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Stratigraphy of the Upper Silurian Hitoegane Formation and Auloporid Tabulate Corals from a New Outcrop of the Formation in the Shinhirayuonsen Area, Gifu Prefecture

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Abstract A new outcrop of the Hitoegane Formation in the Shinhirayuonsen area, Takayama-shi, Gifu Prefecture is discovered, resulting in a stratigraphic redefinition of the formation as the Late Silurian (mainly Ludlow) shallow marine succession. Fossiliferous limestone (biolithite and bioclastic wackestone), tuffaceous sandstone and shale are principal constituents of the formation, whose thickness ranges 40–50 m, but its original thickness was in excess of those amounts. The auloporid tabulate corals in the present new locality are described. They are *Aulopora*? sp. indet., *Syringoporella yamakoshii* Niko, 2001 and *Aulostegites*? sp. indet. Among them, *S. yamakoshii* is a common species with the type locality of the formation.

Key words : Late Silurian, tabulate corals, Auloporida, stratigraphic redefinition, Hitoegane Formation, Gifu.

Introduction

The first stratigraphic knowledge of the Hitoegane and Shinhirayuonsen area in Okuhidaonsengou, Takayama-shi, Gifu Prefecture, Central Japan was provided by Nakai (1984), who divided the Silurian sediments into the Hitoegane and Uwajigane Formations. In his definitions, the Hitoegane Formation considered a unit largely of "andesitic pyroclastic rocks", with minor interbedded fossiliferous limestone in its uppermost horizon, alternation of tuffaceous shale and sandstone, and conglomerate. The Uwajigane Formation consists mostly of alternating beds of tuffaceous shale and sandstone with frequent intercalations of felsic tuff. Subsequently, two different interpretations were proposed for these formations. Igo (1990) stated that the Uwajigane Formation and the most part of the Hitoegane Formation are equivalent to the Yoshiki Formation, defined by Igo *et al.*, (1980) for the sandstone to shale sequence in the adjoining Fukuji area, and the uppermost limestone represents the upper division of the Yoshiki Formation as the Hitoegane Limestone Member. Harayama (1990) denied the Nakai's (1984) subdivision, and united these strata into the Hitoegane Formation. In more recent mapping and stratigraphic work by Tsukada (1997), a rather broad diagnosis has given for the Hitoegane Formation, which he considered as a thick (more than 800 m) stratum ranging from the Middle or Late Ordovician to Late Silurian age. The designated type localities for the Hitoegane Formation (or the Hitoegane Limestone Member) in the preceding stratigraphic workers are as follows; a ridge sandwiched between Takahara-gawa and Gamata-gawa Rivers (locality A; see fig. 1 in Niko, 2001) in Nakai (1984), locality A in Igo (1990), locality A and road cut on the Hitoegane Forest Road (locality B) in Harayama (1990), and locality B and road cut on a forest road along the lower reaches of the Iwatsubodani Valley (locality C) in Tsukada (1997).

The purposes of this paper are to document auloporid tabulate corals from the newly fund

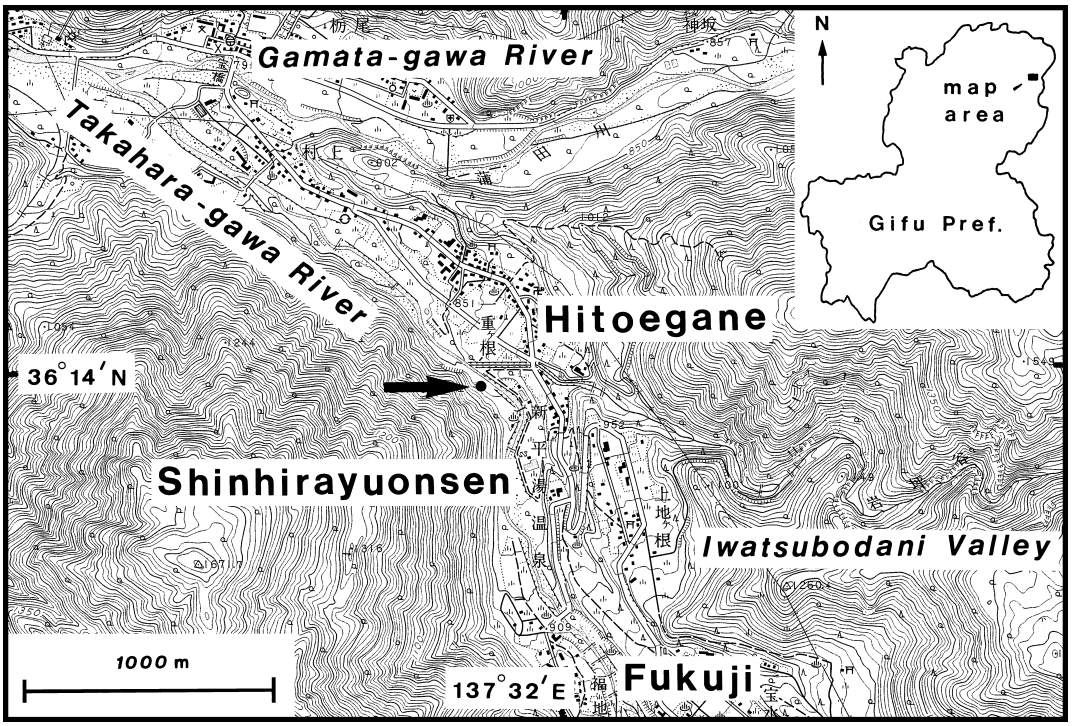

Fig. 1. Index map of the Shinhirayuonsen, Hitoegane and Fukuji area in Okuhidaonsen-gou, Takayama-shi, Gifu Prefecture. Arrow indicates position of the present new outcrop (locality D). Base map is "Yakedake" (1 : 25,000 quadrangle) published by Geological Survey Institution.

outcrop, and to redefine the Hitoegane Formation on the basis of information from the locality. All specimens dealt with this study are deposited in the National Science Museum (abbreviation NSM).

Stratigraphy

The new locality studied here is situated at the western bank of the Takahara-gawa River in the Shinhirayuonsen area (locality D; Fig. 1), where steeply (70°) north-dipping beds with general strikes of N 50°W are exposed. Its typical rock types and lithostratigraphic section are given in Figs. 2, 3. The lower and upper limits in this locality are in fault contact with basaltic to andesitic volcanic rocks of the Sorayama Formation. Although this stratum has been identified as a part of the Devonian Fukuji Formation by Niikawa (1980), its lithology and auloporid tabulate corals apparently indicate affinities to those of the Hitoegane Formation at the type locality (see below). On the basis of the present knowledge, the concept of the formation is restricted to the shallow marine sedimentary succession of Late Silurian age in the Hitoegane and Shinhirayuonsen area.

Type locality and geographic distribution: The distribution of the Hitoegane Formation is confined to NE-SW trending narrow zone having up to 50 m in width and approximately 1500 m in length. The main outcrops are observable on an unnamed ridge (above mentioned locality A) and the present new outcrop. Among them, outcrop at locality A serves as the type locality. Tazawa and Kaneko (1991) documented the occurrence of a Silurian trilobite, *Encrinurus* cf. *fimbriatus* Kobayashi and Hamada, 1974, from the tuff bed, that is in roughly midway of these main outcrops and probably assignable to the formation. There

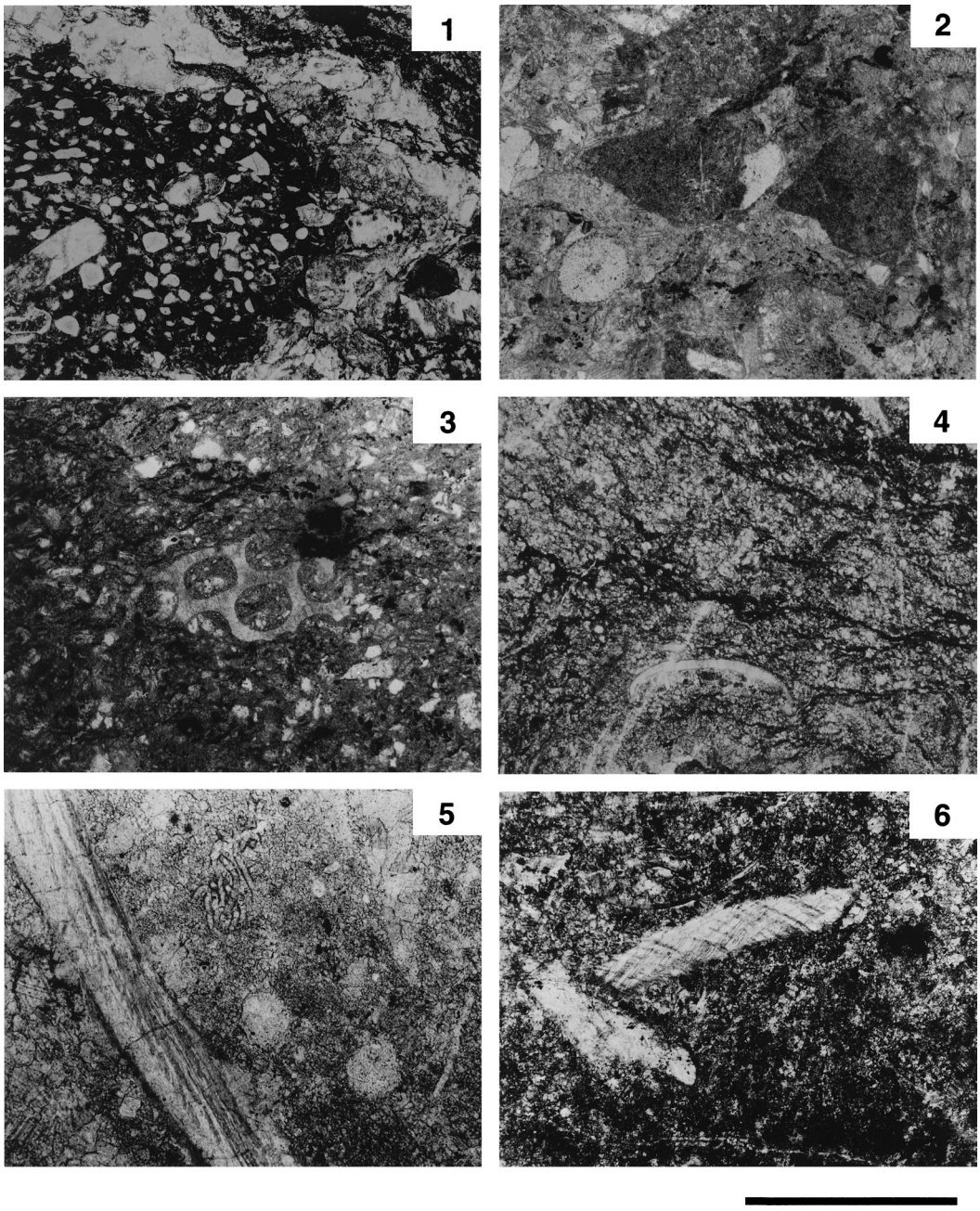

Fig. 2. Lithology of the Hitoegane Formation in a new outcrop. All figures are photomicrographs of thin sections. **1**, **2**, tuffaceous sandstones including gravels of basaltic lava (Fig. 2-1) and crinoid ossicle (Fig. 2-2). **3**, **4**, calcareous shales including favositid tabulate coral (Fig. 2-3) and ostracode (Fig. 2-4). **5**, **6**, impure limestones of bioclastic wackestones including brachiopod and bluegreen algae, *Girvanella* (Fig. 2-5) and bioclasts of unknown origin (Fig. 2-6). Scale bar equals 1.0 mm for Figs. 2-1–4, 6, and 0.4 mm for Fig. 2-5.

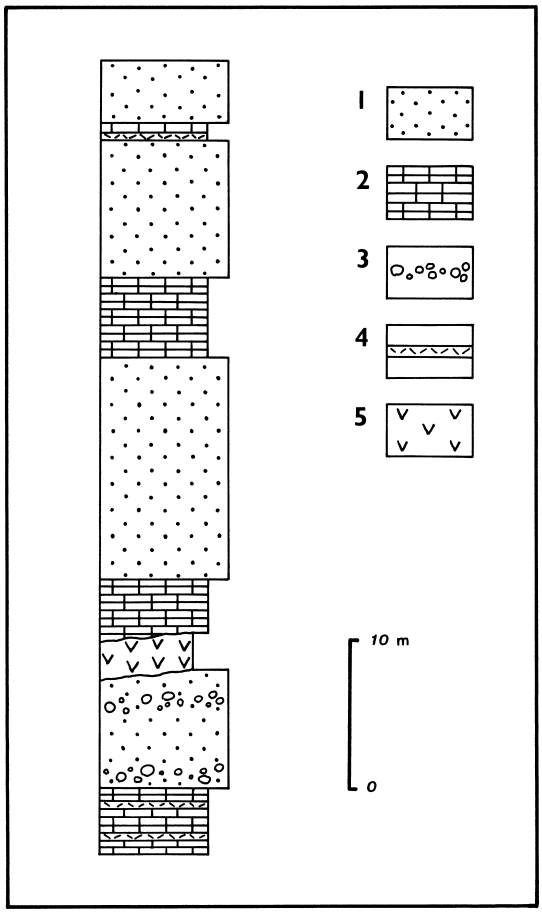

Fig. 3. Stratigraphic columnar section of the Hitoegane Formation at a new outcrop. **1**, tuffaceous sandstone. **2**, calcareous shale – impure limestone. **3**, gravels. **4**, tuffaceous shale – mudstone. **5**, dyke rock.

is a possibility that the sequences at localities B and C belong to the Yoshiki Formation. Thus, the subsequently designated two stratigraphic types in Harayama (1990) and Tsukada (1997) are now proposed to discard.

Lithology: In the type locality, the formation is composed of dark gray limestone intercalated with shale films and greenish gray calcareous shale. Biolithite consisting mainly of tabulate corals is recognized as a main sedimentary facies of the limestone. On the other hand, an alternating series of tuffaceous sandstone and calcareous (or partly tuffaceous) shale to impure limestone predominate in locality D. The sandstones are principal constituents, greenish gray color and laminated, interbedded with gravels of basaltic lava (Fig. 2-1) and limestone fragments. Isolated crinoid ossicles are rarely found in the sandstones (Fig. 2-2). Numerous macro-fossils, such as echinoderms, corals, brachiopods, ostracodes and trilobites, are visible in the calcareous shales to impure limestones (Figs. 2-3–6). Lithology of the limestones is bioclastic wackestone (Figs. 2-5, 6). The most noticeable feature linking these limestones in the both area is the presence of tuffaceous material. Based on microfacies of the limestones, the environment of deposition is interpreted as a shallow marine condition. As noted by Harayama (1990), "andesitic pyroclastic rocks" in the original definition are apparently intrusive rocks and eliminated from the formation.

Thickness: The thickness is estimated to be about 40 m in the type locality (Igo, 1990) and exceeds 50 m in locality D. Judging from the measured strike and dip (N 50°W, 70°N), geographic positions and disparity in altitudes of the localities, there is a possibility that the less calcareous succession in locality D occupies the more lower part of the formation than that in the type locality. Thus, the original thickness was in excess of those amounts.

Age: On the basis of trilobites (Kobayashi and Hamada, 1974, 1987) the formation at locality A has been dated as the Late Silurian (middle to late Ludlow, and may be extending to Pridoli in part). Its tabulate coral fauna (Kamiya and Niko, 1998; Niko, 2001, 2004, 2007) also indicates a resemblance to those from the Late Silurian in Tarim, Siberia and the Southern Kitakami Mountains in northeast Japan. An auloporid, *Syringoporella yamakoshii* Niko, 2001, is common to localities A and D.

Systematic Paleontology

Order Auloporida Sokolov, 1947

Superfamily Auloporoidea Mile-Edwards and Haime, 1851

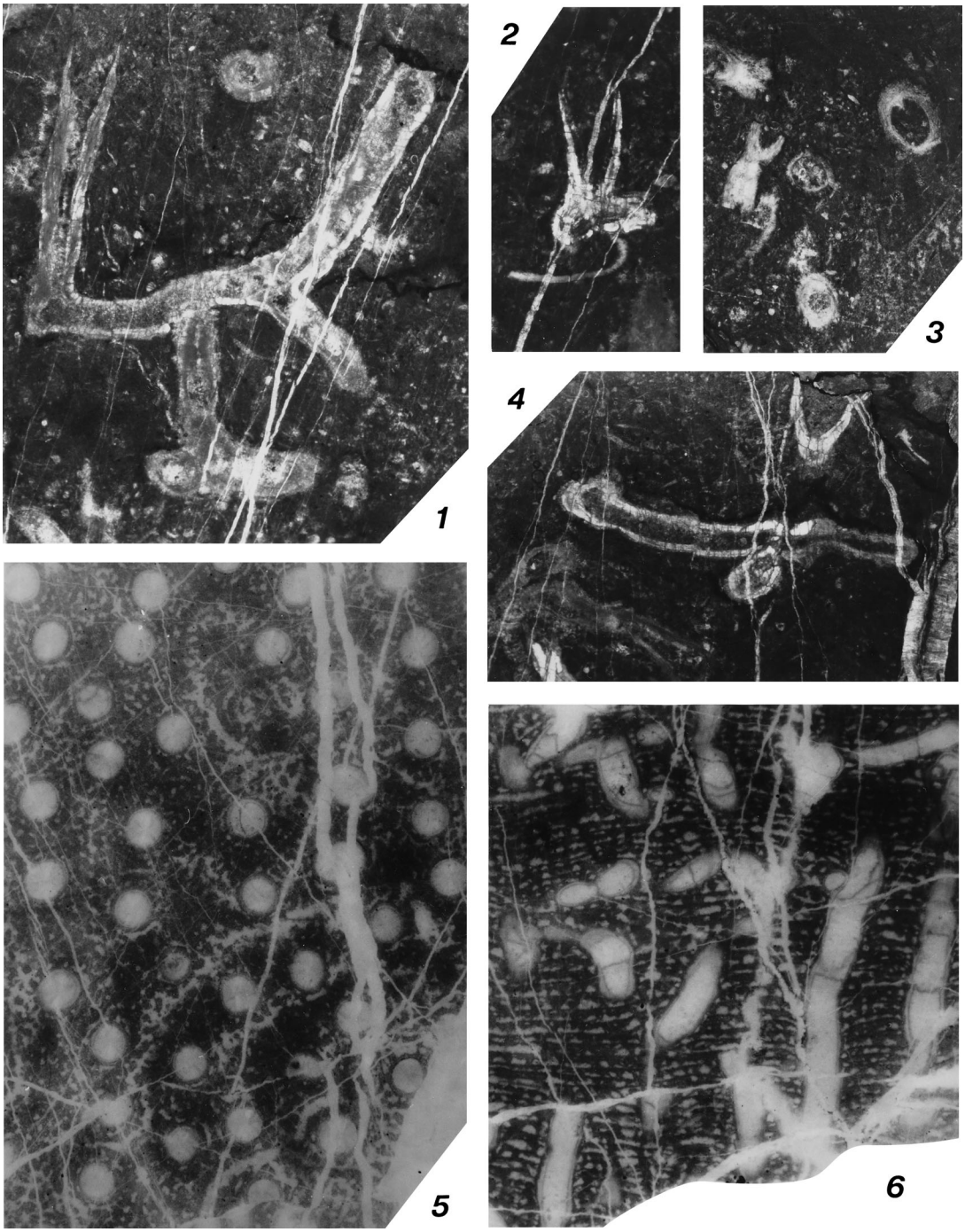

Fig. 4. **1**–**4**, *Aulopora*? sp. indet., NSM PA16382, thin sections. **1**, **2**, **4**, longitudinal to oblique sections of corallites, ×10. **3**, transverse to oblique sections of corallites, ×10. **5**, **6**. *Syringoporella yamakoshii* Niko, 2001, NSM PA16378, thin sections. **5**, transverse sections of corallites, ×10. **6**, longitudinal to oblique sections of corallites, ×10.

Family Auloporidae Milne-Edwards and Haime, 1851

Genus ***Aulopora*** Goldfuss, 1829

Type species: *Aulopora serpens* Goldfuss, 1829.

Aulopora? sp. indet.

(Figs. 4-1–4)

Material examined: Two coralla, NSM PA16382, 16385.

Description: Coralla encrusting, composed of proximal prostrate and distal free portions, the former of which may be anastomosed. Corallites cylindrical with weakly inflated calice, 0.5–0.9 mm in diameter; length of free portions is variable, ranging from 1.7 to 4.0 mm. Thickness of corallite walls is 0.09–0.13 mm in proximal portion, then thickened attaining 0.17 mm in distal one; high-conical septal spines, 0.16 mm in length, are rarely developed; apparent tabula not detected.

Occurrence: This species was collected from the float blocks of greenish gray tuffaceous shale (NSM PA16382) and dark gray impure limestone (NSM PA16385).

Discussion: No adequate material is available for the basis of the above description, this identification is questionable because of the lack of attachment scar in the proximal portions.

Superfamily Syringoporoidea Fromentel, 1861

Family Multithecoporidae Sokolv, 1955

Genus ***Syringoporella*** Kettner, 1934

Type species: *Syringopora moravica* Roemer, 1883.

Syringoporella yamakoshii Niko, 2001

(Figs. 4-5, 6)

Syringoporella yamakoshii Niko, 2001, p. 68, 70, figs. 4-1–4; Hirata, 2006, p. 32, pl. 10, figs. 36-1, 2.

Material examined: Five coralla, NSM PA16377, 16378, 16381, 16383, 16384.

Occurrence: All examined coralla occur inside stromatoporoid colonies, that were collected from the float brocks of black calcareous shale (NSM PA16377, 16381), greenish gray tuffaceous sandstone (NSM PA16378), and dark gray impure limestone (NSM PA16383, 16384).

Discussion: Although the material from the new outcrop shows slightly larger corallite diameters than the type specimens of *Syringoporella yamakoshii* from the Hitoegane Formation in the stratigraphic type locality of the Hitoegane area, I can see no significant differences in other morphologic respects between the coralla from the two localities. Thus, it is not to need redescription.

Family Roemeriidae Počta, 1904

Genus ***Aulostegites*** Lejeune and Pel, 1973

Type species: *Aulostegites hillae* Lejenue and Pel, 1973.

Aulostegites? sp. indet.

(Figs. 5-1–8)

Material examined: Two coralla, NSM PA16379, 16380.

Description: Coralla encrusting, thin tabular growth form. Each corallite consists of proximal prostrate portion indicating alveolitoid-like arrangement and distal upwardly directed portion; distal corallites are phaceloid in basic arrangement, but corallite adherence commonly developed; transverse sections of corallites are subcircular, subtriangular, or semicircular to crescentic in adhered portions; approximate corallite diameters range from 1.1 to 2.4 mm; calices very shallow to relatively shallow. Corallite walls thick, 0.16–0.30 mm in usual thickness, and differentiated into epitheca and stereoplasm; microstructure of stereoplasm is not preserved; relatively large mural pores, with 0.18 mm in diameter, occur between adhered corallites; no septal spine detected; tabulae well developed, incomplete with vesicular profiles, or complete in rare cases, and form discontinuous axial syrinxes

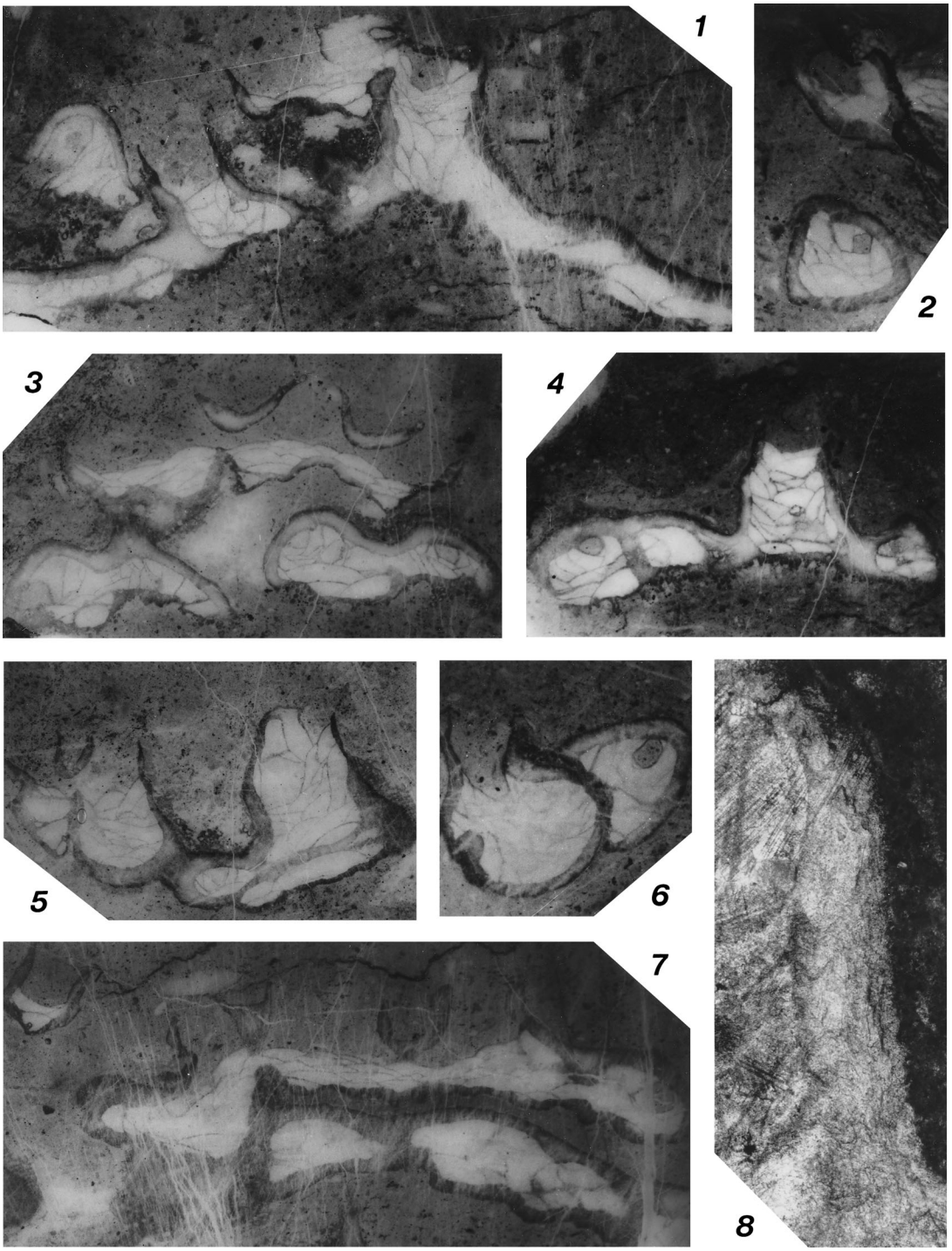

Fig. 5. *Aulostegites*? sp. indet., NSM PA16380, thin sections. **1**, **3**–**7**, transverse sections of corallum, ×10. **2**, transverse and oblique sections of corallites, ×10. **6**, transverse sections of adhered corallites, ×10. **8**, partial enlargement to show corallite wall structure, longitudinal section, ×75.

with 0.25–0.47 mm in diameter; position of axial syrinxes is tabularium margin.

Occurrence: This species was collected from the float brocks of dark gray impure limestone (NSM PA16379) and brownish gray calcareous shale (NSM PA16380).

Discussion: These two coralla differ from typical form of *Aulostegites* by having the axial syrinxes. There are also other possibilities that the specimens represent a new genus of the Auloporida or the immature growth stages of a genus *Thecostegites* Milne-Edwards and Haime, 1849. Well-preserved material must be discovered before this can be evaluated. The present assignment is, therefore, tentative.

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