with a cross fault to the N.W., which has manifestly helped to protect certain patches of Boulder-clay, and expose others, giving an unequal activity and various directions to the denudation which during the rise of the land took place to so large an extent over the whole district. The undulations in the Boulder-clay are often exceedingly rapid and deep, within very limited areas.

At the same time there is evidence that the land was uplifted by a force acting upon different points with different degrees of intensity. A series of shell-beds may be traced from the half-tide mark opposite Dumbarton, by Dalmuir, Jordan Hill, to Airdrie, occupying levels which gradually rise until at Chappel Hall they reach the height of 526 feet.

Recollecting, therefore, that the shell-bed in question is on the slope of a ridge of Boulder-clay, and that the denuding and elevating forces were both unequal, it is evident in what way the old Boulder-clay may have been carried over the shell-bed, its stones in the process losing their striations and much of their smooth polish, at a period long subsequent to its own original deposition.

As regards the whole case, it is submitted that while there is no evidence whatever that the Chappel Hall fossils were *in* the Boulder-clay, in any sense which would make that clay a marine formation, it is also not proved that they occupy any position different from that held by the common shell-beds of the Glacial epoch in the west of Scotland.

FEBRUARY 8, 1865.

Captain William Arbuthnot, 25 Hyde Park Gardens, W.; Robert Bell, Esq., Professor of Geology in Queen's College, Canada West; William Henry Leighton, Esq., 2 Merton Place, Chiswick; and Viscount Milton, F.R.G.S., of Wentworth Park, and 4 Grosvenor Square, W., were elected Fellows.

The following communications were read:—

1. *On the* SOURCES *of the* MAMMALIAN FOSSILS *of the* RED CRAG, *and on the* DISCOVERY *of a* NEW MAMMAL *in that Deposit, allied to the* WALRUS. By E. RAY LANKESTER, Esq.

[Communicated by Prof. T. H. Huxley, F.R.S., F.G.S.]

(PLATES X. and XI.)

I. THE SOURCES OF THE MAMMALIAN FOSSILS OF THE RED CRAG.

THE very remarkable deposit extending over a small area on the east coast of England, and known as the Red Crag of Suffolk, from time to time furnishes fresh remains of a very various Mammalian fauna. Indeed, so diverse are the forms which occur in this small deposit (whose total number of Mammalian fossils does not exceed

at present 20 species), that, apart from lithological or stratigraphical considerations, the conclusion is forced upon us that we have, in the Red Crag, fossils derived from several preceding deposits—in fact, we have not one fauna, but a mixture of selections from several. As an example of this, in the list of Mammalia alone, we may take the occurrence of such forms as—1st, the Ziphioid Cetaceans; 2nd, the *Mastodon*, *Rhinoceros*, *Tapirus*, *Felis*, *Hyœna*, and *Sus*; and 3rd, the *Hyracotherium* and *Coryphodon*, which forms are elsewhere eminently characteristic of very distinct Pliocene, Miocene, and Eocene strata.

In speaking of the terrestrial Mammalia as probably identical with Miocene forms, it must not be supposed that I in any way overlook the excellent researches of the late Dr. Falconer; and indeed I am quite disposed to consider the Mastodon identical with the Subapennine form *M. Arvernensis*, and distinct from the *M. angustidens*. But since, in his otherwise exhaustive and satisfactory treatise, Dr. Falconer does not finally decide the affinities of the Crag *Rhinoceros*, *Tapirus*, *Sus*, and *Felis*, one must still regard it as a doubtful question whether they are Miocene or Pliocene forms.

An examination of the Molluscan fauna of the Red Crag demonstrates its late Pliocene age, and the researches of Sir Charles Lyell, published in the Journal of the Geological Society for 1852, which I have lately been able to confirm upon more ample data, indicate that the Red Crag was a litoral deposit of the same sea as that which formed the Upper or Yellow Crag of Antwerp. This fact has never been directly called in question; and since it is allowed to be true, there arises the necessity of explaining the occurrence, in this Upper Pliocene deposit of Suffolk, of fossils which properly belong to Middle or Lower Pliocene, perhaps Miocene and Eocene formations.

The teeth, otolites, facial and other bones of Cetaceans abound in an *un*worn and *un*rolled condition in the Middle Crag of Antwerp, where I have collected them; the teeth and bones of forms of Mastodon, of Rhinoceros, of Tapir, and of *Sus*, similar to those of the Red Crag, occur in the Miocene of Darmstadt on the one hand and in the Pliocene Subapennine formations on the other; but in neither case are they associated with Ziphioid Cetaceans, and they are always well preserved and little fractured. The teeth of *Coryphodon* and *Hyracotherium* are well known as characteristic Eocene fossils, unassociated with any of the forementioned Mammalia. All these forms, however, are met with, indiscriminately associated, in this litoral deposit of the Upper Pliocene, namely the Red Crag, and more or less *at the base of the Coralline Crag*. It might be hazarded as an explanation of this phenomenon, that all or some of these types existed together under peculiar conditions, and that their remains were simultaneously imbedded in a common sepulchre. The correctness of this view, however, must appear at once to be very improbable, since nowhere else are these remains associated: and seeing that an examination of the other fossils of the deposit does not bear it out in any way, this improbability is rendered almost a

negative certainty when the character and preservation of the Mammalian fossils is observed, and the conditions of their occurrence noted.

The Crag is, as is well known, a very loose sandy deposit, containing a very unusual amount of oxide of iron, which stains it of a deep-red or orange colour; all the shells of Mollusca which it contains, and which are not *known* to be derived from previous deposits, are excessively fragile, disintegrated, and merely superficially stained by iron, the action of which has tended to render them fragile and pulverulent, rather than to mineralize or strengthen them, whilst the shells and other fossils which are acknowledged to be washed from preceding beds have considerable tenacity, are very heavy, and deeply impregnated with mineral matter. As examples of these two classes of fossils the *Tellinæ*, *Mactræ*, and *Fusi* may be quoted on the one hand, and the derived specimens of *Terebratula spondyloides*, *Voluta Lamberti*, and numerous Crustacean and Piscine remains on the other. The action, then, of the Red Crag on its *proper* fossils appears to be a fragilizing and destructive one; its action on derived fossils an indurating and preservative one. This action may doubtless be satisfactorily explained by the laws of chemical affinity. The oxide of iron, which so deeply colours the Red Crag, existed in the sea as carbonate of the protoxide. It is well known that with recent organic matters, which are necessarily decomposing, this salt of iron forms a sulphide of the metal, whilst water and carbonic anhydride are liberated. The unfossilized shells, bones, &c., therefore, in the Red Crag sea were not subjected to the action of the protoxide of iron at all, the sulphide of iron being formed, which rapidly decomposes and destroys the structure it invests.

Phosphatic nodules, however, and bones and shells thoroughly deprived of their organic matter by previous fossilization, do not act similarly on the carbonate of the protoxide of iron. It infiltrates them, and thoroughly mineralizes them, eventually becoming deposited within their structure as peroxide, silicate, or phosphate, as the case may be, part of their constituents being dissolved and removed by the carbonic acid.

The question here involved, although a chemical one, is of very great importance to the palæontologist; and the investigation of the processes of fossilization cannot but afford the inquirer important results. Much and very valuable assistance has already been furnished to this branch of inquiry by Dr. Bischof in his work on Chemical Geology. It appears that no fossils in any loose sandy deposit attain that degree of mineralization and firmness observed in most bones and teeth from the Red Crag, until they have been subjected for the second time to the action of water containing mineral matter, either by the submergence of the whole deposit or by the separate action on individual specimens.

The fossils of the Middle Crag of Antwerp, of the Darmstadt Miocene, and of those beds of our own Tertiaries which are sandy and *not argillaceous* are all very friable, light, and slightly mineralized.

It is only in such deposits as the older sandstones, which have been in a great measure altered, or in clays where water can accumulate, that heavy and thoroughly mineralized specimens are formed.

If, bearing these facts in mind, the fossil Mammalian remains of the Red Crag are examined, a very important light may be thrown on the origin of their association. With the exception of a few very rare, fragile, and indeterminable pieces of bone, all the Mammalian fossils of the Red Crag are very heavy, compact, thoroughly mineralized, and indurated. This induration could not have taken place in the Crag Sea whilst these remains were fresh, nor in the Crag afterwards; hence it is inferred that the specimens were washed from previous strata, and that those not destroyed by rolling and water-action were thoroughly imbued with salts of iron. No specimen of bone from the Crag is free from evidence of much rolling and washing as though on a sea-beach, and all are disconnected and fragmentary: the so-called Coprolites, now acknowledged to be concretionary nodules, often when *in situ* show fractures across their former centres of concretion, with worn edges; so that semicircular and rectangular pieces often occur. These facts again point but to one conclusion with regard to the association of the Mammalian fossils, Sharks' teeth, and phosphatic nodules with the Molluscan fauna of the Crag; and it is that the sea in which the Molluscan fauna lived broke up various previous Pliocene, Miocene, and Eocene beds, and appropriated some of their organic contents.

It is allowed by most geologists that this is the case as far as concerns the teeth of *Coryphodon*, *Otodus*, *Lamna*, &c., and the phosphatic masses, which all occur in abundance in the Lower Eocene clays of Sheppey; and the same reasoning should apply in the case of the Ziphioid Cetaceans and Miocene Mammalia which occur so abundantly in the earlier strata of Antwerp and Darmstadt in an *unrolled* condition.

There is, however, further evidence of the derivative nature of these two latter groups of remains. Fractured specimens occur of Cetacean bones and teeth which must have been broken subsequently to their partial fossilization, on the broken surfaces of which "*Balani*" of Crag species are attached. A dark indurated matrix, totally differing from the Red Crag, and resembling the Middle Antwerp deposit, frequently surrounds the Cetacean teeth; it could only have been attached to the teeth by their having previously been imbedded in such a deposit as that of Antwerp. The teeth of the Mastodon and the Rhinoceros, again, frequently contain in their interstices and cavities a light-coloured fine matrix, which must have been obtained by their deposition in an earlier bed totally differing from the Red Crag.

On the following grounds, then, it seems fair to conclude that the Mammalian fossils of the Red Crag are mostly derived from earlier beds—the Ziphioid Cetaceans (with *Carcharodon*, &c.) from an equivalent of the Middle Antwerp Crag, the Mastodon, Rhinoceros, Tapir, *Sus*, *Felis*, &c. perhaps from a late Miocene, or more probably from an early Pliocene bed:—

1st. The occurrence of the Mammalian remains in question elsewhere, separately, and in widely different formations.

2nd. The improbability of the coexistence of several Mammals of Miocene and early Pliocene "facies" with a Molluscan fauna shown elsewhere to be of late Pliocene origin.

3rd. The rounded, washed, and worn nature of the specimens, as well as their rarity and fragmentary character.

4th. The complete mineralization of these fossils, their hardness and great weight, which tend to prove their derivative nature,

(1st) Because the proper fossils of the Crag are light, unmineralized, disintegrated, and pulverulent.

(2nd) Because specimens known to be derived are heavy and hard, as these are.

(3rd) Because a loose sand, such as the Crag, cannot produce the complete induration of specimens.

5th. The very frequent presence of attached marine organisms of the Crag age on the broken surfaces of these specimens.

6th. The occurrence of a matrix surrounding the teeth differing entirely from the Red Crag.

In addition to the considerations thus stated, there is, with regard to the terrestrial Mammalia, the very important fact that the teeth of *Mastodon* and *Rhinoceros* of the same species as the Red Crag forms have been found at the *base* of the Coralline Crag, associated with phosphatic nodules and other débris, which leaves very little room for doubt that, whatever species they may be identical with, the Mastodon, Rhinoceros, and other molars are derived from beds of a period previous to the Red Crag era. For these reasons I would urge the probability of a previous extension of the Middle Crag of Antwerp*, and also possibly of the earlier Pliocene or late Miocene deposits of North Europe, along their natural horizon to the line of the present coast of Suffolk—an extension which does not *primâ facie* appear at all unlikely or impossible. From the Middle Crag beds, then, the Ziphioid and other Cetacean remains were derived; from the Miocene or early Pliocene, the terrestrial Pachyderms; from our own Tertiaries, the *Coryphodon*, *Hyracotherium*, &c. The appended Table may be of assistance in explaining the relations of the various strata. The percentages of Mollusca are compiled from the various publications of Mr. Wood and Mr. Nyst; and perhaps in some cases either or both of these gentlemen have been too prone to establish new species distinct from recent forms, which makes the percentage of living Mollusca appear unusually small.

The remarks made in the foregoing pages must be considered merely as an extension or modification of views which have been formerly advanced, chiefly by Mr. Searles Wood, sen., who, in 1859, published a valuable paper on the extraneous fossils of the Red Crag, in which, however, less conclusive evidence was adduced†.

* On these beds, see my paper in the Geological Magazine, vol. ii. pp. 103 & 149, 1865.

† Since this paper was read, Professor Owen has forwarded me an abstract

Red Crag ..... Coralline Crag ..	Molluscan fauna, northern, tropical, and extinct species, 53 per cent. recent. Derived Ziphioid Cetaceans, *Mastodon*, *Rhinoceros*, *Tapirus*, *Sus*, *Hipparion*, &c., *Carcharodon*, *Otodus*, Phosphatic nodules.
Upper Antwerp Crag.....	Molluscan fauna, northern, tropical, extinct, 53 per cent. recent. Few bones, derived teeth of *Oxyrhina*.
Middle Antwerp Crag	Molluscan fauna, 41 per cent. recent. Ziphioid Cetaceans, *Carcharodon*, *Oxyrhina* proper.
Black Crag (Antwerp)	Molluscan fauna, 35 per cent. recent. Few Sharks, Cetaceans?
Miocene (Darmstadt).....	*Mastodon*, *Dinotherium*, *Sus*, *Hipparion*, *Rhinoceros*, &c.
Lower Eocene (Sheppey)	Phosphatic nodules. Fish-remains: *Otodus*. Mammalia: *Coryphodon*, *Hyracotherium*.

II. Trichecodon Huxleyi, a new Mammalian Fossil from the Red Crag of Suffolk.

Specimens and localities.—Amongst a variety of specimens of Mammalian teeth which I had collected from the Red Crag, certain pieces of a large tusk were observed, the form and structure of which seemed to indicate the presence of a new form of Mammal of very considerable size.

Examples of these tusks have been in the collections of Mr. Whincop, of Woodbridge, the late Mr. Acton, and others, for some time, and have been supposed to be either the ponderous lower incisors of a species of *Dinotherium*, or else belonging to the *Mastodon angustidens*, whose molar teeth are so frequently met with in the Red Crag. There is nothing, however, in their structure to warrant this supposition, although in their size and outline they somewhat resemble the tusks of *Dinotherium*. The matter is one which has never as yet been handled by any competent persons, excepting on one occasion, when a fine specimen of one of these tusks, brought to the British Museum by a dealer, was declared *not* to be *Dinotherium* or *Mastodon*; but what it was, was not hinted at. The various specimens of this fossil which have come under my notice are as follows:—1. Three large specimens, more or less perfect, from the Red Crag of Sutton and Felixstow, in the collection of Mr. Whincop. 2. Four smaller specimens of the terminal points of young tusks, from Felixstow, Bawdsey, and Sutton, also in the collection of Mr. Whincop. 3. Three fine specimens of portions of the tusk, as well as smaller ones, in the collection of Mr. Calvert,

of a paper by him on some Mammalian fossils from the Red Crag of Suffolk, read Feb. 20th, 1856. In this paper he expresses his opinion that the "Red Crag is the *débris* of former Tertiary strata, and in a great proportion of the Miocene period."

from various Crag pits. 4. Large fragments from Felixstow, in the author's cabinet. To this list I may now add two fine fragments, which I lately observed in the collection of my friend Mr. Packard, of Westerfield.

When travelling in Belgium last summer, I was much gratified by finding a large portion of one of these tusks in the collection of Professor Van Beneden, of Louvain. This specimen, which is unique, was not obtained from the "Crag supérieur" or "Crag jaune," which is the exact equivalent of our Red Crag, but was met with in the "Crag moyen" or "Crag gris," an older and well-defined deposit, abounding in unrolled remains of Cetaceans and Sharks, as well as Molluscan fossils. Professor Van Beneden had been unable at this time to decide the affinities of the animal to which this tooth belonged; but since then he has communicated his opinion to me in a letter, that it was closely allied to the Walrus—a conclusion at which I had previously arrived. The grounds upon which this conclusion is founded will now be given.

General Form and Outline.—The majority of the specimens of the tusk which have been obtained are its pointed terminations; but other specimens, of the base and intermediate portions, have come to light. Throughout its length, which in some examples must have been fully three feet, the tusk is slightly curved; but in those which appear to be fully grown the curve is considerably greater towards the terminal point, the direction of the curve probably giving the tusk, if its Pinnigrade affinities be established, a retroflected position, as in the *Dinotherium*. The Crag tusk is very much compressed laterally, so that its transverse section has an elliptical outline, whilst that of the *Dinotherium*-tusk is nearly circular. The amount of lateral compression is, however, extremely variable, as it is also in the living Walruses; the amount also of the lateral as well as the antero-posterior flection of the tusk appears to vary, as in the recent *Trichecus*, the variability of which in the size and form of its tusks is well known. A single large furrow on the outer surface, two on the inner, and one on the inner curved margin, extend along the whole length of the tusk in many specimens, exactly similar to those noticed on some tusks of Walrus; but in both the recent and fossil specimens they are subject to much variation, in their major or minor development. No appearance of any wearing of the point of the tusks by use during life is observable; and indeed the greater backward curvature of that part seems to result from its freedom from usage, since in the Walrus the point of the tusk is rapidly worn away, which of course checks any tendency to curvature which might become apparent if the tusk were not used against such hard substances as rocks and blocks of ice (Pl. X. figs. 1–3).

From an examination of the general contour and form of the tusks, without regard to their substance or structure, one would unquestionably be led to regard them as belonging to an animal similar to the existing Walrus, inasmuch as it is in this animal alone that this form of tusk, with its longitudinal furrows, great length, and gentle curvature, is found.

The tusks of Proboscideans are cylindrical, uncompressed, without furrows, and generally much curved. Those of the *Sirenia* are a great deal smaller, proportionately to the body, than these probably were; they are also unfurrowed, nearly cylindrical, and almost straight; whilst the canines and incisors of the *Hippopotami* have an entirely different form.

Structure of the Tusks.—Probably one of the most satisfactory methods of demonstrating the arrangement of the mineral matter in teeth is by means of fossil specimens, since the complete destruction of their organic constituents, and the infiltration and absorption of various chemical substances, in most cases disintegrates them, and developes or renders apparent a structure which would otherwise escape observation. Thus the fossil tusks of the Mammoth easily split up into a series of superimposed hollow cylinders; the Cetacean teeth from the Red Crag often, owing to the varying absorption of iron in the different tissues of the tooth, may be broken into long laminæ, such that the "crusta petrosa" or "cement" is removed, and a very remarkable gyrate and striated arrangement of the subjacent dentine is exposed. So with the fossil tusks under description; the exterior is, when properly preserved, smooth, but marked by a number of fine longitudinal cracks, which are most apparent in the small or young specimens. The lamina of the tooth in which these cracks exist very frequently splits off, and the subjacent surface is thereby exposed. A microscopical examination of this external lamina shows it to be the "cement" investing the whole tusk, no enamel occurring in these teeth. When much of the cement layer has been removed, as very frequently happens, the solid matter of the "dentine" which underlies it is seen to have a very curious arrangement. Its surface, which becomes very glossy and bright in these Crag fossils, is sculptured by a series of small longitudinal grooves or furrows, producing a fluted ornamentation, whilst minute ridges or striations cross these at right angles, the two series of markings together giving an appearance very similar to that observable on the surface of the canine of the Hippopotamus (Pl. X. fig. 1).

This structure in the fossils under notice has led to their being regarded as belonging to a form of *Hippopotamus*; but inasmuch as in that animal the grooves and striations are entirely superficial, whilst in the Crag tusks, as also in Cetacean teeth of the same deposit, these markings are only displayed by the removal of the external lamina of cement, no weight can be attached to an assimilation of the two forms of tusk based upon these grounds.

The "dentine" of the fossil tusks has a tendency to split up into long concentrically annular laminæ, displaying, when removed by the action of the sea or elsewise, a similar series of longitudinal groovings; so that this arrangement of the mineral matter of the dentine may be regarded as persistent throughout its thickness. In a transverse section of one of the tusks, an arrangement of the constituent tissues of the tooth is displayed which leaves very little room for doubt with regard to the affinities of its possessor (Pl. X.

fig. 5). The area of the pulp-cavity, which is very large, is throughout the whole length filled up, a very small and flat space, which is the only true pulp-*cavity*, existing at the base. The substance which occupies its place, and which is known in other teeth as "osseo-dentine," appears to be composed of a number of small globular bodies, closely agglomerated and compacted, and presenting that peculiar appearance and structure which is characteristic of the tusk of the Walrus, and was compared by Cuvier, when writing of that animal, to "pudding-stone." Thus:—"L'ivoire des défenses du Morse est compacte, susceptible d'un poli presque aussi beau que celui de l'Hippopotame, mais sans stries; la partie moyenne de la dent est formée de petits grains ronds placés pêle-mêle, comme le cailloux dans la pierre appellée *poudingue*; c'est ce qui le caractérise. Les dents molaires de cet animal ont leur axe composé des mêmes petits grains que celui des défenses. Elles n'ont aucune cavité dans leur intérieur" *.

This structure, which is in reality formed by numerous distinct calcifications around various vascular canals, from which radiate tubules similar to those of the dentine, occupies a large part of the fossil, as it does of the Walrus-tusk, diminishing as the point is approached. The microscopical appearance of this part of the tusk, and of the dentine and cement exterior to it, is shown in the accompanying drawings of sections, obtained with some difficulty, from the fossils and from the tusk of the living Morse (Pl. X. figs. 4 & 6).

The dentine which surrounds the peculiar "osseo-dentine," and forms the bulk of the tooth, is very hard and compact, and has a radiated fibrous appearance, owing to the direction taken by the dentinal tubules, which, although excessively minute, are thus far rendered apparent by the selective infiltration of mineral matters. The tubules do not appear to exert the least influence on the direction of the fracture of the tooth, which is, as before stated, in longitudinal annular laminæ. Deorganized tusks of the Walrus present this same form of disintegration.

In its microscopical structure, the dentine of the fossil tusks presents a complete resemblance to that of the tusk of the Walrus, which will perhaps be best understood by reference to Plate X. figs. 4 & 6. The dentinal tubes are very nearly of the same size, and equally closely packed, and are connected with stellate lacunæ in some numbers near the periphery of the tooth. This structure, which is not peculiar to the Walrus, is nevertheless a test of affinity, inasmuch as the form of the lacunæ varies in different animals. They are not met with in the tusks of the Proboscidea or the Hippopotamus, but occur in the curious incisors of the Dugong. The "dentinal cells" of the Crag tusks also resemble those of the Walrus.

The "cement," as seen in a transverse section of one of the fossil tusks, which was cut at a distance of nine inches from its terminal point, and the diameter of which was there $2 \times 3\frac{1}{4}$ inches, appeared not to be more than the sixth of an inch in thickness, whilst the thickness of the "dentine," compared to that of the

* Cuvier, Leçons d'Anat. Comparée, tom. iii. (1805), p. 106.

"osseo-dentine," was about as 3 : 1. In structure the cement exactly resembles that of the Walrus, displaying vascular canals, bone-lacunæ, and canaliculi, of the same form and disposition; but the proportion which it bears to the thickness of the other tooth-tissues appears to be larger in the Walrus than in the fossil.

From the foregoing remarks it will be apparent that we have in these fossil tusks characters which ally them most closely to the large canines of the genus *Trichecus*. It will perhaps be well to enumerate the points of form and structure which distinguish them from the tusks of other animals, and those which assimilate them to the canines of the Walrus.

1. They are distinguished from the Proboscidean tusks generally by their lateral compression, slight curvature, and deep superficial groovings, and by the absence of that cylindrical form, smooth surface, and great curvature, which is present in Proboscidean tusks. Structurally by the presence in the fossil tusk of a large core of peculiar globular "osseo-dentine," by the presence of stellate lacunæ in the dentine, by the size and form of its tubes, and by the amount and structure of the cement; and by the absence of peculiar "engine-turning," or "guillochis," which marks the ivory of the Proboscidea.

2. They are distinguished from the tusks of the *Dinotherium* in particular, by all the above-mentioned characters but the last; to which may be added the absence of a deep conical basal pulp-cavity, observed in the tusks of *Dinotherium* and of the Elephants and Mastodons also.

3. They are distinguished from the tusks of *Sirenia*, which resemble somewhat those of the Walrus, by their definite form, grooving, and curvature; by their much larger core of osseo-dentine, and by their short and wide, instead of elongate and angular, pulp-cavity.

4. From the tusks of *Hippopotami* they are distinguished by every character of form and structure, the fluting of the dentine (recalling the markings on the *surface* of the canine of *Hippopotamus*) being the only similarity between the two.

Lastly, they resemble the large canine tusks of the living *Trichecus* in their curvature, varying lateral compression, large surface-furrows, short and wide pulp-cavity, globular "osseo-dentine," and every detail of minute structure. They differ from them in their greater curvature at the point of the tusk, their greater lateral compression, and minor development of cement.

I accordingly propose to establish the genus *Trichecodon* to receive the animal thus indicated. The justification of a generic separation must be sought in the fact of the great antiquity of the Red Crag, and the consequent probability of the association of other and more distinctive attributes with those of the tusks. The name *Trichecodon* was proposed to the author by M. Van Beneden, as one aptly describing all that we at present do, and probably ever shall, know of this animal. In searching for a specific title, I have thought that I cannot do better than dedicate this somewhat interesting form to

my much-valued friend Professor Huxley, whose name has already been associated with the history of the Crag Mammalia by his recent researches on Ziphioid Cetaceans.

It appears that the *Trichecodon Huxleyi*, like the Cetacean remains of the Crag and large Sharks' teeth alluded to in the first part of this paper, is a derived fossil in the Red Crag, belonging properly to the Middle Crag, which is not now observable in this country, but is well developed at and near Antwerp.

III. The probable Identity of the Teeth of the so-called Balænodon physaloides with those of Species of the Genera Belemnoziphius and Squalodon.

The Cetacean teeth which occur in great numbers in the Red Crag, of large size and more or less conical shape, are at present in this country referred to the *Balænodon physaloides* of Professor Owen (Pl. XI. figs. 3 & 5). From a comparison of many hundreds of specimens in various collections, I have ascertained that there are two forms of these teeth—those which simply taper more or less towards the crown and have large bases, and those which have a more elongated base and a nipple-shaped crown coated with enamel (Pl. XI. figs. 6 & 7). To the first form belongs the original specimen figured as *Balænodon physaloides* in the 'British Fossil Mammalia,' whilst the second form, which is most obviously and clearly distinguished from the first in specimens which are only slightly rolled, is entirely distinct. The excavations which have now for some years been going on at Antwerp, have furnished most abundant and beautiful remains of a fossil Cetacean fauna from the Middle Crag. The teeth of the lower jaws of the Ziphioids have been identified, and the remains of the remarkable Cetacean *Squalodon* have been obtained in very fine preservation. M. Van Beneden, who has had the charge of all the Mammalian remains obtained, and whose researches on the subject are well known, assures me, from a comparison with the Antwerp fossils of specimens which I sent to Louvain, that the *Balænodon* teeth of the first form (that originally described) are without doubt the teeth of the bident lower jaws of those Ziphioids whose remains occur with them in the Red Crag; whilst the more elongated teeth with an emarginated nipple-like crown of enamel, more or less worn, are the teeth of a species of *Squalodon*, probably the *Squalodon Antwerpiense*, the restoration and description of which by MM. Van Beneden and Gervais are well known.

If this be the case—and the amount of material afforded to M. Van Beneden by the workings at Antwerp is of so perfect and satisfactory a nature that there can be little doubt on the matter—the *Balænodon physaloides* will have to be removed from the list of our British fossil Mammals, and species of *Ziphius* and *Squalodon* adopted in its place.

EXPLANATION OF PLATES X. & XI.

PLATE X.

Fig. 1. Fragment of the tusk of *Trichecodon Huxleyi*; terminal portion, showing the fluting of the dentine. From the Red Crag of Suffolk. One-third the natural size.

2. A flatter specimen of the same, with point complete, and the surface of cement preserved. One-third the natural size.

3. Basal portion of the same, with the cement preserved. One-third the natural size.

[These three specimens are in the cabinet of W. Whincop, Esq., of Woodbridge.]

4. Section of a portion of the tusk of *Trichecus rosmarus*, showing the microscopic structure of the three layers. Drawn from specimens prepared for the author.

5. Section of a portion of the tusk of *Trichecodon Huxleyi*. Drawn from specimens prepared for the author.

6. Transverse section of the specimen drawn in fig. 1, showing the "core" of granular "osseo-dentine." Natural size.

PLATE XI.

Fig. 1. Restoration of the tusk of *Trichecodon Huxleyi*.

2. Tusk of *Trichecus rosmarus*.

3. Tooth of a large Ziphioid Cetacean, probably one of the *Belemnoziphii* (*Balænodon physaloides* of Owen), from the Red Crag, Felixstow; in the author's cabinet. Three-fourths the natural size.

4. Tooth of *Squalodon*, Van Beneden & Gervais; from the Red Crag, Suffolk. In the Woodwardian Museum, Cambridge.

5. *Balænodon physaloides*; from Owen's 'British Fossil Mammalia,' p. 536.

6 & 7. Teeth of *Squalodon*, more or less worn, sometimes attributed to the *Balænodon* of Owen.

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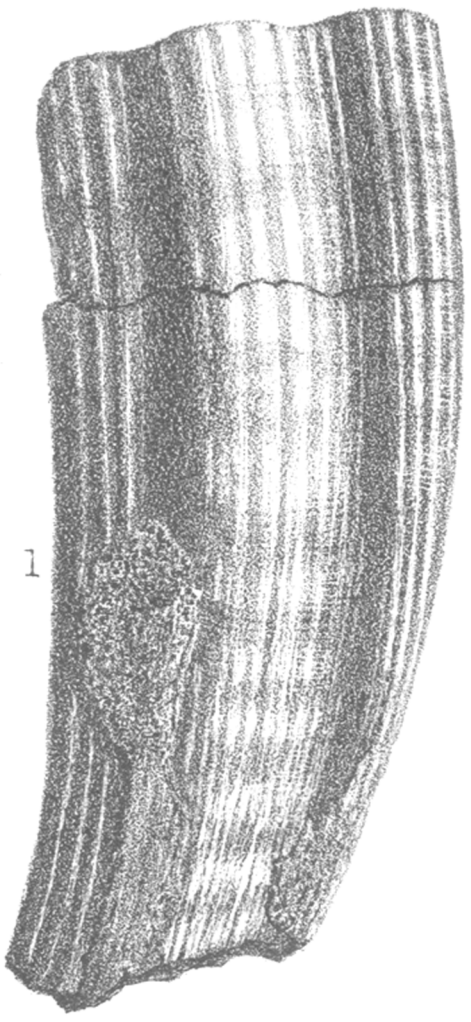
2. *Note on the* GEOLOGY *of* HARROGATE. By JOHN PHILLIPS, M.A. Oxon., LL.D. Dublin, F.R.S., F.G.S., Professor of Geology in the University of Oxford.

DURING more than forty years the uncommon arrangement of the strata about Harrogate has attracted my attention, and I have made frequent examinations of the surrounding country to learn the peculiarities of structure of the Upper Palæozoic rocks which are there exposed. Of late years the information furnished by many quarries has been increased by the cuttings on the North-Eastern Railway, and thus not only the ranges of Millstone-grit, calcareous roadstone, and Yoredale shales have been settled, but some light has been thrown on the relation of the Permian grits to those of the older series, which was formerly doubtful. The mineral springs are also much more surely referable to a deep source along an axis of movement than was possible when, now almost thirty years since, I published my map of the north-western tract of Yorkshire*.

Founded on a mass of particular notices, I propose now to offer to the Society a few results relating to this district, such as it may be well to consider before the closer scrutiny of the Geological Survey

* Illustrations of the Geology of Yorkshire, vol. ii. 1836.



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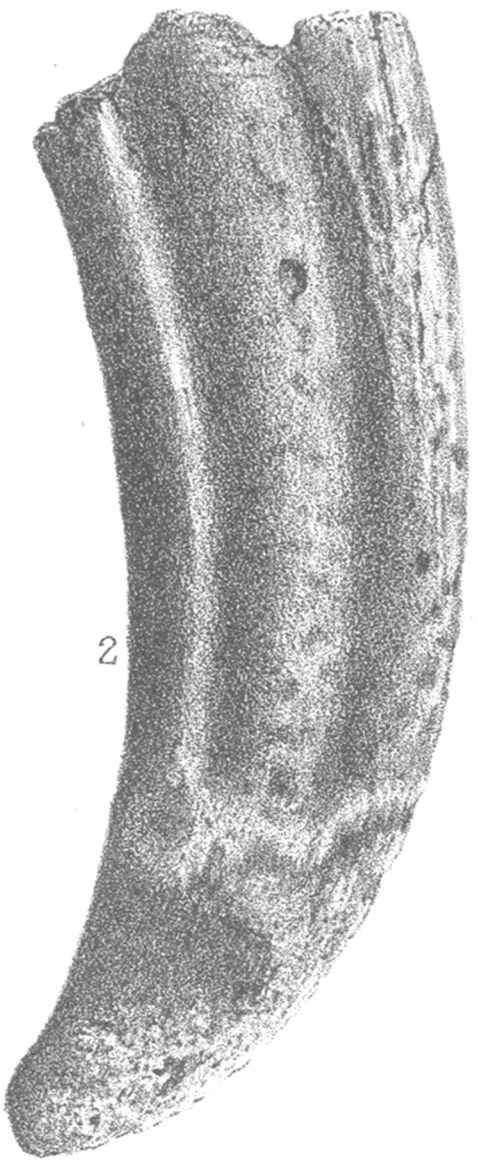

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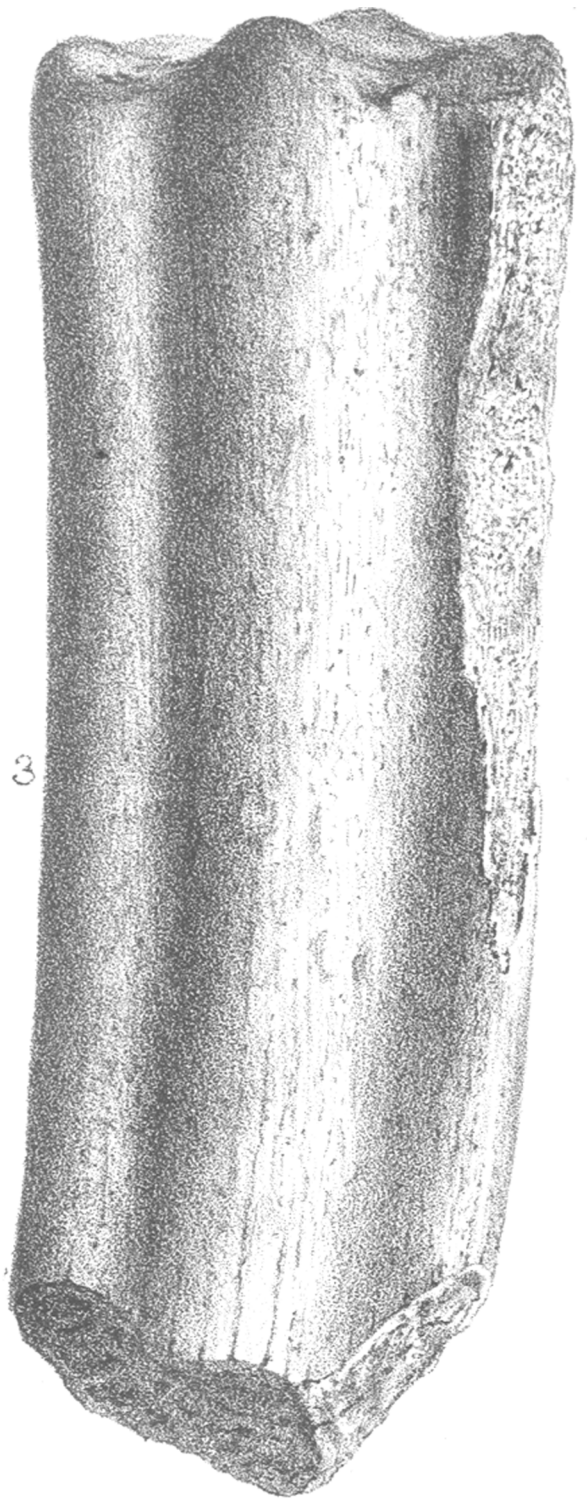

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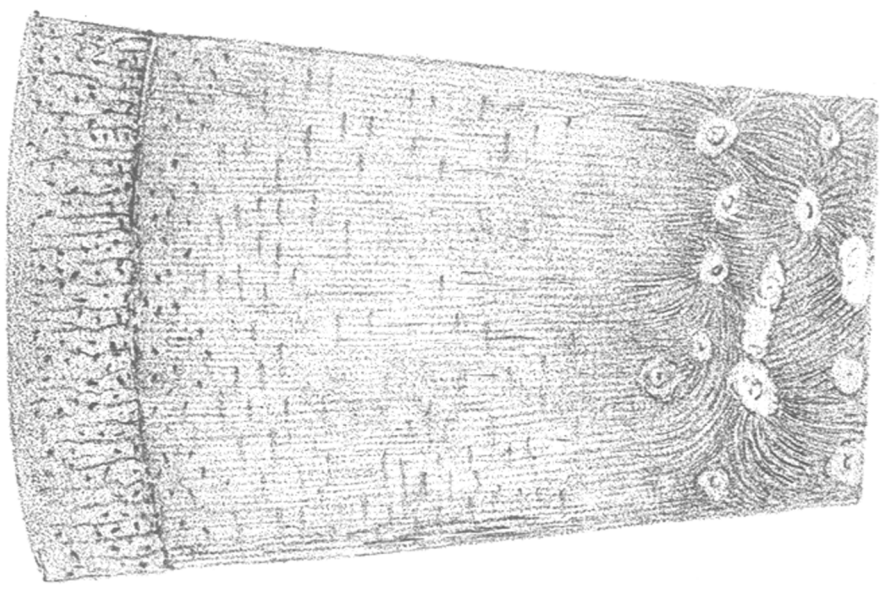

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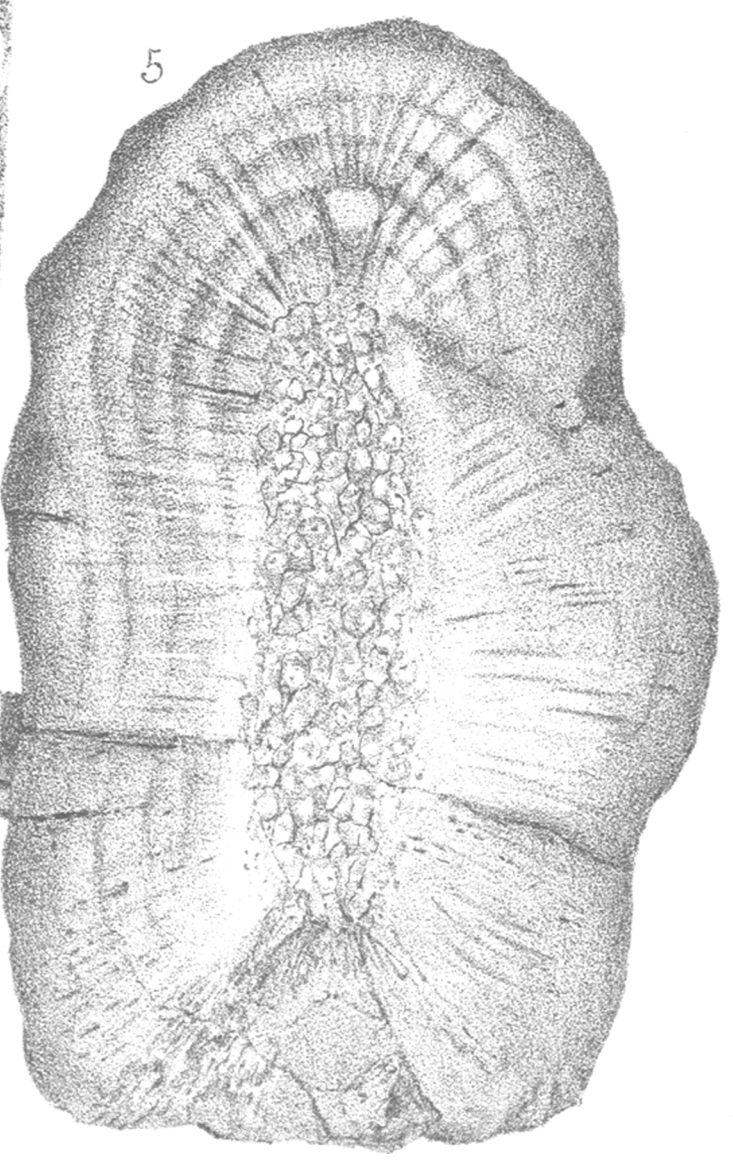

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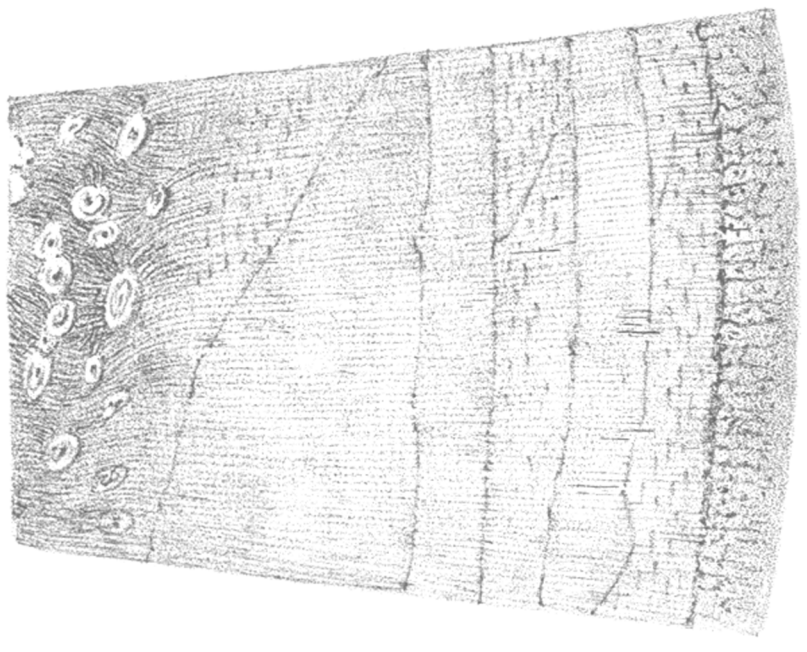

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De Wilde lith ad nat.

Hanhart, Imp.t

CRAG MAMMALIA.

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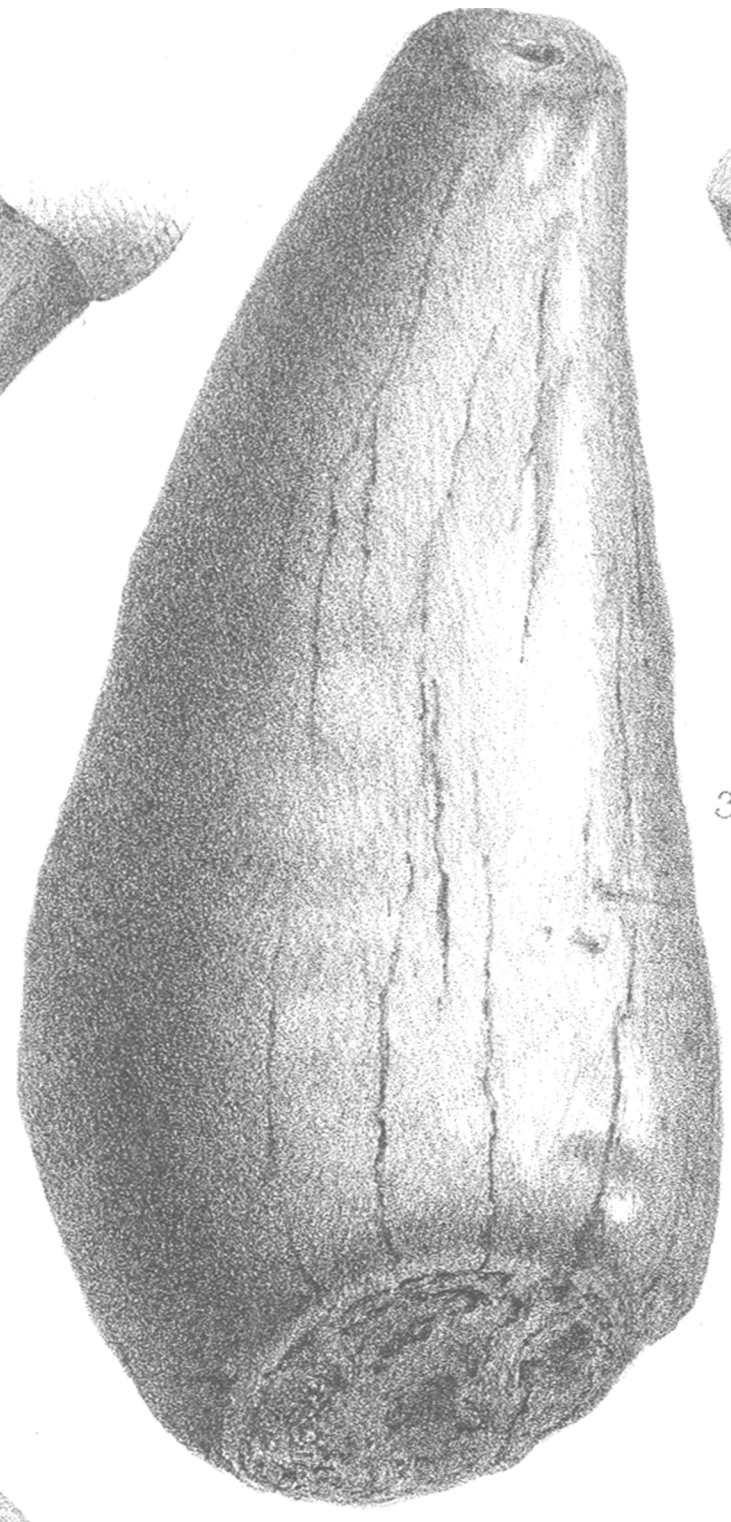

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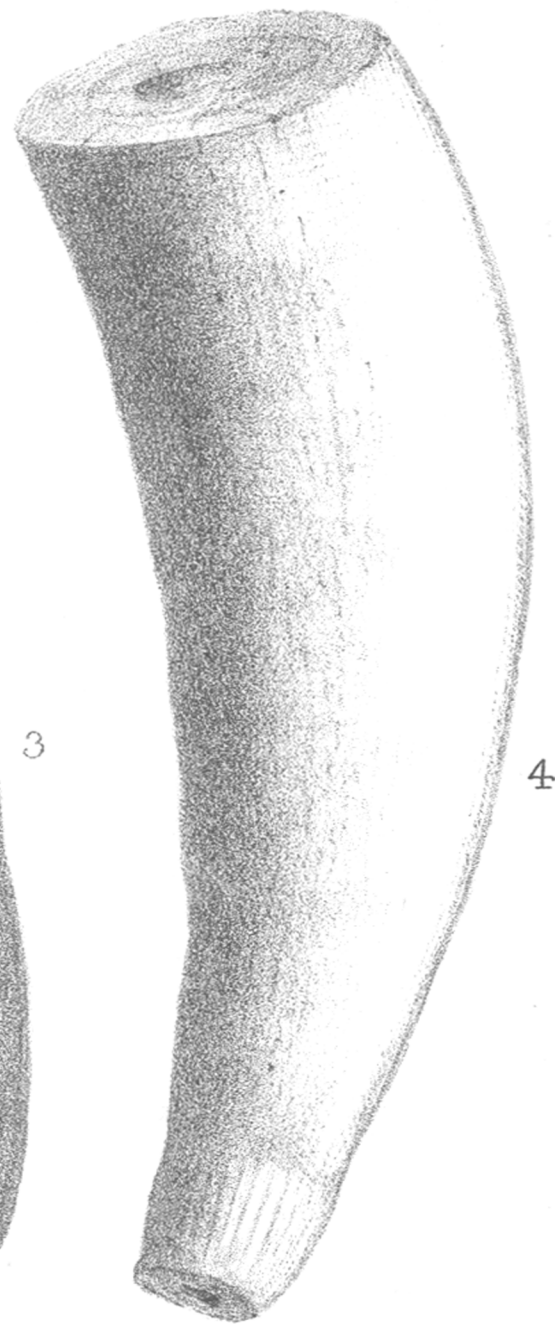

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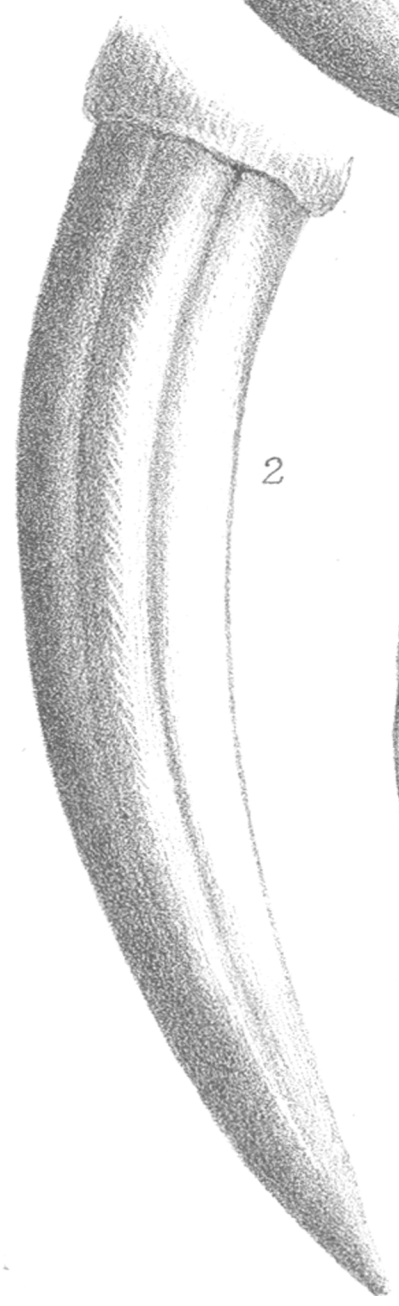

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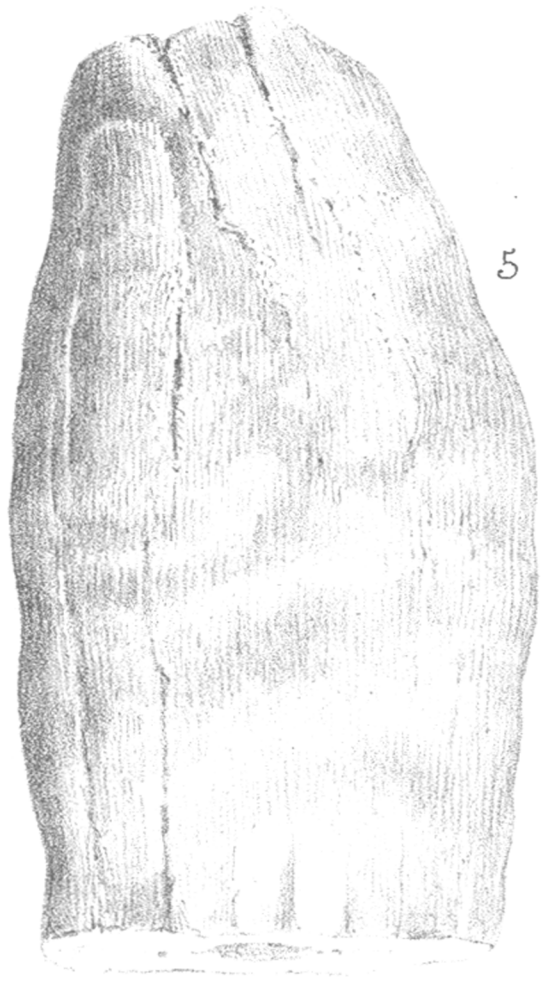

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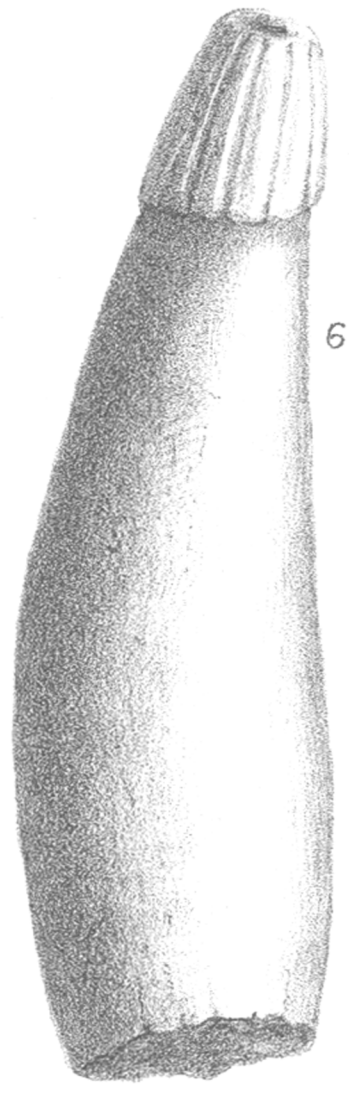

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De Wilde, lith ad nat.

Hanhart, Imp.

CRAG MAMMALIA