Beitr. Paläont., **22**:1–11, Wien 1997

Mineralogy, test architecture and test-wall texture of *Pragsoconulus* OBERHAUSER, 1963 (Foraminiferida, Carnian, Dolomites)

by

Donato di BARI* , Gian Franco LAGHI*, Franco RUSSO, Adelaide MASTANDREA* & Claudio NERI*****

di BARI , D., LAGHI, G.F., RUSSO, F., MASTANDREA, A. & NERI, C., 1997. Mineralogy, test architecture and test-wall texture of *Pragsoconulus* OBERHAUSER, 1963 (Foraminiferida, Carnian, Dolomites). — Beitr. Paläont. **22**:1–11, 2 text-figs., 4 plates., Wien.

Abstract

This paper describes architecture, mineralogy and texture of the test of the Late Triassic foraminifer *Pragsoconulus robustus* OBERHAUSER, 1963 from the San Cassiano Formation (Northeastern Dolomites, Italy). X-ray investigation of tests of *Pragsoconulus robustus* has shown an aragonitic composition. The cone-shaped test, with highly morphological variability, has a spherical proloculus followed by few, small, trochospirally arranged chambers becoming pipe branched in the successive whorls. They are trochospirally arranged around an axial cavity. The latter ends as aperture opening in the centre of the test base. The wall of *Pragsoconulus* is perforate, finely laminated and built by aragonitic needles arranged in a "water-jet" pattern. The lamellae make up the pipe chambers through the development of complex folds.

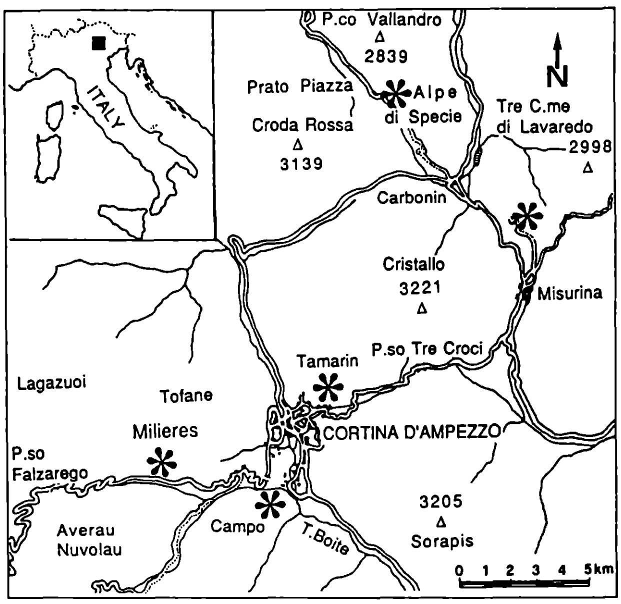

Figure 1: Map showing localities of the sampled areas.

Zusammenfassung

Von der obertriadischen Foraminifere *Pragsoconulus robustus* OBERHAUSER, 1963, werden aus der San Cassian-Formation (nordöstliche Dolomiten, Italien) erstmals detailliert Gehäusearchitektur, Mineralogie und Wandstruktur an sehr gut erhaltenen Exemplaren beschrieben.

Röntgendiffraktometrische Untersuchungen belegen die aragonitische Gehäusezusammensetzung. Das morphologisch sehr variable, konische Gehäuse besteht aus einem kugeligen Proloculus, der von wenigen, kleinen, trochospiral angeordneten Kammern gefolgt wird. Diese Kammern werden in nachfolgenden Umgängen röhrenförmig verzweigt und sind trochospiral um einen achsialen Hohlraum angeordnet. Dieser achsiale Hohlraum mündet als Apertur im Zentrum der Gehäusebasis. Die Gehäusewand von *Pragsoconulus* ist perforiert, fein laminiert und besteht aus Aragonitnadeln, die in einem „water-jet" Muster angeordnet sind. Die röhrenförmigen Kammern werden durch komplexe Faltenbildung der Lamellen gebildet.

Dipartimento di Scienze della Terra, Università di Modena, via Università 4, 41100, Modena
Dipartimento di Scienze della Terra, Università della Calabria, 8703 - Arcavata di Rende (Cosenza).
Dipartimento di Scienze Geologiche e Paleontologiche, Corso Ercole I d'Este 32, 44100 Ferrara.

1. Introduction

1a. Earlier work and Scope of Present Study

The first attempts to classify *Pragsoconulus robustus* in a group of plants or animals were unsatisfactory. FLÜGEL (in OBERHAUSER, 1963:29), for instance, on the base of the literature discarded the hypothesis this organism could belong to calcareous algae. In the same way the attempt of OBERHAUSER (1963) to include it in the cnidarian group was unsatisfying.

Finally, *Pragsoconulus* was considered a foraminifer. *Pragsoconulus robustus* was described for the first time by OBERHAUSER (1963) as a strange looking labyrinthic foraminifer developed from a *Tetrataxis*-like ancestry and having a doubtful suprageneric position. Oberhauser's material is from Alpe di Specie (Seelandalpe).
LOEBLICH & TAPPAN (1981, 1987) ascribed *Pragsoconulus* doubtfully to the family Involutinidae BÜTSCHLI, 1880, subfamily Aulotortinae ZANINETTI, 1984, based only on the original description underlining the necessity of detailed investigation for interpretation of many as yet unknown characteristics of the test.
According to PILLER (1983) the systematic position of *Pragsoconulus* is not quite clear. He supposed it could belong either to the Textulariina or to the Fusulinina, but not to the Involutinina.
di BARI & LAGHI (1994) questioned the position of *Pragsoconulus* in the order Foraminiferida.
Pragsoconulus robustus also was found in the Carnian of West Carpathian (SALAJ et al., 1983) and in the Ladinian-Carnian of China (Sichuan) (HE YAN & YUE ZHI-LAN, 1987; HE YAN & H. NORLING, 1991).
This paper improves the knowledge of *Pragsoconulus* by providing new data on mineralogy, test-architecture and test-wall texture.

1b. Materials and methods

The material investigated consists of more than 6000 specimens collected by R. Zardini from the typical fossiliferous San Cassian localities (Fig. 1).
The sediments of the San Cassiano Formation were deposited in basin areas and interfinger with the coeval prograding Cassian platforms (BOSELLINI, 1984, 1988, 1989; BOSELLINI & DOGLIONI, 1988; De ZANCHE et al., 1993; NERI et al., 1994). They are largely volcanoclastic and turbiditic and record a progressive shallowing of the San Cassiano basin (WENDT & FÜRSICH, 1980). The overlying Dürrenstein Dolomite fills the final San Cassiano basins and onlaps the flanks of the Cassian platforms partly covering them (BOSELLINI, 1991).
The Tamarin and Milieres outcrops belong to the basinal facies of the San Cassiano Formation, while Alpe di Specie belongs to the lower-most part of the Dürrenstein Dolomite (RUSSO et al., 1991).
The material studied consists of isolated tests of *Pragsoconulus* robustus washed out from marls and clays. They were cleaned by ultrasonic before being investigated with light and Scanning Electron Microscopy (SEM). Test structure and test wall texture were studied by SEM on fresh surfaces as well as on polished and etched sections.

2. Results and Discussion

2a. Architectural features of the test

Test free, cone-shaped with high morphological variability, from low to high cone (Pl.1, figs. 3–8). The height of the tests ranges from 1.3–3.5 millimetres; the largest diameter from 1–2 millimetres; the apical angle from 22.5–75.5 degrees. Some of Oberhauser's specimens are lower than the analysed.
The studied specimens clearly show a multi-chambered architecture (Pl. 1, figs. 9, 10; Pl. 2, figs. 4, 5). The spherical, finely perforate proloculus is at the top of the cone (Pl. 1, figs. 5–10). It has 30 microns in diameter and is followed by at least a whorl of small trochospirally enrolled chambers (Pl. 1, figs. 5–10). They are ovoid-shaped and have a perforate wall. The chambers change their morphology in the successive whorls. They become pipe chambers bifurcating or irregularly branching toward the lateral surface (Pl. 2, figs. 1, 3). The pipe chambers are trochospirally arranged around an axial cavity starting under the proloculus and ending as aperture in the centre of the base of the cone (Pl. 1, figs. 1, 2). The pipe chambers extend from the axial cavity, in which they are opened, to the lateral surface and incline gently toward the base of the cone. During the enrollment their length increases constantly. The pipe chambers are about 150 microns in diameter before the branching, while branches range from 40–60 microns each.
The base of the cone is flat or slightly concave. It is characterised by grooves (furrows) and raises (ribs) surrounding the central aperture (Pl. 1, figs. 1, 2, 4).
The trochospiral arrangement of the pipe chambers

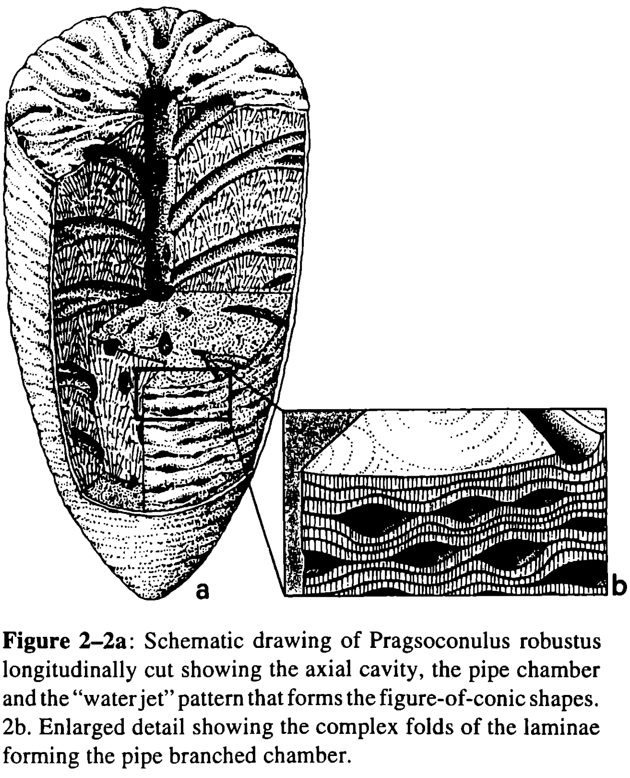

Figure 2–2a: Schematic drawing of Pragsoconulus robustus longitudinally cut showing the axial cavity, the pipe chamber and the "water jet" pattern that forms the figure-of-conic shapes. 2b. Enlarged detail showing the complex folds of the laminae forming the pipe branched chamber.

around the axial cavity can be compared to a spiral staircase (Pl. 2, figs. 1, 3, 4). OBERHAUSER (1963) compared *Pragsoconulus* to a cone having a christmas-tree-like ramificated cavity in axial position.

2b. Test-composition and test-wall texture

An x-ray investigation was done to clarify the mineralogical composition of *Pragsoconulus robustus*. It was analysed with x-ray powder methods and showed clearly an aragonitic composition.

As pointed out by OBERHAUSER (1963) and LOEBLICH & TAPPAN (1987) the wall-texture of *Pragsoconulus* is finely laminated with lamellae roughly parallel to the test base (Pl. 3, fig. 3). Each lamella, of about 10 microns in thickness, consists of aragonite needles with their long axis (c-axis) oblique to the axis of enrolment. The arrangement of aragonite needles is very similar to the "water-jet" pattern described by DIECI et al. (1974) from sponge and is well visible on fresh broken surfaces as well as on polished and etched sections (Pl. 4). This arrangement is accentuated by the folds characterising the lamellae (Pl. 3, figs. 3, 4). Therefore, because of the "water-jet" pattern of aragonite needles and the folds of lamellae, many close figure-of-conic shapes are recognisable in sections parallel or oblique to axis of enrolment. The figure-of-conic shapes have their circular base toward the base of the test on which they appear as many rings without a clear arrangement (Fig. 2a; Pl. 3, fig. 1).

Perforations of 8–10 microns in diameter cross roughly perpendicular the lamellae (Pl. 3, fig. 2; Pl. 4, figs. 2, 3).

2c. Morphogenetic considerations on the chambers growth

The process of construction of the above described pipe chambers depends completely on the folds of lamellae. These lamellae are parallel to the test base and grow trochospirally, around the axis of enrollment, leaving a cavity in axial position (Fig. 2).

During their growth the lamellae form many folds well observed on specimens with a cut-away surface and on the base of the test (Pl. 1, figs. 1, 2, 4, 8; Fig. 2 a, b) on which they form many papillae and furrows, like an "ornamentation"

It is possible to recognise two different kinds of folds:
a) one of greater size (about 150 microns), developed from the centre to the periphery of the test base, that are responsible for the formation of the pipe chamber;
b) one of smaller size (about 50 microns), developed especially toward the lateral surface, that are responsible for the bifurcations and the ramification of the pipe chambers.

The main part of the pipe chambers is formed when a fold concavity covers a fold convexity of a previous whorl. The bifurcations and the ramification derive from a similar process of construction.

3. Concluding Remarks

The test of *Pragsoconulus* consists of a globular proloculus followed by at least a whorl of small chambers that becomes pipe branched in the successive whorls. The test is cone-shaped and trochospiral throughout. The pipe chambers are open into an axial cavity that ends as aperture in the centre of the test base. The calcareous wall is made up of aragonite needles arranged in a "water-jet" pattern.

Based on the above description new problems arise in the suprageneric systematic position of *Pragsoconulus*. PILLER's hypothesis (1983) that this genus could belong either to the Fusulinina or to the Textulariina has to be discarded particularly because of a different test composition and wall-texture. In fact, the foraminifers belonging to the Fusulinina have a wall of homogeneously microgranular calcite, of tightly packed equidimensional subangular crystals, or are differentiated into two or more layers; the Textulariina have an agglutinated test.

Pragsoconulus was grouped among the Involutinina by LOEBLICH & TAPPAN (1981, 1987) and the aragonitic composition agrees with this hypothesis. Nevertheless, the multi-chambered architecture of *Pragsoconulus* excludes the genus from the Involutinina.

At present we prefer to leave the suprageneric systematic position of *Pragsoconulus* open.

Acknowledgements

The authors are very grateful to Prof. W. Piller (University of Vienna) for the critical review of the manuscript and for the german version of the abstract. We are very grateful to Prof. L. Zaninetti and Dr. R. Martini (University of Geneva) for their interesting comments that contributed to improve the first draft of the manuscript. Thanks are also due to Prof. E. Galli (Dipartimento di Scienze della Terra, Università di Modena) for mineralogic analysis. This work has been supported by a grant of MURST.

4. References

di BARI, D. & LAGHI, G. 1994. Involutinidae Bütschli (Foraminiferida) in the Carnian of the northeastern Dolomites (Italy). — Mem. Sci. Geol. **46**:93–118, Padova.

BOSELLINI, A., 1984. Progradation geometries of carbonate platform: examples from the Triassic of the Dolomites, Northern Italy.— Sedimentology, **31**:1–24.

BOSELLINI, A., 1988. Outcrop models for seismic stratigraphy: examples from the Triassic of the Dolomites. [in:] BALLY, A.W. (eds.) Atlas of Seismic Stratigraphy. AAPG, Studies in Geology. **2**:194–203.

BOSELLINI, A., 1989. Dynamics of Tethyan carbonate platforms. [in:] CREVELLO, P.D., WILSON, J.L., SARG, J.F. & READ, J.F. (eds.) Controls on carbonate platforms and basin development. SEPM Spec. Publ. **44**:3–13.

BOSELLINI, A., 1991. Geology of the Dolomites, an introduction: Dolomieu Conference on Carbonate Platforms and Dolomitization. — Ortisei/St. Ulrich, Val Gardena/Grödental.

BOSELLINI, A., DOGLIONI, C., 1988. Progradation geometries of Triassic Carbonate Platforms of the Dolomites, and their large-scale Physical Stratigraphy: field trip n°6 in the Dolomites, guide book. [in] AAPG Mediterranean Basins Conference.

DE ZANCHE, V., GIANOLLA, P., MIETTO, P., SIORPAES, C. & VAIL P.R. 1993. Triassic sequence stratigraphy in the Dolomites (Italy). — Mem. Sc. Geol., **43**:1–27, Padova.

DIECI, G., RUSSO, A. F. RUSSO, F. 1974. Nota preliminare sulla microarchitettura di spugne aragonitiche del Trias medio-superiore. — Soc. Paleont. It., **13**:99–107, Modena.

HE Yan & YUE Zhi-lan, 1987. Bull. Nanjing Inst. Geol. Paleont. — Acad. Sinica, **12**:192–230, Beijing.

HE Yan & NORLING, E. 1991. Upper Triassic Foraminiferida and stratigraphy of Mianzhu, Sichuan province, China. — Sver. Geol. Unders Ser. Ca **76**:1–47, Stockholm.

LOEBLICH, A. & TAPPAN, H., 1981. Suprageneric revisions of some Calcareous Foraminiferida. — J. Foram. Research **11**(2):159–164.

LOEBLICH, A. & TAPPAN, H.,1987. Foraminiferal genera and their classification. — Van Nostrand Reinold Company, New York.

NERI, C., MASTANDREA, A., LAGHI, G., BARACCA, A. & RUSSO, F. 1994. New biostratigraphic data on the S. Cassiano Formation around Sella Platform (Dolomites, Italy). — Paleopelagos **4**:13–21, Roma.

OBERHAUSER, R., 1963. Eine labyrinthische Foraminifere aus der südalpinen Trias. — Sonderb. Verhandl.Geol. Bund., **1/2**:28–33.

PILLER, W., 1983. Remarks on the suborder Involutinina Hohenegger and Piller 1977. — J. Foram. Research. **13**(3):191–201, Hanover.

RUSSO, F., NERI, C., MASTRANDREA, A., LAGHI, G.F., 1991. Deposizional and Diagenetic History the Alpe di Specie (Seelandalpe) Fauna (Carnian, Northeastern Dolomiten. — Facies **25**:187–210, Erlangen.

SALAJ, J, BORZA, K. & SAMUEL, O.,1983. Triassic Foraminifers of the west Carpathians. — Geologicky Ustav Dioniza Stura, 213 pags., 157 pls., Bratislava.

WENDT, J. & FÜRSICH, F.T., 1980. Facies analysis and paleogeography of the Cassian Formation, Triassic, Southern Alps. — Riv. Ital. Paleont. **85**:1003–1028, Modena.

PLATE 1

Pragsoconulus robustus, OBERHAUSER, 1960

Fig. 1. SEM picture showing the test base with grooves and raises around the central aperture; x 46.

Fig. 2. Base of the cone showing the folds of the laminae forming the pipe branched chambers; SEM picture; x 66.

Figs. 3, 5. Exterior edge view; SEM picture; Fig. 3, x 36; Fig. 5, x 46.

Fig. 4. Exterior edge view of a specimen with a cut-away surface. SEM picture; x 37.

Fig. 6. Apical view of a specimen showing the globular proloculus. SEM picture; x 45.

Figs. 7, 8. Exterior edge view of a specimens showing the globular proloculus and the first stage of the enrolment. SEM picture; Fig. 7, x 36; Fig. 8, x 36.

Figs. 9, 10. Enlarged details showing the globular proloculus and the first stage of the enrolment. SEM picture; Fig. 9, x 300; Fig. 10, x 365.

PLATE 1

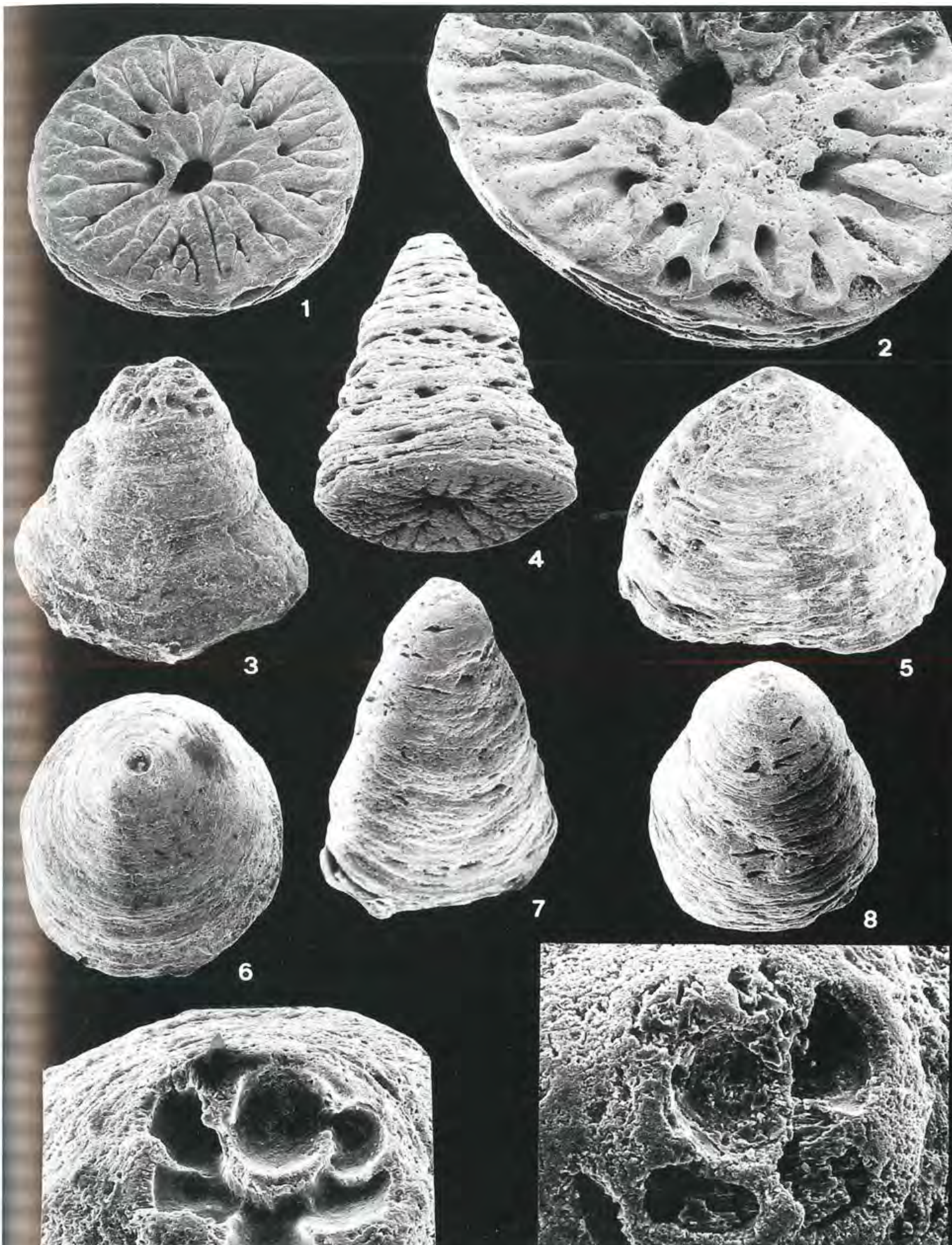

PLATE 2

Pragsoconulus robustus, OBERHAUSER, 1960

Fig. 1.–1a. Axial fresh fracture showing the outline of Fig. 1b. SEM picture; x 25.

Fig. 1b. Fresh fracture detail of the filling of the chamber lumina showing the trochospiral arrangement of the pipe chambers around the axial cavity and their branch; SEM picture; x 100.

Fig. 2. Polished axial section showing the axial cavity. Optical microscope photograph; x 25.

Fig. 3–3a. Axial fresh fracture showing the outline of Fig. 3b. SEM picture; x 25.

Fig. 3b. Detail of the filling of the chamber lumina showing the branch of the pipe chamber; SEM picture; x 120.

Fig. 4. Broken specimen showing the trochospiral arrangement of the pipe chamber by means of the filling of the chamber lumina; SEM picture; x 30.

Fig. 5. Fresh fracture showing the pipe chambers; SEM picture; x 53.

PLATE 2

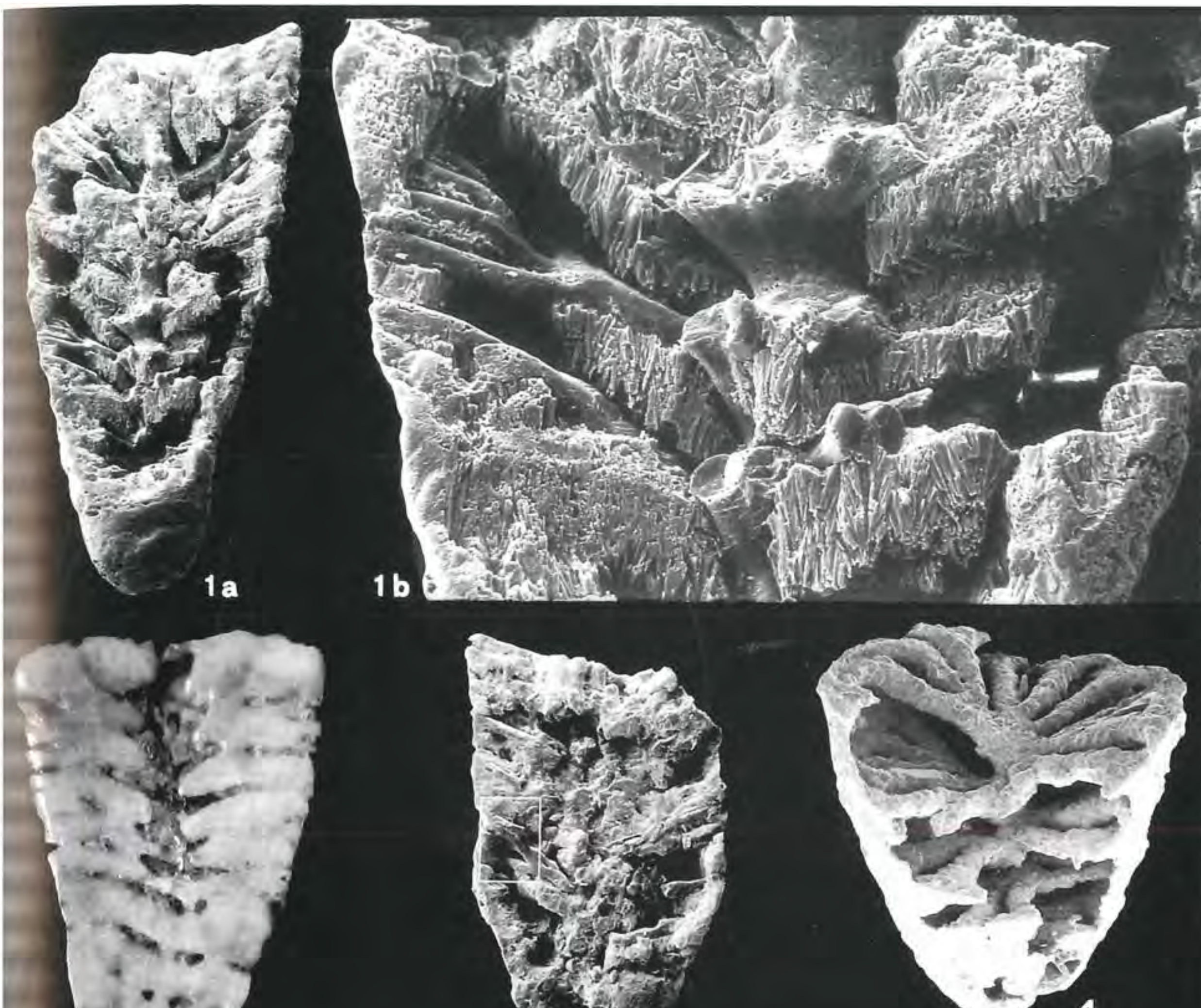

PLATE 3

Pragsoconulus robustus, OBERHAUSER, 1960

Fig. 1–1a. Polished section vertical to axis showing the outline of Fig.1b detail. SEM picture; x 26.

Fig. 1b. Equatorial section detail showing the lamellar structure and the rings derived from the "water jet" pattern; SEM picture; x 190.

Fig. 2. SEM picture showing perforations close to a pipe chamber; x 900.

Fig. 3–3a. Polished axial section showing the outlines of Figs. 3b, 3c details. SEM picture; x 27.

Figs. 3b, 3c. Axial section details showing the lamellar structure and the "water jet" pattern forming figures-of-conic shape; SEM picture Fig. 1b, x 260; Fig.1c, x 185.

Fig. 4 –4a. Polished axial section showing the outline of Fig. 4b detail. 4b. Axial section detail showing the "water jet" pattern forming figures-of-conic shape; Optical microscope photograph; x 250.

PLATE 3

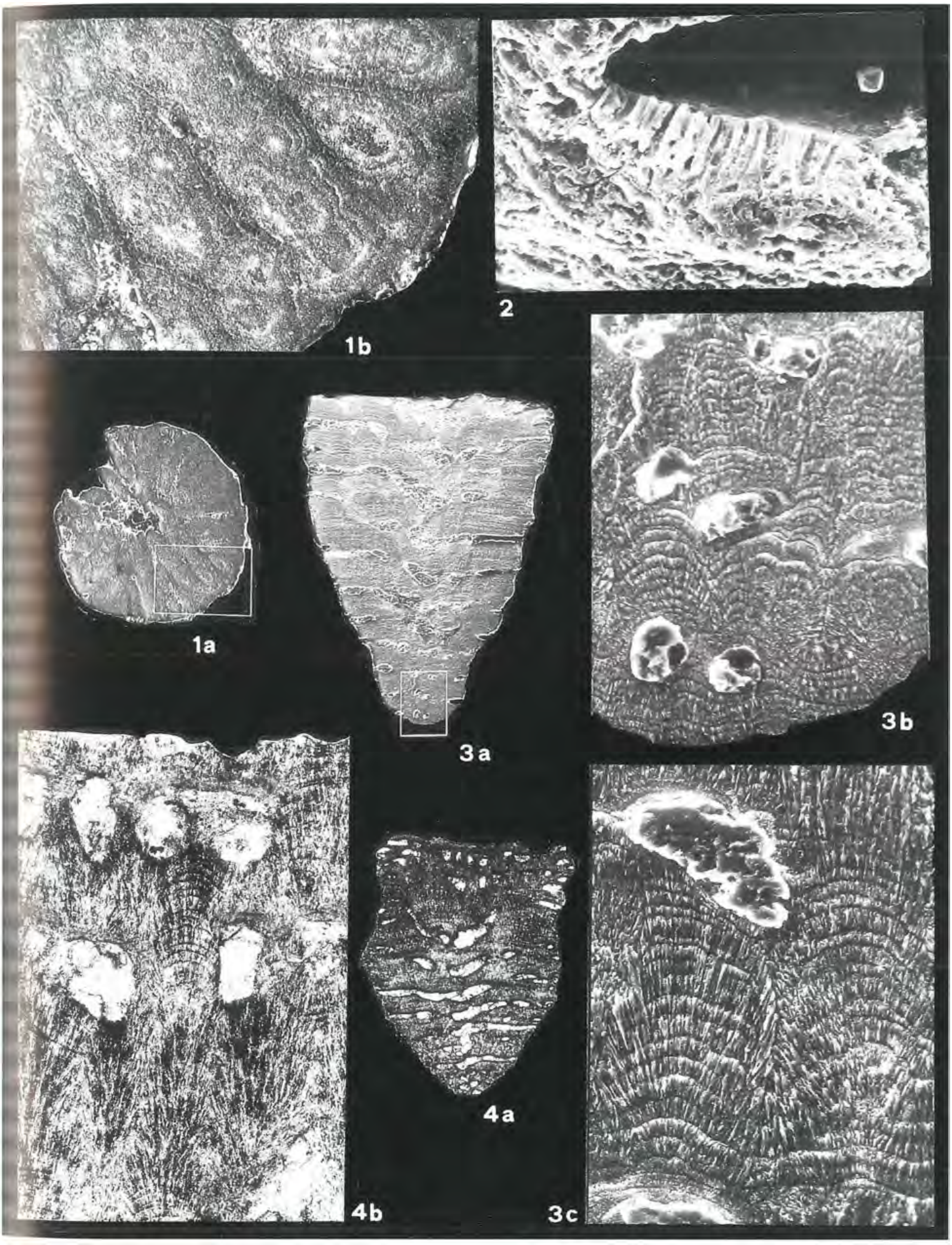

PLATE 4

Pragsoconulus robustus, OBERHAUSER, 1960

Figs. 1, 4, 5. Enlarged details of a fresh broken surfaces showing aragonite needles with the "water-jet" pattern. SEM pictures; Fig. 1 x 300, Fig. 4 x 1000, Fig. 5 x 250.

Fig. 2. Enlarged detail of a fresh broken surfaces showing the "water-jet" pattern of the aragonite needles and the perforations perpendicular to the pipe chambers. SEM picture; x 350.

Fig. 3a. Fresh broken surfaces showing the outlines of Fig. 3b detail. SEM picture; x 130.

Fig. 3b. Fresh broken surfaces detail showing perforations perpendicular to the pipe chambers. SEM picture; x 485.

PLATE 4