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New taxa of tabulate corals from the Lower Permian of Spitsbergen and their stable isotopic data

ABSTRACT: New coral taxa *Tetraporinus siedleckii* sp. n. and *Roemeripora aspinosa major* ssp. n. are erected from the Lower Permian (Sakmarian and Artinskian) Treskelodden Formation of Hornsund area, Spitsbergen and *Syringopora* sp. similar to *S. subreticulata* Nowiński, 1991 are described. Studies on stable isotope ratios of carbon and oxygen in the skeletons of tabulate and rugose corals from Hyrnefjellet and Treskelen areas show that these organism did not fraction the isotopes to much. The differences in isotope fractionation, both for carbon and oxygen, reached 2 ‰ comparable to the concurring brachiopods, accepted as reference level.

Key words: Arctic, Spitsbergen, Lower Permian, paleontology (Anthozoa).

Introduction

The paper presents results of research on tabulate corals from the Lower Permian (Sakmarian and Artinskian) Treskelodden Formation (Birkenmajer 1959, 1964; Harland *et al.* 1997; Dallmann 1999) of the Hornsund area in Spitsbergen (Svalbard). The material described comes from the V coral horizon (see Birkenmajer 1964) of the Upper Treskelodden Beds, from an outcrop on the southern slope of Hyrnefjellet (Text-fig. 1; Pl. 1, Fig. 1) and were collected by A. Gaździcki and A. Kaim during the 1998 Paleontological Expedition to Spitsbergen. One new species belonging to the order Syringoporida: *Tetraporinus siedleckii* (Pl. 4, Fig. 1 a, b) and one new subspecies of the order Favositida: *Roemeripora aspinosa major*

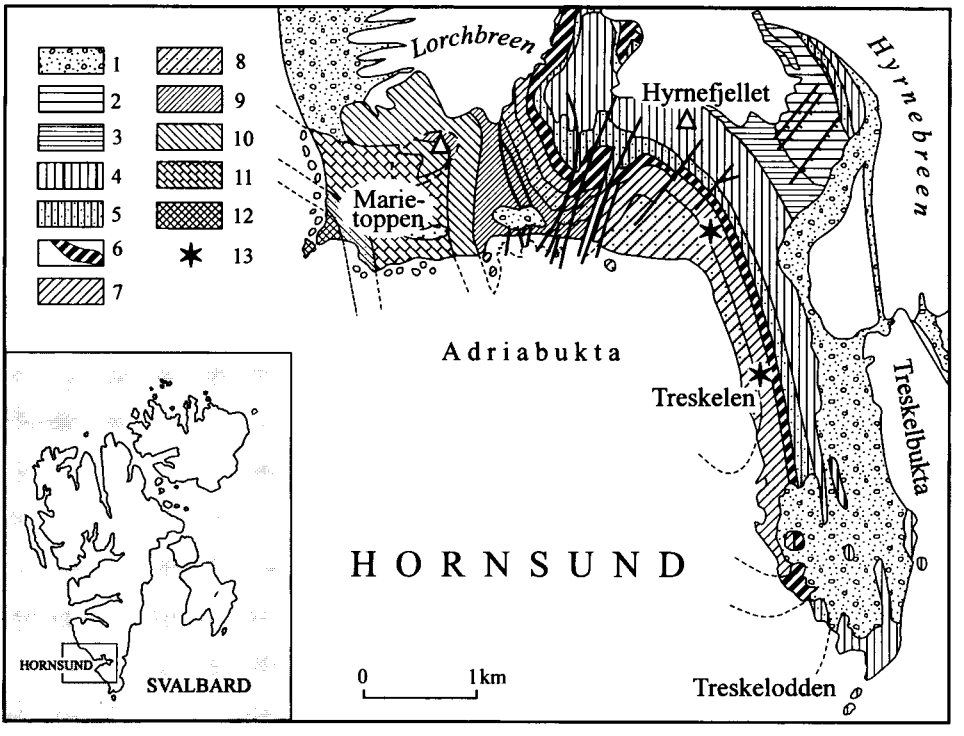

Fig. 1. Geological map of West Spitsbergen (Hornsund area) showing the location of the Hyrnefjellet Mt. and Treskelen Peninsula, where the specimens were collected. 1, Moraines, partly outwash; 2, Festningen sandstone (Hauterivian–Barremian), Ullaberget series (Lower Neocomian); 3, Tirolarpasset series (Volgian–Lower Neocomian); 4, Middle and Upper Triassic; 5, Lower Triassic; 6, Brachiopod Cherty Limestone (Upper Permian); 7, Treskelodden Beds (Upper Carboniferous–Lowermost Permian); 8, Hyrnefjellet Beds (Middle Carboniferous); 9, Adriabukta Series (Visean–Namurian A?); 10, Upper Marietoppen Series (Devonian: Grey Hoek Series?); 11, Middle Marietoppen Series (Devonian: Stjördalen Division?); 12, Sofiebogen Formation (Eocambrian–Precambrian); 13, Coral sampling localities. After Birkenmajer (1964).

(Pl. 2, Fig. 1 a, b) are described and illustrated. The list of identified species of Tabulata present in the outcrop includes: *Roemeripora wimani* Heritsch, *R. minor* Heritsch, *R. aspinosa major* subsp. n., *Syringopora* sp., *Roemerolites laminatus* (Nowiński), *Tetraporinus spitsbergensis* Nowiński, and *T. siedleckii* sp. n.

The material is an important addition to the previously described Early Permian tabulate corals from the Hornsund area (Nowiński 1982, 1991) and confirms its endemic character. The lithology and stratigraphic position of the "Upper Treskelodden Beds" were given by Birkenmajer (1959, 1964). The tabulate faunal community from Hyrnefjellet area was described and correlated with coeval tabulate faunas of various regions of Europe and Asia by Nowiński (1991).

Studies on stable isotope ratios ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) in skeletons of Tabulata, Rugosa and a brachiopod shell as a reference material from Hyrnefjellet Mt. and Treskelen Peninsula were done.

The present work was done in the Institute of Paleobiology of the Polish Academy of Sciences, Warszawa, abbreviated as ZPAL, where the collection is housed. Studies on stable isotopes were done in Stable Isotope Laboratory of Institutes of Paleobiology and Geological Sciences, Polish Academy of Sciences, Warszawa.

Systematic paleontology

Class Anthozoa
Subclass Tabulata Milne-Edwards et Haime, 1850
Order Favositida Wedekind, 1937
Suborder Favositina Wedekind, 1937
Family Syringolitidae Waagen et Wentzel, 1886
Genus *Roemeripora* Kraicz, 1934

Remarks. — In the material from Hyrnefjelett here considered, two species of *Roemeripora* have been recognized: *R. wimani* Heritsch and *R. aspinosa* Nowiński represented by a new subspecies.

Roemeripora wimani Heritsch was described earlier (Nowiński, 1991) from the same beds, but it is worth to mention that a new very well preserved colony (ZPAL T.XXIII/6) differs from earlier described specimens by slightly larger diameters of connecting pores and by the complete lack of tabular spines.

Roemeripora aspinosa major ssp. n.
(Pl. 2, Figs 1a, b)

Holotype: Specimen ZPAL T.XXIII/2; PL. 2, Figs 1a, b.

Type horizon: the V coral horizon of the Upper Treskelodden Beds, Lower Permian.

Type locality: southern slope of Hyrnefjellet Mt., Hornsund, Spitsbergen.

Derivation of the name: with larger corallites than *R. aspinosa aspinosa.*

Diagnosis. — Corallum fasci-cerioid. Corallites in the fascicular zones of corallum irregularly cylindrical, joined by connecting tubes; in cerioid aggregates – irregularly prismatic and cylindro-prismatic, joined by connecting pores. Corallite diameters 1.6–2.0 mm. Connecting pores mural and angular, with 0.2–0.4 mm diameter, 2.2–3.0 mm apart. Connecting tubes short, 0.3–0.5 mm in diameter, spaced as the pores. Tabulae long, strongly oblique and funnel-shaped (infundibuliform), near the pores and connecting tubes – short, horizontal, concave, very densely spaced. Neither septal nor tabular spines exist.

Material. — One large, almost complete, well preserved skeleton of a colony: ZPAL T.XXIII/2 (5 thin sections).

Description. — Corallum cerio-fascicular, irregularly dome-shaped, with 110 mm in diameter and about 80 mm high. Corallites long, very irregularly cylindrical, cylindro-prismatic and prismatic with rounded edges, loosely bent, radially ar-

ranged, of various density. In fascicular (mostly peripheral) zones of corallum, the corallites are very irregularly cylindrical and cylindro-prismatic, irregularly oval or oval-polygonal, rarely round in cross section, connected with short connecting tubes and spaced at distances shorter than their diameters. In cerioid zones of the corallum, the corallites often form aggregates of several individuals. In those zones, they are irregularly prismatic, irregularly polygonal in cross section (tetragonal or pentagonal) and connected with pores. Corallite diameters 1.5–2.2 mm, most often 1.6–2.0 mm. Corallite walls very irregularly convoluted, 0.05–0.1 mm in thickness, and with poorly visible fibro-radial (primary) microstructure. Stereoplasmatic fibres are perpendicular to the epitheca. The epitheca very thin (ca 0.01 mm), dark, discontinuous. Connecting pores mural and angular, 0.2–0.4 mm in diameter, with vertical spacing of 2.2–3.0 mm. Connecting tubes short, 0.3–0.5 mm in length, spaced as the connecting pores. Tabulae thin, of two morphological types: in parts of corallites between the pores and connecting tubes – long, strongly oblique and funnel-shaped (syringoporoid type), fairly rare. Near pores and connecting tubes – short, horizontal and slightly oblique, concave, very dense. Septal and tabular spines absent. Axial canal poorly separated, short, discontinuous.

Remarks. — *Roemeripora aspinosa major* ssp. n. differs from the nominotypic subspecies of *R. aspinosa* Nowiński, 1982 described from the same beds of Treskelen and Hyrnefjellet (Nowiński 1982, 1991) by having corallites with greater diameter, slightly more distant pores and connecting tubes, rarely spaced and strongly obliquely oriented tabulae, and very poorly developed axial canal. For comparison of *R. aspinosa* with a related species from Novaya Zemlya – *R. terrae-novae* Smirnova, 1957 – see Nowiński (1982).

Occurrence. — Treskelodden Formation, Lower Permian: Spitsbergen (Hornsund, Hyrnefjellet).

Order Syringoporida Sokolov, 1962
Family Syringoporidae de Fromentel, 1861
Genus *Syringopora* Goldfuss, 1826
Syringopora sp.
(Pl. 3, Figs 1a–c)

Material. — One very large, poorly preserved fragment of a colony skeleton: ZPAL T.XXIII/4 (3 thin sections).

Description. — Corallum fascicular, bulbous, some 200 mm in diameter. Corallites very long, straight or slightly wavy, irregularly cylindrical and prismatic with strongly rounded edges, radially arranged, irregularly spaced (0.0–0.8 mm), sporadically forming small cerioid aggregates (a couple of corallites each). In cross section, the corallites are irregularly oval or slightly polygonal with rounded angles, rarely round, 1.3–2.0 mm in diameter, most often 1.5–1.8 mm. Corallite walls uneven, slightly meandering, with thickness varying extensively: 0.08–0.25 mm.

Wall microstructure obliterated. Epitheca not separated. Connecting tubes with 0.3–0.4 mm in diameter, spaced each 1.2–1.8 mm. Tabulae long, funnel-shaped, strongly oblique. Septal spines invisible. Tabular spines absent. Axial canal barely separated, short, discontinuous.

Remarks. — *Syringopora* sp. is most similar to *S. subreticulata* Nowiński from the same Lower Permian beds of Treskelen and Hyrnefjellet (Nowiński 1991). The similarity concerns morphology, arrangement, cross-sectional outlines and diameters of corallites, as well as the arrangement and morphology of the tabulae. Nevertheless, *Syringopora* sp. differs from *S. subreticulata* in having more densely spaced corallites, much thinner corallite walls, narrower and rarer connecting tubes, total lack of septal and tabular spines, and poorly developed axial canal.

Occurrence. — Treskelodden Formation, Lower Permian: Spitsbergen (Hornsund, Hyrnefjellet).

Family Tetraporellidae Sokolov, 1950
Genus *Tetraporinus* Sokolov, 1947
Tetraporinus siedleckii sp. n.
(Pl. 4, Figs 1a, b)

Holotype: specimen ZPAL T.XXIII/5; PL. 6, Figs 1a, b.
Type horizon: the V coral horizon of the Upper Treskelodden Beds, Lower Permian.
Type locality: southern slope of Hyrnefjellet Mt., Hornsund, Spitsbergen.
Derivation of the name: in honour of Professor Stanisław Siedlecki.

Diagnosis. — Semicircular fascicular corallum. Corallites irregularly cylindrical and prismatic, with 0.0–0.5 mm spacing, in cross section polygonal with rounded angles, 1.4–1.7 mm diameter. Corallite walls 0.2–0.4 mm thick. Connecting tubes numerous, short, with 0.4–0.5 mm diameter and 0.4–1.0 mm spacing. Tabulae funnel-shaped, oblique and horizontal, rarely vesicular. Septal spines numerous, thick, with blunt tips. Axial canal not developed.

Material. — One almost complete, well preserved skeleton of a colony: ZPAL T.XXIII/5.

Description. — Irregularly semicircular fascicular corallum, about 120 mm in diameter and about 70 mm high. Corallites very long, very irregularly cylindrical and cylindro-prismatic with strongly rounded edges, bent, radially arranged, spaced each 0.0–0.7 mm, most often 0.0–0.5 mm. In cross section of the corallum the corallites appear round, irregularly oval, or sometimes slightly polygonal (tetragonal or pentagonal) with strongly rounded angles, chaotically arranged, sometimes forming short chains, closed or open rings, sporadically forming small cerioid aggregates. Corallites 1.2–1.8 mm in diameter, most often 1.4–1.7 mm. Corallite walls uneven, bent, 0.1–0.5 mm thick, usually 0.2–0.4 mm thick. Wall microstructure poorly visible, concentric-lamellar. Epitheca thin, dark, often discontinuous, with poorly visible radial microstructure. Connecting tubes short,

solenia-like 0.4–0.5 mm (usually 0.2–0.3 mm) in diameter, densely arranged along the corallite edges, spaced each 0.2–1.2 mm, most often 0.4–1.0 mm. Tabulae short, funnel-shaped, of syringoporoid type, oblique or horizontal, wavy or rarely straight, sometimes vesicular. Septal spines numerous, long (up to one-third of corallite diameter), thick, with blunt tips. Tabular spines absent. Axial canal not developed.

Remarks. — The new species is most similar to *Tetraporinus spinosus* Nowiński from the Lower Permian beds of Hornsund (Nowiński 1991). The similarity concerns arrangement (ring and short chains) and cross-sectional outline of corallites, their spacing, presence of short connecting tubes, morphology and arrangement of tabulae, and presence of numerous, long and thick septal spines. However, *T. siedleckii* sp. n. differs from *T. spinosus* in having long corallites of larger diameter and slightly thicker walls, and by lesser diameter of the connecting tubes, which are also more densely spaced. The new species bears some resemblance to *T. virgatus* Tchudinova from the Tournaisian of Novaya Zemlya (Tchudinova 1986). This similarity is manifested in diameters of corallites and connecting tubes, as well as in the arrangement of corallites in cross-sections of the corallum. Still, *T. siedleckii* sp. n. differs from *T. virgatus* by having less angular corallites, by their lesser distances and thicker walls, more densely spaced connecting tubes and by the presence of well-developed septal spines.

The isotopic analysis procedure

Samples were converted to CO_2 by treating with anhydrous orthophosphoric acid d = 1.90 g·cm^{-1}, at 25°C overnight under vacuum (McRea 1950). The CO_2 for isotopic analysis was purified by cryogenic destillation. Isotopic analysis was performed on mass spectrometer FinniganMat Delta Plus working in dual inlet mode with universal triple collector. All δ values were corrected by a factor of 1.01025 and for ^{17}O using standard procedure of Craig (1957). Isotopic ratios are expressed in δ notation relative to V-PDB standard. Analytical reproducibility of in-house standard was better than ± 0.05 ‰ and ± 0.1 ‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively.

Discussion and conclusions

The analysis of isotope proportions of $^{13}C/^{12}C$ and $^{18}O/^{16}O$ in selected skeletons of tabulate and rugose corals from the V coral horizon of Treskelen (Pl. 1, Fig. 2) and Hyrnefjellet (Pl. 1, Fig. 1) areas, led to general conclusions about the so-called vital effect occurring among these organisms, *i.e.* specific local fractioning of these isotopes relative to the marine paleoenvironment by given species.

Table 1

The analysis of isotopic content of C and O in coral (Rugosa and Tabulata) skeletons and in a brachiopod shell from the V Coral Horizon (Upper Treskelodden Beds, Lower Permian) on Hyrnefjellet and Treskelen (Hornsund, Spitsbergen).

Skeletons	Sample no.	$^{13}C/^{12}C$	$^{18}O/^{16}O$
Brachiopod shell	MK-3	+1.151	-7.810
Rugose coral	MK-2	–2.629	–7.535
Rugose coral	NA-1	–1.220	–8.443
Rugose coral	MK-4	–1.815	–8.427
Tabulate coral	MK-1	–1.877	–7.536
Tabulate coral	NA-4	–0.758	–8.766
Tabulate coral	NA-4R	–2.400	–8.166
Tabulate coral	NA-8R	–1.578	–8.377

Most carbon and oxygen isotope readings obtained from the tabulates, and from rugosans as comparative material (Table 1), show remarkable similarity, though their vital effect is more pronounced in the differences of relative proportions of carbon rather than oxygen isotopes. The variation of fractioning intensity does not exceed 2‰. The difference in measured proportions of carbon and oxygen isotopes between the Tabulata and Rugosa, and the Brachiopoda from the same coral horizon is positive and exceeds 2‰, but in the case of oxygen it is not pronounced. Assuming that the data from brachiopods are close to the environmental isotope proportions (Popp *et al.* 1986), it should be noted that the intensity of carbon and oxygen isotope fractioning by Tabulata and Rugosa was similar in scope to that by brachiopods, and thus the groups did not exhibit any strong vital effect. Besides, it is noteworthy that the average isotopic ratios, typical of the V coral horizon dated as Early Permian, in the case of carbon isotope ratio ($^{13}C/^{12}C$) yield much lower values than those in the overlaying Late Permian Kapp Starostin Formation. This indicates a shift towards higher carbon and oxygen isotope ratios occurred within this geological time frame. This shift was due to extensive organic carbon deposition in sediments and was marked in the Late Permian by a fundamental change in palaeooceanographic conditions and mass extinction (Gruszczyński *et al.* 1989).

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References

BIRKENMAJER K. 1959. Report on the geological investigations of the Hornsund area, Vest-spitsbergen, in 1958. Pt. II. The Post-Caledonian succesion. – Bull. Acad. Sci., Sér. sci. chim., géol., géogr., 7: 191–196.

BIRKENMAJER K. 1964. Devonian, Carboniferous and Permian formations of Hornsund, Vest-spitsbergen. – Stud. Geol. Polonica, 11: 47–123.

CRAIG H. 1957. Isotopic standards for carbon and oxygen and correction factors for mass spectrometric analysis of carbon dioxyde. Geochim. Cosmochim. Acta, 12: 133–149

DALLMANN W.K. (ed.) 1999. Lithostratigraphic Lexicon of Svalbard. — Norsk Polarinst., 1–318. Tromsø.

GRUSZCZYŃSKI M., HAŁAS S., HOFFMAN A. and MAŁKOWSKI K. 1989. A brachiopod calcite record of the oceanic carbon and oxygen isotope shifts at the Permian/Triassic transition. — Nature, 337: 64–67.

HARLAND W.B. 1997. The geology of Svalbard. — Geological Society Memoir, No. 17

MCCREA J.M. 1950. On the isotope chemistry of carbonates and a paleo-temperature scale. — J. Chem. Phys. 18: 849–858

NOWIŃSKI A. 1982. Some new species of Tabulata from the Lower Permian of Hornsund, Spitsbergen. *In*: G. Biernat and W. Szymańska (eds), Palaeontological Spitsbergen Studies, Part I. — Palaeont. Polonica, 43: 83–96.

NOWIŃSKI A. 1991. Late Carboniferous to Early Permian Tabulata from Spitsbergen. — Palaeont. Polonica, 51: 3–74.

POPP B. N., ANDERSON T.F. and SANDBERG P.A. 1986. Brachiopods as indicators of original isotopic compositions in some Paleozoic limestones. — Geol. Soc. Am. Bull., 97: 1262–1269.

SOKOLOV B.S. 1947. Novyje siringoporidy Tajmyra. — Byull. Moskov. Obscest. Inst. Prir. (MOIP), (otd. geol.), 22: 19–28.

TCHUDINOVA I.I. 1986. Sostav, sistema i filogenija – Otriad Siringoporida. — Nauka, 216: 7–204. Moskva.

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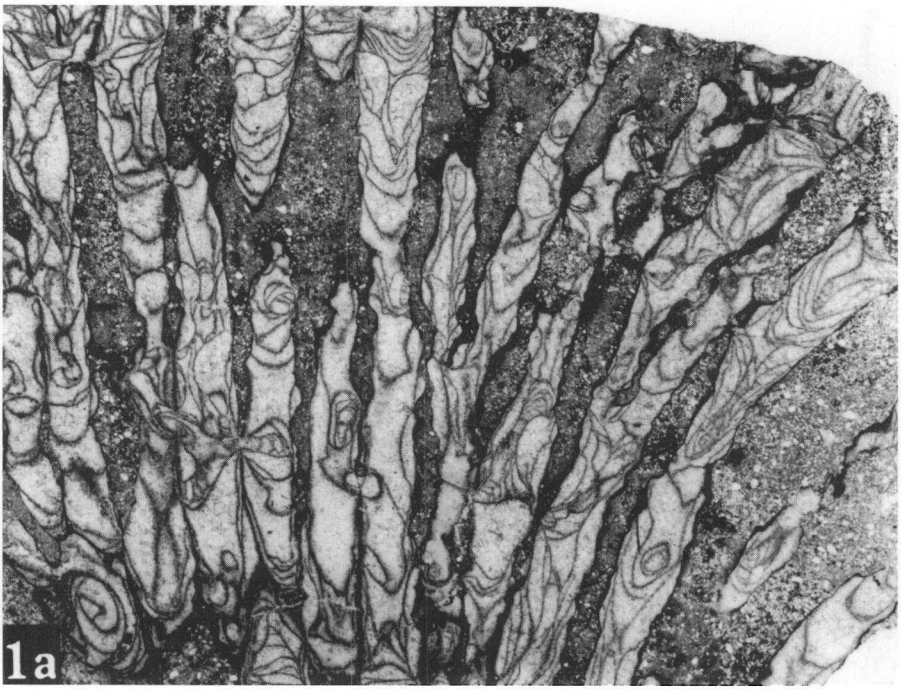
Streszczenie

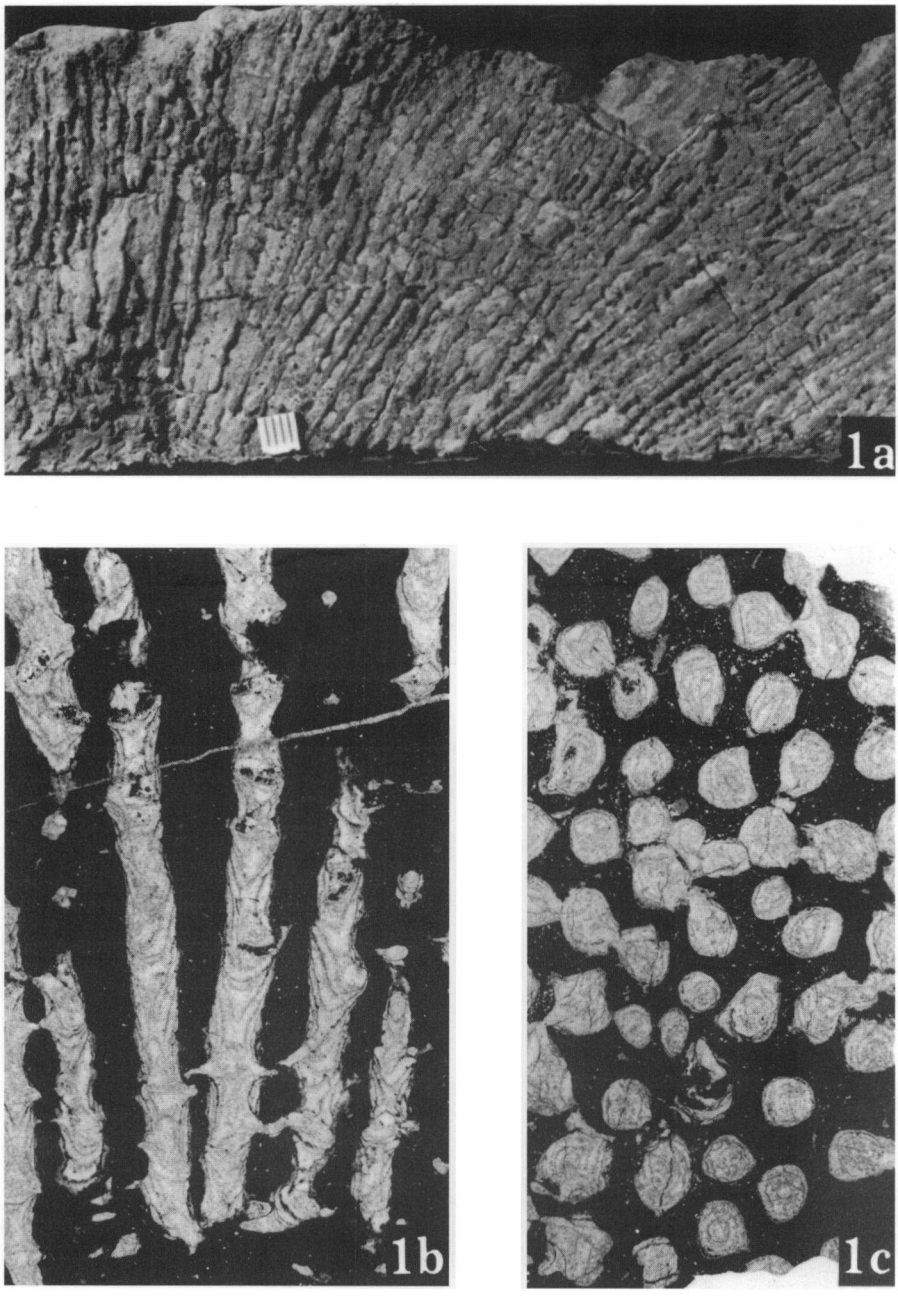
Opisano i zilustrowano dwa nowe taksony korali denkowych: *Tetraporinus siedleckii* (pl. 4, fig. 1 a, b) i *Roemeripora aspinosa major* (pl. 2, fig. 1 a, b) z permskiej formacji Treskelodden z odsłonięć na południowym zboczu Hyrnefjellet w fiordzie Hornsund na Spitsbergenie. Stanowią one istotny element uzupełniający dla poznania wcześniej opisanego zespołu dolno-permskiej fauny tabulatowej z tego obszaru (Nowiński 1982, 1991) i potwierdzają jej endemiczny charakter. Przeprowadzono badania składu stosunków izotopowych węgla $^{13}C/^{12}C$ i tlenu $^{18}O/^{16}O$ na wybranych szkieletach korali z podgromad Tabulata i Rugosa z V poziomu koralowego górnych warstw formacji Treskelodden rejonu Hyrnefjellet i Półwyspu Treskelen. Ustalono, że zarówno Tabulata jak i Rugosa nie wykazują silnego efektu wynikającego z przyżyciowego frakcjonowania izotopów stabilnych węgla i tlenu. Fizjologiczna intensywność frakcjonowania izotopów węgla i tlenu była u nich na poziomie około 2‰ w stosunku do poziomu rozfrakcjonowania tych izotopów u towarzyszących im ramienionogów, który to poziom przyjmuje się jako najbardziej zbliżony do otaczającej wody morskiej. Średnie stosunki izotopowe, charakterystyczne dla wczesno-permskiej formacji Treskelodden są znacznie niższe od takich stosunków, występujących w nadległej późnopermskiej formacji Kapp Starostin.

Outcrops of the late Paleozoic–early Mesozoic sequence. Adriabukta, Hornsund.
1. Hyrnefjellet Mt., 2. Treskelen Peninsula

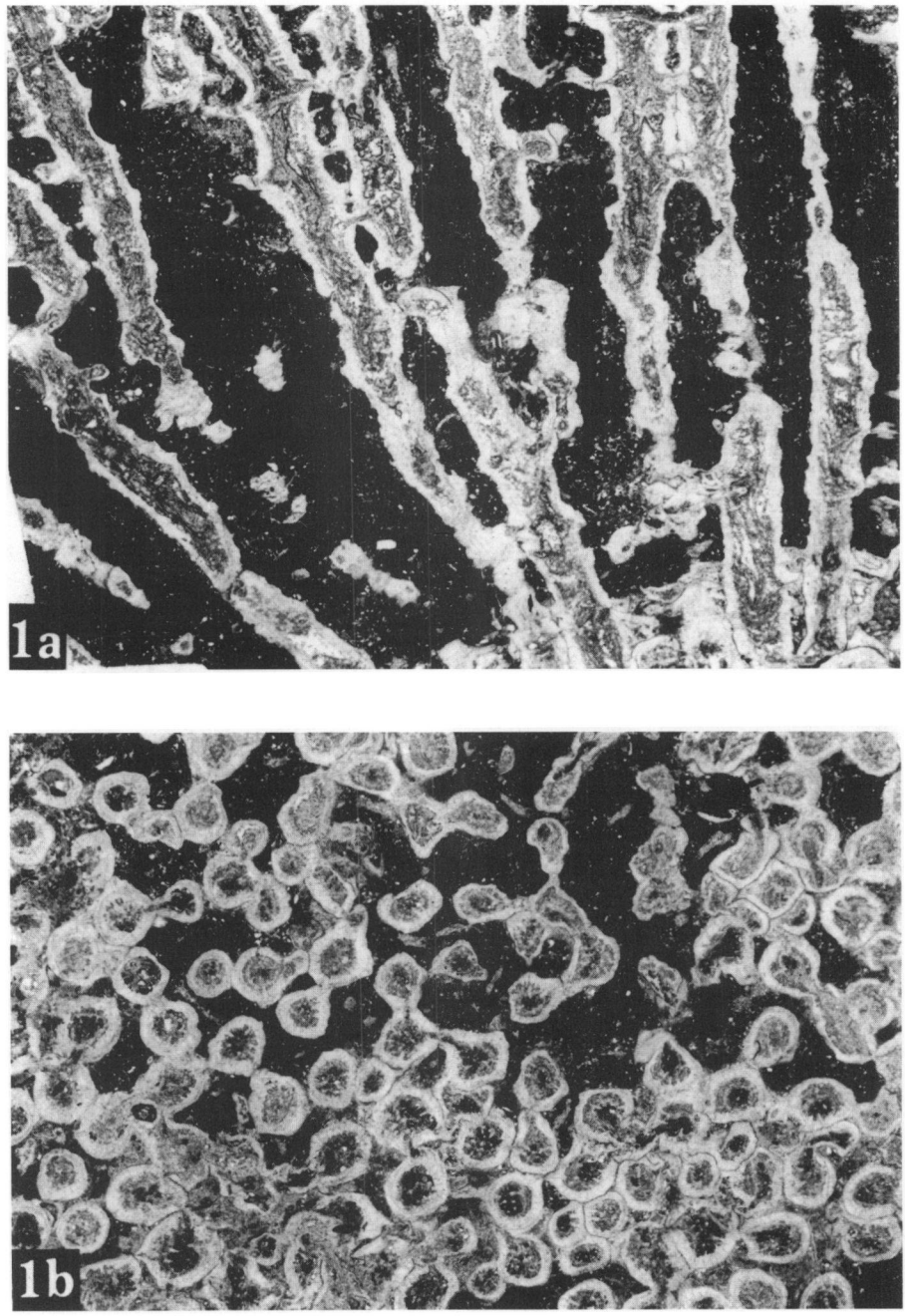
Photos taken by Andrzej Gaździcki, July 1998



Roemeripora aspinosa major ssp. n., holotype ZPAL T.XXIII/2
1a. Longitudinal section, × 5; 1b. Transverse section, × 5.
Upper Treskelodden Beds (Lower Permian) southern slope of Hyrnefjellet Mt., Hornsund, Spitsbergen.



Syringopora sp., ZPAL T.XXIII/4
1a. Naturally exposed longitudinal section of the corallum, × 1; 1b. Longitudinal section, × 5;
1c. Transverse section, × 5.
Upper Treskelodden Beds (Lower Permian) southern slope of Hyrnefjellet Mt., Hornsund, Spitsbergen.



Tetraporinus siedleckii sp. n., holotype ZPAL T.XXIII/5
1a. Longitudinal section, × 5, 1b. Transverse section, × 5.
Upper Treskelodden Beds (Lower Permian) southern slope of Hyrnefjellet Mt., Hornsund, Spitsbergen.