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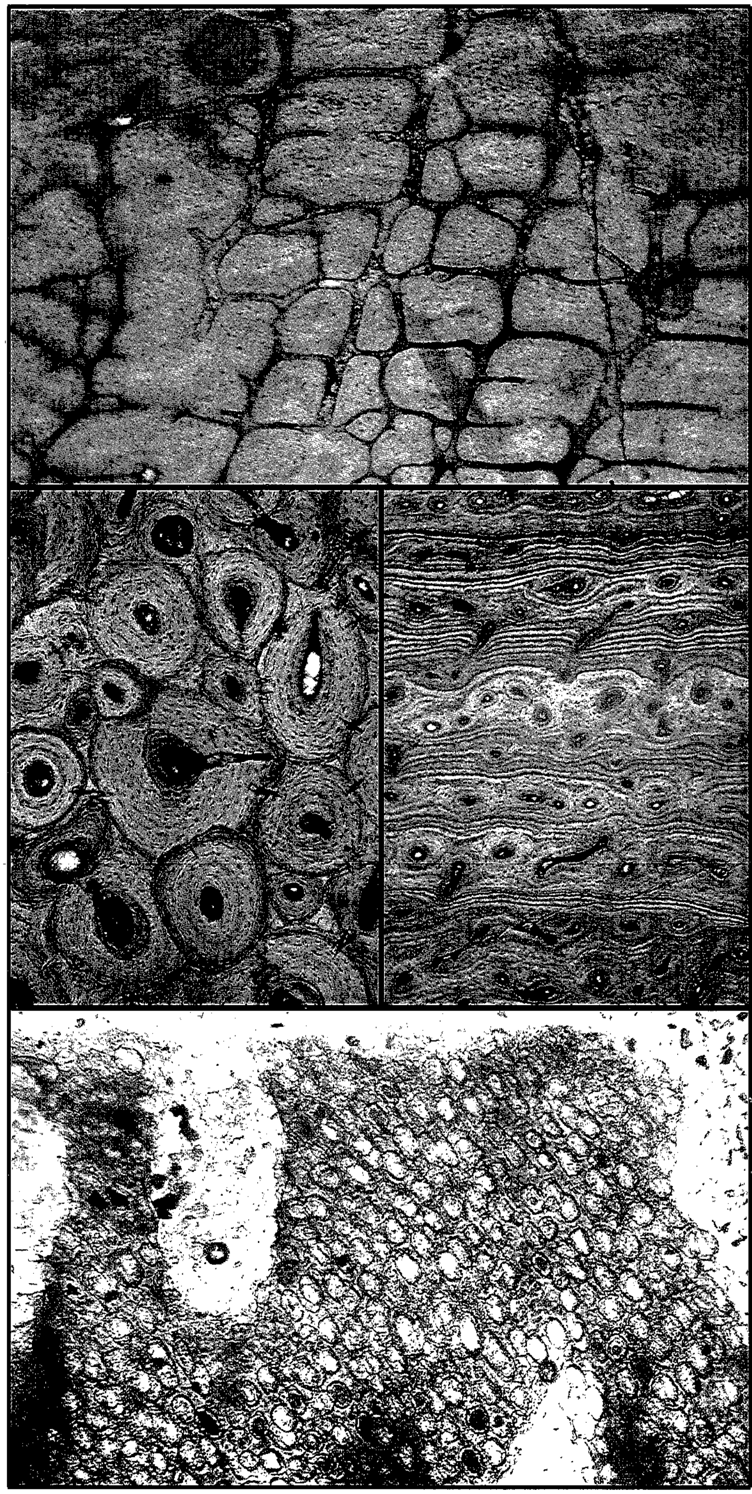
GEOLOGY STUDIES



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Cover: Fossil tissues from Cleveland-Lloyd allosaurs.

Top: Uniform periosteal bone with reticulating primary vascular canals, some of which are aligned longitudinally (left to right) and radially. Caudal vertebra, centrum; longitudinal section; C-LQ 087.

Middle left: Vascular zonal bone with lamellated annuli and non-lamellated zones. Local development in a right radius; transverse section; C-LQ 109.

Middle right: Dense Haversian bone showing secondary osteons, secondary vascular canals at their centers, and the concentric arrangement of osteocyte lacunae (small dark bodies) around them. Dorsal rib; transverse section; C-LQ 106.

Bottom: Calcified cartilage showing the rounded form of the spaces (lacunae) once occupied by chondrocytes. Proximal end of a fibula; longitudinal section; C-LQ 014.

In all sections the direction of the external surface is upward.

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Lower Triassic Hexactinellid Sponges from the Confusion Range, Western Utah

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ABSTRACT

Hexactinellid sponges have been discovered recently in the Lower Triassic Thaynes Limestone in the northern Confusion Range in western Millard County, Utah. They occur in greenish gray calcareous shale in the lower part of the Spathian transgressive sequence above a thick tongue of red beds. The sponges are from rocks of Conodont Zones 5 and 6, essentially from the same biostratigraphic level that the species was reported from the Thaynes Limestone in eastern Nevada and central Utah. Sponges are principally fragments of *Cypellospongia fimbriartis* Rigby and Gosney, 1983, and include both long stems and bases to upper fragments of gobletlike to platterlike parts of the sponge. Fragments range from those with small ostia 1.3–2.0 mm across to coarsely canalled forms where ostia range to 3–5 mm in diameter, where circular, and 5–7 mm across where elliptical. Fragments with small ostia have relatively thin walls, but those with coarse ostia range to 12 mm thick. Ostia and plates of intermediate dimensions are numerous, so all the fragments are considered as parts of a single, variable species.

INTRODUCTION

A new locality of moderately rare Lower Triassic hexactinellid sponges has been discovered recently in the Thaynes Limestone in the northern Confusion Range of western Millard County, Utah (Fig. 1). The locality was discovered by Bylund in 1963 while examining extensive Upper Paleozoic and Lower Triassic outcrops in the Confusion Range. The present collection was largely assembled early in May 1994, when Bylund, Pisera, and their associates in the Utah Friends of Paleontology visited the outcrop, and added to when we recollected and studied the area in late May. The sponge-bearing Thaynes rocks are well exposed in a moderately sharp, faulted syncline along the northeastern side of the Confusion Range, north of Cowboy Pass and old U.S. 6. The locality is 1400 feet north and 400 feet west of the southeast corner of section 12, T17S, R14W, on the Cowboy Pass 7 1/2-Minute Quadrangle (Fig. 1). The locality is at 39°20′28″ north and 113°41′50″ west in low hills in the northern part of the Triassic outcrops.

Distribution of outcrops of the Triassic Thaynes Formation is documented on U.S. Geological Survey MGI Map I-390 (Hose and Repenning, 1964). Exact stratigraphic level of the productive beds above the base of the Thaynes Formation is uncertain, but they are approximately 260 m (850 ft) above the base, based on sponge occurrences above a moderately thick red bed tongue (Figs. 2 and 3).

The Thaynes Formation has produced all of the Triassic hexactinellid sponges known thus far from eastern Nevada and western and central Utah (Rigby and Gosney, 1983). The Triassic *Cypellospongia fimbriartis* Rigby and Gosney, 1983, was first discovered and recognized as a sponge in outcrops of the Thaynes Formation in Spanish Fork Canyon, in section 17, T9S, R4E, on the Spanish Fork Peak 7 1/2-Minute Quadrangle in the southern Wasatch Mountains. The species was reported by Rigby and Gosney (1983) from fragments, also from the Thaynes Limestone, collected on the ridge crest between Little Cottonwood and Big Cottonwood Canyons, west of Park City, Utah, in section 9, T2S, R3E, on the Park City West 7 1/2-Minute Quadrangle, and a fragment also from the Thaynes Limestone in section

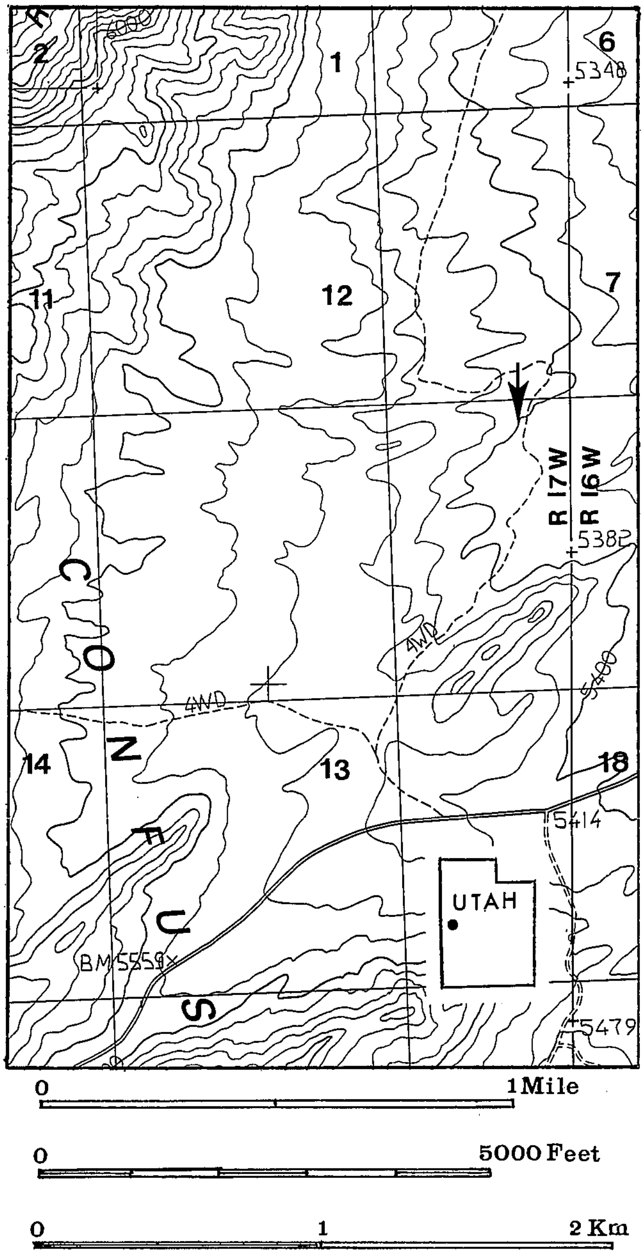


Figure 1. Index map to the locality in the east central Confusion Range in section 12, T17S, R17W, on the Cowboy Pass 7 1/2-Minute Quadrangle. Small cross latitude/longitude marker in the lower left center marks 115°42'30" west longitude and 30°20' north latitude (from Hose and Repenning, 1964).

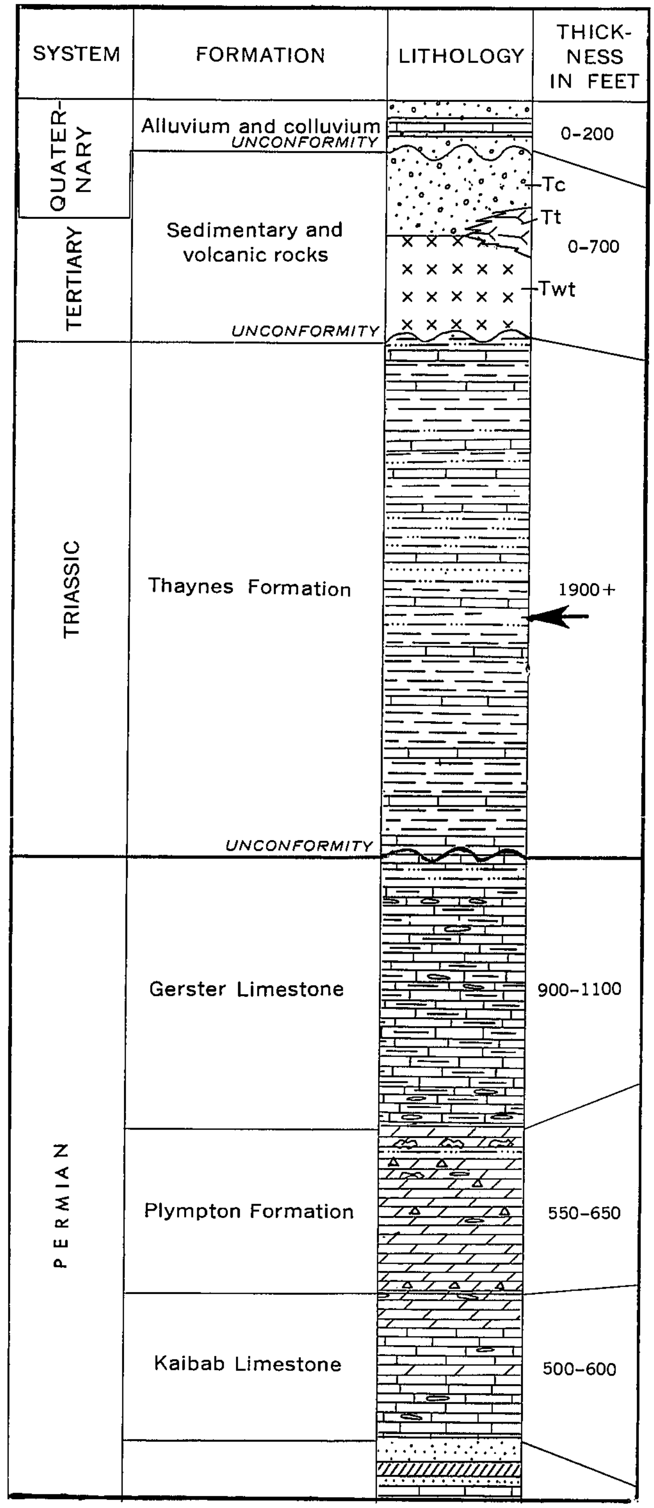


Figure 2. Upper part of the stratigraphic section exposed in the Cowboy Pass Quadrangle in the Confusion Range in Millard County, Utah. The arrow indicates the approximate stratigraphic position of the hexactinellid sponge locality (modified from Hose and Repenning, 1964).

34, T1N, R1E, on the Fort Douglas 7 1/2-Minute Quadrangle, both in Salt Lake County, Utah. More sponges of the same species were collected from the Thaynes Limestone in eastern Nevada, in section 33 (unsurveyed), T20N, R60E, on the Ely 2° quadrangle, in White Pine County, Nevada. The sponges described here come from a

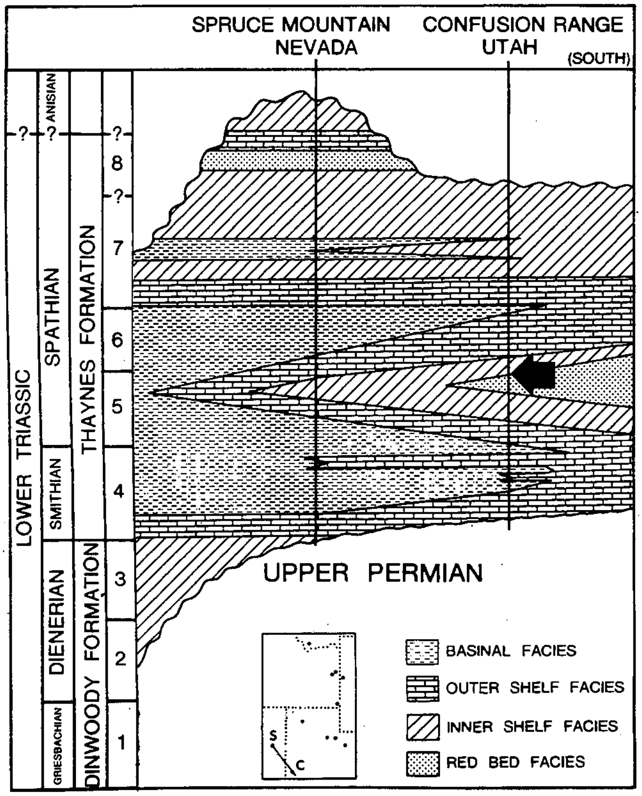


Figure 3. Part of a diagrammatic cross section showing relationships in uppermost Permian and Lower Triassic rocks in east central Nevada and western Utah. The coarse arrow indicates the position of the sponge locality at the base of a trangressive sequence of early Spathian age in the Confusion Range (modified from Carr and Paull, 1983).

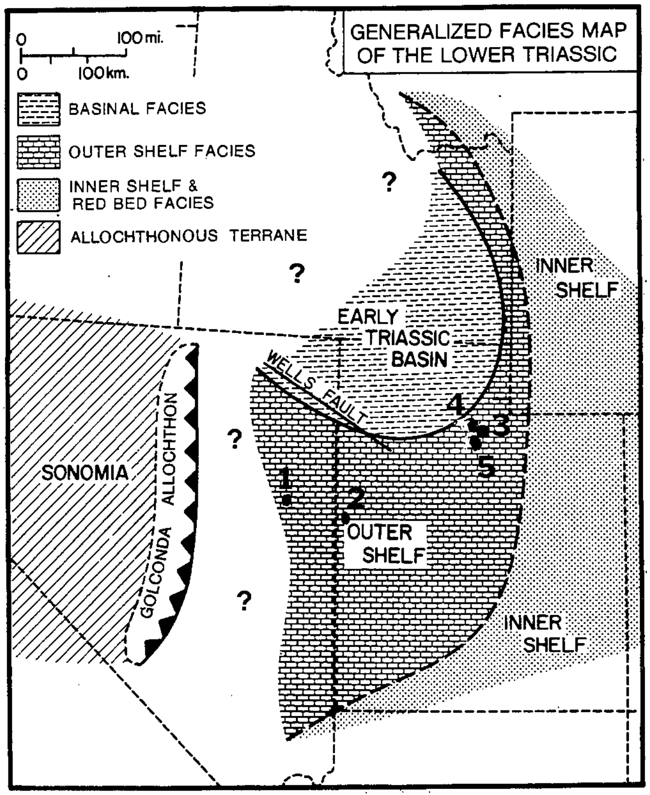


Figure 4. Generalized facies map of Lower Triassic rocks in part of the Cordilleran region showing positions of the known Triassic sponge localities in the Thaynes Limestone in Utah and Nevada. 1, "32-Mile Spring outcrop"; 2, Confusion Range sponges described here; 3, Little Cottonwood–Big Cottonwood Canyon locality near Park City, Utah; 4, Fort Douglas Quadrangle locality, near Salt Lake City, both 3 and 4 are in the central Wasatch Mountains; and 5, Diamond Fork Creek–Spanish Fork Canyon locality southeast of Provo, Utah, in the southern Wasatch Mountains (modified from Carr and Paull, 1983).

new locality, the fifth, and the only one known thus far from western Utah.

The Thaynes Formation was first described by Boutwell (1907, p. 448; 1912, p. 55) from exposures in Thaynes Canyon in the Park City mining district in central Utah. Clark (1957) provided preliminary descriptions of the main exposures of Triassic rocks of western Utah and northeastern Nevada and of Triassic exposures in the Confusion Range. Regional relationships and stratigraphy and paleogeography of Lower Triassic rocks in the Cordilleran miogeocline was provided by Carr and Paull (1983), based in part on early work of Collinson and Hasenmueller (1978) and Collinson, Kendell, and Marcantel (1976) and others. Additional reviews of the Triassic rocks and conodont zonation of the region were provided by Clark and others (1979); Carr, Paull, and Clark (1984); and Clark and Carr (1984).

Carr and Paull (1983) summarized conodont ranges for the Lower Triassic and observed that the Thaynes Formation bridges Smithian and Spathian Ages in the Lower Triassic, generally in Conodont Zones 4 to 8. In a diagrammatic cross section (Fig. 3) of Lower Triassic rocks from southeastern Idaho to west central Utah, they included the section in the Confusion Range that shows the relationship of the sponge-bearing rocks to the early Spathian regression of Conodont Zones 4 and 5 and the following transgressions in Conodont Zones 5 and 6.

The sponges occur in greenish gray, calcareous shales of the lower part of the outer shelf facies, immediately above the tongue of red bed facies (Carr and Paull, 1983, Fig. 14) in rocks of the minor lower Spathian transgression of Conodont Zones 5 and 6. Ammonites associated with the sponge assemblage are characteristic of the *Columbites-Tirolites* Zone or possibly of the *Prohungarites-Subcolumbites* beds above. In the stratigraphic section (Fig. 2), Hose and Repenning (1964) noted that reddish claystones and siltstones occur from 170 to 290 m (550 to 850 ft) above the base of the Thaynes Formation in rocks stratigraphically immediately below the marls, bioclastic grainstones, and wackestones in which the sponges accumulated.

Carr and Paull (1983) showed that this part of western Utah and eastern Nevada, during early Spathian time, was included in outer shelf–red bed facies at the southern end of a major marine transgression from the north (Fig. 4). They observed that these shallower shelves are characterized by siltstones and silty and pelletoidal limestones laterally equivalent to red beds in areas to the east and southeast in Utah, and they observed (1983, p. 47) that the sequence of vertical facies patterns of this southern shelf shows progressive north-to-south transgression of the Thaynes seaway. It is from rocks of this same major transgressive sequence that sponges have been collected in the Wasatch Mountains of central Utah and in the Egan Range in White Pine County, Nevada (Rigby and Gosney, 1983). The Thaynes outcrops and sponge fauna, reported here from the Confusion Range, occur approximately midway between the previously known Utah and Nevada occurrences of the sponges.

The sponges occur in greenish shales above and below a sandstone bed that is cut by transverse faults. Two of the faults are shown on the map by Hose and Repenning (1964) and are indicated by minor offset of the thin sandstone. A gray-green shale, approximately 2 m thick, erodes to form part of a broad saddle, in large part cut in underlying chocolate brown to reddish mudstone and siltstones. The platelike sponge fragments occur principally below the sandy bed, and the round stemlike parts of the goblet-shaped sponges occur in the greenish marine beds above the sandstone. Three large ammonites, one about 20 cm in diameter and another 10–12 cm across, were collected with the sponges. None of our sponges were collected from in place, but were transported. The sponge collections are largely from lag gravels, but their concentrations and distributions are such that there is little question about which beds produce the fossils.

The locality is on the west side of a low pass (Fig. 1), in exposures 15–30 m west of the road, northwest of where the access road bends sharply northward after passing close to a steep, narrow, ledgy exposure at the gully crossing in the second L-shaped bend of the road north from the main Cowboy Pass road.

SYSTEMATIC PALEONTOLOGY

Class HEXACTINELLIDA Schmidt, 1870
Subclass HEXASTEROPHORA Schulze, 1887
Order LYSSAKIDA Zittel, 1877
Superfamily EUPLECTELLOIDEA Finks, 1960
Family EUPLECTELLIDAE Gray, 1867

Discussion. The superfamily Euplectelloidea Finks, 1960, was proposed for hexasterophoran sponges that have continuous but non-cubic skeletal mesh composed of hexactines joined by fusion at their points of mutual contact and by synapticulae. Within that superfamily, Finks included the Euplectellidae Gray, 1867, and the new family Pileolitidae Finks, 1960. Both families include hexactinellid sponges with a rigid skeleton that virtually lack a regular dictyonine cubic fused skeletal net. Rigby and Gosney (1983, p. 790) observed, "*Cypellospongia* sponges from the Thaynes Limestone do not fit easily into either of the two families presently included within the Euplectelloidea," but they included the Triassic sponges in the Euplectellidae because the Thaynes fossils lack the massive dermal layer so distinctive of sponges included in the pileolitids. We continue that taxonomic placement.

Genus CYPELLOSPONGIA
Rigby and Gosney, 1983

Diagnosis. "Thick-walled, goblet-shaped sponges with a lower tubular, somewhat anastomosing, stemlike part; walls thick, pierced by circular parietal gaps and by at least two additional sizes of canals showing full diplorhysis, although with somewhat irregular development elsewhere. Skeleton of fused hexactine-based spicules solidly cemented together at contact points where they cross, in addition to being united by synapticulae. Hexactine-based origin of most spicules obscure because of extensive development of synapticulae and because of irregular non-cubic orientation of the skeleton. Small hexacts evident in thin dermal layer. Hexactine-based origin of larger, main body, spicules locally evident where hexact-oriented axial canals are preserved in the siliceous replacement. Microscleres not preserved" (from Rigby and Gosney, 1983, p. 790).

Type species. Cypellospongia fimbriartis Rigby and Gosney, 1983.

CYPELLOSPONGIA FIMBRIARTIS
Rigby and Gosney, 1983

Figs. 5, 6
Lyssakid sponge RIGBY, 1966, p. 178; JAMES, 1980, p. 95, Fig. 18.
Cypellospongia fimbriartis RIGBY AND GOSNEY, 1983, p. 791–796, Figs. 2–5.

Emended diagnosis. Large, stemmed, goblet- to funnel-shaped or platterlike sponges, stems and "goblets," with deep, simple, spongocoel and basal part tubular to anastomosing or irregularly branched; thinner-walled parts terminate in irregular basal nodes or bullet-shaped tips. Walls perforated by circular to vertically elongate, elliptical, parietal gaps or canals and by two smaller radial canal series, approximately 0.5 and 1.1 mm in diameter. Coarse apertures mostly 2.5–3.5 mm across but up to 5 mm long.

Skeleton of fused diactines and derivatives of hexactines in somewhat matted, irregular arrangement; spicules dominantly subparallel to dermal and gastral surfaces, but at more irregular orientations in interior. Beams largely wanting, but skeleton fused into solid nonrectangular net, mainly by synapticulae. Spicules better aligned in stalks than in upper gobletlike or platterlike parts of sponge. Parietal gaps more common, and canal sizes generally increase upward in cuplike or platterlike parts of sponges.

Description. Numerous fragments in collection either subcylindrical or steeply obconical, stemlike and gobletlike, or funnel-like to platterlike. Rare specimens show transition from stems into expanded funnel-like upper parts.

Nearly complete, pointed to bullet-shaped basal tips 3–5 mm in diameter; skeletons continue above bases as smooth cylindrical to steeply obconical stems to 20–25 mm in diameter and 85–90 mm long (Figs. 5.3, 6.6). Other bases irregularly lobate, nodular, or abbreviated bifid and continue upward as stems with elliptical cross sections, approximately 20 by 28 mm. Basal lobes extend laterally, generally parallel to oval axis, to produce bilobed structures to 45 mm across but only 25 mm thick, like stem shown in original description (Rigby and Gosney, 1983, Fig. 3D).

Small cylindrical fragments of lower stem 12–15 mm in diameter and to 3–4 cm long (Fig. 5.2), with central tubular opening approximately 6 mm in diameter, surrounded by walls 2–3 mm thick in which numerous small canals characteristic of species occur. More numerous larger fragments of middle part of stem (Fig. 5.1) with circular to elliptical cross sections 20 by 30 mm in diameter range to 90 mm long, but generally broken at both ends. Larger stems, 35–40 mm in diameter, generally expand gently and smoothly upward, although some flare abruptly into base of gobletlike or funnel-like upper parts of sponges. These stem segments generally with walls 7–10 mm thick and with central openings 18–20 mm in diameter.

Rare specimens show transition from subcylindrical or steeply obconical stems to broad funnel-like parts (Fig. 6.9) with abrupt expansions so lateral slopes of funnels diverge upward at 90°–130°. Most non-stem fragments gently curved to weakly annulate parts of upper platter or funnel-like margins. As in type material, walls only 3–5 mm thick at base, but wall thicknesses generally increase upward to 7–12 mm thick in upper part of some of coarsest specimens. Central tubular spongocoel with sublobate or semidigitate lower terminations where bases nodelike or bifid, but simple conical openings where bases pointed.

Fragments of upper funnel- or platterlike parts generally of three types: either thin plates with small apertures (Figs. 6.7, 6.8), or thick plates with very coarse apertures (Figs. 5.4–5.7), or plates of intermediate thickness and dimensions of apertures (Figs. 5.4, 5.5). Thin plates in collection generally triangular to subquadrate fragments 5–7 mm thick and to 5 by 10 cm across. Most irregularly subquadrate, 3–4 cm across, and generally curved like parts of bowls or low funnels. Ostia on convex, presumed inhalant, surface in irregular discontinuous rows, separated by vertical skeletal tracts 0.5–2.0 wide, but commonly approximately 1.0 mm across between adjacent ostia. Ostia crudely aligned and more or less equally spaced. Coarsest ostia of thin plates 1.3–1.5 mm in diameter and circular, but locally elliptical and vertically or radially elongate to 1.5 mm wide and 2 mm high. Coarse ostia commonly spaced 10–15 per cm^2 and usually 1–2 mm apart, but with great irregularity.

Intermediate ostia of thin plates 0.6–1.0 mm in diameter, with most approximately 0.7–0.8 mm in diameter, as irregularly spaced circular openings in wide tracts between larger ostia and also 10–15 per cm^2. Smaller, less commonly preserved ostia 0.2–0.3 mm in diameter, irregularly preserved interruptions in relatively massive skeletal tracts.

Apertures on concave, presumed exhalant, surface of thin plates mostly 2.0 mm in diameter, circular, and in funnel-like pits 2.5–3.0 mm or slightly coarser in maximum diameter. Intermediate openings approximately 1.0 mm in diameter in skeletal tracts between coarse ostia. Other openings essentially same size as small openings on convex surface and appear as openings between spicules and synapticulae rather than interruptions in regular skeletal net. Most fragments in collection somewhat sigmoidal in transverse section, obscuring relationships of inhalant and exhalant canals, but in general, probable exhalant surface with slightly coarser openings than those on presumed inhalant surface.

Many flat, thicker, coarsely canalled fragments also in collection. These range 8–12 mm thick, and fragments from triangular 11 by 5 cm to quadrangular fragments up to 7 by 9 cm across, which do not show convex concave surfaces. Side with coarsest canals presumably exhalant surface, with coarse ostia 3–5 mm in diameter where circular and up to 5–7 mm wide and long where elliptical. Apertures one to rarely two openings per cm^2 separated by skeletal tracts 1–5 mm across. In broken edges, canals commonly normal to two surfaces, but some canals with elliptical cross sections at surface slope 70°–80° from parallel surfaces. Sections of canals exposed in broken edges show diplorhizal nature of system where large canals from one side taper abruptly to rounded tips near opposite surface and either terminate or continue as very small openings in patterns somewhat reminiscent of those shown by Reid (1964, Text-Fig. 52).

Thick tracts perforated by smaller ostia, coarsest of which approximately 2 mm in diameter and circular where interrupt skeletal net in widest parts between coarse ostia. Still smaller and more numerous openings range 0.8–1.5 mm in diameter as circular interruptions. Most of these approximately 1.0 mm in diameter and side-by-side, separated by only 0.2–0.3 mm of skeletal material. Other smaller openings may be present but ill-defined in weathered, calcareously replaced plates.

Openings on reverse, commonly convex, side of plates somewhat smaller and presumably indicate inhalant surfaces. Apertures commonly 2.5–3.0 mm across, but range up to 4 mm in diameter, if circular, and locally to 5–6 mm long, if elliptical. Somewhat more common apertures approximately 2.0 mm in diameter, and also circular, in wide skeletal tracts between triangularly spaced, coarse ostia. Other smaller openings not clearly defined because skeleton commonly replaced and filled by crystalline sparry calcite.

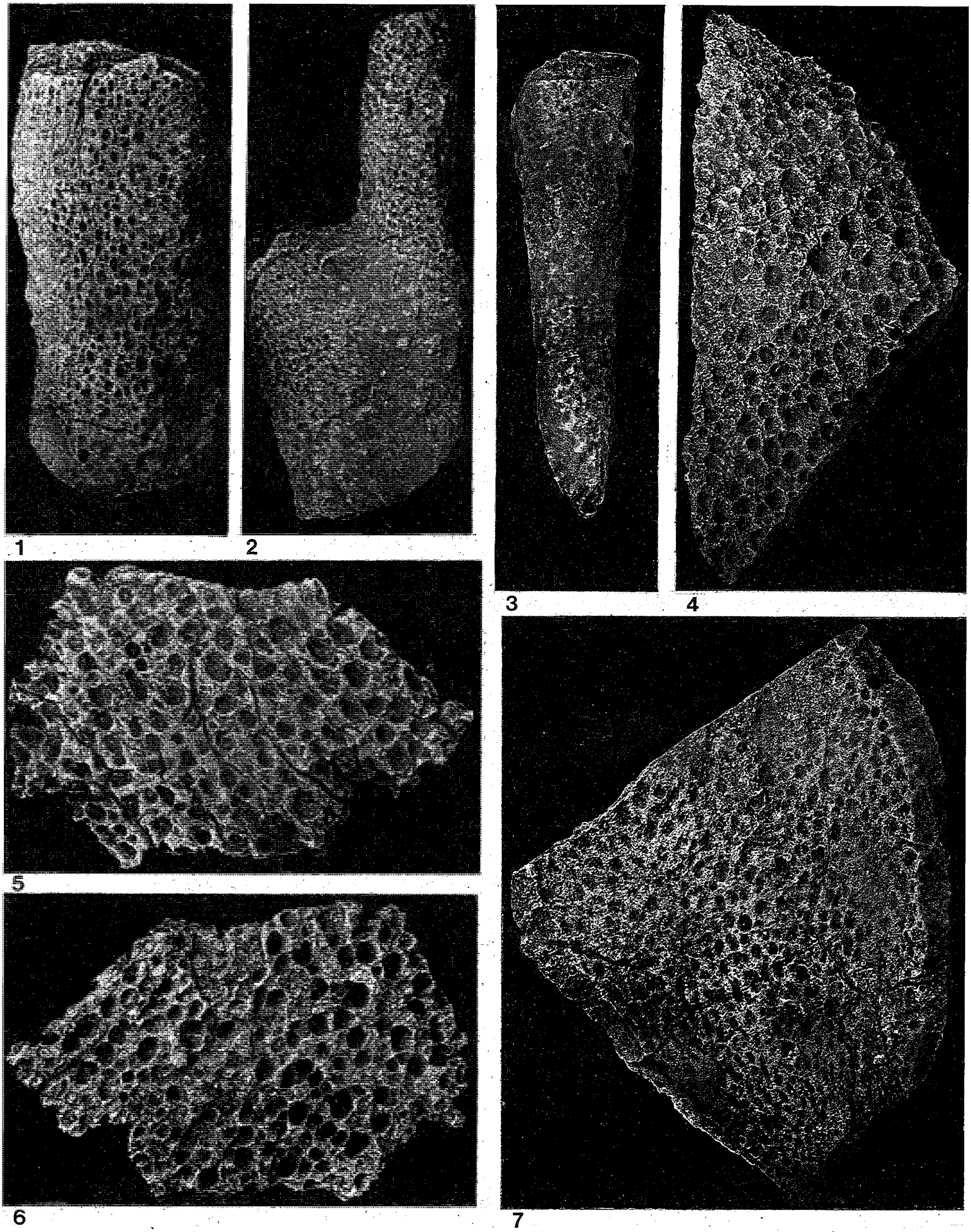
Plates of intermediate thickness make up perhaps two-thirds of collection. Because of these fragments with intermediate and gradational aperture dimensions, plates of two extremes not considered distinct species but recognized as part of continuum of one species. At present, thinner plates considered immature parts of skeleton of platterlike or funnel-like sponges.

Some rounded, thickened margins of probable growing edges of sponges preserved. These commonly flexed upward and thickened, almost like rims of saucers. Most fragments in collection rectangular, 7–10 mm thick, of intermediate or interior parts of plates, without either obvious relationships to base or lower parts of "funnels" or to rounded distal edges of platters. Most gently curved, but some slightly sigmoidal, others virtually flat.

Skeletons calcified in all sponges in collection, but spicules show moderately well as clear spar, in contrast to fine silty matrix on surfaces etched with dilute acetic acid (Figs. 6.1–6.3). Structure irregular, as in type specimens, of variously oriented hexactine-based spicules and some obvious small hexactines in nonrectangular, irregular, matted structure. Most evident spicules with long dermal or gastral rays, commonly oriented subradially or subparallel to elongate tracts in stemlike structures, or subradially to radially in platelike fragments. Broken plate edges show many similar-sized spicules irregularly oriented in interiors. Because of irregular spicule packing and development of numerous synapticulae, identification of individual spicules difficult, particularly compounded by calcareous replacement. Crude diagonal, diamond-like spacing of coarse spicules developed locally in some areas of more uniform skeleton around large ostia.

Coarsest spicules up to 7–8 mm long in stemlike fragments, up to 4–5 mm long in platelike fragments. In both, maximum diameters approximately 0.10–0.14 mm. More common spicules 0.04–0.05 mm in diameter and preserved with crossing hexactine rays, with four tangential rays exposed on surfaces. Locally, largest spicules arranged in subparallel tractlike fashion (Fig. 6.3), but such packing not laterally nor vertically continuous. Because of irregularity in calcareous replacement and because many fragments of synapticulae attached to major spicules, entire skeleton appears spinose, but this is interpreted largely as artifact of preservation.

Figure 5. Examples of stem parts and platterlike parts of Cypellospongia fimbriartis *Rigby and Gosney, 1983, from the Lower Triassic Thaynes Limestone of the Confusion Range in western Utah. All figures X1. 1, Expanded, subcylindrical gobletlike or stemlike part of sponge with ostia of intermediate dimensions, USNM 480442; 2, branched stem, two upper branches with essentially common diameter, each with small ostia that lead into tubular spongocoels in branches, spongocoels converge downward, but are still distinct in the broken base, USNM 480443; 3, essentially complete, pointed base of a stem with small to intermediate-size ostia, USNM 480444; 4, gently convex, presumed outer or dermal surface of saucerlike fragment of the sponge, with ostia of several diameters, including some relatively large ostia characteristic of the coarse end member of the species, USNM 480445; 5, 6, platelike coarse fragment, USNM 480446; 5, presumed dermal surface with relatively broad tracts and ostia of several sizes, but including some large ostia characteristic of thick-walled, coarse, members of the species; 6, presumed upper or gastral surface in which coarse ostia are dominant and skeletal tracts relatively thin between canal openings; 7, gently concave surface of platelike fragment showing relatively thick sponge wall on both the left and right, with a moderately defined, upward divergent, lineation of canal apertures, grading from relatively fine openings near the base to coarser ones in the upper part, USNM 480447.*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Most fragments lack evidence of dermal layer, but some with irregular, closely spaced almost stippled-appearing areas, perhaps produced by poorly preserved spicule junctions at finer scale than in relatively open main part of skeleton. Differentiated spicules not present in dermal layer, but suggested by relatively fine spacing and textures of surficial layers.

Discussion. In most respects, the Confusion Range Triassic sponges are similar to those described from the Thaynes Formation from central Utah and eastern Nevada by Rigby and Gosney (1983), but the greater proportion of broad saucerlike and open funnel-like fragments is a relatively distinctive feature of the collection. Stemlike segments with pointed or bifid terminations of subcylindrical and steeply obconical parts of the sponge are similar to type specimens of the species.

The outcrops were reexamined during the spring of 1995, after winter storms had eroded the surface. Distributions suggest that the coarse, thick plates occur more commonly in the greenish beds immediately beneath the faulted sandstones and limestones, whereas the cylindrical stems and the thin plates with fine canals and apertures occur most commonly above the limestone.

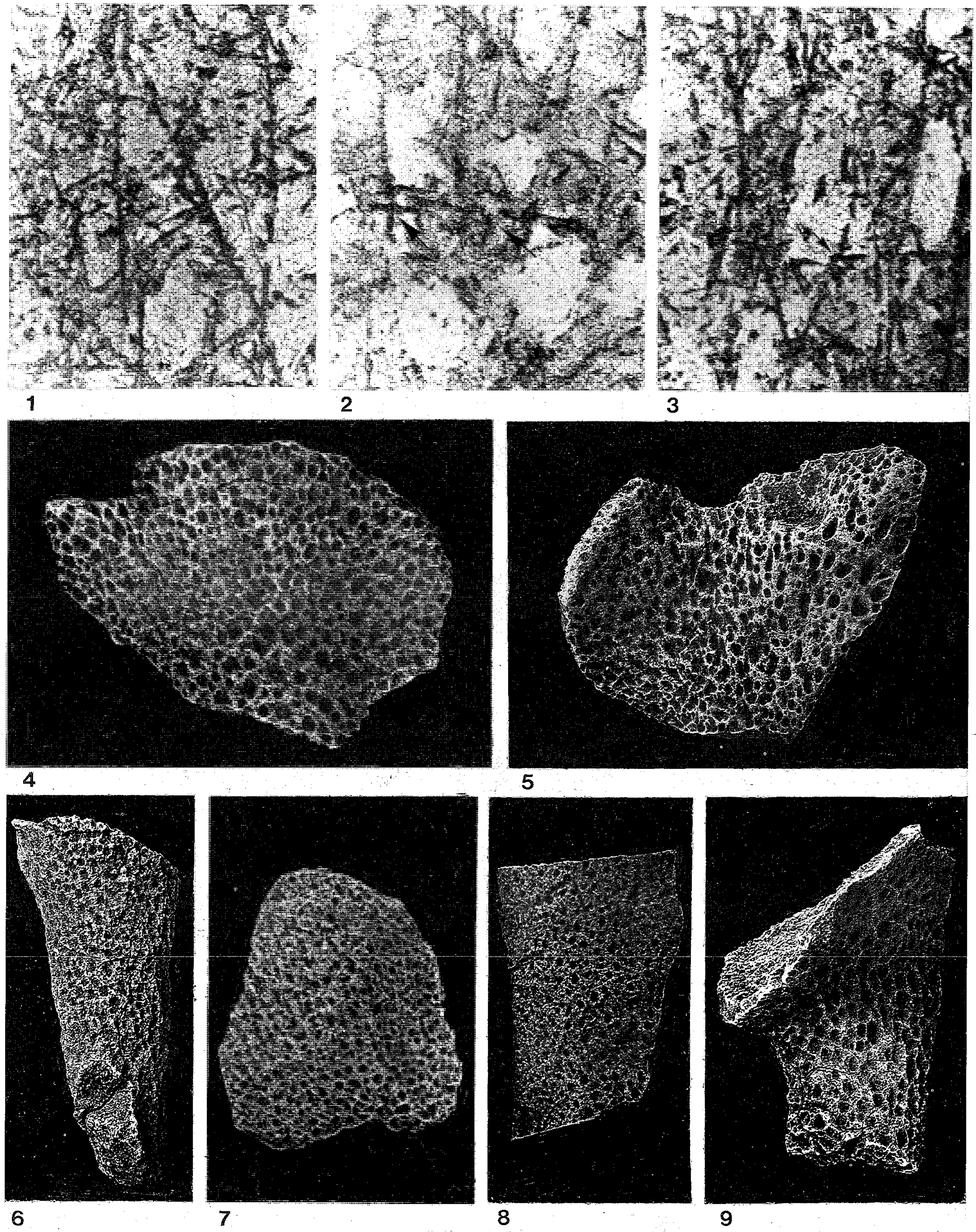
Separation of the two end members of the platelike fragments into two species was considered, but because the collection includes numerous plates with intermediate transitional textures and thicknesses, the fragments are still considered within the same species. From general stratigraphic relationships, those with relatively thick plates probably accumulated in shallower water of the transgression, a short distance above the red beds (Figs. 2, 3), whereas those with more prominent stems and finer textures appear to have occupied somewhat deeper water recorded in sediments that accumulated a few meters farther up in the transgressive sequence.

Depository. Figured specimens and other reference specimens from the locality are in collections of the U.S. National Museum. Figured specimens include USNM 480442–480455.

ACKNOWLEDGMENTS

Support for the study was provided by COBASE Grant 5-20694 to Rigby from the National Academy of Sciences/National Research Council, support which is much appreciated. Several versions of the manuscript were

Figure 6. Photomicrographs of skeletal structure in acid-etched surfaces of platelike upper wall, and stems of the lower part of the sponge, Cypellospongia fimbriartis *Rigby and Gosney, 1983, from the Lower Triassic Thaynes Limestone in the Confusion Range of western Utah. Photomicrographs X10, and other figures X1. 1–3, Weathered surfaces of platelike fragments etched with dilute acetic acid so that silty matrix shows light gray and spicule elements of the skeleton, now preserved as sparry calcite, show as dark gray. The skeleton shows a general lack of cubic arrangement, and many elements appear almost spinose, as a function of cemented synapticulae attached to the spicules. Matrix-filled apertures are commonly elongated, either vertically in the stems or radially in the platelike fragments. Most evident long rays of hexactine spicules are also generally vertically oriented and may occur either singly or roughly grouped into discontinuous tracts. Arrows indicate ray junctions of hexactines, or junctions where distal rays rise. 1, 3, USNM 480448; 2, USNM 480449; 4, thin plate of upper part of the sponge, with apertures of intermediate dimensions characteristic of most sponges in the collections. Apertures crudely aligned in gently upwardly and outwardly radiating pattern, USNM 480450; 5, thin platelike fragment shows thickness of the plate in the upper left and moderately aligned and upwardly expanding pattern of apertures of intermediate to small dimensions on the concave, presumed gastral, surface of the sponge, USNM 480451; 6, pointed base, fractured at the bottom and the top, shows crude alignment of small ostia in characteristic small stems of the sponge—an axial spongocoel extends through the specimen, USNM 480452; 7, gently concave outer or dermal surface of thin, platelike fragment of the sponge, with small ostia, such as characterize the finer-textured end members of the species, essentially full thickness of the plate shows in the upper right—ostia crudely aligned vertically, with ostia separated by relatively thick skeletal tracts, USNM 480453; 8, exterior of a thin-walled stem fragment, with small ostia, stem broken top and bottom, USNM 480454; 9, side view of a stem, with somewhat oval cross section, that expands abruptly upward into proximal upper platelike part of the sponge—full thickness of the wall shows in the left center, but with matrix fill of the large spongocoel on the upper part. Apertures are of intermediate to large dimensions for the species in the collection, USNM 480455.*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typed by C. Cohen and C. M. Middleton; C. M. Middleton also printed some of the photographs in Figures 5 and 6. We appreciate the help and thoughtful reviews of our colleagues.

REFERENCES CITED

Boutwell, J. M., 1907, Stratigraphy and structure of the Park City mining district, Utah: Journal of Geology, v. 15, p. 434–458.

Boutwell, J. M., 1912, Geology and ore deposits of the Park City district, with contributions by L. H. Woolsey: U.S. Geological Survey Professional Paper 77, 231 p.

Carr, T. R., and Paull, R. K., 1983, Early Triassic stratigraphy and paleogeography of the Cordilleran Miogeocline, *in* Reynolds, M. W., and Dolly, E. D., eds., Mesozoic paleogeography of the west-central United States: Denver, Rocky Mountain Section of the Society of Economic Paleontologists and Mineralogists, Rocky Mountain Paleogeography Symposium 2, p. 39–55.

Carr, T. R., and Paull, R. K., and Clark, D. L., 1984, Conodont paleoecology and biofacies analysis of the Lower Triassic Thaynes Formation in the Cordilleran Miogeocline, *in* Clark, D. L., ed., Conodont biofacies and provincialism: Geological Society of America Special Paper 196, p. 283–293.

Clark, D. L., 1957, Marine Triassic stratigraphy in eastern Great Basin: American Association Petroleum Geologists Bulletin, v. 41, p. 2192–2222.

Clark, D. L., and Carr, T. R., 1984, Conodont biofacies and biostratigraphic schemes in western North America—a model, *in* Clark, D. L., ed., Conodont biofacies and provincialism: Geological Society of America Special Paper 196, p. 1–9.

Clark, D. L., Paull, R. K., Solien, M. A., and Morgan, W. A., 1979, Triassic conodont biostratigraphy in the Great Basin, *in* Sandberg, C. A., and Clark, D. L., eds., Conodont biostratigraphy of the Great Basin and Rocky Mountains: Brigham Young University Geology Studies, v. 26, p. 179–185.

Collinson, J. W., and Hasenmueller, W. A., 1978, Early Triassic paleogeography and biostratigraphy of the Cordilleran Miogeosyncline, *in* Howell, D. G., and McDougall, K. A., eds., Mesozoic paleogeography of the western United States: Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium 2, p. 175–187.

Collinson, J. W., Kendall, C. G., and Marcantel, J. B., 1976, Permian-Triassic boundary in eastern Nevada and west-central Utah: Geological Society of America Bulletin, v. 87, p. 821–824.

Finks, R. M., 1960, Late Paleozoic sponge faunas of the Texas region—the siliceous sponges: American Museum of Natural History Bulletin, v. 120, Article 1, 160 p.

Gray, J. E., 1867, Notes on the arrangement of sponges, with the description of some new genera: Zoological Society of London, Proceedings for 1867, p. 492–558.

Hose, R. K., and Repenning, C. A., 1964, Geologic map and sections of the Cowboy Pass, SW Quadrangle, Confusion Range, Millard County, Utah: U.S. Geological Survey Miscellaneous Geological Investigations, Map I-390.

James, B. H., 1980, Paleoenvironments of the Lower Triassic Thaynes Formation in Spanish Fork Canyon, Utah County, Utah: Brigham Young University Geology Studies, v. 27, no. 1, p. 81–100.

Reid, R. E. H., 1964, A monograph of the Upper Cretaceous Hexactinellida of Great Britain and Northern Ireland, Part IV: London, Palaeontographical Society, p. xlix–cliv.

Rigby, J. K., 1966, Triassic lyssakid sponges from Utah, *in* Abstracts for 1966: Geological Society of America Special Paper 101, p. 178.

Rigby, J. K., and Gosney, T. C., 1983, First reported Triassic lyssakid sponges from North America: Journal of Paleontology, v. 57, p. 787–796.

Schmidt, O., 1870, Grundzüge einer Spongien Fauna des atlantischen Gebeites: Leipzig, Wilhelm Engelmann, p. i–iv, 1–88.

Schrammen, A., 1912, Die Kieselspongien der oberen Kreide von Nordwestdeutschland, II Teil, Triaxonia (Hexactinellida): Palaeontographica, Supplement 5, p. 177–385.

Schulze, F. E., 1887, Report on the Hexactinellida collected by H. M. S. Challenger during the years 1873–1876, Report of Scientific Results of the Voyager of H. M. S. Challenger: Zoology, v. 21, p. 1–513.

Zittel, K. A. von, 1877, Studien über fossile Spongien, 1, Hexactinellidae: Abhandlungen der Königlich Bayerischen Akademie der Wissenschaften Mathematisch-Physikalischen Klasse, v. 13, p. 1–63.