First record of the genus *Trichites* (Mollusca, Bivalvia) from the Upper Jurassic (Kimmeridgian) of Santiago Coatepec, Puebla, Mexico

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ABSTRACT

This article proves the presence of the bivalve of the genus Trichites in the Upper Jurassic of Santiago Coatepec, a small area located at the southeast of the state of Puebla, Mexico, and describes a new species, Trichites pueblaensis. This is also the first Upper Jurassic record of the genus for the American continent. The associated larger foraminifera indicate a Kimmeridgian age for this sedimentary sequence. Other important aspect is that during about two centuries it was supposed that the genus Trichites did not exist in the American continent. However, in this article is shown that this assumption was wrong, because the genus has been reported from some places of the western hemisphere.

Key words: Trichites, bivalve, larger foraminifers, Upper Jurassic, Mexico.

RESUMEN

Este artículo prueba la presencia del bivalvo del genero Trichites, en el Jurásico Superior de Santiago Coatepec, una pequeña área localizada en el sureste del Estado de Puebla, México, y se describe una nueva especie, Trichites pueblaensis. También es el primer registro del Jurásico Superior del género en el continente americano. Los macroforaminíferos asociados indican una edad del Kimmeridgiano para esta secuencia sedimentaria. Otro aspecto importante es que durante dos siglos se supuso que el género Trichites no existió en el continente americano. Sin embargo en este artículo se demuestra que esta suposición estaba equivocada, ya que el género ha sido reportado en varios lugares del hemisferio occidental.

Palabras clave: Trichites, bivalvo, macroforaminíferos, Jurásico Superior, México.

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INTRODUCTION

The extinct bivalve genus *Trichites* is very interesting for several reasons. It was abundant in shallow water seas from the Upper Triassic to the Upper Jurassic of Europe, Asia, North and East Africa and very scarce during the Lower Cretaceous. For more than two centuries, it was believed that the genus was absent on the American continent (Cox and Hertlein, 1969, p. N284; Hallam, 1977, Appendix, p.71, and others). However, it was recorded from the Lower Jurassic of Mendoza, Argentina (Damborenea, 1987, p. 98) and from Chile, on deposits of the same age (Pérez d'Angelo, 1982, p. 118, pl. 12, fig. 12). *Trichites* was also recorded from the Lower Cretaceous of Venezuela (Guillaumé *et al.*, 1972; Vivas, 1987) and from the Upper Triassic of the Karluk Quadrangle, Alaska (Silberling, 1965). Still does occur in the Lower Cretaceous of Puebla, México (Alencáster and Hernández-Láscares, 1991). In all these places it is reported as *Trichites* sp. On the American continent as in the Old World, these species lived as suspensivorous epifauna in marine shallow water (Fürsich, 1980).

GEOGRAPHIC AND STRATIGRAPHIC POSITION

The specimens of *Trichites* here described were collected from a measured section that crops out in the brook located to the east of the town of Santiago Coatepec, southeast Puebla (Figure 1), not far from Zapotitlán and San Juan Raya, well known fossiliferous localities. This area belongs to the Tlaxiaco Basin (López-Ticha, 1985), which includes part of the states of Oaxaca, Guerrero and Puebla, within the Sierra Madre del Sur province, characterized by a tectonic evolution with folding, normal and thrust faults and intrusive and volcanic events, all of which contribute to make a very complex structure.

The sedimentary sequence (Figure 2) contains at the bottom the Matzitzi Formation, which is a continental unit with an abundant and well-preserved Upper Paleozoic flora (Silva-Pineda, 1970; Silva-Pineda *et al.*, 1992) with lepidodendrales, calamitales, pteridosperms and ferns. Overlying the continental Matzitzi Formation, there is a bed of red conglomerate and above this there is a marine unit, still not named, of thick and thin sandstone layers from where the marine fauna was collected, including *Trichites,* other bivalves and large gastropods. This mollusk fauna is associated with larger foraminifers (Omaña and González-Arreola, 2008), of which the following species are of stratigraphic value: *Alveosepta jaccardi, Everticyclammina virguliana, Rectocyclammina chouberti, Nautiloculina oolitica* and *Pseudocyclammina lituus*. These species are the base to establish the age of the deposit. The assemblage is Kimmeridgian, on account of the stratigraphic distribution of these foraminifers (Omaña *et al.*, 2006; Omaña and González-Arreola, 2008).

NOMENCLATURAL NOTES

The word trichites (from *latin trichos*=hair) has several meanings, and it applies to things shaped like needles, threads, spines, rods, etc. of many sizes, different chemical composition, either organic or inorganic, and natural or artificial. The most important for us, is the generic name of the studied bivalve, which was named owing the resemblance of its fibrous shell wall to inorganic fibrous prismatic crystals, long known as trichites. These inorganic crystals may be of different nature, and are found in diverse type of rocks, and of different ages. For instance, trichites and needles of vesuvianite are found in Lower Cretaceous granites; in Quaternary alluvium deposits (Galuskin *et al.*, 2003); in the Cretaceous area north of the Colorado River, trichites are scattered through the whole mass (Cragin, 1892) and in Upper Cretaceous rocks of Woodson County there are longulites and trichites which are most likely pyroxene (Cullers *et al.*, 1985).

Artificial trichites, also called whiskers, are commonly fabricated as monocrystals of silicon carbide, and used in the ceramic, vitreous, and petroleum industries (Bagnol, 1974; Bessaguet *et al.*, 1990). But the artificial trichites are made of many different components and have very varied applications (IMPI, 2000).

In Protozoology the word trichites designates diverse elements, like hairs or rods, as in the Ciliophora, they are in different places of the cell, as in the oral aperture, or in a citofaringeal basket (Colin and Curds, 1982). Also in the Ciliophora *Strombidium* and related genera, trichites were considered a cytoskeletal armature, but the authors concluded that the structure is the result of extrusomes (Modeo *et al.*, 2001).

Historical background of *Trichites* as scientific name

The earliest publication mentioning *Trichites* was by Plot in 1677 (p. 128, pl.7, fig.7). Lhuyd was the successor of Plot as keeper of the Museum of Natural History of Oxford and published *Trichites* in 1699 (p. 90), described *T. Plotii* and three species more of this genus, from the Corallian of Burlington, near Oxford. These species were distinguished by him with the numbers from 1748 to 1753. The descriptions were very brief and in latin. In 1760 Lhuyd published an exact reprint of the same article. This reprint appeared in the second edition of Lhuyd's Lithophylacii Britanici, two years after the Tenth edition of Linné´s (1758) Systema Naturae, and therefore, it could be regarded as a valid name.

However, the International Code of Zoological Nomenclature did not give validity to Lhuyd, because the publication of 1760 was a reprint of a study made in 1699. There was need to look for another author.

Arkell (1933, p. 224) remarked that there is no rule or opinion in the ICZN to indicate that revived pre-Linnéan

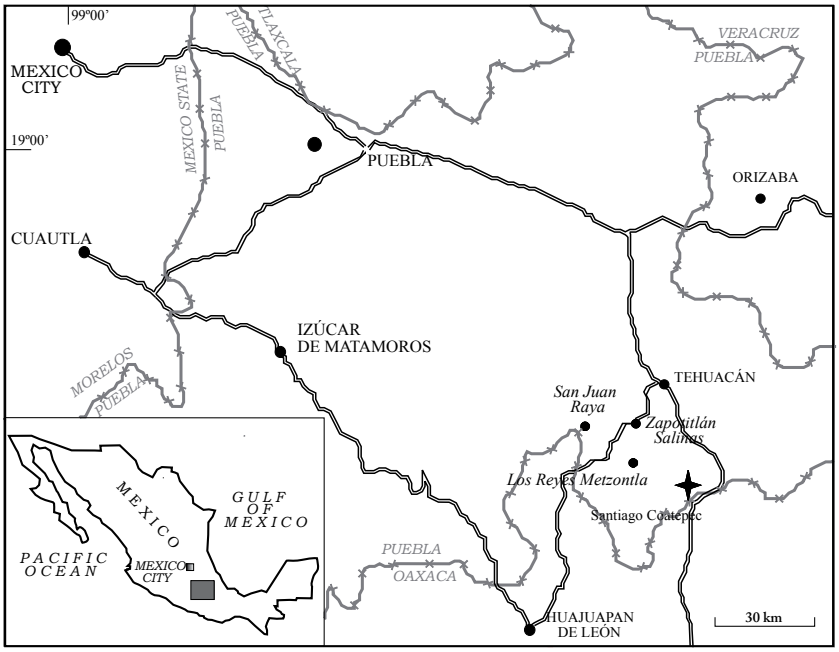


Figure 1. Geographic map of the studied area.

names should never be adopted. Moreover, Opinion 5 may imply that if a pre-Linnéan name is adopted by a post-Linnéan author before any other post-Linnéan name has been published in its place, then validity is secured for the pre-Linnéan name.

Related with this concept, De Saussure made an extensive work in four tomes entitled "Voyages dans les Alpes" (1779-1796, of 618 pages). On the first tome, chapter 7, there is an article in which De Luc (1779, p. 190-194) studied a peculiar bivalve which he named *Pinnigene*. This form is like *Trichites* and became a synonym. Undoubtedly De Luc was not acquainted with Lhuyd´s work. This idea is accepted by Cox (1940) and is in disagreement to Arkell (1933), who regarded them as two different genera.

After that appeared a publication of Thurmann about the geological structure of Porrentruy (1832-1836). On page 13 is a list of Jurassic invertebrates, and only on a line is the following: «*Trichites* Saussiri, Voltz (*Pinnegénne* de Saussure, Voy. dans les Alpes, t.1)».

More recently, on the Treatise of Invertebrate Paleontology (Cox and Hertlein, 1969, p. N 284) is written: «*Trichites* Voltz (in Thurmann, 1833, p.13)».

These are the documents where the authorship of *Trichites* is given to Voltz by Thurmann. In my opinion, Voltz should not be considered the author of *Trichites*, since he never published any study of this genus. It is known that Voltz and Thurmann were great friends and Thurmann was indebted to Voltz because he determined some of his fossils, as well as other paleontologists.

At the contrary to Voltz, Lycett (1850, p. 343-347) made a detailed study of *Thichites*, and manifested respect and admiration to the first naturalists Plot and Lhuyd, who discovered the genus. Also considered as valid the species *Trichites Plotii* (Lycett, 1850, p. 344). This species existed, is well-known and excellently described by Arkel (1934, p. 225, pl. 30, fig. 1-3). Furthermore, is the oldest species of *Trichites,* and should be the true type species of this genus. Arkell considered to Quenstedt (1857) the author of *Trichites* because he assumed that the study of *Trichites* of Lycett (1850) corresponded to *Pinnigena*. Arkell did not accept that *Pinnigena* was a synonym of *Trichites.*

Trichites saussurei was described by Thurmann from the Kimmeridgian of Yonne, France. Thurmann is considered the author of this species, which is to some authors the type species of *Trichites.* Loriol (1888, p. 300) and Loriol and Lambert (1893, p.136) studied *T. sausurei* Thurmann, and in the synonymy list they cited Thurmann 1830, p 25. This paper was not found by us, in spite of an intensive search. Its title is the same that the large work by Thurmann (1832-1836). The paper of 1830 possibly does not exist anymore.

T. saussurei was first discovered by De Luc in 1779 (*in* De Saussure, 1779-1796) under the name *Pinnigene* (p.192). As this name is a synonym of *Trichites*, the real author of the species is De Luc, and his name should be in parenthesis because the change of genus: *Trichites saussurei* (De Luc, 1779). This species occurs in many places of Europe (Bayle, 1878; Loriol et Lambert, 1893, and others). Some paleontologists attributed to them the authorship of this species, for instance Favre (1867).

About the prismatic shell wall structure, *Pinna* and *Trichites* are similar in the fibrous calcite outer layer, which in *Pinna* is thinner, and is provided by a nacreous layer (Cox, 1969 p. N76; Carter, 1990, p.212) which is not present in

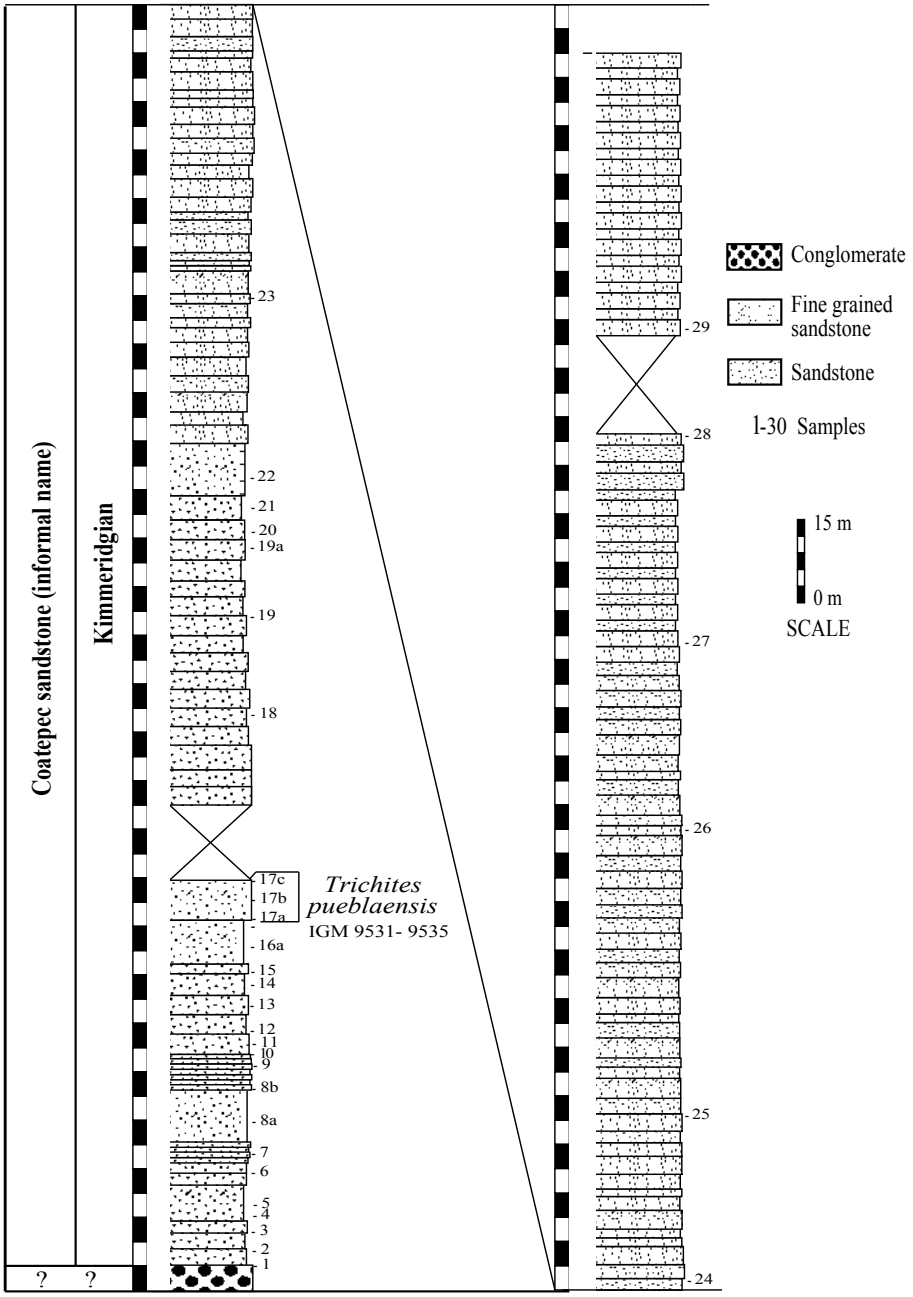


Figure 2. Lithologic column of the Santiago Coatepec section.

Trichites. However, they are so different in shape to that level that is not possible to confuse them. Nevertheless, Cox (1940) included *T. plotti, T. granulatus* (Sowerby, 1823, p. 65, pl. 347) and other similar forms in *Stegoconcha* Böhm, a subgenus of *Pinna.* Also Rollier (1914) confused both genera, since considered *Trichites* as a subgenus of *Pinna*.

Robert Plot (1640-1696)

Although Robert Plot is an almost unknown pioneer naturalist, it seems adequate to get slightly acquainted with him because he first gave the name *Trichites,* and the type species of the genus, *T. plotii* Lhuyd 1760, was named in his honor. He was born in 1640 in Kent, England, and died in 1696. He obtained a doctoral degree and wrote The Natural History of Oxfordshire (Plot, 1677), which contains an illustrated list of fossils, minerals and rocks. He was professor and the first Keeper of the Museum of the School of Natural History of Oxford. At that time, the nature of fossils was still matter of debate in England, and Plot, in spite of his many observations and illustrations of fossils, considered them as inorganic salt crystals resembling living organisms.

SYSTEMATIC PALEONTOLOGY BY GLORIA ALENCÁSTER

The specimens studied are deposited in the Colección Nacional de Paleontología, Museo Ma. Carmen Perrilliat M., Instituto de Geología, Universidad Nacional Autónoma de México, in Ciudad Universitaria, 04510 México, D. F., Mexico.

Class Bivalvia Linné, 1758
Subclass Pteriomorphia Beurlen, 1944
Order Mytiloida Férussac, 1822
Superfamily Pinnoidea Leach, 1819
Family Pinnidae Leach, 1819
Genus *Trichites* Lhuyd, 1760, Lycett, 1850

Type species. *Trichites plotii* Lhuyd, 1760

***Trichites pueblaensis*, new species**
Figures 3-6

Diagnosis. Large-sized species (about 30×20 cm) with very thick fibrous outer shell wall (from 30 to 60 mm). Outline oval, elongated, nearly equivalve and inequilateral; both valves convex. Anterior side with a short depressed extension. Surface smooth. Umbo central to terminal and acute.

Description. The holotype (IGM- 9531) is a large specimen, of about 30 cm height and 20 cm length with a very thick outer wall of fibrous calcite. The long and slender prismatic fibers (from 30 mm to 60 mm long and 1 mm wide) are parallel each other, and perpendicular to shell surface. The fibrous layer shell wall is black in color, and is covered by a thin and smooth layer of light cream color.

Shell biconvex, inequilateral and nearly equivalve. The left valve is a little larger and slightly more convex. The commissure in both valves is slightly undulated with some waves long and others short. The outline is oval-elongated. The height (dorso-ventral measure) is larger than the length (antero-posterior measure). The umbonal beak is central to terminal, and acute. From there the valves gradually increase in length towards the ventral area, which is the wider part of the valve, with a slightly curved margin. The posterior margin is straight, forming an angle varying from 90° to 75°, with the dorsal hinge line, which is edentulous, short and straight. The anterior side is extended a short distance, where the convexity gradually decreases, ending in an acute angle formed by both valves. In adult specimens the outer surface is smooth, somewhat wavy, with well-marked concentric growth lines, and presents a very short gibbosity located at the anterior center of the valve.

A complete left valve of a juvenile specimen (IGM-9533) probably of the same species, presents three radial ridges, with concentric lamellae, more prominent in the ventral half. The umbonal area is long and narrow, with a concave anterior margin. The ventral half is wider and the anterior margin, in the ventral half, is extended and curved; the posterior margin is straight, and the postero-ventral and ventral margins are a continuous curve. Medium-sized specimen (IGM-9532) has a smooth surface with prominent growth lines, and a central, acute keel. These specimens show that the ornamentation and keel change with age, disappearing in the adult, probably because of erosion.

Measurements. The largest, almost complete left valve (IGM-9531) measures 32 cm height and 20 cm length. A smaller specimen (IGM-9535) with the two valves joined, on tangential section has a diameter of 14 cm. The thickest fibrous layer of a large specimen (IGM-9531) measures 60 mm, and smaller individuals present a fibrous layer about 30 mm thick.

Materials. The study was made on a few almost complete valves and ten fragments of different size.

Types. Holotype IGM-9531 left valve almost complete.

Paratypes. IGM-9532, IGM-9533, IGM-9534, IGM-9535.

Etymology. The name of the new species *Trichites pueblaensis*, refers to the state of Puebla, where the fossils were found, plus the latin suffix *ensis,* which means place.

Occurrence. The fossils were collected on the thick layers of sandstone, on the lower part of the column, corresponding to a stratigraphic unit, still not formally named, but provisionally called Coatepec sandstone. The red conglomerate and the Matzitzi Formation are below this unit.

DISCUSSION

Trichites plotii Lhuyd is the species most similar to *T. pueblaensis* and, therefore, is the species phylogenetically most closely related. They resemble each other in the large size, the thick fibrous wall, lack of ornamentation, and somewhat in the shape, because both species are biconvex and nearly equivalves. However, they differ in that *T. plotii* is frankly trapezoidal, with the dorsal half narrower, the beak longer and more acute, and the ventral half wider with the margin straight. The most notable difference is that the Mexican species presents a short depressed extension of the anterior margin of both valves.

T. plotii was first described by Plot in 1677 (p. 128, pl. 7, fig.7) from the Corallian (Oxfordian) of Oxfordshire, England. Arkell (1933, p. 224-228, and 1934, pl. 30, fig. 1-3) detailly described this species from the Kimmeridgian (Osmington Oolite Series) of Malton in Yorkshire. This species is among the largest of the genus and the measurements are comparable to those of the new species, since a fragmentary specimen has an actual height of 258 mm, so that the calculated complete height was probably between 300 to 350 mm.

Trichites thurmanni (Choffat, 1885) from the Upper Jurassic (Malm) of Lisboa, Portugal has a similar, smooth

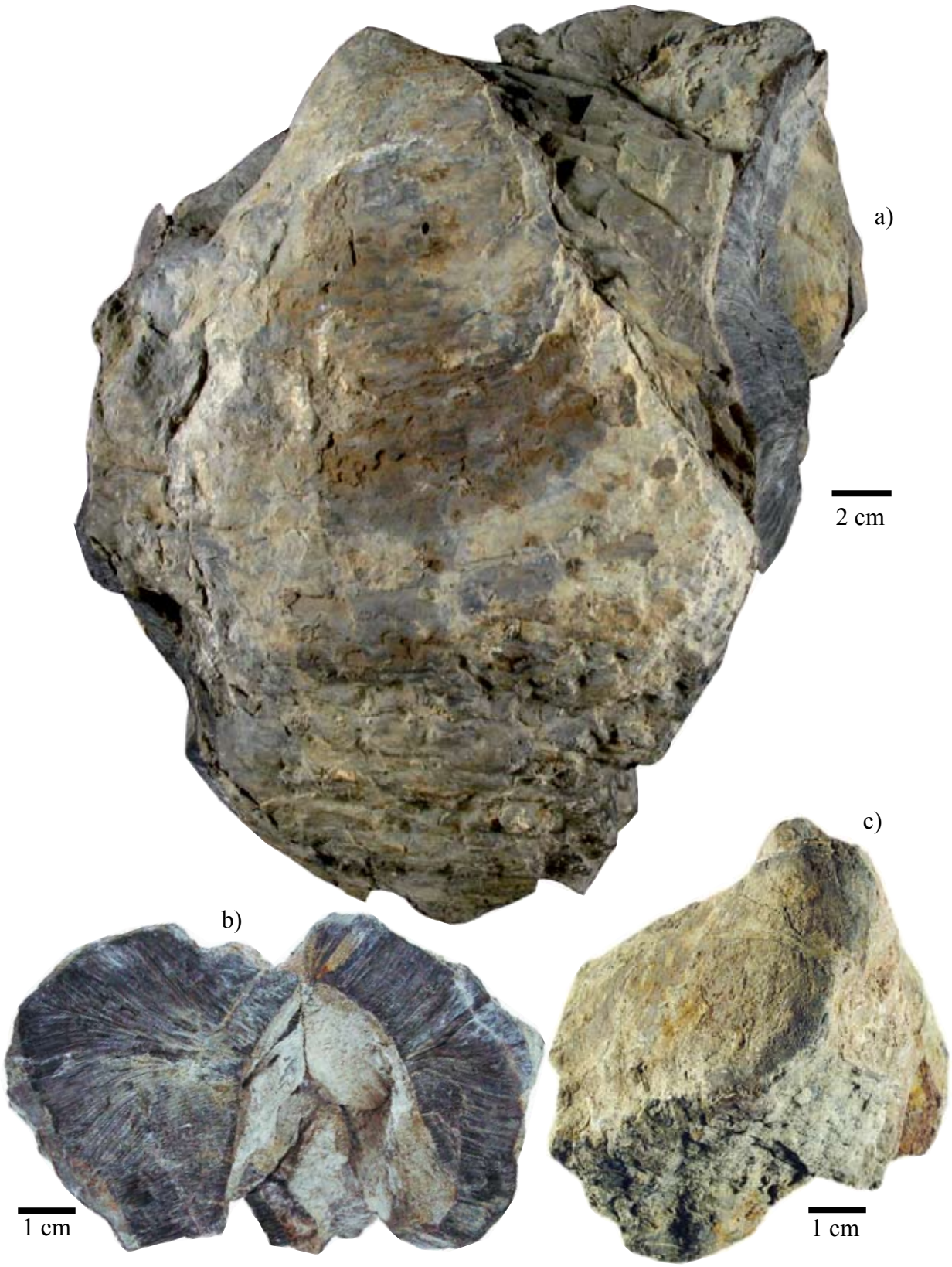


Figure 3. *Trichites pueblaensis* Alencáster n. sp. a) Holotype IGM-9531 (X 0.5) left valve almost complete, b) Paratype IGM-9532 (X 1) cross section of a fragment of a specimen with the umbonal area of both valves showing the fibrous layer. c) Paratype IGM-9532 (X 1) one valve of the same specimen, showing the outer surface with the longitudinal central keel.

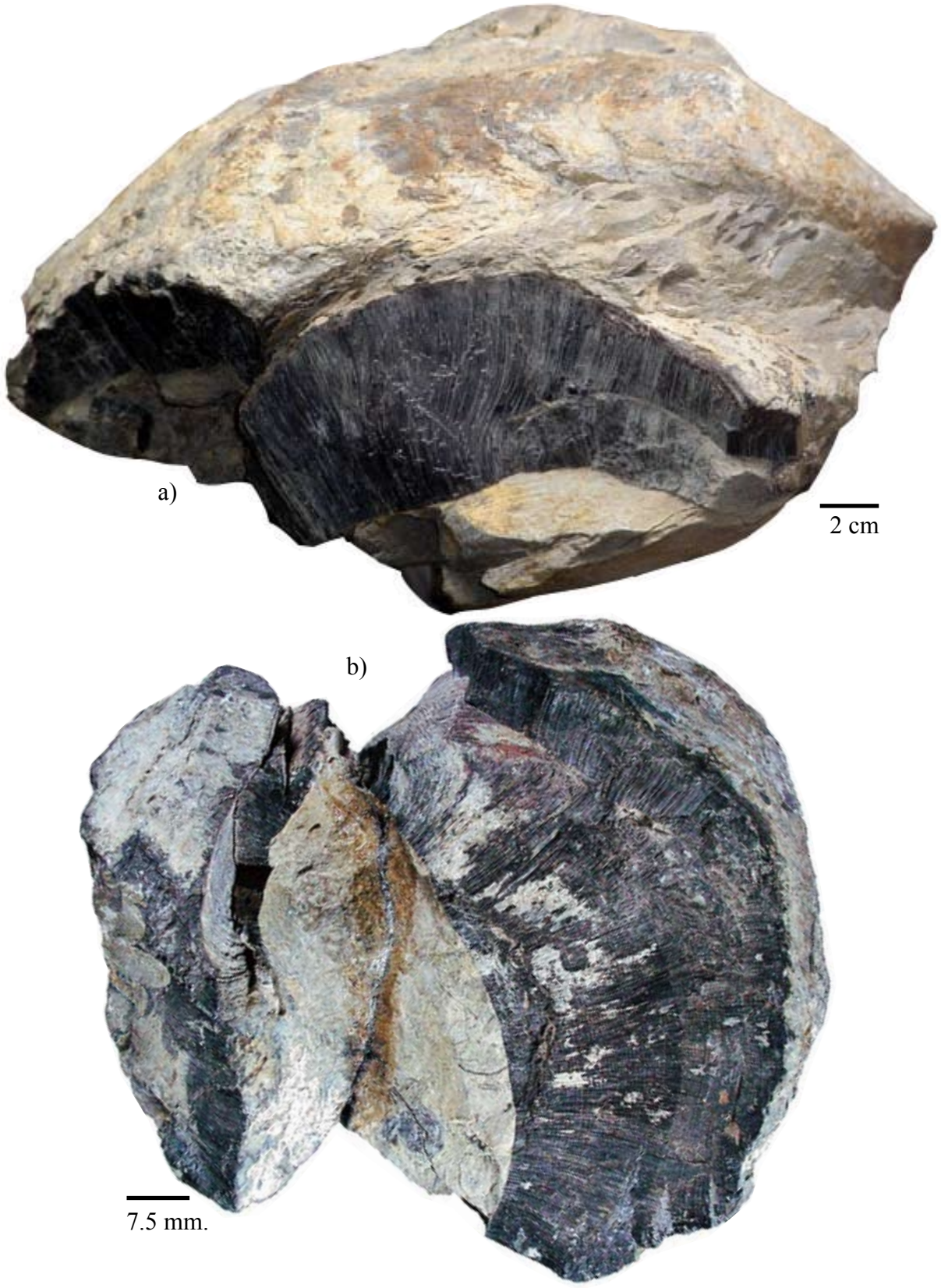


Figure 4. *Trichites pueblaensis* Alencáster n. sp. a) Paratype IGM 9535 (X 0.5) the tangential section presents the upper valve complete, showing the thick fibrous shell layer; the other valve presents only a small part. b) Holotype IGM-9531 (X 0.75) profile of the almost complete left valve showing the acute beak and short central gibbousity. The thick fibrous shell of the lower half of the photo belongs to another individual.

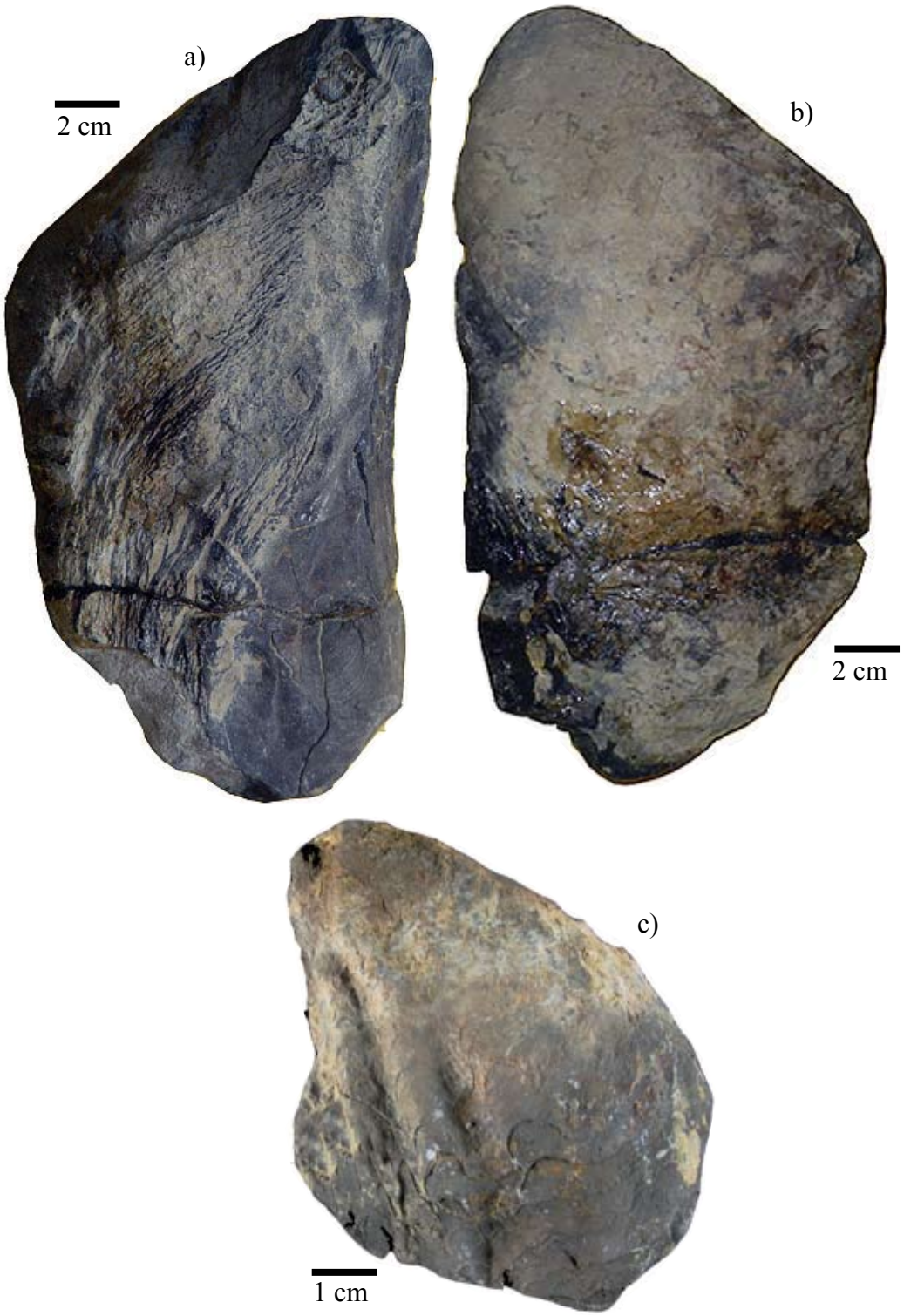
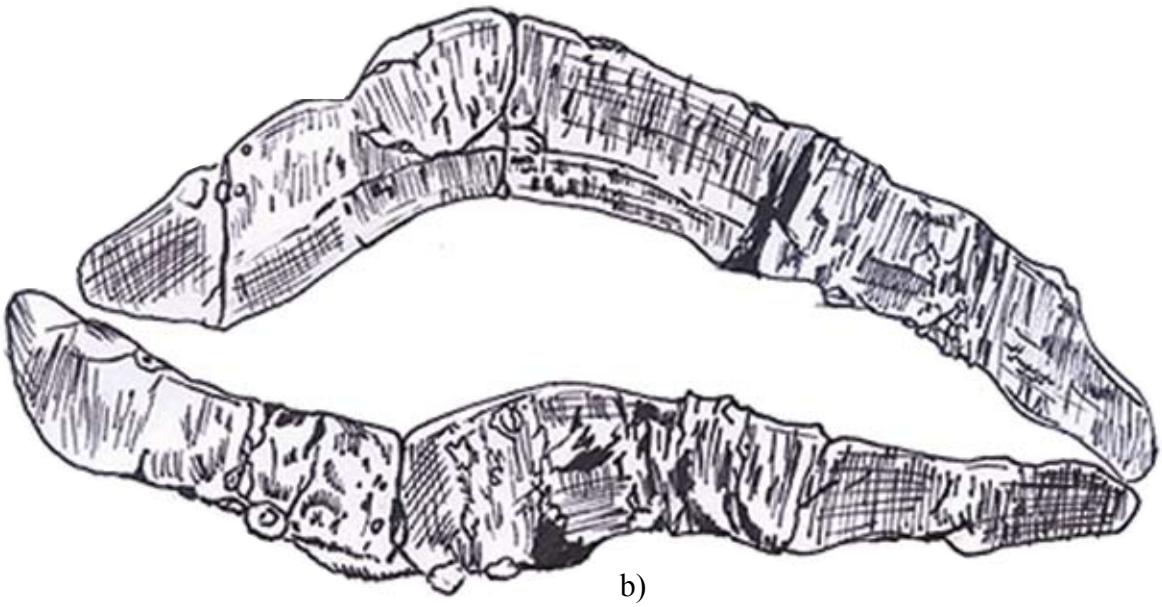


Figure 5. *Trichites pueblaensis* Alencáster n. sp. a) Paratype IGM-9534 (X 0.5) incomplete left valve, interior view showing the thick inner shell wall with growth lines and the muscle impression at the right lower space. b) Paratype IGM-9534 (X 0.5) the same specimen, outer view. c) Paratype IGM-9533 (X 1) complete left valve of a juvenile specimen, showing the shape and the ornamentation.

a)



b)

Figure 6. *Trichites pueblaensis* Alencáster n. sp. a) Field photograph of natural size, showing the transverse section of a biconvex specimen. b) Sketch of the same specimen to show the shape of the cross section of the two valves, their convexity and the anterior short projection.

surface but differs in outline and the markedly inequivalve shell, the right valve shell flat or concave; the shell is also smaller. *Trichites granulatus* (Sowerby) (1823, p. 65, pl. 347) from the Kimmeridgian of Dorset, U. K., is similar to *T. pueblaensis* in shape, but smaller, and in the adult has ornamentation of radial ridges and tubercles.

Trichites saussurei Thurmann (1830, p 25) was described from the Kimmeridgian of Yonne, France. It differs from the Mexican species because it is inequivalve and has prominent radial ridges.

The Early Cretaceous species *Trichites picteti* Campiche et Pictet (1868-1871, p. 76, pl.153) from

Switzerland, and *T. marcou* Choffat (1886, p. 34, pl.1) from Portugal, differ from the new species because they are smaller and inequivalves, one valve is flat and the other convex, arched in shape, and with radial ribs.

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