBERT, ESQ. M.P. V.P.R.S.

PRESIDENT OF THE GEOLOGICAL SOCIETY OF CORNWALL;
MEMBER OF THE BOARD OF LONGITUDE,
&c. &c. &c.

MY DEAR SIR,

In being permitted to inscribe to you another volume on the Geology of Sussex, I cannot but feel the utmost anxiety that it shall be found worthy of so honourable a distinction.

The peculiar situation in which I am placed, has rendered that an arduous undertaking, which, under more favourable circumstances, would have proved a delightful amusement; but it is gratifying to me to reflect, that you, who can best appreciate the value of my researches, are fully aware of the disadvantages under which I have laboured, and will generously make every allowance for the imperfections of a work, composed amidst engagements of the most harassing nature.

With sentiments of the liveliest gratitude, respect, and esteem,

I have the honour to be,

My dear Sir,

Your much obliged and devoted friend and servant,

GIDEON MANTELL.

Castle Place, Lewes,
December, 1826.

PREFACE.

To boast of a stability of opinion in Geognosy, is to boast of an extreme indolence of mind: it is to remain stationary amidst those who go forward.

Humboldt.

So rapid has been the advancement of geological science, that although but four years have elapsed since the publication of my former volume on the Geology of Sussex, the new and important facts that have subsequently been established, render a different classification of the strata indispensible; and also the adoption, in some instances, of a new nomenclature.

I have therefore found it necessary, in the following pages, to take a general view of the geological relations of the whole county; and although a repetition of some portions of the first volume has thereby been rendered unavoidable, yet the whole subject is placed before the reader in a more intelligible and interesting point of view, than could possibly have been obtained by any other method. Nor will this plan, in any respect, diminish the interest of the former part of the work; which, as a faithful record of numerous important facts relating to the geology of the south of England; and containing a more extended description of the fossils of the chalk formation, than any other publication; can in no way be deteriorated by the present volume.

The strata of Tilgate Forest, from their containing so extraordinary an assemblage of organic remains, have attracted the attention of the most eminent philosophers of Europe; and it was therefore my anxious wish, to have given a more particular account of these remarkable relics of the ancient world, than I have found it possible to do within the limits, which a necessary consideration of the expenses of publication has imposed.*

For many valuable suggestions in the course of my labours, I acknowledge, with gratitude, my great obligations to my kind and excellent friends, Baron Cuvier, MM. Alexander and Adolphus Brongniart, Dr. Buckland, Dr. Fitton, the Rev. W. Conybeare, Mr. Clift, and Mr. Webster; but more especially to Charles Lyell, Esq. F.R.S. Barrister at Law; a gentleman whose classical and scientific attainments, and profound legal knowledge, are well known and appreciated.

In concluding this volume, the last, in all probability, that I shall ever publish on the geology of my native county, I would remark, that the subject is far from being exhausted: for, interesting and numerous as are the relics of a former world, which my humble labours have brought to light, they are, in truth, but mere indications of the vast and important geological treasures, which remain to reward more active, judicious, and extended researches than mine.

Castle Place, Lewes,
December, 1826.

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TO THE BINDER.

☞ *The plate of the Quarry in Tilgate Forest is to be placed as the frontispiece; the Map and Sections, immediately after the description of the plates; and the other plates are to follow in numerical order, at the end of the volume.*

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I.

A COMPREHENSIVE VIEW OF THE GEOLOGICAL RELATIONS OF THE COUNTY OF SUSSEX, AND THE ADJOINING PARTS OF HAMPSHIRE, SURREY, AND KENT.

SUSSEX, the ancient kingdom of the South Saxons, and the southernmost maritime province of England, is bounded on the west, north, east, and north-east, by Hampshire, Surrey, and Kent; and on the south, and south-east, by the British Channel. It is 76 miles in length, and about 28 in average breadth; containing 1461 square miles. It is composed of portions of all the secondary formations of England, from the Purbeck limestone, to the tertiary deposits; outliers of the London and Isle of Wight Basin; and accumulations of diluvial and alluvial debris. The principal regular deposits are the PLASTIC and LONDON CLAY, CHALK, SHANKLIN SAND, WEALD CLAY, and the SANDS and CLAYS OF HASTINGS. The physical characters of the district depend on the range and extent of these mineral masses; along the southern division, the chalk formation constitutes a magnificent chain of hills or downs, which extends through the county in a direction nearly east and west, from Beachy Head to Hampshire. On the north of the downs a valley ot clay or marl appears, which is succeeded by a belt of sand, that, in the western part of

Sussex, rises into hills of considerable elevation; a valley of clay, forming the Weald, runs parallel with the northern edge of the sand; and this vale is bounded by another ridge of sand and sandstone, which constitutes the northern limits of the county. The drainage of the country is effected by four rivers, viz. the Arun, Adur, Ouse, and Cuckmere, which take their rise in the Forest-ridge, and crossing the Weald, flow through separate transverse valleys of the chalk, into the British Channel. The agricultural features of the district vary, of course, with the nature of the subsoil. The chalk hills are principally reserved for pasturage, and support a breed of sheep equal to any in the kingdom; at the foot of the Downs, where the marl emerges from beneath the chalk, the land is a very productive arable; the clay of the Weald produces a stiff soil, remarkably favorable for the growth of forest trees, particularly the oak; and the sand of the Forest-ridge constitutes the most picturesque, but barren tract, of the whole county.

Before proceeding to a more particular examination of the geological structure of Sussex, we present the following tabular arrangement of the strata, which will render our subsequent remarks more intelligible to the general reader, and, with the assistance of the map and sections, convey a correct idea of the stratification of this county, and of the adjoining parts of Surrey, Kent, and Hampshire.

The STRATA *of* SUSSEX, *arranged according to their* ORDER *of* SUPERPOSITION: *commencing with the uppermost or newest deposit.*

ALLUVIAL DEPOSITS.

Formations.	*Subdivisions and Mineralogical Characters.*	*Organic Remains, Observations, &c.*	*Localities.*
ALLUVIUM. *The effect of causes still in action.*	Tufaceous deposits.	Incrustations of tufa on moss, leaves, &c.	Springs near Pounceford, Folkington, and Tower Hill near Horsham.
	Blue clay, silt, sand, and gravel.	Trunks of trees, marine and fresh water shells of recent species.	Valleys of the Arun, Adur, Ouse, and Cuckmere.
	Peat and subterranean forests.	Trunks and branches of trees, leaves, hazel nuts, &c.	Lewes and Pevensey Levels, Felpham, Little Horsted, Isfield, Hastings.
	Sand, gravel, and comminuted shells, drifted inland from the sea shore.	Comminuted shells, &c.	Cliffs near Shoreham.

Formations.	*Subdivisions and Mineralogical Characters.*	*Organic Remains, Observations, &c.*	*Localities.*
DILUVIUM. *The effect of causes no longer in action.*	Clay, loam, and gravel.	Bones and teeth of the horse and elephant.	Indiscriminately on the surface and in the valleys of the older formations.
	Chalk rubble and partially rolled flints, &c.	The same.	Cliffs from near Shoreham to Rottingdean.
	Boulders and pebbles of sandstone and ferruginous breccia.	Siliceous sandstone, the grey wethers of the western counties.	Summits and valleys of the Downs, Brighton, Falmer, Alfriston, Lewes.

TERTIARY FORMATIONS.

(*Partly Marine, and partly Fresh Water.*)

PLASTIC CLAY.	Clay, sand, and gravel.	Cerithia, Cyclades, Ostreæ, Cyrenæ, teeth of fishes, &c; Leaves of terrestrial vegetables; cone of an unknown plant; Subsulphate of Alumine, Gypsum, Surturbrand, &c.	Castle Hill, near Newhaven. Chimting Castle, near Seaford. Falmer, Lewes, &c.
LONDON CLAY.	Blue clay.	Ampullariæ, Turritellæ, Venericardiæ, and other marine shells peculiar to the London clay. Vertebræ, teeth, and palates of fishes.	Bracklesham Bay, Stubbington, &c.
	Grey calcareous sandstone.	Pectunculi, vermiculariæ, ampullariæ, teeth of fishes.	Bognor, Barn, and Mixen rocks.

SECONDARY FORMATIONS.

(*Marine.*)

CHALK.	Chalk with flints. (*Craie blanche.*)	Nodules and veins of flint; pyrites, chalcedony, crystallised carbonate of lime, &c. Ammonitæ, nautili, belemnitæ, &c. fishes, crustaceæ, echini; vertebræ, and other bones, of saurian animals; zoophytes, wood, marine plants.	Upper portion of the South Downs.
	Chalk without flints.	Pyrites; calcareous spar; fishes, crustaceæ, shells, zoophytes, echini, wood, marine plants.	Lower division of the South Downs.
	Grey marl. (*Craie tufeau.*)	Calcareous spar, pyrites, ammonitæ, Turrilitæ, scaphitæ, echini; fishes rarely; crustaceæ; marine plants.	Base of the Downs; Hamsey, Southbourn, Lewes, &c.
	Firestone—or upper green sand. (*Craie chloritèe ou glauconie crayeuse.*)	Marl, with an intermixture of green sand.—Ostrea carinata, cirri, ammonitæ, turrilitæ, and other fossils of the grey marl.	Southbourn, Steyning, Bignor, Nursted; on the Northern edge of the Grey Marl.
	Galt or Folkstone marl—a blue marl, with veins of red ochre.	Gypsum; sulphuret of iron; nuculæ, belemnitæ, ammonitæ, nautili, catilli, inocerami; fishes, crustaceæ, &c.	Willingdon, Ringmer, Newtimber, near Arundel, &c.
SHANKLIN SAND.	Sand of various colours; green, grey, white, and ferruginous. Beds and concretions of chert, &c. Ironstone.	Casts of gervilliæ, trigoniæ, patellæ, modiolæ, venericardiæ, &c.	Pevensey, Chilley, Langley Point, Laughton, Ditchling, Wiston, Parham, Haslemere, &c.

(*Fresh Water?*)

Formations.	*Subdivisions and Mineralogical Characters.*	*Organic Remains, Observations, &c.*	*Localities.*
WEALD CLAY.	Septaria of argillaceous ironstone.	Abounds with the remains of Cypris-faba; also Paludinæ, Cyrenæ, and scales of fishes.	Resting-Oak-Hill, near Cooksbridge, Harting Combe, &c.
	Blue clay with beds of Sussex marble.	Viviparæ and Paludinæ; Cypris-faba.	Weald of Sussex, from Laughton to near Petworth.
HASTINGS. SANDS AND CLAYS.	Fawn coloured sand and friable sandstone.	Lignite; imperfect remains of ferns.	Bexhill, Horsted, Fletching, Eridge Park.
	Strata of Tilgate Forest. — Sand and friable sand-stone. Compact calciferous sandstone. (*Tilgate Stone.*) Conglomeritic sand-stone.	Teeth and bones of Megalosaurus Iguanodon, Plesiosaurus, and Crocodile; turtles, birds, fishes; arborescent ferns and palms, shells of the genera unio, paludina, cyrena, mactra, &c.	Hastings, Ore, Chailey, Tilgate Forest, Horsham, Loxwood, &c.
	Blue clay or marl.	Viviparæ and bones—rarely.	
	White sand, friable sandstone, grit, &c. alternating with clay, &c.	Several species of fern; lignite; the sandstone contains immense quantities of bivalves, probably tellinæ or cyrenæ.	Rye, Winchelsea, Hastings; East Grinstead, Worth, Crawley, Tunbridge Wells, &c.
	Ashburnham beds; bluish grey limestone, alternating with blue clay, and sandstone shale. The lowermost strata in Sussex; contain beds of the *Tilgate stone.*	Immense quantities of the casts of bivalve shells, resembling tellinæ or cyrenæ. Lignite and carbonized vegetables.	Archer's Wood, near Battel, Brightling, near Burwash, Pounceford, Hurst-green, Rotherfield, Darvel's Wood, Etchingham.

ALLUVIUM.

The geological changes effected by agents which are still in active operation, form the subject of this section. The encroachments of the sea upon the shore, by which the cliffs are undermined and their ruins swept away; the overflowing of low districts, and their conversion into marshes subject to periodical inundations; or, on the contrary, the formation of downs along the coast by the drifting inland of sand and gravel; the production of alluvial tracts by rivers, and the accumulation of estuaries at their mouths; and the disintegration of the exposed surface of the strata, by atmospherical causes; are the principal changes taking place in the strata of the county of Sussex. These operations, even if carried on upon an extended scale, are manifestly so unimportant, and so inadequate to produce any of the grand revolutions which constitute the principal objects of geological inquiry, that it is unnecessary to devote much time to their investigation; and a hasty sketch of the subject will be sufficient for our present purpose.

1. Blue Clay or Silt, deposited by Rivers, Lakes, &c.

The numerous tributary rills and streams which flow through the sand and clay districts into the rivers, bring with them particles of mud, sand, &c.: these are carried on by the current, towards the sea; but as the motion of the waters becomes less rapid, the larger particles subside, and, by degrees, the greater portion is deposited at the bottom of the river, or on its banks. It is clear, that by a process of this kind, Lewes and Arundel levels have been produced. If the operation be continued without interruption, the bed of the river becomes more shallow, and the water overflows its banks, till, by degrees, an extensive lake is formed. The levels in the vicinity of Lewes offer an instructive explanation of the manner in which such a change is effected; a section of the soil presents the following deposits.

1. Vegetable mould—1 foot.
2. Peat—a mass of decayed vegetable matter, with leaves, and occasionally trunks of trees; from 3 to 5 feet.
3. Dark blue clay, provincially termed silt, containing fresh water shells in the upper part; and an intermixture of sand and marine shells in the lower: from 5 to 25 feet.
4. Pipe clay; the detritus of the chalk-marl basin, in which the preceding beds are deposited;—from 1 to 2 feet.

The shells of the clay are *Turbo ulva, Tellina solidula, Cardium edule*, and *Mactra listeri*, in the lower part; and in the upper portion, several species of *Planorbis, Helix, Turbo fontinalis, Cyclas cornea, &c.;* the intermediate layers containing an intermixture of both. Hence it appears, that after the catastrophe which broke through the chalk hills, and thus formed the transverse valleys of the South Downs, the basins of chalk were filled with salt water; the currents of fresh water flowing from the interior, soon occasioned an intermixture of lacustral testaceæ, and at length so far changed the nature of the element, as to render it fit for the habitation of fresh-water shell-fish only. The transition of the ancient lake into a narrow river, has probably been occasioned partly by natural, and partly by artificial causes; within the last 50 years the levels were covered with water, during several months in the winter season; and even now it requires all the resources of art, to confine the river within the limits of its own bed.

2. Subterranean Forests.

In alluvial valleys, and low marshy tracts, the occurrence beneath the surface, of trees, with their leaves, fruits, &c., more or less preserved, is not uncommon. Several remarkable instances of this kind have been mentioned in the former volume of this work. These subterranean forests have evidently been torn up, by some sudden eruption of the sea, and overwhelmed by the sand, mud, &c, which it brought along with it.*

3. Tufaceous Depositions.

Water flowing through beds of limestone, holds a certain portion of lime in solution, which it afterwards deposits on any extraneous substance within its reach. It is by this process that moss, leaves, twigs of trees, &c., are incrusted by the "petrifying springs" of Derbyshire, and other places. Three springs of this kind are known in Sussex; one of these is situated at Pounceford, between Heathfield and Burwash;† another at Tower-hill near Horsham; and the third rises at Folkington, and crosses the Eastbourn road; there are probably several others in the county, which have not yet been noticed. ‡

4. Sand, &c. drifted inland.

In Sussex, the effects of this operation are scarcely visible; a few low banks along the sea-shore, and a ridge of sand and comminuted shells near the entrance of Shoreham harbour, being the only instances worth recording; but in other parts of England they have produced very important changes on the surface of the country, covering extensive tracts, and

* See Vol. i., p. 288.

† This spring issues from between the strata of shelly limestone, that occur in the valley at Pounceford; and so great is its lapidescent power that sprigs of heath, &c., placed in its bed, become completely incrusted in six months.

‡ See Vol. i., p. 290.

overwhelming churches and villages with sand, which has subsequently been converted into compact sandstone. *

5. Encroachments of the Sea.

The destruction and removal of extensive tracts of land, on the Sussex Coast, by the inroads of the sea, have been noticed in the most ancient historical records of the county: at the present time, the ocean, silently but incessantly, is carrying on the work of destruction, with but few exceptions, along the whole line of coast. In a few centuries, even without the aid of any sudden inroad, the patches of tertiary strata still remaining on the Sussex chalk cliffs, must entirely disappear: within the memory of the writer, the Plastic clay, at Castle Hill, near Newhaven, the cliffs at Brighton, and the sandstone of Bognor, have visibly diminished.

Diluvium.

Beds of partially rolled flint appear immediately beneath the turf on the summits, and in the valleys of the Downs; and loam, clay, sand, gravel, and other diluvial debris, are spread over the surface of the regular strata throughout the interior of the county, obscuring their outcrop, and forming the immediate subsoil of the district. These accumulations of water-worn materials have clearly resulted from the destruction of the more ancient deposits; the flints and gravel from the disintegration of the upper strata of the chalk; and the loam, clay, &c. from that of the sands and clays of the weald, and forest ridge. Large blocks of a siliceous sandstone, of which no regular bed now exists in this country, and of the ferruginous breccia of the tertiary formations, are also of frequent occurrence. It is in these accumulations of diluvial debris only, that the bones and teeth of elephants, horses, and other quadrupeds, are discovered. We shall not, however, in this place, dwell upon the inferences which may be deduced from these striking facts, but confine our remarks to a brief notice of the most interesting examples of these deposits.

* Vide a most interesting account of a recent formation of sandstone, on the Northern Coast of Cornwall, by Dr. Paris.—*Trans. Geolog. Soc. of Cornwall,* Vol. i., p. 4. et seq.

1. Chalk Rubble, Rolled Flints, Beds of Gravel, Sand, &c.

The most important accumulation of the debris of the chalk formation, is that which fills up the extensive valley of the chalk, between Hove and Rottingdean; forming the platform on which a considerable part of the town of Brighton is situated. As a particular account of this deposit is given in the former volume, a short description will here suffice. A vertical section of the cliffs at Brighton presents—

1. Vegetable mould.
2. Calcareous bed, or coombe rock—50 to 60 feet thick.
3. Shingle, consisting of rolled chalk flints—5 to 8 feet.
4. Sand with friable shells—3 to 4 feet.
5. Chalk with flints—forming the base of the cliff, and the sea shore.

The shells contained in the sand are too much broken to admit of being determined; the shingle bed is, in many parts, converted into a curious conglomerate by stalactitical calcareous spar. The *Coombe rock* is composed of broken chalk, rolled and angular portions of flints, clay, &c. which, in some instances, form blocks of exceeding hardness; it contains bones and teeth of the horse, and of a species of elephant; boulders of the siliceous sandstone previously described, of granite, porphyry, slate, and other primitive rocks.

The debris of the chalk formation also occurs in many places in the interior; in some instances filling up hollows in the chalk, and in others, forming hillocks and ridges on the surface of the older strata.*

Clay, Loam, Gravel, &c.

On the surface of the plains, and in the bottom of the valleys, ochraceous clay and loam more or less prevail throughout the county. In many other parts of England, similar beds contain the bones, &c. of land quadrupeds; but in the south-eastern part of our island these remains are comparatively rare. In the diluvial loam at Hove near Brighton, at Burton Park, and at Peppering, near Arundel, the bones and teeth of a species of elephant, allied to the Asiatic, have been discovered.

* See Vol. i., p. 277.

In the deposits above described, but little order or regularity is perceptible; their varied contents are, for the most part, indiscriminately mingled, and bear incontestible proofs of having been produced by the action of water in a state of agitation, on the more ancient strata; but those which form the subject of the following sections, will be found to present a certain and constant order of superposition; particular fossils will be seen to occur in some of the strata, and to be wanting in others; yet, even in these formations, traces of diluvial action appear in the pebbles, and other water-worn materials, of which some of the strata are almost entirely composed.

Tertiary Formations.

Of the strata which once existed above the chalk, traces are perceptible in many localities of Sussex, and the adjoining counties; so numerous indeed are the proofs of their having formerly extended very far beyond the limits generally assigned to the Isle of Wight basin, that it seems highly probable the basins of London and Hampshire were united, previously to the displacement of the chalk, and its superincumbent strata. The flat maritime district, which extends from Shoreham to Bracklesham bay, and from thence into Hampshire, is composed of the clay, sand, brick-earth, and gravel of the Isle of Wight basin; and at Chimting Castle, near Seaford, and Castle Hill, near Newhaven, outlying portions of the same series of beds remain in situ. The tertiary formations of Sussex may be arranged in two groups:

1. The London Clay, including the Bracklesham Clay, and the sandstone rocks of Bognor;

2. The Plastic Clay, comprising the strata of Newhaven and Seaford.

1. London Clay. (*Calcaire grossier*, Geog. Min., p. 420.)

Blue clay of Bracklesham. Arenaceous Limestone of Bognor.

This formation " consists of a vast argillaceous deposit, containing subordinate beds of calcareous concretions, sometimes passing into solid rocks, or exhibiting some local variations from the occasional intermixture of sand or calcareous matter in the mass of clay."

The blue clay of Bracklesham forms the line of coast from near Worthing, to Christchurch, in Hampshire, extending inland as far as the southern base of the Downs, and gradually increasing in breadth as it approaches the western part of Sussex. This clay contains an abundance of those marine shells, which characterize the London clay and Calcaire grossier; and which are well known to collectors from the celebrated locality in Hampshire, Hordwell cliffs. In Sussex, they are found most abundantly at Bracklesham, near Selsea, Emsworth, and Stubbington. They are enumerated in the former volume, p. 268. The grey sandstone of Bognor contains a large proportion of carbonate of lime, and resembles the limestone of the blue clay at Alum Bay, in the Isle of Wight. Within the last century, it formed a line of low cliffs along the coast near Bognor, but the encroachments of the sea have been so considerable, that a few groups of rocks, covered at high water, are all that now remain of this once extensive deposit. The Barn rocks between Selsea and Bognor, the hound-gate and street rocks on the west, and the mixen rocks on the south of Selsea, are also portions of the same strata. The sandstone is of a grey colour, inclining to green, and varies considerably in its hardness and composition. It contains fossils in great abundance, but the number of genera and species is not considerable, viz. shells of the genera rostellaria, natica, lingula, lutraria, vermicularia, pyrula, ampullaria, mya, pinna, pectunculus, &c.; zoophytes; wood perforated by the teredo; and the teeth of fishes.*

2. Plastic Clay. *(Argile plastique.)*

An indefinite number of beds of sand, clay, and pebbles, characterize this formation, which in Sussex is best displayed at Castle hill, near Newhaven; and at Chimting Castle, the opposite extremity of the chalk cliffs. Traces of the clay are also seen, skirting the London clay, on the south of Chichester and Arundel, and near Worthing; but the indications of its course and extent are too obscure to admit of particular description.

* Vol. i., p. 271.

Castle hill is the Eastern extremity of the chalk cliffs, that extend from Rottingdean to Newhaven harbour, and is about a mile to the south of the town, on the west of the embouchure of the Ouse; eight miles from Lewes. Its summit bears marks of an ancient entrenchment, which, when first constructed, must have embraced an area of twelve or fourteen acres; although, from the encroachments of the ocean, scarcely a third of it remains. The hill is about 130 feet high, and presents a ruinous aspect towards the sea: near the edge of the cliff the strata are in so crumbling a state, and the fissures so numerous, as to render their examination difficult and dangerous. From the decomposition and destruction of the strata which is constantly going on, their surface seldom exposes an instructive section, except after recent falls of the cliff. The thickness of the strata, exclusive of the chalk, does not exceed 70 or 80 feet; and they reach along the coast to about a mile west of the signal house, gradually becoming less, till a thin cap of clay and sand marks their termination. Commencing with the uppermost bed, the cliff is composed of

1. *Sand and pebbles*—from 10 to 15 feet.

2. *Coarse argillaceous rock;* chiefly composed of oyster shells; with a few cerithia, &c. 5 feet.

3. *Foliated blue clay,* with an immense quantity of shells; the upper part contains shells of the genera Cytherea, and Cyclas; the lower division Cerithia, and teeth of sharks.* 10 feet.

4. *Reddish brown marl,* more or less slaty, bearing impressions of leaves, wood, cones of a plant of the palm tribe? and casts of Cerithia, and Cyclades. from 4 to 5 inches.

5. *Surturbrand or lignite*—from 4 to 6 inches.

6. *Blue clay,* with marl of a sulphur colour, including gypsum both crystallized and fibrous. 20 feet.

7. *Sand* of various shades of yellow, green, ash colour, &c. without fossils, 20 feet.

* A few shells of the genus *Cyrena* have been discovered in it.

8. *Breccia* of pebbles, broken flints, and green sand, strongly impregnated with iron, forming a hard conglomerate. 1 foot.

9. *Ochraceous clay*, containing *hydrate* and *subsulphate* of *alumine*, with gypsum, &c. 1½ foot.

10. Chalk with flints. about 50 or 60 feet.

The strata of Castle hill have been minutely described in the former part of this work.* The remains of plants in the red marl, (Platanus orientalis, &c.) the oysters, cerithia, cyclades, &c. of the clay; and the subsulphate and hydrate of alumine, (which have not been discovered elsewhere in England,) are their most remarkable productions.

Between Castle Hill and Seaford, an alluvial tract intervenes, through which the Ouse flows into the British Channel. The truncated termination of the Downs, along the north-eastern borders of this marshy plain, are capped with green and fawn coloured sand, containing rolled blocks of chalk and flints. At Chimting Castle, about half a mile to the south-east of Seaford, the upper part of the cliff is composed of sand, between 40 and 50 feet in thickness. The sand is of a fawn colour, passing into olive green, and contains particles of mica, and veins and concretions of ironstone. Beneath this sand, and reposing immediately upon the chalk, is a stratum of ferruginous breccia, composed of pebbles and flints, imbedded in a ferrugino-ochreous mass, forming a puddingstone like that of Castle Hill, with which there can be no doubt it was continuous before the excavation of the valley of the Ouse. From this bed, the large blocks of breccia which occur in the diluvium were derived. The deposits above mentioned, extend eastward, along the cliffs, about half a mile, and then disappear.

From the immense quantity of marine, and the almost entire exclusion of fresh water shells, in the strata at Castle Hill, it is clear that the beds below the blue clay with cerethites, can alone be considered as analogous to the fresh water formation of the Paris basin. In the *Géographie Minéralogique des Environs de Paris*, the Plastic clay formation is divided as follows :—

* Vol. i., p. 256, et seq.

Premier terrain d'eau douce.	{ Argile plastique. Lignites. Premier grès.

From the description of the strata around Paris, in the celebrated work above referred to, it appears, that although its illustrious authors consider the Plastic clay as a fresh-water formation, yet, in its upper divisions, marine shells predominate. That, generally, in the beds resting immediately upon the chalk, organic remains do not occur;* that, in the middle portion, fresh water shells (Planorbis, Lymnea, Paludina, Cyrena, &c.) and vegetable remains, commonly prevail; and that if marine exuviæ occur in this division, or in the lowermost bed of clay, upon the chalk itself, we may conclude that the inferior or fresh water deposits are wanting, and that the uppermost division reposes immediately upon the chalk. Such appears to be the case at Castle Hill; and we must therefore refer the lignite, red marl with vegetable remains, and the few fresh water shells which accompany them, to the *middle* of the series; and the clay, with cerithia and other marine shells that form so large a proportion of the cliff, to the *upper* division; the lowermost bed of the French series, the pure *argile plastique* being absent. In the London clay at Bracklesham, (the *Premier terrain marin*, of M. Cuvier and Brongniart,) a more striking analogy with the corresponding strata in France is observable; and the fossils are identical with those of the *Calcaire grossier*, of the environs of Paris.

Chalk Formation,

comprising

1. Chalk, with flints;	} *Craie blanche.*
2. ——— without flints;	
3. Chalk marl;	*Craie tufeau.*
4. Firestone;	} *Craie chloritée, ou*
5. Galt or Folkstone Marl;	*Glauconie crayeuse.*

* "C'est ordinairement dans les parties inférieures que se trouve la *véritable argile plastique;* l'argile pure, infusible, ne renfermant aucun débris organique."—*Geog. Min.* p. 261.

It is scarcely necessary to observe, that the chalk constitutes one of the most extensive and important formations of the south-eastern part of England. In Sussex, the chalk hills, or South Downs as they are called, pass in a direction nearly east and west, from one end of the county to the other, being between 50 and 60 miles in length, from Beachy Head to the borders of Hampshire, and about seven miles in average breadth. The height of the chain varies from 300 to nearly 900 feet; Ditchling beacon, the most elevated point, being 858 feet above the level of the sea. The corresponding range of chalk hills, the North Downs, which extends through Surrey and Kent, and terminates in the celebrated cliffs at Dover, is shewn in the map, as well as the union of both chains with the central mass of chalk in Hampshire. The central area, formed by the bifurcation of the downs, consists of the sands and clays of the older deposits, and appears to have been caused by a force operating from east to west, which has destroyed the continuity of the chalk, and lifted up the inferior strata: the various formations being inclined on each side the central line of elevation, as is shewn in the sections; those on the north, dipping towards the N. E., and those on the south, towards the S. E.

The northern escarpment of the south downs is in general precipitous; but the southern descends, with a gentle slope, beneath the outlying portions of the Hampshire basin; on the south-eastern margin, the inroads of the sea have formed a magnificent line of cliffs, that extends from Rottingdean to Beachy Head, and presents one of the most interesting sections of the chalk, in England. The chalk hills of Sussex are every where deeply furrowed by coombes or narrow undulating ravines, which uniting, form vallies that terminate in the grand transverse openings, through which, as already mentioned, the rivers flow into the ocean. The face of the chalk is also marked with fissures, wells, &c., and scooped into deep hollows or basins, which are more or less filled with diluvial debris, or by the tertiary formations. Masses of stalactitical and stalagmitical carbonate of lime, which must have been formed originally in caverns or grottoes of the chalk, also occur in the most elevated parts of the downs. From these facts, it is obvious that the chalk had suffered considerable destruction before the deposition of the tertiary beds; and the displacement and dislocation which the latter have sustained in common with the chalk, prove that some catastrophe has thrown the strata into their present situation, at a subsequent period.

The upper portion of the chalk formation (*Craie blanche* of M. M. Cuvier and Brongniart) is naturally separated into two divisions; viz. the CHALK with FLINTS, and the CHALK without FLINTS. The lower strata also form two well marked deposits; the CHALK MARL, which contains a large proportion of argillaceous earth; and the FIRESTONE or malm-rock, that principally differs from the marl in having a considerable intermixture of green and grey sand. The Gault or Galt, the blue marl of Folkstone, may likewise be ranked as a subordinate member of the chalk formation, notwithstanding the dissimilarity of its mineralogical characters; for its organic contents correspond in so many particulars with those of the marl, firestone, and chalk, as to warrant the conclusion, that it was deposited by the same ocean, and that the entire series constitutes but one geological epoch or formation * †. We proceed to take a rapid view of the characters and distribution of these deposits, premising, that the white chalk forms the downs; the argillaceous and arenaceous strata emerging from their base along their northern escarpment, and constituting the low banks and terraces of the district which intervenes between the sand and the chalk hills. In Sussex, the entire series dips towards the south-east.

I. CHALK with FLINT.

From the situation occupied by this division of the chalk, it has suffered most extensively from the effects of those catastrophes to which we

* See the excellent observations on the relative value of the mineralogical and zoological characters of rocks, by M. Brongniart. Essai Minéralogique; note to pp. 327, et seq.

Messrs. Conybeare and Phillips have separated not only the galt and firestone from the chalk, but also the chalk marl, including the whole under the general name of "Chalk Marl." These gentlemen however remark, that in applying the term formation to these subdivisions, they merely use it as a convenient designation for a large assemblage of similar strata.

† It perhaps would be still more correct to include the Shanklin sand also; the strata of Sussex would then constitute three grand formations; viz.

1st. *Partly fresh water and partly marine.* The strata above the chalk.

2nd. *Marine.* The chalk and Shanklin sand inclusive.

3rd. *Fresh water.* The Weald clay, Hastings sands, and Ashburnham limestone.

have already alluded. In almost every part of the interior of the country its ruins may be seen in the form of beds of gravel, or partially rolled flints. What its original thickness may have been, cannot be ascertained; but the occurrence of large blocks of stalagmites and stalactites on the summits of the highest hills, proves that chalk caverns formerly existed above the most elevated points of the south downs. It is regularly stratified, and is characterized by the horizontal layers of silicious nodules by which it is traversed: veins of tabular flint also intersect it in every direction. The nodules of flint are very irregular in form and magnitude, but generally present a rude outline of the fossils they inclose; almost every flint appearing to have had an organic body for its nucleus.*

II. Chalk without flint.

As its name implies, the lower chalk is destitute of flints; it is generally of a finer texture than the upper, and is occasionally of a grey colour, including masses of a pure white. Like the flinty chalk, it is stratified; the lines of stratification being formed of a softer chalk or marl. The chalk pits near Lewes, Brighton, Steyning, and the cliffs from Seaford to near Southbourn, present magnificent sections both of this and the preceding division of the chalk. The only metalliferous ore found in the white chalk is sulphuret of iron, which occurs in irregular masses, and in octaëdral crystals. Crystallized carbonate of lime, in large blocks, prevails in many of the upper beds.

III. Chalk marl.

Beneath the chalk without flints, an argillaceo-cretaceous bed appears, to which the name of chalk marl is now restricted; it forms the foundation rock of the downs, and in conjunction with the firestone and galt, constitutes a terrace of variable breadth, on the northern side of the south downs, and on the southern edge of the north downs. In the south-eastern part of Sussex, the marl and galt predominate; in the western division of the county and the adjoining parts of Hants and Surrey, the firestone becomes the most important, and forms distinct terraces, which vary in breadth, from a quarter of a mile to two or three miles; but in

* Vide Vol. i., p. 144, et seq.

some parts of Kent, the galt occupies the greatest extent of surface. The soil of the district formed by this division of the chalk, is very productive, and gives rise to many of the best farms in the county.

The chalk marl is of a grey colour, and consists principally of carbonate of lime and alumine, with an intermixture of silica, and a small proportion of iron. In some localities it is exceedingly hard, but crumbles to pieces on exposure to damp; it forms an excellent grey lime, which is much used in Lewes and Brighton for in-door masonry. Crystallized carbonate of lime occasionally occurs in it; and sulphuret of iron, or iron pyrites: no flints have been observed.

IV. Firestone, or merstham beds. (*Green sand* of the former volume.*)

The chalk marl rests upon an arenaceo-argillaceous deposit of a greyish green colour, composed of marl and grains of silicate of iron;† in some places, in the state of sand; in others, forming a stone sufficiently hard for building. The transition from the marl to the firestone, in many localities is so gradual, and the sandy particles are so sparingly distributed, that the chalk marl may be said to repose immediately on the galt; in others, however, the characters of the firestone are so peculiar, that some geologists have deemed them sufficiently important to rank this deposit as an independent formation. As some of the beds which occur near Southbourn, were erroneously referred, in the former volume, to the green sand, (*Shanklin sand*,) it will be necessary in this place, to describe the course and extent of the firestone, rather in detail.

The low cliffs, near Southbourn, expose a section of the arenaceous variety of the firestone. Eastward of Beachy Head, and to the west of

* Vol. i., pp. 76, 77. The beds at Willingdon and Southbourn belong to the firestone; all the other localities mentioned in the pages quoted, are of the Shanklin sand.

† The green particles of the firestone (*Glauconie crayeuse*) of Havre, have been analysed by M. Berthier, who found them to consist of

Silica	50
Protoxide of iron	21
Alumine	7
Potash	10
Water	11

M. Brongniart names these grains, a granular chlorite of iron: Geog. Min., p. 249.

Holywell quarries, the chalk marl bassets out from beneath the chalk without flints, dipping about 5° to the S. W.;* proceeding along the beach, a bed of greyish sand emerges from beneath the marl, to the east of the first martello tower; this quickly rises, till it constitutes one half of the cliff, and beneath it is seen a stratum of friable sandstone of a deep green colour; at the distance of about forty or fifty yards the cliff, which is twenty feet high, is entirely composed of these strata, with the exception of a covering of diluvial loam on the summit. The alluvial tract called "the wish" obscures the beds near this spot, but they reappear at about a hundred yards to the eastward, where the firestone forms the base of the cliff, and is covered with rubbly marl of a greenish yellow colour; the latter being twelve, and the former six feet in thickness. Approaching the sea-houses, the firestone occupies the middle of the cliff, resting on grey marl six feet thick, with scarcely any intermixture of sand: chalk marl, regularly stratified, lies above it; and were we to judge of the geological character of the firestone from this locality only, we should certainly consider it to be a subordinate bed of the chalk marl.† At the sea-houses, the firestone gradually descends and forms the base of the cliffs, which are there of an inconsiderable height; the buildings along the sea-shore obscure the strata to the eastward, and prevent the junction of the firestone and galt from being seen; specimens of the latter are observed, however, on the shore at low water, and it probably rises to the surface not far from the library. The fossils discovered in the firestone at Southbourn, are, with but few exceptions, similar to those which are common in the chalk marl: viz. ammonites varians, mantelli, &c. turrilites, scaphites, &c. In attempting to trace the firestone through the interior of the county, we find its course, in many localities, but obscurely indicated; in others, the prevalence of a few green particles in the lower beds of chalk marl, is the only proof of its presence. It is not until we approach the Adur that

* The lowermost bed of marl, and which is in contact with the firestone, is almost wholly composed of the remains of ramose milleporites, madreporites, &c., so as to form a ridge or reef of corals: in this bed, we found a long cylindrical zoophyte of the same kind as those which occur in the vale of Pewsey, in Wiltshire; it is partly composed of chert.

† See the section of the cliffs at Southbourn, in the plate.

its characters are sufficiently developed to merit attention. At Steyning, which stands near the northern escarpment of the Downs, to the west of the Adur, a bluish grey marl-stone emerges from under the chalk marl, and forms a terrace of inconsiderable breadth; this is the first appearance of that variety of the firestone which, in the west of Sussex, is called "*malm rock*," and which, interposed between the chalk-marl and the galt, must be regarded as the equivalent of the more arenaceous strata of Southbourn. From Steyning the firestone, gradually acquiring greater breadth and thickness, may be traced along the northern edge of the Downs to Sullington, Amberley, Sutton, Elstead, Nursted, &c.; it forms a terrace of considerable breadth along the eastern edge of the Alton chalk hills, and on it are situated Selbourne, Binsted, Bentley, &c.* On the southern margin of the Hog's-back, in Surrey (the commencement of the north Downs,) it is scarcely seen, but appears at Reigate; and may be traced by Merstham, Godstone, and through Kent, to its termination on the coast, near Folkstone, forming a boundary line between the chalk hills, and the galt which constitutes the vale of Holmesdale. In some localities in Sussex and Hampshire, a bluish chert occurs in this deposit.

5. GALT,† OR FOLKSTONE MARL. (*Blue chalk marl*, of vol. i., p. 80.)

A bed of stiff marl, varying in colour from a light grey to a dark blue, and abounding in ammonites, nautili, and other marine shells, succeeds the firestone, emerging from beneath the northern edge of that deposit where the latter is visible, and appearing to form the base of the chalk marl where the firestone is absent. It generally constitutes a valley within the central edge of the chalk of Sussex, Hampshire, Surrey, and Kent, and may be traced, with but little interruption, from Southbourn, through

* Mr. Murchison, in his excellent Memoir on the Geology of the North-western part of Sussex, &c. observes: "These terraces are covered by a tenacious grayish white soil, celebrated for its wheat crops. From the rapid decomposition of this rock, the roads are worn into deep hollows, and, in many places, present sections 20 or 30 feet deep. The harder beds are used for building. The deep and woody glens which intersect the escarpment of the firestone, offer the most picturesque varieties of landscape."

† *Galt*, or *gault*, a provincial term used in Cambridgeshire: it is employed by geologists from its not being so likely to mislead, as a name derived from the colour, or chemical and mineralogical character, of a deposit; since those characters may vary in different localities, or be equally applicable to some other formation.

Laughton, Ringmer, Plumpton, Newtimber, Steyning, Bignor, &c. in Sussex, to Folkstone in Kent, near which town it forms a cliff celebrated, in the geology of England, for the beauty and variety of its organic remains.

The shells of the Galt have, for the most part, their pearly coats preserved in a splendid manner, oftentimes surpassing in lustre the nacreous covering of recent ones.

The Galt gives rise to a stiff but fertile soil, which in Surrey, is called "black land." Its greatest thickness, in the vicinity of Lewes, is 250 feet. In some localities, it is traversed by seams of red ochreous marl, and contains crystals of gypsum.

The ORGANIC REMAINS of the several deposits which are included above in the chalk formation, are so exceedingly numerous, that we cannot attempt to describe them here.

The WHITE CHALK contains fish of several genera, particularly squali; crustaceæ of the genera astacus and cancer; bones of the Maestricht animal; echini of many kinds; belemnitæ, ammonitæ, nautili, inocerami, plagiostomæ, terebratulæ, cirri, and other shells; zoophytes of the genera marsupites, madrepora, turbinolia, alcyonium, syphonia, mantellia, spongia, &c. and the remains of a few plants which are supposed to be marine.*

The CHALK MARL is equally prolific; its most characteristic fossils are ammonitæ, nautili, *scaphitæ*, *turrilitæ*, *hamitæ*, belemnitæ, &c.: fish and crustaceæ are rare: zoophytes, principally alcyonia or other analogous genera, are not unfrequent.

The *Firestone* contains many of the productions of the chalk marl; indeed, the only fossil that has been found exclusively in it, is the *ostrea carinata:* this is figured by White, in the Natural History of Selbourn, and has been discovered at Southbourn; wood occurs in it near Willingdon.†

The GALT abounds in ammonitæ, nautili, belemnitæ, inocerami, &c. and its fossils are distinguished from those of the other divisions, by their

* Vide Volume i., in which all the then known fossils of the Sussex chalk are fully described and delineated. Those of France and other countries are specified by M. Brongniart. Descrip. Geol. p. 250.

† The fossil wood of Willingdon, with its *fistulanæ*, was referred, in the former volume, to the green sand; it belongs to the lowermost bed of firestone, which is incumbent on the galt. See Volume i., p. 76.

splendid shelly coverings. The most characteristic species are belemnites listeri, inoceramus sulcatus and concentricus; and turbinolia konigii.*

SHANKLIN SAND. (*Green or Chlorite Sand.* Vol. i., p. 69.)

Siliceous sand and sandstone, of various shades of green, grey, red, brown, yellow, ferruginous, and white, with subordinate beds of chert, limestone, fuller's earth, &c. constitute the group of strata to which the name "Shanklin-sand formation" is now applied.

In the south-eastern part of Sussex, this formation occupies but an inconsiderable extent on the surface; and, in many instances, a few insulated hillocks are the only indications of its presence. At Langley point, near Southbourn, and at Pevensey,† the sand may be observed, although much covered by alluvium; and may be traced westward, in a line parallel with the outcrop of the Galt, through Arlington, Selmeston, Laughton, Norlington, &c. to Ditchling, where sand and sandstone of a red colour, suddenly rise from beneath the Galt, near the foot of the Downs, and form the mound on which that town is situated.

To the west of Ditchling, the sand gradually assumes a bolder aspect, and constitutes an elevated tract, which runs parallel with the northern escarpment of the South Downs, and in the western extremity of Sussex, rises into a chain of hills superior in altitude to the chalk itself. This range passes into Surrey, and finally into Kent, terminating in the cliffs of Folkestone and Hythe. Our limits will not admit of an extended notice of this formation, and we must restrict our remarks to a description of a few of the most interesting localities.

An instructive section of the sands, which much resembles that of Dunnose-point in the Isle of Wight, is seen at Stone-pound-gate, near Hurstperpoint, on the Brighton Road. The bank is nearly 30 feet high, and has on the top a layer of loam and clay, beneath which is a bed of bluish clay,

* The organic remains found in the arenaceous marl of St. Catharine's Mount, near Rouen, are identical with those of the chalk marl at Hamsey, near Lewes, viz. scaphites, turrilites, &c. Those of Folkstone occur at the falls of the Rhone, near Bellegarde, and in the rocks on the summits of the mountains of Fis, part of the Alpine Chain of Savoy. See M. Brongniart's *Description Géologique des environs de Paris*. 2nd. Edit. p. 331, 335.

† At Chilley, near Pevensey, the sand and sandstone are strongly impregnated with bitumen. See Vol. i., p. 77.

with an intermixture of sand, which reposes on the greenish ferruginous sand, forming the base of the hill. Sand, of a deep reddish brown colour mottled with pure white, appears on the south side of the turnpike-gate. The weald clay bassets out from beneath the sand, to the north of this place.

At Parham Park, the seat of Lord De la Zouche, sand highly ferruginous, and containing veins and concretions of ironstone occurs, and is remarkable for the abundance and variety of the casts of univalve and bivalve shells, of the genera trigonia, gervillia, venericardia, thetis, modiola, &c.*

In the western part of Sussex, layers of chert or hornstone, provincially termed "*whinstone*," prevail in the sand near Petworth, at Bexley-heath, Black-down hill, &c.† and a bed of calcareous grit, which sometimes passes into a blue limestone, occurs at Dean Farm, near "Petworth, and may be "traced to Stedham, Rogate, Lyss, Headley and Godalming; in the last-"mentioned localities, the grit is a conglomerate of quartz grains and "pebbles, held together by a calcareous cement, and is called *Bargate-stone*.‡" This bed extends eastward through Surrey and Kent. Mr. Murchison observes, that the lowest beds of the sand are marked by a great change of appearance; green particles prevail in the mass, and all the hills immediately adjoining the valley of the weald clay, afford a yellowish sandstone, filled with green particles, which is used for building, and is the only bed of the shanklin-sand formation west of the River Arun, that has been observed to contain fossils, or rather casts,—probably of ammonitæ and terebratulæ.

Tilvester Hill, on the south of Godstone, in Surrey, presents a most interesting section of this formation; and as the main road from London to Lewes passes directly across it, and a considerable fault or displacement of the strata is exposed on the road side near the top, this locality generally attracts the notice of travellers. For this reason, as well as from the section being an excellent example of the beds of chert, &c., a sketch of the hill is given in the plate of sections, which the following description will explain.—From Fellbridge Waters, a few miles to the north of East Grin-

* Vol. i., p. 78. † Vol. i., p. 70. ‡ Mr. Murchison, in *Geolog. Trans.* New Series, Vol. 2., p. 101.

stead, the weald clay prevails, and its peculiar limestone, with *paludinæ*, is dug up in a farm at the very foot of Tilvester-hill. Ascending the hill, sand, resembling that of Red-hill near Reigate, appears, containing veins and large concretionary masses of ironstone: this is succeeded by grey sand and layers of chert, alternating with marl and sand of various colours. From their first emergence, to near the summit of the hill, the strata are highly inclined, dipping at an angle of about 40° to the north; they then reappear, with but a slight degree of inclination, the red sand forming a bank on the side of the road, nearly 30 feet high. On the northern slope of the hill, the chert is seen immediately beneath the turf, and is quarried for road-making. Godstone is situated on the sand, but the wind-mill near it stands on the Galt, which forms a plain or terrace extending to the foot of the neighbouring chalk hills, where the firestone, marl, and chalk, appear in their usual order of superposition. The following is a more particular enumeration of the strata at Tilvester-hill.

First and lowermost deposit, Weald clay with Sussex marble.

2. Red and fawn-coloured sand, with ironstone.
3. Grey sand, with veins of a reddish colour.
4. Greyish green sand.
5. Olive green, and ferruginous sand.
6. Grey sand, with veins, layers, and lenticular masses of chert; thickness five feet.*
7. Sandstone, with veins of ironstone; thickness 4 feet.
8. Chert, in layers, alternating with sand and marl; thickness, 12 feet.
9. Grey, green, and red, mottled sand; thickness 2 feet.
10. Pale yellow sand.
11. Diluvial loam and rubble.

The fuller's-earth pits of Nutfield, near Bletchingley, so celebrated for magnificent specimens of Sulphate of Barytes, are situated in the range of Shanklin sand-hills, of which Tilvester-hill is a part.

Organic remains. In some parts of England, the shanklin sand contains a numerous and highly interesting assemblage of organic remains; but in

* The chert in this bed, like that of Western Sussex, occurs in large lenticular blocks in the sand, and not in regular horizontal layers. *Vide* vol. i., p. 71.

Sussex, fossils rarely occur; and Parham Park, and its vicinity, are the only localities at present known. Casts of univalves and bivalves, particularly of trigoniæ, gervilliæ and rostellariæ, are there found in profusion, in the indurated blocks of ferruginous sand.*

WEALD CLAY.—(*Weald or Oak-tree clay.*—Vol. i. p. 61.)

A tenacious blue clay, containing subordinate beds of shelly limestone, and layers of septaria of argillaceous iron-stone, forms the subsoil of the wealds of Sussex and Kent, and separates the Shanklin sand from the central mass of the Hastings beds. It constitutes a low tract, from five to seven miles in breadth, which forms a zone round the central mass of the Hastings Sands, and extends from the Sussex Coast between Pevensey and Bexhill, to Petworth, and Harting Combe in the west of the county, and from thence passes to near Tunbridge, and the Isle of Oxney, in Kent. At its western angle at Harting Combe, it forms a narrow gorge for several miles, which is flanked on the north by the lofty hills of Blackdown, and on the south by the corresponding ridge, extending from Holder and Bexley hills to near Petworth; the valley then suddenly expands to three times its former breadth, by the retirement at a right angle of the sand escarpment of Blackdown and Haslemere.† Presenting no remarkable characters on the surface, except that the soil it produces is favourable to the growth of forest trees, (particularly the oak,) its range and extent scarcely require farther observation. Its outcrop forms a valley between the hills of the Shanklin sand on the one side, and the chalk downs on the other, throughout the northern and north-western division of the "southern denudation of the chalk," but in the south-eastern part of Sussex, where the Shanklin sand is scarcely seen on the surface, it constitutes a low ridge, rather than a valley.

The Sussex marble, so strikingly characteristic of the Weald clay in

* Those genera and species which can be determined, are mentioned in p 72. Vol. i., Ammonitæ, and terebratulæ, are said to occur in the sand-stone west of the river Arun.

† Mr. Murchison's Memoir. *Geological Trans.* vol. 2. p. 104: the form of the valley of the weald clay is well displayed in the beautiful map which accompanies Mr. Murchison's paper.

England, occurs in layers that vary from a few inches to a foot or more in thickness, and are separated from each other by seams of clay, or of coarse friable limestone. The compact varieties are subcrystalline, and susceptible of a high polish, exhibiting sections of the enclosed univalves, of which the marble is almost wholly composed.* The shells are supposed to belong to the genera *vivipara* and *paludina*,† the recent species of which inhabit fresh water; and they are associated with the shelly remains of a minute crustaceous animal of the genus Cypris, (*C. faba*. Min. Conchology, pl. 485.) that abounds in a fresh-water lime-stone, in France;‡ a circumstance tending to corroborate the opinion, now generally entertained by geologists, that the weald clay is of fresh-water origin. The Sussex marble has been found in almost every part of the weald clay; from Laughton, near Lewes, to near Petworth, Kirdford, Newdigate, Charlwood, south of Tilvester-hill in Surrey, and at Bethersden, in Kent.

In some localities the clay, alternating with the marble, contains the remains of cyrenæ, and other shells too imperfect to be determined. At Shipley, near West-Grinstead Park, in sinking a well in the weald clay, masses of broken spiral univalves, (apparently potamides,) and bivalves (cyrenæ?) were found at the depth of 30 feet; and layers of the same kinds of fossils were passed through, at the depth of 100 feet:§ and in a well near Cowfold, similar remains were observed. From observations made in many places in Sussex, the marble would appear to occupy, chiefly, the middle beds of the weald clay, &c.: there are, probably, five or six alternations of it, but in the upper divisions of the clay, septaria, composed of a deep red argillaceous ironstone, occur, in layers of two or three feet in thickness, which dip in conformity to the general inclination of this formation.

At Resting-oak-hill, on the Chailey road, about four miles to the N.N.W. of Lewes, a fine section of these septaria was lately exposed by the

* See Vol. i., page 63.

† Mr. G. B. Sowerby, the scientific author of the "Genera of fossil shells," doubts the correctness of this opinion; he considers the shells of the Sussex marble to be nearly related to the *Turbo littoreus*, or periwinkle. See Vol. i., p. 67.

‡ "Description Géologique des Environs de Paris."

§ To the politeness of Sir Charles Merrick Burrel, Bart., M.P., I owe the knowledge of this interesting fact.

removal of the summit of the hill, for the improvement of the road. The indurated marl, which formed the nuclei of the septaria, was of a pale yellowish grey colour, and so hard and fine as to be employed by the peasantry and carpenters to set their tools;* the ironstone surrounding it, was of a deep reddish brown colour, and contained the remains of shells of the genera cyrena and paludina in great abundance; the scales and bones of small fishes; and myriads of the shelly coverings of the cypris faba. As the fossils of the weald clay belong to but few genera and species, and were but imperfectly known when the former volume of this work appeared, we subjoin the following list.

Organic Remains of the Weald Clay.

Scales and bones of fishes, apparently of a very small species. Resting-oak hill.

Tooth of Crocodile.	Swanage Bay, Isle of Wight.†
Cypris faba.	in the marble, and septaria.
Vivipara fluviorum.	in the marble.
——— extensa.	———
Cardium turgidum.	Swanage Bay.
Melania attenuata.	———
——— tricarinata.	———

Cyrena membranacea, (Cyclas membranaceus "Min. Conch." Tab. 527;) Resting-oak hill.

Paludina elongata.	———
Pinna.	Swanage Bay.
Venus	———
Potamides?	Shipley, near Cowfold.

Of these, the vivipara, paludina, and the cypris faba, are the most characteristic of this formation.

* At Wapping-thorn hill, near Steyning, septaria of argillaceous ironstone were lately found, and applied to the same purposes. I am indebted for this information to the polite attention of the Earl of Egremont.

† It is to the discrimination of Dr. Fitton, that we are indebted for the first correct list of the characteristic fossils of the Weald clay ("Annals of Philosophy," November, 1824.) Those from the Isle of Wight, enumerated in the text, are on the authority of his masterly paper on the geological relations of the beds between the chalk and purbeck limestone.

HASTINGS SANDS AND CLAYS. *Iron sand formation.* Vol. i., p. 24.

The alternating sands, sandstone, clay, &c., which form the central group of strata, in the district we have proposed to examine, are distinguished by Dr. Fitton,* by the name of "HASTINGS SANDS;" and we adopt this term, as being by far the most appropriate of any previously proposed, as the cliffs in the vicinity of Hastings present so instructive a section, that they must be examined by every one desirous of investigating the geological characters and relations of this important division of the British strata.

This formation consists of numerous beds of sand, sandstone, grit, fuller's earth, marl, shale, &c.; some of which enclose a great variety of organic remains. On the coast, it extends from Bexhill, in Sussex, to Hamstreet, near Aldington, in Kent, forming a line of irregular cliffs, 30 or 40 miles in length, and from 20 or 30 to upwards of 600 feet in height: Crowborough hill, which is situated in the interior, (near Tunbridge Wells,) and is the highest point in the range, is 804 feet above the level of the sea. The anticlinal axis of the strata may be placed near Winchelsea, from whence the beds diverge towards the E. N. E. and W. S. W.; or, in other words, towards Sussex on the one side, and Kent on the other. The district occupied by the Hastings Sands, is in the form of a long narrow triangle, the base being the line of coast above mentioned, and the apex at Loxwood, ten miles west of Horsham.

To facilitate our inquiries, we subjoin a synoptical arrangement of the subdivisions of this formation, and after briefly noticing the peculiar characters of each, shall proceed to describe the most interesting localities that occur in Sussex.—It must, however, be remarked, that these subdivisions are very irregular, and their extent exceedingly variable.†

* "Annals of Philosophy." November, 1824.

† In the Isle of Wight, the Hastings Sands consist of an alternating series of beds of sand, more or less abundant in ferruginous matter, and containing courses of *calcareous grit*, with clay mixed with sand; subordinate beds containing fullers' earth; wood, more or less changed; wood-coal, and ironstone; the proportion of the clay to the sands is very great; the reverse is the case in Sussex. *Dr. Fitton—Annals of Philosophy.*

Hastings Sands and Clays.

HORSTED SAND.

Characters.	*Organic Remains.*	*Localities.*
Grey, white, ferruginous, and fawn-coloured sand, and friable sandstone, with abundance of small portions of lignite.	Traces of carbonized vegetables.	Little Horsted, Uckfield, Framfield, Bexhill, Chailey, Fletching, Eridge Park, Tunbridge Wells, &c.

STRATA OF TILGATE FOREST.

Sand and friable sandstone, of various shades of green, yellow, and ferruginous; surface oftentimes deeply furrowed. *Tilgate stone*, very fine compact bluish or greenish grey sandstone, in lenticular masses; surface oftentimes covered with mammillary concretions; the lower beds frequently conglomeritic, and containing large quartz pebbles.	Ferns, stems of vegetables; bones of saurian animals, birds, turtles, fishes, &c. Shells of the genera *unio*, *cyrena*, *mya*, *paludina*, &c. lignite, wood.	Loxwood, Horsham, Tilgate and St. Leonard's forests; Chailey, Ore near Battel, Hastings, &c. Rye, Winchelsea.
Clay or marl, of a bluish grey colour; alternating with sand, sandstone, and shale.	Bones and shells, very rarely. Stems of vegetables.	

WORTH SANDSTONE.

White and yellow friable sandstone and sand.	Ferns, and arundinaceous plants. Lignite, &c.	Worth, near Crawley; Hastings, &c.

ASHBURNHAM BEDS.

A series of highly ferruginous sands, alternating with clay and shale, containing ironstone and lignite.	Ferns, and carbonized vegetables.	Lower part of Hastings Cliffs, Crawley, &c.
Shelly limestone, alternating with sandstone, shale, and marl: and layers of Tilgate stone.	Shells of the genera cyrena, and tellina? lignite, carbonized vegetables.	Archer's Wood, near Battel; Brightling, Pounceford, Burwash, Hurst Green, Eason's Green, Etchingham.

Horsted sand. The Hastings beds, on their first emergence from beneath the Weald clay, consist of sand, and friable sandstone, of various shades of grey, yellow, and ferruginous; with occasional interspersions of ironstone; and containing a very great intermixture of *small linear* portions of lignite. The sandstone is composed of siliceous sand, with particles of mica, held together by a ferruginous cement; sometimes having a considerable proportion of calcareous matter. These beds alternate with a stiff grey loam or marl. The lignite, disseminated in small fragments through the grey sands, forms an excellent character, by which these upper strata may be identified; it, probably, has originated from the carbonization of plants of the fern tribe. The Horsted sand and loam occur along the northern border of the Weald of Sussex, and the southern of that of Kent.

Tilgate beds. Beneath the Horsted beds, irregular alternations of sand and sandstone succeed—the lowermost stratum containing large concretional or lenticular masses of a compact calciferous grit or sandstone, which was formerly extensively quarried in the neighbourhood of Tilgate and St. Leonard's forests, near Horsham.* This stone is a fine grit, of a light grey colour, inclining to blue or green, and is composed of siliceous sand, cemented together by crystallized carbonate of lime, containing about 25 per cent. of the latter substance. Some portions of this bed form a conglomerate, and contain pebbles of quartz and jasper, many of which are of chemical origin, but others have evidently been transported from a distance. There are three or four layers of the Tilgate stone, varying, in thickness, from 2 or 3 inches, to 1½ or 2 feet.

These beds rest on blue clay and shale, which separate them from the next sub-division. They are the principal repository of the organic remains of the waters which deposited the Hastings sands, and are therefore, by far the most interesting strata of that formation. They extend from its western extremity at Loxwood, to Hastings, where they occupy the upper part of the cliffs, as will hereafter be particularly mentioned.

Worth sands, and sandstone. The blue clay, &c., which support the Tilgate beds, are succeeded by a series of arenaceous strata, some of which afford a fine, soft, building-stone, which is extensively dug at Worth, near Crawley. This sandstone is, for the most part, of a white or pale fawn or yellow colour, and occasionally contains leaves and stems of ferns, and other plants. The Worth sands occur in great force at Hastings, occupying the middle part of the cliffs.

Ashburnham Beds. Alternations of sand, friable sandstone, shale, and clay, occur beneath the Worth stone: they are, for the most part, highly

* These strata were first described by the author in a paper read before the Geological Society, in the beginning of 1822; and further noticed in the first volume of this work, (pp. 37 to 60,) and also in another memoir read before the Geological Society of London, in June, 1822.

ferruginous, and enclose rich argillaceous iron ore, and large masses of lignite. They occupy the base of the cliffs at Hastings, and appear in many places in the interior. They are succeeded by beds of shelly limestone, alternating with shale, and including layers of a fine sandstone, precisely similar to the Tilgate stone; so much so, that specimens from the respective strata could not be distinguished from each other. This sandstone abounds, like that of Hastings, with carbonized vegetables (ferns) and casts of bivalves, but we have not yet ascertained whether any animal remains have been found in it. We consider the discovery of this bed highly important, and should have doubted the correctness of placing it so low in the series, had not a bed of the shelly *bivalve* limestone of Ashburnham, been found lying upon it, as will be particularly described in our account of the strata at Pounceford.

Strata around Hastings.

We have already remarked, that the cliffs extending along the Sussex coast, from Bexhill to Winchelsea, present the most illustrative section of the Hastings strata, in England. At Bexhill, the Horsted sand, sandstone, clay, &c., rise into a cliff which forms the hill on which that watering-place is situated.* Near Bulverhithe, sand and sandstone, in thin laminæ, alternating with beds more or less argillaceous, form an irregular line of cliffs. Proceeding eastward, we find, to the west of Hastings, the first indication of the Tilgate beds, in the form of large masses of grey calciferous sandstone, which lie scattered along the sea shore. The blocks of this substance, that have been long exposed to the action of the waves, are almost white; and hence the name of "*White Rock*," given to a large portion of the cliff which has slipped from its original situation, and is now exposed on the beach, near one of the stations of the blockade service. The largest mass of the strata, in this place, is about 30 feet high, and consists of—

* A section of the strata, near Bexhill, in an ineffectual attempt to find coal, is given in Vol. i., page 35.

1. Loam and vegetable mould; the summit of the cliff.*

2. Sand, and friable sandstone, of a fawn colour and laminated structure. from 3 to 5 feet thick.

3. *Tilgate stone*, bluish grey, with numerous casts of bivalves. 2 feet.

4. White and fawn-coloured sand. 15 feet.

5. *Tilgate stone*, with bivalves. 1½ foot.

6. Thin layers of a coarse friable aggregate, with remains of fishes, vegetables, and paludinæ. 2 to 6 inches.

7. Laminated ferruginous sandstone, with layers of blue clay and shale; containing innumerable traces of carbonized vegetables. 3 to 4 feet.

The *Tilgate stone* resembles, in every respect, the sandstone of the forest from which its name is derived; it abounds with casts of a small bivalve, of a species which is comparatively rare in the stone of the interior of the county. The thickness of the blocks which are in situ, does not exceed two feet, but there are detached masses on the beach, which are upwards of four feet. The alternations of the sand and Tilgate-stone, and the concretionary form of the latter, are strikingly displayed at this interesting and picturesque spot.† The sandstone occurs, not in continuous layers, but in irregular lenticular masses imbedded in the sand, yet preserving the same sedimentary line, as if its consolidation were owing to the infiltration of a fluid holding carbonate of lime in solution, which has produced a subcrystalline structure in certain portions of the bed, subsequently to their mechanical deposition.‡ This opinion is corroborated by the fact of many of the blocks being covered with obtuse, mammillary projections, of various sizes, from two to five or six inches in diameter; and which, when the lines of stratification are washed away by the action of the waves, appear like clusters of depressed spherical bodies; but in the quarries in the forest, where a similar structure oftentimes prevails, these projections have an external coating of sand, and bear decided proofs of original stratification, in the numerous annular sedimentary lines, with

* See the section of "White Rock," in the plate. † See the section in the plate.

‡ The whin-stone of the Shanklin sand, in Western Sussex, occurs also in lenticular masses; this remark will apply to the compact portions of almost all arenaceous deposits. Vide p. 28.

which they are encircled. The thin layers of coarse aggregate consist of a grey sand, loosely held together by a calcareous cement, and are remarkable only for the innumerable remains of fishes, shells, &c., which they contain; this bed is, probably, the equivalent of the more friable varieties of the conglomerate of the forest. It does not, however, in any instance possess the compactness of the latter, but contains the same kinds of fossils: it is from this bed that the specimens of *Endogenites erosa*, so frequently thrown upon the shore by the waves, are derived.

The ferruginous sand, No. 7, rests on a sandy shale, which occurs in thin laminæ, and presents traces of ferns, and other vegetables: it may, probably, be identical with those beds of Tilgate forest, which contain the *sphenopterites and pecopterites*. Beneath this is a coarse, friable, yellowish sandstone, of a laminated structure, having the surface of the laminæ deeply furrowed; it reposes on a dark-coloured shale, which forms the base of the cliffs. A few yards behind White Rock, a bank of ferruginous sand and clay is cut through by the road; the strata are highly inclined, dipping to the west, at an angle of 25°. This mass, probably, belongs to the uppermost portion of the series.

A diluvial valley intervenes between White Rock and the west cliff where the ruins of the Castle are situated, and which next requires our attention. This cliff is about 150 feet high; and when we last visited the spot, a fine section, formed by the labourers employed, in carrying on the improvement at Pelham Place, was exposed. It consisted of,

1st. (Or uppermost bed.*) White sand and friable sandstone, with veins of ferruginous sand—the Worth beds—about 100 feet thick.

2. Loam, shale, clay, and sand. 30 feet.

3. Clay, approaching to fuller's earth, enclosing undulating veins of lignite. 10 feet.

4. Soft sandstone in horizontal layers, alternating with clay and shale: contains traces of lignite. 10 feet.

The lignite in this place corresponds, in every particular, with that

* Traces of clay and shale, apparently situated *above* the *Worth sands*, were observed, in the late excavations near the Castle; but the relative position of the beds could not be ascertained.

which has been noticed at Bexhill, Newick, Waldron and Tilgate Forest.* It occurs in nearly horizontal layers, which become extenuated into mere lines. It is very brittle, possesses the lustre of jet, and contains nuclei of a ligneous appearance, somewhat approaching to that of Bovey coal. The largest masses do not exceed two inches in thickness.

Pursuing our course eastward, another deep valley occurs, through which is the romantic entrance to Hastings, by the London road; at the east cliff, the strata rise into a majestic range, from 4 to 500 feet high,† which extends with but little interruption, to Haddock point, a few miles from Winchelsea. The upper part of these cliffs consists of yellow and ferruginous sand, in which two or more layers of the *Tilgate stone* are imbedded: the middle portion is composed of the Worth sand, and sandstone; and the lowermost of ferruginous sand, and dark shale, with carbonized vegetable remains, lignite, and rich argillaceous iron-ore. The following section presented by the cliffs, near Eaglesbourn, (a spot well known to visitors, from the romantic beauties of the neighbouring fish-ponds,) will convey an idea of the whole.

1. Uppermost beds; fawn-coloured sand, and friable sandstone—about 10 feet.

2. *Tilgate stone*—from two to 6 feet.

3. Clay, loam, &c. alternating with sand and sandstone—contain lignite, &c.—20 feet.

4. White and fawn coloured sandstone, (*Worth sandstone*) 100 feet.

5. Ferruginous sand and sandstone, alternating with dark blue shale, and reddish clay;—lignite, ironstone, vegetable remains: these beds form nearly the lower third of the cliff. The strata are slightly inclined towards the east.

The *Tilgate stone*, presenting the same characters as the beds at "White Rock," may be traced along the upper part of the cliffs, to within a short distance of the town; and its ruins are scattered along the shore, particularly near Fairlight point and Eaglesbourn; at which places, large portions of the stems of *Endogenites erosa* are frequently thrown up by the waves.

* Vol. i., p. 54., et seq.

† Fairlight Down, the highest point, is 540 feet above the level of the sea.

At Hollington, near Hastings, the Tilgate stone also occurs; and at Ore, between Battel and Hastings, it is quarried for repairing the roads. In a quarry on the road side, near Ore, the following section is presented:

1. Diluvial loam, 6 to 8 feet.
2. White and fawn-coloured sandstone, 10 feet.
3. *Tilgate stone*, 3 to 4 feet.
4. Blue clay, depth unknown.

The reader will perceive hereafter, that this section is precisely similar to that of many quarries in Tilgate Forest.

Having thus briefly noticed the geological phenomena, which the cliffs in the vicinity of Hastings present to our observation, before quitting this part of our subject, we would remark, that, notwithstanding the irregularity of the strata, and the ruinous state in which they occur, certain well marked characters are exhibited.

1st. We have a series of ferruginous and fawn-coloured sands, sandstones, and clays, *(the Horsted beds,)* forming the uppermost part of the series: these appear at Bexhill, behind the White Rock, and on the top of West and East Cliffs.

2ndly. The *Tilgate beds*, with their peculiar calciferous grit, and accompanying sand, clay, and shale: these occur at White Rock, are wanting on the West Cliff, but reappear on the East Cliff, in a very striking manner.

3rdly. A series of white and yellow sands and sandstone (the *Worth sandstone*) succeeds, containing ferns, and other vegetable remains.

4thly. Shale, ferruginous sand, and sandstone, with ironstone, lignite, and other carbonized remains of vegetables, in vast quantities; forming a part of the Ashburnham beds.

The Organic Remains of the cliffs at Hastings, though comparatively presenting but little variety are nevertheless important, from their identity with those of Tilgate Forest. The following were collected in a few hasty visits to Hastings; but if the research were made under more favourable circumstances, there can be no doubt a far more extended list might easily be obtained

Horsted beds. Lignite; carbonized remains of vegetables, too imperfect to admit of being determined.

Tilgate stone.

Casts of *nuculæ?* and *cyrenæ?* in abundance.
Ribs of saurian animals.
*Bones of birds.**
Plates of turtles.
Radii of fish allied to the balistes.†
Jaw of an unknown fish.‡

Tilgate coarse grit, and shale, &c.

Tricuspid teeth of fishes, resembling fig. 14. pl. v.
Molar teeth of ditto. fig. 2. pl. x.
Lozenge-shaped scales. fig. 16. pl. v.
Rolled fragments of bones.
Paludina carinifera. Min. Conch. Tab. 509.
——— lenta.§
Aviculæ ? a very thin shell, apparently of this genus.
Cyrena media,§ (*Cyclas medius*, Min. Conch. Tab. 527.)
Cypris faba.§
Endogenites erosa.
Traces of carbonized vegetables.
——— a ramose zoophyte ?‖

Worth sandstone, &c.

Three or more species of ferns.
Stems of arundinaceous plants.

Ashburnham beds,—

Lignite and carbonized vegetables.

* Mr. Cumberland discovered a bone, resembling fig. 18. pl. viii.; it is nearly seven inches long, and was found in the *Tilgate stone*, near Fairlight cliff.

† On the authority of George Cumberland, Esq. of Bristol.

‡ Mr. Cumberland obliged us with a drawing of this elegant specimen, which consists of a portion of the jaw, with five subconical pointed teeth, still attached. Mr. C. refers it to a saurian animal; but, from the resemblance of the teeth to some we have observed at Tilgate Forest, there is reason to suppose it belonged to a fish of an unknown genus. We believe this specimen will be figured by Mr. Webster, to illustrate his paper on the Hastings' beds.

§ Found in calcareous grit, at Hollington, near Hastings, by Dr. Fitton.

‖ In some instances, the Tilgate stone has numerous subcylindrical ramose bodies, lying in relief on its surface: these bear some resemblance to the stems of the *Syphonia* (Tulip alcyonium of Webster): but whether this be merely an accidental resemblance, or not, is at present undetermined.

At Rye and Winchelsea, beds of the Tilgate stone occur in sand of the same character, and under precisely similar circumstances, as those of the Hastings cliffs, above described.* The rock on which Winchelsea is built, is surrounded by an alluvial marsh, and presents a cliff, more or less abrupt, on every side. In a quarry, near the ancient gateway, leading towards Rye, a layer of the *Tilgate stone* nearly five feet thick, occurs in ferruginous sand; and in a cliff considerably lower than the base of this quarry, another bed is seen in situ. The mound on which Rye is situated, presents a similar arrangement of the strata. The Tilgate stone, in these places, contains casts of the small bivalves, which occur in such abundance at "White Rock."

Hastings beds, in the interior of the County.

From the coast, to the western-most point of this formation, the *Tilgate stone* is but sparingly distributed near the surface, except in the immediate vicinity of the forests. The Horsted and Worth strata, and the lower ferruginous sands and clays, occupy the whole country, and offer but few points of attraction to the geologist.† The romantic groups of rocks at Uckfield, Buxted, and Fletching, where large masses lie bare, as when left by the waters of the deluge;‡ the lignite of Waldron, Newick,§ &c.; are so fully described in the former volume, as not to require notice here.

In attempting to trace the Tilgate stone, from Hastings to the west of Sussex, with the exception of Ore, previously mentioned, the first locality where it has been quarried, is on Chailey north-common, about seven

* The occurrence of the Tilgate stone, in these localities, was first described by Mr. Lyell; vide "Notice on the Iron-sand Formation of Sussex," by the author; and it should be remarked, that although this Notice will appear in the Geological Transactions of the present Year, (1826, vol. 2., part i.) yet it was read before the society so long since as June 14th, 1822. The same volume will contain a memoir on the strata at Hastings; with a beautiful drawing of the coast, by Mr. Webster.

† In the sandstone on Tunbridge Wells Common, the casts of Paludinæ or Viviparæ, and the tooth of a Crocodile, have been discovered by Mr. Jansons, Junior, of Dudley House. Quartz pebbles are very frequent in the sandstone, at Hamswell bridge; and in Eridge Park, lignite and traces of carbonized vegetables are abundant in the whiter varieties of the sandstone.

‡ Vol. i., p. 26. The high rocks, near Tunbridge Wells, on the borders of the County, present the same picturesque and romantic characters as those of Uckfield, but upon a grander scale; some of these masses are upwards of 40 feet high.

§ Ibid. p. 34.

miles north of Lewes.* A rivulet, which runs along the valley on the north of Chailey, marks the termination of the Weald clay, and the emergence of the Horsted sands with lignite; the latter beds continue on to the valley, beyond the little public house on the road side, near the eighth mile stone, where the Tilgate beds basset out, and form a bold ridge or hill. The strata in this place are disposed in the following order:—

1. Ferruginous and fawn-coloured sands, and sandstone.
2. *Tilgate stone*, from two to four feet thick.
3. Clay and shale.
4. White sandstone, and sand (the *Worth beds.*)

Tilgate Forest.—Proceeding towards the west, we arrive at Tilgate Forest, and within an area of eight or ten miles in length, and three or four in breadth, the compact varieties of the sandstone have been extensively quarried, the rapid increase of Brighton rendering the repair of the roads that lead to it, from the metropolis, a subject of the first importance. Before we enter into a detailed account of the more interesting localities in this tract, we request the reader to notice the section (in the plate) from Brighton, to near Tilgate Forest, as the relative position of the strata is there distinctly shewn.

1. Diluvium, on which part of Brighton is situated.
2. Chalk, forming the range of Downs.
3. Firestone, } but obscurely seen on the surface.
4. Galt, }
5. Shanklin sand, a fine section at Stone-pound gate.
6. Weald Clay, and Sussex marble—St. John's common.
7. Emergence of the upper beds of the Hastings sands, at Taylor's bridge.
8. Tilgate beds, near Cuckfield, &c.

If this section were continued still farther north, we should find the

* That it approaches the surface, in many places, between Ore and Chailey, is, however, scarcely doubtful; but its course is hid by the deep bed of diluvial clay and loam, that constitutes the subsoil of this district; the sinking of a well, or some other artificial opening, will one day or other detect it; and as it is decidedly one of the best road materials in the county, a knowledge of its probable range and extent is of great importance in many parts of Sussex.

white sands and sandstone, with fern-leaves, at Worth, near Crawley: then the ferruginous sand, with ironstone, &c.

Although, as we have elsewhere remarked, the subdivisions of the strata under examination are so variable, that scarcely any two quarries present precisely the same characters, yet a certain order of superposition prevails in the distribution of the principal masses, which order is never inverted; this is well illustrated in the quarry, represented in the frontispiece to the present volume.*

The upper part of the pit consists of,—

1. (A) Diluvial loam, from 5 to 7 feet.

2. (B) Sand, and soft friable sandstone, of various shades of yellow, green, grey, and ferruginous. 8 feet.

3. (C) A bed of fine, compact, bluish-grey, calciferous sandstone, *(Carstone,†)* imbedded in sand; varying in thickness, from one to nine feet; the lower portion conglomeritic.

4. Blue clay,—the bottom of the quarry. Depth unknown: wells are sunk in it, to the depth of 17 feet.

Of these strata, the calciferous sandstone alone requires notice. It differs in a few particulars from that of "White Rock:"— it is less homogeneous; is generally of a darker shade of bluish or greenish grey; occurs in masses that are more tabular, and the lower portions form a very compact conglomerate, enveloping large rolled pebbles of variously-coloured quartz; and small ones of pure white quartz, which appear to be of chemical origin. It also contains organic remains, in far greater quantities than the stone at Hastings; bones, more or less rolled; teeth, &c. are to be seen in almost every fragment; and the carbonized remains of vegetables are equally abundant. Carbonate of lime, in lenticular and tabular crystals, frequently occurs in the hollows of the stone, and in the medullary cavities of the bones, fissures of the lignite, &c. This bed is separated into irregular layers, of from 3 to 12 inches in thickness, by blue marl or clay; and the

* This ancient quarry is now filled up, and the spot it occupied converted into arable land; a method invariably adopted by the proprietors of the estates in the environs of the forests, &c. after the harder sandstones have been extracted.

† A provincial term.

compact masses, when removed by the quarry-men, and cleared of the surrounding sand or clay, present the same concretional or lenticular forms as those on the shore, at Hastings, that have been washed out by the breakers; the same kind of mammillary projections on the surface of the stone, are also observable.* The *conglomerate* is one of the most remarkable features of these strata; it appears to be composed of the grosser materials of the bed, such as pebbles, rolled masses of sandstone, bones, &c., and even the finer parts of it are made up of grains of sand, and comminuted bones, teeth, &c.; the whole has evidently been the sediment of a current of water, subsequently consolidated by a subcrystalline, calcareous cement: almost all the bones found in it are more or less rolled, the greater part being mere fragments, rounded by attrition. This conglomerate, varying in texture and composition, occurs in greater or less force, in almost every quarry, in this part of the Tilgate strata. In some instances layers of a coarse friable grit, with calcareous concretions, occupy the upper part of the beds, as is the case in many places in the town of Cuckfield, where it rises so near the surface as to be exposed in digging the foundations of houses, &c. In a quarry to the east of Cuckfield, this bed of coarse grit is seen in situ,† the section offering the following series. 1. loam. 2. friable sandstone. 3. *coarse grit*. 4. sand and friable sandstone. 5. *calciferous sandstone;* the *lower part conglomeritic*. 6. *blue clay* or *marl*. In *Pear-tree* pit, the strata exposed are, 1. loam and clay, 11 feet. 2. sand, and calciferous sandstone, with a layer of compact conglomerate, at the bottom, abounding in lignite, ferns, and other carbonized vegetables, 6 feet. 3. *blue clay;* dipping 10° to the S.S.W.‡

The sections above described present the most remarkable variations of the strata around Tilgate forest; and it is unnecessary to multiply examples. In all these localities, organic remains are more or less abundant. The bones of enormous saurians; of turtles, fishes, and birds; remains of

* In many of the quarries, near Tilgate Forest, the concretional formation of the stone is clearly shewn; although, from its being incrusted with sand, it appears like blocks of the friable sandstone; and as it maintains the same sedimentary lime as the sand in which it is imbedded, the layers appear like tabular strata, till examined with attention.

† Vide the section in the map and sections.

‡ Vide the sections.

large arborescent ferns; shells of the genera cyrena, paludina, unio, &c. are found in all the beds, but more particularly in the calciferous sandstone, and the sand which covers it; in the ferruginous sands above these, they are seldom, if ever, discovered; and in the blue clay beneath, they are almost equally rare; as the latter bed, however, contains nothing worth the attention of the proprietors, it has been but little explored, and its contents are, consequently, but imperfectly known.

On Wivelsfield common, about 5 miles to the south-east of Cuckfield, a thin bed of the Tilgate stone, containing carbonized vegetables, occurs beneath a ferruginous friable sandstone; and near Lindfield a calciferous sandstone, more calcareous than that of the forest, is quarried on the estate of Mr. Crawford.

Approaching Horsham, we find numerous quarries of sandstone, along the southern edge of the forest, and on many farms and villages in the vicinity of the town; as Stammerham, Coltstaple, Southwater, Slinfold, Broadbridge, Strood, Nuthurst, Oakhurst, Warnham, &c.; and at Wisborough green, Skiff-common, Headfold-wood, and Loxwood, ten miles farther westward, and the extreme point of the Hastings sand formation, in Sussex. The most considerable quarry in the vicinity of Horsham is that of Stammerham, two and a half miles to the south west of that town, and of which the following is a section.*

1. Clay and loam .... 10 feet.
2. *Calciferous sandstone;* surface deeply undulated, (*prov.* rough causeway.) .... 4 inches.
3. The same stone, but more indurated; in two layers; used for repairing the roads, (*prov.* scrubstone,) .... 1ft. 4 inc.
4. Ferruginous sandstone: pulverized for bricks.......... 1ft.
5. Blue soapy marl .... 1½ft.
6. Hard calciferous sandstone; used for roads, and rough paving, (*prov.* ground pinning-stone.) .... 1ft.
7. Compact *calciferous sandstone* of finer texture, than any of the above.

* Communicated by my excellent friend, Charles Lyell, Esq. F.R.S. &c., &c.; vide Geolog. Trans. New Series, vol. ii. p. 132.

It occurs in large slabs, and forms excellent paving stone for kitchens, &c; it is slightly marked with undulating furrows, on the upper surface. 2ft.

8. Marl, sunk through, but not worked .... 4ft.

9. Stone in slabs, reached by boring—depth unknown.

Organic remains are comparatively rare in these beds; in No. 7, Mr. Lyell informs me, that a rib of an animal was discovered, a few years since; and vegetables, in a carbonized state, are not uncommon. The stone is not so uniform in colour as that of Cuckfield, and is more micaceous; the conglomerate has not been observed in any of the localities above mentioned. The furrowed appearance on the surface of the sandstone, as already remarked, is of frequent occurrence in the arenaceous strata of Sussex, and, doubtless, has been produced by the advance and retrocession of the waves.*

At Sedgwick, near Stammerham, large quantities of this sandstone, or grit, are quarried for the purposes of paving, roofing, &c.; this variety is sent to many parts of the county, and is distinguished by the name of *Horsham-stone.* The dip of the strata around Horsham, and Tilgate forest, is exceedingly variable; the general inclination is towards the S. E; but on the forest, according to the information of an intelligent old quarry-man, the beds formerly worked there, were found to be nearly horizontal over a considerable area, so as to render the drainage of the quarries very difficult.†

In the westernmost portion of the Hastings beds, the strata rise in gentle undulations immediately to the east of Kirdford, in the parish of Wisborough-green, where at Headfold-wood Common, near Loxwood, its outline makes an angle, corresponding to that formed by the Weald clay and superior strata. Although these beds, at their first emergence, consist chiefly of clay, yet they differ essentially from the Weald clay, in containing

* An appearance of this kind may be observed at low water, on the sands at Brighton.

† The western extremity of the Hastings sand was first noticed by Mr. Murchison, and is described in a memoir on the Geology of the north-western extremity of Sussex, and the adjoining parts of Hants and Surrey, communicated by that gentleman to the Geological Society of London, and published in their Transactions, Vol. ii. part i. New Series; and from which the description in the text is extracted.

small slabs of a slightly *calcareous sandstone;* and, beneath these, large tabular masses of a calcareous grit, which is very similar to certain beds of the Stammerham and Slinfold quarries; unlike, however, the latter, the calcareous grit of Wisborough-green is based upon a deep mass of red ferruginous marl, and is only found in detached portions. The strata are arranged in the following manner:—

1. Calcareous sandstone (containing about 30 per cent. of carbonate of lime,) in clay, with casts of viviparæ, &c.
2. Tabular calcareous grit, with bones of large saurian animals.
3. Deep red clay, with argillaceous ironstone.
4. Blue clay, with selenites—the lowermost bed.

In these strata, Mr. Murchison discovered vertebræ, a femur of enormous magnitude, (3 feet 7 inches long, and 34 inches in circumference at the largest extremity,) and portions of other bones of some of the saurian animals of Tilgate-forest.* The greater part of these fossils were found at Headfold-wood common, in ferruginous marly clay, about 5 feet below the surface, and beneath a stratum of calcareous sandstone. At Loxwood, bones have also been found in the clay, north of the residence of J. King, Esq.; but as these remains are similar to some of those we shall hereafter have occasion to mention, it is unnecessary to describe them in this place.

Organic Remains of *Tilgate Forest*. These are exceedingly numerous, and present as extraordinary an assemblage of "the relics of a former creation," as any hitherto recorded. In this division of the work we purpose to give a general idea only, of the fossils contained in these strata; their zoological characters will be fully detailed in the section expressly devoted to that purpose.

Vegetable remains. Stems of large plants allied to the genera Dicksonia, Cycas, &c.

Clathraria Lyellii.

Endogenites erosa.

Leaves, &c. of plants of the fern tribe

* Vide *Geological Trans*. Vol. ii., Plate xv.

Pecopteris reticulata; in the Worth sandstone.

Hymenopteris psilotoides; in the Tilgate-stone.

Carpolithus mantellii.

Carbonized vegetables; too imperfect to determine their characters.—

Zoophytes??? Their existence in these strata is very doubtful: the only supposed instances are the ramose subcylindrical bodies mentioned in page 35.

Testaceæ.—The testaceæ which are found in these beds, seldom have any traces of the shells remaining, but occur in the form of casts and impressions; their generic characters are, therefore, seldom sufficiently manifest to afford any positive conclusions. Those we have noticed appear to belong to the following genera:—

Paludina, resembling one of the species found in the Purbeck marble.

Vivipara: the spire more elongated than that of *V. fluviorum.*

Unio, mya,* cyrena.

Remains of fishes.—Tricuspid teeth, longitudinally striated.
Molar teeth, resembling those of Spari.
Scales, and fins like those of Balistæ, or Siluri.

Turtles.—Three kinds: the first resembling a fresh-water, the 2nd. approaching to a terrestrial, and the 3rd. to a marine species. The bones, and detached parts of the sternum and buckler, are very abundant in the *calciferous sandstone,* as well as in the sand.

Saurian animals.—The bones, teeth, scales, &c. of four, (if not more) gigantic animals, of the saurian order, are found in these deposits: viz.

Iguanodon.—The teeth, and many enormous bones, supposed to belong to this animal. These remains have not been found in any other deposit, nor in any other country.

Megalosaurus.—The teeth, vertebræ, ribs, and some of the bones of the extremities: the only other known locality, is the slate of Stonesfield.

Crocodile.—The teeth, vertebræ, ribs, and other bones of a species

* Casts of shells of these genera sometimes form the entire mass of the layers of sandstone; and it is worthy of remark, that they occur, also, in the shale and grit of the coal measures, and in the ironstone of Derbyshire.

allied to the Gavial or Gangetic Crocodile.—Teeth of another species, not determined.

Plesiosaurus.—Teeth; caudal, lumbar, dorsal, and cervical vertebræ; probably some of the large humeri, and other bones, may have belonged to an animal of this genus.

Many bones, not referrible to any recent ones.

Birds: bones of some species of Ardea?

In this list of the fossils of Tilgate-forest, the reader cannot but remark on the almost entire absence of the remains of the inhabitants of the sea. The vegetables are either terrestrial, or belong to those tribes which affect a marshy soil; the shells are lacustral; and the amphibiæ, with but one or two exceptions, are those which bear a resemblance to the living species that now inhabit the banks of lakes and rivers, of tropical regions; the fish, also, appear to be of fresh-water origin; but on this point, some degree of uncertainty may exist. The *absence of ammonites, belemnites, and other multilocular* shells of our ancient seas, whose remains are so frequent in the sands and chalk above the Hastings sand and Weald clay, and in the Portland stone and other deposits beneath, is also another remarkable feature in the oryctological characters of the strata of Tilgate-forest.*

Ashburnham beds. In this division of the Hastings sands formation, we include the beds of shale, forming the lowermost strata in the cliffs at Hastings; and the limestone, shale, and blue clays, which appear beneath them, in various places in the interior of the country. But the strata under consideration have suffered such extensive displacement and destruction; and even where accessible to observation, present so many obstacles to an accurate knowledge of their position and relations, that we can only attempt an outline of their general characters, which future observations must fill up and correct. They may be defined as a series of shelly limestone and shale, alternating with blue clay, and containing subordinate beds of ironstone and sandstone.

* The *ammonites, nautili,* &c. mentioned in Messrs. Conybeare and Phillips' Geology of England as occuring in the iron sand, as well, as those figured in Sowerby's Mineral Conchology, which are referred to that formation, must not be admitted as exceptions, until their several localities have been carefully examined; the confusion that formerly existed in the geological nomenclature of the sands below the chalk, having given rise to many errors.

Limestone, of a dark, bluish-grey colour, containing immense quantities of bivalve shells, (nuculæ, cyrenæ, or tellinæ?) which are more or less changed into a spathose calcareous spar, and whose characters and forms are but rarely preserved, is the most characteristic deposit of this group. In texture, appearance, and fracture, it bears considerable resemblance to the Sussex marble, but is readily distinguished by the semilunar markings which the sections of the bivalves present. The shale, by which it is accompanied, is also of a dark blue colour, very stiff, sometimes slaty, and laminated; and, occasionally, contains the same kinds of shells as the limestone, in a white friable state.

At Archer's Wood, near Battel, on the estate of the Earl of Ashburnham, extensive limeworks have been carried on for the last century; shafts are sunk through the shale and clay, to the depth of 100 or 120 feet, to the limestone, which lies beneath, and is dug up and converted into lime; the thinner slabs are used for paving.* These strata present the following section:—

1. Loam, of an ochreous or grey-colour, with thin layers of friable shelly limestone.

2. Compact blue limestone with bivalves, (provincially termed *greys*,) alternating with shale.

3. Compact blue limestone and shale, alternating in layers of from 14 to 20 inches each, in thickness: these are almost destitute of organic remains. There are not less than fourteen or fifteen alternations of the limestone and shale, making a total thickness of upwards of 100 feet. The workmen informed us, that the beds at Archer's Wood generally dip towards the south, or south-west: the inclination of the strata, however, from the displacement they have suffered, is so variable, in different localities, as to render it impossible to obtain an approach to accuracy. Strata of a similar kind are worked in Darvel's Wood, about four miles north-west of Battel; at Brightling, on the estate of John Fuller, of Rose Hill, Esq.; near Burwash; at West down, Willingford, and Hurst Green. But the most interesting locality of these beds is *Pounceford*, a

* The strata of Ashburnham lime-works are fully described in Vol. i., p. 31.

farm belonging to the Earl of Ashburnham, situated in a deep glen, about a mile to the right of the turnpike road, leading from Cross-in-hand to Burwash.*

The forest ridge, along which the main road passes, consists of sand and friable sandstone, more or less ferruginous. Descending the narrow winding way that leads to Pouncenford, occasional openings are seen in the white varieties of the sandstone, along the sides of the deep valleys; shale and blue clay appear on the surface; and springs issue from the defiles of the glens, the water being thrown out by the argillaceous partings of the strata. Before reaching the bottom of the valley, to which the road conducts, lime-works are seen, on a rising ground on the left hand; and, to the right, a path-way leads by the farm house of Mr. Sims, to a deep glen, where a quarry has been opened, and from whence the incrusting spring has its source. This quarry, moreover, presents a most interesting section to the geologist; for there, *in situ*, is seen a bed of the Tilgate stone, beneath a layer of the Ashburnham bivalve limestone: it is not a little extraordinary, that the occurrence of calciferous sandstone, in this division of the Hastings beds, should have so long eluded observation. The quarry, of which a sketch is annexed, is composed of :—

1. Diluvial loam . . . . 8 feet.

2. Bed of laminated shale, clay, &c. containing thin septaria of iron-stone, with bivalves, and a layer of *very hard, dark, blue limestone*, 2½ inches thick; similar to the most compact masses of Archer's wood; 2ft. 5 inc.

3. Bluish grey loam, or soapy marl 3. 9

4. Friable sandstone, with traces of carbonized vegetables 5. 6

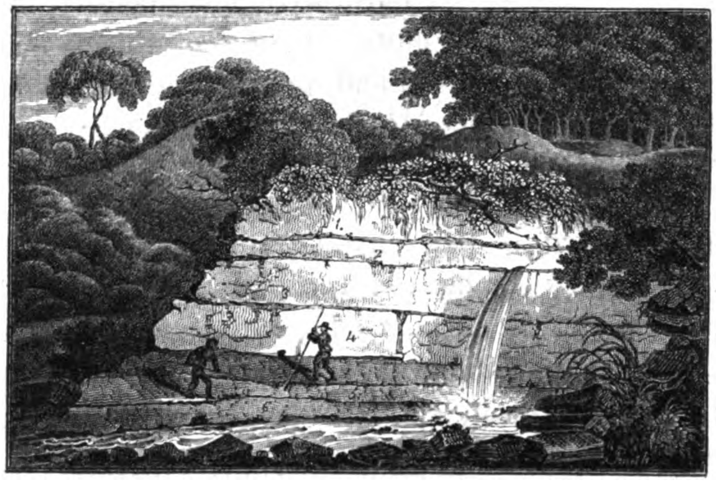
5. *Compact calciferous sandstone (Tilgate stone)* containing casts of the small bivalves of "White Rock," lignite, and traces of carbonized vegetables :† . . . . 1ft. 10 in.

* Pounceford was particularly mentioned in Vol. i., p. 291, on account of the incrusting spring which issues from the limestone beds, and flows into the adjacent valley. Mr. E. Sims still occupies the farm; and whoever may be led by curiosity to visit this sequestered, but highly interesting spot, may depend upon meeting with a plain, but most hospitable reception, from that intelligent Sussex farmer.

† This stone so entirely agrees in its mineralogical characters, with that of Tilgate Forest, that specimens from the respective localities could not be distinguished from each other. The same bed is quarried at Etchingham, three miles north-east of Burwash.

6. Blue clay, or shale . . . . depth unknown.

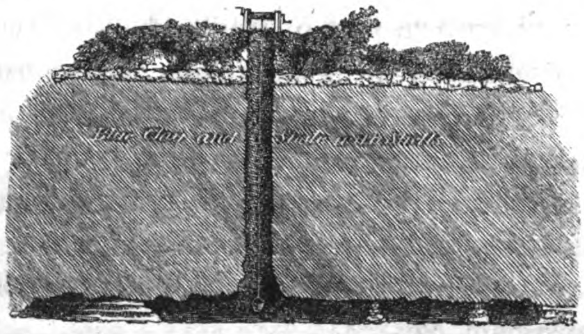
The strata dip to the N.N.E. with an angle of about 5°. The incrusting spring is seen in the engraving, issuing from between the limestone beds above the Tilgate stone.



Proceeding to the opposite valley, on the sides of which the limeworks are situated, indications of the *Tilgate stone* may be observed at the depth of about 20 feet; and it is a curious fact, that the perforation of this stratum, (which could not be avoided in sinking the shafts for limestone,) was formerly one of the most expensive processes in the whole works, and cost the Earl of Ashburnham a very large sum annually; the excellence of the stone, as a road material, and for which it is now quarried, having escaped observation, till the system of McAdam became more generally known and appreciated.

The limestone here, as in Archer's Wood, and at Brightling, lies at the depth of from 30 to upwards of 100 feet, and is extracted by means of shafts, sunk in the most favourable situations; the stone is dug from under the shale to a considerable distance, the excavations forming an area of many acres, occasional props of limestone being left to support the strata, as is shewn in the subjoined sketch of one of the principal shafts.

Limestone.



The sections formed by the shafts, are hid by the frame-work employed; but, from the specimens of the beds pointed out to us by the workmen, it appeared that loam, friable sandstone, and a thin layer of Tilgate stone, with a succession of blue laminated shale, more or less shelly, were generally passed through, before the limestone was reached: the latter is irregularly divided into three layers, but the thickness of the whole seldom exceeds two feet. It is more friable than that of Archer's Wood; and the softer masses are composed of white friable shells, held together by clay or shale. The lime it produces is held in great estimation* by the agriculturists of that part of Sussex.

The shelly limestone that alternates with blue clay, and shale, at Eason's Green, in the parish of Framfield,† belongs to this series; and a very beautiful compact variety is dug up in Barnet's Wood, adjoining the 9th mile stone, on the turnpike road, leading from Lewes to the Black-boys' public house; this limestone is strongly impregnated with iron, and traversed by veins of white calcareous spar; the bivalves resemble the smaller species of those found in the Ashburnham *greys*. The same kind of stone occurs at Rotherfield.

We have not observed the Ashburnham beds farther west than Framfield; nor, indeed, should we expect to find them but in the eastern part

* A kiln, containing 600 bushels, is converted into lime in twenty-four hours; it sells for 6*d*. per bushel.

† Vide Vol. i., p. 32.

of the county, when we consider the low situation they occupy, and the probable nature, direction, and extent of the catastrophe, which dislocated the strata of the south-eastern part of England.

The *Organic remains* of the *Ashburnham beds* consist principally, as already mentioned, of bivalves, whose characters are obscured by their mineralization; there are several species, and probably genera, but at present the following are all we can venture to particularize.

Cyrena media; in the shale and *Tilgate stone.*

———; species undetermined; in the limestone of Barnet's Wood, Pounceford, Ashburnham, &c.

Mytilus? Avicula? blue shale of Pounceford.

Paludina, or Vivipera; limestone of Barnet's Wood.

Scales, and other remains of fishes; limestone of Barnet's Wood.

Vertebra of crocodile; }
Quadrangular scale of a fish; } in the clay between the beds of limestone, at Darvel's Wood.*
Potamides ventricosus? }

Carbonized remains of vegetables; in the Tilgate stone.

The argillo-calcareous strata of Sandown Bay, in the Isle of Wight,† are evidently identical with those above described. "Near the termination of the cliffs, towards the middle of the bay, are several thin strata of a stone composed wholly of *bivalve shells*, in a calcareous matrix, much resembling the Purbeck-stone; but the shells are larger. These strata are from three inches to one inch in thickness, and separated from each other by beds of shale, and fibrous carbonate of lime; they have the same inclination as the strata lying above them. These strata are the lowest in the Island."‡

From the facts above stated, the "Hastings sands and clays," are shewn to consist of an extensive suite of argillaceous strata, sandstones, limestones, and sand, alternating with each other, very frequently; their alternations being exceedingly irregular in some parts of the series. So

* On the authority of Dr. Fitton.

† Conybeare and Phillips's *Geology of England*, p. 157.

‡ Specimens from these limestone beds could not be distinguished from those of Ashburnham.

far as our present knowledge extends, they may, however, be presumed to maintain the following order of superposition.

1. Beds of sand and friable sandstone, with clay and marl; the argillaceous, bearing but a small proportion to the arenaceous strata. *Organic remains.* Traces of vegetables, &c.

2. Compact grit, or sandstone, (the Tilgate stone,) with friable sandstone above, and argillaceous beds beneath.

Organic remains. Bones of saurian animals, turtles, birds, &c. bivalves, univalves, vegetables, &c.

3. Sand, and friable sandstone; with but few argillaceous strata.

Organic remains. Ferns, and other vegetable remains.

4. Limestone, shale, and blue clays, alternating very frequently; the argillaceous strata forming a very large proportion of the whole; a subordinate bed of compact grit, (Tilgate stone,) occurring in the upper part of the series.

Organic remains. Bivalves, &c.; remains of fishes, and vegetables.

We now proceed to a more particular description of the organic remains of the strata of Tilgate Forest, and shall conclude our observations by a brief recapitulation of some of the principal geological phenomena, which our researches appear to have established.

II.

DESCRIPTION OF THE ORGANIC REMAINS OF THE STRATA OF TILGATE FOREST.

Before we enter upon the description of the fossils of Tilgate Forest, let us for a moment consider what would be the nature of an estuary, formed by a mighty river flowing, in a tropical climate, over sandstone rocks and argillaceous strata, through a country clothed with palms, arborescent ferns, and the usual vegetable productions of equinoctial regions, and inhabited by turtles, crocodiles, and other amphibious reptiles? In such a deposit we should expect to find sand more or less consolidated, with layers of clay and silt; containing water-worn fragments of the harder portions of the rocks, in the form of pebbles, or gravel; bones, teeth, and scales, more or less rolled, of the amphibiæ that had lived and died on the borders of the river; the branches, and stems, and leaves, of the vegetables that grew on its banks; intermingled with fresh-water shells, and a small proportion of marine poductions: a few bones of aquatic birds, might also probably be observed;—the strata of Tilgate Forest present precisely such characters, and such an assemblage of animal and vegetable remains.

VEGETABLES. These consist of the petrified trunks of large plants, belonging to that tribe of vegetables of the ancient world, which is so common in the carboniferous strata, and appears to have held an intermediate place between the Equiseti and the Palms; of the stems of a gigantic monocotyledonous vegetable, bearing some analogy to the Cacti and Euphorbiæ; the foliage of ferns; and the stalks of arundinaceous plants. Of these, the most interesting species is that which has been described as *Clathraria anomala*, in the *Geological Transactions*;* but as we had previously named it in honour of Charles Lyell, Esq. F.R.S. &c., a gentleman to whose active intelligence, and unweared exertions, the Geological Society of London is much indebted, we claim the privilege of original discoverers, and retain that specific designation.

Clathraria Lyellii. Pl. 1. fig. 1. 2. 7. Pl. 2. fig. 1. 2. 3.
Pl. 3. fig. 8. Pl. 3.* fig. 4.

———— *anomala: Geolog. Trans.* Vol. 1, p. 423. New Series.

This vegetable appears to have possessed a thick epidermis, or bark,† covered externally with distinct rhomboidal scales, each scale being surrounded by an elevated ridge; a character which distinguishes it from the species described by M. Ad. Brongniart. These cicatrices, or scales, have evidently been formed by the attachments of the petioles of the leaves, or by the bases of the leaves themselves; but no traces of the foliage have been observed in the sandstone surrounding the specimens here delineated. The interior part of the trunk, originally enclosed by the bark, occurs in the state of solid, subcylindrical blocks of sandstone, attenuated

* To avoid the charge of plagiarism, it may be necessary to state, that Pl. 45 and 46. *Geol. Trans.* Vol. i., *New Series*, were drawn expressly for this work; but Messrs. Stokes and Webb, having requested that some notice of the fossil vegetables of Tilgate Forest might appear in the *Transactions*, a sufficient number of impressions was permitted to be taken for that purpose; and the Society, in return, furnished us with proofs from the supplementary Plate 3,* which was drawn at their expense.

† Pl. 2. fig. 2; Pl. 1. fig. 2; Pl. 3.* fig. 4.

at their base; the surfaces of which are marked with longitudinal interrupted ridges, and, in some instances, are deeply imbricated: they are, generally, of a dark brown colour, (Pl. 3.* fig. 4. c.) A specimen, surrounded by the cortical covering, is represented in Pl. 2. fig. 1; and a branched example in Pl. 1. fig. 1. A cellular interstitial substance appears to have existed between the internal part and the bark, and which is frequently found attached to the former, appearing like a fibrous carbonized integument, an eighth of an inch thick, as shewn in pl. 3*. fig. 4. d. Cicatrices are occasionally seen on the stems, (*a*. fig. 1. Pl. 1. and 4. *b*. Pl. 3.*) the nature of which has not been determined; they have been supposed to indicate the setting off of branches, but, in the ramose specimens, the appearance is by no means similar: they are more like what Mr. Stokes has observed in the *Dracæna draco*. "This tree possesses a thin outer bark, marked by the cicatrices of the leaves: and, within that, an internal, somewhat reticulated, surface, in which we remarked a singular plexus of the vessels, formed where the dragon's blood was secreted, to which the cicatrix in our vegetable bears a striking resemblance."* The casts of the stems are composed of solid sandstone throughout, and shew no traces of internal organization: the original, if not hollow, must, therefore, have possessed a structure too delicate to be preserved by mineralization. The recent plants which present the greatest analogy to these fossils, are those of the genera *Cycas*, *Zamia*, and *Dracæna*. The impressions of the petioles on the bark, bear a great resemblance to those on the stems of *Cycas revoluta*,† and *C. circinnalis*; but, as M. Adolphe Brongniart observes, the dichotomous stem or branch, brings it nearer to the *Yucca*, and *Dracæna*; the internal part of the caudex is, however, very different to that of the true monocotyledonous plants. In the *Dracæna*, there is no internal axis, and distinct bark, as in the fossil; and the bases of the leaves, in the former, are more transverse. This clathraria belongs to the same

* *Geolog. Trans.* Vol. i., p. 423. New Series.

† A beautiful plant of this species exists in the unrivalled collection of living palms, of Messrs. Loddiges of Hackney. The scorings on the stem, formed by the shedding of the leaves, are very like those on C. Lyellii; the leaves that remain are sent off from the upper part of the plant.

tribe of fossil-plants as the *Lepidodendron*, figured by Sternberg, Tab. 1. 2. 3:* the lozenge-shaped bases of the acini, or leaves, are similar in many respects, but the Count's specimens do not appear to have shewn any trace of the internal part; it does not, however, follow, that such a structure may not have prevailed, since, in some examples of the *C. Lyellii*, the central axis is not preserved.†

Endogenites erosa, Pl. 3. fig. 1, 2. Pl. 3.* fig. 5.

——————— *Geolog. Trans.* Vol. 1. p. 423, New Series.

This is the only other vegetable, of any considerable size, that occurs in the strata of Tilgate Forest. A small specimen, exhibiting that peculiar eroded appearance of the surface, denoted by the specific name, is so beautifully represented by fig. 1. Pl. 3, as to convey a most correct idea of the original. This singular plant is of various forms and sizes: it is generally more or less flattened, attenuated at the base, and swells out at intervals, like some of the *Cacti*, and *Euphorbia*. Some examples are hatchet-shaped, and nearly flat, being from three to four feet long, twelve inches broad at the widest part, and not more than two or three inches in thickness: others are subcylindrical. All of them are covered with a dark carbonaceous matter, which is removed by washing. The external surface is scored with small meandering grooves, and deep longitudinal furrows; a transverse section exhibits numerous pores, formed by the division of vessels, proving the monocotyledonous structure of the original: these are seen in Pl. 3. fig. 2; and in the magnified representation, Pl. 3.* fig. 5. *b:* a portion of the outer surface, magnified, is delineated in fig. 5. *a.*

The constituent substance of these fossils is a dark grey sandstone; the cavities of the vessels are generally lined with crystallized quartz; and the fissures are frequently filled with white calcareous spar. We are not acquainted with any recent or fossil vegetables that are identical with this

* *Essai d'un Exposé Géognostico-botanique de la Flore du Monde primitif, par Gaspard Comte de Sternberg; folio, Leipsic et Prague,* 1820.

† To give the general reader an idea of the probable form of the originals of these fossil plants, one of Count Sternberg's figure is copied in Plate xx., fig. 3.

It may be remarked that many species of the living arborescent ferns acquire a great size: in New South Wales, some of these plants are above 30 feet high; and their caudices or stems measure from 12 to 16 inches in diameter, at their base. *See Mr. Baron Field's Geographical Memoir of New South Wales.*

endogenite. M. Adolphe Brongniart informs us, that it bears some resemblance to the base, or the short and almost subterranean stems, of some recent species of ferns, that are not arborescent. Mr. Stokes observes, that a mass of monocotyledonous wood, from Upper Egypt, figured in the great work on that country, published by authority of the late Emperor Napoleon, has considerable resemblance to this fossil: and among some interesting specimens of the trunks of fossil palms, from Antigua, presented to us by Mrs. Thomas, of Ratton, near Eastbourne, there are examples which expose a structure in every respect analogous.

Hymenopteris psilotides. Pl. 1. fig. 3. Pl. 3. fig. 6, 7.
Pl. 3.* fig. 2. Pl. 20. fig. 1. 2.
———————— *Geolog. Trans.* Vol. 1. New Series, p. 424.

The form of this elegant fern is so remarkable, that it is easily recognized. Messrs. Stokes and Webb, from the shape of its frond, supposed that it resembled the plants of the genus *psilotum;* but from the disposition of the vessels in the ultimate segments, more nearly approaching to that observable in those of the genera *Trichomanes* and *Hymenophyllum*, and from the circumstance of all the divisions of the frond being, in the fossil, bordered by a decurrent membrane, those gentlemen formed a new sub-genus for its reception, which they named *Hymenopteris*. M. Adolphe Brongniart does not, however, admit the propriety of this distinction, but refers the fossil to his sub-genus *Sphænopteris.** "The ramification of the fronds, indicated by the different planes in which the branches are disposed, appears to be very distinct from the mere distichous frond of the recent ferns," and is another instance of the difference existing between the vegetation of the ancient and modern condition of our planet, even in those genera that are in many respects analogous. The specimens figured, present considerable variety both in the form, and disposition, of the fronds; perhaps, here-

* Cette fougère appartient au sous-genre que j'ai nommé *Sphænopteris*, et non au s. g. hymenopteris: le nom de *psilotoides* ne me paraît pas très convenable en ce que cette plante diffère totalement du genre psilotum; si par cette raison vous me permettiez de lui donner le nom de *Sp. mantellii*, on éviterait une comparaison qui ne me paraît pas exacte, et on consacrerait le nom de la personne qui a la première prouvé la présence de fougères dans des terrains aussi modernes." Extract of a letter from M. Adolphe Brongniart to the author.

after these variations may be found sufficiently permanent, and important, to constitute specific characters. This fern has, hitherto, been noticed in the hard calciferous sandstone only; it is generally in a carbonized state, and occurs in small portions, so that a knowledge of the entire form of the original plant is still a desideratum. It appears to have been very abundant, for no considerable block of stone is without traces of it: but it generally occurs in confused masses, presenting the appearance of fig. 6. Pl. 3.

Pecopteris reticulata. Pl. 3. fig. 5, Pl. 3.* fig. 3.

——— ——— *Geolog. Trans.* Vol. 1. New Series, p. 423.

This beautiful filicite "approaches in habit to some of the tropical *Nephrodia;* but the ramifications and interlacing of the veins, at the tips of the pinnæ, are peculiar, and serve to distinguish it from other species."* There is a plant in the coal shales which has reticulated leaves, but the form and size of the pinnæ are altogether different. This fern is found in the Worth sands, both in the Forest, and in the cliffs at Hastings; it has not been noticed in the harder strata; it always occurs in a carbonized state.

Carpolithus mantellii. Pl. 3. fig. 3, 4. Pl. 3.* 1.

——— ——— *Geolog. Trans.* Vol. 1. New Series, p. 423.

The fossil fruit, here represented, is exceedingly rare. The surface bears marks of the ramifications of veins, probably the impressions of the vessels of the integument, and not those of the nucleus itself; a magnified view of them is given in Pl. 3.* This carpolithe resembles the grains or kernels of some kinds of palms, such as the *areca;* but the disposition of the nerves is not precisely the same: four specimens only have been found, and these were imbedded in the Tilgate stone.

Of the other vegetable remains of Tilgate Forest, but few require notice: the flattened stems of arundinaceous plants, too imperfect to admit of delineation or description, but bearing some resemblance to the *Syringodendra* of the coal measures; two or three species of ferns, of which no perfect specimens have yet occurred; and masses of carbonized wood, are the only additional fossils of the vegetable kingdom, we have

* *Geolog. Trans.* Vol. i., New Series, p. 423.

observed. It should be remarked, that no unequivocal example of a dicotyledonous tree has been discovered; and also that the fossils above described appear to be peculiar to the Hastings formation; they are not known to occur in the coal measures, nor in the chalk and tertiary deposits. M. Ad. Brongniart remarks, that the only fossils at all similar are some discovered in Germany and Denmark, in strata apparently of the same epoch.*

Shells. The remains of testaceous animals found in these strata, occur for the most part in the state of casts; the structure of the hinge in the bivalves, and the form of the mouth in the univalves, having, in no instance, been exhibited. Their external form is, therefore, the only character by which we can arrange them; and although this may not afford positive conclusions, it will yet enable us to approach very nearly to correctness.

Cyrena. Casts of a small species are very common in the Tilgate stone at Hastings, but comparatively rare in that of Pounceford, and the forest. There are, probably, two larger species of this genus.

Unio.—Mya. Casts, possessing the general form of the shells of these genera, occur in vast numbers in the sandstone; in some instances forming thin layers between the more compact strata; they are, oftentimes, accompanied by casts of a small species of *Paludina.*

Paludina.—Vivipara. Species of both these genera are frequently found; some resembling the shells of the Sussex marble, and others those of the Purbeck: figures 7, 8, 9, Plate x.

Fig. 11. Pl. x. represents a cast of an inequilateral transverse bivalve, in which a portion of the shell converted into calcareous spar, still remains, and which is very thick in proportion to the size of the shell.

Remains of Fishes. These consist of the detached bones, teeth, and scales, of several kinds; but as no united part of the skeletons, or of the scaly coverings, has been found, it is scarcely possible to ascertain how far they are related to existing species.

* Vide "Observations sur les Végétaux fossiles renfermés dans les Grés de Hoer en Scanie, par M. Ad. Brongniart. "Annales des Sciences Naturelles," Février, 1825.

1. *Tricuspid teeth, longitudinally striated.* Pl. v. fig. 14, Pl. xv. fig. 2, 6. These differ from the sharks' teeth, found in the chalk, in being striated; but closely resemble some of those discovered at Stonesfield.

2. *Teeth of a hemispherical form;* very strong, and possessing a high polish. These resemble the *bufonites* of ancient writers. Fig. 2, pl. x. represents a series of them attached to a portion of the bony palate: detached specimens are common, particularly in the conglomerate. In the *Light-horseman fish*, a similar dentature is observable.*

3. *Teeth with a cylindrical shank*, and somewhat angular, obtuse apex, obscurely striated longitudinally. Pl. xv. fig. 3, 4. These differ from any recent or fossil teeth with which we are acquainted.

4. *Teeth slightly curved*, slender, and very sharp. Pl. x. fig. 5. Part of the jaw, with eight teeth attached, is here represented; we are unacquainted with any recent analogue. The original is in the possession of Mr. R. Weekes, of Hurstperpoint.

5. *Palates of an unknown fish.* Pl. xvii. fig. 26, 27. The bony palate of a small fish, with the teeth attached. Slightly curved, and nearly flat, pieces of enamel, occupy the centre, and are bordered with two rows of depressed, subconical teeth. From this structure of the palates, we may infer that the original fed on crustaceæ, and other hard bodies; but we know of no recent fish with exactly similar organs of trituration.

6. *Scales of a quadrangular form*, with bifurcating processes of attachment. Pl. v. fig. 4, 15, 16. These scales are of a dark-brown colour, very hard, and possess a high polish on the external surface; the processes of attachment are of a paler colour and softer texture. These scales, probably, belong to the same species of fish as the hemispherical bufonites above mentioned, for they are very commonly found together. The original must have attained a large size, and been capable of resisting the attacks of the most powerful assailants, for the imbricated coat of mail, formed by the scales, must have been almost impenetrable.

7. *Fins, resembling those of a species of Silurus.* Pl. x. fig. 4, 6. These

* From a specimen in our cabinet, it is probable that the recent animal was furnished with sharp pointed teeth for seizing its prey, and that these occupied the front margin of the jaws.

fins are occasionally found in the Tilgate stone, and also in the sandstones beneath it. Some examples are more delicate, slender, and have sharper spines, than those represented. The bony fin of a recent species of Silurus,* in the museum of the College of Surgeons, (which was pointed out to us by Mr. Clift,) is almost identical with figure 4, both in form and magnitude.

8. *Minute scales, and vertebræ of fishes.* Some portions of the argillaceous partings of the strata abound in the bones and scales of small fishes; but of what genus, or species, has not been determined.

Testudines, or Turtles. The disjointed bony skeletons are, with but few exceptions, the only remains of Chelonian reptiles that occur in a fossil state; and it is, therefore, by a careful comparison of the fossil with the recent bones, that we must attempt to obtain satisfactory conclusions respecting the forms and habits of the originals. Among the osseous remains of this curious order of animals, which have been discovered in the strata of Tilgate Forest, none have been found in so perfect a state as to exhibit any considerable portion of the upper shell or *carapace;* but the detached ribs, vertebræ, portions of the bones of the sternum, pelvis, and extremities, which are abundantly distributed both in the Tilgate stone, and in the friable sandstone, will, with the light which the illustrious Cuvier has thrown upon the anatomy of the recent animals, enable us to obtain results that are highly interesting.

The bones of turtles, as well as those of the other oviparous quadrupeds of Tilgate Forest, are generally of a dark-brown colour, very heavy, brittle, and strongly impregnated with iron. Their cellular structure is, in many instances, beautifully displayed, being injected, as it were, with limestone, or white calcareous spar; and, in numerous examples, the medullary cavity of the long bones is filled with the same substance. There are, however, some remarkable exceptions, in which the bones are as light and porous as the osseous remains of diluvial deposits.†

* The *Silurus glanis* inhabits the rivers of Europe and the East; it is the largest of all fresh-water fishes, being frequently 24 feet long, and weighing 300 pounds. "Elements of Nat. Hist." Vol. i., p. 368.

† See Vol. i., p. 48.

Trionyx. Pl. vi. fig. 1, 3, 4, 5, 8. Pl. vii. 4. 7.

To this subgenus of M. Geoffroy, which contains fresh-water turtles only, the specimens referred to, bear the strongest affinity. The recent trionyx are distinguished by the intervals between the ribs not being ossified throughout; by their extremities not being articulated to an osseous border; and by their surface being chagreened, and marked with little pits or hollows, that the soft skin, the only integument with which the trionyx is covered, may be firmly attached.* Being destitute of scales, their bones exhibit no traces of the furrows, or depressions, produced by their margins, as in the other subgenera. The fossils we are about to describe, possess a chagreen surface, like the trionyx, but differ from the recent species in bearing decided marks of having had a scaly covering. In the rib, fig. 1. Pl. vi., these impressions are clearly shewn; and it is necessary to remark, that this bone, instead of being nearly of an equal width throughout, as in the fresh-water and marine species, gradually enlarges till the outer termination is twice as wide as the inner. Such a character obtains in the ribs of land tortoises only,† and therefore presents another anomaly in the structure of the fossil animal. Fig. 3, Pl. vi. and fig. 4, Pl. vii. are portions of the sternum or *plastron;* and the scale represented fig. 5, Pl. vi. belongs, probably, to the same species. Fig. 7 is one of either the 2d or 3d pairs of the sternal plates, and shews traces of the hollow formed for the passage of one of the paws. The large bone Pl. vi. fig. 8, and the small fragment fig. 4, are covered with little pits, or fossæ, as in the soft turtles; but they are too imperfect to be identified, except by more experienced comparative anatomists than ourselves.—Many fragments of the ribs, and other parts of the upper shell, or carapace, of this species, have been discovered since the drawings were made, but none that afford any material additional information. From the slight degree of convexity of the rib. (Pl. vii. fig. 1.) it is clear that the original was of a flattened form, like the common turtle, *Testudo mydas;* the cha-

* Cuvier Oss. Foss. Tome 3, p. 329.
† Cuvier Oss. Foss. Tome 3, p. 333. Edit. 1822.

greened surface proves its analogy to the trionyx; but the impressions of the scales shew that it cannot be identified with any recent species. It may be mentioned, that among the numerous portions of the osseous border of the carapace, found in Tilgate Forest, we have not observed any that have a chagreen surface; a negative proof, that the fossil, like the recent trionyx, was destitute of that appendage.

Emydes. Fresh-water Turtles. Pl. vi. fig. 6, 7. Pl. vii. fig 3. In referring some of the bones of the Tilgate beds to this subgenus, we proceed on certain grounds; since the subject has already been elucidated by Baron Cuvier. Among the Sussex fossils which we transmitted to that celebrated naturalist, some years since, were portions of the buckler, or carapace, of the same species as the fragments here delineated. These M. Cuvier determined to belong to a remarkably flat, unknown species of *Emys;* which occurs also in the Jura limestone, in the vicinity of Soleure;* they even corresponded, in size, with a specimen figured in Pl. xv. fig. 6, "Oss. Foss." tome v.; and which, if entire, would have exceeded 20 inches in breadth. Fig. 6, Pl. vi. is evidently part of the breast-plate or sternum, and exhibits the notch for the passage of one of the legs; fig. 7 is, probably, a portion of the carapace; and fig. 3, Pl. vii. a fragment of the osseous border.

The species with smooth plates and ribs are by far the most abundant in the Tilgate strata; but, from our not having been so fortunate as to discover any united portions of the upper shell, we cannot, in every instance, determine whether the specimens presented to our notice belong to fresh-water, or marine sub-genera. The opinion of M. Cuvier is decisive as to the existence of an Emys in these deposits; and, from the details we shall now offer, that of a marine turtle is more than problematical.

Cheloniæ, or *Marine Turtles*. Pl. vi. fig. 2. Pl. vii. fig. 1, 2, 5, 8. Ribs with a smooth surface, of nearly an equal width throughout, with pointed, striated extremities, and marked with impressions of scales; portions of a smooth

* The specimens at Soleure are associated with the jaws and teeth of Spari, and other fishes; Terebratulæ, Echini, and other marine exuviæ.

osseous border; and sternal plates with radiated or dentated margins, are the remains we propose to refer to this subgenus.

The fragment, Pl. vi. fig. 2, possesses the striated projecting extremity, so characteristic of the ribs of the *cheloniæ;* but as it is not connected with an osseous margin, it might be supposed to belong to the trionyx. From this division of turtles it is, however, separated by its smooth surface, and the impressions of scales.* Figs. 1, 2. Pl. vii. are also of this species; *a. a.* fig 2, mark the pointed extremities of two ribs, which, from the form of the portion of the osseous border adhering to them, are probably the first and second ribs of the left side; the inner surface alone is seen in the drawing. Figs. 5, 8, Pl. vii. are either the second or third sternal plates, and exhibit the curvature for the passage of the paws. The marine turtles have the plates of the breast-plate lobed and dentated, as in fig. 8; and we have very recently obtained a fine example of the third sternal plate of a turtle, from Tilgate, in which the dentated margin closely resembles that of the *Testudo imbricata,* or T. *carinata,* and of the fossil species found at Mæstricht.† We have also part of a shoulder-bone, which is very like that figured in Pl. xiv. fig. 6. *Ossemens Fossiles,* tome v.‡ The specimen delineated, in fig. 6, Pl. vii. also bears a greater affinity to the shoulder-bones of a marine turtle, than to those of a land or fresh-water species. *a.* is the coracoid process; *b.* the process, which, if perfect, would form part of the humeral articulation; and 6. is placed near the extremity of the omoplate. Pl. xiv. fig. 7, is a fragment of the pelvis of a small turtle.

Our cabinet contains numerous other fragments of the carapace, ster-

* Mr. Clift, Curator of the Museum of the Royal College of Surgeons, obliged us by comparing this specimen with the recent skeletons in the Museum, and informed us that it resembled the third rib of *Testudo imbricata.*

Burtin *(Oryctographie de Bruxelles,)* figures the extremity of a rib, very like this fossil: and as M. Cuvier has referred the turtles of Melsbroeck to the Emydes, we at first entertained doubts whether our appropriation of this specimen, to the *cheloniæ,* were correct. Mr. Clift's remark, however, tends to confirm the opinion that it belongs to a marine turtle; and we are not aware, that the ribs of the recent Emydes possess such a character.

The largest ribs in our cabinet must have belonged to a turtle about 34 inches in length.

† Oss. Foss. Pl. xiv. fig. 3. Tome v.

‡ In Pl. xix. fig. 11 of this work, an outline of the shoulder-bone of a marine turtle is delineated.

num, ribs, humerus, clavicle, &c. but none sufficiently perfect to throw any additional light upon our investigations. From what has been advanced, we may, however, infer, that the strata of Tilgate forest contain the remains of at least *three* very distinct kinds of turtles; viz.

1st. A fresh-water species, allied to the *Trionyx*.

2dly. An unknown species of *Emys*, resembling a fossil fresh-water turtle, found in the Jura limestone.

3dly. A marine species belonging to the subgenus *Chelonia*, and related to the fossil turtle of Mæstricht.

Saurian Animals, or Lizards. Of the family of the Saurians, the bones, teeth, and scales, of at least four genera of gigantic species, have been discovered in the strata of Tilgate Forest, namely Crocodile, Plesiosaurus, Megalosaurus, and Iguanodon; but hitherto no connected portions of their skeletons have come under our observation. The teeth, both in form and structure, present such striking differences, as to be readily distinguished from each other, and from those of existing species; but the bones possess so many characters in common, that when we consider the broken and detached state in which they occur, and their intermixture with the debris of turtles, of vegetables, of fishes, and of shells, the difficulty of the attempt to identify the bones of the respective animals, seems almost insurmountable to observers so distant from any collection of comparative anatomy as ourselves. We therefore claim the indulgence of the reader, should the results of our investigations appear to be in some respects inconclusive and unsatisfactory; since, under such circumstances, rigorous conclusions must not be expected. We shall first describe the teeth, and such of the bones, as are referrible, with but little doubt, to one or other of the above-mentioned genera; and afterwards notice those osseous remains, which we are unable to appropriate with any degree of certainty or probability.

Crocodile. The remains of Crocodiles have been found in all the secondary formations of England, from the Oolite to the chalk, inclusive; and also in the tertiary deposits. Their existence in the Hastings formation was first noticed in the former volume of this work; and imperfect as were the specimens then in our possession, we expressed our conviction that they approached very nearly to the crocodile with concave vertebræ, found at Havre. M. Cuvier, in the new edition of his immortal work, confirms our conjectures, and also states, that the bones in question are almost identical with the fossil crocodile of Caen,* which belongs to the *Gavials*, a subdivision of the genus, characterized by the narrow, elongated, almost cylindrical jaws, which form an extremely lengthened muzzle. The teeth of the crocodile are distinguished by their conical form, striated surface, and lateral edges, but more particularly by their internal structure. They never become solid, but consist, as it were, of a series of cones enclosed within each other (see figs. 7, 12, Pl. v.); the outer cone, or old tooth, being burst by the pressure of the included one, on the latter increasing in size. Hence, at whatever age a tooth is removed, we find, either in the socket, or in the cavity of the tooth, a small tooth ready to occupy the place of the old one, when the latter is destroyed by age or accident. This succession is repeated very frequently; and it is from this cause, that the fossil teeth of these animals are always so sharp, and well defined; for, although larger when old, they are not less perfect than in the young state. The lateral ridges are placed anteriorly and posteriorly, as shewn in the fossils fig. 1, 2, 3, Pl. v.

Teeth of the *Gavial* of *Tilgate Forest*. These will be found to present all the essential characters of the teeth of the recent crocodile; but they

* The presence of Crocodilian remains in the Lias is not at present positively determined. Mr. Conybeare observes, that "the bones from Whitby are of the Ichthyosaurus, and Plesiosaurus." *(a)* Crocodiles' teeth and bones occur in the Stonesfield slate, Purbeck limestone, &c. and in the Hastings formation: we have not observed them in the Weald clay, Shanklin sand, nor in the Galt; but they are found, though very rarely, in the lower chalk. In the autumn of 1825, Mrs. Mantell discovered the teeth, and fragments of the jaw, of a crocodile, of large size, in the grey chalk at Dover. M. Cuvier mentions, as a solitary instance, a crocodile's tooth in chalk from Meudon, which agrees in its curvature with those from Dover. It should be remarked, that there are occasionally found in the chalk, fishes' teeth of a conical form, and longitudinally striated, which, from their external appearance only, might be taken for those of crocodiles; but an examination of their internal structure readily distinguishes them. Mr. Parkinson describes the remains of a crocodile found in the London clay at Hackney, in which the vertebræ were concavo-convex, as in the recent species. *(b)*

(a) Parkinson's Introd. Org. Rem. p. 387. *(b)* Ibid. p. 286.

are more obtuse than those of the crocodile of the Nile, and resemble the teeth of the second species of the fossil crocodiles of the Jura limestone, described by Baron Cuvier, vol. v. p. 142, *Oss. Foss.* But others are more slender, and possess a greater degree of curvature, bearing a close analogy to those from Caen. In Plate vii., the principal varieties from Tilgate Forest are represented of the natural size: figs. 1, 2, 3, 7, 10, 12, are the obtuser kinds, resembling those of the Jura Gavial; figs. 5, 6, 8, are more slender, and have a greater curve, approaching very nearly to those of Caen; figs. 5, 8, are very like the teeth of the recent crocodile of the Ganges.* The largest specimens in my possession, must have belonged to an animal between 20 and 30 feet long.

Scales of a Gavial? Strong, thick scales, of a dark-brown colour, and possessing a high polish, are very abundant in the Tilgate strata; those with bifurcating processes of attachment, we have assigned to the fish with hemispherical teeth; but there are others of a different form (fig. 3, Pl. v.) which we compared with the scales of a living alligator, and found them to resemble those which covered the legs of that animal. The scales of the fossil crocodile of Caen, are described as being very thick, rectangular, thin towards the edge, and having the outer surface covered with little pits or hollows; we have not observed any with the characters here described, in the strata of Tilgate Forest.

Vertebræ. In the recent crocodile, the vertebræ are convex posteriorly, and concave anteriorly; but those from Tilgate, like the vertebræ of the crocodile of Caen, and of one of the species of Havre, are, with but very few exceptions, slightly concave at both extremities. It may, perhaps, be observed, that in the animals of this tribe, the epiphyses of the bones are cartilaginous in the young individuals, and that this circumstance may, in many instances, have given rise to this appearance: and we have ourselves remarked, among some detached crocodilian bones, sent by Sir Thomas Stamford Raffles to the College of Surgeons, vertebræ destitute of the convex articulating face, from this cause. But this character is too con-

* We compared these fossils with the teeth of a crocodile from the banks of the Ganges, preserved in the museum of the East India Company, and could not detect any essential difference. Figs. 25, 26, 27, 30, Pl. x. tome v. Cuvier's "Ossemens Fossiles," represent teeth of the Tilgate Gavial.

stant in the fossil vertebræ to be the result of such a circumstance, and can only have been produced by original conformation. Since the plates were completed, we have discovered several cervical, and more perfect examples of the dorsal, and lumbar vertebræ, than those represented; but they do not present any characters sufficiently distinct to serve as specific differences. The vertebræ are more contracted in the middle than those of the recent species, and are generally more or less compressed laterally; the last mentioned form, has evidently been produced by the pressure of the strata, when the bones were in a softened state. The caudal vertebræ, as in all the other lacertæ, are, of course, by far the most numerous. A dorsal vertebra of a young crocodile, is figured Pl. xvii. figs. 22, 23: *a.* marks the spinous process: *b. b.* the lateral processes: *c.* the medullary canal. Two caudal vertebræ, probably from the middle of the tail, are delineated Pl. ix. figs. 1, 7: *a. a.* the transverse processes: *b.* spinous process: *c. c.* articulating apophyses; *d.* situation of the spinal canal. Pl. ix. fig. 8, is one of the caudal vertebræ, towards the extremity of the tail; and fig. 21, Pl. xvii., from its elongated form, must have been within a few of the end. Pl. x. fig. 1, is a middle caudal vertebra, in which the annular part is wanting; the vertebræ of the tail are very often found in this state.

Ribs. Many of the ribs found in the Tilgate beds are decidedly those of crocodiles; fig. 5, Pl. xi. represents a fragment of a small one; *b.* denotes the tubercle that articulates with the body of the vertebra; and *c.* the situation of the part which unites with the transverse process. In the fragment, fig. 7, Pl. xiii. the double head of a rib is distinctly shewn.

Bones of the extremities. These, for the most part, occur in so mutilated a state, that but few examples can be identified with certainty. *Humerus?* Pl. xv. fig. 1, is the upper part, probably, of the humerus; *a.* denotes the head of the bone; *b.* an eminence or tubercle; *c.* the fractured part; *d.* a depression that extends towards the end of the bone. From the fine state of preservation in which this specimen occurs, there could be no difficulty in determining, with certainty, the place it held in the skeleton, if we had but an opportunity of comparing it with the bones of the recent animal; but, without so indispensible a guide, we are even doubtful whether this bone may not be part of the femur.

Radius: fig. 5, Pl. xiii. is probably the humeral; and fig. 4, the carpal extremity; the grooved appearance at *a.* is produced by the separation of the epiphysis. Fig. 3 is also a fragment of a radius: at *a.* the medullary cavity is seen filled with white calcareous spar.

Tibia. Of this bone we have several examples. Fig. 6, Pl. xiii. represents the head of a tibia; the cartilage or epiphysis being absent, occasions its peculiar form.

Metacarpal or Metatarsal bones. These resemble the bones of mammalia, and, in fact, cannot be readily distinguished from them: we have many examples, which, from their slightly depressed form, there is reason to conclude belonged to crocodiles. We have also a nail, or claw, apparently of this animal.

Os frontis. We have reserved for this place, a notice of the small bone (Pl. viii. fig. 8,) which, imperfect as it is, and partly obscured by the stone, bears a striking resemblance to the frontal bone of a small crocodile, about two feet in length, from the gypsum of Montmartre:* the inner surface only is exposed, and exhibits a channel which, if our conjecture be correct, formed the passage of the olfactory nerve to the nose; on the upper part, the orbital arches are seen. Fig. 9, Pl. viii. represents a bone, which appears also to be the os frontis of a species of gavial: 9 *a** gives a posterior view, and shews two semilunar arches, which are probably portions of the orbits: we are not, however, acquainted with any fossil, or recent species, with a frontal bone of this form. From the above remarks, it appears that the strata of Tilgate Forest contain the remains of at least two, if not four, species of crocodiles: that one of these (that with slender curved teeth,) resembled the gavial of Caen, and probably was about twenty-five-feet in length; and the other, with obtuse teeth, the fossil crocodile of Jura.

Megalosaurus Bucklandii. Of this gigantic animal, whose remains were first discovered by Dr. Buckland in the slate of Stonesfield, the teeth, ribs, vertebræ, and other bones, have been found in the strata of Tilgate

* Cuvier, "Oss. Foss." Tome iii. Pl. 76. fig. 8. See also Pl. xix. fig. 19 of this volume.

Forest; the teeth occur also in the Purbeck limestone.* No connected part of the skeleton has been discovered, with the exception of part of the vertebral column, consisting of five anchylosed vertebræ; and a magnificent example of a portion of the lower jaw, with several teeth remaining in their sockets. The bones which Dr. Buckland appropriates to the Megalosaurus, besides those above mentioned, are a perfect femur; a coracoid bone; ribs; a clavicle; fibula; and a metatarsal bone; but, as M. Cuvier remarks, since these bones were found promiscuously intermingled with those of crocodiles and other oviparous reptiles, it is simply from their being discovered in the same stratum, and from their zoological characters, that we conclude they belong to the same kind of animal; a conclusion, which, as we shall hereafter have occasion to remark when treating of the Iguanodon, must not be regarded as unequivocal.

Teeth. Pl. x. fig. 13. Pl. ix. 2, 3, 6. Pl. xix. 1, 2. The teeth of the Megalosaurus are compressed laterally, and slightly recurved backwards; their edges are finely serrated, the anterior edge being much thicker than the posterior, which is very sharp and thin. They bear a great analogy to the teeth of several species of the recent Monitors; and the structure of the jaw of the Megalosaurus indicates,† also, a strong affinity to the animals of that genus. In the jaw found at Stonesfield,‡ (see Pl. xix. fig. 1,) the teeth

* The Stonesfield slate, according to Professor Buckland, belongs to the middle beds of the Oolite; but M. Prevost, a most intelligent and scientific French geologist, who has carefully examined the strata around Oxford, has expressed his doubts whether the geological situation assigned to those beds by the distinguished and learned professor be correct; and his conviction that a more rigorous and careful investigation of the surrounding strata is necessary, before their geognostic position can be considered as unequivocally determined. M. Prevost has published his remarks in the Annales des Sciences Naturelles, (for April, 1825,) and takes occasion to notice the striking analogy existing between the organic contents of the Stonesfield slate, and Tilgate stone. This fact was particularly mentioned in our first volume; and subsequently noticed by Professor Buckland, in his memoir on the Megalosaurus. M. Prevost has evidently misunderstood our remarks upon this singular coincidence; and appears to suppose, that from the general resemblance of the fossils of the strata in question, we believe these beds to be portions of the same formation, and that the Tilgate strata are a protrusion or hillock of the Stonesfield slate: if such be the opinion of the learned geologist, it is erroneous, as will appear by a reference to vol. i. page 59. It seems to have originated from his having supposed that the terms *Purbeck* strata and *Stonesfield* slate were synonymous.

† Vide Oss. Foss. tome v. Pl. xvi. p. 276.

‡ To render this description more intelligible to the general reader, outlines of the bones of the Megalosaurus, described by Dr. Buckland in the Geological Transactions, (New Series, Vol. i.) are given in Plate xix.

are lodged in distinct alveoli, and do not adhere, as in the monitors, to the substance of the jaw, by any incorporation of the root, or sides. In this respect they agree with the crocodile, but the outer edge of the jaw rises almost an inch above the inner margin, forming, as it were, a continuous lateral parapet to support the teeth externally, after the manner of the monitors. A series of triangular plates of bone arises from the inner edge, and constitutes a zig-zag buttress internally; and from the centre of each plate, a bony septum passes across to the outer parapet, by which the alveoli are formed. The new teeth rise in the angle between each triangular plate. None of the recent saurians have an analogous structure: in the monitors there is no inner alveolar ridge; the new teeth are formed in the substance of the gums between the bases of the old teeth: and they have no alveoli. The iguanas, which have the outer parapet very high, extending half way up the teeth, are also destitute of any internal osseous border. (see Pl. xx. fig. 5, 6.) Hence it may be inferred, that this monster of the ancient world, belongs to an extinct genus of saurians, which partook of the characters of the crocodile and monitor; but was most nearly related to the latter.* From the straitness of the portion of the jaw found by Dr. Buckland, which is eleven inches long, it is evident that the jaws must have terminated in a flat, strait, and very narrow snout.

Vertebræ.† These differ from the vertebræ of any known recent monitors, but bear a great resemblance to those of the fossil crocodiles of

* The teeth are hollow in the young state, but become solid by age; from their structure, the original was evidently a voracious animal.

† In by far the greater part of the lizards of the ancient world, the vertebræ are more or less concave at both faces; and these characters are so constant, and so remarkably distinct from those of existing species, that we cannot but infer that this peculiar structure was required by the condition of the earth, at the time when these ancient saurian animals made it their abode. Linck observes, that the primitive world had probably seas more vast, and lakes and marshes more extensive, than those of the present day. The number of aquatic animals buried in the earth, is incomparably greater than that of terrestrial animals; and even the structure of the latter indicates that they lived in marshes. The vast numbers of Tapirs of the ancient world, probably lived like the living species, in marshy forests. The palms, and arborescent ferns, associated with these animal remains, delight in fens and bogs. Even if the correctness of these facts be questioned, still there cannot be a doubt, from the immense number of aquatic animals enclosed in the secondary formations, that the water once covered a much more considerable portion of the surface of the globe than it does at present. The structure of the vertebral column of the ancient lizards even, as we have above remarked, approaches more nearly to that of fishes, than to that of the recent saurians; the name of *ichthyosauri* would, in fact, apply to the greater part of the extinct genera.

Tilgate Forest, Havre, Caen, &c. They are generally a third longer than wide; slightly concave at both extremities; and more or less contracted in the middle; their annular part is united to the body by a suture, as in the crocodile, and monitor; but there is a considerable lateral depression immediately beneath the annular part. Fig. 11, Pl. ix. represents a very fine lumbar vertebra of this animal, from Tilgate; it will be found to correspond in every respect with those from Stonesfield. (fig. 16, Pl. xix.) *d.* marks the spinal canal; and *e.* the suture which unites the body with the annular part of the vertebra. It must, however, be confessed, that our knowledge of the osteological structure of the Megalosaurus, is at present too limited to enable us to determine the distinguishing characters of its vertebral column.

Coracoid bone. Fig. 8, Pl. xix. This bone alone is sufficient to prove that the original animal was entirely distinct from the crocodiles, and approached very nearly to the monitors, and iguanas. It differs, however, from the corresponding bone of existing species: the original is upwards of *two feet* in length.

Ribs, and supposed Pelvis. The ribs which Dr. Buckland has appropriated to this animal, have a double articulation like those of the crocodile: but in the ribs of the monitors and other lizards, the spinal extremities are never divided into a head and tubercle; it is, therefore, probable, that the supposed ribs of the megalosaurus may have belonged to the crocodile, with whose remains they are associated; and that the ribs of the former have not yet been observed. Figs. 1, 4, 6, Pl. xi. represent ribs from Tilgate Forest, which are of the same form as the Stonesfield specimens. Fig. 14, Pl. xix. is supposed to be the *pubis:* it is the only bone of the pelvis hitherto discovered.

Extremities. A remarkably perfect thigh-bone was found at Stonesfield, by Professor Buckland, and is represented in Pl. xviii. fig. 2; it is two feet nine inches in length; the medullary cavity is filled with calcareous spar. We have numerous fragments of the femur, from Tilgate forest. The bone fig. 3, Pl. xviii. is twenty-one inches long, and supposed to be a clavicle; we have a most perfect specimen of this kind from Tilgate, which shews that the dotted outline in the figure, intended to convey an idea of its form when entire, is incorrect.—The metatarsal bones present no particular characters.

IGUANODON. The discovery of the teeth and other remains of a nondescript herbivorous reptile, in the strata of Tilgate Forest, a reptile "encore plus extraordinaire que tous ceux dont nous avons connoissance,"* is, to us, one of the most gratifying results of our labours. The first specimens of the teeth were found by Mrs. Mantell, in the coarse conglomerate of the Forest, in the spring of 1822;† and we have, subsequently, collected a most interesting series, displaying every gradation of form, from the perfect tooth in the young animal, to the last stage, that of a mere bony stump, worn away by mastication. These teeth are comparatively rare; and the only locality in which they have hitherto been noticed, is in the immediate vicinity of Tilgate Forest: they have not been discovered in any other part of England. Their external form is so remarkable, and bears so striking a resemblance to the grinders of the herbivorous mammalia, that when the tooth figured in Pl. xiv. fig. 14, first came under our notice, its analogy to the incisors of the rhinoceros, led us to suspect whether the deposit in which it was found might not be of diluvial origin. Subsequent discoveries proved that these teeth belonged to an unknown herbivorous reptile; but their structure was so extraordinary that we determined to obtain, if possible, the opinion of Baron Cuvier upon the subject. We accordingly transmitted specimens to our kind friend Mr. Lyell, who was then residing in Paris, and by whom they were presented to that illustrious naturalist. M. Cuvier favored us with the following remarks on the fossils submitted to his examination. "Ces dents me sont certainement inconnues; elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la couche mince d'émail qui les revêt, à l'ordre des reptiles; à l'apparence extérieure on pourrait aussi les prendre pour des dents de pois-

* Cuvier, Oss. Foss. Tome v. 2nd part, p. 351.
† See Vol. i., p. 54. No. 40, 41.

sons analogues aux tetrodons, ou aux diodons; mais leur structure intérieure est fort différente de celles là. N'aurions-nous pas ici un animal nouveau, un reptile herbivore ? et de même qu' actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étoient les seuls animaux terrestres, les plus grands d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possidez appartiendrait à cet animal, unique jusqu'à présent dans son genre. Le tems confirmera ou infirmera cette idèe, puisqu'il est impossible qu'on ne trouve pas un jour une partie du squelette réunie à des portions de mâchoires portant des dents. Si vous pouviez obtenir de ces dents adhérentes encore à une portion un peu considérable de mâchoire, je crois que l'on pourrait résoudre le problème." In the second part of the fifth volume of the *Ossemens Fossiles*, the learned author figures several of these teeth, and minutely describes their form and structure.* From the resemblance of the perfect specimens to the teeth of certain species of Iguana, we proposed to distinguish the fossil animal by the name of *Iguanodon;* and a memoir on the extraordinary dentature of the original was read before the Royal Society, and honored with a place in its transactions.† The following description presents a condensed view of M. Cuvier's observations, and our own.

In the perfect teeth, and in those which have been but little worn, the crown is somewhat of a prismatic form; widest and most depressed in front; convex posteriorly, and rather flattened at the sides. As soon as the tooth emerges from the gum it gradually enlarges, and its edges approach each other and terminate in a point, making the upper part of the crown angular; the edges forming the sides of this angle are deeply serrated, or dentated; see Pl. iv. fig. 1, Pl. xvii. fig. 11, 16. The outer surface of the crown is covered with a thick enamel, but on the sides and back, a thin coating of this substance only appears, as in the incisors of the gnawers. The anterior surface is divided longitudinally into three or more slightly concave

* Oss. Foss. Vol. v., p. 350.

† "Notice on the Iguanodon, a newly-discovered fossil herbivorous reptile, from the sandstone of Tilgate Forest, in Sussex." *Philosophical Transactions,* 1825, part 1.

parts, by obtuse ridges, of which the most prominent one is situated rather towards one side; in figs. 8, 10, 11, 13, 14, 16, Pl. xvii., this character is strongly developed. In the young teeth, seldom more than one ridge occurs, dividing the surface into two unequal parts; but in some examples, several finer lines are observable: a specimen of the former is shewn in Pl. xiv. fig. 1, and of the latter variety, in the same plate, figs. 4, 7. The shank, or fang of the tooth, partakes of the form of the crown; it is slightly curved, rather flat anteriorly, and convex posteriorly, and much depressed at the sides; it gradually diminishes in size towards the base. The magnitude of the teeth is shewn by the drawings, all of which are of the natural size: we have a young and almost perfect tooth, in our possession, which is two inches and a half in length; being twelve times the length of the teeth of the recent Iguana: the largest specimens figured, are twenty times larger than the teeth of that animal. All the teeth we have noticed, possess traces of the characters above described; the vast difference of form they exhibit, depending on a cause which we shall now proceed to explain. In the elegant specimen, fig. 10, Pl. xvii. we perceive the first variation from that angular form, which we have already stated to have been the original shape of the crown; and if we observe the internal surface at *b*, we see that the point of the tooth has been partially worn away, leaving an oblique triangular surface: if the reader compare this appearance with the convex surface of the perfect tooth, fig. 11, *b*, he will form a correct idea of the change that has taken place. In a series of specimens, this wearing away of the crown of the teeth may be observed in every stage, from the slight appearance perceptible in fig. 10, Pl. xvii. to figs. 14, 15, 13, 6, 1, 4, 7, and 5, in which the entire angular part of the tooth and its dentated edges disappear; it is in this state that the teeth so much resemble the incisors of the Rhinoceros. If we trace the effects of this operation still farther, we find it going on as in Pl. xvii. figs. 2, 3, 19, till it reaches its maximum in fig. 18, which is merely a bony plate, without a fang, and with but a slight portion of enamel remaining on the anterior part. The process by which these changes have been effected, is clearly that of mastication. So soon as the tooth performs its part in that operation, its point is, by degrees, worn away, till, by little and little, the serrated edges disappear, and the tooth assumes a truncated form; the masticating surface gradually becomes larger, and is always oblique, (because the anterior coat of enamel is, from its superior thickness, less used than the rest of the tooth,) till the tooth is worn down to the gum. During these changes in the crown of the tooth, the fang is suffering destruction from another, but not less certain, process. A new tooth is formed at the base of the old one, which increasing in size, occasions the absorption of the fang of the latter, till at length, when it is sufficiently developed, it displaces its predecessor, and occupies its place. The gradual progress of this change is shewn in Pl. xvii. fig. 9, *a.*; and in figures 1, 5, 3, 2, 19, in which the impression of the new tooth, or *dent de remplacement*, is marked *c.*

The teeth are hollow in the young animal, but become solid, almost throughout, in the adult state. Pl. xvii. fig. 6, shews a transverse section of a fang which is quite solid: 15 *a.* part of the crown, slightly hollow; and fig. 25, a very large fang, the upper part of which is also hollow.

If we attempt to discover, among the recent lizards, a dentature at all analogous, we shall find among the Iguanas alone any kind of resemblance; yet even here, we cannot fail to remark, that in this, as in every other instance, if there be a general analogy, there are, also, striking and important differences, in the structure of the primitive animals of our planet, and of those which are its present inhabitants. Of the Iguana, there are several species; but the only skull we have had an opportunity of examining, is that of an individual from Barbadoes, we believe of *I. tuberculata.** Fig. 6, Pl. xx. is a view of the inner surface of the right side of the upper jaw of this animal, of the natural size; and which is magnified four diameters

* "Oss. Foss." Vol. v. Pl. xvi. figs. 24, 25.

The Iguanas are natives of many parts of America and the West India Islands, and are rarely met with any where north or south of the tropics. They are from three to five feet long, from the end of the snout to the tip of the tail. They inhabit rocky and woody places, and feed on insects and vegetables. Many of the Bahama islands abound with them; they nestle in hollow rocks and trees: their eggs have a thin skin like those of the turtle. Though they are not amphibious, they are said to keep under water an hour. When they swim, they do not use their feet, but place them close to their body, and guide themselves with their tails; they *swallow all they eat whole.* They are so impatient of cold, that they scarcely appear out of their holes, but when the sun shines. *Shaw's Zoology*, Vol. 3. p. 199.

at fig. 5.* The teeth are slightly convex externally, and have a ridge down the middle; they are slightly concave on the inner surface; different views of the crown of a tooth are seen, largely magnified, in fig. 4, Pl. xvii. In the angular form of the crown, and its serrated edges, they strikingly resemble the fossil, fig. 11, of the same plate. The new teeth are formed at the bases of the old ones, and lie in a depression at the root of the fang, as is beautifully shewn in the magnified drawing, fig. 5. The jaw throws up a lateral parapet on the outside of the teeth; but they have no alveoli, nor any internal protection but the gum. From the above observations, it appears that the fossil teeth bear a greater analogy to those of the recent Iguana, both in their form, and in the process by which dentition is effected, than to those of the crocodiles, monitors, and other living saurians. But, notwithstanding this general resemblance, the remarkable characters resulting from the act of mastication, separate the original animal from all known genera. None of the existing reptiles perform mastication; their food or prey is taken by the teeth or tongue, so that a moveable covering of the jaws, similar to the lips and cheeks of the mammalia, is not necessary, either for confining substances subjected to the action of teeth as organs of mastication, or for the purposes of seizing or reaching food.† The herbivorous amphibia gnaw off the vegetable productions on which they feed, but do not chew them. Now "as every organic individual forms an entire system of its own, all the parts of which mutually correspond, and concur to produce a certain definite purpose by reciprocal reaction, or by combining towards the same end," it follows from the peculiar structure of the fossil teeth alone, that the muscles which moved the jaws, and the bones to which they were attached, were widely different from those of any of the living lizards; and, consequently, the form of the head of the Iguanodon must have been modified by these causes, and have differed from those of existing reptiles. Since the vegetable remains with which the teeth of the Iguanodon are associated, consist principally of those

* We are indebted to the kindness of Mr. Clift, for the original drawings of these parts of the recent Iguana.

† "Rees Cycloped." art. Reptiles.

tribes of plants that are furnished with tough thick stems, and which, probably, were the principal food of the original animal, we may be permitted to remark, that this peculiar structure of the teeth seems to have been required, to enable the animal to accommodate itself to the condition in which it was placed. Hereafter, perhaps, some more fortunate observers may discover a portion of the head or jaw, and be able to confirm or refute our conjectures.

Bones, supposed to be referrible to the Iguanodon.—We have already stated, that no united portion of the skeleton of this animal has been discovered: and since the bones of other gigantic reptiles are entombed with those of the Iguanodon, the attempt to identify the latter must not, of course, be regarded as affording positive conclusions.

Vertebræ.—Pl. x. fig. 12, Pl. xii. figs. 1, 3, 4. With the able assistance of the Rev. W. D. Conybeare, we examined our collection of vertebræ from Tilgate Forest, and after having separated those that appeared to belong to the Crocodile, Plesiosaurus, and Megalosaurus, (or, rather, which resembled those from Stonesfield,) several enormous vertebræ remained, which corresponded with each other, but differed from any we had previously noticed. Fig. 12, Pl. x. represents one of these specimens imbedded in a block of sandstone; and fig. 3, Pl. xii. another example detached from its matrix. The faces of the bodies of these vertebræ are almost flat on one side, and slightly depressed on the other; and are obscurely quadrangular. The spinous and lateral processes are very strong and thick. There is not that deep depression beneath the annular part of the vertebræ, which is observable in those of the Megalosaurus. From their enormous magnitude, and from the circumstances above stated, we are induced to refer them to the Iguanodon, the only other gigantic lizard of the Tilgate strata. We have one sacral vertebra, which is almost identical with that of the monitor,* except that the body is slightly concave on both faces; this bone, if perfect, would measure ten inches, from the extremity of one transverse process to the other. Some of the detached processes in our possession in-

* Oss. Foss. Vol. v. Pl. xvii. fig. 27.

dicate vertebræ of enormous proportions.* Our cabinet contains three very small vertebræ, which are anteriorly concave, and posteriorly convex, as in the recent Iguana; and these, with the exception of the vertebræ of the Mæstricht animal,† are the only instances of such a structure we have met with in the fossils of Sussex. A *Chevron-bone*, of a magnitude corresponding with the largest of the vertebræ, is figured in Pl. xii. fig. 4. A *Coracoid-bone*, about 14 inches long, more nearly resembling the coracoid process of the recent Iguanas than the Stonesfield specimen.‡

Ribs. A flat rib, very like that of an ox; fig. 2, Pl. xi. The bone represented figs. 1, 2, Pl. xvi., is, perhaps, a rib also, but it is too imperfect to admit of positive determination; its enormous magnitude proves that it must have belonged either to the Iguanodon, or Megalosaurus: the drawing is only one half the size of the original.

Extremities. Fragments of thigh-bones, of a monstrous size, are occasionally found in the sandstone of the Forest. To convey some idea of their enormous magnitude, we have figured, in Pl. xviii. fig. 1, a portion of a femur, which is no less than 23 inches in circumference! Were it clothed with muscles and integuments of suitable proportions, where is the living animal, with a thigh that could rival this extremity of a lizard of the primitive ages of the world?

Metatarsal bones. Some of these are so large that they appear more like the bones of mammoths or elephants, than of reptiles. M. Cuvier, with his usual candour, observes "des fragments d'os du métacarpe ou du métatarse sont si gros, qu'au premier coup d'œil, je les avois pris pour ceux d'un grand hippopotame."§ A very perfect metatarsal bone is delineated in Pl. xvii. figs. 28, 29; and another in Pl. xiv. figs. 4, 5; the former, probably belonged to the second phalanx; and the latter to the third or fourth. We have one bone of this kind, of the following gigantic proportions:

* A spinous process, probably, of a caudal vertebra, is ten inches long; the extreme strength and thickness of another is shewn in fig. 1, Pl. xii.

† See Vol. i. Pl. xli. fig. 3, page 242. ‡ See Pl. xix. fig. 8. § "Oss. Foss." Vol. v. p. 350.

Length of the bone 4½ inches.

Circumference of the largest *(tarsal)* extremity, 13 inches.

We have shewn that the teeth of the Iguanodon are, at least, twenty times larger than those of the Iguana; that the thigh-bone is of equally enormous proportions; and were we to calculate the probable magnitude of the original, from the data which this metatarsal bone affords, our readers might well exclaim that the realities of Geology far exceed the fictions of romance. Even if we admit, what is, indeed, probable, that the linear dimensions of the extinct and living animals were not of the same relative proportions, still it must be allowed that the Iguanodon was one of the most gigantic reptiles of the ancient world; and a colossus in comparison to the pigmy alligators and crocodiles that now inhabit the globe.*

Horn of the Iguanodon. We have now to request the reader's attention to a very remarkable appendage, with which there is every reason to believe the Iguanodon was provided. This is no less than a *horn*, equal in size, and not very different in form, to the lesser horn of the Rhinoceros. This unique relic is represented of the natural size, Pl. xx. fig. 8. It is externally of a dark brown colour; and while some parts of its surface are smooth, others are rugous and furrowed, as if by the passage of blood-vessels. Its base is of an irregular oval form, and slightly concave. It possesses an osseous structure, and appears to have no internal cavity. It is evident that it was not united to the skull by a bony union, as are the horns of the mammalia. The nature of this extraordinary fossil was for some time unknown; and it is to the discrimination of M. Pentland, to

* The interesting discoveries of Mr. Murchison, in the extreme western point of the Tilgate beds already alluded to, must not be unnoticed here. That gentleman discovered at Headfold-wood Common, a femur, (probably of the Iguanodon,) three feet seven inches long; and several caudal, lumbar, and sacral vertebræ. Some of the last-mentioned were transmitted to Baron Cuvier, who made the following remarks upon them. "They are probably the remains of a new species of large saurian, for I am not acquainted with any thing similar amongst either recent or fossil reptiles; nevertheless, as Mr. Mantell has not yet found, that I am aware of, the different parts of the skeleton of the *Iguanodon*, and the strata in which these bones occur, appear to be a continuation of those of Tilgate Forest, I think it not impossible, that some of these vertebræ may have belonged to that animal." We have not space to admit of a detailed account of the bones which are figured, and described by Mr. Murchison, in his valuable memoir; and shall therefore only remark, that the vertebræ, femur, &c. are decidedly analogous to many of those we have discovered in Tilgate Forest, and belong either to the *Iguanodon*, or *Megalosaurus*. See *Geolog. Trans.* New Series, Vol. ii. p. 104.

whom a cast of it was shewn by Professor Buckland, that we are indebted for the suggestion that it probably belonged to a saurian animal. It is well known that some reptiles of that order have bony or horny projections on their foreheads; and it is not a little curious, that, among the Iguanas, the horned species most prevail. The *Iguana cornuta*, which is a native of Saint Domingo, resembles the common Iguana in size, colour, and general proportions; on the front of the head, between the eyes and nostrils, are seated four rather large, scaly, tubercles; behind which rises *an osseous conical horn, or process, covered by a single scale.** That our fossil was such an appendage, there can be no doubt; and its surface bears marks of the impression of an integument by which it was covered, and probably attached to the skull. This fact establishes another remarkable analogy between the Iguanodon, and the animal from which its name is derived.

Plesiosaurus. The vertebræ, teeth, and other bones of this extraordinary genus, whose osteology has been so admirably and so fully described by M. Conybeare,† occur in the strata of Tilgate Forest. The vertebræ agree with those from the Lias, but whether they belong to a new species, or to one of those already described, cannot at present be determined. A dorsal vertebra is figured, Pl. ix. fig. 5; a cervical, fig. 4; and a larger cervical, fig. 20, Pl. xvii. The tooth fig. 11, Pl. v. possesses the curvature, and finely striated surface, of those of the Plesiosauri. We have portions of humeri and other bones, which appear to have belonged to these animals.

* Shaw's Zoology, Vol. iii. Part i. p. 203.

† *Geological Transactions*, Vol. v., and Vol. i., New Series. It may be interesting to the general reader, to state that the *Plesiosaurus*, and *Ichthyosaurus*, are two genera of fossil animals, supposed to have been oviparous, and to belong to the family of the saurians, but differing very essentially from all existing species, and in such particulars as evidently must have fitted them to live entirely in the sea. Their vertebræ are deeply cupped like those of fishes, and are as thin as those of the shark, so as to admit of a vibratory motion of the tail to assist progression. The extremities terminate in four paddles, composed of a series of flat polygonal bones, greatly exceeding in number, even the phalengic cartilages of the fins of fishes. The most wonderful animal of this division is the *Plesiosaurus dolichodeirus*, or long-necked plesiosaurus; the neck of this animal is equal to half the entire length of the body and tail united, and is composed of 35 vertebræ: the back of 27, and the tail of 28; making a total of 90. The head is so small, that its length is not more than a fifth part of that of the neck.

Bones whose characters are not determined. Pl. vii. fig. 9. Portions of two vertebral spinous processes; *a. a.* mark the edge formed by the annular suture; (of plesiosauri?)

Pl. viii. figs. 2, 4, 5, 12, 15, are probably bones of young saurian animals: fig. 14, appears to be the condyles of a femur.

Pl. ix. fig. 9, 10. To these bones we can find no resemblance in the recent lizards: are they portions of vertebral processes? or of the bones of turtles? Pl. xi. fig. 3, bone of a turtle?

Pl. xii. fig. 2, a thick plate or scale, with a furrow along the middle: turtle?

Pl. xii. fig. 5, the radius of an unknown saurian; *Iguanodon?*

Pl. xiii. fig. 1, is the upper part or head of a bone with a spinous process at *a;* it has a medullary canal which is filled with spar; *c.* Fig. 2, is a bone of a very extraordinary form;—turtle? Fig. 8, the head of a large strong bone, with two articulating surfaces, *a, b:* it is broken at *c.* so that its original form cannot be ascertained. Fig. 9 is a thick triangular bone, which would probably have terminated in a point at *a;* in some respects it resembles fig. 7, Pl. xx.

Pl. xiv. figs. 3 and 6, are different views of a large humerus of a saurian animal; it differs from any with which we are acquainted.

Pl. xv. fig. 8, the form of this humerus is widely different either from the above, or the bone represented in the same plate, fig. 1. Its shortness, thickness, and the extreme width of its cubital articulation, *a*, adapt it for swimming only; and prove that the animal to which it belonged, was an inhabitant of the water. It bears a greater analogy to the humeri of the *Cetaceæ*, than to those of the lizards: Dr. Buckland referred it to the whale, but there are essential differences between the humerus of the latter, and this fossil.* It does not correspond with the humeri of the

* M. Cuvier, to whom this opinion was communicated, obliged us with the following observations on the subject:—

" Quant aux ossemens que vous croyez être de *cétacés*, ils méritent certainement d'être étudiés avec attention, car ce serait la première fois que l'on trouverait des ossemens de ces mammifères dans les formations situées audessous de la craie. Mais il y a des vertèbres de grands reptiles, qui ressemblent si fort à celles de certains dauphins, qu'il est facile de s'y tromper; toujours faudrait-il examiner leur position avec beaucoup de soin, et voir s'il n'y aurait point à cet égard de différence entre known plesiosauri; yet it may possibly belong to a new species of that genus. Among the gigantic vertebræ of Tilgate, there are some which approach in their general form to those of the plesiosauri; but their bodies are concave on one side only, the other face being either flat, or slightly elevated; the largest are above six inches in their longest diameter.

Pl. xvi. figs. 3, 4: two views of the fragment of a very curious bone are here given; but we have searched in vain for something analogous in the skeletons of the recent reptiles. Whether it belonged to any part of the pelvis of a turtle, or was a portion of the coracoid bone of a saurian, we are unable to determine. There appears to have been three articulating surfaces; *(a. b. c.)* the bone is broken at *d*, so that its perfect form is unknown. Fig. 5 is a plate, or scale; but of what animal has not been ascertained.

Pl. xx. fig. 7. We are unable to determine the situation this bone held in the skeleton: at first sight it appears like a portion of the pelvis: *b. b.* might be supposed to be part of the sacrum: *a.* the sacro-iliac junction; and the remainder the left os ileum. We have several fragments of this kind, some of which indicate an animal of a large size.*

Bones of Birds. It is so rarely that the remains of birds are found in a fossil state, that although a few mutilated bones are the only relics of these animals which the strata of Tilgate have hitherto afforded, the fact is too remarkable to be passed by unnoticed. Birds' bones are found also at Stonesfield; and we have copied figures of several of them, from a plate presented to us by Dr. Buckland, (Pl. xix. figs. 3, 4, 5, 7, 10, 13,) to serve as objects of comparison.

ces os de cétacés, et ceux de reptiles. Rien n'empêcherait ce me semble, que dans les couches de sables qui se trouvaient former la surface du sol, la mer ne soit venue, dans ses nouvelles irruptions, apporter des dépouilles nouvelles et les confondre avec les anciennes; mais je pense que soit dans leur position, soit dans leur état physique, on trouvera des différences caractéristiques de l'époque à laquelle ces dépouilles ont étés enfouies."

From these remarks of this illustrious philosopher, we have hesitated to refer the fossils in question to the cetaceæ, until the discovery of more illustrative specimens shall establish or refute their supposed analogy, since, of their geological habitat, there cannot be the slightest doubt.

* Since the plates were finished, we have discovered numerous bones, and fragments of bones, many of which present such singular forms, that it were vain to attempt to convey an accurate idea of them, without the assistance of the artist.

Pl. viii. figs. 1, 18, are portions of the tibia of a bird, probably of a species of *Ardea;* and we have very recently discovered specimens much larger and longer; fig. 3 resembles fig. 3, Pl. xix. and is probably a wing-bone. Figs. 6, 7, are ribs somewhat resembling fig. 10, Pl. xix. Fig. 10, is a very delicate small rib. Fig. 11, is analogous to the upper part of fig. 5, Pl. xix. figs. 16, 17, resemble fig. 7, Pl. xix.

In concluding this description of the organic remains of Tilgate Forest, we would repeat, what we have elsewhere remarked, that the vast preponderance of the land and fresh-water exuviæ over those of marine origin, observable in these strata, warrants the conclusion that the Hastings beds were formed by a very different agent to that which effected the deposition of the Portland limestone below, and the sands and chalk above them. The seas in the primitive ages of our planet were inhabited by vast tribes of multilocular shells, which, however variable in their species, were not only of the same family, but also of the same genera, namely, *Belemnites*, *Ammonites*, and *Nautilites*. These shells, if we may draw any conclusions from our knowledge of the habits of the recent species of the only genus that still exists, were indisputably inhabitants of the ocean; and the presence of their remains, in any considerable quantity in a stratum, affords a fair presumption that such stratum is a marine deposit. The converse of this proposition, we conceive, must hold good in a case like the present, where not a vestige of these ancient marine genera can be traced, among innumerable remains of terrestrial vegetables and animals, and of fresh-water testaceæ. The occasional occurrence of marine exuviæ affords no grounds for a contrary opinion, since this fact is no more than might be expected under such circumstances, and is in strict accordance with what may be observed in the deltas and estuaries of all great rivers.

We cannot leave this subject, without offering a few general remarks on the probable condition of the country, through which the waters flowed that deposited the strata of Tilgate Forest; and on the nature of its animal and vegetable productions. Whether it were an island, or a continent, may not be determined; but that it was diversified by hill, and valley, and enjoyed a climate of a higher temperature than any part of modern Europe, is more than probable. Several kinds of ferns appear to have constituted the immediate vegetable clothing of the soil: the elegant *Hymenopteris psilotoides*, which probably never attained a greater height than three or four feet, and the beautiful *Pecopteris reticulata*, of still lesser growth, being abundant every where. It is easy to conceive what would be the appearance of the valleys and plains covered with these plants, from that presented by modern tracts, where the common ferns so generally prevail. But the loftier vegetables were so entirely distinct from any that are now known to exist in European countries, that we seek in vain for any thing, at all analogous, without the tropics. The forests of *Clathrariæ*, and *Endogenitæ*, (the plants of which, like some of the recent arborescent ferns, probably attained a height of thirty or forty feet,) must have borne a much greater resemblance to those of tropical regions, than to any that now occur in temperate climates. That the soil was of a sandy nature on the hills and less elevated parts of the country, and argillaceous in the plains and marshes, may be inferred, from the vegetable remains, and from the nature of the substances in which they are enclosed. Sand and clay every where prevail in the Hastings strata; nor is it unworthy of remark, that the recent vegetables to which the fossil plants bear the greatest analogy, affect soils of this description. If we attempt to pourtray the animals of this ancient country, our description will possess more of the character of a romance, than of a legitimate deduction from established facts. Turtles, of various kinds, must have been seen on the banks of its rivers or lakes, and groups of enormous crocodiles basking in the fens and shallows.

The gigantic *Megalosaurus*, and yet more gigantic *Iguanodon*, to whom the groves of palms and arborescent ferns would be mere beds of reeds, must have been of such prodigious magnitude, that the existing animal creation presents us with no fit objects of comparison. Imagine an animal of the lizard tribe, three or four times as large as the largest crocodile; having jaws, with teeth equal in size to the incisors of the rhinoceros; and crested with horns; such a creature must have been the Iguanodon!

Nor were the inhabitants of the waters much less wonderful; witness the Plesiosaurus, which only required wings to be a flying dragon; the fishes resembling *Siluri*, *Balistæ*, *&c. &c.*

It is unnecessary to dwell longer on the interesting facts which this sketch of the Geology of Sussex, imperfect as it is, has brought to light; or to point out the important inferences relating to the ancient history of our planet, and those revolutions which have taken place before the existence of the human race, that may be deduced from these researches; they will readily occur to the enlightened geologist; and should we have been so fortunate, as to excite in the mind of the intelligent general reader a wish for farther information on subjects of such deep interest, we would refer him to the writings of Cuvier, Brongniart, Buckland, Conybeare, Parkinson, &c. as affording far more comprehensive and philosophical views of the results of such inquiries, than our limited field of observation will enable us to offer. For we agree with the learned Breislak in the opinion, that "il faut bien se garder en géognosie de trop généraliser; car il s'est glissé dans cette science une grande quantité d'erreurs, parcequ'on a voulu appliquer à toute l'étendue du globe, des observations faites dans des espaces très-rétrécis."

EXPLANATION OF THE PLATES.

Quarry in Tilgate Forest, described, p. 38.

A. Diluvial loam.

B. Friable sandstone.

C. Bluish grey sandstone—the *Tilgate*-stone; the base of the quarry is composed of stiff blue clay.

MAP AND SECTIONS.

The first section is copied from Mr. Murchison's Memoir on the Geology of the north-western extremity of Sussex, and part of Hampshire; and is referred to, at pages 19. 22. 24. 41. It gives an interesting view of the structure of that part of the country, which forms the extreme angle of the great south-eastern denudation of the chalk.

The section from Brighton to Tilgate Forest, is described in p. 37.

That of Tilvester Hill, in Surrey, exhibits the beds of chert, &c. of the Shanklin sand formation; see p. 22.

The view of the strata east of Cuckfield, gives the details of the Tilgate strata in that part of Sussex, vide p. 39; and the sketch of White Rock near Hastings, exhibits the characters of the same beds, in the eastern part of the county; see p. 30.

The cliffs at South Bourne expose the marl and firestone beds, and are described at p. 17.

The section of the coast of Sussex and Kent, is that given by Dr. Fitton, in the Annals of Philosophy; see p. 1. 2.

That from Newhaven, to Tring, in Hertfordshire, with the exception of a few verbal alterations, is copied from the invaluable work of Messrs. Conybeare and Phillips.

The Map is intended to convey a *general* idea of the geological structure of the area, inclosed by the chalk-hills of Sussex, Surrey, Kent, and Hampshire. For the purpose of illustration, the lines of colours denoting the several formations, are made continuous throughout the whole tract of country; for although, in many places, a formation may not appear at the surface, through an extent of several miles, yet, as its situation is known in localities not far distant, it is assumed to be continued along the intervening tract, although obscured by diluvial deposits.

The *Diluvium* is not marked on the borders of the rivers; in so small a map, details could not be attempted: an important diluvial deposit, that forms the cliffs from Brighton to Worthing, is, however, denoted by a bright green colour.

The *Tertiary Formations*, extending along the coast, from Bracklesham Bay to near Worthing, together with the insular patches of these deposits at Castle Hill, near Newhaven, and at Seaford, are coloured brown; see p. 9, et seq.

The *Chalk Formation*, restricting the term, in the present instance, to the white chalk and chalk marl, (for the subordinate members, the Galt and Firestone are coloured separately,) is seen extending from Beachy Head to Hampshire, from thence to Surrey, and returning to the sea-coast at Dover; see p. 14.

The *Firestone*, coloured *red*, and the *Galt*, *blue*, form a zone within the chalk-hills; see pp. 17, 19.

The *Shanklin Sand*, denoted by a pink colour, forms a broader belt within the last mentioned; see p. 21; and the *Weald Clay*, (see p. 24,) coloured green, constitutes a valley between the *Shanklin Sand*, and the central nucleus of the *Hastings Formation*, which is distinguished by a ferruginous tint; see p. 27, et. seq.*

PLATE I.

Fig. 1. *Clathraria Lyellii.* A specimen of the inner portion of the plant; the drawing is half the size of the original; *a*, marks a cicatrix, the nature of which is unknown; *b*, *b*, *b*, indicate the situation of branches; *c*, the attenuated base; p. 52.

Fig. 2. *Clathraria Lyellii.* The outer surface of the plant, exhibiting the rhomboidal bases of the petioles.

Fig. 3. *a* and *b*, are corresponding portions of the same block of sandstone, inclosing a specimen of *Hymenopteris psilotoides*; p. 55.

Fig. 4. A leaf of *Hymenophyllum Tunbridgense*, (Tunbridge filmy-leaf,) to compare with the above fossils.

Fig. 6. 7. Two small stems of *Clathraria Lyellii.*

PLATE II.

Fig. 1. *Clathraria Lyellii*: shewing the inner imbricated body, surrounded by the outer integument, marked with the bases of the leaves.

Fig. 2. A specimen of the external integument of the same vegetable, from which the internal body has been removed.

Fig. 3. The outer surface of *Clathraria Lyellii*; see pp. 52. 53.

* It is scarcely necessary to mention, that in these, as in most other geological sections, the altitudes of the strata are drawn on a much larger scale than their longitudinal dimensions; a method, found necessary to accommodate the sketches to the size of the volume.

PLATE III.

Fig. 1. *Endogenites erosa ;* fig. 2. a section of the same; see p. 54.
Fig. 3. 4. *Carpolithus Mantellii ;* p. 56.
Fig. 5. *Pecopteris reticulata ;* p. 56.
Fig. 6. A confused mass of the leaves of Hymenop. psilotoides; see p. 55.
Fig. 7. A beautiful example of *Hymenopteris psilotoides ;* p. 55.
Fig. 8. A cast of the internal cavity of *Clathraria Lyellii ;* p. 52.

PLATE III.*

Fig. 1. Magnified views of *Carpolithus Mantellii,* shewing the ramifications of the veins; p. 56.

Fig. 2. Magnified view of *Hymenopteris psilotoides ;* p. 55.

Fig. 3. Magnified view of part of a frond of *Pecopteris reticulata ;* p. 56.

Fig. 4. *a.* Portion of the outer surface of *Clathraria Lyellii,* shewing the ridge that extends round the margins of the rhomboidal bases of the leaves; p. 53: Fig. 4. *b,* exhibits a cicatrix; see p. 53: Fig. 4. *c,* part of a stem of the same, which is distinctly imbricated: Fig. 4. *d,* portion of a stem, partially covered with an interstitial substance; see p. 52. 53.

PLATE IV.

Contains figures of various specimens of the teeth of the *Iguanodon,* p. 72.

PLATE V.

Fig. 1. 2. 5. 6. 7. 8. 9. 10. 12. Teeth of *crocodiles,* pp. 64, 65.
Fig. 3. 4. 15. 16. Scales of fishes, p. 58.
Fig. 11. Tooth of a *Plesiosaurus,* p. 79.
Fig. 13. Tooth of the *Megalosaurus Bucklandii,* p. 68.
Fig. 14. Tooth of a fish allied to the *Squali,* p. 58.

PLATE VI.

Remains of various kinds of Turtle.
Fig. 1. Rib of a species of *Trionyx,* p. 60.
Fig. 2. Extremity of a rib of a marine turtle, p. 61.
Fig. 3. 4. 8. Remains of the bones of a *Trionyx.*
Fig. 5. Scale of a *Trionyx?* p. 60.
Fig. 6. Sternal plate of an *Emys,* or fresh-water turtle, p. 61.
Fig. 7. Margin of the upper shell, or carapace of an *Emys,* or fresh-water turtle, p. 61.

PLATE VII.

Fig. 1. Rib of a marine turtle.
Fig. 2. Two ribs of a marine turtle; with part of the osseous border, p. 62.

Fig. 3. Part of the osseous border of an *Emys*, or fresh-water turtle, p. 61.

Fig. 4. Bone of a species of *Trionyx*.

Fig. 5. 8. Sternal plates of a marine turtle, p. 62.

Fig. 6. The shoulder-bone of a marine turtle; *a*, *coracoid* process; *b*, *humeral* articulation; *c*, the *omoplate;* p. 62.

Fig. 7. The second *sternal* plate of a *Trionyx*, p. 60.

Fig. 8. Spinous processes of two vertebræ, probably of a *Plesiosaurus*, p. 80.

PLATE VIII.

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Fig. 2. 4. 5. 15. Bones of lizards, or, perhaps, turtles? p. 80.

Fig. 8. *Os frontis* of a crocodile, p. 67.

Fig. 9. *Os frontis* of a crocodile? p. 67; fig. 9* *a*, mark two semicircular arches, probably the orbital.

Fig. 14. The condyles of a femur; probably of a lizard.

PLATE IX.

Fig. 1. Caudal vertebra of a *crocodile:* *a*, *a*, lateral processes; *b*, spinous process; *c*, *c*, processes by which the vertebra articulates with the next; *d*, marks the situation of the spinal canal; p. 66.

Fig. 2. 3. 6. Teeth of the *Megalosaurus;* p. 68. 3 *a*, is an enlarged view of the serrated edge.

Fig. 4. Cervical vertebra of a *Plesiosaurus;* *a*, *a*, tubercles for the attachment of false ribs.

Fig. 5. Dorsal vertebra of a *Plesiosaurus;* *a*, denotes the situation of the spinous process; p. 79.

Fig. 7. 8. Caudal vertebra of a crocodile; *a*, *a*, transverse processes; *b*, articulating processes; *c*, spinous process; *d*, spinal canal.

Fig. 9. 10. Portions of bones, the nature of which is unknown; there is an articulating surface at *a*, *b*. fig. 9.; and at *c*, *b*, in fig. 10.; see p. 80.

PLATE X.

Fig. 1. Caudal vertebra of a crocodile, the annular part is wanting, p. 66.

Fig. 2. Portion of the jaw of a fish, with eight hemispherical teeth, p. 58.

Fig. 3. Extremity of a metatarsal bone of a lizard, p. 67.

Fig. 4. 6. Dorsal fins of a fish allied to the *Silurus*, p. 58.

Fig. 5. Jaw of a fish, with sharp-pointed curved teeth, p. 58.

Fig. 7. 8. 9. Casts of *Paludinæ* and *Viviparæ;* p. 57.

Fig. 10. A small vertebra of a saurian animal.

Fig. 11. Cast of a bivalve, common in the Tilgate-stone, p. 57.

Fig. 12. Vertebra (sacral, or caudal) of the *Iguanodon*, p. 76. *a, a,* transverse processes; *b, b,* articulating processes; *c,* spinal canal: the spinous process is broken off.

PLATE XI.

Fig. 1. 4. 6. Ribs of the *Megalosaurus*, p. 70.

Fig. 2. Rib of the *Iguanodon?* p. 77.

Fig. 3. Bone of a *lizard*, or turtle? p. 80.

Fig. 5. Rib of a *crocodile; 5* a,* shews a section of the bone; p. 66.

PLATE XII.

Fig. 1. Annular part of a lumbar vertebra of the *Iguanodon; a,* transverse process; *b,* spinal canal; *c,* spinous process; p. 76.

Fig. 2. Scale, or plate? see p. 80.

Fig. 3. Vertebra of the *Iguanodon; a, a,* articulating processes; *b,* situation of the transverse process, which is wanting; *c,* spinous process; *d,* spinal canal; *e,* suture that united the annular part with the body of the vertebra; p. 76.

Fig. 4. *Chevron* bone of the *Iguanodon; a,* a deep cleft, or groove, extending nearly half way the length of the bone; *b, c,* mark the articulating surface, by which the bone was united to the body of the vertebra; p. 77.

Fig. 5. *Radius* of a saurian animal; *a,* the upper, and *b,* the lower extremity; p. 80.

PLATE XIII.

Fig. 1. Head of a bone, the nature of which is unknown; *a,* is a spinous process; *b,* the head of the bone, of a prismatic form; *c,* medullary canal, filled with crystallized carbonate of lime; p. 80.

Fig. 2. *Ischium* of a turtle?? *a, a,* two processes which bear marks of attachment to other bones; *b,* the broken end, shewing the medullary canal filled with spar; p. 80.

Fig. 3. 4. 5. Heads of long bones, probably *radii,* p. 67.

Fig. 6. Head of the *tibia* of a crocodile, p. 67.

Fig. 7. Spinal extremity of a rib of a crocodile; *a,* the head of the bone which articulated with the body of the vertebra; and *b,* the tubercle, which united with the transverse process; p. 66.

Fig. 8. The head of a large bone, which differs from any we have hitherto observed. Its surface is divided into two articulations, *a* and *b;* the shaft of the bone is broken off at *c,* so that the perfect form of the original cannot be ascertained; p. 80.

Fig. 9. A bone of an irregular triangular form: it appears as if the extremity at *a,* must have terminated in a point; can it be a part of the pelvis of a saurian? see p. 80.

PLATE XIV.

Figs. 1. 2. Two views of a *metatarsal*, or *metacarpal* bone of a saurian animal; *a*, *b*, mark the articulating surfaces; p. 67.

Figs. 3. 6. Are different representations of a very large *humerus* of an unknown animal; *a*, points out a groove near the head of the bone; *b*, appears to be the lower extremity or condyles; *c*, marks a tubercle with a rugous surface, as if for the attachment or insertion of a large muscle; see page 80.

Figs. 4. 5. Two views of a *metatarsal* bone of the *Iguanodon*? probably of the second phalanx; *a*, the *metatarsal* extremity; *b*, the *tarsal* extremity; *c*, the inferior surface of the bone; p. 77.

Fig. 7. Part of the pelvis of a small turtle, p. 62.

PLATE XV.

Fig. 1. *Humerus* of a *Crocodile*; *a*, head of the bone; *b*, a tubercle for the insertion or attachment of a muscle; *c*, broken extremity; *d*, groove, probably for the passage of a tendon; p. 66.

Figs. 2. 6. Tricuspid teeth longitudinally striated, probably of fishes; p. 58.

Figs. 3. 4. Pointed teeth, with a cylindrical shank, of some unknown fish? p. 58.

Fig. 5. Scale of a fish?

Fig. 7. Tooth of a crocodile?

Fig. 8. *Humerus* of an unknown aquatic animal; *a*, cubital extremity; *b*, the head of the bone; p. 80.

PLATE XVI.

Figs. 1. 2. Represent two views of a very large bone, which is probably a rib of the *Iguanodon*; p. 77.

Figs. 3. 4. Different views of a fragment of bone, the nature of which it is difficult to determine: the surfaces marked *a*, *b*, *c*, appear to have been articulations; the shank, or body of the bone, is broken off at *d*; see p. 81.

Fig. 5. A scale—of a turtle? p. 81.

PLATE XVII.

Figs. from 1 to 19 inclusive, represent teeth of the *Iguanodon*, in different stages of growth, from the almost perfect tooth, fig. 10, to the bony plate, fig. 18. The letters *a*, *b*, with the exceptions hereafter mentioned, point out the corresponding parts of the crown of the tooth; *c*, the hollow or depression in the fang of the tooth, occasioned by the pressure of a new tooth. Fig. 9. *a*, points out the cavity in the fang of a tooth produced by this cause. Fig. 12, is a magnified representation of the dentated margin of the tooth, fig. 4, viewed laterally; see pp. 71, et seq.

Fig. 20. *Cervical* vertebra of a *Plesiosaurus*; *a*, the surface for the articulation of the false ribs; *b*, the annular suture; p. 79.

Fig. 21. *Caudal* vertebra of a *Crocodile*, from near the extremity of the tail, p. 66.

Figs. 22. 23. *Dorsal* vertebra of a *Crocodile*; *a*, spinous process; *b*, *b*, transverse processes; *c*, spinal canal; p. 66.

Figs. 24. 25. Portions of the fangs of teeth of the *Iguanodon*, p. 71.

Figs. 26. 27. Palates of fishes, p. 58.

Fig. 28. A lateral view, and fig. 29. the under surface of a large *metatarsal* bone of the *Iguanodon*? *a*, the upper, and *b*, the lower, end of the tarsal articulation; *c*, the metatarsal extremity; p. 77.

PLATE XVIII.

Fig. 1. Fragment of an enormous bone, of an obscurely quadrangular form, supposed to be part of a *femur* of the *Iguanodon*; p. 77.

Fig. 2. *Femur* of the *Megalosaurus*, from Stonesfield, p. 70.

Fig. 3. *Clavicle*? of the same, from Stonesfield, p. 70.

PLATE XIX.

The figures in this Plate are copied from other works, for the purpose of illustration.

Fig. 1. Part of the jaw of the *Megalosaurus*, from Stonesfield, p. 68.

Fig. 2. Tooth of the *Megalosaurus*, p. 68.

Figs. 3. 4. 5. 7, 10. 13. *Bones of birds*, from Stonesfield, p. 81.

Fig. 6. *Caudal* vertebra of a *Plesiosaurus*; from the Geological Transactions, Vol. V., Plate 41; see p. 79.

Fig. 8. *Coracoid* bone of the *Megalosaurus*, from Stonesfield, p. 70.

Fig. 9. *Frontal bone* of a *Crocodile*, from Montmartre, Cuvier, Oss. Foss., Tome III.; see p. 67.

Fig. 11. *Shoulder-bone* of a marine turtle, from Cuvier, Oss. Foss., Tome V., Pl. 14; see p. 62.

Fig. 12. Chain of vertebræ of the *Megalosaurus*, from Stonesfield, p. 70.

Fig. 14. *Pubis*? of the *Megalosaurus*, p. 70.

Fig. 15. A *caudal*, and fig. 16, a *lumbar* vertebra of the *Megalosaurus*, from Stonesfield; see p. 70.

PLATE XX.

Figs. 1. 2. Specimens of *Hymenopteris psilotoides*, from Tilgate Forest, p. 55.

Fig. 3. A species of *Lepidodendron*, copied from Count Sternberg's work, to give an idea of the manner in which the leaves were, probably, disposed round the stem of *Clathraria Lyellii*; see p. 54.

Fig. 4. *a, b*, different magnified views of the crown of a tooth of *Iguana tuberculata*.

Fig. 5. Representation of the inner surface of the upper jaw of the *Iguana tuberculata*, of the natural size, by W. Clift, Esq., of the College of Surgeons; p. 74.

Fig. 6. View of the same, magnified four diameters; see p. 74.

Fig. 7. A bone, the nature of which is at present unknown, see p. 81.

Fig. 8. HORN *of the* IGUANODON, p. 78.

THE END.

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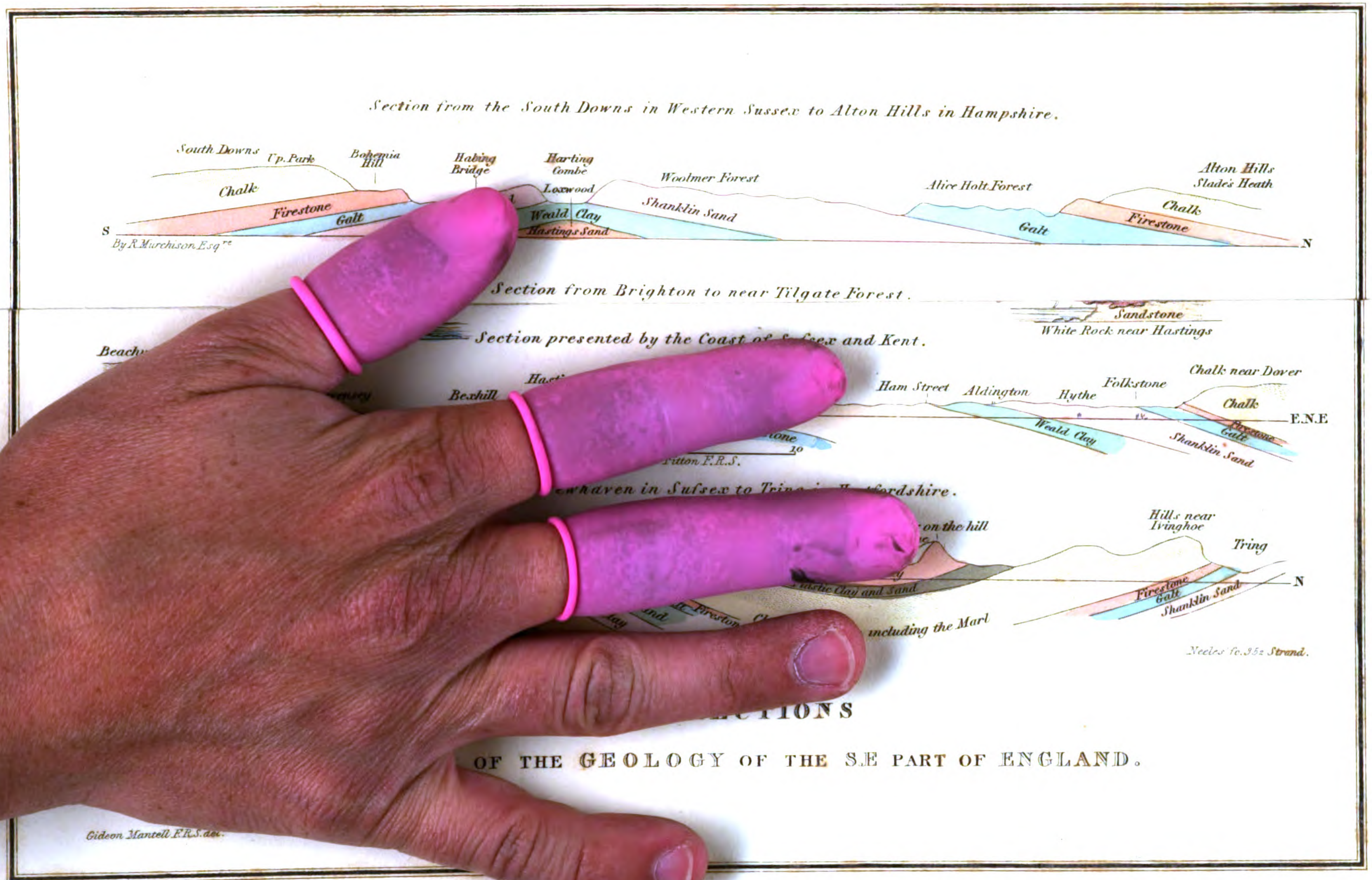

Section from the South Downs in Western Sussex to Alton Hills in Hampshire.
South Downs
Up Park
Bohemia Hill
Habing Bridge
Harting Combe
Loxwood
Woolmer Forest
Alice Holt Forest
Alton Hills
Slade's Heath
Chalk
Firestone
Galt
Weald Clay
Hastings Sand
Shanklin Sand
S
N
By R. Murchison Esqre
Section from Brighton to near Tilgate Forest.
Sandstone
White Rock near Hastings
Section presented by the Coast
and Kent.
Bexhill
Ham Street
Aldington
Hythe
Folkstone
Chalk near Dover
E.N.E
Fitton F.R.S.
Hills near Ivinghoe
Tring
including the Marl
Neele fc. 352 Strand.
OF THE GEOLOGY OF THE S.E PART OF ENGLAND.
Gideon Mantell F.R.S. del.

Pollard del.

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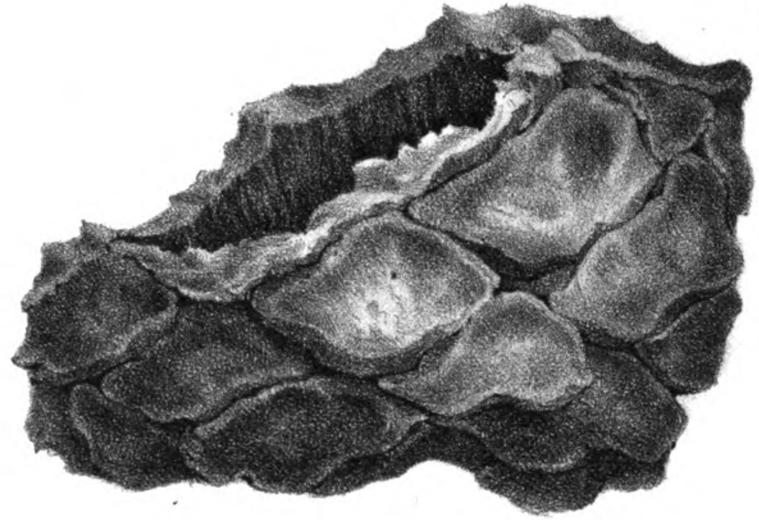

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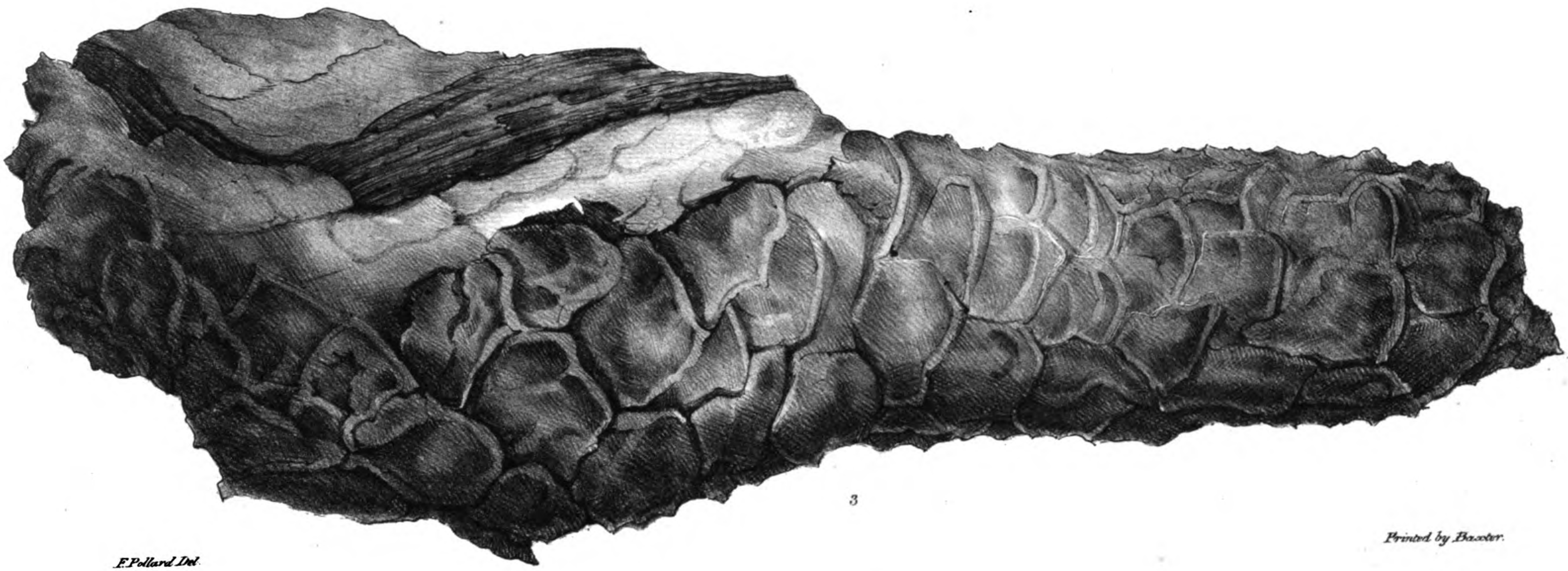

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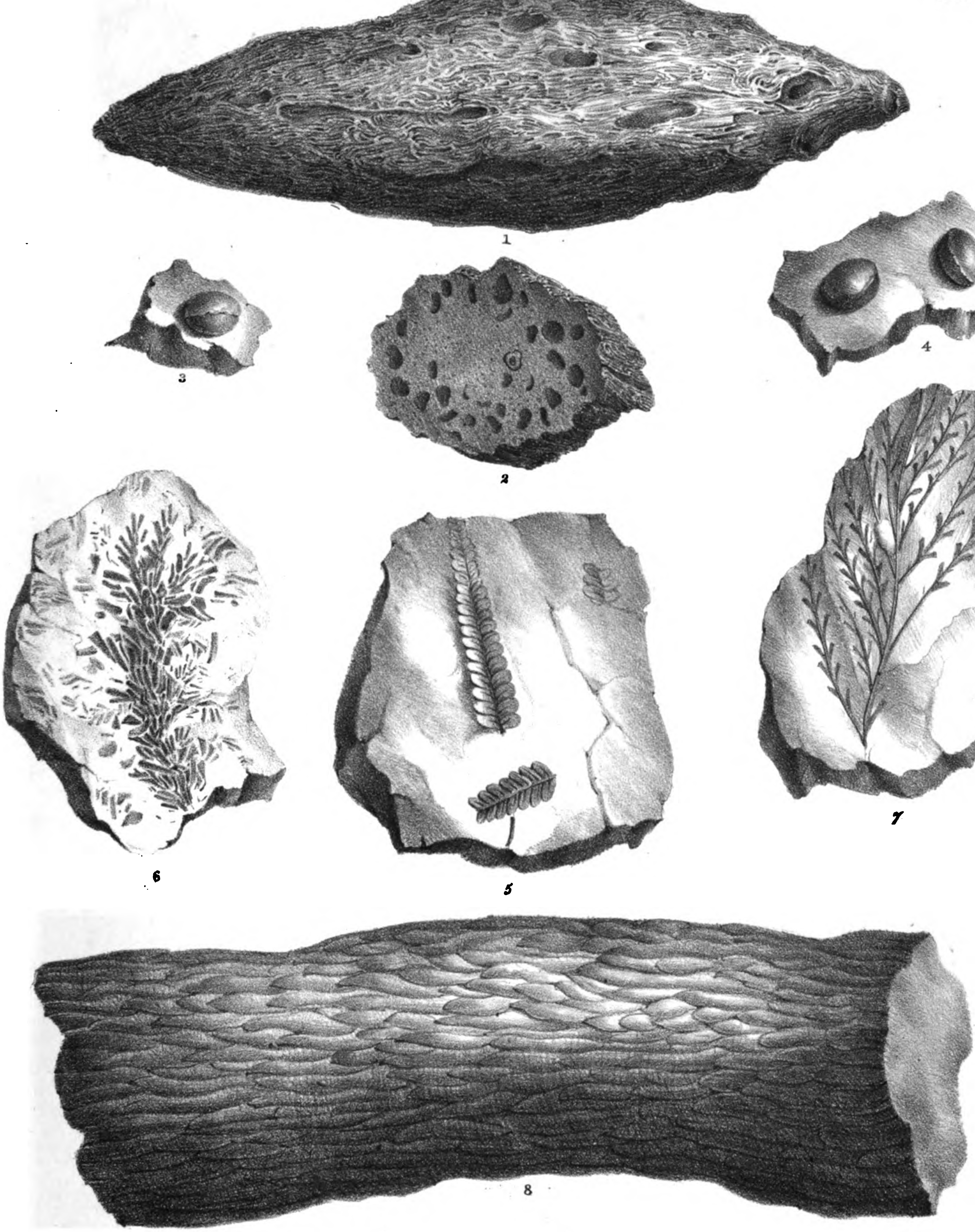

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Pl. XIII.

Fig: 1. a

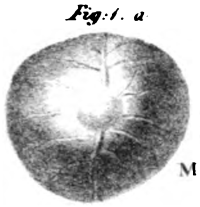


Fig: 1. b

Fig: 2

Fig: 3.

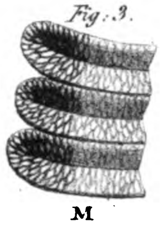
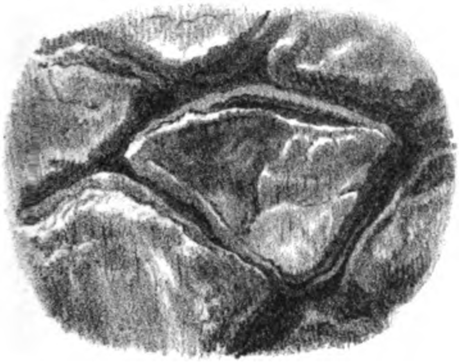


Fig: 4. a



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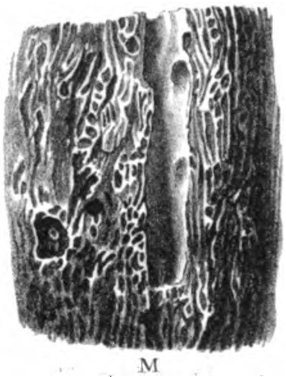


Fig: 5. b

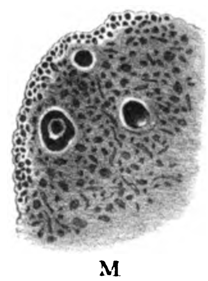
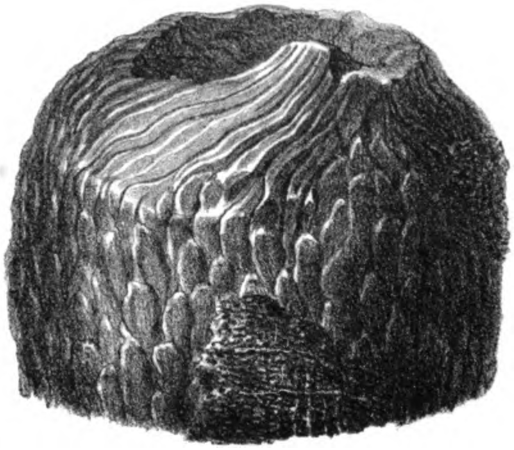


Fig: 4. b.

Fig: 4. c.



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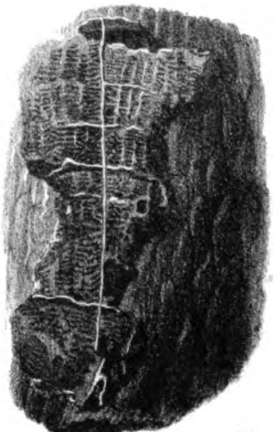

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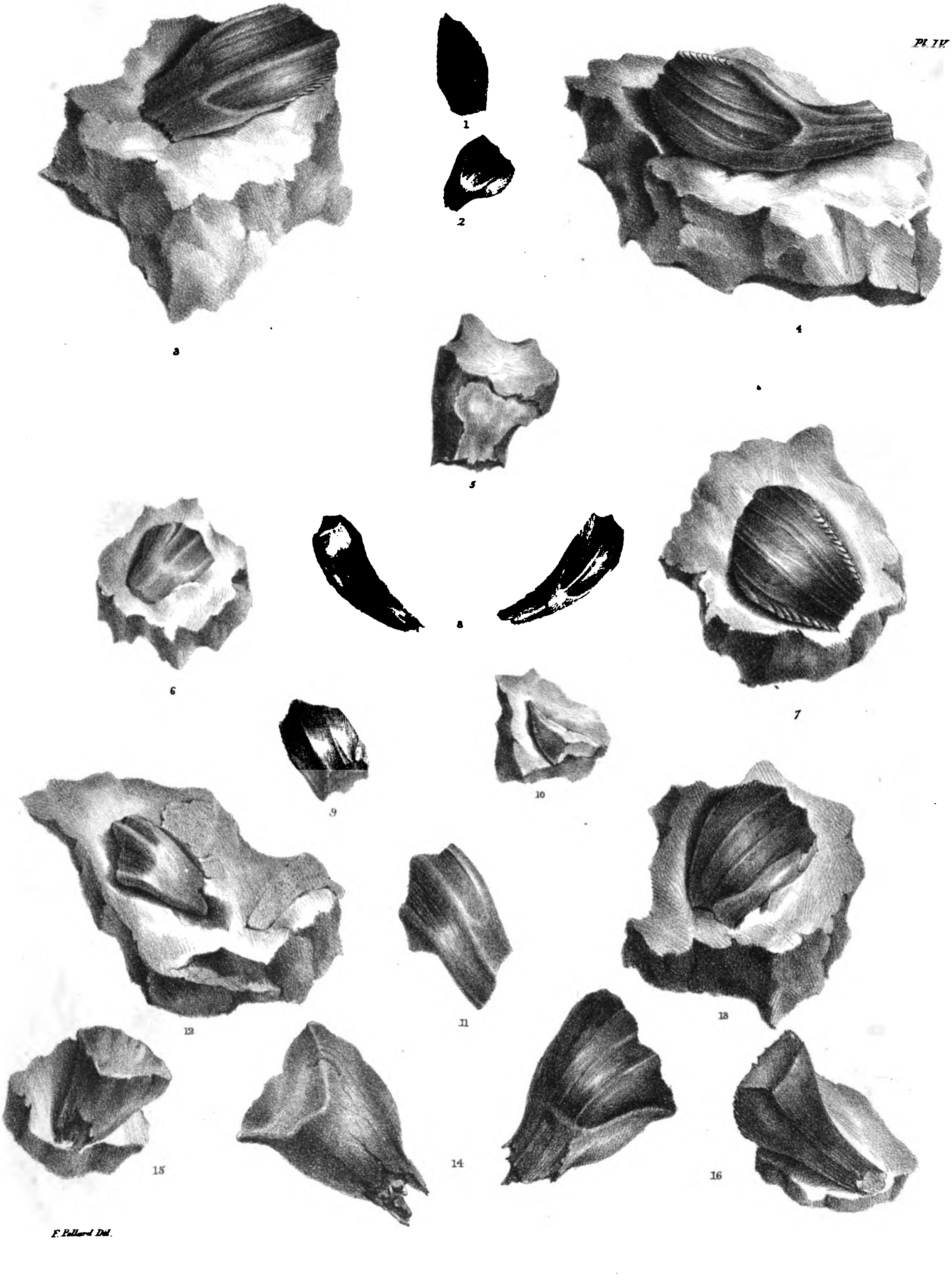
Pl. IV.



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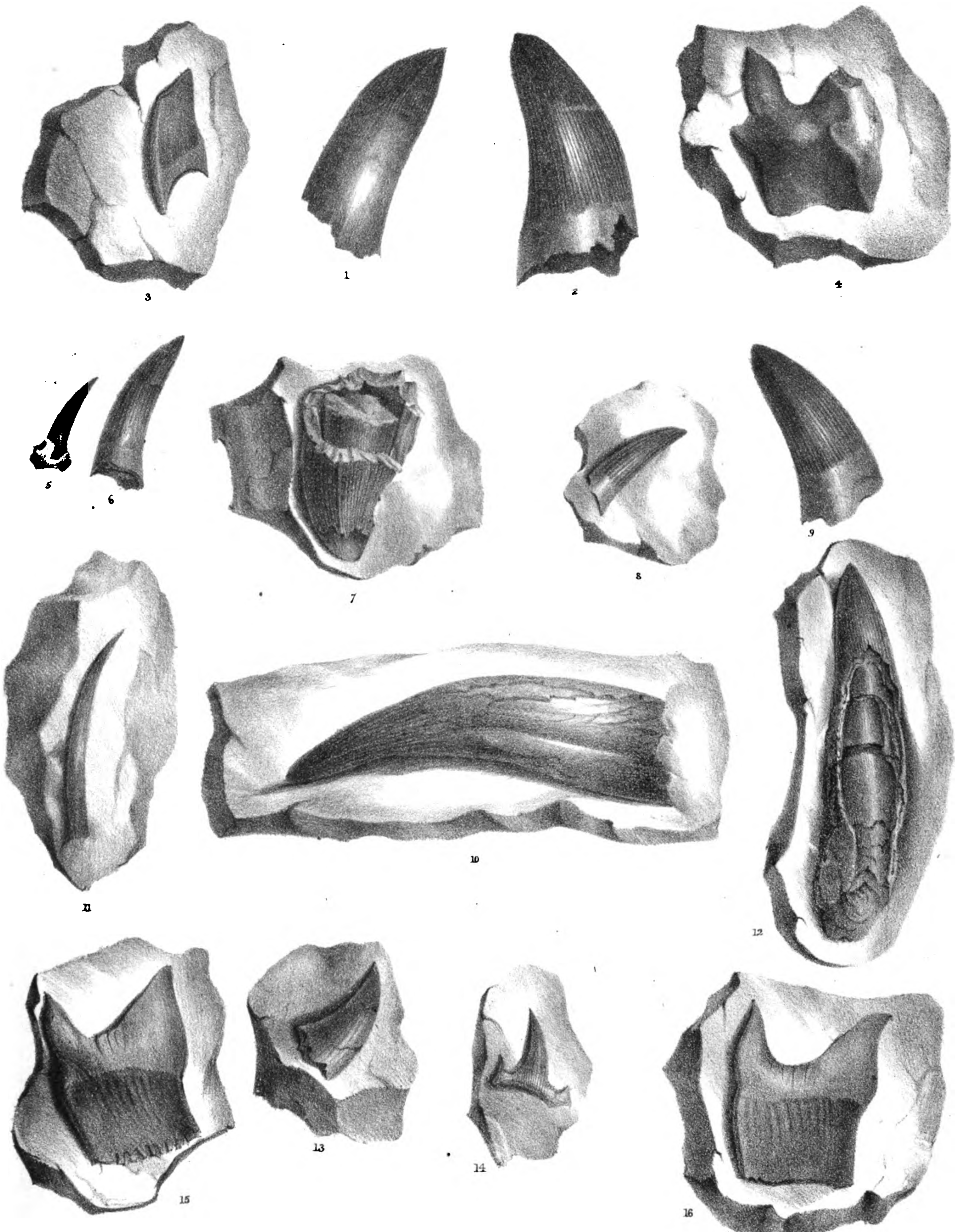
Pl. V



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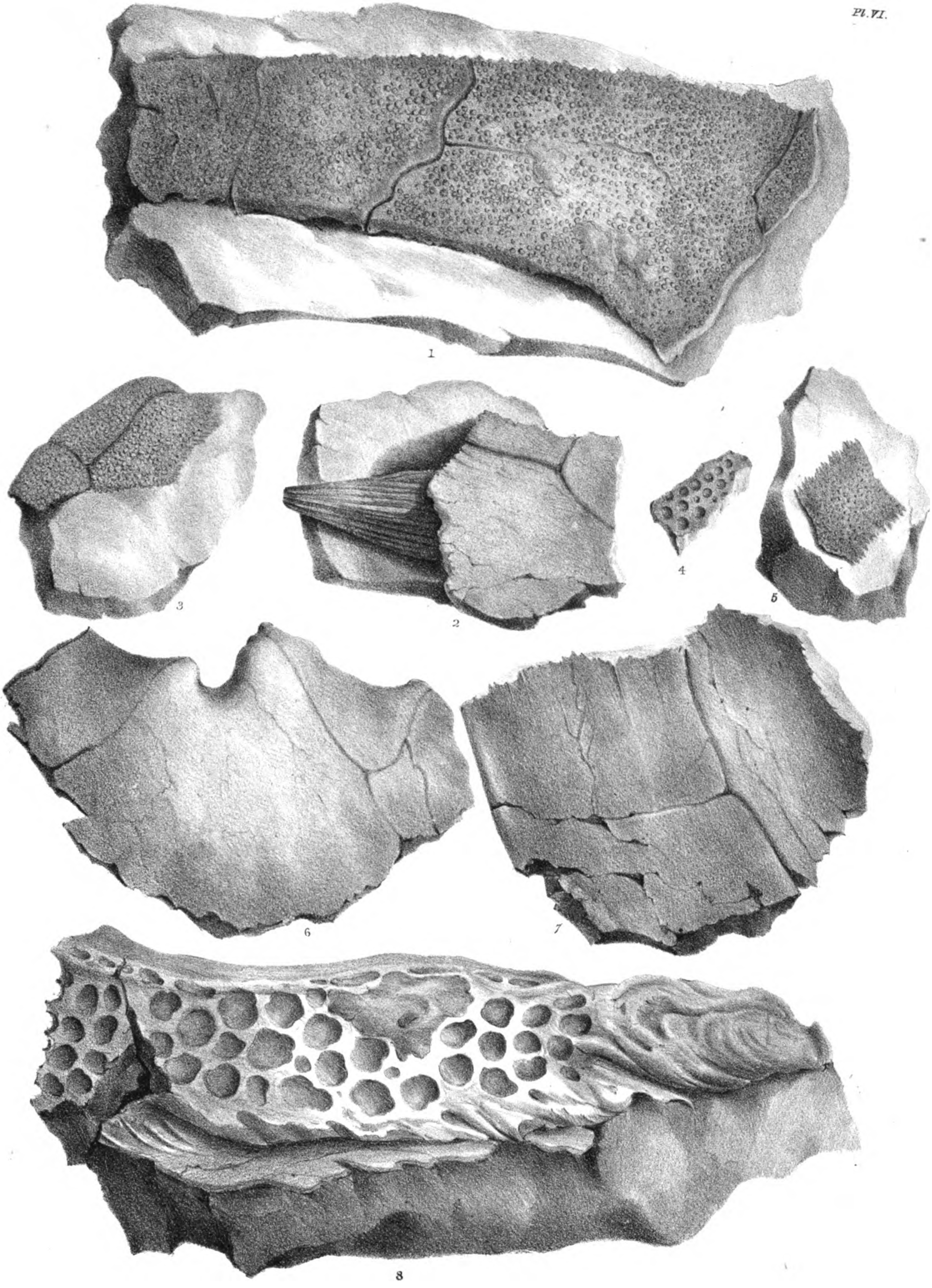
Pl. VI.



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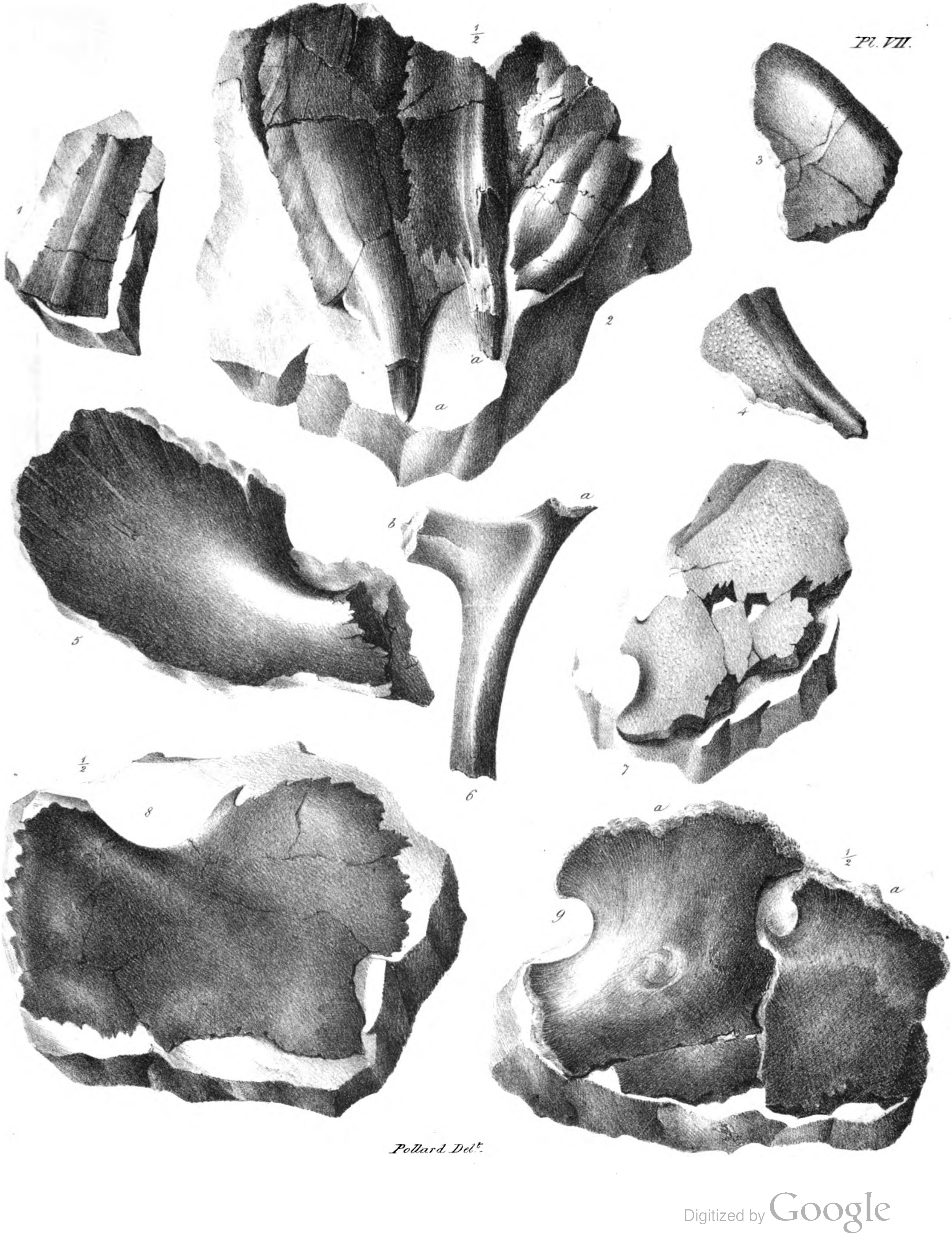

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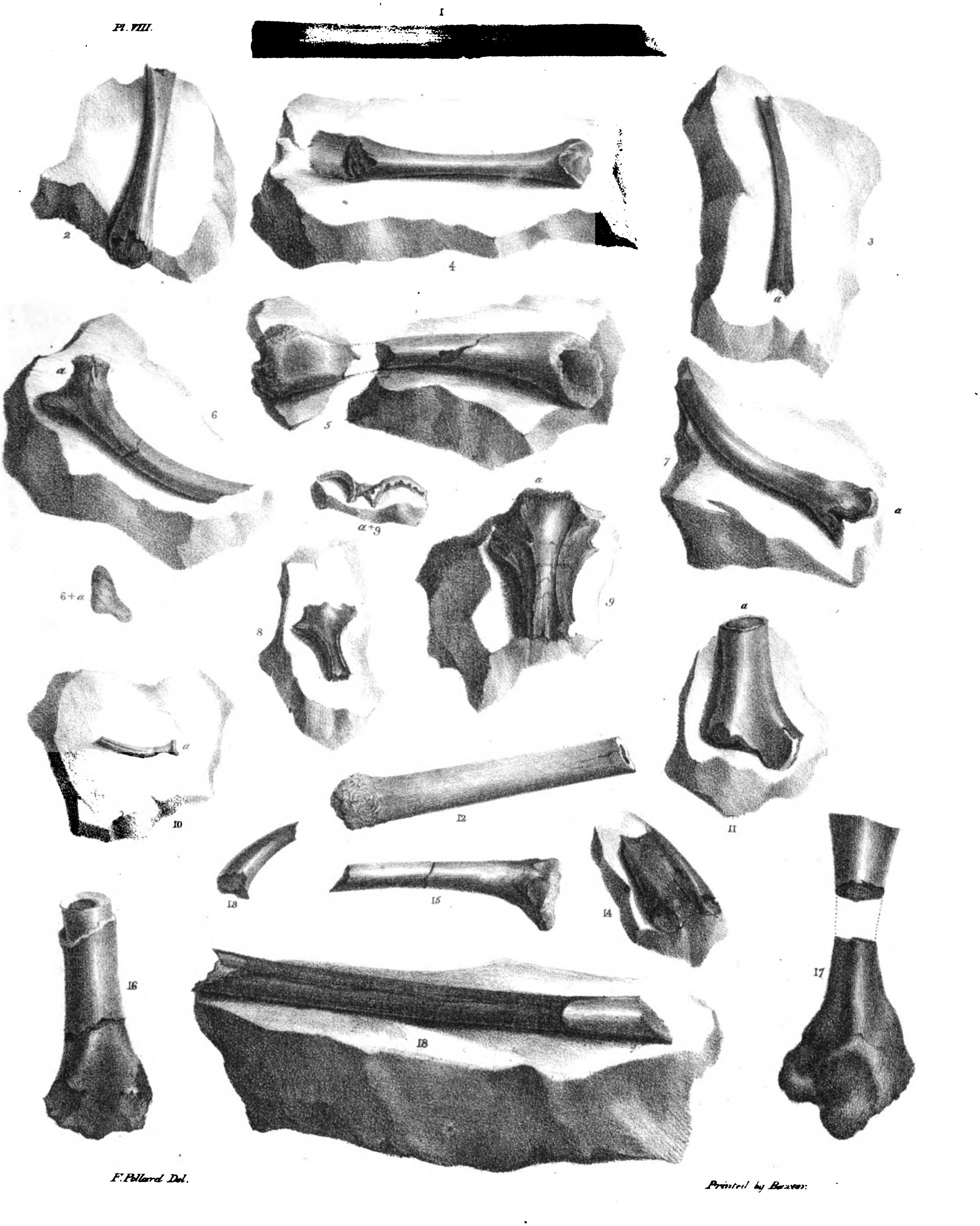

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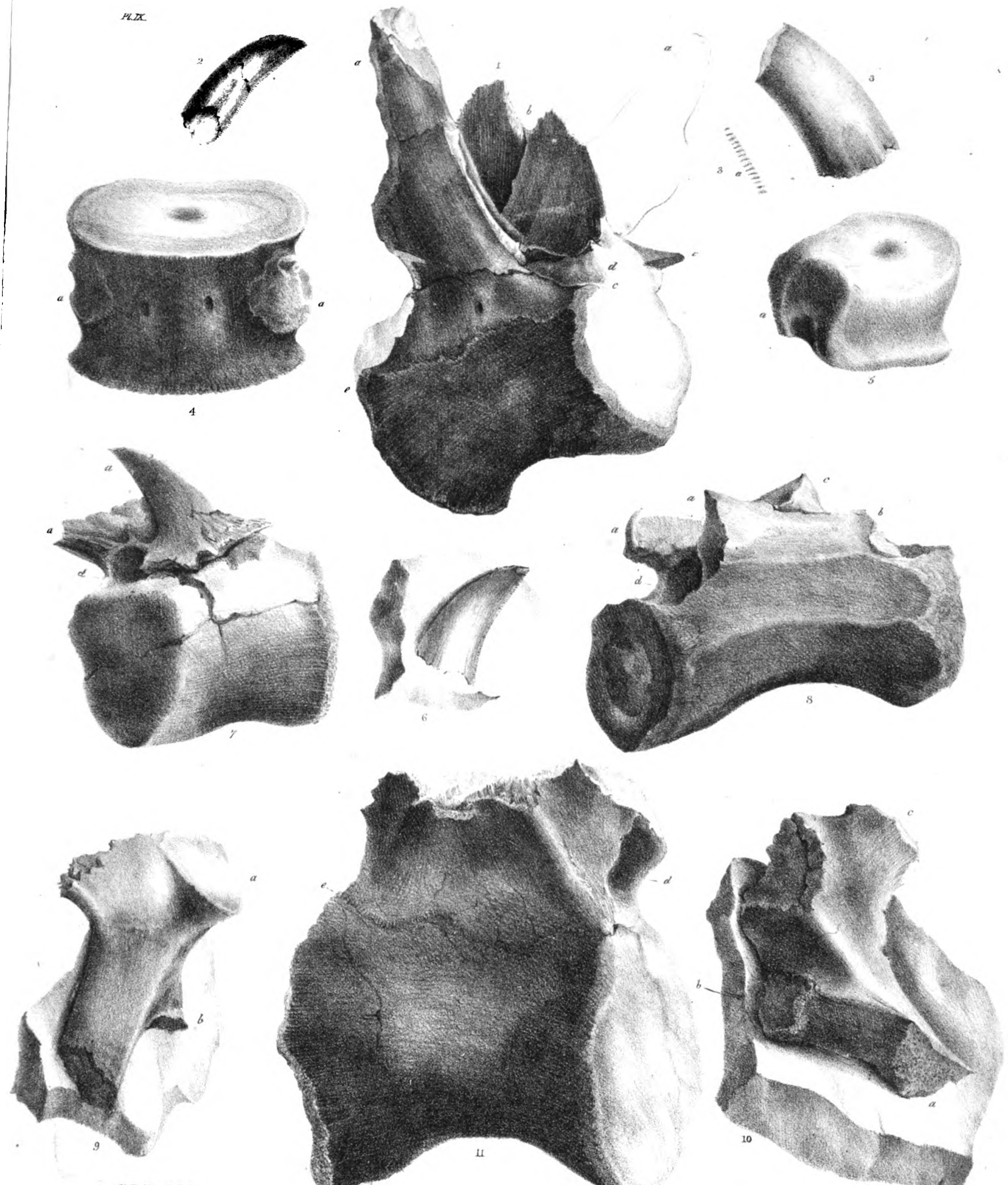

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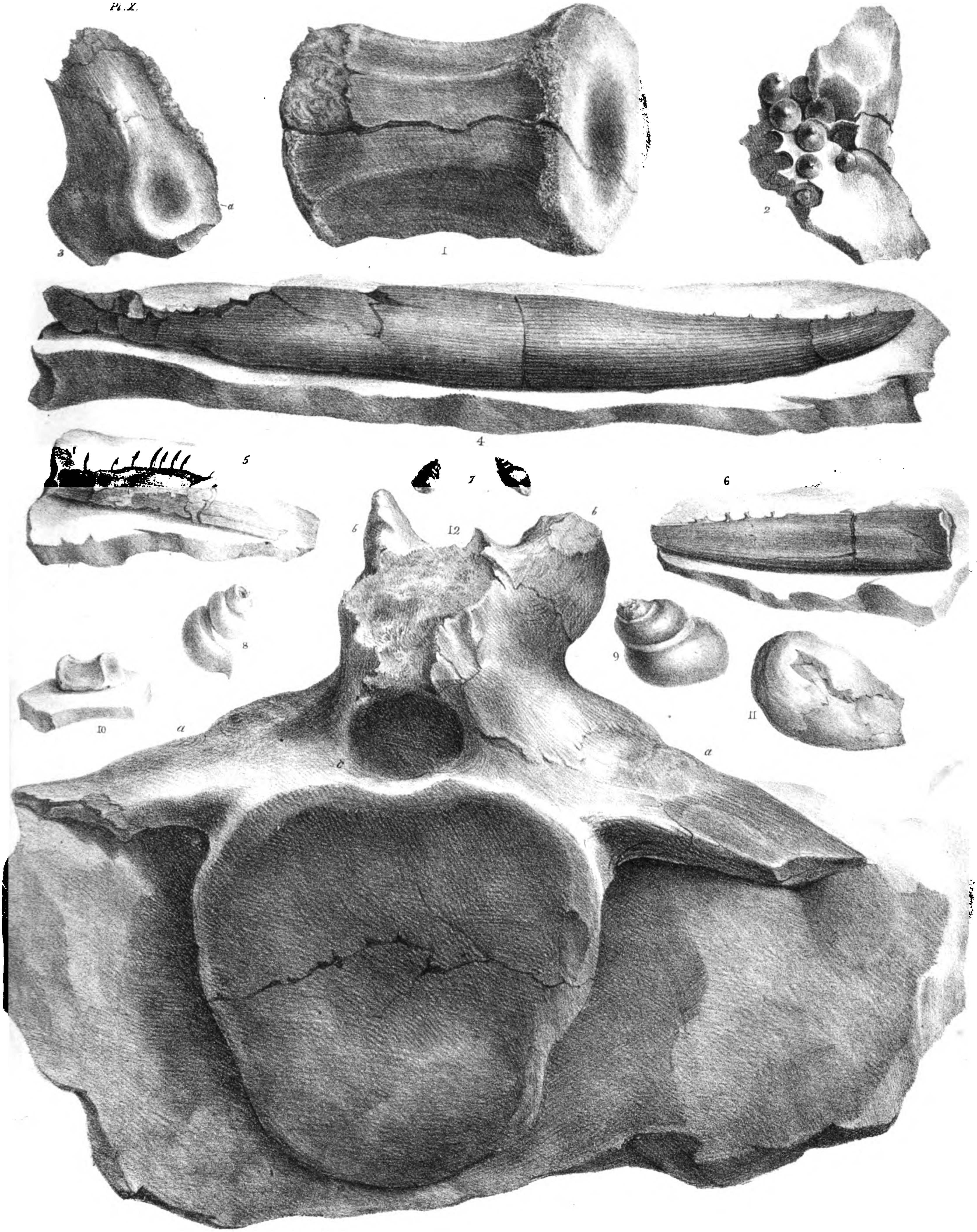

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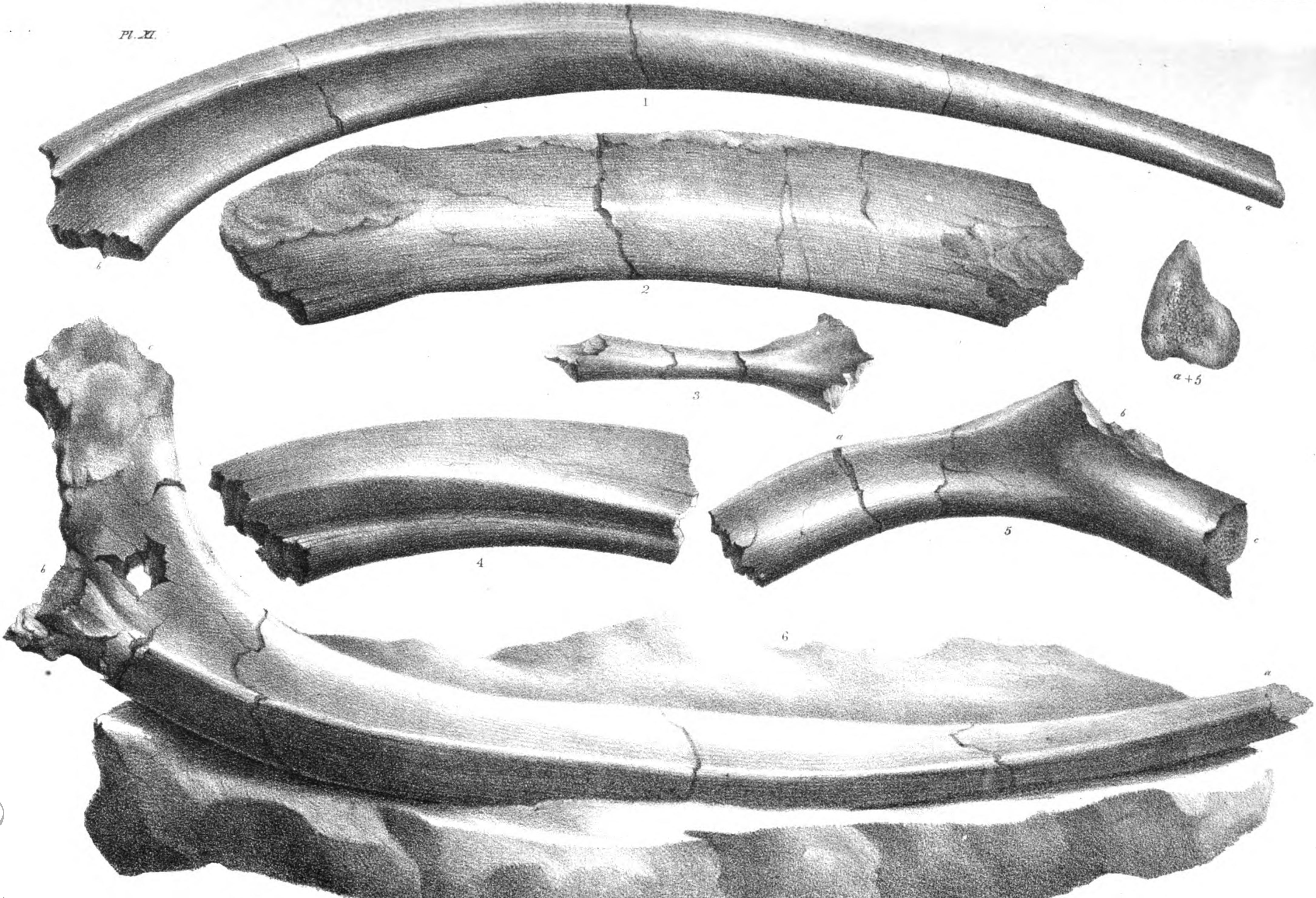

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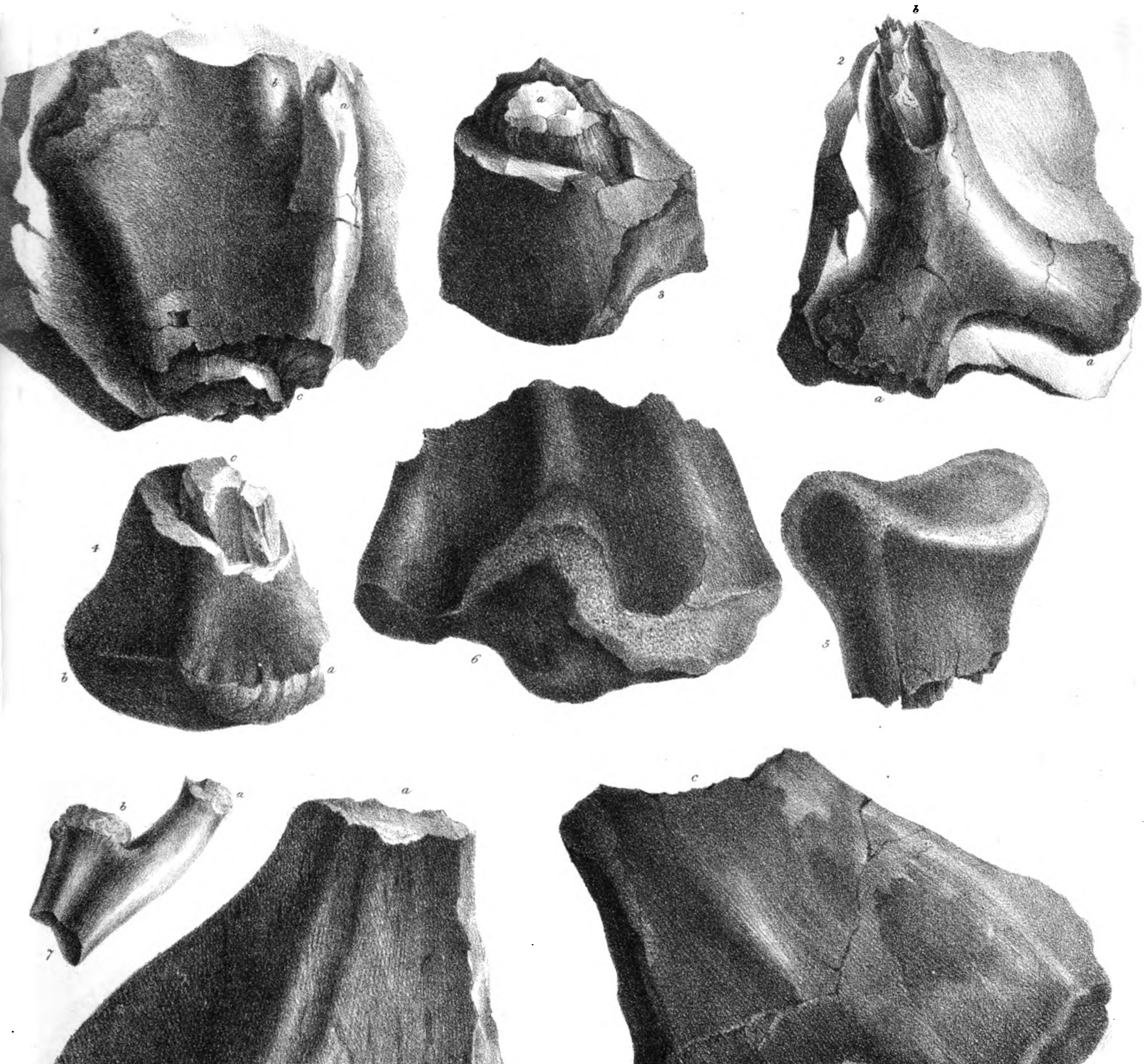

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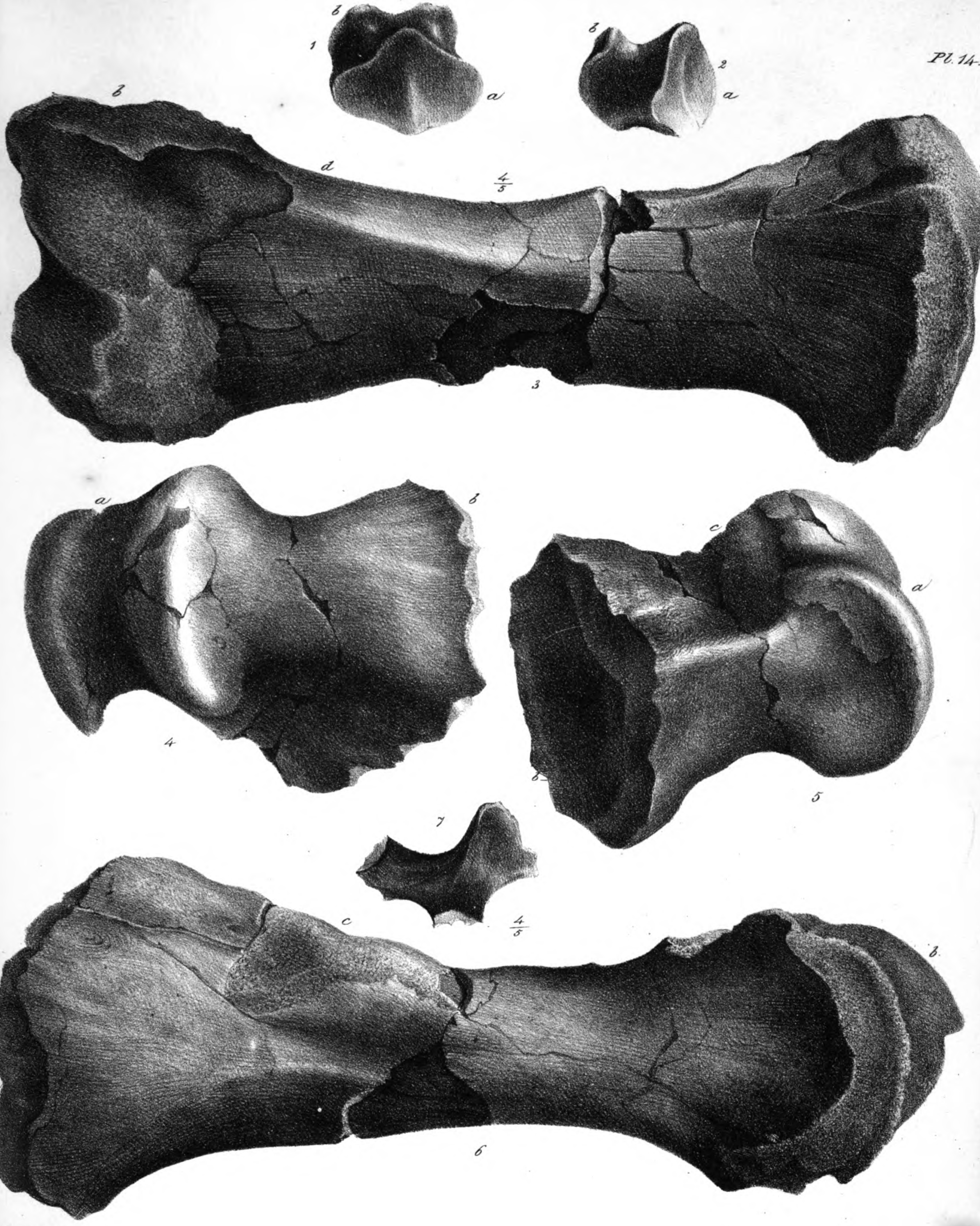

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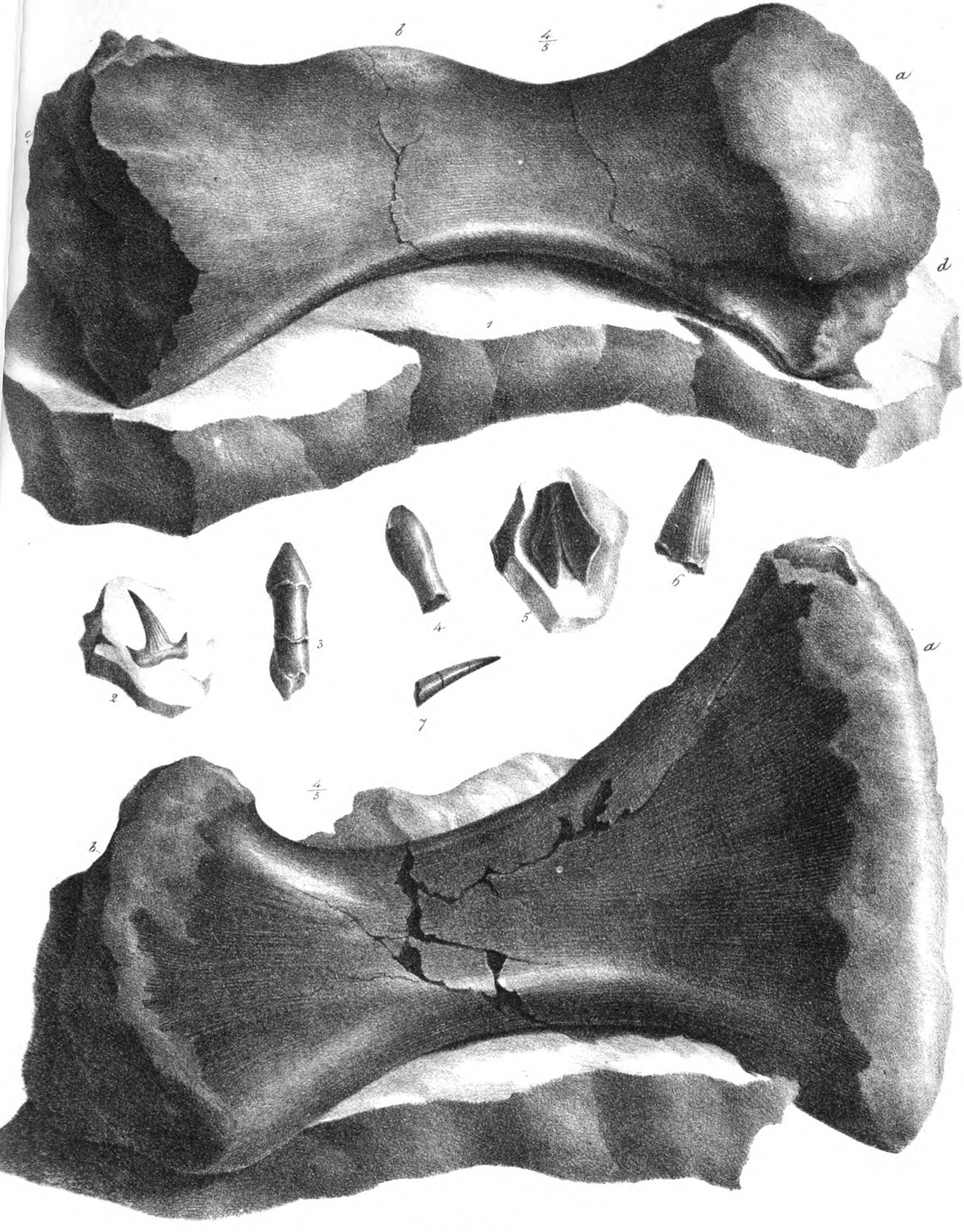

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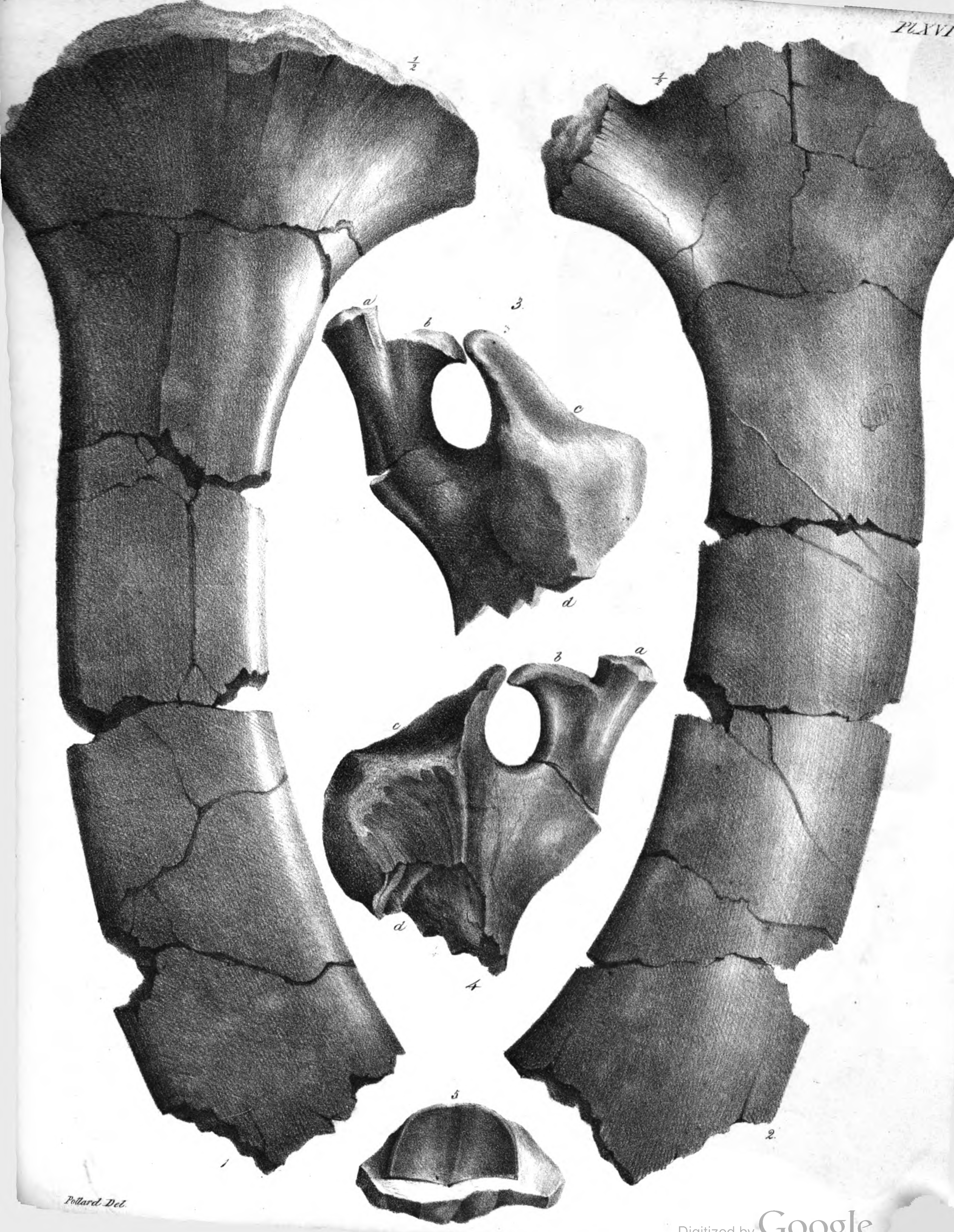

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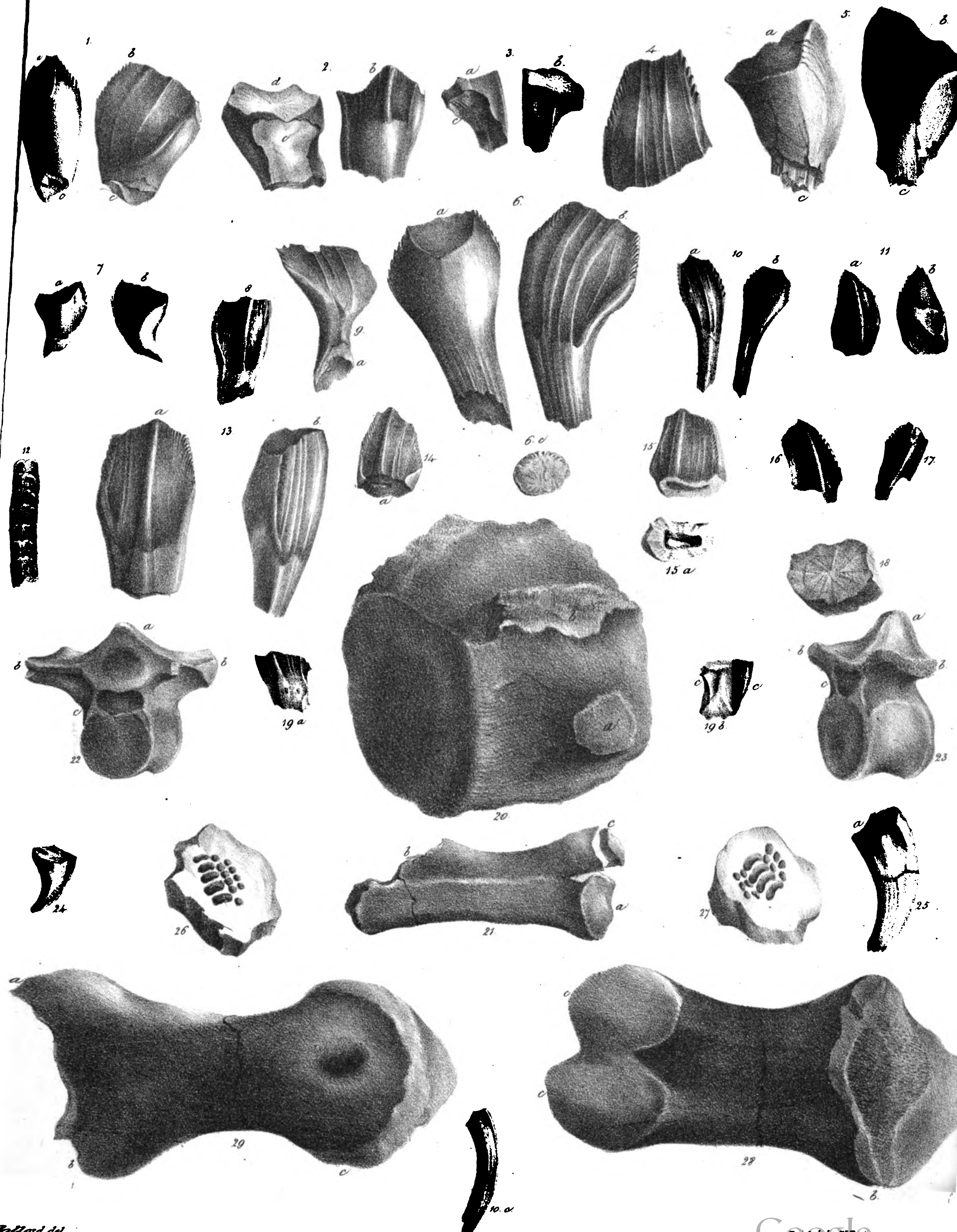

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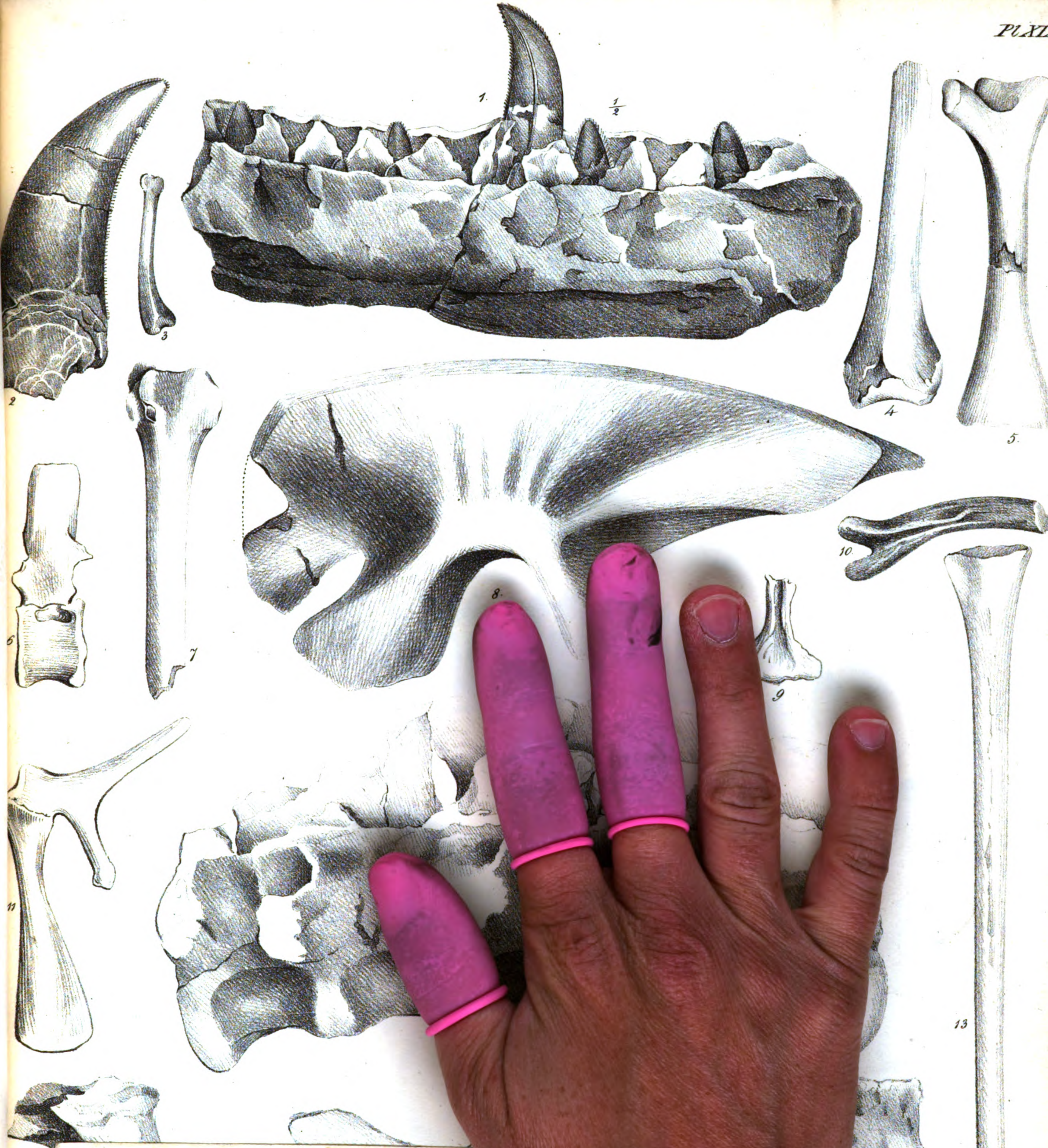
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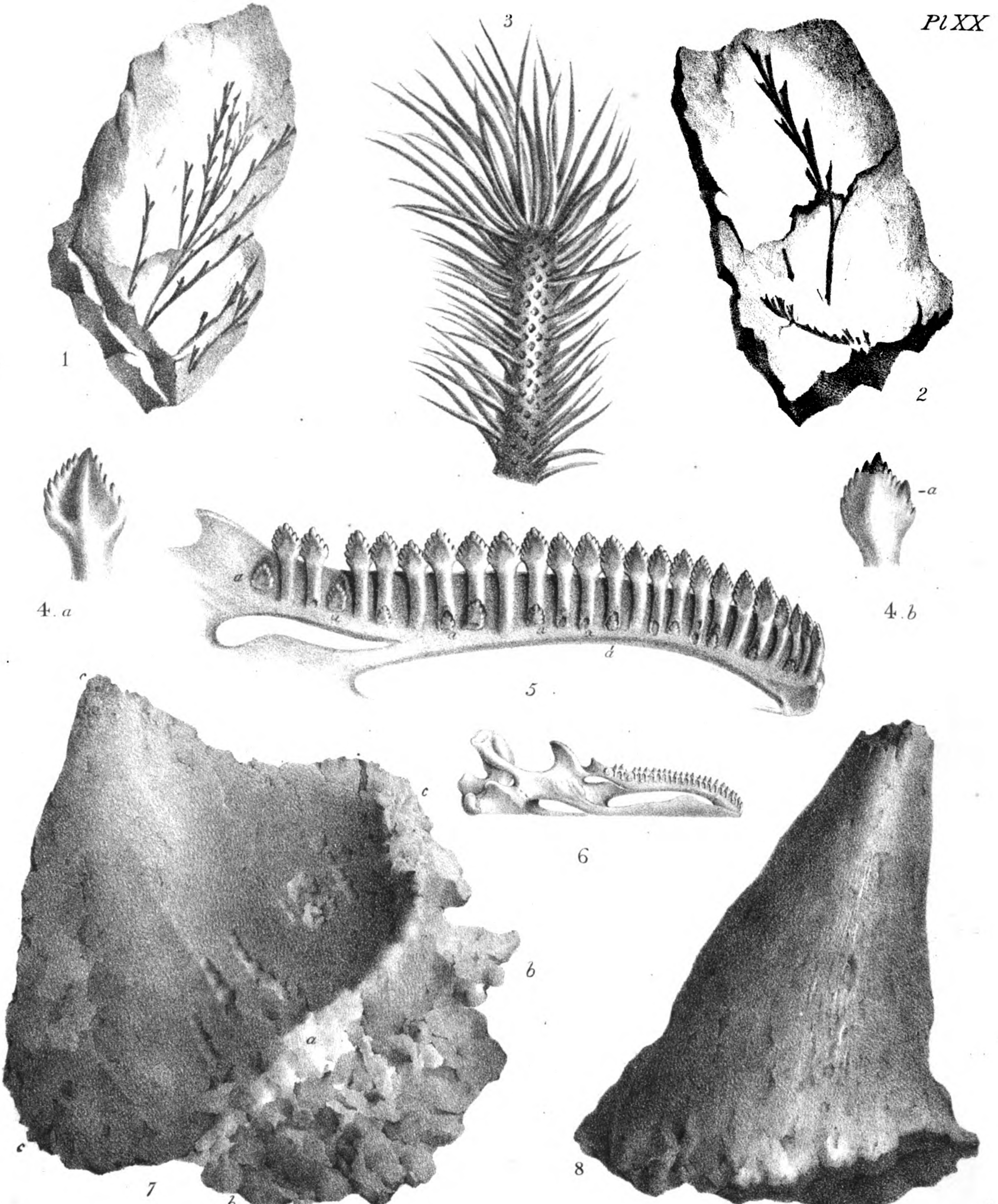
Pl XX



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