Géominpal Belgica

Découvertes géologiques, minéralogiques et paléontologiques en Belgique.

5.3

Additional Contributions to the Knowledge of the Sediments, Taphonomy, Ichnofossils, Bacteria, Invertebrata,Vertebrata, Algae and Plantae of the *Sint Niklaas Phosphorite Bed* in its type locality: Sint Niklaas (Eastern Flanders, Belgium)

Part Three: Vertebrata

By

Jacques Herman[1], Hilde Van Waes[1], Hugues Doutrelepont[2], Lutgard Kenis[2],
Julien Van Nuffel[3] Jacqueline Cloetens[3],
Vanderhoeft[4] & Marcel Vervoenen[5]

[1]Herman J. & Van Waes H. : Mail: jacquesalbertherman@gmail.com
[2]Doutrelepont H. & Kenis L. : Mail: hugues.doutrelepont@skynet.be
[3]Van Nuffel J. & Cloetens J. : Rue Jules Lahaye 203, 1090 Brussels (Belgium)
[4]Vanderhoeft E. : Rue Simonis, 31, 1050 Ixelles (Belgium)
[5]Vervoenen M. : Beekstraat 35, 9300 Aalst (Belgium)

Three side views of a marine sea turtle, with its almost mature embryo.
Chelonia - Family Carrettidae GRAY, 1825 - *cf.* Genus *Carreta* RAFINESQUE, 1814.
Origin: Belsele (Flemish Brabant),
Scheerders Van Kerchove Claypit N°4: B.G.S. Archives 42 W 394: Sint Niklaas Phosphorite Bed
Lower marine Oligocene of Belgium.
Collection Jacques Boel. Photographs: Jacques Herman.

HERMAN Jacques Editor **H**

Dedication:

This work is dedicated to the memory of Maître Pierre Vanderhoeft,
the father of Eric Vanderhoeft

formerly:

Advocate of the Court of Justice of Brussels

and

to the memory of Edmond de le Court

formerly:

First Class Soldier of the French Foreign Legion

Military Cross and North Africa Medal

Our friend, neighbour and our teacher in Computer Science,

Their friends, Jacques Herman, Hilde Van Waes
and Eric Vanderhoeft,

at Beigem, 4 February 2013

Jacques Herman, Hilde Van Waes,
and Eric Vanderhoeft

Plan of this Publication

Summary

(Hilde Van Waes)

In the third of the four parts of this Study, all the data furnished by the study of all the fossil remains of Invertebrata discovered in this Horizon are re-examined, and consequently, the geological age of this Horizon itself is reconsidered.

The slow and progressive formation of this irregular conglomerate has been detailed. Its formation could be explained by the continuous action of a subaquatic stream, sporadically changing of direction.

A short emersion succeeded the initial phase of the formation of this conglomerate. Marine waters came back, but the environment remained coastal to intertidal.

The successive phases of the sedimentation of the upper part of the Sands of Ruisbroek, of the *Sint Niklaas Phosphorite Bed*, the lower and upper parts of the Boom Clay Formation (*sensu stricto*) are examined in function of the data provided by the study of their vertebrates.

Keywords: Belgium, Oligocene, Rupelian, Sands of Ruisbroek, *Sint Niklaas Phosphorite Bed*, Boom Clay Formation, Vertebrata, Systematics, Parasystematics, Evolution, Genetics, Plate Tectonics, Geophysics, Van Allen Rings, Taphonomy, Sedimentology, Paleoclimatology, Astrophysics.

Résumé

(Jacques Herman)

Dans la troisième des quatre parties de cette Etude, les données fournies par l'examen de tous les restes d'Invertebrata fossiles découverts dans cet Horizon sont réexaminés, et par conséquent, l'âge géologique de cet Horizon est reconsidéré.

La formation lente et progressive de ce conglomérat irrégulier est minutieusement détaillée. Elle peut s'expliquer par l'action continue d'un courant subaquatique, changeant sporadiquement de direction.

Une brève émersion succéda à la phase initiale de la formation de ce conglomérat. Les eaux marines revinrent, mais l'environnement resta littoral à intertidal. Les phases successives de la sédimentation de la partie supérieure des Sables de Ruisbroek, de l'*Horizon des Phosphorites de Sint Niklaas*, des parties inférieure et supérieure de l'Argile de Boom (*sensu stricto*) sont examinées et détaillées en fonction des données fournies par l'étude de leurs vertébrés.

Mots-clés: Belgique, Oligocène, Rupélien, Sables de Ruisbroek, *Horizon à Phosphorites de Sint Niklaas*, Formation de l'Argile de Boom, Invertebrata, Systématique, Parasystématique, Evolution, Génétique, Tectonique des Plaques, Géophysique, Ceintures de Van Allen, Taphonomie, Sédimentologie, Paléo-climatologie, Astrophysique.

Samenvatting

(Hilde Van Waes)

In het derde van de vier delen van deze Studie wordt de werkelijke geologische ouderdom van al de fossiele Invertebrata in deze Horizon gevonden herzien, en bijgevolg ook de werkelijke geologische ouderdom van deze Horizon zelf.

De langzame en progressieve formatie van dit onregelmatig conglomeraat wordt zorgvuldig gedetailleerd. Zijn formatie wordt verklaard door de permanente actie van een sub-aquatische stroom die sporadisch van richting veranderde.

Een korte emersie fase volgde op de initiële fase van de formatie van dit conglomeraat. Mariene waters kwamen terug maar het milieu bleef litoraal tot tussentijdig.

De opeenvolgende fasen van de sedimentatie van het bovenste deel van de Zanden van Ruisbroek, het *Sint Niklaas Fosforiet Bed*, van het onderste deel en het bovenste deel van de Boomse Klei (*sensu stricto*) worden onderzocht en gedetailleerd in functie van de data verkregen door de studie van hun vertebraten.

Sleutelwoorden: België, Oligoceen, Rupeliaan, Zanden van Ruisbroek, *Sint Niklaas Fosforiet Bed*, Boom Klei Formatie, Vertebrata, Systematiek, Parasystematiek, Evolutie, Genetica, Plaattektoniek, Geofysica, Van Allen Ringen, Taphonomie, Sedimentologie, Paleoclimatologie, Astrofysica.

Resumen

(Lutgard Kenis)

En la tercera de las cuatro partes de este Trabajo, la edad de todos los fósiles Vertebrata descubiertos en ese horizonte fueron reexaminados, y por lo tanto, la edad geológica de ese horizonte es reconsiderada.

La lenta y progresiva formación de ese conglomerado es minuciosamente detallada. Ella puede explicarse por la acción continua de una corriente subacuática que cambiaba esporádicamente de dirección.

Una emersión breve ocurrió a la fase inicial de formación del conglomerado. Las aguas marinas regresaron, pero el medio ambiente permació siendo litoral a intermareal.

Las fases sucesivas de la sedimentación de la parte superior de las Arenas de Ruisbroek, del *Horizonte de Fosforitas de Sint Niklaas*) y de las partes inferior y superior de la Arcilla de Boom (*sensu stricto*) son examinadas y destalladas.

Palabras claves: Bélgica, Oligoceno, Rupeliense, Arenas de Ruisbroek, *Horizonte à Phosphorites de Sint Niklaas*, Formación de la Arcilla de Boom, Vertebrata, Sistemática, Parasistemática, Evolución, Genética, Tectónica de Placas, Geofísica, Cinturones de Van Allen, Tafonomía, Sedimentología, Paleoclimatología, Astrofísica.

Kurzfassung

(Fritz Pfeil)

In dem dritten der vier Teile dieser Abhandlung, werden das Alter aller fossilen Vertebrata in diesem Horizont gefunden revidiert und folglich wird das geologische Alter dieses Horizont erneut erwogen.

Die langsame und progressive Entstehung dieses Konglomerats wird detailliert beschrieben. Sie kann durch den ununterbrochenen Fluss einer subaquatischen Strömung erklärt werden der sporadisch die Richtung ändert.

Der ursprünglichen Phase der Bildung dieses Konglomerats folgte eine kurzzeitige Regression. Meerwasser kam zurück, aber das Paläoenvironment blieb Küstenzone bis Gezeitenbereich.

Die darauf folgenden Phasen der Sedimentation des oberen Teils der Sande von Ruisbroek, des *Sint Niklaas Phosphorite Horizonts* und der unteren und oberen Teile der Boom Clay Formation (*sensu stricto*) werden detailliert beschrieben.

Slüsselwörten: Belgien, Oligozän, Rupelium, Sande von Ruisbroek, *Sint Niklaas Phosphorite Horizon*, Boom Clay Formation, Vertebrata, Systematik, Parasystematik, Evolution, Genetik, Plattentektonik, Geophysik, Van Allen Ringe, Taphonomie, Sedimentologie, Paläoclimatologie, Astrophysik.

Резюме

(Tatiana Malyshkina & Evgeny Popov)

В третьей из четырех частей данного исследования все представленные данные пересматриваются на основе изучения всех ископаемых остатков беспозвоночных животных, найденных в этом горизонте. Соответственно, геологический возраст горизонта пересматривается.

Подробно изучается медленное и постепенное формирование этого беспорядочно сложенного конгломерата. Его образование может быть объяснено непрерывным действием подводного течения, время от времени меняющего направление.

В начальной фазе формирования конгломерата произошло короткое осушение. Морские воды вернулись, но окружающая среда сохранила условия от прибрежной до приливно-отливной обстановок.

Последовательные фазы седиментации верхней части песков Руисбрек, фосфоритового горизонта Синт Никлаас, нижней и верхней частей формации Бум Клэй (*sensu stricto*) проверяются на основе изучения остатков позвоночных животных.

Ключевые слова: Бельгия, олигоцен, рюпель, пески Руисбрек, фосфоритовый горизонт Синт Никлаас, глина Бум, позвоночные, систематика, парасистематика, эволюция, генетика, тектоника плит, геофизика, пояса Ван Аллена, тафономия, седиментология, палеоклиматология, астрофизика.

2. Introduction

After having carefully examined the sedimentological compounds, the lithological elements, the taphonomical data, all the ichnofossils (*sensu lato*)*, and after having drawn up a systematic inventory, as complete as possible** of all the remains of marine invertebrates, this third part is entirely devoted to the examination of all the marine vertebrate remains discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*, and to the examination of the rare ones discovered *in situ* in the uppermost part of the Ruisbroek Sands Formation and to their descendants in the three Units which constitute the Boom Clay Member.

*See *Géominpal Belgica* 5 (Part One) **See *Géominpal Belgica* 5 (Part Two).

The quality of preservation of the major part of these vertebrate remains is perfect. Only some of them, ingested by a predator were, more or less intensively, affected by the action of gastric enzymes.

The dominance of fish remains (Pisces) is normal in a marine environment. These are represented by some dental plates of chimaera (Holocephali), thousands of shark teeth (Neoselachii) and rays (Batoidei), all being cartilaginous fishes (Chondrichthyes).

The bony fishes (Teleostei) are represented by thousands of teeth and diverse bones, which in function of their physical preservation, may be separated into two groups explaining their respective succession in this fossiliferous level.

The other marine or amphibian vertebrates are only represented by three eggs, some plates of the bony carapace
and some jaw bones of marine sea turtles (Reptilia - Chelonia), and some small osteoderms of varanids (Reptilia - Squamata).

The existence of terrestrial vertebrates is demonstrated by the discovery of two caudal osteoderms of a small mangrovial crocodile, two teeth of small rodents and an astragalium attributable to a primitive rhinoceros (Family Rhinocerotidae GRAY, 1821).

Some very rare bones testify of the presence of the last populations of the Genus *Odontopteryx* OWEN, 1873 (Family Pelagornithidae, Protoaves *vel* Paleornithes).

3. Introduction

Après avoir procédé à l’examen détaillé des composants sédimentaires, des éléments lithiques, des données taphonomiques et de tous les ichnofossiles (*sensu lato*)*, et avoir effectué un inventaire systématique aussi complet que possible** de tous les restes d’invertébrés marins, cette troisième partie est entièrement dévolue à l’examen de tous les restes de vertébrés fossiles découverts dans les résidus de tamisage de l’*Horizon à Phosphorites de Sint Niklaas*, des quelques-uns découverts *in situ* dans la partie sommitale de la Formation des Sables de Ruisbroek et de leurs descendants dans les trois Unités qui constituent le Membre de l’Argile de Boom.

*Voir *Géominpal Belgica* 5 (Part One) **Voir *Géominpal Belgica* 5 (Part Two).

La qualité de préservation de la majeure partie de ces restes de vertébrés est parfaite. Seuls quelques-uns d’entre eux, ayant été ingérés par un prédateur, ont été, plus ou moins intensément, marqués par l’action d’enzymes gastriques.

La prédominance des restes de poissons (Pisces) est chose normale pour un environnement marin. Ceux-ci sont représentés par quelques plaques dentaires de chimères (Holocephali), des milliers de dents de requins (Neoselachii) et de raies (Batoidei), tous poissons cartilagineux (Chondrichthyes).

Les poissons osseux (Teleostei) sont représentés par des milliers de dents et d’ossements divers qui peuvent être, en fonction de leur état de conservation physique, séparés en deux groupes qui révèlent leur succession respective dans ce gisement fossilifère.

Les autres vertébrés marins ou amphibiens sont seulement représentés par trois œufs, quelques plaques de carapace osseuse et quelques ossements de mâchoires de tortues marines (Reptilia - Chelonia), ainsi que par quelques petits ostéodermes de varanides (Reptilia - Squamata) et une vertèbre de serpent marin (Reptilia - Ophidia).

L'existence de vertébrés terrestres est démontrée par la découverte de deux ostéodermes de la queue d'un petit crocodilien de mangroves, de deux dents de petits rongeurs et d'un astragale attribuable à un ancêtre des rhinocéros (Famille des Rhinocerotidae GRAY, 1821).

Quelques très rares ossements témoignent de la présence des dernières populations du Genre *Odontopteryx* OWEN, 1873 (Famille des Pelagornithidae, Protoaves *vel* Paleornithes).

4. Introductie

Na een gedetailleerd onderzoek van al de sedimentologische en lithische elementen, van al de tafonomische gegevens en van al de ichnofossielen (*sensu lato*)*, en na een zo volledig** als mogelijk systematische inventaris van al de resten van mariene invertebraten opgesteld te hebben, is dit derde deel volledig gewijd aan het onderzoek van al de resten van de fossiele vertebraten gevonden in de ziften residu van het *Sint Niklaas Fosforieten Bed*, sommige gevonden *in situ* in het bovenste deel van de Ruisbroek Zanden Formatie en enkele van hun afstammelingen ontdekt in de drie Eenheden die het Member van de Boom Klei vormen.

*Zie *Géominpal Belgica* 5 (Part One) **Zie *Géominpal Belgica* 5 (Part Two).

De kwaliteit van de bewaring van het grootste gedeelte van de resten van de vertebraten is perfect. Slechts enkele die door een predator werden ingeslikt zijn min of meer aangetast door de werking van gastrische enzymen.

Het overwicht van de resten van de vissen (Pisces) is vanzelfsprekend in een mariene omgeving. Ze zijn vertegenwoordigd door enkele dentale platen van chimaera (Holocephali), duizenden haaientanden (Neoselachii) en roggentanden (Batoidei), alle kraakbeenvissen (Chondrichthyes).

De beenvissen (Teleostei) zijn vertegenwoordigd door duizenden tanden en diverse beenderen die in functie van hun fysische staat van bewaring kunnen ingedeeld worden in twee groepen die hun respectieve opeenvolging in deze fossiele vindplaats onthullen.

De andere mariene vertebraten of de vertebraten van amfibieën zijn alleen maar vertegenwoordigd door drie eieren, enkele platen van een benig schild van zeeschildpadden alsook enkele beenderen van kaken van deze (Reptilia - Chelonia); evenals door enkele kleine osteodermen van varaniden (Reptilia - Squamata) en één wervel van een zeeslang (Reptilia - Ophidia).

Het bestaan van landelijke vertebraten is gedemonstreerd door de vondst van twee osteodermen van de staart van een kleine mangrove krokodil, twee tanden van kleine knaagdieren en één astragalium toegeschreven aan een voorouder van de neushoorns (Familie Rhinocerotidae GRAY, 1821).

Enkele zeer zeldzame beenderen zijn de enige getuigen van de aanwezigheid van de laatste bevolkingen van de Genus *Odontopteryx* OWEN, 1873 (Familie Pelagornithidae, Protoaves *vel* Paleornithes).

5. The loss, the fall and the embedding of a tooth of a living Neoselachii

5.1. Generalities

The following experiments, very easy to realise, demonstrate that the outermost functional teeth of one living Neoselachii have only one possibility to reach the sea bottom.

According to their position in the jaw sets, the teeth fall with their upper extremity in the direction of the sea bottom. After possible spiral movements, the Gravity Law imposes very quickly that the heaviest part of the tooth reaches the sea bottom and embeds in the sediment.

A quite perfectly symmetric tooth, such as a symphyseal tooth of a Hexanchiformes or one anterior tooth of an Isuriformes directly embeds the sediment with a lightly inclined position, inducing the displacement of the finest particles. The extremity of its crown then indicates the momentaneous direction of the dominant submarine current.

An asymmetric tooth, such as the lateral teeth of the same groups, firstly effectuates some spiral movements and finally embeds the sediment with its heaviest side (the intern or labial one) pointing at the bottom.

One example of this event is illustrated (Plate 4, fig.: 1a-1b) by one lateral anterior tooth of a *Notidanion howelli* REED, 1946 adhering to the upper side of the burrow of a little Gobiidae.

5.2. The loss, the fall and the embedding of the drifting carcass of a dead Neoselachii

Vertebrae, teeth, dorsal spines, caudal spines and dermic denticules of drifting carcasses of dead Neoselachii also progressively came off from these carcasses.

These remained associated with, more or less, voluminous masses of corrupted flesh with a very high concentration of Bacteria. These remains favoured the formation of massive surrounding sideritic concretions (See Plate 30, fig.: 2).

5.3. Particular marks on the crown of the teeth

Mycelium traces

(Plate 47: figs.: 1-2)

Such traces, easily recognizable, signify that these teeth were disembedded and shortly exposed to an aerial humid environment (equatorial to temperate).

5.4. Obvious transversal difference of the coloration of some crown teeth

(Plate 30: fig.: 2)

This phenomenon indicates that these teeth were only partially embedded in the bottom sediment, or after a sufficiently long period to obtain their normal coloration. They were then partially disembedded and the emerging part of their crown was submitted to a sub-aquatic oxidation phase.

When this event occurs for asymmetric teeth, the direction of the extremity of their dental crown indicates the dominant direction of the sea bottom current.

5.5. Traces of high chemical corrosion

This phenomenon indicates that these teeth, and their owners, were ingested by larger predators and submitted to the action of gastric acids.

5.6. Rolled teeth, intensity and frequency

The intensity of the fading of the intern and extern ornamentations of the dental crown and the degree of polishing of both dental crown and extremities of the dental root indicate that these teeth were for a certain time rolled on a beach, or exposed to desert winds.

If only a part of the discovered teeth of one level is rolled, it indicates that this level mixed at least two faunas.

5.7. Last deduction

Generalities

If all the Elasmobranches teeth collected in one stratum present a dental crown and a dental root with the same coloration and the same quality of preservation and if they present no fungi marks, the fauna collected in this geological level may be considered as having the same origin.

This is the case for the majority of the Chondrichthyan remains discovered in the *Sint Niklaas Phosphorite Bed*, but not for all their remains.

The best examples (See Plate 30) are given by the different patterns of coloration of the crown of some teeth of *Carcharocles angustidens* (AGASSIZ, 1843).

The size, corresponding to diverse positions in one jaw, and the identic creamish brown coloration of the crown of the teeth illustrated on Plate 28 allow supposing that these teeth belonged to the same individual.

The dark blue black coloration of the crown of the tooth illustrated on Plate 30: figs.: 1a-1b, demonstrates that this tooth came from another individual and that this tooth had a more complex geochemical history.
The poor quality of preservation of the tooth illustrated on Plate 30: figs.: 3a-3b, demonstrates that this tooth was submitted to an aerial alteration (oxidation) for a long time.

Altogether these teeth of the same specific taxon demonstrate that the constitution of the *Sint Niklaas Phosphorite Bed* resulted from multiple phases.

Additional Systematic data

Some new arguments allow specifying the determination of the Bacteria illustrated in *Géominpal Belgica* 1 (Revised Edition). These Bacteria may be considered as Cyanophyta.

6. Systematic list of the Vertebrate remains discovered in the *Sint Niklaas Phosphorite Bed*

6.1. Generalities

The list presented is subdivided into the classical systematic taxa, from the primitive ones to the more evolved ones.

Each group includes Generalities concerning its living representatives and is followed by quantitative data concerning the presence of each systematic taxon discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed.*

The dispersal in the three prospected sectors of these remains is also mentioned. These data demonstrate the existence of a selective dispersal according to their weight and their steric configuration.

6.2. Systematic adopted and justification

Generalities

The Systematic used in this Publication is the one suggested as odontological Parasystematic by the senior-author in his Publications of 2012: *Géominpal Belgica* 2 (Part One) to *Géominpal Belgica* 4.

In fact this Parasystematic brings together odontological and biological characteristics of Chondrichthyes, allowing the proposal of a complete revision of the obsolete preceding classifications, based only on biological criteria* or only on odontological criteria.

*Sometimes limited to colour pattern argumentations.

This proposed restructuration includes only one dubious Order: the Order Polyacrodontiformes which regroups all the surviving Cretaceous hybodont-like taxa.

Each of these surviving taxa, such as e.g. *Polyacrodus illingworthi* is in fact the end of a long lineage having a Triassic origin. The majority of the ancestors of such taxon being absent in the Belgian territory, it was not possible to reconstitute their Natural History, and not scientifically honest to propose plenty of new taxa.

The system proposed for all the former higher Taxa, was so simple that five principal criteria allow identifying a Super-Order, four criteria an Order, three criteria a Family, two a Genus and a single additional odontological criterion to identify a species.

The principal biological criteria proposed were: the three reproduction modes: oviparity, ovoviviparity or viviparity; the possession or the absence of two dorsal spines and the existence or the absence of a rigid anterior part of the vertebral column.

Altogether this represents seven possibilities. All these criteria are easily discernible on living taxa and occasionally on more or less complete fossil skeletons.

The principal odontological criteria proposed were: the relation between the dental crown and the dental root (with three possibilities); the vascularisation types: anaulacorhizid, hemiaulacorhizid, polyhemiaulacorhizid, holaulacorhizid or secondary anaulacorhizid; the possession of an apron; the imbrication or the juxtaposition of the teeth of a same series and the absence or the presence of lateral cusplets, as well as the morphology of these cusplets: short, massive and conical; short, flat and rounded or very fine and elongated.

This represents sixteen other possibilities also easily discernible on isolated teeth of living and fossil animals.

It was demonstrated that with only five of these twenty three principal criteria it is possible to define a Super-Order, with four of these an Order, with three of these a Family and with two of these a Genus.

The presence of an extern or intern striation on the dental crown or the possession of saw-like cutting edges were considered as criteria of lower importance, but sufficient to distinguish two species.

According to the 2011 C.E.E. recommendations concerning the electronic publications, this Parasystematic was presented for examination and reflexion to eminent German, French, British, American and Australian neontologists and palaeontologists, making of them potential reviewers. None of them has presented any criticism or other suggestions.

In absence of any reaction, the choice of this bivalent Parasystematic was adopted for the redaction of this Paper.

Compagno's Systematic and help

The Systematic proposed by Leonardo Compagno in 1984 remains the most understandable for classic biologists, because it is based on visual and undeniable facts, but it does not consider the odontological data that are fundamental to the palaeontologists.

Leonardo Compagno is the biologist who furnished the major party of the teeth sets that the senior-author utilised with his friends Dirk and Maria Hovestadt to realise their fifteen years' Series* devoted to the odontology of the Chondrichthyes.

*Contributions to the study of the comparative morphology of teeth and other relevant ichthyodorulites in living supraspecific taxa of Chondrichthyan fishes.

Berg's Systematic
and its similarities with the present one

In 1940, Dr. Berg suggested that the variation of characteristics* in one species is confined within certain limits due to both intern and extern factors.

*The senior-author proposes to add to this suggestion: transmitted by its genetic code.

Dr. Berg had for principal argument that his conception of the Evolution was supported by the paleontological records, considered that all the phylogenetic branches look more or less like straight lines and concluded that new species may only arise by means of mass transformation of a great number of individuals.

The senior-author also considers a species as an assemblage of more or less isolated populations, each being submitted to different intern and extern agressions.

The very restricted possibilities of the U.R.S.S. to access to any Ocean made it impossible for its geologists to try to validate Wegener's theory which was however largely accepted by the Russian scientists and by many other geologists*.

*Wegener's theory figured on the geological course of the U.L.B. (Belgium), between September 1940 and September 1944, and was suppressed till to September 1969 after the demonstration of its reality by the Deep Sea Drilling Project.

For references, see Bibliography-Holocephali: Berg 1940: Classification of fishes both recent and fossil. *Travaux de l'Institut Zoologique de l'Académie des Sciences de l'U.R.S.S.* **5**: 85-517 (in Russian).

6.3. Slumbering genetic codes

Generalities

Although all the Treatises on Paleontology cover the whole evolution of all the fossil taxa discovered in Precambrian strata to these of the beginning of the Holocene Period, the authors of the majority of Handbooks prefer to examine only the post Triadici taxa.

The reason seems to be that while phylogenetic relations remain relatively easy to propose between extant taxa and Jurassic taxa, genetic relations between pre-Triassic extinct taxa and the extant ones seem, if not are, pure suppositions.

Even with human individuals*, the genetic code inducing the prolongation of the vertebral column by a variable number of vertebrae may be reactivated.

*See diverse Daily Papers and Anthropological Reviews.

Pre-Triassic Chondrichthyological studies signalise two unexplained examples: the Genus *Pseudocetorhinus* DUFFIN, 1988 attributed by the author himself with some hesitation to the Family Cethorhinidae GILL, 1862 and the Genus *Pseudolatias* REIF, 1978, generotype of the extinct Family *Pseudolatiidae* REIF, 1978.

For some very primitive* taxa, only some details of the vascularisation of the root and the histology of the tooth, e.g.: for *Pseudocetorhinus pickfordi* DUFFIN, 1982 and *Pseudolatias barnstonensis* (SYKES, 1971) may help to understand their real phylogenetic position.

*From Permo-Triassic ages.

In the Upper Rhaetic sifting residues of the three successive coarse sandy levels prospected in the profiles of the motorway A4 at Habay-la-Vieille (Luxembourg Province, Belgium), the senior-author and his field friends have discovered hundreds of teeth of *Pseudoceterhinus pickfordi* and 26 teeth of *Pseudolatias barnstonensis*, but no remains comparable to gill-racket elements attributable to a cethorhinid-like Selachii.

The fact that there are no similar teeth, or transitional forms of teeth between these Upper Rhaetic fossils and the two extant taxa *Cetorhinus* and *Dalatias*, anywhere in the world* is another argument to allow supposing that the tooth morphology of the extant taxa could be the result of a reactivation of some slumbering genes.

*In the preceding centuries, paleontological researches were geographically very limited, but since the 1960s such researches are realised in the large majority of the Nations. It is difficult to imagine that transitional fossil forms have never been encountered.

For principal references, see Bibliography-Chondrichthyes: Duffin 1982, Sykes 1971and Tintori 1980.

6.4. Evolution of the number of pairs of gill slits

Exception made for the species of the Genus *Cetorhinus* de BLAINVILLE, 1816, for which the gill slits have also a nutritional function, the gill slits of all the other Pisces have only a fundamental respiratory function.

More precisely, this function consists of the extraction of oxygen molecules from their natural environment, which is seawater, brackish water or freshwater.

The common rule is that all the living Fishes possess five pairs of gill slits. But some living taxa possess six or seven pairs of gill slits.

The two living species of the Genus *Chlamydoselachus* GARMAN, 1884, the two living species of the Genus *Hexanchus* RAFINESQUE, 1810 (two Neoselachii) and the Genus *Hexatrygon* HEEMSTRA & SMITH, 1980 (a Batoidei) present six pairs of gill slits.

All the taxa of the Family Petromyzonidae RISSO, 1828 and of the Family Myxinidae RAFINESQUE, 1815, both being Marsipobranchii present seven pairs of gill slits, such as all the taxa of the Genus *Heptranchias* RAFINESQUE, 1810 (a Neoselachii).

Louis Taverne's personal communication: *In fact, the Holocephali have the same number of branchial slits as the rays or the sharks. But these branchial slits are covered and protected by an 'operculum' which gives an appearance of a single aperture located on the rear side of this operculum.*

The conclusion is that all the living taxa of the Holocephali possess also five gill slits and each additional pair of gill slits represents a significant increase of the possibility of oxygen caption.
Living Fishes with two, three or four pairs of gill slits were never found.

In previous publications*, the senior-author has explained his astrophysical suggestion for the causality of these different phases of the increasing number of gill slits.

*See *Géominpal Belgica* 2, 3 and 4.

It is difficult to precise the age of the first and major structural modification* of the respiratory system of the Fishes, but such a modification implies a very important decrease of oxygen content of their aquatic environment.

*The transition from one pair to five pairs of gill slits.

Such a decrease of oxygen content signifies that the process of production of oxygen in waters was highly perturbed, which allows supposing that all the unicellular forms of life liberating oxygen were drastically reduced.

7. PISCES - CHONDRICHTHYES – HOLOCEPHALI

Reminder

Species conception of the senior-author

A species is an assemblage of diverse populations of a highly variable number of individuals, each characterised by its DNA.

Horizontal distribution

Each of these populations occupies a more or less extended geographical area.

Vertical distribution

Each of these populations occupies a more or less extended depth habitat.

Geological time distribution

Each of its fossil populations is represented by remains discovered in a limited number of geological strata.

Common spatial and temporal zones

As long as numerous members of these diverse populations have reproduced among them, the genetic patrimonium of the species remains approximately identic.

Non biological causes of changes

Climatological variations

Ice time periods have interrupted the continuity of the distribution areas of these populations and isolated them for a, more or less, long time.

The isolation of these populations progressively induced a decrease of the richness of their gene pool.

Tectonic interventions

Tectonic events opened new Seas but interrupted definitely diverse Interoceanic Communications,
sometimes isolating many populations for tenths of millions of years.
These events have, of course, induced the blowing up of new taxa.

Astrophysical influences

Regular inversions of the earth’s magnetic field have perturbed, and sometimes completely destroyed, the Van Allen Rings allowing the penetration of highly ionisated and radioactive particles in the biosphere.

Difference between two species

Two extant or extinct species have in common all the biological* and odontological** criteria characterising their Genus, but differ, at least, by the possession of a criterium of lower signification.

*Affirmation supposed valid for all the Neoselachii and Batoidei.
**Affirmation directly checking up on the fossil tooth examined.

This difference may be an ornamental criterium such as the presence of a saw-like ornamentation on the cutting edges of their crown: e.g.: *Pseudocorax laevis* LERICHE, 1906 and *Pseudocorax affinis** MÜNSTER *in* AGASSIZ, 1843, international indicators of the limit between the Lower Campanian and the Upper Campanian.

*Also present in the Lower an Upper Maastrichtian.

Chondrichthyes - Holocephali

Generalities

The term Holocephali is generally used to regroup all the representatives of the most primitive cartilaginous fishes, classified in four Orders: The extinct Eugeneodontida (or Eugeneodontiformes) ZANGERL, 1981, the extinct Iniopterygiformes ZANGERL, 1981, the extinct Petalodontiformes ZANGERL, 1981 and the single extant Chimaeriformes OBRUCHEV, 1953.

The living Holocephali are benthic animals, or remaining close to the bottom, feeding on molluscs and other invertebrates. They are very supple oviparous animals having Lower Devonian ancestors.

All their living representatives present a dorsal fin serrulated spine*. Their stomach is in fact the anterior part of their intestine. Their mouth presents a variable number of dental plates.

*See Bibliography-Holocephali: Herman, Hovestadt-Euler & Hovestadt 2001.

Only the Order Chimaeriformes has living representatives, distributed in the three following Families: Family Chimaeridae BONAPARTE, 1831, Family Rhinochimaeridae GARMAN, 1901 and Family Callorhinchidae GARMAN, 1901.

Family Chimaeridae BONAPARTE, 1831

According to FishBase 2011, the Family Chimaeridae BONAPARTE, 1831 regroups the two living Genera: the Genus *Chimaera* LINNAEUS, 1758 and the Genus *Hydrolagus* GILL, 1862 and,*fide* Stahl 1999 only one* fossil Genus: the Genus *Belgorodon* NESSOV & AVERIANOV, 1996.

According to FishBase, the Genus *Chimaera* LINNAEUS, 1758 is represented by the fourteen following living species: *C. argiloba* LAST, WHITE & POGONOSKI, 2008, *C. bahamaensis* KEMPER, EBERT, DIDIER & COMPAGNO, 2010, *C. cubana* HOWELL-RIVEIRO, 1936, *C. fulva* DIDIER, LAST & WHITE, 2008, *C. jordani* TANAKA, 1905, *C. ligniaria* DIDIER, 2002, *C. macrospina* DIDIER, LAST & WHITE, 2008, *C. monstrosa* LINNAEUS, 1758, *C. notafricana* DIDIER, LAST & WHITE, 2008, *C. obscura* DIDIER, LAST & WHITE, 2008, *C. opalescens* LUCHETTI, IGLESIAS & SELLOS, 2011, *C. owstoni* TANAKA, 1905, *C. panthera* DIDIER, 1998 and *C. phantasma* JORDAN & SNYDER, 1900.

According to FishBase, the Genus *Hydrolagus* GILL, 1862 is represented by the twenty-four following living species: *H. affinis* (de BRITO CAPELLO, 1868), *H. africanus* (GILCHRIST, 1922), *H. alberti* BIGELOW & SCHROEDER, 1951, *H. alphus* QUARANTA, DIDIER, & EBERT, 2006, *H. barbouri* (GARMAN, 1908), *H. bemisi* DIDIER, 2002, *H. colliei* (LAY & BENNETT, 1839), *H. deani* (SMITH & RADCLIFFE, 1912), *H. eiodon* (JORDAN & HUBBS, 1925), *H. homonycteris* DIDIER, 2008, *H. lemures* (WHITLEY, 1939), *H. macrophtalmus* de BUEN, 1959, *H. marmoratus* DIDIER, 2008, *H. matalanasi* SOTTO & VOOREN, 2004, *H. mccoskerii* BARNETT, DIDIER, LONG & EBERT, 2006, *H. melanophasma* JAMES, EBERT, LONG & DIDIER, 2009, *H. mirabilis* (COLLETT, 1904), *H. mitsukurii* (JORDAN & SNYDER, 1904), *H. Novaezealandiae* (FOWLER, 1911), *H. ogilbyi* (WAITE, 1898), *H. pallidus* HARDY & STEHMANN, 1990, *H. purpurescens* (GILBERT, 1905), *H. trolli* DIDIER & SERET, 2002 and *H. waitei* FOWLER, 1907.

Some Oligocene Belgian holocephalian remains were considered as representatives of two extinct taxa of the Genus *Chimaera* LINNAEUS, 1758: *Chimaera gosseleti* WINKLER, 1880 and *Chimaera rupeliensis* STORMS, 1894.

All these dental plates remains must be considered as dental elements of a representative of the extant Genus *Harriota and* named: *Harriota gosseleti* (WINKLER, 1880)*.

*Personal information received on 24.07.2013. Source: Dr. Evgeny Popov (Department of Paleontology, Saratov State University, Russia).

This means that the Family Chimaeridae has no Belgian representatives. Dental plates of *Harriota gosseleti* (WINKLER, 1880) were sporadically discovered in the Terhaegen Lid of the Boom Clay Member.

Family Rhinochimaeridae GARMAN, 1901

(Plates 61-63)

According to FishBase 2011, the Family Rhinochimaeridae GARMAN, 1901 regroups the 3 following living Genera: the Genus *Harriotta* GOODE & BEAN, 1895, with 2 species: *H. Haeckelli* KARRER, 1972 and *H. raleighana* GOODE & BEAN, 1895, the Genus *Neohariotta* BIGELOW & SCHROEDER, 1950, with 3 species: *N. carri* BULLIS & CARPENTER, 1966, *N. pinnata* (SCHNAKENECK, 1931) and *N. pumilla* DIDIER & STHEMANN, 1966, the Genus *Rhinochimaera* GARMAN, 1901, with also 3 species: *R. africana* COMPAGNO, STHEMANN & EBERT, 1990, *R. atlantica* HOLT & BYRNE, 1909 and *R. pacifica* (MITSUKURI, 1895).

Family Callorhinchidae GARMAN, 1901

The Family Callorhinchidae GARMAN, 1901 is represented by the living Genus *Callorhinchus* LACEPEDE, 1798, with its three species: *C. callorhinchus** (LINNAEUS, 1758), *C. capensis** DUMERIL, 1865 and *C. milii** BORY de SAINT-VINCENT, 1823.

*Respectively from both sides of South America, from the Cape (South-Africa) and from Australia.

The relatively restricted geographical distributions of the different specific taxa proposed, clearly indicate the geological age of the separation of the different populations forming these taxa.

The fossil Genus *Edaphodon* BUCKLAND, 1838 is considered as an extinct member of this Family and, according to the Paleontology Database 2009, represented by the following fourteen specific taxa: *E. agassizi* BUCKLAND, 1835, *E. antwerpiensis* LERICHE, 1926, , *E. bucklandi* AGASSIZ, 1843, *E. eyrensis* LONG, 1985, *E. hesperis* SHUN, 2010, *E. kawai* CONSOLI, 2006, *E. laqueatus* LEIDY, 1873, *E. leptognathus* AGASSIZ, 1843, *E. mirabilis* CHAPMAN & CUDMORE, 1924, *E. mirificus* LEIDY, 1856, *E. sedgwicki* AGASSIZ, 1843, *E. smocki* COPE, 1873, *E. stenobryus* COPE, 1873 and *E. tripartitus* COPE, 1873.

Once more, the restricted geographical distributions of the different specific taxa proposed clearly indicate the geological age of the separation of the different populations forming these taxa.

The fossil Genus *Ischyodus* EGERTON, 1843 is another extinct Genus attributed to the Family Callorhinchidae and, according to Barbara Stahl (1999) regroups the thirty seven following taxa: *I. aalensis* (QUENSTEDT, 1852), *I. acutus* MEYER, 1859, *I. avidus* (MEYER, 1859), *I. beaugrandi* SAUVAGE, 1867, *I. beaumonti* EGERTON, 1843, *I. bifurcatus* CASE, 1978, *I. bouchardi* SAUVAGE, 1867, *I. brevirostris* DAVIS, 1888, *I. curvidens* EGERTON, 1843, *I. divaricatus* COPE, 1869, *I. dolloi* LERICHE, 1902, *I. dufresneyi* EGERTON, 1843, *I. dutertrei* EGERTON, 1843, *I. egertoni* BUCKLAND, 1835, *I. emarginatus* EGERTON, 1843, *I. ferrugineus* RIESS, 1887, *I. gubkini* (NESSOV, 1986), *I. incisus* NEWTON, 1878, *I. latus* NEWTON, 1878, *I. lonzeensis* LERICHE, 1929, *I.minor* ROGOVITCH, 1860, *I. mortoni* CHAPMAN & PRITCHARD, 1907, *I. obrutchevi* AVERIANOV, 1992, *I. personati* (QUENSTEDT, 1852), *I. planus* NEWTON, 1878, *I. quendstedti* WAGNER, 1857, *I. rayhaasi* HOGANSON & ERIKSON, 2004, *I. rostratus* MEYER, 1859, *I. sauvagei* HAMY, 1866, *I. schluberi* QUENSTEDT, 1858, *I. suevicus* PHILIPPI, 1897, *I. suprajurensis* SAUVAGE, 1867, *I. thurmanni* PICTET & CAMPICHE, 1878, *I. townsendi* BUCKLAND, 1835, the type species, *I. williamsae* CASE, 1991, *I. yanshini* AVERIANOV, 1991 and *I. zinsmeisteri* APPLEGATE, 1975.

**I. minor* WARD, 1973 was based on the remains of a juvenile specimen of an undetermined *Edaphodon*.

The critical review of these thirty seven taxa realized by Barbara Stahl in 1999 demonstrates the poorness of the definition of the majority of these taxa, generally based only on one of their six dental plates.

Additional data

During his trawling expeditions in the winters 1977 to 1983, in the North-West Atlantic Ocean, the senior-author had diverse occasions to examine numerous freshly caught individuals of *Chimaera monstrosa* LINNAEUS, 1758 and *Chimaera opalescens* LUCHETTI, IGLESIAS & SELLOS 2011 at depths comprised between 450 and 1020 metres.

All these adult specimens had their mouths full with remnants of their last meals consisting of deep water shrimps, small crustaceans and small fishes.

The diverse populations of *Chimaera opalescens* live a little deeper than the populations of *Chimaera monstrosa*, which are more frequent at depths comprised between 450 and 630 metres*.

*630 metres is the deeper catch observed in December 1978 by the senior-author on the southern side of the Bill Bailey Bank.

Captain Pierre Gueguen (Lorient Harbour, France) said to him that during some springs he had observed plenty juvenile specimens of 15 to 25 centimetres length, but only on the southern side of the Porcupine Bank.

Last Systematics remark

It is a tragic truth that deep sea trawling increased continuously after 1965, but considering the fact that Portuguese, French, German, Spanish and Japanese fishermen were able to trawl deeper than 1.000 metres since the 1930s, the validity of the species described after the 1990s on basis of such slight morphological differences or colour patterns and without DNA analysis remains doubtful.

For references, see Bibliography-Holocephali: Dean 1906, Didier 1995, Garman 1901, Herman, Hovestadt-Euler & Hovestadt 2001 and Newton 1878.

Family Rhinochimaeridae GARMAN, 1901

(Plates 61 to 63)

Genus *Amylodon* STORMS, 1894

(Plates 1 and 2)

Amylodon delheidi STORMS, 1894

Storms, R 1894: *Amylodon delheidi in Bulletin de la Société belge de Géologie, Paléontologie et Hydrologie*: 8: 68.

Total: 24 dental plates and 4 elements attributable to a tenaculum.

Twenty four dental plates attributable to the Genus *Amylodon*, and more precisely to the species *Amylodon delheidi* described by Storms (1894) and illustrated by Leriche (1948), were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

For some dental plates, the senior author, first hesitated between a generic attribution to the Genus *Chimaera* or to the Genus *Amylodon*, but after re-examination of the specimen illustrated by Leriche which is conserved in the Collections of the I.R.S.N.B. (Brussels, Belgium), he finally opted for the Genus *Amylodon*.

Three of these dental plates are very badly preserved remains of *Amylodon delheidi*, and may be considered as dejections after ingurgitation by unknown predators. These last plates seem to have been submitted to a relatively long corrosion by digestive stomach enzymes.

All the other dental plates of Holocephali are relatively well preserved and are attributable to the species *Amylodon delheidi*.

The four tenaculum elements (See Plate 3: figs.: 2a-2c) are the first discovered in the Belgian Cenozoic. Two of them, presenting an elongated nutritional central cavity, are absolutely similar to these of the extant *Rhinochimaera atlantica* HOLT & BYRNE, 1909.

If systematically correct interpretated, the two other little fossils are also tenaculum elements, and allow to suggest that the central cavity of the two first ones represents an evolutive stadium.

Very few data concerning other Oligocene fossil remains* of the Genus *Amylodon* are available**.** Some other fossils from the Upper Cretaceous from Russia, are considered by Averinov and Popov (1995) as another distinct species of the Genus *Amylodon*: *Amylodon emba* (See Bibliography-Holocephali: Averianov & Popov 1995).

*The senior-author had the possibility to examine some specimens from the German Oligocene (Rupel Ton Formation).

The Russian fossils called *Amylodon emba* seem to be the oldest representatives of this Genus.

All the species of the recent Rhinochimaeridae are also poorly known. In contradiction to the general idea that they are only deep water to abyssal animals they may be observed just below the surface level (*cf.* some recent documentary: T.V. emissions *La Mer* par Jacques Perrin).

8. PISCES - CHONDRICHTHYES – NEOSELACHII

Generalities

For the determination of the Oligocene teeth of the different large species of Chondrichthyes, the numerous drawings of the remarkable work* of Dirk Nolf: *Dents de requins et de raies du Tertiaire de la Belgique* is highly recommended.

*See Bibliography: Nolf 1988. A Dutch version is also available.

A first list of the Chondrichthyes from the *Sint Niklaas Phosphorite Bed* was drawn up by the senior-author (J. Herman) in July 2005 and introduced in the Archives of the Belgian Geological Survey.

A last revision which mentioned some additional discovered taxa was introduced in March 2010 in the same databank.

Contrarily to the wishes of the senior-author none of these lists was ever accessible to the great public, but strictly reserved to people having access to the databank of the Belgian Geological Survey.

This last list results from the compilation of personal observations realized between 1985 and 2005 and the examinations of the different private collections generously submitted for investigations to the senior-author.

The following persons who collected the analysed material or offered their collections for examination are: Luc Anthonis, Jacques Boel, Wim Creytens, Pieter De Schutter, Benjamin D’Haeze, Bertrand Génault (F), Dirk en Maria Hovestadt (NL), Theo Lambrechts, Jean-Pierre Luypaerts, Gino Mariën, Frederik Mollen, Guy Van Den Eeckhaut, Eric Wille, and Didier Winderickx, all former Collaborators of the Belgian Geological Survey.

According to the field observations of the senior-author, all the Chondrichthyes remains discovered in the *Sint Niklaas Phosphorite Bed* are much older than the beginning of the sedimentation of the Boom Clay Formation.

After careful reconsiderations of all the objective data in their possession, the above are the definite conclusions of the authors of this present paper.

A list of all the vertebrate fossils discovered in the *Sint Niklaas Phosphorite Bed*, with their relative abundance and their morphological singularities, is presented in this paper.

The list of the Chondrichthyes remains as well as all the other Vertebrate living in the Boom Clay *sensu stricto* is compared with the previous one.

These lists include some precisions concerning the ecological signification of their presence, or absence, in these different stratigraphic Units.

The evolution of an animal or vegetal group is, of course, a tetra-dimensional concept, which is impossible to figure in a bi-dimensional scheme or in a nominal check list.

Nearly 8.500 teeth of Neoselachii were discovered by the different operating crews. These teeth were dispersed over an area of *circa* 1.200 m².

Very few people realize how scarce the Chondrichthyan remains are in the majority of the Belgian marine layers.

To obtain the quantity of teeth, necessary to try to evaluate the composition of one fauna, Belgian paleontologists are always obliged to sift hundreds of cubic meters of sediments*.

*With only two exceptional levels encountered in the Ypresian Clay at Ampe Clay Pit (Egem-Egemkapelle - West Flanders).

In this synthetic schedule of all the Elasmobranchii teeth discovered in the *Sint Niklaas Phosphorite Bed* by the different operating crews, a total number of teeth is given per species and followed by details concerning their sectorial distribution.

These details are very important to appreciate the significance of their selective dispersion and the main orientation of the lixiviation stream having reconcentred these teeth.

Super-Order Echinorhinomorphii HERMAN & VAN WAES, 2012

Following Cappetta 2006 (pp.: 394-395), the four Families: Family Chlamydoselachidae, Family Heptranchidae, Family Hexanchidae and the fossil Family Orthacodontidae were presented as forming one single taxon: the Order Hexanchiformes.

This conception grouped animals that have five, six or seven pairs of branchial arches and two fossil taxa: One Family* and one Genus of which we ignore the number of pairs of branchial arches.

*The Family Orthacodontidae de BEAUMONT, 1960 and the Genus *Notidanodon* CAPPETTA, 1975 because both extinct.

The Herman-Van Waes systematic revision of this chondrichthyan group (electronically published from end of May to mid-July 2012), extracted the Family Orthacodontidae from this conception because all the taxa attributed to this Family possess an incompatible radicular structure with the three other Families.

Their polyhemiaulacorhyzid vascularisation stadium, allowed regrouping them with the two Families Paleospinacidae and Synechondontidae, of which all the taxa also possess a similar polyhemiaulacorhyzid dental root structure.

The revision proposed a continuous evolutionary process for these Elasmobranchii, linking these primitive fishes that pass from a respiratory system constituted by five pairs of branchial arches, to a respiratory system constituted by six pairs of branchial arches, and suddenly to a respiratory system constituted by seven pairs of branchial arches.

In this same Revision, the members of the Family Chlamydoselachidae were considered as survivors of much older Paleozoic Chondrichthyes.

The transition from an anatomical constitution comprising five pairs of branchial arches to an anatomical constitution comprising six pairs of branchial arches is accompanied by the acquisition of one lower row of symphyseal teeth, enhancing considerably the cohesion of the dentition of the lower jaw.

Cappetta, ignoring completely all the other suggestions posterior to 2006, and all the fundamental biological and paleontological evidences, proposed in 2012 his own Systematics conception (See Bibliography-Chondrichthyes: Cappetta 2012).

The recent discovery* of teeth of Echinorhinidae in the Lower Cretaceous of France points out the elderness of this group.

*See reference: Bibliography-Neoselachii: Adnet, Guinot, Cappetta & Welcomme 2012.

Order Heptranchiformes HERMAN & VAN WAES, 2012

Family Heptranchidae BARNARD, 1925

(Plate 64: fig.: 1 and Plate 65: fig.: 2)

Genus *Heptranchias* RAFINESQUE, 1810

Principal data concerning the living species of the Genus *Heptranchias*

Distribution and habitat

The extant species *Heptranchias perlo* is uncommon but widely distributed in the tropical and temperate regions of all oceans except for the northeastern Pacific Ocean. It is principally found in deep waters.

It is found from North Carolina to Cuba, including the northern Gulf of Mexico, and from Venezuela to Argentina in the western Atlantic.

In the eastern Atlantic, it occurs from Morocco to Namibia, including the Mediterranean Sea. It is reported from the Indian Ocean off southwestern India, Aldabra Island, southern Mozambique, and South Africa.

In the Pacific Ocean, it is known from Japan to China, Indonesia, Australia, New Zealand, and northern Chile.

This is a demersal to semi-pelagic species usually captured at a depth of 300 to 600 metres or down to 1.000 metres.

It is mainly found on the outer shelves and upper continental slopes, and may form important shoals around sea mounts.

Biology and ecology

Despite its relatively small size, the sharp nose seven gill shark is considered to be a top predator in the ecosystem it inhabits. The different living populations of this species seem to have selective types of food.

At the Great Meteor Seamount in the eastern Atlantic, this species feeds primarily on teleosts and cephalopods, and to a lesser extent on small cartilaginous fishes.

Along the Andalusian Spanish coast it is obvious that its representatives prefer big prawns and small squids.

Off Tunisia, crustaceans are the second-most common prey taken after teleosts. Off Australia, this species consumes mostly teleosts, with smaller individuals taking mainly *Lepidorhynchus denticulatus* RICHARDSON, 1846 (Macrouridae, Gadiformes) and larger individuals taking increasing numbers of snake mackerels and cutlass fishes.

It is a quick-swimming species, whose feeding and activity level increase at night. This species may be preyed upon by larger sharks.

Living *Heptranchias* are principally benthic animals with a very large distribution but restricted to certain small areas. Its reproductive system is ovoviviparity with no apparent selective reproductive season.

The Genus *Heptranchias* is represented by its generotype, the living species *Heptranchias perlo* (BONNATERRE, 1788) and some other fossil taxa*.

*These fossil taxa are supposed to be in possession of seven pairs of gill slits.

They are benthic animals encountered in tropical and temperate waters, on insular and continental shelves and upper slopes. *Heptranchias perlo* (BONNATERRE, 1788) may also be caught at depths over 1.200 metres.

The senior-author had the opportunity, in July 1976, to examine the dentition and the stomach contents of seven gravide females in the small Harbour of Motril (Granada, Spain). This harbour had for principal activity the fishing of big prawn fishes (*gambas*).

These seven specimens were caught together at a depth comprised between 350 and 420 metres, and their stomach content was principally constituted by small prawn fishes: diverse members of the Family Crangonidae, and small squids, principally *Sepiola* sp. of the Family Sepiidae.

Principal data concerning the fossil species of the Genus *Heptranchias*

The Genus *Heptranchias* is also represented by three fossil taxa: *Heptranchias ezoensis* APPLEGATE & UYENO 1986 from the Upper Oligocene of Japan, *Heptranchias howelii* (REED, 1946) recorded from the Eocene of the Atlantic coast of the USA and *Heptranchias tenuidens* (Leriche, 1938) recorded from the late Oligocene of Venezuela.

Cf. Heptranchias howelli (REED, 1946)

Origin. Ref.: Reed M., D.: *Notidanion howelli in Notulae Naturae*.: p.:1, fig.: 4

(Plate 4: figs.: 1a-1b and Plate 5: figs.: 9-10)

Material

One upper latero-anterior tooth firmly adhering to the upper face of a teleostean gobiid burrow and three other lower teeth: two functional teeth and one in formation.

For reference, see Bibliography Chondrichthyes: Reed 1946.

Remark

The association of one hexanchid species and one heptranchid species in shallow waters is not exceptional. In the Strait of Messina, the nocturnal observation of the association of adult individuals of *Hexanchus griseus* (BONNATERRE, 1788) and *Heptranchias perlo* (BONNATERRE, 1788) is relatively common, but the first one is always* represented by numerous individuals and the second one, only by some individuals.

*Communication of Dr. Franco Cigala-Fulgosi (University of Parma, Italy), local fishermen and also signalised in an Arte scientific documentary (2013): *The Messina Strait*, which concerned the fauna of this strait.

For references concerning the Genus *Heptranchias*, see Bibliography Chondrichthyes: Applegate & Uyeno 1986, Braccini 2008, Compagno 1984, Herman, Hovestadt-Euler & Hovestadt 1987, Herman, Hovestadt-Euler & Hovestadt 1993, Leriche 1938 and Reed 1946.

Genus *Notorynchus* AYRES, 1855

(Plate 64: fig. 2, Plate 65: fig. 2 and Plate 67)

Generalities

The Genus *Notorynchus* is represented by the single extant species *Notorynchus cepedianus* (PERON, 1807). Despite the fact that all the individuals of this specific and generic taxon have seven pairs of branchial arches, it remained considered as a member of the Family Hexanchidae by the majority of the ichthyologists.

In 2012, a proposal of revision of this strange systematic conception was suggested by the senior-author*

*This systematic readjustment is based on biological and odontological criteria. See Bibliography: Herman & Van Waes 2012.

For reference, See Bibliography-Chondrichthyes: Compagno 2005 and Herman & Van Waes 2012.

Notorynchus cepedianus (PERON, 1807)

Ref. : Agassiz L., 1843: *Notidanus primigenius in* Recherches sur les Poissons fossiles. Neuchâtel. III: p.: 218, pl.27: 6-8, 13-17.
(Plate 5: figs.: 1-8, 11 and 12 and Plate 6)

Total: 146 teeth, including 9 symphyseal teeth.
Total in the Northern Sector: 31 teeth.
Total in the Southern Sector: 51 teeth.
Total in the South -Eastern Sector: 64 teeth.

The presence of this species in this level is marked by numerous teeth of different positions, with the exception of the commissural teeth. This species is very common in this Horizon. Some teeth, according to their size and the similar delicate nuances of colour spectre, part of the dentition of one animal, were concentrated on very small areas (less than 2m²).

The recent species of this Genus are common *nectic* inhabitants of warm to temperate littoral waters, but they also occur in deeper waters (See Bibliography: Compagno 1984).

Genus *Hexanchus* RAFINESQUE, 1810

(Plates 66, 68 and 69)

For comparison the morpholgy of the teeth of the type species of this Genus: *Hexanchus griseus* (BONNATERRE, 1788) is illustrated on these Plates.

Super-Order Squalomorphii CAPPETTA, 2006 Sup. Ord. rev.

(*sensu* HERMAN & VAN WAES, 2012)

Order Squaliformes GOODRICH, 1909 Ord. rev.

(*sensu* HERMAN & VAN WAES, 2012)

Family Squalidae BONAPARTE, 1834

Genus *Squalus* LINNAEUS, 1758

(See Plates 79 and 80)

Generalities

According to Compagno 1984 (p.: 110), this Genus is represented by the nine following living species: *S. acanthias* LINNAEUS, 1758, *S. asper* MERRETT, 1973, *S. blainvillei* (RISSO, 1827), *S. cubensis* HOWELL-RIVERO, 1936, *S. japonicus* ISHIKAWA, 1908, *S. megalops* (MCLEAY, 1881), *S. melanurus* FOURMANOIR & RIVATON, 1979, *S. mistukurii* JORDAN & SNYDER, 1903 and *S. rancureli* FOURMANOIR & RIVATON, 1979.

Squalus asper is the single species immediately distinguishable from all the others by its very large dermal denticles, but the extreme dispersion* of its three populations is difficult to explain and allow supposing that these populations are maybe genetically distinct.

*One lives in the Strait of Magellan, the second one along the south-eastern coast of Africa and northern Madagascar and the third one completely isolated in the Central Pacific. The holotype of this species was caught in the Aldabra Islands, its mitochondrial DNA represents, of course, this of its authentic population.

Only *S. japonicus*, *S. melanurus and S. rancurelli* have distribution areas easily understandable from a geological point of view.

The distribution of *S. cubensis* is also understandable taking into account that the huge central Basin of Brazil was an open Sea till to the end of the Miocene.

All the living species of the Genus *Squalus* are common nectic inhabitants of warm to temperate littoral waters, but they also occur in deeper waters* (See Bibliography- Chondrichthyes: Compagno 1984).

*The senior-author has seen a catch of approximately nine hundred specimens of *Squalus acanthias* at a depth of 540 metres, southern of Lousy Bank (April 1979).

In Belgium, this Genus is represented by the three fossil taxa: *S. minor* (DAIMERIES, 1888) from the Selandian strata, *S. smithi* HERMAN, 1982 from the Ypresian and Lutetian strata *and S. alsaticus* (ANDREAE, 1892) from the Oligocene and Miocene strata.

Teeth of the extant species of *S. acanthias* are commonly encountered in the Pliocene and Pleistocene sediments of Belgium.

Squalus alsaticus (ANDREAE, 1892)

Ref.: Andreae A., 1892: *Acanthias alsaticus* in *Mitteilungen der Geologische Landesantstalt von Elsasz-Lothringen*. 3: 105-113.
(Plates 7 to 10)

Total: 436 teeth and one dorsal fin spine. Their teeth, passing through the 1cm mesh, are just a little too small to make it possible to detect abnormal concentrations.

Total in the Northern Sector: 128 teeth.
Total in the Southern Sector: 147 teeth.
Total in the South -Eastern Sector: 161 teeth.

Super-Order Pristiomorphii HERMAN & VAN WAES, 2012

Order Pristiophoriformes BERG, 1958 Ord. rev.

(*sensu* HERMAN & VAN WAES, 2012)

Family Pristiophoridae BLEEKER, 1859

Only one recent species *Pristiophorus schroederi* BIGELOW & BULLIS, 1960 is known in North Atlantic waters and seems to be able to live in coastal waters.

Genus *Pristiophorus* MÜLLER & HENLE, 1837

(Plate 82: fig.: 2)

Pristiophorus rupeliensis STEURBAUT & HERMAN, 1978

Ref. : Steurbaut E. & Herman J., 1978 : *Pristiophorus rupeliensis in* ***Géobios*****. Lyon.11(3). P.305, pl.1, fig. 6-7.**
(Plates 11 and 12)

Total: Only one tooth and one *neurocranium* discovered in the same sector (South East).

The process used to try to identify the Genus to which this *neurocranium* is attributed was the following: considering its particular, very massive, granulous and flat morphology, only five Genera were retained: *Squatina* DUMERIL, 1806, *Anoxypristis* WHITE & MOY-THOMAS, 1941, *Pristis* BONAPARTE, 1838, *Pliotrema* REGAN, 1906 and *Pristiophorus* MÜLLER & HENLE, 1837.

The Genus *Squatina* may directly be excluded because the posterior cranial aperture was circular.

The Genus *Anoxypristis* seems to have no fossil records before the Pliocene. M. Lenglet gave the senior-author the authorisation to examine one juvenile specimen of *Anoxypristis cuspidata* (LATHAM, 1794), preserved in alcohol in the Collection of the Department of Recent Vertebrates of the I.R.S.N.B. (Brussels, Belgium).

The Genus *Pliotrema* also seems to have no fossil records before the Pliocene.

Considering the existence of what looks like the beginning of one nasal cartilaginous extension, the two remaining possible attributions are the two Genera *Pristis* and *Pristiophorus*.

Although plenty of rostrae of different species of *Pristis* were examinable, no whole specimens existed in any official Belgian Scientific Institutions.

Mr Eric Vanderhoeft, one of the Collaborators of the Belgian Geological Survey, was in possession of different stuffed specimens of young animals of these two Genera. He realised macro photographs of his specimens (See Plate 82) and allowed the taking of X-ray photographs of these specimens.

These X-ray photographs (See Plate 81) were, friendly and generously, realized by the radiologist Dr. Jean-Marie Geurts (Wemmel, Provincie Vlaams Brabant, Belgium).

Considering that, in the European Oligocene, only one species of *Pristiophorus* was present, the most logical solution seems to attribute this *neurocranium* to the species *Pristiophorus rupeliensis* STEURBAUT & HERMAN, 1978.

Reflexions concerning the recent distribution and the paleodistribution of the Genus *Pristiophorus*

The senior-author would not be surprised if DNA analyses could demonstrate that the different living taxa of the Genus *Pristiophorus*, odontologically very difficult to distinguish, had one same ancestor. It occupied the central part of the richest food reserve constituted by the shallow warm waters of the Central Pacific Ocean.

Their primitive populations radiated from this central point to reach progressively, the Indian coasts, the Red Sea and the South African coasts on the western side.

On the eastern side, they progressed along the coasts of engulfed mini-continents and archipelagos and so reached the coasts of Central America.

When the Cordillera de los Andes emerged, the Caribbean population of the Genus *Pristiophorus* was split into two communities: one Pacific population and one Atlantic population which evolved separately, finishing giving rise to genetic distinct Atlantic and Pacific species.

Super-Order Orectolobomorphii HERMAN & VAN WAES, 2012

Order Orectolobiformes APPLEGATE, 1972

Family Orectolobidae JORDAN & FOWLER, 1903

Extant Orectolobidae are the survivors of a Family largely distributed in the marine sediments of Upper Jurassic to Upper Eocene Age.

Genus *Orectolobus* BONAPARTE, 1834

(Plate 72)

Generalities

Living representatives of the Genus *Orectolobus* are common inhabitants of shallow temperate and tropical waters of the western Pacific Ocean and the eastern Indian Ocean, principally off the Australian and Indonesian coasts. One living species presents isolated populations off the Japanese coasts.

All the extant species of this Genus are inhabitants of the sea bottoms, awaiting potential preys. Some species have only nocturnal activities.

Cf. Orectolobus sp.

(See *Géominpal Belgica* 5 Part 1: Plate 13: fig.: 4)

Total: 3 teeth.

Only three teeth are attributed, with doubts, to this Genus because the cusp of their crown is lower than this of normal populations of the Genus *Squatina* and their apron is wider and shorter than this of the Genus *Squatina*.

The cohabitation on Indo-Pacific shallow sandy bottoms of these two Genera is not exceptional.

Order Squatiniformes de BUEN, 1926

Family Squatinidae BONAPARTE, 1838

Genus *Squatina* DUMERIL, 1806

(Plate 73)

Generalities

The Genus *Squatina* is theoretically represented by thirteen extant species*: *S. aculeata* DUMERIL, 1829, *S. africana* REGAN, 1908, *S. argentina (*MARGINI, 1930), *S. australis REGAN*, 1906, *S. californica AYRES*, 1859, *S. dumeril* LE SUEUR, 1818, *S. formosa* SHEN & TING, 1972, *S. japonica* BLEEKER, 1858, *S. nebulosa* REGAN, 1906, *S. oculata* BONAPARTE, 1840, *S. squatina* (LINNAEUS, 1758), *S. tergocellata* McCULLOCH, 1914 and *S. tergocellatoides* CHEN, 1963.

*See Compagno 1984: p.: 139.

For the paleoichthyologists, the most important point is that none of their specific biological criteria is observable on isolated recent or fossil tooth.

Paleoichthyologists agree only on one point: Since the Upper Cretaceous to the end of the Eocene the diverse species of this Genus comprised multiple populations of medium-sized demersal predators having relatively large distribution areas.

After the Eocene-Oligocene-Transition, their abundance seems to decrease significantly in the northern hemisphere. In Europe, the diverse populations of the Genus *Squatina* remain common inhabitants of coastal and outer continental shelves in the Northeast Atlantic, the Mediterranean and the Black Sea.

Squatina subserrata MÜNSTER, 1846

Ref.: Münster G., G. 1846: *Squatina angeloides in Beitragen zur Petrefakten-Kunde*. 7: 34, pl.: 2, fig.: 23.
(See Plate 13 and Plate 53: fig.: 1)

The preferential specific attribution of these teeth to *Squatina subserrata* MÜNSTER, 1846 rather than to *Squatina angeloides* VAN BENEDEN, 1873 results from the fact that the type-set of this last one consists only of a lot of grouped vertebrae and no teeth.

Total: 1293 teeth, including the posterior part of one *neurocranium** and 3 vertebrae.

Total in the Northern Sector: 311teeth.
Total in the Southern Sector: 408 teeth.
Total in the South-Eastern Sector: 574 teeth.

*This fossil is illustrated on Plate 53: fig.: 1.

The size of the teeth of this species allowed them to easily pass through the 1 cm mesh, so that it was impossible to be sure that local abnormal concentrations existed.

This is another relatively common species of this Horizon. A portion of the posterior part of a *neurocranium* in the Northern sector and numerous vertebrae, easily recognizable by their oval section were also discovered in this Horizon.

The recent different species proposed for the Genus *Squatina* are practically not identifiable by their isolated teeth. The different species of *Squatina* are relatively common in temperate to equatorial waters. They remain, practically always on the bottom of the sea, but at a certain distance of the shallow sandy coasts, which was the case during the sedimentation of the Sands of Ruisbroek.

Super-Order Heterodontomorphii HERMAN & VAN WAES, 2012

Order Heterodontiformes BERG, 1940

All the biological data and all the paleontological arguments that allow proposing this Super-Order and detailing the conception of the revised Order Heterodontiformes and the strict conception of the Family Heterodontidae were given in *Géominpal Belgica* 3 (See Bibliography- Chondrichthyes: Herman & Van Waes 2012).

Without living representatives of this Genus, anterior and lateral fossil teeth would surely be considered as teeth of different Genera.

Family Heterodontidae GRAY, 1851

Genus *Heterodontus* de BLAINVILLE, 1816

(Synonym: *Cestracion*)
(See Plates 74 to 77)

Generalities

The diverse extant* specific taxa of the Genus *Heterodontus* do all present the following singularities: a relatively short massive and blunt skull with jaws showing one unique monognathic heterodonty**; they have two dorsal spines located in front of their dorsal fins and they are oviparous animals producing strange spiralled eggs (See Plate 77).

**H. francisci* (GIRARD, 1855) from California, *H. galeatus* (GÜNTHER, 1870) from eastern Australia, *H. japonicus* (MACLAY & MACLEAY, 1884) from Japan, *H. mexicanus* (TAYLOR & CASTRO-AGUIRRE, 1972) from the Pacific coasts of Mexico, *H. omanensis* (BALDWIN, 2005) from the Sea of Oman, *H.portusjacksoni* (MEYER, 1793) from South Australia, *H. quoyi* (FREMINVILLE, 1840) from the Galapagos, *H.ramamheira* (SMITH, 1949) from South East Africa, Natal, Somalia, Yemen and Oman and *H. zebra* (GRAY, 1831) from the Western Pacific: Japan to northwestern Australia and Queensland.

**Already quite identic on Upper Jurassic skeletons.

The majority of the living species of the Genus *Heterodontus* are living near the sea bottom and in coral reefs or rocky environments, but some species are common inhabitants of sandy bottoms and of wide sea grass zones.

Feeding Habit

The *Heterodontus* populations feed, principally and nightly, on diverse echinids, molluscs, crustaceans and even on small fishes. They also eat eggs of other congeneric taxa.

Distribution

All the extant species are inhabitants of shallow waters, of more or less, discontinued parts of the Oceans.

Relative abundance of their fossil representatives in Belgian strata

Its abundance may be resumed as follows: Upper Cretaceous (Turonian to Maastrichtian): common, Dano-Montian (Calcarenite of Ciply): present, Lower Selandian (Sands of Orp-le-Grand): unextant, Upper Selandian (Clay of Ghlin): very rare, Lower Ypresian (Clay of Ypres): present, Upper Ypresian (Sands of Forest): very abundant, Lutetian (Sands of Brussels): very abundant, Bartonian: unknown, Oligocene: extremely rare and Miocene to Recent: unextant because of climatic reasons.

Heterodontus cf. janefirdae CASE, 1980

Ref: Case, J., R., 1980: *Heterodontus janefirdae in Paleontographica Abt. A.* 1171(1-3): p.: 79.
(Plates 14 and 41: figs.: 1a-1b)

In Cappetta 2012, this specific taxon is purely forgotten (or suppressed?, but without any explanation) in his list of the fossil species of the Genus *Heterodontus*.

The anterior teeth of *Heterodontus janefirdae* CASE, 1980 were the only ones supporting the comparison with the five anterior teeth here discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

If this attribution is correct, this means that an *early* Gulf Stream carried remains of dead individuals from the American western Atlantic coasts to the European ones, or that some living individuals have crossed the young North Atlantic Ocean.

Total: 5 teeth in one very restricted area of the Northern sector.

Only five teeth were discovered, in a very small area, during one of the last prospections of Frederik Mollen and his group (*Elasmobranch Research Group*). Teeth of this species were never found in another part of the Clay Pit.

This discovery clearly demonstrates the existence of very local concentrations of teeth of the same animal.

One dorsal fin spine of *Heterogonous* was also discovered. This spine was strongly affected by the action of gastric enzymes.

The action of the digestive enzymes of these animals is very rapid and singularly and deeply affects cartilaginous and corneous ichthyodorulites such as dorsal fin spines.

Reflexions concerning the recent distribution and the paleodistribution of the Heterodontomorphii

The senior-author thinks that the suggestions proposed for the Genus *Pristiophorus* (see above) are also valid for the Genus *Heterodontus*.

Super Order Isuromorphii HERMAN & VAN WAES, 2012

Order Isuriformes HERMAN & VAN WAES, 2012

Family Isuridae HERMAN & VAN WAES, 2012

Genus *Isurus* RAFINESQUE, 1810

(Synonyms: *Isuropsis* GILL, 1862, *Lamiostoma* GLICKMAN, 1964, *Oxyrhina* AGASSIZ, 1838)
(Plates 84 to 86)

Systematics

The Genus *Isurus* is represented by the two living species: *Isurus oxyrinchus* RAFINESQUE, 1810 and *Isurus paucus* GUITART-MANDAY, 1966.

In Belgium this Genus is represented by two Fossil species: *I. desori* (AGASSIZ, 1843) from the Lower to Middle Oligocene and *I. flandrica* LERICHE, 1910 from the Middle Oligocene to the Upper Miocene.

Cappetta 2006 (pp.: 321-323) enumerated more than forty fossil taxa that the senior-author never had the possibility to examine by lack of materials.

If the Eocene Genus *Anomotodon* ARAMBOURG, 1952 may be considered as the ancestor of the Genus *Isurus* RAFINESQUE, 1810, the validity of the majority of these taxa is really doubtful.

The long isolation* of the Atlantic and Pacific populations could have generated some distinct specific taxa.

*Geologically: at least since the end of the Eocene.

Generalities

Isurus oxyrinchus lives preferentially in equatorial, tropical and subtropical waters in the three Oceans. But its diverse populations may be encountered between 64°N* and 49°S.

*Along the European coasts, the warm waters of the Gulf Stream allow it to reach 66°N.

Isurus oxyrinchus may be encountered from superficial waters to more than 700 metres depth*.

*Stomachal contents from Spanish specimens examined by the senior-author at Gibraltar revealed the presence of diverse Macruridae of deep waters such as *Nezumia* sp., *Coryphaenoides* sp. and Trichiuridae such as *Aphannopus carbo* LOWE, 1839.

Isurus paucus seems to be an inhabitant of tropical and warm temperate waters. Its actual distribution remains to be determined.

The Genus *Isurus* regroups only two extant species: *Isurus oxyrinchus* RAFINESQUE, 1810 and *Isurus paucus* GUITART, 1966.

Both species are tropical inhabitants and have a very wide distribution, but *Isurus paucus* seems* to be rarer.

*The two species are easily distinguishable, but many ancient information sources of catches were insufficiently verified.

Feeding habit

Extinct* and extant taxa of the Genus *Isurus* have teeth with crowns presenting very sharp and smooth cutting edges and no lateral cusplets.

*Such as *Isurus desori* and *Isurus flandrica,* their principal Oligo-Miocene representatives in Belgium.

They feed on large Teleosteans, on Teuthida (Cephalopoda), on small cetaceans (principally Delphinida) and even on other smaller sharks.

Isurus desori SISMONDA, 1849

Sismonda E., 1949: *Isurus desori in Memorie della reale Academia delle Scienze di Torino*. 2(10): 44, pl.2: 7-16.

Total of discovered teeth: 182 teeth,
with at least, four abnormal concentrations on 2-3m².

Total in the Northern Sector: 49 teeth.
Total in the South-Eastern Sector: 69 teeth.
Total in the Southern Sector: 64 teeth.

The teeth of the normal population of this species are relatively abundant. Here and there, some little concentrations of teeth of the same animal were also encountered. In the *Phosphorite Horizon of Sint Niklaas*, we never observed teeth of the *flandrica* variety (Leriche used the term mutation), or a slightly distinct population of *Isurus desori*.

In the upper part of the Boom Clay Formation *sensu stricto* (level number 31 to the top), the variety *flandrica* is obviously present, but only its anterior teeth are really distinguishable. The lateral ones remain morphologically practically the same as the teeth of *Isurus desori*, confirming their supposed filiation.

Ecological signification

182 teeth are just enough to represent approximately the number of functional and replacement teeth of the whole dentition of one specimen*****, but two local concentrations of 22 and 34 teeth allow supposing that at least one floating carcass derived in this relatively closed area.

*****It always remains hazardous to try to reconstruct the dentition of a fossil species if this seems to be only a variation.

Order Alopiiformes HERMAN & VAN WAES, 2012 (Ord. rev.)

Family Alopiidae BONAPARTE, 1838

Systematics

Genus *Alopias* RAFINESQUE, 1810 and Genus *Usakias* ZHELEZKO & POPOV, 1960

Following the logic proposed in *Géominpal Belgica**, the possession of two principal odontological criteria allows the immediate distinguishment of a Genus. *See Bibliography-Chondrichthyes: Herman & Van Waes 2012.

All the teeth presenting the general morphology of an Alopiidae having a holaulacorhizid root and a dental crown without lateral cusplets are attributable to specific taxa of the Genus *Alopias* RAFINESQUE, 1810.

All the teeth presenting the general morphology of an Alopiidae having an holaulacorhizid root and a dental crown with lateral cusplets are attributable to the specific taxa of the Genus *Usakias* ZHELEZKO & POPOV, 1960.

This was a hypothesis proposed by the senior-author, which Zhelezko already accepted in 1984, during his short visit to the senior-author at his domicile.

Genus *Usakias* ZHELEZKO & POPOV, 1960

The generotype of the Genus *Usakias* is *Usakias wardi* ZHELEZKO & POPOV, 1960. Its teeth were discovered in uppermost Eocene layers*, in Kazakhstan (Central Asia, Russia).

*Considered of Bartonian Age.

According to Cappetta 2006 (p.: 389), this extinct Genus regroups the three following species*: *U. asiaticus* KOZLOV, 2000 from the Middle Ypresian of Uzbekistan (Central Asia, Russia), *U. lerichei* KOZLOV, 2000 from the Rupelian of western Kazakhstan (Central Asia, Russia), and *U. wardi* ZHELEZKO & POPOV, 1960.

*Discussion concerning the different subspecies, later proposed, is of no interest for this publication.

The teeth of these three species are so similar to these of the extant Genus *Alopias* that some palaeontologists have already proposed to synonymize its geologically oldest taxon *Usakias asiaticus* with *Alopias denticulatus* CAPPETTA, 1981.

But in fact it is *Alopias denticulatus* which must be considered as *Usakias denticulatus* (CAPPETTA, 1981).

All the crown teeth of *Alopias denticulatus*, such as their specific name precisely states, are in possession of lateral cusplets.

Only histological studies of all these fossil taxa could maybe clarify the phylogenetic relations existing between the different specific taxa of the Genus *Usakias* and reveal which population of this Genus could be the ancestor of the extant Genus *Alopias*.

In addition to its three living specific representatives, the Genus *Alopias* includes, at least, the four following fossil taxa: *A. acutidens* CASIER, 1958 from the Burdigalian of the Barbados Islands, *A. exigua* PROBST, 1879 from the Burdigalian of Baden-Würtemberg (Germany), *A. hermani* KOZLOV *in* ZHELEZKO & KOZLOV, 1999 from the Lower Bartonian of Kazakhstan (Central Asia, Russia) and *A. latidens* LERICHE, 1909 from the Rupelian of Belgium.

It is difficult to contest the validity of three of these species, because they are protected by the law of anteriority*, but essentially because they were discovered in other Basins, having apparently no connexion with the Central Asiatic Basin.

*Argument considered as insufficient by the senior-author.

As conclusion, the teeth presenting the same general morphology and the same root vascularisation type as these of the living and fossil taxa of the Genus *Alopias* RAFINESQUE, 1810 are considered as fossil teeth of this Genus.

The disappearance of the Genus *Usakias* and its replacement by the Genus *Alopias* is another faunal event marking the importance of the Eocene-Oligocene-Transition.

In Belgium, the Genus *Usakias* is represented by its numerous teeth collected in the Ypresian strata (Silt of Kortemark and Clay of Egemkapelle in the Ampe Clay Pit at Egem (Western Flanders Province) and in the Sands of Forest at Forest-lez-Bruxelles (Brussels Regio).

In the Belgian Upper Eocene, teeth of *Usakias* were also discovered in the basal conglomerate of the Sands of Lede in different Flemish localities* (Balegem, Oosterzeele, Meldert), in the Brussels Sands at Woluwe-Saint-Pierre (Brussels Regio), in the Lede Sands at Meldert (Eastern Flanders) and in strata of Bartonian age in a recently exploited Sandpit in Eastern Flanders.

*Materials of the *Collection Crochard* in repository in the Department of Vertebrate Paleontology (I.R.S.N.B., Brussels, Belgium)

Genus *Alopias* RAFINESQUE, 1810

Generalities

The Genus *Alopias* regroups only three living species: *A. pelagicus* NAKAMURA, 1935, *A. superciliosus* (LOWE, 1840) and *A. vulpinus* (BONNATERRE, 1788).

Analysis of mitochondrial DNA has shown that Atlantic and Indo-Pacific populations are genetically slightly different* from each other.

*See Bibliography-Chondrichthyes: Trejo 2005.

Recent work investigating population structure of all three *Alopias* species, using mitochondrial DNA control region sequences (Trejo 2004), has found no evidence indicating that the fourth species of *Alopias**, proposed by Eitner, exists.

*See Bibliography-Chondrichthyes: Eitner 1995.

Geographic distribution of the three living species

A. pelagicus is a common shark inhabiting the tropical to subtropical waters of the Indian Ocean and the Pacific Ocean. The individuals of this species are high sea inhabitants, entering only occasionally in coastal waters.

A. superciliosus has a world-wide circum-tropical distribution*. In the western Atlantic Ocean, it has been reported from Cape Cod to Florida, the Bahamas, the Caribbean Sea and southern coasts of Brazil.

In the eastern Atlantic, it is known from southern Portugal to Angola, and the Mediterranean Sea. In the western Indian Ocean, it inhabits off South Africa, Madagascar and the Arabian Sea. In the Pacific Ocean, it is frequently caught along the southern Japanese, Taiwanese, northwestern Australian, New Caledonian and New Zealand coasts.

In the western Pacific Ocean, it was frequently caught from the Hawaii Islands to southern California, the Gulf of California but more rarely off the Galapagos Islands.

*See Bibliography-Chondrichthyes: Compagno 2002: pp. 83-85.

A. vulpinus has a worldwide tropical to temperate distribution, but is more frequent in cooler waters. It can be encountered near the shore and in the open ocean, from the surface to a depth of more than 500 metres. It is a seasonal migrator and lives at higher latitudes during the summer.

In the western Atlantic Ocean, it may be encountered from Newfoundland to the Caribbean Sea and from Venezuela to Argentina.

In the eastern Atlantic, the senior-author had many opportunities to examine specimens from the North Sea, the Irish Sea, the Gulf of Biscay and also specimens from diverse parts of the Mediterranean. It is also present in the Black Sea.

Along the African coasts, it lives along the northern coasts of Morocco to the South African coasts.

In the Indian and Pacific Oceans, fishermen have signalized its presence in Tanzania, Zanzibar, India, Japan, Korea and along the majority of the Pacific Islands.

In the western Pacific, it has been recorded from Columbia to Chile and the Gulf of California.

Despite their high mobility potential, its scattered populations seem to have very few contacts among them. Analyses of mitochondrial DNA have revealed significant regional genetic variations in all the three Oceans.

Environment

Members of the diverse populations of the extant species of the Genus *Alopias* are inhabitants of continental shelves in open seas.

Some being migratory animals, swimming near the surface of the Oceans where they are able to perform spectacular jumps.

They seem to be confined to waters with surface temperatures comprised between 16 and 25°C, but some specimens of *A. superciliosus* were caught deeper than 720 meters.

Feeding habits of the Genus *Alopias*

The three extant species of the Genus *Alopias* feed principally on small to middle-sized teleostean fishes such as the diverse species of the Family Scombridae REGAN, 1909*. The developing embryos are oophagous, eating the unfertilized eggs produced by their mother.

* Which means, at least, fifteen Genera regrouping fifty-one species.

For references, See Bibliography-Chondrichthyes: Chen, Liu & Chang 1997, Eitner 1995, Liu, Chen, Liao & Joung 1999, Otake & Mizue 1981, Trejo 2005, Visser 2005 and Weng & Block 2004.

Genus *Alopias* RAFINESQUE, 1810

Alopias latidens (LERICHE, 1908)

Leriche M., 1908: *Alopecias latidens, in Bulletin de la Société belge de Géologie, Paléontologie et Hydrologie*. 22: 379 (p. PV.).
(Plate 15: fig.: 3)

Abnormal observed concentrations: one time 18 teeth on less than 1m² (Southern sector), another time 22 teeth concentrated on less than 1m² (Southern sector).

It was an unknown part of its population which suddenly generated the Genus *Cetorhinus* during the Eocene-Oligocene Transition.

In contrast with the recent species of *Cetorhinus*, the recent species of *Alopias* are super agile animals able to perform very high spiral jumps above the water level.

Total: 24 teeth.

Total in the Northern Sector: 8 teeth.
Total in the Southern Sector: 12 teeth.
Total in the South -Eastern Sector: 4 teeth.

Ecological signification: the 24 teeth discovered in the mass of the sieved sediments, are not numerous enough to represent the upper and lower functional teeth set of one single animal. Consequently, this species is not representative of the elasmobranches assemblage of the original environment.

Alopias exigua (PROBST, 1879)

Ref.: Probst J., *Alopecias exigua, in Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*. 34:135, pl.2: 20-25.
(Plate 15: figs.: 1-2 and Plate 16: figs.: 3-4)

Total: 8 teeth.

Total in the Northern Sector: 2 teeth.
Total in the Southern Sector: 2 teeth.
Total in the South -Eastern Sector: 4 teeth

Ecological signification: the same as the conclusion proposed for *Alopias latidens*. This species is a little more common in the Boom Clay Member.

Family Cetorhinidae GILL, 1862

Genus *Cetorhinus* de BLAINVILLE, 1816

(Plate 71)

Generalities

This Genus seems* to be represented by a single extant species: *Cetorhinus maximus* (GUNNERUS, 1765) and, at least, one fossil species: *Cetorhinus parvus* LERICHE, 1908.

*See Bibliography-Chondrichthyes: Compagno 1984, Herman 1979, Siccardi 1960, Siccardi 1960 and Welton 2012.

Cetorhinus maximus is a species able to effectuate important migrations near the surface of all the Oceans and is supposed to overwinter in deep waters. It may occur in small groups or, more generally, isolated.

Small groups of six to twelve individuals have been seen* in the Bay of Fundy (New Brunswick, Canada) swimming nose to tail in circles. This unusual behaviour is interpreted by some ichthyologists as a mating ritual.

*See Bibliography-Chondrichthyes: Mattews 1950 and Mattews & Parker 1950.

The morphology, the residual vascularisation and the histology of the teeth of Cetorhinus *parvus* and *Cetorhinus maximus* suggest that the ancestor of this Genus was an Alopiiformes drastically affected in its genetic code (mitochondrial DNA) during the Eocene-Oligocene Transition.

Populations of middle-sized carnivorous Chondrichthyes suddenly changed into big filtring animals. This event was contemporaneous with the event that transformed, so suddenly carnivorous Odontoceta into filtring Mysticeta (Mammalia).

Feeding habit

Extant and living *Cetorhinus* are exclusively filtring Chondrichthyes. Some of their *fanoncular apparatus* were discovered* in the Belgian Oligocene to Holocene strata, but parts of elements (*fanonculi*) were also discovered in all the Oligocene to Holocene strata of the world.

*More or less complete.

Distribution

Individuals of *Cetorhinus maximus* are generally encountered in temperate waters of the Pacific and Atlantic Oceans.

They are usually observable at, or just below, the surface and have been signalized along almost every coastline bordering both the Atlantic and Pacific Oceans.

Teeth and reproduction

Cetorhinus maximus are ovoviviparous and have numerous small* teeth.They have more than 1.200 teeth which have as principal utility to firmly hold their partner during copulation.

*Of a maximum of 8 mm height, for individuals of nearly 8 metres length.

The proportion between the size of the teeth and the size of the individual seems to have been similar for its Oligocene ancestor *Cetorhinus parvus*.

This fact was demonstrated by the discovery of a nearly complete specimen in the indurated Rupel Ton from Germany, meticulously described by Dirk Hovestadt and Maria Hovestadt-Euler in 2012.

Migration of extant *Cetorhinus*

Satellite tagging confirmed that extant *Cetorhinus maximus* move thousands of kilometers during the winter months, seeking plankton blooms*.

It also evidenced that they shed and renew their gill rakers in an ongoing process, rather than over a short period*.

*See Bibliography: Chondrichthyes: Skomal, Zeeman, Stephen, Chisholm, Summers, Walsh, McMahon & Thorrold 2009.

In 2009, the pre-cited authors followed 25 tagged *Cetorhinus maximus* off the coast of Cape Cod, Massachusetts (USA), and indicated that some individuals migrate south in the winter.

These individuals remained at depths between 200 metres and 1.000 metres for many weeks and crossed the equator to reach Brazil. One individual remained near the mouth of the Amazon River for a month.

Remark concerning the Genus *Cetorhinus* and the Genus *Rhincodon*

The adult specimens of *Cetorhinus maximus* (GUNNERUS, 1765), such as the adult specimens of *Rhincodon typus* SMITH, 1828 represent a drifting mass of flesh reaching more than four tons for the first ones, and more than thirty tons for the second ones. Except for their parasites, they have no identified predators.

Taking into account the fact that the species *Cetorhinus maximus* has very poorly calcified vertebrae and minuscule teeth , it is really amazing that no attacks by sharks nor whale-toothed fishes of such massive, slowly moving or simply drifting potential preys were signalized.

Specimens with emitter have been followed by airplanes or satellites during days and days over thousands and thousands of kilometres without detecting any attack.

The simplest explanation for this phenomenon could be that they possess an unidentified powerful repellent.

Cetorhinus parvus LERICHE, 1908

Ref. : Leriche M., 1908: *Cetorhinus parvus in Comptes rendus des séances de l'Académie des Sciences de Paris*.14(6): p. 878.
(Plates 19 and 20)

Only two teeth, but a little lot of fragments of *fanonculi* were discovered in all our residues. We have only one plausible explanation for this fact. The sea waters were, at this period, not deep enough to be visited by these huge and massive animals feeding only on sea plankton.

Total: 2 teeth and 78 *fanonculi*.

1 tooth in the Northern Sector, and 1 tooth in the South-Eastern Sector.
46 *fanonculi* in the Northern Sector, 18 in the South-Eastern Sector and 14 in the in the Southern Sector.

The living populations of the Genus *Cetorhinus* have distinct repartition areas in the Oceans. Several biologists and paleontogists, these last ones with arguments based on both recent and fossil teeth of these different populations, have proposed different specific names. This question remains controversial.

But, the fact that these animals regularly renew the totality of their *branchial apparatus* is indubitable, and consequently reduces its frequential representativeness significantly.

Ecological signification: The teeth attributed to this species came from occasional visitors to this area or are just scattered remains of a floated carcass. This species was a very sporadic visitor of the nectic waters at a relative distance of all the European coasts.

Order Lamniformes *sensu* HERMAN & VAN WAES, 2012

(*Pro parte* Order Lamniformes BERG, 1958)

For the odontological justification of the proposal of this revised Order, see *Géomipal Belgica* **2**: p.55.

Reflexions concerning the Genera *Isurolamna* CAPPPETTA, 1976 and *Rhizoquadrangulus* BAUT & GENAULT, 1999

The Genus *Isurolamna* CAPPPETTA, 1976 is based on *Isurolamna affinis* CASIER, 1946, a characteristic and relatively common lamnoid shark from the Ypresian to Middle Lutetian fossiliferous levels of the Anglo-French-Belgian Basin.

Its lateral teeth have singularly dissymmetric roots (See Cappetta 2012: fig.: 202, p. 216).

The Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999 is based on *Isurus rupeliensis* LE HON, 1871 presenting perfectly symmetric lateral teeth.

This species is relatively common in the Belgian Lower Oligocene Formations (Sands of Kerniel, Sands of Berg, Sands of Ruisbroek) and it remains common in the Belgian Middle Oligocene (Boom Clay Member).

The morphological differences existing between the teeth of these two generic taxa are obvious enough to allow considering that these two taxa have had genetic relations but are really distinct.

Histological preparations could maybe help to understand this probable phylogenetic relation.

Family Lamnidae sensu HERMAN & VAN WAES, 2012

(*Pro parte* Family Lamnidae MÜLLER & HENLE, 1838)

Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999

Rhizoquadrangulus rupeliensis (LE HON, 1871)

Le Hon H., 1871: *Otodus rupeliensis in* Préliminiaires d'un Mémoire sur les Poissons tertiaires de Belgique: 11, 2figs.
(Plate 16: figs.: 1-2, Plates 17 and 18)

Total of discovered teeth: 409 teeth, with at least two abnormal concentrations on 2-3m² in Southern and South-Eastern sectors: Once 19 teeth concentrated in circa 2m², and another time, 12 teeth concentrated in less than 2m².

Total: 409 teeth.

Total in the Northern Sector: 135 teeth.
Total in the South-Eastern Sector: 142 teeth.
Total in the Southern Sector: 132 teeth.

This species is relatively frequent in the Sands of Fontainebleau (Oligocene of the Paris Basin) and, in Belgium in the Upper part of the Boom Clay Formation (See Bibliography-Chondrichthyes: Winkler 1880 and Leriche 1910.

This species is much more common* in the Kerniel Sands at Lethen (Province of Limburg, Belgium) and in the Vliermael Formation Sands at Berg (Province of Limburg, Belgium).

*Senior-author's observations.

Eleven specimens of this species were also discovered (1983-1984) in the Lede Sands Formation in the old Dejonge Sandpit at Meldert (Flemish Brabant, Belgium - J. Herman field observations).

These last Middle Lutetian specimens differ from their relatives of the Belgian and French Oligocene only by their slightly smaller size.

Illustrations of specimens from Meldert will be published in another volume of *Géominpal Belgica* completely devoted to the site of Meldert (Lede Sands Formation - Lower part of the Upper Belgian Eocene).

Ecological signification:

Rhizoquadrangulus rupeliensis was a relatively large-sized predator with a considerable distribution area in western Europa.

The abundance of diverse large teleost-fishes in the Belsele area were, apparently, sufficient to assure the feeding for some small populations* crossing this area.

*409 teeth perfectly preserved represent a maximum of ten individuals losing their functional teeth. Among these 409 teeth, some fell from jaws of adults, but the majority came from jaws of juveniles.

Genus *Lethenia* BAUT & GENAULT, 1999

Lethenia vandenbroecki (WINKLER, 1880)

Winkler T.C., 1880: *Lamna Van den Broecki in* Archives du Musée Teyler 5(2): 77, fig.3.

Total: 3 teeth.

This species is relatively frequent in the Sands of Fontainebleau (Oligocene of the Paris Basin) and is only present, but rare, in Belgium in the Upper part of the Boom Clay Formation (See Bibliography: Winkler 1880, Leriche 1910 and Bault & Génaut 1999).

These higher frequencies were confirmed by the diggings of J. Herman, J.-P. Luypaerts, E. Vanderhoeft and P. De Sutter (December 1985 to Juny 1986) in the Kerniel Formation Sands at Lethen (Province of Limburg, Belgium).

This species is much more common in the Kerniel Formation Sands at Lethen (Province of Limburg, Belgium) and in the Vliermael Sands Formation at Berg (Province of Limburg, Belgium).

Ecological signification: three teeth just indicate that at least one individual passed in this area.

Order Odontaspidiformes *sensu* HERMAN & VAN WAES, 2012

Family Odontaspididae MÜLLER & HENLE, 1839

***sensu* HERMAN & VAN WAES, 2012**

Taxonomical Remarks concerning the Genera *Carcharias*, *Synodontaspis*, *Odontaspis*, *Sylvestrilamia* and *Araloselachus*

In 1929, Louis Bertin* insisted on the urgent necessity to definitely abandon the use of the generic term *Carcharhias* de BLAINVILLE, 1816, source of permanent confusions.

*See Bibliography-Neoselachii: BERTIN, L. 1929: Essai de classification et de nomenclature de la sous-classe des Sélaciens. *Bulletin de l'Institut Océanographique de Monaco*. **775**: 1-24.

In 1931, Errol White*, reconsidering this classification, suggested its replacement by three subgeneric taxa: *Odontaspis*, *Synodontaspis* and *Parodontaspis*.

*See Bibliography-Chondrichthyes: White 1931: *The vertebrate faunas of the English Eocene. I. From the Thanet Sands to the Basement Bed of the London Clay*. British Museum (Natural History). London. 121 p., 162 figs.

The Genus *Odontaspis* AGASSIZ, 1838, regrouping all the specific taxa distributed in the three subgenera proposed by White, was progressively reutilised after the invalidation of the sub Genus *Parodontaspis*.

The fossil Genus *Araloselachus* was proposed in 1964 by Glickman for a Miocene (Burdigalian) taxon: *Araloselachus agespensis* from Kazakhstan, Central Asia (Russia).

Long before these researches numerous fossil teeth of the west European Cenozoic were already attributed to fossil species, considered as ancestors of the populations of the living Genera* *Odontaspis* AGASSIZ, 1838 and *Synodontaspis* WHITE, 1931.

Dr. White included a significative part of the European Eocene, Oligocene and Mio-Pilocene taxa in this Genus with numerous arguments.

The sub-Genus *Synodontaspis* was, momentaneously, considered as a generic taxon (See Bibliography-Chondrichthyes: Herman and Van Waes 2012), and its taxonomic replacement by the designation *Sylvestrilamia* superficially and insufficiently argumented must be definitely rejected.

Its reviewed definition (Cappetta 2012: p.: 208) includes no significant odontological criterion that allows distinguishing this new taxon, based on the same type species, from any other Odontaspididae taxon.

Geological remark concerning the Genus *Araloselachus*

Generalities

The Genus *Odontaspis* is represented by the three following living species*: *Odontaspis ferox* (RISSO, 1810), *Odontaspis taurus* (RAFINESQUE, 1810) and *Odontaspis noronhai* (MAUL, 1955).

*The criteria allowing a possible distinction between the Genera *Odontaspis* AGASSIZ, 1838 and *Carcharias* RAFINESQUE, 1810 being purely physiological, it is impossible to distinguish these taxa on isolated teeth.

The generic name *Carcharhias* was proposed before the generic name *Odontaspis*, but the ICZN having suggested the non-utilisation of the generic name *Carcharias*, all the fossil teeth must be considered as teeth of diverse taxa of the Genus *Odontaspis*.

All the teeth of all the extant or extinct taxa of the Family Odontaspididae present the same fundamental odontological criteria*, which simplifies the problem for paleoichthyologists.

*See Bibliography-Chondrichthyes: Herman & Van Waes 2012.

The easier criterion to identify teeth of members of this Family is the possession of an elongated crown tooth presenting one principal long cuspid without intern striation and flanked by long and, more or less, sharp lateral cusplets.

Remark concerning the Genus *Sylvestrilamia* CAPPETTA & NOLF, 2005

Generalities

The generotype of this Genus is *Synodontaspis teretidens* WHITE, 1931 from the Lower Eocene of Great Britain.

This Genus is characterised* by the possession of teeth with crown presenting one pair of lateral cusplets and numerous intern more or less elongated striations.

*See Bibliography-Chondrichthyes: Cappetta & Nolf 2005 and White 1931.

Synodontaspis teretidens WHITE, 1931 is a species represented by numerous teeth in the uppermost levels of the Paleocene and in diverse levels of the Lower Eocene of Belgium.

The abundance of *Synodontaspis teretidens* decreases significantly in the Upper Eocene of Belgium.

The odontological argumentation of Cappetta (2012: p.: 208) to replace the subgeneric name *Synodontaspis* by the generic name *Sylvestrilamia* is based on very light morphological differences observed on the dental crowns of some teeth.

These differences concern only the dental crowns of some individuals collected in other environments than this of its type locality Abbey Wood (South-East London, Great Britain). These morphological differences are just significant enough to allow distinguishing two populations of a species.

The paleoenvironment of the Thanet Sands deposits in this locality may be interpreted as light brackish water deposits.

Their brackhish nature is demonstrated by the abundance of teeth of the batoid *Hypolophodon sylvestris* (WHITE, 1931).

Teeth of Chondrichthyes living in brackish water are characterised by the, more or less, higher porosity of the root of their teeth. This higher porosity made the absorption of mineral elements in their dental roots easier.

This is necessary to produce the apatite of the crown of their teeth.The apatite formula is: $Ca_{10}(PO_4)_6(OH,F,Cl)_2$.

The intern face of the dental crown of the teeth of *Odontaspis acutissimus* presents the same general morphology, but their intern striation is reduced to sporadic basal foldings.

Consequently, the Genus *Sylvestrilamia* CAPPETTA & NOLF, 2005, proposed without any significant odontological criterion, is considered by the senior-author as a junior synonym of *Synodontaspis* WHITE, 1931.

According to the generic conception of the senior-author, the sub-Genus *Synodontaspis* is considered as a Genus, or elevated to the generic rank.

Synodontaspis teretidens seems to have been the last representative taxon of this monospecific Genus in the Belgian Cenozoic.

Genus *Odontaspis* AGASSIZ, 1838

(Synonyms: *Carcharhias*, *Eugomphodus*, *Parodontaspis*)

(Plate 87)

The Genus *Odontaspis* is represented by three extant taxa: *O. taurus* (RAFINESQUE, 1810), *O. ferox* (RISSO, 1810) and *O. noronhai* (MAUL, 1955).

Odontological data concerning the three extant *Odontaspis*

According to the figuration of its dentition (Compagno 1984: p: 60) and personal observations of the senior-author, *Odontaspis noronhai* possesses only one eye-teeth file and the crown of its teeth possesses only one pair of lateral cusplets.

According to the same sources, *Odontaspis ferox* possesses four eye-teeth files and the crown of its teeth possesses two or three pair of lateral cusplets.

O. taurus and *O. ferox*, are widely distributed*, but it is sure that these two species were, and remain, very frequently misidentified.

*See their distribution maps in Compagno 2001 (p.: 59, 65 and 67).

The single common point of these two species is to be inhabitants of equatorial to temperate warm waters. They are obviously more common in warm and shallow waters.

The validity of the recent species *Odontaspis tricuspidatus* (DAY, 1878) is not certain: Its Holotype is lost, but its single drawing is accompanied by the drawing of two anterior teeth presenting only one pair of lateral cusplets.

Multiple figurations of the head or of the jaws of *Odontaspis tricuspidatus* discovered on Internet guarantee the fact that this species possesses only one file of eye-teeth and that the crown of their teeth presents only one pair of poorly developed, lateral cusplets.

The diverse populations of *Odontaspis noronhai* inhabit the large zone covering the eastern side of the Great Eastern Pacific Barrier and the coasts of the southern Atlantic between the NE of Brazil and Urugay, and the caughts of many individuals were recently signalised* from the central part of the western North Atlantic.

*Fishermen’s information.

First deduction: The dentition of *Odontaspis noronhai* is more primitive than this of *Odontaspis ferox*.

Second deduction: Such as diverse Mollusca and Decapoda, the ancestors of this species have crossed the Amazonian Basin during the Miocene or the Pliocene Period, before that this huge intern Sea* was reduced to the Lake of Maracaibo (Venezuela).

*See Bibliography - Generalities: Figuetredo, Hoorn, van der Ven & Soares 2009, Landini, Ragaini, Sorbini, Valleri, Varola, Vera & Azzaroli 1991, Miller & Vokes 1988 and Walker 2001.

Fossil Taxa

The three following extinct taxa seem to be considered as valid by the majority of the paleoichthyologists: *Odontaspis aculeatus* CAPPETTA & CASE, 1975, *Odontaspis speyeri* (DARTEVELLE & CASIER, 1943) and *Odontaspis winkleri* LERICHE, 1905.

Feeding habit

The extant species of the Genus *Odontaspis* have a large variety of marine animals to feed on. All the marine animals smaller than themselves are potential preys, except for one group, the large sea turtles.

The possession of teeth which have a crown with lateral cusplets made it dangerous to try to feed on large sea turtles.

It is preferable to have jaws with serrulated teeth to destroy the carapace of the sea turtles without suffocating risk. This is the case with the extant taxa *Galeocerdo cuvieri* or *Carcharodon carcharias* and their ancestors.

For references, see Bibliography-Chondrichthyes: Bertin 1929, Compagno 1984, Compagno 2001, Cione, Menucci, Santalucita & Hospitaleche 2007 and Herman & Van Waes 2012.

Odontaspis acutissimus (AGASSIZ, 1843)

Agassiz L., 1843: *Lamna (Odontaspis) acutissima in* Recherches sur les Poissons fossiles. III: 294, pl. 37a.Fig.: 33 and **34.**
(Plates 21 to 23)

Total of discovered teeth: 5.236 teeth,
with at least, four abnormal concentrations (16, 18, 22 and 26 teeth)
observed in the Southern sector on areas of 2-3m².

Total in the Northern Sector: 881 teeth.
Total in the South-Eastern Sector: 2.267 teeth.
Total in the Southern Sector: 2.088 teeth.

The teeth of this species are the most common teeth collected in the *Sint Niklaas Phosphorite Bed*, and even if proportionally reduced, this species remains one of the most common of this sedimentary Unit.

Ecological signification

Considering its mass, *Odontasîs acutissimus* must have been a very large and relatively supple predator. Living Odontaspididae are characteristic inhabitants of coastal to continental slopes of equatorial to tropical areas and frequent principally undeep waters with sandy bottoms, rarely muddy bottoms.

The paleoenvironment during the sedimentation of the upper part of the Ruisbroek Sands seems to have been very similar.

Such animals needed huge quantities of food principally contstituted by large fishes. They may have fed on Scombridae and maybe on Xiphiidae, which were abundant* in the Belgian Lower Oligocene.

*Fragments of rostrae of Xiphiidae are commonly observed in the stomachal content of living Odontaspididae.

Odontaspis cuspidatus (AGASSIZ, 1843)

Agassiz L., 1844: *Lamna cuspidata* in Recherches sur les Poissons fossiles. III: 290, pl.: 37a: 45 - 49.
(Plates 24 and 25)

Total: 449 teeth,
including at least 3 abnormal concentrations in the Southern Sector.

Total in the Northern Sector: 119 teeth.
Total in the South-Eastern Sector: 169 teeth.
Total in the Southern Sector: 161 teeth.

Ecological signification

The same considerations as those proposed for *Odontaspis acutissimus* seem to be valid for this species, but considering its higher frequency in the silty clayish strata of the Boom Clay, it is possible that muddy bottoms were more favourable for this species.

Geological remark concerning the Genus *Araloselachus* GLYCKMAN, 1964

The first authentic populations of the Genus *Araloselachus* being post Eocene taxa, its presence in the reduced* Oligocene North Sea Basin may be excluded.

*The Rupelian Sea covered a part of northern Belgium and southern Germany (Rupel Ton in the Mainzer Bekken); with an extension reaching the southern part of Alsace (France).

The uplift of the Cordillera de los Andes having interrupted the relations between the Indo-Pacific Oceans and the Atlantic Ocean since the Lower Oligocene, the diverse Indo-Pacific animal populations had no more possibility to penetrate into the Atlantic Ocean.

In 1964, having obtained a copy of the Publication of Dr. Glyckman, Dr. Casier was so astonished that Dr. Glyckman had based the proposal of the Genus *Araloselachus* nov. Genus on material of such poor quality of preservation that he decided to interrupt any communication with him and all his team.

But, if some day the Genus *Araloselachus* is validated, it will remain true that this Genus had the possibility to present some diversified populations in the Indo-Pacific.

References for *Araloselachus agespensis* GLICKMAN, 1964

See Bibliography-Chondrichthyes: Glyckman 1964, Zhelezko & Kozlov 1999 and Cappetta & Nolf 2005.

Comment on the Glyckman *Araloselachus* type-set

In 1972 the senior-author received the copy of Dr. Glyckman's work. He then realised a French translation of the pages concerning the systematic conception of the 'Lamniformes' of Dr. Glyckman and distributed it to diverse European and American colleagues.

The senior-author was also really surprised by the very poor quality* of preservation of all the teeth constituting the type set of this new Genus and he understood, partially, the reaction of Dr. Casier in 1964.

*See Glyckman: Plate 29: figs.: 3 to 12 and Plate 30: figs.: 2 to 4, 6 and 8.

In 1972 the senior-author pointed out only one singularity authorising to consider this lot of teeth as representative of a new taxon: the crown of the teeth that were not too abraded presented a variable number of anterior and posterior cusplets.

Such a single secondary criterion may allow proposing a new specific taxon but surely not a new generic taxon.

Histological sections of these teeth could bring additional arguments to definitely justify the validity of this new specific taxon and maybe of a new Asiatic generic taxon.

Comments on its Lectotype

This specimen, preserved in the State Darwin Museum (Moscow, Russia), Nr.: GIK 8057/15, is a very badly preserved anterior tooth, without any lateral cusplets, allowing no scientific determination.

*Search on *Shark References* or on *ION*: *Araloselachus agespensis*: Figuration of the intern (lingual) side of its Lectotype.

Its root is completely abraded, the enamel of its crown is fragmented in multiple vertical lamels and it is impossible to discern the presence or the absence of vertical striations as well as of lateral cusplets.

In such a poor preservation stage, this tooth could be an anterior tooth of an undeterminable *Isurus*.

Scarce presence of Chondrichthyes super predators

As the super predators share the top of the ecological pyramid, the number of their taxa and individuals is limited and, in normal environments*, auto regulated.

*In this context it means: before the existence of Humanity.

With the apparition of the Odontoceta, the Chondrichthyes encountered very significant feeding competitors and so progressively restricted the number and the diversity of their super *predators*.

The definition of *super predator* is, of course, subjective. In this publication are considered as *super predators* all the specific taxa from which the adult specimens are in possession of teeth of, at least, three centimetres height.

With such a restriction, only the eight extant following taxa are concerned: *Carcharodon carcharias* (LINNAEUS, 1754), *Galeocerdo cuvieri* (PERON & LE SUEUR, 1822), *Odontaspis taurus* RAFINESQUE, 1810, Odontaspis *ferox* (RISSO, 1810), *Odontaspis tricuspidatus* (DAY, 1878), *Odontaspis noronhai* (MAUL, 1955), *Isurus oxyrinchus* RAFINESQUE, 1810 and *Isurus paucus* GUITART-MANDAY, 1966.

This list allows supposing that, at least, since the difficult Eocene-Oligocene Transition, the generic and specific taxa defined as *super predators* were really not numerous and must have been of equal importance.

In the Belgian Lower Oligocene these taxa were represented by some of their ancestors: *Carcharocles angustidens* (AGASSIZ, 1843), *Odontaspis acutissima* (AGASSIZ, 1843), *Odontaspis cuspidata* (AGASSIZ, 1843), *Isurus desori* (AGASSIZ, 1843), *Isurus flandrica* LERICHE, 1910 and *Rhizoquadrangulus rupeliensis* (LE HON, 1871).

During the Belgian Upper Oligocene, *Isurus desori* (AGASSIZ, 1843) disappeared, but the other taxa survived.

In the Belgian Miocene, *Megaselachus megalodon* (AGASSIZ, 1843), *Odontaspis vorax* (LE HON, 1871), *Cosmopolitodus hastalis* (AGASSIZ, 1843), *Cosmopolitodus escheri* (AGASSIZ, 1843), *Anotodus reflexus* (AGASSIZ, 1843), *Parotodus benedeni* (LE HON, 1871) and *Galeocerdo cuvieri* (PERON & LE SUEUR, 1822) replaced them.

In the Belgian Lower Pliocene, the most relevant fact is the disappearance of *Megaselachus megalodon* (AGASSIZ, 1843).

In the Belgian Upper Pliocene only teeth of *Cosmopolitodus hastalis* (AGASSIZ, 1843) are common, teeth of *Galeocerdo cuvieri* (PERON & LE SUEUR, 1822) are rarities and teeth of *Carcharodon carcharias* (LINNAEUS, 1754) exceptional discoveries.

In Belgium, the constant decrease of the populations of super predators during the Miocene and the Pliocene was a direct consequence of the progressive cooling of the environment.

Family Otodontidae GLÜCKMAN, 1964

Genus *Parotodus* CAPPETTA, 1980

Parotodus benedeni (LE HON, 1871)

Le Hon H., 1871: *Oxyrhina Benedeni in* Préliminiaires d’un Mémoire sur les Poissons tertiaires de Belgique: 6, 2figs.

Total: 0 teeth
Conclusion: this species is absent.

The massive teeth of this powerful species are also completely absent in the *Sint Niklaas Phosphorite Bed*. Its presence in the Boom Clay Formation is demonstrated by some isolated teeth, and by a jaw set illustrated by Maurice Leriche (See Bibliography: Leriche 1910).

In fact, such as all the large elasmobranch teeth, the teeth of this species are extremely rare in the Boom Clay deposits. It is only due to the fact that the extraction of the clay was not mechanised up to the 1920s that big specimens seem to be so frequent.

The size record for the teeth of this species reached a height of 48mm for one anterior tooth, discovered in the basis of the Antwerpen Formation Sands at Rumst (Miocene of Belgium).

Genus *Carcharocles* JORDAN & HANNIBAL, 1923

Carcharocles angustidens (AGASSIZ, 1843)

Agassiz L., 1843 : *Carcharodon angustidens in* Recherches sur les Poissons fossiles. III: 255, pl.28: 20-25.
(Plates 28 to 31)

Total: 19 teeth.
Total in the Northern Sector: 3 teeth.
Total in the South-Eastern Sector: 8 teeth.
Total in the Southern Sector: 8 teeth.

Such a scarcity means that the hugest marine predator of this epoch did not find its common sources of food: large sea turtles, small delphinids or small cetaceans, which did not yet exist in our countries.

The quality of preservation, the same creamish colour and the regular decrease of size of some discovered teeth allow supposing that the teeth illustrated on Plate 28 came from the jaw of one very large individual.

Other observations

Primo

Other *Carcharocles angustidens* teeth discovered in the same level present a grey-blue crown and one tooth is completely blackish (See Plate 30: fig.: 1), which means that they originate from different strata, each having been affected by different geochemical impregnations.

Secundo

The size record (93 mm height) of teeth of *Carcharocles angustidens* discovered in the *Sint Niklaas Phosphorite Bed* (Lower Belgian Oligocene deposits) was not superior to the height size record of the uppermost Eocene *Carcharocles auriculatus* teeth and equals the height size record of the *Carcharocles angustidens* teeth discovered in the Boom Clay Member (Private Collections, See Plate 30: fig.: 2).

The teeth of this Genus seem to have suddenly and momentarily stopped their growth. This is a very rare event for their apparent continuous evolution to the gigantism of *Megaselachus megalodon*.

It is a fact that the unique relevant difference between uppermost Eocene teeth of *Carcharocles auriculatus* and Lower Oligocene teeth of *Carcharocles angustidens* consist in the number and size of their serrulation elements and in the degree of resorption of their lateral cuspids by their principal cuspid.

But these phenomena do not explain this momentary stop of size increase.

The lack of big fish preys such the Xiphiidae (Teleostei), the scarcity of large marine chelonian preys and the absence of mammalian preys such the sirenian, the phocinids and the delphinids in the Belgian Lower Oligocene deposits could be the valuable explanation of this strange phenomenon.

An explanation for the process of the increase of the serrulation pattern on the cutting edges of Elasmobranchii teeth was proposed in a preceding paragraph.

Numerous teeth* of *Carcharocles angustidens* were also collected in the basis of the Bassevelde Sands Formation during the enlargement of the Albert Canal.

*Eighteen specimens observed in four private Collections.

Order Anacoraciformes HERMAN & VAN WAES, 2012

The argumentation, based on major odontological criteria, justifying the proposal of this Ordrer was detailed in *Géominpal Belgica* **2**: p.: 63.

Family Galeocerdidae HERMAN & VAN DEN EECKAUT, 2011

The argumentation, based on major odontological criteria, justifying the proposal of this Family was detailed in *Géominpal Belgica* **1**: p.: 51 and precised in *Géominpal Belgica* **2**: p.: 64.

Genus *Galeocerdo* MÜLLER & HENLE, 1837

(Plate 90)

Generalities

This Genus has only one living representative, its generotype: *Galeocerdo cuvieri* PERON & LESUEUR, 1822, its theoretical* direct ancestor is *Galeocerdo aduncus* AGASSIZ, 1843 of Mio-Pliocene age.

*Theoretical, because the only obvious difference between its teeth and the teeth of the living taxon is their size.

Galeocerdo aduncus is already represented by some teeth discovered in the Sands of Edegem Formation* at Rumst (Antwerpen Province, Belgium) and numerous teeth in the Sands of Antwerpen Formation at Wilrijk-Berchem (Antwerpen Province, Belgium).

*Discoveries of the senior-author between 1969 and 1974, all teeth of the *Collection Crochard* in repository in the Collections of the Department of Vertebrate Paleontology of the I.R.S.N.B. (Brussels, Belgium).

In all the Eocene strata of Belgium the Genus is represented by *Galeocerdo acutidens* AGASSIZ, 1843. The abundance of this species reached its maximum during the sedimentation of the Brussels Sands Formation (Lower Lutetian) in which its teeth were collected in all the classic localities of the Brussels Regio, the Flemish Brabant and the Eastern Flanders.

Teeth of *Galeocerdo acutidens* are particularly abundant where* fossil remains of marine chelonian and large teleostean fishes are also very abundant.

*In the lenticular shell concentrations characterised by the abundance of disarticulated valves of *Divaricella brabantica* and *Cymbulostrea cymbula* (both Bivalvia, Mollusca).

Systematics

The odontological argumentation allowing the separation of this Genus from the Family Carcharhinidae JORDAN & EVERMANN, 1896 and its distinction as generotype of the Family Galeocerdidae HERMAN & VAN DEN EECKHAUT, 2010 was largely detailed in *Géominpal Belgica* **1**.

For references: See Bibliography-Chondrichthyes: Herman & Van Den Eeckhaut 2010 and Herman & Van Waes 2012.

A little more than forty fossil species* were proposed for a single tooth or for a lot of teeth discovered in diverse countries of the world. The senior-author had only the possibility to examine the type sets of Dartevelle and Casier as well as diverse Belgian materials.

*For their enumeration, see Cappetta 2006: pp.: 306-307.

G. mayumbensis DARTEVELLE & CASIER, 1943 and *G. praecursor* DARTEVELLE & CASIER, 1959 are two African taxa apparently representing the oldest records of this Genus in the southern Atlantic Ocean.

Distribution

The Genus *Galeocerdo*, or its single living representative, has presently a very large distribution area covering nearly all the latitudes comprised between 40°N and 55°S with three un-colonised areas.

The largest one includes the whole central eastern Pacific*, the southern coasts of Australia, the southern Ecuador to the southern Chilean coasts and the Atlantic African coasts more southern than Congo-Libreville.

***Galeocerdo cuvieri* not being an abyssal inhabitant, it could not colonise this area after the submersion of the tectonic plates of this zone named the Great Pacific Barrier (See Bibliography-Chondrichthyes: Briggs 1961). It did not occupy the three other zones mentioned because sea streams, such as the Benguela Stream, cooled the superficial waters.

If all the fossil species attributed to the Genus *Galeocerdo* are valid, then they occupied much more restricted areas than the single living one.

Galeocerdo aduncus **(AGASSIZ, 1843)**

Agassiz L., 1843: *Galeus aduncus in* Recherches sur les Poissons fossiles. III: p.: 231, pl.26: fig. 24 -28.

Total: 0 teeth
Conclusion: this species is absent.

Considering the temperature of the sea water during the sedimentation of the Sands of Ruisbroek this species had the possibility to be present in these waters, but not a single tooth of this large species has been discovered in this Horizon.

This fact may be a consequence of the very low number of sea-turtles, the low number of large teleostean fishes and the complete absence of sea-mammals, principal sources of nourishment for all the large predators.

Super Order Galeomorphii (*Sensu* HERMAN & VAN WAES, 2012)
(*Pro parte* Order Carcharhininomorphii CAPPETTA, 2006)

In 2006, Cappetta included (See: 397-399) in this Super-Order the two following Orders: the Order Heterodontiformes and the Order Orectolobiformes.

The reasons to separate the most primitive taxa of the Orectolobiformes from the other ones, and the arguments to separate the other recent and fossil taxa from the other *Orectolobiformes* were given and argued in *Géominpal Belgica* 2.

Generalities

Before the senior-author's revision and restructuration of 2012, the Family was an incredible association of very distinct lineages of different elasmobranch groups, now easily distinguishable by the general morphology of the crown of their teeth, the vascularisation of their root and the histology of their teeth.

This Family is represented by three Genera in this Horizon: *Abdounia*, *Physogaleus* and *Carcharhinus*, all represented by a single species.

The Genus *Triaenodon* MÜLLER & HENLE, 1837 was already considered as the genotype of the Family Triaenodonidae HERMAN & VAN DEN EECKHAUT, 2010.

The Genus *Galeocerdo* MÜLLER & HENLE, 1838 was also considered in the same publication as the genotype of the new Family Galeocerdidae HERMAN & VAN DEN EECKHAUT, 2010.

The authors of this publication consider *Corax jaekeli* WOODWARD, 1895 as the type species of the Genus *Eugaleocerdo* and the ancestor* of the Genus *Galeocerdo*.

*See Bibliography-Chondrichthyes: Herman & Van Waes 2012.

Once more, in his 'revised' Handbook, Cappetta ignores or refuses, without any justifications, all these taxa and scientific proposals.

For additional adjustments of this Super-Order: See *Géominpal Belgica* 4

Family Carcharhinidae JORDAN & EVERMANN, 1896

(*sensu* HERMAN & VAN WAES 2012)

Systematics

A first, partial, systematic revision of this Family was proposed by Herman & Van Den Eeckhaut in 2010 and a complementary systematic revision of this Family was proposed in 2012 by Herman & Van Waes.

The different taxa of the Family Galeocerdidae (generotype: Genus *Galeocerdo* MÜLLER & HENLE, 1837) and the different taxa of the Family Triaenodonidae (generotype: Genus *Triaenodon* MÜLLER & HENLE, 1837) were separated from this Family*.

*See Bibliography-Chondrichthyes: Herman & Van Den Eeckhaut 2010 and Herman & Van Waes 2012.

Generalities

In the Belgian Oligocene, this Family was represented by the three following Genera: the extinct Genus *Abdounia* CAPPETTA, 1980 and the two extant Genera: Genus *Physogaleus* CAPPETTA, 1980 and Genus *Carcharhinus* de BLAINVILLE, 1816, each represented by only one species*.

*Considering the weakness of the morphological arguments admitted by the Ichthyologists to distinguish two living taxa, it is impossible to know how many fossil taxa of this Genus have existed.

Genus *Abdounia* CAPPETTA, 1980

Abdounia belselensis MOLLEN, 2007

Mollen F., 2007: *Abdounia belselensis in Geologica Belgica* 10(1-2), p.: 71, pl. 1-2.
(Plate 27)

Abdounia belselensis is the last species known of the Genus *Abdounia*, which was one of the most representative generic taxa of the Eocene faunas of Morocco.

It seems that only seven teeth (those mentioned by Frederik Mollen in 2007) were discovered at Sint Niklaas (S.V.K.) in the conglomerate between the top of the Sands of Ruisbroek and the beginning of the sedimentation of the Boom Clay *sensu stricto*.

Total: 8 teeth.

7 teeth concentrated in a small area of the Northern Sector.
1 tooth was discovered in the Eastern Sector.

Seven of these eight teeth were discovered in a very limited area in the Northern Sector of the clay pit. An important taphonomical detail is that these teeth present very limited size variability.

This fact allows, once more, supposing that they come from one jaw of the same animal. By courtesy of its inventor, the type-set teeth could be re-illustrated on Plate 25.

Genus *Physogaleus* CAPPETTA, 1980

Physogaleus latus (STORMS, 1894)

Storms R., 1894: *Protogaleus latus in Bulletin de la Société belge de Géologie, Paléontologie et Hydrologie*. 8: 78 (p. *M.*), pl. 6: 17.
(Plate 26: figs.: 3 and 4)

Total: 1.227 teeth, with three abnormal concentrations observed in the Southern Sector.

Total in the Northern Sector: 347 teeth.
Total in the South -Eastern Sector: 498 teeth.
Total in the Southern Sector: 382 teeth.

All the fossil teeth attributed to specific taxa of this Genus were discovered in sediments of shallow and warm waters paleoenvironment.

The abundance of teeth of this species is an additional argument demonstrating that the paleotemperature of the period during which the Sands of Ruisbroek sedimented was also that one of warm waters paleoenvironment.

Genus *Carcharhinus* de BLAINVILLE, 1816

(Synonyms : *Aprionodon* and *Hypoprion*)
(Plates 91 to 94)

Generalities

The Genus *Carcharhinus* regroups numerous living specific taxa. As the enumeration of these much controverted living taxa presents no interest for this study, it is purely omitted.

The crown of all the teeth of all the extant and fossil taxa attributed to this Genus have only one obvious common point: their anterior and posterior cutting edges are serrulated.

All the extant taxa of the Genus *Carcharhinus* are principally nectic animals. The diversity of the dignathic heterodonty of their dentitions is extreme. For many zoologists as well as for all the paleontologists it is this odontological diversity which justified, and still justifies, the creation of many of these species.

This observation allows supposing that the diverse populations representative of each of its taxa were, during the Oligocene to the Pliocene, regularly exposed to biospheric environmental problems sufficiently significant to be able to modify, at least, the genetic codification of the morphology of their teeth.

Fossil records have, of course, increased the number of species attributed to the Genus *Carcharhinus*.

But if the paleogeographic distribution of these fossil taxa was re-examined, it would be possible to reconstitute diverse phylogenetic lineages of numerous taxa regrouped in this Genus.

This study cannot be included in this Publication devoted to Belgian Oligocene taxa.

The important taxonomic data is that, after a re-examination of the specific and generic extant taxa of the Family Carcharhinidae (*sensu* Compagno 1984), Dr. Garrick concluded, in 1985, that the two extant Genera: Genus *Aprionodon* GILL, 1862 and Genus *Hypoprion* MÜLLER & HENLE, 1838 were synonyms of the Genus *Carcharhinus*.

Dr. Garrick considered also that all the taxa they regrouped could be integrated in this Genus. This was generally admitted by the paleochondrichthyologists for all their extinct representatives.

Feeding habit

All the extant populations of this Genus being tremendous middle-sized predators, they feed on all the smaller vertebrates they detect in their vicinity.

The morphology of the teeth of their suggested Eocene to Pliocene ancestors being identical, no valuable argument exists necessitating to conceive other types of behaviour.

Distribution

The multiplicity of the specific taxa made the control of all the ancient or recent catching data difficult. But the Genus itself has a worldwide distribution in the equatorial to subtropical zones.

Once more, all the fossil teeth attributed to specific taxa of this Genus were discovered in sediments of shallow and warm waters paleoenvironment, which is the same for all the extant taxa.

For references, see Bibliography-Chondrichthyes: Compagno 1984 and Garrick 1985.

Carcharhinus elongatus (LERICHE, 1910)

Leriche M., 1910: *Sphyrna elongata in Mémoires du Musée royal d'Histoire naturelle de Belgique*. 5: 300-301, pl. 19: 26-30.
(Plate 26, figs.: 1 and 2)

Total: 11 teeth.

Total in the Northern Sector: 3 teeth.
Total in the Southern Sector: 4 teeth.
Total in the South-Eastern Sector: 4 teeth.

The scarcity of teeth of this representative of this extant Genus whose living representatives prefer an open sea is an argument that allows considering that the environment when the Sands of Ruisbroek sedimented looked more like a bay than an open sea.

Super-Order Scyliorhinomorphii HERMAN & VAN WAES 2012

Order Scyliorhiniformes Order rev.

(*Sensu* HERMAN & VAN WAES 2012)

Family Scyliorhinidae GILL, 1862

(*Sensu* HERMAN & VAN WAES 2012)

Genus *Parmaturus* GARMAN, 1906

(Synonym ?: *Pentanchus*)

Systematics

The attribution of this fossil specific taxon to an extant Genus remains temporary, because depending on the conclusions of the future systematic studies of diverse neoichthyologist colleagues.

After the recent investigations of Dr. Séret (M.N.H.N., Paris, France) and his colleague Dr. Last (C.S.I.R.O., Canberra, Australia), the Genus *Parmaturus* regroups nine extant species: *P. pilosus* GARMAN, 1906, its generotype, *P. xaniurus* GILBERT, 1892, *P. melanobranchus* CHAN, 1966, *P. campechensis* SPRINGER, 1979, *P. macmillani* HARDY, 1985, *P. albimarginatus* SERET & LAST, 2007, *P. albipennis* SERET & LAST, 2007, *P. bigus* SERET & LAST, 2007 and *P. lanatus* SERET & LAST, 2007.

The validity of the four last taxa was quickly criticised by other neoichthyologists and still remains without unanimous conclusions.

According to the ICZN, the Genus *Parmaturus* GARMAN, 1906 benefits from the priority rule, because the Genus *Pentanchus* was proposed by SMITH & RADCLIFFE six years later: in 1912.

Only considering the significant extern morphology of the type species of these two taxa, it is very difficult to admit their attribution to the same generic taxon.

Individuals of *Parmaturus pilosus* have a cigar-shaped and massive body*. Individuals of '*Parmaturus*' *xaniurius* have an elongated, spindle-shaped and flat body**, such as the extant *Apristurus* taxa.

The teeth of *Parmaturus pilosus** are narrow, elongated and possess only one pair of lateral cusplets.

*See Herman, Hovestadt & Hovestadt-Euler 1990: plates 26 and 35.

This observation allows suggesting* that the teeth of the *Pentanchus* taxa are wider, shorter and in possession of two, or more, pairs of lateral cusplets.

*Lesson of Comparative Morphology: E.g.: *The general morphology of the teeth of the Equidae (Perissodactyla, Mammalia) suggests elegant animals. The general morphology of the teeth of the Rhinocerotidae (other Perissodactyla, Mammalia) immediately suggests massive animals. Such observation is valid for all the Vertebrates* (Dr. Serge Freschkop, 1969).

These significant odontological differences existing between the dentition of these taxa need to be confirmed, but this is not the aim of this ecological Publication.

Feeding Habit

According to the data of Dr. Cross*, the different species of *Parmaturus*, described before 1988 feed principally on diverse benthic crustaceans, such as members of the Families Galatheidae SAMOUELLE, 1819 and Munopsidae ORTMANN, 1898 (Crustacea, Decapoda), diverse small deep water bony fishes (Teleostei) and small deep water cephalopods (Mollusca, Cephalopoda).

*See Bibliography-Chondrichthyes: Cross 1987, Garman 1906 and Gilbert 1892.

Dr. Stehmann (I.S.H., Hamburg, Germany) and Dr. Séret (M.N.H.N., Paris, France) seem to have made very similar observations.

Distribution

The diverse living populations of the Genus *Parmaturus* are scattered in very restricted parts of the world. They are inhabitants of deep waters to abyssal waters.

Only some specimens of *Parmaturus campechensis* were reported* to have been caught in superficial waters at night.

*Local Mexican fishermen's communication 1977.

For principal references, see Bibliography-Chondrichthyes: Balart, Gonzalez-Garcia & Villavicencio-Garayzar 2000, Compagno 1984, Cross 1988, Garman 1906, Lee 1969 and Séret & Last 2007.

Reconsideration of the taxon *Bythaelurus steurbauti* HOVESTADT & HOVESTADT-EULER, 1995

This species was assigned to the sub-Genus *Bythaelurus*, one of the sub-Genera of the Genus *Halaelurus* GILL, 1866, by Dirk and Maria Hovestadt in 1995.

They considered this sub-Genus as one Genus: Genus *Bythaelurus* nov. Genus, without generic definition. The Genus *Bythaelurus* is, presently considered as non-validated (See I.T.I.S. list).

Reconsidering the dental morphology and the root structure of the few specimens presently known*, it seems

that their attribution to the Genus *Parmaturus* GARMAN, 1906 is more justified than their attribution to the Genus *Halaelurus*.

*This taxon is, presently, known by 12 teeth from the Boom Clay Member and the four teeth at Belsele, SVK Clay Pit 4, here mentioned.

Reflexions concerning the recent distribution and the paleodistribution of the Genus *Parmaturus*

The senior-author should not be surprised if DNA analyses could demonstrate that the different living taxa attributed to the Genus *Parmaturus* and odontologically very difficult to distinguish, had really the same ancestor.

Valid species of the Genus *Parmaturus* must have occupied the central part of the richest food reserve constituted by the shallow warm waters of the Central Pacific Ocean.

Their primitive populations radiated from this central point to reach progressively, on the western side, the Indian coasts, the Red Sea and the South African coasts.

On the eastern side, they progressed along the coasts of disappeared continents and archipelagos and then reached Central America, which means both sides of the Panamanean coasts.

When the Cordillera de los Andes emerged, the Caribbean population of the Genus *Parmaturus* was split into two communities: one Pacific population and one Atlantic population which evolved separately, finishing by representing, at least, two distinct species.

What happened for the different populations of the Genus *Parmaturus* is surely also valid for all the Scyliorhinomorphii.

Parmaturus steurbauti (HOVESTADT & HOVESTADT-EULER, 1995)

Hovestadt D. & Hovestadt-Euler M. 1995: _Bythaelurus steurbauti in Professional Paper_. 278: 268-269, pl.: 9.

(Plates 33 and **34)**

Total: 4 teeth.

North Sector: 2 teeth.
South-Eastern Sector: 1 tooth.
Southern Sector: 1 tooth.

One tooth discovered in the Southern Sector of this *Horizon*, was deeply affected by the action of gastric enzymes, but the three others are perfectly preserved.

This fact demonstrates that this species discovered in the upper part of the Boom Clay Formation already existed in the *Sint Niklaas Phosphorite Bed*. But that the majority of their teeth were dispersed far away from this locality by the *mass selection effect* induced by the lixiviation phase of the upper part of the Sands of Ruisbroek.

The single, strongly chemically damaged tooth came logically from the dejections of an unknown predator.

The three perfectly preserved teeth demonstrate the occasional passage of this species in the Sint Niklaas area. The recent species of this Genus are common in littoral and deeper waters.

The type species of the Genus *Parmaturus* GARMAN, 1906 is *Parmaturus campechiensis* GARMAN, 1906. Its name indicates its provenance and actual distribution area: the Gulf of Mexico, in the Caribbean Sea, where this species is present from the continental slope up to 1.047 metres depth.

The presence of this Genus is another indication of the possible existence of a primitive Gulf Stream at this epoch. The presence in the Ruisbroek Sands Formation of one fossil species of the Genus *Heterodontus*, whose holotype was discovered in the Upper Eocene strata of the Atlantic coast of the U.S.A. and one fossil species of the Genus *Pristiophorus*, whose holotype was discovered in the Bahamas Islands, are two other arguments that reinforce this hypothesis.

9. PISCES - CHONDRICHTHYES – BATOIDEI

Super Order Rajomorphii HERMAN & VAN WAES, 2012

Order Rajiformes BERG, 1940

Family Rajidae de BLAINVILLE, 1816

Genus *Raja* LINNAEUS, 1758

(Plates 100 and **101)**

Generalities

Froese & Pauly considered, in 2005, that the Genus *Raja* was represented, at least, by the 29 extant taxa: *R. ackleyi* GARMAN, 1881, *R. africana* CAPAPE, 1977, *R. asterias* DELAROCHE, 1809, *R. bahamensis* BIGELOW & SCHROEDER, 1965, *R. binoculata* GIRARD, 1855, *R. brachyura* LAFONT, 1873, *R. cervigoni* BIGELOW & SCHROEDER, 1964, *R. chinensis* BASILEWSKY, 1855, *R. clavata* LINNAEUS, 1758, *R. cortezi* McEACHRAN &

MIYAKE, 1988, *R. eglanteria* BOSC, 1800, *R. equatorialis* JORDAN & BOLLMAN, 1890, *R. herwigi* KREFFT, 1965, *R. inornata* JORDAN & GILBERT, 1881, *R. maderensis* LOWE, 1838, *R. microocellata* MONTAGU, 1818, *R. miraletus* LINNAEUS, 1758, *R. montagui* FOWLER, 1910, *R. polystigma* REGAN, 1923, *R. pulchra* LIU, 1932, *R. radula* DELAROCHE, 1809, *R. rhina* JORDAN & GILBERT, 1880, *R. rondeleti* BOUGIS, 1959, *R. rouxi* CAPAPE, 1977, *R. stellulata* JORDAN & GILBERT, 1880, *R. straeleni* POLL, 1951, *R. texana* CHANDLER, 1921, *R. undulata* LACEPEDE, 1802 and *R. velezi* CHIRICHIGNO, 1973.

The number of proposed new species continues to increase regularly. Only DNA analysis would allow guaranteeing which of these species are valid.

The principal odontological criteria of these oviparous animals without dorsal spines are the holaulacorhizid structure of their dental root and the fact that the dental crown completely overlaps the top of their root.

For references and figurations, see Bibliography-Chondrichthyes: Herman, Hovestadt-Euler & Hovestadt 1994, Herman, Hovestadt-Euler & Hovestadt 1995 and Herman, Hovestadt-Euler & Hovestadt 1996.

They have Cretaceous, Paleocene and Eocene ancestors*, but the first species attributable to the Genus *Raja* are of Lower Oligocene age and were discovered in Belgium (Sands of Vliermael, Sands of Ruisbroek, *Sint-Niklaas Phosphorite Bed*, Boom Clay Member) and in Germany (Rupel Ton Formation).

*Such as *D. louisi* CAPPETTA, 1972 from the Thanetian of Niger and *D. harrisae* WARD, 1984 from the Lower Ypresian of Great Britain.

The most interesting fossil taxa are these discovered and described by Dr. Adnet (2005): *Raja marandati* and *Raja michauxi*. These two taxa demonstrate that the nearest ancestors of the Genus *Raja* seem to have been representatives of its sub-genera *Malacoraja* and *Cruriraja*.

They also demonstrate the fundamental paleontological utility of the twenty years'long Series: *Contributions to the study of the comparative morphology of teeth and other relevant ichthyodorulites in living supraspecific taxa of Chondrichthyan* fishes (Dr. M. Stehmann Editor, I.S.F., Hamburg, Germany).

In 1978, the senior-author, knowing only partially the very large odontological morphological variability spectrum of the diverse living species of the Genus *Raja* published* with his young colleague Etienne Steurbaut four Belgian Oligocene taxa: *R. casieri*, *R. cecilae*, *R. heinzelini* and *R. terhaegenensis*. The validity of *R. cecilae* and *R. heinzelini* is uncertain.

*See Bibliography Chondrichthyes: Steurbaut & Herman 1978.

Feeding habit

The majority of the diverse populations of the Genus *Raja* live near the sea bottom and are permanently* active predators of annelids, molluscs, crustaceans and even small bony fishes.

*This means: daily and nightly.

Distribution

Extant species of the Genus *Raja* (*sensu stricto* or subgenus *Raja*) are present in most parts of the world, from tropical to cool waters.

They are typical inhabitants of shallow waters, living preferentially on sandy bottoms. The Genus *Raja (sensu lato**) includes many subgenera inhabiting deep to abyssal waters.

*The senior author considers taxa such as *Cruriraja, Dipturus and Pavoraja* as Genera.

***Raja* sp.**

(Plates 35 and 36)

In this Horizon cohabited, at least, two species of the Genus *Raja*: *Raja casieri* HERMAN & STEURBAUT, 1978 and *Raja heinzelini* HERMAN & STEURBAUT, 1978.

In this publication, these specific names are only utilised to distinguish two odontological morphotypes, but without certitude of the validity of these two taxa. They could have represented two populations of the same species of an active malacophagous species.

Ecologically, the complete absence of the *Raja terhaegenensis* HERMAN & STEURBAUT, 1978 odontological morphotype indicates that strictly benthic and necrophagous populations of the Family Rajidae were absent during the sedimentation of the upper part of the Ruisbroek Sands Formation.

Total: 68 teeth: 42 ***R. cecilae*** and 26 ***R. heinzelini***.

Total in the Northern Sector: 36 teeth (25-11).
Total in the Southern Sector: 18 teeth (13-5).
Total in the South-Eastern Sector: 14 teeth (8-6).

These small teeth were more frequent in the northern part and the eastern parts of the clay pit, and teeth of *Raja cecilae* STEURBAUT & HERMAN, 1978 was obviously more abundant than *Raja heinzelini* STEURBAUT & HERMAN, 1978.

Taxonomic and Systematic remark concerning the Family Dasyatidae JORDAN, 1888 and the Family Pastinachidae nov. Fam.

Family Dasyatidae JORDAN, 1888

According to Rainer and Pauly 2012, this Family regroups the eight extant Genera: *Dasyatis* RAFINESQUE, 1810, *Himantura* MÜLLER & HENLE, 1837, *Makaraja* ROBERTS, 2007, *Neotrygon* CASTELNAU, 1873, *Pastinachus** RÜPPEL, 1829, *Pteroplatytrygon* FOWLER, 1910, *Taeniura* MÜLLER & HENLE, 1837 and *Urogymnus* MÜLLER & HENLE, 1837.

*Some ichthyologists still consider this Genus as synonym of the Genus *Dasyatis* RAFINESQUE, 1810, or more frequently as synonym of the Genus *Hypolophus* RÜPPEL, 1829.

For references, see Bibliography-Chondrichthyes: Herman, Hovestadt-Euler & Hovestadt 1997, Herman, Hovestadt-Euler & Hovestadt 1998 and Last, Manjaji & Yearsley 2005.

Genus *Dasyatis* RAFINESQUE, 1810

(Synonyms: *Amphotistius, Trygon*)

Generalities

The Genus *Dasyatis* regroups, at least, 41 extant specific taxa of controversial validity. The interesting point of its relative diversity is that it reveals the ability of its diverse populations to colonise equatorial to warm temperate shallow waters.

The water temperature was, and remains, more important for the populations of this Genus than for the populations of the Genus *Raja*.

Dasyatis populations appeared earlier than *Raja* populations, but they were never able to colonise cool water environments.

Feeding Habit

Some *Dasyatis* populations feed principally* on callianassid crustaceans, diverse shrimps and bivalves such as *Donax* sp. (Bivalvia, Mollusca), others, occasionally, on Branchiostomidae**, the most primitive extant Chordata, or small teleostean fishes.

*Fide Ebert and Cowley 2003. **Fide Stokes and Holland 1992.

For references, see Bibliography-Chondrichthyes: Blonder & Alevizon 1988, Cartamil, Vaudo, Wetherbee & Holland 2003, Ebert & Cowley 2003 and Stokes & Holland 1992.

Dasyatis cf. rugosa (PROBST, 1877)

Probst J. 1877: *Raja rugosa in Jahreshefte der Gesellschaft für Naturkunde in Württemberg.*33(3): 76, pl.1: figs.: 5, 8, 9)
(Plates: 37 to 40)

Total: 1.307 teeth.
Total in the Northern Sector: 1.038 teeth.
Total in the South-Eastern Sector: 162 teeth.

Total in the Southern Sector: 107 teeth.

The quantity of perfectly preserved discovered teeth, demonstrates that this species was common in the *Sint Niklaas Phosphorite Bed*, and consequently in the upper part of the Formation of the Sands of Ruisbroek.

The strong morphological similarities existing between the teeth of the extant species of the Genus *Dasyatis* Allow to consider more than dubious the validity of the majority of the fossil taxa attributed to this Genus.

Some of their teeth present important anomalies, and may be interpreted as a growing traumatism (See Plates 38 and 39) others may be interpreted as the beginning of a fusion of two dental germinae (See Plate 40).

Some other teeth of *Dasyatis cf. rugosa* were strongly affected by chemical corrosion probably resulting from a relatively long submission to gastric digestive enzymes. This means that a lot of these animals were consumed by larger predators.

Order Myliobatiformes COMPAGNO, 1973

Family Myliobatidae BONAPARTE, 1838

Comments on the Genus *Myliobatis* and the Genus *Weissobatis*

The living Genus *Myliobatis* CUVIER, 1816 is based on the specific taxon *Myliobatis aquila* LINNAEUS, 1758, of which the holotype was theoretically* preserved in R.N.H.M. Leiden (NL) and includes, at least, the eleven additional specific taxa: *M. australis* MCLEAY, 1881, *M. californica* GILL, 1865, *M. chilensis* PHILLIPI, 1893, *M. freminvillei* LE SUEUR, 1824, *M. goodei* GARMAN, 1855 *M. hamlyi* OGILBY, 1911, *M. longirostris* APPLEGATE & FITCH, 1964, *M. peruvianus* GARMAN, 1913, *M. ridens* LUCIFORA, DIAZ de ASTARLOA, MABRAGANA & DELPIANI, 2012, *M. tenuicaudatus* HECTOR, 1877 and *M. tobijei* BLEEKER, 1854.

*Fide: HOLTHUIS, L., B. 1996: Original water colours donated by Cornelius Sittardus to Conrad Gesner, and published by Gesner in his (1558 -1570) works on aquatic animals. *Zoologische Mededelingen*. **70(11)**: 169-196, figs 1-14, pls.: 1-2.

This Genus *Myliobatis* also includes numerous fossil specific taxa of controversial validity. The two following extinct species are mentioned because of their European distribution and the abundance of references concerning the discoveries of dental elements attributed to these taxa.

M. dixoni AGASSIZ, 1843 is the most representative species of the Eocene strata of Great Britain, France, Belgium and Germany and *M. oligocaena* LERICHE, 1910 is the most representative species of the Oligocene strata of Belgium and Germany.

M. plicatilis DAVIS, 1888 from the Oamaru Formation (Oligocene) from Castle Hill (New Zealand) is also known by some isolated dental plates morphologically very similar to these of *M. oligocaena* LERICHE, 1910.

But representatives of this taxon of the southern hemisphere had no possibility to penetrate into the reduced Boom Clay Basin after the Eocene-Oligocene Transition.

The extinct Genus *Weissobatis* is based on two well preserved skeletons*, one of these shows its two complete dental plates. They were discovered in the Oligocene Rupel Ton Formation at Frauenweiler in Baden-Württemberg (Germany).

*Preserved in the Staatliche Museum of Karlsruhe (Baden-Wurttemberg, Germany).

Before this Publication, the extinct Genus *Weissobatis* was supposed to include only one specific taxon: *Weissobatis micklichi* HOVESTADT & EULER-HOVESTADT, 1999.

Genus *Myliobatis* CUVIER, 1816

(Plates 102 and 105: fig.: 2)

Generalities

Recent species of this Genus are benthic and fairly to very common in littoral and more or less deep waters, in equatorial to subtropical waters, particularly on sandy bottoms. All the species possess poisonous caudal spines and large caudal denticules.

Considering the high number of caudal spines observed, deep included in the jaw cartilage of numerous living large Neoselachii predators*, their efficacy seems very relative.

*Such as *Galeocerdo cuvieri* PERON & LE SUEUR, 1822 and *Carcharodon carcharias* LINNAEUS, 1758.

For some references, see Bibliography-Chondrichthyes: Davis 1888, Froese & Pauly 2012, Hovestadt & Euler-Hovestadt 1999, Ruocco, Luciflora, de Astarloa, Madabragana & Delpiani 2012.

Field observations realised in the Belgian Cenozoic levels.

In the Lower to the Upper Eocene, both lower and upper tooth plates of all the fossil species attributed to the Genus *Myliobatis* were relatively flat and were formed by the imbrication of a maximum of 10 central elements. The lateral elements were 3 to 4 times more abundant.

In the Oligocene, the lower and upper tooth plates of all the fossil species attributed to the Genus *Myliobatis* were lightly curved and comprised obviously more than 10 central elements. The proportion of lateral elements seems to remain the same.

During the Miocene and the Pliocene, the lower and upper tooth plates of all the fossil species attributed to the Genus *Myliobatis* were much more curved and were formed by the imbrication of a very high number of central elements.

The number of the imbricated central elements seems to continue to increase. The proportion of lateral elements seems to increase lightly.

Maybe these elementary observations have an additional signification for the evolution of this Order.

But more significant is the fact that all the teeth of all the different living species of the Family Myliobatidae BONAPARTE, 1838 and the Family Rhinopteridae JORDAN & EVERMAN, 1896 have another characteristic in common.

The root of all their teeth is polyaulacorhizid. Their lateral as well as their central dental elements result from the fusion of holaulacorhizid dasyatid-like tooth germinae.

The teeth of the recent and fossil species of the Genera *Burnhamia* CAPPETTA, 1976 and *Rhinoptera* CUVIER, 1829 present a kind of degeneration, which is difficult to explain by a lack of calcium-carbonate in marine waters where nummulite beds or dense shelly lenses are so abundant.

The sudden occurrence of a genetic problem could explain this.

All the odontological data, presently collected, are obviously insufficient to allow a significant revision of the classification of the extant and extinct taxa of the Order Myliobatiformes.

A complete and trustable phylogenetic restructuration of the living taxa of the Order Myliobatiformes is only possible if based on a combination of their mitochondrial DNA structure and the re-examination of their cranial and pectoral skeleton.

Genus *Weissobatis* HOVESTADT & EULER-HOVESTADT, 1999

Hovestadt D. & Euler-Hovestadt M. 1999: *Weissobatis micklichi in Paläontische Zeitschriften*. 73(3-4): 338.
(Plate 103 and Plate 104: fig.: 1)

As they had the chance to dispose of one nearly complete skeleton, Dirk and Maria Hovestadt have described and interpreted* this fossil as thoroughly as possible.

*see Bibliography-Chondrichthyes: Hovestadt & Euler-Hovestadt 1999.

While it is certain that this skeleton presents some important osteological differences with the skeleton of adult living species of the Genus *Myliobatis* CUVIER, 1816, it could represent a specimen of another species than *Myliobatis oligocaena* LERICHE, 1910.

Odontologically, it is very difficult to isolate dental elements of this species in the considerable lot of fossil dental elements preserved in West European musea attributed to *Myliobatis oligocaena* LERICHE, 1910.

In case of doubt, the specific taxon of Leriche benefits from its anteriority.

Examining the lot of *Myliobatis* dental remains discovered in the *Sint Niklaas Phosphorite Bed* and in diverse layers of the Boom Clay Member, it is possible to put forward that approximately sixty-five myliobatid remains may be attributed to juvenile specimens and the others to adult specimens of a myliobatid taxon.

Considering the fact that 38 million years is a time sufficiently long to produce a new generic taxon by a slow but continuous evolution process, the dental remains generally attributed to the extant Genus *Myliobatis* are presently attributed to *Weissobatis oligocaena* (LERICHE, 1910).

Weissobatis micklichi HOVESTADT & EULER-HOVESTADT, 1999 is maybe a synonym of *Weissobatis oligocaena* (LERICHE, 1910).

The diagnostic odontological characteristics of the Genus *Weissobatis* need to be specified. The momentary conclusion is that this Genus is officially represented by two skeletons and three well preserved dental plates.

Weissobatis oligocaena **(LERICHE, 1910)**

Leriche M., 1910: *Myliobatis oligocaena in Mémoires du Musée royal d'Histoire naturelle de Belgique*. 5: 252-254, fig.: 66-69.
(Plate 103 and Plate 104: fig.: 1)

Total: 420 teeth, and 2 caudal spines

Total in the Northern Sector: 224 teeth.
Total in the South-Eastern Sector: 94 teeth.
Total in the Southern Sector: 102 teeth.

The abundance of gastropod and bivalve Mollusca such as the abundance of diverse crustaceans was surely a sufficient feeding source for this species.

10. Pisces - Chondrichthyes - Neoselachii and Batoidei - Inventory

Circa 8.000 teeth and some other elasmobranch remains were discovered in the *Sint Niklaas Phosphorite Bed*.

Species listed by the abundance of their teeth

Odontaspis acutissimus **(AGASSIZ, 1843)**
5.236 teeth.
4 concentrations of teeth (in the Southern sector).

Squatina subserrata **MÜNSTER, 1846**
1.582 teeth,
one part of one neurocranium and 3 vertebrae still connected

Physogaleus latus **(STORMS, 1894)**
1.276 teeth.
3 concentrations (in the Southern sector).

Dasyatis **cf.** ***rugosa*** **(PROBST, 1877)**
1.307 teeth.
Potential concentrations impossible to detect on the field (teeth too small).

Squalus alsaticus **(ANDREAE, 1892)**
624 teeth and
two dorsal spines, one affected by digestive enzymes, the other perfectly preserved

Odontaspis cuspidatus **(AGASSIZ, 1843)**
449 teeth.
including at least 3 abnormal concentrations in the Southern Sector

Weissobatis oligocena **(LERICHE, 1910)**
420 teeth.
3 concentrations of central elements (in the Southern sector).

Rhizoquadrangulus rupeliensis **(LE HON, 1871)**

301 teeth.
2 concentrations: one of 19 teeth and one of 22 teeth (in the Southern sector).

***Notorynchus primigenius* (AGASSIZ, 1843)**
248 teeth.
No commissural tooth, but 34 symphyseal teeth.

***Isurus desori* SISMONDA, 1849**
101 teeth.
25 teeth on *circa* 2m² (in the South-Eastern sector).

Raja sp.
52 teeth.
Potential concentrations were impossible to detect, because the teeth are too small.

***Carcharocles angustidens* (AGASSIZ, 1843)**
18 teeth.
Principally in the South – South-Eastern sectors.

***Alopias latidens* (LERICHE, 1908)**
16 teeth.

***Carcharhinus elongatus* (LERICHE, 1908)**
12 teeth.
No dispersion remark.

***Alopias exigua* (PROBST, 1879)**
8 teeth.

***Abdounia belselensis* MOLLEN, 2008**
7 teeth.
All discovered in the Northern sector.

and
***Heterodontus cf. janefirdae* CASE, 1980**
5 anterior teeth,
All discovered in one very small area (Northern Sector).

***Lethenia vandenbroecki* (WINKLER, 1880)**
3 teeth.
Dispersion without signification.

***Notidanion howelli* (REEDS, 1946)**
4 teeth.

***Bythaelurus steurbauti* (STEURBAUT & HERMAN, 1978)**
3 teeth,
2 in the Northern Sector.

***Cetorhinus parvus* LERICHE, 1908**
2 teeth and 56 *fanonculi*.

***Pristiophorus rupeliensis* STEURBAUT & HERMAN,** 1978
One *neurocranium*, no oral tooth, no rostral tooth.

Geographical distribution of the discovered Neoselachii teeth, and the relativity of their numeric abundance.

With two hundred teeth of *Squalus* completely formed, we may suppose the presence of two animals (functional set and first replacement set included), but two hundred teeth of *Rhinobatos* are not sufficient to suppose the presence of a single animal.

Following the same logic, one skull means the presence of one carcass, and a number of large teeth concentrated on a very small area means a part of a carcass.

The selective dispersion, in function of the mass of the teeth, in the different sectors of the clay pit is another interesting point.

The number of the biggest teeth discovered is obviously higher in the southern part of the clay pit than the number of these discovered in the northern part. The highest number of teeth was, without any doubt, collected in the south-eastern part of the prospected area.

The number of the smallest teeth discovered is obviously higher in the northern part of the prospected area. Parts of carcasses or jaws were discovered principally in the southern area of the clay pit.

The presence of floating and deriving carcasses of elasmobranches in a channel, in a bay, and particularly in a relatively closed bay, may explain the local concentrations of their teeth and of their vertebrae.

Fossils dispersed in a mass of sediments need a particular mode of transport to be re-concentrated in one horizon, therefore the process of a progressive but continuous lixiviation was suggested as principal cause of the formation of the lower part of the *Sint Niklaas Phosphorite Bed*.

11. Possible Evolution trends furnished by the morphology of the egg capsules of the oviparous Chondrichthyes

Generalities

Many extant Chondrichthyes taxa have preserved the most primitive reproduction mode: oviparity. That is the case for all the Holocephali, all the Heterodontomorphii*, all the Scyliorhinomorphii* and all the Rajiformes.

*See Herman & Van Waes 2012: *Géominpal Belgica* 3 and *Géominpal Belgica* 4 to understand the systematic signification of these two taxonomic taxa.

But the morphology of the eggs of these taxa presents a large pattern of variations resulting principally from the time necessary for their maturation.

Holocephali eggs

(Plate 99: fig.: 1)

The eggs of the Holocephali are spindle-shaped, more or less elongated and constituted by an elongated horny capsule fringed by numerous folded marginal extensions that are short and supple.

These marginal extensions seem to increase the oxygenation capacity of the embryo enclosed in the capsule, for these taxa have a very low reproduction ratio because of the long maturation time of their embryos (Personal information: Dr. M. Stehmann, I.S.H., Hamburg, D).

References: see Bibliography-Chondrichthyes: Alarcon, Cubillos & Acuna 2011, Barnett, Earle, Ebert & Cailliet 2009 and Moura, Figueiredo, Bordalo-Machado & Serrano-Gordo 2004.

Heterodontomorphii eggs

(Plate 77)

The eggs of the Heterodontomorphii have a morphology, at least, as surprising as their monognathic heterodontic dentition. Their capsule is relatively voluminous but completely masked by a very large spiral band of soft tissue.

During the mating season* only adult females are seen, laying their eggs in coastal waters, and more juvenile individuals are seen in these zones just after the hatching season.

*Nearly identic for all the southern Australian species: End of Summer to mid-Autumn.

All the extant taxa of *Heterodontus* seem to have a great spatial memory and territory conception. The different extant taxa protect their own territory by eating the eggs of the intrusive species.

Scyliorhinomorphii eggs

(Plate 99: figs.: 4 and 5)

The eggs of the majority of the Scyliorhinomorphii present a very simplified morphology. Their egg capsules have an oblong morphology and possess at their extremities very long terminal filaments allowing a good anchorage on all the branched Hydrocorallia.

Except for the extant taxa of the Genus *Cephaloscyllium* GILL, 1862, the extern surface of the egg capsule of the majority of them*, presents only numerous, more or less distinctive, longitudinal *costulae* and, sometimes, a dense but very short and soft hairy aspect.

*This means: at least the extant taxa of the four following Genera: Genus *Apristurus* GARMAN, 1913, Genus *Galeus* CUVIER, 1816, Genus *Pentanchus* SMITH & RADCLIFFE, 1912 and Genus *Schroederichthys* SMITH, 1838.

The extern surface of the egg capsule of the extant species of the Genus *Cephaloscyllium* presents numerous transversal short but strong folds.

The fact that the egg capsules of the extant species of the Genus *Cephaloscyllium* GILL, 1862 are in possession of transversal and not marginal fringes is an argument that allows suggesting that these Scyliorhinomorphii could be the ancestors of the Rajiformes.

The teeth of the extant taxa of the Genus *Cephalloscyllium* have a very primitive histology and their root presents, such as these of the Rajiformes, a holaulacorhizid root.

For the histology, the morphology of the dental crown and the root vascularision of the teeth of all the Scyliorhinomorphii, see Bibliography-Neoselachii: Herman, Hovestadt & Hovestadt-Euler 1990.

For references concerning Scyliorhinomorphii eggs: see Bibliography-Chondrichthyes: Gomez & De Carvalho 1995 and Iglesias, Du Buit &. & Nakaya 2002.

Rajiformes eggs

(Plate 99: fig.: 2)

Generalities

The eggs of the majority of the extant Rajiformes are smooth and present a quadrate inflatable cushion morphology the four corners of which are prolonged by, more or less, elongated horn-like supple extensions.

Except for the extant species of the Genus *Rajella* STEHMANN, 1970, their periphery, their dark brown to blackish colour and their thickness make them virtually impenetrable to light.

The Genus *Rajella* has for geographical distribution: the Atlantic Ocean, South Africa and the Indian Ocean. This Genus has never been encountered on the eastern side of the Great Pacific Barrier.

The periphery of the eggs of the extant species *Rajella leopardus* (von BONDE & SWART, 1923) presents a marginal fringe similar to this of the Holocephali.

For references concerning Rajiformes eggs, see Bibliography-Chondrichthyes: Ishihara, Treloar, Bor, Senou & Jeong, 2012.

Important records of Batoidei teeth discoveries

In Belgium, the oldest teeth attributable to the Genus *Raja* LINNAEUS, 1758 were discovered in sifting residues of Lower and Middle Oligocene sediments, which means in sediments significantly more recent than the sediments* where teeth of the Genus *Dasyatis* RAFINESQUE, 1810 were collected for the first time.

*Of Lower Eocene age.

Recently Dr. Sylvain Adnet (Montpellier University II, France) has signalized the discovery of some teeth attributable to the Genus *Rajella* in Eocene deep water sediments from south-western France.

For references, see Bibliography-Chondrichthyes: Ishihara, Treloar, Bor, Senou & Jeong 2012 and Whitley 1938.

Importance of some morphological differences in the body constitution of the Chondrichthyes

1. Distance between the two dorsal fins

Even such an apparently insignificant criterion is the indication of a modification of the basal genetic codification.

The modification of this distance implies an increase of the number of the vertebrae or a significant elongation of the vertebrae located between these two fins.

The second possibility seems to have never been observed, but the first one always.

2. Relative position of the insertion of the pectoral fins

A modification of this insertion position implies also a modification of the basal genetic codification of the taxa of the Genus concerned.

3. Lack of dorsal fins

Absence of dorsal fins is the rule for all the extant taxa of the Rajiformes, but occasionally one central dorsal fin has been observed*.

*Personal information from Marie-Henriette Dubuit, (Concarneau, France) and from diverse European, African and Asiatic fishermen.

12. PISCES - TELEOSTEI - CONCLUSIONS

Only the bones of two Orders of Teleostei could be identified: the Order Perciformes and the Order Scorpaeniformes.

Order Perciformes BLEEKER, 1859

Family Gobiidae CUVIER, 1816

Generalities

Members of the Family Gobiidae are inhabitants of coarse sandy and shelly bottoms. The majority of them are benthic animals, but some are burrowing and may edify a very long and complex net of cylindrical tunnels from which the walls are constituted of sand cores hardly cemented.

They may be encountered from coastal zones to depths of 50 metres. They feed on small crustacea and small fishes swimming in the vicinity of the entrance of their burrow.

Symbiotic associations with some caridean decapoda, commonly called shrimps, were frequently mentioned.

Order Scorpaeniformes GREENWOOD, WEITZMAN, ROSEN & MYERS, 1966

Family Scorpaenidae RISSO, 1826

Systematics

This Family was formerly included in the Order Perciformes BLEEKER, 1859, but different anatomical characteristics seem to allow the proposal of this new Order.

This Family is considered by Seposky (2006) and Rainer & Pauly (2012) as the type Family of a distinct Order: The Order Scorpaeniformes, proposed since 1966, by Greenwood, Weitzman, Rosen & Myers.

During the Oligocene, the Family Scorpaenidae, presently including twenty-three extant Genera, was only represented by the ten following Genera: Genus *Ctenopomichtys** WHITLEY, KEMELKIA & MOY-THOMAS, 1940, Genus *Platycephalus* BLOCH, 1795, Genus *Lepidotrigla* GÜNTHER, 1860, Genus *Notesthes* OGILBY, 1903, Genus *Podothecus* GILL, 1861, Genus *Scorpaena* LINNAEUS, 1758, Genus *Agonus* BLOCH &

SCHNEIDER, 1801, Genus *Pontinus* POEY, 1860, Genus *Sebastes* CUVIER, 1829 and Genus *Trigla* LINNAEUS, 1758.

*The Genus *Ctenopomichtys* is a fossil taxon, known from the uppermost Paleocene to the end of the Miocene.

The four, particularly armoured, Genera *Agonus*, *Pontinus*, *Sebastes* and *Trigla* may be considered as world-wide indicators of the beginning of the Oligocene Period.

Greenwood, Weitzman, Rosen and Myers have pointed out that all the taxa of the Order Scorpaeniformes, as recognised here, are clearly related to the Order Perciformes and both members of the Acanthopterygii.

The systematic position of some groups request further investigations. Considering diverse anatomical criteria, the members of the Family Dactylopteridae RAFINESQUE, 1810, commonly called flying gurnards, have been placed by some researchers in the Order Scorpaeniformes.

Generalities

Anatomy

All the members of the Family Scorpaenidae, commonly called spiny-finned fishes, have a solid and, more or less rigid body. Their second infraorbital bone has been fused with their preopercular bone to form a rigid arch.

All their cranial bones present rectilinear cristae and a rough ornamentation (See Plate 46). They possess numerous dorsal fin spines, sometimes connected with venom glands. Additionally, they present a very distinctive type of caudal skeleton.

Distribution

All the populations of the different species of this Family are exclusively marine fishes inhabiting tropical, temperate and cool waters.

For principal references, see Bibliography-Teleostei: Greenwood, Weitzman, Rosen & Myers 1966, Rainer & Pauly 2012, Regan 1913 and Seposky 2006.

Bathymetrical and ecological implications deducible from the presence of some small Teleostei and from the absence of large Teleostei

Teleostei remains

(See Plates: 44 to 53)

The number of fossil teleostean remains is impossible to precise. In the residues of the 80 m³ of sifted sediment from the sole southern sector, more than 20.000 centimetric to millimetric bones and more than 8.000 millimetric teeth were extracted.

The vertebrae were of course the most abundant. The majority of these vertebrae were still in possession of their delicate extremities. Those animals that left these fossils remains are impossible to identify.

The position of diverse bones, ornamented or not, of the skull: parietal, dental, occipital, nasal *etc.* is easy to recognise and some caudal elements such as hypural plates are also easy to recognise but, by lack of precise comparative figurations of these bones, their owners remain of uncertain attribution.

Referring to Osteobase, different skull bones are identifiable such as premaxillary, maxillary, dentary, quadrate, opercular, hyomandibular or neurocranium elements but they are not attributable with certitude to a Genus or a Family*.

*With one exception: some operculars and skull bones of Gobiidae or a related Family.

Considering the morphology of some of these bones, the presence of the Families Acanthuridae, Gobiesocidae, Gobiidae, Labridae, Sciaenidae, Scorpaenidae, Serranidae, Sparidae, Sphyraenidae and Triglidae may be supposed* but not certified.

*Suggestion based on recent comparative materials in possession of the senior-author.

Referring to the remarkable Publication of Monsch 2005, some singularly shaped or ornamented teeth may be assigned to generic taxa.

As for conclusion, some isolated teeth of middle-sized teleostean fishes, such as those classically attributed to the Genera usually called *Cybium*, *Sphyraena*, *Sphyraenodus*,*Trichiurus*, *Trichiurides* and *Labrus* were regularly discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

Despite the quantity of sediment sieved, we never encountered remains of large teleostean fishes, such as those of the Family Xiphiidae, which were relatively common in the uppermost levels of the Belgian Eocene deposits.

Xiphiidae are large, migratory and predator fishes. Their living representatives possess a long and flat rostrum. For the interpretation of their apparent relative abundance in fossiliferous levels, it is important to know that they lose all their teeth at adulthood.

These fishes are common inhabitants of tropical and temperate waters of the Atlantic, Pacific and Indian Oceans, and can be encountered from shallow waters to a depth of more than 500 metres.

For references, see Bibliography-Teleostei: Dawson, Staton & Jacobs 2001, Monod, Hureau & Bullock 1994, Monsch 2005, Osteobase (Internet) 2013, Stillwell & Hohler 1985 and Sun, Wang & Yeh 2002.

Ecological conclusion

These fishes were sufficiently abundant to provide enough food for all the small and medium-sized elasmobranches.

The abundance of the teeth of the Trichiuridae is the occasion to remember that this Family has a Natural History very similar to the Natural History of the Scyliorhiniformes, with a geological interval, because the Teleostei are biologically, more evolved and more recent fishes than the Elasmobranchii.

The Trichiuridae have followed the same orientations and rhythms of double progression, geographically, in the eastern direction and, environmentally in the direction of deeper and deeper waters.

This phenomenon is magisterially demonstrated by their distribution maps carefully drawn by Nakamura and Parin. (See Bibliography-Teleostei: Nakamura & Parin 1993).

This observation confirms the scarcity of large preys, which the biggest marine predators needed for their survival, but also the abundance of food for the smaller predators.

Otoliths

Otoliths in the *Sint Niklaas Phosphorite Bed*

After the intense decalcification phase having affected the *Sint Niklaas Phosphorite Bed*, no otolith was discovered in the sifting residues of this Horizon.

Otoliths in the Boom Clay Member

Based on his own discoveries of otoliths, Etienne Steurbaut already signalised in 1978*, the presence of the 18 following Families of Teleostei: Family Albulidae BLEEKER, 1959, Family Anguillidae RAFINESQUE, 1810, Family Argentinidae BONAPARTE, 1838, Family Lophiidae RAFINESQUE, 1810, Family Merluciidae GILL, 1884 , Family Gadidae RAFINESQUE, 1810, Family Ophidiidae RAFINESQUE, 1810, Family Macrouridae GILBERT & HUBBS, 1916, Family Scorpaenidae RISSO, 1826, Family Triglidae RISSO, 1826, Family Cottidae BONAPARTE, 1832, Family Cyclopteridae BONAPARTE, 1831, Family Serranidae INNAMURA & YABE, 2002, Family Carangidae RAFINESQUE, 1815, Family Sciaenidae**, Family Trichiuridae**, Family Scombridae** and Family Xiphiidae REGAN, 1909.

*See Bibliography-Teleostei: Steurbaut & Herman 1978: p.: 303.

**The specific taxa of these three Families are frequently considered as members of a single Family: the Family Scombridae.

The Family Serranidae is considered by INNAMURA & YABE, 2002 as a Family regrouping the former Families Serraniidae and Moronidae, both mentioned by E. Steurbaut as distinct Families.

Only the members of the two Families Albulidae and Anguillidae may be considered as indicators of brackish or fresh waters.

It is also important to point out that two species: *Argentina parvula* (KOKEN, 1891), with 512 specimens, and *Gadidarum parvus* GAEMERS, 1976, with 1.840 specimens, totalised 2.352 otoliths on the 2.488 discovered.

The extant species of the Genus *Argentina* LINNAEUS, 1758 inhabit coastal bottoms and the continental slope to 450-500 metres depth. They feed on benthic annelids, small molluscs, small crustaceans and sometimes on small pelagic fishes.

The Genus *Gadidarum* is a taxon proposed by Gaemers in 1976 allowing regrouping diverse gadid fossils species supposed to be genetically related with the extant Genus *Gadus* LINNAEUS, 1758.

Despite the huge volumetric prospections realised between 1980 and 1994 by the senior-author and some of his field partners, in the apparently richer levels of the Boom Clay Member, it was not possible to increase the number of taxa of this list.

For principal references, see Bibliography-Teleostei: Menzel 1980, Nolf 1977 and Nolf 2014 (*under press*).

13. REPTILIA – CHELONIA

Order Testudines

Family Chelonidae OPPEL, 1811

Generalities

The living (or extant) taxa of this Family are regrouped into two Subfamilies: Subfamily Carettinae and Subfamily Cheloniinae.

The first one regroups the two Genera: Genus *Caretta* RAFINESQUE, 1814, with only one species: *Caretta caretta* (LINNAEUS, 1758) and the fossil Genus *Lepidochelys* GARMAN, 1880, with two species: *Lepidochelys kempi* GARMAN, 1880 and *Lepidochelys olivacea* GARMAN, 1880.

The second one regroups the three Genera: Genus *Chelonia* BRONGNIART, 1800, with the single species *Chelonia mydas* (LINNAEUS, 1758), the Genus *Eretmochelys* MLYNASKY, 1961 with the single species *Eretmochelys imbricata* (LINNAEUS, 1766) and the Genus *Natator* McCULLOCH, 1908 with also only one species: *Natator depressus* GARMAN, 1880.

The fossil (or extinct) taxa of this Family are represented by the five following Genera: Genus *Argillochelys* LYDEKKER, 1889, Genus *Carolinochelys* HAY, 1923, Genus *Gigantatypus* KADDUMI, 2006, Genus *Procolpochelys* HAY, 1908 and the Genus *Itilochelys* DANILOV, AVERIANOV & YARKOV, 2010.

Calcification of the sea-turle's eggs

Such as all these of the extant reptiles, the majority of the eggs of the extant sea turtles have a supple and flexible envelope*, insufficiently calcified to be rigid.

*This fact explains that the print of some stones could be observed in the envelope of one of these discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

But some of these are rigid. In his Summary, Hirsch wrote in 1983: *The calcareous layer of turtle eggshells, unlike those of any other amniote, is composed of aragonite. While contemporary chelonian eggshells vary from very flexible to rigid.*

All bird's eggs, such as these of their dinosaurian ancestors, have a strongly calcified and rigid envelope.

The unsolved problem remains to explain the oval shape* of the three chelonian eggs discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

*Because the eggs of all the extant sea turtles are nearly spherical.

For references, see Bibliography-Reptilia: Choquenot & Whitehead 1986, Gans, Billett, Maderson & Ewert

1985, Hirsch 1983, Packard, Packard & Broadman 1981, Palmer 1988, Raferty & Reina 2002, Risley 1944, Romer 1959 and Young 1950, Webb.

Remark: Only Hirsch 1983 and Booth 2002 mentions the existence of rigid shelled turtle eggs.

Genus *Caretta* RAFINESQUE, 1814

Distribution

The diverse populations of *Caretta caretta* (LINNAEUS, 1758) can be found in almost all the temperate and subtropical waters of the world.

They are present in the Pacific, Indian, and the Atlantic Ocean as far north as Newfoundland and as far south as Argentina.

Caretta's feeding behaviour

The populations of *Caretta caretta* (LINNAEUS, 1758) are essentially carnivorous marine animals. During the first months after their hatching, they feed on selected sponges (Porifera) and jellyfishes (Hydrozoa) and also on S*argassum* (Family Phaeophyceae, Algae), small gastropods and diverse crustaceans.

Juveniles, sub-adults and adults, feed on diverse gastropods and bivalves (Mollusca), limulids (Xiphosura) as well as other crustaceans. During their long migration they feed on all kinds of swimming or drifting animals. They have powerful jaws that enable them to crush the hard parts of their prey.

Eggs

Extant populations of *Caretta caretta* lay numerous* perfectly spherical eggs in a nest dug in sandy sediment a little higher than the highest tides.

*More than hundred. See Bibliography-Reptilia: Miller, Limpus & Godfrey 2003.

The three eggs discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* are oval-shaped such as varanid, crocodilian or ophidian eggs.

The almost mature embryos (See Plates 55 and 56) is enclosed in an elongated oval-shaped egg; but its chelonian nature is obvious.

It is possible to suppose that the marine turtles have modified the form and increased the number of their eggs after the Eocene-Oligocene-Transition to increase their survival chances significantly.

For references, see Bibliography-Reptilia: Ackerman 1980, Hirth 1980, Mendoca & Ehrart 1982, Owens 1980, Talbert, Stephens, Stancyck & Will 1980 and Uchida 1967.

Cf. Caretta sp.

(See Plates 54 to 56, Plate 59: figs.: 2a-2d and Plate 60: figs.: 3a-3b)

Eighteen complete lower jaws, sixteen complete upper jaws and the mould of three same-sized eggs of an undetermined species of sea-turtle were discovered.

The jaws are very similar to the jaws of the recent marine species *Caretta caretta*, but the attribution to this living species was a doubtful choice, because the more recent compilation* concerning fossil and living species of sea-turtle does not signalize the presence of any member of the Family Carettidae in the European Oligocene strata.

*See Bibliography-Reptilia.

But, the discovery of the mould of three eggs attributable, without any doubt, to one species of a marine Chelonian allows adding some precisions to the generic attribution of the jaw bones discovered in this level.

Eggs of birds are easy to recognise because of their constant ovoidal form (See Plate 114).

Eggs of the different reptilian groups are more difficult to recognise because of their diverse forms.

One of these three eggs shows its content perfectly preserved allowing the examination of the details of various embryonic bones: an important part of the skull, a large part of the hypoplastron, some ribs, the delicate bone assemblages of an anterior member and some ornamented plates of the carapace.

Consequently this egg may surely be attributed to a Chelonia, and possibly to a fossil Carettidae.

The second egg was examined under X-rays and these show the presence of an elongated body with a head and legs similar to the other one.

Consequently this egg may also be attributed to a Reptile, and possibly to a fossil Chelonia.

The shell of the third egg was frozen and cracked during an Ice Time Period, but not eroded, so that it is impossible to detail its content without sawing it. (See *Géominpal Belgica* 5 Part 1: Plate 14: figs.: 5a-5b).

Ecological implications of the presence of these three eggs

Same size, same form, same fossilisation, same patina allow supposing they come from the same nest located at a short distance from a tide level.

The skeleton and the plates of the turtle box visible in the first egg suggest a possible attribution to the Family Carettidae, one of the most common sea turtles of subtropical to warm temperate waters.

This again confirms the suggestion that the Upper part of the Sands of Ruisbroek sedimented in such environment.

CHELONIA

Undetermined remains

Some complete or fragmentary hard plates of the shell box of a sea-turtle were also discovered. Two of them present obvious superficial cutting traces.

Ecological implications of their presence.

These remains allow supposing that another marine chelonian sporadically frequented the area where the Sands of Ruisbroek have sedimented.

14. REPTILIA - CROCODYLIA

The Family Gavialidae CUVIER, 1807 having disappeared after the Lower Lutetian in Belgium, only some very rare osteoderms of Crocodylia were discovered in Belgian Oligocene strata.

Family Crocodylidae CUVIER, 1807

Generalities

The Family Crocodylidae (*sensu stricto*) is represented by the two following extant Genera: *Crocodylus* LAURENTI, 1768 and *Osteolaemus* COPE, 1861.

For references: See Bibliography-Reptilia: Gatesy, Amato, Norell, De Salle & Hayashi 2003, Eaton, Andrew, Thorbjarnson & Amato 2009, McAliley, White, Brochu & Densmore 2006 and Willis, McAliley, Neeley & Densmore 2007.

Genus *Osteolaemus* COPE, 1861

(Plate 109)

Generalities

Extant species of the Genus *Osteolaemus*, called dwarf crocodiles, live in the tropical forests of Central and West Africa. Adult individuals reach a maximum length of 180 centimetres.

Such as their local competitors, the Varanidae, they feed principally on mangrovial decapod crustaceans and sometimes on small vertebrates (fishes, lizards, frogs or mammals).

Fossil records

Diverse *Osteolaemus* populations are present in Belgian deposits from the Lower Eocene to the Lower Pliocene, but their fossils remains are extremely rare.

Only five caudal osteoderms may be attributed to this Genus. These fossils were discovered in the sifting residues of more than 2.000 cubic metres of sediments of two levels.

In 1999, Oaks suggested that the extant Genus *Osteolaemus* regroups at least two species: *O. tetraspis COPE,* 1861 and *O. osborni* (ROSS, 1998), both living in African swamps.

As principal references, see: Bibliography-Reptilia: Eaton, Martin, Thorbjarnarson & Amato 2009, Hulse 1978, Luiselli, Akani & Capizzi 1999 and Oaks 1999.

***Osteolaemus* sp.**

(See Plate 57: figs.: 2a-2b)

Material

Only two elements of the caudal carinae attributable to this Genus were discovered by Eric Wille in sifting residues of the *Sint Niklaas Phosphorite Bed,* in the northern sector of the clay pit.

Ecological implications of their presence.

This Genus is only represented in the recent fauna, by small individuals living in central Africa, in a hot and very humid climatic terrestrial environment, which corresponds to a mangrovial environment.

In an attempt to recreate the lower Oligocene landscape of the Sint Niklaas Regio these discoveries lead to admit the existence of a mangrovial area at some distance of the reconcentration of the fossils extracted from the marine Sands of Ruisbroek.

15. Reptilia – Squamata

Family Varanidae MERREM, 1820

***Varanus* sp.**

(Plate 3: figs.: 1a-1c)

Eight corpuscles of 2.5 to 5 millimetres width, presenting a massive, porous and rounded radicular structure and an enamelled crown-like structure are interpreted as osteoderms of an undetermined varanid Squamata.

Only one tooth may be attributed to an undetermined Helodermidae (Squamata). Its black coloration and its polished aspect made its Sands of Ruisbroek's origin doubtful. This one is not considered as a representative form of the *Sint Niklaas Phosphorite Bed*.

16. Reptilia - Ophidia

No remains of Ophiidae, or of a member of the Family Palaeophidae LYDEKKER, 1888 were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

This observation allows supposing that the last representatives of this Family disappeared from the Belgian territory after the Eocene-Oligocene Transition.

17. Mammalia

Generalities

In the uppermost Ruisbroek Sands Formation and in the *Sint Niklaas Phosphorite Bed*, the Mammalia being only represented by two millimetric teeth of one individual of a Rodentia and by a massive *calcaneum* of a Perissodactyla, only the composition of these two Orders of Mammalia will be examined.

17.1. Rodentia BOWDICH, 1821

Generalities

The Rodentia are classically subdivided into five suborders: the Anomaluromorpha, the Castorimorpha, the Hystricomorpha, the Myomorpha and the Sciuromorpha.

Genetic researches have proposed diverse phylogenetic suggestions, but none of these has received the agreement of all the rodentologists or paleorodentologists.

The most relevant conclusion of these studies is the suggestion that the Rodentia could be polyphyletic and not monophyletic, such as it was generally supposed.

This is not really surprising, because, as for other vertebrate groups, a nutritional mode may have been adopted by diverse distinct lineages.

The top of the crown of the two reworked and polished small mammal teeth discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* presents a sub-horizontal surface of abrasion. This detail is characteristic for all the living or fossil ruminant and rodent mammals.

The size* and the general morphology of these two millimetric teeth immediately orientated the researches of the senior-author in the direction of the Rodentia.

*Delicate argument when knowing the existence of some cow-sized fossil Rodentia.

The Order Rodentia regroups two extant Families: the Family Anomaluridae GERVAIS *in* d'ORBIGNY, 1849 and the Family Pedetidae GRAY, 1825 form the suborder Anomaluromorpha.

The three Families: Castoridae HEMPRITCH, 1820, Geomyidae BONAPARTE, 1845 and the Family Heteromyidae GRAY, 1868 form the suborder Castorimorpha.

The sixteen Families: Diatomyidae MEIN & GINSBURG, 1977, Ctenodactylidae GERVAIS, 1853, Bathyergidae WATERHOUSE, 1841, Hystricidae FISCHER de WALDHEIM, 1817, Petromuridae TULLBERG, 1899, Thryomyidae POCOCK, 1922, Abrocomidae MILLER & GIDLEY, 1918, Caviidae FISCHER von WALDHEIM, 1817, Chinchillidae, BENNETT, 1833, Ctenomyidae LESSON, 1842, Dasyproctidae GRAY, 1825, Cuniculidae MILLER & GIDLEY, 1918, Echinimyidae GRAY, 1825, Erethizontidae BONAPARTE, 1845, Myocastoridae KERR, 1792* and the Family Octodontidae WATERHOUSE, 1839 constitute the suborder Hystricomorpha.

*Not sure, but plausible.

The seven Families: Dipodidae FISCHER von WALDHEIM, 1817, Calomyscidae VORONTSOV & POTAPOVA, 1979, Cricetidae FISCHER von WALDHEIM, 1817, Muridae ILLIGER, 1811, Nesomyidae MAJOR, 1897, Platacanthomyidae ALSTON, 1876 and Spalacidae GRAY, 1821 form the suborder Myomorpha.

The three Families: Aplodontiidae, GRAY, 1825, Gliridae MUIRHEAD *in* BREWSTER, 1819 and Sciuridae FISCHER von WALDHEIM, 1817 represent the suborder Sciuromorpha.

After a long and careful examination of the dentition of the principal generic taxa of the extant Rodentia in repository in diverse National* and Private Collections**, the senior-author considered that the fossil teeth illustrated on Plate 58, present strong affinities with these of the suborder Sciuromorpha and particularly with these of the Family Gliridae MUIRHEAD *in* BREWSTER, 1819.

*Collections of the Recent Vertebrates of the I.R.S.N.B., Brussels, Belgium. **Collection Coupatez (Brussels, Belgium) and Collection Wouters (Brussels, Belgium).

The fossil Rodentia are also represented by more than seventeen extinct Genera. The most spectacular of these is surely the South American Genus *Jopsephoartigasia* MILLIEN, 2008 of the Family Dinomyidae PETERS, 1873, with a weight reaching up to five hundred kilograms.

Data concerning the Family Gliridae MUIRHEAD *in* BREWSTER, 1819

Generalities

The Family Gliridae is subdivided into three Subfamilies: the Glirinae regrouping the two Genera: Genus

Glis BRISSON, 1762 and Genus *Glirulus* THOMAS, 1906, the Graphiurinae represented by the single Genus *Graphiurus* SMUTS, 1832 and the Leithiinae regrouping the seven Genera: Genus *Chaetocauda* WANG, 1985, Genus *Dryomis* CORBET, 1978, Genus *Eliomys* WAGNER, 1840, Genus *Muscardinus* KAUP, 1829, Genus *Miomymus* HOLDEN, 2005, Genus *Selevinia* HOLDEN, 2005 and one extinct Genus: Genus *Hypnomys* BATE, 1919.

In addition to these three extant subfamilies, another Subfamily is included in the Family Gliridae, the Subfamily Bransatoglirinae including two Genera: Genus *Oligodyromys* BAHLO, 1975and Genus *Bransatoglis* HUGUENEY, 1967 both from Oligocene Age.

The Family Gliridae is one of the oldest extant families of the Rodentia. This Family has fossil records from the Lower Eocene.

The Genus *Eogliravus*, from the Lower and Middle Eocene, represents the earliest and most primitive glirid taxon.

Its oldest species, *Eogliravus wildi*, is known from isolated teeth from the Lower Eocene of France and a complete specimen of the beginning of the Middle Eocene of the Messel pit in Germany.

The Gliridae are present in Africa in the upper Miocene and later in Asia. During the Pleistocene, giant Gliridae, such as *Leithia melitensis*, lived on the islands of Malta and Sicily.

For references, see Bibliography-Mammalia: Holden & Levine 2009 and Storch & Seiffert 2007.

Genus *Glis* BRISSON, 1762

The Genus *Glis* is represented by only one extant species: *Glis glis* (LINNAEUS, 1766) and, at least, ten extinct taxa.

Genus *Glamys* VIANEY-LIAUD, 1989

The extinct Genus *Glamys* is represented by the two following extinct taxa: *Glamys fordi* (BOSMAN & de BRUIJN, 1978) from the Eocene of Great Britain and *Glamys umbriae* FREUDENTHAL, 2004 from the Miocene of Spain.

For references, see Bibliography-Mammalia: Adkins, Gelke, Rowe & Honeycutt 2001, Jansa & Weksler 2004, Miller (Jr.) & Gidley 1918, Misonne 1957 and Wilson & Reeder 2005.

Glamys sp.

(Plate 58)

Only two teeth of, apparently, the same individual were discovered in the sorted* residues of the 250 m³ of the *Sint Niklaas Phosphorite Bed* extracted between 2000 and 2004, in the S.V.K. Clay Pit N°4, at Belsele.

*Approximately 80 % of these residues were already sorted in June 2013.

The paleoecological signification of the discovery of these two mammal teeth is maybe not relevant in a marine environment, but demonstrates that some Rodentia inhabited the north-western part of our countries since the Lower Oligocene.

Dr. Mathijs Freudenthal (Madrid University, Spain) said to the senior-author that he thought that these two teeth are teeth of a Theridomorpha, possibly of the Genus *Blainvillimys* GERVAIS, 1848-1852. For more precisions he advised me to contact Dr. Jerry Hooker.

Dr. Jerry Hooker (B.M.N.H., London) said to the senior-author that these two teeth are teeth of a member of the Family Theridomyidae (Mammalia-Rodentia-Theridomorpha) and possibly of the species *Isoptychus margaritae* (VIANEY-LIAUD, 1995) discovered at Hoogbutsel (Limburg Province, Belgium).

Data concerning the Family Theridomyidae ALSTON, 1876

Generalities

This Family regroups the two following extinct Genera: Genus Blainvillomys GERVAIS, 1848-1852 and Genus *Isoptychus* POMEL, 1852.

17.2. Perissodactyla OWEN, 1845

(Plates 110 to 113)

Generalities

This Order is presently represented by the three following Families: the Family Equidae GRAY, 1821, with eight species, the Family Tapiridae GRAY, 1821, with four species and the Family Rhinocerotidae OWEN, 1845 with five species.

The Family Chalicotheriidae GILL, 1872 is one of its extinct taxa from which fossil remains were discovered in Oligo-Miocene strata from the countries surrounding Belgium.

Fossil material

Only one massive and perfectly preserved bone* presenting the characteristics of a calcaneum revealed the presence of one Perissodactyla in a relative vicinity of the SVK Clay Pit 4.

*Discovered by Guy Van Den Eeckhaut in the south-eastern sector.

The approach of the generic determination of its owner required plenty of patience and comparisons but, finally, revealed a very important paleogeographical data.

The senior-author has adopted a very usual classification among the multiple ones proposed.

Sub Order Rhinocerotina

Generalities

The attempts made for the determination of a single calcaneum are scientifically presented but they lack the lyricism of the romanticized history* of the horn of an Indian Rhinoceros passing from the menagerie of King Sebastian of Portugal to the successive collections of a King of Spain, an Emperor of Austria and a Queen of Sweden.

*****Catherine Clément 2010: Dix mille guitares. Editions du Seuil. 474 p. ISBN: 9782020208055. (French edition).

Ecology

These animals may be considered, with the Elephantidae, as the biggest herbivores of the Cenozoic Period. Their size, their mass and their natural dermic protection made of them powerful forms of life. Their principal enemies are their parasites.

The first European artist* to have been fascinated by such a mass of flesh protected by a leather armour was Dürer.

*Dürer’s famous woodcut of circa 1515, preserved in the British Museum.

Except for Australia, their ancestors have colonised nearly all the countries on both sides of the Atlantic Ocean.

For references, see Bibliography-Mammalia: Laurie 1982, Leuberdina & Nazymbetova 2011 and Prothero 2005, Toutgard, Delefosse, Hänni & Montgelard 2001.

Systematics

The senior-author prefers the term Sub Order to the cladistic term Tribe. This sub Order is classically divided into three Families*: the Rhinocerotidae GRAY, 1821, the Elasmotheriidae GRAY, 1821 and the Anthracotheridae GRAY, 1821.

*Other authors still consider these Families as Subfamilies.

After multiple researches, the senior author has composed an alphabetic list of forty-four extinct and extant generic taxa composing the Order Rhinocerotida OWEN, 1848: *Aceratherium* KAUP, 1832, *Acerorhinus* KAUP, 1832, *Alicornops* GINSBURG & GUERIN, 1979, *Aphelops* OWEN, 1845, *Aprotodon* FORSTER-COOPER, 1915, *Brachydiceratherium* LAVOCAT, 1952, *Brachypotherium* ROGER, 1904, *Bugtirhinus* ANTOINE & WELCOMME, 2000, *Caementodon* HEISSIG, 1972, *Chilotherium* RINGSTRÖM, 1924, *Chilotheridium* HOOIJER, 1971, *Coelodonta* BRONN, 1831, *Diceratherium* MARSH, 1871, *Dihoplus* BRANDT, 1878, *Dromoceratherium* CRUSAFONT-VILLALTA & TRUYOLS, 1955, *Elasmotherium* FISCHER, 1808, *Floridaceras* WOOD, 1964, *Gaindatherium* COLBERT, 1934, *Gulfoceras* ALBRIGHT, 1999, *Hoploaceratherium* GINSBURG & HEISSIG, 1989, *Huaqingtherium* HUANG & YAN, 1983, *Iranotherium* RINGSTRÖM, 1924, *Kenyatherium* AGUIRRE & GUERIN, 1974, *Lartetotherium* GINSBURG, 1974, *Meninatherium* ABEL, 1910, *Menoceras* TROXELL, 1921, *Mesaceratherium* HEISSIG, 1969, *Ougandatherium* GUERIN & PICKFORD, 2003, *Paradiceros* HOOIJER, 1968, *Parelasmotherium* DENG, 2007, *Peraceras* COPE, 1880, *Plesiaceratherium* YOUNG, 1936, *Proaceratherium* GINSBURG & HUGUENEY, 1980, *Procoelodonta* MATTHEW, 1931, *Prosantorhinus* HEISSIG, 1974, *Rusingaceros* GERAADS, 2010, *Shennongtherium* HUANG & YAN, 1983, *Sinorhinus* RINGSTRÖM, 1924, *Sinotherium* RINGSTRÖM, 1923, *Stephanorhinus* KRETZOI, 1942, *Subchilotherium* RINGSTRÖM, 1924, *Subhyracodon* BRANDT, 1878, *Teleoceras* HATCHER, 1894 and *Victoriaceros* GERAADS, MCCROSSIN & BENEFIT, 2012.

Feeding habit

All the members of this important Mammalia taxon are exclusively grazers and their teeth present an occlusal surface more or less abraded depending on their age.

All the Perissodactyla present two particular characteristics: they feed exclusively on grasses or young tree-sproutings and displace their impressive mass of flesh on the single extremity of one of their foot bones.

They are, of course, unable to cross an Ocean and their progressive colonisation of the four principal continents America, Europe, Asia and Africa is a continental history.

Having discovered only one calcaneum in the *Sint Niklaas Phosphorite Bed*, it was obvious that this bone must be compared with a maximum of extant and extinct taxa of the four Families constituting the Perissodactyla.

A possible attribution to an extant or extinct member of the Family Equidae GRAY, 1821 was quickly eliminated by the grace of the equid calcanea (See Plate 110: fig.: 1).

A possible attribution to an extant or extinct member of the Family Tapiridae GRAY, 1821 was also quickly eliminated by the important morphological difference with the tapirid calcanea (See Plate 110: fig.: 2).

Only, the massive and compacted aspect of the calcanea of the extant and the extinct members of the Family Rhinocerotidae GRAY, 1821 seem comparable with this bone (See Plate 110: fig.: 3).

Conclusion

This calcaneum may only be a calcaneum of one of the three following Genera: *Aceratherium* KAUP, 1832, *Meninatherium* ABEL, 1910, from the Upper Oligocene of Asia and *Subhyracodon* BRANDT, 1878, from the Early Oligocene from the USA.

The country of discovery (Belgium, Europe) and the geological age (Lower Oligocene) of this calcaneum allow only one reasonable possibility: this calcaneum was a bone of an individual of an *Aceratherium* sp. population and consequently a member of the Family Rhinocerotidae GRAY, 1821.

The presence of Perissodactyla and Rodentia confirm the existence of large emerged areas in the vicinity of Sint Niklaas and the isolation* of the Oligocene North Sea Basin from the Central Asia Seas and the Indo-Pacific Oceans.

*Isolation existing in fact since the Upper Eocene, if not the Upper Cretaceous marked by the upheaval of the Mount Lebanon.

The scarcity of land vertebrate remains is normal in a marine environment.

Family Rhinocerotidae GRAY, 1821

Genetic reflexion

The Family Rhinocerotidae, still extant, is represented by numerous fossil taxa from which the oldest known were discovered in Oligocene strata from Kazakstan (Russia), the Czech Republic, Germany and France.

For a paleoichthyologist it is really difficult to believe that such a diversity of generic taxa could appear in less than forty million years. This is not the central interest of this publication.

Which is more significant is the fact that the genetic code of the terrestrial mammals, being representatives of the most evolved animal taxa, is also the most complex, and consequently, the more sensitive to sudden variations of the content of radioactive particles in the biosphere.

The hypothesis of the variation of the content of radioactive particles in the biosphere, already evoked for diverse other vertebrate lineages, could eventually explain the successive renewals of their diversity.

Considering the generally admitted geological distribution of these forty-four extinct Genera, only three of these last ones lived at the period of the sedimentation of the upper part of the Ruisbroek Sands Formation or during the formation of the *Sint Niklaas Phosphorite Bed*: the Genus *Gaindatherium* COLBERT, 1934, a member of the Rhinocerotini, the Genus *Subhyracodon BRANDT*, 1878, a member of the Diceratheriini and the Genus *Aceratherium* KAUP, 1832, a member of the Aceratheriinae.

Data concerning the Genus *Gaindatherium* COLBERT, 1934

The extinct Genus *Gaindatherium* is represented by only one taxon: *G. browni* COLBERT, 1934. Remains of *G. browni* COLBERT, 1934 were only discovered in the Lower Siwaliks Formation of India, which seems to be younger* than the Oligocene.

*See: Gautam, P. & Fujiwara, Y. 2000: Magnetic polarity stratigraphy of Siwalik Group sediments of Karnali River Section in western Nepal. *Geophysical Journal International*. **142(3)**: 812-824.

Data concerning the Genus *Subhyracodon* BRANDT, 1878

The extinct Genus *Subhyracodon* is represented by three validated taxa: *S. kewi* (COPE, 1880), *S. mitis* COPE, 1874 and *S. occidentalis* LEIDY, 1854.

Remains of *S. occidentalis* LEIDY, 1854 were discovered in the USA: in the Eocene of the Wyoming and in the Oligocene of Colorado, Mississipi, North Dakota, South Dakota and Wyoming, but never in Europe.

Remains of *S. mitis* COPE, 1874 were only discovered in North America and remains of *S. kewi* (COPE, 1880) were also only discovered in North America.

Considering the fact that Rhinocerotidae could not cross the North Atlantic Ocean, these observations exclude the possibility to attribute this *calcaneum* to a representative of the Genus *Subhyracodon*.

Data concerning the Genus *Aceratherium* KAUP, 1832

This Genus was represented by *A. acutum* MARSH, 1887 from the U.S.A., *A. incisivum* KAUP, 1832 from Europe and Russia and *A. porpani* DENG, HANTA & JINTASAKUL, 2013 from the Miocene of Thailand.

The Genus *Aceratherium* was an Afro-Asiatic Genus of the Aceratheriidae having existed from the Oligocene to the Pliocene, which represents a little more than thirty million years.

Last, but not least, this calcaneum shows also some morphological similarities with the calcaneum of *Brachyodus** *onoides* from the Burdigalian (Miocene) of the Helvetic Conferedation and from the Miocene of Savigny-sur Lathan (Indre-et-Loire Department, France).

*The Genus *Brachyodus* DEPERET, 1825 is a Genus of the Family Seligeriaceae (Bryophyta, Plantae) and its mammalian taxa are presently considered as members of the Genus *Sihongotherium* HUANG & YAN, 1983.

Taxonomic remark

One vegetal Genus *Brachyodus* (Family Seligeraceae) was proposed for one species of Bryophyta (mosses). It seems that the mammal Genus proposed by Depéret had priority by its older definition, but the confusion sometimes persists.

Ultimate doubt

A fourth possibility* was that this *calcaneum* could make part of the skeleton of a specific taxon of the Genus *Chalicotherium* KAUP, 1833 of the Family Chalicotheridae GILL,1872, another member of the Perissodactyla, relatively abundant in the Miocene of France and Germany and recently discovered in the Miocene deposits of the Breda Formation (The Netherlands).

*Suggestion of Noud Peters (Oertijd Museum, Boxtell, NL).

Data concerning the Genus *Chalicotherium* KAUP, 1833

Generalities

The extinct Genus *Chalicotherium* is only* represented by its type species: *Chalicotherium grande* (LARTET, 1851) discovered in Middle Miocene strata of the Basin of the Loire River (France).

**Chalicotherium wetzleri* (KOWALEWSKY, 1873) represents maybe a second species of this Genus.

Some remains of this species were recently discovered at Mill-Langeboom (Brabant Province) in the Breda Formation (Middle Miocene of the Netherlands).

For references, see Bibliography-Mammalia: Ginsburg 2001 and Noud 2013.

Paleodistribution

The Genus *Chalicotherium* seems to have had a distribution area covering a part of the French territory, the Netherlands territory and the German territory.

Conclusion

The continental mass called Eurasia existing before the Oligocene, the *calcaneum* discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* may only be attributed to an unknown European ancestor of the Genus *Aceratherium* KAUP, 1832.

Special Acknowledgements

M. Georges Lenglet, head of the Recent Vertebrates Department of the I.R.S.N.B. (Brussels, Belgium) gave the senior-author and his co-authors the possibility to examine and to take photographs of calcanea of diverse extant Perissodactyla*: N°: 13071: *Equus caballus** LINNAEUS, 1758, N°: 1184: *Tapirus indicus* (DESMARET, 1819), N°: 1304: *Cerathotherium simum* (BURCHELL, 1817), and N°: 1204: *Dicerorhinus sumatrensis* (FISCHER, 1814). See Plates 110 and 111.

*Or *Equus ferus subsp. caballus* for purists.

M. Loïc Costeur, conservator of the Basel Natürhistorisch Museum, sent the senior-author photographs of the calcaneum of *Chalicotherium grande (*LARTET, 1851) from the Miocene of Slovenia. (See Plate 113).

Absent Mammalia

It is very important to realise that all the marine Mammalia taxa seem to have been completely absent in the Lower Belgian marine Oligocene*.

*The Belgian Chattian Sands have also never furnished a single bone or a single tooth of marine Mammalia.

It is only in the Upper part of the Boom Clay Formation that Sirenian remains were discovered.

Sirenia

Sirenian mammals seem to have been absent in the Sands of Ruisbroek Formation and in the *Sint Niklaas Phosphorite Horizon Bed.*

Cetacea: Odontoceta and Mysticeta

A very important paleobiological observation is that, if Mysticeta remains were never discovered in sediments of the beginning of the Belgian marine Oligocene, the first mysticetes cetacean appeared at the end of the Eocene (See Bibliography-Mammalia: Sanders & Barnes 2002).

That means that during the Eocene-Oligocene Transition, huge *nectic* mammals such as the Mysticeta were also affected by similar genetic problems as some alopiiform elasmobranches and that they were simultaneously confronted with the same geophysical event.

Another interesting point is that the living mysticeti only have teeth during their embryonic phase. Teeth of Mysticeta are real teeth and are not comparable with the elasmobranches *teeth* which have an epidermical origin.

In fact, practically, all the different groups of living organisms: nectic marines (such as Fishes), avian vertebrates (Aves) or land vertebrates (Reptilia and Mammalia) and Plantae seem to have been confronted with the same climatic change but also with a particular geophysical event. (See Bibliography: Prothero, Ivany & Nesbitt 2003).

18. AVES

PROTOAVES

Order Odontopterygiformes HOWARD, 1957

Family Pelargonithidae FÜRBRINGER, 1888

The members of the fossil Family Pelargonithidae were large pelecanid-like birds characterised by the possession of large irregular, triangular and flat tooth-like bony formations on the very thin *tomia* of their long beaks.

Their oldest representatives are of Paleocene age and their more recent ones from Miocene* age.

*The Belgian Pliocene bones attributed to this Family have been reworked from Miocene or from Oligocene deposits.

For references: See Bibliography-Aves: Mayr 2009 and Mlikovsky 1996.

Genus *Odontopteryx* OWEN, 1873

***cf. Odondopteryx* sp.**

(See Plate 60: figs.: 1 and 2)

This species is known by two fragments of dental bone (Collection Eric Wille), one fragment of dental bone (Collection Gino Mariën) and two long bones (Collection Guy Van Den Eeckhaut).

Ecological signification of their presence

The senior-author and one of his field friends have also discovered some fragments of dental bones in the Belgian lower Lutetian (Herman & Van Den Eeckhaut, 2011) and in the Belgian lower Ypresian at Egem – Egemkapelle – Ampe Clay pit (unpublished material, Collection G. Van Den Eeckhaut), as well as one complete humerus, also at Egem – Egemkapelle – Ampe Clay pit (unpublished material, Collection G. Van Den Eeckhaut). The five fossil remains of *Odontopteryx* here mentioned seem to be the oldest discovered in Belgium.

On the base of the rare discovered bones in different epochs and parts of the world, these large primitive sea birds, are supposed to look like pelicans. Diverse authors suggested that their normal food consisted of little sea fishes.

Their scarce and fragmentary fossils confirm that their population was just an occasional supplement for the feeding of the largest elasmobranches of this Horizon. The different classifications proposed are always based on different fragments of different bones.

Consequently the systematic of these primitive birds is of the more controverted.

AVES - NEORNITHES

Except for extremely rare bones of Pelargonithidae, bird fossil remains were never discovered in the Ruisbroek Sands Formation nor in the *Sint Niklaas Phosphorite Bed*.

19.The scarcity of the Chondrichthyan taxa discovered in the *Sint Niklaas Phosphorite Bed*

A definite account of the species of Chondrichthyes discovered in all our residues of the *Sint Niklaas Phosphorite Bed* amounts to only 21 species: 16 Neoselachii, 4 Batoïds and 1 Holocephali.
This fauna is the poorest one of the Belgian Caenozoic.

This scarcity seems to be a logical consequence of the important decrease of the general temperature, after the maximum temperature was reached at the end of the Eocene in the European countries.

In the Boom Clay Member, the Chondrichthyan fauna increases to 27 species: 18 Neoselachii, 7 Batoïds and 2 Holocephali.

But, more relevant is the fact that, in the Formation of the Sands of Ruisbroek, in the *Sint Niklaas Phosphorite Bed* and in the Boom Clay Formation, the number of large-sized elasmobranches remains incredibly low.

The explanation the senior- author proposes is a combination of the complete absence of large preys such as sea turtles, sea mammals and the scarcity of large teleostean fishes.

This scarcity of large Chondrichthyes species is more significant if we consider that the constant faunal composition of all the upper levels of the Boom Clay gives: at least 90% of teeth of the species *Squalus alsaticus*, 9% of teeth of diverse little species of the Genus *Raja* and 1% of any other species.

20. Absence of some taxa of Chondrichthyes and climatological signification

We never discovered in our residues teeth of Elasmobranchii of the Order Orectolobiformes and of the largest part of the Genera of the Order Scyliorhiniformes, nor any teeth of many Families and Genera of Batoidei typical for warm waters.

The diverse Genera of diverse Families of the Order Orectolobiformes, such as *Nebrius* RÜPPEL, 1837, *Eostegostoma* HERMAN, 1977, *Paraginglymostoma* HERMAN, 1982, *Protoginglymostoma* HERMAN, 1977, *Hemiscyllium* MÜLLER & HENLE, 1838, *Orectoloboides* CAPPETTA, 1977 and Pararhincodon (HERMAN) *in* CAPPETTA & CASE, 1975, frequently present, or very abundant in the Belgian Eocene levels are not represented by a single tooth in the Sands of Ruisbroek and the *Sint Niklaas Phosphorite Bed*.

All the species of the evoked Genera of the Order Orectolobiformes inhabit or inhabited equatorial, tropical and subtropical waters. Their absence seems to prove that the temperature of these waters was surely lower than these of our uppermost Eocene marine waters.

The same observation is also valid for the Family Halaeluridae HERMAN & VAN WAES, 2012, represented in the *Sint Niklaas Phosphorite Bed* by only one species of the former subgenus *Bythaelurus* COMPAGNO, 1988.

A possible and logical explanation for these two observations is that the mass-selection occurring during the lixiviation phase has, maybe, concentrated the smallest teeth on other areas we never had the possibility to prospect.

The absence of the following genera of Batoïdei, so abundant in the Belgian Upper Eocene layers, such as: *Pristis* LINCK, 1790, *Rhinobatos* LINCK, 1790, *Smithraja* HERMAN, 1986, *Coupatezia* CAPPETTA, 1982 and Jacqhermania CAPPETTA, 1982 in the *Sint Niklaas Phosphorite Bed* and in the upper part of the Boom Clay Formation confirms this ecological conclusion.

In Belgium, after the Eocene, the first presence of batoid teeth of the Family Rajidae BONAPARTE, 1831 is observed in the *Sint Niklaas Phosphorite Bed*, and during the beginning of the sedimentation of the upper part of the Boom Clay, but never in the lowest part of the Boom Clay Formation *sensu stricto*.

In Belgium, after the Eocene, the first teeth of the Family Dasyatidae BONAPARTE, 1831 are observed in the *Sint Niklaas Phosphorite Bed*, and during the beginning of the sedimentation of the upper part of the Boom Clay, but never in the relatively brackish sediments of the lowest part of the Boom Clay Formation *sensu stricto*.

The abundance of species of the Family Dasyatidae JORDAN, 1888 starts a little later, and is demonstrated by the very high frequency of their teeth in the Miocene and Pliocene Belgian sediments.

21. Singularities of the teeth of some Elasmobranchii taxa

The few teeth of *Carcharocles angustidens*, discovered in this Horizon, are very similar in size and morphology to those discovered in the Belgian Uppermost Eocene (Zemst, Flemish Brabant), or those discovered in the upper part of the Boom Clay Formation (Oligocene).

All these teeth show the same degree of absorption of the lateral *cusplets* by the main cusp. The strength of their *serrulation*, on both sides, of their principal cusp is also the same. It seems that their morphological and their volumetric evolution were suddenly and temporarily interrupted.

One explanation for such phenomenon may be proposed. At this period these animals, occupying the top of the pyramid of the biggest predators, were unable to find enough food to pursue their normal evolution, i.e. to increase their size.

22. Scarcity of sea-turtles remains and absence of sea-mammal remains

Despite the volume of sediment washed, we cannot mention the presence of any relevant bone of the skeleton of sea-turtles. Among others Luc Anthonis, Frederik Mollen and Eric Wille have discovered some lower jaws, not perfectly preserved, of different small individuals and some fragments of the carapace of rare individuals. The majority of these fossil remains seem to have been more or less affected by digestive enzymes.

The conclusion is that two of the principal sources of food for huge predators such as *Carcharocles angustidens* and *Isurus desori* or *Galeocerdo aduncus* were lacking.

23. The Vertebrate Fauna of the Boom Clay. Elasmobranchii.

With the very sporadic presence of the last discovered species *Plinthicus kruibekensis* BOR, T., J., 1990, of the Genus *Plinthicus* COPE, 1869 (Family Mobulidae GILL, 1893), the Chondrichthan fauna of the Boom Clay remains very poor.

As previously mentioned, the number of Chondrichthyes species increased from 19 species to 27 (or 28, if a second species of Holocephali was present) species.

The different levels re-explored after 1978, presented a constant dominant frequency of *Squalus alsaticus*, but their frequency decreased from 90-91% (Herman J. and Hovestadt observations) in the lower calcareous silty levels of the Boom Clay to only 75-56% in the upper levels (J. Herman and D. & M. Hovestadt observations, confirmed by the T. Bor samplings).

Teeth or bones of crocodilian reptiles or bones of the primitive pseudo-toothed birds (Odontopterygiidae – Protoaves) were never discovered in the Boom Clay Formation *sensu stricto*, but some remains of marine Chelonia, marine mammals, land-mammals and modern birds were.

24. Other Vertebrata groups affected during the Eocene-Oligocene Transition

At least 17 generic extinctions and 20 first appearances of land mammals presented also significant changes in their composition around the Eocene- Oligocene boundary in Western Europe (Diverse pieces of information collected by the senior-author). For more details, see Bibliography: Prothero, Ivany & & Nesbitt 2003).

Birds were also seriously affected during this Eocene-Oligocene Transition (See Bibliography-Aves: Mayer 2009 and Mayer Peters & Rietschel 2002).

At the Eocene-Oligocene Transition, some nectic alopiiform Elasmobranches were affected by such strong genetic modifications that their anatomy modified these middle-sized aggressive predators into huge drifting animals with micro teeth and a branchial filter feeding mode.

At the same moment, some nectic cetacean Mammalia were also affected by such strong modifications of their gene pool that the anatomy of these large carnivorous predators was transformed into that of huge drifting toothless animals with a branchial filter feeding mode.

Young Mysticeta only possess true teeth during their embryonic stage (See Bibliography-Mammalia: Sanders & Barnes 2002).

Some of the last odontological convictions of Dr. Casier were that the Genus *Rhinobatos* was the direct ancestor of the Genus *Pristis*, that the Family Ganopristidae such as the Family Pristiophoridae may also have a Rhinobatidae as ancestor, and that the Family Dasyatidae was the direct ancestor of the Order Myliobatiformes.

25. Formation of the Elasmobranchii tooth serrulation, one hypothesis

If we refer to the Heisenberg's Indetermination Principle: *Nothing is really continuous and all the molecules are constantly mobile*, then the consequence is: *It is not possible to precise simultaneously the localisation and the form of one corpus.*

A continuous line is a pure geometrical conception. The size and the complexity of the molecules of all the mineralogical, vegetal or animal forms compose an illusionary line.

Consequently, the apparent continuity of the cutting edges of the crown of one elasmobranch tooth (even if functional) is limited by the size of its molecular compounds.

This fact is controllable by S.E.M. photographs of very high resolutions. This apparent continuous line is in fact imperceptibly undulated.

This undulation can, however, be detected by people having a high developed sense of touch, by passing, slowly, the border of one of their nails from the lower part of the cutting edges of teeth of *Otodus obliquus* or *Cosmopolitodus hastalis* to the top of their crown.

This fact results from the size of the very complex apatite molecules: $_{10}(PO_4)_{6-x}(CO_3)_xF_y(H_2O)$ constituting these cutting edges. In this formula the numbers $_x$ and $_y$ may vary considerably.

To allow a regular growth of the teeth, each part constituting these cutting edges requests a continuous supply of pure apatite.

This continuous supply of the compounds of the enamel is assured by microscopic *canaliculi* originating from the central pulp cavity of the tooth.

If the number of *canaliculi* decreases, so that only one *canaliculus* remains where two *canaliculi* existed before, a strong traction is produced between the extremities of the remaining elements of the front lines.

To avoid splits of the enamel line, it is physically necessary to reduce the gaps between the marginal (or border) elements, which produces a discrete serrulation.

The more repetitive this phenomenon occurs, the larger and more visible the serrulation *cristae* are. The first time this incident occurs it produces the discrete serrulation of the cutting edges of the dental crown of species such as: *Pseudocorax affinis*, *Carcharocles subserratus*, *Cosmopolitodus escheri*, *Prionace glauca* etc.

The cause of the reduction of the original number of *canaliculi* may result from a lack of one of the different compounds of the very complex apatite molecules, resulting from environmental conditions.

It may also result from the perturbation of the genetic codification of the enamel production of a part of the diverse populations constituting one species.

This phenomenon was also observed at Hiroshima and Nagasaki by American and Japanese human dentition experts.

One rectification

According to the ICS list, the subgenus and the Genus *Bythaelurus* are not valid. Consequently *Bythaelurus steurbauti* HOVESTADT & HOVESTADT-EULER, 1995 is renamed *Parmaturus steurbauti* (HOVESTADT & HOVESTADT-EULER, 1995).

26. General conclusions concerning the Vertebrata

Marine Vertebrata

All the Vertebrata discovered *in situ* in the uppermost part of the Ruisbroek Sands Formation, in the different agglutinated masses constituting the *Sint Niklaas Phosphorite Bed* and in the massive *Pycnododonte callifera* bank present sufficient data to consider their sedimentological paleoenvironment as this of a shallow coastal to tidal subtropical modern environment.

The taxa of Vertebrata not represented by fossil remains in the sifting residues of these three paleoenvironments are absent because of the lack of feeding resources.

Eocene survival taxa, as well as absent taxa, confirm the deep ecological importance of the Eocene-Oligocene Transition in the western European countries.

Continental Vertebrata

Extremely rare fossils remains of Crocodylia, Rodentia, Perissodactyla and Protoaves remind us that terrestrial and mangrovial environments have existed at a certain distance of the sedimentation place of the upper part othe Ruisbroek Sands. All these remains are also typical fossils of equatorial to subtropical environments.

27. Ultimate reflections

The aim of these reflections is an attempt to answer frequently asked questions by some of the senior-author's friends.

1. Capacity to survive in hostile environments or Extremophyly

In all the extant populations of multicellular organisms there always exists a percentage of individuals which are more resistant against some forms of extern aggressions such as a sudden increase of the PH, a sudden decrease of the luminosity, a sudden decrease or increase of the temperature, a variation of salinity and other factors.

If a population of one species is, or was, suddenly isolated from the others, its individuals possessing this exceptional resistance will survive and progressively increase their rare capacity to resist against these hostile environmental conditions.

Some individuals will die, but a lot of them will permanently continue to enhance their performances and become what scientists presently call extremophyles.

What is true for unicellular marine organisms is also true for diverse multicellular organisms: from Algae to Fishes.

Once engaged, these processes seem to be irreversible. As far as known Paleontology has no examples to propose of any re-adaptation to previous conditions.

The secret of the extraordinary resistance of some animal groups* against radioactivity is supposed to be a chemical substance they could possess in their carapace.

*E.g.: The Scorpionida, the Arachnida and the extant Xiphosurida.

If this substance has never been identified it may be due to the fact that these animals only produce this substance when it is absolutely necessary.

It is quite sure that the production of such a biochemical substance requests the use of important quantities of diverse heavy elements (such as: iridium, selenium, zinc, lead and gold), and vital compounds permanently present in their body.

But it is possible that this production is only initiated after the perception of the first signs of the instability of the earth magnetic field that they perceive more quickly than all other marine or terrestrial invertebrates

The Xiphosurida, being oceanic animals, eventually have the possibility to extract quickly from oceanic waters some additional heavy elements, but Arachnida and Scorpionida being terrestrial animals it is impossible for these to extract additional elements or compounds in their environments.

Scientists have identified and experimented on diverse vertebrates with various organic compounds as radioactivity protectors.

Indraline seems to be the most efficient one, but indraline was never discovered in any organs of a Xiphosurida, a Scorpionida or an Arachnida.

As principal references, see Bibliography: Extremophyly: Weiss & Landauer 2003 and Bibliography: Indraline.

2. Evolution of the composition of the athmosphere

This long and complex geochemical phenomenon concerns principally the increasing of the quantitity of oxygene present in the terrestrial athmosphere which make possible the colonization of the continents by all the interdepending vegetal and animal forms of life.

The best summary concerning this very long history is detailed in the 2006 Publication of Mm Ward, Labandeira, Laurin & Berner

As principal reference, see Bibliography: Extremophyly: Ward, Labandeira, Laurin & Berner 2006.

3. Biodiversity of the fauna of the hot vents

The fauna of the hot vents presents a biodiversity nearly as large as this of the extant fauna of the marine shallow waters. The hot vent fauna includes species of all the major taxa already existing in the Early Paleozoic Period.

Bacteria, unicellular Algae, all the Phylla of marine Invertebrata, Holocephali, Neoselachii* and Teleostei taxa are common inhabitants of these acid and aphotic environments.

*Their first representatives were discovered in 2007: some Scyliorhinomorphii of the Genus *Parmaturus*.

This reality allows supposing that the primitive Oceans presented similar conditions of life.

Main reference: Desbruyères, D., Sigonzac, M. & Bright, M. 2009: Handbook of deep-sea Hydrothermal Vent Fauna.

3. Estimation of the longevity of one Chondrichthyes species

Four Genera will illustrate the difficulty to estimate this longevity: *Chlamydoselachus* GARMAN, 1884, *Heterodontus* de BLAINVILLE, 1816, *Ptychodus* AGASSIZ, 1843 and *Carcharocles* JORDAN & HANNIBAL, 1923.

In the North Sea Basin*, the first one seems to have its first representatives since the Lower Miocene, which represents 18 million years of existence.

*Including the Norvegian continental shelf.

The second Genus is represented by five succeeding species from the Cenomanian to the Upper Eocene, which means 50 million years, or 10 million years for each species.

The third one is represented by ten species from the Upper Aptian to the Lower Campanian, which means 30 million years for six species, or 5 million years for each species.

And the last one by three species from the Lower Ypresian to the end of the Oligocene, which means 30 million years for three species, or 10 million years for each species.

The conclusion is that the geological longevity of one chondrichthyan species may easily vary, at least, from 5 to 18 million years.

Of course, this approach remains very relative and depends on the choice of the fossil specific taxa for this estimation, but an attempt is always better than no attempt at all.

4. Biodiversity of the fauna of the hot vents

The fauna of the hot vents presents a biodiversity nearly as large as this of the extant fauna of the marine shallow waters. The hot vent fauna includes species of all the major taxa already existing in the Early Paleozoic Period.

Bacteria, unicellular Algae, all the Phylla of marine Invertebrata, Holocephali, Neoselachii* and Teleostei taxa are common inhabitants of these acid and aphotic environments.

*Their first representatives were discovered in 2007: some Scyliorhinomorphii of the Genus *Parmaturus*.

This reality allows supposing that the primitive Oceans presented similar conditions of life.

Reference: Desbruyères, D., Sigonzac, M. & Bright, M. 2009: Handbook of deep-sea Hydrothermal Vent Fauna.

28. Plates 1 to 60:

Plates presenting the fossils discovered in the *Sint Niklaas Phosphorite Bed* and their survivals in the Boom Clay Member

General information

All the Plates are accompanied by a short legend.

Each Plate has also its own comments,
presented in the Chapter: Comments to the Plates.

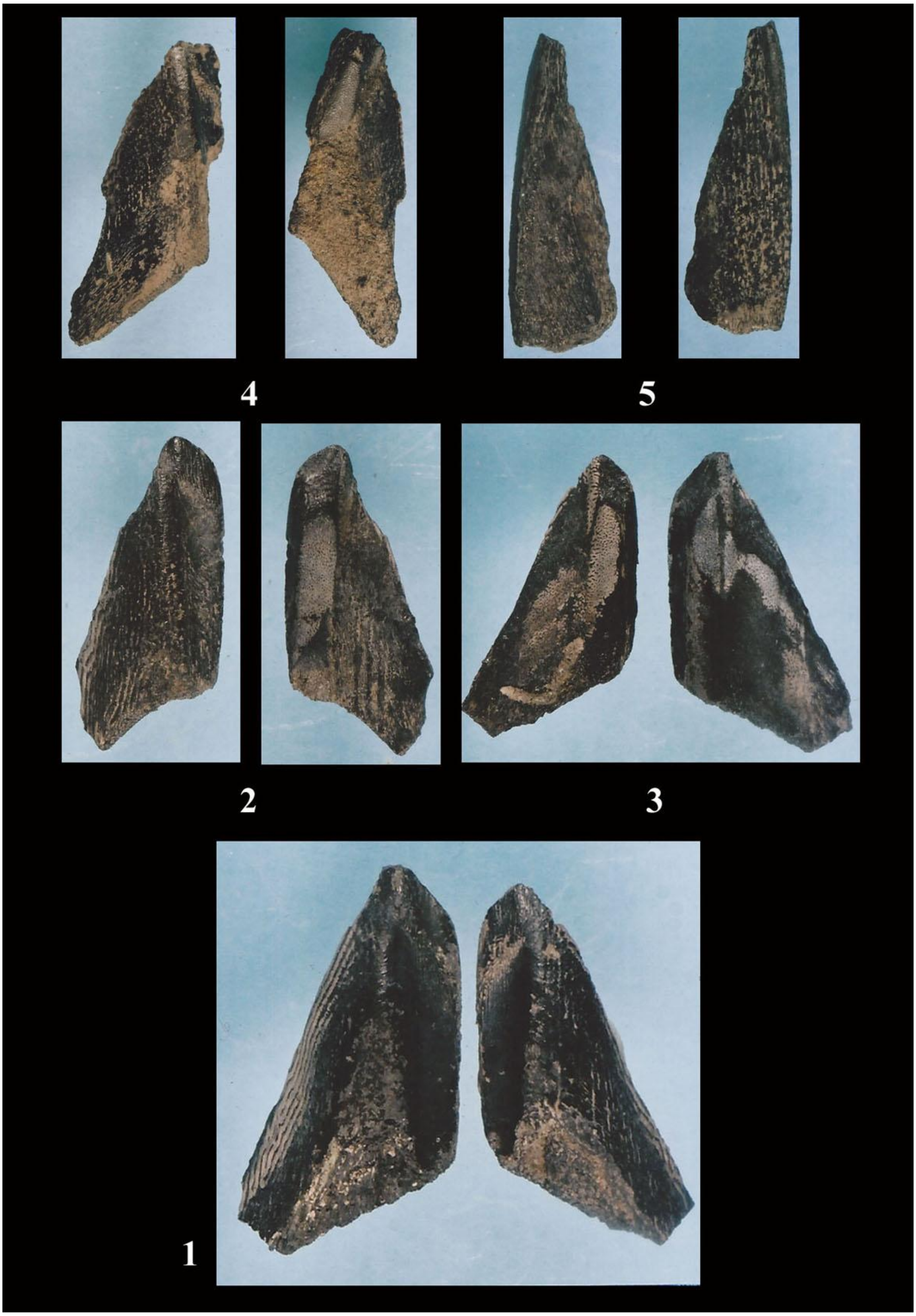

Plate 1: BELSELE: S.V.K. Clay Pit 4: BGS Archives N°: 42 W 394

Fossils from the *Sint Niklaas Phosphorite Bed*

Pisces - Chondrichthyes - Holocephali - Family Rhinochimaeridae GARMAN, **1901**.

Dental plates of the **Genus *Amylodon* STORMS, 1894**: ***Amylodon delheidi* STORMS, 1894**.

1 to **4**: Views of palatines plate. **5**: Views of a fragment of a mandibular plate. Sizes given in the comments.

Private Collections. Photographs Jacques Herman. See comments.

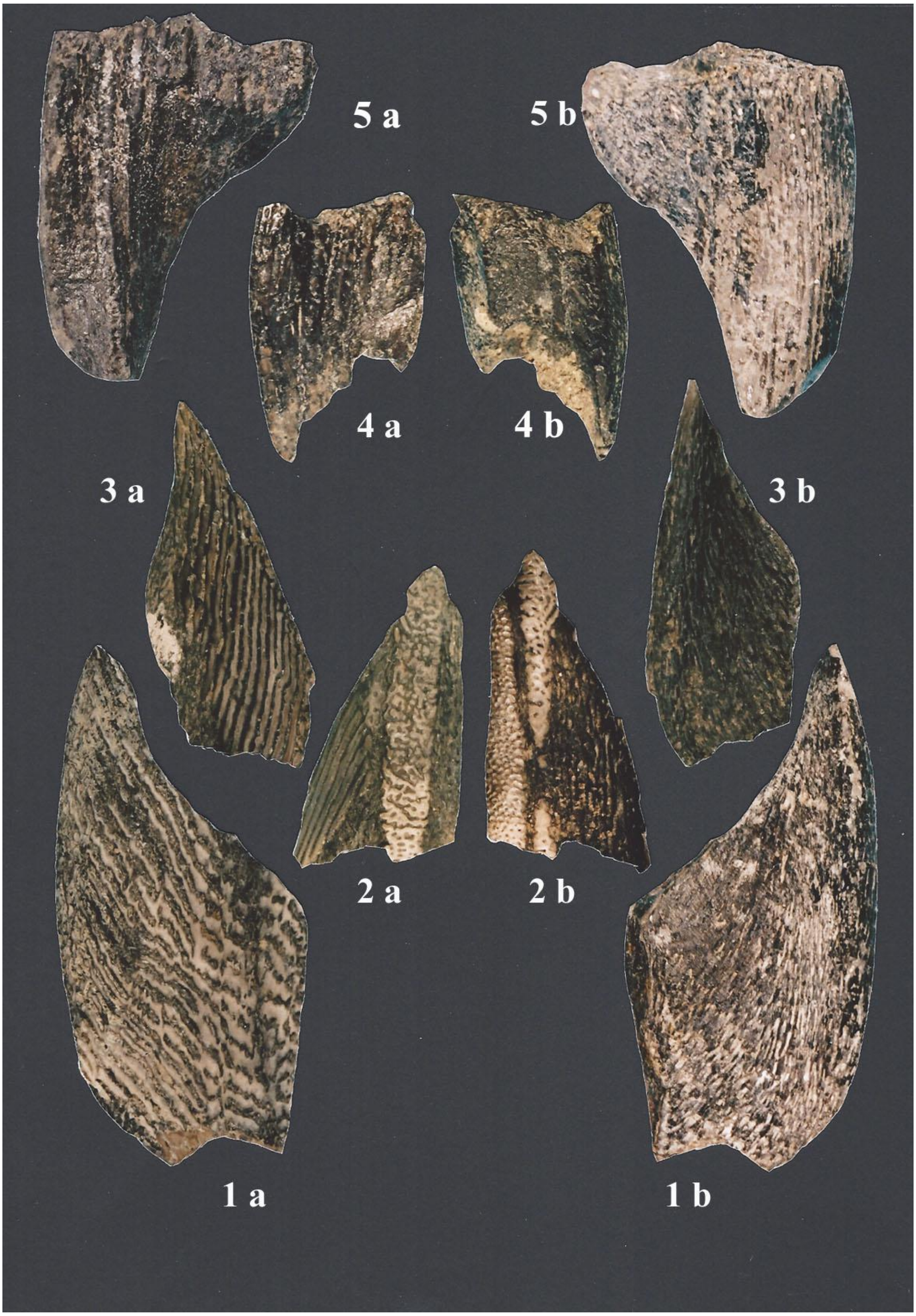

Plate 2: BELSELE: S.V.K. Clay Pit 4: BGS Archives N°: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Holocephali - Family Rhinochimaeridae Garman, 1901:
Dental plates of the **Genus *Amylodon* Storms, 1894**: ***Amylodon delheidi* Storms, 1894**.
1a-1b: Views of a left mandibular plate. **2a-2b**: Views of a left palatine plate. **3a-3b**: Views of a fragment of a right mandibular plate. ***Amylodon* sp.** undetermined pieces. **4a-4b**: juvenile specimen. **5a-5b**: adult specimen. Private Collections. Photographs Guy Van Den Eeckhaut. See comments.

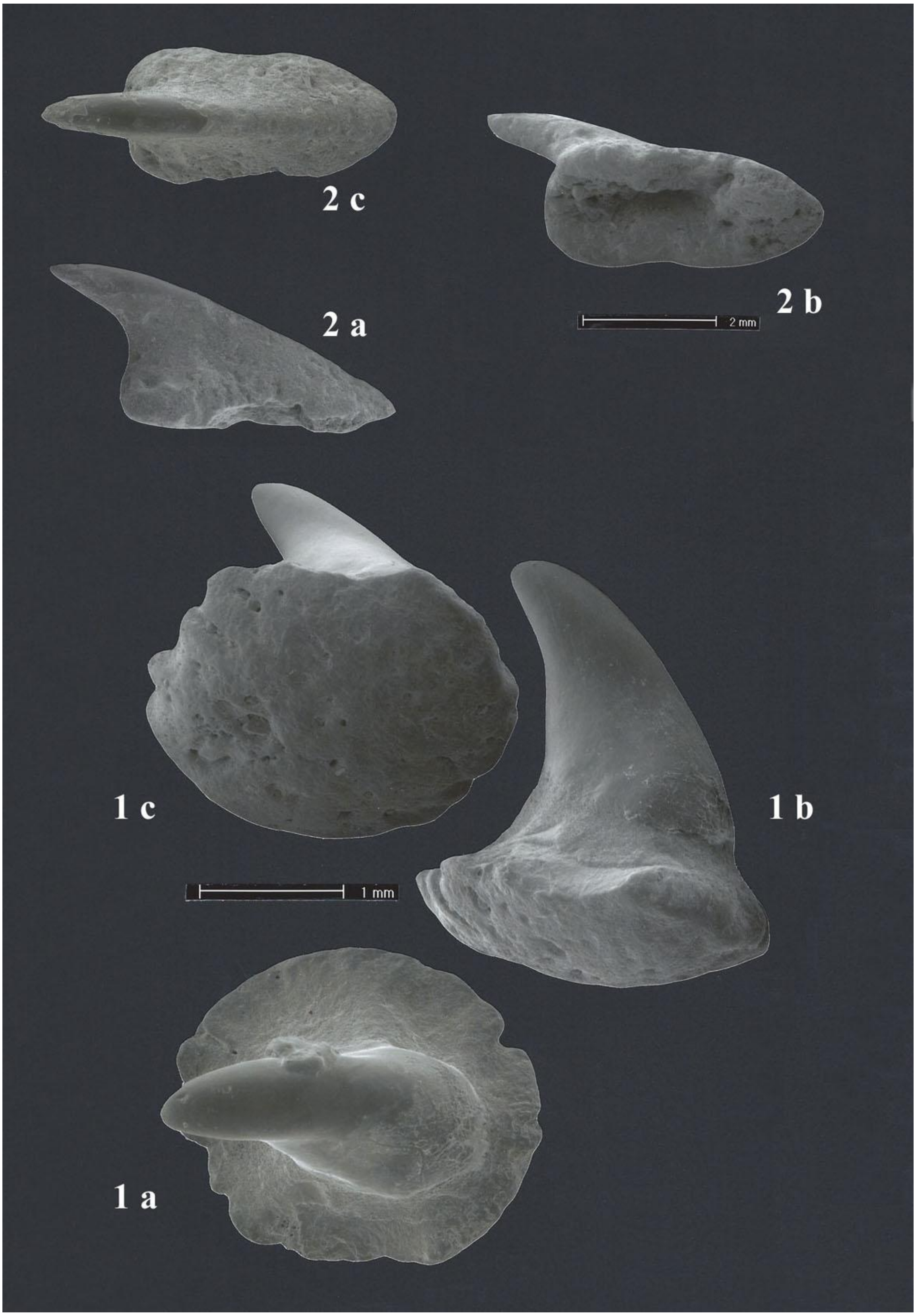

Plate 3: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 513

Fossils from the *Sint Niklaas Phosphorite Bed*

Reptilia - Squamata: **Family Varanidae** MERREM, **1820**:

1a-1c: Different views of a fossil interpreted as dermal denticle of ***Varanus* sp.**

Pisces - Chondrichthyes - Holocephali: **Family Rhinochimaeridae**: ***Cf.* Genus *Amylodon*** **STORMS, 1894**.

2a-2c: Different views of two fossils interpreted as tenaculum elements of *Amylodon delheidi* STORMS, 1894.

Private Collection. S.E.M. photographs Julien Cillis I.R.S.N.B. (Brussels, Belgium).

See comments.

Plate 4: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives N°: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii - Family Heptranchidae BARNARD, 1925:
Genus *Notidanion* JORDAN, 1923: *Notidanion howelli* REED, 1946.
1a: View of the upper wall of the burrow of a gobiid teleostean on which a superior tooth of a *Notidanion howelli* partially adheres. **1b**: Magnification of this tooth.
Private Collection. Photographs Eric Vanderhoeft. See comments.


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Plate 5: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives N°: 42 W 394, 434 and 494
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1-8, **11** and **12: Family Hexanchidae RAFINESQUE**, **1810**: **Genus *Notorynchus* AYRES**, **1855**:
***Notorynchus primigenius* AGASSIZ**, **1843. 9** and **10: Family Heptranchidae BARNARD**, **1925:**
Genus *Notidanion* JORDAN, **1923:** ***Notidanion howelli* REED**, **1946.**
Private Collections. Photographs Guy Van Den Eeckhaut. See comments.

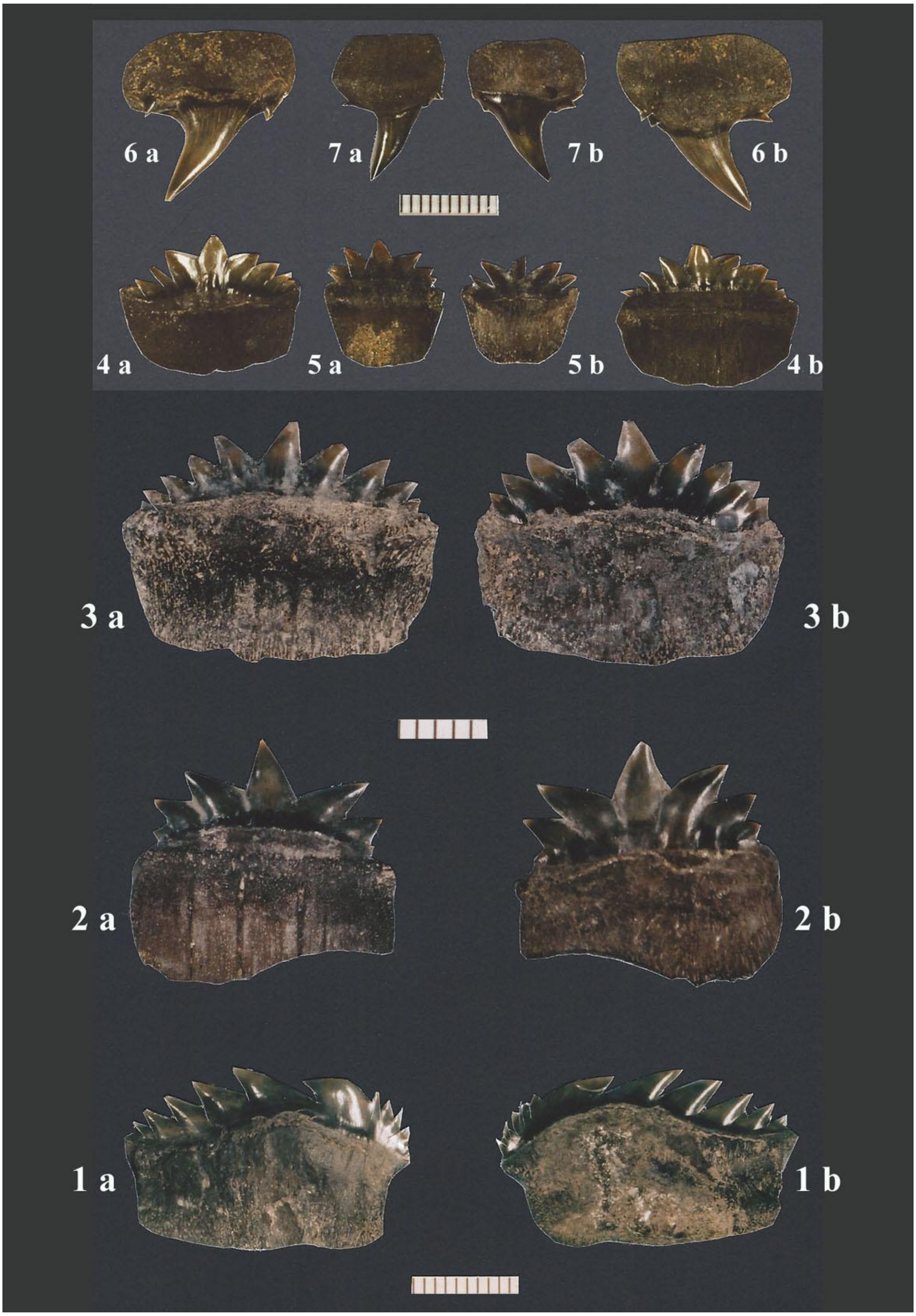


Plate 6: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives N°: 42 W 394 and 434
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1-7: **Family Hexanchidae RAFINESQUE, 1810**: **Genus *Notorynchus* AYRES, 1855**:
***Notorynchus primigenius* AGASSIZ, 1843**.
Private Collections. Photographs Guy Van Den Eeckhaut. See comments.

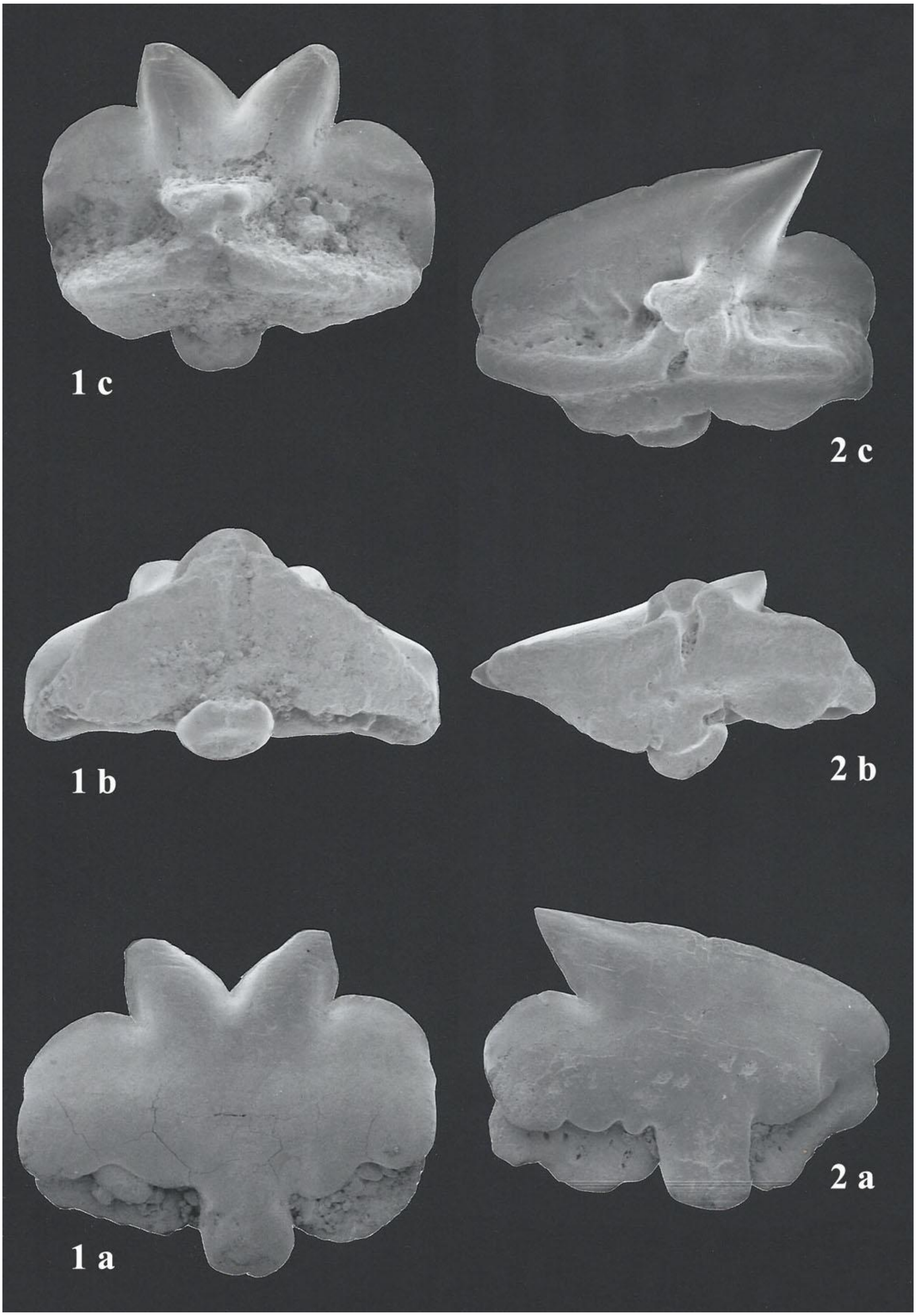


Plate 7: BELSELE: S.V.K. Clay Pit 4: BGS Archives N°: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1a-2d: **Family Squalidae BONAPARTE, 1834**: **Genus *Squalus* LINNAEUS, 1758**.
1a to **1c**: Pseudosymphyseal tooth and **2a** to **2c**: anterior tooth of ***Squalus alsaticus*** **(ANDREAE, 1892)**.
Private Collections. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

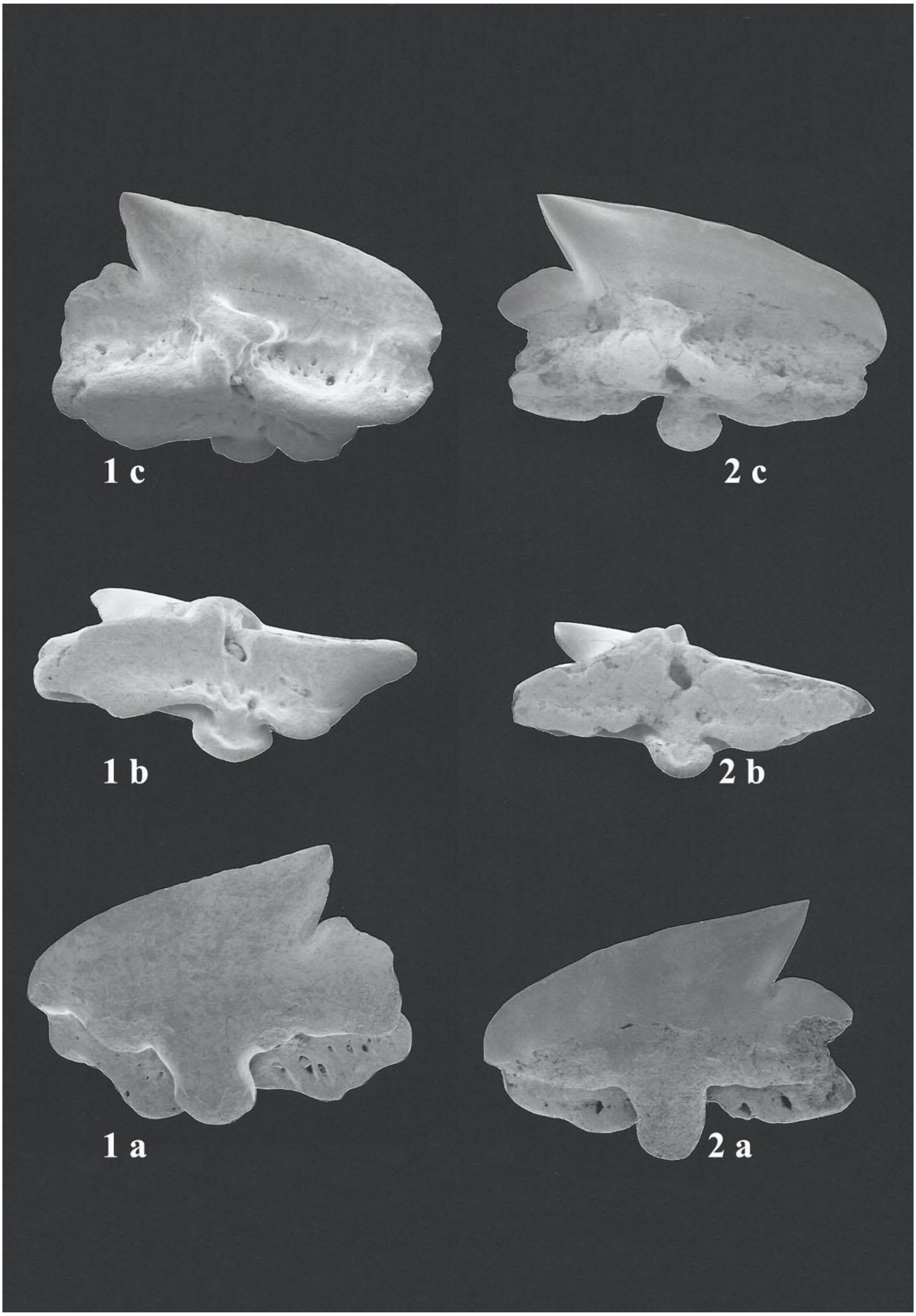
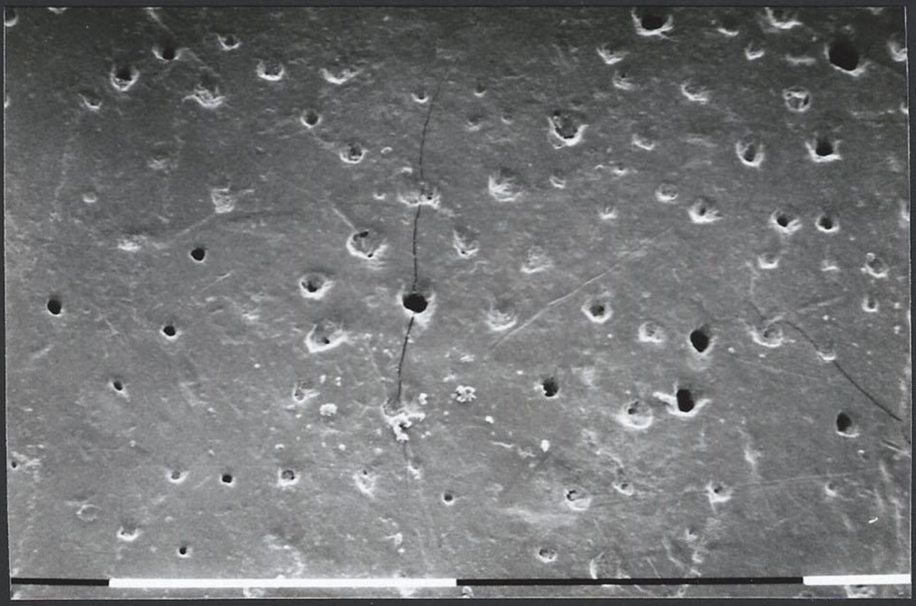
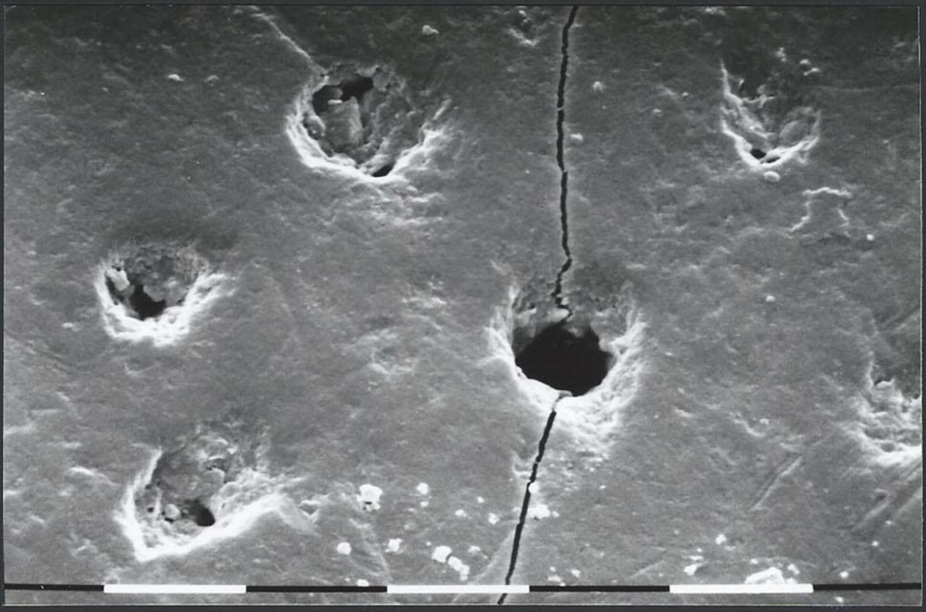


Plate 8: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 434
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1a to **2c**: **Family Squalidae BONAPARTE, 1834**: **Genus *Squalus* LINNAEUS, 1758**.
Three views of two anterior teeth of ***Squalus alsaticus*** **(ANDREAE, 1892)**. See comments.
Private Collections. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).



1 b



1 a

Plate 9: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 434
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1a-1b: Family Squalidae BONAPARTE, 1834: **Genus *Squalus* LINNAEUS, 1758**.
Damaged tooth-crown of a ***Squalus alsaticus*** **(ANDREAE, 1892)**. See comments.
Private Collections. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).

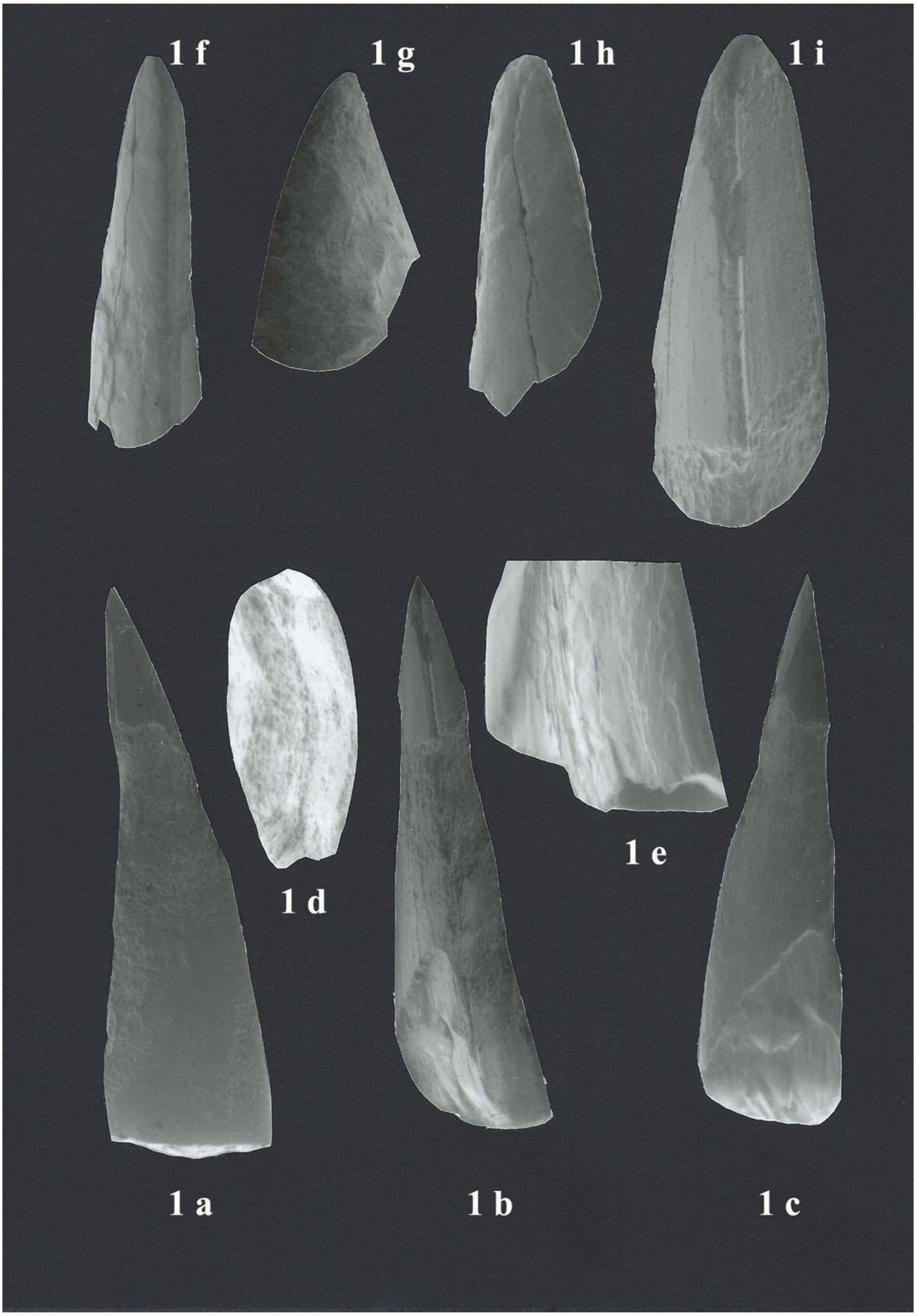


Plate 10: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 513
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1a to **1i**: **Family Squalidae BONAPARTE, 1834**: **Genus *Squalus* LINNAEUS, 1758**.
Different views of two dorsal fin spines of ***Squalus alsaticus* (ANDREAE, 1892)**. See comments.
Private Collections. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).

Plate 11: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives N°: 42 W 513
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Family Pristiophoridae BLEEKER, 1859:
1a-1b: Dorsal and ventral views of a part of the *neurocranium* of one specimen of the
Genus ***Pristiophorus* MÜLLER & HENLE, 1837**: ***Pristiophorus rupeliensis* HERMAN & STEURBAUT, 1974**,
discovered by Pieter De Schutter (Aalst, Belgium) in the Eastern Sector of the Clay Pit.
Photographs Guy Van Den Eeckhaut. See comments.

Plate 12: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Family Pristiophoridae BLEEKER, 1859:
1a-1b: Two rear views of a part of the same *neurocranium* of one specimen of the
Genus ***Pristiophorus*** **MÜLLER & HENLE, 1837**: ***Pristiophorus rupeliensis*** **HERMAN & STEURBAUT, 1978**
discovered by Pieter De Schutter (Aalst, Belgium) in the Eastern Sector of the Clay Pit.
Photographs Guy Van Den Eeckhaut. See comments.

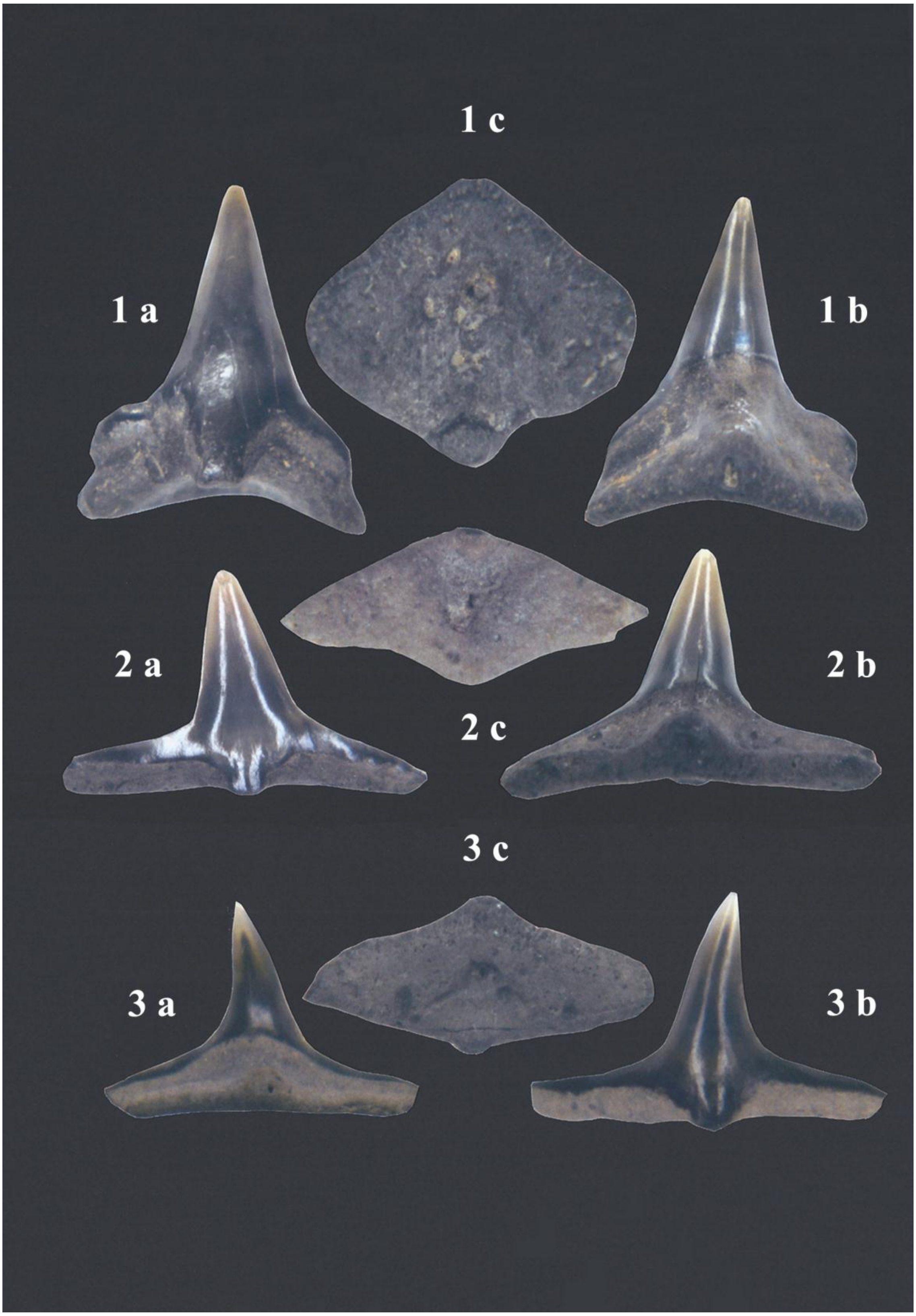


Plate 13: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii
1a to **3c**: **Family Squatinidae BONAPARTE, 1838**: **Genus *Squatina* DUMERIL, 1806**:
***Squatina subserrata* MÜNSTER**, 1846: Intern, radicular and extern views of three teeth.
1a to **1c**: Lower anterior tooth. **2a** to **2c**: Lower lateral tooth. **3a** to **3c**: Upper lateral tooth.
Pieter De Schutter Collection. Photographs Pieter De Schutter.
See comments.

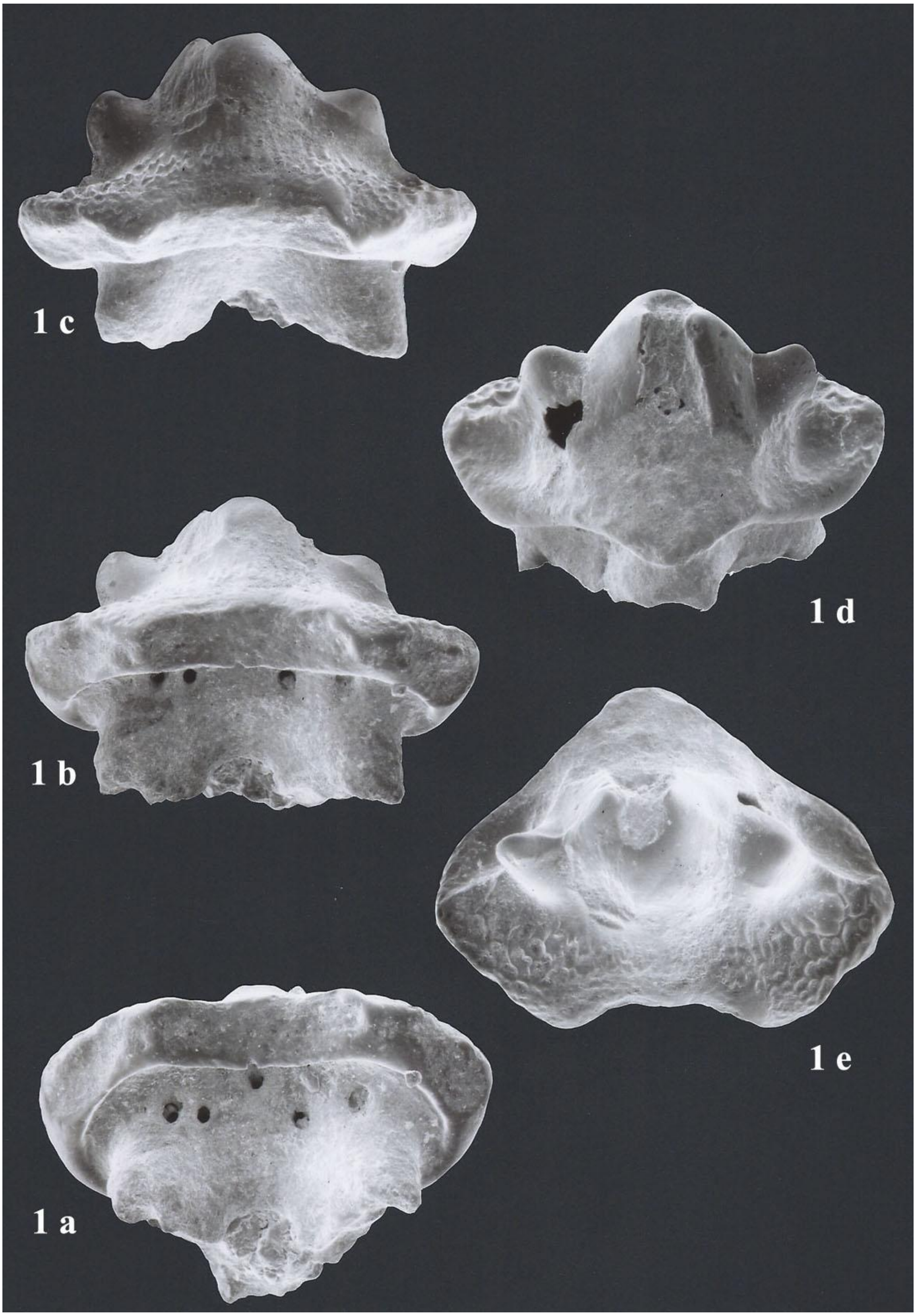


Plate 14: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 494
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Family Heterodontidae GRAY, 1851.
1a to **1e**: Different views of an anterior tooth of ***Heterodontus janefirdae*** **CASE, 1980**.
Private Collection. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

3 a

3 b

2 a

2 b

1 a

1 b

Plate 15: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1a to **3b**: **Family Alopiidae** BONAPARTE, **1838**: **Genus *Alopias*** RAFINESQUE, **1810**.
1a-1b and **2a-2b**: Intern and extern views of two teeth of ***Alopias exigua*** **(**PROBST, **1879)** and
3a-3b: Intern and extern views of one tooth of ***Alopias latidens*** LERICHE, **1909**.
Pieter De Schutter Collection. Photographs Pieter De Schutter. See comments.

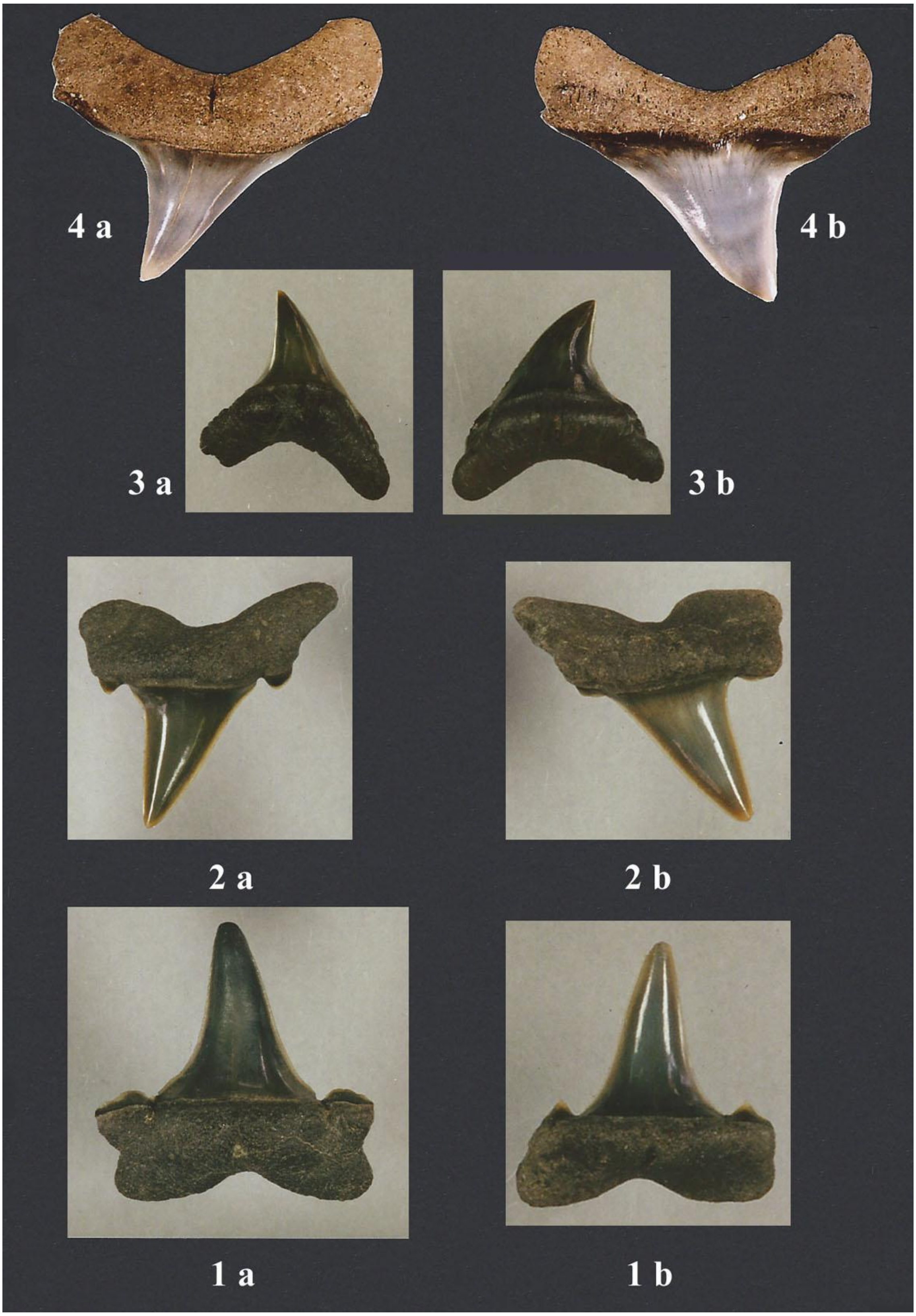


Plate 16: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
1a to **2b**: **Family Lamnidae MÜLLER & HENLE, 1838**: **Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999**:
***Rhizoquadrangulus rupeliensis* (LE HON, 1871)**.
3a to **4b**: **Family Alopiidae BONAPARTE, 1838**: **Genus *Alopias* RAFINESQUE, 1810**:
***Alopias exigua* (PROBST, 1879)**. Collection and Photographs Guy Van Den Eeckhaut. See comments.

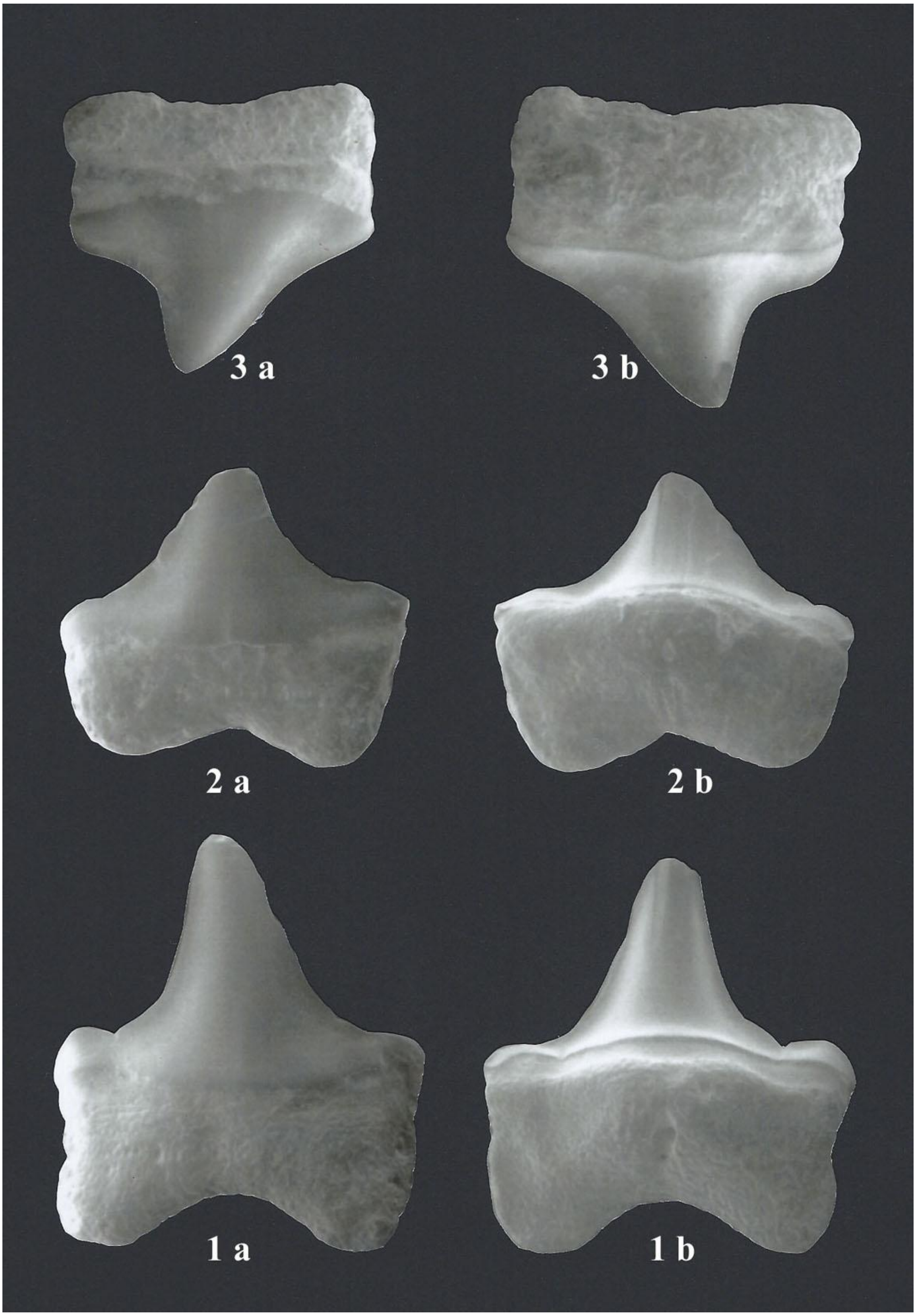


Plate 17: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394

Fossils from the *Sint Niklaas Phosphorite Bed*

Pisces - Chondrichthyes - Neoselachii:

1a to **3b**: **Family Lamnidae MÜLLER & HENLE, 1838**: **Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999**:

Three lateral hemi-centimetric sized teeth of ***Rhizoquadrangulus rupeliensis* (LE HON, 1871)**.

Private Collections. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).

See comments.

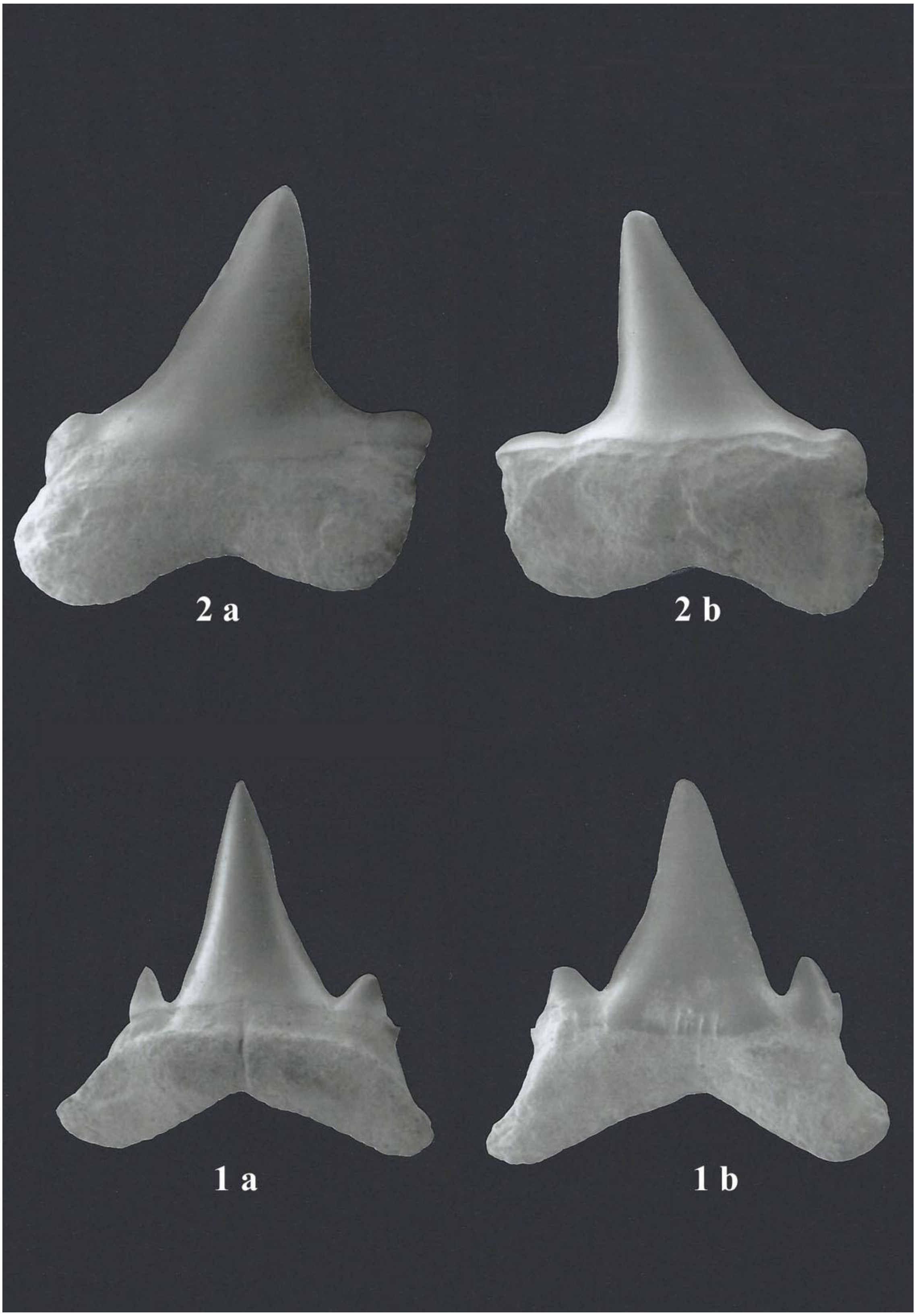


Plate 18: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii:
Family Lamnidae MÜLLER & HENLE, 1838: **Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999**:
1a-1b: Extern and intern views of one upper posterior tooth of ***Rhizoquadrangulus rupeliensis* (LE HON, 1871)**.
2a-2b: Intern and extern views of one lower posterior tooth of ***Rhizoquadrangulus rupeliensis* (LE HON, 1871)**.
Different magnifications. See comments.
Private Collections. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).

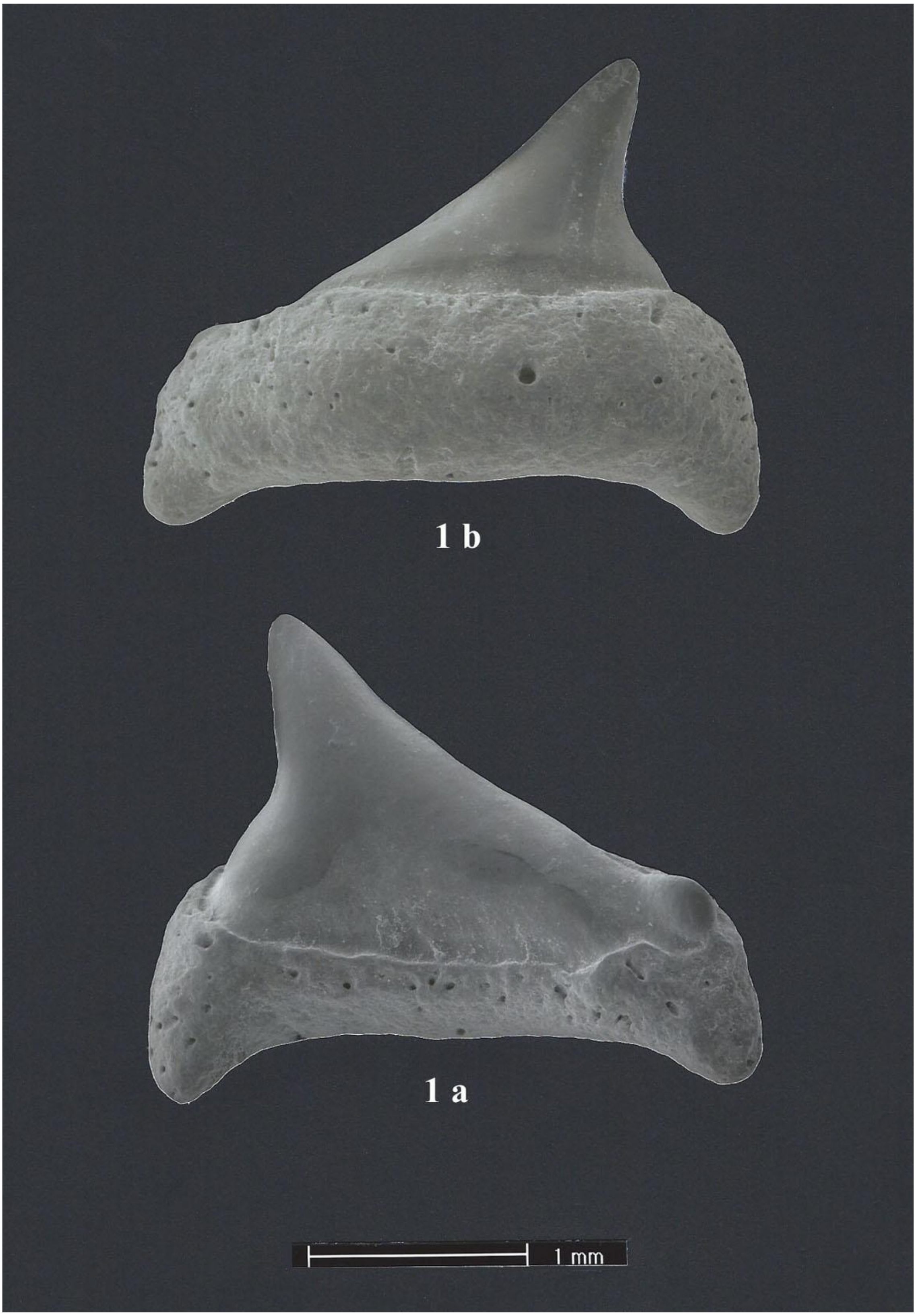


Plate 19: **BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 513**

Fossil from the *Sint Niklaas Phosphorite Bed*

Pisces - Chondrichthyes - Neoselachii:

1a-1b: **Family Cetorhinidae Gill, 1862**: **Genus *Cetorhinus* de Blainville, 1816**:

Extern and intern views of a tooth of ***Cetorhinus parvus* (Leriche, 1908)**.

Collection Pieter De Schutter. SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium).

See comments.

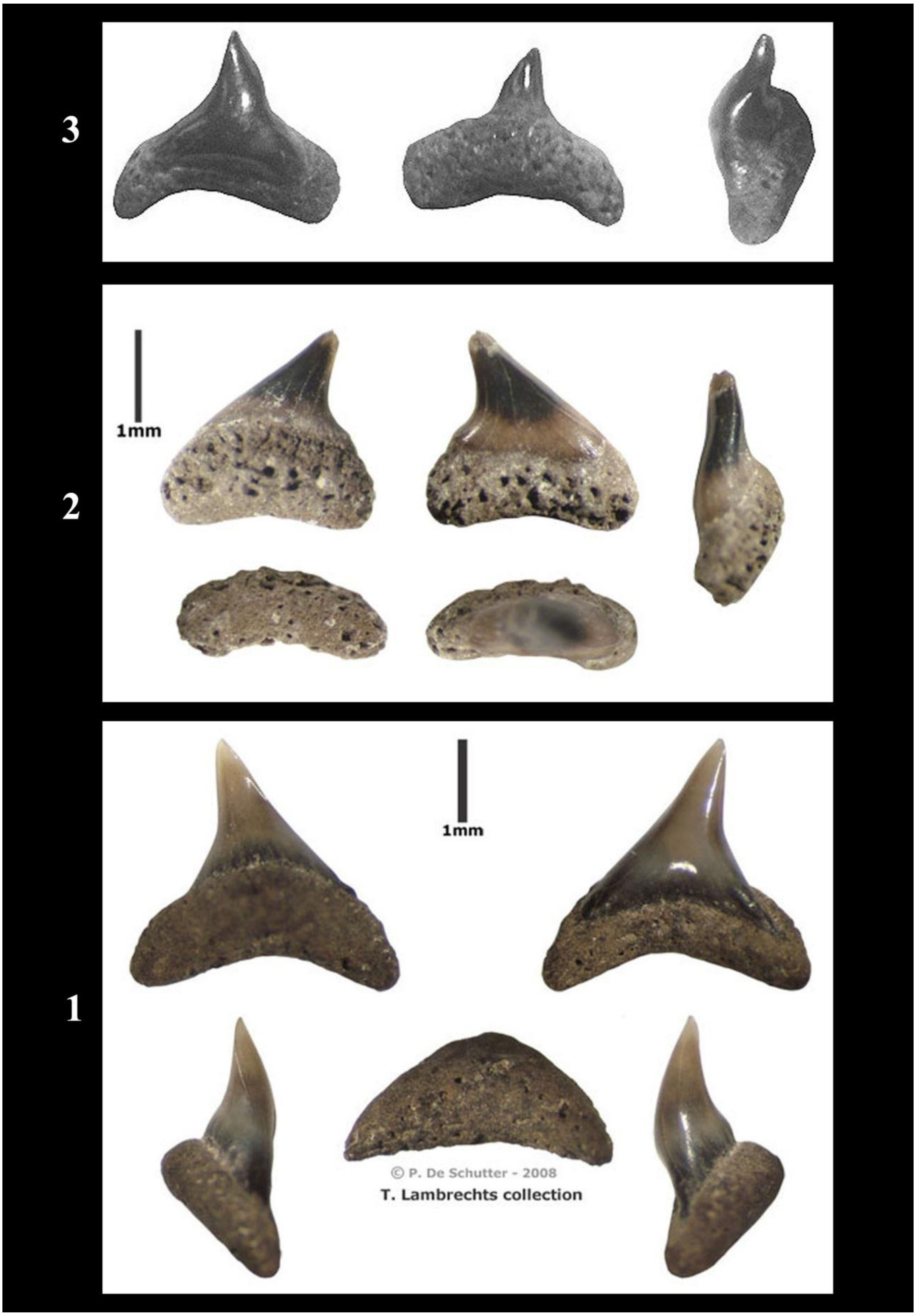


Plate 20: Pisces - Chondrichthyes - Neoselachii: **Additional fossil materials**
Family Cetorhinidae GILL, 1862: **Genus *Cetorhinus* de BLAINVILLE, 1816**:
***Cetorhinus parvus* LERICHE, 1910**:
1 and **2**: Five views of two different teeth, reworked from the Boom Clay, discovered in the basal gravel of the Kattendijck Sands Formation in the Albert II dock at Doel.
3: Three views of a tooth discovered in the *Sint Niklaas Phosphorite Bed* at Belsele (SVK Clay Pit 4).
Private Collections. Photographs: Courtesy of Mr Pieter De Schutter. See comments.

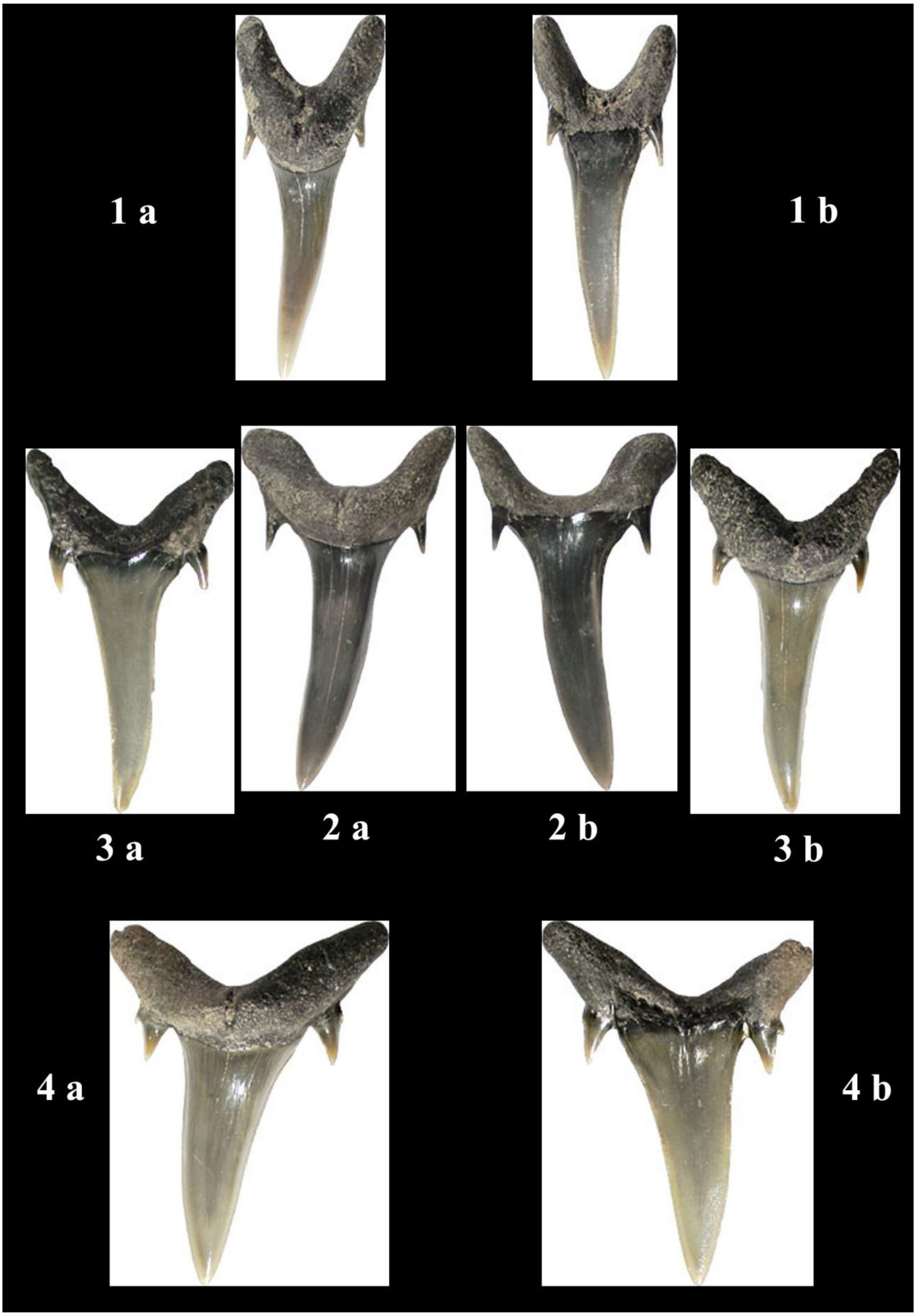


Plate 21: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii
Family Odontaspididae MÜLLER & HENLE, **1839**: **Genus *Odontaspis*** AGASSIZ, **1838**:
1-4: Upper teeth of ***Odontaspis acutissima*** **(**AGASSIZ, **1843)**.
Collection and photographs Pieter De Schutter. See comments.

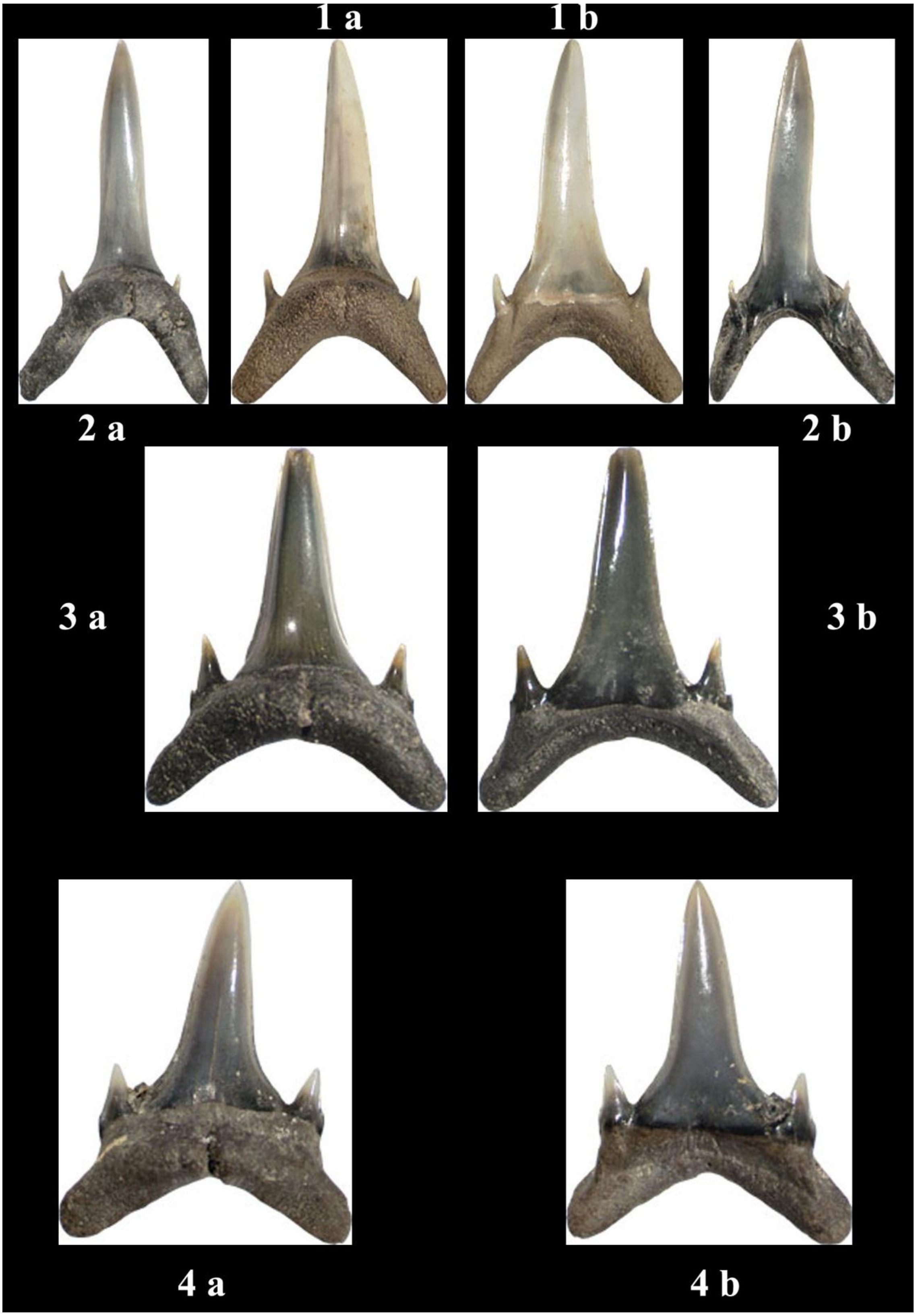


Plate 22: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii
Family Odontaspididae MÜLLER & HENLE, 1839: **Genus *Odontaspis* AGASSIZ, 1838**:
1-4: Lower teeth of ***Odontaspis acutissima*** **(AGASSIZ, 1843)**.
Collection and photographs Pieter De Schutter. See comments.

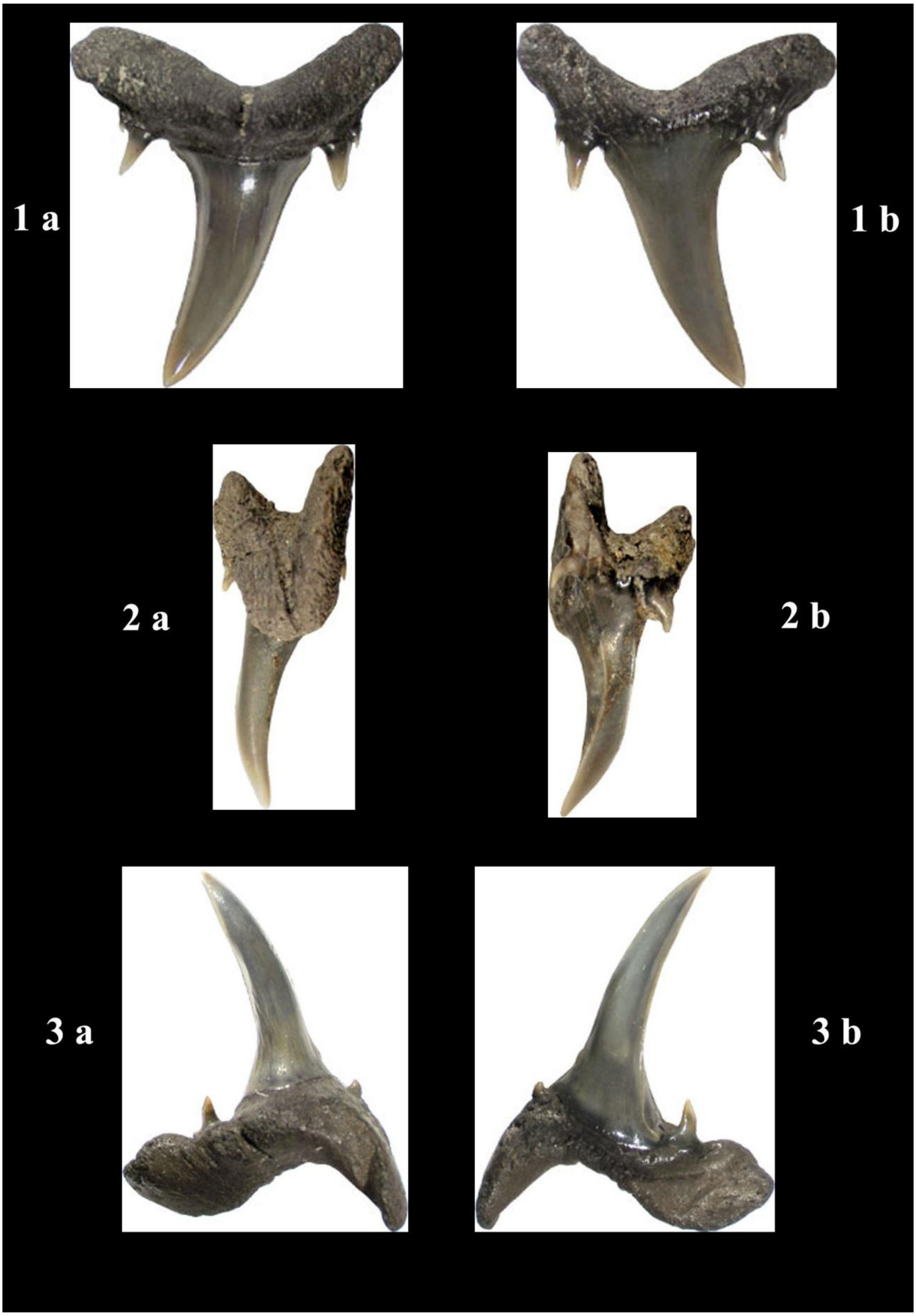


Plate 23: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii
Family Odontaspididae MÜLLER & HENLE, 1839: **Genus *Odontaspis* AGASSIZ, 1838**:
***Odontaspis acutissima* (AGASSIZ, 1843)**.
1a-1b: Intern and extern views of an anterio-lateral tooth. **2a-2b**: Intern and extern views of an eye-tooth.
3a-3b: Intern and extern views of a traumatic upper tooth.
Collection and photographs Pieter De Schutter. See comments.

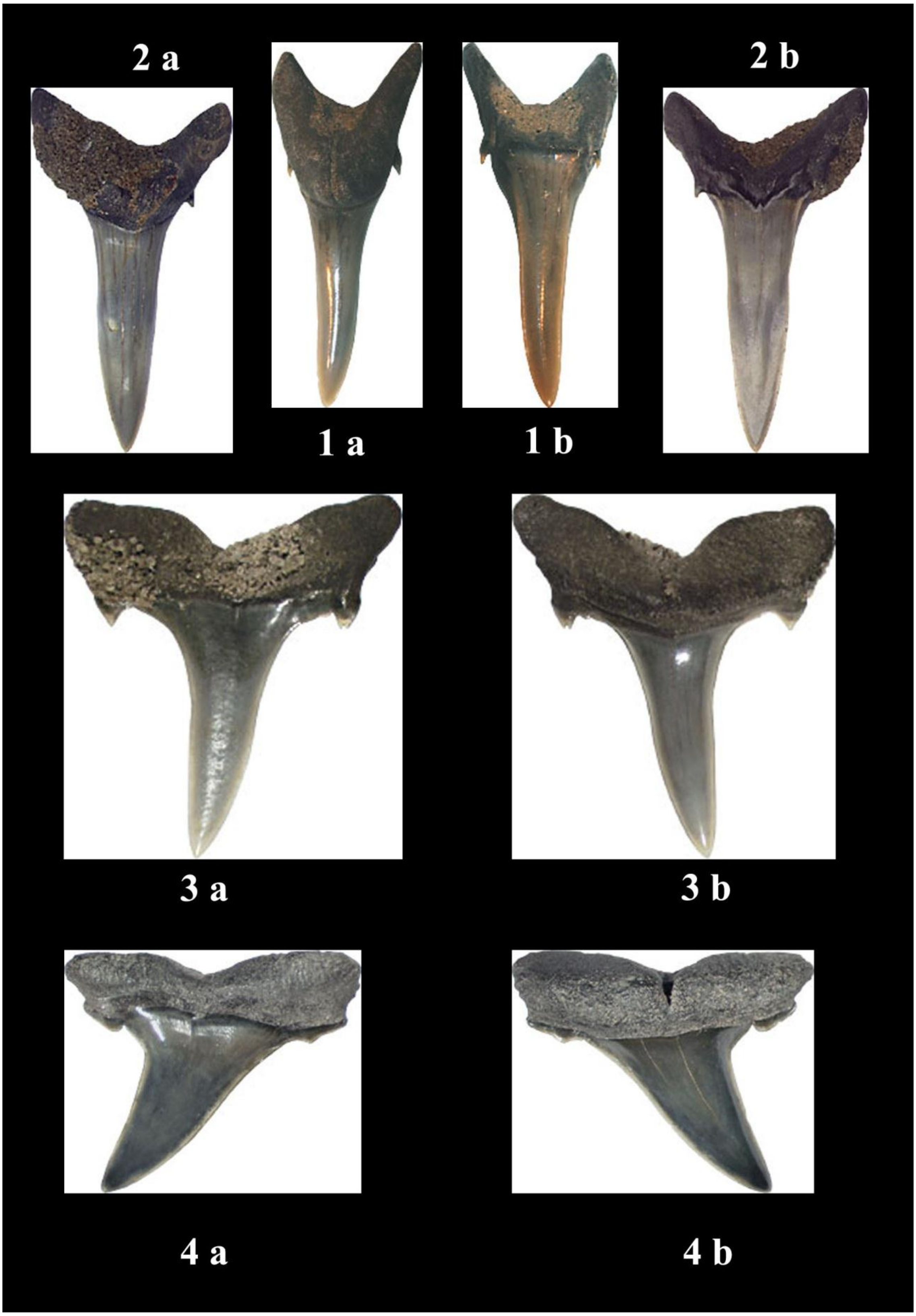


Plate 24: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii
Family Odontaspididae MÜLLER & HENLE, 1839: **Genus *Odontaspis* AGASSIZ, 1838**:
1-4: Upper teeth of ***Odontaspis acutissima*** **(AGASSIZ, 1843)**.
Collection and photographs Pieter De Schutter. See comments.

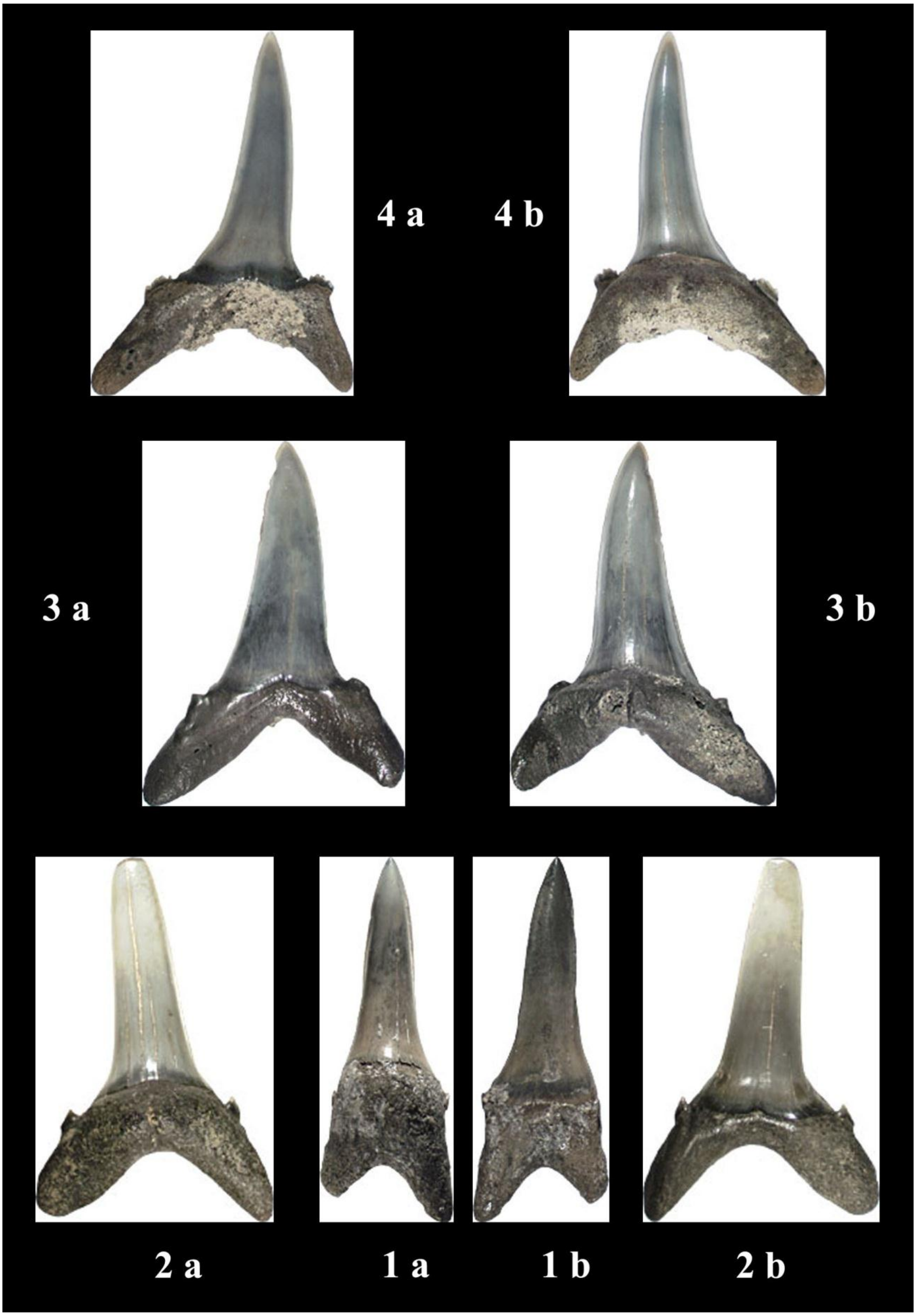


Plate 25: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii
Family Odontaspididae MÜLLER & HENLE, 1839: Genus *Odontaspis* AGASSIZ, 1838:
1-4: Lower teeth of ***Odontaspis cuspidata*** **(AGASSIZ, 1843)**.
Collection and photographs Pieter De Schutter. See comments.

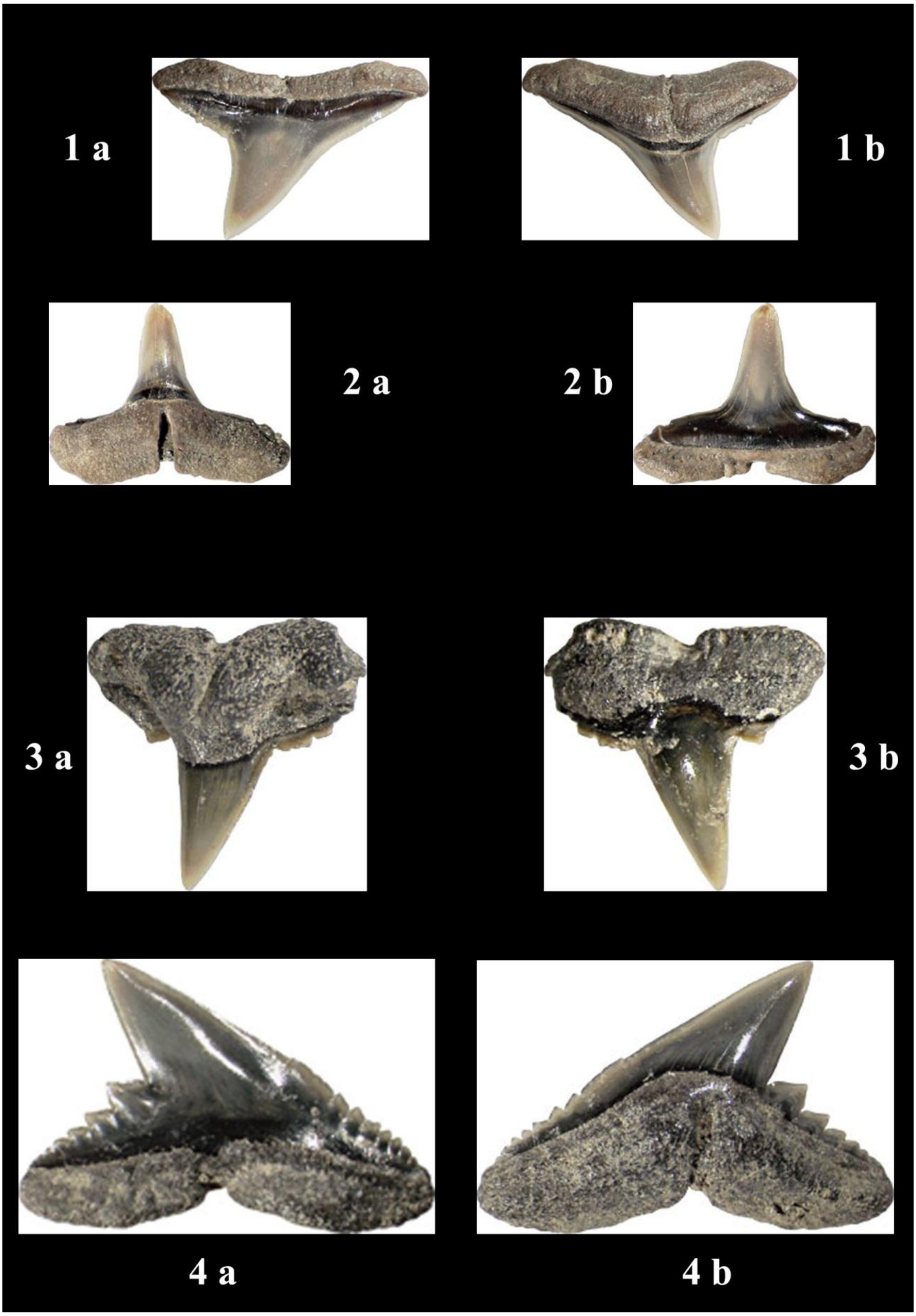


Plate 26: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii - Family Carcharhinidae JORDAN & EVERMANN, 1896:
1-2: **Genus *Carcharhinus* de BLAINVILLE, 1816**: ***Carcharhinus elongatus* (LERICHE, 1910)**.
1a-1b: Extern and intern views of an upper tooth. **2a-2b**: Intern and extern views of a lower tooth.
3-4: **Genus *Physogaleus* CAPPETTA, 1980**: ***Physogaleus latus* (STORMS, 1891)**.
3a-3b: Intern and extern views of an upper tooth. **4a-4b**: Extern and intern views of a lower tooth.
Collection and photographs Pieter De Schutter. See comments.

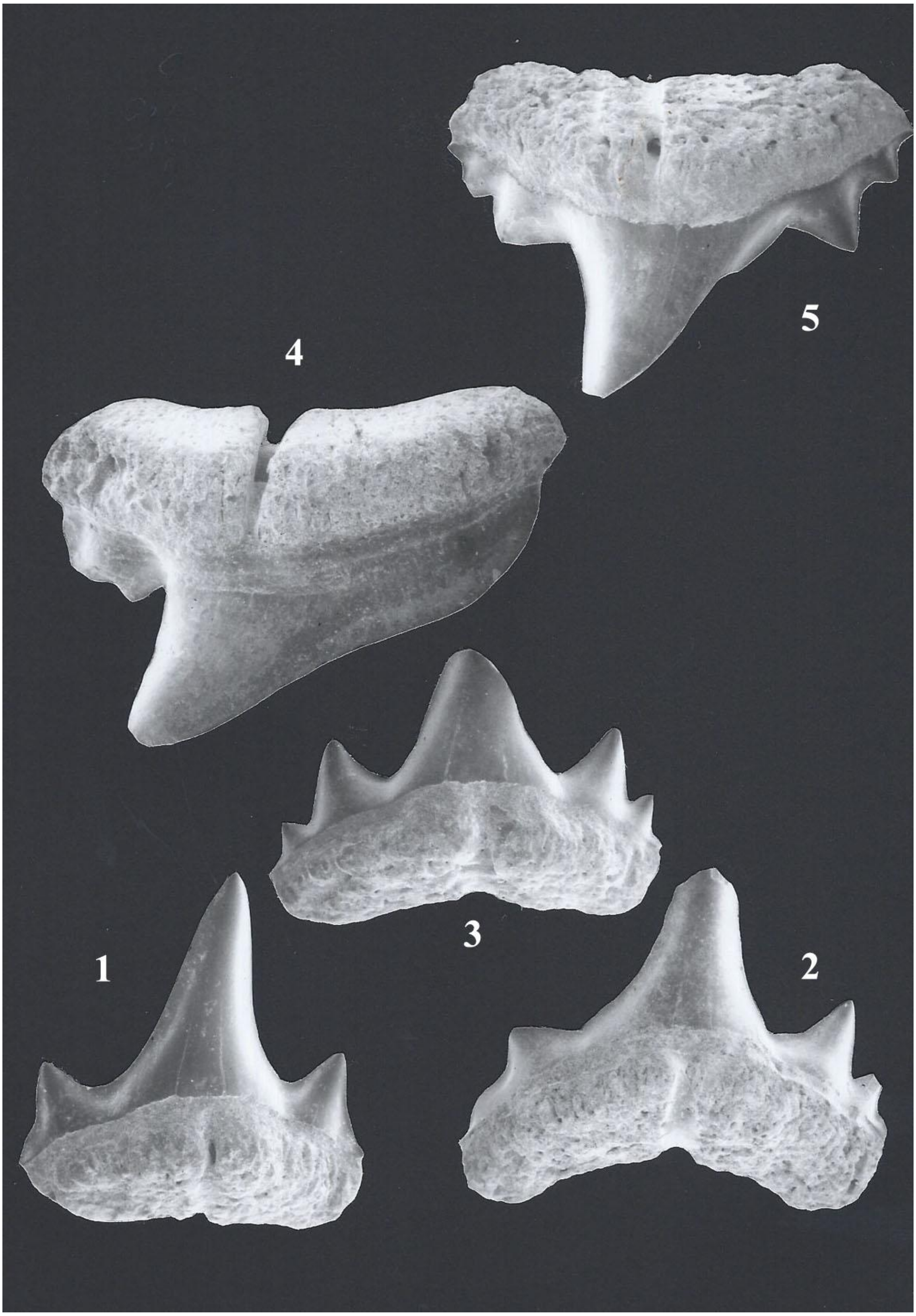


Plate 27: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 434
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii: **Family Carcharhinidae JORDAN & EVERMANN, 1896**:
Genus *Abdounia* CAPPETTA, 1980: ***Abdounia belselensis* MOLLEN, 2007**.
1 to **3**: Views of the intern side of lower teeth. **4** and **5**: Views of the intern side of upper teeth.
Reproduction by courtesy of its inventor. Magnification: *circa* x10.
SEM Photographs Jullien Cillis (I.R.S.N.B., Brussels, Belgium). See comments.

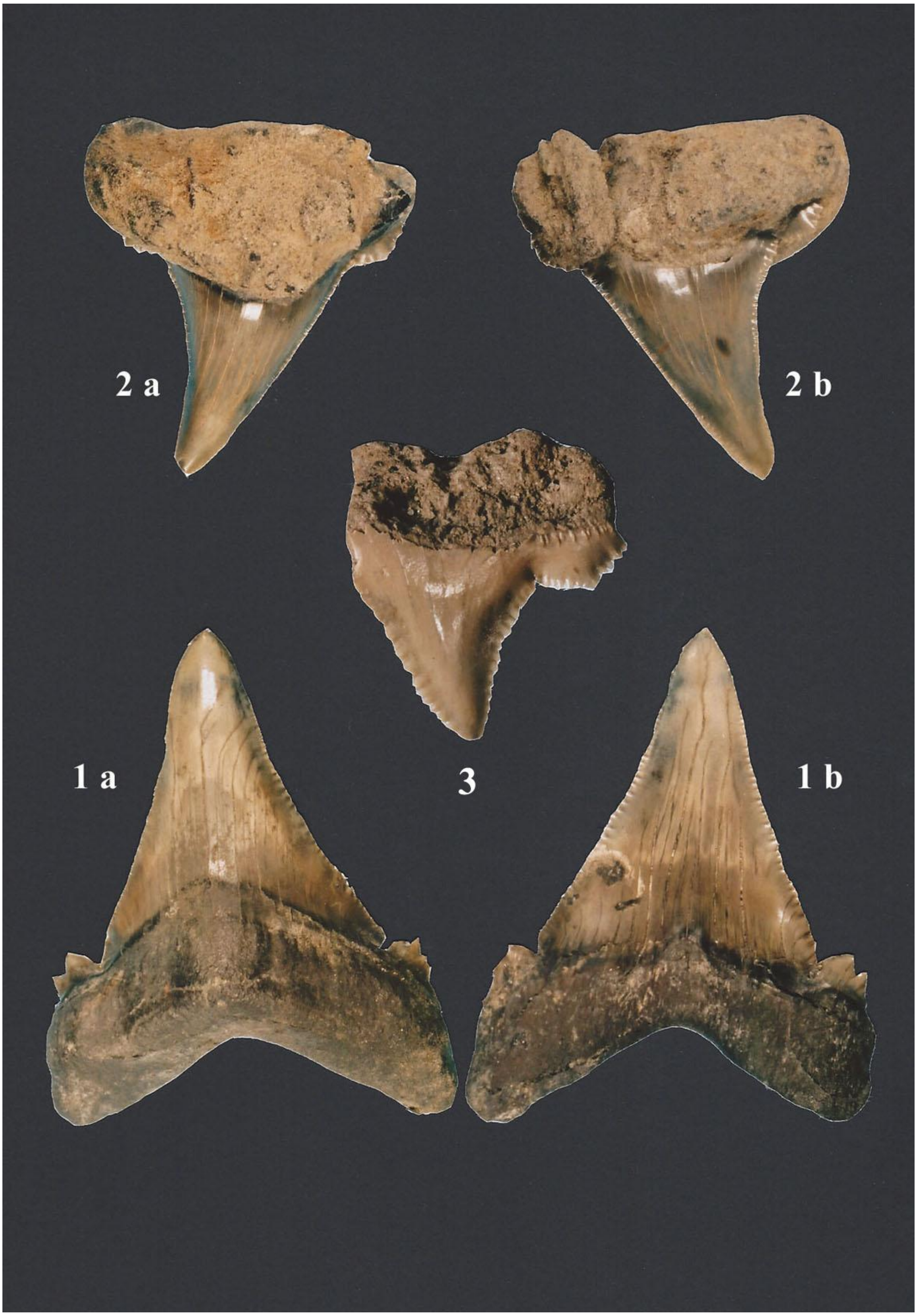


Plate 28: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394

Fossils from the *Sint Niklaas Phosphorite Bed*

Pisces - Chondrichthyes - Neoselachii: **Family Otodontidae GLYCKMAN, 1964**:
Genus *Carcharocles* JORDAN & HANNIBAL, 1923: ***Carcharocles angustidens* (AGASSIZ, 1843)**.
1a-1b: Views of the intern and extern faces of a lower anterior tooth.
2a-2b: Views of the intern and extern faces of an upper lateral tooth.
3: View of the intern face of an upper commissural tooth.
Private Collections. Photographs Jacques Herman. See comments.

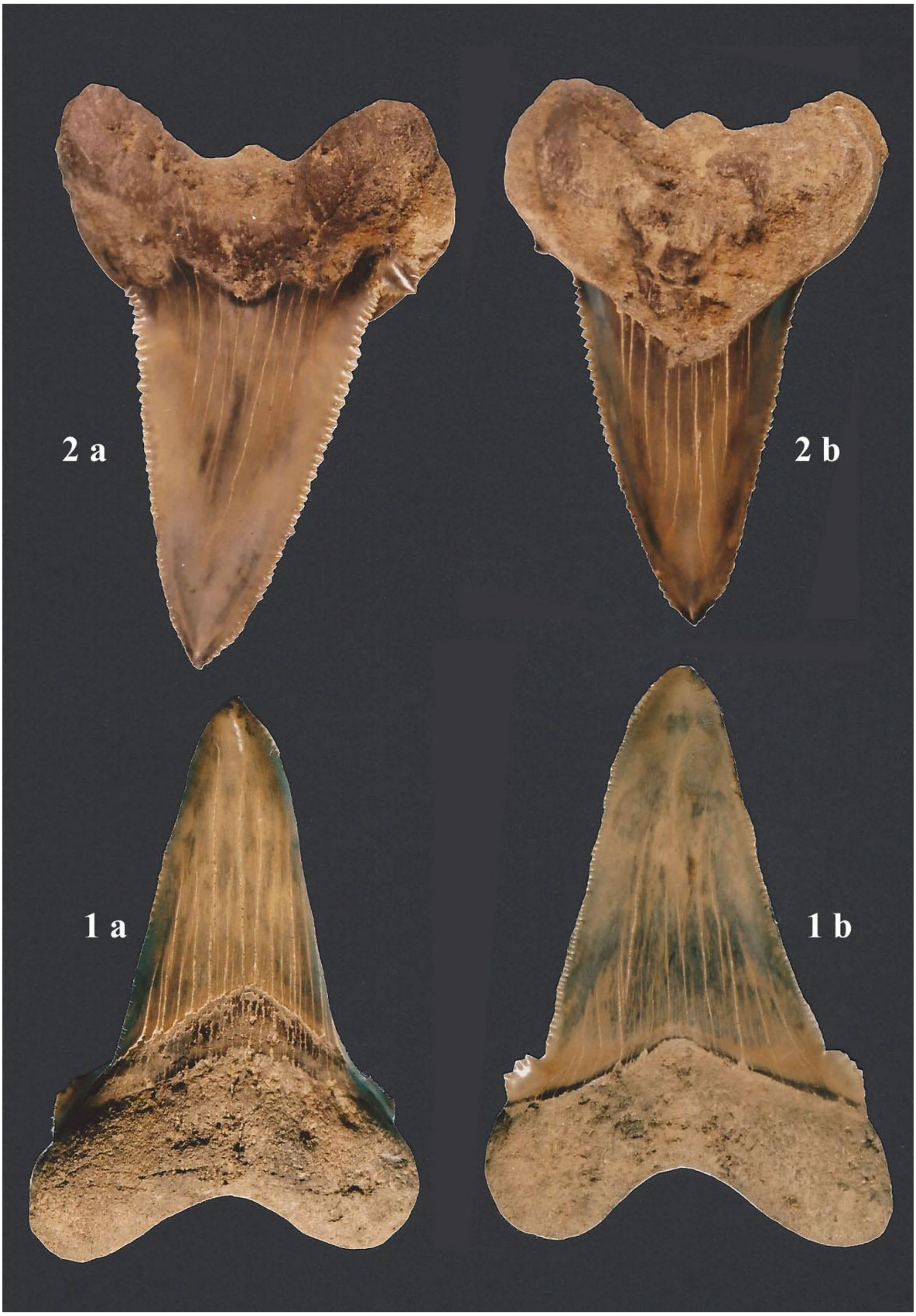


Plate 29: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii: **Family Otodontidae GLYCKMAN, 1964**:
1-2: Genus ***Carcharocles*** **JORDAN & HANNIBAL**, 1923: ***Carcharocles angustidens*** **(AGASSIZ, 1843)**.
Private Collections. Photographs Jacques Herman.
See comments.

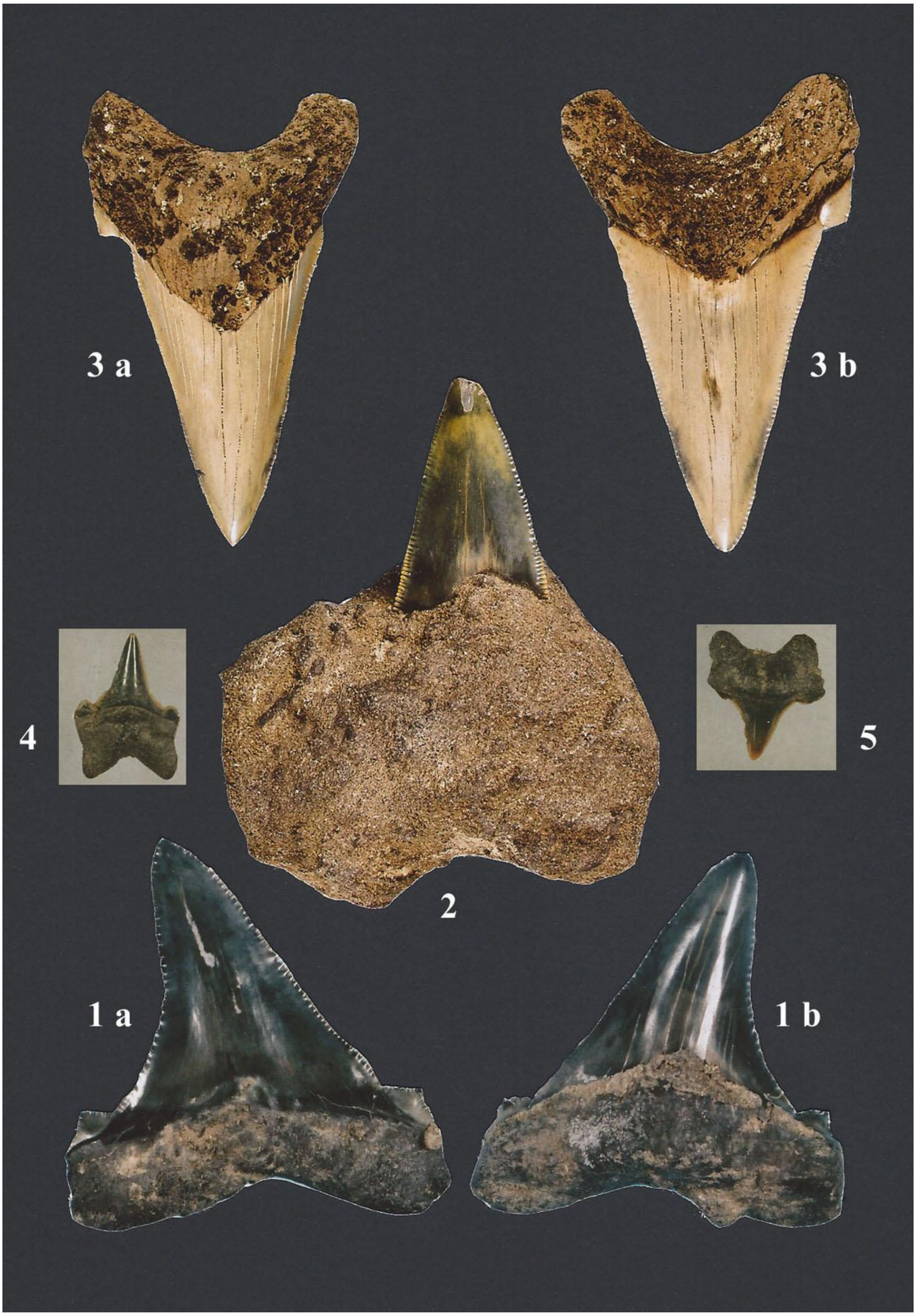


Plate 30: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394
Pisces - Chondrichthyes - Neoselachii: 1-3: **Family Otodontidae GLYCKMAN**, **1964**:
Genus *Carcharocles* JORDAN & HANNIBAL, **1923**: ***Carcharocles angustidens* (AGASSIZ**, **1843)**.
Specimens from diverse strata showing diverse qualities of preservation.
4 and **5**: Upper and lower teeth of ***Rhizoquadrangulus rupeliensis* (LE HON**, **1871)**.
Private Collections. Photographs Jacques Herman.
See comments.

Plate 31: TIELRODE: Old Clay Pit, last owner: SVK
Fossils from the Boom Clay Member
Pisces - Chondrichthyes - Neoselachii: **Family Otodontidae GLYCKMAN, 1964**
Genus *Carcharocles* JORDAN & HANNIBAL, 1923.
1-2: Extern views of two teeth of ***Carcharocles angustidens*** **(AGASSIZ, 1843)**.
Collection Hélin de Wavrin. Photographs Jacques Herman.
See Comments.

Plate 32: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1: Siderite concretion enveloping four vertebrae of a small Elasmobranch, still in anatomical connection. Taxon undetermined.
2a-2c: Three different views of an assemblage of three massive vertebrae, still in anatomical connection, of one large Elasmobranch: ***Cf.* Family Odontaspididae MÜLLER & HENLE, 1839**.
Collection Jean-Pierre Luypaerts. Photographs Jacques Herman.
See comments.

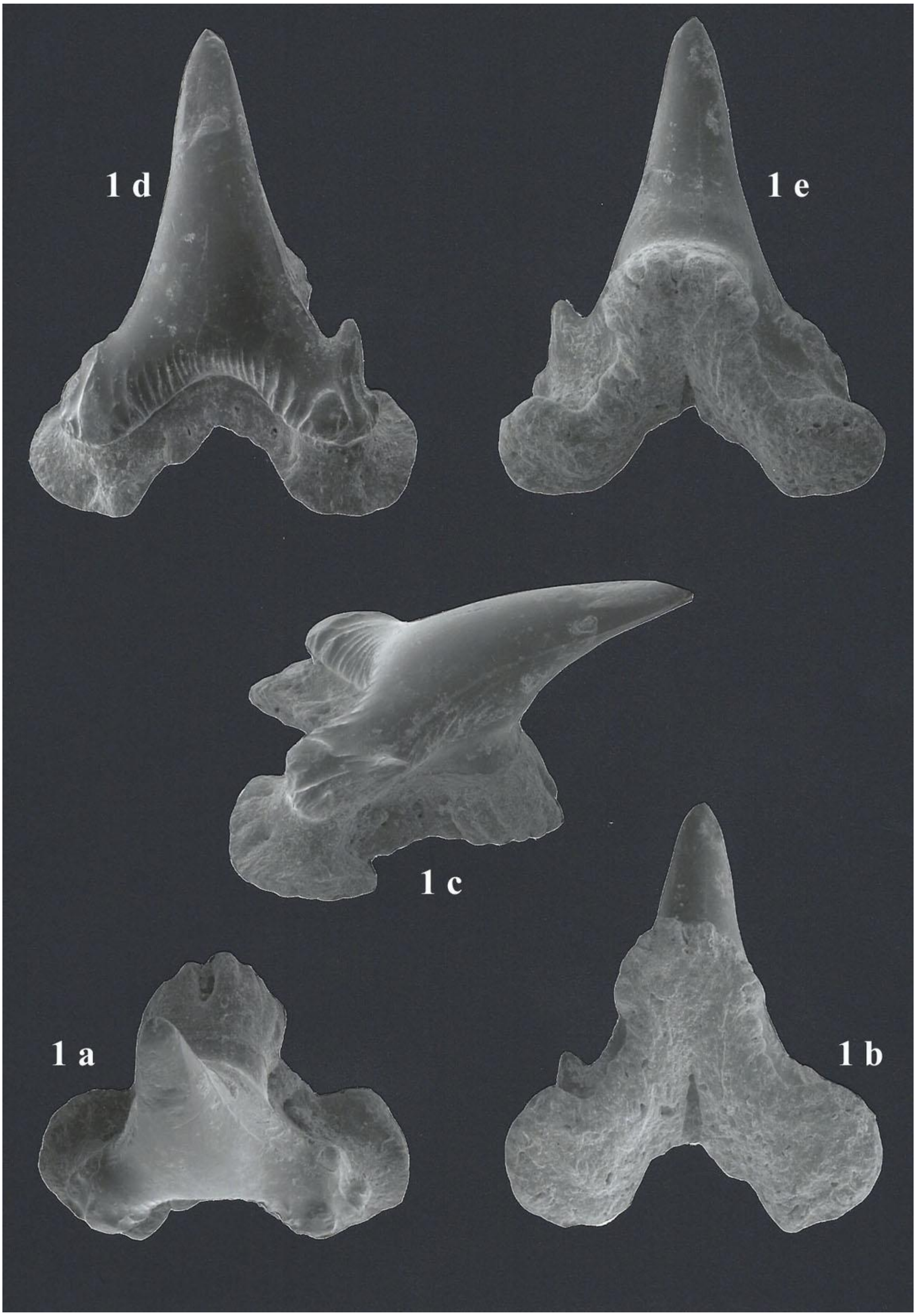


Plate 33: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 434
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii: Family Halaeluridae HERMAN & VAN WAES, 2012:
Genus *Parmaturus* GARMAN, 1906: *Parmaturus steurbauti* (HOVESTADT & HOVESTADT-EULER, 1995).
1a-1e: Five views of an upper lateral tooth
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium). See comments.

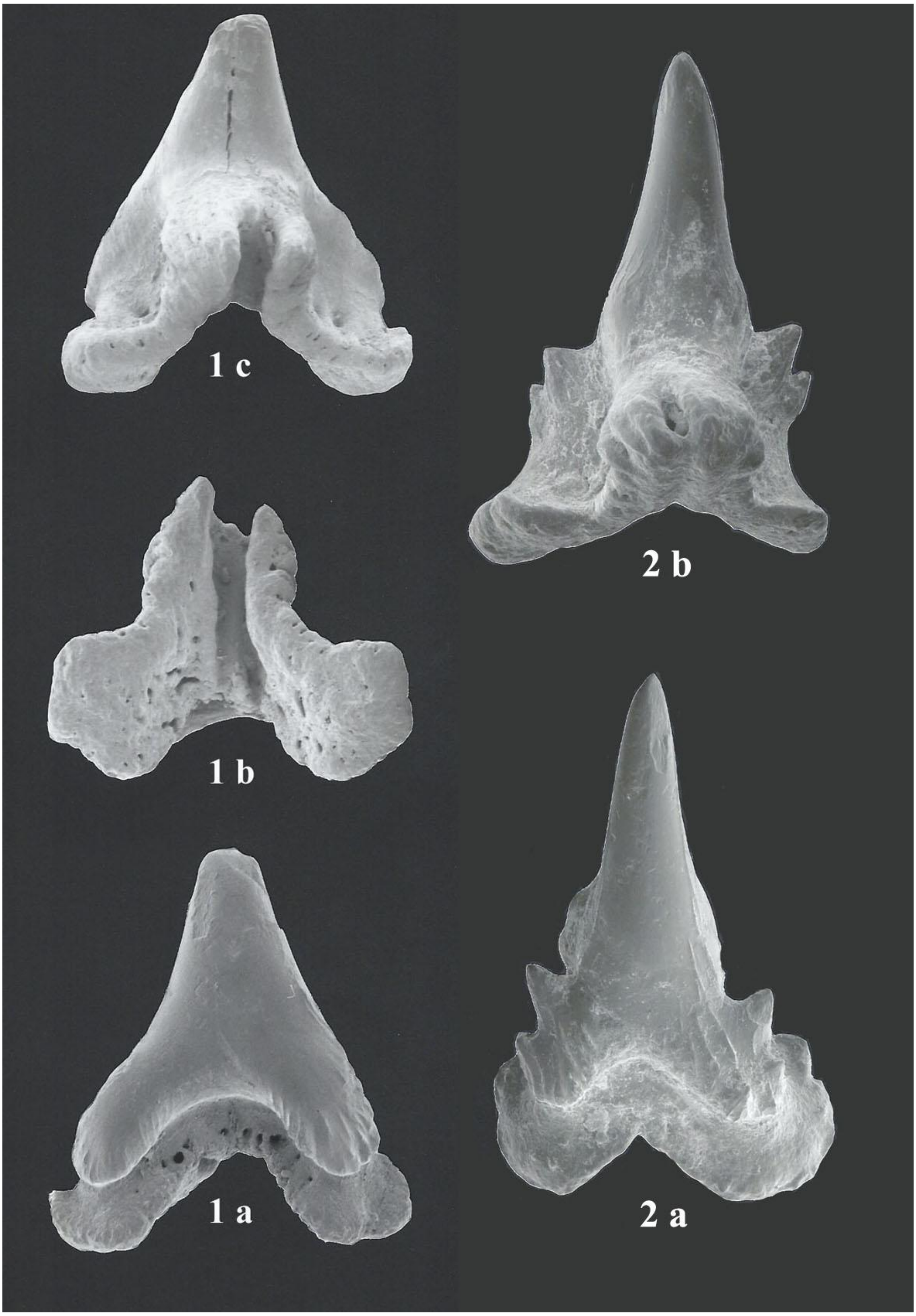


Plate 34: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 434
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Neoselachii: **Family Halaeluridae HERMAN & VAN WAES, 2012**.
Genus *Parmaturus* GARMAN, 1906: ***Parmaturus steurbauti* (HOVESTADT & HOVESTADT-EULER, 1995)**.
1a-1c: Three views of a lateral tooth. **2a-2b**: Two views of a lower anterior tooth.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).See comments.

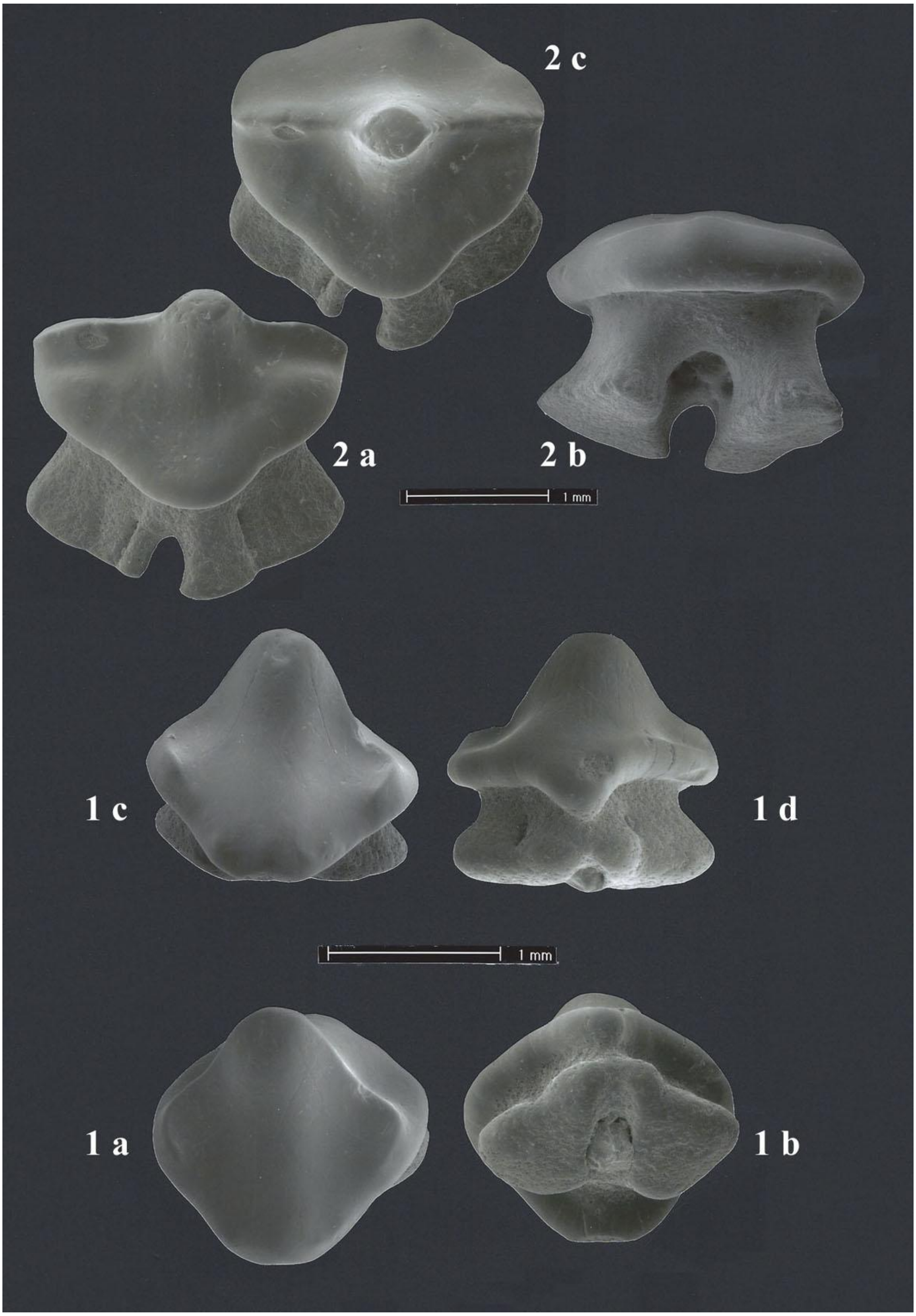


Plate 35: **BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394**
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Batoidei: **Family Rajidae BONAPARTE, 1831**: **Genus Raja LINNAEUS, 1758**:
1a to **1d**: Four views of one lower anterior tooth of ***Raja cf. casieri*** **HERMAN & STEURBAUT, 1978**.
2a to **2c**: Three views of one upper anterior tooth of ***Raja cf. casieri*** **HERMAN & STEURBAUT, 1978**.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium). See comments.

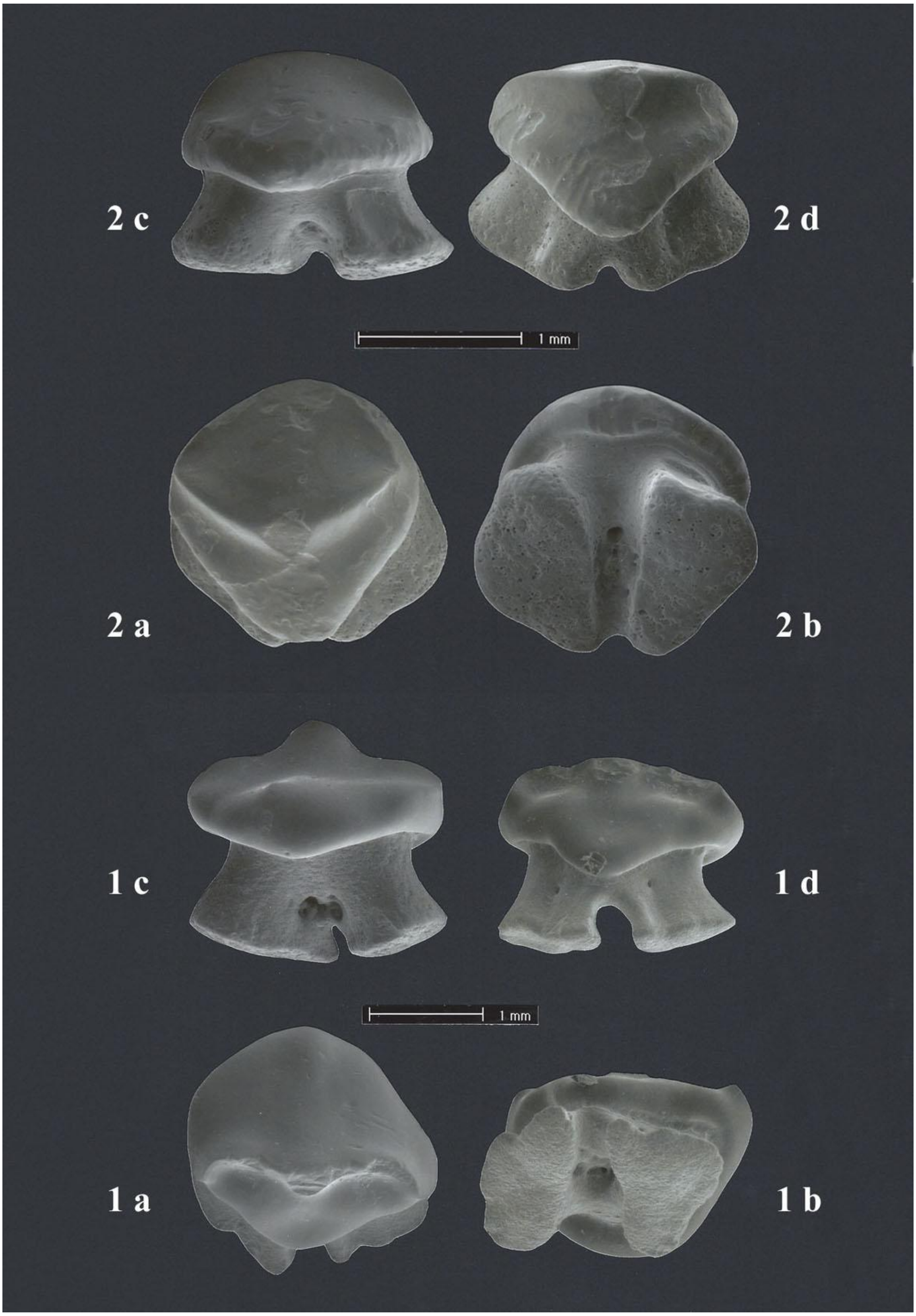


Plate 36: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Batoidei: **Family Rajidae BONAPARTE, 1831**: **Genus *Raja* LINNAEUS, 1758**:
1a to **1d**: Four views of one lateral tooth of ***Raja cf. casieri*** **HERMAN & STEURBAUT, 1978**.
2a to **2d**: Four views of one tooth of ***Raja cf. heinzelini*** **HERMAN & STEURBAUT, 1978**.
SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium). See comments.

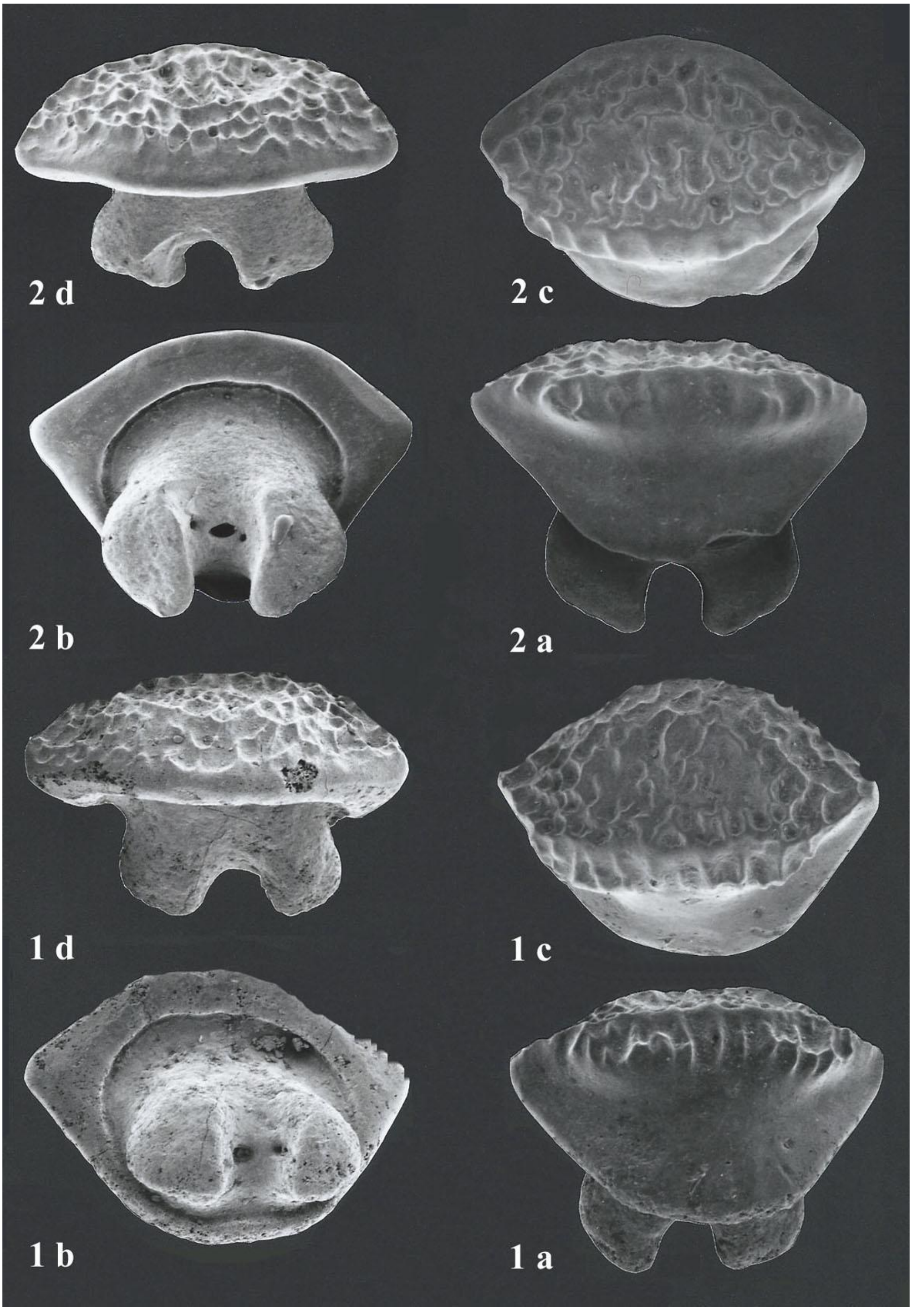


Plate 37: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 434
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Batoidei: **Family Dasyatidae JORDAN, 1888**: **Genus *Dasyatis* RAFINESQUE, 1810**:
1-2: Different views of two teeth of ***Dasyatis cf. rugosa*** **(PROBST, 1877)**.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

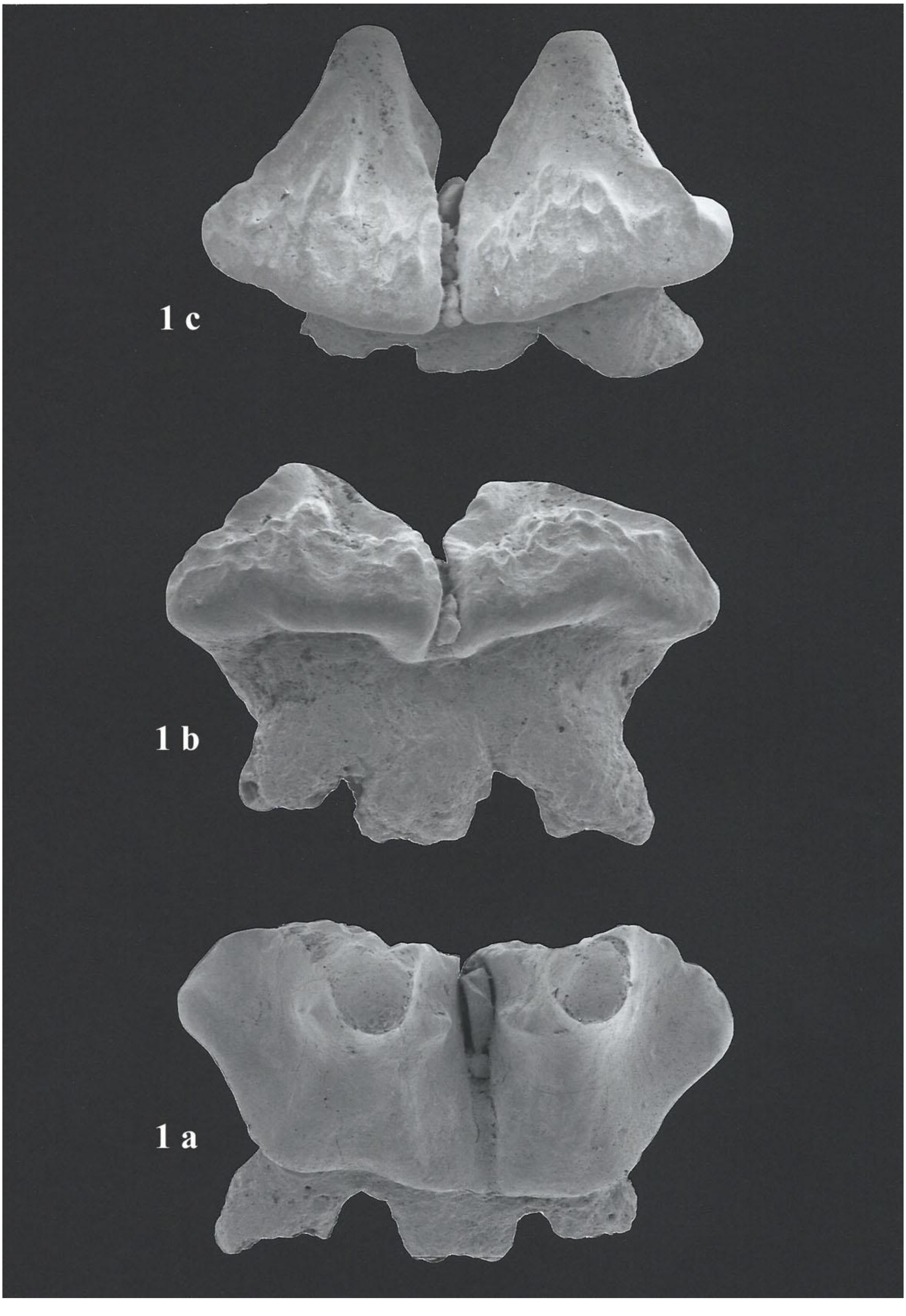


Plate 38: **BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 513**
Fossil from the *Sint Niklaas Phosphorite Bed*
Pisces - Chondrichthyes - Batoidei: **Family Dasyatidae JORDAN, 1888**: **Genus *Dasyatis* RAFINESQUE, 1810**:
1a to **1c**: Intern, extern and occlusal views of a traumatic tooth of
Dasyatis cf. rugosa **(PROBST, 1877)**. See comments.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).

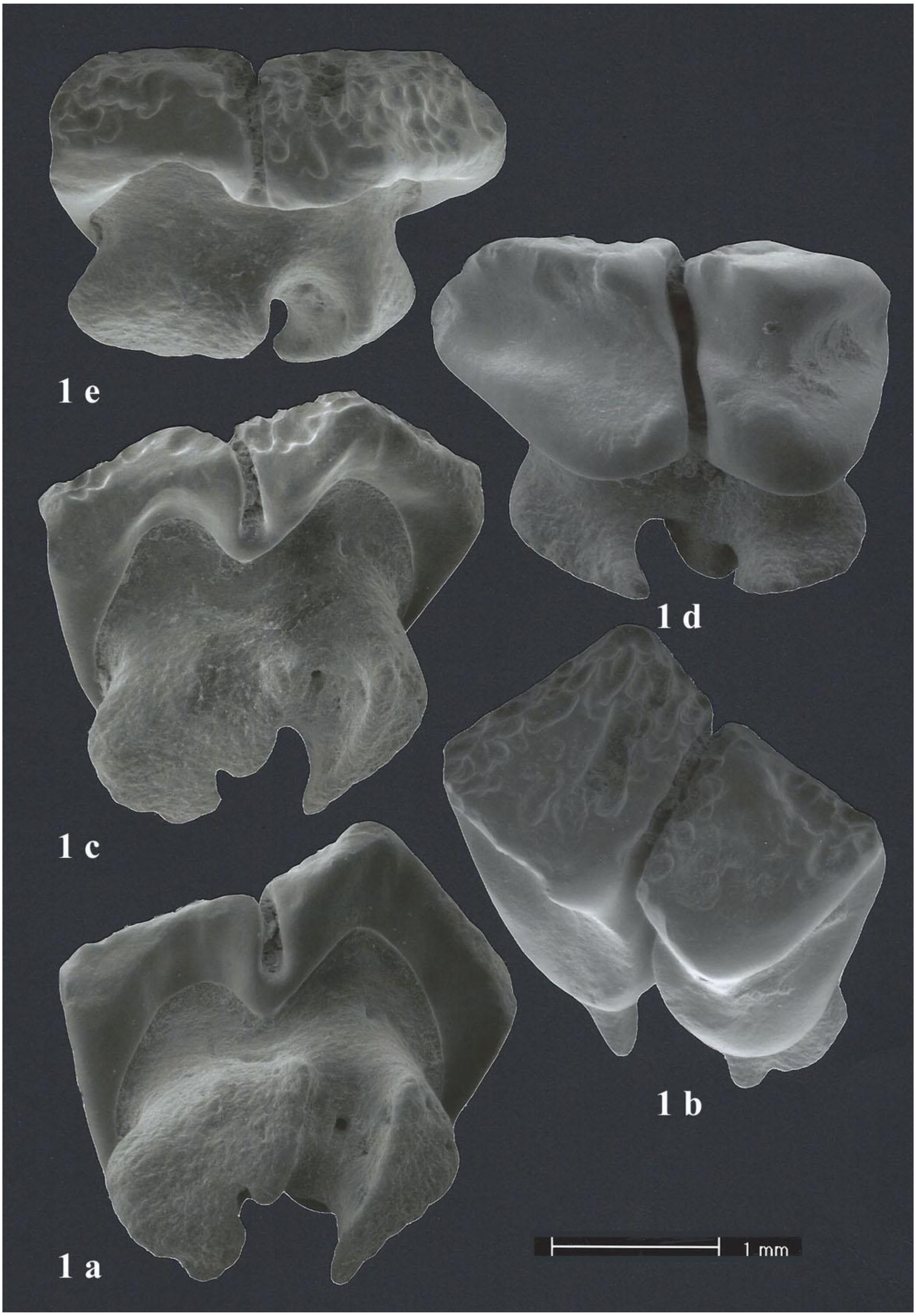


Plate 39: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
Family Dasyatidae JORDAN, 1888: **Genus *Dasyatis* RAFINESQUE, 1810**:
1a to **1e**: Diverse views of a traumatic tooth of ***Dasyatis cf. rugosa*** **(PROBST, 1877)**.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

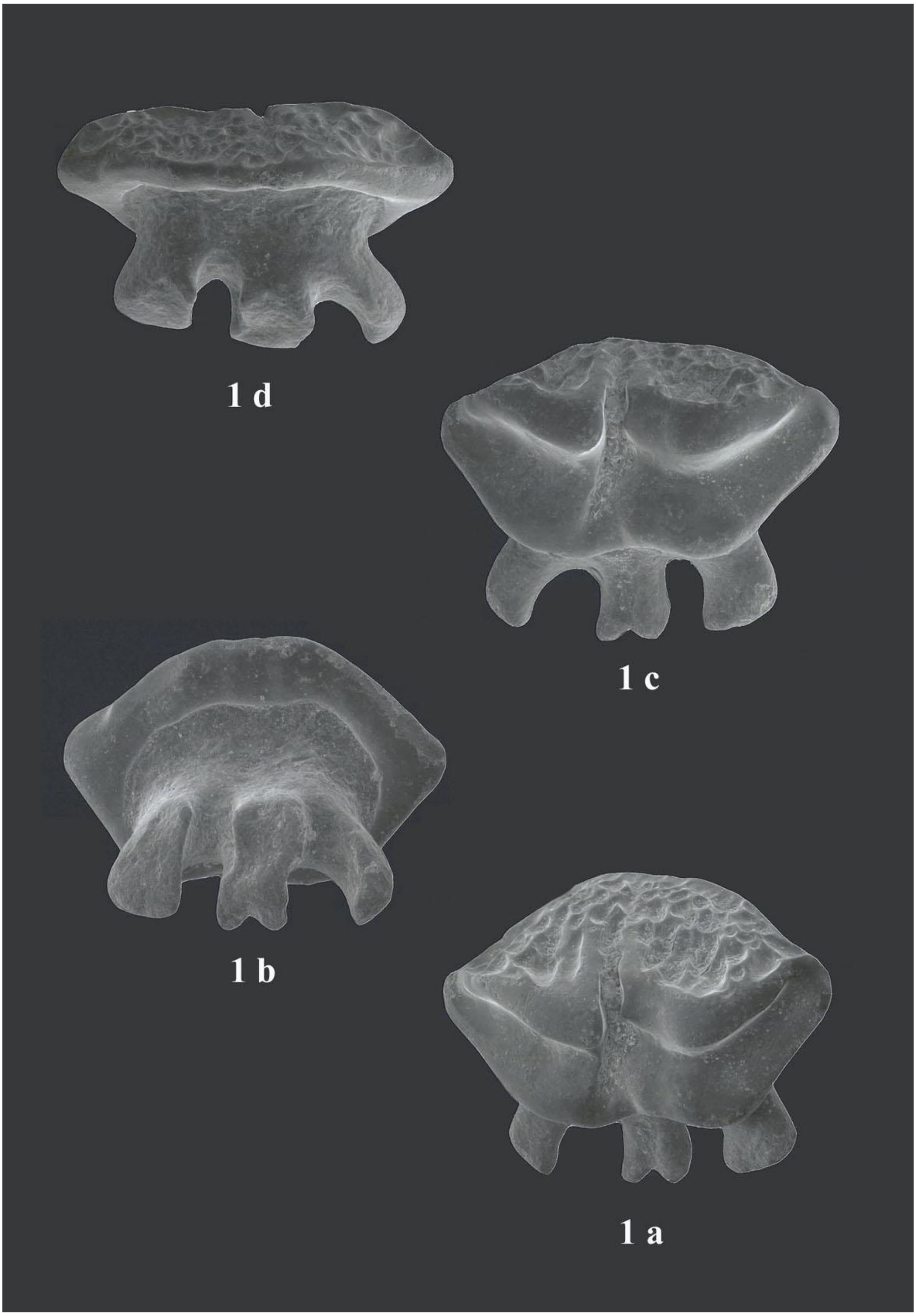


Plate 40: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
Family Dasyatidae JORDAN, 1888: Genus *Dasyatis* RAFINESQUE, 1810:
1a to **1d**: Diverse views of a traumatic tooth of ***Dasyatis cf. rugosa*** **(PROBST, 1877)**.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

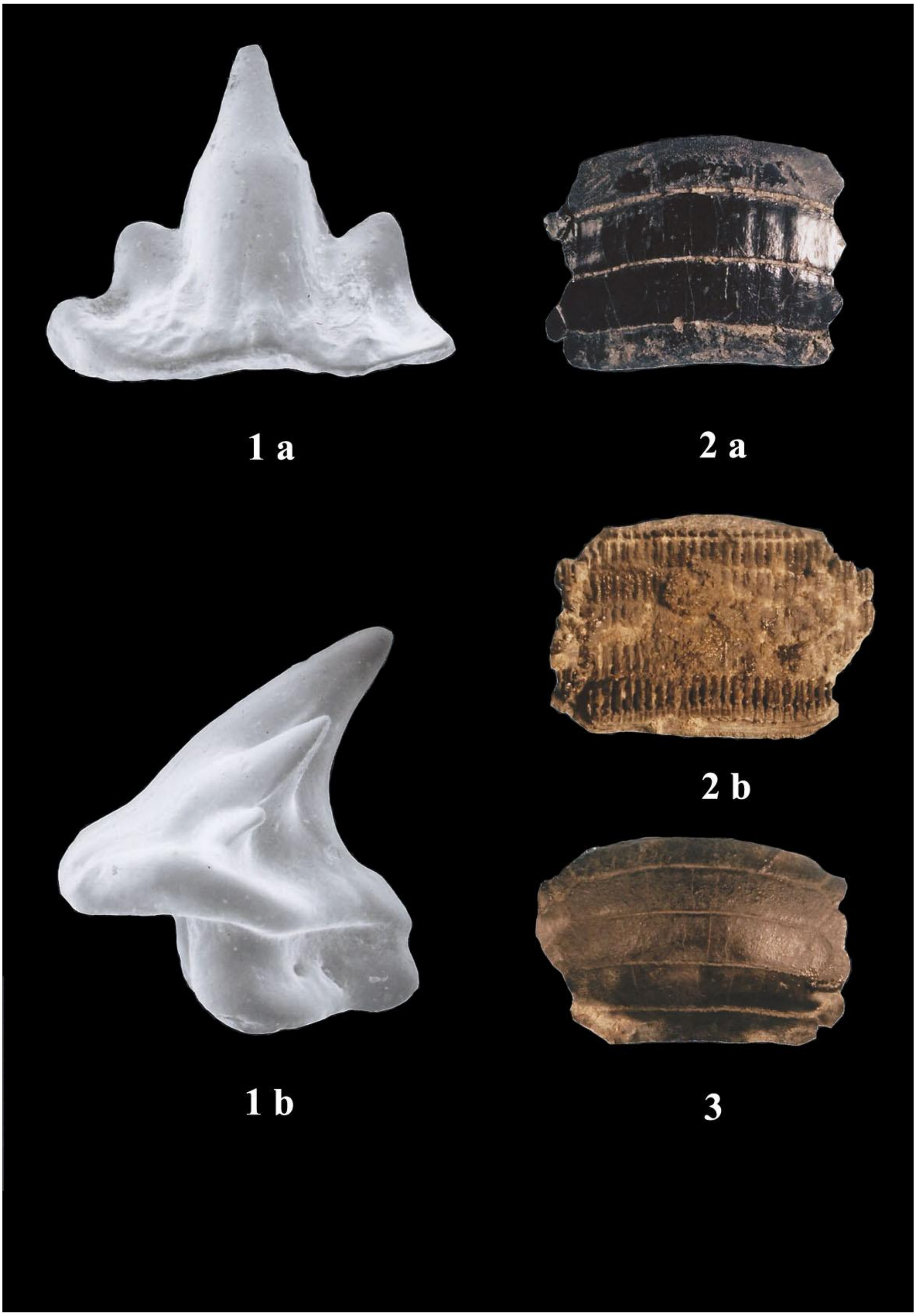


Plate 41: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 494
Fossils from the *Sint Niklaas Phosphorite Bed*
1a-1b: **Pisces - Chondrichthyes - Neoselachii**: **Family Heterodontidae** GRAY, **1851**:
Genus *Heterodontus* de BLAINVILLE, **1816**: Anterior tooth of a juvenile ***Heterodontus janefirdae*** CASE, **1980**.
2a-2b and **3**: **Pisces - Chondrichthyes - Neoselachii**: **Family Myliobatidae** BONAPARTE, **1838**:
Genus *Weissobatis* HOVESTADT & EULER-HOVESTADT: ***Weissobatis oligocaena*** **(**LERICHE, **1910)**.
2a-2b: Occlusal and intern views of a dental plate. **3**: Occlusal view of another dental plate.
Private Collections. See comments.

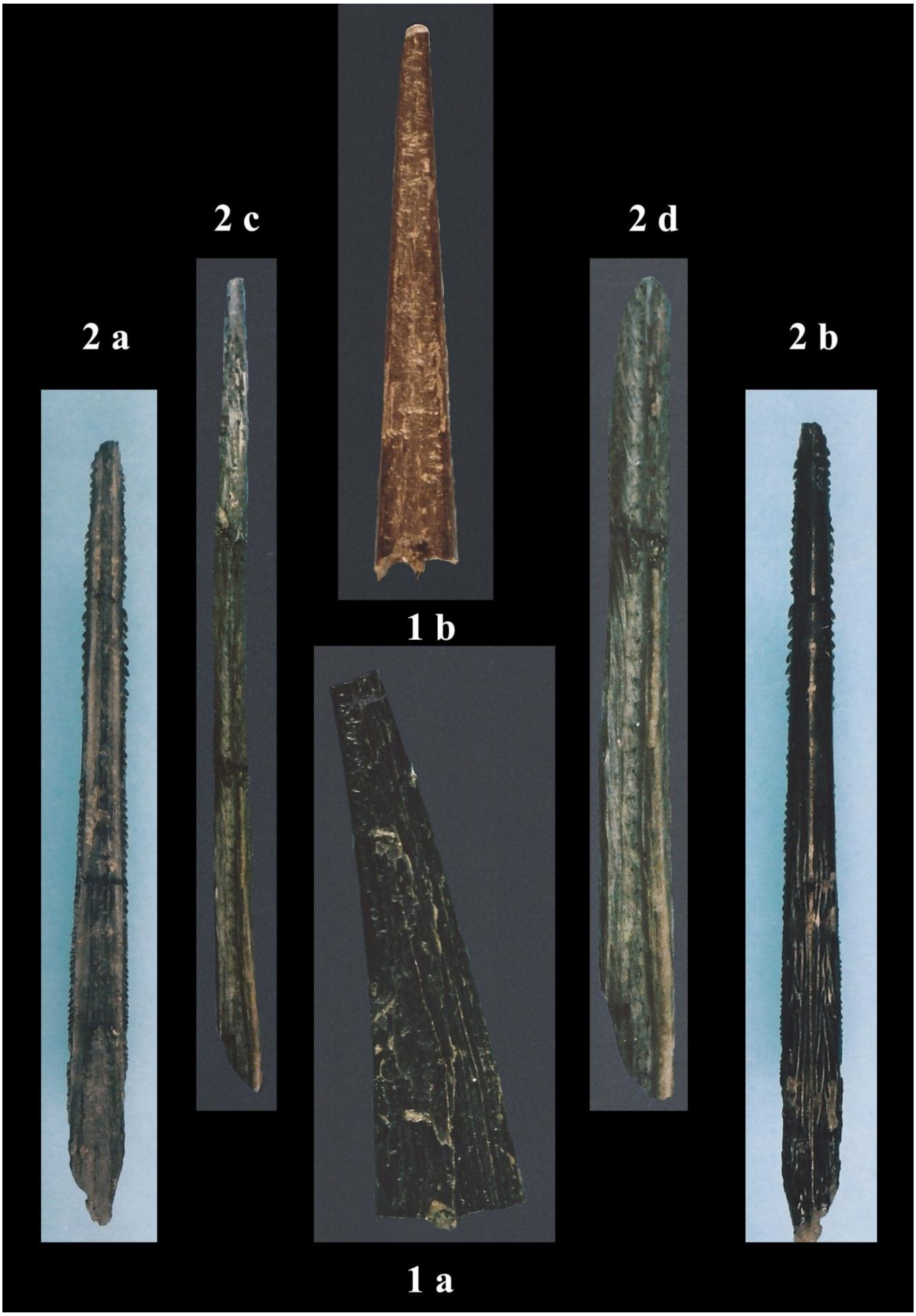


Plate 42: Pisces - Chondrichthyes - SVK Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1a-1b: Lateral and posterior views of a dorsal fin spine of a ***Squalus alsaticus*** **ANDREAE**, **1892**. H.: 38.5 mm.
2a to **2d**: Lower, upper, lateral and oblique views of a caudal spine of a member
of the **Family Dasyatidae JORDAN**, **1888**. Length: 149 millimetres.
Jean-Pierre Luypaerts Collection. Photographs Jacques Herman. See comments.

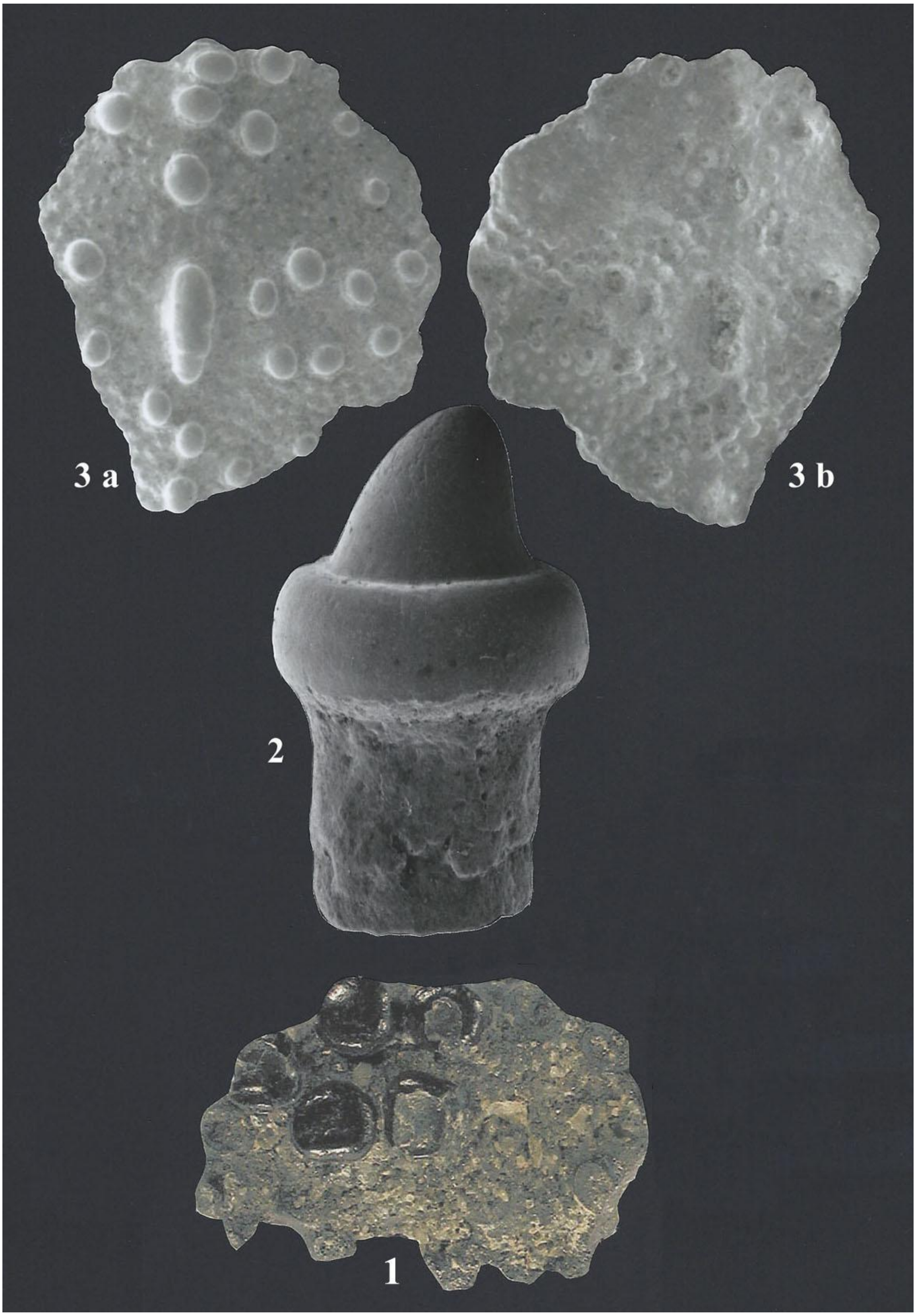


Plate 43: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*: Pisces -Teleostei:
1: View of a broken buccal dentiferous plate of an undetermined species of the ***Cf.*** **Family Sparidae**.
2: Lateral view of a tooth of an undetermined teleostean fish. See comments.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
3a-3b: Extern and intern views of a dermal plate of a member of the **Family Ostraciidae RAFINESQUE, 1810**.
Private Collections. Photograph Guy Van Den Eeckhaut. See comments.

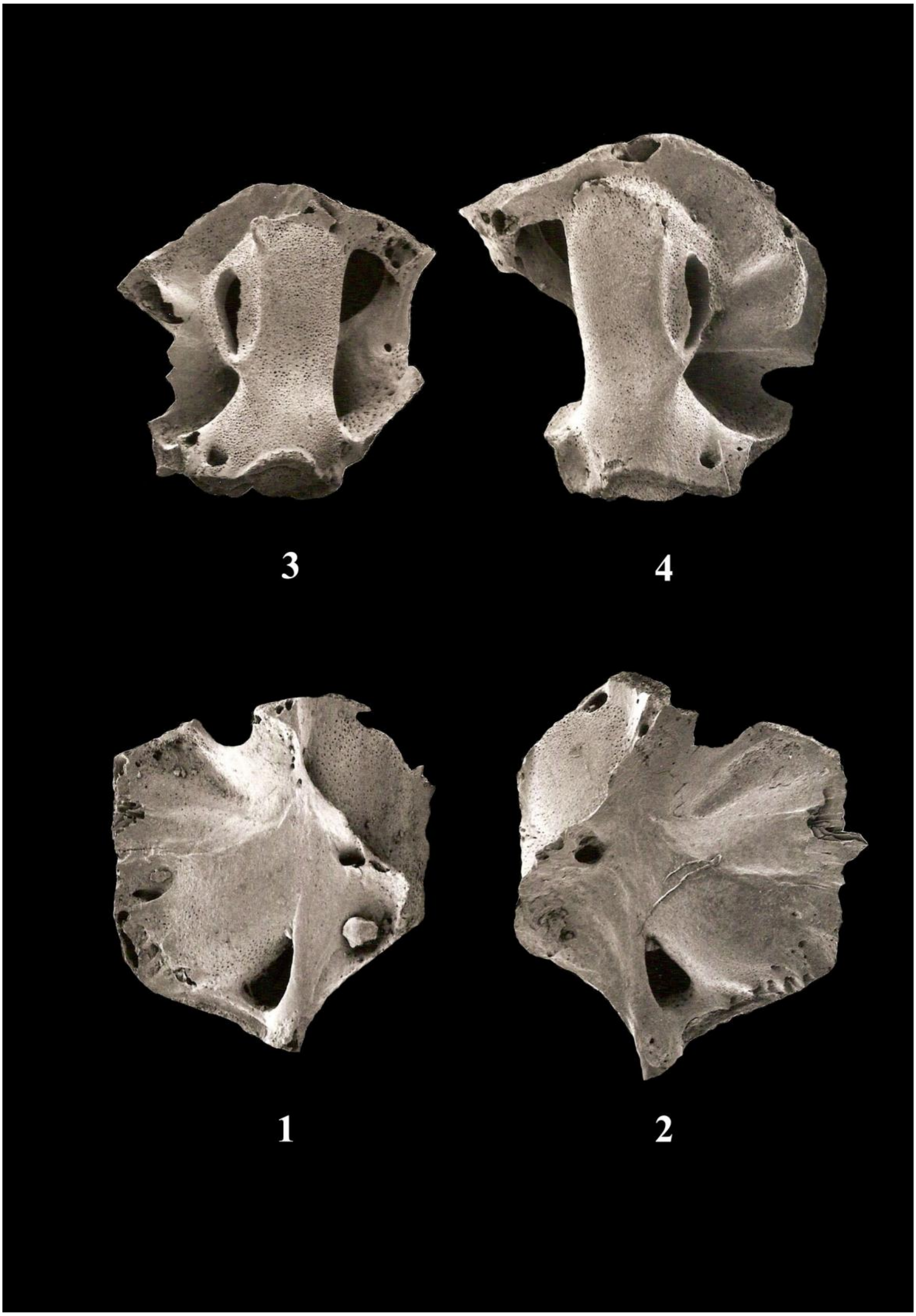


Plate 44: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
1-4: **Pisces - Teleostei**:
Diverse views of a part of the ear bones set of a very small skull:
an exoccipital attributed to a gobiid Teleostei.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

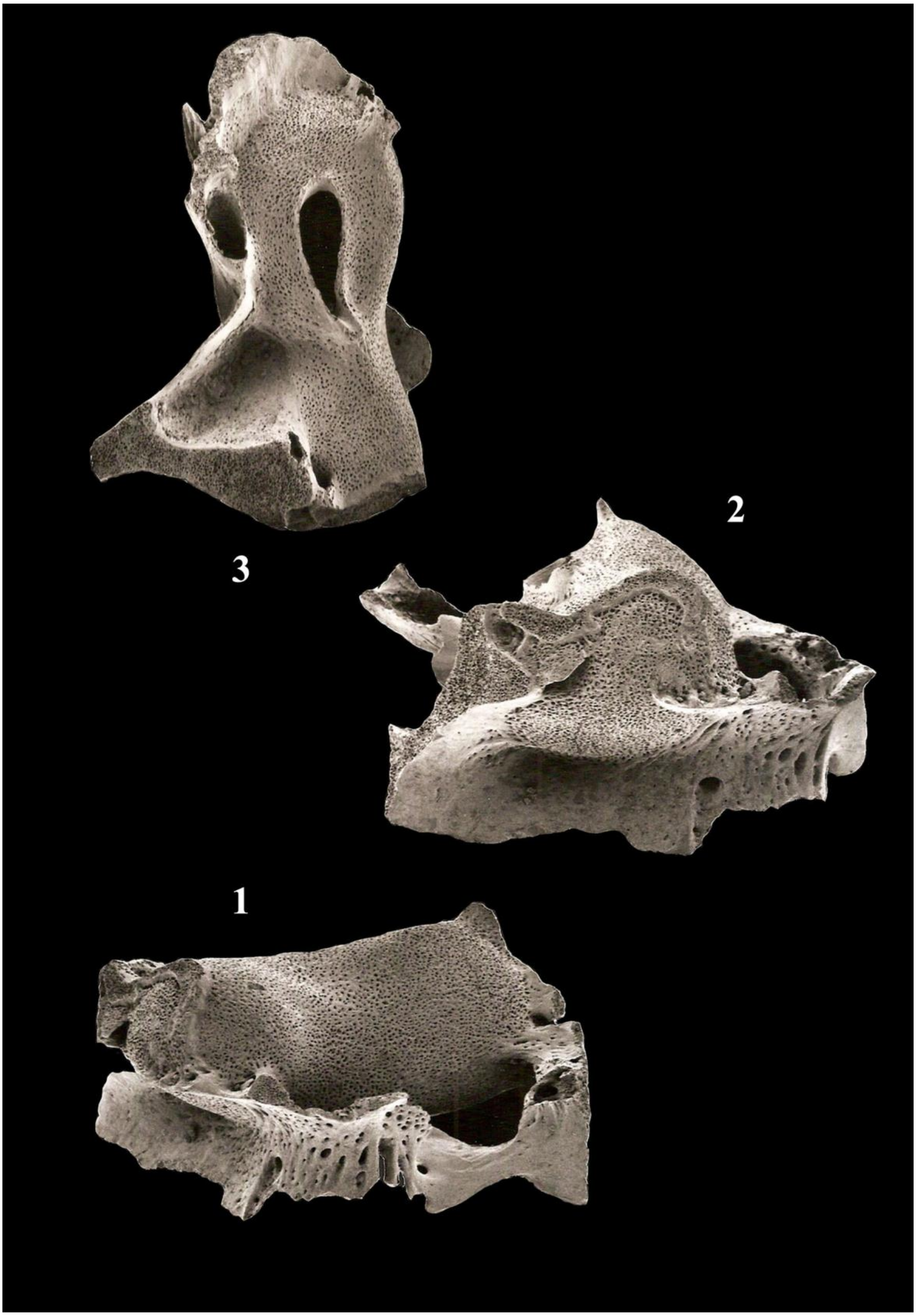


Plate 45: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
1-3: **Pisces - Teleostei**:
Diverse views of a part of the ear bones set of a very small skull:
an exoccipital attributed to a gobiid Teleostei.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

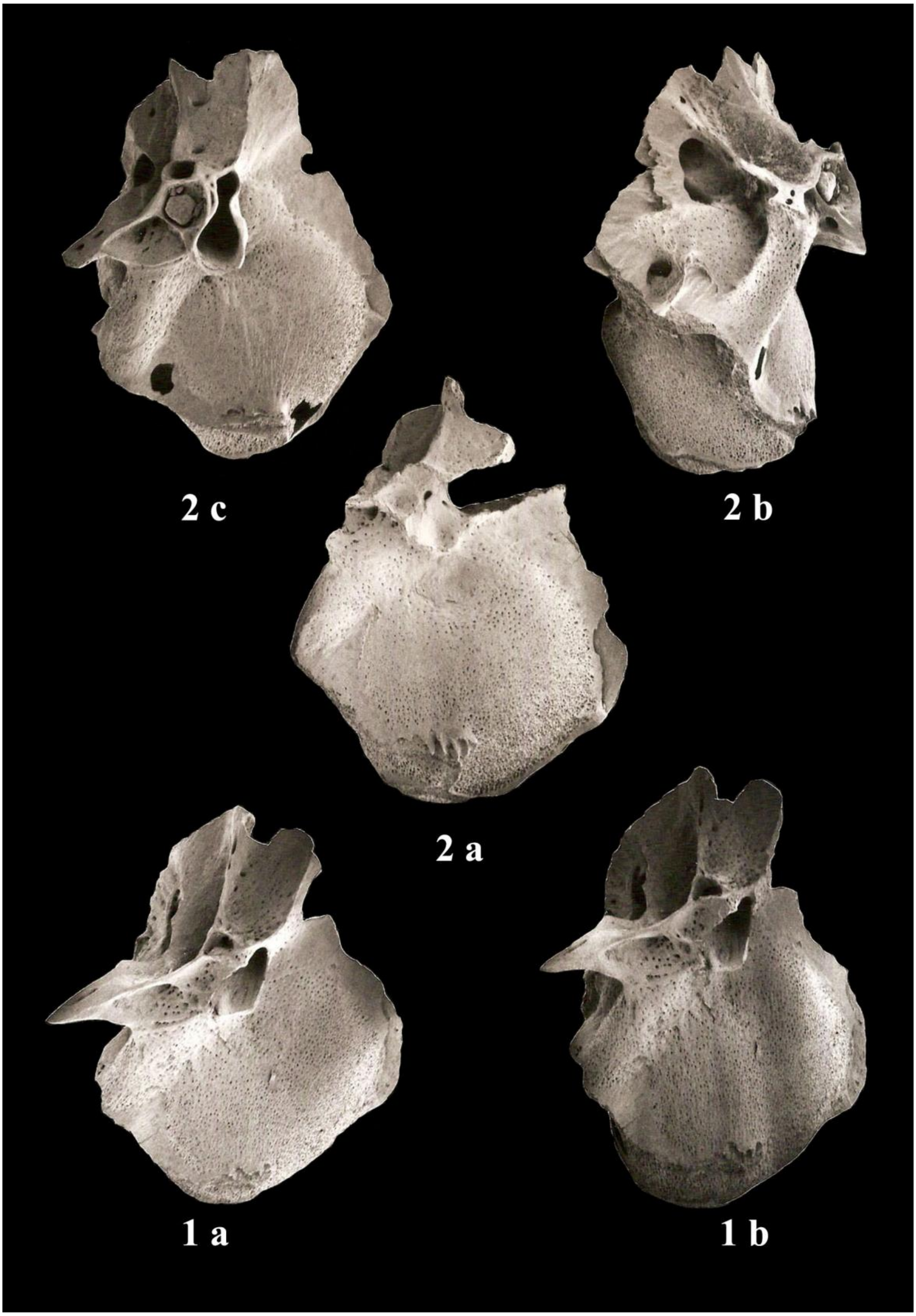
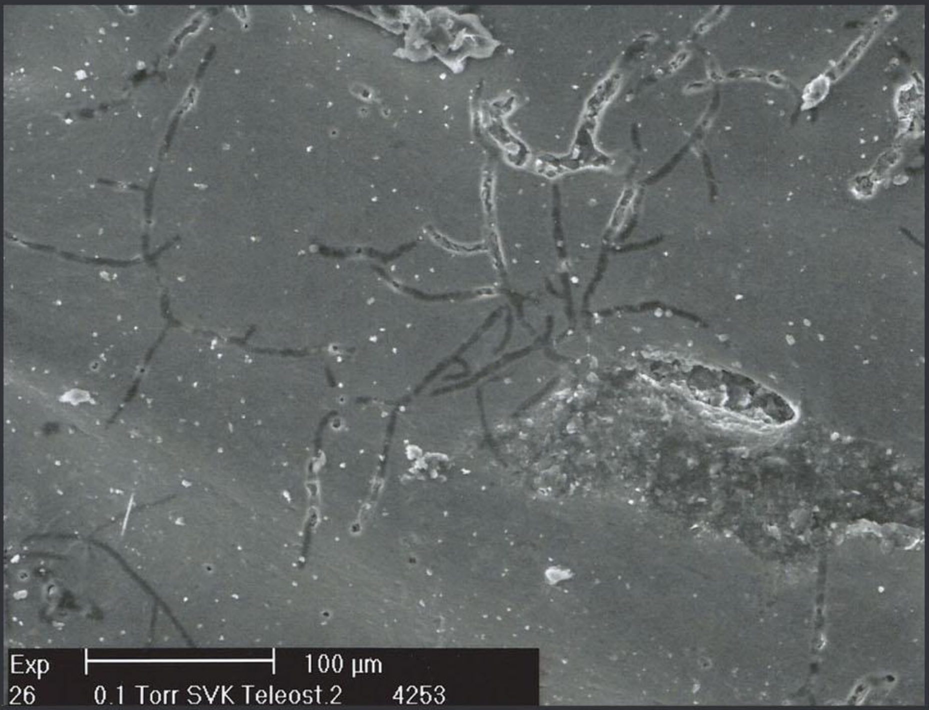
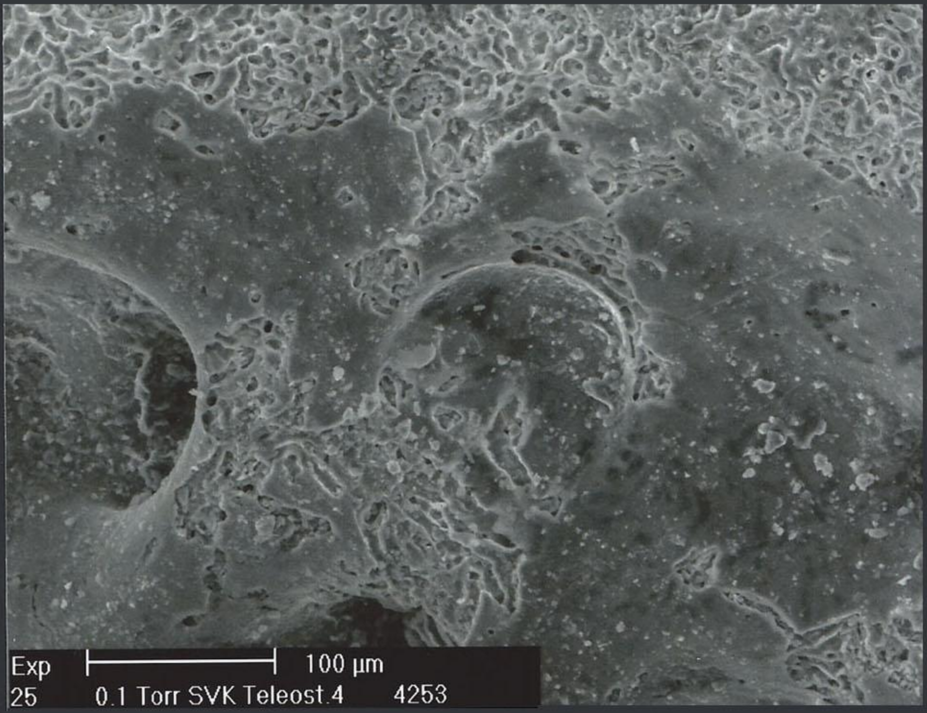


Plate 46: **BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394**
Fossils from the *Sint Niklaas Phosphorite Bed*
Pisces - Teleostei:
1a-**2c**: Diverse views of a part of two ear bones set of a very small skull
attributed to a gobiid Teleostei.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.



2



1

Plate 47: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394

Fossils from the *Sint Niklaas Phosphorite Bed*

1-2: **Pisces - Teleostei**: Mycelium damage on a teleost bone.

Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).

See comments.

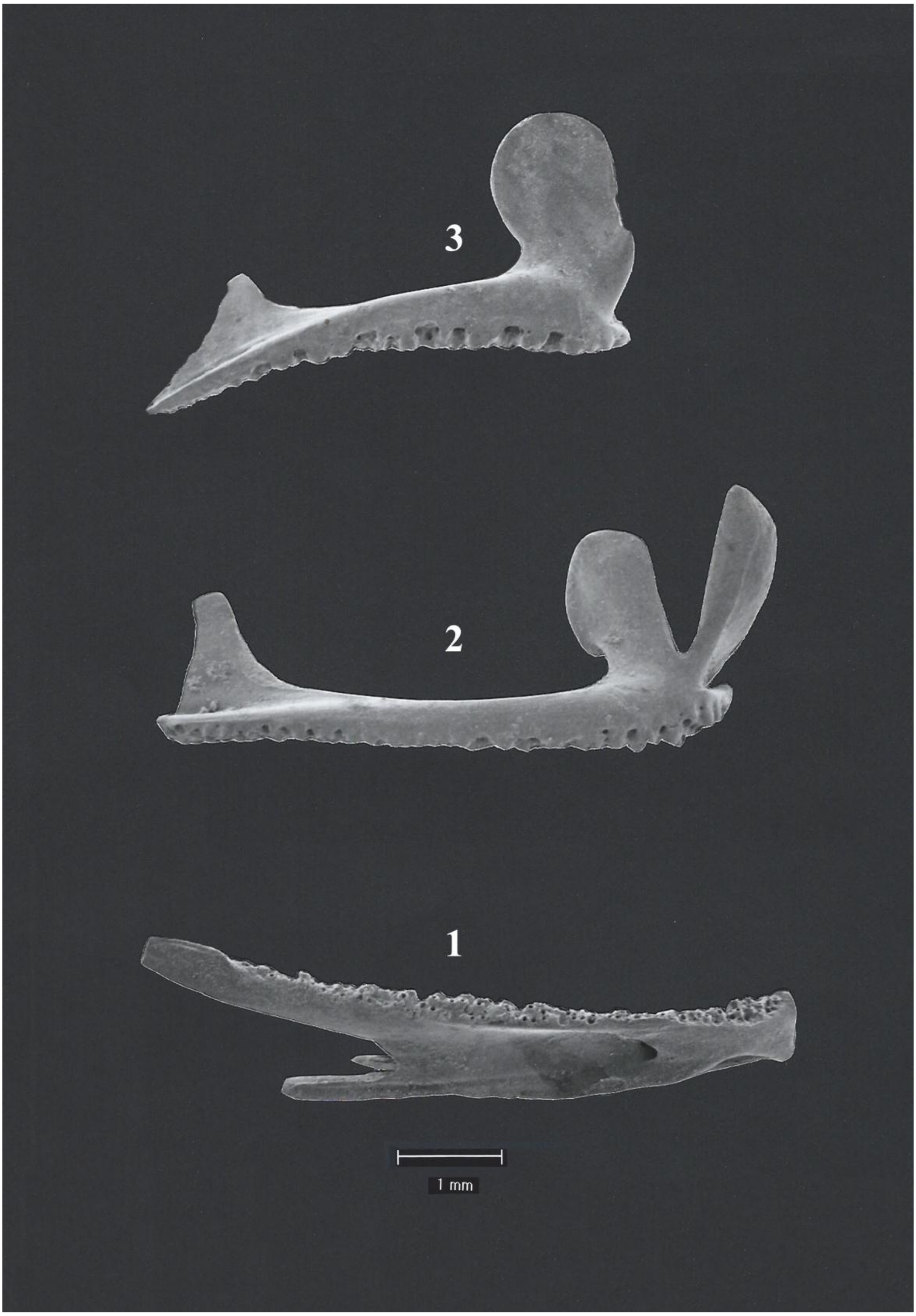


Plate 48: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1-3: **Pisces - Teleostei**: **Jaw bones**.
1: Lateral view of a right dentar. **2** and **3**: Lateral views of two right premaxillars.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

Plate 49: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1-5: **Pisces - Teleostei**: **Order Percomoformes**: **Family Scorpaenidae Risso, 1826**: Diverse cranial bones:
1: Extern view of a frontal. **2**: Extern view of a lachrymal. **3**: Extern view of a supracleithrum. **4**: Extern view of a large fragment of a preopercular. **5**: Extern view of a large fragment of a supracleithrum.
Private Collections. Determinations by Dr. Louis Taverne (I.R.S.N.B., Brussels, Belgium).
SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

Plate 50: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1-5: **Pisces - Teleostei**: Oblique anterior views of diverse vertebrae.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

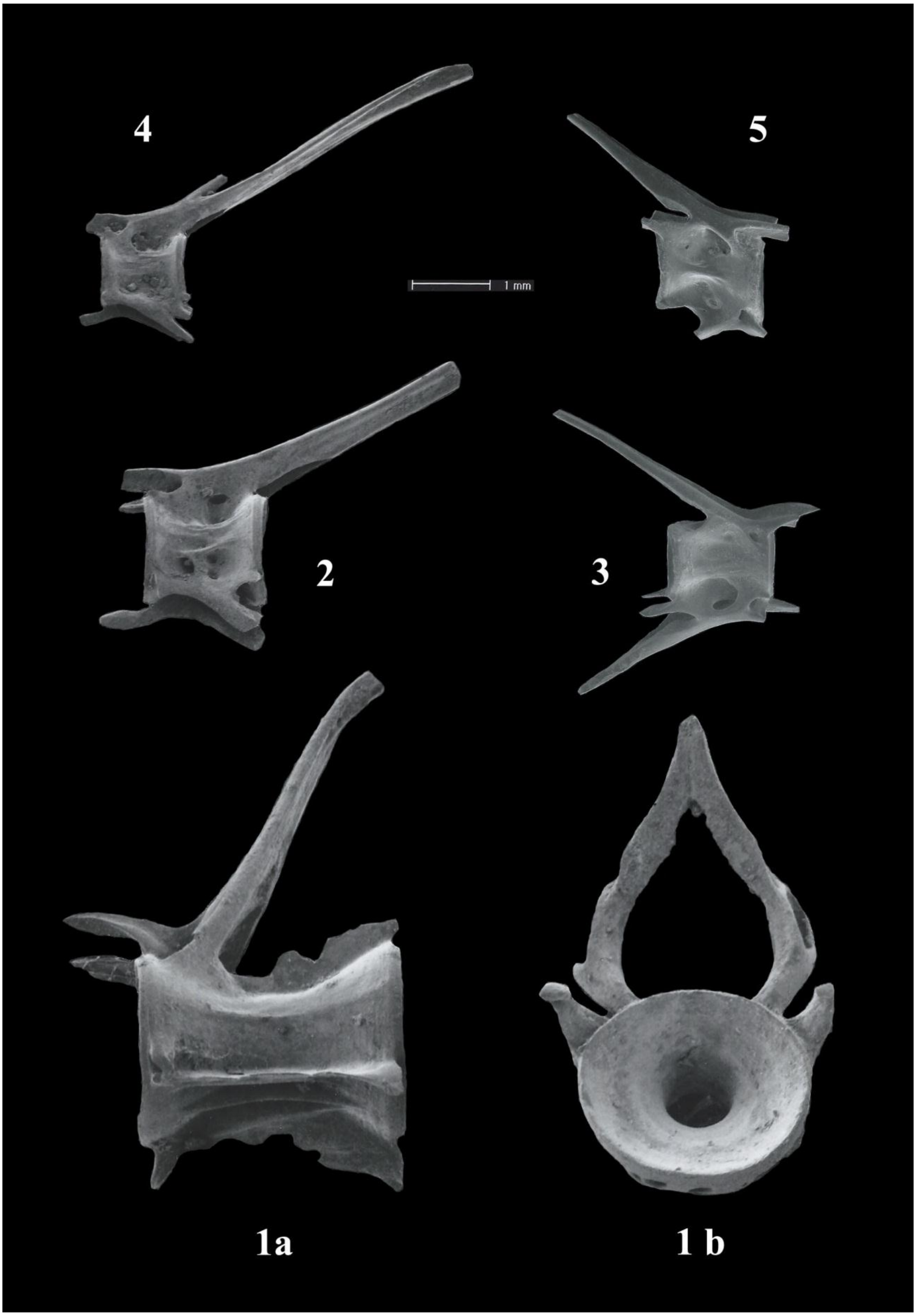


Plate 51: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1-5: **Pisces - Teleostei**: Views of diverse vertebrae.
1a-1b: A caudal vertebra. **2-5**: Four precaudal vertebrae.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

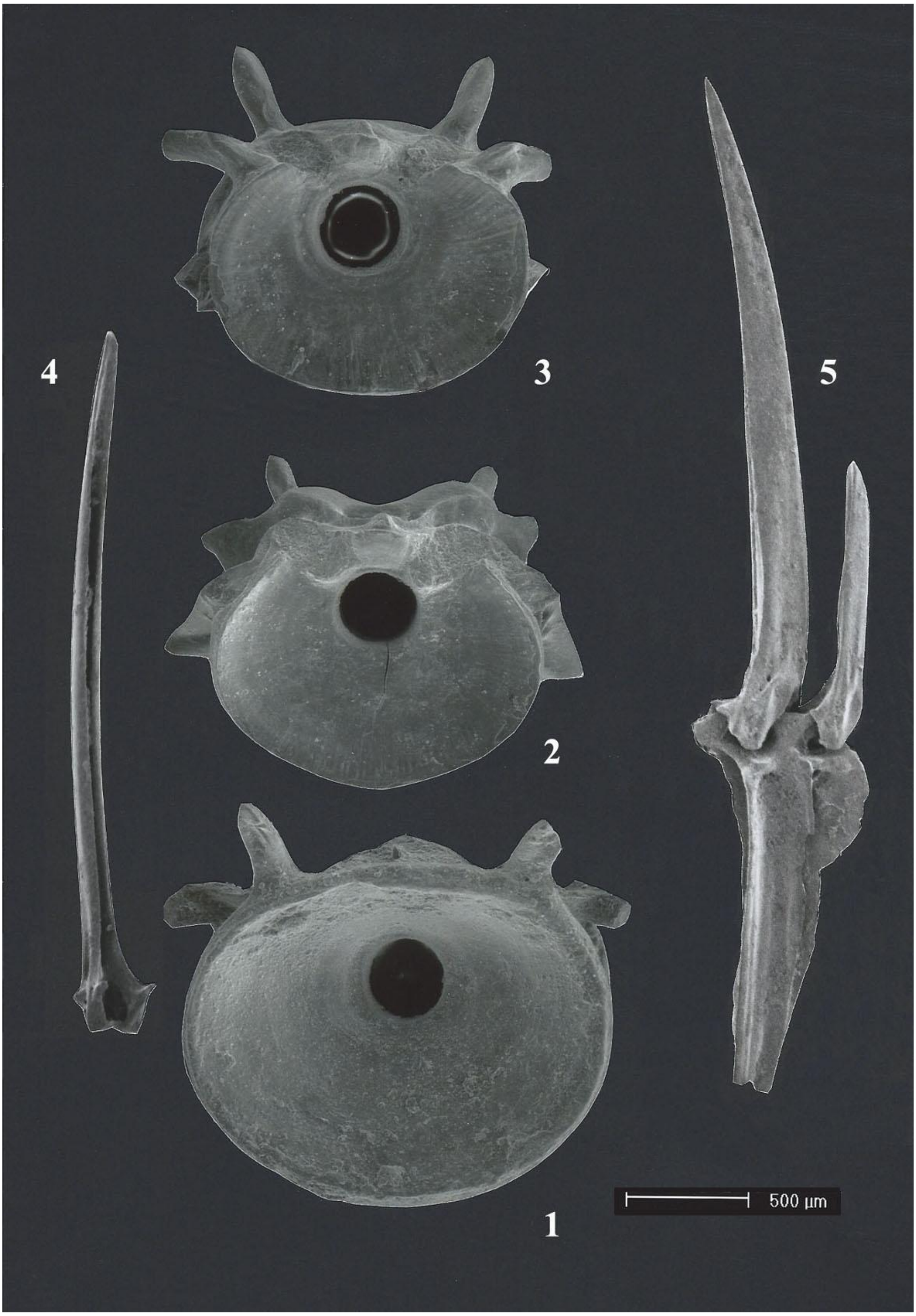


Plate 52: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1-5: **Pisces - Teleostei**: **Diverse axial bones**.
1-3: Anterior view of vertebrae centra. **4**: Lateral view of a dorsal spine.
5: Lateral view of articulated elements of a fin, remained in connection.
Private Collection. SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).
See comments.

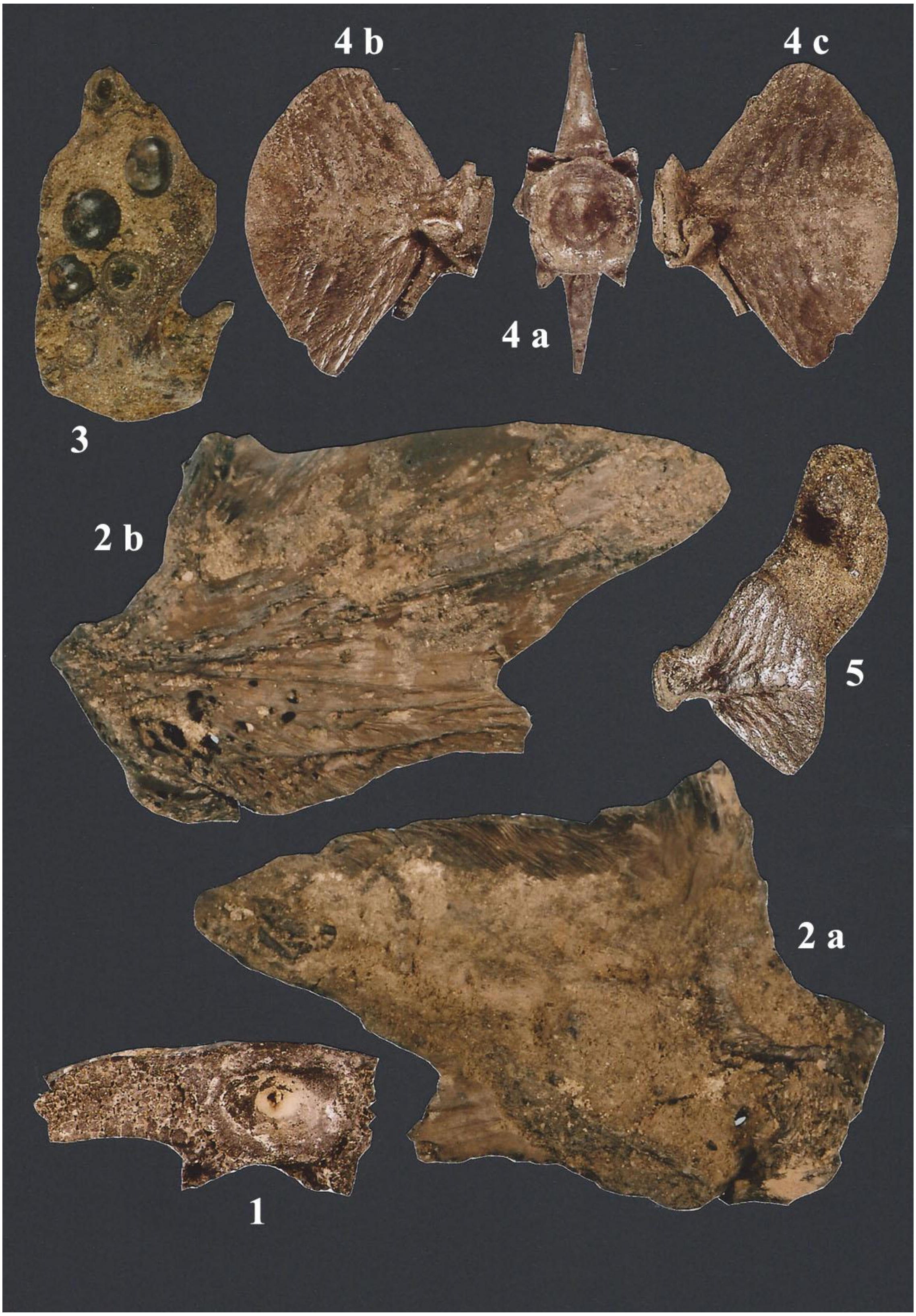


Plate 53: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossils from the *Sint Niklaas Phosphorite Bed*
1: **Pisces - Chondrichthyes**: **Family Squatinidae BONAPARTE, 1838**: **Genus *Squatina* DUMERIL, 1806**:
***Squatina angeloides* (VAN BENEDEN, 1873)**: View of the rear part of a *neurocranium*.
2 to **5**: **Pisces - Teleostei**: Diverse bones.
Private Collections. Photographs Guy Van Den Eeckhaut. See comments.

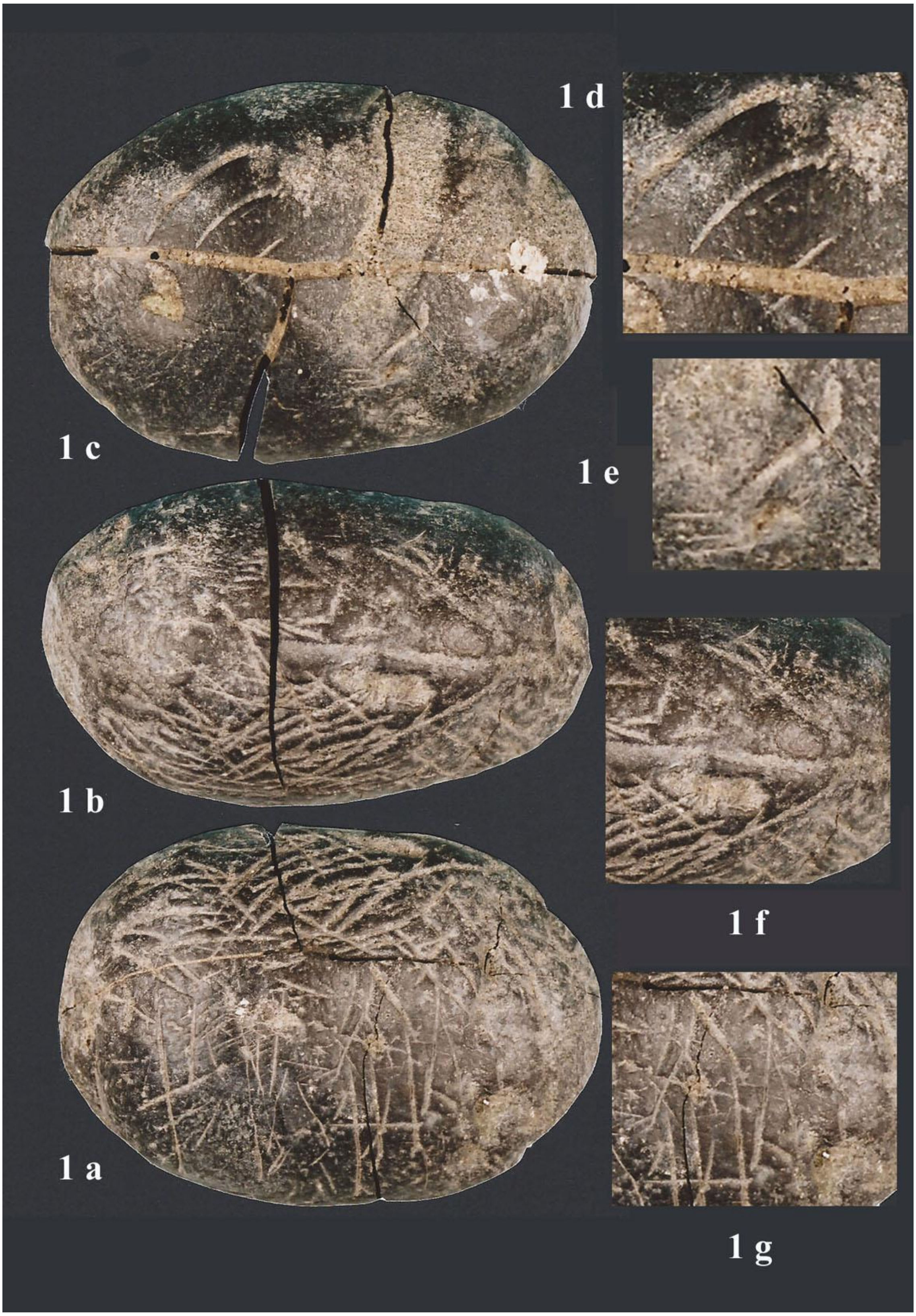


Plate 54: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394

Fossil from the *Sint Niklaas Phosphorite Bed*

Reptilia - Chelonia: *Cf.* Family Carettidae MERREM, 1820.

1a to **1c**: Three views of a weatherworn egg attributed to a sea turtle. **1d** to **1g**: Details. **1d**: This magnification shows a part of the future plastron and three ribs. **1e**: This magnification shows a rear leg in formation. **1f**: This magnification shows the short triangular section of the skull and the vertebral column, both in formation.**1g**: This magnification shows the regular disposition of the future hexagonal granular plates of the dorsal side of the future shell box.

Private Collection. Photographs Jacques Herman. See comments.

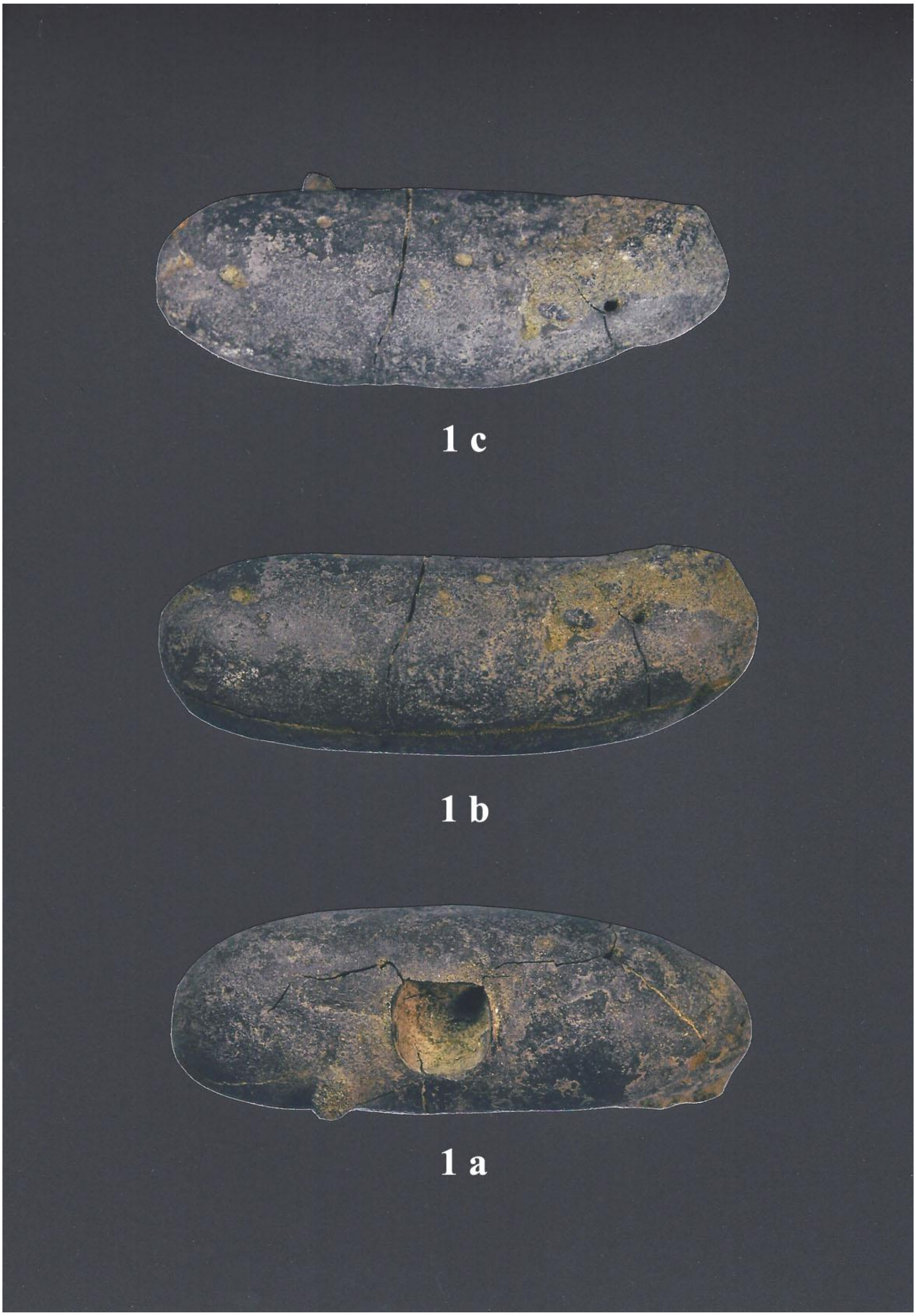


Plate 55: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
Reptilia - Chelonia: ***Cf.* Family Carettidae MERREM, 1820**.
1a to **1c**: Three views of a damaged weatherworn egg attributed to a sea turtle.
See X-rays photographs on Plate 56.
Private Collection. Photographs Jacques Herman.
See comments.

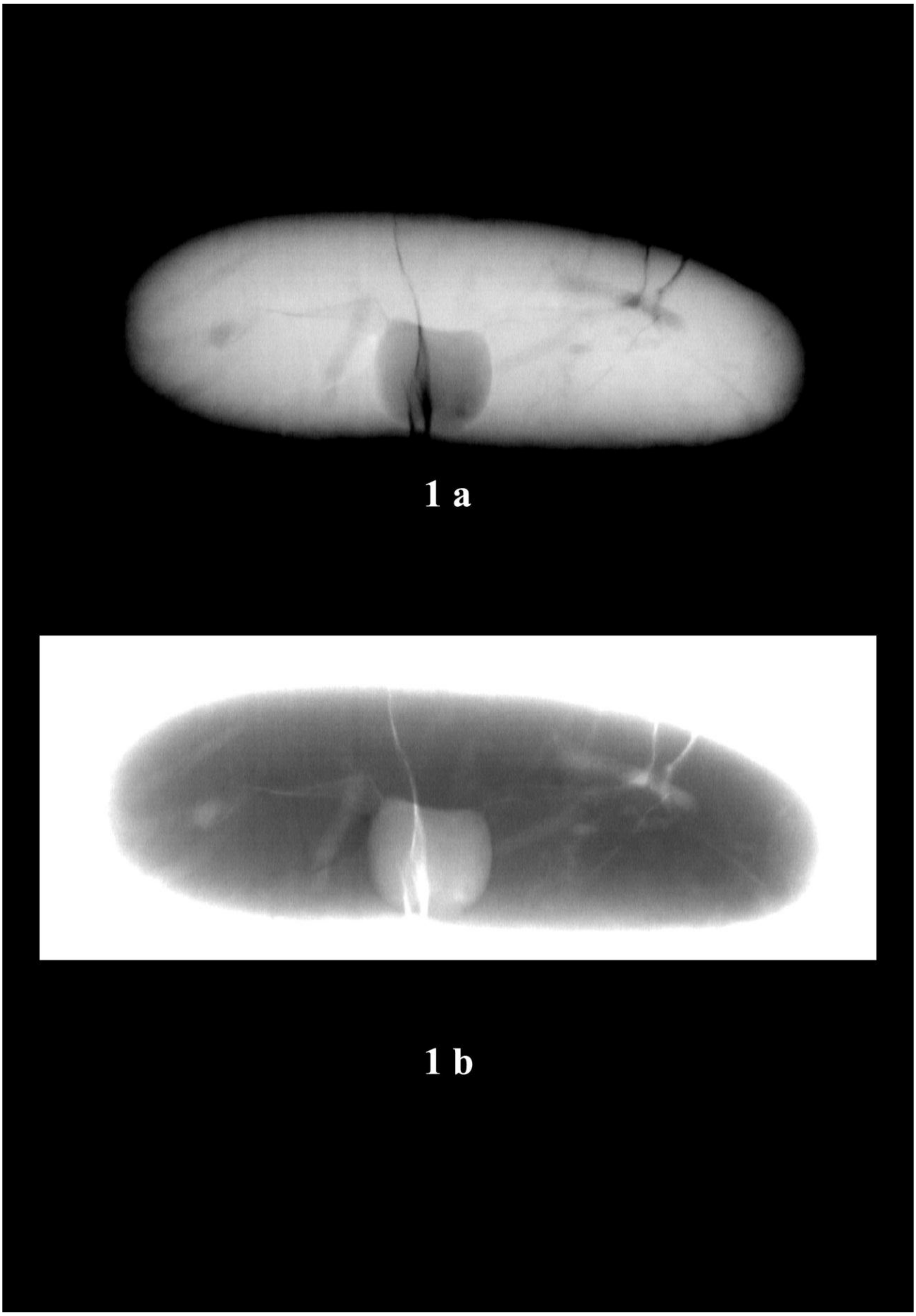


Plate 56: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 394
Fossil from the *Sint Niklaas Phosphorite Bed*
Reptilia - Chelonia: *Cf.* Family Carettidae MERREM, 1820
1a-1b: X-ray photographs of the damaged sea turtle egg illustrated on Plate 55.
Courtesy of the Laboratoire d’Analyse Physique et de Caractérisation du Matériau (Douai, France).
Private Collection. Photographs Lucille Géant. See comments.

Plate 57: SVK Clay Pit 4: B.G.S. Archives Codification: 42 W 513
1: **Pisces - Chondrichthyes - Neoselachii**:
1: Two views of a spur of a clasper of an adult male of ***Carcharocles angustidens*** **(Agassiz, 1843)** of *circa* 5m50 length. Total length: 10.5 millimetres.
2: **Reptilia - Crocodylia**:
2a and **2b**: Two lateral views of one caudal osteoderm of ***Osteolaemus*** **sp.** Height: 12.5 millimetres. Private Collections. Photographs Guy Van Den Eeckhaut. See comments.

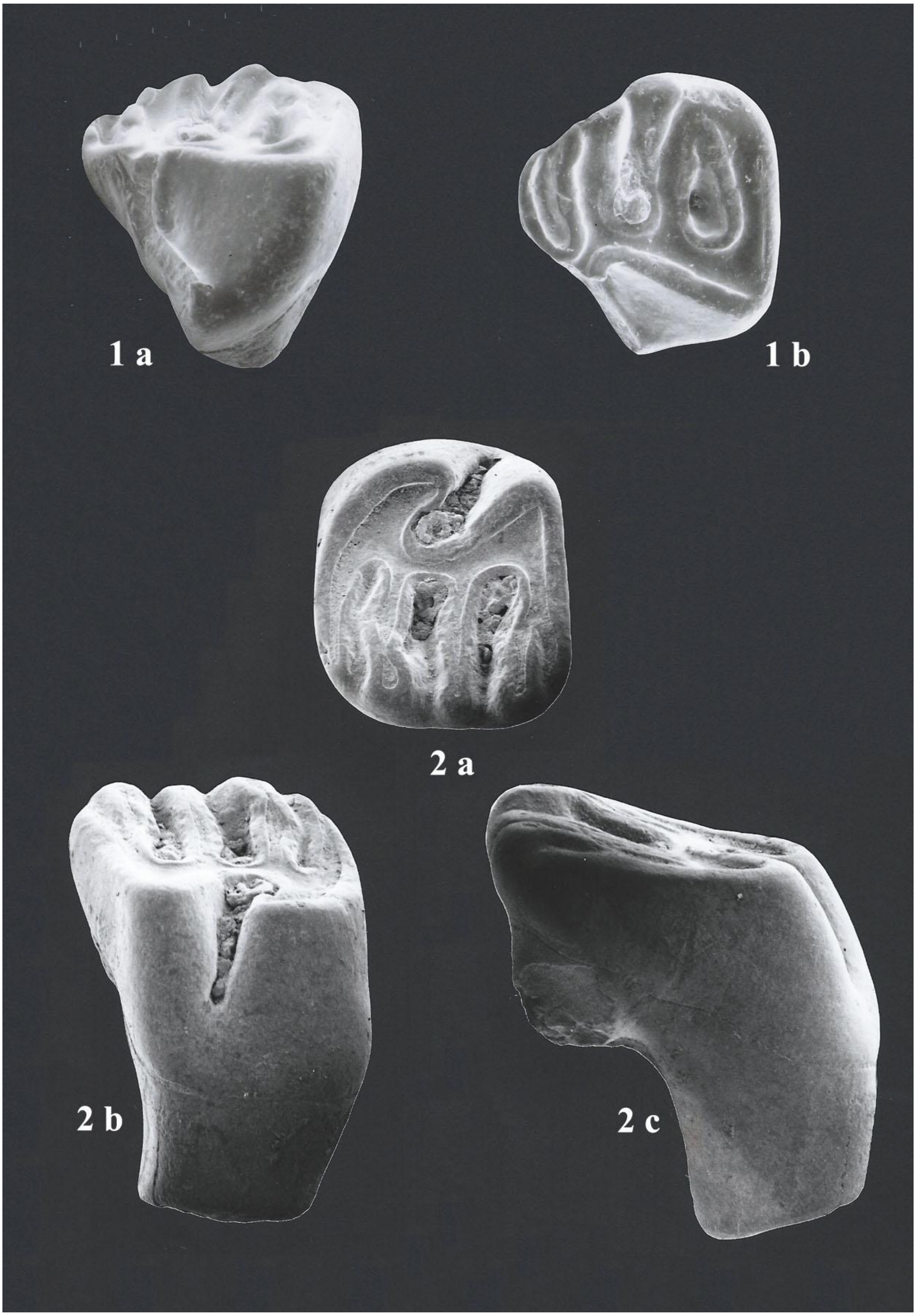


Plate 58: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 494
Fossils from the *Sint Niklaas Phosphorite Bed*
Mammalia - Rodentia - Theridomorpha - Family Theromyidae ALSTON, 1876:
Genus *Isoptychus* POMEL, 1852: ***Isoptychus cf. margaritae* (VIANEY-LIAUD, 1995)**.
1a-1b: Lateral and occlusal views of one incomplete right lower molar.
2a-2c: Occlusal, extern and lateral views of one complete right upper molar, or last premolar.
Collection Luc Anthonis. SEM photographs Julien Cillis I.R.S.N.B. (Brussels, Belgium). See comments.

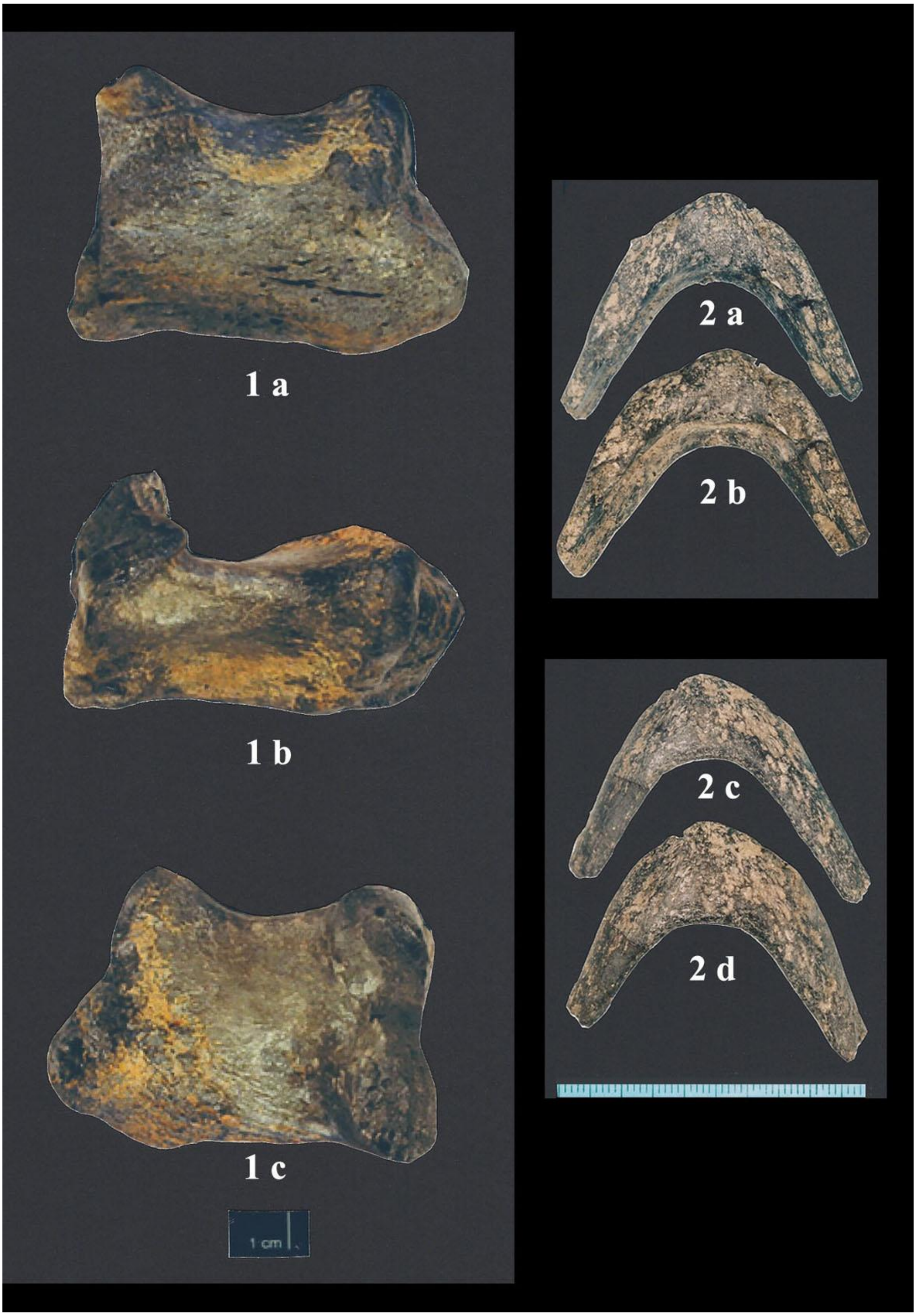


Plate 59: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives: N°: 42 W 515
Fossils from the *Sint Niklaas Phosphorite Bed*
1a to **1c**: **Mammalia**: Three different views of a *calcaneum* of an ***Anthracotherium* sp**.
Family Rhinocerotidae Gray, 1820 (**Perissodactyla - Mammalia**)
discovered by Guy Van Den Eeckhaut in the south-eastern Sector of the Clay Pit.
2a-2d: **Chelonia** – **Reptilia**: **Family Carettidae Gray, 1825**: Buccal and ventral views of two mandibles of a ***cf. Caretta* sp.** Private Collections. Photographs Guy Van Den Eeckhaut. See comments.

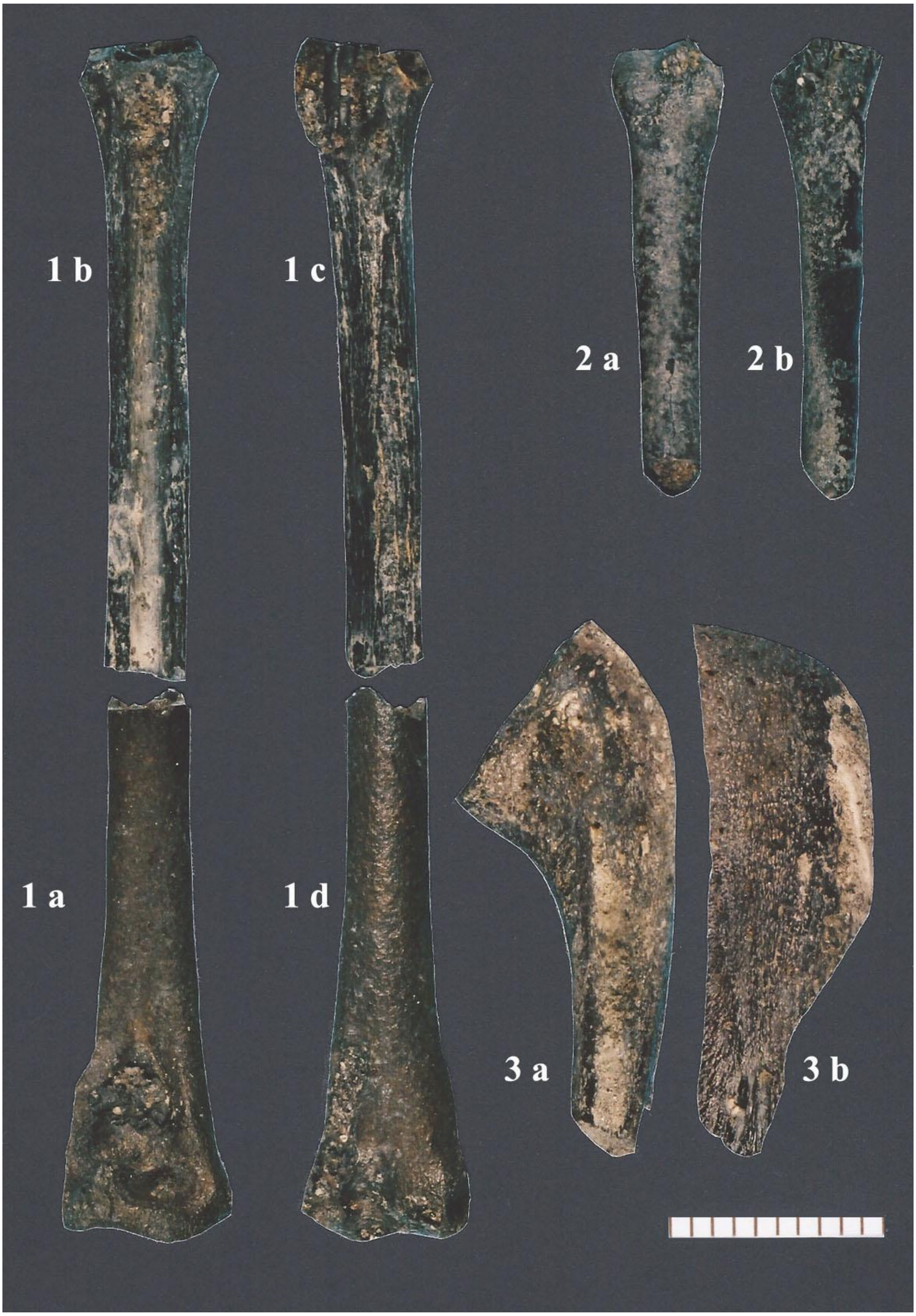


Plate 60: BELSELE: S.V.K. Clay Pit 4: B.G.S. Archives Codification: 42 W 513
Fossils from the *Sint Niklaas Phosphorite Bed*
Aves - Paleornithes - Family Pelargonithidae FÜRBRINGER, 1868: **Genus *Odontopteryx* OWEN, 1875**:
1a to **1d**: Four views of a broken *tibiotarsus*. **2a**-**2b**: Two views of an incomplete *tibiometatarsus*.
Reptilia - Chelonia - *cf.* Family Carettidae GRAY, 1825:
3a-**3b**: Buccal and ventral views of a right half mandible of a juvenile specimen.
Collection and Photographs Guy Van Den Eeckhaut. See Comments.

29. Comparison Plates: 61 to 114

General information

Composition of these Plates

The aim of each of these Plates is to illustrate some extant taxa* representatives of the fossil vertebrate taxa discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

*Or relevant parts of these taxa.

Sources of their iconography

Thanks to its Conservator: Mr Georges Lenglet, the senior-author has utilised comparative materials of the Department of Recent Vertrebrates of the I.R.S.N.B. (Brussels, Belgium).

Friends of the senior-author have also given the possibility to use diverse specimens of their own Collections: Messrs. Alain Bouvry, Pieter De Schutter, Theo Lambrechts, Frederik Mollen, Guy Van Den Eeckhaut, Eric Vanderhoeft and Eric Wille.

Consultation of the very rich Google's Imagery was another precious source of information, but sometimes needed some corrections. E.g.: Photos of *Rhincodon typus*, the whale shark, are mixed with photos of *Cetorhinus maximus*, the pilgrim shark.

Authorisation to reproduce some photographs

Photographs of private educational or scientific sources are utilised in the composition of these plates only destined for a non-commercial use.

Diverse national Institutions and some private photographers have generously contributed to the realisation of these Comparison Plates.

1 b

1 a

Plate 61: Pisces - Chondrichthyes - Holocephali: Family Rhinochimaeridae GARMAN, 1901: Genus *Rhinochimaera* GARMAN, 1901: *Rhinochimaera atlantica* HOLT & BYRNE, 1909.
1a-1b: Male of 110 centimetres of total length.
1a: Oblique view of this individual. **1b**: Detail of its head.
Senior-author's catch and Photographs. See comments.

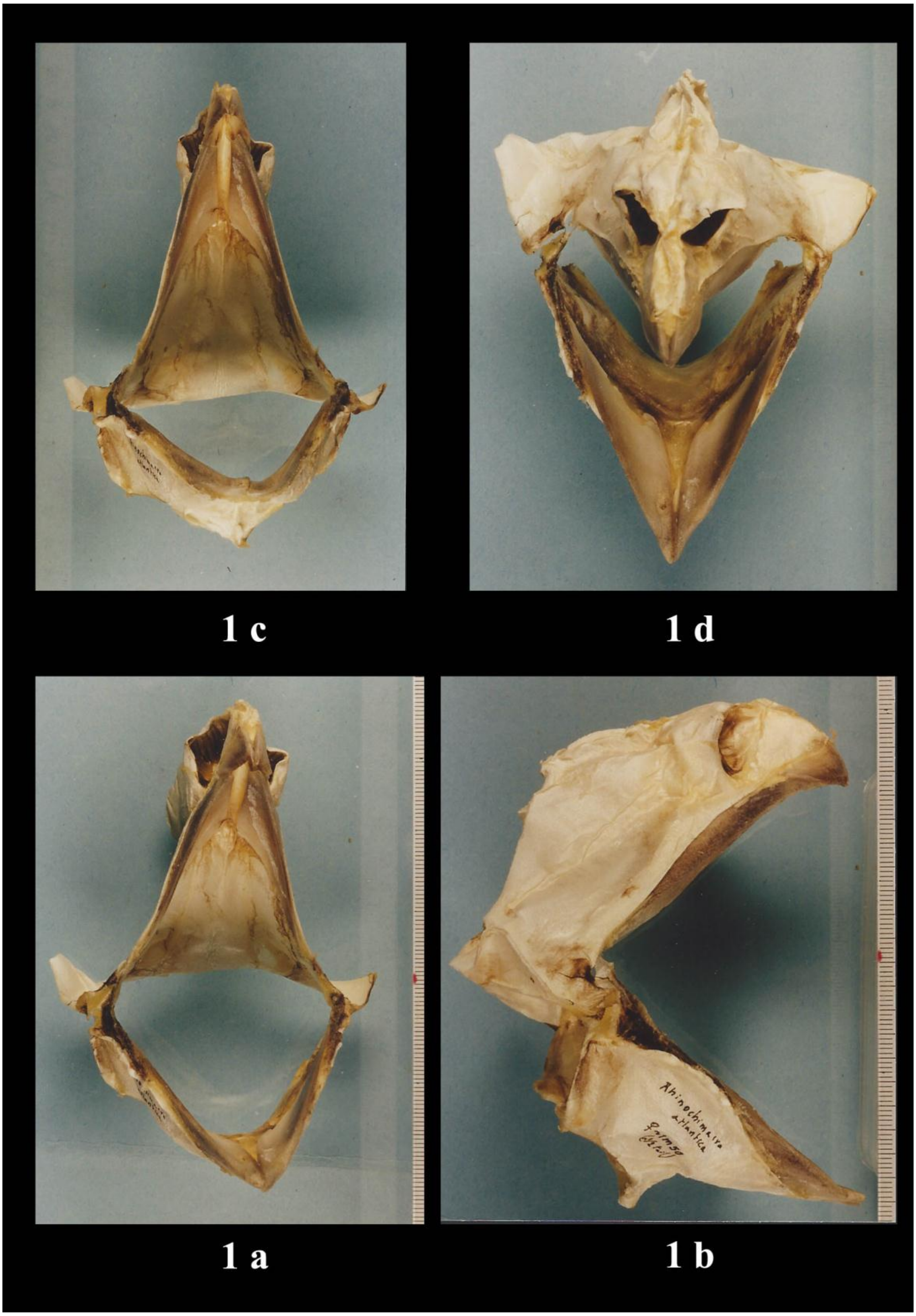


Plate 62: Pisces - Chondrichthyes - Holocephali: **Family Rhinochimaeridae** G**ARMAN**, **1901: Genus** ***Rhinochimaera*** G**ARMAN**, **1901**: ***Rhinochimaera atlantica*** **H**OLT **& B**YRNE, **1909**.
1a to 1d: Different views of the jaws and the dental plates of a female of 120 centimetres of total length.
Origin: Senior-author’s explorations 10.04.1979 between 840 and 900 metres depth.
Position of the trawler: 60°00’N - 13°15’ W, South Lousy Bank, North-East Atlantic.
Collection Frederik Mollen. Photographs Jacques Herman.
See comments.

Plate 63: Pisces - Chondrichthyes - Holocephali: **Family Rhinochimaeridae GARMAN, 1901**: **Genus *Rhinochimaera* GARMAN, 1901**: ***Rhinochimaera atlantica* HOLT & BYRNE, 1909**.
1a: Lateral view of the tenaculum of a male of 110 centimetres of total length.
1b: Intern view of this tenaculum after dissolution by digestive enzymes.
2 and **3**: Lateral and basal views of two *tenaculum* spines. Magnification X 45.
SEM photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium). See Comments.

2

1

Plate 64: Pisces - Chondrichthyes: **Comparison between the jaws of**
1: **Family Hexanchidae Gray**, **1851** and **2**: **Family Heptranchidae Barnard**, **1925**.
1: Extern view of the jaws of a ***Heptranchias perlo*** **(Bonnaterre**, **1788)**.
2: Extern view of the jaws of a ***Notorynchus cepedianus*** **(Peron**, **1807)**.
Collection and photographs Frederik Mollen. See comments.

Plate 65: Pisces - Chondrichthyes: Comparison between the jaws of
1: Family Hexanchidae GRAY, 1851: Genus *Hexanchus* RAFINESQUE, 1810
Extern view of the jaws of a female ***Hexanchus griseus*** **(BONNATERRE, 1788)** of 315 centimetres length.
2: Family Heptranchidae HERMAN & VAN WAES, 2012: Genus *Notorynchus* AYRES, 1855:
Extern view of the jaws of a juvenile female ***Notorynchus cepedianus*** **(PERON, 1807)** of 130 centimetres length.
Collection and Photographs Dirk and Maria Hovestadt. See comments.

1

Plate 66: Pisces - Chondrichthyes - Neoselachii:
Family Hexanchidae GRAY, 1851:
1: Genus *Hexanchus* RAFINESQUE, 1810: ***Hexanchus griseus* (BONNATERRE, 1788)**.
Collection and Photograph Frederik Mollen. Female of 463 centimetres of total length. N-E. Atlantic.
See Comments.

1 a

1 b

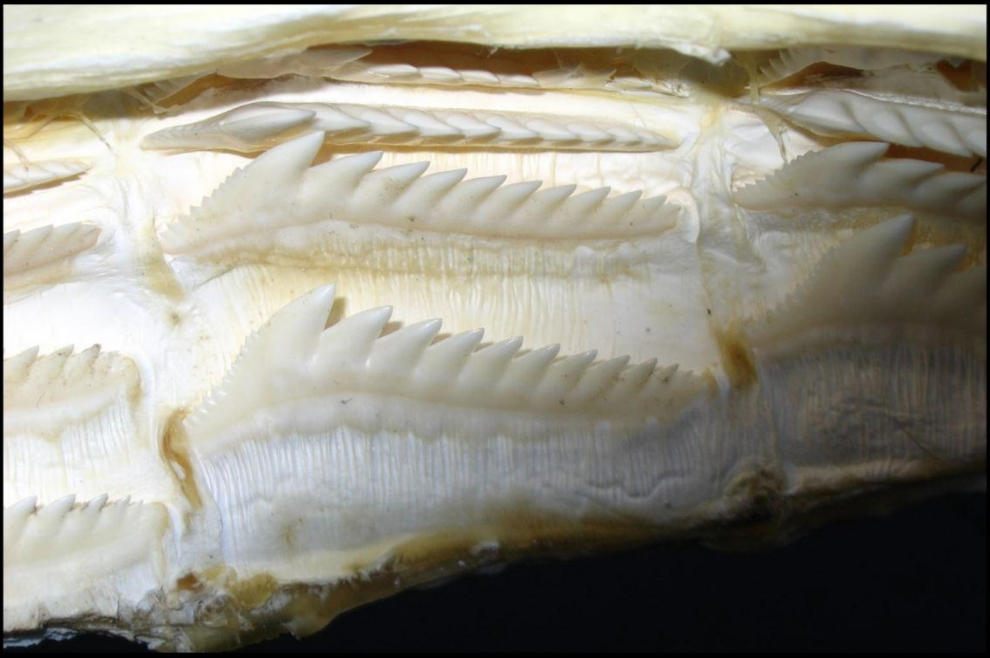
1 c

Plate 67: Pisces - Chondrichthyes - Neoselachii:
Family Heptranchidae BARNARD, 1925:
Genus *Notorynchus* AYRES, 1855: ***Notorynchus cepedianus*** (**PERON, 1807**).
1a: Lateral view of a female. **1b**: Detail of its head. **1c**: View of its head and its dentition.
Origin: Off the South Africa coasts.
Photos and Collection Frederik Mollen. See comments.

2

1

Plate 68: Pisces - Chondrichthyes - Neoselachii:
Family Hexanchidae Gray, 1851:
Genus *Hexanchus* Rafinesque, 1810: ***Hexanchus griseus* (Bonnaterre, 1788)**.
1: Lower symphyseal and first anterior rows. **2**: Upper symphyseal and first anterior rows.
Collection and Photographs Frederik Mollen.
See comments.



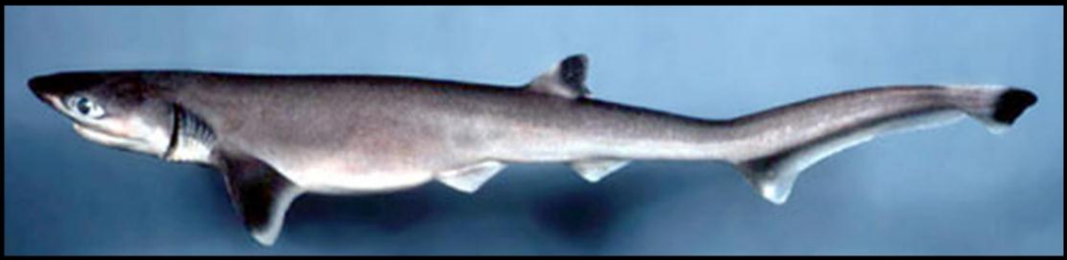
2

1

Plate 69: Pisces - Chondrichthyes - Neoselachii:
Family Hexanchidae Gray, 1851:
Genus *Hexanchus* Rafinesque, 1810: ***Hexanchus griseus* (Bonnaterre, 1788)**.
1-2: Views of the first and second lower anterior teeth rows.
Collection and Photographs Frederik Mollen.
See comments.

3

2



1

Plate 70: Pisces - Chondrichthyes - Neoselachii:
Family Heptranchidae BARNARD, 1925:
Genus *Heptranchias* RAFINESQUE, 1810: ***Heptranchias perlo* (BONNATERRE, 1788)**.
1: Lateral view of an adult female. Source: The National Marine Fisheries Service (NMFS), a U.S. government organization. **2**: Detail of a part of the lower dentition of another specimen. **3**: Intern view of the dentition of the lower part of another specimen. **2** and **3**: Courtesy of George H. Burgess, Florida Museum of Natural History
All the Websites are given in the Comments.

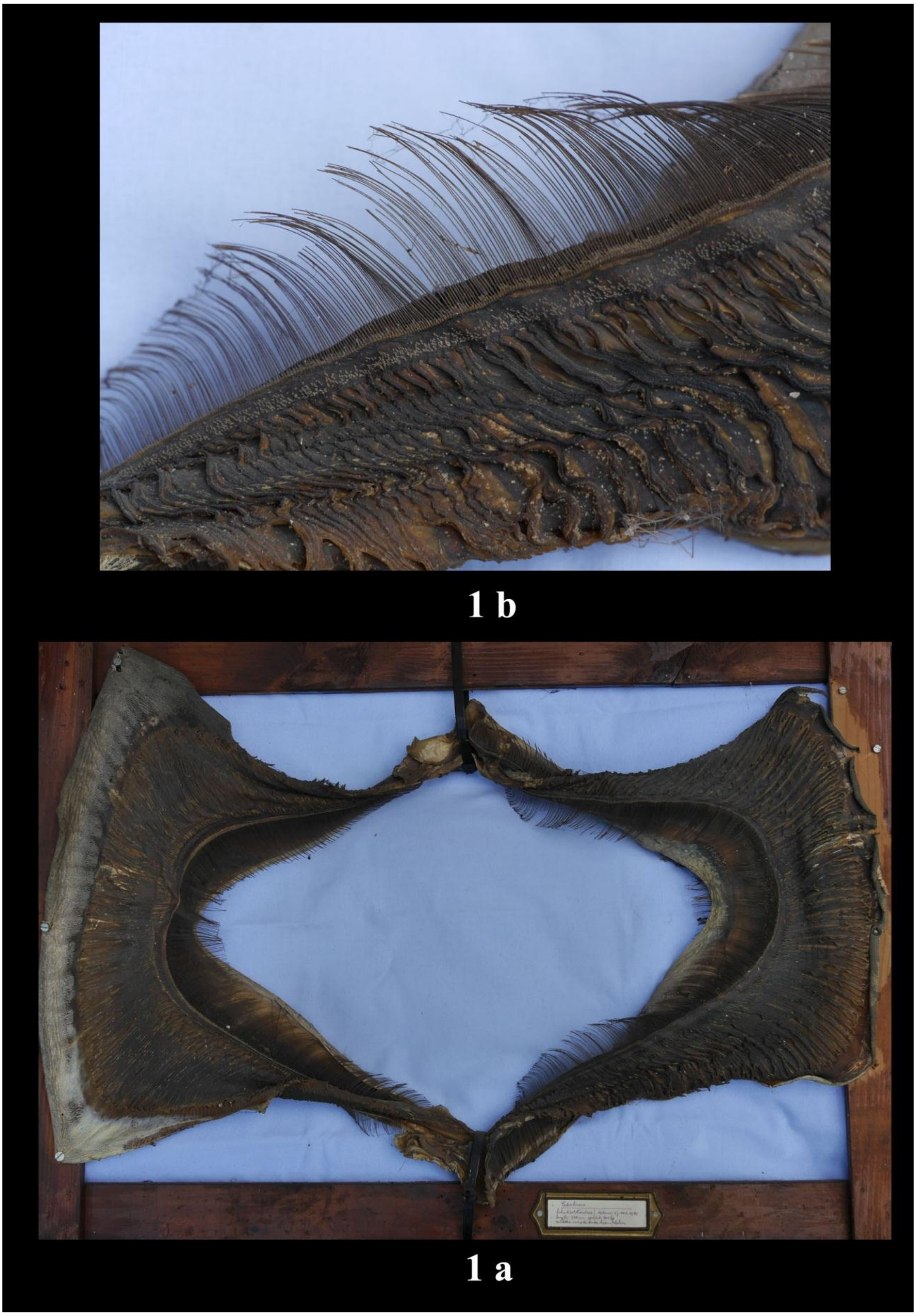


Plate 71: Pisces - Chondrichthyes - Neoselachii: Family Cetorhinidae GILL, 1862: Genus *Cetorhinus* de BLAINVILLE, 1816: *Cetorhinus maximus* (GUNNERUS, 1765).
1a: Intern view of one complete gill arch. **1b**: Magnification allowing a better view of its *fanonculi*.
Fish-market of Breskens. Origin: North Sea.
Gift of Dirk and Maria Hovestadt. Photographs Eric Vanderhoeft.
See comments.

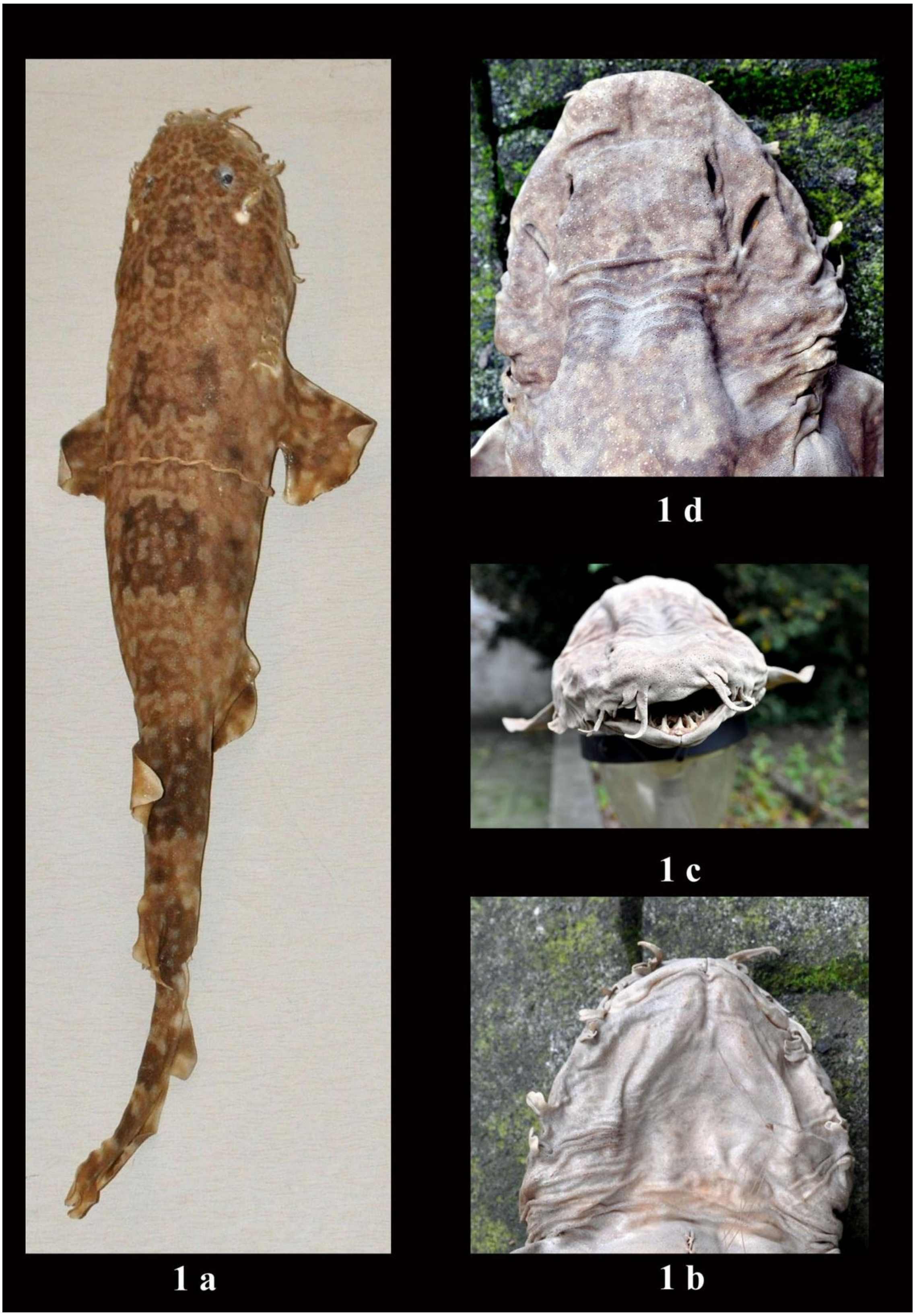


Plate 72: Pisces - Chondrichthyes - Neoselachii:
Family Orectolobidae GILL, 1896: **Genus *Orectolobus* BONAPARTE, 1834**:
***Orectolobus japonicus* REGAN, 1906**.
1a: Dorsal view of an adult specimen. Total length: 78 cm. Origin: The Philippines.
1b to **1d**: Details of its head.
Collection and Photographs Eric Vanderhoeft. See comments.

1 b

1 a

Plate 73: Pisces - Chondrichthyes - Neoselachii:
Family Squatinidae BONAPARTE, 1838:
Genus *Squatina* DUMERIL, 1806: ***Squatina africana* REGAN, 1908**.
1a: Dorsal view of a female of 88 centimetres length. **1b**: Detail of its head.
Origin: off South African coasts. Photographs Frederik Mollen.
See comments.

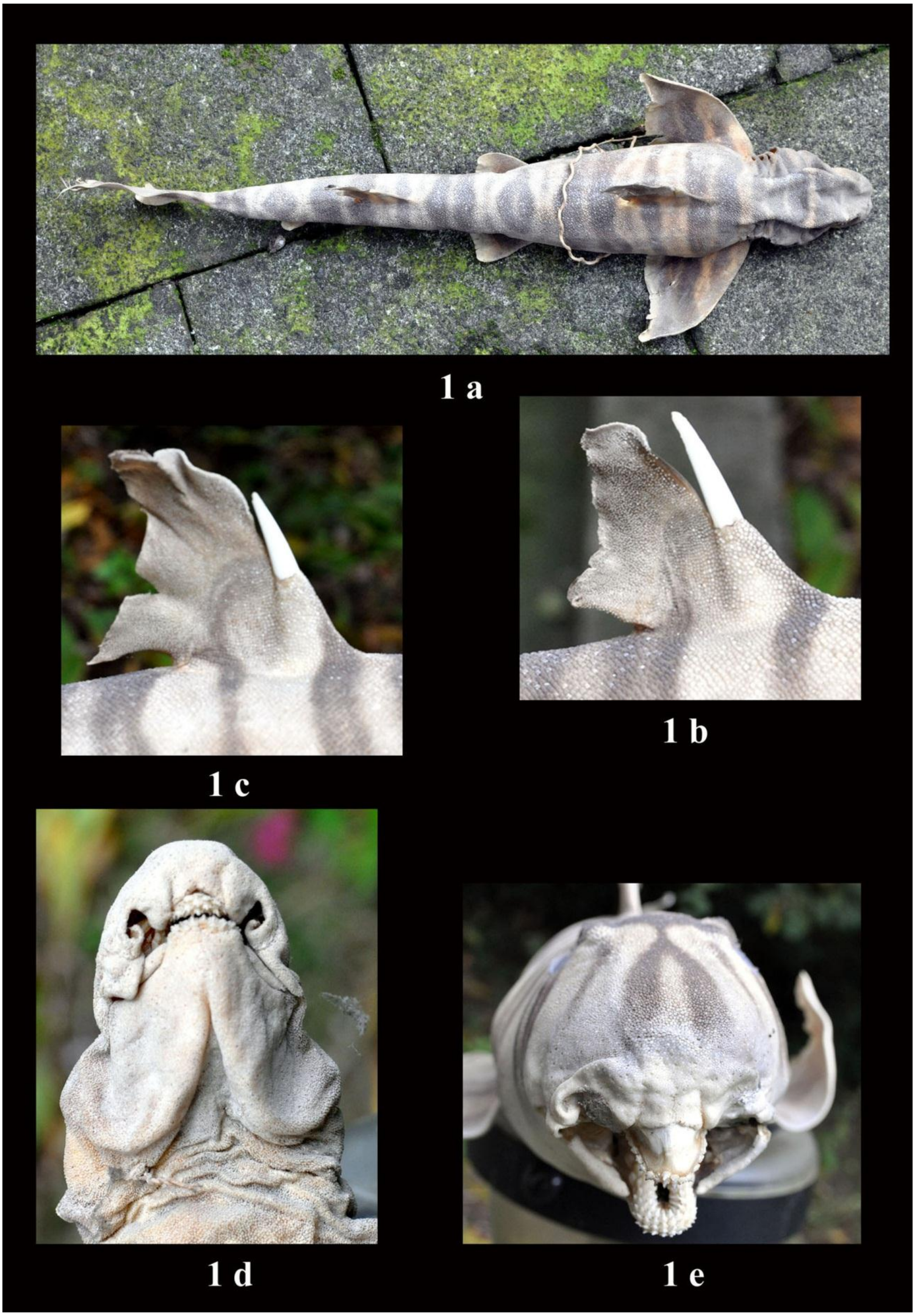
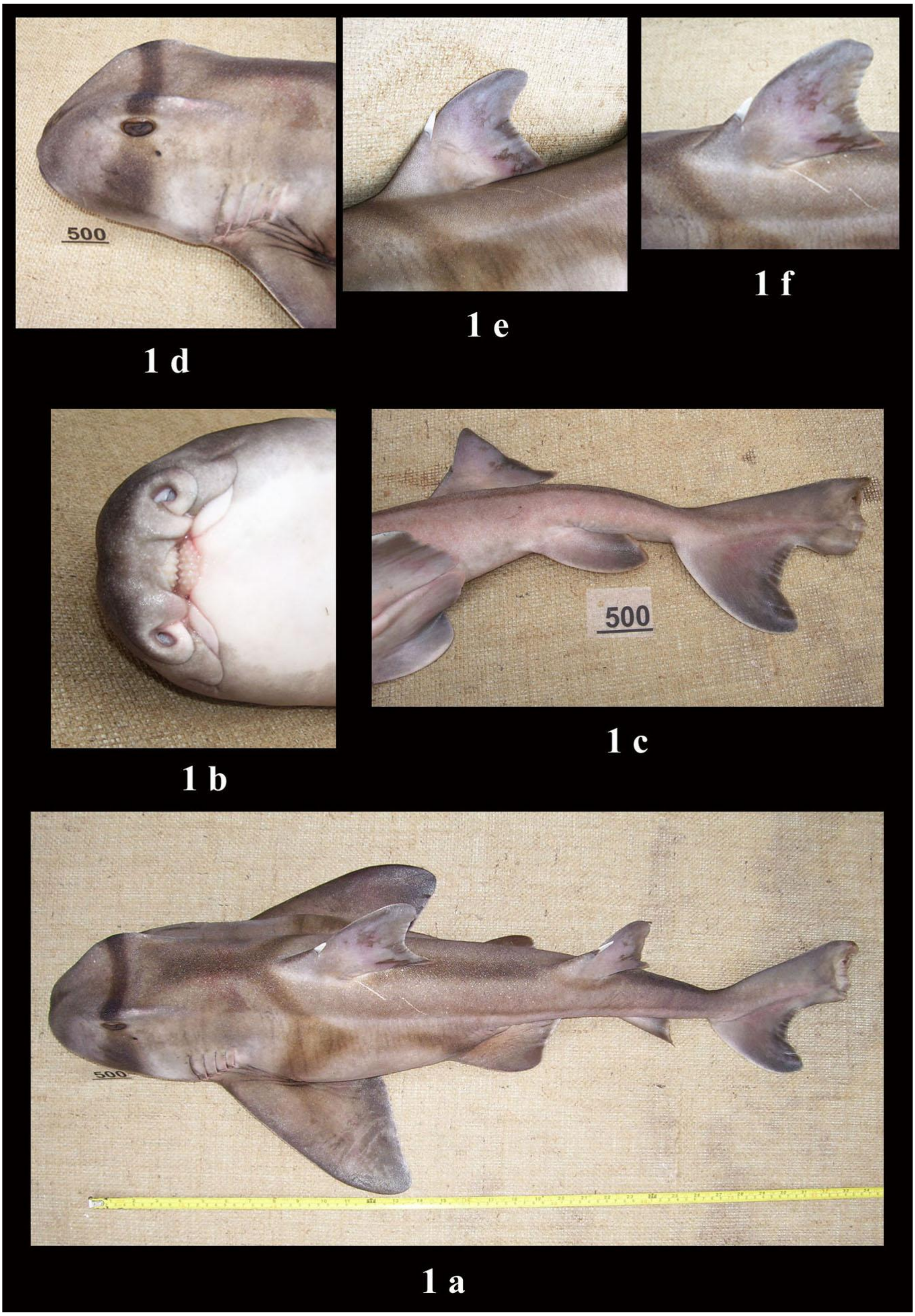


Plate 74: Pisces - Chondrichthyes - Neoselachii:
Family Heterodontidae GRAY, 1851:
Genus *Heterodontus* de BLAINVILLE, 1816: ***Heterodontus zebra* (GRAY, 1831)**.
1a: Dorsal view of a stuffed juvenile specimen. Total length: 39.5 cm. **1b**: Detail of its first dorsal fin and spine. **1c**: Detail of its second dorsal fin and spine. **1d**: View of the lower face of its head. **1e**: Anterior view of its head. Lower anterior teeth are visible. Origin: The Philippines.
Collection and Photographs Eric Vanderhoeft. See comments.



1 d

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Plate 75: Pisces - Chondrichthyes - Neoselachii: **Family Heterodontidae GRAY, 1851**: **Genus *Heterodontus* de BLAINVILLE, 1816**: ***Heterodontus portusjacksoni* MEYER, 1793**.
1a: Dorsal view of a female of 84.5 centimetres length. **1b**: Detail of the lower side of its head.
1c: Lateral view of its rear part. Origin: off South African coasts.
Collection and Photographs Frederik Mollen.
See comments.

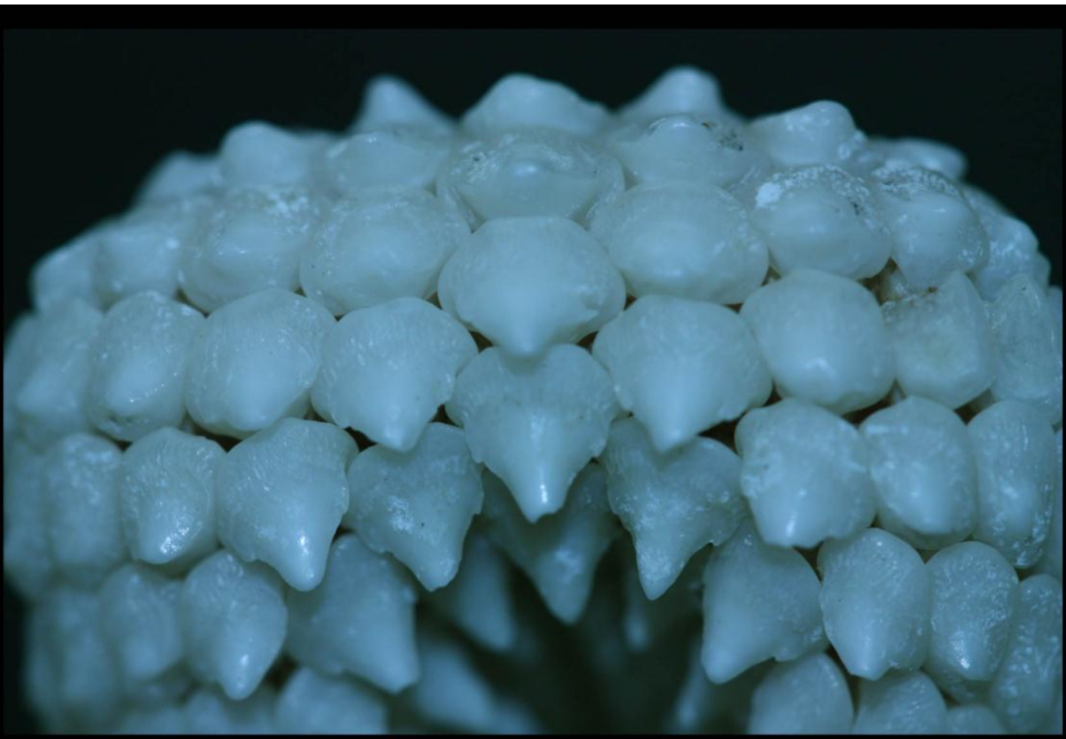

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Plate 76: Pisces - Chondrichthyes - Neoselachii: **Family Heterodontidae Gray, 1851**:
Genus *Heterodontus* de Blainville, 1816: ***Heterodontus portusjacksoni* Meyer, 1793**.
Female of 84.5 centimetre length. Origin: Off south-western coasts of Australia.
1a: Upper view of the lower anterior dental rows.
1b: Oblique view of the lower latero-anterior and first lateral dental rows.
Collection and Photographs Frederik Mollen. See comments.

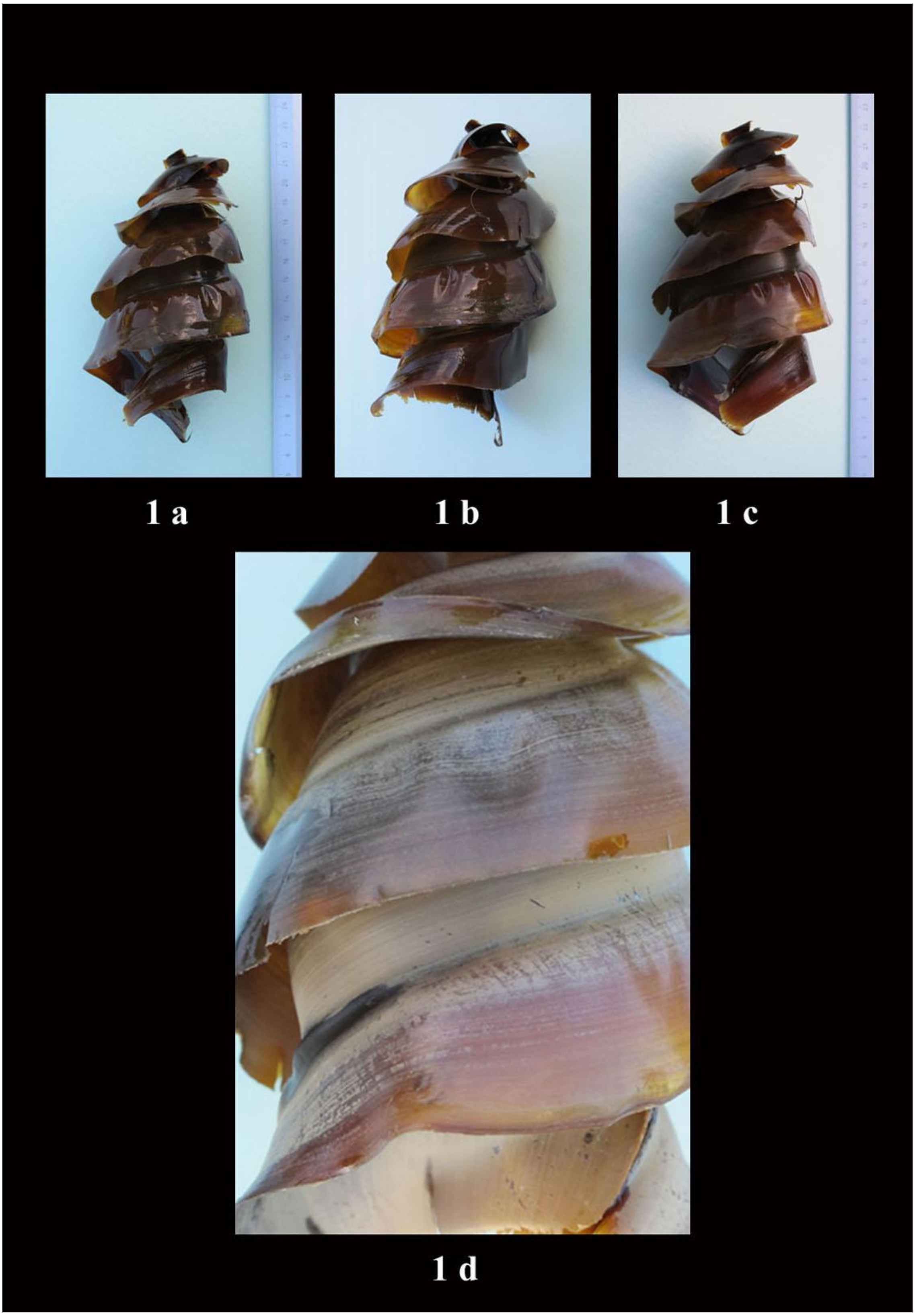

Plate 77: Pisces - Chondrichthyes - Neoselachii: **Family Heterodontidae GRAY**, **1851**: **Genus *Heterodontus* de BLAINVILLE**, **1816**: ***Heterodontus portusjacksoni* MEYER**, **1793**:

1a to **1c**: Three lateral views of one egg of this species.

1d: Magnification of the upper part of this egg.

Gift to the senior-author. Photographs Frederik Mollen.

See comments.

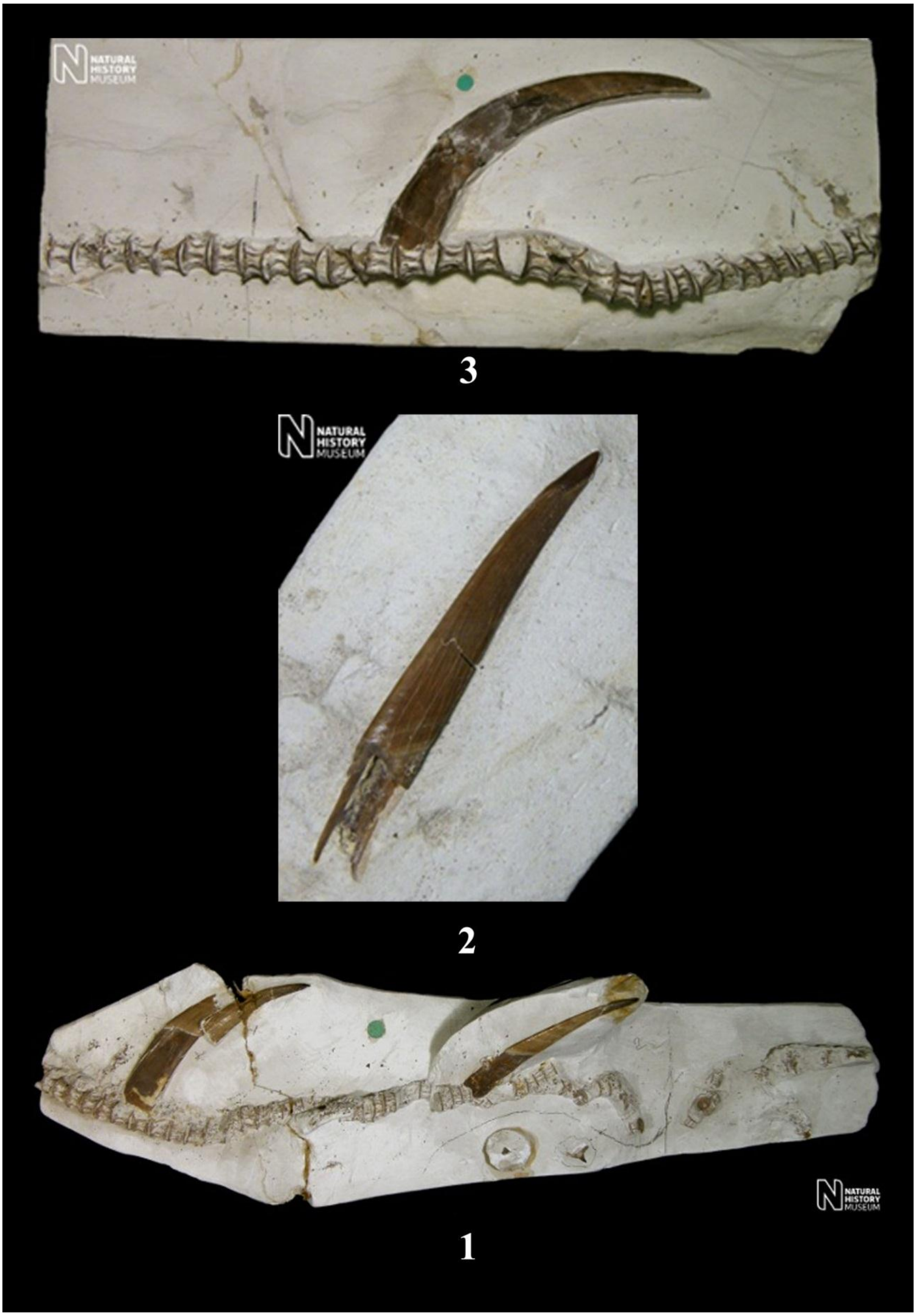

Plate 78: Upper Cretaceous British remains of the Family Squalidae.
Courtesy of the British Natural History Museum of London.
1 and **3**: Lateral views of a part of the vertebral columns with their two dorsal fin spines still in position.
2: Detail of the morphology and the structure of a dorsal fin spine.
See comments.

Plate 79: Pisces - Chondrichthyes - Neoselachii:
Family Squalidae de BLAINVILLE, 1816:
Genus *Squalus* LINNAEUS, 1758: ***Squalus acanthias* LINNAEUS, 1758**.
1: Frontal view of a skull with its jaws. Website: www.biolib.cz
Courtesy of Pavel Zuber
See comments.

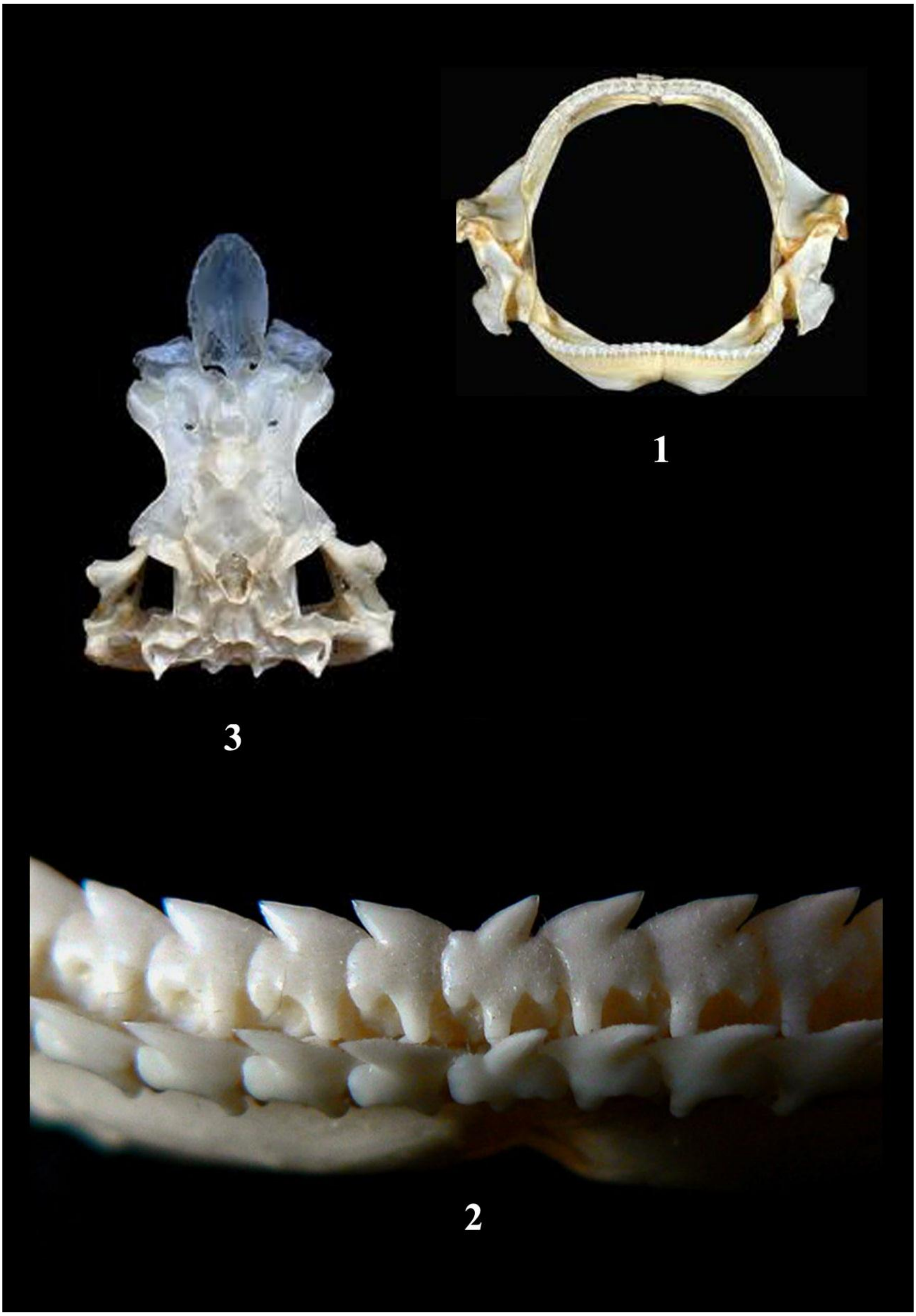

Plate 80: Pisces - Chondrichthyes - Neoselachii:
Family Squalidae de BLAINVILLE, 1816:
Genus *Squalus* LINNAEUS, 1758: ***Squalus acanthias* LINNAEUS, 1758**. See Comments.
1: Jaws of an adult specimen. Website: www.neotropicalfishes.lifedesks.org
2: Detail of the symphyseal zone of another jaw. Website: www.biolib.cz
3: Lower face of the skull. Website: www.biolib.cz
1: Courtesy of Ross Robertson. 2-3: Courtesy of Pavel Zuber.

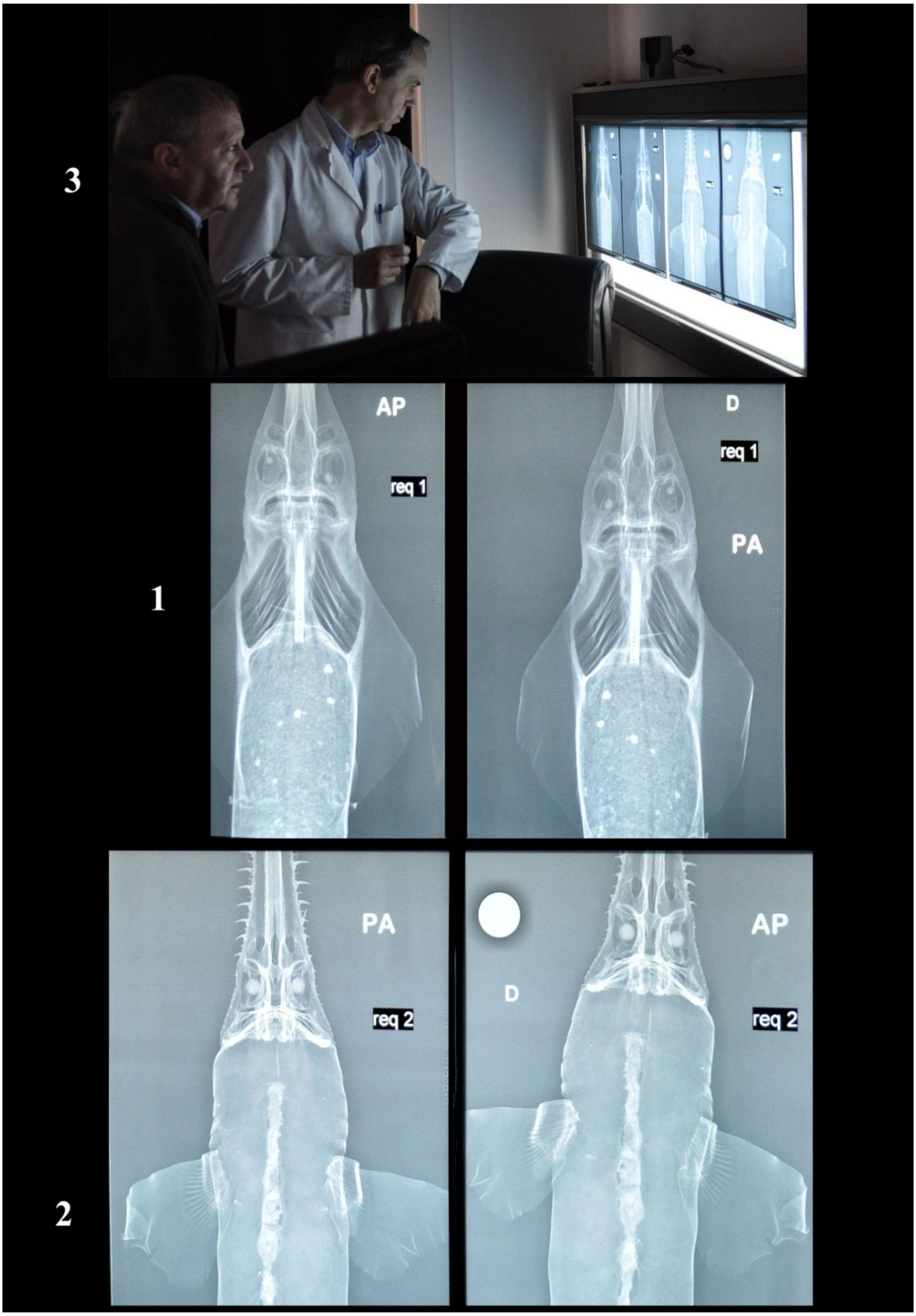

Plate 81: 1: Recent specimen of ***Pristis microdon*** **LATHAM, 1794** (Indonesia, Female,76 cm t. l.) and **2:** Recent specimen of ***Pristiophorus cirratus*** **LATHAM, 1794** (Japan, Female,70.5cm t. l.), from the Private Collection Eric Vanderhoeft) for comparison, by x-rays, with the fossil skull discovered in the *Sint Niklaas Phosphorite Bed* by Pieter De Schutter. The X-rays are a courtesy of Dr. Jean-Marie Geurts (Wemmel, Brussels, Belgium).
3: The senior author on the left and Dr. J.-M. Geurts on the right. See comments.

Plate 82: Recent specimens of **1**: ***Pristis microdon*** **LATHAM**, **1794** (Indonesia,76 cm t. l.)
and **2**: ***Pristiophorus cirratus*** **LATHAM**, **1794** (Japan,70.5cm t. l.),
from the Private Collection Eric Vanderhoeft) for comparison, by x-rays,
with the fossil skull discovered in the *Sint Niklaas Phosphorite Bed* by Pieter De Schutter.
See comments.

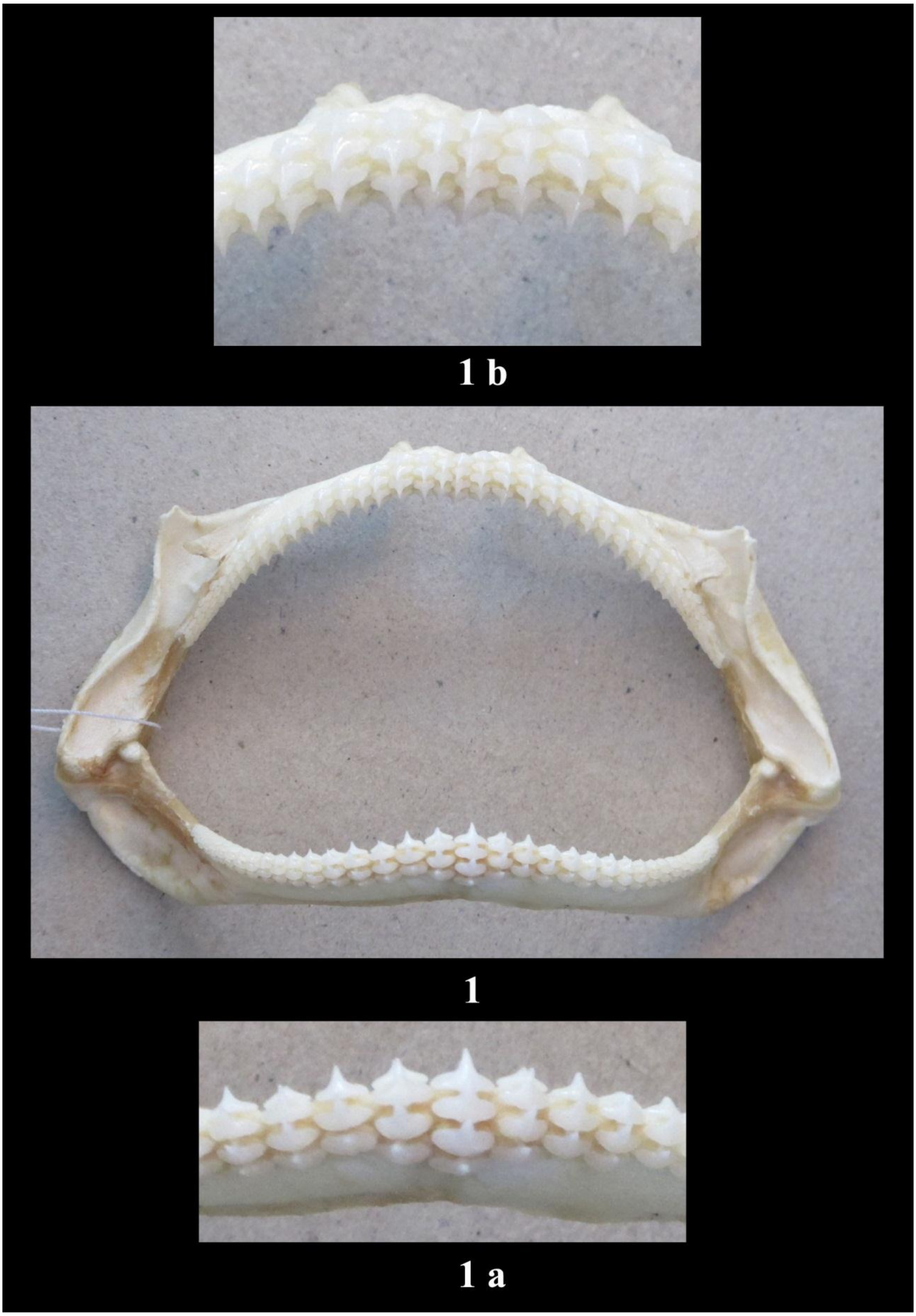

Plate 83: Pisces - Chondrichthyes - Neoselachii:
Family Pristiophoridae Bleeker, 1859: **Genus *Pristiophorus* Müller & Henle, 1837**:
***Pristiophorus cirratus* (Latham, 1794)**, female of 107 centimetres of total length, off Western Australia.
1: View of its jaws.
1a: Magnification of the lower symphyseal zone. **1b**: Magnification of the upper symphyseal zone.
Collection and Photographs Frederik Mollen. See Comments.

Plate 84: Pisces - Chondrichthyes - Neoselachii: **Family Isuridae HERMAN & VAN WAES, 2012**: **Genus *Isurus* RAFINESQUE, 1810**: ***Isurus oxyrhynchus* RAFINESQUE, 1810**.

1: Dried head of a female of 305 centimetres of total length.

Origin: Off Moroccan Atlantic coast. Harbour of Algesiras (Spain).

Gift of Jean-Pierre Luypaerts. Photographs Eric Vanderhoeft.

See comments.

1 b

1 a

Plate 85: Pisces - Chondrichthyes - Neoselachii: **Family Isuridae HERMAN & VAN WAES, 2012**: **Genus *Isurus* RAFINESQUE, 1810**: ***Isurus oxyrhynchus* RAFINESQUE, 1810**.

1a: View of the lower sympyhseal dentition and **1b:** View of the upper sympyhseal dentition of a female of 305 centimetres of total length. Origin: Off Moroccan Atlantic coast. Harbour of Algesiras (Spain). Gift of Jean-Pierre Luypaerts. Photographs Eric Vanderhoeft.
See comments.

1 b

1 a

Plate 86: Pisces - Chondrichthyes - Neoselachii: **Family Isuridae Herman & Van Waes, 2012**.
Genus *Isurus* Rafinesque, 1810: ***Isurus oxyrhynchus* Rafinesque, 1810**.
1a: Lateral oblique view of a female of *circa* 280 centimetres length. **1b**: Detail of its head.
Origin: off South Africa coasts. Photographs Frederik Mollen.
See comments.

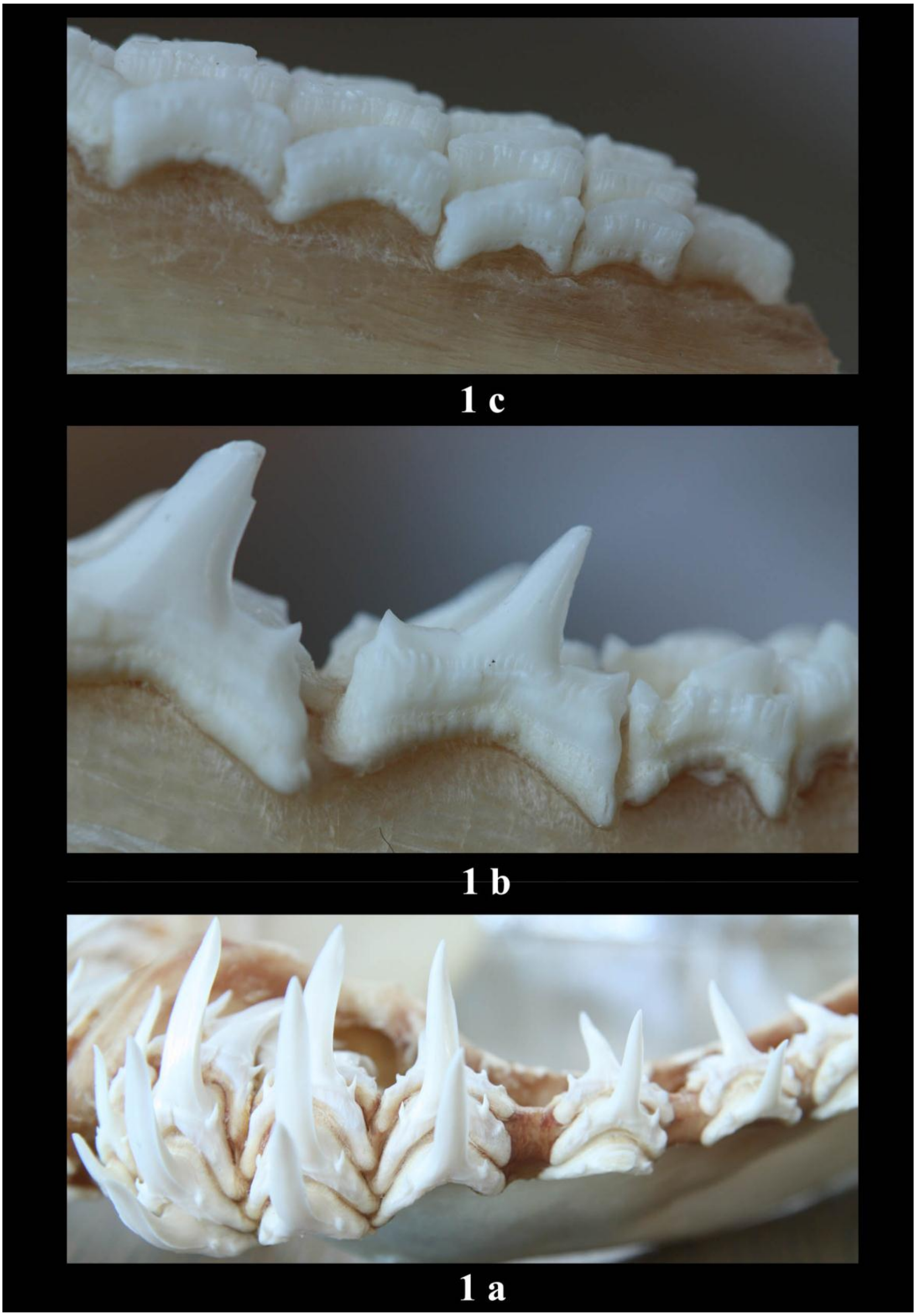

Plate 87: Pisces - Chondrichthyes - Neoselachii:
Family Odontaspididae MÜLLER & HENLE, **1839**:
Genus *Odontaspis* AGASSIZ, **1838**: ***Odontaspis taurus*** RAFINESQUE, **1810**.
Female of 266 centimetres length. Origin: Off South African coasts.
1a: View of the left lower anterior teeth rows. **1b**: View of left lower lateral teeth rows.
1c: View of left lower commissural teeth rows. Different magnifications.
Collection and Photographs Frederik Mollen. See comments.

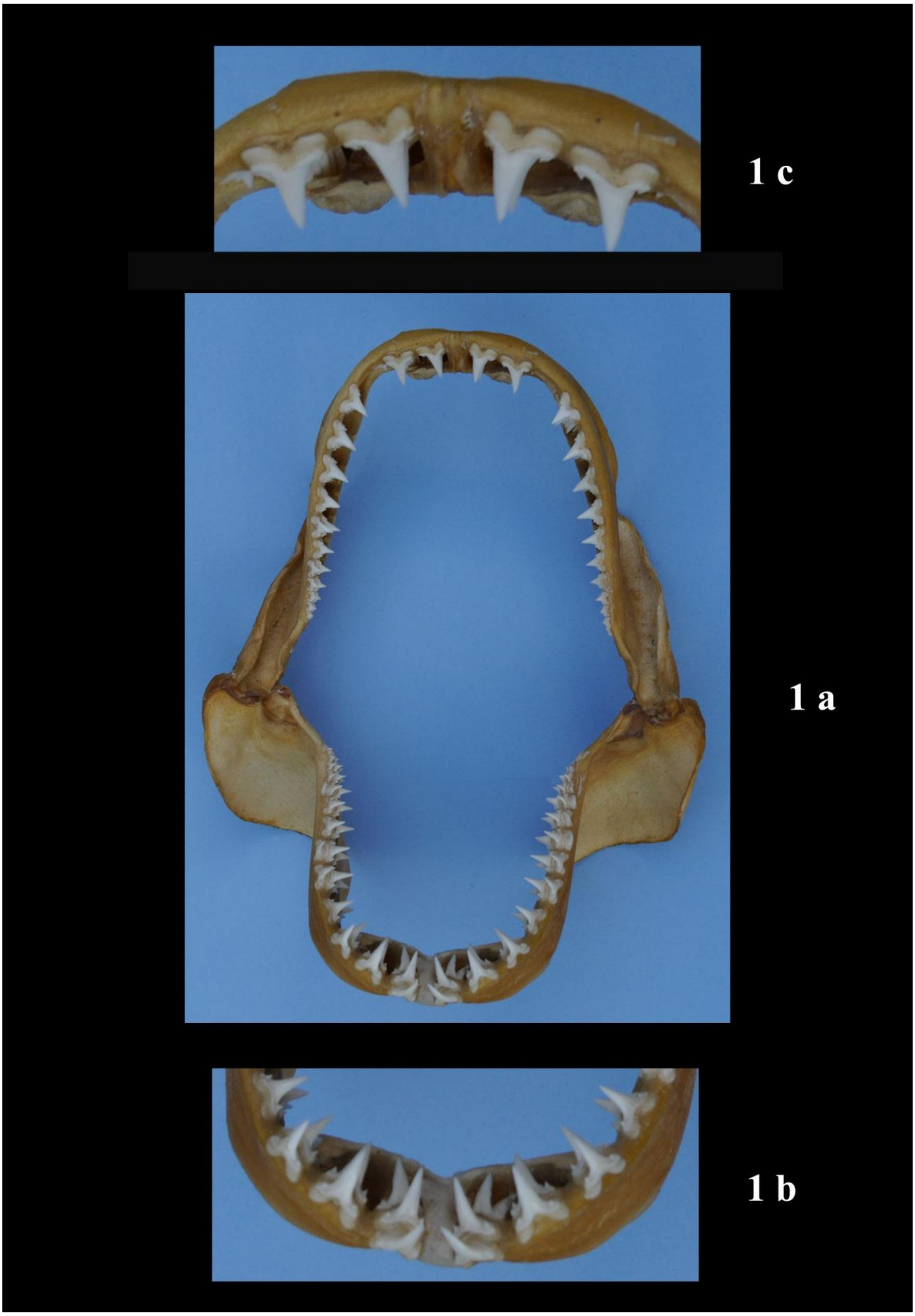

Plate 88: Pisces - Chondrichthyes - Neoselachii: Family Lamnidae MÜLLER & HENLE, 1838: Genus *Lamna* CUVIER, 1816: *Lamna nasus* (BONNATERRE, 1788).

Origin: Gulf of Gascogne, without precisions.

1a: Extern view of the jaws of a female of *circa* 235 centimetres length.

1b: Detail of the central part of its lower dentition.

1c: Detail of the central part of its upper dentition.

Gift Jean-Claude Quéro (I.F.R.E.M.E.R., La Rochelle, France). See comments.

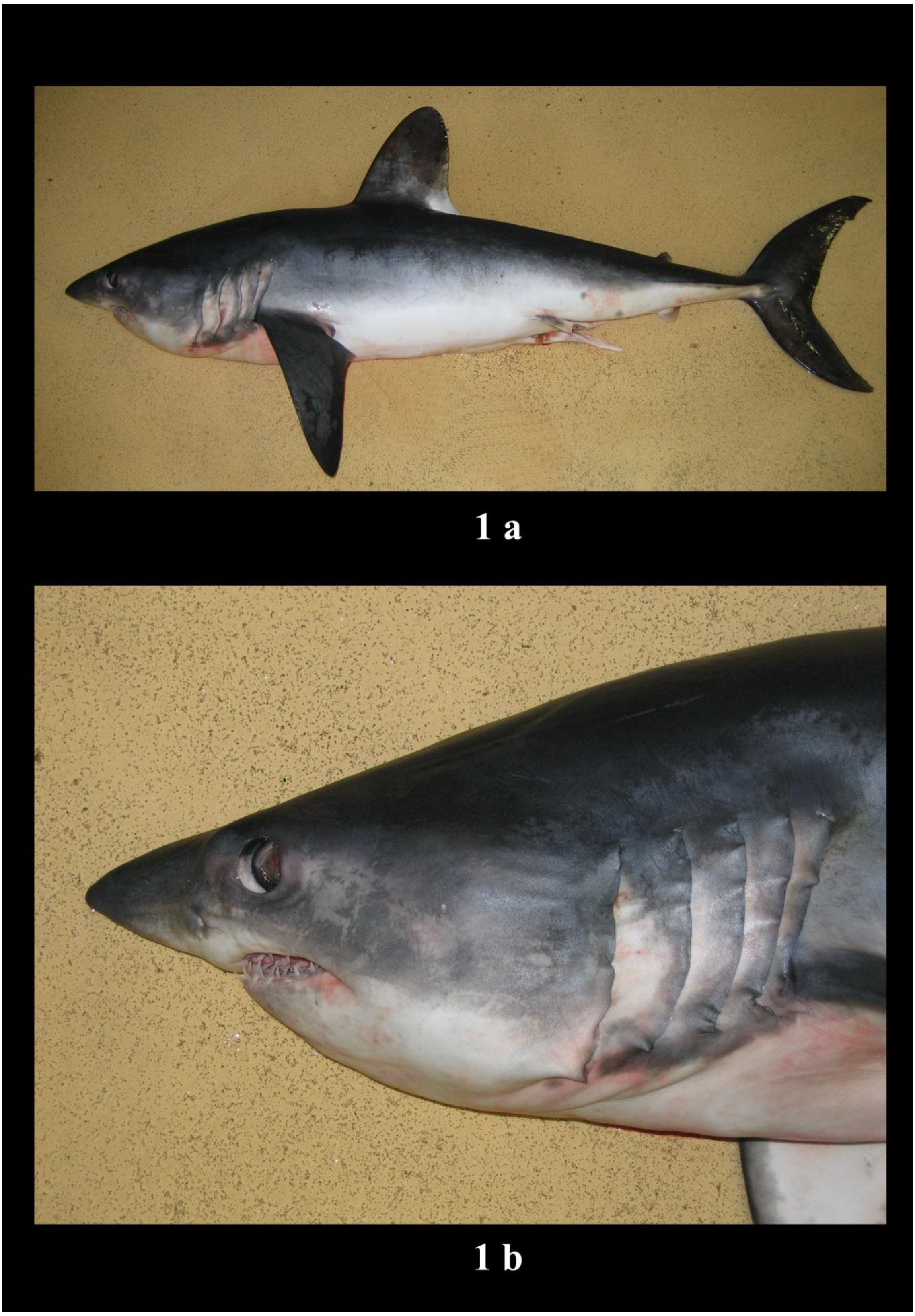

Plate 89: Pisces - Chondrichthyes - Neoselachii: Family Lamnidae MÜLLER & HENLE, 1838: Genus *Lamna* CUVIER, 1816: *Lamna nasus* (BONNATERRE, 1788).

1a: Lateral view of a male of *circa* 260 centimetres of total length.

1b: Detail of the head of the same specimen.

Origin: off South African coasts.

Photographs Frederik Mollen. See comments.

1 b

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Plate 90: Pisces - Chondrichthyes - Neoselachii:
Family Galeocerdidae HERMAN & VAN DEN EECKHAUT, 2010:
Genus *Galeocerdo* MÜLLER & HENLE, 1837: ***Galeocerdo cuvier* PERON & LESUEUR, 1822**.
1a: Jaws of a male of *circa* 5.5 metres of total length. Off Florida (USA). **1b**: Detail of upper right anterior teeth.
Private Collection. Photographs Eric Vanderhoeft.
See comments.

Plate 91: Pisces - Chondrichthyes - Neoselachii:
Family Carcharhinidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Carcharhinus* de BLAINVILLE, 1816:
Jaws of a ***Carcharhinus brevipinna*** **MÜLLER & HENLE, 1839** of 230 centimetres length.
Collection and Photograph Dirk and Maria Hovestadt (Terneuzen, NL).
See comments.

Plate 92: Pisces - Chondrichthyes - Neoselachii:
Family Carcharhinidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Carcharhinus* de BLAINVILLE, 1816:
Jaws of a ***Carcharhinus albimarginatus* (RÜPPEL , 1837)** of 160 centimetres length.
Collection and Photograph Dirk and Maria Hovestadt (Terneuzen, NL).
See comments.

Plate 93: Pisces - Chondrichthyes - Neoselachii:
Family Carcharhinidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Carcharhinus* de BLAINVILLE, 1816:
Jaws of a ***Carcharhinus limbatus* (MÜLLER & HENLE , 1839)** of 220 centimetres length.
Collection and Photograph Dirk and Maria Hovestadt (Terneuzen, NL).
See comments.

1 b

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Plate 94: Pisces - Chondrichthyes - Neoselachii:
Family Carcharhinidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Carcharhinus* de BLAINVILLE, 1816: ***Carcharhinus brevipinna* (MÜLLER & HENLE, 1839)**.
1a: Lateral view of an adult female of 264 centimetres length. **1b:** Detail of its head.
Origin: off South African coasts.
Photographs and Collection Frederik Mollen. See comments.

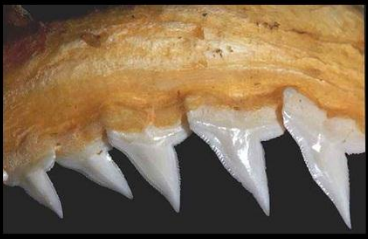

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Plate 95: Pisces - Chondrichthyes - Neoselachii:
Family Carcharhinidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Carcharhinus* de BLAINVILLE, 1816: Dentition of some species of this Genus. See comments.
1: ***Carcharhinus leucas* MÜLLER & HENLE, 1839**. Website: www.neotropicalfishes.lifedesks.org
2: ***Carcharhinus acronotus* (POEY, 1860)**. Website: www.neotropicalfishes.lifedesks.org
3: ***Carcharhinus acronotus* (POEY, 1860)**. Website: www.neotropicalfishes.lifedesks.org
4: ***Carcharhinus altimus* SPRINGER, 1950**. Website: www.neotropicalfishes.lifedesks.org
1-4: Courtesy of Ross Robertson.

1

Plate 96: Pisces - Chondrichthyes - Neoselachii: Family Otodontidae GLYCKMAN, 1964: Genus *Carcharodon* SMITH, 1838: *Carcharodon carcharias* (LINNAEUS, 1758).

1: Extern view of the jaws of an old individual. Real size: 69 cm on 55 cm.
Collection and Photographs Eric Vanderhoeft. Origin: The Pacific Ocean.
See comments.

Plate 97: Pisces - Chondrichthyes - Neoselachii: Family Otodontidae GLYCKMAN, 1964: Genus *Carcharodon* SMITH, 1838: *Carcharodon carcharias* (LINNAEUS, 1758).
Details of the dentition of a senile individual. Real size: 69 cm on 55 cm.
1: Lower left anterior teeth. **2**: First upper anterior tooth. Height: 62 millimetres. **3**: Upper lateral left teeth.
Collection and Photographs Eric Vanderhoeft. Origin: The Pacific Ocean, without other precision.
See comments.

Plate 98: Pisces - Chondrichthyes - Neoselachii: **Family Otodontidae** **GLYCKMAN**, **1964**:
Genus *Carcharodon* SMITH, **1838**: ***Carcharodon carcharias*** **(LINNAEUS**, **1758)**.
1a: Extern view of the jaws of a juvenile individual of 245 centimetres length.
Real size: 32.5 cm on 31 cm. Origin: caught in Summer 1981 in the Messina Strait (Sicilia, Italia).
1b: View of the lower symphyseal part. **1c**: View of the upper symphyseal part.
Gift Dr. Franco Cigala-Fulgosi (Universita di Parma, Italia).
Private Collection. See comments.

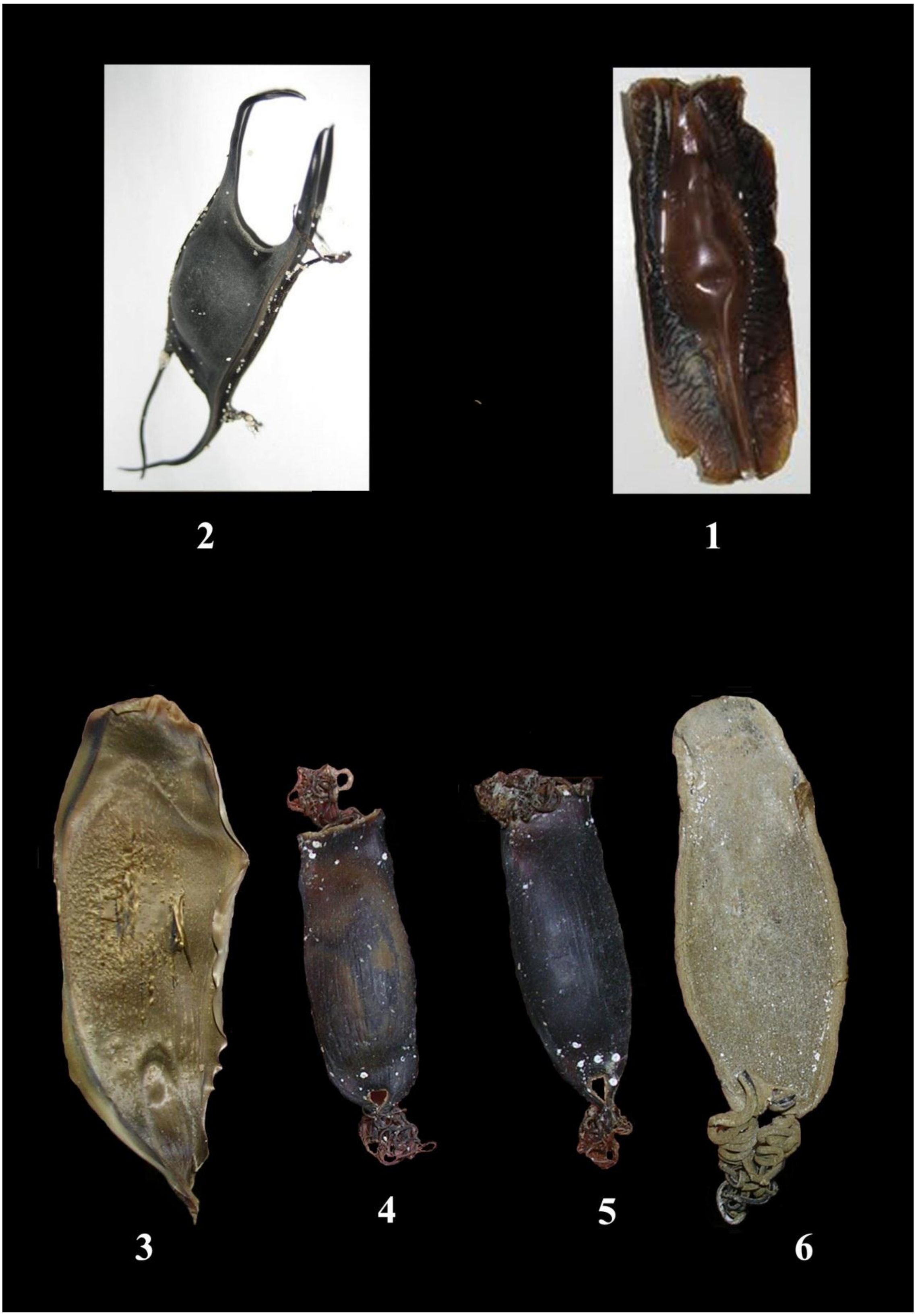

Plate 99: Chondrichthyes:
Comparison between egg capsules of Holocephali, Neoselachii and Batoidei:
1: Egg capsule of *Callorhinchus millii* BORY de SAINT-VINCENT, 1823. (Holocephali).
2: **Egg of *Raja clavata* LINNAEUS, 1758. (Batoidei).**
3 and 6: Eggs of *Hemiscyllium trispeculare* RICHARDSON, 1843. (Neoselachii).
4 and 5: Eggs of *Scyliorhinus torazame* (TANAKA, 1908). (Neoselachii).
3 to **6**: Photographs and Private Collection Guy Van Den Eeckhaut. See comments.

1 b

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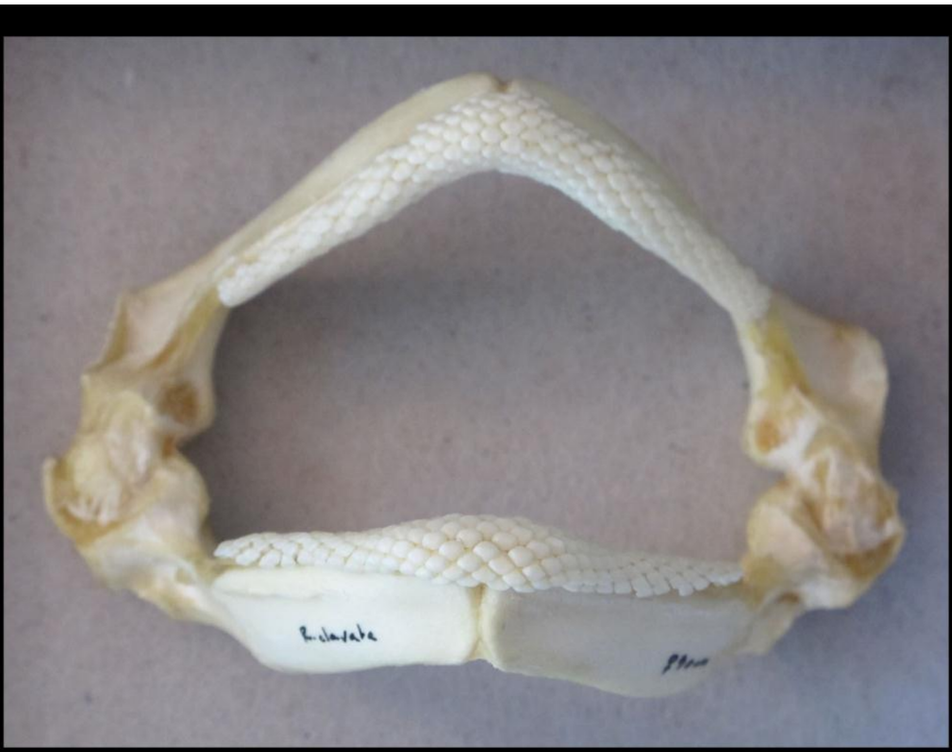
Plate 100: Pisces - Chondrichthyes - Batoidei: **Family Rajidae BONAPARTE, 1831**:
Genus *Raja* LINNAEUS, 1758: ***Raja naevus* MÜLLER & HENLE, 1841**:
1a: Ventral view of female of *circa* 64 centimetres length. **1b**: Dorsal view of the same individual.
Origin: North Atlantic.
Collection and Photographs Frederik Mollen. See comments.



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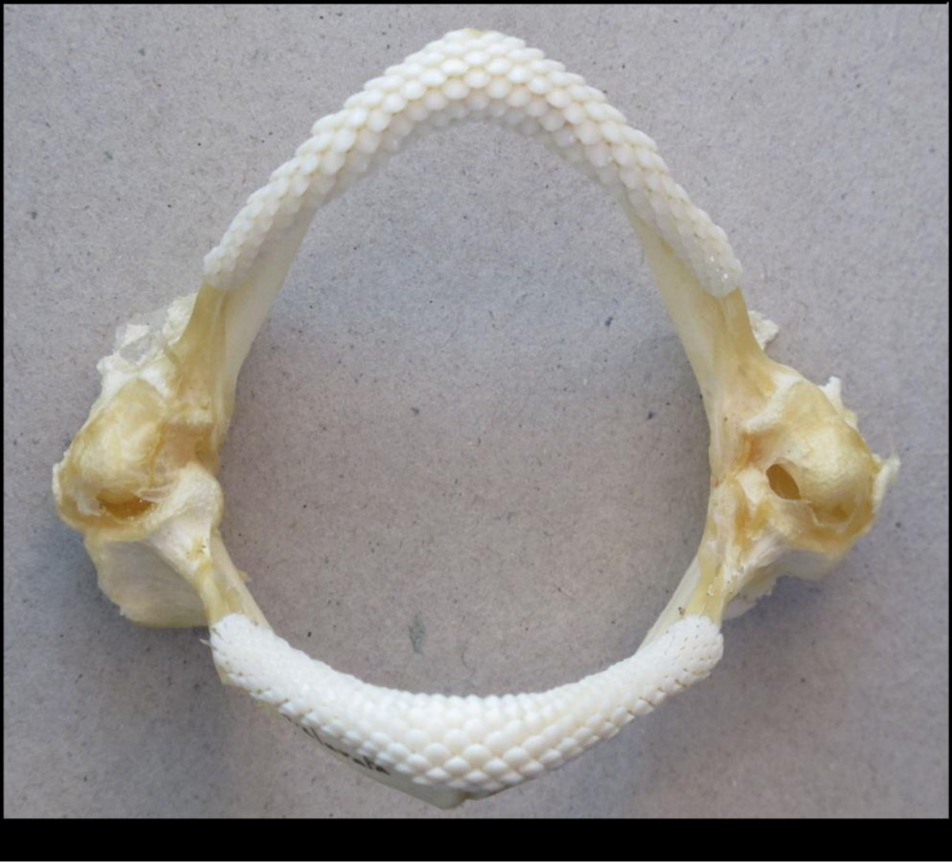

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Plate 101: Pisces - Chondrichthyes - Batoidei:
Family Rajidae BONAPARTE, 1831, Genus Raja LINNAEUS, 1758:
***Raja clavata* LINNAEUS, 1758**.
1: Jaws of a male of 71 centimetres of total length. **2**: Jaws of a female of 90 centimetres of total length.
Origin: North Sea, off Oostende (Western Flanders, B).
Collection and Photographs Frederik Mollen.
See Comments.

1 b

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Plate 102: Pisces - Chondrichthyes - Batoidei: **Family Myliobatidae BONAPARTE, 1838**: **Genus *Myliobatis* CUVIER, 1816**: ***Myliobatis goodei* GARMAN, 1885**.
1a: Dorsal view of a male of 72 centimetres disc width. **1b**: Ventral view of the same specimen.
Collection and Photographs Frederik Mollen.
See comments.

1

Plate 103: Pisces - Chondrichthyes - Batoidei: **Family Myliobatidae BONAPARTE, 1838**:
Genre *Weissobatis* HOVESTADT & HOVESTADT-EULER, 1999:
***Weissobatis micklichi* HOVESTADT & HOVESTADT-EULER, 1999**.
1: Dorsal view of the Holotype (N° 2336 PAL, Museum of Karlsruhe, Baden -Würtemberg, D).
Total length: *circa* 124 centimetres. Disc width: *circa* 63 centimetres.
See comments.

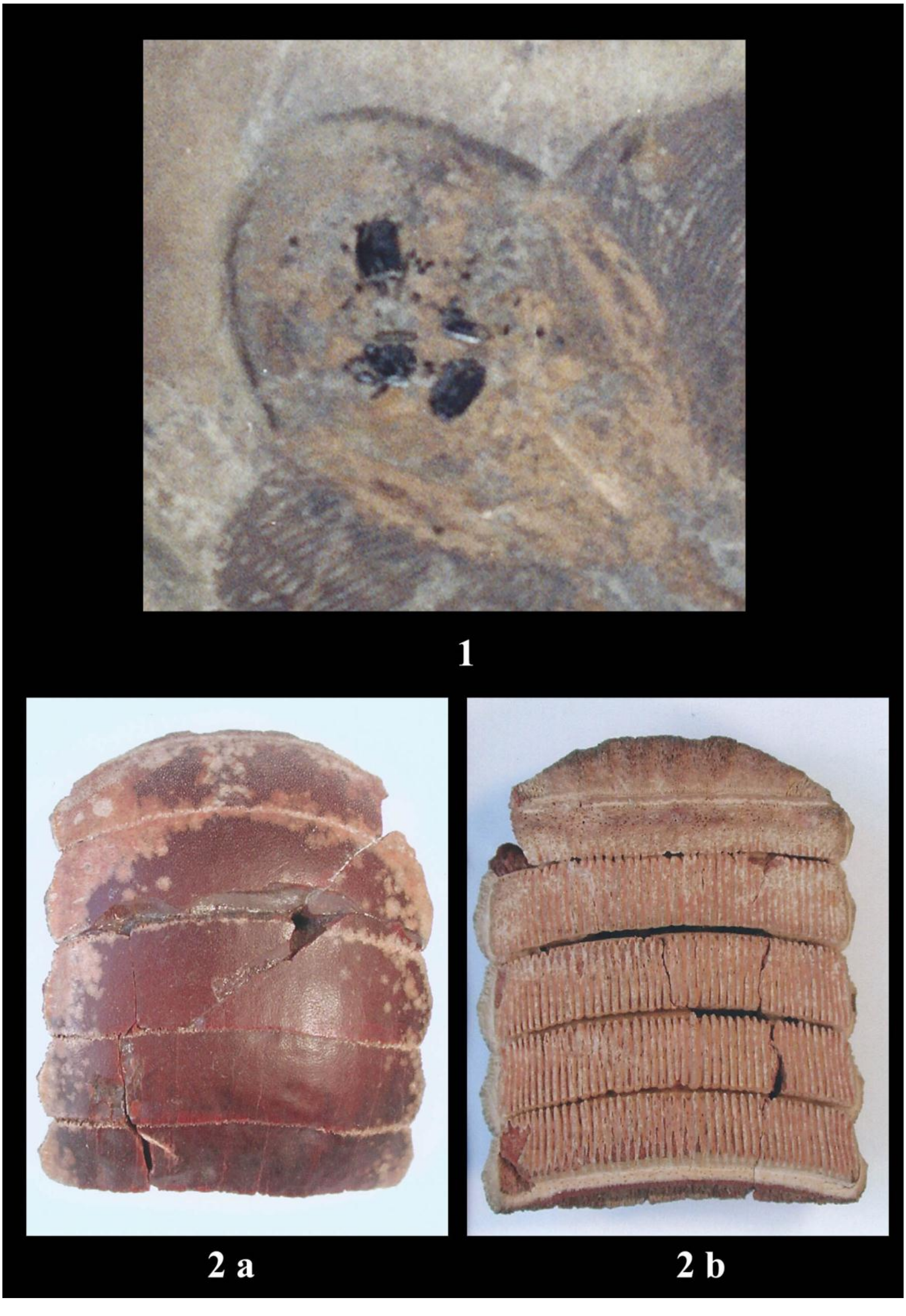

Plate 104: Pisces - Chondrichthyes - Batoidei:
Two taxa of the Order Myliobatiformes: **Genus** ***Weissobatis*** and **Genus** ***Myliobatis***.
Issue of their validity and distinction: See comments.
1: Detail of the head of the Holotype of
Weissobatis micklichi **HOVESTADT & HOVESTADT-EULER**, **1999** from the German Oligocene.
2a: Occlusal view of a dental tooth plate of ***Myliobatis dixoni*** **(AGASSIZ**, **1843)** from the Middle Eocene of Belgium. **2b:** Radicular view of the same plate. Private Collection. Size: 61 on 54 millimetres.

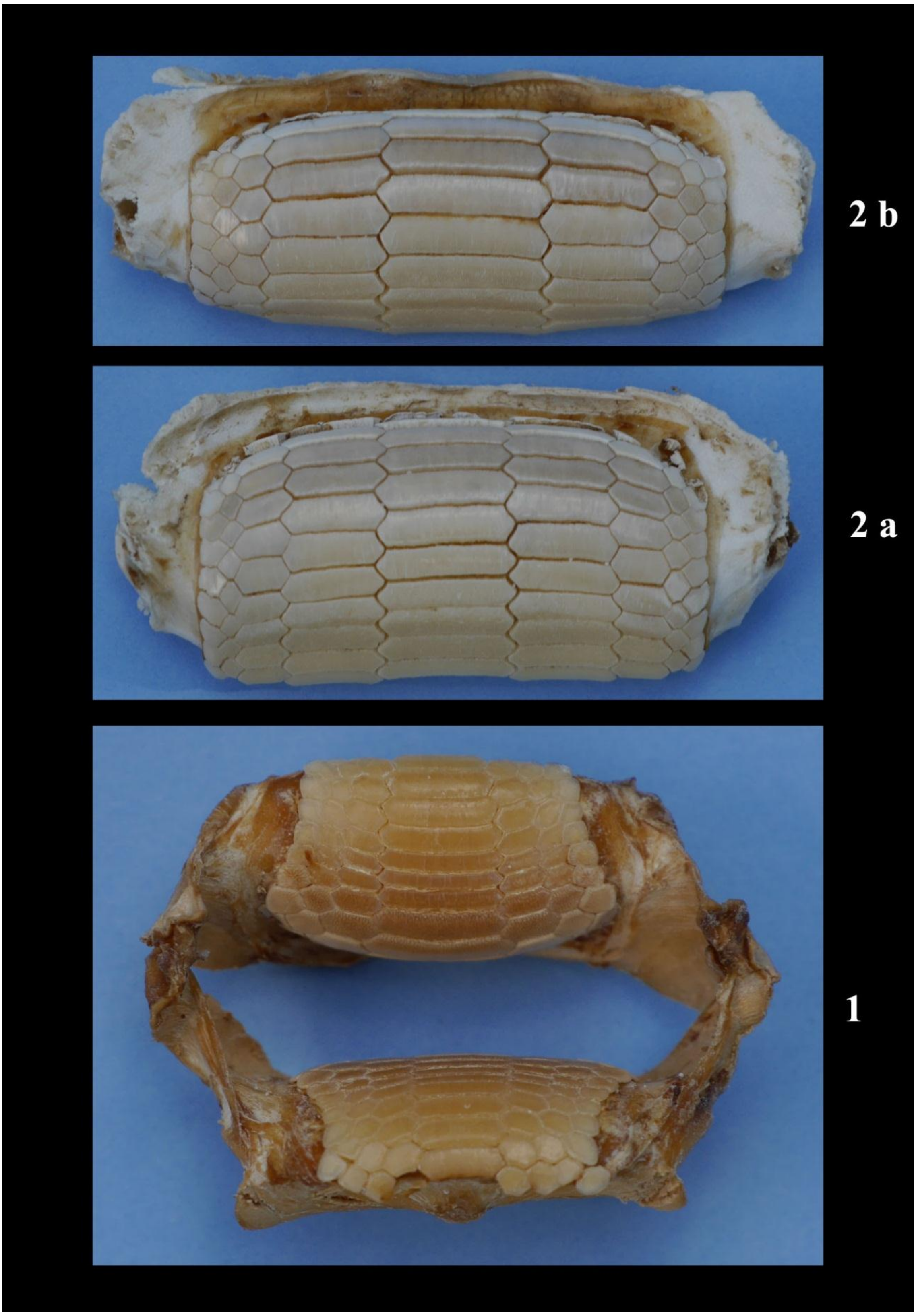

Plate 105: Pisces - Chondrichthyes - Batoidei:
Family Pastinachidae nov. Fam. and **Family Myliobatidae BONAPARTE**, **1838**.
1: Jaws of ***Pastinachus sephen*** **FORSKALL**, **1775**. Origin: Mouth of the Gange River.
2a-2b: Jaws of ***Myliobatis aquila*** **(LINNAEUS**, **1758)**. Origin: Off Ceuta (Morocco).
See comments.

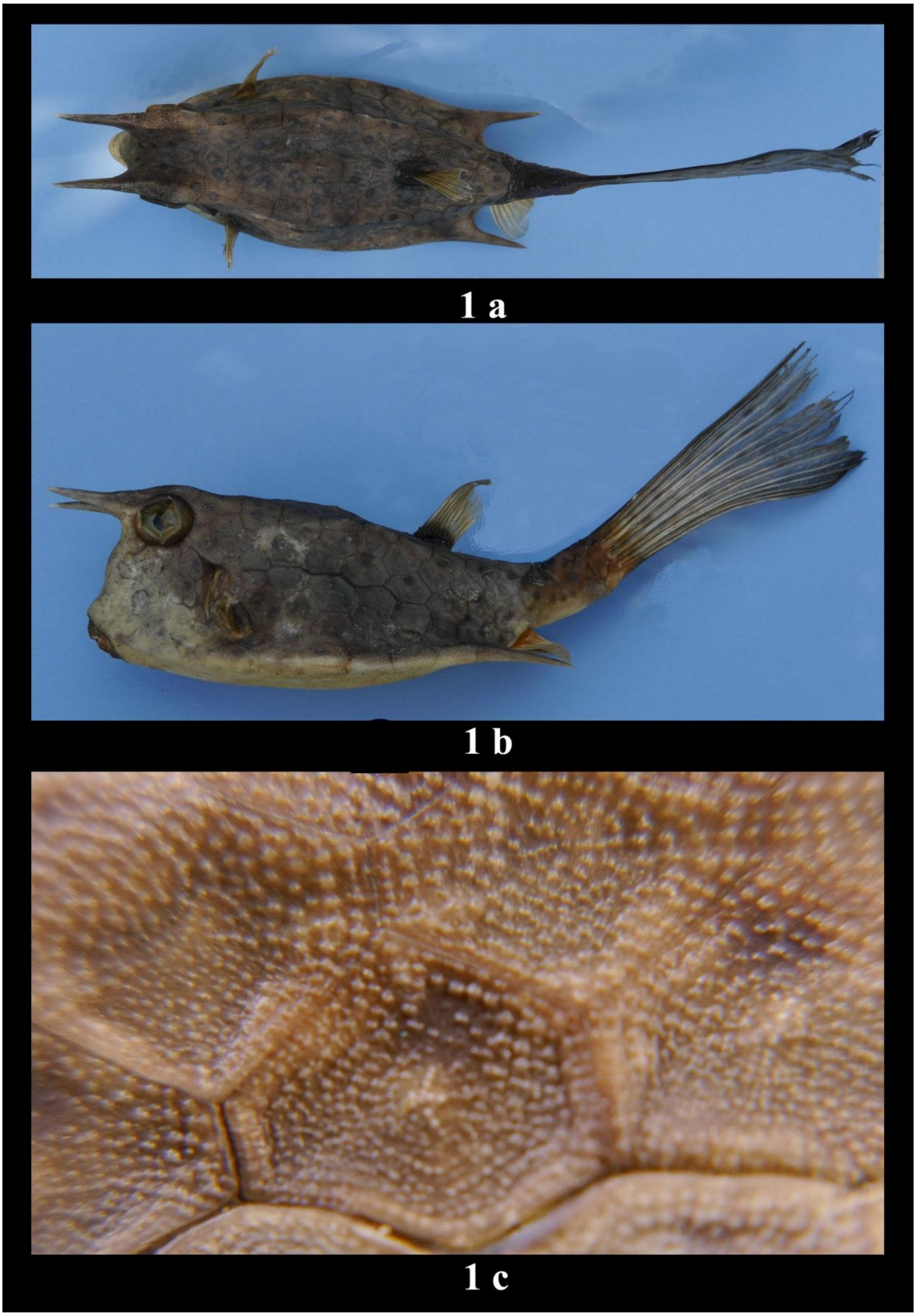

Plate 106: Pisces - Actinopterygii - Teleostei: Family Ostraciidae RAFINESQUE, 1810: Genus *Lactoria* JORDAN & FOWLER, 1902: *Lactoria cornuta* (LINNAEUS, 1758).

1a: Dorsal view of a dried specimen of 24.5 centimetres length. **1b**: Lateral view of the same specimen. **1c**: Magnification of some of its plates.

Collection and Photographs Eric Vanderhoeft.

See comments.

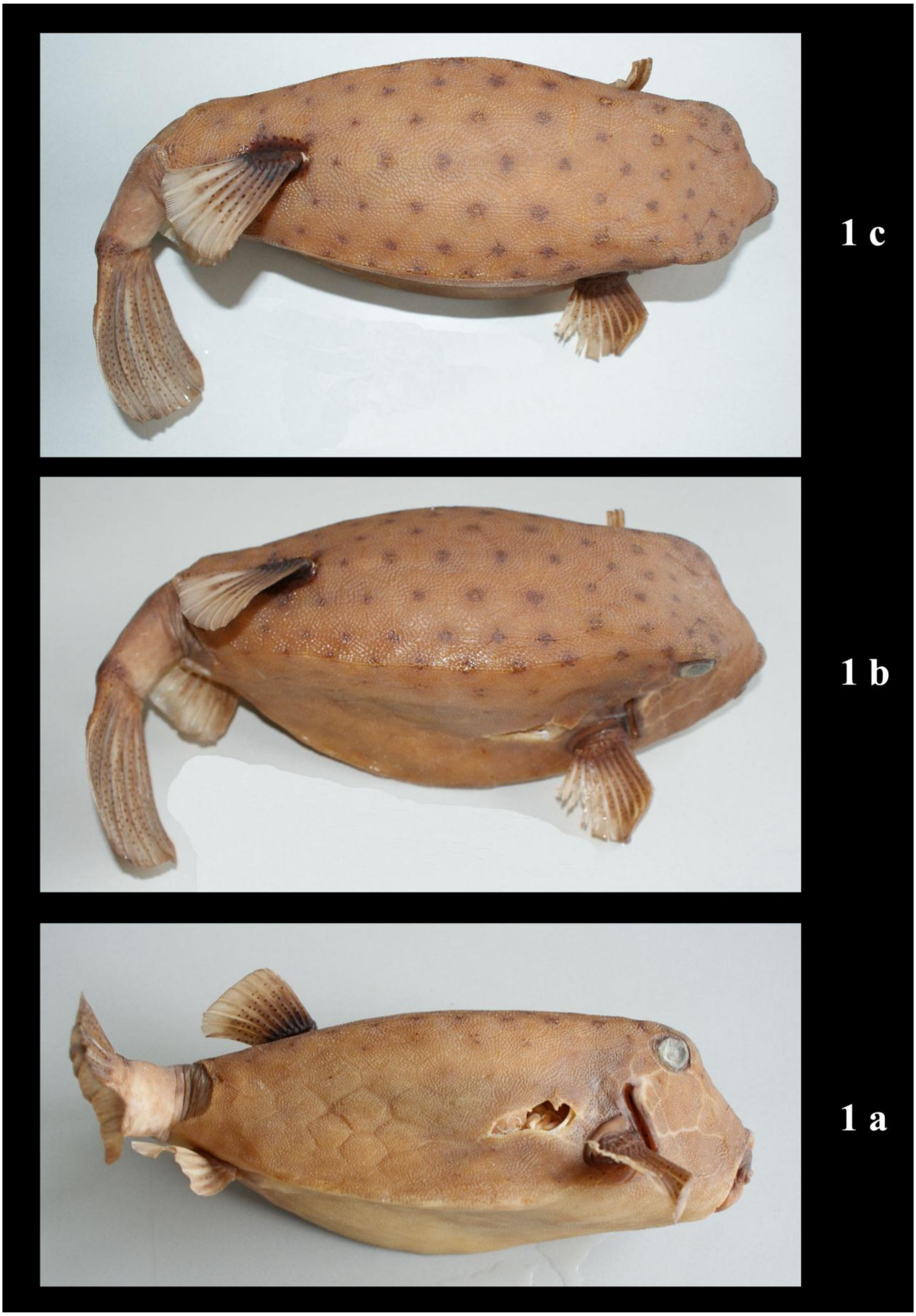

Plate 107: Pisces - Actinopterygii - Teleostei: **Family Ostraciidae RAFINESQUE, 1810**.
Genus *Ostracion* LINNAEUS, 1758: ***Ostracion cubicus* LINNAEUS, 1758.**
1a: Lateral view of a specimen preserved in alcohol. Total length: 18.5 centimetres. Origin: The Indian Ocean.
1b: Oblique view of the same specimen. **1c**: Dorsal view of the same specimen.
Collection I.R.S.N.B., Brussels, Belgium. Photographs Dirk Hovestadt.
See comments.

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Plate 108: Pisces - Actinopterygii - Teleostei: **Family Lophiidae** **RAFINESQUE**, **1810**:
Genus *Lophius* LINNAEUS, **1758**: ***Lophius piscatorius*** **LINNAEUS**, **1758**.
1a to **1c**: Stranted right maxillar of an adult specimen of this species,
collected by the senior-author’s father in November 1958.
1: Lateral view of this bone of 24.5 centimetres length. **1a** and **1b**: Magnifications.
Photographs Eric Vanderhoeft. See comments.

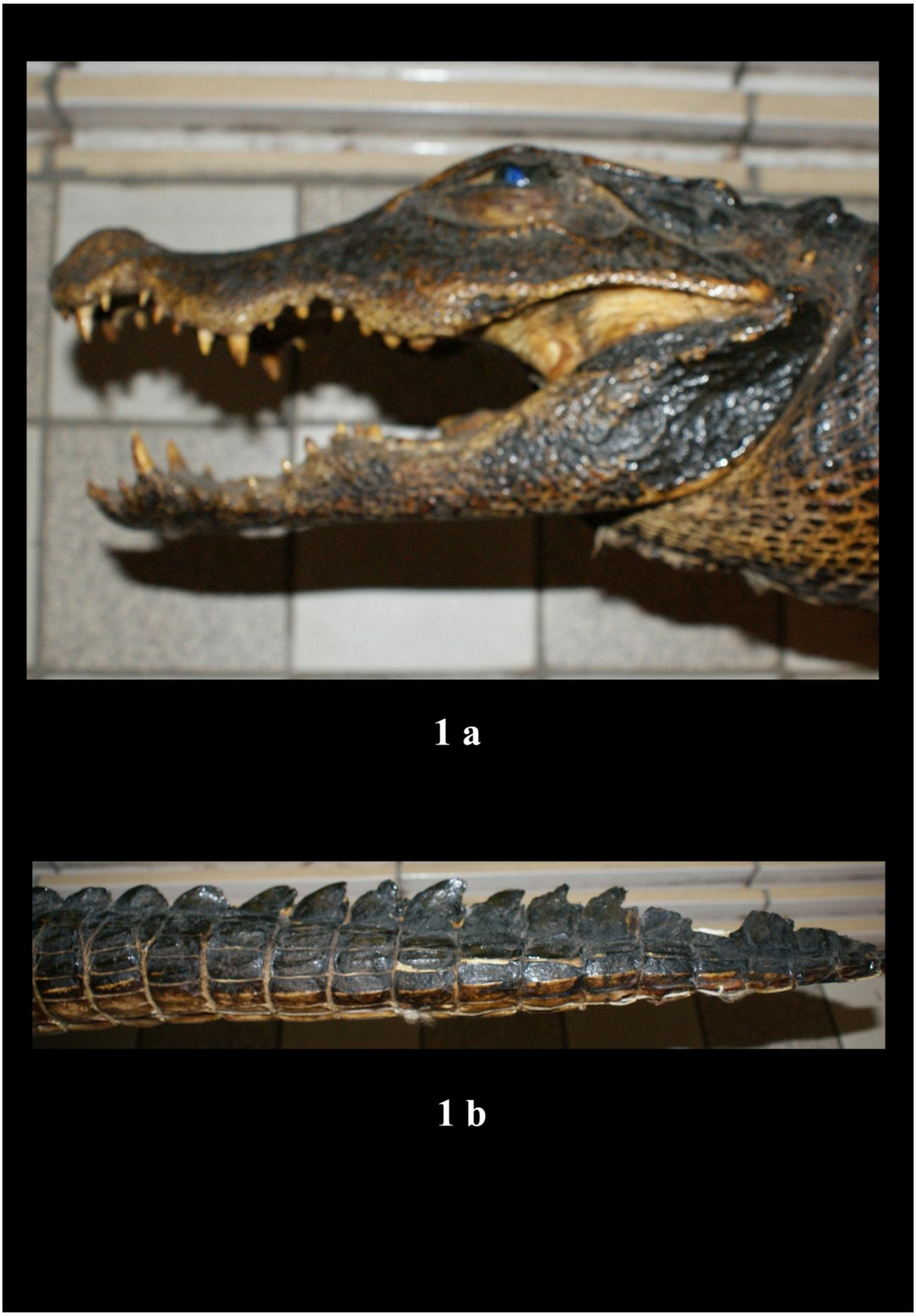

Plate 109: Reptilia - Crocodylia - Family Crocodilidae Cope, 1861:
Genus *Osteolaemus* Cope, 1861: ***Osteolaemus tetraspis* Cope, 1861**.
1a: Lateral view of the head of an adult male of 1m40 total length (Origin: R.D. Congo).
1b: Lateral view of the tail of the same specimen.
Collections of the Department of Recent Vertebrates of the I.R.S.N.B. (Brussels, Belgium). Courtesy of M. Georges Lenglet. Photographs Eric Vanderhoeft. See comments.

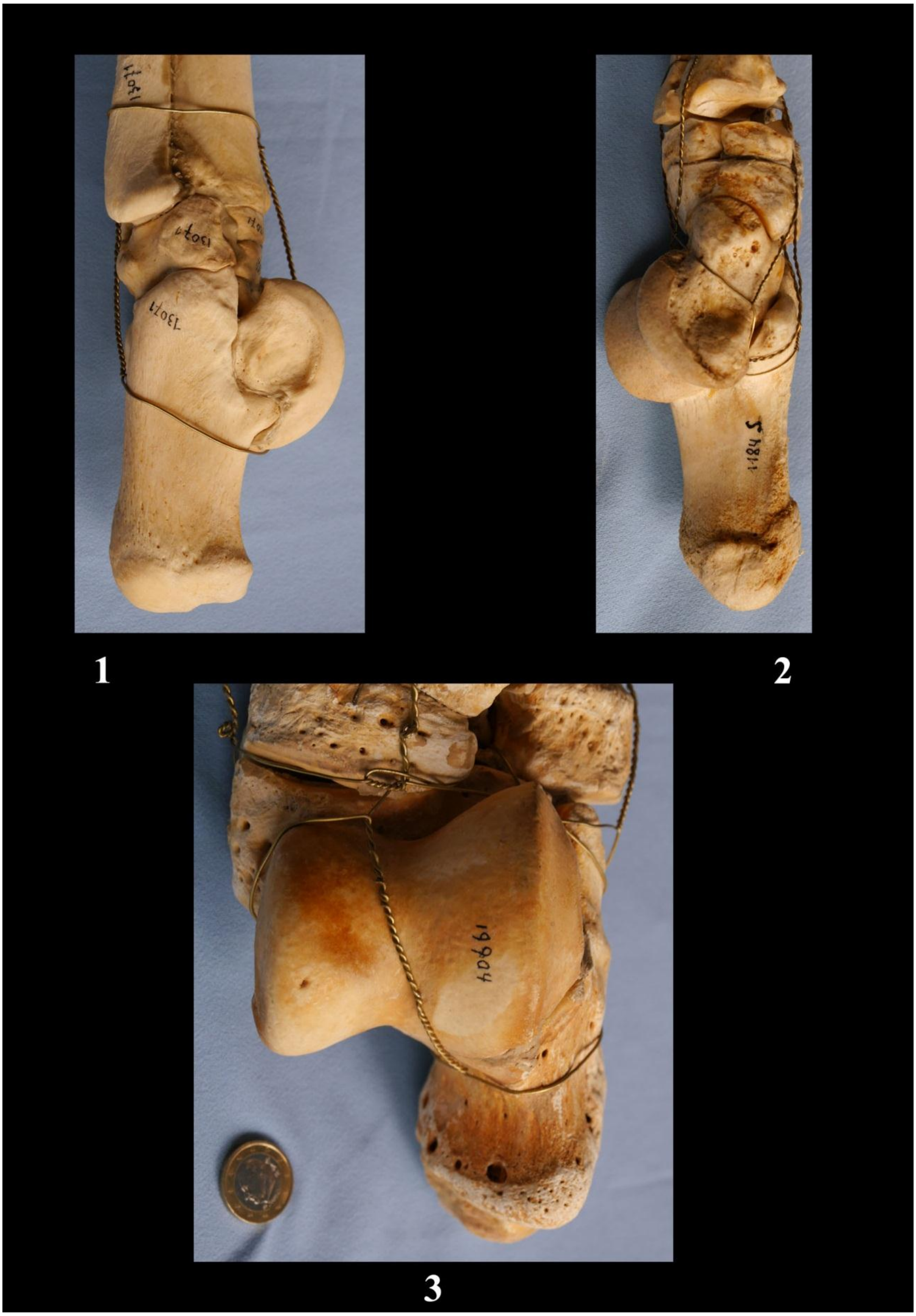

Plate 110: Comparison between the hind legs of an Equidae, a Tapiridae and a Rhinocerotidae:
1: Family Equidae GRAY, 1821: Genus *Equus* LINNAEUS, 1758: *Equus caballus* LINNAEUS, 1758.
2: Family Tapiridae GRAY, 1821: Genus *Tapirus* BRÜNNICH, 1772: *Tapirus indicus* (DESMAREST, 1819).
3: Family Rhinocerotidae GRAY, 1820: Genus *Dicerorhinus* GLOGER, 1841:
***Dicerorhinus sumatrensis* (FISCHER, 1814).**
Collections of the Recent Vertebrates Department of the I.R.S.N.B. (Brussels, Belgium).
Courtesy of M. Georges Lenglet. Photographs Eric Vanderhoeft. See comments.

Plate 111: Mammalia - Perissodactyla - Family Rhinocerotidae OWEN, 1820: Genus *Dicerorhinus* GLOGER, 1841: *Dicerorhinus sumatrensis* (FISCHER, 1814).
1a to **1c**: Three different views of a *calcaneum* of an adult male of this species.
Collection of the Department of recent Vertebrates of the I.R.S.N.B., Brussels, Belgium.
Courtesy of M. Georges Lenglet. Photographs Eric Vanderhoeft.
See comments.

2

1

Plate 112: Mammalia - Perissodactyla: **Family Rhinocerotidae GRAY, 1820**:
Genus *Coelodonta* BRONN, 1891: ***Coelodonta antiquitatis* (BLUMENBACH, 1807)**.
1 and **2**: Views of two calcanea of this species.
Origin: Basal gravel of the Eemian of Zemst, Bos van A Sandpit (Flemish Brabant, Belgium).
Collection Alain Bouvry. Photographs Eric Vanderhoeft.
See comments.

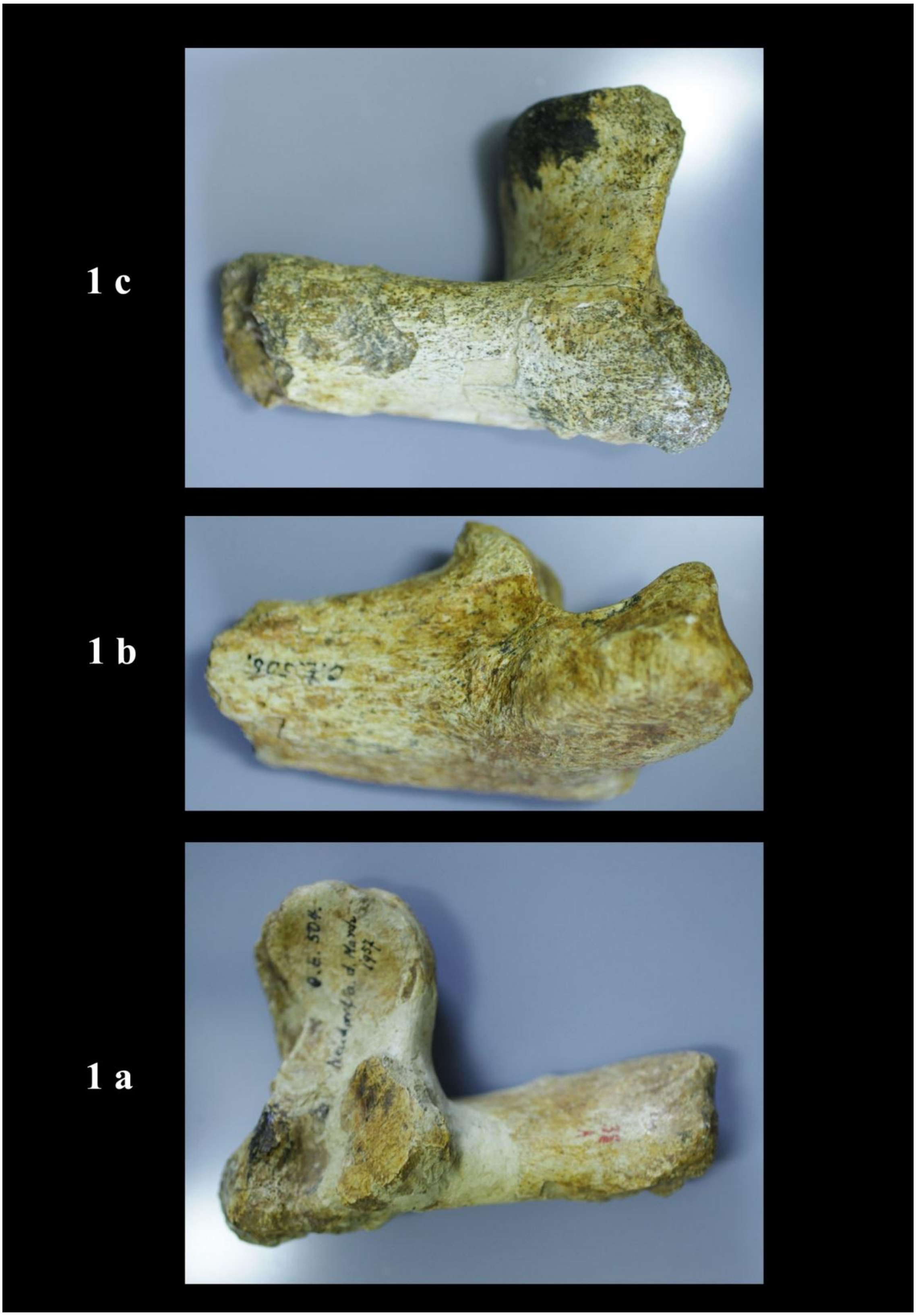

Plate 113: Mammalia - Perissodactyla - Family Chalicotheriidae Gill, 1872:
Genus *Chalicotherium* Kaup, 1833: *Chalicotherium grande* (de Blainville, 1849).
1a-1c: Three views of a calcaneum.
Naturhistorisches Museum Basel: N°. D. E. 504: filling of middle Miocene Age in Jurassic limestones.
Locality: Devinska Nova Ves (formerly Neudorf) - Slovakia.
Photographs: Courtesy of M. Loïc Costeur, Conservator of the Naturhistorisches Museum of Basel (CH).
See comments.

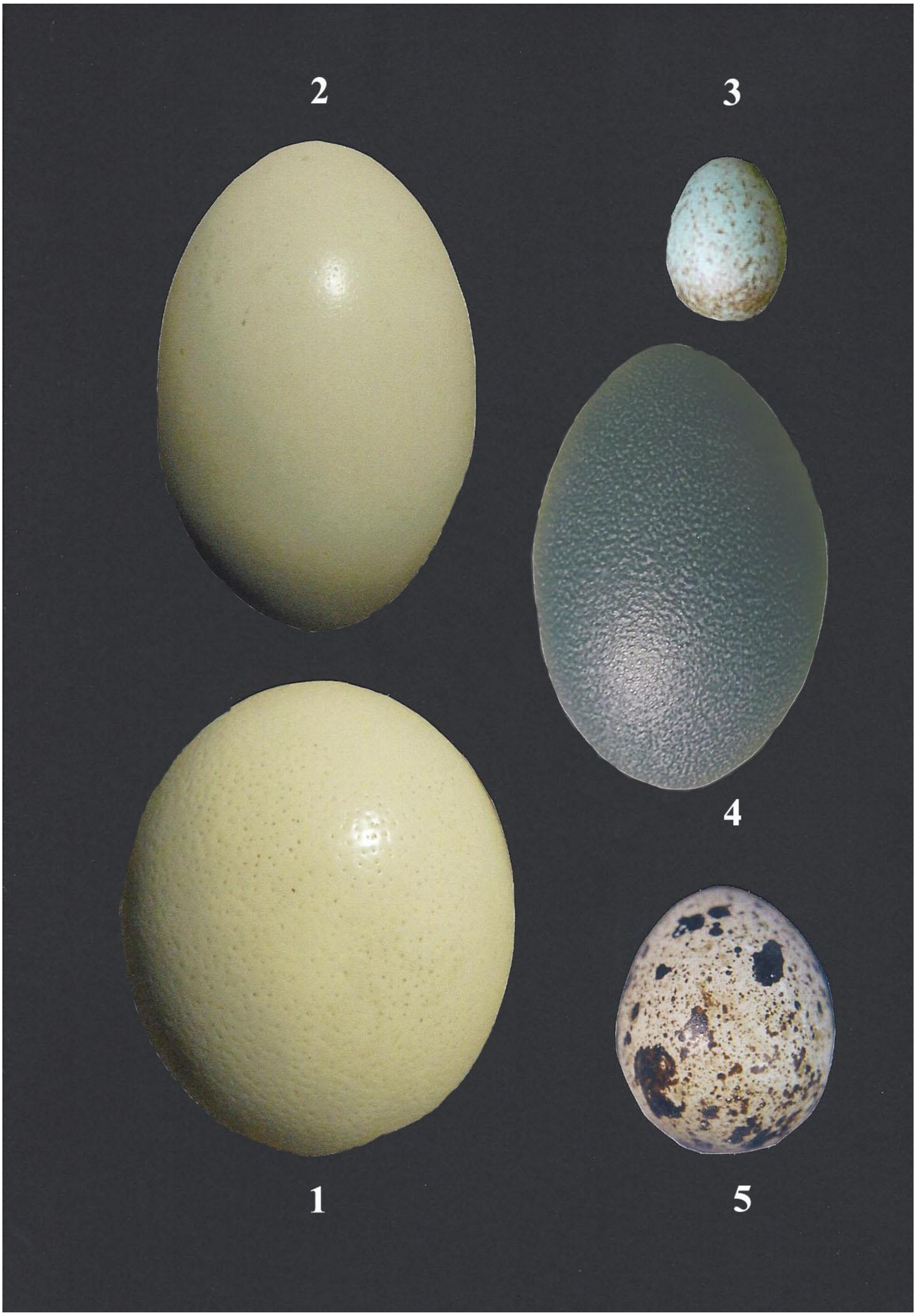

Plate 114: Aves - Neornithes:
Eggs of diverse extant species. Variation of the oval form of bird's eggs.
1: Egg of ***Struthio camelus*** **LINNAEUS, 1758**. H.: 16 cm. **2**: Egg of ***Rhea pennata*** **d'ORBIGNY, 1834**. H.: 15 cm.
3: Egg of ***Turdus merula*** **LINNAEUS, 1758**. Height: 2.5 cm.
4: Egg of ***Dromaius novaehollandiae*** **(LATHAM, 1790)**. Height: 11.5 cm.
5: Egg of ***Coturnix vulgaris*** **LINNAEUS, 1758**. Height: 3.5 cm.
Photographs and Collection Eric Wille. See comments.

30. Comments to the Plates

Comments to Plate 1

Pisces - Chondrichthyes - Holocephali - Family Rhinochimaeridae GARMAN, 1901
Dental plates of the Genus *Amylodon* STORMS, 1894: *Amylodon delheidi* STORMS, 1894

The precise identification of these dental plates is a courtesy of Dr. Jerry Hooker (B.M.N.H., London, Great Britain).

These holocephalian dental plates remained at the disposal of the senior-author as long as necessary for the realisation of their photographs and their identification and they were then returned to their different owners.

1: Height: 40 millimetres. **2**: Height: 28 millimetres. **3**: Height: 28 millimetres. **4**: Height: 41 millimetres. **5**: Height: 29 millimetres. Photographs and size data: Jacques Herman.

All these dental plates were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed.*

Comments to Plate 2

Pisces – Chondrichthyes – Holocephali – Family Rhinochimaeridae GARMAN, 1901
Dental plates of the Genus *Amylodon* STORMS, 1894: *Amylodon delheidi* STORMS, 1894

The precise identification of these dental plates is a courtesy of Dr. Jerry Hooker (B.M.N.H., London, Great Britain).

These holocephalian dental plates remained at the disposal of the senior-author as long as necessary for the realisation of their photographs and their identification and they were then returned to their different owners.

1: Height 42 millimetres. **2**: Height 28 millimetres. **3**: Height 28 millimetres. **4**: Height 21 millimetres, this dental plate was one of a juvenile specimen. **5**: Height 36 millimetres, this dental plate was one of an adult specimen.

These two vomerine plates allow appreciating the morphological differences existing between juvenile and adult individuals. Photographs and size data: Guy Van Den Eeckhaut.

All these dental plates were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed.*

Comment concerning Plate 1 and Plate 2

The complete absence of any remains of the Genus *Edaphodon* BUCKLAND, 1838 in all the Belgian Oligocene deposits allows supposing that all the taxa of this extinct Genus inhabited only sandy bottoms.

The holocephalian materials discovered in the *Sint Niklaas Phosphorite Bed* will be re-examined by our Russian colleague Evgeny Popov in 2014 or 2015.

Comments to Plate 3

Pisces - Chondrichthyes - Holocephali
Cf. Family Rhinochmaeridae GARMAN, 1901
Cf. Genus *Amylodon* STORMS, 1894

1a to **2c**: Different views of two fossils interpreted as tenaculum elements of
Amylodon delheidi STORMS, 1894.

It seems that this discovery of some fossil parts of a holocephalian tenaculum is the first one in Western Europe.

Comments to Plate 4

Pisces - Chondrichthyes - Neoselachii - Family Heptranchidae BARNARD, 1925
Genus *Notidanion* JORDAN, 1923: *Notidanion howelli* REED, 1946

1a: This ichnofossil is a cemented horizontal gallery of a small teleostean fish, probably a species of the Family Gobiidae CUVIER, 1816 (Perciformes, Acanthopterygii) on the top of which sticks a Chondrichthyes tooth.

1b: Magnification of the chondrichthyan tooth of 21 millimetres length, considered as a tooth of *Notidanion howelli* REED, 1946.

This concretion *circa* 15 centimetres long was discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed.*

Comments to Plate 5

Pisces - Chondrichthyes - Neoselachii
1-8, **11** and **12: Family Hexanchidae RAFINESQUE, 1810:**
Genus *Notorynchus* AYRES, 1855: *Notorynchus primigenius* AGASSIZ, 1843

9 and **10: Family Heptranchidae BARNARD, 1925:**
Genus *Notidanion* JORDAN, 1923: *Notidanion howelli* REED, 1946

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

The discovery of some teeth attributable to *Notidanion howelli* REED, 1946 in this Horizon constitutes one of the five arguments that allow supposing that an earlier Gulf Stream facilitated momentarily the crossing of the North Atlantic Ocean for some north-eastern American Chondrichthyes.

It is important to remind that, at this epoch, the North Atlantic Ocean was only three thousands kilometres wide.

Comments to Plate 6

Pisces - Chondrichthyes - Neoselachii
1- 7: Family Hexanchidae RAFINESQUE, 1810:
Genus *Notorynchus* AYRES, 1855: *Notorynchus primigenius* AGASSIZ, 1843

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. This species is already present in the Berg Sands Formation.

Some isolated teeth were discovered in different levels of the Terhaegen Lid of the Boom Clay Member in diverse active or abandoned Clay Pits at Hemiksem, Niel, Reet, Rumst, Schelle, Terhaegen and Tielrode.

Comment to Plates 7 and 8

Pisces - Chondrichthyes - Neoselachii
Family Squalidae BONAPARTE, 1834:
Genus *Squalus* LINNAEUS, 1758: *Squalus alsaticus* (ANDREAE, 1892)

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

Some isolated teeth were observed with naked eyes in different levels of the Terhaegen Lid of the Boom Clay Member in diverse active or abandoned Clay Pits at Hemiksem, Niel, Reet, Rumst, Schelle, Terhaegen and Tielrode.

Plate 7

This plate shows one pseudo- symphyseal tooth (**1a**-**1c**) resulting of the fusion of two parasymphyseal teeth and one anterior tooth of this species (**2a**-**2c**).

Plate 8

This plate shows different views of one upper anterior tooth (**1a**-**1c**) and of one lower anterior tooth (**2a**-**2c**).

The teeth of this species represented always more than 90% in our diverse prospections realised in the Terhaegen Lid of the Boom Clay Member.

Comments to Plate 9

Pisces - Chondrichthyes - Neoselachii
Family Squalidae BONAPARTE, 1834:
Genus *Squalus* LINNAEUS, 1758: *Squalus alsaticus* (ANDREAE, 1892)
A damaged tooth-crown of a *Squalus alsaticus* (ANDREAE, 1892).

The extern face of this tooth presents multiple traces of the intern development of iron sulphides crystals which must be contemporaneous of the short emersion phase having induced the oxidation of these sulphides and the oxidation of all the siderite concretions coating the diverse annelids and stomatopods burrows.

Comments to Plate 10

Pisces - Chondrichthyes - Neoselachii
Family Squalidae BONAPARTE, 1834: Genus *Squalus* LINNAEUS, 1758:
***Squalus alsaticus* (ANDREAE, 1892)**

Two dorsal fin spines of *Squalus alsaticus* deeply corroded by the stomachal enzymes of an unknown large predator. Private Collections. SEM Photographs Julien Cillis (I.R.S.N.B., Brussels, Belgium).

A third dorsal fin spine of *Squalus alsaticus*, perfectly preserved, was later discovered (see Plate 42: figs.: 1a and 1b) in the south-eastern sector of the Clay Pit.

Comment to Plates 11 and 12

Pisces - Chondrichthyes - Family Pristiophoridae BLEEKER, 1859
Genus ***Pristiophorus* MÜLLER & HENLE, 1837**: ***Pristiophorus rupeliensis* HERMAN & STEURBAUT, 1974**

Dorsal and ventral views of a part of a *neurocranium* attributed to this species. This unique fossil was discovered by Pieter De Schutter (Aalst, Belgium) in the Eastern Sector of the Clay Pit.

Rear views of a part of a neurocranium of one specimen of the Genus *Pristiophorus* MÜLLER & HENLE, 1837: *Pristiophorus rupeliensis* HERMAN & STEURBAUT, 1974.

This unique fossil was discovered by Pieter De Schutter (Aalst, Belgium) in the Eastern Sector of the Clay Pit.

Its determination has requested comparisons with the neurocranium of living representatives of the Genera *Pristis* BONAPARTE, 1838 and *Pristiophorus* BLEEKER, 1859. See Plates 81 and 82.

Comments to Plate 13

Pisces - Chondrichthyes - Family Squatinidae BONAPARTE, 1838
Genus *Squatina* DUMERIL, 1806: *Squatina subserrata* MÜNSTER, 1846.

The Belgian Rupelian taxon *Squatina angeloides* VAN BENEDEN, 1873 is not based on teeth, but on a lot of grouped vertebrae. This fact decreases considerably the validity of this taxon.

The only Western European Oligocene taxon of the Genus *Squatina* based on teeth is *Squatina subserrata* MÜNSTER, 1846, taxon proposed before *Squatina angeloides* and consequently, it is this designation which is adopted in this Publication.

This benthic species was a fairly common inhabitant of the sandy bottoms of the upper part of the Ruisbroek Sands Formation. The posterior part of the *neurocranium* of one individual is figured on Plate 53: fig.: 1.

The oval section of the vertebrae of the diverse extant or extinct species of this Genus is considered as an easy and trustable identification criterion, but some primitive orectolobiforms possess similar vertebrae.

In the different levels of the Boom Clay Member, this species is only represented by some rare scattered teeth.

Comments to Plate 14

Pisces - Chondrichthyes - Family Heterodontidae GRAY, 1851
1a to **1e**: **Genus *Heterodontus* de BLAINVILLE, 1816: *Heterodontus janefirdae* CASE, 1980**

The discovery of five teeth, one of a juvenile specimen and four of one adult specimen, attributable to *Heterodontus janefirdae* CASE, 1980 in this Horizon constitutes one of the five arguments that allow supposing that an earlier Gulf Stream momentarily facilitated the crossing of the young North Atlantic Ocean for some north-eastern American Chondrichthyes.

This tooth is considered as a tooth of a juvenile individual because the enamel of its crown was so thin that its crown could have been pierced by its predator.

Comments to Plate 15

In the Belgian Oligocene deposits, the Genus *Alopias* RAFINESQUE, 1810 (Family Alopiidae BONAPARTE, 1838) is represented by two species: *A. exigua* (PROBST, 1879) and *A. latidens* LERICHE, 1909.

In the uppermost part of the Sands of Ruisbroek and in the *Sint Niklaas Phosphorite Bed*, both species are extremely rare.

The addition of the numbers of teeth of these two species represent less than 0.3 % of the total of the Neoselachii teeth discovered in this level.

The figures of the three teeth illustrated on this plate allow distinguishing the principal odontological difference existing between these two specific taxa: The massive and short dental crown of *A. latidens* and the fine and elongated dental crown of *A. exigua*.

The photographs of the two teeth presented on Plate 15 present four views of two other teeth of *A. exigua* which illustrate this specific difference very well.

Comments to Plates 16, 17 and 18

Pisces - Chondrichthyes - Neoselachii

1a-2b: Family Lamnidae MÜLLER & HENLE, 1838: Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999:
***Rhizoquadrangulus rupeliensis* (LE HON, 1871).**

The illustration of the morphology of the teeth of this taxon considered by the senior-author as the direct ancestor of the first populations of the Genus *Lamna* CUVIER, 1816 is completed by the photographs of five other teeth presented on Plates 17 and 18.

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. This species is already present in the Berg Sands Formation.

Some isolated teeth were discovered in different levels of the Terhaegen Lid of the Boom Clay Member in diverse active or abandoned Clay Pits at Hemiksem, Kruibeke, Niel and Schelle.

Comments to Plates 19 and 20

Pisces - Chondrichthyes - Neoselachii

1a-1b: Family Cetorhinidae GILL, 1862: Genus *Cetorhinus* de BLAINVILLE, 1816:
Intern and extern views of one tooth of ***Cetorhinus parvus* (LERICHE, 1908)**.

This tooth and some gill-rackers elements were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

Some isolated teeth were discovered in different levels of the Terhaegen Lid of the Boom Clay Member in active Clay Pits at Hemiksem, Kruibeke and Niel.

Oligocene reworked teeth were also discovered in sifting residues of the basal gravel of the Kattendijck Sands Formation, where this Formation covers the top of the Boom Clay.

Where other Neogene Formations exist between the top of the Boom Clay and the basal gravel of the Kattendijck Sands, teeth of this species are absent or obviously damaged by geochemical processes.

Comments to Plates 21 to 23

Pisces - Chondrichthyes – Neoselachii

Family Odontaspididae MÜLLER & HENLE, 1839: Genus *Odontaspis* AGASSIZ, 1838:
***Odontaspis acutissima* (AGASSIZ, 1843).**

Plate 21 illustrates the dentition of the upper jaw of this species, Plate 22 illustrates the dentition of the lower jaw of this species and Plate 23 presents one eye-tooth and one traumatic tooth of this species.

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. This species is already present in the Berg Sands Formation.

Some isolated teeth were discovered in different levels of the Terhaegen Lid of the Boom Clay Member in diverse active or abandoned Clay Pits at Boom, Hemiksem, Kruibeke, Niel, Rumst and Schelle.

Comments to Plates 24 and 25

Pisces - Chondrichthyes - Neoselachii
Family Odontaspididae MÜLLER & HENLE, 1839: Genus *Odontaspis* AGASSIZ, 1838:
***Odontaspis cuspidata* (AGASSIZ, 1843).**

Plate 24 illustrates the dentition of the upper jaw of this species and Plate 25 illustrates the dentition of the lower jaw of this species.

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. This species is already present in the Berg Sands Formation.

Some isolated teeth were discovered in different levels of the Terhaegen Lid of the Boom Clay Member in diverse active or abandoned Clay Pits at Boom, Hemiksem, Kruibeke, Niel, Rumst and Schelle.

Comments to Plate 26

Pisces - Chondrichthyes - Neoselachii - Family Carcharhinidae JORDAN & EVERMANN, 1896:
1-2: Genus *Carcharhinus* de BLAINVILLE, 1816: *Carcharhinus elongatus* (LERICHE, 1910).
And
3-4: Genus *Physogaleus* CAPPETTA, 1980: *Physogaleus latus* (STORMS, 1891).

Explanations concerning the evolution of the systematic conceptions are given in the text. In 2010 and in 2012, the senior-author has thoroughly explained the necessity to completely re-examine the numbers of extant and extinct taxa attributable to this Family.

Comments to Plate 27

Pisces - Chondrichthyes - Neoselachii: Family Carcharhinidae JORDAN & EVERMANN, 1896:
Genus *Abdounia* CAPPETTA, 1980: *Abdounia belselensis* MOLLEN, 2007.

These seven teeth were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* in the northern sector of the SVK Clay Pit N°4.

This easily distinguishable species seems to have never been discovered in other Belgian Oligocene fossiliferous levels.

Comments to Plates 28, 29 and 30

Pisces - Chondrichthyes - Neoselachii: Family Otodontidae GLYCKMAN, 1964:
Genus *Carcharocles* JORDAN & HANNIBAL, 1923: *Carcharocles angustidens* (AGASSIZ, 1843).

The teeth of this species were by their scarcity and their size, of course, the most impressive discoveries of our sifting operations.

Six of these teeth discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* with identic coloration and size variation came from the jaw of a single individual of *circa* six metres length, dead in a relative vicinity of their discovery place.

The quality of preservation and the coloration of the teeth illustrated on Plate 30 demonstrate that sometimes other individuals were present there.

Comments to Plate 31

Pisces - Chondrichthyes - Neoselachii: Family Otodontidae GLYCKMAN, 1964:

Genus *Carcharocles* JORDAN & HANNIBAL, 1923: *Carcharocles angustidens* (AGASSIZ, 1843).

These two superb teeth are preserved in the Collection of the senior-author's friend, the baron Hélin de Wavrin.

They have another geographical and time-related origin. They were discovered in the Terhaegen Lid of the Boom Clay Member at Tielrode (Eastern Flanders Province, Belgium).

Comments to Plate 32

This Plate presents two types of fossil preservation of parts of vertebral columns. Figure **1** shows a siderite concretion enveloping four chondrichthyan vertebrae of an undetermined taxon*, still in anatomical connection.

*Their small size and their massive and compact centrae allow supposing their attribution to a carcharhinid Chondrichthyes.

Figures **2a** to **2c** present three different views of one assemblage of three massive vertebrae, still in anatomical connection, of one large Elasmobranch: *Cf.* Family Odontaspididae MÜLLER & HENLE, 1839.

Comments to Plates 33 and 34

Pisces - Chondrichthyes - Neoselachii: Family Halaeluridae HERMAN & VAN WAES, 2012: Genus *Parmaturus* GARMAN, 1906: *Parmaturus steurbauti* (HOVESTADT & HOVESTADT-EULER, 1995).

These two teeth were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. Teeth of this taxon seem to have never been encountered in Formations younger than this Unit, but their small size allows supposing that they escaped from the exploration attempts realised by other people principally interested in the fauna of the molluscs.

Comments to Plates 35 and 36

Pisces - Chondrichthyes - Batoidei: Family Rajidae BONAPARTE, 1831: Genus Raja LINNAEUS, 1758.
1a to **1d**: Four views of one lower anterior tooth of ***Raja cf. casieri*** **HERMAN & STEURBAUT, 1978**.
2a and **2b**: Two views of one upper anterior tooth of ***Raja cf. casieri*** **HERMAN & STEURBAUT, 1978**

1a to **1d**: Four views of one lateral tooth of ***Raja cf. casieri*** HERMAN **& STEURBAUT, 1978.**
2a to **2d**: Four views of one tooth of ***Raja cf. heinzelini*** **HERMAN & STEURBAUT, 1978.**

All these teeth were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. Such as teeth of *Parmaturus steurbauti* (HOVESTADT & HOVESTADT-EULER, 1995), teeth of these taxa seem to have never been encountered in Formations younger than the Boom Clay Member.

Their small size allows supposing that they escaped from the exploration attempts realised by other people principally interested in the fauna of the molluscs.

Comments to Plate 37

Pisces - Chondrichthyes - Batoidei: Family Dasyatidae JORDAN, 1888: Genus *Dasyatis* RAFINESQUE, 1810: 1-2: Different views of two teeth of ***Dasyatis cf. rugosa*** **(PROBST, 1877).**

Such as the *Raja* teeth, the small size of the *Dasyatis* teeth allows supposing that they escaped from the exploration attempts realised by other people principally interested in the fauna of the molluscs.

Comments to Plates 38, 39 and 40

Pisces - Chondrichthyes - Batoidei: Family Dasyatidae JORDAN, 1888: Genus *Dasyatis* RAFINESQUE, 1810: 1-2: Different views of a traumatic tooth of ***Dasyatis cf. rugosa*** **(PROBST, 1877).**

All these fossil teeth were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. The frequency of teeth presenting similar anomalies is relatively important.

Comments to Plate 41

1a-1b: **Pisces - Chondrichthyes - Neoselachii**: **Family Heterodontidae GRAY, 1851**: **Genus *Heterodontus* de BLAINVILLE, 1816**:

Anterior tooth of a juvenile ***Heterodontus janefirdae*** **CASE, 1980**.

The discovery of some teeth of this American east coast fossil in the sifting residues of the *Sint Niklaas Phosphorite Bed* is one of the five arguments allowing to suppose the existence of an earlier Gulf Stream.

2a-2b and **3**: **Pisces - Chondrichthyes - Neoselachii**: **Family Myliobatidae BONAPARTE, 1838**: **Genus *Weissobatis* HOVESTADT & EULER-HOVESTADT 1999**: ***Weissobatis oligocaena* (LERICHE, 1910)**.

The choice of a skeleton, and not its teeth, as generotype for a Batoid poses a serious problem for the revision of the generic attribution of all the specific Eocene, Oligocene and Miocene taxa of the Family Myliobatidae.

Comments to Plate 42

1a and **1b** are lateral and posterior views of a dorsal fin spine of *Squalus alsaticus* ANDREAE, 1892 corroded by stomachal enzymes.

2a to **2d** are lower, upper, lateral and oblique views of a caudal spine of a member of the Family Dasyatidae JORDAN, 1888. Its 149 millimetres of total length allows to attribute this caudal spine to an indidual of *circa* two metres of length.

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

Comments to Plate 43

Pisces -Teleostei:

1: View of a broken buccal dentiferous plate of an undetermined species of the *Cf.* Family Sparidae.
2: Lateral view of a tooth of an undetermined teleostean fish.
3a-3b: Extern and intern views of a dermal plate of a member of the Family Ostraciidae RAFINESQUE, 1810.

A better generic attribution of the hundred thousands isolated fossil teeth of Teleostei discovered in the diverse Belgian Cenozoic ls evelwill only be possible after a minutious examination of, at least, all the dentiferous bones of all the extant generic taxa of the Teleostei.

Such a work is of course impossible to realise by one isolated ichthyologist. The proposal of new fossil taxa based on isolated teeth of this huge group of fishes is consequently unacceptable.

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

Comments to Plates 44, 45 and 46

Pisces - Teleostei: Three Ear bones.

All the fossils illustrated on these three plates were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. Determination Dr. Louis Taverne.

Plate 44

Diverse views of a part of the ear bones complex of a very small skull:
an exoccipital attributed to a gobiid Teleostei.

Plate 45

Diverse views of a part of the ear bones complex of a very small skull:
an exocipital attributed to a gobiid Teleostei.

Plate 46

Diverse views of a part of the ear bones complex of a very small skull:
an exocipital attributed to a gobiid Teleostei.

Comments to Plate 47

1-2: **Pisces - Teleostei**: **Mycelium damages on teleost bones**.

This partially damaged fossil was discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

The fact that only a small part of its surface shows traces of mycelium ramifications means surely that only this part was submitted to a terrestrial deterioration.

The existence of some traces of a terrestrial fungal deterioration demonstrates the existence of an emersive phasis. Their scarcity allows to suppose that this emersive phasis very short was.

Comments to Plate 48

1-3: **Pisces - Teleostei**: **Jaw bones.**

1: Lateral view of a right dentary. **2** and **3**: Lateral view of two right premaxillaries.

All these fossils were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

The nature of these bones was determined thanks to the photos published on the site:
http://www.bishopmuseum.org

Comments to Plate 49

1-5: **Pisces - Teleostei**: **Order Percomoformes**: **Family Scorpaenidae RISSO, 1826**: **Diverse cranial bones**:

1: Extern view of a frontal. **2**: Extern view of a lachrymal. **3**: Extern view of a supracleithrum.
4: View of a large fragment of a preopercular. **5**: View of a large fragment of a supracleithrum.

All these determinations were friendly provided by Dr. Louis Taverne (I.R.S.N.B., Brussels, Belgium).

All these delicate fossil cranial bones were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

Comments to Plate 50

1-5: **Pisces - Teleostei**: Oblique views of the anterior face of diverse vertebrae.

All these vertebrae are cervical vertebrae of undetermined Teleostei. The extraordinary quality of their preservation suggests the existence of a short period during which the marine water movements were very calm.

Comments to Plate 51

1-5: **Pisces - Teleostei: Vertebrae**.

1a-1b: Anterior and lateral views of caudal vertebrae.

2 to **5**: Lateral views of four precaudal vertebrae representatives of nearly 90 % of the vertebrae discovered in the sifting residues of the uppermost part of the *Sint Niklaas Phosphorite Bed*.

All their delicate apophyses: zygapophyses (lower apophyses), haemapophyses (upper apophyses) and parapophyses (lateral apophyses) are still, more or less, complete.

The position of these vertebrae (caudal or precaudal) was determined thanks to the photos published on the site: http://www.bishopmuseum.org

The extraordinary quality of preservation of these delicate bones suggests the existence of a short period during which the marine water movements were very calm.

Their quality of preservation is identic to the quality of the preservation of the bones of the complete skeletons discovered in diverse lithographic limestones, such as the Jurassic limestones of Cerin (France) and Solnhofen (Germany), the Cretaceous limestones of Lebanon and the Eocene limestones of Monte-Bolca (Italia).

For references, see Bibliography-Teleostei: Chanet, Guintard, Picard, Bugnon, Touzalin & Betti 2009 and Radu 2005.

Comments to Plate 52

1-5: **Pisces - Teleostei**: **Diverse axial bones.**

1 to **3**: Anterior view of three *centrae* of caudal vertebrae of a small undetermined taxon.
4: An isolated spin of the dorsal fin of a small undetermined taxon.
5: Two articulated spins of the dorsal fin of a small scorpaeniform fish.
These last are still in connection with their zygapophyse and still mobile.

All these bones were discovered in the sifting residues of
the of the uppermost part of the *Sint Niklaas Phosphorite Bed*.

Such discoveries, relatively frequent, demonstrate that, after the formation of *Sint Niklaas Phosphorite Bed* and during the beginning of the formation of the huge ostreid banks, a short period has existed during which the marine water movements were very calm.

Such an environment is only conceivable in a protected bay, where superficial sea currents occasionally bring along some carcasses of dead fishes.

Comments to Plate 53

1: **Pisces - Chondrichthyes**: **Family Squatinidae BONAPARTE, 1838**: **Genus *Squatina* DUMERIL, 1806**: ***Squatina angeloides* (VAN BENEDEN, 1873)**: View of the rear part of a *neurocranium*.

The rear face of this remains of a *neurocranium* presents an oval *basicranial* aperture, which is a characteristic of all the extant species of the Genus *Squatina*.

This fossil is the second remains of a skull of a Chondrichthyes discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*. Its very strong calcification must be pointed out.

2 to **5**: **Pisces - Teleostei**: **Diverse bones**.

2: Vomer with some teeth attributable to *Sphyraenodus rupeliensis* DOLLO & STORMS, 1888. Length: 38 mm.
3a-3c: Three views of a hypural of *Cybium dumonti* VAN BENEDEN, 1874. Height: 82 mm.
4: Hypural of *Neocybium rostratum* LERICHE, 1908.
5a-b: Right dentar of *Pelamys brachycephalus* LERICHE, 1908.

All these fossil teleostean bones were discovered in the sifting residues from the *Sint Niklaas Phosphorite Bed* and such as all the Teleostei remains discovered and illustrated by M. Leriche* in the Boom Clay Member they request a complete systematic revision.

*See Bibliography-Teleostei: Leriche 1910.

These remarkably preserved fossils were determined without sufficient comparisons with extant taxa of their Families and Orders. The overabundance of new generic taxa and their approximate generic attributions result from this fact.

The teleostean bones discovered in the *Sint Niklaas Phosphorite Bed* request the same taxonomic revision. They are destined to further investigations by the paleoichthyologist who would like to contact the senior-author.

Comments to Plate 54

Reptilia - Chelonia: *Cf.* Family Carettidae MERREM, 1820.

1a to **1c**: A weatherworn egg of a sea turtle

This fossil discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* remained a mystery for a long time.

But one day, using only one source of strong oblique lighting, diverse details of different parts of the skeleton of a quite mature embryo of a sea turtle appeared distinctly: a part of a plastron, some ribs, the bones of a leg and the future hexagonal granular plates of the dorsal side of the future shell box.

This spectacular and emotional discovery was the first one in Western Europe. Two other eggs were waiting for examinations.

Comments to Plate 55

Reptilia – Chelonia: *Cf.* Family Carettidae MERREM, 1820.

1a to **1c**: Three views of a damaged weatherworn egg attributed to a sea turtle. See X-ray photographs of this egg on Plate 56.

This oval, slightly polished and elongated *corpus* was discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

It was the third specimen discovered in an area of *circa* 20 square metres, in the southern part of the SVK Clay Pit 4.

The first one was initially considered as an enigmatic ichnofossil (See *Géominpal Belgica* 5 Part 2: Plate 14: fig.: 5) but its similar morphology, sizes and patina allow considering this *ichnofossil* as the third egg of apparently the same nest.

Comments to Plate 56

Reptilia - Chelonia: *Cf.* Family Carettidae MERREM, 1820.

1a-1b: X-ray photographs of the damaged sea turtle egg illustrated on Plate 55.

These X-ray photographs are a courtesy of the Laboratoire d'Analyse Physique et de Caractérisation du Matériau (Douai, France) and were realised by Miss Lucille Géant*. They demonstrate the presence of the skeleton of an elongated tetrapod with a short head.

*Technicienne de Laboratoire à la Direction de l'Archéologie Préventive. Communauté d'agglomérations du Douaisis (59 351 Douai Cedex, France).

The attribution of this skeleton to a chelonian may be argumented by the shortness of the nose of this embryo, a nose which cannot be the nose of a squamate, a lacertilian or a crocodile, these last ones being always more elongated.

The general morphology of this skull and the presence of legs made the attribution of this skeleton to an ophidian impossible.

Comments to Plate 57

1: Pisces - Chondrichthyes - Neoselachii:

1: Two views of a spur of a clasper of an adult male of ***Carcharocles angustidens* (AGASSIZ, 1843)**
of *circa* 5m50 length. Total length of the spur: 10.5 millimetres.

Such as the males of all the Chondrichthyes, the males of *Carcharodon carcharhias* (LINNAEUS, 1758) possess a pair of pelvic claspers for the seminal injection during mating.

Some taxa of Chondrichthyes possess claspers with a spur presenting a groove facilitating this function.

These claspers are well calcified, with a conical spur. The spur of a *Carcharodon carcharhias* of 517 centimetres of length was 8 millimetres long. (See Domsky & Northcutt: p.: 133).

For references concerning the claspers of the Chondrichthyes, see Bibliography-Neoselachii: Demsky & Northcutt 1996, Georgio 1970, Gilbert & Heath 1955 and Leigh-Sharpe 1920-1926.

Good images of Claspers of Neoselachii and Batoidei can be found on the following websites:
Neoselachii: Website: www.flmnh.ufl.edu, and Website: www.pc.maricopa.edu
Batoidei: Website: www.courses.washington.edu and Website: www.courses.washington.edu

2: **Reptilia - Crocodylia**:

2a and **2b**: Two lateral views of one caudal osteoderm of ***Osteolaemus* sp.** Height: 12.5 millimetres.

Such as the specimen not represented, the insertion part of this small caudal osteoderm is strongly corrupted, which suggests that if the existence of mangrovial zones is a real possibility, their vicinity is more relative than proposed in the text.

Comments to Plate 58

Thanks to our friend and colleague Dr. Jerry Hooker (B.M.N.H., London, Great Britain), these two millimetric teeth discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*, and probably of the same individual, could be determined as follows.

1-2: Mammalia - Rodentia - Theridomorpha - Family Theromyidae ALSTON, **1876**:
Genus *Isoptychus* **POMEL**, **1852**: ***Isoptychus cf. margaritae*** **(VIANEY-LIAUD,** 1995).
1a-1b: Lateral and occlusal views of one incomplete right lower molar.
2a-2c: Occlusal, extern and lateral views of one complete right upper molar, or last premolar.

These two teeth are the oldest Belgian remains of this taxon, abundantly represented in the continental Upper Oligocene deposits at Hoeleden and Hoogbutsel (Limburg Province, Belgium).

Comments to Plate 59

1: Mammalia - Perissodactyla: **Family Rhinocerotidae** **GRAY**, **1820**.

1a-1c: Three different views of a *calcaneum* of an ***Anthracotherium* sp**. discovered by Guy Van Den Eeckhaut in the south-eastern Sector of the Clay Pit.

The argumentation authorising this attribution is thoroughly detailed in the text. This bone is the first Belgian fossil remains of the Family Rhinocerotidae.

2: Reptilia - Chelonia: **Family Carettidae** **GRAY**, **1825**.

2a-2d: **Chelonia**: Buccal and ventral views of two mandibles of a ***cf. Caretta* sp.**

Comments to Plate 60

1-2: Aves - Paleornithes - Family Odontopterygiidae.

1a to **1d**: Two views of a broken *tibiotarsus*. **2a-2b**: Two views of an incomplete *tibiometatarsus*.

Remains of members of the Family Odontopterygiidae (or pseudo-toothed birds) are relatively common in the diverse Belgian Eocene deposits.

Such fossils are extremely rare in the lowermost Belgian Oligocene Belgian deposits and those discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* seem to be the remains of the ultimate survivors of this Family in Western Europe.

In diverse Museum Collections, the fragments of their jaws were, and remain, frequently catalogued as Perciforms or Scombridae jaw fragments.

3: Reptilia - Chelonia - *cf.* Family Carettidae **GRAY**, **1825**.

3a-3b: Buccal and ventral views of a right half mandible of a juvenile specimen.

In the Belgian Lower Oligocene marine deposits, the Chelonia are only represented by some jaws, shell box fragments and three eggs of one species attributed to the Family Carettidae GRAY, 1825.

Comments to Plates 61 to 63

Pisces - Chondrichthyes - Holocephali:
Family Rhinochimaeridae **GARMAN**, **1901**:
Genus *Rhinochimaera* **GARMAN**, **1901**: ***Rhinochimaera atlantica*** **HOLT & BYRNE**, **1909**.

These three Plates illustrate the general morphology and some singularities of these primitive fishes.

Such as all the extant taxa of the Holocephali, the males are in possession of a frontal organ called *tenaculum*.

The males of the Holocephali being also in possession of claspers, this cephalic organ seems to have as single function to encourage females during the copulation.

*Clasper: *In biology, a clasper or valva (plural valvae) is an anatomical structure of certain male animals used in mating.* In fact an elongated rigid testis. All the normal chondrichthyan males possess two claspers.

A very good illustration of the claspers of an Holocephalian is visible
on the Net: Website: www.evolutionistrue.wordpress.com

During his North Atlantic expeditions, the senior-author had, only one time, the possibility to examine the morphology and the stomachal contents of three specimens* trawled between 840 and 900 metres depth, South Louisy Bank, North-East Atlantic.

*One male of 110 centimetres of total length and two females of 120 and 150 centimetres of total length.

The complete skulls of these three specimens were preserved. Their dental plates as well as their cephalic spines were figured in the Series*: *Contributions to the study of the comparative morphology of teeth and other relevant ichthodorulites in living supraspecific taxa of Chondrichthyes fishes.* Editor M. Stehmann.

*See Bibliography-Holocephali: Herman, Hovestadt & Hovestadt-Euler 2001.

The *tenaculum* of the male was photographed in its integrity, before proceeding to a slow and careful dissolution of the organic remains making the examination of their assemblage and the examination of the vascularisation of their basal plate possible.

All the extant species of the three holocephalian Genera: Genus *Rhinochimaera* GARMAN, 1901, Genus *Hariotta* GOODE & BEAN, 1895 and Genus *Neohariotta* STHAL, 1999 are in possession of a more or less elongated nose* resulting from the extension of the nasal cartilaginous elements.

* In this case, the term *nose* is preferentially utilised than the term *rostrum* because only the nasal extension of the taxa of the Genera *Hariotta* and *Neohariotta* presents a relative rigidity.

For all the extant or extinct species of the Families Sclerorhynchidae CAPPETTA, 1974, Pristiophoridae BLEEKER, 1859 and Pristidae BONAPARTE, 1838 this cartilaginous extension is rigid and seems to have been, and still is, a very efficient tool to increase their nutritional possibilities.

The removal actions of the sediments located just below this rostrum make the capture of their small preys easier.

For the holocephalian Chondrichthyes this nasal extension seems to have as principal function the enhancing of their olfactory capacity.

For references, see Bibliography-Holocephali: Bullis & Carpenter 1966, Didier, Sthal & Zangerl 1994, Garman 1901 and Woodward & White 1930.

Additional comments to Plates 61 to 63

Pisces - Chondrichthyes - Holocephali: Family Chimaeridae BONAPARTE, 1831: Genus *Chimaera* LINNAEUS, 1758: *Chimaera monstrosa* LINNAEUS, 1758.

During his North Atlantic expeditions, the senior-author often had the possibility to examine the morphology and the stomachal contents of numerous specimens* trawled between 480 and 960 metres depth, in diverse trawling or fishing sectors of the North-East Atlantic.

*More than 250 individuals caught on the Porcupine Bank, or off the Hebrides, Faer Oë, Orcades and Shetlands Islands, at depths comprised between 450 and 830 metres (September 1977 - April 1982).

The complete skulls of many specimens were preserved. Some of their dental plates as well as their cephalic spines were figured in the same Series*: *Contributions to the study of the comparative morphology of teeth and other relevant ichthodorulites in living supraspecific taxa of Chondrichthyes fishes.* Editor M. Stehmann.

*See Bibliography-Holocephali: Herman, Hovestadt & Hovestadt-Euler 2001.

The *tenaculum* of one male was photographed in its integrity, before proceeding to a slow and careful dissolution of the organic remains making the examination of their assemblage and the examination of the vascularisation of their basal plate possible.

The crowns of the *tenaculum* spines of the Genus *Chimaera* present lateral cutting edges never observed on the crowns of the *tenaculum* spines of the Genus *Rhinochimaera*.

For the numerous morphological differences existing between the dental plates of these two Genera: See Bibliography-Holocephali: Herman, Hovestadt & Hovestadt-Euler 2001 and Stahl 1966.

Holocephalian eggs were discovered in strata of Paleozoic Age, and the oldest known *Callorhynchus* egg was discovered in Upper Aalenian (Middle Jurassic) Age*.

**Callorhynchus germanicus* (BROWN, 1946).

Captain Pierre Gueguen signalised to the senior-author that, at the end of the summer and in the beginning of the autumn, the deck of his trawler was sometimes covered by plenty of horny spindle-like eggs and that plenty of female *Chimaera* were present in his trawl.

For references, see Bibliography-Holocephali: Brown 1946, Brown 1950, Fischer & Kogan 2008 and Stahl 1999.

Comments to Plates 64 to 70

Pisces - Chondrichthyes - Neoselachii:
Family Hexanchidae GRAY, 1851 and Family Heptranchidae BARNARD, 1925

The Super-Order Echinorhinomorphii was proposed in 2012 for regrouping three orders presenting a singular discontinuous evolution: the Order Echinorhiniformes represented by the extant and extinct taxa of the Family Echinorhinidae GILL, 1862, the Order Hexanchiformes represented by the extant and extinct taxa of the Family Hexanchidae GRAY, 1851 and the Order Heptranchiformes represented by the extant and extinct taxa of the Family Heptranchidae BARNARD, 1925.

Their members passed from five, to six and finally to seven pairs of gills. During this process they realised the imbrication of their teeth rows and enhanced the rigidity of their lower jaw by the formation of one symphyseal teeth row.

The biological and the odontological arguments justifying the proposal of this new Super Order are detailed in *Géominpal Belgica* **2**.

In the Belgian Oligocene, only teeth of the extant Genus *Notorynchus* AYRES, 1855 and the extinct Genus *Notidanion* JORDAN & HANNIBAL, 1923 were discovered.

Apparently, teeth of *Notidanion howelli* REED, 1946 were never discovered in the sediments of the Boom Clay Member, but this species was already present in Belgium, in the Berg Sands Formation*.

*Eleven specimens observed in three Private Collections.

The presence of some teeth attributable to the species *Notidanion howelli* REED, 1946 is one of the five paleoichthyological arguments that allow supposing that an earlier Gulf Stream already existed in the Lower Oligocene Age.

Sources of the illustrations of Plate 70

1: Lateral view of an adult female. Origin: The National Marine Fisheries Service (NMFS), a U.S. government organization. **2**: Detail of a part of the lower anterior part of the dentition of one adult specimen. **3**: Intern view of the anterior part of the dentition of one adult specimen.
2 and **3**: Website: http://www.flmnh.ufl.edu/fish/Gallery/Descript/SnoseSgillShark/SnoseSgillShark.html

Comments to Plate 71

Fig.1a illustrates this superb taxidermist's preparation of the intern part of one gill arch of a juvenile specimen. **Fig.1b** is a magnification of a part of this preparation.

This Plate is a courtesy of the senior-author's friends Dirk Hovestadt and Maria Euler-Hovestadt (Terneuzen, The Netherlands).

Comments to Plate 72

Pisces - Chondrichthyes – Neoselachii:
Family Orectolobidae GILL, 1896:
Genus *Orectolobus* BONAPARTE, 1834: *Orectolobus japonicus* REGAN, 1906.

The motivation for illustrating the morphology of one member of this Family is the necessity to demonstrate that for all the species of the Family Squatinidae BONAPARTE, 1838 (See Plate 73) and the Family Orectolobidae GILL, 1896, only extern morphological criteria allow distinguishing the numerous specific taxa of these two Families, despite the numerous odontological similarities signalised by diverse palaeontologists.

For references: See Bibliography-Chondrichthyes: Compagno 1984, Herman, Hovestadt & Hovestadt-Euler 1992, and Herman & Van Waes 2012.

Comments to Plate 73

Family Squatinidae BONAPARTE, 1838:
Genus *Squatina* DUMERIL, 1806: *Squatina africana* REGAN, 1908.

All the extant members of this Genus possess a flat and massive skull presenting an oval-shaped occipital aperture making their identification easier as well as the identification of the first columnar vertebrae.

Teeth attributable to the Genus *Squatina* are very common in all the Paleocene to Miocene Belgian sediments.

In the Belgian Upper Cretaceous, this Genus seems to have co-habited with the Genus *Squatirhina* CASIER, 1947, another taxon which must presently be considered as an Orectolobiformes and no longer as a Squatiniformes.

Comments to Plates 74 to 78

Pisces - Chondrichthyes - Neoselachii:
Family Heterodontidae GRAY, 1850:
Genus *Heterodontus* de BLAINVILLE, 1816:

The attribution of the paternity of the Order Heterodontiformes to J. L. V. Compagno 1973 is an example of the lack of communication between occidental and Russian scientific communities during the Cold War.

During this long and difficult period, some divergent attitudes were also difficult to understand. In Belgium, the Direction* of the I.R.S.N.B. suggested to follow the Classification of Dr. Lev Berg**, but many scientists referred only to diverse occidental classifications: the one of Dr. Maurice Leriche (F), the one of his follower Dr. Edgard Casier (B) or, later, to the one proposed by Leonardo Compagno (U.S.A.).

*Dr. Director André Capart and Dr. Jean-Pierre Gosse, Conservator of the Recent Fishes Collections had officially adopted the Classification of their Russian colleague, the Dr. Lev Berg, because this Classification was the more recent including both extant and extinct fishes taxa.

See the paragraph: Berg's conception of the Evolution: **6.2.

Plate 77 presents diverse views of one egg capsule of *Heterodontus portusjacksoni* MEYER, 1793. This type of egg capsule, characteristic for all the extant species of the Genus *Heterodontus*, is the most singular morphotype of Neoselachii eggs and an additional criterion demonstrating the singularity of this lineage.

Comments to Plates 79 and 80

Pisces - Chondrichthyes – Neoselachii:
Family Squalidae de BLAINVILLE, 1816:
Genus *Squalus* LINNAEUS, 1758: *Squalus acanthias* LINNAEUS, 1758.

All the extant members of this Genus possess an elongated skull presenting a circular-shaped occipital aperture, two dorsal fin spines, a relatively supple vertebral column and spaced dermal denticles.

The tendency of all the extant and extinct taxa of this Genus to fusion their two lower parasymphyseal teeth rows to produce a symphyseal teeth row is illustrated on Plate 80: fig.: 2.

Courtesy of D. Ross Robertson: Shorefishes of the Neotropics: http://neotropicalfishes.lifedesks.org/

Comments to Plates 81, 82 and 83

Pisces - Chondrichthyes - Neoselachii:
Family Pristiophoridae BLEEKER, 1859: Genus *Pristiophorus* MÜLLER & HENLE, 1837:

Comparison between the skulls of an extant Pristidae BONAPARTE, 1938 and an extant Pristiophoridae BLEEKER, 1859

Two stuffed specimens of the Collection Eric Vanderhoeft: one female of 76 centimetres of total length *Pristis microdon*, LATHAM, 1794: Origin: *Indonesia* (without precisions), and one female of 70.5 centimetres of total length *Pristiophorus cirratus* LATHAM, 1794: Origin: *Japan* (without precisions), were used for comparison with the X-rays of the fossil skull discovered in the *Sint Niklaas Phosphorite Bed* by the senior-author's friend Pieter De Schutter.

These X-ray photographs were a courtesy of Dr. Jean-Marie Geurts (Wemmel, Brussels, Belgium).

After the realisation of these X-ray photographs, the possibility that this skull could be attributed to any taxa of the Families Orectolobidae, Squatinidae and Pristidae was definitively excluded.

The unique possible owner of this skull was a member of the Family Pristiophoridae BLEEKER, 1859 which regroups only two Genera: the Genus *Pristiophorus* MÜLLER & HENLE, 1837 and the Genus *Pliotrema* REGAN, 1906.

The oldest taxa known of the Genus *Pliotrema* being of Pliocene Age of the southern hemisphere and the Genus
Pristiophorus being represented by oral and rostral teeth of only one species in the Belgian Oligocene, the problems of the generic and the specific attributions of this skull seem to be resolved.

This exceptionally well preserved skull is the skull of a *Pristiophorus rupeliensis* STEURBAUT & HERMAN, 1978.

Objectivity of Dr. Geurts: At the systematic question asked by Eric Vanderhoeft: *What do you think about?* … Dr. Geurts neutrally answered: *These two animals have been dead for a long time. Bacteria have destroyed some delicate tissue structures*.

Plate 83 presents the jaws of an adult female of 107 centimetres of total length, caught off Western Australia and magnifications of its two symphyseal zones.

Comments to Plates 84 to 86
Pisces - Chondrichthyes - Neoselachii:
Family Isuridae HERMAN & VAN WAES, 2012:
Genus *Isurus* RAFINESQUE, 1810: *Isurus oxyrhynchus* RAFINESQUE, 1810.

This plate presents another remarkable taxidermic preparation of the whole head of a female of 305 centimetres of total length, realised by senior-author's friend Jean-Pierre Luypaerts (Brussels, B).

The upper and lower symphyseal parts of the dentition of this large individual perfectly illustrate the tripod-like morphology of the anterior teeth of the extant species of this Genus.

The shortening of the root lobes and the integration in the same vertical plane, or profile, of the crown and the root will be later realised in the jaws of *Carcharodon carcharias* (LINNAEUS, 1758).

A tooth morphotype intermediary between the typical *Isurus* morphotype and the *Carcharodon* morphotype is presently a subject of reflexion of the senior-author's friend Pieter De Schutter (Aalst, Belgium).

Plate 84 presents some views of a large female freshly caught off the South African coasts and shows its powerful nose, resulting of the ultra-calcification of its nasal cartilages.

Comments to Plate 87

Pisces - Chondrichthyes - Neoselachii:
Family Odontaspididae MÜLLER & HENLE, 1839:

Genus *Odontaspis* AGASSIZ, 1838: *Odontaspis taurus* RAFINESQUE, 1810.
***Odontaspis taurus* RAFINESQUE, 1810**

The different parts of the dentition of this species are a perfect example to illustrate the theory that, in some lineages, the commissural teeth reveal which generic taxon could be its ancestor.

In this case, the lateral teeth-rows of *Odontaspis taurus* suggest a direct phylogenetic relation with the Genus *Palaeohypotodus* GLYCMAN, 1964.

Comments to Plates 88 and 89

Pisces - Chondrichthyes - Neoselachii:
Family Lamnidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Lamna* CUVIER, 1816: *Lamna nasus* (BONNATERRE, 1788).

In the new Parasystematic proposed in 2012, the generotype of the Family Lamnidae MÜLLER & HENLE, 1838 remains the extant Genus *Lamna* CUVIER, 1816, but this emended Family includes only the two following extinct Genera: Genus *Rhizoquadrangulus* BAUT & GENAULT, 1999 and Genus *Lethenia* BAUT & GENAULT, 1999.

The odontological arguments justifying such a drastic emendation of this Family were presented in *Géominpal Belgica* **2**.

For precisions, see Bibliography: Herman & Van Waes 2012.

Comments to Plate 90

Pisces - Chondrichthyes - Neoselachii:

Family Galeocerdidae HERMAN & VAN DEN EECKHAUT, 2010:
Genus *Galeocerdo* MÜLLER & HENLE, 1837: *Galeocerdo cuvier* PERON & LESUEUR, 1822.

WoRMS 2012 persits to propose the designation *Galeocerdo arcticus* (FABER, 1793) for this species.

The extant Genus *Galeocerdo* MÜLLER & HENLE, 1837 is considered as a descendant of the cretaceous Genus *Squalicorax* WHITLEY, 1939.

All the odontological arguments justifying this new phylogenetic conception were presented in *Géominpal Belgica* **2**.

For precisions, see Bibliography: Herman & Van Waes 2012.

Comments to Plates 91 to 95

Pisces - Chondrichthyes - Neoselachii:

Family Carcharhinidae *sensu* HERMAN & VAN WAES, 2012:
Genus *Carcharhinus* de BLAINVILLE, 1816:

The odontological argumentation justifying the successive emendations of this Family were presented in *Géominpal Belgica* **1** and in *Géominpal Belgica* **2**.

All the species of this Genus are considered as middle sized predators but may be considered as dangerous potential man aggressors.

Historical tragedy

The sinking of the *US Indianapolis* is one of the most tragic events demonstrating this reality. The 30 July 1945, the USS *Indianapolis* shortly after delivering important elements of the first atomic bomb at Tinian Island, one of the Northern Mariana Islands, was torpedoed by the submarine *I-58* of the Imperial Japanese Navy and sank, with a part of its crew, in less than 12 minutes.

The remaining men tried to survive the natural elements and the constant sharks' aggressions*. Only *circa* 317 sailors survived.

*Apparently only species of the two Genera *Carcharhinus* de BLAINVILLE, 1816 and *Sphyrna* RAFINESQUE, 1810.

It is after this dramatic event that the Allied Occidental Powers started the testing of diverse shark repellents.

Dignathic morphology

The extraordinary dignathic diversity of the teeth of the diverse extant species of this Genus is the reason for presenting some extreme cases.

But, resulting from minor genetic code alterations, this extraordinary dignathic diversity surely has a very significant geological signification, still insufficiently analysed.

When the proportional distance between the insertions of the dorsal and pectoral fins changes, a genetic alteration must be the underlying cause.

The photographs of the complete dentition of the three different extant taxa presented on the Plates 89, 90 and 91 are a friendly help of the senior-authors friend's Dirk and Maria Hovestadt (Terneuzen, The Netherlands).

The photographs of the Plate 93 are a courtesy of M. Ross Robertson: http://neotropicalfishes.lifedesks.org.

Comments to Plates 96 to 98

Pisces - Chondrichthyes - Neoselachii: Family Otodontidae GLYCKMAN, 1964: Genus *Carcharodon* SMITH, 1838: *Carcharodon carcharias* (LINNAEUS, 1758).

Plates 96 and 97

The jaws of this very large specimen were discovered in the granary of the father of Guy Antoine (Herstal, Belgium), a senior-author's friend, with a simple label: *Souvenir de Durban, Juillet 1873*.

Plate 98

The jaws of this juvenile individual, gift of the senior-author friend's Dr. Franco Cigala-Fulgosi (Universita di Parma, Italia) help to understand the ontogeny of this huge extant predator.

The largest tooth of the old specimen illustrated on Plate 97 is 60.2 millimetres high and the largest tooth of the juvenile specimen is 28 millimetres high.

The interesting fact is that the number of the crenulations of the cutting edges of their crown is nearly identic.

Comments to Plate 99

Comparison between egg capsules of Holocephali, Neoselachii and Batoidei:

1: Egg of *Callorhinchus millii* BORY de SAINT-VINCENT, 1823. **2**: Egg of *Raja clavata* LINNAEUS, 1758.
3 and **6**: Eggs of *Hemiscyllium trispeculare* RICHARDSON, 1843.
4 and **5**: Eggs of *Scyliorhinus torazame* (TANAKA, 1908).

This plate presents photographs of eggs of some* specific taxa of the three subclasses of the Class Chondrichthyes proposed by Huxley in 1880.

*Diverse photographs of one egg of *Heterodontus portusjacksoni* were presented on Plate 77 of this Publication.

The morphology of the eggs of the Chondrichthyes presents some obvious evolutionary trends already evoked in this Publication.

The major problem seems to have been to secure a sufficient oxygenation of the embryo enclosed in their eggs.

The paleontological data suggest that the first solution adopted was the formation of a folded fringe, more or less significant, according to the diverse subclasses. This considerably increases the surface of the oxygen caption.

All the Holocephali, all the extant species of the Genus *Heterodontus* and some species of the Genus *Raja* produce egg capsules with a folded fringe.

For Rajidae egg capsules, see the Website: www.mexfish.com

The second problem was the development of diverse types of anchorage for these eggs so easily stranded. It was solved by the development of long filaments at one extremity* or both extremities (Diverse evolved Orectolobiformes and all the other Scyliorhiniformes).

* Some species of the Genus *Heterodontus* and all the species of the Genus *Scyliorhinus*.

For eggs of the Genus *Heterodontus*, see the Websites:

www.commons.wikimedia.org : photo taken by Taso Viglas: practice of oophagy.
www.commons.wikimedia.org : photo taken by Mark Norman: isolated egg on sandy bottom.
www. arkive.org : egg between algae.

A transitory solution is this presented by the egg capsules of the Genus *Cephaloscyllium* which have these elongated filaments and a transversal folding.

For eggs of the Genus *Cephaloscyllium*, see the Websites:
www.en.wikipedia.org
www.flickr.edu

Sources of the illustrations

1: Courtesy of M. Georges Lenglet, Conservator of the Collections of the Recent Vertebrates Department of the I.R.S.N.B., Brussels (B).
2: http://en.wikipedia.org
3 to **6**: M. Lutz Avilla: www.benthicsharks.fl

Comments to Plate 100

Pisces - Chondrichthyes - Batoidei: Family Rajidae BONAPARTE, 1831: Genus *Raja* LINNAEUS, 1758: *Raja naevus* MÜLLER & HENLE, 1841:

This Plate illustrates the general morphology of the majority of the shallow water representatives of this Genus.

Diverse deep water taxa of the Family Rajidae present numerous odontological criteria justifying their generic distinction.

Comments to Plate 101

Pisces - Chondrichthyes - Batoidei: Family Rajidae BONAPARTE, 1831: Genus *Raja* LINNAEUS, 1758: *Raja clavata* LINNAEUS, 1758.

This Plate illustrates the important sexual dimorphism existing between teeth of males and teeth of females of all the specific taxa of the Genus *Raja*.

Many other specific and generic taxa of the Family Rajidae present this odontological sexual dimorphism.

Comments to Plate 102

Pisces - Chondrichthyes - Batoidei: Family Myliobatidae BONAPARTE, 1838: Genus *Myliobatis* CUVIER, 1816: *Myliobatis goodei* GARMAN, 1885.

The evolution and the phylogenetic relations of the Genera and Families of the Order Myliobatiformes are essentially deductible from the successive modifications of the structure of their pectoral fins, the structure of their neurocranium and the modifications of their dental apparatus.

X-rays photos, and some fossil skeletons, of the diverse Genera of this Order allow observing a progressive elongation of the nuchal part of the neurocranium from a Dasyatid structure to a Myliobatid structure.

The dental plates of the extinct* and the four extant** taxa of the Genus *Aetobatus* de BLAINVILLE, 1816 represent a singular deformation of the normal dental myliobatid plates.

***Aetobatus arcuatus* AGASSIZ, 1843 from Miocene layers.
***Aetobatus flagellum* (BLOCH & SCHNEIDER, 1801), *Aetobatus guttatus* (SHAW, 1804), *Aetobatus ocellatus* (KUHL, 1823) and *Aetobatus narinari* (EUPHRASEN, 1790).

These dental plates are constituted by a succession of large central arched elements, without lateral elements.

For illustrations of such dental plates, see the Website: Photos Cathleen Bester: www.flmnh.ufl.edu

Comments to Plate 103

Pisces - Chondrichthyes - Batoidei: Family Myliobatidae BONAPARTE, 1838: Genre *Weissobatis* HOVESTADT & HOVESTADT-EULER, 1999:
Weissobatis micklichi HOVESTADT & HOVESTADT-EULER, 1999.

Dorsal view of the Holotype (N° 2336 PAL, Museum of Karlsruhe, Baden -Würtemberg, D).
Total length: *circa* 124 centimetres. Disc width: *circa* 63 centimetres.

According to the inventors of this new Genus, its skeleton presents structural differences that allow considering this fossil as the holotype of a new species and a new Genus of the Family Myliobatidae BONAPARTE, 1838.

The differences between the dental elements of this extinct Genus and those of the extant Genus *Myliobatis* CUVIER *ex* DUMERIL, 1816 are not clearly defined, which induces a lot of problems for the generic attribution of, at least, all the Eocene, Oligocene and Miocene fossils classically considered as members of the Genus *Myliobatis*.

Comments to Plate 104

Pisces - Chondrichthyes - Batoidei: Two taxa of the Order Myliobatiformes: Genus *Weissobatis* and Genus *Myliobatis*.
The issue of their validity and distinction

1: Detail of the head of the Holotype of ***Weissobatis micklichi*** **HOVESTADT & HOVESTADT-EULER, 1999**.
2a-2b: A dental tooth plate of ***Myliobatis dixoni*** **(AGASSIZ, 1843)** from the Middle Eocene of Belgium.

With only one well preserved dental plate* (figs.: 2a and 2b), this Plate illustrates the problem of the generic attribution of typical *Myliobatis dental plates* discovered everywhere in Upper Paleocene to Upper Miocene levels.

*From the Brussels Sands Formation, Middle Lutetian at Neder-Okkerzeel (Flemish Brabant, Belgium).

For illustrations of dental plates of extant species of the Genus *Myliobatis*,
see the Websites: www.flickr.com and www.skullsunlimited.com

Comments to Plate 105

Pisces - Chondrichthyes - Batoidei:
Family Dasyatidae JORDAN, 1888: Genus *Pastinachus* RÜPPEL, 1829:
1: Jaws of ***Pastinachus sephen*** **FORSKALL, 1775**. Origin: Mouth of the Ganges River.
Family Myliobatidae BONAPARTE, 1838: Genus *Myliobatis* CUVIER, 1816:

2a-2b: Jaws of ***Myliobatis aquila*** **(LINNAEUS, 1758)**.

The extant representative of the Genus *Pastinachus* RÜPPEL, 1829, has a remarkable adaptation to life in brackish and sweet waters in common with the extinct representatives of the Genera *Hypolophus* MÜLLER & HENLE, 1837 and *Hypolophodon* CAPPETTA, 1980.

The dental root of all these taxa presents a higher porosity than those of species restricted to normal marine waters.

A south American species of *Hypolophodon*: *H. patagoniensis* CIONE, TEJEDOR & GOIN, 2013 was recently discovered and published*.

*See Bibliography- Batoidei: Cione, Tejedor & Goin 2013.

Comments to Plates 106 and 107

Plate 106

Pisces - Actinopterygii - Teleostei: Family Ostraciidae RAFINESQUE, 1810: Genus *Lactoria* JORDAN & FOWLER, 1902: *Lactoria cornuta* (LINNAEUS, 1758).

Plate 107

Pisces - Actinopterygii - Teleostei: Family Ostraciidae RAFINESQUE, 1810. Genus *Ostracion* LINNAEUS, 1758: *Ostracion cubicus* LINNAEUS, 1758.

The Family Ostraciidae regroups the eight extant Genera: Genus *Acanthostracion* BLEEKER, 1865, Genus *Lactophrys* SWAINSON, 1839, Genus *Lactoria* JORDAN & FOWLER, 1902, Genus *Ostracion* LINNAEUS, 1758, Genus *Paracanthostracion* WHITLEY, 1933, Genus *Rhinesomus* SWAINSON, 1839, Genus *Rhynchostracion* FRASER-BRUNER, 1935 and Genus *Tetrosomus* SWAINSON, 1839 and the two fossil taxa: Genus *Eolactoria*, represented by *Eolactoria sorbinii* TYLER, 1976 from the Lutetian of the Monte Bolca (Italy) and Genus *Oligolactoria* represented by *Oligolactoria bubiki* TYLER, 1980 from the Rupelian of Moravia (Czech Republic).

Some fossil isolated plates attributable to the Family Ostraciidae were discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed*.

All the fossil remains of the Family Ostraciidae RAFINESQUE, 1810 discovered in the Belgian Uppermost Cenozoic were always attributed to the Genus *Ostracion* LINNAEUS, 1758 and to the taxon *Ostracion meretrix* DAIMERIES, 1891.

For references, see Bibliography-Teleostei: Carnevale & Tyler 2010, Sepkoski 2002, Tyler 1980 and Tyler & Gregorova 1991.

Comments to Plate 108

Pisces - Actinopterygii - Teleostei: Family Lophiidae RAFINESQUE, 1810: Genus *Lophius* LINNAEUS, 1758: *Lophius piscatorius* LINNAEUS, 1758.

The right dentary illustrated on this plate shows the very singular type of fixation of the teeth of this Genus.

Comments to Plate 109

Reptilia - Crocodylia – Family Crocodilidae COPE, 1861: Genus *Osteolaemus* COPE, 1861: *Osteolaemus tetraspis* COPE, 1861.

The two small elements of the caudal carina discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* are morphologically so similar to these of this specimen that they could easily replace some of its.

Some geneticists have demonstrated that there exist two distinct populations of these African small crocodiles.

For reference, see Bibliography-Reptilia: Eaton, Martin, Thornbjarnarson & Amato 2009.

Comments to Plate 110

Comparison between the hind legs of an Equidae, a Tapiridae and a Rhinocerotidae

1: Family Equidae GRAY, 1821: Genus *Equus* LINNAEUS, 1758: *Equus caballus* LINNAEUS, 1758.
2: Family Tapiridae GRAY, 1821: Genus *Tapirus* BRÜNNICH, 1772: *Tapirus indicus* (DESMAREST, 1819)
3: Family Rhinocerotidae GRAY, 1820: Genus *Dicerorhinus* GLOGER, 1841:
Dicerorhinus sumatrensis (FISCHER, 1814).

This Plate demonstrates clearly the strong affinities of the calcaneum discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* with a calcaneum of a member of the Family Rhinocerotidae GRAY, 1820.

Comments to Plate 111

Mammalia - Perissodactyla - Family Rhinocerotidae OWEN, 1820: Genus *Dicerorhinus* GLOGER, 1841: *Dicerorhinus sumatrensis* (FISCHER, 1814).

This Plate presents three different views of the calcaneum of an extant member of the Family Rhinocerotidae OWEN, 1820.

The morphological similitude and the mass of this calcaneum with the morphology and the mass of the specimen discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* are arguments that allow supposing that this last one is a calcaneum of an ancestor of the extant rhinoceroses.

The inventor of the Genus *Dicerorhinus*, Constantin Wilhem Lambert Gloger (1803-1863) was an ornithologist principally known for his ecological and geographical observations focused on the influence of the climatic conditions as possible source of specific differentiation.

Comments to Plate 112

Mammalia - Perissodactyla: Family Rhinocerotidae GRAY, 1820: Genus *Coelodonta* BRONN, 1891: *Coelodonta antiquitatis* (BLUMENBACH, 1807).

This Plate illustrates the morphology of two calcanea collected in the Basal gravel of the Eemian of Zemst, Bos van A Sandpit (Flemish Brabant, Belgium).

An interval of *circa* 38 million years separates these calcanea from the one discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* but their morphological similarity is evident.

Comments to Plate 113

Mammalia - Perissodactyla - Family Chalicotheriidae GILL, 1872: Genus *Chalicotherium* KAUP, 1833: *Chalicotherium grande* (de BLAINVILLE, 1849).

This Plate presents three different views of a calcaneum of one individual of the species *Chalicotherium grande* and excludes the possibility to consider the calcaneum discovered in the sifting residues of the *Sint Niklaas Phosphorite Bed* as a calcaneum of this Family.

Comments to Plate 114

Aves - Neornithes:
Eggs of diverse extant species.
Illustration of the variation of the oval form of birds' eggs.

This Plate illustrates the limits of the variability existing between the morphology of birds' eggs.
1: Egg of ***Struthio camelus*** **LINNAEUS, 1758**. **2**: Egg of ***Rhea pennata*** **d'ORBIGNY, 1834**.
3: Egg of ***Turdus merula*** **LINNAEUS, 1758**.
4: Egg of ***Dromaius novaehollandiae*** **(LATHAM, 1790)**.
5: Egg of ***Coturnix vulgaris*** **LINNAEUS, 1758**.

31. Philosophical Conclusion

Boileau said: *Ce qui se conçoit bien s'énonce clairement et les mots pour le dire viennent aisément,* which may be translated into English as: *What is well conceived is clearly said, and the words to say it flow easily.*

But an honest scientist is never absolutely sure to have perfectly conceived his proposals.

Dr. Jacques Herman
22.09.2013.

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Beigemsesteenweg 319. 1852 Beigem (Grimbergen)
Belgique - België - Belgien
G-mail : jacquesalbertherman@gcom.be
Website, freely accessible: www.geominpal.be