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EARLY PERMIAN CORALS FROM ARROW CANYON, CLARK COUNTY, NEVADA

EDWARD C. WILSON AND RALPH L. LANGENHEIM, JR.
Natural History Museum of Los Angeles County, Los Angeles, California 90007 and
Department of Geology, University of Illinois, Urbana, 61801

ABSTRACT—Rugose and tabulate corals from the Lower Permian (Wolfcampian) part of the Bird Spring Group in Arrow Canyon, Arrow Canyon Range, Clark County, Nevada, comprise eight species in eight genera. *Stylastraea rowetti* n. sp. is the first unequivocal record of this genus west of Texas in North America. *Heritschiella girtyi,* the only endemic North American waagenophyllid genus and species, is recorded outside Kansas for the first time. *Paraheritschioides stevensi* formerly was known only from northern California. The other species also occur elsewhere in the Permian of Nevada and nearby. This southeast Nevada shelf area has the first known intermixture of corals from the Durhaminid Coral Province and subprovinces of far western North America and the Cyathaxonid Coral Province of middle and southwestern North America.

INTRODUCTION

THE EIGHT coral taxa in the Wolfcampian part of the BS_e Formation, Bird Spring Group, include taxa also occurring in contemporaneous faunas in northern California, Kansas, west Texas, and British Columbia, as well as elsewhere in eastern and southern Nevada. Thus, this faunule provides evidence of communication between disparate faunas once thought to be physically isolated. It is for this reason that we are illustrating and documenting the Arrow Canyon Fauna.

Arrow Canyon is about 75 km northeast of Las Vegas, Nevada (Figure 1). A continuous sequence ranging from highest Devonian through Wolfcampian rocks is exposed in a superposed drainage canyon crossing the northern end of the eastern ridge of the Arrow Canyon Range. Corals for this study were collected in the SW¼, sec. 7, T14S, R65E on the southern flanks of a flat-topped spur bordering the north side of Arrow Canyon wash at its lower end. This locality is reached by following Nevada Highway 168 to the point where it begins to climb out of the northern end of the irrigated and/or inhabited flats about 17 km northwest of Glendale, Nevada. At this point a secondary paved road enters the state highway from the southwest. Follow this road about 500 m southwest, crossing the wash, to a desert track that joins the paved road from the northwest. Follow this road about 1.5 km up the Arrow Canyon drainage, proceeding in part in the wash itself, to the collecting locality.

Two of the corals at this locality were described by McCutcheon (1961) and by McCutcheon and Wilson (1961). The bulk of the fauna was illustrated and described in a thesis by V. A. M. Langenheim (1964), who later (V. A. M. Langenheim and R. L. Langenheim, 1965) published a faunal list of Bird Spring Group invertebrates keyed to a described stratigraphic section. Cassity and Langenheim (1966) described and correlated the fusulinid fauna of the Bird Spring Group at Arrow Canyon, refining and enhancing biostratigraphic control. Because of its excellent exposure and ease of access, the Arrow Canyon section has attracted many students of Chesterian through Wolfcampian stratigraphy and paleontology. Most of this work is summarized by Webster and Langenheim (1979) and Langenheim and Webster (1979), who also provided a comprehensive bibliography.

Collections upon which this work is based were obtained in part by students enrolled in a University of California at Berkeley stratigraphy class on October 6 and 7, 1957. The students collected from localities B–4993 through B–4997 in beds designated, at that time, by painted numbers. Collections B–6152 through B–6163 were collected by V. A. M. Langenheim between December 17 and 30, 1957, from a section she measured by tape and compass and described (Langenheim, 1964). Additional collections, LACMIP 2544–2548 and 12613, were obtained by E. C. Wilson and William Fletcher on March 27, 1972, and by E. C. Wilson and P. G. Owen on February 8, 1991, along an east to west measured section traverse (not shown on Figure 1) that is approximately perpendicular to that of Langenheim and Langenheim (1965). In 1966, Cassity and Langenheim collected fusulinids from the V. A. M. Langenheim section and remeasured it by tape and compass techniques. They (Cassity and Langenheim, 1966) retained bed level stratigraphic units as described by V. A. M. Langenheim (1964). We employ those descriptions herein, but have adopted the remeasured thicknesses.

STRATIGRAPHY

The Bird Spring Group, also referred to as a formation, has not, as yet, been subdivided into regionally recognized formational units, excepting the basal Battleship Wash and Indian Springs Formations. Langenheim and Langenheim (1965), however, did define informal formational units at Arrow Canyon to facilitate study of the section and, tentatively, to guide geologic mapping in the immediate vicinity. Their uppermost BS_e formation consists of about 120 m of thick-bedded dolomite and limestone (Fig. 2). Units 227 through 231 are predominately thick-bedded, nearly chert-free, poorly fossiliferous dolomite. Subsequent mapping has shown that these rocks, occurring in the hinge of a major fold, have suffered local dolomitization and are not characteristic of the lowermost Permian in the Arrow Canyon Range. This interval is occupied by thick-bedded limestone elsewhere. Units 232 through 239 consist of interbedded cliff-forming limestone, some of which is cherty, and bench forming, silty limestone. Rocks of this part of the section are regionally persistent, containing abundant fusulinids and the corals described in this paper. The BS_e formation is succeeded at Arrow Canyon by about 125 m of silty limestone and calcareous siltstone capped by about 25 m of ledge-forming limestone measured by Welsh (1959) on the divide south of the canyon. Additional silty limestone and argillaceous siltstone form much of the eastern margin of the Arrow Canyon Range to the south, but have not been measured.

Bissell (1962) proposed the Spring Mountain Formation for open marine basinal carbonates of Wolfcampian and Leonardian age belonging to the Bird Spring Group. Stevens (1977), in a more recent regional synthesis of Cordilleran Permian stratigraphy, followed this usage. According to this classification, the BS_e formation belongs to the lower part of the Spring Mountain Formation, with the suprajacent silty rocks comprising the remainder. The BS_e formation, however, correlates well in both

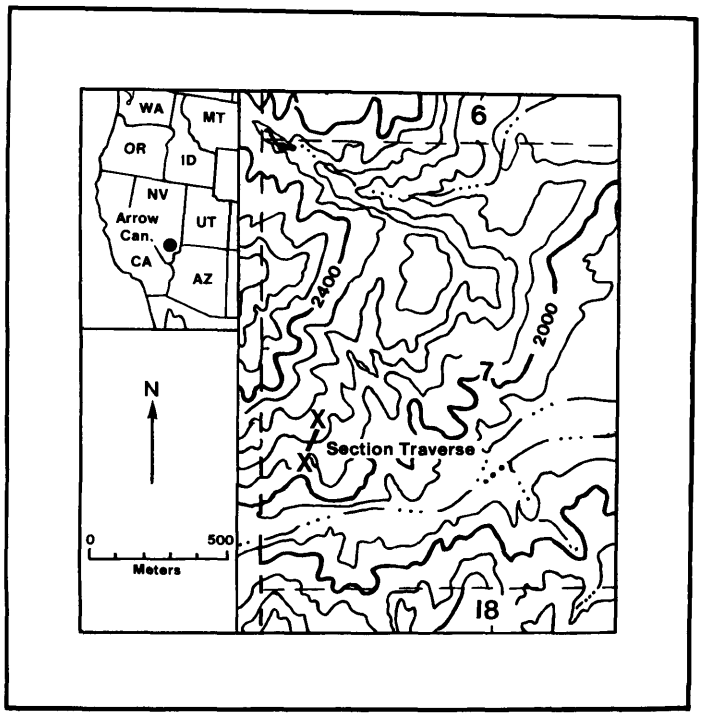

FIGURE 1—Map showing location of measured section traverse. Base from Arrow Canyon 15' quadrangle, U.S.G.S., 1958.

lithology and biostratigraphy with Longwell and Dunbar's (1936) informal "No. 3 member" of the Bird Spring Formation in the Spring Mountains, also recognized by Rich (1961). Barosh (1968) considered the "No. 3 Member" closely similar in lithologic and paleontologic character to the Riepe Spring Limestone of the Ely District. Inasmuch as the BS_e formation appears to be distinctive and recognizable over an extensive area, we use it in this paper.

Unit 237 (Figure 2) is part of the widespread, informally recognized Early Permian "coral bed" of the eastern Great Basin. At Arrow Canyon, Unit 236, directly below the coral bed, contains *Schwagerina moapaensis, S. ? multispira,* and *Pseudofusulina arrowensis. Oketaela waldripensis, Pseudofusulina arrowensis, Schwagerina paiutensis,* and *S.* cf. *S. grandensis* are present in Unit 235. In addition, *Pseudoschwagerina* cf. *P. convexa* occurs in unit 239 above the coral bed. These fusulinids, along with an occurrence of *Triticites creekensis* in Unit 227, place the coral bed in the Zone of *Pseudoschwagerina* s.l. or the Wolfcampian according to Cassity and Langenheim (1966). Stevens et al. (1979) recognized more narrowly defined fusulinid zones in the same sequence that would place Unit 239 in their Zone of *Pseudoschwagerina convexa,* Units 235 through 238 in

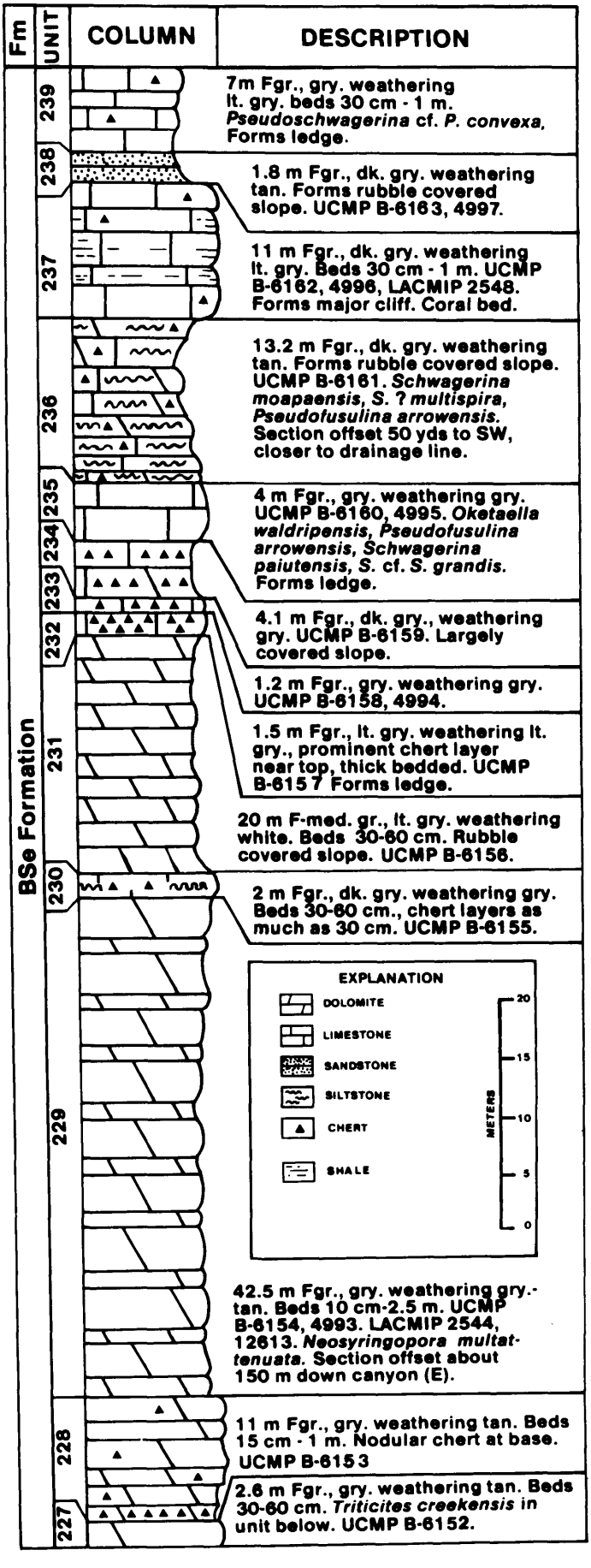

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FIGURE 2—Columnar section of units 227 through 239, BS_e formation, Bird Spring Group, at Arrow Canyon. Lithologic descriptions modified from Langenheim (1964). Fusulinid occurrences and unit thicknesses from Cassity and Langenheim (1966). Numbers UCMP B-0000 and LACMIP 0000 are locality numbers of the University of California Museum of Paleontology and the Natural History Museum of Los Angeles County, Invertebrate Paleontology Section. The following corals occur in Unit 237: *Caninia* (?) sp., *Kleopatrina ftatateeta, Paraheritschioides stevensi, Stylastraea rowetti, Heritschiella girtyi, Neomultithecopora mccutcheonae,* and *Cornwallia tabularia. Neosyringopora multattenuata* occurs in Unit 229.

AREAS / CORALS	WESTERN DURHAMINID CORAL PROVINCE		SOUTHERN DURHAMINID CORAL PROVINCE				CYATHAXONID CORAL PROVINCE	
	NORTHWEST BRITISH COLUMBIA	EASTERN KLAMATH MTNS.	SOUTHWEST NEVADA	CENTRAL NORTHERN NEVADA; CENTRAL SOUTHERN IDAHO	EAST CENTRAL NEVADA	SOUTHEAST NEVADA (this paper)	TEXAS	KANSAS
Caninia (?) sp.	**	?	?	?	?	X	?	?
Kleopatrina ftatateeta	*	*	X		X	X		
Paraheritschioides stevensi	*	X	*	*		X		
Heritschiella girtyi						X		X
Stylastraea rowetti						X	*	
Neomultithecopora mccutcheonae	**	X	X		X	X		
Cornwallatia tabularia	**		X	X		X		
Neosyringopora multattenuata	**	X	X			X		

X-species present; ?-insufficiently known taxon; *-other species in genus present; **-Tabulata & solitary Rugosa not published.

FIGURE 3—Correlation of Permian corals of the Arrow Canyon section with other areas of North America.

their Zone of *Schwagerina* cf. *S. crebisepta,* and Units 227 through 234 somewhere between their Zone of *Triticites californicus* and their Zone of *Schwagerina* cf. *S. crebrisepta.* Thus, the coral bed at Arrow Canyon is in the middle part of the Wolfcampian.

CORRELATION

In the Great Basin, all of the Pennsylvanian and the basal lower Permian rocks are devoid of colonial rugose corals, except for a loosely fasciculate one that is present locally in the Lower Pennsylvanian (Morrowan) rocks. In White Pine County, east-central Nevada, and nearby areas, the lowest Permian colonial rugose coral fauna is very rich and dominated by coralla of *Thysanophyllum,* some of which are a meter or more in diameter (Easton, 1960; Wilson and Langenheim, 1962). In the northern Spring Mountains of southwest Nevada, taxa of this fauna are a little more widespread stratigraphically, the coralla are smaller, and there is a somewhat lower occurrence of *Fomichevella* (Wilson, 1991). *Thysanophyllum* is absent in Arrow Canyon but some other taxa of the fauna associated elsewhere with it are present. In Arrow Canyon the dominant coral in size and abundance of coralla is *Stylastraea,* a genus unknown elsewhere in Nevada.

Western North America was curiously devoid of colonial rugose corals for the long period of the Pennsylvanian and the very earliest Permian, but then abruptly was invaded by them. Explanations for the long absence of colonial Rugosa followed by an explosive appearance can only be speculative. Perhaps the environment changed favorably, barriers preventing migration opened, lands or islands with corals drifted into properly directed currents, or a combination of these possibilities occurred. Apparently similar absences, appearances, and disappearances of scleractinian hermatypic corals throughout the stratigraphic record of the tropical western American Mesozoic and Cenozoic may have had similar causes.

In the Great Basin, the limestone units containing the lowest Permian rugose coral fauna are overlain by largely non-coral-bearing arenaceous rocks (Riepetown Sandstone of east-central Nevada, thick unnamed sandstone in northern Spring Mountains, unit 238 in Arrow Canyon). Above this sandstone, other coral faunas may occur where limestone is present, in some cases with the same genera, but invariably with different species. The basal fauna does not reappear.

In the Lower Permian McCloud Limestone of northern California, colonial rugose corals are large and distributed somewhat more evenly throughout the formation, although their ranges define a useful biostratigraphy. Absence of abrupt appearances and disappearances of entire faunas such as occur in the Great Basin suggests a more established fauna in a more stable environment. The coral faunas of the two differ one from the other to a rather surprising degree. The similarities, however, especially at the species level, indicate affinities and suggest paleogeographic relationships and migration events.

The Arrow Canyon Permian section is thin because the top is eroded away, but it possesses the rich first Early Permian colonial rugose coral fauna and has a few other kinds of corals in the Permian beds below it. Some of the rocks eroded from the line of section are present on the south side of the canyon as silty dolomites, but they lack corals. The entire fauna consists of only eight species, but these correlate with several areas (Figure 3). *Caninia* (?) can be disregarded because of doubtful identification. The *Kleopatrina ftatateeta* and *Neomultithecopora mccutcheonae* association correlates Arrow Canyon with sequences in east-central Nevada and southwest Nevada. These common occurrences indicate that the corals had ready access between the areas, perhaps somewhat complicated by the presence of Antler Highland islands. *Cornwallatia tabularia* occurs in Arrow Canyon, in southwest Nevada, and in the Sunflower Formation of central northern Nevada (probably an Antler Highland embayment). It is also present in the Providence Mountains of southeast California. Ready access between these areas must have been possible. *Cornwallatia* does not occur in east-central Nevada. *Paraheritschioides* was erected for a species from south-central Idaho, probably of Late Pennsylvanian age. The Arrow Canyon *Paraheritschioides* is another species, but the genus is restricted to western North America, suggesting affinity with the Idaho occurrence at the generic level. More importantly, the Arrow Canyon species, *P. stevensi,* was originally described from the McCloud Limestone of northern California, and provides an especially significant correlation between these two areas inasmuch as the northern California area

has been considered to be an exotic terrain that was remote from North America during the Permian (Stevens et al., 1990). The two tabulate corals *Neomultithecopora mccutcheonae* and *Neosyringopora multattenuata* are widespread in the western United States. Both occur in the same stratigraphic relationship (*N. multattenuata* is lower) at Arrow Canyon, in southwest Nevada, and in northern California. *Neomultithecopora mccutcheonae,* as mentioned earlier, also occurs in east-central Nevada, but not *Neosyringopora multattenuata,* although it occurs in the Pennsylvanian of the midwestern United States. A surprising member of the Arrow Canyon coral fauna is *Heritschiella girtyi,* previously known only from the Lower Permian of Kansas. This coral must have ranged from Kansas, through Oklahoma, Texas, and Sonora, to Nevada. It is the first correlation at the species level between the Durhaminid Coral Province of far western North America and the Cyathaxonid Coral Province that ranges from Kansas to Bolivia. A described species of *Stylastraea* previously was unknown in the United States, although a specimen was figured from the Permian of Texas by LeMone et al. (1976) and the genus has appeared in lists and brief citations. A species was described from Bolivia by Wilson (1990). The Arrow Canyon occurrence of this genus, although a new species, is another correlation with the Cyathaxonid Coral Province, although the genus is not known with certainty from elsewhere in western North America. It is present, however, in the Lower Permian faunas of the Arctic.

Thus, the Arrow Canyon section Permian coral fauna correlates to some degree at the genus and species levels with all major coral provinces and subprovinces of North America. It has more species in common with nearby localities than with more distant areas. The fauna provides a key correlation, heretofore lacking, between the western North American Permian coral provinces, which demonstrates that even though faunas at the ends of geographic ranges (Kansas and northern California, for example) may be radically different, they can be correlated through geographically intermediate faunas.

PALEOECOLOGY

Wilson (1991) described the Permian coral fauna from a section in the northern Spring Mountains of western Clark County, Nevada. Both that section and the Arrow Canyon Permian section are in the Bird Spring Group. For the purposes of paleoecology, the faunas of both sections are so similar that Wilson's (1991) conclusions are used here. The Permian part of the Bird Spring Group in Arrow Canyon was deposited in clear, shallow, warm marine water, of normal salinity, and with full access to the open sea.

COLLECTIONS AND METHODS

Morphological terminology is from Hill (1981), with a few additional terms that are in widespread use. Locality and type numbers are from the Natural History Museum of Los Angeles County, Invertebrate Paleontology Section (abbreviated LACMIP). Locality descriptions are given in the appendix. The University of California Museum of Paleontology is abbreviated UCMP. The term hypotype is used for a figured specimen of a previously described or an unidentified species.

The major collection of corals used for this study is in LACMIP. In addition, we examined the type specimens of Arrow Canyon corals deposited in UCMP by V. A. McCutcheon Langenheim, but we have searched for her non-type collections without success.

SYSTEMATIC PALEONTOLOGY

Phylum COELENTERATA Frey and Leuckart, 1847
Subphylum CNIDARIA Hatschek, 1888
Class ANTHOZOA Ehrenberg, 1834
Subclass RUGOSA Milne Edwards and Haime, 1850
Order STAURIIDA Verrill, 1865
Suborder CANINIINA Wang, 1950
Family CYATHOPSIDAE Dybowski, 1873

CANINIA? sp.

Figure 4.1

Documentation.—LACMIP hypotype 11431. One thin section and two polished sections from one corallite from LACMIP loc. 2548 were studied.

Discussion.—This taxon is based on an incomplete, abraded corallite and is included only because solitary corals are so rare in the section. The largest corallite diameter is 2.1 cm (dissepimentarium removed before burial), there are 38 major septa (no minors preserved), all greatly dilated in the cardinal quadrants, but less so in the counter quadrants. The cardinal septum is short and in a closed cardinal fossula. Although the axis is slightly crushed, there appears to have been no axial structure.

Suborder LITHOSTROTIONINA Spasskiy and Kachanov, 1971
Family DURHAMINIDAE Minato and Kato, 1965
Genus KLEOPATRINA McCutcheon and Wilson, 1963

KLEOPATRINA (KLEOPATRINA) FTATATEETA

(McCutcheon and Wilson, 1961)

Figure 4.2–4.5

Ptolemaia ftatateeta MCCUTCHEON AND WILSON, 1961, p. 1025, Pl. 123, figs. 1–6; WILSON AND LANGENHEIM, 1962, Pl. 87, figs. 1, 2.
Kleopatrina ftatateeta (McCutcheon and Wilson). LANGENHEIM AND LANGENHEIM, 1965, p. 238.
Kleopatrina (Kleopatrina) ftatateeta (McCutcheon and Wilson). WILSON, 1991, p. 733, figs. 5.1–5.2.

Documentation.—LACMIP hypotype 11432. Six thin sections and 67 polished sections from nine coralla from LACMIP loc. 2548 were studied. In addition, UCMP paratypes 30268, 30269, 34599, and 34600, all from UCMP loc. B-6162 in Arrow Canyon, were re-examined.

Discussion.—Wilson (1991) most recently discussed this species and extended its geographic range to the Spring Mountains, eastern Clark County, Nevada.

Some corallites of UCMP paratype 32068 have axial structures that are more complex than generally considered typical for the species. Other corallites in the same corallum have the typical simpler axial structure.

Family HERITSCHIOIDAE Sando, 1985
Genus PARAHERITSCHIOIDES Sando, 1985

PARAHERITSCHIOIDES STEVENSI (Wilson, 1982)

Figure 4.6, 4.7

Heritschioides stevensi WILSON, 1982, p. 45, figs. 27a–b.
Paraheritschioides stevensi (Wilson, 1982). STEVENS AND RYCERSKI, 1989, p. 172.

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FIGURE 4—*1, Caninia* (?) sp., LACMIP hypotype, 11431. *2–5, Kleopatrina ftatateeta* (McCutcheon and Wilson). *2, 3,* UCMP paratype 32068, Arrow Canyon, transverse and longitudinal sections; *4, 5,* LACMIP hypotype 11432, transverse and longitudinal sections. *6, 7, Paraheritschioides stevensi* (Wilson), LACMIP hypotype 11433, transverse and longitudinal sections. *8–10, Heritschiella girtyi* (Moore and Jeffords). *8, 9,* LACMIP hypotype 11434, Arrow Canyon, transverse section and ink-and-bleach tracing of it; *10,* LACMIP hypotype 11435, Kansas, transverse section, note short cardinal septum. All figures ×3.