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An early Umbilical Canal System in *Trocholina chouberti* n.sp. from the Lower Cretaceous of North-Eastern Morocco

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ABSTRACT

Particularly well preserved and unusually large Trocholinids show a complex umbilical canal system. The undivided, tubelike "chamber lumen" has spirally arranged radial passages where the "chamber" protoplasm communicates with the umbilical canal system. The geometric arrangement of the umbilical canal system is similar to the one of Recent Rotalids. It indicates, therefore, a functional analogy and suggests the presence of permanent protoplasmic differentiation in a foraminiferal shell since Upper Jurassic times.

RÉSUMÉ

Grâce à un remplissage des cavités avec des sédiments pélitiques avant la diagénèse, un système complexe de canaux ombilicaux fut observé dans des Trocholines de taille exceptionelle. Remplaçant les loges, le tuyau spiral caractéristique des Trocholines communique au moyen de fentes ombilicales radiaires avec un plexus spiral qui fait partie d'un système réticuliforme de canaux ombilicaux. Cette disposition géométrique des canaux est analogue à celle des Rotalidés récents et suggère une fonction analogue à celle des canaux rotaloïdes. La différenciation plus ou moins permanente du protoplasme à l'intérieur du test des foraminifères à système de canaux pourrait dater par conséquent du Jurassique supérieur.

Introduction

Recent, canal bearing foraminifers, in particular Nummulitids, show a more or less permanent differentiation of their protoplasm: Vacuolar endoplasm fills the chamber cavities of the shell and pseudopodial ectoplasm rich in microtubuli circulates in the canal system. The communications between chamber lumen and canal system are usually located in the umbilical chamber wall. In many genera, they represent the functional apertures of the chamber to the ambient environment (HOTTINGER & DREHER, 1974).

The umbilical canal system of foraminiferans seems to have two main functions: 1) Transport of particulate or dissolved matter from the ambient environment to the chamber lumen and back, as directly as possible to all parts of the chamber lumen system, and in particular to early, innermost whorls of the shell. 2) The canal system might be a device to guarantee the motility of a foraminifer during retraction of

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protoplasm to inner whorls of the chamber lumen system. The endoplasm is retracted as a response to chemical or mechanical irritation of the cell. The retraction of the endoplasm becomes independent of pseudopodial movement when intercameral foramina and functional apertures are geometrically separated (HOTTINGER, 1977).

For both functions, a basic geometrical pattern of umbilical canal systems is essential: The foraminiferal growth program, creating spiral rows of successive chambers, is responsible for the stretching of the endoplast during ontogeny from the first to the last chamber. The geometry of the canal systems guarantees a direct access of the earlier chambers to the ambient environment. In other words, it creates a "short cut" of the growth spiral. Often, this direct connection of inner whorls with the ambient environment is restricted to the ultimate and penultimate whorls where the major part of the volume of the chamber plasma is housed.

The following structural analysis of *Trocholina chouberti* n.sp. is a test to check whether or not an umbilical canal system of an unchambered foraminifer meets the geometric requirements to fulfil the same functions as umbilical canal systems in chambered foraminiferans. If early parts of the growth spiral are directly connected with the ambient environment by the umbilical canals, the canal system must have functions similiar to recent ones. These functions would suggest the presence of more or less permanent differentiation of the protoplasm in a foraminiferal shell since Upper Jurassic times.

The present study is one of several checks on geometric patterns of umbilical canal systems which will include Recent and Neogene Rotaliids and Elphidiids to be published in Mém. Suisse de Paléont. The three dimensional model drawn in Fig. 2 has been conceived so as to be comparable with the Rotalid models prepared for this other publication. Both give part of the results of Swiss Nat. Science Found. Project 2361.70. The thin sections figured and supplementary, non figured specimens are deposited in the Natural History Museum of Basel, Switzerland.

Material

The faunule of *Trocholina chouberti* n.sp. described here was collected in North-Eastern Morocco, where lower Cretaceous turbiditic sandstones and marls overlay with an unconformity the Upper Jurassic Limestones of the South-Eastern foreland of the Rif (see HAMEL & LEHMANN, 1964). The Northern border of the small Neogene basin of Gerrouaou is crossed by the road from Nador to Afso. Along this road, at the pass called Tizi el Arneb, there are large outcrops of blue-green marls and dark mudstones interbedded with turbiditic sandstones. They contain an abundant microfauna with *Choffatella decipiens* SCHLUMBERGER (HOTTINGER, 1967, pl. 14, figs. 24, 26), *Haplophragmium* sp. 1 (HOTTINGER, 1967, pl. 9, fig. 23), a number of undetermined smaller agglutinated Foraminifers and Lagenids, some Ostracods and debris of Echinoderms, Serpulids and Molluscs. In one thin-section there is a small number of Tintinnid sections identified as *Remaniella cadischiana* (COLOM) and *Calpionellites darderi* (COLOM) of Valanginian age.

Specimens of *Trocholina chouberti* n.sp. occur in hard rock and in marls where they can be washed out and isolated. The shells have been considerably eroded by transport prior to their definite deposition. The cavities of dead shells have been filled with silty sediments before the usual recrystallization (REICHEL, 1955) during early diagenesis took place. Chamber cavities and the coarser part of the extensive canal system have thus been preserved in a rather unusual manner (Fig. 1). I have seen specimens of *Trocholina palastiniensis* and of *Trocholina* sp. from the lower Cretaceous of the Swiss Alps in a similar state of conservation, preserved again in mudstones of dark colour.

Description of umbilical canal system (Fig. 2)

The "chamber cavity" of Trocholinids consists of a trochospirally arranged tube of roughly triangular section (compare model in GUILLAUME & REICHEL, 1957, p. 287). In *T. chouberti* n. sp., the umbilical edge of the tube cavity is extended towards the umbilicus forming a spiral slit. This slit bears broad connections (arrows in Fig. 2) to the umbilical canal system.

The canal system consists of a spiral plexus similar to a spiral canal in complex Recent Rotaliids *("Rotalia" gaimardii)*. In the last whorl in particular, the spiral canal may be doubled, the two parallel branches being connected by more or less radial, broad passages. The central part of the umbilicus is occupied by a three dimensional irregular network. Two or three superimposed layers of mesh correspond to the last spiral whorl, where the canals are best preserved. Numerous vertical and oblique passages connect the mesh layers in axial direction.

Below the last whorl of the tubular cavity, a layer of marginal "canals" develop. The preservation of the material does not permit determination of whether the radial marginal "canals" are closed on their ventral side, or if they represent fillings of deep radial grooves on the ventral surface of the margin. The free specimens show only very shallow grooves on the ventral surface of the margin, but in smaller forms of *Trocholina* deep radial grooves do exist.

The geometric pattern of the umbilical canal system, however, meets the requirements of the functions of modern rotalid canal systems: It establishes short connections between inner whorls of the tube cavity and the ambient environment.

Morphogenetic considerations

The process of construction of the complex canal system described above is difficult to imagine, but the far reaching geometric analogies with the umbilical systems in Recent Rotalids suggest similar mechanisms of construction. The lamellar nature of the walls in the equally non-chambered *Neotrocholina* (REICHEL, 1955) suggests the presence of lamellar walls in *Trocholina*. The roughly polygonal pattern of the canal network and the spiral canal are similar to the "ornamentation" of the umbilical shell surface in simpler forms (GUILLAUME & REICHEL, 1957). Umbilical canals might be generated therefore partly by lamellae covering preexisting "ornamental grooves" of the ventral surface and partly by resorption as in the marginal canal system of Nummulitids (HOTTINGER, 1977). The radial passages from the tube cavity to the canal system are probably formed by partial resorption of shell material in between the radial marginal canals when covered by a new

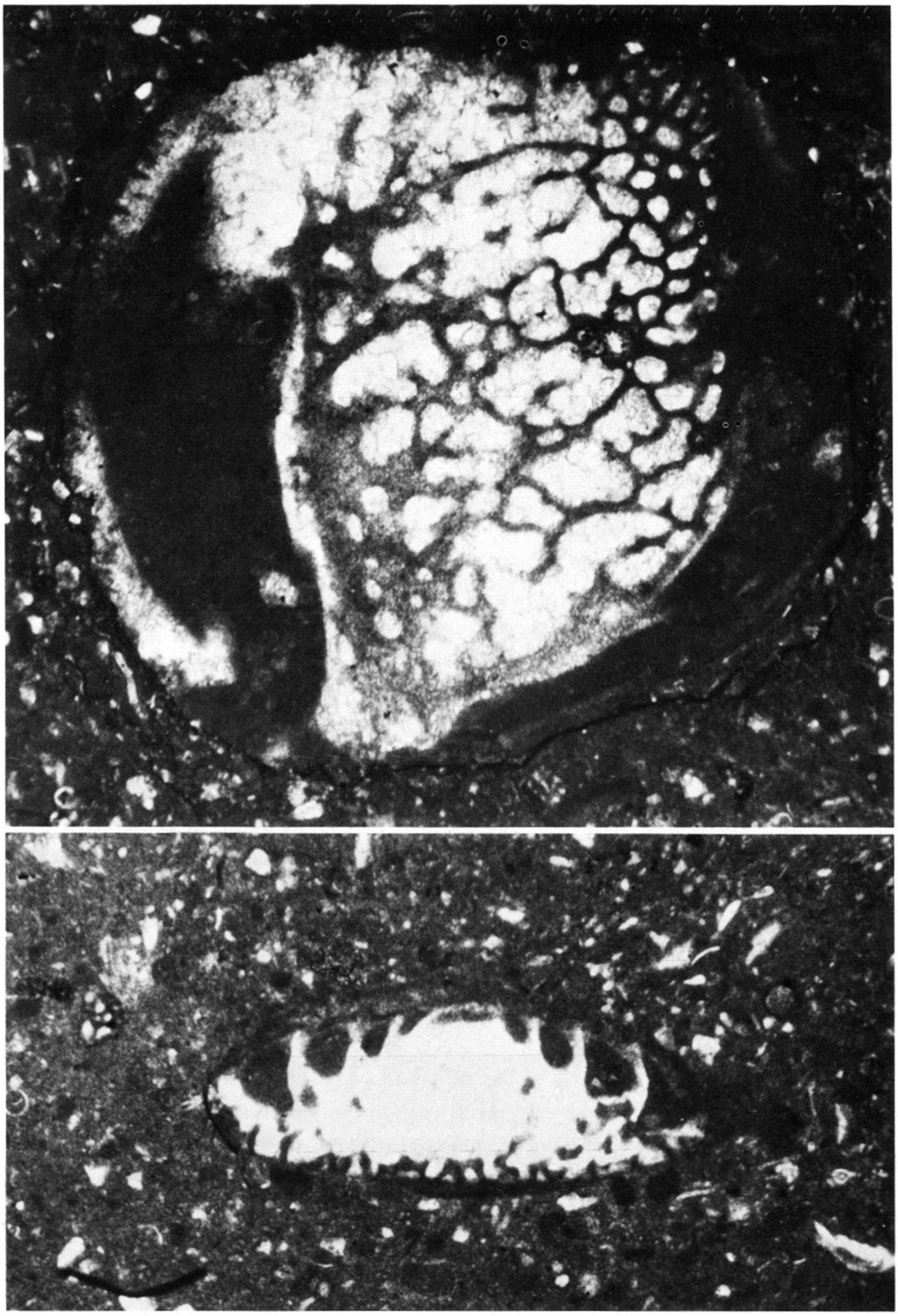

Fig. 1. *Trocholina chouberti* n. sp. from hard rock of type locality, Valanginian. Sections roughly vertical and parallel to axis, slightly oblique, showing dark sediment infiltrating in the cavities of the shell. Test eroded prior to final deposition. Transparent light, × 50.

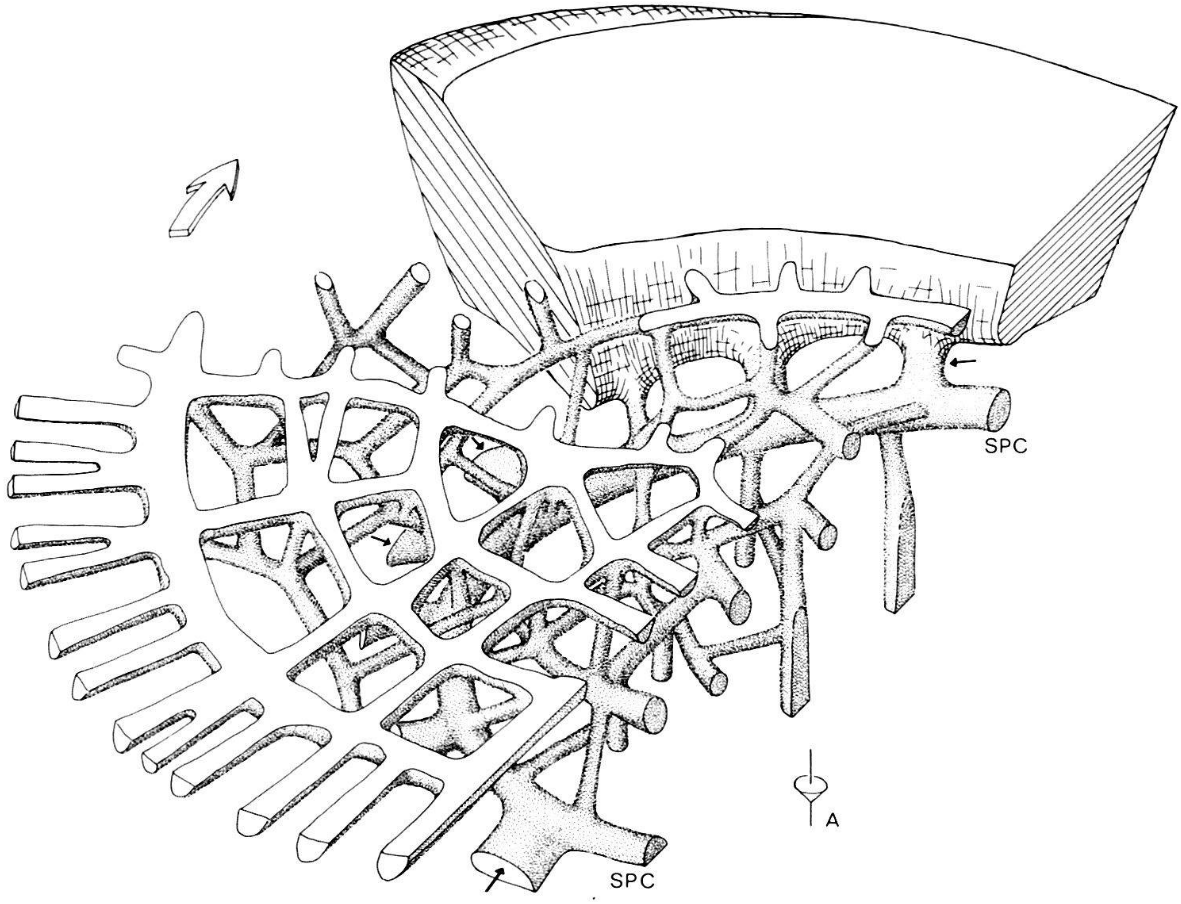

Fig. 2. *Trocholina chouberti* n. sp. Model of umbilical canal system, schematic. Approximate scale: × 150. The model is delimited by two parallel sections vertical to axis and by the axial section. Two thirds of the tubular cavity are cut away. Black arrows: Passages from tubular cavity to spiral canal (SPC). White arrow: Direction of growth. A: Axis of shell.

whorl of the spiral tube. Such a process would be analogous to Rotaliids where intraseptal canals are often transformed into passages from chamber lumen to canal system when covered by a new chamber whorl.

Systematics

Genus *Trocholina* Paalzow, 1922

Generotype: *T. conica* Schlumberger emend. Reichel, 1955.

Trocholina chouberti n. sp.

(Text-figs. 1, 2; Pl. I, Fig. 1-15)

Syntypes. - Pl. I, Fig. 1-15 deposited in the Natural History Museum Basel.
Type locality. - Tizi el Arneb, Gerrouaou, North-Eastern Morocco.

Type level. - Valanginian (Lower Cretaceous).

Derivation of the name. - In honour of Dr. Georges Choubert, pioneer of moroccan geology.

Diagnosis. - Low conical *Trocholina* of large size. Largest diameter 1,4-2,2 mm. Ratio of largest diameter to axial height 2,8-3,4. 5-6 volutions of the tubular cavity in adult forms. Tube roughly triangular in section. The ventral side of the triangle, parallel to the base of the shell cone, is about equal in length to the dorsal side parallel to the cone surface. There is a complex umbilical canal system in the ultimate and penultimate shell whorls. Details of its geometric pattern see p. 817.

Due to erosion of the shells by transport prior to their definite deposition, the diameter of the proloculus, the thickness of the dorsal, perforated wall, the ornamentation of the umbilicus and the primary aperture are unknown.

Differential diagnosis. - This species is larger and flatter than the largest forms known from Lower Cretaceous deposits in Europe (see GUILLAUME, 1963). It is twice as large and much flatter than *T. burgeri* EMBERGER, 1955, from the Valanginian of Algeria, much larger than the American species *T. floridana* CUSHMAN & APPLIN, 1947, and much larger also than all the Rumanian forms from the Lower Cretaceous described recently by NEAGU (1975).

The presence of a complex umbilical canal system has never been described in other species of *Trocholina.* This is not only a result of different study techniques and different states of preservation in *Trocholina* species of small size. From my own observations, smaller, undetermined specimens from the Lower Cretaceous or from the Upper Jurassic, sometimes show umbilical canal systems, but with much simpler geometric patterns than the one in *T. chouberti* n. sp.

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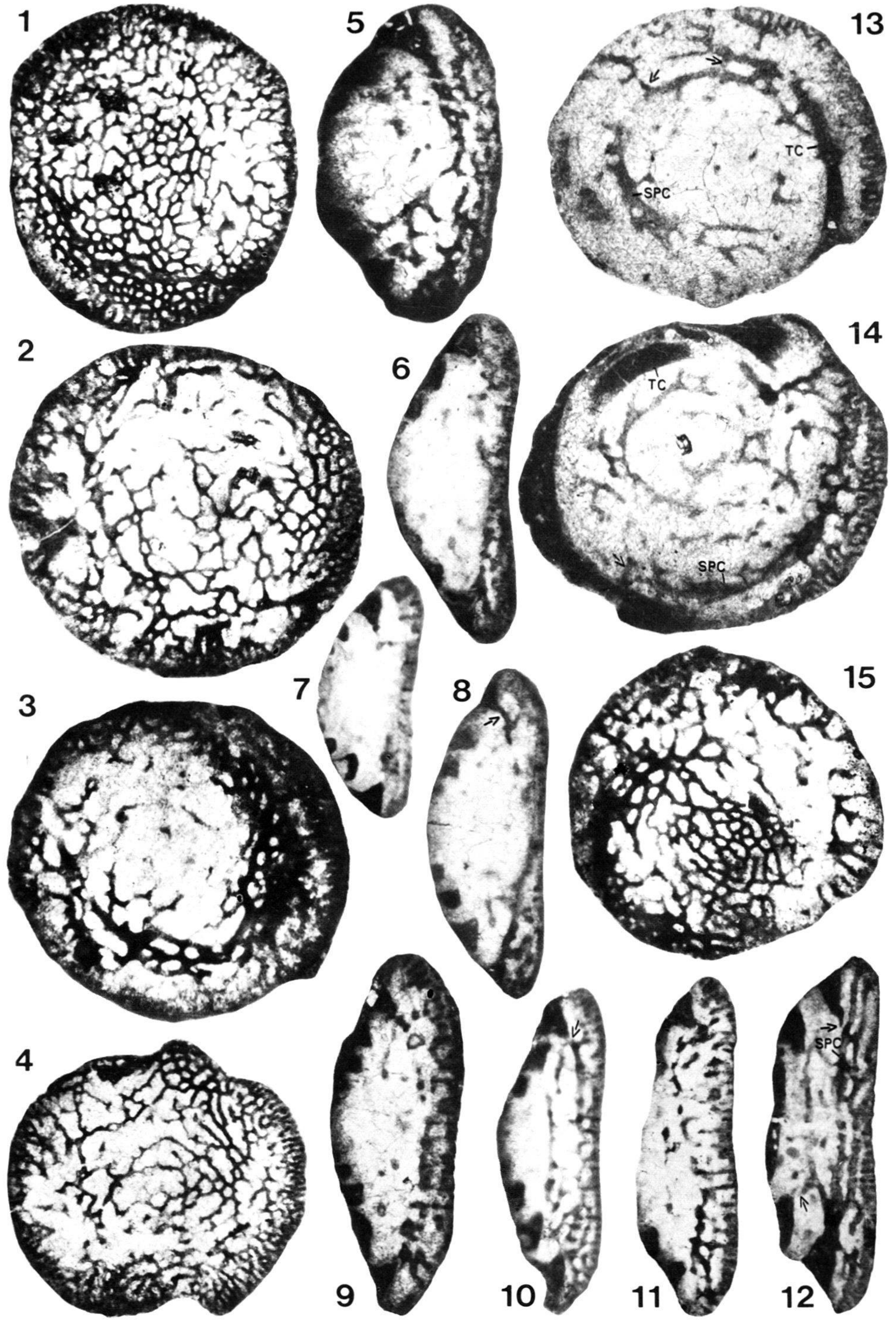
Plate I

Trocholina chouberti n.sp. Syntypes. Tizi el Arneb, Gerrouaou, North-Eastern Morocco. Valanginian (Lower Cretaceous).
Relatively thick sections seen in transparent light, optical microscope, ×25. All specimens are eroded by transport prior to deposition.

Fig. 1-4	Sections roughly parallel to base of cone below last whorl of tubular cavity.
Fig. 5	Oblique section cutting axis at about 45°.
Fig. 6-8	Axial sections.
Fig. 9-12	Transverse sections parallel to each other, becoming progressively lateral from 9-12. Arrows designate radial passages from tubular cavity to umbilical canal system. SPC: spiral canal in tangential section.
Fig. 13-14	Section parallel to base of cone, vertical to axis, at the base of last whorl of tubular cavity (TC), showing spiral canal (SPC) and radial passages (arrows).
Fig. 15	Section parallel to base of cone, vertical to axis, showing spiral plexus of last whorl.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